ERDC/CERL TR-23-FINAL

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# Utilitarian Buildings in the DoD: A Historic Context and Analysis

**Legacy Program Project 15-783**

Madison L. Story, Adam D. Smith, Benjamin C. Mertens, Susan I. Enscore, and Courtney F. Wesa

September 2023

**Cover Photo:** Top left, covered storage at MCB Hawaii; bottom left, open storage at Fort Polk, LA; top right, open storage at NAWS (Naval Air Weapons Station China Lake, CA, and bottom right, storage at White Sands Missile Base, NM (all photos ERDC-CERL 2019).

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Final Report



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# Abstract

The United States (US) Congress codified the National Historic Preservation Act of 1966 (NHPA), the nation's most effective cultural resources legislation to date, to provide guidelines and requirements for identifying tangible elements of our nation's past. This legislative requirement was met through the establishment of the National Register of Historic Places (NRHP). The NHPA requires federal agencies to address their historic properties, which are defined as any prehistoric or historic district, site, building, structure, or object listed, or eligible for listing, on the NRHP. Section 110 of the NHPA requires federal agencies to inventory and evaluate their historic properties, and Section 106 requires them to determine the effect of federal undertakings on those properties. Section 106 also allows federal agencies and the Advisory Council on Historic Preservation (ACHP) to pursue program alternatives to the Section 106 process.

Program alternatives allow federal agencies to meet Section 106 requirements in alternate ways to balance historic preservation concerns with federal mission requirements and needs. Program alternatives are individually tailored to both federal agencies and the group of undertakings or program that is affecting historic properties. A goal of program alternatives is to improve effectiveness and efficiency of Section 106 reviews by streamlining review of routine undertakings occurring at historic buildings and structures and other historic properties. The Department of Defense (DoD) and the ACHP have negotiated and the ACHP has signed a variety of program alternatives through the years for Capehart-Wherry housing, unaccompanied personnel housing (UPH), ammunition storage, and ammunition manufacturing.

This report is an investigation into the history and types of utilitarian buildings and structures on DoD installations from 1946 through 1991. Utilitarian buildings and structures are those of practical design. They are typically prefabricated or follow a standardized plan and construction process, and they typically serve basic, industrial, non-mission critical functions. They are defined by both their design and construction process and their use.

In the US, many utilitarian buildings and structures have reached or are reaching 50 years of age, the benchmark at which typical buildings and structures are evaluated for NRHP eligibility. This report contains a historic context for utilitarian buildings and structures constructed during the twentieth century, an investigation into the DoD Real Property Assets Database (RPAD), the results of typology examinations in the field, and an account of the evolution of metal construction. This report will provide DoD cultural resource managers (CRMs) with a basis for identifying and evaluating potentially historic utilitarian buildings and structures that have reached 50 years of age and may be eligible for the NRHP. It may also provide the foundation for the creation of a program alternative to the Section 106 process for undertakings that affect these buildings and structures.

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# Figures

# Preface

This study was conducted for the Legacy Resource Management Program under Project Number 15-783, “Utilitarian Buildings: A Historic Context” and ERDC-CERL Project Number 332112, “FY15 Legacy Development of Typology and Historic Context Documentation.” The technical monitors were DoD Legacy Resource Management Program (Legacy Program) staff and DoD Historic Preservation Working Group members.

The work was performed by the Training Lands & Heritage Branch of the Operational Science & Engineering Division, US Amy Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL).

# Unit Conversion Factors

| Multiply | By | To Obtain |
|---|---|---|
| acres | 4,046.873 | square meters |
| hectares | 1.0 E+04 | square meters |
| square feet | 0.09290304 | square meters |
| square inches | 6.4516 E-04 | square meters |
| square miles | 2.589998 E+06 | square meters |
| square yards | 0.8361274 | square meters |
| yards | 0.9144 | meters |

# Abbreviations

| Term | Meaning |
|---|---|
| ACHP | Advisory Council on Historic Preservation |
| AFB | Air Force Base |
| CRM | Cultural Resources Manager |
| DoD | Department of Defense |
| DoDI | DoD Instruction |
| ERDC-CERL | Engineer Research and Development Center – Construction Engineering Research Laboratory |
| GIS | Geographic Information System |
| HABS | Historic American Buildings Survey |
| MCB | Marine Corps Base |
| MCAGCC | Marine Corps Air Ground Combat Center |
| NARA | National Archives and Records Administration |
| NAWS | Naval Air Weapons Station |
| NHPA | National Historic Preservation Act |
| NPS | National Park Service |
| NRHP | National Register of Historic Places |
| OSD | Office of the Secretary of Defense |
| RPAD | DoD Real Property Assets Database |
| SHPO | State Historic Preservation Officer |
| WWII | World War II |

# 1 Methodology

## 1.1 Background

The US Congress codified the National Historic Preservation Act of 1966 (NHPA), the nation's most effective cultural resources legislation to date, in order to provide guidelines and requirements for identifying tangible elements of our nation's past. This legislative requirement was met through creation of the National Register of Historic Places (NRHP). Contained within this piece of legislation (NHPA Sections 110 and 106) are requirements for federal agencies to address their historic properties, defined as any prehistoric or historic district, site, building, structure, or object listed, or eligible for listed, on the NRHP. Section 110 requires federal agencies to inventory and evaluate their historic properties. Section 106 requires the effects of federal undertakings on historic properties to be taken into account.

This report is a component of a larger series of documents on facilities constructed in the post-World War II (WWII) era, funded by the Department of Defense (DoD) Legacy Resource Management Program (Legacy Program). This report focuses on utilitarian resources constructed to support the DoD's mission. The basic understanding of utilitarian resources, or utilitarian buildings and structures, utilized by ERDC-CERL researchers through the course of research for this report is as follows: buildings and structures of practical design that are typically either prefabricated or constructed based on a standardized plan and process. They typically have little architectural design, complexity, or uniqueness; and were constructed quickly. They exhibit minimal defining characteristics related to design and ornamentation and were constructed to meet a basic need. Utilitarian buildings and structures are defined by their design and construction process rather than their intended or ultimate use; therefore, any building typology may be considered utilitarian.[1]

The information presented here contributes to the broader context of understanding the built environment for identifying and evaluating utilitarian buildings and structures on DoD installations. When identifying and evaluating utilitarian resources, this report should be supplemented with installation historic contexts, Service branch histories, and other resources related to site-specific historic contexts.

## 1.2 Objective

The project proposal outlined the objective of this report as a documentation of utilitarian resources, specifically those constructed as prefabricated temporary and semi-permanent buildings from 1946 to 1991 during the Cold War. The goal of this report is to enhance the management of these DoD resources and reduce costs associated with Determinations of Eligibility conducted during NHPA Section 106 and Section 110 processes for utilitarian facilities. Researchers expected to find a minimum of 6,000 facilities in the DoD Real Property Assets Database (RPAD) system that could be classified for basic utilitarian purposes; however, they anticipated finding many more temporary and other semi-permanent utilitarian buildings in DoD RPAD when searching with a basic definition for utilitarian resources, defining them as properties that exhibit no characteristics and are extant to provide a resource that solves a basic need.

Currently, there is no federal or DoD guidance regarding the criteria for eligibility of utilitarian resources for listing on the NRHP. As a result, many installations include them in their annual Section 110 architectural inventories based on age. The project developed a nationwide context for utilitarian buildings, created a building typology, established potential NRHP eligibility processes, and identified DoD RPAD codes of those

[1] This definition is based on and modified from the Department of Veterans Affairs and ACHP's definition of utilitarian properties in a 2018 Program Comment for Vacant and Underutilized Properties. This definition is presented in full in Chapter 3; John M. Fowler, "Notice of Issuance of the U.S. Department of Veterans Affairs Program Comment for Vacant and Underutilized Properties," *Federal Register* 83, no. 208 (October 26, 2018): 54119–54128, https://www.govinfo.gov/content/pkg/FR-2018-10-26/html/2018-23397.htm.

resources that could be included in a potential utilitarian buildings and structures Program Comment.

### 1.2.1 Project funding

Under a Military Interdepartmental Purchase Request (MIPR; DSAM40430), the Legacy Program retained the Engineer Research and Development Center-Construction Engineering Research Laboratory (ERDC-CERL) to complete a historic context, building typology assessment, and an overview of NRHP eligibility processes for utilitarian buildings and structures constructed on DoD installations from 1946 through 1991 with the goal of identifying a management solution for these resources.

### 1.2.2 Research design

This project focused on determining the most common types of utilitarian buildings and structures constructed between 1946 and 1991 and located on installations. The hypothesis developed during project proposal was that most utilitarian buildings would be prefabricated metal and that DoD RPAD would include over 6,000 metal buildings that could be classified as utilitarian. However, the actual numbers of buildings reviewed in this project exceeded the anticipated number (28,668) due to the finding that utilitarian buildings were constructed of wood and concrete block in addition to metal. Furthermore, while the hypothesis presumed that most utilitarian buildings would be classified as semi-permanent construction, researchers found that utilitarian buildings were also classified as temporary and permanent construction.

The pre-proposal for this project recommended 20 installation visits on eight five-day trips; however, after reductions in funding and alterations to the project plan, the research team ultimately visited six installations on six five-day trips. Researchers utilized the site visits to obtain information on building uses and types; installation history, including defense contract references, when available;[2] and utilitarian building manufacturer plans, when available.[3] This information, including defense contract references

[2] It became clear to researchers after completing two site visits that defense contract references were neither available nor applicable to the project.

[3] Researchers were unable to find manufacturer plans in installation archives, and still-active metal manufacturing building companies were largely unresponsive to requests to visit archives and retrieve plans. Companies that did respond denied archive access, citing proprietary trademarked information.

where available, is provided in Chapter 4 with supplementary photographs in Appendix D. The site visits allowed researchers to analyze historical and physical information to produce recommendations for a potential future program alternative.

#### 1.2.3 Overview of previously published literature regarding utilitarian buildings

Researchers conducted preliminary research to identify and evaluate existing published literature on the subjects of utility buildings and metal buildings before and through WWII. Researchers, though, were only able to identify two existing studies:

- *Support and Utility Structures and Facilities (1917-1946): Overview, Inventory, and Treatment Plan*, Katherine E. Grandine and Deborah K. Cannan, 1995.
- *World War II Temporary Military Buildings: A Brief History of the Architecture and Planning of Cantonments and Training Stations in the United States*, John S. Garner, 1993.

These two studies provided only a narrow understanding of early utilitarian buildings, as they did not investigate prefabricated buildings beyond Quonset and Nissen Bow Huts.

### 1.3 Site visits

The six sites selected for field visits after completion of the proposal stage were Naval Air Weapons Station (NAWS) China Lake, California; Marine Corps Base (MCB), Hawaii; Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, California; White Sands Missile Range, New Mexico; and Fort Polk, Louisiana.[4] The Legacy Program authorized a sixth site visit to Wright-Patterson Air Force Base (AFB), Ohio, as it is within driving distance of ERDC-CERL. Prior to visiting, researchers coordinated with the installation Cultural Resources Manager (CRM) to obtain authorization for visitation. CRMs did not accompany the team for all visits. The researchers gathered supplementary information while on temporary duty for other projects at Francis E. Warren AFB, Wyoming;

[4] This installation was Fort Polk during the research for this project; DoD renamed it Fort Johnson in 2023. This report will refer to the installation as Fort Polk to reflect the time when research was conducted for this project in 2016.

Joint Base Pearl Harbor-Hickam, Hawaii; MCB Camp Pendleton, California; Schofield Barracks, Hawaii; and Wheeler Army Airfield, Hawaii.

## 1.4 Report Layout

This report consists of three substantive chapters (Chapters 2–4). The information presented in these chapters provide the necessary background to produce empirical recommendations for program alternatives to Section 106, presented in Chapter 5.

The body of this report begins in Chapter 2, Historic Context, which presents a historic context for utilitarian buildings constructed between 1946 and 1991. The chapter first presents a brief history of prefabricated and standardized building materials and plans, followed by an explanation of utilitarian building development during four periods: WWII (roughly 1939–1945), the Early Cold War (roughly 1945–1955), the Vietnam War Era (roughly 1955–1975), and the Late Cold War and Gulf War Era (roughly 1975–1991). This chapter is supplemented by Appendix A, which provides a list of prefabricated metal building manufacturers and a textual and illustrated history of metal corrugation and metal roofing. This information may help CRMs identify manufacturers and periods of manufacture for utilitarian buildings on their respective installations.

Chapter 3, DoD RPAD, provides a summary of researchers' analysis of RPAD. DoD RPAD is the DoD-wide database of real property data compiled annually by the Office of the Secretary of Defense (OSD) based on inventories gathered by the individual Armed Services. DoD RPAD is a vital management tool utilized by the DoD, as the DoD has a real estate portfolio encompassing over 500,000 buildings and structures at more than 500 installations in the United States, US Territories, and foreign nations.[5] The process of gathering real property information begins at the installation, and each installation has its own DoD RPAD-equivalent database (such as the Accountable Property System of Record) . Data elements in the DoD RPAD include information such as age, use, and historic resource status.

[5] Office of the Assistant Secretary of Defense for Sustainment, "Real Property Accountability (RPA)," Real Property, accessed November 17, 2021, https://www.acq.osd.mil/eie/bsi/bei_rpa.html.

Chapter 4, Site Visits and Typology, presents the findings of the six site visits. The chapter presents a brief history of the installation, focusing on historic context regarding the construction of utilitarian buildings at that installation between 1946 and 1991; an inventory of utilitarian buildings at that installation per DoD RPAD; and an analysis of the definition of utilitarian buildings based on that installation's Real Property inventory. This analysis is supported by photographs of the many types of buildings classified as utilitarian in DoD RPAD, providing researchers and CRMs with a visual representation of these buildings to improve understanding of the utilitarian typology.

## 1.5 Authors

This project was conducted by a team of ERDC-CERL researchers based in Champaign, Illinois. The researchers were Madison L. Story, preservation specialist; Adam D. Smith, architectural historian; Benjamin M. Mertens, historian; Susan I. Enscore, cultural geographer and historian; and Courtney F. Wesa, data science intern. The project was managed by Susan I. Enscore.

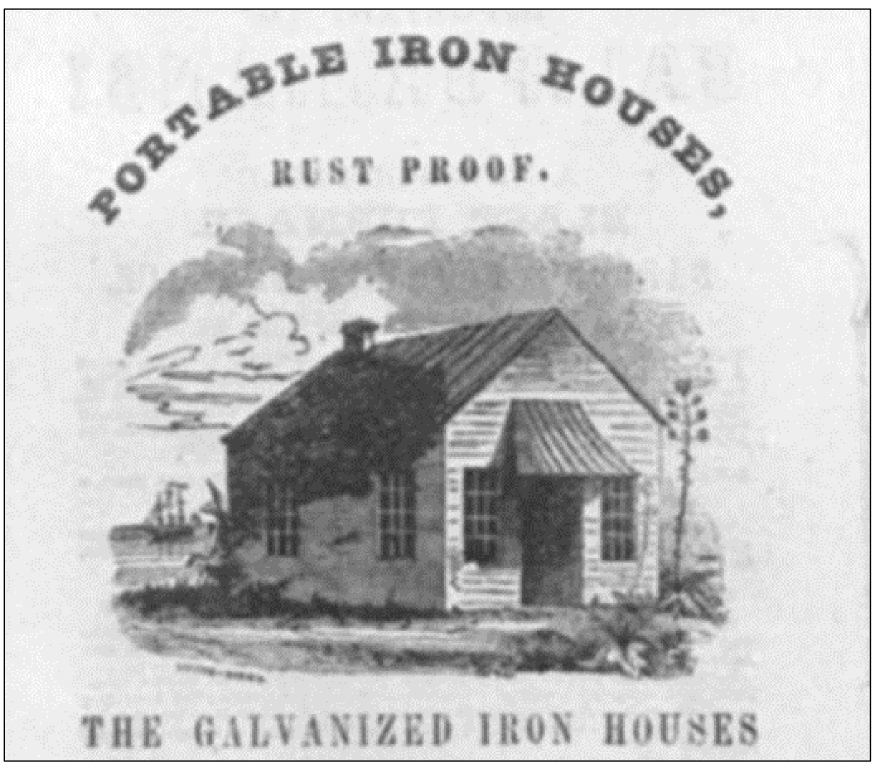
# 2 Historic Context

## 2.1 Utilitarian building construction prior to WWII

### 2.1.1 Origins of Metal Buildings

The origins of metal building history in the United States date back to the mid-nineteenth century, when the California Gold Rush resulted in an influx of workers to the state. This created an acute need for temporary, easily constructable housing. Peter Naylor of New York, a metal roof manufacturer, marketed "portable iron houses for California." These structures were 20 ft by 15 ft and could be assembled "in less than a day (and) were cheaper than wood, fireproof and more comfortable than a tent," per the advertisement (Figure 1). Naylor sold between 500 and 600 of these buildings during 1849.[6]

Figure 1. Advertisement for "Galvanized Iron Houses" marketed by Peter Naylor of New York, 1849 (Charles E. Peterson, "Prefabs in the California Gold Rush, 1849," Journal of the Society of Architectural Historians 24, no. 4 (Dec. 1965): 318-324).




[6] Metal Building Manufacturers Association, "50th Anniversary Brochure," Cleveland, OH: Metal Building Manufacturers Association, July 2006, 8.

By the 1840s, metal—specifically cast-iron—began to see use as structural members in traditional construction. James Bogardus, who was an American watchmaker and inventor, pioneered a method for mass-producing cast iron designs cheaply, with members being forged from molds in a foundry. The use of cast-iron as structural members allowed for taller and thinner columns which could support open interior spaces far larger than previously attainable with masonry bearing walls. Cast iron is strong in compression, making it perfect for building slim structures at great heights; however, it does have drawbacks, notably that it is "brittle, prone to cracking, and weak in tension and shear," which historically restricted its structural use mostly to vertical columns.[7]

The structural use of cast iron allowed for many aesthetic differences between cast iron and masonry structures. First, its vertical strength allowed buildings to have far wider and taller windows, with less room being devoted to load-bearing masonry. Cast iron's allowance for large windows was taken to its extreme in the Crystal Palace, which was constructed in London in 1851 and had an exterior almost completely encased in glass. More commonly, cast iron was used to increase exterior ornamentation through complex pieces that were forged to mimic intricate exterior details in the latest architectural fashions, which in the second half of the nineteenth century included Italian Renaissance and French Second Empire styles. Cast iron's aesthetic capabilities were also applied to previously existing structures. Store fronts and facades were popular uses for cast iron, as it could be used to convert residential structures into flashy retail fronts with relative ease. This method was used across the country, as these fronts were typically formed out of various members which could be easily "transported, replaced, painted and assembled quickly with nuts and bolts."[8] The Geo. L. Mesker Company (Mesker), located in Evansville, Indiana, was one of the largest manufacturers of metal architectural components in the latter quarter of the nineteenth century and offered many varieties of facades and other metal building components. Many were aesthetic, but they also offered structural columns (Figure 2). By the beginning of the twentieth century, cast iron began to be phased out of use in construction due to the trend towards less

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[7] Allen Ho, Marco Shmerykowsky, and Andrew Steinkuehler, "Cast iron: A historical background," *Civil and Structural Engineering Magazine*, Feb. 19, 2014, https://csengineermag.com/article/cast-iron-a-historical-background/.

[8] Michael Kimmelman, "Rediscovering An Ornate Cast Of Cast-Iron Buildings," *New York Times*, April 22, 1988, 1, https://www.nytimes.com/1988/04/22/arts/rediscovering-an-ornate-cast-of-cast-iron-buildings.html?searchResultPosition=1.

elaborate exterior designs, as well as the introduction of stronger metals, such as wrought iron and steel, for structural members.[9]

Figure 2. Two double-story structures finished with architectural components manufactured by Mesker, with metal components serving both aesthetic and structural purposes, such as the cast iron columns, 1892 (Geo. L. Mesker & Co., https://digital.evpl.org/digital/collection/evaebooks/id/97.).


By the beginning of the twentieth century, steel manufacturers began to market metal prefabricated buildings. The most common early market for metal prefabricated structures was for small garages. Butler Manufacturing Company of Kansas City, Missouri (Butler), which was at the forefront of the prefabricated metal building industry for much of the twentieth and into the twenty-first century, got their start in this manner in the early 1900s, with their first building being a metal garage with a semicircular corrugated roof (Figure 3).[10] These garages featured a

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[9] Geo. L. Mesker & Co., "Architectural iron works [catalog]," Evansville, IN: Geo. L. Mesker Steel Corporation, 1892, https://digital.evpl.org/digital/collection/evaebooks/id/97.

[10] Bill Cowles, Butler Company History, unpublished, undated manuscript on file with Butler Company, 33.

semicircular roof constructed via the same process that was used to produce siding for grain bins.

Figure 3. The first model of corrugated metal garages sold by Butler, 1909 (Butler Manufacturing Company, "Built By Hand, Backed By Experience," About, accessed August 20, 2021, https://www.butlermfg.com/about/).


In general, steel manufacturers entered the prefabricated building industry during the pre-WWII period through the agricultural or oil industry markets. For example, Butler focused much of their pre-WWII business on the agricultural market through building grain bins and other farm structures.[11] In the oil industry, the need for fireproof structures was essential, making metal buildings easily marketable. Star Manufacturing Company of Oklahoma City, Oklahoma (Star), was founded in 1927 as a manufacturer exclusively marketing small all-metal buildings to the oil industry as oil rigs known as "dog houses" before later transitioning to more general types of buildings.[12] Parkersburg Rig and Reel, of Parkersburg, West Virginia, was another company that saw the market for

[11] Cowles, Butler Company History, 109.

[12] "Star History," Star Building Systems, an NCI Buildings Systems Company, accessed December 3, 2018, http://www.starbuildings.com/au_starhistory.html.

metal buildings in the oil industry and created their own building division in the early 1930s.[13]

### 2.1.2 Nissen Huts

The history of prefabricated metal structures' use by the military began in World War I (WWI), with the introduction of the Nissen Bow Hut. It was originally designed in 1916 by its namesake, British Major Peter Nissen, while he served in France.[14] His design sought to fill a need for "cheap but functional structures for a variety of purposes, including offices and housing for military personnel."[15] It featured a distinct semi-cylindrical shape covering a span of 16 ft, with metal ribs joined to wooden purlins by hook bolts supporting the exterior, which was comprised of galvanized corrugated sheet metal. The semi-circular ends of the buildings were wooden, using board and batten construction, although brick was used in some circumstances. They featured a door and two windows (Figure 4). This design was mass produced by the British, who created over 100,000 Nissen huts throughout WWI, and is considered by some to be the first complete, mass-produced building.[16] Plans for these structures were provided to War and Navy Department personnel upon the US's entry into the war in 1917, and Nissen huts were used at airfields in France by the US Army Air Signal Corps as squadron offices, guardhouses, field stores, and hospitals (Figure 5).[17]

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[13] Parkline, Inc., "Building four decades of history," About Us, accessed December 5, 2018, https://www.parkline.com/about-us/.

[14] Iain Stuart, "Of the hut I bolted: A preliminary account of prefabricated semi-cylindrical huts in Australia," *Historic Environment* 19, no. 1 (2005): 51-57, 52.

[15] Aldo H. Bagnulo, "Nothing But Praise: A History of the 1321st Engineer General Service Regiment," Office of History, Headquarters, US Army Corps of Engineers: Alexandria, VA, 2009, 31.

[16] Chris Chiei and Julie Decker, *Quonset Hut: Metal Living for a Modern Age*, New York: Princeton Architectural Press, 2005, 6.

[17] John S. Garner, *World War II Temporary Buildings: A Brief History of the Architecture and Planning of Cantonments and Training Stations in the United States*, USACERL Technical Report CRC-93/01. Champaign, IL: US Army, Construction Engineering Research Laboratories, 1993, 30.

Figure 4. Diagram of a Nissen Bow Hut, 1919 (Charles C. Loring, "American Combat Airdomes," *Architectural Record*, 45 (April 1919): 311-324, https://www.architecturalrecord.com/ext/resources/archives/backissues/1919-04.pdf?-1601668800, 314).

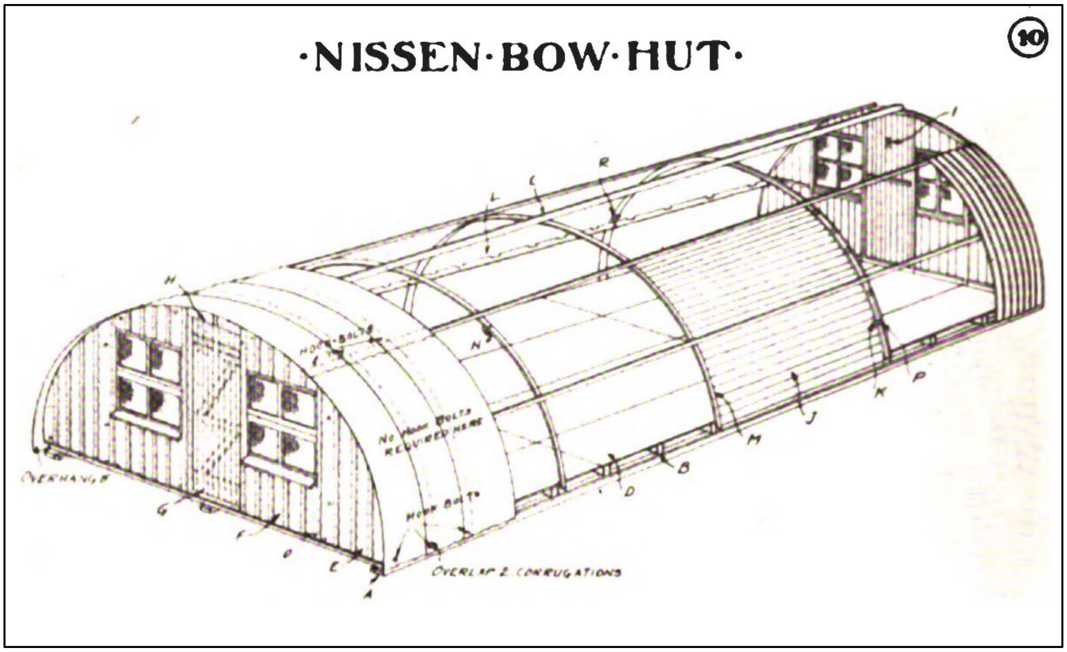
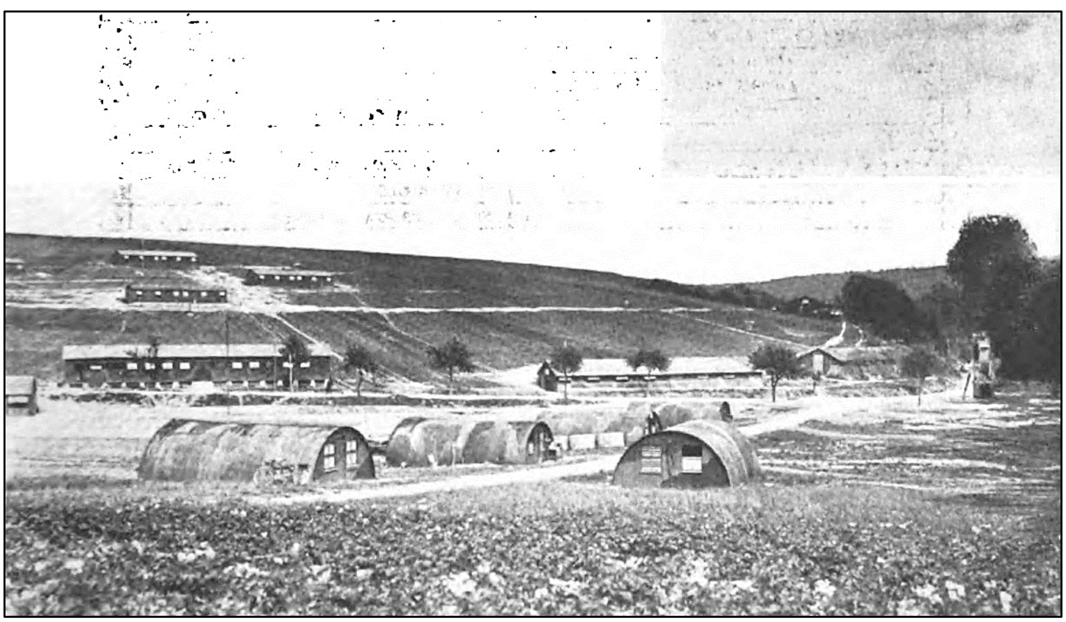


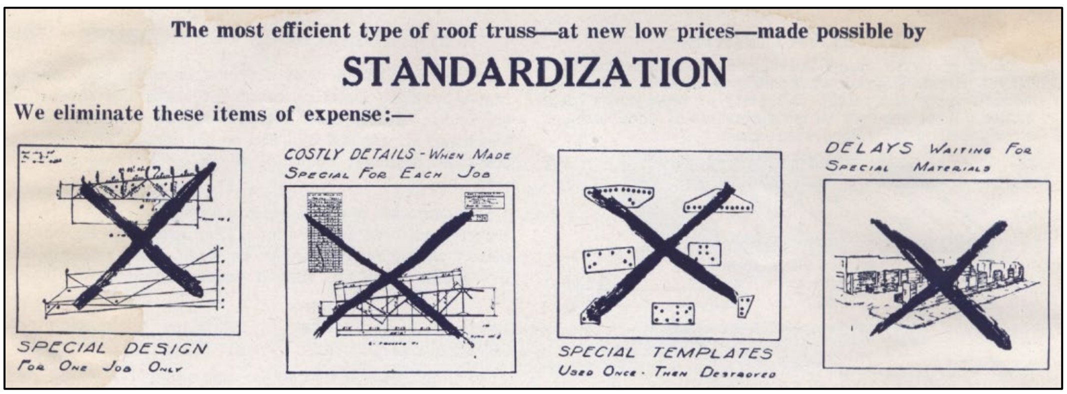

Figure 5. Several Nissen huts erected at an American airfield in France used during WWI, 1919 (Charles C. Loring, "American Combat Airdomes." *Architectural Record*, 45 (April 1919), https://www.architecturalrecord.com/ext/resources/archives/backissues/1919-04.pdf?-1601668800, 313).



### 2.1.3 Trend Toward Standardization

The metal building industry in the early twentieth century was largely operated on a special-order basis. Beginning when steel started to enter widespread use for structural members, pieces were often uniquely designed for single structures. This required a great deal of machinery retooling and delay in the manufacturing process, which led to a gradual trend toward standardization in the construction industry from the 1920s to the 1950s. Mesker, an early leader in the metal building industry, highlighted the benefits of standardization, specifically the associated cost savings, in a 1927 brochure (Figure 6).[18]

Figure 6. Part of an advertisement for Mesker highlighting the benefits of standardization in their roof trusses, 1927 (Geo. L. Mesker & Company. “Mesker: Standard Bowstring Steel Roof Trusses, Complete Store Fronts, Marquise” Evansville, IN: Geo. L. Mesker Steel Corporation, 1927, https://archive.org/details/GeoLMeskerMeskercompletestorefronts0001/, 11).




### 2.1.4 Prefabricated Metal Truss Structures

Mesker used standardization to offer several varieties of prefabricated metal roof trusses that could be used in structures of differing construction so long as the span was over 35 ft and there was adequate support for the truss weight. Mesker’s standardized trusses came in double pitch, single pitch, gabled, and flat roof designs, and all of Mesker’s trusses were delivered completely assembled with rivets (Figure 7).[19] Additionally, in

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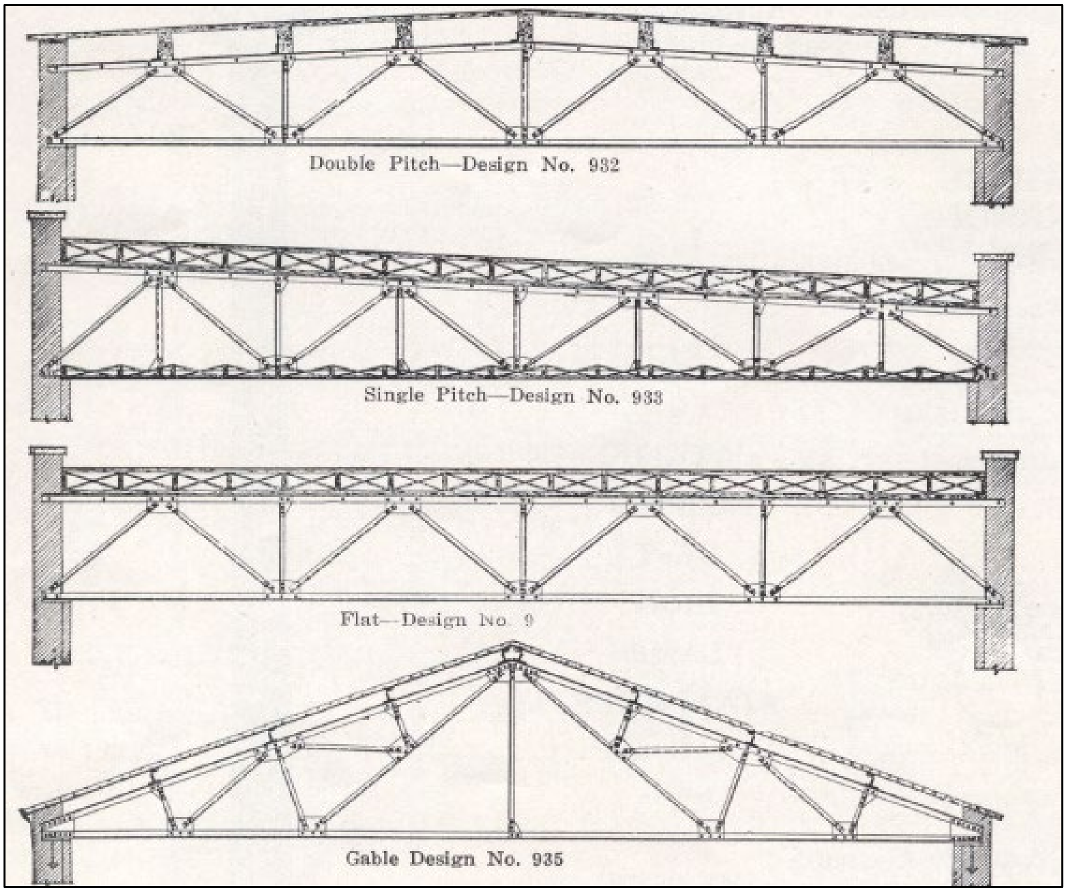
[18] Geo. L. Mesker & Co., “Mesker: Standard Bowstring Steel Roof Trusses, Complete Store Fronts, Marquise,” Evansville, IN: Geo L. Mesker Steel Corporation, 1927, https://archive.org/details/GeoLMeskerMeskercompletestorefronts0001/, 12.

[19] Geo. L. Mesker & Co., “Mesker: Standard Bowstring Steel Roof Trusses, Complete Store Fronts, Marquise,” 17.

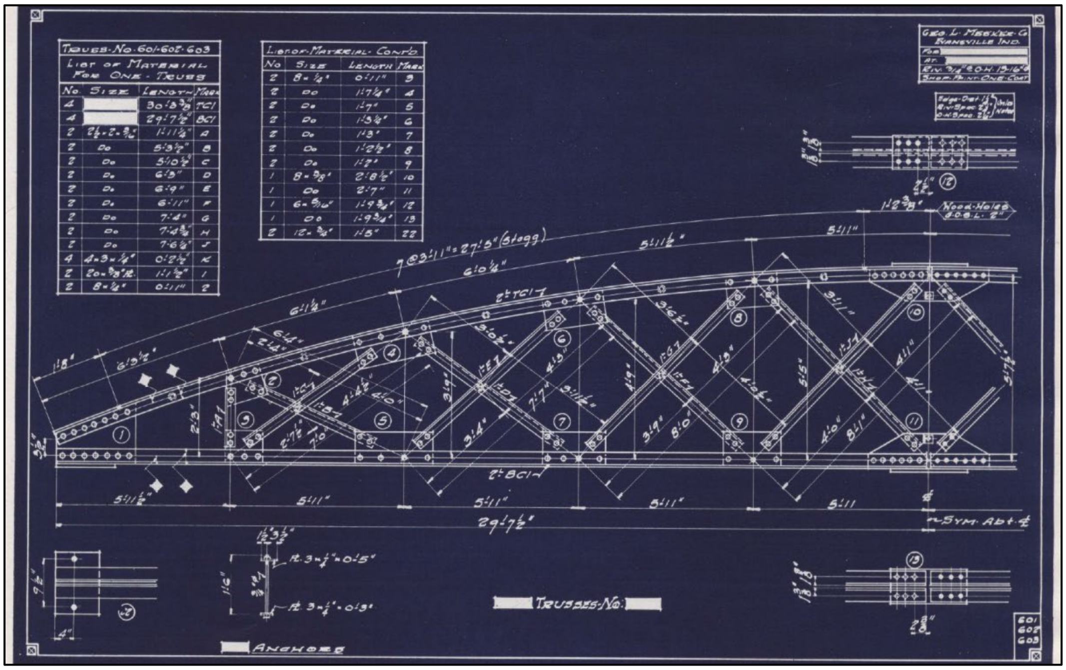
1927, Mesker became the first metal manufacturer to sell prefabricated bowstring trusses (Figure 8).[20]

Figure 7. Truss types offered by Mesker in their 1927 catalog (Geo. L. Mesker & Company, “Mesker: Standard Bowstring Steel Roof Trusses, Complete Store Fronts, Marquise,” Evansville, IN: Geo. L. Mesker Steel Corporation, 1927, https://archive.org/details/GeoLMeskerMeskercompletestorefronts0001/, 17).




[20] Geo. L. Mesker & Co., “Mesker: Standard Bowstring Steel Roof Trusses, Complete Store Fronts, Marquise,” 12.

Figure 8. Blueprint for the Mesker Standard Bowstring Steel Roof Truss featured in their 1927 catalog (Geo. L. Mesker & Company, "Mesker: Standard Bowstring Steel Roof Trusses, Complete Store Fronts, Marquise," Evansville, IN: Geo. L. Mesker Steel Corporation, 1927, https://archive.org/details/GeoLMeskerMeskercompletestorefronts0001/, 12).




Mesker's truss varieties soon came to be used in their line of prefabricated buildings, which came in standard gable designs or with the bowstring truss roof. These structures were entirely metal excluding the foundation. The roofs were comprised of copper bearing galvanized steel sheets, which came in both straight and curved panels to accommodate for the curve of bowstring trusses. They were marketed for their fireproof nature, for their ability be taken down and rebuilt, and with recommended uses including "warehouses, factories, airplane hangars, (and) garages" (Figure 9, Figure 10, and Figure 11).[21]

[21] Geo. L. Mesker & Co., "Mesker: Standard Bowstring Steel Roof Trusses, Complete Store Fronts, Marquise," 17.

Figure 9. The steel frame of a 50 ft x 60 ft. Mesker airplane hangar with galvanized steel roofing panels beginning to be applied, Pennco Airport, Madison, Wisconsin, 1928 (Geo. L. Mesker & Company, "Mesker store fronts and metal building products," Evansville, IN: Geo. L. Mesker Steel Corporation, 1928. https://archive.org/details/GeoLMeskerstorefrontsandmetalbuilding0001/, 12).

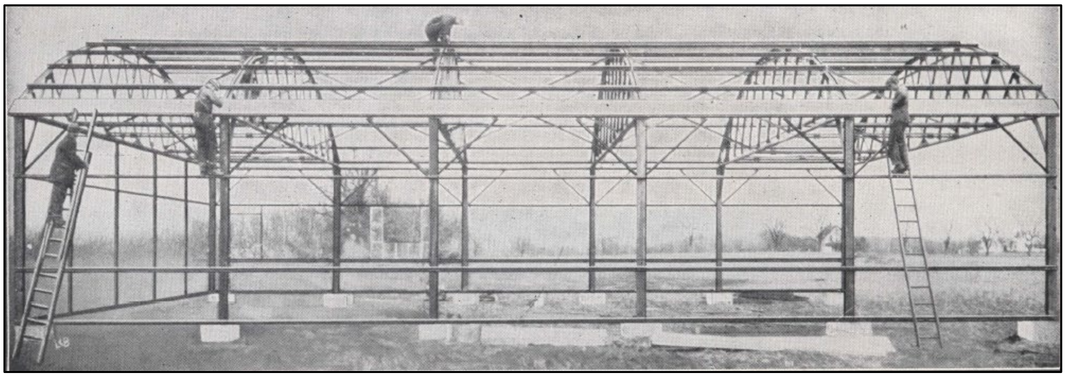


Figure 10. A fully completed Mesker hangar, measuring 60 ft by 72 ft, featuring double sliding doors and a lean-to addition on one side, Palwaukee Airport, Des Plaines, Illinois, 1928 (Geo. L. Mesker & Company, "Mesker store fronts and metal building products," Evansville, IN: Geo. L. Mesker Steel Corporation, 1928. https://archive.org/details/GeoLMeskerstorefrontsandmetalbuilding0001/, 12).

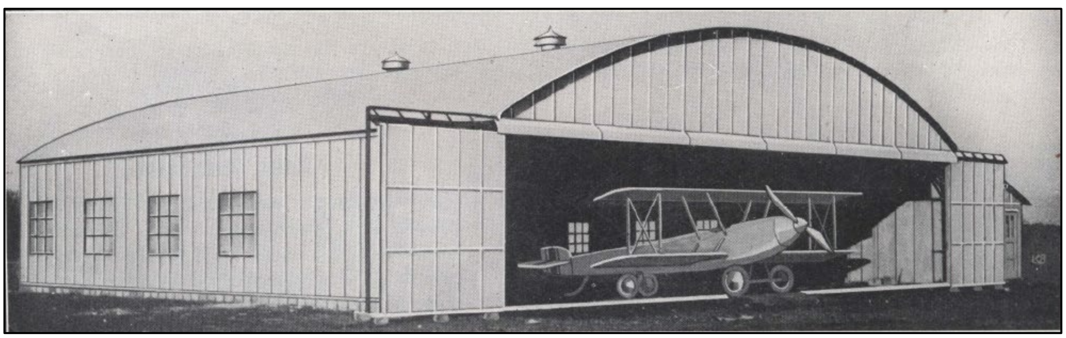
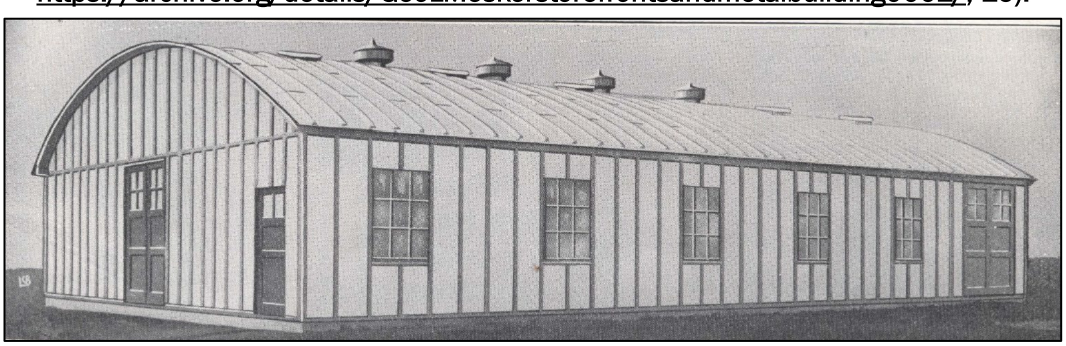


Figure 11. A Mesker prefabricated building being used as a warehouse featuring large loading doors, personnel doors, skylights, and significant ventilation, Two Rivers, WI, 1928 (Geo. L. Mesker & Company, "Mesker store fronts and metal building products," Evansville, IN: Geo. L. Mesker Steel Corporation, 1928. https://archive.org/details/GeoLMeskerstorefrontsandmetalbuilding0001/, 16).



### 2.1.5 Pressed Concrete Block

Advances in concrete technology during the nineteenth century allowed for an increase in concrete's construction use. The most significant of these advances was the development of Portland cement, which used hydraulic lime, in England. Though popular in the United States, domestic production of Portland cement did not outpace importation from England until the final decade of the nineteenth century. In 1855, Ambrose Foster and John Messinger of Wisconsin applied for a patent for the "Improved Building Block, or Artificial Granite." This was the earliest attempt to create a method for manufacturing pressed concrete blocks to allow the material to be used with more ease in construction (Figure 12).[22] Foster and Messinger's designs for concrete blocks had several different options for hollow cores, which would decrease the weight of the block without significantly reducing its structural abilities.[23]

Despite Foster and Messinger's patent, concrete blocks would not significantly enter the American building market for another half century, as early processes for its creation were time consuming, and the natural cement used prior to Portland cement's penetration into the American market was too expensive. Several attempts were made to create a machine that could easily manufacture pressed concrete blocks in the latter half of the nineteenth century, but many were too complex or too large to be moved. In 1900, Harmon S. Palmer designed a machine with a removable core and collapsible sides which permitted the removal of blocks before they had completely set, allowing for far faster production. Soon after Palmer, many others built upon Palmer's innovations and developed similar machines. The creation of more efficient machinery, combined with the large increase in domestic production of Portland concrete in the 1890s, allowed for pressed concrete block to see widespread use in the United States during the early part of the twentieth century. An additional factor that contributed to pressed concrete block's popularity during this period was its customization potential, as they could be made in a variety of colors to imitate different rock types and pressed

[22] James P. Hall, "The Early Developmental History of Concrete Block in America," Master's thesis, Ball State University, April 2009, 27.

[23] Ambrose Foster, "Improved Building Blocks, or Artificial Granite," US Patent 12264. 16 Jan. 1855.

with designs that could imitate stone or other decorative finishes (Figure 13).[24]

[24] Hall, "The Early Developmental History of Concrete Block," 27.

Figure 12. The patent for Foster and Messinger's pressed concrete blocks, which were designed with several open-cavity options (Ambrose Foster, "Improved Building Blocks, or Artificial Granite," US Patent 12264. 16 Jan. 1855).

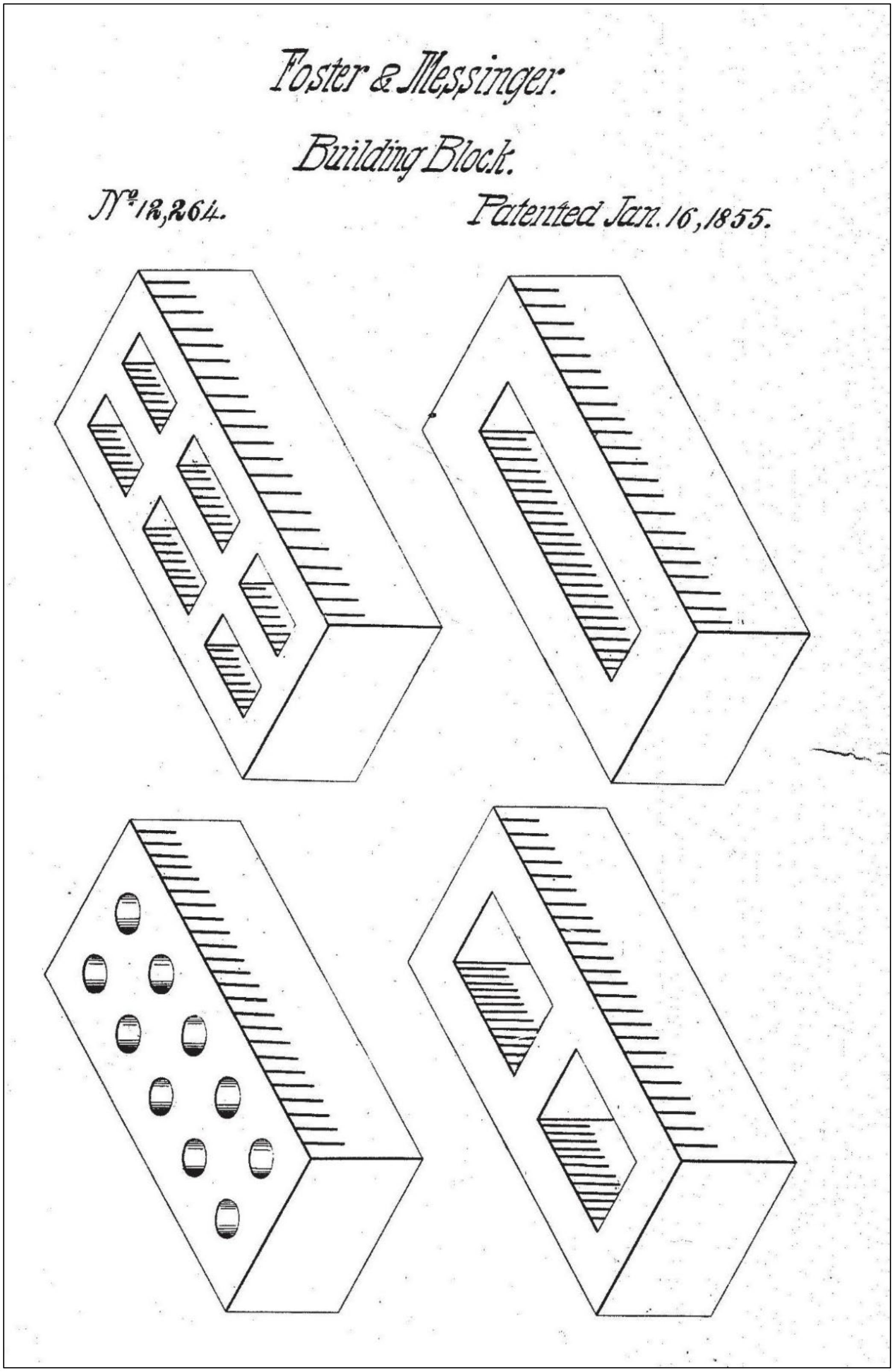
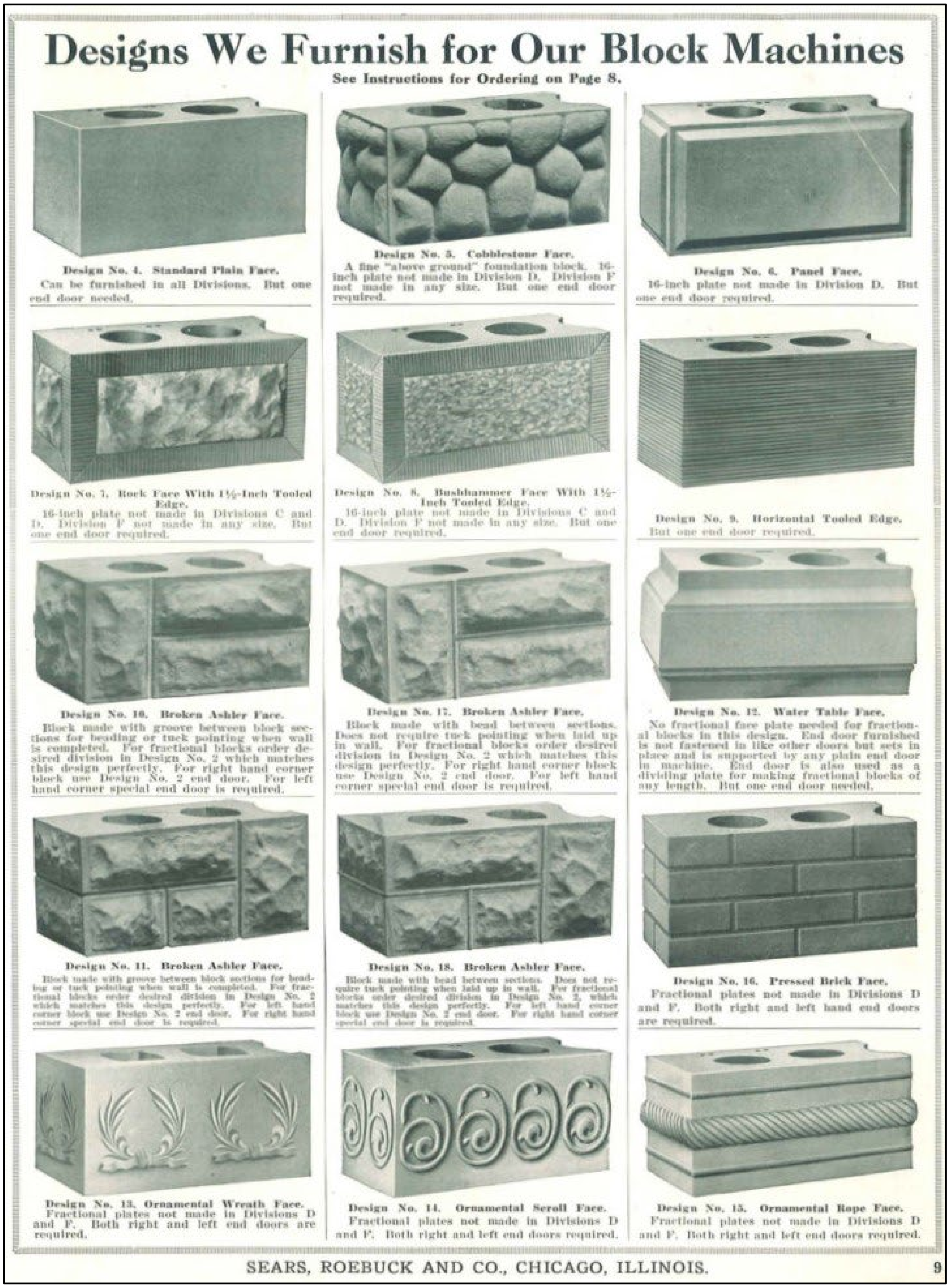


Figure 13. A page from an early twentieth century Sears catalog showing the variety of exterior finishes available in their pressed concrete blocks, 1915 (Classic Rock Faced Block, "Block History," About Us, accessed September 5, 2019, https://classicrock.wpengine.com/history-of-rock-face-block).



# Designs We Furnish for Our Block Machines

See Instructions for Ordering on Page 8.

**Design No. 4. Standard Plain Face.**
Can be furnished in all Divisions. But one end door needed.

**Design No. 5. Cobblestone Face.**
A fine "above ground" foundation block. 16-inch plate not made in Division D. Division F not made in any size. But one end door required.

**Design No. 6. Panel Face.**
16-inch plate not made in Division D. But one end door required.

**Design No. 7. Rock Face With 1½-Inch Tooled Edge.**
16-inch plate not made in Divisions C and D. Division F not made in any size. But one end door required.

**Design No. 8. Bushhammer Face With 1½-Inch Tooled Edge.**
16-inch plate not made in Divisions C and D. Division F not made in any size. But one end door required.

**Design No. 9. Horizontal Tooled Edge.**
But one end door required.

**Design No. 10. Broken Ashler Face.**
Block made with groove between block sections for beading or tuck pointing when wall is completed. For fractional blocks order desired division in Design No. 2 which matches this design perfectly. For right hand corner block use Design No. 2 end door. For left hand corner special end door is required.

**Design No. 17. Broken Ashler Face.**
Block made with bead between sections. Does not require tuck pointing when laid up in wall. For fractional blocks order desired division in Design No. 2 which matches this design perfectly. For right hand corner block use Design No. 2 end door. For left hand corner special end door is required.

**Design No. 12. Water Table Face.**
No fractional face plate needed for fractional blocks in this design. End door furnished is not fastened in like other doors but sets in place and is supported by any plain end door in machine. End door is also used as a dividing plate for making fractional blocks of any length. But one end door needed.

**Design No. 11. Broken Ashler Face.**
Block made with groove between block sections for beading or tuck pointing when wall is completed. For fractional blocks order desired division in Design No. 2 which matches this design perfectly. For left hand corner block use Design No. 2 end door. For right hand corner special end door is required.

**Design No. 18. Broken Ashler Face.**
Block made with bead between sections. Does not require tuck pointing when laid up in wall. For fractional blocks order desired division in Design No. 2, which matches this design perfectly. For left hand corner block use Design No. 2 end door. For right hand corner special end door is required.

**Design No. 16. Pressed Brick Face.**
Fractional plates not made in Divisions D and F. Both right and left hand end doors are required.

**Design No. 13. Ornamental Wreath Face.**
Fractional plates not made in Divisions D and F. Both right and left end doors are required.

**Design No. 14. Ornamental Scroll Face.**
Fractional plates not made in Divisions D and F. Both right and left end doors required.

**Design No. 15. Ornamental Rope Face.**
Fractional plates not made in Divisions D and F. Both right and left end doors required.

SEARS, ROEBUCK AND CO., CHICAGO, ILLINOIS. 9

### 2.1.6 Structural Terra Cotta

As early as the 1890s, structural terra cotta began to be manufactured in the United States, and it quickly became popular in the construction industry through the first quarter of the twentieth century. Structural terra cotta was made of either natural clay or clay produced from pulverized shale, which was then forced through a die. The blocks were then fired in a kiln just like a traditional brick would be. The blocks' interior featured several open champers within the clay, separated by an internal webbing. This added strength to the block while reducing both the amount of clay used and the final weight of the block. The webbing was visible from two ends of the block, while the remaining four sides had grooves, which were used to create better bonds between the terra cotta blocks and mortar, as well as plaster for interior walls and stucco for exterior walls (Figure 14). Terra cotta block could also serve as the structural wall behind an anchored brick veneer. Structural terra cotta was commonly used in buildings under three stories, but terra cotta bricks were used as infill between steel structural elements in commercial and high-rise structures, as well. Other uses of terra cotta blocks include being a filler under concrete floors, serving as a fireproof surround for steel beams, or as interior walls (Figure 15). One major drawback of structural terra cotta blocks was their brittleness, especially if left exposed. Terra cotta saw use in military construction as late as 1940, by which time concrete began to replace terra cotta.[25]

[25] William Kibbel, III, "Historic Buildings – Structural Terra Cotta," published 2004, accessed September 4, 2019, https://historicbldgs.com/terra_cotta.htm.

Figure 14. Examples of the common dimensions of structural terra cotta, notice webbed interior and the grooves on the exterior (William Kibbel, III, “Historic Buildings – Structural Terra Cotta,” published 2004, accessed September 4, 2019, https://historicbldgs.com/terra_cotta.htm.).

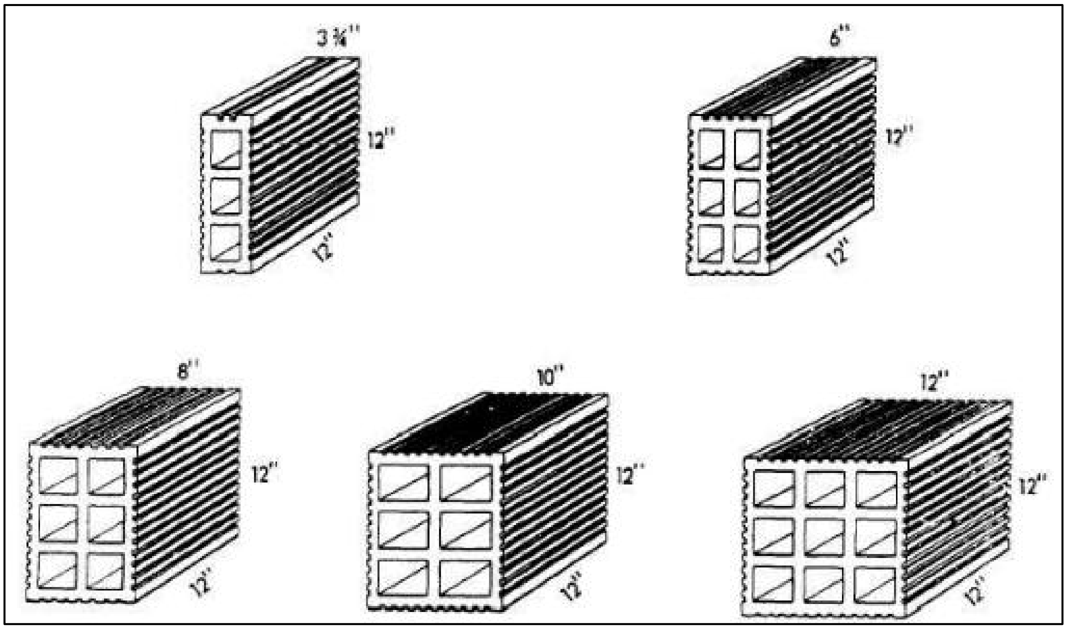
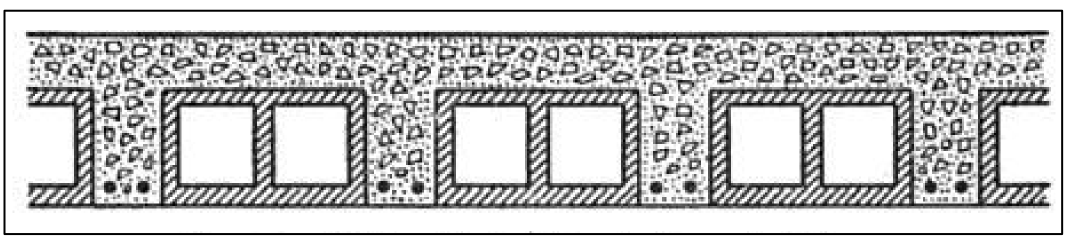



Figure 15. An example of how structural terra cotta was used as filler underneath concrete floors (William Kibbel, III, “Historic Buildings – Structural Terra Cotta,” published 2004, accessed September 4, 2019, https://historicbldgs.com/terra_cotta.htm.).



## 2.2 WWII Era

### 2.2.1 Quonset Huts

By the onset of the Second World War, the US had created their own version of the Nissen Bow Hut, called the Quonset hut. As a result of a series of agreements with the British including the 1940 Destroyers-for-Bases Agreement and the Lend-Lease Act of 1941, the War and Navy Department now had many bases that needed to be constructed in the Western Hemisphere, as well as forward operating bases in Britain (Figure 16). Due to lack of local labor and materials, especially in Britain, there was little choice but to supply prefabricated buildings shipped from the United States.[26]

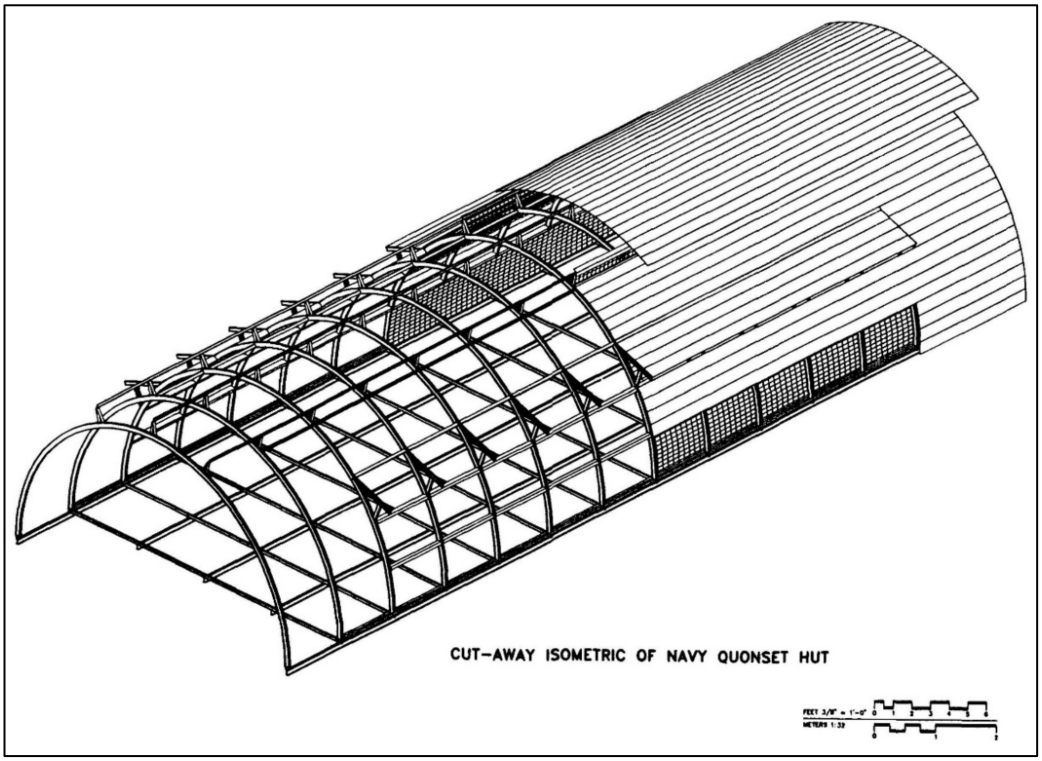
Figure 16. British civilian contractors erecting a Nissen hut, 1940–1946 (Library of Congress LC-USE6- D-008298 (P & P) LOT 3476).

In 1941, the Bureau of Yards and Docks contracted George A. Fuller and Co. (Fuller) to create a design for a prefabricated hut system for housing troops abroad, as well as a factory for their construction at the newly completed Quonset Point Naval Air Station, in the town of North Kingstown, Rhode Island on the Quonset Point peninsula, from which the design derived its name. In April 1941, Fuller's architects finished two hut designs, one with a 20 ft span and another with a 40 ft span (Figure 17). These designs were different from the Nissen hut in that they were entirely metal, other than windows and flooring, and that they used horizontally corrugated sheet metal. The Navy quickly signed off on the design, and production of Quonset huts began in the newly completed Davisville Naval Construction Battalion Center at Quonset Point Naval Air Station. [27]

[26] Chiei and Decker, *Quonset Hut*, 2.

[27] Garner, *World War II Temporary Buildings*, 56.

Figure 17. Cut-Away Isometric of Navy Quonset huts by Fuller, 1941 (John S. Garner, *World War II Temporary Buildings: A Brief History of the Architecture and Planning of Cantonments and Training Stations in the United States*, USACERL Technical Report CRC 93/01, Champaign, IL: US Army, Construction Engineering Research Laboratories, 1993, 57).




An early redesign of the Quonset hut incorporated the Stran-Steel framing system, which increased ease of assembly. The Stran-Steel framing system, first developed in 1933, featured steel I-shaped members consisting of two steel channels welded back-to-back, creating a groove in to which nails could be driven, allowing for 25% more grip than wood (Figure 18).[28] This allowed for the corrugated sheet metal exterior to be nailed directly into the frame and for Masonite hardboard to be nailed on from the interior, reducing length of assembly to one day with eight unskilled men and only hand tools.[29] Soon the demand for Quonset huts was high enough that production was taken over by Stran-Steel in Detroit, a division of Great Lakes Steel. By the end of WWII, over 153,000 Quonsets had been deployed and erected (Figure 19).[30]

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[28] Stran-Steel Division of the Great Lakes Steel Corporation, “Stran-Steel Construction Data,” Detroit, MI: Stran-Steel Division, 1938.

[29] Garner, *World War II Temporary Buildings*, 56.

[30] Chiei and Decker, *Quonset Hut*, 24.

Figure 18. A close-up of Stran-Steel's patented nailing groove, 1938. (Stran-Steel Division of the Great Lakes Steel Corporation, "Stran-Steel Construction Data," Detroit, MI: Stran-Steel Division, 1938).

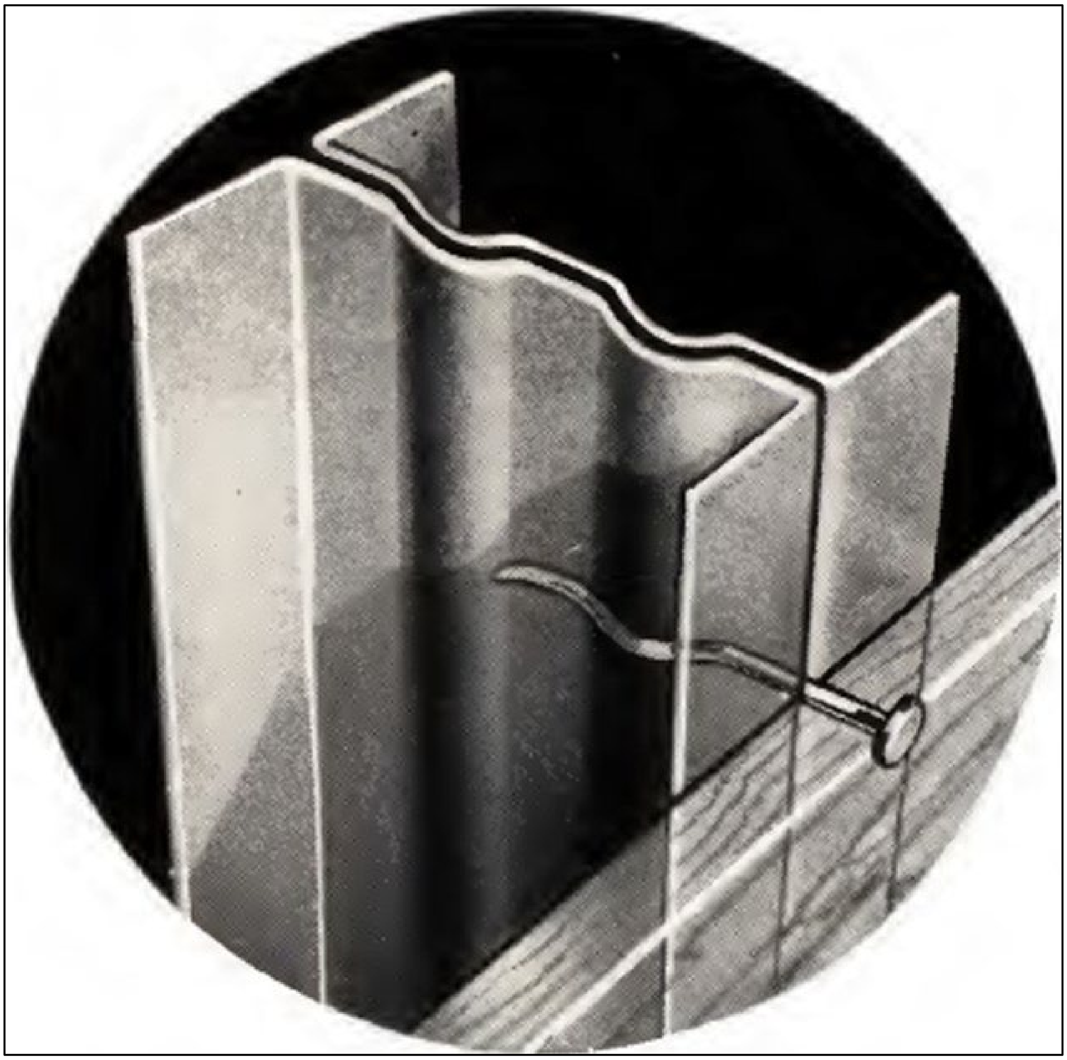


Figure 19. An array of Quonset huts being used as barracks at Fentress Field, Norfolk, Virginia, 1942 (NARA HR 9640).

### 2.2.2 Butler Huts

Stran-Steel was not the only company that manufactured semi-circular structures for the War and Navy Departments during WWII. Butler Company had their own design of a "half-round" known as the Butler hut. These structures were practically self-supporting through deep vertical ribs added to the curved steel exterior. Butler huts had a single entrance on one end, four windows on each side, and three windows on each end. On the end featuring the door, two large windows were on either side of the door and a smaller window was above the door. The end without the door featured similar window placement. Air was kept moving through the Butler huts by way of three ventilators at the top of the arch along the roof. Approximately 3,000 Butler huts were purchased by the War and Navy Department and were used "in the tropical pacific, along the Alcan Highway in Alaska, in Iceland, or in the British Isles." Butler did receive complaints from the Navy, however, for their lack of adaptability, as the single-entry point made it difficult to combine these structures or add walkways connecting them (Figure 20 and Figure 21).[31]

Figure 20. Oblique of a Butler hut deployed in a tropical environment, 1944 (“Prefabricated Emergency Housing and Structures for the Armed Forces,” *Prefabricated Homes* 1-5 (1944): 16–17).

Figure 21. Interior of a Butler hut being used by the Women’s Army Corps, 1944 (“Prefabricated Emergency Housing and Structures for the Armed Forces,” *Prefabricated Homes* 1-5 (1944): 16–17).

[31] Cowles, Butler Company History, 45-46; “Prefabricated Emergency Housing and Structures for the Armed Forces,” *Prefabricated Home* 1-5 (1944): 16-17.

### 2.2.3 Dymaxion Deployable Units

In November 1940, while driving through Illinois, the famous architect, author, and inventor Buckminster Fuller was inspired by the countless grain bins he saw along the road. Fuller met with the manufacturers of these grain bins, Butler Manufacturing Company (Butler), and pitched his idea for a yurt-like, prefabricated metal structure that could be used as low-cost housing.[32] Fuller also believed that these structures could serve as bomb shelters that, while not able to sustain a direct hit, would deflect bomb fragments and debris. Its circular shape further provided camouflage from aerial attacks because "it coincides with nature-forms such as trees and hillocks" (Figure 22).[33] Butler agreed with the potential of Fuller's idea and preliminary plans were submitted to the government by the end of the year.[34]

Figure 22. A Dymaxion Deployable Unit on display in Washington DC, 1941 (Library of Congress LC-USF34- 057367-D)


[32] Cowles, Butler Company History, 130.

[33] Alistair Gordon, "War Shelters, Short-Lived Yet Living On," *New York Times*, December 31, 2013, https://www.nytimes.com/2014/01/02/garden/war-shelters-short-lived-yet-living-on.html?searchResultPosition=1.

[34] Cowles, Butler Company History, 130.

The design for the structure consisted of circular corrugated steel walls, a conic 30-piece roof with ventilator at the top, a door, and 10 porthole windows. It stood 12 ft high and had a diameter of 20 ft, providing 314 square ft of floor space. A benefit of this design's similarity to a grain bin was that Butler would be able to use existing dies and not need to retool any machinery, resulting in a full-size prototype being constructed and sent to Washington for official inspection by April 1941.[35] In October 1941, a Dymaxion Deployable Unit was installed in the sculpture garden of the Museum of Modern Art in New York City (Figure 23 and Figure 24).[36] Erection required laying a brick foundation in sand and laying the Masonite floor, before bolting together the structure, waterproofing the joints, installing insulation board, and applying interior finish. A Dymaxion could be assembled from start to finish in six days by two unskilled workers.[37]

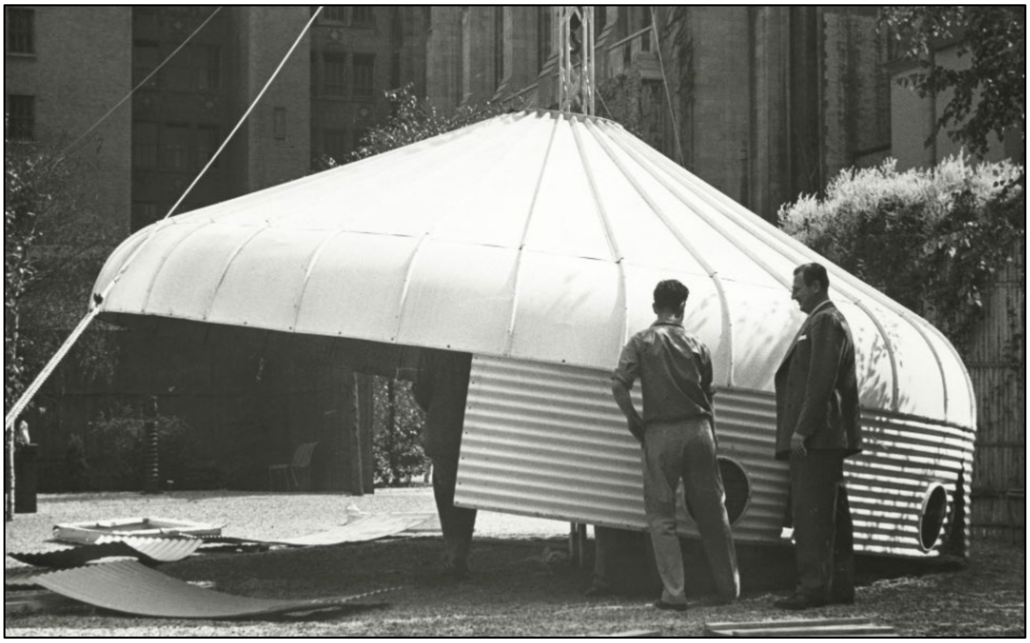
Figure 23. Buckminster Fuller assembling a Dymaxion Deployable Unit outside of the Museum of Modern Art, New York City, 1941 (The Museum of Modern Art Archives, New York. IN151.5).

[35] Cowles, Butler Company History, 130

[36] Adam D. Smith and Megan W. Tooker, "Naval Weapons Station Earle Reassessment," ERDC/CERL TR-13-26, (Champaign, IL: Engineer Research and Development Center-Construction Engineering Research Lab, 2013), 40.

[37] Cowles, Butler Company History, 131.

Figure 24. Construction crew beginning to attach horizontally corrugated steel sheet side panels, after raising the conical roof through the circular opening at the top with pulleys (The Museum of Modern Art Archives, New York. IN151.7).



Butler was prepared to supply up to 1,000 Dymaxion Deployable Units per day between their three factories at a price of $1,200 per unit; however due to steel rationing for the war effort, the government declined to contract any large quantity of Dymaxions, and production ended almost as soon as it began. In the short period of production however, Butler produced a few hundred Dymaxions, with most being purchased by the Army Signal Corps and shipped to Mediterranean, Persian Gulf, and Pacific bases. Approximately 50 air-conditioned units went to US Army officers in East Africa to be used as operating rooms. As late as November 1944, Butler anticipated resuming construction for Dymaxions that would be marketed as housing in Europe after steel rationing ended, but those plans never came to fruition (Figure 25, Figure 26, and Figure 27).[38]

Several Dymaxion Deployable Units have survived to the present day, with seven at Naval Weapons Station Earle and 12 at decommissioned Camp Evans, both in New Jersey.[39]

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[38] Cowles, Butler Company History, 131.

[39] Gordon, “War Shelters, Short-Lived Yet Living On;” Smith and Tooker, “Naval Weapons Station Earle Reassessment,” 41.

Figure 25. Floor plans demonstrating how multiple Dymaxion Deployable Units could be fit together and marketed as affordable post-war housing (The Museum of Modern Art Archives, New York. IN151.7).

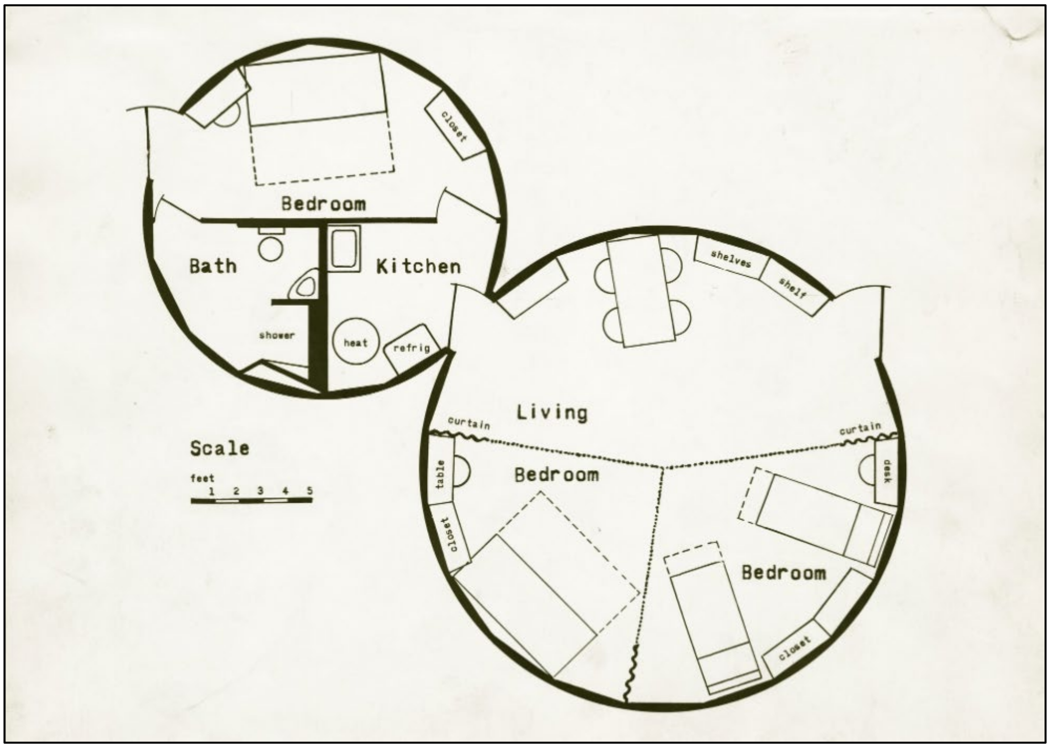



Figure 26. An exterior view of two Dymaxion Deployable Units connected to make a housing unit, 1944 ("Prefabricated Emergency Housing and Structures for the Armed Forces," *Prefabricated Homes* 1-5 (1944): 16–17).

Figure 27. An interior view of a Dymaxion Deployable Unit showing the use of curtains as internal room dividers, 1944 ("Prefabricated Emergency Housing and Structures for the Armed Forces," *Prefabricated Homes* 1-5, (1944): 16–17).

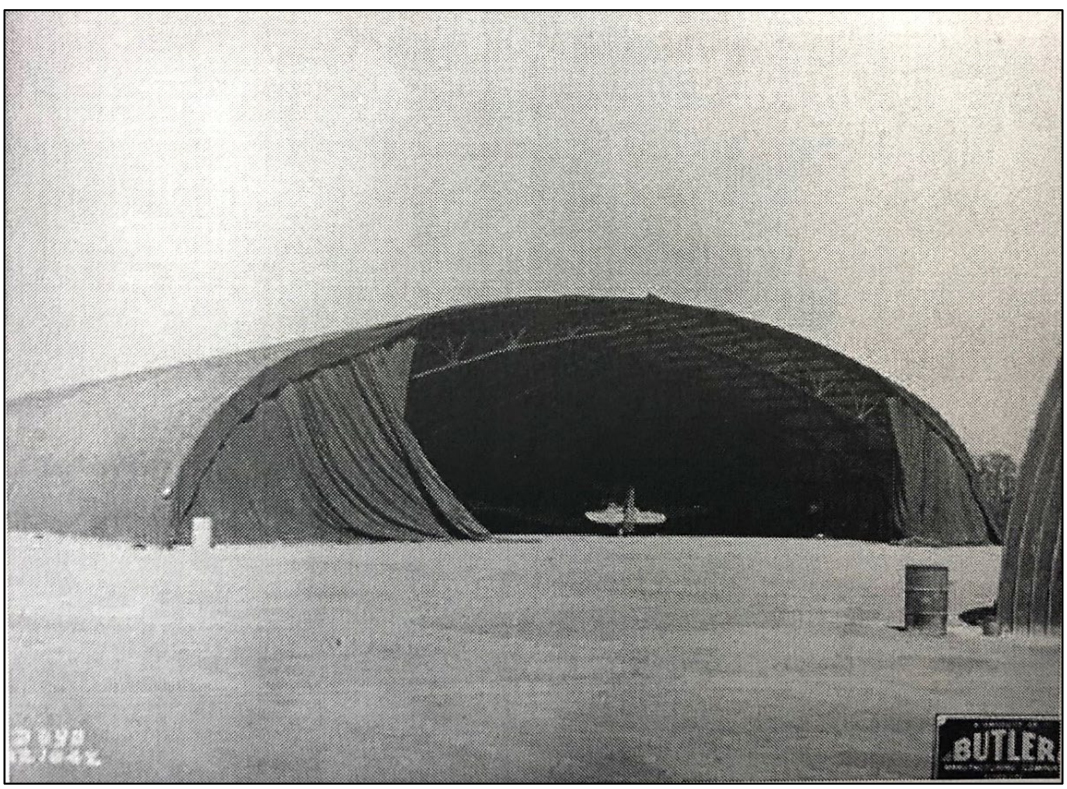
### 2.2.4 Hangars

Throughout WWII, the military found a need for rapidly deployable, demountable hangars for forward operating air bases. The Army Corps of Engineers looked for designs which were light and small enough to be flown to the site. These features were prioritized over needs for 100% weather resistance and complete structural integrity, so "if three or four out of a hundred hangars blew down, that's what they'd expect," said Wilbur Larkin, a chief engineer at Butler. Butler Manufacturing designed and produced a series of steel prefabricated hangars to fit these specifications. One such design featured a canvas cover pulled over a series of truss arches (Figure 28 and Figure 29). [40]

[40] Cowles, Butler Company History, 141.

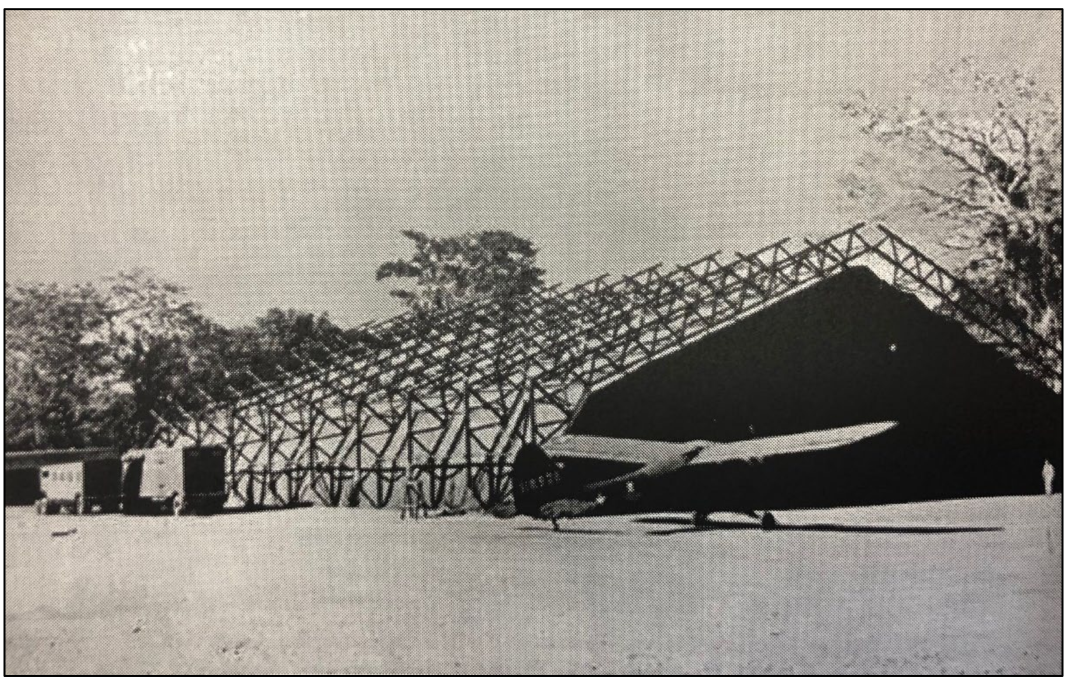
Figure 28. A Butler Manufacturing canvas covered hangar under construction, 1942 (Courtesy of Butler Manufacturing Company Archives).


Figure 29. A prefabricated canvas covered hangar used by the Army Air Corps, 1942 (Courtesy of Butler Manufacturing Company Archives).



Another hangar design manufactured by Butler was deemed by Butler historian Bill Cowles as “one of the most innovative products developed by Butler.”[41] This hangar, dubbed “Type CH,” featured a tent-like structure of trusses, meeting at a ridge along the center where both sides were joined with pins. It was 130 ft by 180 ft and 39 ft high at the ridge. The trusses were made of light cold-form strip steel material and the pieces were made to nest within one another to allow for easy transportation and assembly. In addition, the light weight of the structure allowed for construction without a foundation. All that was required were steel footing pads. The Type CH hangar was seen as innovative due to the manner with which the canvas was raised. Instead of being pulled overtop the steel framework, the canvas was raised from within the structure by a series of pulleys. After receiving approval for production of their Type CH hangar prototype in September of 1942, several hundred of these hangars were quickly ordered for military use (Figure 30).[42]

Figure 30. A Type CH hangar used by the Army Air Corps at Espiritu Santo, New Hebrides, 1942 (Courtesy of Butler Manufacturing Company Archives).



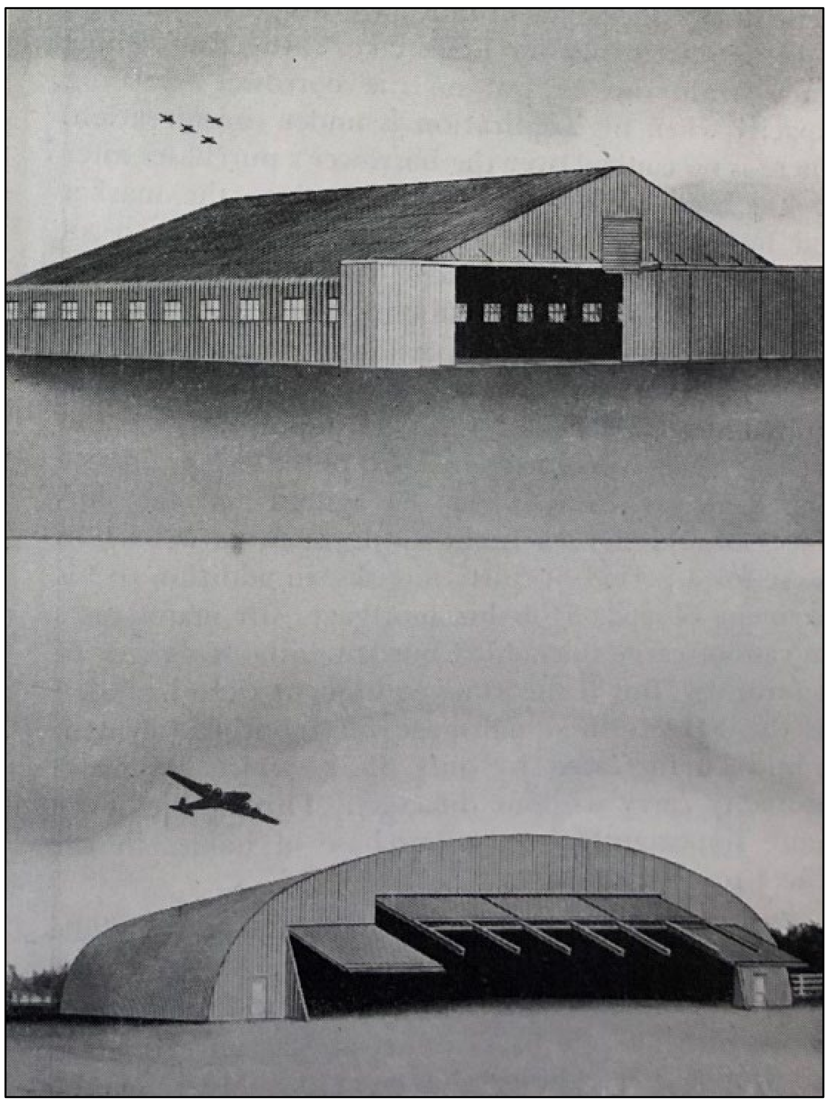
When these short-term, forward operating hangars needed to be converted into more permanent structures, Butler was contracted to manufacture steel covers which could fit on existing hangars (Figure 31). These were

[41] Cowles, Butler Company History, 141.

[42] Cowles, Butler Company History, 141.

furnished for all existing hangars as well as for all future hangars Butler supplied throughout the remainder of the war. Butler supplied 500 Type CH hangars with canvas covers, along with 500 steel covers, and then 250 hangars made initially with steel covers. Butler also designed the first all steel, radial, multiple "T" hangar around the end of WWII. All in all, Butler was responsible for "90% of all the prefabricated steel hangars shipped overseas to the Army and the Navy" during WWII.[43]

Figure 31. The two main variations of prefabricated hangars manufactured by Butler for the War and Navy Departments during WWII. The gabled roof featured double sliding doors while the rounded design required three separate doors that opened outward and upward, 1944 ("Prefabricated Emergency Housing and Structures for the Armed Forces," *Prefabricated Homes* 1-5 (1944): 16–17).



[43] Cowles, Butler Company History, 142, 154.

### 2.2.5 Deployable Structures

One of the chief reasons that prefabricated structures were growing in popularity during this period was that they could be shipped and deployed across the globe to assist Allied Forces. The Houston Ready-Cut House Company designed a rapidly deployable barracks for tropical conditions. The structure, aptly dubbed “The Tropical Pre-cut Building,” shipped fully contained in a 14 ft long crate to ease deployment. The buildings were wood framed with corrugated sheet metal for the siding and roofing. Due to its design for tropical conditions, a gap is left between the corrugated siding and both the floor and the ceiling in order to improve ventilation (Figure 32).[44]

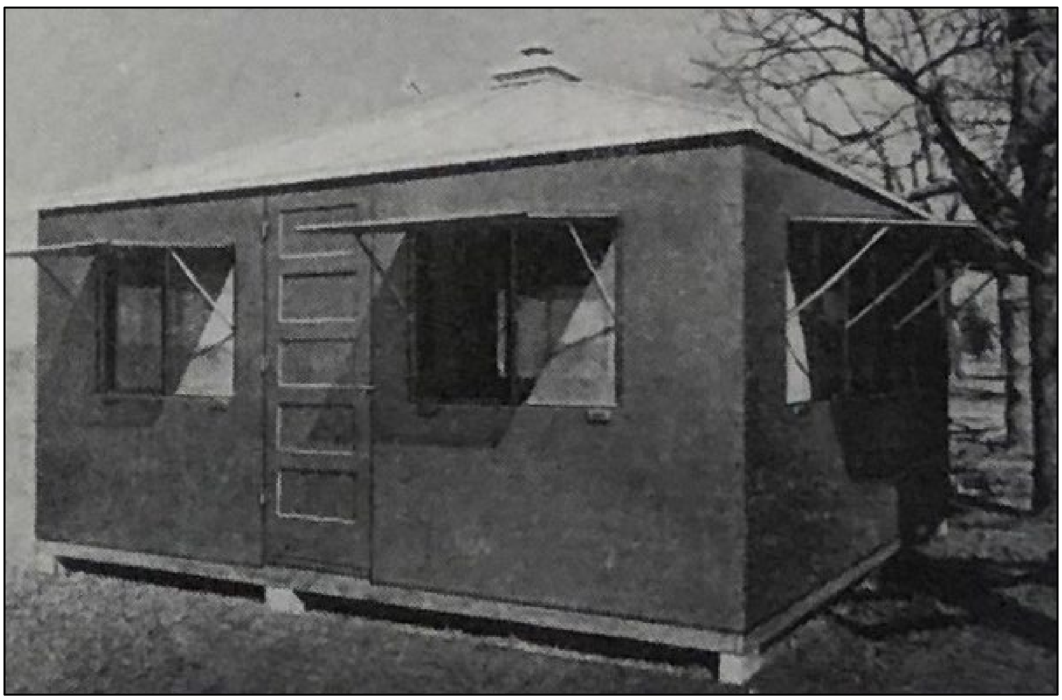
Figure 32. An advertisement for the “Tropical Pre-cut Building” designed as a rapidly deployable barracks and featured a wooden frame with steel corrugated siding and roofing, 1945 (Houston Ready-Cut Housing Co., “Typical War Work From out Houston Plant – The Tropical Pre-cut Building,” *Prefabricated Homes* 1-5 (June 1945): 3).


In addition to hybrid wood/metal structures like the “Tropical Pre-cut Building,” strictly wooden prefabricated structures were also designed and marketed to the War and Navy Departments as deployable barracks and

[44] Houston Ready-Cut Housing Co., “Typical War Work From out Houston Plant – The Tropical Pre-cut Building,” *Prefabricated Homes* 1-5 (June 1945): 3.

housing. One example is the Victory Hut, also known as the Dallas Hut, manufactured by the Texas Prefabricated House & Tent Company of Dallas, Texas (Texas Pre-Fab) (Figure 33). Victory Huts were developed by architects H.F. Pettigrew and John A. Worley in 1940 as a plywood alternative to canvas tents.[45] Pettigrew and Worley established Texas Pre-Fab the following year.[46] Though Army personnel initially doubted the huts' ability to be quickly and easily constructed by soldiers, a demonstration of four or five men constructing them in Washington D.C. convinced the Army of the huts' potential.[47] By 1943, Texas Pre-Fab was producing 500 Victory Huts each day.[48]

Figure 33. A Victory Hut built by the Texas Prefabricated House and Tent Company with all window panels propped open for better ventilation, April 1943 ("Victory Huts and Homes," *Prefabricated Homes* 1-5 (April 1943): 26).



Victory Huts were initially designed as 16 ft by 16 ft prefabricated, portable, demountable housing units "which would be superior to tents – and at the same time, the most economical, compared to conventional

[45] Nancy Hopkins Riley, *Georgia O'Keeffe: A Private Friendship*, Santa Fe, NM: Sunstone Press, 2007, 46; Felix McNight, "Texas Pre-Fabricated Company Making Huge Contributions to Victory Effort," *The Dallas Morning News*, May 2, 1943, 1.

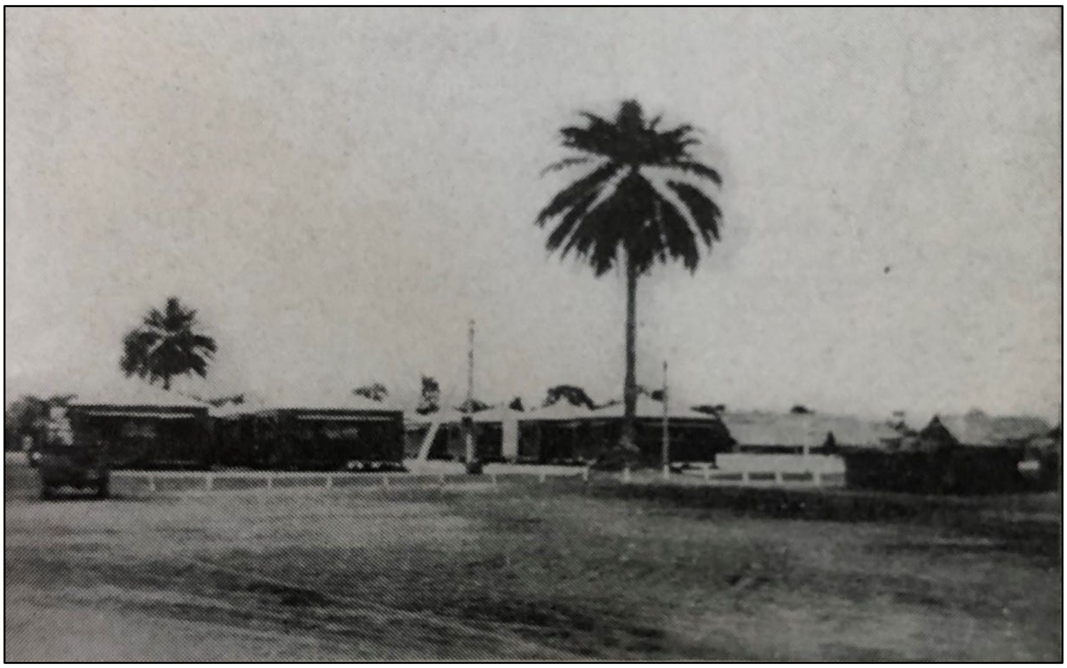
[46] McNight, "Texas Pre-Fabricated Company."

[47] Riley, *Georgia O'Keeffe*, 47.

[48] McNight, "Texas Pre-Fabricated Company."

troop housing."[49] They were "100% salvageable and easy to demount, transport and erect."[50] Their frame consisted of 2 in. by 2 in. members enclosed by waterproof plywood panels, which were also used for the pyramid hip roof. Each wall had several large, screened windows with plywood hinged flaps that could be propped open or closed to regulate temperature in warmer climates (Figure 34).[51] They were assembled in 40 minutes using 16 bolts and 32 screws.[52]

Figure 34. Several Victory Huts erected in formation at an unknown location "somewhere in Africa," 1944 ("Victory Huts and Homes," *Prefabricated Homes* 1-5 (April 1943): 14-15).



Texas Pre-Fab ultimately expanded their line to include huts that could serve as "a small home, partitioned, with living room, bedroom, bath and kitchenette," as well as special huts for Arctic regions with a storm vestibule for window protection.[53] For Arctic and other windy conditions, insulated wall panels added to the interior along with storm doors and a

[49] McNight, "Texas Pre-Fabricated Company."

[50] Texas Prefabricated House and Tent Company, "Housing for Military Personnel…with a bright civilian future," *The Military Engineer* 36, no. 230 (Dec. 1944): 11.

[51] "Victory Huts and Homes," *Prefabricated Homes* 1-5 (April 1943): 26.

[52] Riley, *Georgia O'Keeffe*, 47; McNight, "Texas Pre-Fabricated Company."

[53] McNight, "Texas Pre-Fabricated Company."

potbelly stove (Figure 35). The windows were also available in cellophane "Cel-o-glass."[54]

Figure 35. Two Victory Huts outfitted for winter weather, as seen by the ventilator for the potbelly stove at the roof peak, featured in an advertisement, 1943 (Texas Prefabricated House and Tent Company, "Housing for Military Personnel…with a bright civilian future," *The Military Engineer* 36, no. 230 (Dec. 1944): 11).


Perhaps inspired by the success of the Quonset hut, Victory Huts were designed to be easily joined together by "omitting wall sections" (Figure 36). These larger structures could now serve additional purposes to troop housing, with its recommended uses being "field hospitals, field offices, (or) shelters to protect valuable machinery."[55] At Naval Air Station Ellyson Field, Pensacola, Florida, for example, four huts were joined together in a row to form one large room that could seat up to 120 people. This building served as the chapel. Similarly, at Naval Air Station Banana River, Florida, six huts were joined together to create a cruciform chapel with a capacity of approximately 200.[56] Because of their ability to serve a variety of uses while being quickly deployable and easy to erect, Victory Huts were used at

54 "Victory Huts and Homes."

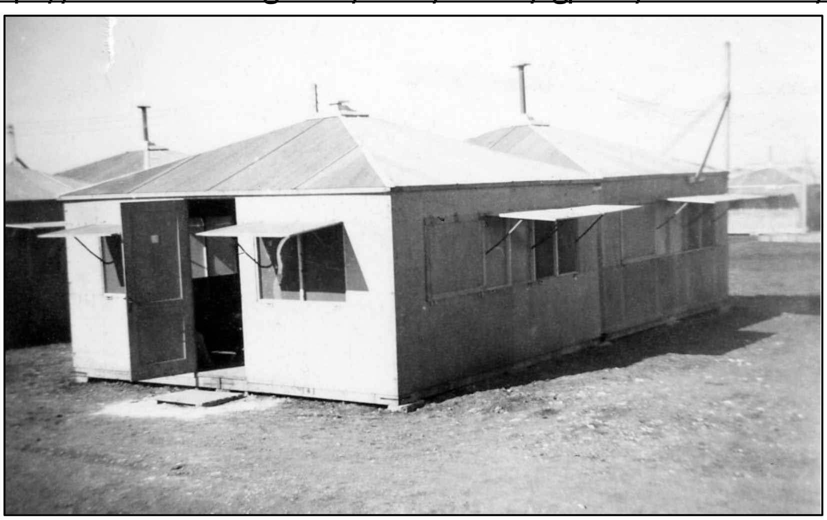
55 "Victory Huts and Homes."

56 US Bureau of Naval Personnel, *History of the Chaplain Corps, United States Navy, Volume 2, 1939-1940*, Washington, D.C.: US Government Printing Office, 1948, 126.

US Military installations worldwide, and their use continued through at least the Korean War (Figure 37).[57]

Figure 36. Three Victory Huts erected three in a row to highlight the ease with which these structures can be joined together, April 1943 ("Victory Huts and Homes," *Prefabricated Homes* 1-5 (April 1943): 26).

Figure 37. Two Dallas Huts joined together with a potbelly stove, one of many Dallas Huts deployed at three locations in North Africa in support of the Korean War effort, Nouasseur AFB, North Africa, 1952 (NCANG Heritage Program, "Korean War Deployed Site" (photograph), NC Air National Guard, accessed Aug. 13 2021, https://www.145aw.ang.af.mil/News/Photos/igphoto/2001012145/).



57 NCANG Heritage Program, "Korean War Deployed Site" [photograph], NC Air National Guard, accessed Aug. 13, 2021, https://www.145aw.ang.af.mil/News/Photos/igphoto/2001012145/.

### 2.2.6 Bush "Type B" Building

Strictly wooden prefabrication was also employed in larger structures. The Bush Type-B Building was a popular all-wooden deployable structure originally designed by Bush Prefabricate Structures Inc., a Division of Clinton G Bush Co. (Bush), which traces its origins in the market to work done for the National Housing Administration beginning in 1933 out of plants in Brooklyn, New York and Groton, Connecticut. As of April 1943, large quantities of the Bush Type-B Buildings were "being supplied to US Army Engineers…for both occupancy and storage."[58] The structure was advertised for use as "barracks, mess halls, post exchanges, headquarters buildings, officers' quarters, repair shops, warehouses, hospitals, utility buildings, latrines, construction offices."[59] They required no foundation and could be erected on leveled wooden beams running the perimeter of the building (Figure 38). The structures were 100% salvageable and featured a gabled roof supported by knee braces with a rectangular footprint measuring 20 ft wide (Figure 39 through Figure 41). The length came in multiples of eight due to the walls being comprised of 8 ft-wide wooden panels, with a 264 ft-long linear Bush Type-B Building reportedly being constructed. In the spirit of standardization that made prefabrication more economical and faster, these panels came in only six varieties and came with preinstalled windows and doors. Prefabricated 20 ft by 20 ft "Valley-sections" were required to join Type-Bs into a right angle (Figure 42). Additionally, separate Type-B huts could be joined by 8 ft-wide corridors from any non-corner section of panel (Figure 43). These two methods of joining Type-B Buildings eased site planning for camps and diversified the potential uses of the structure. A further benefit of the Bush Type-B Building was its design for long-term service through the use of redwood for exterior finish, as "redwood has the top Government rating for durability, decay resistance, and is lowest in percentage of shrinkage and warping. The need for painting is eliminated for many years."[60] Stoves were available for Bush Type-B buildings if they were to be used as shelter (Figure 44).[61]

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[58] Clinton G. Bush Co., "The Bush Type 'B' All Purpose Building," *Prefabricated Homes* 1-5 (April 1943): 1.

[59] Clinton G. Bush Co., "The Bush Type 'B' All Purpose Building," 1.

[60] Clinton G. Bush Co., "The Bush Type 'B' All Purpose Building," 1.

[61] "All-Purpose Buildings Provide housing and Other Facilities," *Prefabricated Homes* 36, no. 233 (May 1944): 14–15, 14.

Figure 38. An advertisement for the Bush Type-B All Purpose Building (April 1943 advertisement for Bush Prefabricated Structures, Inc. (Clinton G. Bush Co., “The Bush Type ‘B’ All Purpose Building,” *Prefabricated Homes* 1-5 (April 1943): 1).


Figure 39. Floor panels of Bush Type-B building are being placed on the foundation, consisting of long horizontal wooden beams supported by wood footing (April 1943 advertisement for Bush Prefabricated Structures, Inc. (Clinton G. Bush Co., “The Bush Type ‘B’ All Purpose Building,” *Prefabricated Homes* 1-5 (April 1943): 1).

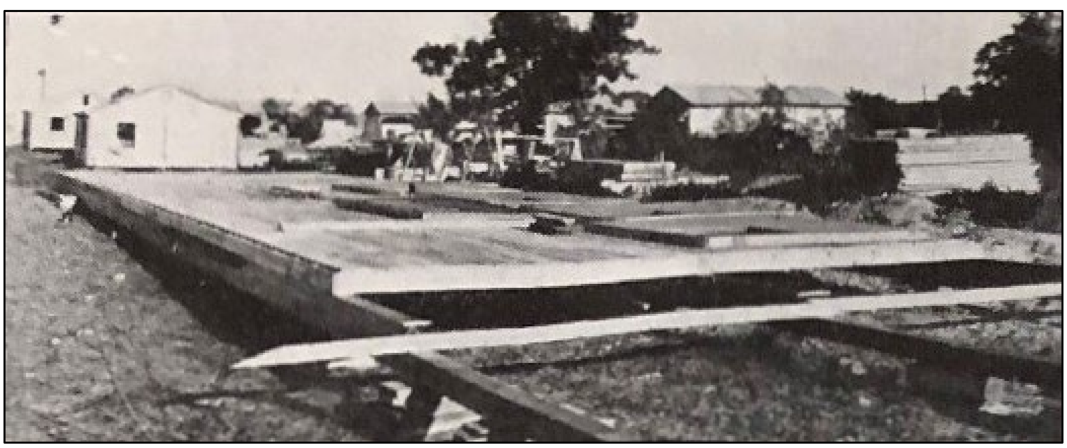


Figure 40. A partially erected Bush Type-B. As wall panels are lifted and secured into place with a temporary diagonal member, knee braces for the flooring panels are added allowing for easy installation of the roof panels (April 1943 advertisement for Bush Prefabricated Structures, Inc. (Clinton G. Bush Co., “The Bush Type ‘B’ All Purpose Building,” *Prefabricated Homes* 1-5 (April 1943): 1).

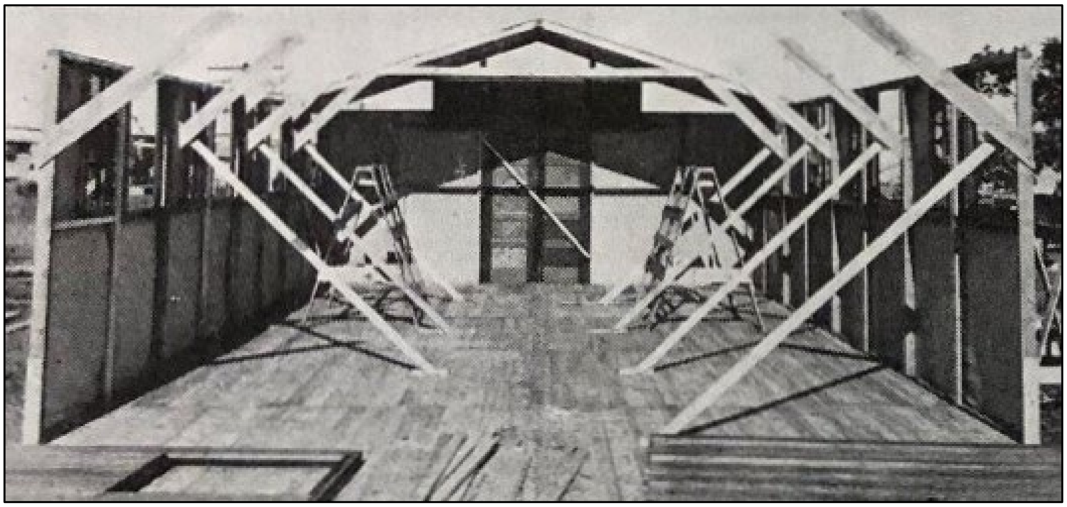


Figure 41. The interior of a fully completed Bush Type-B building with rows of bunkbeds along each side, November 1943 (Clinton G. Bush Co., “Bush Housing for Labor,” *Prefabricated Homes* 1-5 (Nov. 1943): 6).

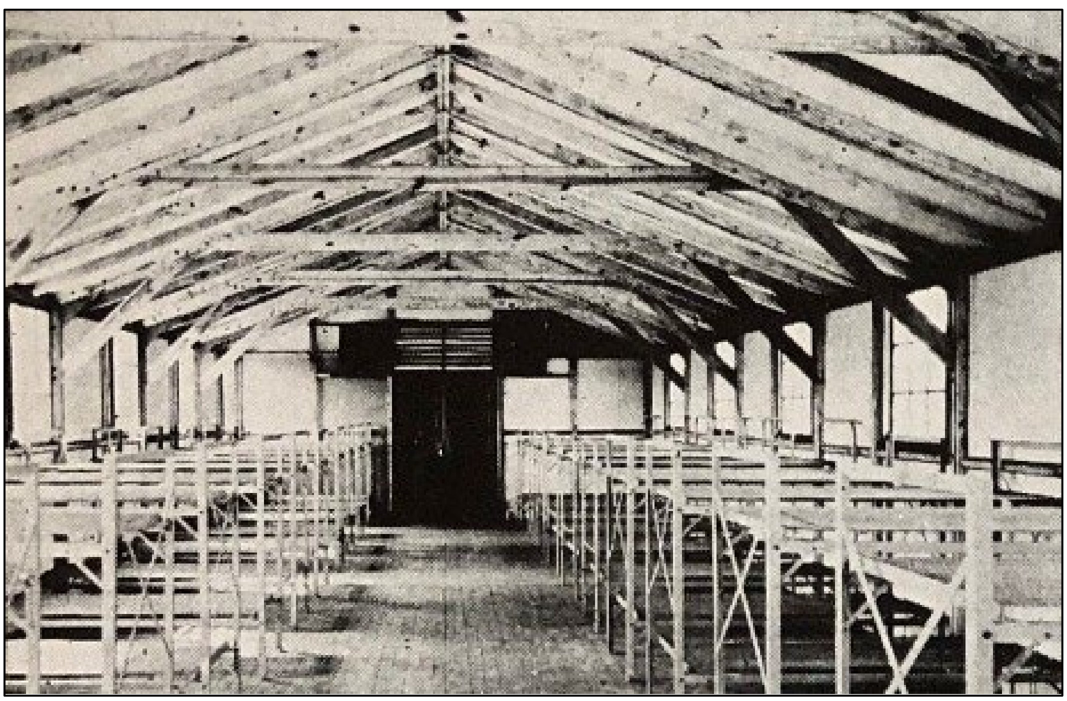


Figure 42. Two Bush Type-B Buildings erected in an "L" shape through the use of prefabricated "valley sections." Also of note are the smokestacks, which protrude many feet above the gabled roof peak to reduce fire hazards ("All-Purpose Buildings Provide Housing and Other Facilities," *Prefabricated Homes* 36, no. 233, (May 1944): 14–15).

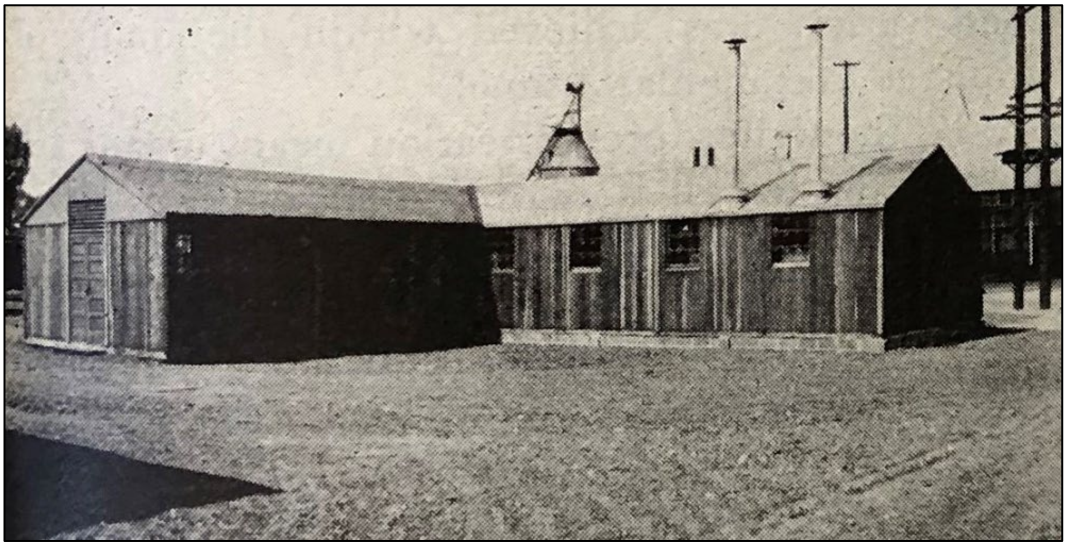


Figure 43. A plan for a labor camp composed entirely out of Bush Type Buildings and joined with connection hallways, making much of the camp traversable through interior paths ("All-Purpose Buildings Provide Housing and Other Facilities," *Prefabricated Homes* 36, no. 233, (May 1944): 14–15).

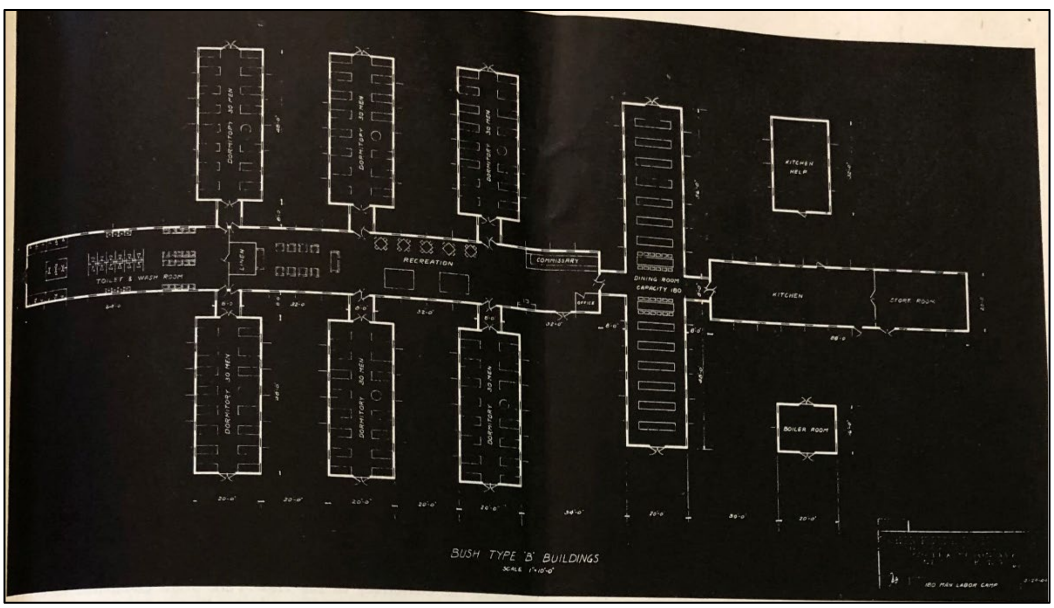
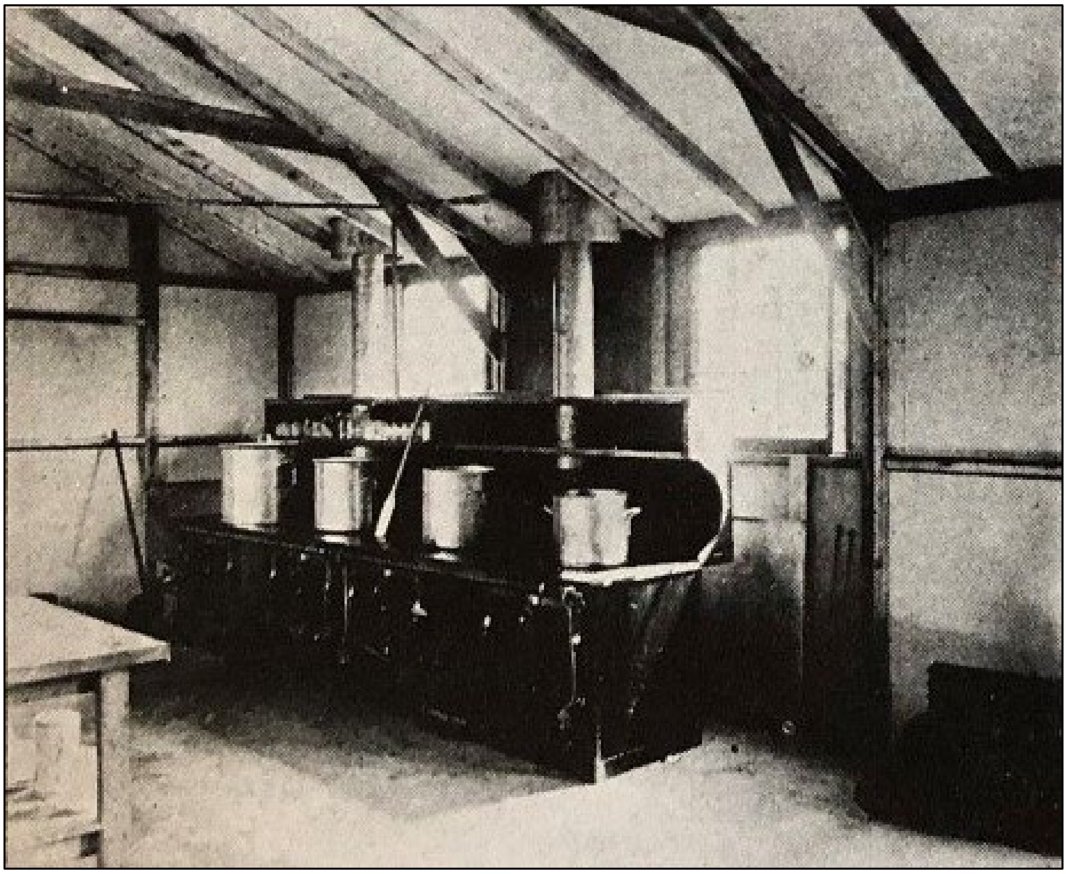


Figure 44. Two potbelly stoves installed in one of the corners of a Bush Type-B, (Clinton G. Bush Co., "Bush Housing for Labor," *Prefabricated Homes* 1-5 (Nov. 1943): 6).



### 2.2.7 Wooden Construction

Wood construction improved in efficiency during WWII with the rise of new building materials. These technological improvements resulted from a need to minimize timber usage and make continued timber usage more efficient, as the United States experienced a critical shortage of lumber for military use between 1941 and 1945. During this period, sawmill and other timber industry infrastructural capacity could not meet the need that had rapidly increased due to the war. Further, some wood could not be directed away from critical uses—such as railroad and mine construction—towards building construction for the war effort.[62]

[62] Ben Meyer Huey, "Problems of timber products procurement during World War II, 1941–1945" (Master's thesis, Montana State University, 1951), https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=4333&context=etd.

Perhaps the most important technology that allowed the Army to reduce its lumber—or cut wooden boards—usage was plywood—or a manufactured product made of thin layers of wood that have been glued together.[63] In his January 1946 article in the Military Engineer titled "Plywood Came out of the Kitchen to Fight," Robert Turner argued that "plywood is the Cinderella of the war" due to its rise in prevalence during this period.[64] The technology was not new, as it had been available commercially for several decades, but the resin was previously not strong enough to allow for widespread, practical use.[65] During the 1940s plywood became far more durable through advancements in resin technology combined with "hot press bonding methods which make it impervious to saltwater, extremes of heat and cold, and fungus." This new strength and durability allowed for plywood to be used not only in construction but also in military applications for things like boats, planes, and sleds.[66]

As for the construction applications, the military began using plywood in conventional construction of barracks to accommodate mobilization. For example, the Army's 700 Series and 800 series standardized plans, which were developed and utilized during WWII to provide easy-to-construct and modern buildings on Army installations, used standard stud construction in an assembly line fashion, using plywood as exterior sheathing to make the building less drafty.[67] The Navy preferred artificial composite boards such as gypsum boards or asbestos-cement for their standardized barracks plans—called B-1 and B-2 plans—though they were occasionally replaced with plywood or other wood alternatives.[68] Plywood was also used in prefabrication by the military during WWII, and 35,000,000 square ft of plywood were used in prefabricated housing for the "the two atom bomb plants" (Figure 45).[69]

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63 Freres Building Supply, "Do you know the difference between timber, lumber, & plywood?" Connect2Local, September 14, 2018, https://connect2local.com/l/138709/c/543429/do-you-know-the-difference-between-timber--lumber----plywood; Robert Turner, "Plywood came out of the kitchen to fight," *The Military Engineer* 38, no. 243 (Jan. 1946): 18-21, 18.

64 Turner, "Plywood came out of the kitchen to fight," 18.

65 Garner, *World War II Temporary Buildings*, 35.

66 Turner, "Plywood came out of the kitchen to fight," 18.

67 Garner, *World War II Temporary Buildings*, 35.

68 Garner, *World War II Temporary Buildings*, =47–48.

69 Turner, "Plywood came out of the kitchen to fight," 21.

Figure 45. A one-bedroom, prefabricated house for a worker on the Manhattan Project, Richland Village, Washington (Robert Turner, "Plywood came out of the kitchen to fight," *Military Engineer*, Vol. 38 (Jan. 1946): 18).

Other composite boards found extensive use in wooden prefabrication, especially with the prefabricator Modulok, Inc., who "completed fifteen navy projects including: barracks, mess-halls; administration buildings, war apartments, staff residences, infirmaries and other types of buildings as well as three 100-bed hospitals."[70] Their trademarked building method involved prefabricated 4 ft wide floor, wall and roof panels, with self-aligning, interlocking connections. The exteriors of the panels were Cemesto board, made of a sugarcane fiber core coated in asbestos cement, and the interiors were gypsum boards with 2-¾ in. of airspace in between. Interior and exterior panels were either painted or left with a factory applied "wood grain effect." These structures were easy to assemble as well as being demountable and could accommodate projects of varying size. [71]

Modulok also prefabricated officer residences for US naval operational training stations. These structures, designed by architect Arnold Southwell, were "very attractive and livable" and within the $7,500 limit for such housing. The exterior design featured a white painted wooden trip and clapboard wainscoting, with a trellis next to the entrance door (Figure 46). The houses had seven rooms total, including two baths, a 13 ft by 24 ft living room, and a kitchen with built-in cabinets. A maid's room with bath was separated from the main part of the house at the back of the garage, connected to the house via breezeway (Figure 47).[72]

70 "Prefabricated Naval Hospitals and Housing," *Prefabricated Homes* 1-5 (Oct. 1944): 14-15 & 21, 14.

71 "Prefabricated Naval Hospitals and Housing," 15.

72 "Prefabricated Naval Hospitals and Housing," 15.

Figure 46. One of the prefabricated officer housing units manufactured by Modulok for various US naval operational training stations ("Prefabricated Naval Hospitals and Housing." *Prefabricated Homes* 1-5 (Oct. 1944): 14–15 & 21, 15).

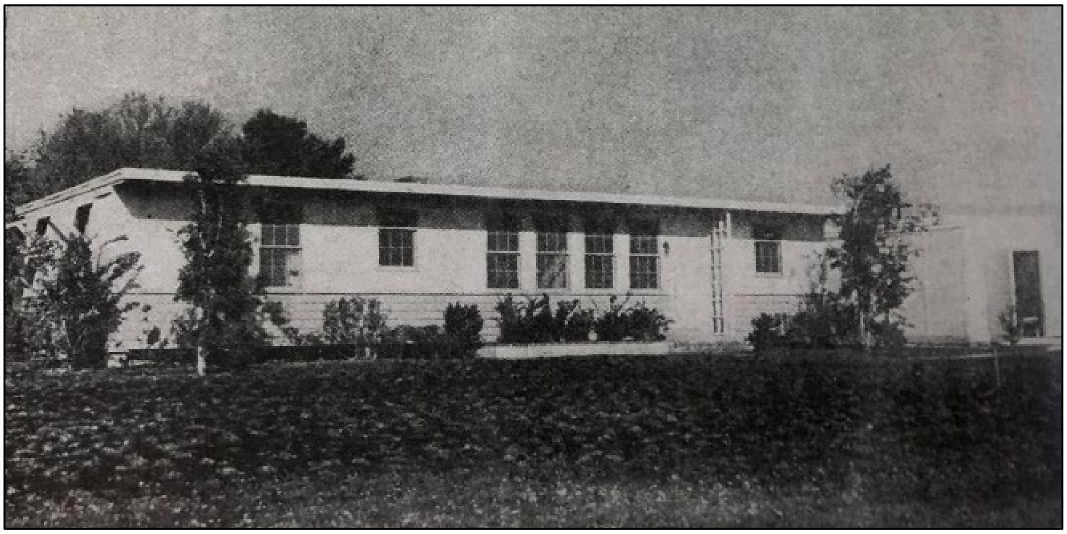
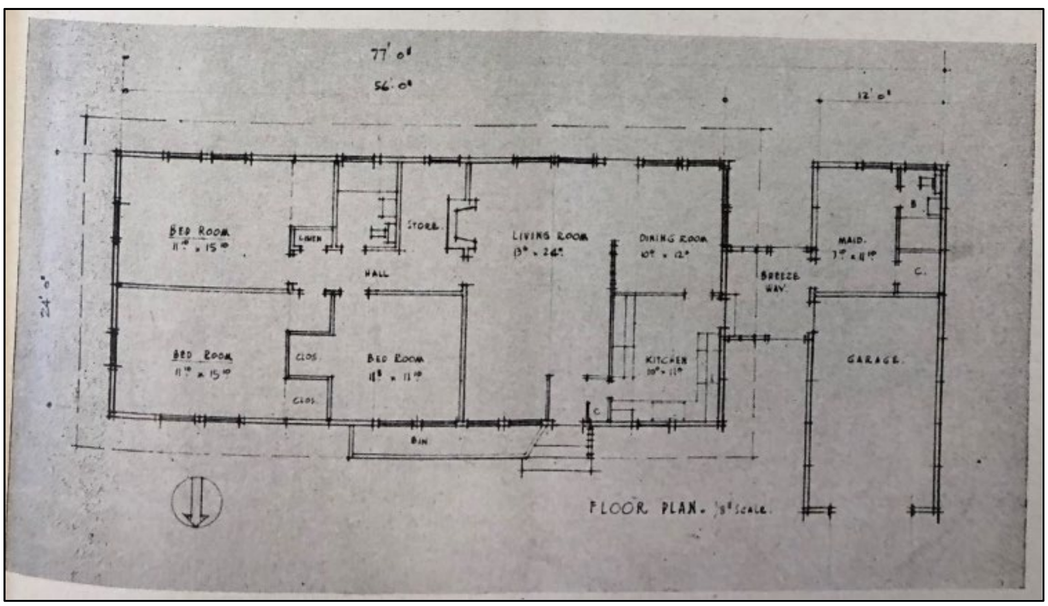
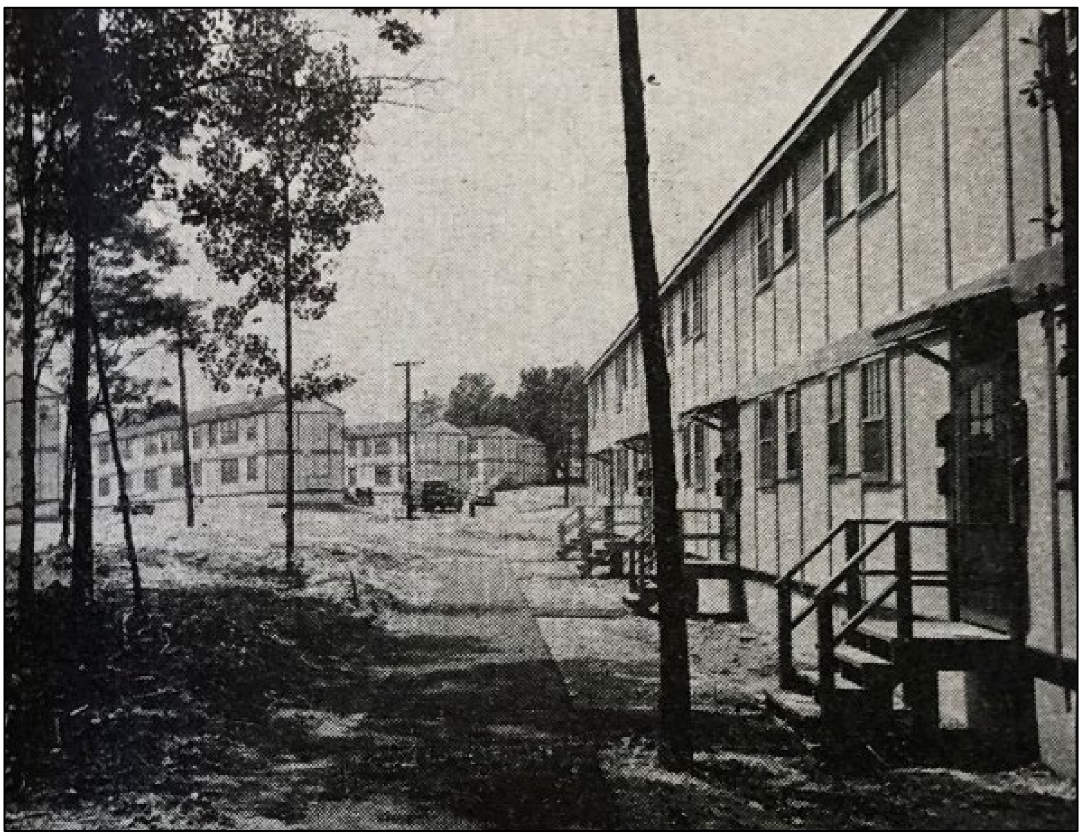


Figure 47. The floor plan of Modulok's prefabricated officer housing units, featuring maid's quarters attached to the rear of the garage, separated from the main house by a breezeway ("Prefabricated Naval Hospitals and Housing," *Prefabricated Homes* 1-5 (Oct. 1944): 14–15 & 21, 15).



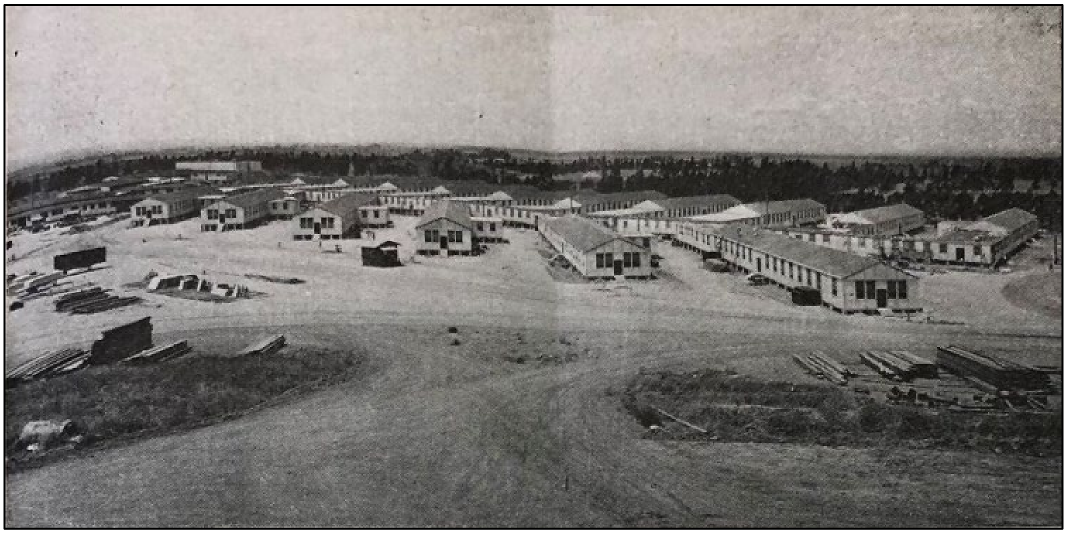

Modulok also constructed prefabricated buildings for the Navy that were "among the largest structures ever prefabricated, at two stories high and over 300 feet in length" (Figure 48). Modulok's panel-based construction method allowed for such long lengths due to the ease of adaptability of the method. This can be seen in two hospital projects for the Navy in Southern California, which together totaled over thirty separate buildings. Here, one-story 210 ft hospital wards were arranged in a “herring-bone” plan where two rows of these structures were angled inward towards a central long connecting corridor (Figure 49). Structurally, these buildings were supported by lumber flash-proofed with a chemical dip, with 1-in. thick gypsum board subflooring and roof decking and finished wood floors. The Cemesto board exteriors were naturally light grey, and the trim was either paint]ed lighter grey, dark green, or creamy pink. The gabled roof was covered in red tile shingles.[73]

Figure 48. A series of Modulok structures erected as “housing for civilian employees at an East-coast naval base,” presents a close view of the panelized design, with some panels having preinstalled windows placed off-center along one of the panel’s edges (“Prefabricated Naval Hospitals and Housing,” *Prefabricated Homes* 1-5 (Oct. 1944): 14–15 & 21, 21).



[73] “Prefabricated Naval Hospitals and Housing,” 21.

Figure 49. An overview of a naval hospital erected by Modulok in an "unusual herring-bone plan" with one central corridor running in between the two rows of 210' hospital wards, Southern California ("Prefabricated Naval Hospitals and Housing," *Prefabricated Homes* 1-5 (Oct. 1944): 14–15 & 21, 21).



Using a similar building principle to Modulok (i.e. standard sized prefabricated panels) combined with other advancements in prefabrication techniques that were used "extensively," John A. Johnson Contracting Corporation out of Brooklyn, New York (Johnson), fulfilled over "40 war-emergency contracts [that] included War and Navy Department Cantonments, Hospitals, and Naval Training stations" by mid-1943, with "many large contracts totaling over 150 million dollars" (Figure 50 and Figure 51). This was a massive operation with over 20,000 workers on payroll and additional locations in Atlanta, Georgia, Philadelphia, Pennsylvania, and Washington, D.C. The increased preassembly of parts offsite and improved construction techniques allowed for increased on-site construction speed (Figure 52, Figure 53, and Figure 54). This is attested to in an extract from a "recent Navy Department letter" used in a Johnson Advertisement:

> This work was started under difficulties that involved delays in acquisition of land, but was so well organized and expedited by the contractors that the 450 housing units were completed in 120 working days. The job was organized on an assembly line basis that proved so efficient that the final costs, including the fixed fee for the contractors, was 11% under the original allotment.[74]

[74] John A. Johnson Contracting Corporation, "Prefabricated-Demountable Structures," *Prefabricated Homes* 1-5 (May 1953): n.p.

Figure 50. Six workers lifting a prefabricated panel into place on an unknown structure, used in an advertisement to highlight the panelized, demountable nature of many of Johnson Contraction Corp. constructions (John A. Johnson Contracting Corporation, “Prefabricated-Demountable Structures,” *Prefabricated Homes* 1-5 (May 1953): n.p.).

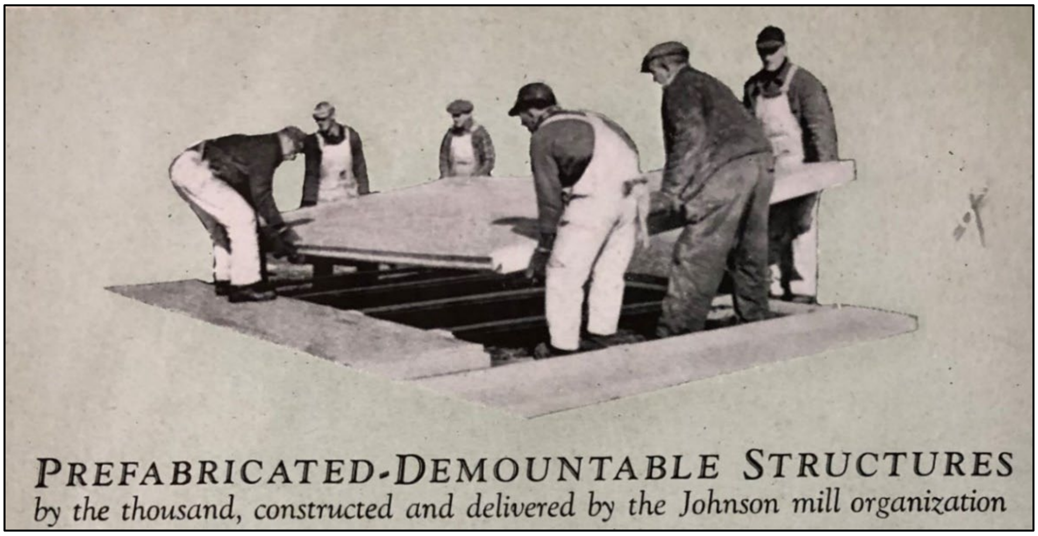



Figure 51. A list of government contracts handled by Johnson as part of an advertisement (John A. Johnson Contracting Corporation, “Prefabricated-Demountable Structures,” *Prefabricated Homes* 1-5 (May 1953): n.p.).

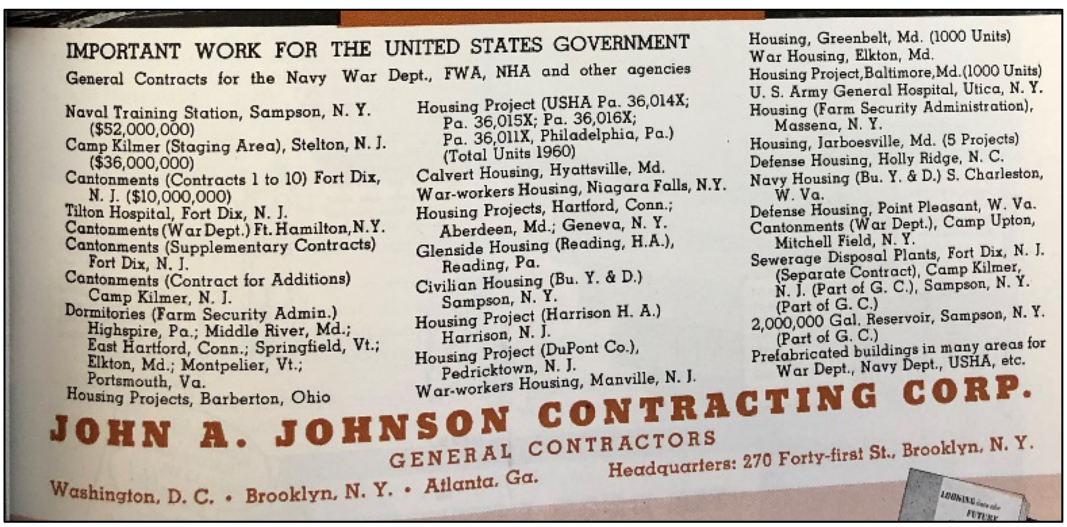


Figure 52. Several prefabricated end-panels for gabled roof structures, next to stacks of prefabricated wall paneling at a Johnson Manufacturing Plant (John A. Johnson Contracting Corporation, "War speed is typical Johnson Speed!" *Prefabricated Homes* 1-5 (Feb 1944): n.p.).

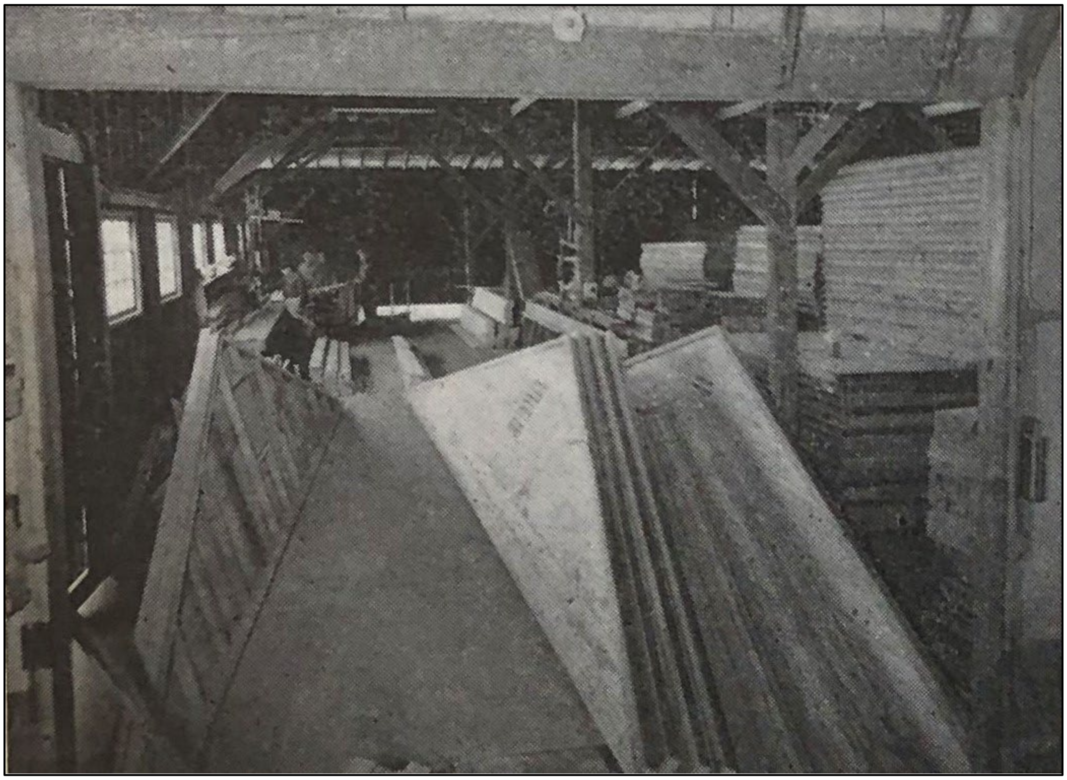
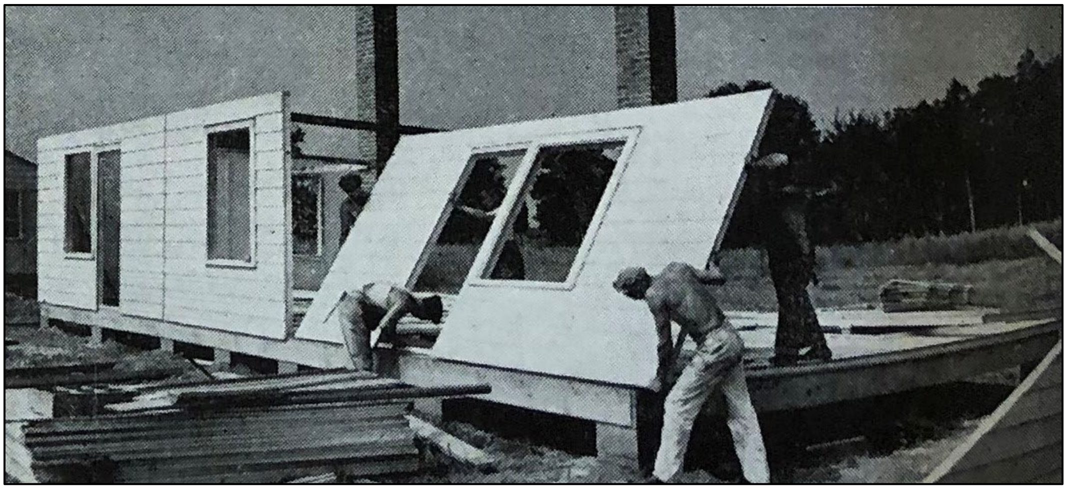


Figure 53. The floor of one of Johnson's prefabricated, demountable "standardized war housing units" is being loaded off the truck and directly into place on the block foundation, showing the level of efficiency sought in on-site construction (John A. Johnson Contracting Corporation, "War speed is typical Johnson Speed!" *Prefabricated Homes* 1-5 (Feb. 1944), n.p.).

Figure 54. A prefabricated wall panel in a standardized war housing unit being raised into position, notice the already completed masonry, demonstrating the assembly line building process (John A. Johnson Contracting Corporation, “War speed is typical Johnson Speed!” *Prefabricated Homes* 1-5 (Feb 1944), n.p.).



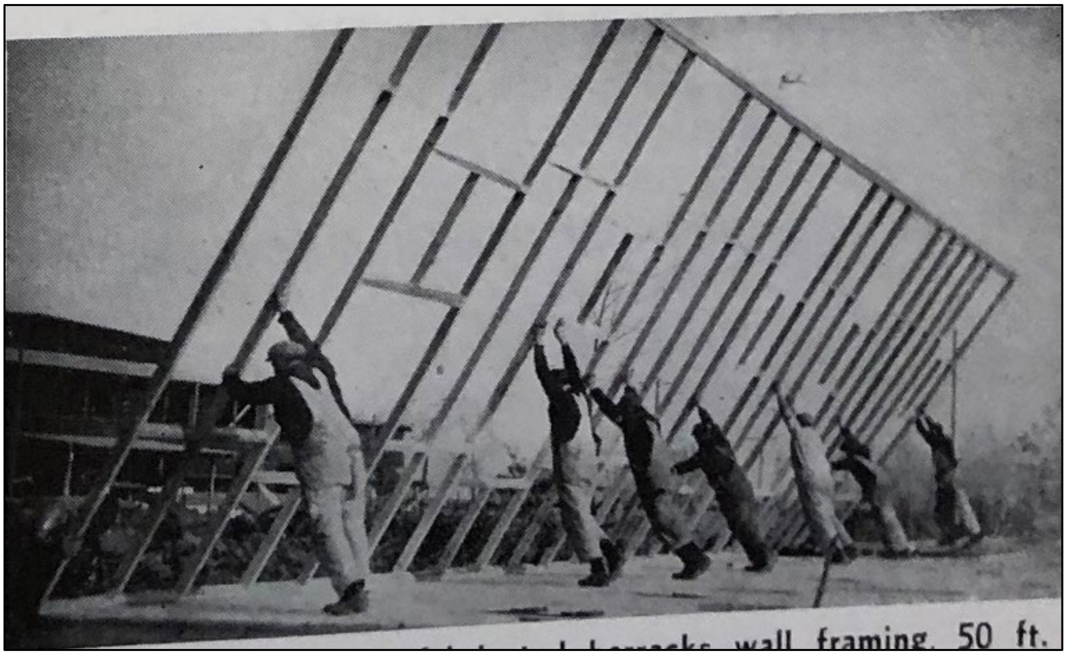
These building techniques not only saved time and money, but they were also adaptable for unique or large-scale projects. At Fort Dix, New Jersey, a 1,000-bed hospital unit was constructed that included thousands of feet of covered walkways between wards. “These walk-ways (had) roof trusses heavy enough to carry the . . . heat pipes from the powerhouse throughout the area” and were completely prefabricated. Construction was completed within the 60 calendar days given for the task, despite work being in the “dead of winter” with several blizzards, freezes, and thaws. Construction of a hospital and storehouse using the same techniques at Camp Kilmer, New Jersey, occurred in less than six months at a cost of $36,000,000.[75]

One of the larger contracts received by the company was at Sampson Naval Training Station, New Jersey, for $52,000,000 where “prefabrication was employed in the construction of row houses, dormitories, barracks and other types of buildings” totaling “more than 450.” Seven large mess halls that required “68-foot prefabricated roof trusses constructed of three to five thicknesses of 2-in. lumber bolted together, forming heavy members to support large roof areas” were constructed. Large portions of wall

[75] John A. Johnson Contracting Corporation, “Prefabricated-Demountable Structures;” John A. Johnson Contracting Corporation, “War Speed is typical Johnson Speed!” *Prefabricated Homes* 1-5 (Feb. 1944): n.p.

framing were prefabricated off site, allowing for a wall to be framed in 20 to 30 seconds (Figure 55).[76]

Figure 55. "Complete section of prefabricated barracks wall framing, 50 ft. long and two stories high, being raised into position in from 20 to 30 seconds" ("Prefabricated Naval Hospitals and Housing." *Prefabricated Homes* 1-5 (Oct. 1944): 14–15 & 21, 15).



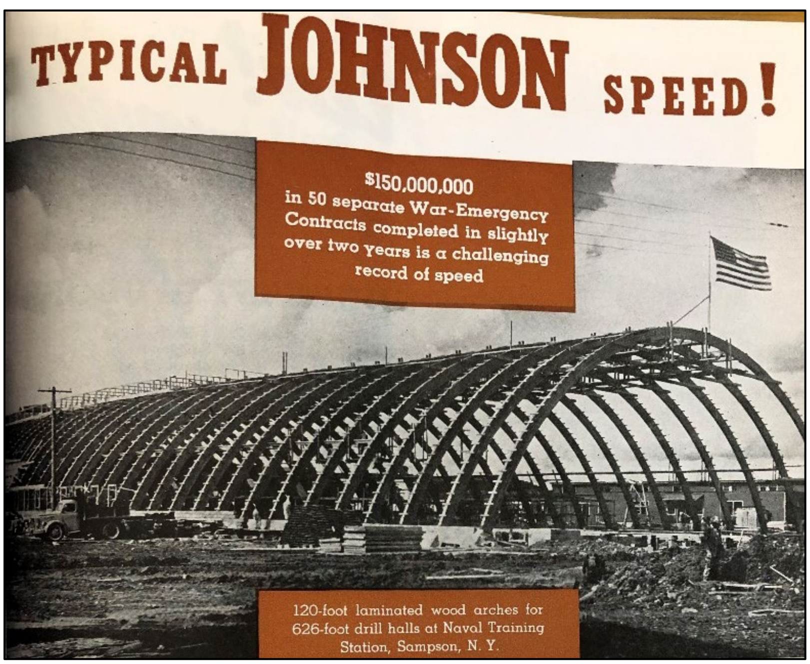

The largest structures erected by Johnson were six 626 ft by 120 ft arched drill halls (Figure 56). Though steel was the preferred material for arched structures, these halls were constructed with laminated wood arches, which required less wood than wooden trusses of the same size. The drill hall design was created in 1943 by the firm Shreve, Lamb and Harmon, who also designed the Empire State Building. Their design called for the massive 120 ft wide arch to be constructed of three prefabricated sections which were bolted into place onsite. During construction, horizontal connecting members were bolted to the arch members prior to being erected, further speeding up construction (Figure 57 and Figure 58). Similar drill halls were constructed at other sites and, depending on the location, the arches were either prefabricated or laminated on site;

[76] "Prefabricated Naval Hospitals and Housing."

however, green, low-quality lumber and poor glue led to distortions or delamination in the field-constructed arches.[77]

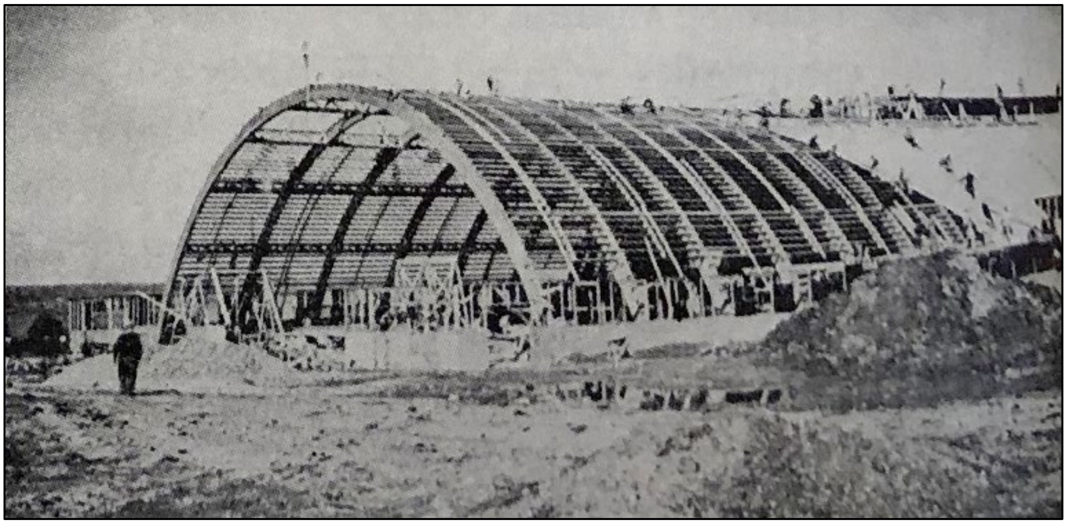
Figure 56. One of six 626 ft long drill halls completed as part of a $50,000,000 contract, Sampson Naval Base, New Jersey, 1944 (John A. Johnson Contracting Corporation, "War speed is typical Johnson Speed!" *Prefabricated Homes* 1-5 (Feb. 1944): n.p.).


Figure 57. One of the six large naval drill halls constructed by Johnson using wooden laminated arches with horizontal connection pieces preinstalled on the arch before erection to speed production, Sampson Naval Station, New Jersey, 1944 (John A. Johnson Contracting Corporation, "War speed is typical Johnson Speed!" *Prefabricated Homes* 1-5 (Feb. 1944): n.p.).




[77] John A. Johnson Contracting Corporation, "Prefabricated-Demountable Structures;" "Prefabrication on a Cost-Efficiency Engineering Basis," *Prefabricated Homes* 1-5 (Feb 1944): 20-22; Garner, *World War II Temporary Buildings*, 52; John A. Johnson Contracting Corporation, "War Speed is typical Johnson Speed!"

Figure 58. The frame of a 626 ft long naval drill hall constructed with horizontal support beams already installed by Johnson, Sampson Naval Training Station, New Jersey, 1944 (John A. Johnson Contracting Corporation, "War speed is typical Johnson Speed!" *Prefabricated Homes* 1-5 (Feb. 1944): n.p.).



The use of laminated wood grew in popularity during the mid-twentieth century as glue and resin technology advanced. One of the earliest segments of the market penetrated by laminated wood arches was for agricultural structures. Barns and Quonset-like half rounds were designed for agricultural uses by companies like RILCO Laminated Products, Inc. of St. Paul Minnesota (RILCO) (Figure 59).[78]

[78] RILCO Laminated Products, Inc., "RILCO Laminated Wood Rafter Archers," *Agricultural Engineer* 27 (1946): n.p.

Figure 59. An advertisement for RILCO, showing the growing popularity of this construction method, 1946 (RILCO Laminated Products, Inc., "RILCO Laminated Wood Rafter Archers," *Agricultural Engineer* 27 (1946): n.p.).


An alternative wood construction method for arched structures was the trussed arch. The Timber Engineering Company or TECO constructed several large arched structures for the Navy, including the world's largest clear span timber structure at the time. This was a 1000 ft long, 153 ft high, and 237 ft wide airship hangar (Figure 60). Smaller arches were also constructed for airplane hangars (Figure 61). The Timber Engineering Company's building system used prefabricated truss sections joined by "TECO" connection, ensuring stronger bonds than onsite construction methods (Figure 62).[79]

Figure 60. Two hangars constructed for Navy war planes by TECO using wooden trusses (Timber Engineering Company, "The Navy Builds with Wood," *The Military Engineer* 36, no. 220 (Feb. 1944): 13).

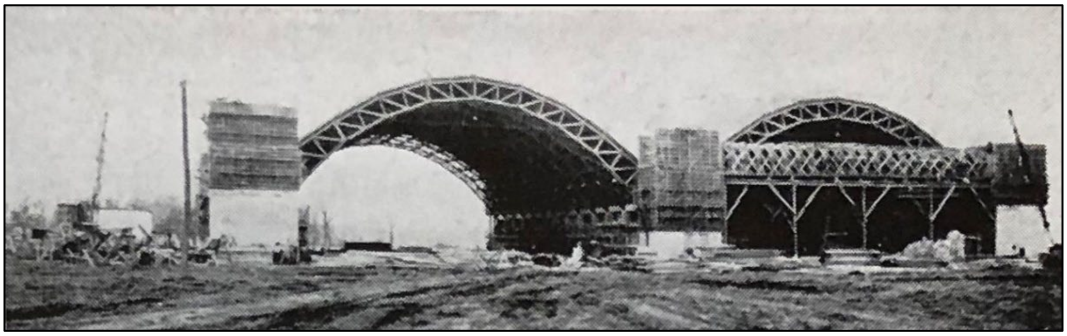
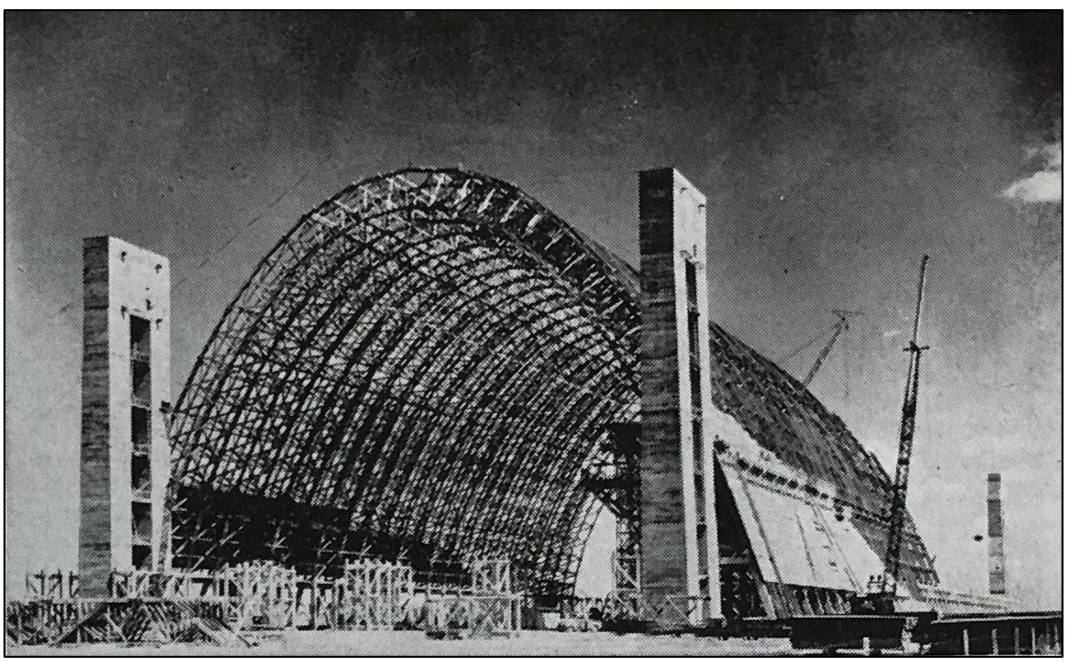
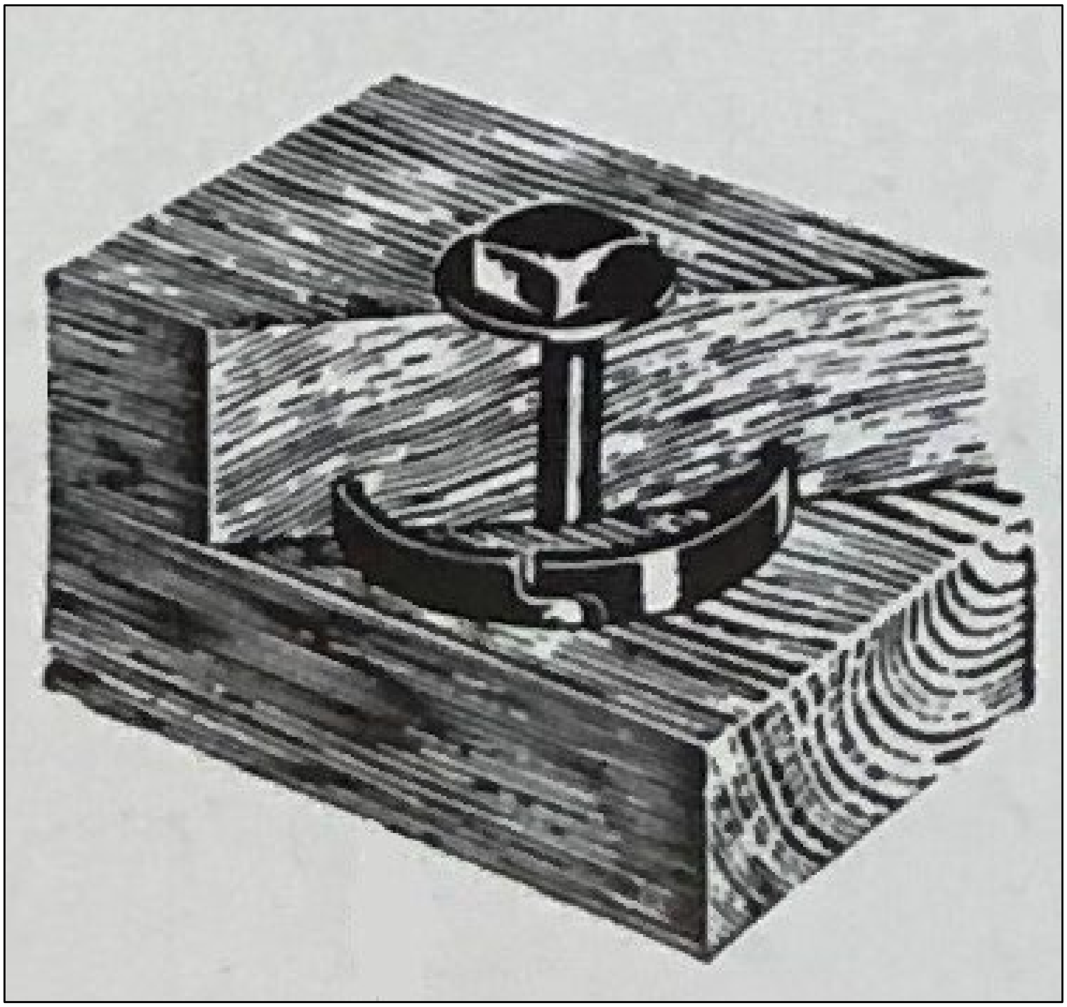


Figure 61. A 1000 ft long, 153 ft high airship hangar constructed by TECO, with a clear span of 237 ft (Timber Engineering Company, "The Navy Builds with Wood," *The Military Engineer* 36, no. 220 (Feb. 1944): 13).



[79] Timber Engineering Company, "The Navy Builds with Wood," *The Military Engineer* 36, no. 220 (Feb. 1944): 13.

Figure 62. A cross sectional view of a TECO joint connection, which provided far more strength than traditional building methods (Timber Engineering Company, "The Navy Builds with Wood," *The Military Engineer* 36, no. 220 (Feb. 1944): 13).



### 2.2.8 Pre-cast Concrete Construction

Pre-cast concrete was used extensively during WWII for structures that required extra strength or reinforcement. Ordnance igloos, semi-underground structures used to store explosives and other dangerous materials, were commonly constructed out of concrete. Advancements were made during the war that allowed for increased construction speed and structural strength of these and other pre-cast concrete structures. Pozzolith Concrete was a brand of concrete that incorporated "cement dispersion," a practice in which chemical agents are added to the cement to keep it properly mixed and maintain a high flow speed when pouring.

This practice allowed the contracting company Brown and Root, Inc., to construct 150 concrete igloos in just 14 days (Figure 63).[80]

Figure 63. An advertisement for the Master Builders Company, highlighting their Pozzolith Concrete used in 150 ordnance igloos (Master Builders Company, "Another Speed Record with Pozzolith through Cement Dispersion," *The Military Engineer* 34 (1942): n.p.).


### 2.2.1 Concrete Block and Concrete Masonry Units (CMUs)

Concrete block construction rose in popularity for construction in all fields during the first decades of the twentieth century because it was cheaper than brick and, depending on location, wood; was fireproof; and was able to be mass produced on-site using a cast-iron press invented by Harmon S. Palmer.[81] Its popularity was also influenced by a large marketing

[80] Master Builders Company, "Another Speed Record with Pozzolith through Cement Dispersion," *The Military Engineer* 34 (1942): n.p.

[81] Dale Heckendorn, "Ornamental Concrete Block Buildings in Colorado, 1900 to 1940," National Register of Historic Places Multiple Property Documentation Form (Washington, D.C.: US Department of the Interior, National Park Service, 1996), E, 2; J. Randall Cotton, "Return to Concrete Block Houses," *Old House Journal* (March/April 1995): 32-39.

campaign led by Sears, Roebuck & Co. to encourage the sale of concrete block as part of its program to sell houses by catalog and ship the components by rail. Other corporations led similar advertising campaigns for similar programs.[82] Other features that influenced concrete block's popularity were its uniform size, which made it easy to build with, and its relative light weight.[83]

Beginning in the 1920s, attitudes began shifting away from rock-faced blocks to smooth-faced blocks.[84] This was soon followed by technological advancements in the 1930s, including the use of lighter weight aggregates and the invention of large automated production machines late in the decade.[85] Lightweight aggregates, which included "coal cinders, expanded shale, clay or slag, and natural lightweight materials such as volcanic cinders, pumice and scoria," reduced the need for tamping, which allowed the mechanized production machines to use a vibration method for compacting the blocks, rather than the previously-used tamp method.[86] This was far more efficient than previous production techniques, allowing for a production increase from 200 to 600-900 blocks per hour. The machines also required only one man for operation. These machines were so impactful to the industry that they were used well into the 1970s.[87]

These machines couldn't produce the ornamental designs that had been popular early in the century but produced only the then-popular smooth-faced block.[88] The architectural elite's disdain for concrete block's imitation of natural stone, as well as the wide availability of smooth-faced block resulted in "the realization that block had many potential uses other than in foundations."[89] The resultant increased market necessitated some

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[82] Pamela H. Simpson, "Cheap, Quick, and Easy: The Early History of Rockfaced Concrete Block Building," *Perspectives in Vernacular Architecture* 3 (1939): 108-1198, https://www.jstor.org/stable/3514298.

[83] Kelley Barnhart, "The History Behind Rock Face Block," Classic Rock Face Block published April 4, 2020, accessed August 12, 2021, https://classicrockfaceblock.com/history-of-rock-face-block/.

[84] T.G. Langton, G.H.K. Schenk, and S.C. Sun, "A Study of the Concrete Block Industry: A National and Regional Approach," Special Research Report Number SR-19 for the Department of Environmental Resources of the Commonwealth of Pennsylvania, May 1972, 171.

[85] Heckendorn, "Ornamental Concrete Block Buildings;" Barnhart, "The History Behind Rock Face Block."

[86] Portland Cement Association, "Concrete Masonry Handbook for Architects and Builders," Chicago, IL: Portland Cement Association, 1951, 5.

[87] Langton, Schenk, and Sun, "A Study of the Concrete Block Industry," 172.

[88] Heckendorn, "Ornamental Concrete Block Buildings."

[89] Simpson, "Cheap, Quick, and Easy;" Langton, Schenk, and Sun, "A Study of the Concrete Block Industry," 171.

standardization of sizes, and the process of standardization of masonry began.

By the 1930s, the industry started to drift towards a commonly agreed upon "concrete masonry unit" which was a roughly 8 by 8 by 16-in. block.[90] These were rough measurements as even the "Standard for Concrete Masonry Units," released in 1938 by the not-for-profit Underwriters' Laboratories, Inc., allowed for "a tolerance of ¼ in. plus or minus" for the 8 by 8 by 16-in.[91] Small differences could make blocks from different manufacturers totally incompatible with each other in construction. The standard also included stipulations for block design, allowing for hollow blocks of either two or three square or oval core holes.[92]

During WWII, the need for easily adaptable and interchangeable standardized concrete block increased. Critical shortages of lumber resulted in the use of concrete masonry in temporary war housing. "Approximately 210,000 temporary family dwelling units with wall area aggregating about 180,000,000 sq. ft." were constructed out of concrete masonry, "requiring more than 200,000,000 units."[93] In addition to general "speedy erection," concrete masonry had several beneficial properties.[94] First, the hollow core blocks provide a great deal of insulation against temperature and sound. These blocks also substantially reduced fire hazards and risk of wall collapse. Similar properties made concrete masonry ideal for "sabotage protection" in the form of "protection walls for vital power plants, war industrial plants, wharves and docks, and other essential structures with their vulnerable transformers and switching stations, etc." (Figure 64). These features contributed to CMUs' continued use beyond WWII.[95]

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[90] R.E. Copeland, "Concrete in Modern Home Construction," *Industrial and Engineering Chemistry* 29, no. 9 (1935): 1009-1011, 1009.

[91] Underwriters Laboratories, Inc., "Standard for Concrete Masonry Units," Chicago, IL: Underwriters Laboratories, November 1938, 5.

[92] Underwriters Laboratories, Inc., "Standard for Concrete Masonry Units, 6.

[93] C.F. Moore, "War-Born Concrete Products," *Journal of the American Concrete Institute* 15, no. 5 (April 1944): 441-454, 445.

[94] Moore, "War-Born Concrete Products," 447.

[95] Moore, "War-Born Concrete Products," 445.

Figure 64. Two examples of concrete masonry being deployed during World War II as part of “sabotage protection” measures, April 1944 (C.F. Moore, “War-Born Concrete Products,” *Journal of the American Concrete Institute* 15, no. 5 (April 1944): 441–454, 445).

446 JOURNAL OF THE AMERICAN CONCRETE INSTITUTE April 1944

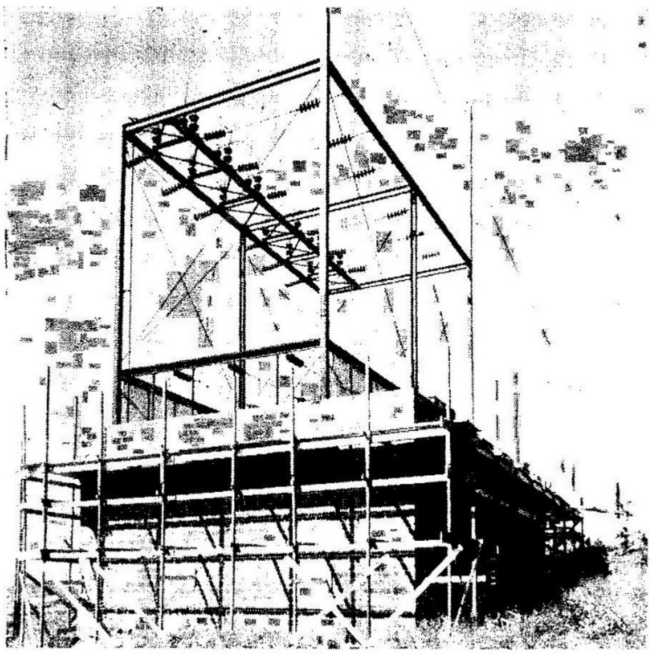
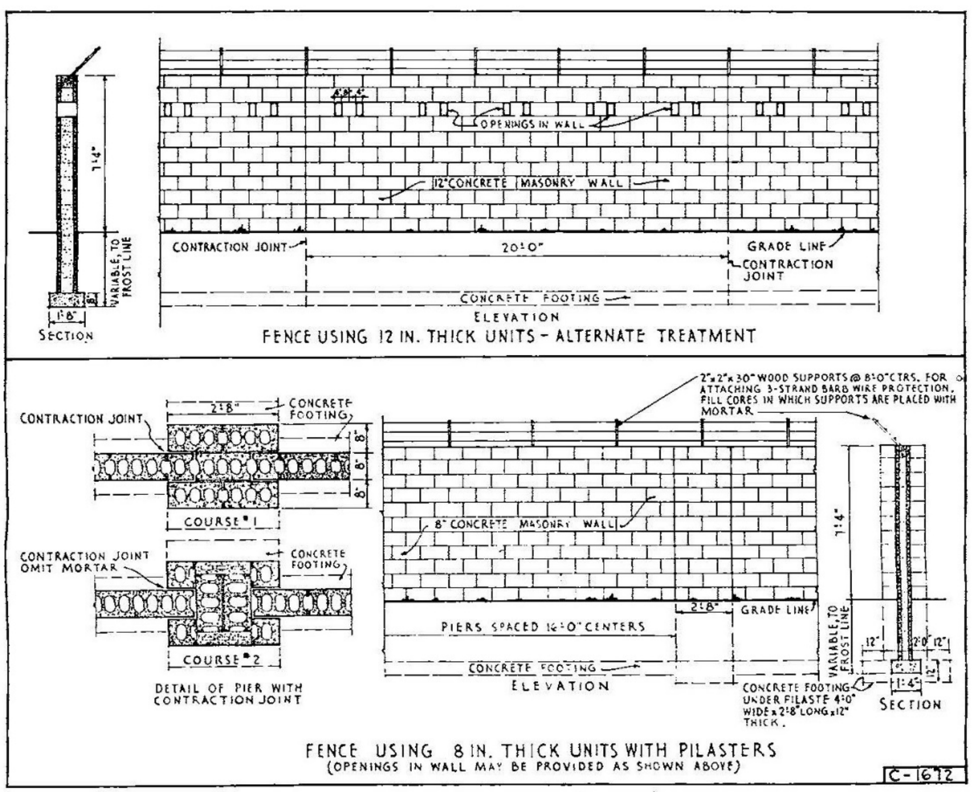


**Fig. 7—Concrete masonry wall for sabotage protection in Kansas City**

**Fig. 8—Concrete masonry for industrial walls**

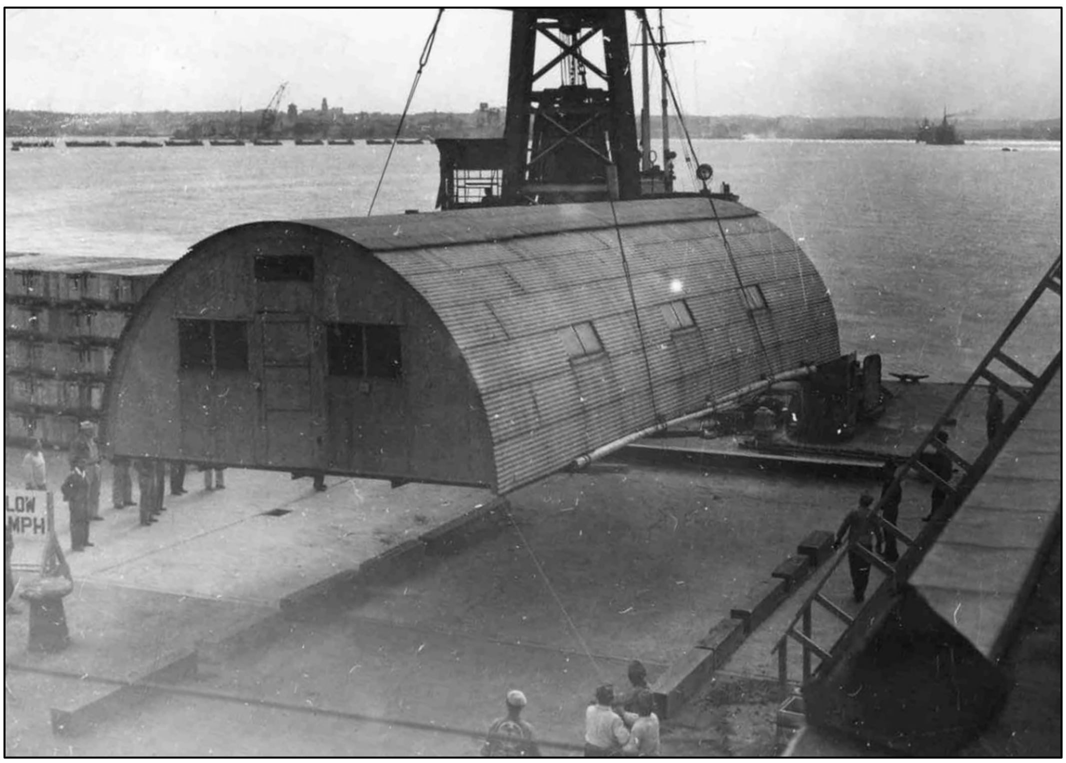


## 2.3 Early Cold War Era

### 2.3.1 Quonset Huts

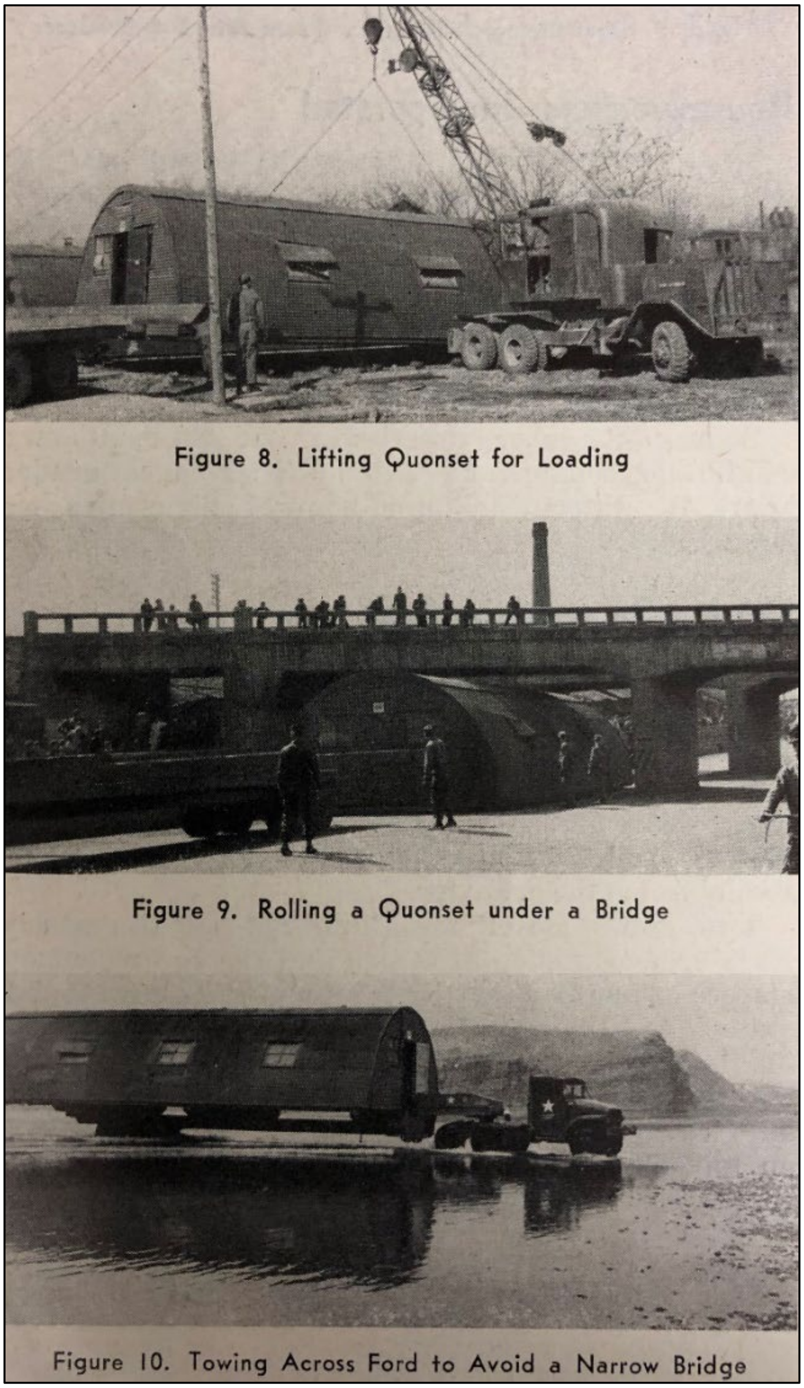
Following WWII, there were large surpluses of Quonset huts. Being completely demountable, these buildings were ideal for repurposing to meet post war needs both domestically and abroad. Their light weight meant that they could be easily repositioned by crane and transported on trailers (Figure 65 and Figure 66).[96]

Figure 65. A Quonset hut, which had served as barracks for the 736th Engineers, is being repositioned to serve its new role as office space for the 598th Engineer Base Depot in post-WWII Japan, 1947-1948 (USACE, https://en.wikipedia.org/wiki/Quonset_hut#/media/File:Quonset_hut_emplacement_in_Japan.jpg).



[96] Chelsea Pogorelac, Adam Smith, Sunny Stone, and Megan Tooker, "Camp Upshur, Marine Corps Base Quantico, VA Architectural Survey," ERDC/CERL SR-09-11, Champaign, IL: Engineer Research and Development Center – Construction Engineering Research Lab.

Figure 66. 1956 366th Engineer Aviation Battalion in Taegu, Korea moving Quonsets to be used as barracks. “Two crews moved two buildings simultaneously. Each crew consisted of 6 men and the equipment operator of one 2½-ton tractor and one ¾ -yard mobile crane. A 12-ton, 40-foot trailer was used for each building. The entire crew prepared the Quonset for lifting, and 4 men controlled the sway as it was lifted onto trailer” (American Rolling Mill Company, “Armco Designs, Makes and Erects Armco Buildings,” *The Military Engineer* 45 (1956): n.p.).



Consequently, though commonly associated with their utilization in WWII, Quonset huts remained in use by US Department of Defense (DoD) throughout the 1950s. Quonsets were used extensively in the Marine school system during the expansion of Quantico in the early 1950s. For example, Camp Upshur and Camp Barrett, which both housed the Marines Corps Basic School during the 1950s, utilized Quonsets as everything from classrooms to mess halls. Camp Barrett, in particular, was described as "a university campus amidst a cluster of Quonset Huts and Butler Buildings."[97]

However, the era of new construction with Quonsets was waning. Stran-Steel, a subsidiary of National Steel who had manufactured the bulk of Quonsets during WWII, had tried various avenues to market the Quonset hut immediately following WWII. They had unsuccessfully been marketed as forms of affordable, permanent housing during the housing shortage that immediately followed the war, although they had been deployed in settlements as short term veteran housing from Los Angeles to New York City.[98] Stran-Steel also attempted unsuccessfully to market Quonsets for industrial purposes, creating a 200,000 square foot warehouse for Boeing in 1952 by raising Quonsets up 18 ft and placing them adjacent to one another, as well as constructing another smaller warehouse of similar design for Nash-Kelvinator in Milwaukee (Figure 67).[99] Existing Quonset structures, however, continue to be used on military installations in the twenty-first century.

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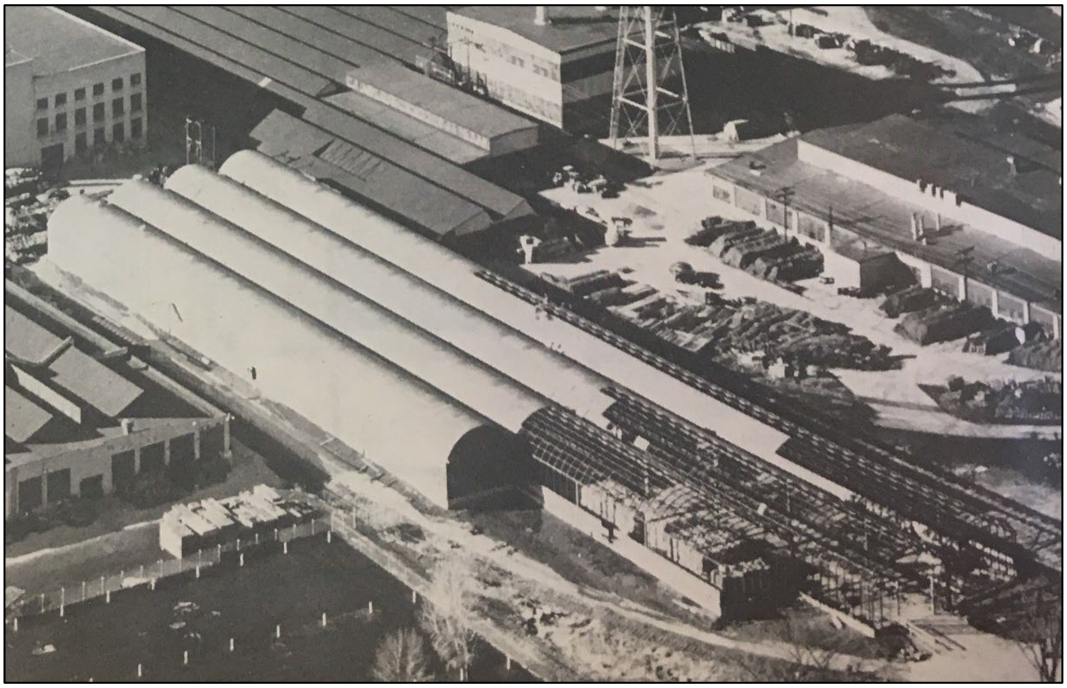
[97] Pogorelac, Smith, Stone, and Tooker, "Camp Upshur."

[98] Chiei and Decker, *Quonset Hut*, 72.

[99] "New Industrial Building Technique," *Architectural Forum* 96 (Jan.–Mar. 1952): 154–156.

Figure 67. A warehouse constructed out of Quonset huts erected for Nash-Kelvinator, Milwaukee, Wisconsin, 1952 ("New Industrial Building Technique," *Architectural Forum* 96 (Jan.–Mar. 1952): 154–156).



Quonsets did become popular for use in agriculture, which Stran-Steel realized early on by releasing the "Quonset 24" design marketed for rural utility purposes. The design resembled a typical Quonset except with one of the sides not arcing completely to the ground, but with a roughly 10-foot flat side that has two hopper windows and a horizontal square sliding door that extends the entire height of the side (Figure 68).[100] A 1946 advertisement for Flintkote building materials highlights their popularity by showing how customers can "get the most out of Quonsets" with their products, such as insulation boards and weatherproofing asphalt (Figure 69).[101] It took some time for Quonset huts to penetrate the agricultural building market, though they were perfectly suited to fill a need within it for fire-resistant prefabricated farm buildings, as described in a letter to the editor of Agricultural Engineering Magazine in April 1946.[102]

[100] "New Type Quonset," *Prefabricated Homes* 1-5 (Nov. 1945): n.p.

[101] Flintkote Company, "Getting the Most out of Quonsets…," *Agricultural Engineering* 27 (1946): 435.

[102] F.N.G. Kranick, "Questions about Farm Building" (Letter to the Editor), *Agricultural Engineering* 27 (April 1946): 179.

Figure 68. A promotional photograph of Stran-Steel's "Quonset 24" which was designed for rural utility purposes, Nov. 1945 ("New Type Quonset," *Prefabricated Homes* 1-5 (Nov. 1945): n.p.).

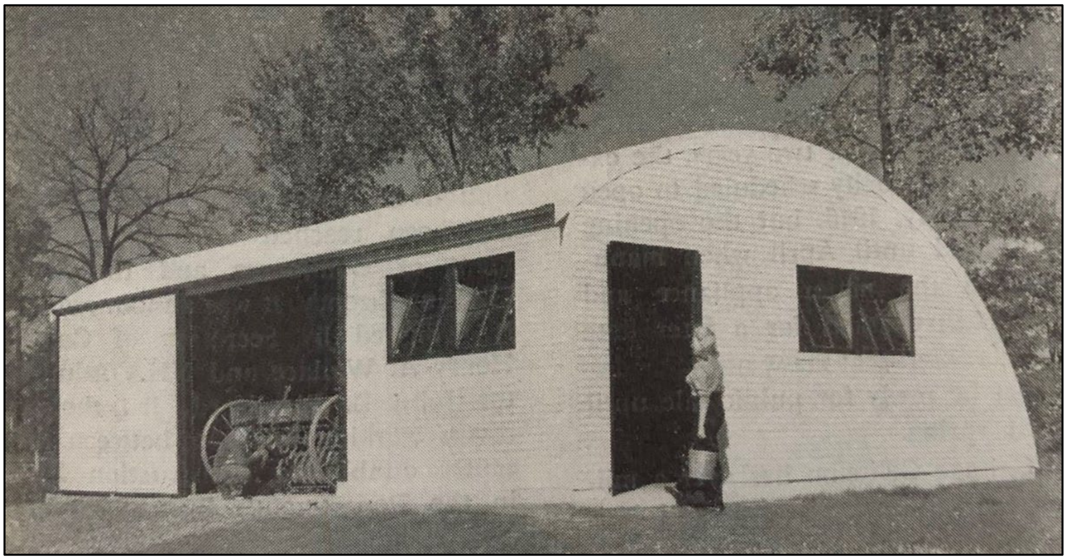
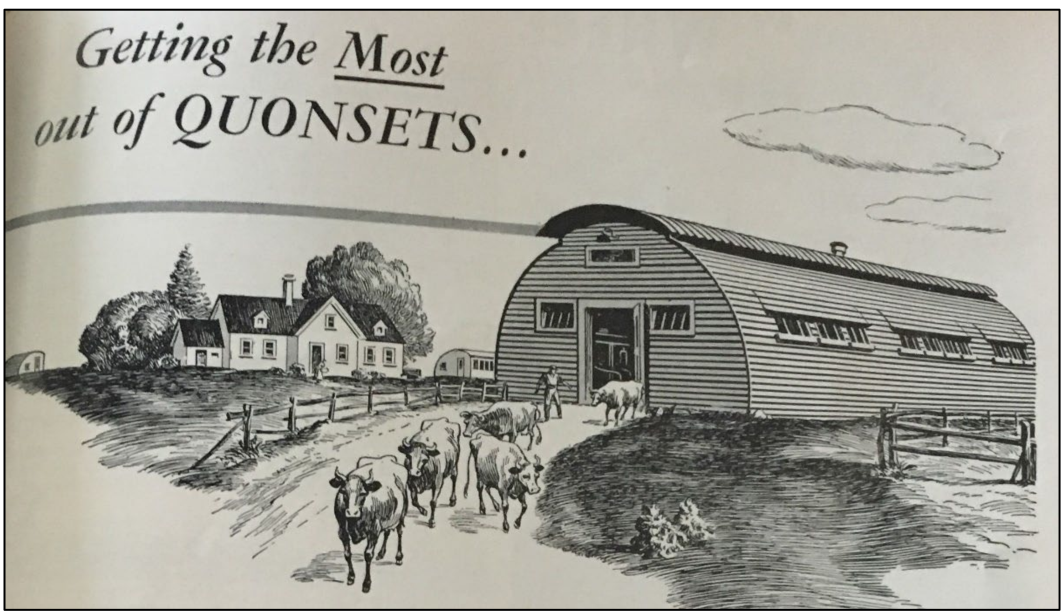


Figure 69. Flintkote Company advertisement for their products that can be used to get "the most out of Quonsets," 1946 (James L. Strahan, "A Professional Architectural Service to Farmers," *Agricultural Engineering* 27 (Dec. 1946): 558-561).



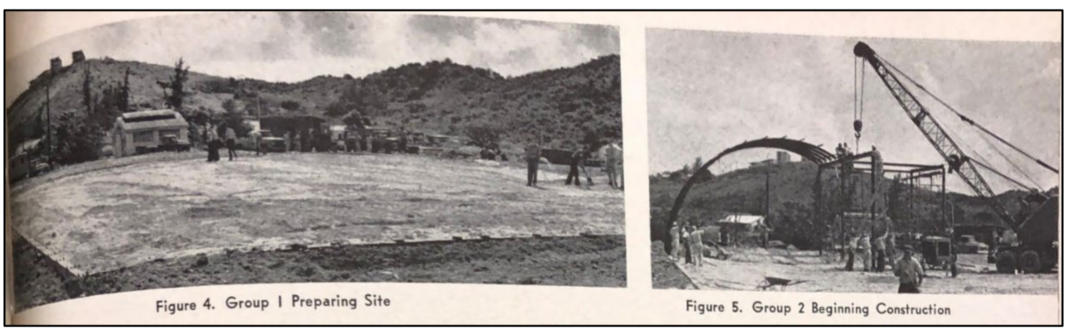

Though Great Lakes Steel Corps and their subsidiary Stran-Steel founded "The Better Farm Building Association" with other manufacturers, colleges, magazines, and trade associations to find the best materials for farm buildings in June 1946, the agricultural market for prefabricated farm buildings was soon taken over by self-framing "half-round" structures, like those built by Wonder Buildings and Behlen

Manufacturing.[103] These buildings were seen as superior to the Quonset by farmers for the added strength provided by the self-framing structure. Specifically, farmers sought these for their ability to withstand internal pressure as well as external, unlike the Quonset, whose nails would frequently pop under the outward pressure of loose grain.[104]

By the late 1950s, Stran-Steel saw the need to transition away from the production of Quonsets, and towards more traditional structures in order to remain competitive. In 1960, Stran-Steel completed this pivot away from Quonsets by launching its new line of rigid-framed structures. To highlight the trend of standardization and interchangeability of materials, Stran-Steel was able to increase its selection from 65 to 350 buildings while concurrently reducing the number of different components.[105]

After Stran-Steel ceased production of Quonsets, surplus Quonset huts continued to be used by the War and Navy Department. Many of these uses were creative, such as at Roosevelt Roads Naval Station in Puerto Rico. The nearest city to the base was 50 miles away, so Seabee reserves constructed a bowling alley out of three 40 ft by 100 ft Quonset huts with concrete block side walls (Figure 70 and Figure 71).[106]

Figure 70. Site preparation and start of construction, Roosevelt Roads Naval Station, Puerto Rico, 1962 (Lawrence S. Kroll, "Seabee Reserves on Active Duty Training," *The Military Engineer* 54, no. 335 (Sept.–Oct. 1962): 339).



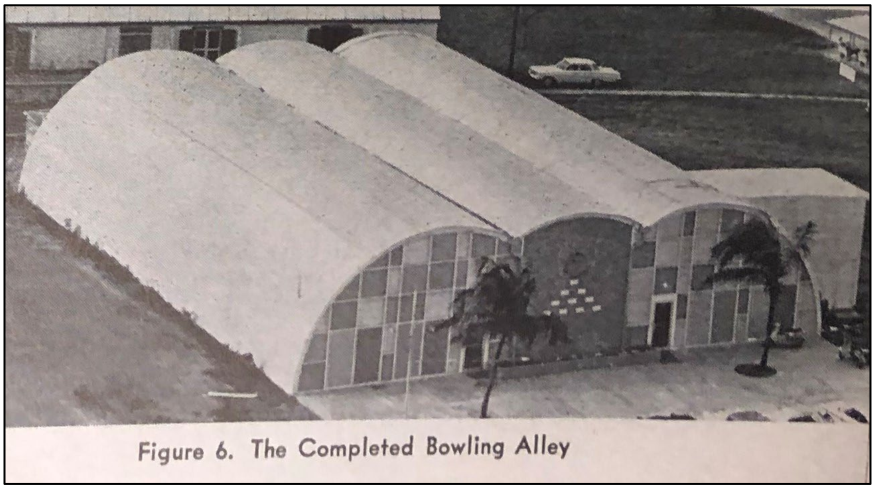

[103] James L. Strahan, "A Professional Architectural Service to Farmers," *Agricultural Engineering* 27 (Dec. 194): 558-561; Historitecture, L.L.C., *Soldiers of the Sword, Soldiers of the Ploughshare: Quonset Huts in the Fort Collins Urban Growth Area, a Historical Context and Survey Report*, submitted to Advance Planning Dept. of the City of Fort Collins, Colorado, July 2003.

[104] Historitecture, *Soldiers of the Sword*.

[105] "A Touch of Glamor for Steel Prefabs," *Business Week* 1615 (August 13, 1960): 120–122.

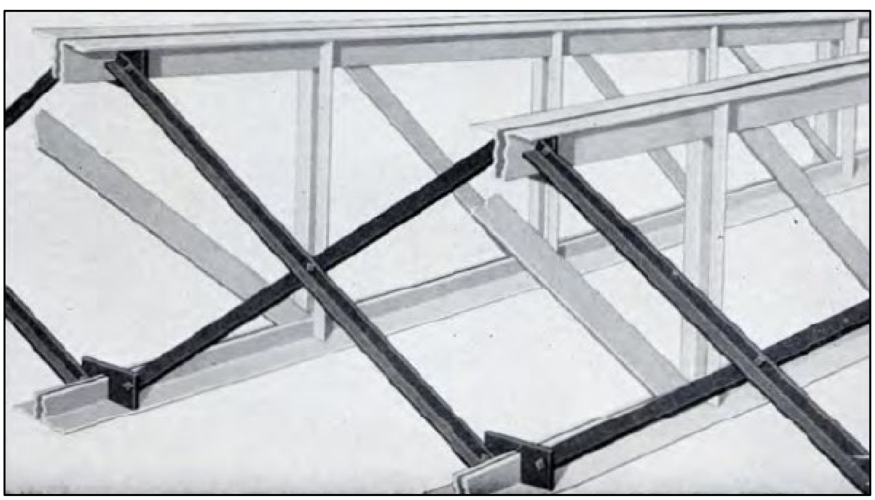
[106] Lawrence S. Kroll, "Seabee Reserves on Active Duty Training," *The Military Engineer* 54 (Sept.–Oct. 1962): 339.

Figure 71. The finished 12-lane bowling alley, Roosevelt Roads Naval Station, Puerto Rico, 1962 (Lawrence S. Kroll, “Seabee Reserves on Active Duty Training,” *The Military Engineer* 54, no. 335 (Sept.–Oct. 1962): 339).




Additionally, Stran-Steel’s nailable steel channel, developed in 1933, was incorporated across the metal building industry beyond in Quonset huts following World War II. Macomber, Inc., of Canton, Ohio (Macomber) marketed a roof truss that came with a nailable framing member on both the top and bottom to allow wooden subflooring or subroofing to be nailed into the steel directly (Figure 72).[107]

Figure 72. A roof truss made by Macomber, incorporating a nailable channel, January 1952 (United States Steel Company, “Ingenious hangar has no columns…,” *Architectural Forum* 96 (Jan.–Mar. 1952): n.p.).



107 United States Steel Company, “Ingenious hangar has no columns…,” *Architectural Forum* 96 (Jan.–Mar. 1952): n.p.

### 2.3.2 Fasteners

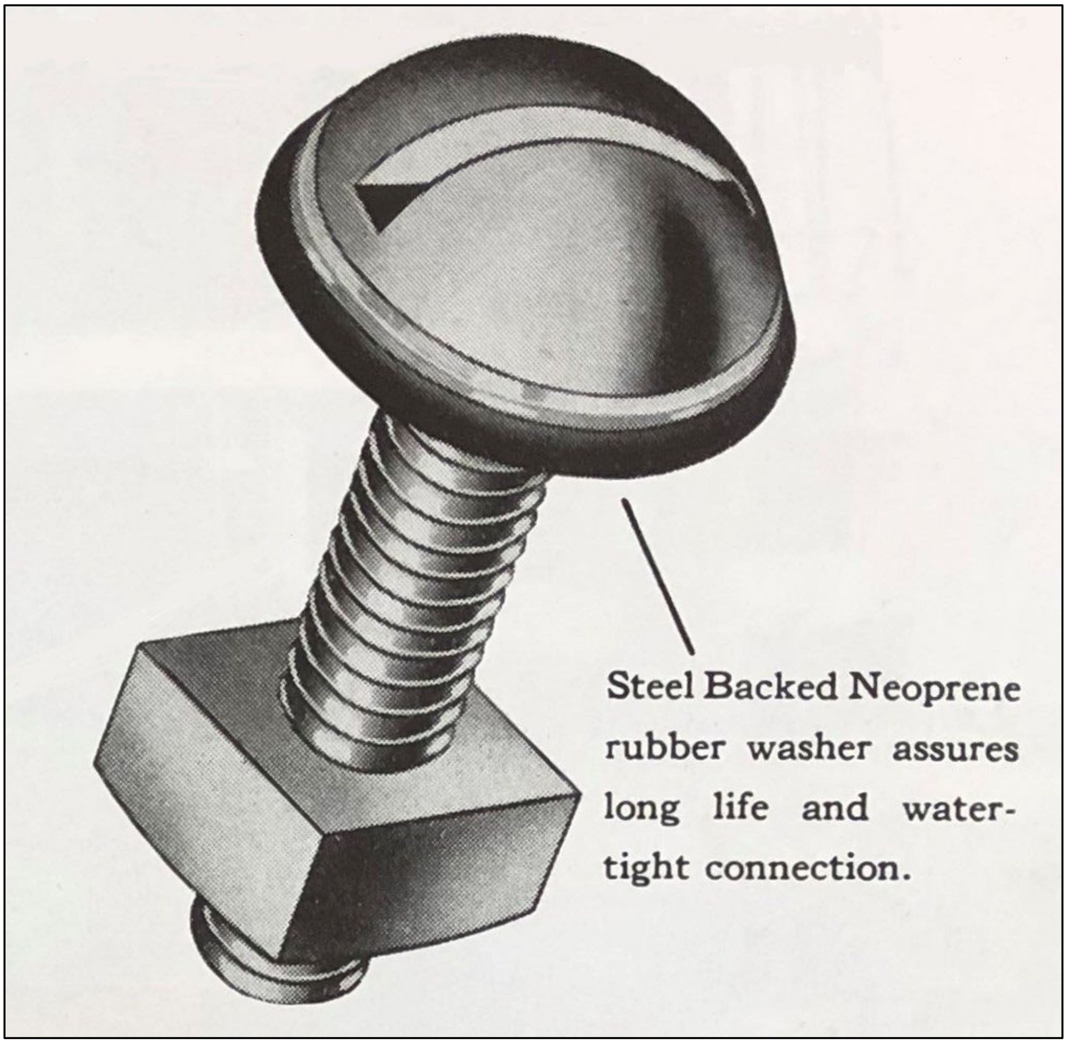
While nailable steel members increased steel's use in conjunction with other building materials, the future success of metal buildings would rely on metal-to-metal connection. Advancements were made in fastening technology during the early Cold War period that made metal buildings more resistant to weather and easier to erect. The first major development in this field was the transition away from rivets towards bolt-centered assembly. Rivets created strong bonds but made disassembly of the building or increasing space with additions more challenging. Rivets were still in use well into the early Cold War period and beyond, but they decreased in popularity as newer alternatives became available.[108]

By contrast, Neoprene washers, while available during the war, gained in popularity in the early Cold War period (Figure 73). These washers could be inserted under bolts or rivets to add a weatherproof seal to the structure, as these connections were previously the usual sources of leaky roofs in metal buildings; however, Neoprene washers must be replaced after prolonged use due to deterioration.[109]

[108] Butler Manufacturing Company, "For Features that Pay Off…Buy Butler Buildings," *The Military Engineer* 44 (Jan. – Feb. 1952): n.p; A.F.L. Deeson, ed., Comprehensive Industrialised Building Annual (Systems and Components) 1966. London: House Publications Limited, 1966, 90.

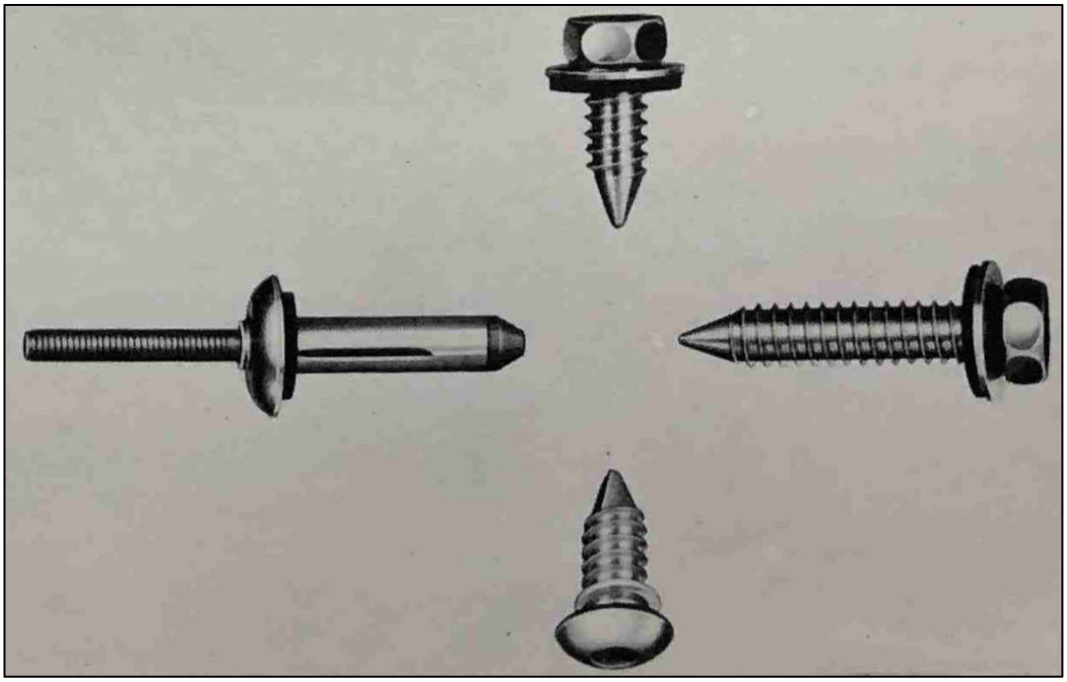
[109] Butler, "For Features that Pay Off…Buy Butler Buildings."

Figure 73. A close-up of Butler's standard nut and bolt, highlighting the recent development of steel backed neoprene rubber washers, a marked improvement in the ease of weatherproofing of metal buildings (Butler Manufacturing Company, "For Features that Pay Off...Buy Butler Buildings," *The Military Engineer* 44, no. 297 (Jan.–Feb. 1952): 16).



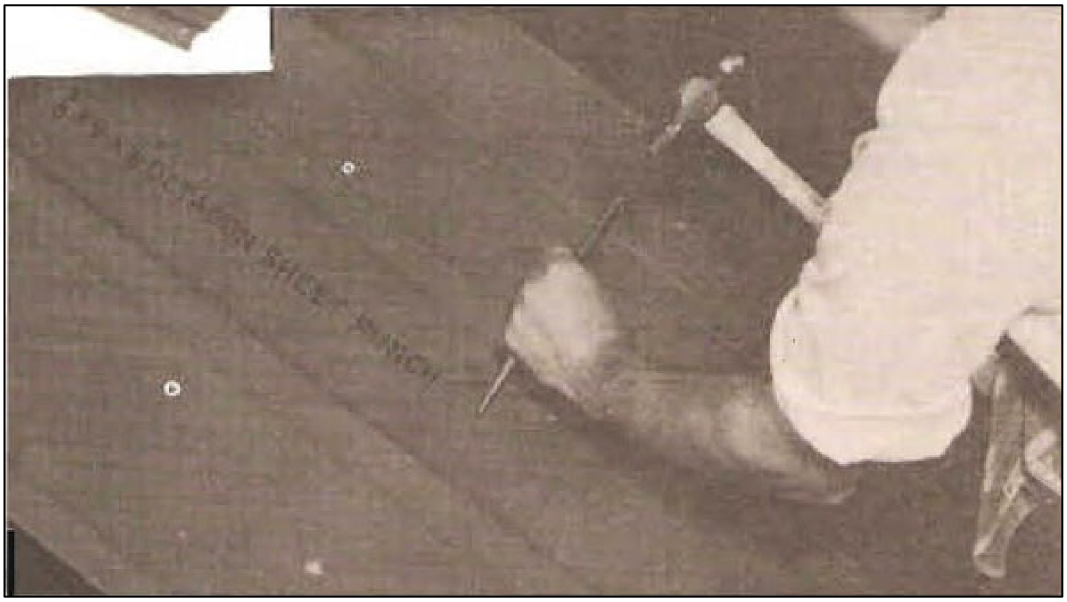

New screws were developed in this period that further increased assembly speed. Self-tapping screws were the first to be developed in the late 1950s (Figure 74). These had pointed ends and could be inserted and fastened into any unthreaded hole in sheet metal, which was previously impossible. This saved further time over traditional bolts, as they no longer required nuts, meaning that connections could be made by one person when previously two were required, with one holding the nut. Self-drilling screws developed later than the self-tapping screws and removed the step of either pre-punching or field-punching the hole through the metal (Figure 75). These screws featured a drill bit leading into the threading at the end of the screw, allowing for it to be screwed directly through sheet metal.[110]

Figure 74. The four fasteners used in Butler's metal building systems, showing both how rivets were still being utilized, as well as showing the newer self-tapping screws, which created the threads in metal holes as the screw is being tightened, reducing the need for either pre-threading of holes or using other fasteners like rivets or nuts and bolts (A.F.L. Deeson, ed. Comprehensive Industrialised Building Annual (Systems and Components) 1966, London: House Publications Limited, 1966).



110 Tom Hulsey, "The history and evolution of building fasteners," Construction Magazine Network, May 10, 2014, https://www.constructionmagnet.com/rural-builder/the-history-and-evolution-of-building-fasteners; Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions for the 40'-0" x 100'-0" building," Kansas City, MO: Butler Manufacturing Company, 1945.

Figure 75. Depicted is the method used for field punching holes for a Butler prefabricated warehouse. Field punching would become unnecessary with the advent of self-tapping screws in the 1960s. (Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions for the 40'-0" x 100'-0" building," Kansas City, MO: Butler Manufacturing Company, 1945).

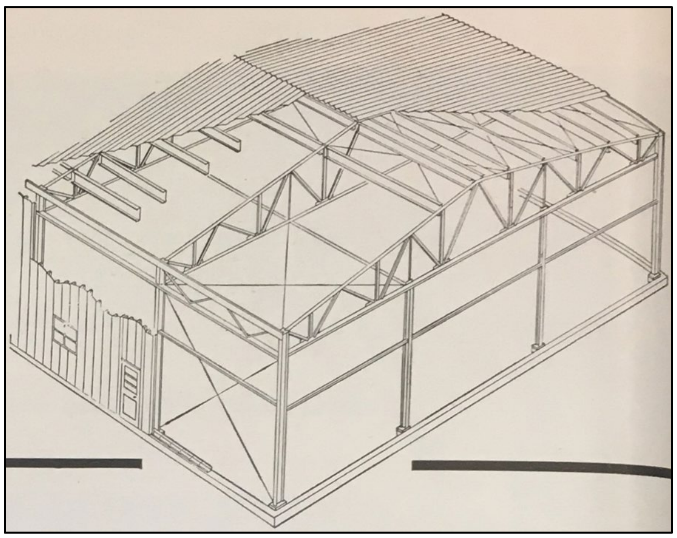


### 2.3.3 Truss

Most prefabricated metal building designs in the post-war construction boom featured a metal truss roof. By the 1950s, companies were able to provide extensive customization of truss configuration, and therefore the building as a whole. For example, a 1957 advertisement for American Rolling Mill Company (Armco) allows for buildings with five different wall heights between 12 ft and 24 ft, span widths from 60 ft to 100 ft, and lengths being any increment of 20 ft (Figure 76). Mesker continued to manufacture truss-supported structures during the Early Cold War. Their gabled buildings started at 6 ft widths with height offerings from 8 ft to 30 ft at 2 ft intervals (Figure 77, Figure 78, and Figure 79).

In addition to more standard gabled structures, Mesker's bowstring truss was still popular during this period (Figure 80, Figure 81, and Figure 82). Mesker was unique in the metal building industry in the level of prefabrication that was done before reaching the construction site. As late as 1959, Mesker was delivering all of their trusses fully factory-assembled, which was a tall task as this meant transporting large complete trusses to the construction site. Trusses up to 38 ft were welded together in the factory using 3/16-in. thick gusset places at minimum. For larger trusses of 40 ft and bigger, hot driven rivets were applied in the factory. In addition to the prefabrication of trusses, Mesker also prefabricated large portions of their walls. “All roofing and sidewall sheets are no. 24 gauge commercial grade galvanized sheets, hot galvanized for strength and long life. Sidewall sheets are factory applied to steel framework with aluminum rivets.” All the metal siding that was required to be attached on the construction site were vertical panels that covered the joints between panels. These wall sections were between 6 ft and 12 ft wide and shipped as one piece on Mesker owned and operated trucks (Figure 83).[111]

Figure 76. A cross section of Armco Steel Buildings’ truss-type design, featured in a 1957 advertisement (American Rolling Mill Company, “Look at the design advantages you get in truss-type Armco Steel Buildings,” *Architectural Forum* 106 (Jan. – Mar. 1957): 28).



[111] American Rolling Mill Company, “Look at the design advantages you get in truss-type Armco Steel Buildings,” *Architectural Forum* 106 (Jan. – Mar. 1957): 28; Geo. L. Mesker Steel Co., “For economy…for endurance. Mesker Prefabricated Sectional Type Steel Buildings,” Evansville, IN: Geo. L. Mesker Steel Corporation, 1959, 4.

Figure 77. An example of a gabled Mesker building on the smaller side of the size spectrum, complete with window, as well as ground and ceiling ventilation (Geo. L. Mesker Steel Corporation, “For economy…for endurance. Mesker Prefabricated Sectional Type Steel Buildings,” Evansville, IN: Geo. L. Mesker Steel Corporation, 1959, 4).

Figure 78. A Mesker prefabricated steel structure using a truss design, with this particular structure featuring single and double sized doorways as well as awning windows (Geo. L. Mesker Steel Corporation, “For economy…for endurance. Mesker Prefabricated Sectional Type Steel Buildings,” Evansville, IN: Geo. L. Mesker Steel Corporation, 1959, 4).

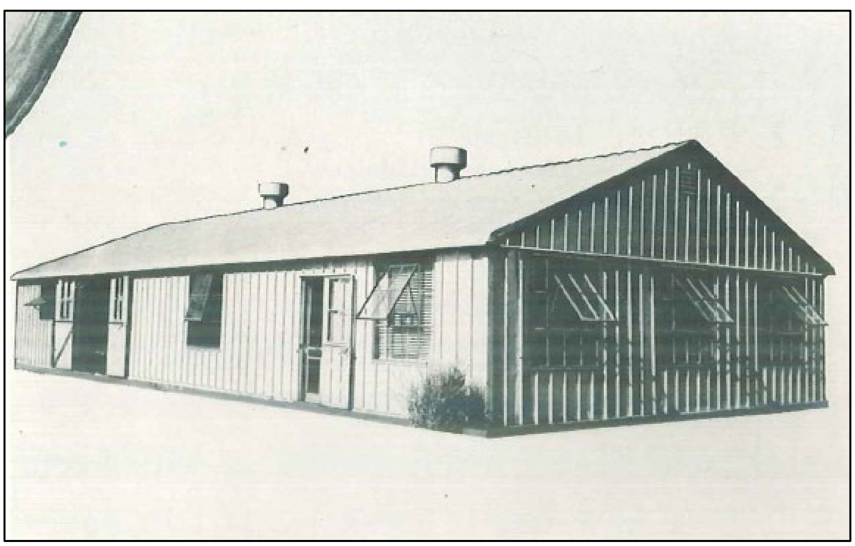


Figure 79. An internal view of the Mesker Prefabricated metal building, providing clear view of Mesker's prefabricated trusses as well as the corner braces along the top of each factory assembled side wall panel (Geo. L. Mesker Steel Corporation, "For economy…for endurance. Mesker Prefabricated Sectional Type Steel Buildings," Evansville, IN: Geo. L. Mesker Steel Corporation, 1959, 4).

Figure 80. The steel frame of a Mesker prefabricated building with bowstring truss roof supports, 1948 (Geo. L. Mesker Steel Corporation, "Catalog E," Evansville, IN: Geo. L. Mesker Steel Corporation, 1948).

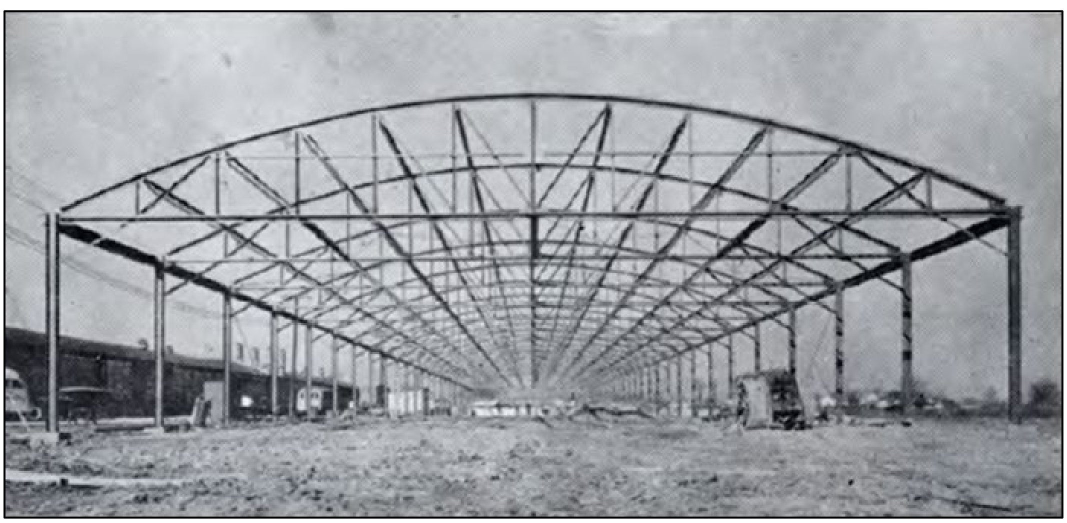


Figure 81. A prefabricated hangar by Mesker using their bowstring truss (Geo. L. Mesker Steel Corporation, “Catalog E,” Evansville, IN: Geo. L. Mesker Steel Corporation, 1948).

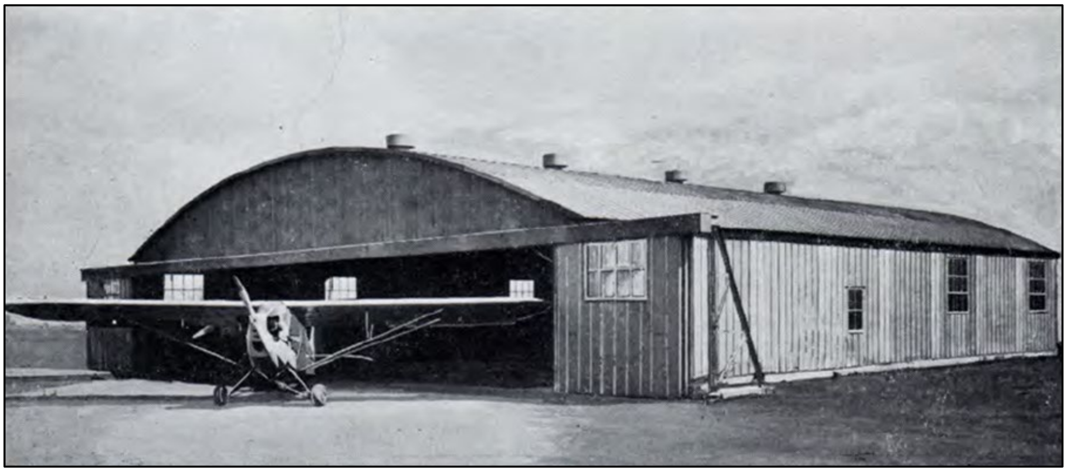


Figure 82. An example of a “Mesker Prefabricated Sectional Type Steel Building,” pictured in a promotional catalogue to show their adaptability, with an open end and several overhead garage doors, 1959 (Geo. L. Mesker Steel Corporation, “For economy…for endurance. Mesker Prefabricated Sectional Type Steel Buildings,” Evansville, IN: Geo. L. Mesker Steel Corporation, 1959, 4).

Figure 83. An advertisement for Mesker's prefabricated steel buildings, showing the gap left between joining prefabricated sectional side wall panels where field-applied siding is required (Geo. L. Mesker Steel Corporation, "For economy…for endurance. Mesker Prefabricated Sectional Type Steel Buildings," Evansville, IN: Geo. L. Mesker Steel Corporation, 1959, 4).


### 2.3.4 Rigid Frame

One of the most impactful advancements in the field of prefabricated metal buildings was the development of the rigid frame design by Butler in 1940. Prior to this innovation, the most common design for steel buildings was the truss design, which drew its stability from the triangular arrangement of members. These truss-design buildings required a great deal of effort in terms of fabrication and erection, as well as reducing the usable volume of the building.[112]

Rigid frame construction was not a new idea, as it had been used in practically all skyscrapers since the 1920s, but it had not yet been adapted to prefabricated buildings due in large part to the complex and laborious stress calculations required. In 1939, Chief Engineer of the Steel Building Department of Butler Manufacturing, Wilbur Larkin, hired his older brother Kenneth Larkin as an engineering consultant to begin development of a rigid frame design for prefabricated buildings after he had persuaded Wilbur of the design's potential. Butler, under the direction of Kenneth Larkin, designed and tested various frame designs and by 1940 had a complete line of pre-engineered buildings ready to announce.[113]

These buildings featured a frame consisting of columns, roof sections, and knees, with the knee being the joint at the eaves between the column and the roof section. The columns and roof sections were comprised of tapered I-beams, which gave the structure both vertical and lateral strength. In the words of designer Kenneth Larkin, "this type of structure becomes more of an enclosing shell around the necessary functions of the building and that the structure itself uses up less space of the enclosed building."[114]

Due to the onset of WWII, Butler was required to shelve their plans temporarily while they focused on the production of war materials. By 1945, however, they were marketing their design to the private sector, with a 40 ft by 100 ft warehouse with 14 ft eaves and a 20 ft ridge for $4,000 (Figure 84 and Figure 85).[115] Erection of these structures required six main steps of assembly. First, the preparation work had to be done, which involved setting and pouring the foundation with anchor bolts set in the correct spots. Additional preparation was needed to create a jig by assembling one of the end frames and adding "jig clips" which allowed for accurate speedy welding of the remainder of the rigid frame on site, which was added for further support (Figure 86, Figure 87, and Figure 88). The second step was the assembly of the main frame along with the installation of eave struts, purlins, girts, and diagonal bracing. After this, the end

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112 Cowles, Butler Company History, 128.

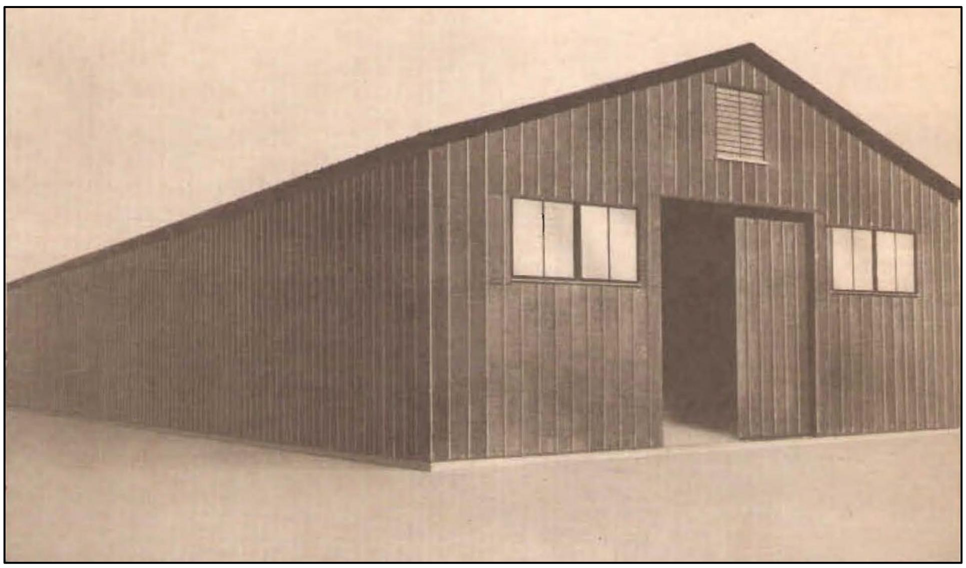
113 Ibid, 127-129.

114 Ibid, 129.

115 E.C. Livingston Co., "Why Wait For That Much Needed Shop, Store or Warehouse?" *Berkley Daily Gazette*, December 3, 1945.

framing was added, including the channel door posts, header, and girts (Figure 89). The fourth step involved applying the doors, windows, and corrugated sheets to the end sections. The fifth step involved the remaining corrugated sheets being bolted to the sides and roof, requiring field punching of holes. For this step, scaffolding, which could be created out of the crating lumber, was used to access the underside of the roof to secure the nuts. This left the sixth and final step as just a site cleanup, gathering the inevitable lost nuts and bolts or spare parts.[116]

Figure 84. Oblique of a 40 ft by 100 ft rigid framed steel warehouse by Butler, 1945 (Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions for the 40'-0" x 100'-0" building," Kansas City, MO: Butler Manufacturing Company, 1945).



[116] Butler Manufacturing Company. "U.S. Navy rigid frame utility warehouse building erection instructions."

Figure 85. Interior of a 40 ft by 100 ft rigid framed steel warehouse by Butler, highlighting the extra usable space provided in a rigid frame structure over previous truss-based design, 1945 (Butler Manufacturing Company, “U.S. Navy rigid frame utility warehouse building erection instructions for the 40’-0” x 100’-0” building,” Kansas City, MO: Butler Manufacturing Company, 1945).

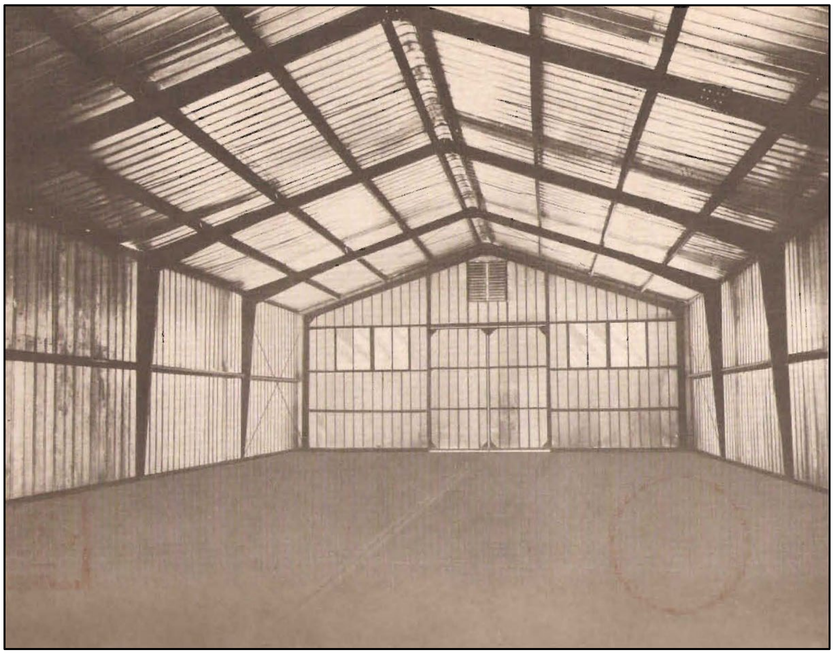


Figure 86. A fully assembled “jig” created for the welding of rigid frames, using end frame members with specially designed jig pieces labeled FJ-1 (Butler Manufacturing Company, “U.S. Navy rigid frame utility warehouse building erection instructions for the 40’-0” x 100’-0” building,” Kansas City, MO: Butler Manufacturing Company, 1945).

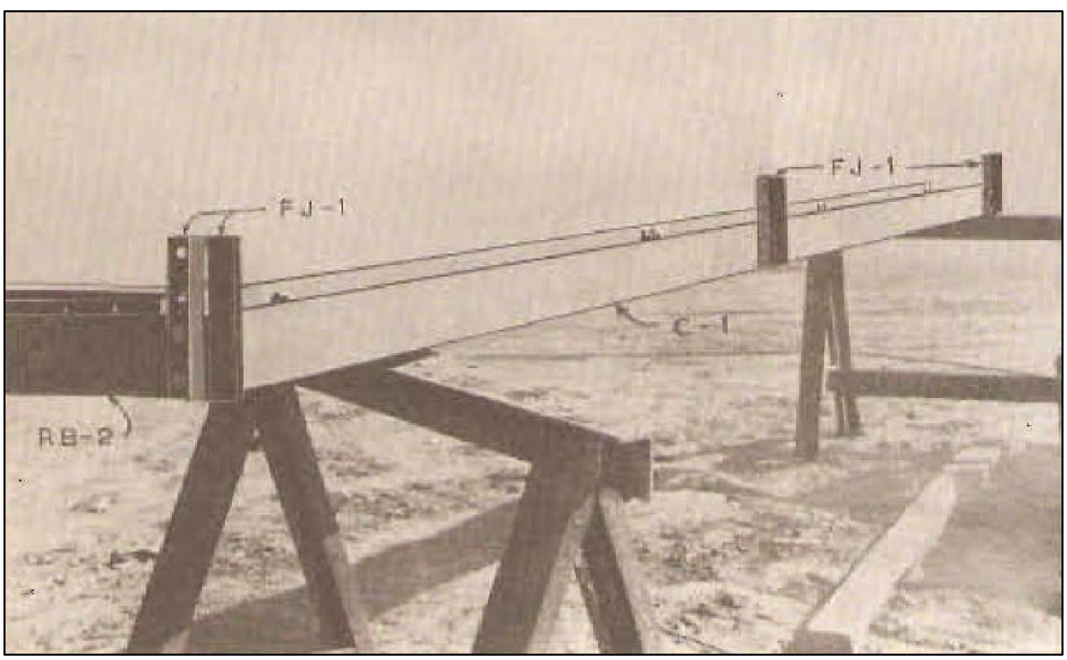


Figure 87. Jig with attached steel rigid frame members as welders are preparing to join two members (Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions for the 40'-0" x 100'-0" building," Kansas City, MO: Butler Manufacturing Company, 1945).

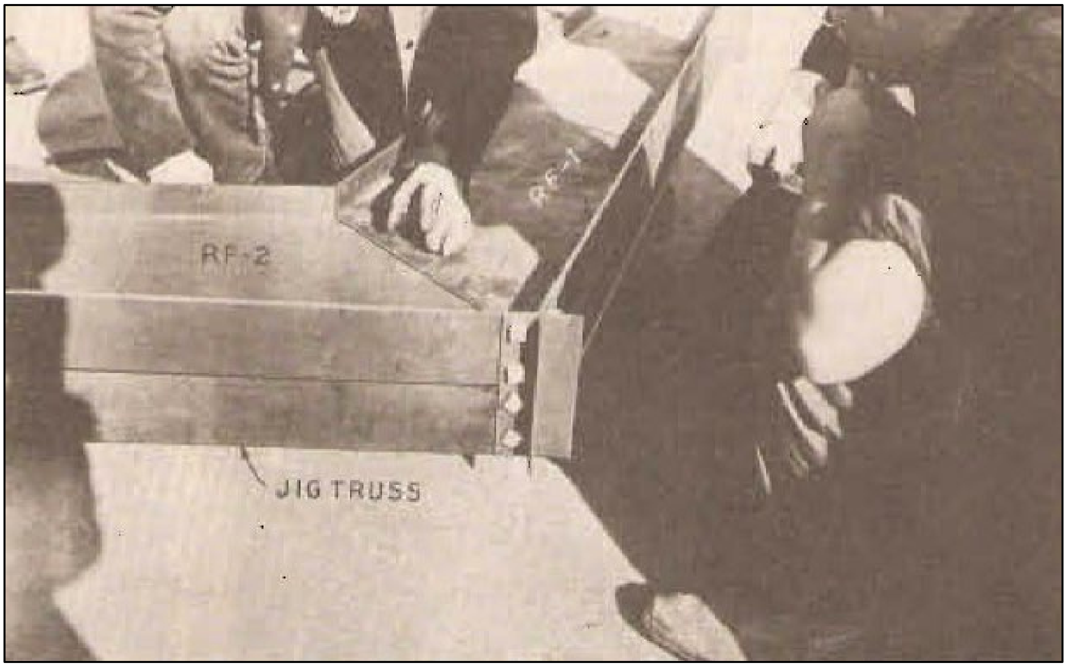



Figure 88. A completed connection between two metal frame members after being removed from the welding jig (Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions for the 40'-0" x 100'-0" building," Kansas City, MO: Butler Manufacturing Company, 1945).

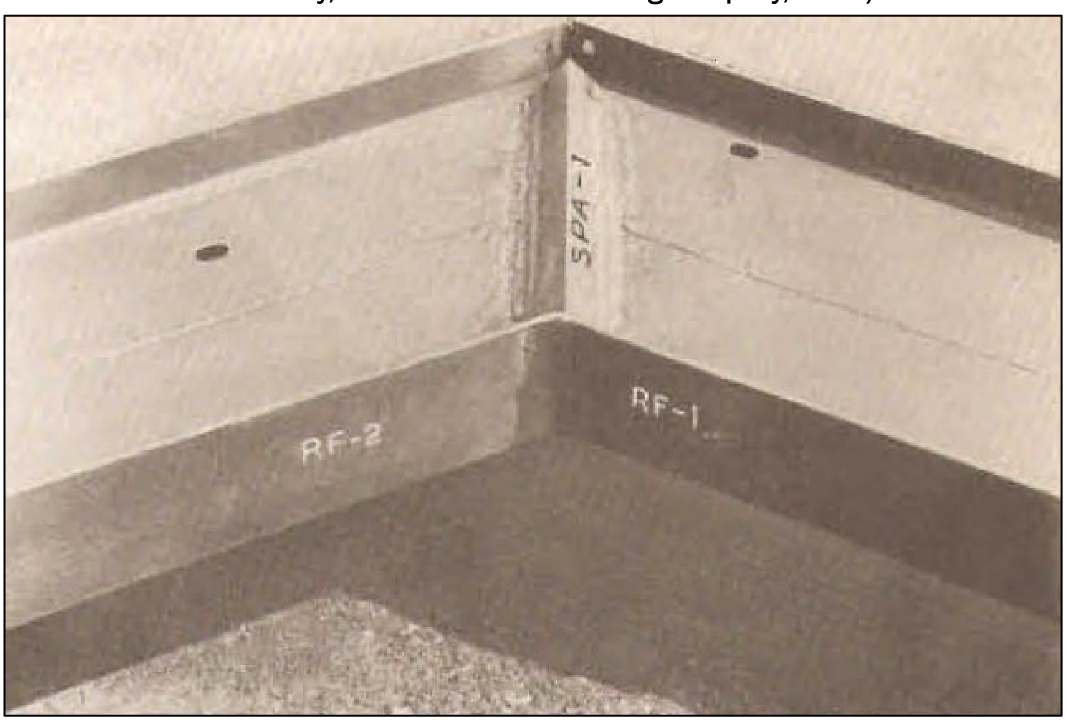


Figure 89. The frame of a 40 ft by 100 ft Butler Warehouse with important frame members identified, 1945 (Butler Manufacturing Company, “U.S. Navy rigid frame utility warehouse building erection instructions for the 40’-0” x 100’-0” building,” Kansas City, MO: Butler Manufacturing Company, 1945).

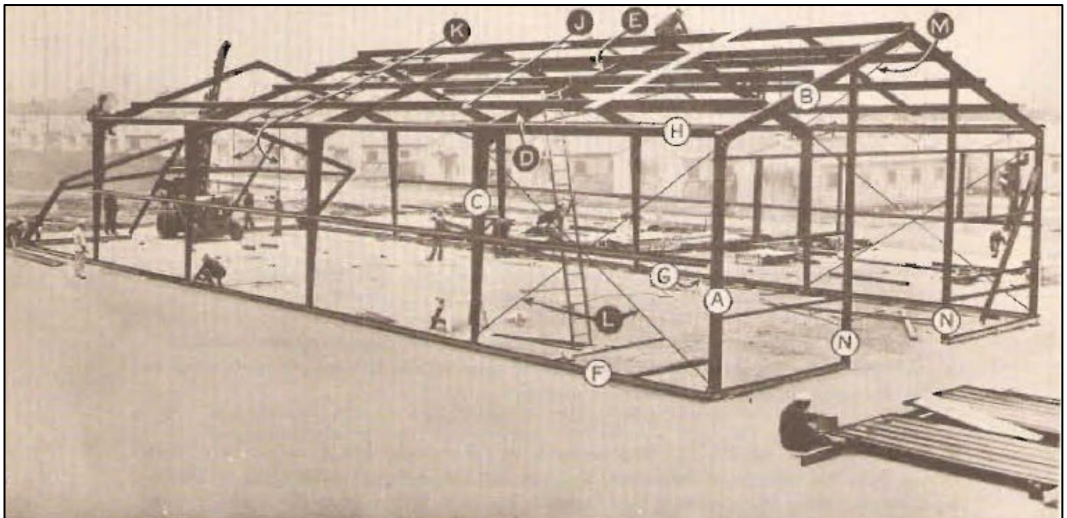



***Figure 1 Showing the Following:***

**A**—End Column

**B**—End Roof Beam

**C**—Rigid Frame Column

**D**—Rigid Frame Haunch

**E**—Rigid Frame Roof Beam

**F**—Bottom Angle

**G**—Wall Girt

**H**—Eave Strut

**J**—Purlins (four on each side)

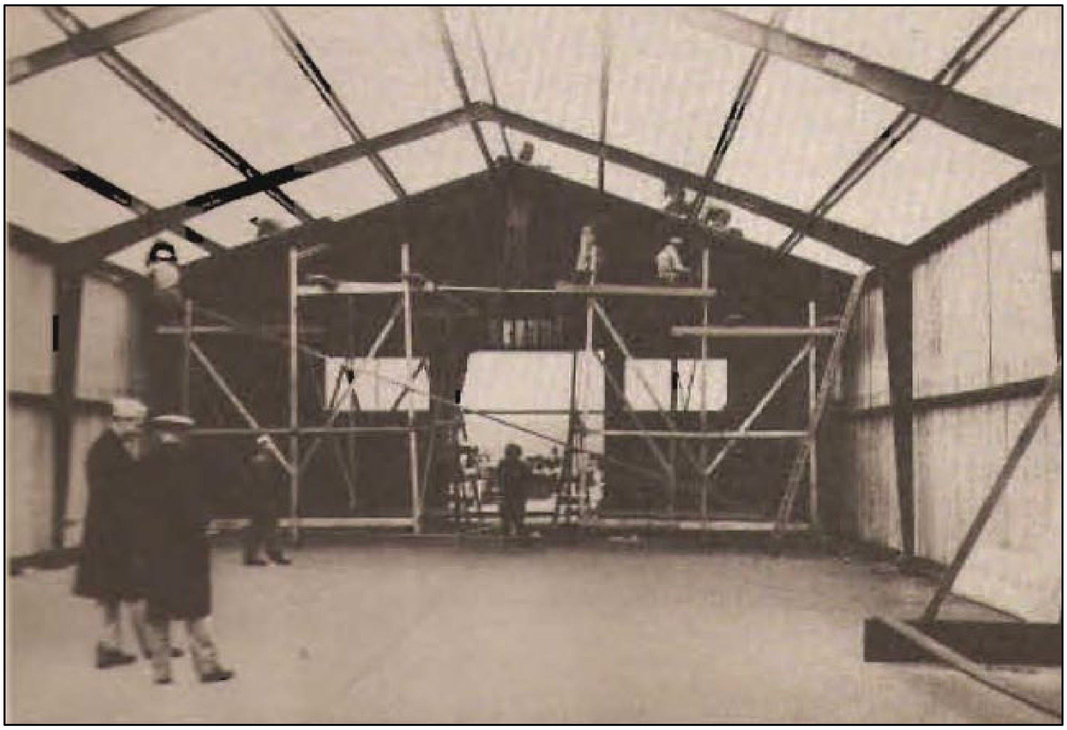
**K**—Sag Rods (double row)

**L**—Wall Diagonal Rods

**M**—Roof Diagonal Rods

**N**—Door Posts

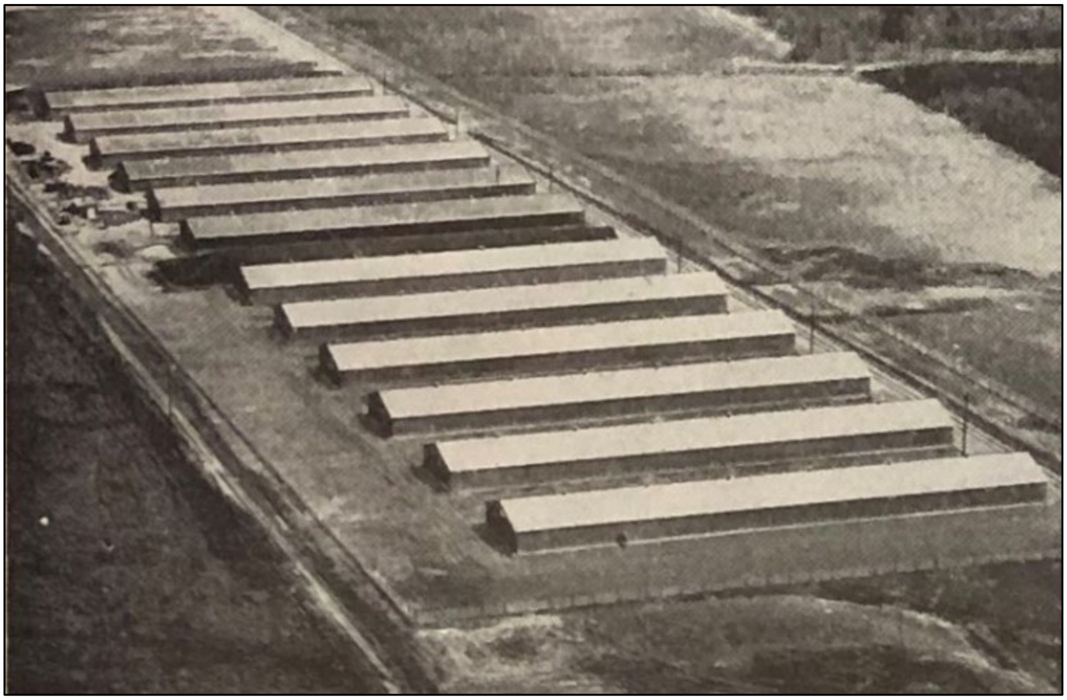
Figure 90. An interior view of the scaffolding required for roof assembly, notice the need for men above and under the roofing panels for installation, 1945 (Butler Manufacturing Company, “U.S. Navy rigid frame utility warehouse building erection instructions for the 40’-0” x 100’-0” building,” Kansas City, MO: Butler Manufacturing Company, 1945).



These warehouses were popular with the DoD during the early Cold War period due to the design’s adaptability along with the increased durability added by the rigid frame. They could be assembled end to end with ease and could even be made clear span with the removal of the end rigid frames (Figure 91). While less common, these warehouses were also easily joined along the side walls (Figure 92). Timber could be used instead of the foundation but required wood 8 in. in diameter and 4 ft deep. Adaptations of this basic 40 ft by 100 ft warehouse were quickly developed and, in 1948, Butler was offering rigid framed buildings in 20 ft and 32 ft widths, with lengths at multiples of 12 ft. By the 1950s, Butler’s marketing began emphasizing the rigid frame’s adaptability for uses beyond industrial. This was due to the load bearing nature of the rigid frame, which permitted non-load bearing walls to be constructed out of any material, allowing the prefabricated structure to be used as churches, gyms, office buildings, and retail stores (Figure 93). Other companies like

Mesker and Armco began to develop and market their own rigid frame, which soon entered the market to compete with Butler's (Figure 94).[117]

Figure 91. Twelve rigid framed Butler Buildings measuring 42 ft by 260 ft by 10 ft that were used for the storage of 15,000 tons of sacked ammonium nitrate, Military, Kansas, 1952 (Butler Manufacturing Company, "For Features that Pay Off…Buy Butler Buildings," *The Military Engineer* 44, no. 297 (1952): 16).



[117] Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions;" "Butler Manufacturing Company, "You don't need a big budget to provide good looks…with Butler Steel Buildings," *Architectural Forum* 102 (Jan.–Mar. 1955): 233; Butler Manufacturing Company, "You can satisfy your clients' expensive tastes with economical metal buildings…" *Architectural Forum* 106 (Jan.–Mar. 1957): 55.

Figure 92. Two Butler rigid-framed warehouses joined lengthwise, requiring little adaptation other than omitting steel siding and installing a gutter along the structures' middle, Cleveland, Ohio, 1952 (Butler Manufacturing Company, "For Features that Pay Off…Buy Butler Buildings," *The Military Engineer* 44, no. 297 (Jan.–Feb. 1952): 16).

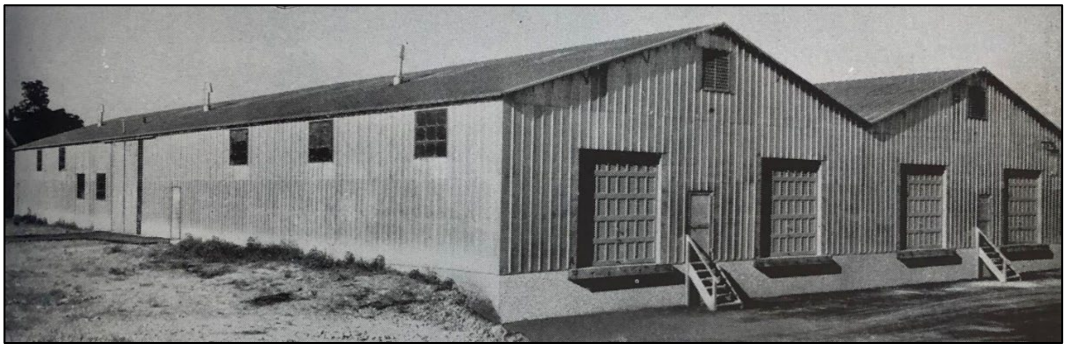


Figure 93. A Butler advertisement highlighting the adaptability of their prefabricated rigid frame design, 1955 (Butler Manufacturing Company, "You don't need a big budget to provide good looks…with Butler Steel Buildings," *Architectural Forum* 102 (Jan.–Mar. 1955): 233).

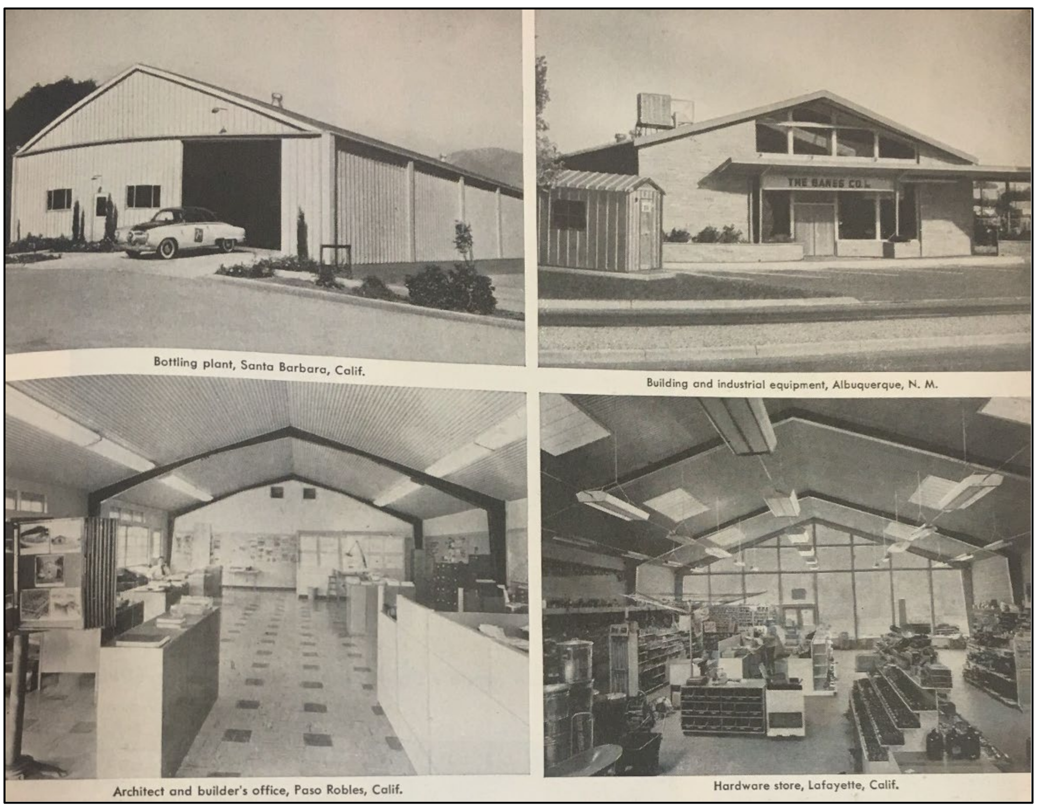
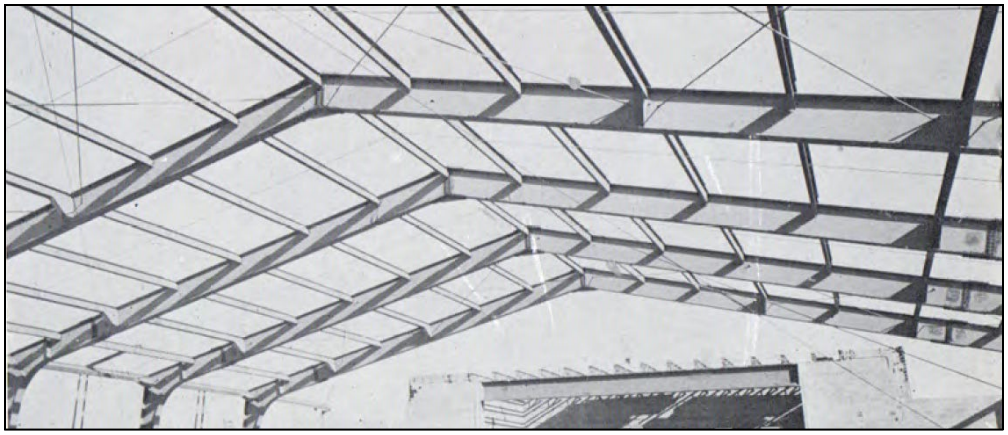


Figure 94. The frame of a Mesker rigid framed steel building being used in the construction of Rex Mundi High School, Evansville, Indiana (Geo. L. Mesker Steel Corporation, "For economy…for endurance. Mesker Prefabricated Sectional Type Steel Buildings," Evansville, IN: Geo. L. Mesker Steel Corporation, 1959).



### 2.3.5 Self-Framing

Self-framing buildings were prefabricated metal buildings that did not require framing, as they were supported by their walls and roofs. The most significant producer of these structures was the Wonder Building Corporation of Chicago (Wonder Buildings), founded in 1949. Wonder Buildings quickly became popular, with 10,000 being sold from 1952 to 1955.[118] Their structure used two-foot-wide, ten-foot-long curved panels that, when assembled, formed a Quonset-like corrugated "half-round" structure. Wonder Buildings came in any length, so long as it was a multiple of two, and widths of 20 to 63 ft.[119] Each panel was horizontally corrugated for added strength (Figure 95). A single size of bolt, weather-sealed with Neoprene washers, was used throughout (Figure 96). Wonder Buildings also offered a straight wall design with more usable area than the half-round design and a roofing system, which could be used on any structure requiring clear spans of 20 ft to 300 ft (Figure 97). Wonder Buildings' end walls were constructed entirely of steel with a variety of door and window options. These structures became popular for agricultural applications, as structure could withstand both internal and

118 "Wonder Corp. sets speedy buildings pace," *Chicago Tribune*, November 25, 1955.

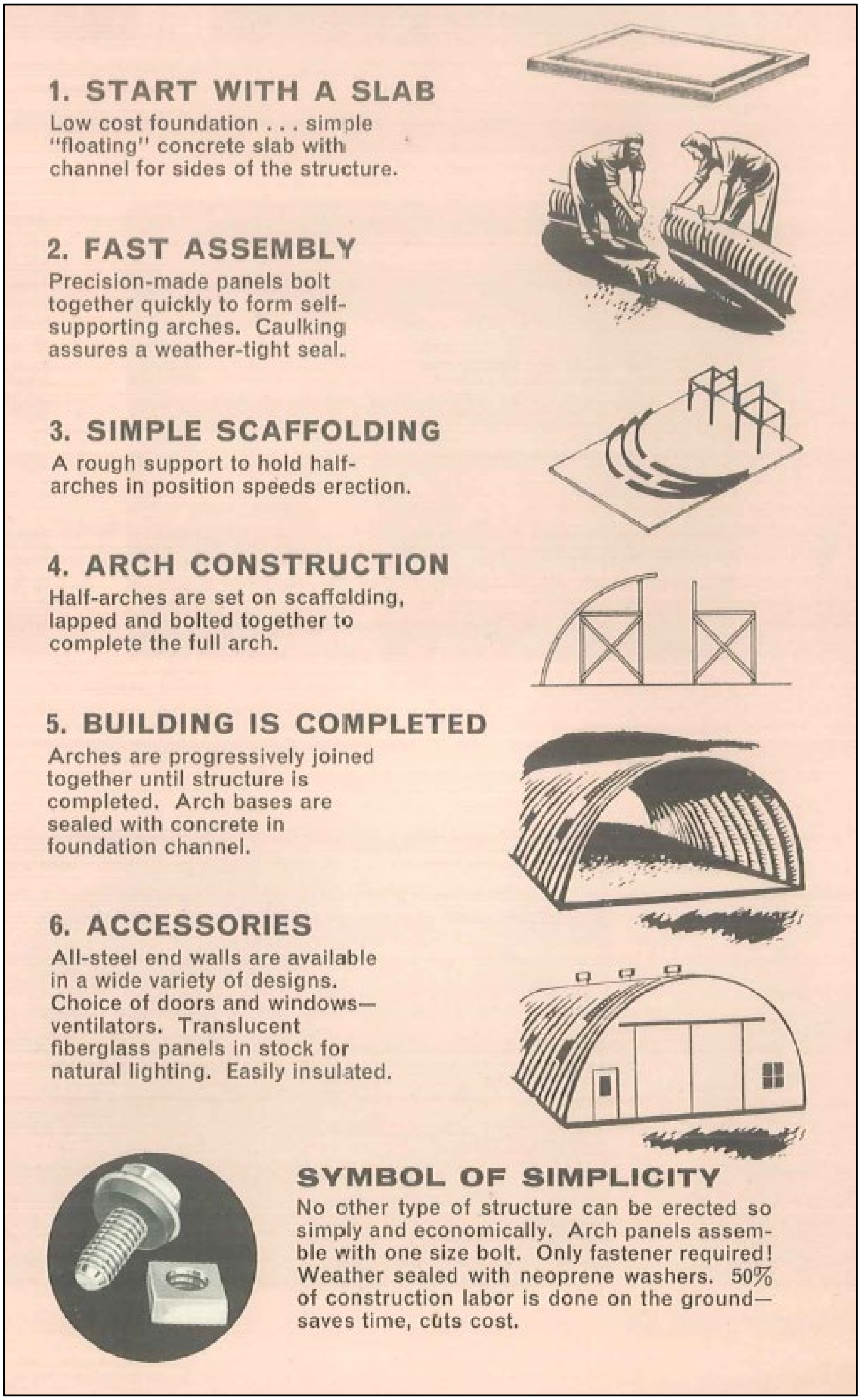
119 "Wonder Corp. sets speedy buildings pace," *Chicago Tribune*, November 25, 1955.

external forces, allowing for use as feed or grain storage. Self-framing "half-rounds" continue to be popular today (Figure 98).[120]

Figure 95. A close-up view of the double corrugation that provides additional strength to Wonder Buildings' frameless design, 1958 (Wonder Trussless Building, Inc., "Wonder Building Assembly and Specification Manual," Chicago, IL: Wonder Trussless Building Co., 1958, n.p.)


[120] Wonder Trussless Building, Inc., "Wonder Building Assembly and Specification Manual," Chicago, IL: Wonder Trussless Building, Inc., 1958; Wonder Steel Buildings, "Special Factory Offer," *Progressive Farmer* 89 (Jan.–June 1974): n.p.; Southeastern Steel Buildings, "Our Buildings Will Save You Thousands," *Progressive Farmer* 101 (Jan.–June 1986): n.p.

Figure 96. The steps required to assemble a Wonder Building, 1958 (Wonder Trussless Building, Inc., “Wonder Building Assembly and Specification Manual,” Chicago, IL: Wonder Trussless Building Co., 1958, n.p.).



**1. START WITH A SLAB**

Low cost foundation . . . simple "floating" concrete slab with channel for sides of the structure.

**2. FAST ASSEMBLY**

Precision-made panels bolt together quickly to form self-supporting arches. Caulking assures a weather-tight seal.

**3. SIMPLE SCAFFOLDING**

A rough support to hold half-arches in position speeds erection.

**4. ARCH CONSTRUCTION**

Half-arches are set on scaffolding, lapped and bolted together to complete the full arch.

**5. BUILDING IS COMPLETED**

Arches are progressively joined together until structure is completed. Arch bases are sealed with concrete in foundation channel.

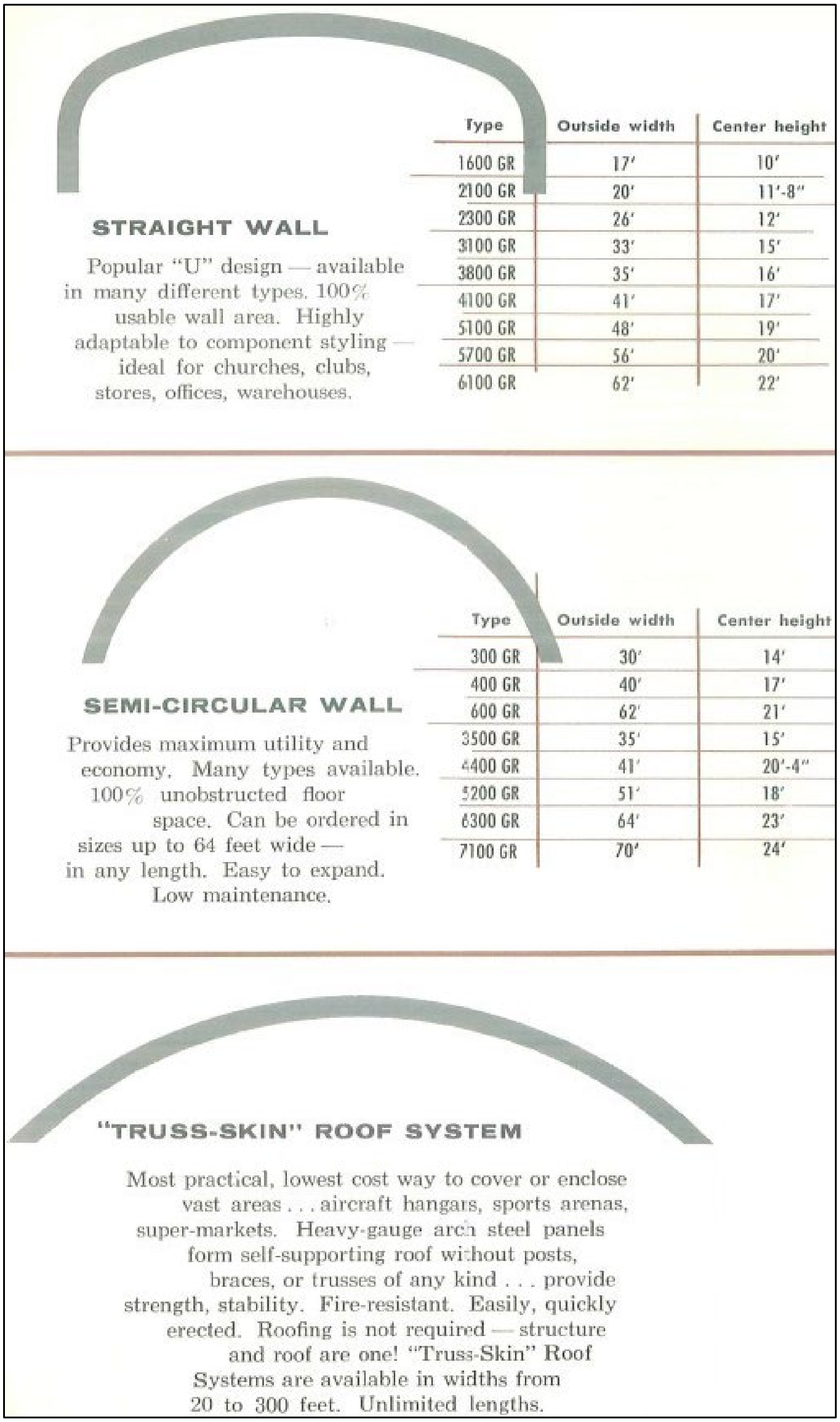
**6. ACCESSORIES**

All-steel end walls are available in a wide variety of designs. Choice of doors and windows—ventilators. Translucent fiberglass panels in stock for natural lighting. Easily insulated.

**SYMBOL OF SIMPLICITY**

No other type of structure can be erected so simply and economically. Arch panels assemble with one size bolt. Only fastener required! Weather sealed with neoprene washers. 50% of construction labor is done on the ground—saves time, cuts cost.

Figure 97. The two building options as well as a roofing system available from Wonder Buildings, 1958 (Wonder Trussless Building, Inc., "Wonder Building Assembly and Specification Manual," Chicago, IL: Wonder Trussless Building Co., 1958, n.p.).



**STRAIGHT WALL**

Popular "U" design — available in many different types. 100% usable wall area. Highly adaptable to component styling — ideal for churches, clubs, stores, offices, warehouses.

| Type | Outside width | Center height |
|---|---|---|
| 1600 GR | 17′ | 10′ |
| 2100 GR | 20′ | 11′-8″ |
| 2300 GR | 26′ | 12′ |
| 3100 GR | 33′ | 15′ |
| 3800 GR | 35′ | 16′ |
| 4100 GR | 41′ | 17′ |
| 5100 GR | 48′ | 19′ |
| 5700 GR | 56′ | 20′ |
| 6100 GR | 62′ | 22′ |

**SEMI-CIRCULAR WALL**

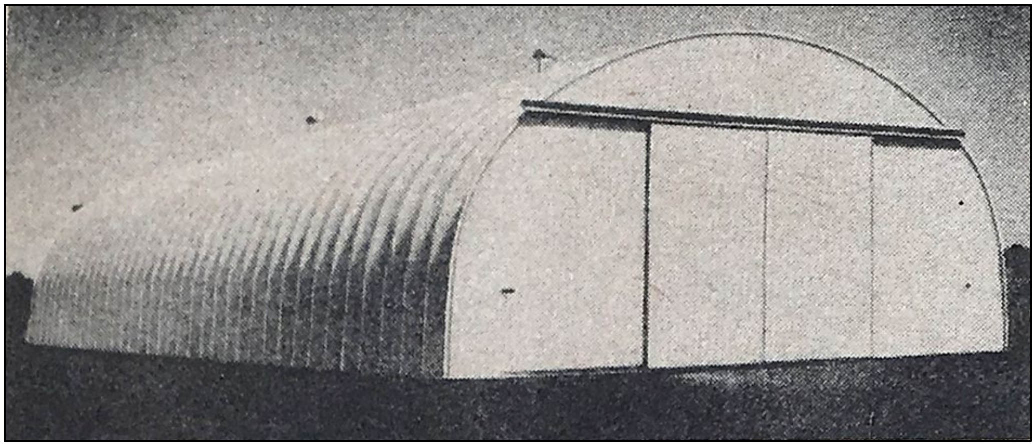
Provides maximum utility and economy. Many types available. 100% unobstructed floor space. Can be ordered in sizes up to 64 feet wide — in any length. Easy to expand. Low maintenance.

| Type | Outside width | Center height |
|---|---|---|
| 300 GR | 30′ | 14′ |
| 400 GR | 40′ | 17′ |
| 600 GR | 62′ | 21′ |
| 3500 GR | 35′ | 15′ |
| 4400 GR | 41′ | 20′-4″ |
| 5200 GR | 51′ | 18′ |
| 6300 GR | 64′ | 23′ |
| 7100 GR | 70′ | 24′ |

**"TRUSS-SKIN" ROOF SYSTEM**

Most practical, lowest cost way to cover or enclose vast areas . . . aircraft hangars, sports arenas, super-markets. Heavy-gauge arch steel panels form self-supporting roof without posts, braces, or trusses of any kind . . . provide strength, stability. Fire-resistant. Easily, quickly erected. Roofing is not required — structure and roof are one! "Truss-Skin" Roof Systems are available in widths from 20 to 300 feet. Unlimited lengths.

Figure 98. A Wonder Building advertised for $2,714 for a 30 ft by 50 ft and $5,144 for a 49 ft by 80 ft with sliding door, walk-in door, caulking and vents all included, 1974 (Wonder Steel Buildings, "Special Factory Offer," *Progressive Farmer* 89 (Jan.–June 1974): n.p.).



The Behlen S-Span was similar to the half-round Wonder Building (Figure 99). Introduced in 1950, this self-framing structure used large corrugations to provide structural stability without the need for internal framing. The S-Span resembled a more traditional building, with four walls and a gable roof. Both the walls and the roof were comprised of steel sheets with large corrugations. The S-Span surged in popularity in 1955 after one of the buildings survived the blast of an atomic bomb at Yucca Flats, Nevada (Figure 100).[121]

121 "Behlen Manufacturing Company History," Behlen Manufacturing Company, accessed December 18, 2018, https://www.behlenmfg.com/history.

Figure 99. The S-Span was the first self-framing structure manufactured by Behlen Manufacturing of Columbus, Nebraska, 1950 (Behlen Manufacturing Company, "One of Many Firsts," History, accessed December 18, 2018, https://www.behlenmfg.com/history).

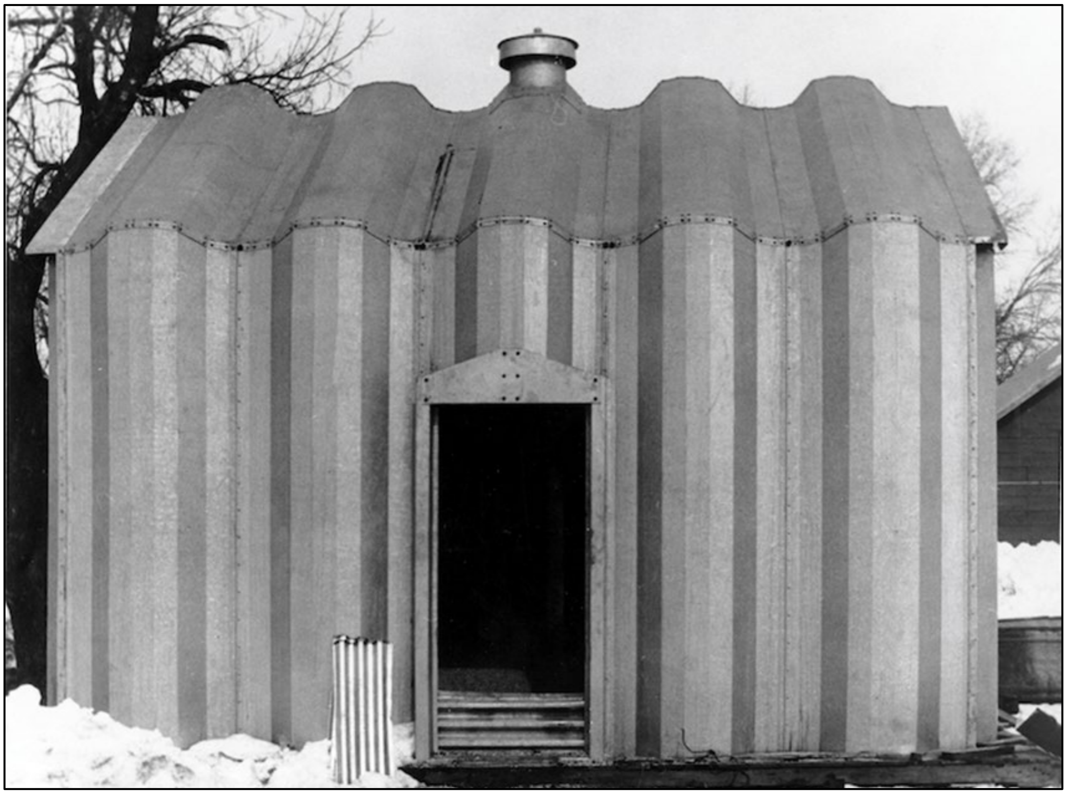
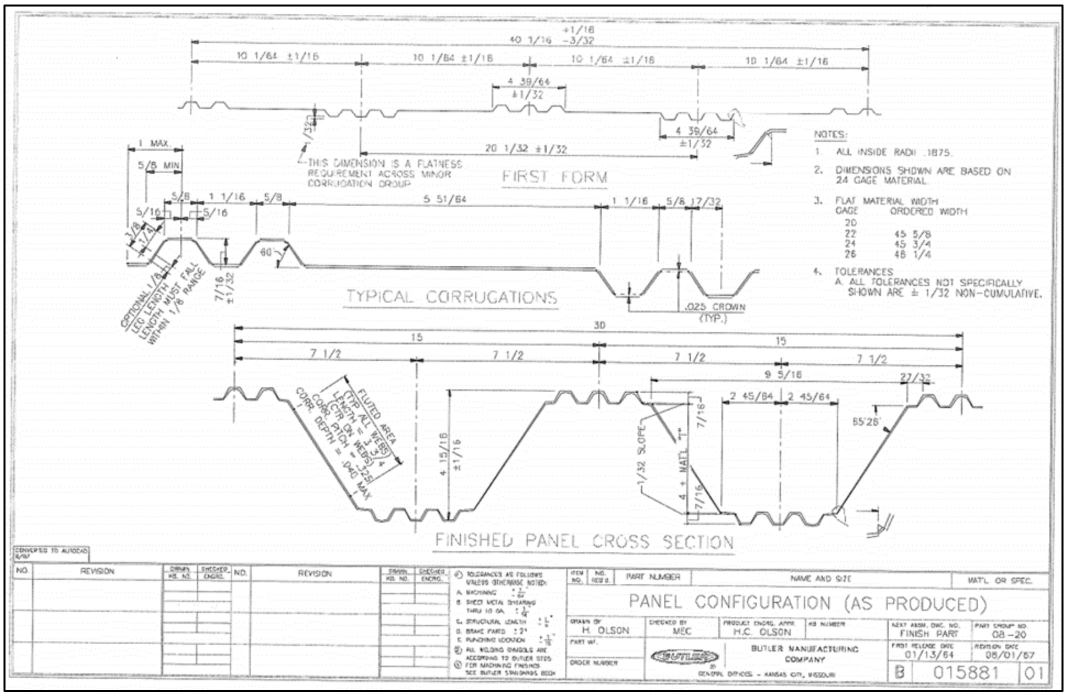


Figure 100. A Behlen frameless stressed skin building after surviving an atomic blast at Yucca Flats, Nevada, 1955 (Behlen Manufacturing Company, "Bomb Shelters," History, accessed December 18, 2018, https://www.behlenmfg.com/history).

In 1954, Butler introduced "Panl-Frame" buildings, which were similar to Behlen's self-framing buildings, for smaller structures (Figure 101). "Panl-Frame" buildings had wall heights of 8 ft or 10 ft, widths of 4 ft to 16 ft, lengths of any multiple of two, and came into existence as a result of reports from dealers that this was the kind of building they needed in their inventory in order to compete.[122]

Figure 101. Schematic for a Panl-Frame panel, using series of three corrugations, while these series were corrugated in relation to each other (Courtesy of Butler Manufacturing Company Archives).



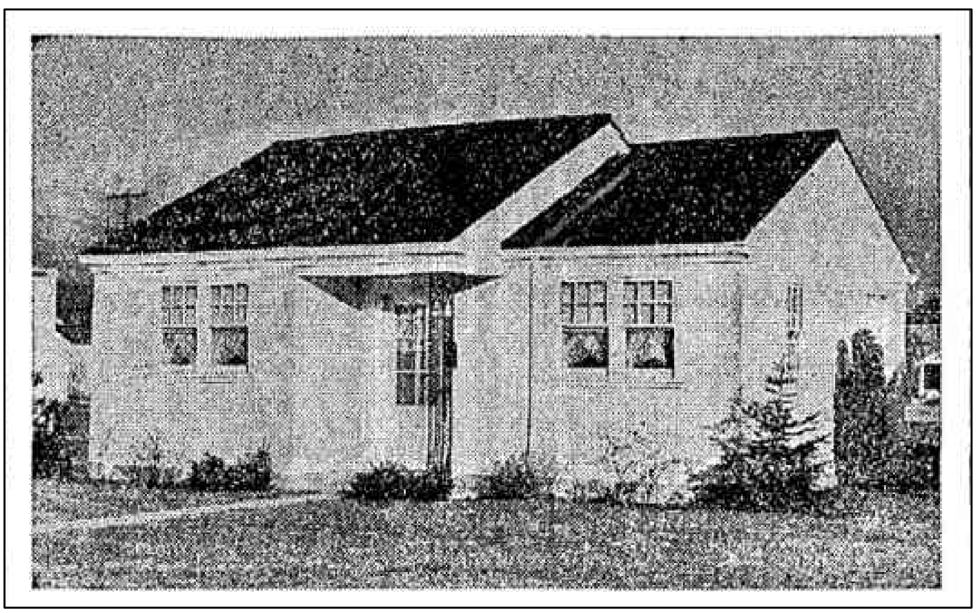

### 2.3.6 Armco's Steelox

The American Rolling Mill Company (Armco) of Middletown, Ohio was one of the nation's largest metal building prefabricators during the Cold War period, largely thanks to the Steelox building method the company created. This was not a new development, as Steelox had been around since the 1930s (Figure 102). The Steelox method was originally marketed for small, four-room houses with little success. It used vertical flat Steelox panels with an interlocking rib, which were strong enough to bear some of the vertical load from the roof in addition to providing a weatherproof seal (Figure 103). Steelox saw increased use by the military following the release of Armco's "Armed Forces Building" in 1952, which was "designed by Army Engineer Research and Development Board to better meet the

122 Cowles, Butler Company History, 189.

needs of the Armed Forces." These buildings were 20 ft by 48 ft and were designed as 20-man barracks but could serve a variety of purposes due to their adaptability, as they could be erected end to end or side to side with ease. Construction of "Armed Forces Buildings" required only 60–70 hours with unskilled military personnel to assemble due in part to the fact that the Steelox panels could be fit together on the ground and then raised as one wall section (Figure 104). These buildings were light enough that they could be erected on wooden sills, piers, or concrete blocks (Figure 105). The windows on this building type were vertical sliding windows of clear plastic with screens. Further adding to the potential uses of "Armed Forces Buildings," they were marketed in three types for frigid, temperate, and tropical weather. Additionally, they could be constructed with or without floor systems, lining, ceiling, or insulation depending on usage. The Steelox system in general was easily adaptable, with a wide range of possible door and window types and locations on the structure (Figure 106 and Figure 107). Other Steelox buildings were available in lengths between 4 ft and 40 ft, although Armco increased this to 100 ft by 1956 (Figure 108).[123]

Figure 102. Four-room Steelox panel house, which cost $2,600 to construct in Middletown, Ohio and $3,000 in the Chicago area, 1938 ("Factory Built Home May Lead U.S. Industry," *Chicago Tribune*, January 30, 1938).



[123] "Factory Built Home May Lead U.S. Industry," *Chicago Tribune*, January 30, 1938; American Rolling Mill Company, "Armed Forces Building," *The Military Engineer* 44, no. 298 (March – April. 1952): 15; American Rolling Mill Company, "Armco Designs, Makes and Erects Armco Buildings," *The Military Engineer* 45 (1956): n.p.

Figure 103. An animated close-up view of the interlocking rib joining two Steelox panels, 1956 (American Rolling Mill Company, “Armco Designs, Makes and Erects Armco Buildings,” *The Military Engineer* 48 (1956): n.p.).

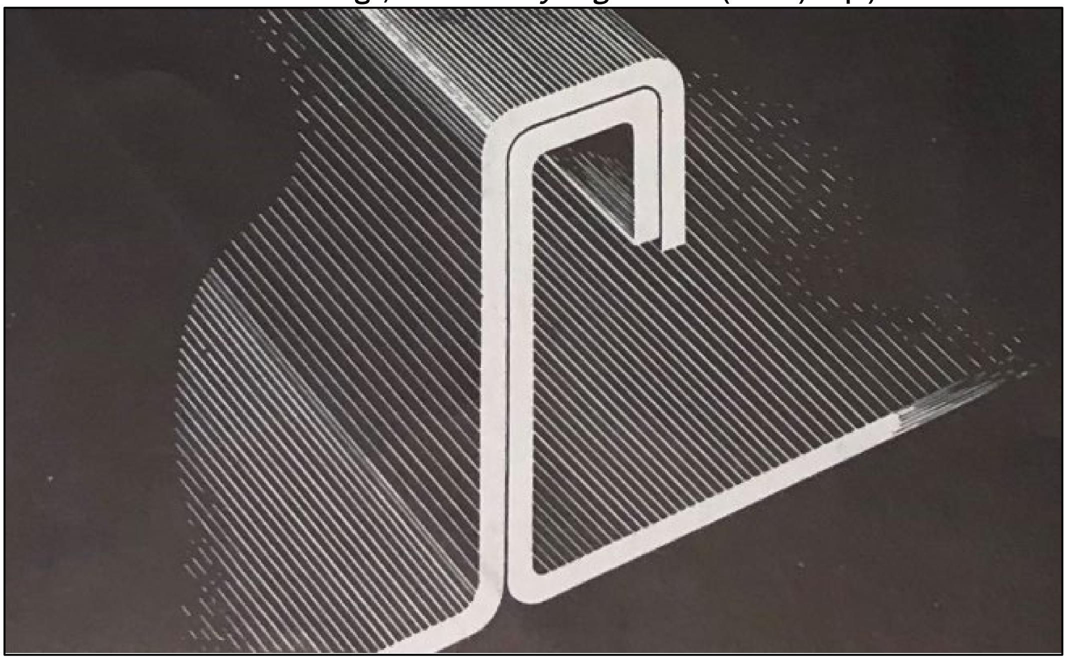


Figure 104. The final wall of an Armco “Armed Forces Building” awaiting the final preparations before being lifted into place, 1952 (American Rolling Mill Company, “Armed Forces Building,” *The Military Engineer* 44, no. 298 (March–April. 1952): 15).

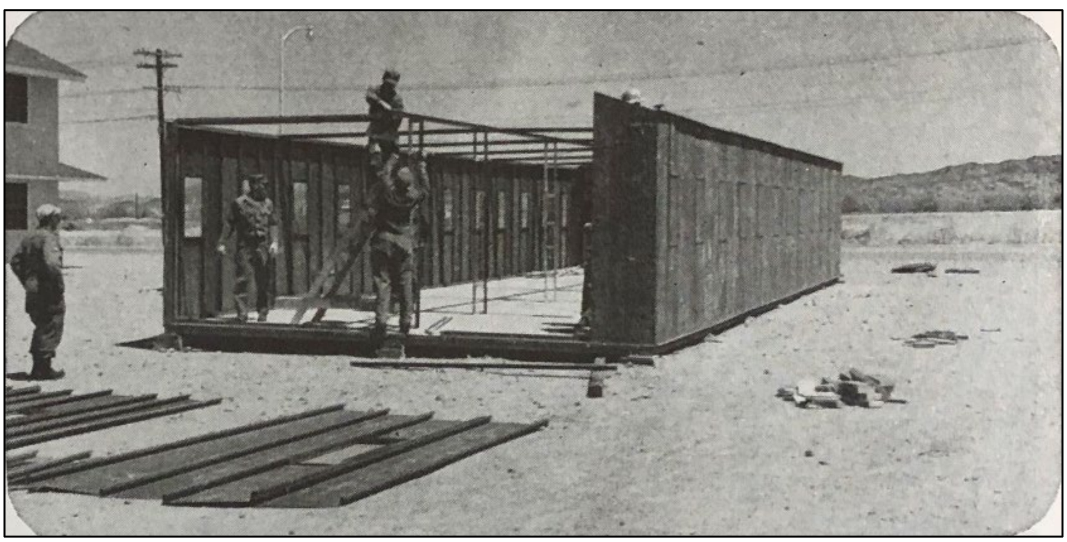


Figure 105. An oblique of the “Armed Forces Building” resting on concrete block foundations due to the structures low weight, 1952 (American Rolling Mill Company, “Armed Forces Building,” *The Military Engineer* 44, no. 298 (March–April. 1952): 15).

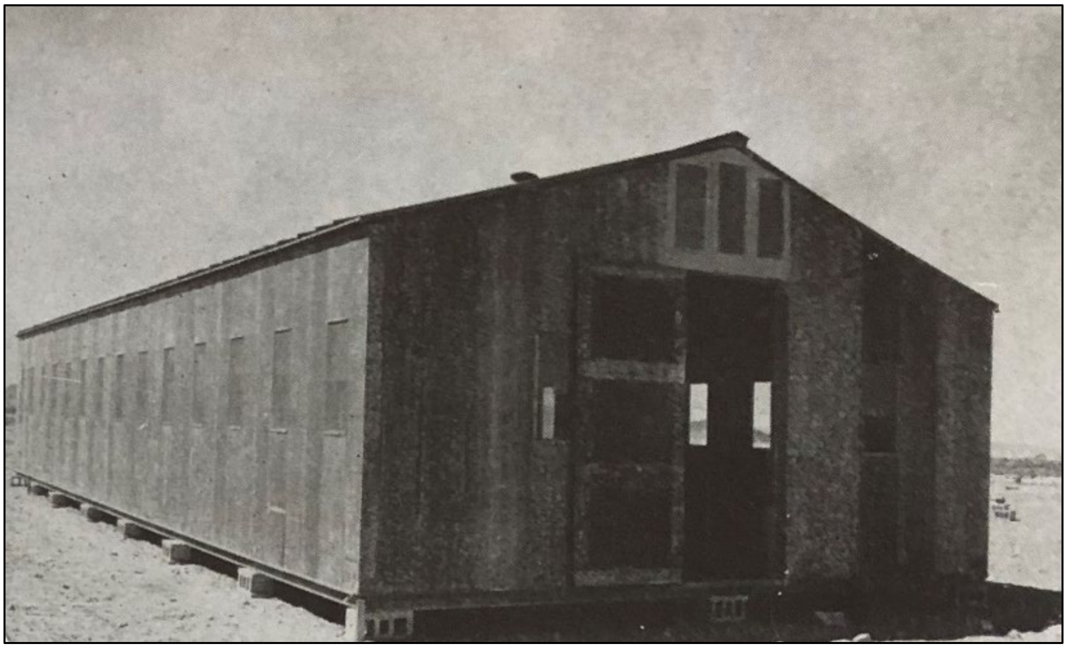


Figure 106. An Armco Steelox metal building with several customizations, such as an overhead door, a personnel door, and awning windows, on a concrete foundation (American Rolling Mill Company, “Armco Designs, Makes and Erects Armco Buildings,” *The Military Engineer* 48 (1956): n.p.).

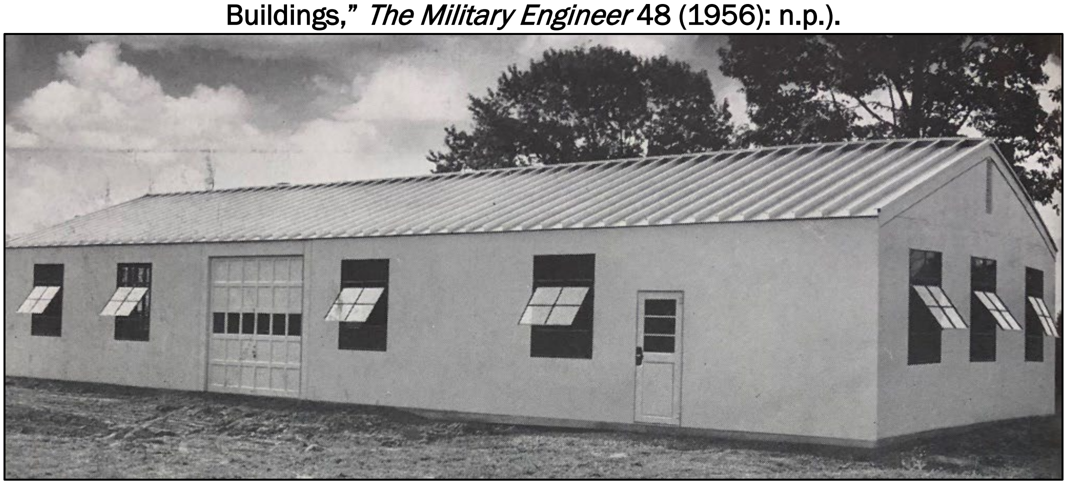


Figure 107. Steelox building with three roof ventilators and a sliding door (American Rolling Mill Company, "Armed Forces Building," *The Military Engineer* 44, no. 298 (March–April. 1952): 15).

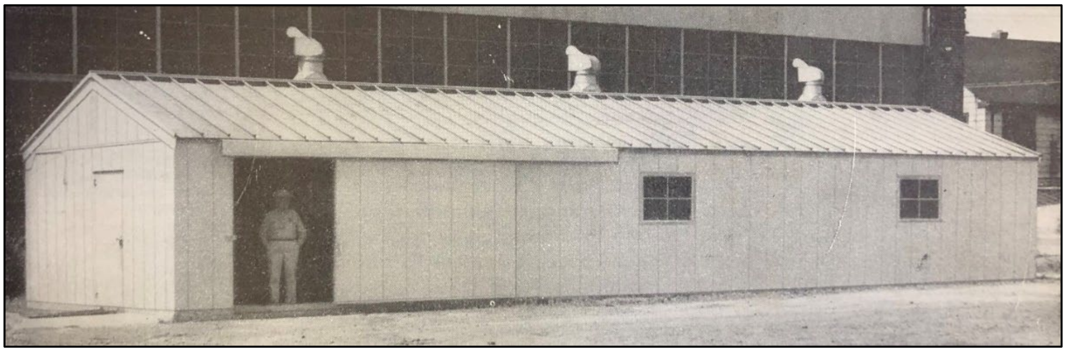
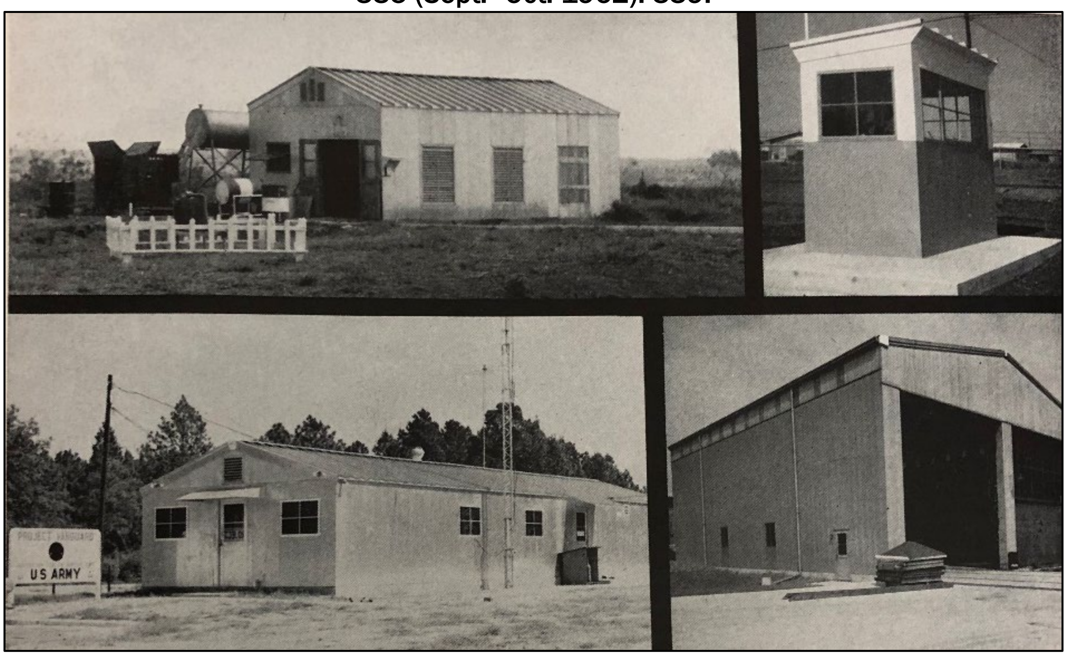


Figure 108. Four Armco Steelox buildings in an advertisement to show the range in size and application of Steelox, from guard houses to warehouses, 1962 (Lawrence S. Kroll, "Seabee Reserves on Active Duty Training," *The Military Engineer* 54, no. 335 (Sept.–Oct. 1962): 339.




### 2.3.7 Metal Building Manufacturers Association (MBMA)

The trend toward standardization in construction continued during the post-war years, making it more and more necessary for companies manufacturing these buildings to form some sort of cooperative group. Wilbur Larkin, Buildings Division General Manager for Butler, attempted to create such an organization in 1956. The first meeting of the Metal Building Manufacturers Association (MBMA) was held on September 25, 1956, and was attended by its charter members: Armco, Behlen, Butler, Carew Corporation, Cowin & Company Inc., Inland-Ryerson Construction

Products Company/INRYCO INC., Marathon Metallic Building Co., Martin Steel Buildings Inc., National Steel Production Company/Stran-Steel, Pascoe Steel Corporation, Soulé Steel Company, Steel Craft Manufacturing Company, and Wonder Building.[124]

Throughout the 1950s and 1960s, the organization began publishing Metal Building Systems Manuals to track market changes as well as provide an industry standard. The MBMA established an Insurance Committee to "address the effects of insurance rates on construction." They also conducted joint research to be used by all member companies in order to find better building methods and better materials.[125]

In addition to more technical work, the MBMA tracked member financials, which now serves a useful source for describing the mid-century metal building industry. For example, MBMA data illustrates the boom of the industry during the 1950s. From 1956 to 1960, MBMA members' sales went from $69.6 million to $98.9 million, making up 20% of the low-rise, nonresidential construction market.[126] MBMA data also highlights the metal building industry's general transition away from agriculture towards other building markets with less volatility, with 34% of MBMA business in 1960 going towards agriculture compared to the 10% of MBMA business agriculture received in 1970.[127]

### 2.3.8 Dealer System

Butler claims to have become the first company to use a system of local dealers and contractors to serve as middlemen for their products in 1939. Contractors would handle erection, field modification, and use local brick and wood when necessary to build Butler's buildings. Additionally, Butler would now be able to target their advertising toward dealers to carry their buildings for sale, rather than focusing solely on the buyer. Wilbur Larkin, Buildings Division General Manager for Butler, remarked that in the post-war market, the idea of the dealer system "was to have a very significant

[124] Cowles, Butler Company History, 194.

[125] Metal Building Manufacturers Association, "60th Anniversary Brochure," Cleveland, OH: Metal Building Manufacturers Association, July 2016, 9.

[126] Metal Building Manufacturers Association, "60th Anniversary Brochure," 10.

[127] Metal Building Manufacturers Association, "60th Anniversary Brochure," 14-15.

bearing and perhaps become the key factor in what was to be the pre-engineered metal building industry."[128]

### 2.3.9 Pre-Fabricated to Pre-Engineered

Throughout the 1950s, there was a boom in construction of prefabricated metal buildings, which initially began with relatively few standard set sizes, but slowly expanded. This increase in the number of standardized sizes soon made prefabrication impossible, and especially the larger companies in the industry began to transition towards pre-engineered structures, which were structural designs for buildings which could be customized to fit exact specifications.[129]

This transition can be best seen in a 1970 advertisement for Macomber's open-web structural systems, which states the following:

> "Your architect has complete freedom of design and structural range; your builder has a modern easy-to-erect package, and you enjoy a quicker occupancy. All of these benefits are yours in a custom-built structure that can cost you less than a pre-fab of comparable size."[130]

The advertisement emphasizes the flexibility and ease of pre-engineered buildings over their completely prefabricated counterparts.[131]

### 2.3.10 Panel Construction

Prefabricated wall and floor panels, which saw some use by the military during WWII, experienced expanded use in the wider industry in the following decades. Beginning around the end of the war, companies began widely marketing standardized building designs and materials. For example, Fenestra, a subsidiary of Detroit Steel Products Company, sold

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[128] Cowles, Butler Company History, 127.

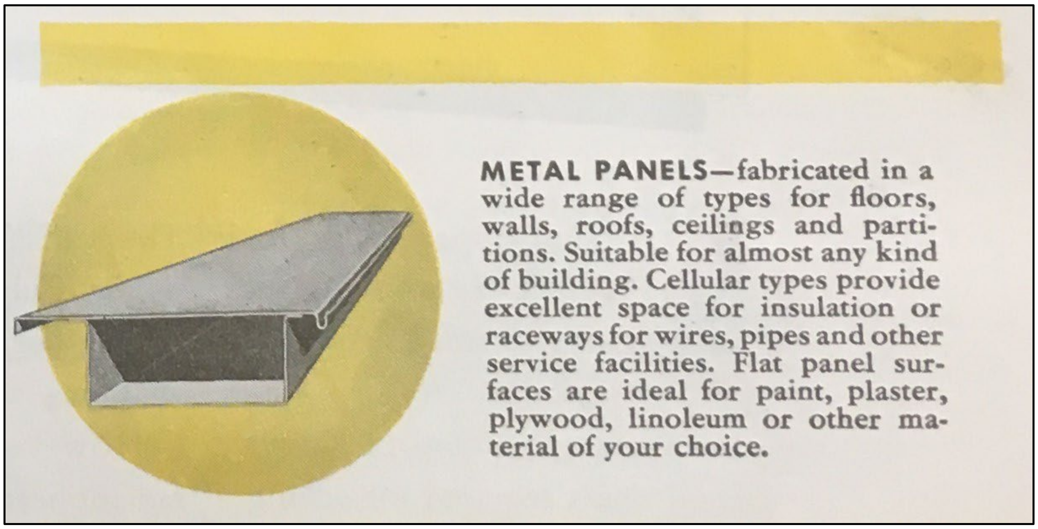
[129] NCI Building Systems, "Metal Building History," Careers, accessed August 5, 2016, https://www.ncibuildingsystems.com/careers/campus/mbi_history.html.

[130] Macomber Incorporation, "Here's how Macomber can give you the building you want at lowest possible cost," *Architectural Forum* 132 (Jan. – June 1970): 159.

[131] Macomber Incorporation, "Here's how Macomber can give you the building you want at lowest possible cost," 159.

products including wall panels, floor panels, and roof panels (Figure 109).[132]

Figure 109. A Fenestra metal floor panel manufactured in an advertisement (Detroit Steel Company, "Standard parts…a moneysaving step for the buildings industry," *Architectural Forum* 88 (Jan.–June 1948): 36).




Panel construction greatly increased the customization capabilities of prefabricated buildings, as well as speed of erection. Many innovations in panel construction were made during this period that highlighted the importance of panel construction in customization. Sandwich panels, in particular, became an important invention in the metal building industry (Figure 110). These panels are comprised of two sheets of metal enclosing insulation and, later, other features, such as wiring and plumbing. Sandwich panels streamlined the building process by eliminating the previously lengthy insulation application process.[133]

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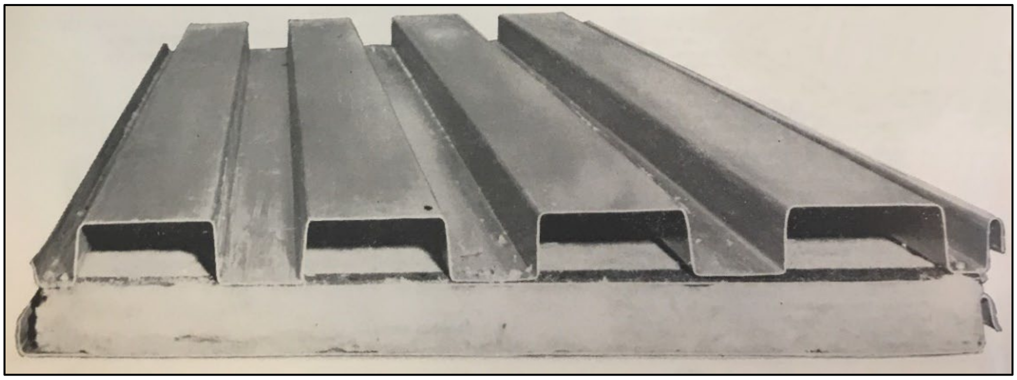
[132] Detroit Steel Company, "Standard parts…a moneysaving step for the buildings industry," *Architectural Forum* 88 (Jan. – June 1948): 36.

[133] Detroit Steel Company, "Standard parts…a moneysaving step for the buildings industry," 36.

Figure 110. United States Steel Corporation advertisement showing their U.S.S. 17, Type 430 stainless steel sandwich wall panel with a 1-½-in. gap for insulation, 1953 (United States Steel Corporation, [U.S.S. 17, Type 430 Advertisement], *Architectural Forum,* 98 (Jan. 1953): n.p.).



The Monopanl, released by Butler in 1952, was a popular model of insulated prefabricated panels. These sandwich panels contained fiberglass insulation between two sheets of either aluminum or galvanized steel (Figure 111). Their design was intended to reduce construction time through interlocking connectors and connector channels, located on each side of the panel, which allowed them to fit together with ease. Monopanls were available in varying thickness for different temperature conditions and remained in production into the 1980s (Figure 112).[134]

[134] Cowles, Butler Company History, 169; Butler Manufacturing Company, "For Features that Pay Off…"

Figure 111. Monopanl cross section (A.F.L. Deeson, ed, Comprehensive Industrialised Building Annual (Systems and Components) 1966, London: House Publications Limited, 1966).

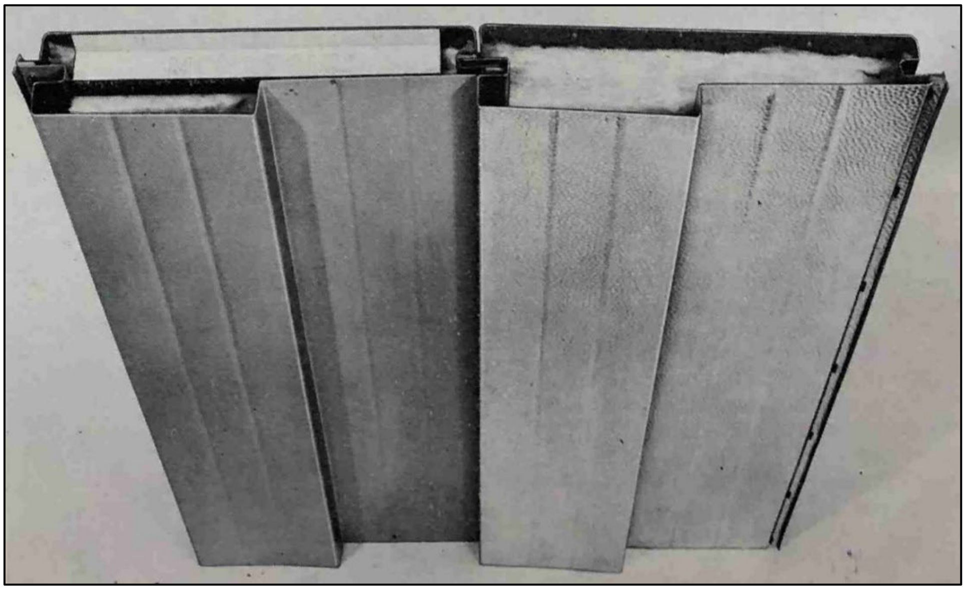
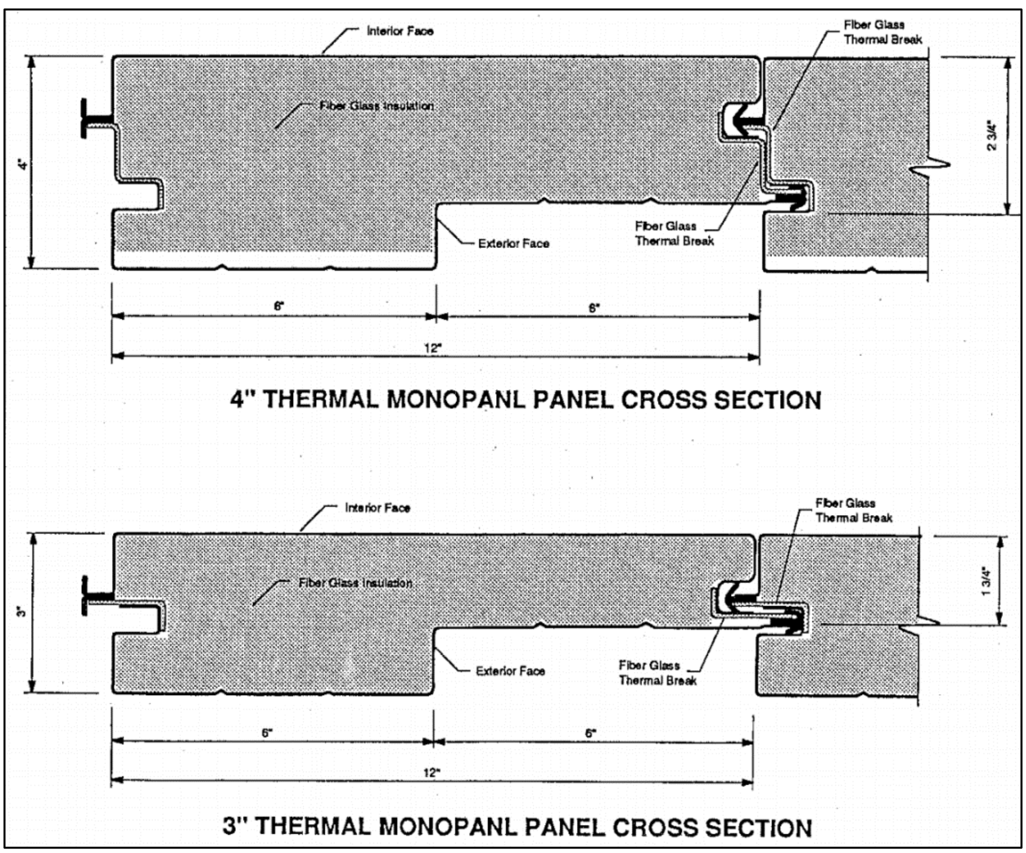


Figure 112. The dimensions of two Monopanls designed for varying levels of insulation (Butler Building Products, "Thermal Monopanl® Wall System, Butler Parts Online, accessed August 12, 2021, https://butlerpartsonline.com/wp-content/uploads/obsolete-Monopanl.pdf).



One of the more in-depth ventures by the military into prefabricated building techniques came in 1951. After moving the headquarters for the Strategic Air Command to Offutt Air Force Base (AFB) in Omaha, Nebraska, General Curtis LeMay attempted to address high personnel turnover by constructing new barracks. After seeking suggestions from his ranking bachelor sergeants, LeMay commissioned a three-story, 216-man barracks that had two-man rooms, each with two closets, a lavatory, an adjoining bath, and two separate twin beds instead of the more typical bunkbeds (Figure 113, Figure 114, and Figure 115).[135] The design featured a steel frame with insulated prefabricated steel curtain walls and prefabricated steel panel floors topped with two inches of concrete and asphalt tile (Figure 116 and Figure 117). The panels were supplied by Fenestra (Figure 118). In addition, all the posts, girders, and window sashes were prefabricated. The slab-on-grade concrete foundation and small boiler room required minimal excavation for the 37 ft by 282 ft structure. The barracks design was more cost effective than the latest wooden barracks built by the Air Force, which were built at $1,867 per man housed compared to this structure's $1,508 per man, and was reproduced at least two additional times, both in Barksdale AFB, Louisiana (Figure 119, Figure 120 and Figure 121). It was soon decided that future barracks would incorporate features of this design, though steel framing and skin would be replaced with masonry and wood "to save critical materials and for economy" (Figure 122).[136]

[135] "Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," *Magazine of Buildings: House and Home Edition* 1, no. 1 (Jan. – March 1952): 154-155, 155.

[136] "Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," 154.

Figure 113. Prefabricated metal barracks, Offutt AFB, Omaha, Nebraska, 1952 ("Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," Magazine of Buildings: House and Home Edition 1, no. 1 (Jan.–March 1952): 154–155).

Figure 114. Typical two-man bedroom of prefabricated metal barracks, Offutt AFB, Omaha, Nebraska, 1952 ("Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," Magazine of Buildings: House and Home Edition 1, no. 1 (Jan.–March 1952): 154–155).

Figure 115. The floor plan of a prefabricated metal barracks, showing each room's bathroom facilities and the floor lounge, Offutt AFB, Omaha, Nebraska, 1952 ("Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," Magazine of Buildings: House and Home Edition 1, no. 1 (Jan.–March 1952): 154–155).

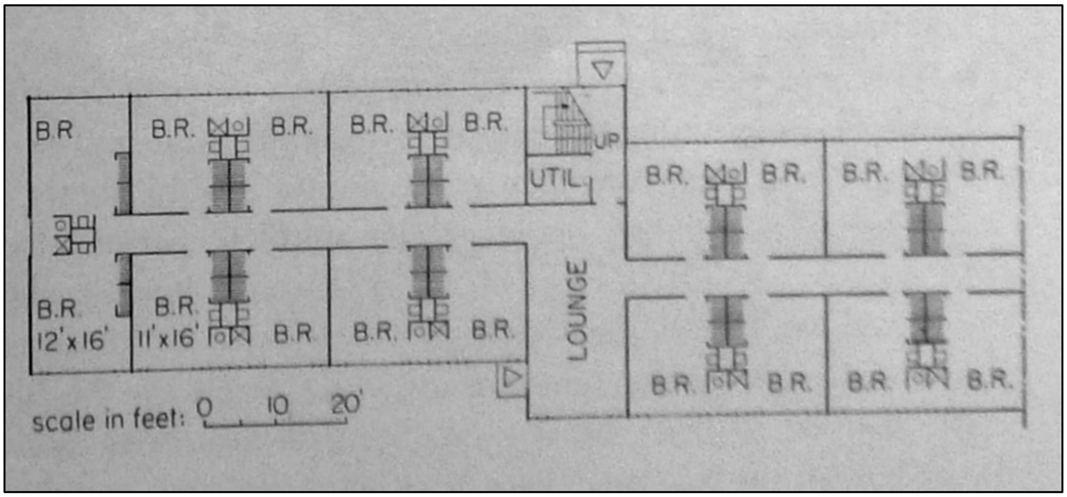


Figure 116. A cross section of exterior wall and flooring showing Fenestra panel connections and closures, Offutt AFB, Omaha, Nebraska, 1952 ("Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," Magazine of Buildings: House and Home Edition 1, no. 1 (Jan.–March 1952): 154–155).

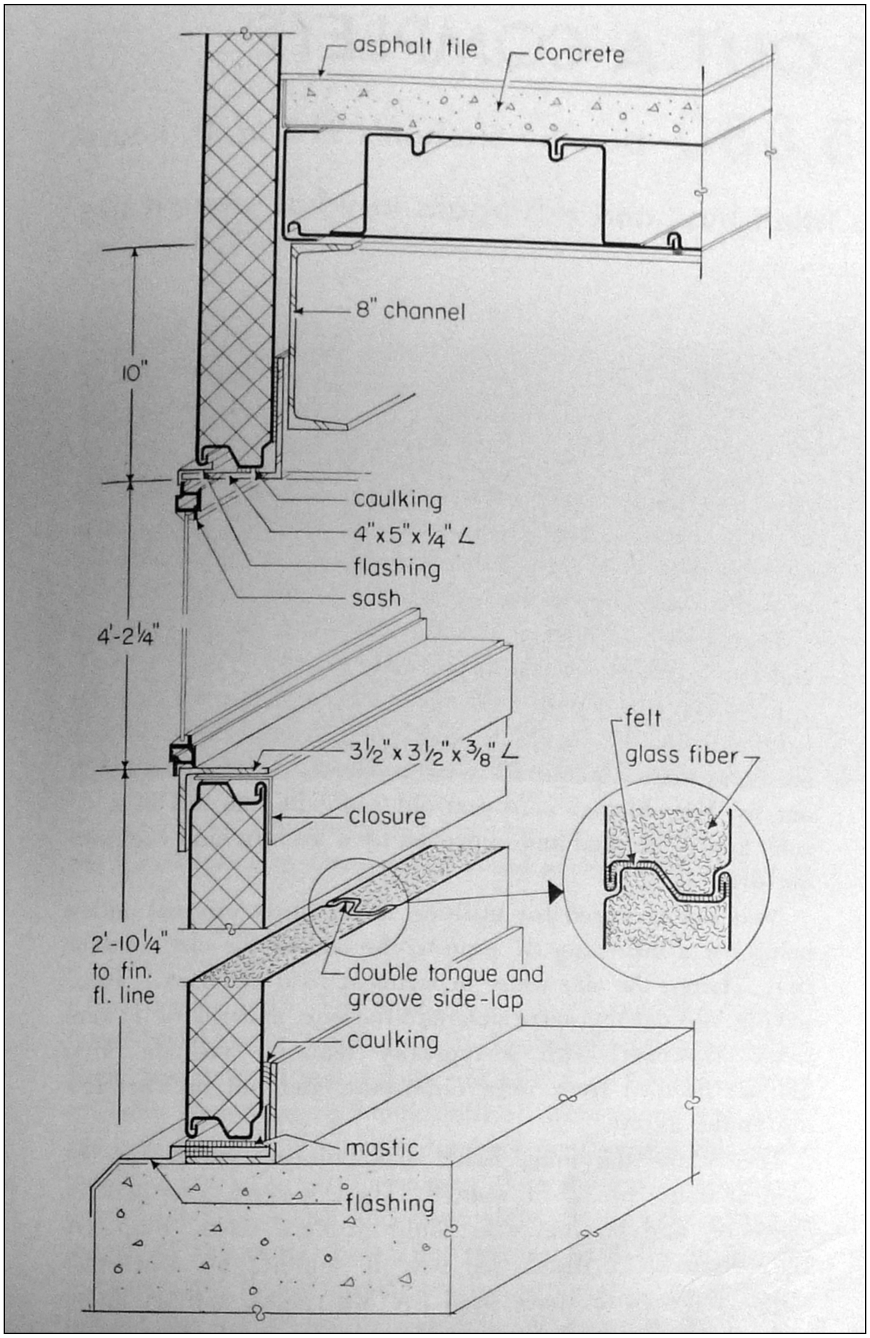


Figure 117. Airman's dormitory prior to the installation of Fenestra wall panels on third floor, Offutt AFB, Omaha, Nebraska, 1952 ("Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," Magazine of Buildings: House and Home Edition 1, no. 1 (Jan.–March 1952): 154–155).

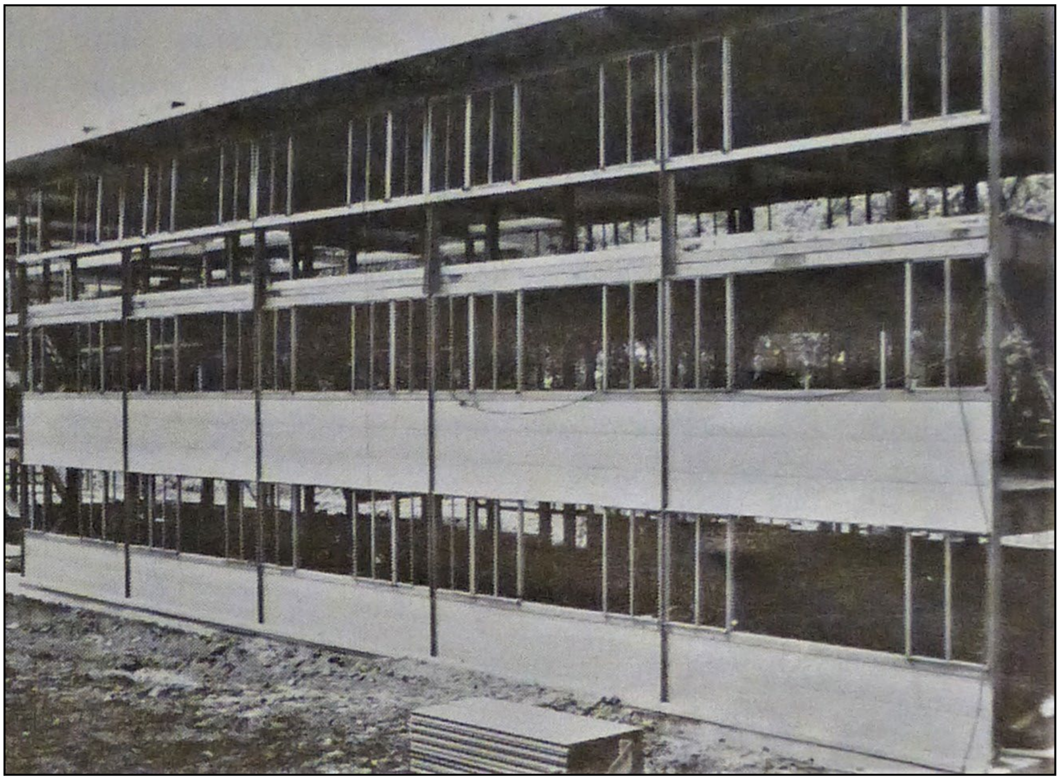


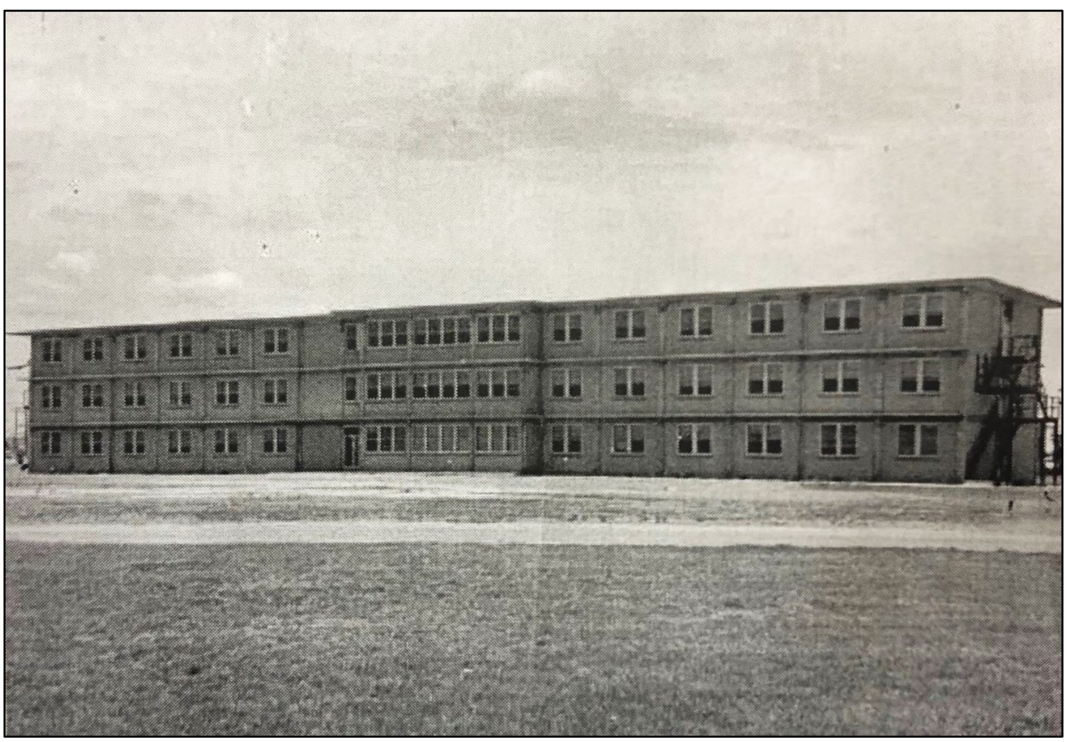
Figure 118. Fenestra advertisement showing the use of their products in the Offutt AFB barracks, with an image of three men in the process of installing an exterior wall panel on the second floor atop scaffolding, 1952 ("Airman's Dormitory of prefab steel parts goes up fast, provides more privacy and comfort than old barracks for less money," Magazine of Buildings: House and Home Edition 1, no. 1 (Jan.–March 1952): 154–155).

Figure 119. Exterior of a prefabricated metal barracks used as the Non-Commissioned Officers' Training Academy, Barksdale AFB, Louisiana, 1955 (NARA College Park, RG342-B).

Figure 120. Interior of a ground floor room in the Non-Commissioned Officers' Training Academy directly opposite another building of the same design, Barksdale AFB, Louisiana, 1955 (NARA College Park, RG342-B).

Figure 121. Exterior of a prefabricated metal barracks used as part of the Non-Commissioned Officers' Training Academy as well as housing the Second Air Force Headquarters' Squadron Division, showing the location of the main door on the center portion of the structure, Barksdale AFB, Louisiana, Date Unknown (NARA College Park, RG342-B).

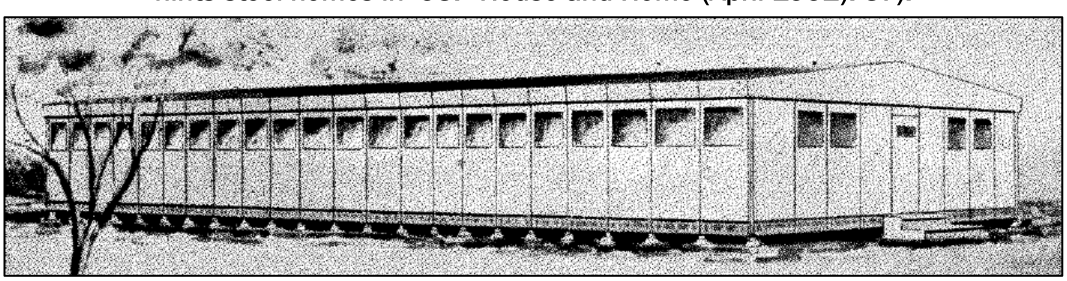

Figure 122. A concrete-block adaptation of the airman's dormitory with three-man rooms, Bergstrom AFB, Austin, Texas, 1952–1953 (Courtesy of the Air Force Historical Research Agency).



### 2.3.11 Gunnison Homes' Steel Barracks

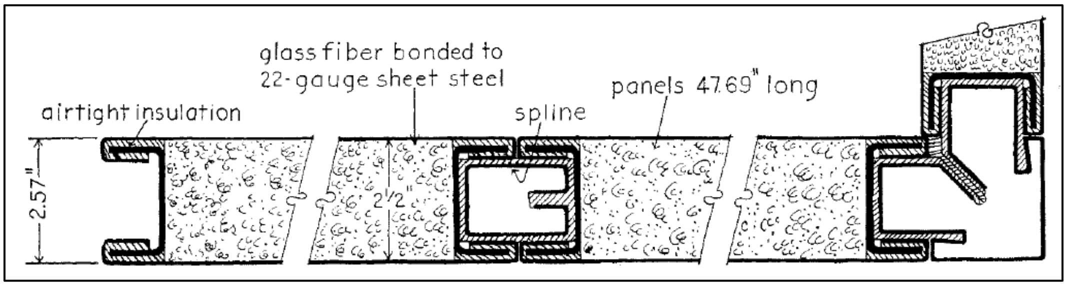
In 1952, United States Steel Corporation (US Steel) acquired the prefabricated housing company Gunnison Homes, Inc., and announced that the former Gunnison plant at Shiremanstown, Pennsylvania would be "immediately" repurposed "to prefabricate a revolutionary, insulated, steel military shelter" at a cost of an estimated $5,550,000. It was designed to serve as 20 ft by 48 ft 18-man barracks but had other potential uses such as "field hospitals, PXs and mess halls." The structures weighed 13.5 tons and rested on an array of steel pedestals, requiring no excavation (Figure 123). Despite its weight, it was claimed that one of these barracks could be erected by five men in a single day. This was due to the barrack's panel design, which featured sandwich panels joined by pin and wedge fasteners. The panels were comprised of 2-½-in. thick glass fiber insulation encased by two 22-gauge steel sheets. The joints between panels were made with treated wood fiber to create an airtight seal (Figure 124). The strength of the steel panels and thorough insulation allowed for Gunnison to recommend use in all climates and even claim that they were hurricane proof. It is unclear how many Gunnison Steel Barracks were supplied to the DoD, or how they were utilized, but it is worth noting that Gunnison estimated their bunk would cost $5.20 per square feet versus the average Army Barracks at the time which were $9.09 per square ft, demonstrating growing competitiveness of metal prefabricated buildings in the building market. The Gunnison Steel Barracks also signaled an advancement in prefabricated technology, as the structures could be quickly built of prefabricated and pre-engineered materials while being comfortable enough for housing and other uses.[137]

Figure 123. A Gunnison Homes steel barracks resting on steel footings, reducing the need for excavation or foundation ("Steel Prefabs: new Gunnison factory for barracks hints steel homes in '53." House and Home (April 1952): 37).



[137] "U.S. Steel Plans Plant in East," *Pittsburgh Press*, April 2, 1952; "Steel Prefabs: new Gunnison factory for barracks hints steel homes in '53," House and Home (April 1952): 37.

Figure 124. Cross section of the connections between steel panels ("Steel Prefabs: new Gunnison factory for barracks hints steel homes in '53." House and Home (April 1952): 37).




### 2.3.12 Housing

During the early Cold War period, the utility core gained popularity as a feature of prefabricated housing (Figure 125). Utility cores were prefabricated units that held important hardware such as heaters and, in later models, central air. As they were designed to be placed in the center of houses, the core's exterior walls would frequently feature pre-installed kitchen, bathroom, and laundry appliances. This greatly decreased on-site construction time, as a crane was all that was required to install many of the home's major appliances. Ingersoll was one manufacturer of utility cores during this period (Figure 126).[138]

[138] Borg-Werner Corporation, "Ingersoll Utility Unit: Now in Volume Production!" *Prefabricated Homes* 1-5 (Jan.–Feb. 1947): 2-3.

Figure 125. An Ingersoll utility core designed to serve as a wall separating a full bathroom and a kitchen with heating and electrical work in the space in between (Borg-Werner Corporation, “Ingersoll Utility Unit: Now in Volume Production! *Prefabricated Homes* 1-5 (1947): 2–3).

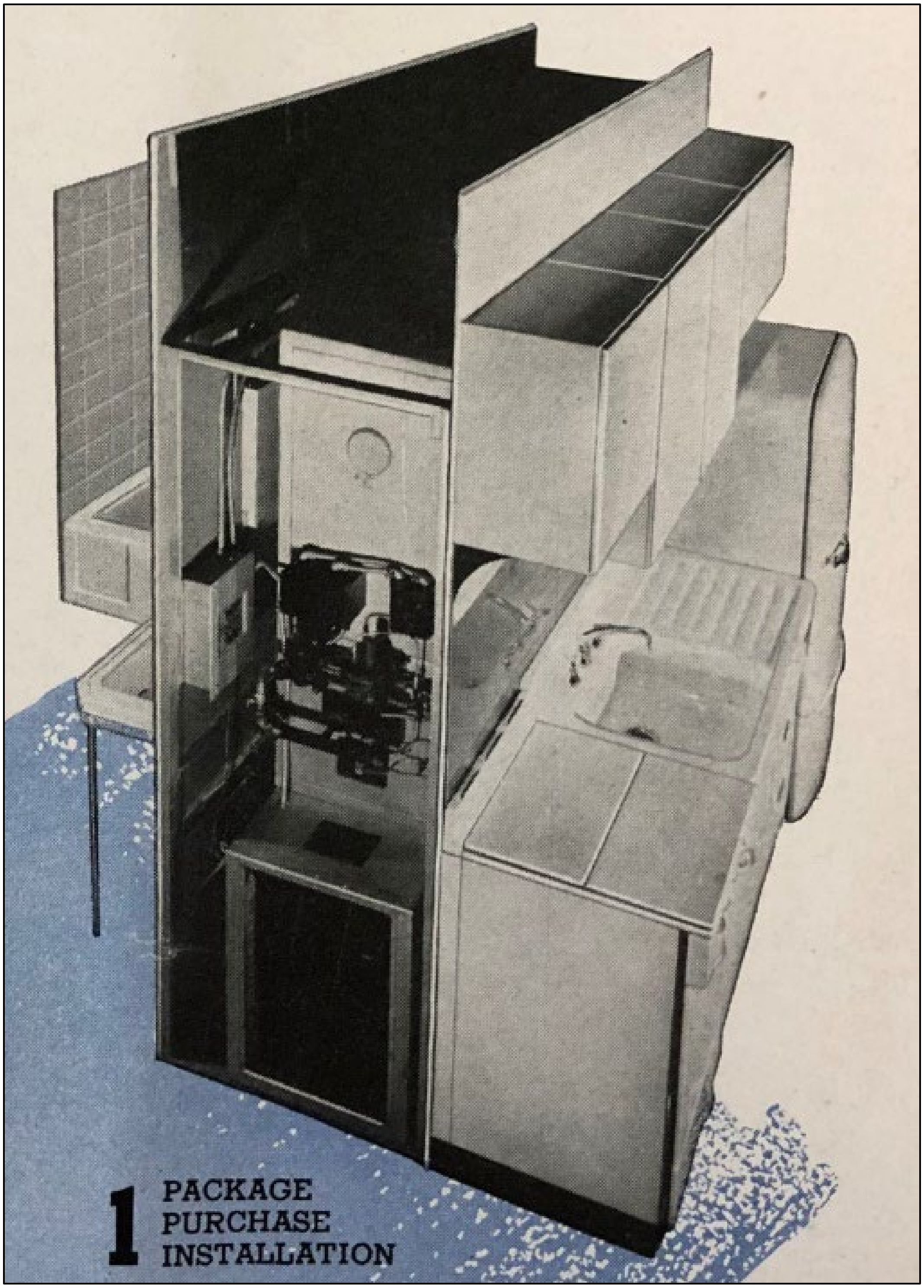
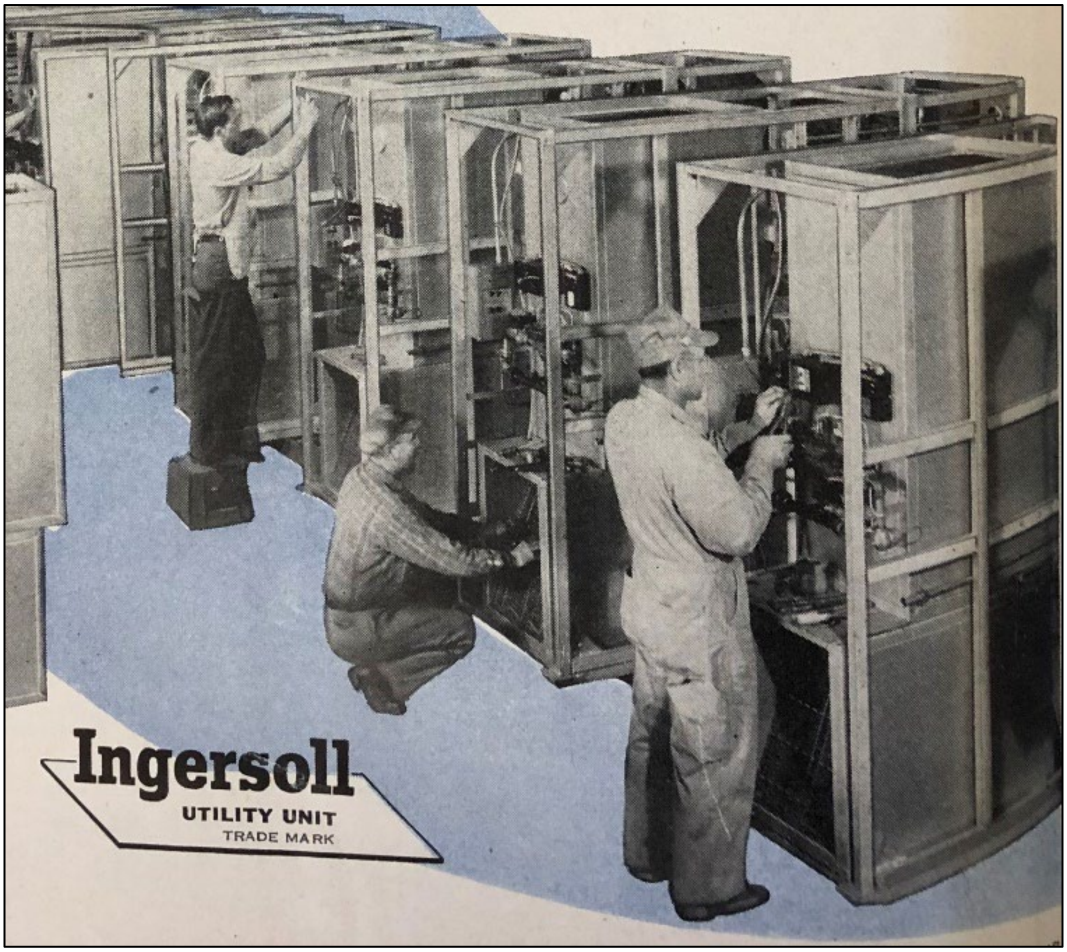


Figure 126. Three utility cores are being worked on at once in an Ingersoll factory, demonstrating the efficiency of production added by the core (Borg-Werner Corporation, "Ingersoll Utility Unit: Now in Volume Production! *Prefabricated Homes* 1-5 (1947): 2–3).




### 2.3.13 Lustron Houses

Following WWII, an acute housing shortage developed as a result of decreased single-family housing construction during the war, combined with the marriage and baby boom that followed. Carl Strandlund, industrial engineer, vice president, and general manager of Vitraeous Enamel Products Company, viewed metal prefabrication as the solution to this housing shortage. In 1946, Strandlund hired architect Roy Blass of Wilmette, Illinois, to design a "modern rambler" using enamel-coated steel panels, which would utilize Strandlund's patented method for bonding enamel to metal.[139] With considerable pressure, including appeals directly to President Truman by veterans' organizations, Strandlund received a

[139] George J. Paduda, "The Little 'Tin' House with an Ironclad Future," *Washington Post*, August 31, 1980.

$13.5 million loan from the Reconstruction and Finance Corporation (RFC), a lending institution created by Congress to stimulate economic progress.[140] With this money, the Lustron Corporation was established as a subsidiary of Vitreous. Lustron soon began constructing a factory outside Columbus, Ohio. The design of this factory would mimic that of automotive factories that used assembly lines, and it would feature the largest and newest continuous-feed, porcelain-enameling furnaces in the world.[141]

The design of Lustron houses featured nearly entirely steel components, including light-gauge steel wall framing around interior and exterior steel wall panels, which supported light-gage steel roof trusses, and even steel shingles. Almost all metal components were coated in porcelain, which came in four colors and protected the metal from weathering. Excluding the concrete slab floors covered with asphalt tiles, practically every exposed surface featured this porcelain enamel.[142] The house came fully furnished along with built in enamel-coated steel cabinets and bookshelves and was heated with oil or gas via radiant panels in the ceiling. Lustron produced three basic models, each available in two-bedroom and three-bedroom floor plans (Figure 127 and Figure 128).[143]

140 Robert A. Mitchell, "What Ever Happened to Lustron Homes?" *APT Bulletin* 23, no. 2 (1991): 44–53, 47.

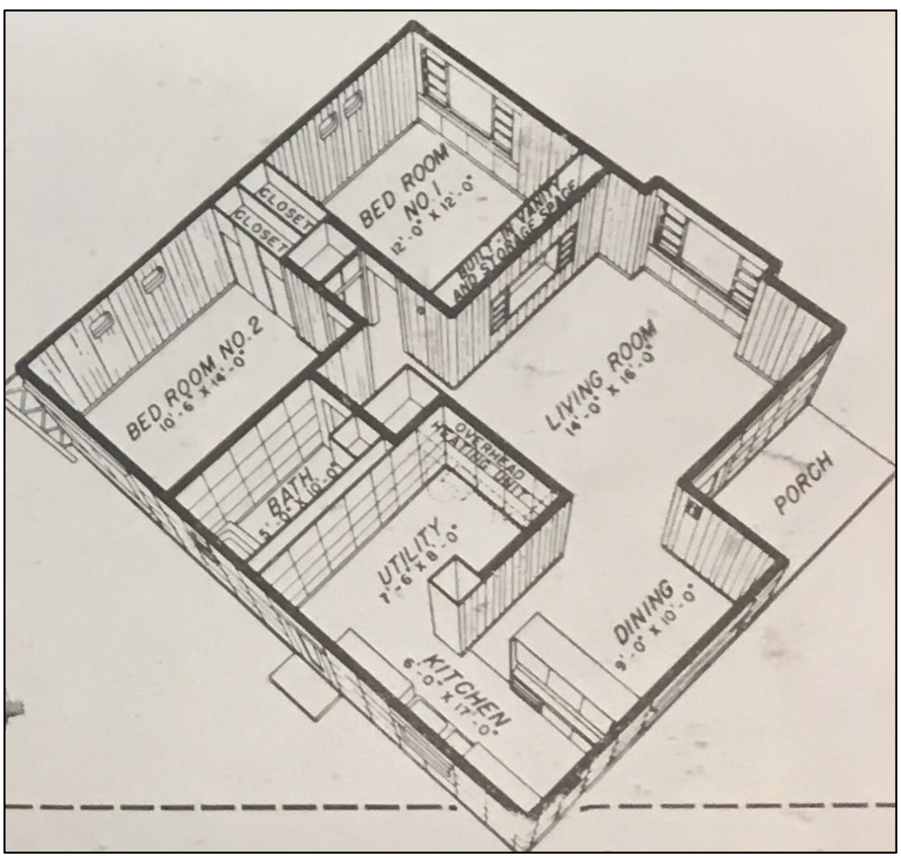
141 Mitchell, "What Ever Happened to Lustron Homes?" 46.

142 Mitchell, "What Ever Happened to Lustron Homes?" 48.

143 Paduda, "The Little 'Tin' House with an Ironclad Future."

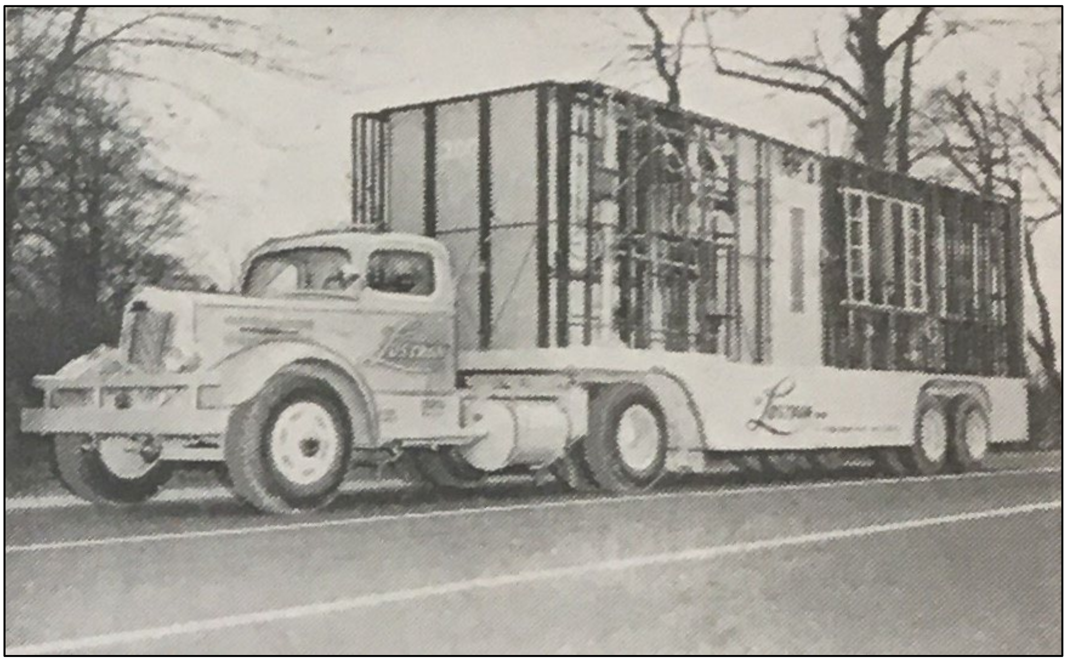
Figure 127. Oblique of a Lustron house in Chesterton, Indiana, constructed in 1950 (Library of Congress HABS IND,64-CHEST,1-).

Figure 128*.* Floor plan of a two-bedroom Lustron Home with over 1,000 square ft of floor area, 1947 (Lustron Corporation, [Advertisement], *Architectural Forum* 90 (Jan.–March 1949): n.p.).



Lustron also created an inventive distribution method for their houses. Each house was shipped on its own custom-designed trailer, which held all 2,334 mass-produced components on racks (Figure 129).[144] These trailers served as both security from theft while construction was ongoing, as well as easing assembly by being loaded in a "first-off, first-up basis."[145] This allowed for a complete and operable house to be finished in 360 hours of on-site labor by a minimum three-man crew.[146]

Figure 129. One of Lustron's custom-designed trailers to efficiently ship and then store building materials during construction, 1949 (Lustron Corporation, [Advertisement], *Architectural Forum 90* (Jan.–March 1949): n.p.).



While Lustron had few problems producing and shipping its product, they experienced financial and legal problems practically from its inception. Antiquated building codes limited where Lustrons could be built, and their shipping method resulted in issues for buyers to receive financing.[147] The company also required large amounts of capital to begin production, roughly $15 million for heavy machinery alone, and were unable to secure a large enough market share quickly enough to recoup their losses. Under increasing political pressure, their main financier, the RFC, ultimately

144 Paduda, "The Little 'Tin' House with an Ironclad Future."

145 Lustron Homes, "How to ship a house…Lustron style!" *Architectural Forum* 90 (Jan. – June 1941): 72-73.

146 Mitchell, "What Ever Happened to Lustron Homes?" 47.

147 Paduda, "The Little 'Tin' House with an Ironclad Future."

called in their nearly $37.5 million in loans and Lustron went bankrupt. All of the company's assets were liquidated in 1954, with the government recouping only $2 million on their investment, and the Columbus plant was taken over by the Navy for aircraft construction.[148]

Throughout Lustron's short history, just under 2,500 Lustron homes were erected in 36 states.[149] While the majority of Lustron's sales went to individuals, perhaps their largest single-buyer was the Navy, who purchased 61 houses to be built at the Marine Corps Base at Quantico, Virginia. These were used as housing for non-commissioned officers and remained in use until all but two were demolished in 2007, a testament to their durability.[150]

### 2.3.14 Hangars

Several companies were involved in the manufacturing of prefabricated hangars during the early Cold War period, such as United States Steel Corporation and Luria Standardized Buildings, a division of Luria Engineering Company. These prefabricated hangars were available in a wide range of designs featuring "girder-type construction" (Figure 130 and Figure 131) or "truss-type construction" (Figure 132). One of Luria's prefabricated hangar designs was used by the military in the early 1950s as the "world's first exclusive military heliport [at] Ft. Eustis, [Virginia]."[151] Luria Standardized Buildings also manufactured prefabricated "Wing hangars" that provided shelter for the front half of the fuselage and the wings of the aircraft and featured sliding double doors with cutout for the exposed tail of the plane (Figure 133). This increased the flexibility of these hangars, which was becoming increasingly important for accommodating a variety of plane sizes, as well as the rapidly changing technology of the time.[152]

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148 Mitchell, "What Ever Happened to Lustron Homes?," 48.

149 Mitchell, "What Ever Happened to Lustron Homes?," 44.

150 Nick Miroff, "Lights out for Lustrons of Quantico," *Washington Post*, September 30, 2007.

151 Luria Engineering Company, "Bell Aircraft Corporation Chooses Luria Standardized Buildings," *Architectural Forum* 102 (Jan–March 1955): 206.

152 Luria Engineering Company, "Bell Aircraft Corporation Chooses Luria Standardized Buildings," 206.

Figure 130. Exterior of two connected “girder-type” Luria Engineering Hangars erected for Bell Aircraft Corporation (Luria Engineering Company, “Bell Aircraft Corporation Chooses Luria Standardized Buildings,” *Architectural Forum* 102 (Jan.–March 1955): 206).


Figure 131. Interior of a “girder-type” Luria hangar showing the rigid frame design, 1955 (Luria Engineering Company, “Bell Aircraft Corporation Chooses Luria Standardized Buildings,” *Architectural Forum* 102 (Jan.–March 1955): 206).

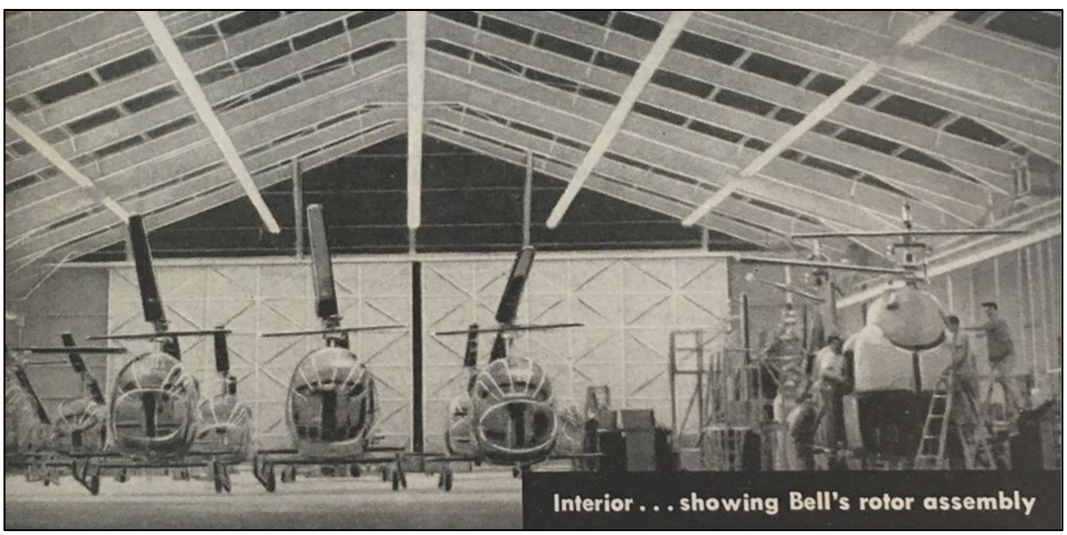
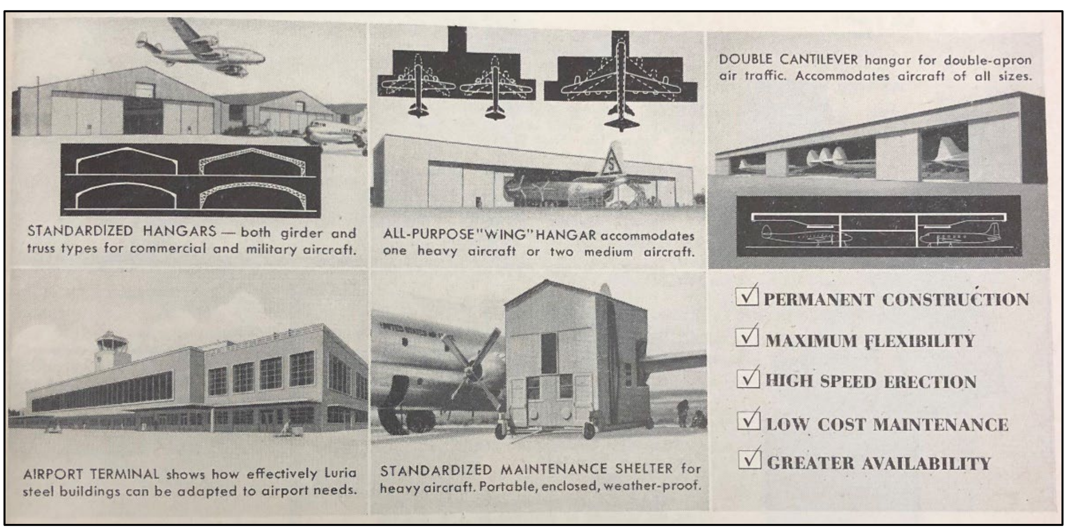


Figure 132. Collection of four photographs as part of a Luria Engineering Company Advertisement, which shows the interior structure of the “truss-type” design on the top picture, as well as the ability for customization of their buildings through the lean-to addition in the bottom left picture, 1956 (Luria Engineering Company, [Advertisement], *Military Engineer* (1956): n.p.).

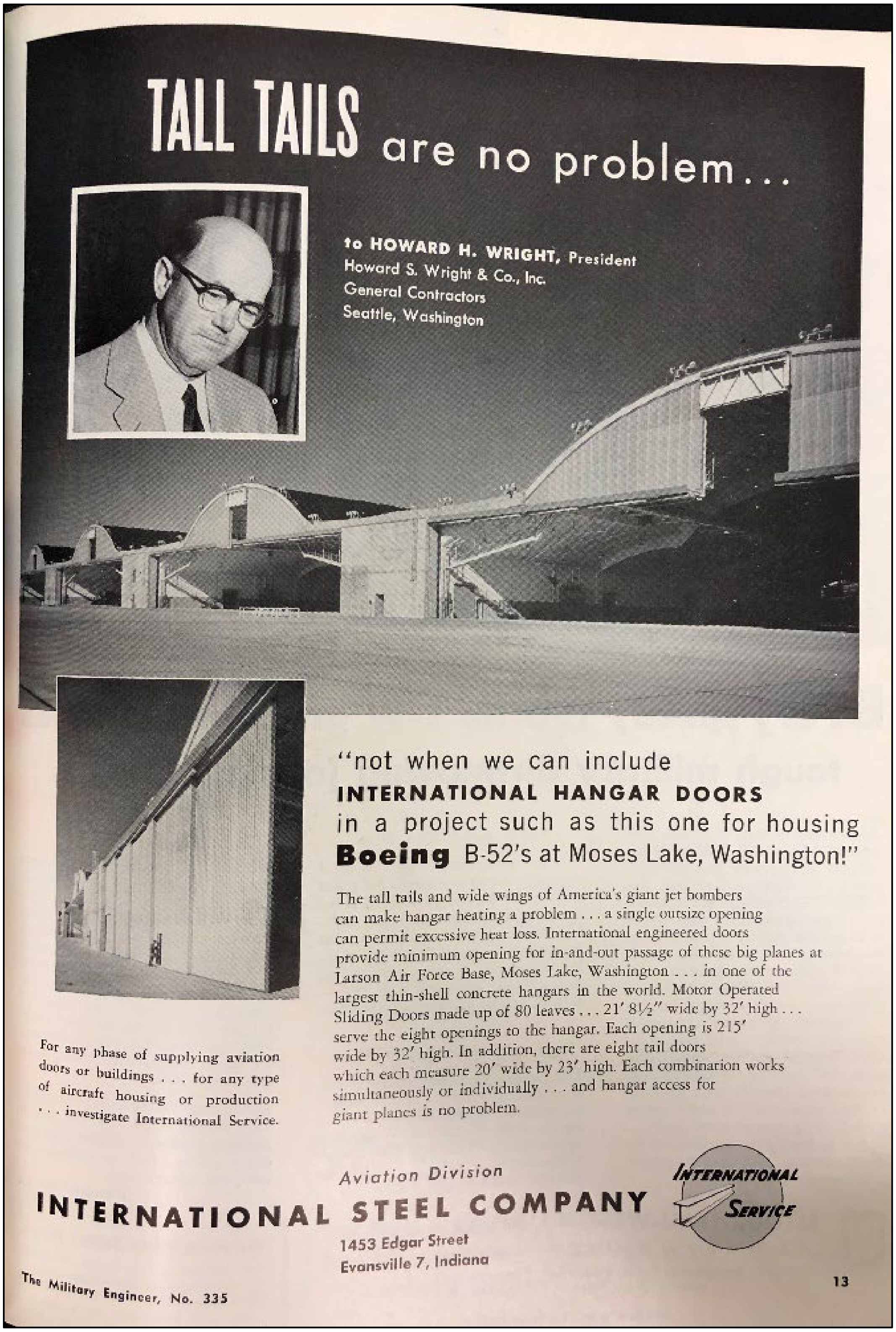

Figure 133. Plane placement inside Luria “wing hangars” and double cantilever hangars access to runways on both side of the structure, 1956 (Luria Engineering Company, [Advertisement], *Military Engineer* (1956): n.p.).



Each corporation, though, appears to have developed its own approach for maintaining flexibility in their hangar designs. For example, International Steel Company's Aviation Division constructed a series of metal doors for B-52 hangars at Larson AFB in Moses Lake, Washington. The large horizontally sliding double doors were comprised of five leaves each 21 ft, 8-½ in. wide by 32 ft high. These leaves spanned the 215 ft opening. In addition, these hangars included a 20 ft wide by 23 ft high "tail door" at the peak of the rounded roof, to allow the B-52s to fully enter the hangar (Figure 134).[153]

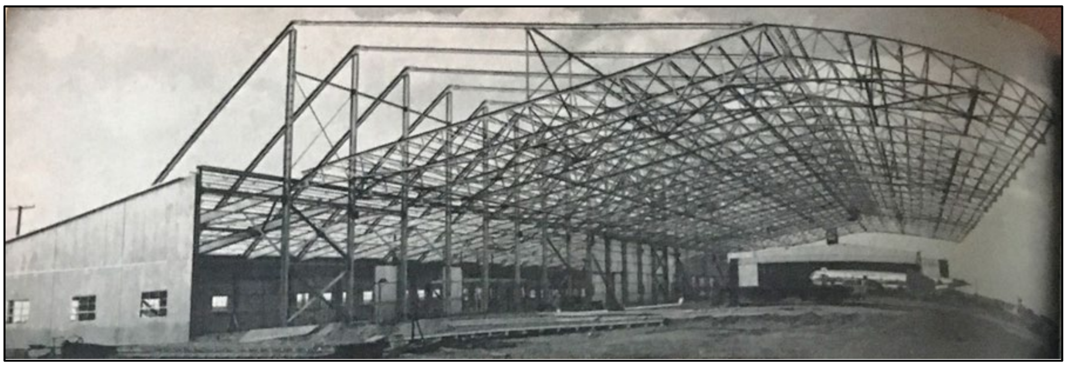
[153] International Steel Company, "Tall Tails are no problem…" *The Military Engineer* 50, no. 335 (May – June 1958): 161-242, 13.

Figure 134. International Steel Company hangar doors for B-52 storage, Larson AFB, Moses Lake, Washington, 1958 (International Steel Company, "Tall Tails are no problem..." *The Military Engineer* 50, no. 335 (May—June 1958): 161–242, 13).



Several companies such as US Steel, in addition to Luria, utilized a cantilever design for aircraft hangars. This design provided wide open spans without requiring structural supports on the side nearest the runways. In 1955, US Steel prefabricated a hangar with a cantilever design for the Temco Aircraft Corporation in Greenville, Texas, which featured an open area 120 ft deep, 432 ft wide, and 30 ft high for only $2.40 per square foot (Figure 135).[154]

Figure 135. Prefabricated hangar with a cantilever design was manufactured by United States Structural Steel and construction in Greenville, Texas, 1955 (United States Steel, "Ingenious hangar has no columns…" *Architectural Forum* 96, (Jan. - March 1952): n.p.).



### 2.3.15 Arctic Prefabs

DoD became increasingly interested in the Arctic during the Cold War due to the relatively short distance between the US and Russia across the Bering Strait and the Arctic Circle. Consequently, a need for deployable structures that could withstand extreme temperatures, wind, and heavy snow loads while also being easy to assemble under those conditions developed. This need for easily erectable, well-insulated structures coincided with the rise in popularity of prefabricated sandwich panels; thus, they were identified as the ideal technology for creating these structures.[155]

The "Arctic Hut," a 16-man barracks, was one of the earliest models of a highly insulated prefabricated structure. It was developed and tested in 1948, and twelve Seabees were able to erect the structure in one hour and forty-five minutes while wearing mittens (Figure 136). This easy assembly was made possible by connections between panels requiring only 6-in.-

[154] United States Steel Company, "Ingenious hangar has no columns."

[155] "Arctic Hut," *The Military Engineer* 40, no. 278 (Dec. 1948): 517–518.

long, 1-in.-thick pins, and metal wedges. The pins were designed out of plastic reinforced with fiberglass to prevent heat conduction. The panels varied in size, but the two side walls were comprised of twelve 4 ft by 8 ft panels, making the completed hut 20 ft by 48 ft (measured from the interior). All but two of the hut's wall panels featured a 16 in. Plexiglas window. The panels were collectively able to maintain an internal temperature of 70° Fahrenheit (F) under temperatures as low as -65° F through "a resin-impregnated paper honey-comb core sandwiched between two 1/50-in. aluminum skins."[156] Notably, aluminum was used because it had recently become widely available as a consequence of ramped-up wartime production. The side panels were 3-in. thick while the floor panels were 5 in. thick. Four mitered joints were used to seal each corner of the structure while other connections were covered with felt sealing strips and sealed with mastic. There was a door at each end of the Arctic Hut, although one was to serve as an emergency exit only. The slight gabled roof was supported by an aluminum frame design, in which:

> "A sectional roof beam along the longitudinal center of the hut rests on a support at each end, and three evenly spaced transverse beams in between. The transverse beams in turn are supported by columns on each end."[157]

The steel foundation was 2 ft high with support beams running parallel to the sectional roof beam. Large circular holes were drilled in the steel foundation just below the floor foundation to allow airflow beneath the hut. This helped the ground remain frozen, which kept the foundation stable. While the fully assembled hut weighed five tons, efforts were made to keep individual components small enough to be handled by a minimal crew of men. Consequently, the largest panel was about 4 ft by 10-½ ft and the foundation beams were 12 ft long. The three 20 ft transverse roof beams were the heaviest component at 147 pounds. Load tests showed that the floors could withstand 100 pounds per square foot and the roof could withstand 80 pounds per square foot, equivalent to roughly 13 ft of snow. Hydraulic jacks showed that the side walls could withstand 60 pounds per square feet, equivalent to winds of 150 mph. Bathrooms could be installed at any 4 ft station in the building, except for those with roof beams.[158]

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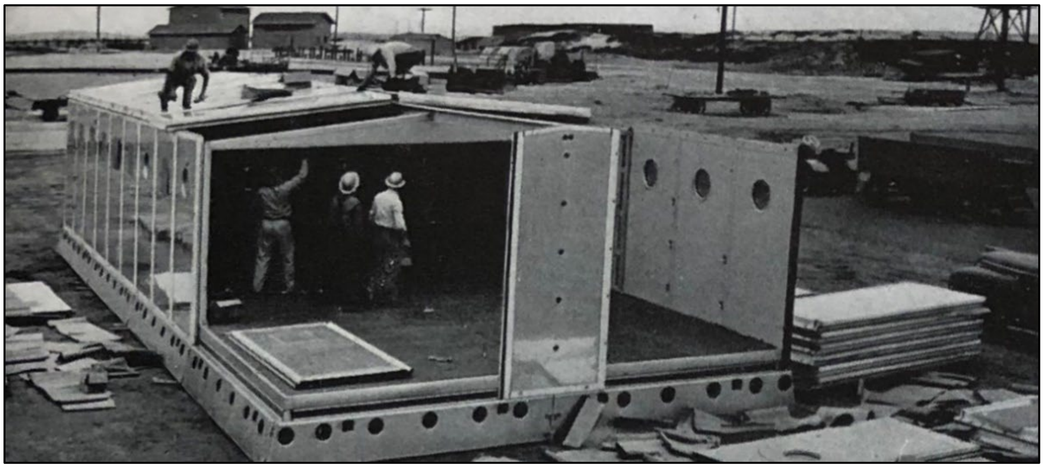
[156] "Arctic Hut," 517–518.

[157] "Arctic Hut," 517–518.

[158] "Arctic Hut," 517–518.

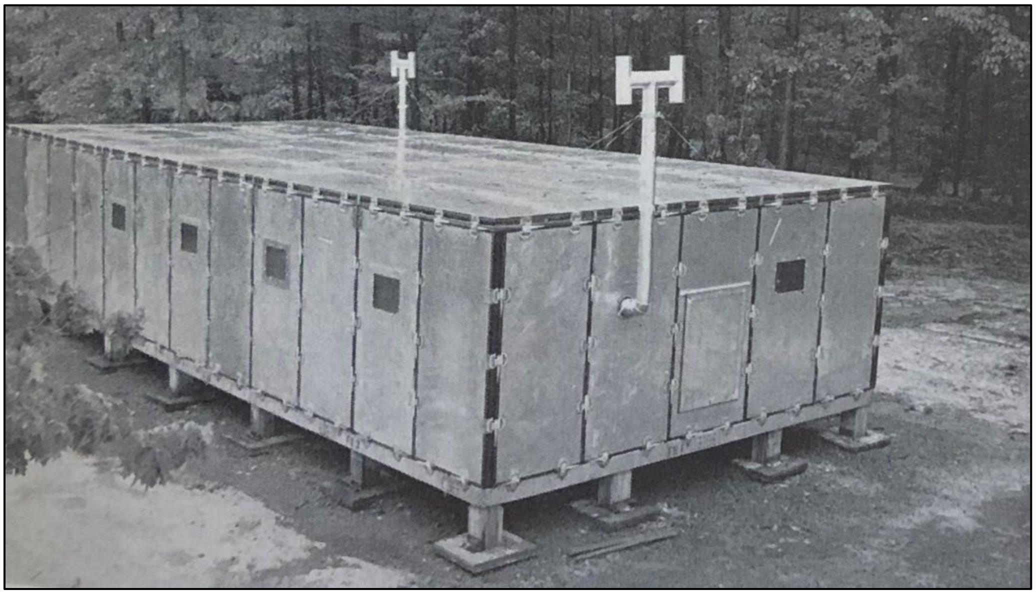
Figure 136. An early model of the Arctic Hut being assembled by a crew of Seabees wearing winter mittens ("Arctic Hut," *The Military Engineer* 40, no. 278 (Dec. 1948): 517–518).



An improved Arctic Hut was developed in 1950 by the Engineering Research and Development Laboratories at Fort Belvoir, Virginia. This design retained the honeycomb core and aluminum exterior panels that could withstand temperatures of -65° F. The basic dimensions were still 20 ft x 48 ft, but the option was now available to alter the hut's length in 8 ft increments. This design moved to a flat roof design, allowing all the wall panels to be the same dimensions at 4 ft by 8 ft (Figure 137). It is unclear how many Arctic Huts were used by the DoD.[159]

[159] "Arctic Housing," *The Military Engineer* 42, no. 289 (Sept.–Oct. 1950): 399.

Figure 137. A later model of the Arctic Hut with more visible metal pins used to join the panels ("Arctic Housing," *The Military Engineer* 42, no. 289 (Sept.–Oct. 1950): 399).



Larger arctic structures were also required by the DoD, for which they turned to Butler. In the late 1950s, Butler developed the "Arctic Panel" that could maintain interior temperatures of 600° F in the face of exterior temperatures of -600° F. These were first utilized as part of a contract for 49 warehouses built at various locations on the Distant Early Warning Line in the Arctic Circle.[160]

### 2.3.16 Wooden Construction

Prefabricated materials and technological advancements contributed to the increased popularity of pole barns during this period, as well. Pole barns were constructed by driving poles into the ground, then using trusses to create a roof before enclosing the sides. Thus, they allowed barns to be built without foundations. Advancements in wood treatment allowed for far more permanent pole barns, making them more appealing to builders. Additionally, this period saw the rise in prefabricated trusses,

[160] Cowles, Butler Company History, 206-207.

both metal and wooden. All of these factors combined to make pole barns "relatively low cost for materials and erection."[161]

### 2.3.17 Concrete Construction

Following WWII, official efforts began to establish a nationwide standard for masonry. It was soon established that a 4 in. module would be the "nominal dimensions in masonry work" (Figure 138).[162] In 1946, the American Standards Association released "Sizes for Clay and Concrete Modular Masonry Units, A62.3-1946," which establish the dimensions of the contemporary concrete masonry unit (CMU), measuring exactly 7-5/8 in. by 7-5/8 in. by 15-5/8 in., while still being referred to as an 8 in. by 8 in. by 16 in. block.[163] Notably, this differed from the 1938 standards released by the not-for profit Underwriters' Laboratories, Inc., by eliminating the "tolerance of ¼ in. plus or minus" for the 8 in. by 8 in. by 16 in. block.[164]

The Army Corps of Engineers were early adopters of modular coordination, sending a circular letter to "all districts and divisions calling attention to the modular system and its benefits."[165] In 1948, Colonel William C. Hall, Commander of the US Army Corps of Engineers, wrote enthusiastically about the progress in an article for the Military Engineer titled "Modular Co-ordination Moves Ahead" in 1948. By that time, "95% of the production of metal windows, and most wooden windows, structural facing tile, masonry and glass block [was] modular."[166] A consequential victory in the quest for standardization was the adaption of the standardized modular size by Detroit Steel Products Corporation, whose subsidiary Fenestra was one of the largest manufacturers of metal windows in the country at the time. The switch to a standard modular size "eliminated more than nine-tenths of their stock sizes" and allowed them to lower prices by one-third.[167]

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[161] Robert Henry Perkins and Stanley Suddarth, "Prefabricated, Demountable Panels For Pole Buildings," Lafayette, Indiana: Purdue University Agricultural Experiment Station, 1959; Koppers Company, Inc., "Built Quickly…Cheaply with Pole-Type Construction," *The Military Engineer* 44, no. 298 (March–April 1952): 6.

[162] William C. Hall, "Modular Co-ordination Moves Ahead," *Military Engineer* 40 (1948): 63.

[163] "What's New in Building," *Industrial Standardization* 19 (May–June 1948): 35.

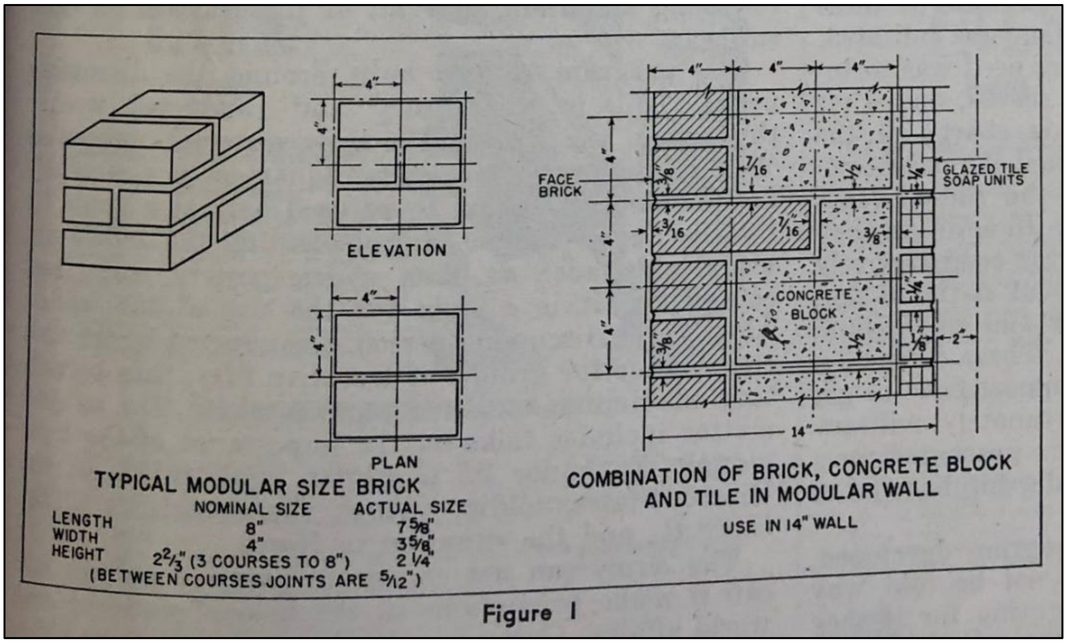
[164] Underwriters Laboratories, Inc., "Standard for Concrete Masonry Units," 5.

[165] William C. Hall, "Module Co-ordination and Tomorrow's Construction," *The Military Engineer* 39, no. 259 (May 1947): 218–219, 219.

[166] Hall, "Modular Co-ordination Moves Ahead," 63.

[167] Hall, "Modular Co-ordination Moves Ahead," 63.

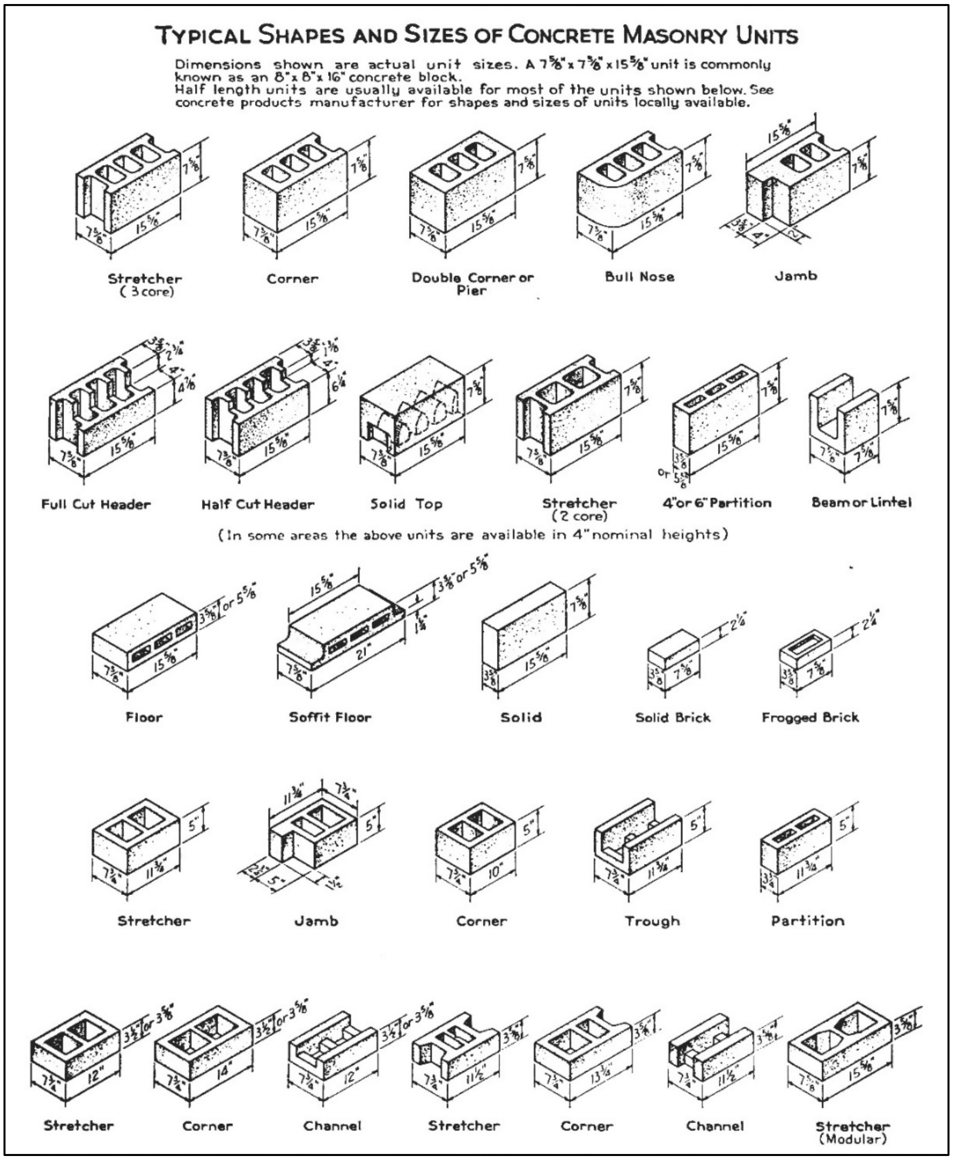
Figure 138. A diagram showing modular brick and how it could be used in conjunction with concrete and glazed tile construction, 1948 article "Modular Co-ordination Moves Ahead" by William C. Hall, Colonel USACE (William C. Hall, "Modular Co-ordination Moves Ahead," *The Military Engineer* 40 (1948): 63).




Though the size of CMUs had become standardized, the design had not. In the 1940s and 1950s, designs moved away from the three-core design towards a two-core design that "many engineers and manufacturers" thought was stronger than the three-core block, leading to a block with many of the same characteristics of the modern CMU (Figure 139).[168]

[168] Jay C. Ehle, "Developments in the Manufacture and Technology of Concrete Masonry Units," *Journal of the American Concrete Institute* 20, no. 5 (April 1949): 613-620, 620.

Figure 139. Typical Concrete Masonry Units; notice the popularity of the three-core blocks, which would soon give way to the two-core block, pictured below as the "stretcher," 1951 (Portland Cement Association, "Concrete Masonry Handbook for Architects and Builders," Chicago, IL: Portland Cement Association, 1951, n.p.).

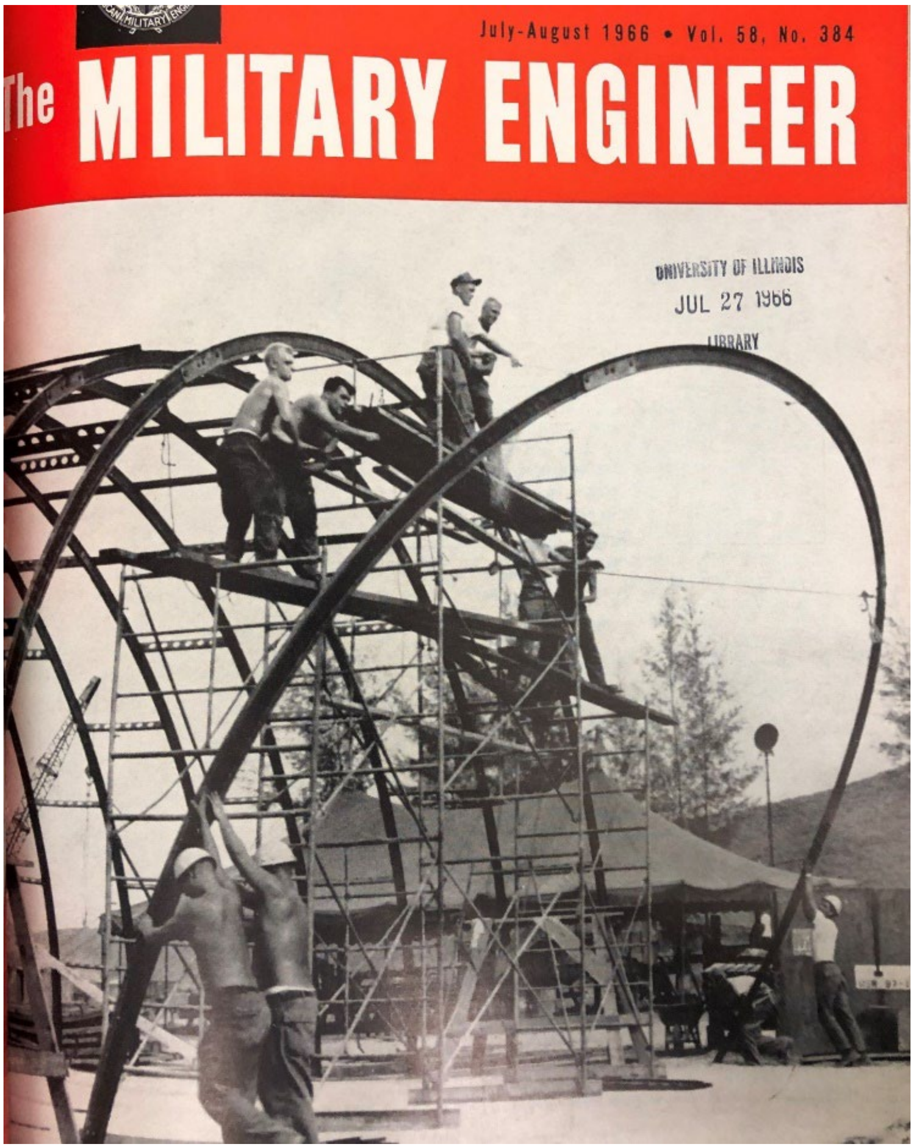



## 2.4 Vietnam War Era

### 2.4.1 Quonset Huts

Surplus Quonset huts appear to have been used in mobilization efforts for Vietnam, as is evidenced by the 1966 July-August issue of *The Military Engineer*, which shows a larger model Quonset known as an 'elephant hut' being erected as a supply warehouse at an unknown location (Figure 140).[169]

Figure 140. Steel arch-rib of a large model Quonset hut, referred to as an "Elephant Hut" at an unknown location, 1966 ([Cover], *The Military Engineer* 58, no. 384 (July–Aug. 1966): 233–316).



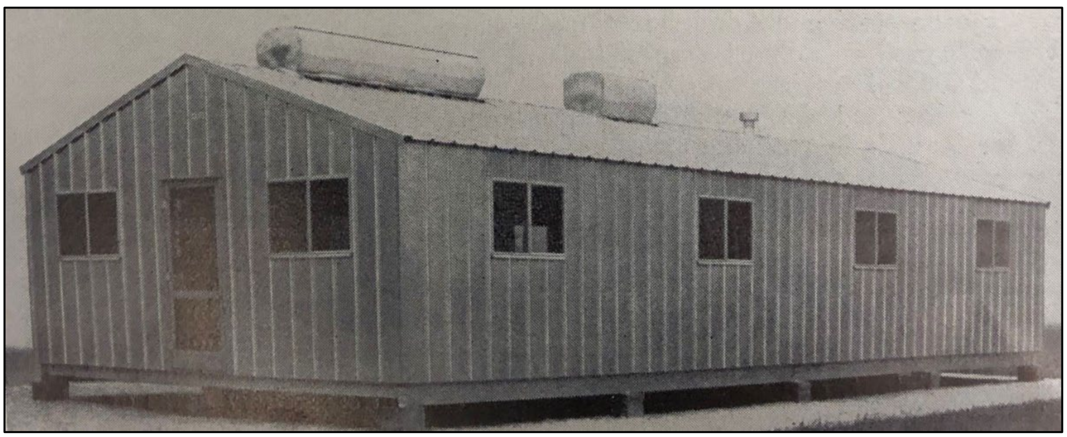

### 2.4.2 Butlerhut

In 1966, Butler's design "for temporary housing of field units overseas," was chosen to replace the Quonset hut (Figure 141). Butler received a contract for $7.73 million dollars from the government for 3,000 of these "Butlerhuts," which bore the same name as poorly received half-round

[169] Cover, *Military Engineer* 58, no. 384 (July–Aug. 1966): 233–316.

barracks they attempted to market during WWII.[170] The new Butlerhuts featured a gable roof and measured 20 ft by 48 ft. The clear span structure could house up to 40 men and be "erected in two days by six unskilled laborers."[171] The structure was demountable and had galvanized steel wall and roof panels, rigid structural steel frames, twelve transparent plastic and glazed aluminum windows with screens, a roof ventilator, a smokestack, doors on each end, and hardboard wall and ceiling liners. For cold climates, fiberglass insulation could be placed under the hardboard.[172]

Figure 141. An oblique of a Butler hut resting on cinderblock supports, 1966 (Butler Manufacturing Co., "Through this new system you may design a room rearrangement at will while maintaining environmental standards," *The Military Engineer* 58, no. 384 (July–Aug. 1966): n.p.).



### 2.4.3 Rigid Frame Developments

Rigid frames, most commonly rigid frame warehouses, were used by the DoD extensively both domestically and abroad throughout the Vietnam War (Figure 142). Some of the structures used featured hybrid construction, in which brick and mortar could be used instead of metal panel siding. This was made possible by the rigid frame, which bore the entirety of the load (Figure 143). The rigid frame was continuously adjusted and improved upon for a variety of purposes and aesthetics. By 1966, Butler, the developer of the original rigid frame, offered three different rigid frame options for different purposes. Their original design

170 Cowles, Butler Company History, 216.

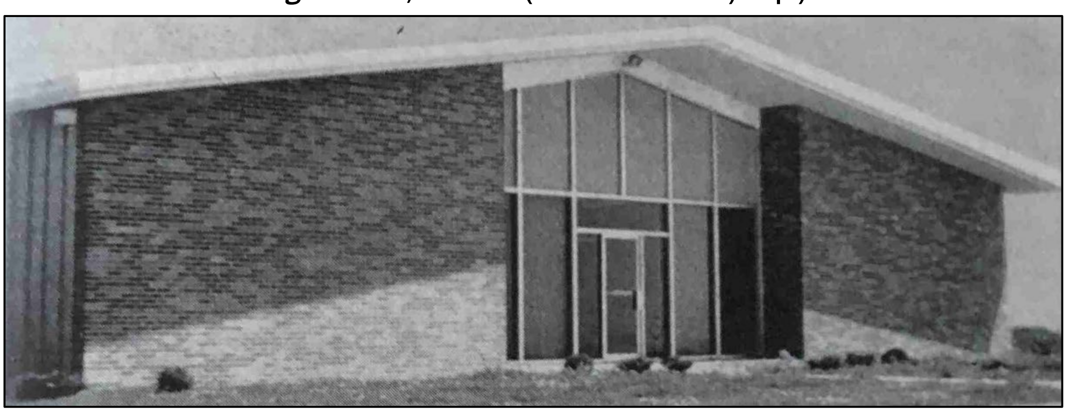
171 Butler Manufacturing Company, "Through this new system you may design a room rearrangement at will while maintaining environmental standards," *The Military Engineer* 58, no. 384 (July – Aug. 1966): n.p.

172 Butler Manufacturing Company, "Through this new system you may design a room rearrangement."

featured a 4/12 roof slope and could be used in clear span structures that were between 20 ft and 80 ft lengths and sidewall heights between 10 ft and 24 ft (Figure 144). A low rigid frame, featuring a 1/12 roof slope, was developed for buildings requiring a lower roof pitch. This frame was used in structures between 24 ft and 120 ft in length and could accommodate wall heights between 10 ft by 24 ft (Figure 145). For larger spans, between 80 ft and 360 ft, a modular rigid frame could be used. This frame also had a 1/12 roof pitch. It used vertical columns at spaced intervals between the walls, with one column in the center of the frame, for support (Figure 146 and Figure 147).[173]

Figure 142. A Butler prefabricated warehouse awaiting siding and roofing at Da Nang, Vietnam (H.N. Wallin, "Military Construction in Vietnam: The Construction Agent," *Military Engineer* 58, no. 385 (Sept.–Oct. 1966): 317–319, 318).

Figure 143. An Armco Rigid Frame being used as the support system for a "Radar Approach Control building," Offutt AFB, Nebraska ("Packaged Building," *The Military Engineer* 58, no. 381 (Jan.–Feb. 1966): n.p.).



[173] Deeson, Comprehensive Industrialised Building Annual (Systems and Components) 1966.

Figure 144. Butler's original Rigid Frame design (A.F.L. Deeson, ed., Comprehensive Industrialised Building Annual (Systems and Components) 1966, London: House Publications Limited, 1966).

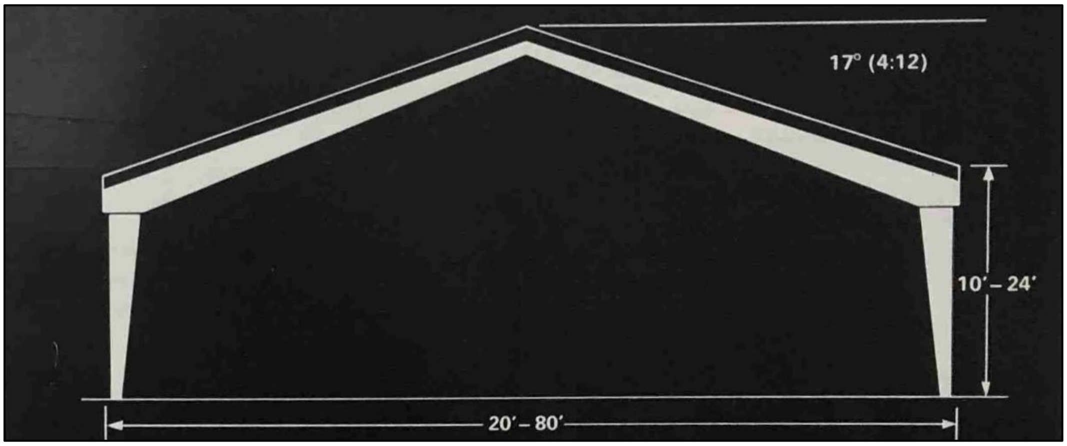



Figure 145. Butler's Low Rigid Frame design (A.F.L. Deeson, ed., Comprehensive Industrialised Building Annual (Systems and Components) 1966, London: House Publications Limited, 1966).

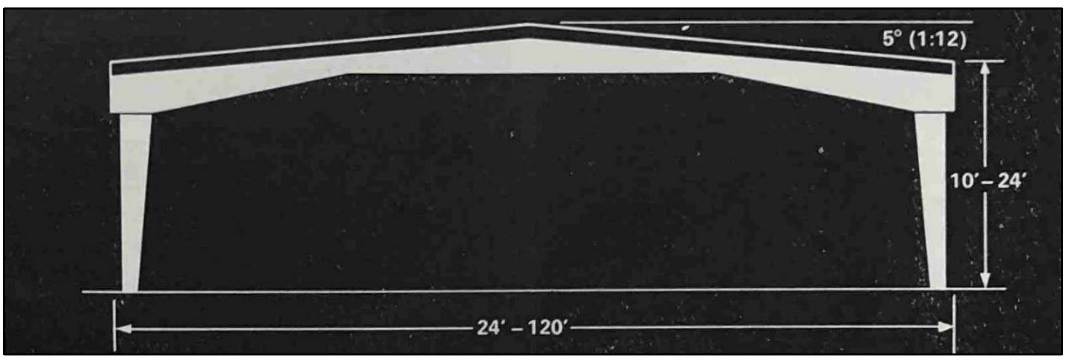



Figure 146. Half of Butler's Modular Rigid Frame design (A.F.L. Deeson, ed., Comprehensive Industrialised Building Annual (Systems and Components) 1966, London: House Publications Limited, 1966).

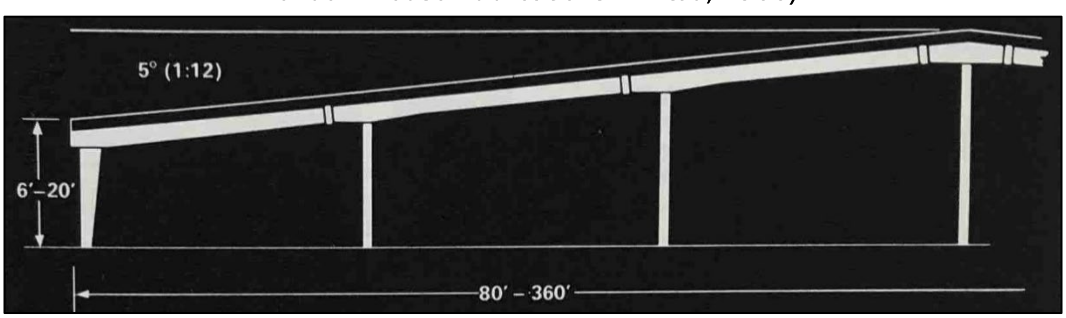
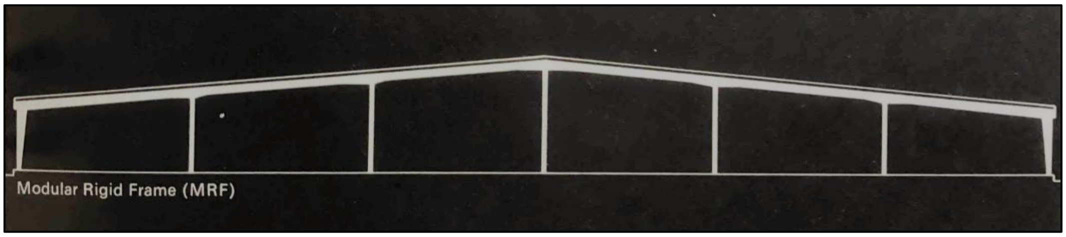


Figure 147. A full view of Butler's Modular Rigid Frame design (A.F.L. Deeson, ed., Comprehensive Industrialised Building Annual (Systems and Components) 1966, London: House Publications Limited, 1966).

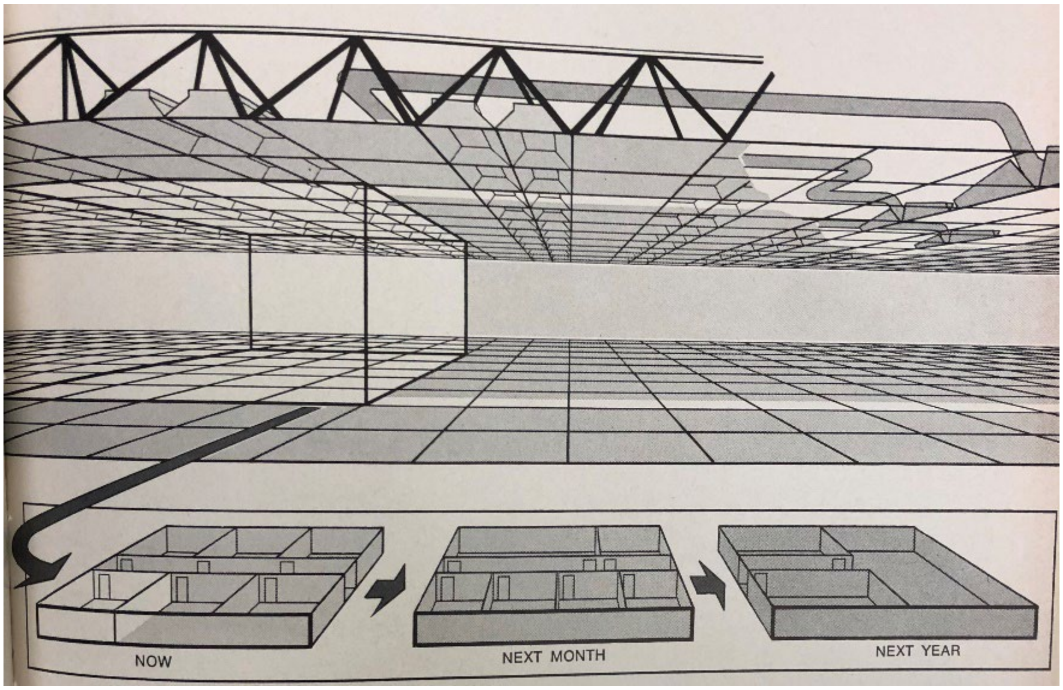



### 2.4.4 Combined System Prefabrication

An important innovation that helped metal buildings penetrate the market for commercial and office structures was the development of prefabricated material that could contain all the electrical, heating, cooling, and plumbing. The previous method required separate electricians, plumbers, and other contractors to run their own wiring and piping. This was often done without significant consideration for the next contractor's work, requiring them to work around the preceding set(s) of wiring or piping. To address this issue, Butler developed the Space Grid System in 1965 in conjunction with four other manufacturers. The Space Grid System contained "a system of integrated structural and mechanical systems" which was supported by flat trusses. There were specific tracks provided for each mechanical system. In addition to reducing space wasted by crossing pipes and wiring, this system also allowed for the movement of internal walls, as the truss grid provided total support for the ceiling (Figure 148).[174]

[174] Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions;" Cowles, Butler Company History, 216.

Figure 148. An advertisement for Butler's Space Grid System which emphasizes the free movement of walls (Butler Manufacturing Co., "Through this new system you may design a room rearrangement at will while maintaining environmental standards," *The Military Engineer* 58, no. 384 (July–Aug. 1966): n.p.).




### 2.4.5 Butler Innovations

Another innovation by Butler in this period was the use of corrugated steel or aluminum as the exterior face of a prefabricated sandwich panel. The F-103 wall or roof panel was designed in 1965 and released in 1966 (Figure 149). This panel featured a urethane core contained within two sheets of steel or aluminum. The interior side was flat, and the exterior sheet was corrugated in Butler's Butlerib pattern. The 3 ft by 12 ft panel weighed only 87 pounds and had a U-Factor—a measure of insulation in which lower numbers signify better insulation—of 0.1. Butler's marketing for the F-103 pitched it as a cheap alternative to concrete block construction, as 36 square ft of concrete block construction would weigh 2880 pounds and would only provide a U-Factor of 0.35.[175]

[175] Butler Manufacturing Company, "Would you buy a Butler building just to get this panel?" *The Military Engineer* 45, no. 381 (Jan. – Feb. 1966): n.p.

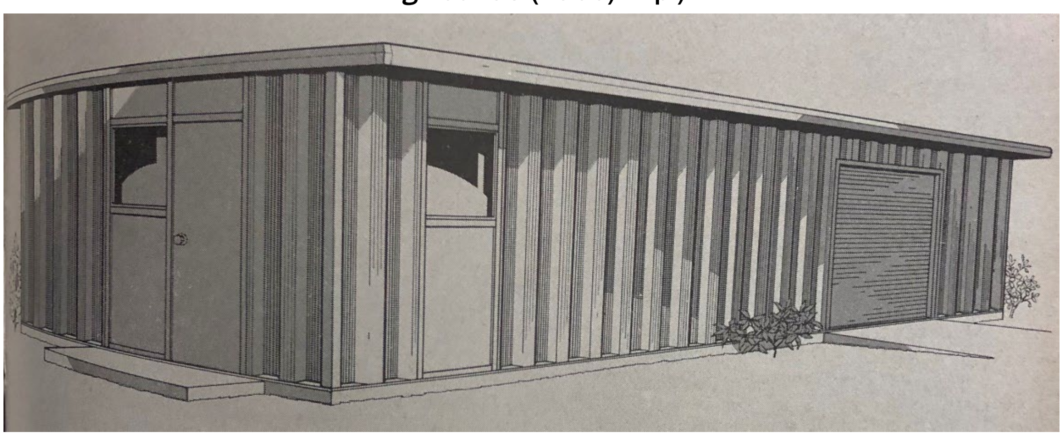
Figure 149. An advertisement for Butler that depicts the F-103 panel, a prefabricated sandwich panel with an exterior of a galvanized steel or aluminum Butlerib (Butler Manufacturing Company, "Would you buy a Butler building just to get this panel?" *The Military Engineer* 45, no. 381 (Jan.–Feb. 1966): n.p.).


Figure 150. A Butler building used as a converter shed, a typical US military utilization of small metal prefabricated building where a wooden structure would provide a fire hazard, Fort Bliss, Texas, 1966 (NARA 111-CCS).

### 2.4.6 Panel Framed Buildings

During the late 1960s and early 1970s, metal building manufacturers began offering options for smaller low-rise structures that, due to their small size, could be structurally supported by their side panels. This was not a new concept, as Armco's Steelox panels provided similar support, but it was beginning to be more widely used during this time. In 1966, Butler released the Panl-Frame Building. This style of building only supported widths between 6 ft and 24 ft and lengths could range between 9 ft and 60 ft. Wall heights came in either 8 ft, 10 ft, or 12 ft. Once a foundation was placed, "two men with ordinary tools [could] build a 12 ft by 15 ft building in less than two days," due to bolt holes being factory punched.[176] Door and window panels could be placed practically anywhere along side walls, and Butler also offered customizable options like sliding overhead doors (Figure 151 and Figure 152).[177]

Figure 151. A Butler Panl-Frame building with a sliding overhead door at one end, 1966 (Butler Manufacturing Co., "Through this new system you may design a room rearrangement at will while maintaining environmental standards," *The Military Engineer* 58 (1966): n.p.).



[176] Butler Manufacturing Co., "Through this new system you may design a room rearrangement at will while maintaining environmental standards."

[177] Butler Manufacturing Co., "Through this new system you may design a room rearrangement at will while maintaining environmental standards;" "Packaged Building;"

Figure 152. A Butler Panl-Frame building, 1966 (Butler Manufacturing Co., "Through this new system you may design a room rearrangement at will while maintaining environmental standards," *The Military Engineer* 58 (1966): n.p.).

Advanced Steel Buildings of Patterson, California, which was a subsidiary of Hallmark Industries, offered self-framing buildings that closely resembled Armco's Steelox panels and had double and single slope models (Figure 153). Their single slope buildings came in widths from 5 ft-4 in. to 16 ft and heights of 8 ft, 10 ft, and 12 ft. There was also a 14 ft option available only for buildings 16 ft wide. The roof had a four-inch rise over the width of the buildings. The double slope buildings came in widths between 8 ft and 32 ft and heights of 8 ft, 10 ft, 12 ft and 16 ft, measured to the eave. The roof slope came in either 2/12 or 4/12. Both single and double slope buildings could be made at any length, so long as it was a multiple of four.[178] Endure-A-Lifetime Products, Inc. of Miami, Florida, was another company that manufactured small panel-based structures. These buildings were of modular panel construction and were available under General Services Administration (GSA) contract (Figure 154).[179]

[178] Hallmark Industry, "Advanced Steel Buildings," *Seabees* 5, no. 1 (Jan.–Feb. 1968): 4.

[179] Endure-A-Lifetime, "Prebuilt Relocatable Structures," *The Military Engineer* 66 (1974): 111.

Figure 153. An advertisement for Advanced Steel Buildings by Hallmark, which came in double slope and single slope models, 1968 (Hallmark Industry, “Advanced Steel Buildings,” *Seabees* 5, no. 1 (Jan.–Feb. 1968): 4).

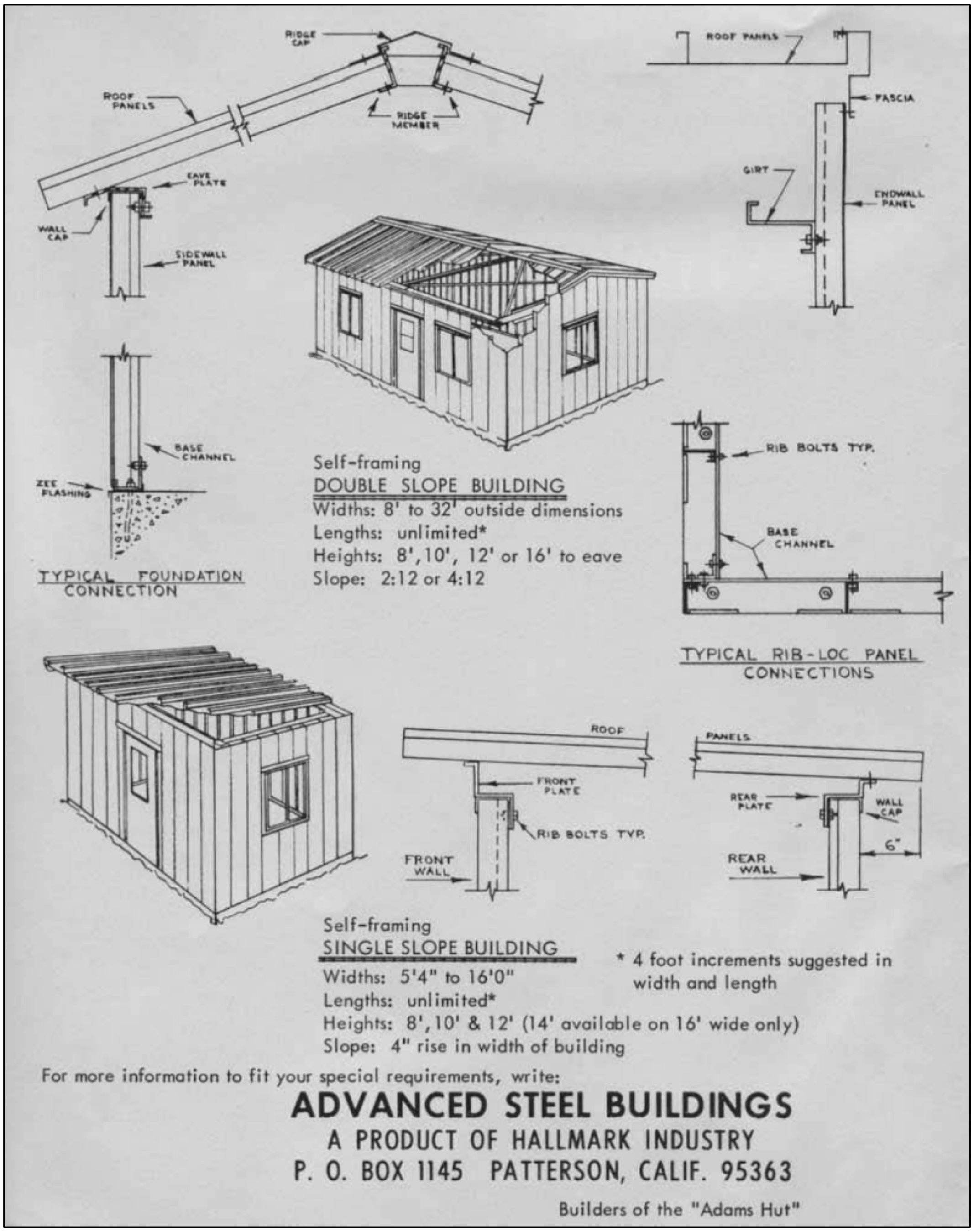


Figure 154. An advertisement for Endure-A-Lifetime Products, Inc., that shows a guardhouse constructed using their panel construction building method, 1974 (Endure-A-Lifetime, "Prebuilt Relocatable Structures," *The Military Engineer* 66 (1974): 111).


### 2.4.7 Air Force Housing

During this period, the Air Force put considerable time and investment into creative housing solutions, placing an emphasis on duplex style housing for Airmen families and barracks. One of the earlier attempts at prefabricated housing for the Air Force was at Andrews AFB, Maryland. In 1964, Madway Main Line Homes, out of Wayne, Pennsylvania, constructed a prototype relocatable two-story duplex. The house was transported to the site via flatbed trucks in two long segments—one for each floor. A crane was required to position them onsite (Figure 155). The structure was designed to ship as compactly as possible through a folding design. The ground floor exterior walls were shipped flat to be folded upward when assembled. The second-floor exterior side walls came fully upright at each end, but in three sections, allowing the sides to be folded inward at 90-degree angles (Figure 156 and Figure 157). The roof was comprised of panels, which were shipped in the attic to save space. Each apartment had a living/dining room, kitchen, three bedrooms, and one-and-one-half baths. Fully assembled, the building measured 45 ft by 26 ft. A duplex cost between $10,000 and $11,000 to construct (Figure 158).[180]

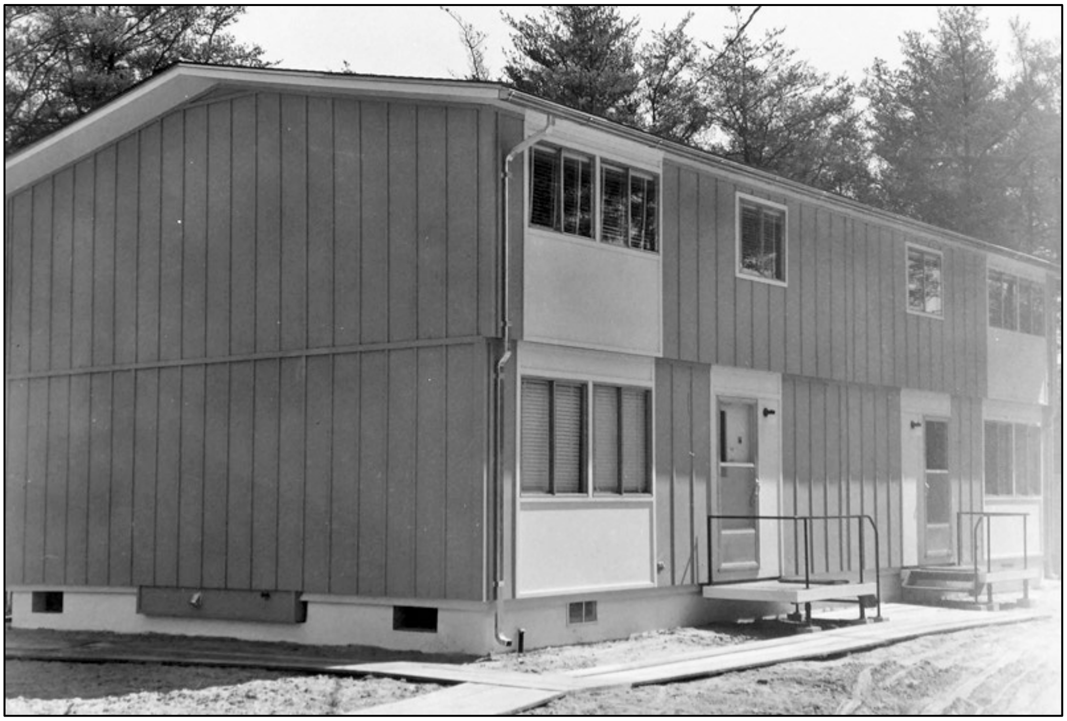
Figure 155. A Madway Main Line Homes house is being lifted into position on top of the foundation, Andrews AFB, Maryland, 1964 (NARA College Park, RG342-B).


[180] "Relocatable House," *The Military Engineer* 56, no. 372 (July–Aug. 1964): 282.

Figure 156. The ground floor front exterior wall is being lifted into place out of the shipping structure, Andrews AFB, Maryland, 1964 (NARA College Park, RG342-B).

Figure 157. Once the ground floor is complete, the second story is lifted into place in one piece, Andrews AFB, Maryland, 1964 (NARA College Park, RG342-B).

Figure 158. A recently erected duplex that cost between $10,000 and $11,000 to construct, with each unit featuring three bedrooms, a dining/living room, a kitchen, and one-and-one-half baths, Andrews AFB, Maryland, 1964 (NARA College Park, RG342-B).



In 1971, two hundred prefabricated duplexes were erected at George AFB, California. These had a similar final appearance to the prototype at Andrews AFB, Maryland, but used different methods of prefabrication (Figure 159).[181] These units were of modular design, with large portions being prefabricated and lowered into place. Each apartment of the duplex was centered around a utility core that housed key features that were labor intensive to install onsite (Figure 160).[182] The core was factory-built by an assembly line of plumbers, carpenters, and electricians who installed a half-bathroom, a kitchen wall complete with appliances, and the heater (Figure 161 and Figure 162).[183]

[181] Photograph KE 50404, Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, National Archives at College Park, College Park, MD.

[182] Photograph KB 42498, "060100 George AFB Modular House Construction," Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, National Archives at College Park, College Park, MD.

[183] Photograph KE 42457 (SSgt. Jerry Montrose), "050100-Modular House George AFB," 5-6 April 71, Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, National Archives at College Park, College Park, MD; Photograph KE 42740, Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, National Archives at College Park, College Park, MD.

Figure 159. A completed modular duplex, one of the two hundred townhouses, apartments, and single-family houses built by General Electric and Del E. Webb Corporation at George AFB, California, 1971 (NARA College Park, RG342-B).

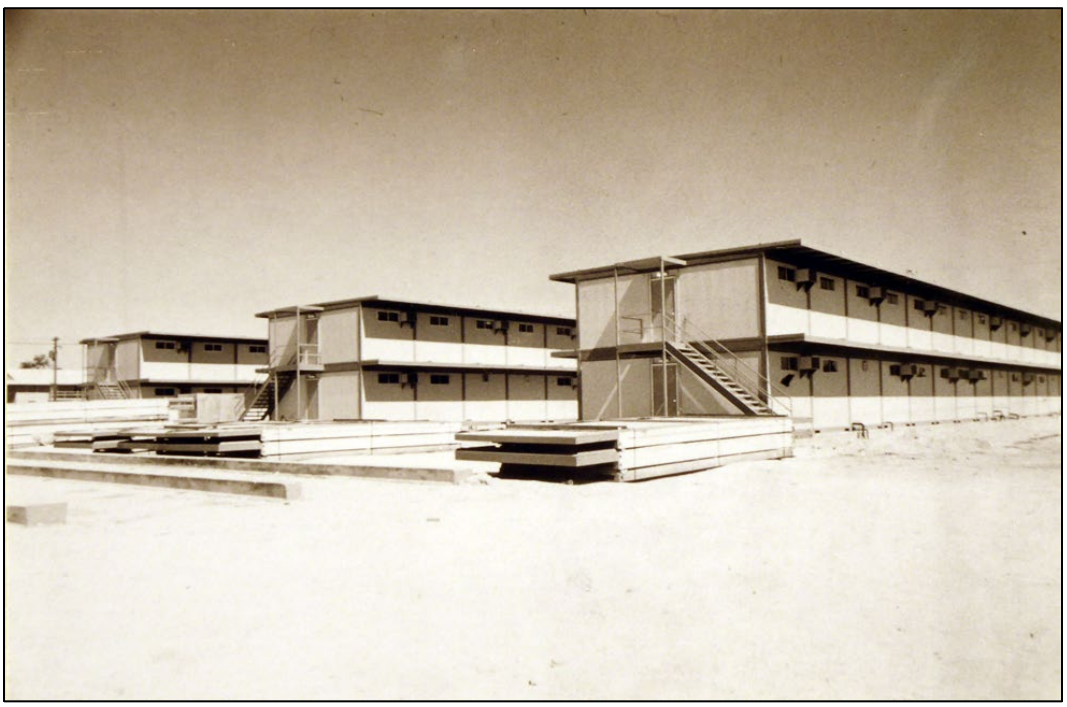
Figure 160. Utility cores being assembled by a line of electricians, plumbers and carpenters, George AFB, California, 1971 (NARA College Park, RG342-B).

Figure 161. The utility core of one side of a modular duplex, George AFB, California 1971 (NARA College Park, RG342-B).

Figure 162. A completed utility core being lifted into place by a crane, George AFB, California 1971 (NARA College Park, RG342-B).

The Air Force did not limit their experimental building practices to family housing, nor was George AFB their first experience with modular construction. At least three two-story barracks of modular design were constructed at Nellis AFB, Nevada in 1968 (Figure 163). The buildings were arranged in two levels of fifteen modular sized units, four of which were occupied by fully prefabricated rooms that stretched the entire width of the structure (Figure 164 and Figure 165). The remainder of the modular sections consisted of prefabricated floor and roof sections spanning the entire modular footprint and held by four metal supports at each corner. Panels were used for walls, which held several window-sized air conditioning units at intervals along the structure. The exterior was white and was contrasted by two red doors, one for each level, at the end of the structure (Figure 166).[184]

Figure 163. Three complete modular housing structures and additional materials for more barracks in the foreground, Nellis AFB, Nevada, 1968 (NARA College Park, RG342-B).



[184] Photograph 169507 USAF, 27 March 1961, Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, Box 265, National Archives at College Park, College Park, MD; Photograph 179180 USAF, April 1967, Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, Box 265, National Archives at College Park, College Park, MD.

Figure 164. Modular barracks under construction, Nellis AFB, Nevada, 1968 (NARA College Park, RG342-B).

Figure 165. A latrine module being hoisted into place, Nellis AFB, Nevada, 1968 (NARA College Park, RG342-B).

Figure 166. Modular barracks at Nellis AFB, Nevada photographed shortly after completion, 1968 (NARA College Park, RG342-B).

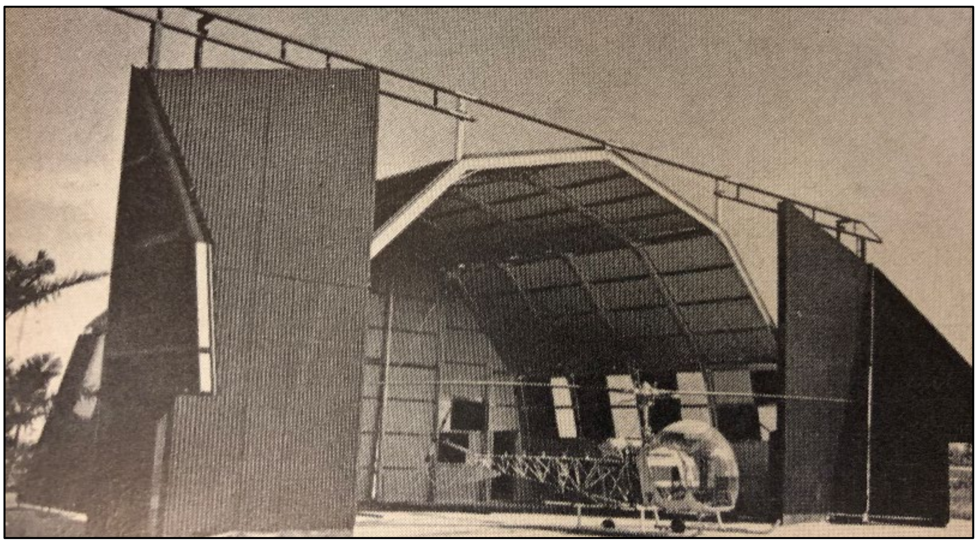

The Air Force was not the only government entity interested in developing modular building technology. In the early 1960s, the Marine Corps launched a program called "USA HOMES" for overseas housing construction which used "factory-built" modular homes. This was despite "estimates at the time [that] indicated that on-site construction of conventional masonry or frame houses of higher quality would cost 10 to 15 percent less." The Department of Housing and Urban Development (HUD) was also interested in the potential of modular construction, but sought to reduce costs, particularly that of component transportation. In 1972, HUD asked the Naval Civil Engineering Laboratory (NCEL) at Port Hueneme, California to conduct tests on the effects of train travel on fiberglass modular housing. A load sensor was used and found no structural issues resulting from train travel.[185]

[185] "Housing Module Test," *The Military Engineer* 64, no. 422 (Nov. – Dec. 1972): 435; Robert J. Newman, "Overseas Housing Strategies," *The Military Engineer* 76, no. 495 (Sept. 1984): 392-393.

### 2.4.8 Mobile Structures

As helicopters became more commonly used in combat during the Vietnam War, the DoD needed to quickly establish forward operating bases. In response to this need, Climatrol Corporation released its "Mobile Aluminum Maintenance Hangar" in 1966. This structure featured a gambrel roof, which is uncommon in metal prefabricated structures, and double doors, hinged at the halfway point to reduce the space required. It weighed 10,000 pounds and could "be assembled on cleared ground without a foundation by six men in 72 hours." The hangar could withstand winds of up to 70 mph (Figure 167).[186]

Figure 167. A "Mobile Aluminum Maintenance Hangar" fully deployed with sliding double doors and hinges fully opened ("Mobile Aluminum Maintenance Hangar," *The Military Engineer* 58, no. 382 (March–April 1966): 128).

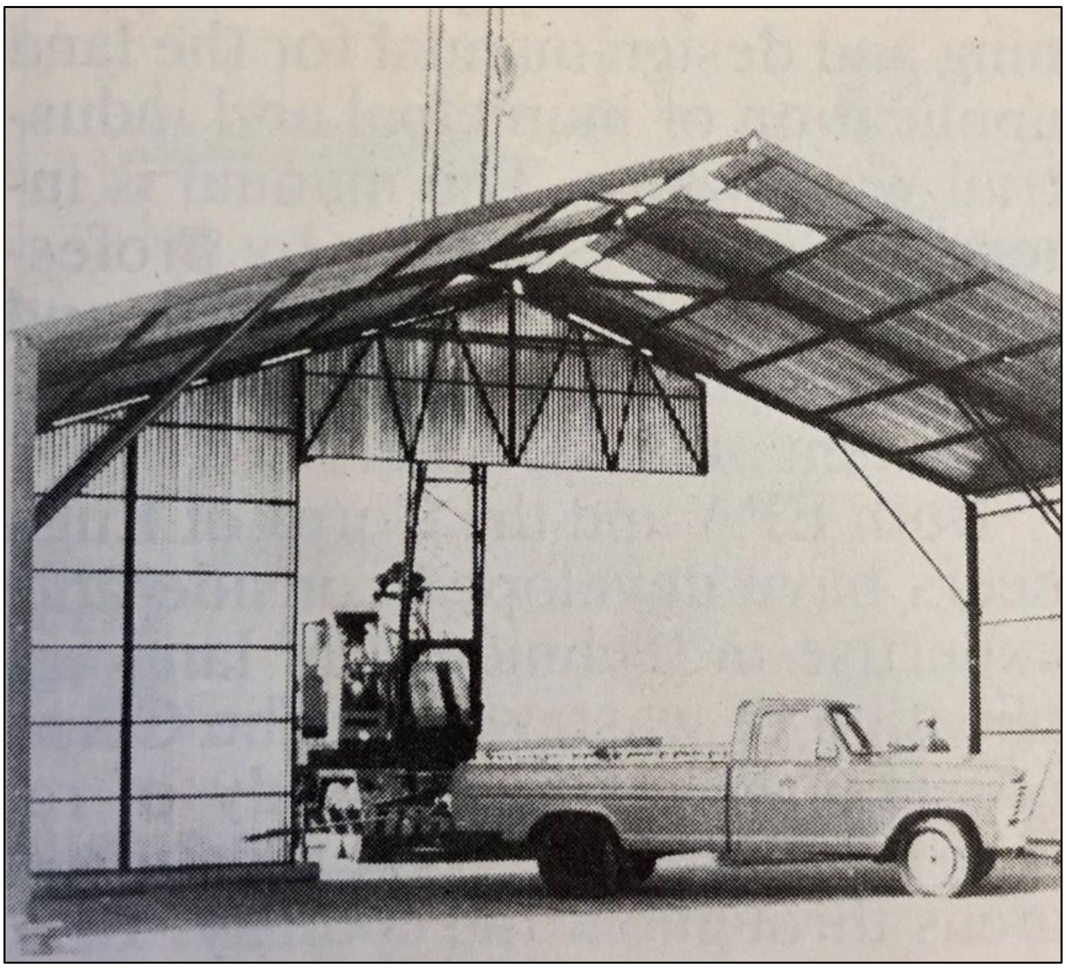


The private sector was also interested in mobile warehouses. Atco Metal Ltd., of Pierre, Canada, developed a highly movable, foldable steel clear-span warehouse "designed specifically for temporary storage and equipment repair at large construction projects." The Fold-A-Way was designed around 10 ft-wide wall sections, comprised of galvanized, corrugated steel sandwich panels with a fiberglass insulation core that spanned the height of the side walls. The roof panels were of similar design, except they incorporated translucent skylights. Each "section," made up of two side-wall panels and two roof panels, was able to fold flat for storage. The 10 ft-long sections came in 24 ft, 40 ft, and 60 ft widths.

[186] "Mobile Aluminum Maintenance Hangar," *The Military Engineer* 58, no. 382 (March – April 1966): 128.

This technology was soon sought out by the military for its potential as a rapidly deployable warehouse in combat zones. Atco developed a 60' Fold-A-Way for the Marine Corps Combat Development Center at Quantico, Virginia, in the mid-1970s for "a fast-erect[able], quickly relocatable tactical aircraft maintenance facility" (Figure 168).[187] The design allowed a plane to "enter through the large cargo doors in the wings-folded configuration with the center height clearance being enough to allow the unfolding of the wings once the aircraft was inside." In addition, two lean-to additions were placed on either side of the structure to provide more storage for large machinery and equipment, making the structure 100' wide and available in lengths in 10 ft increments.[188]

Figure 168. A Fold-A-Way with one of the 10' panels on the end wall missing ("Foldable Steel Buildings," *The Military Engineer* 68 (1976): 111).



[187] "Foldable Steel Buildings," *The Military Engineer* 68 (1976): 111.

[188] "Foldable Steel Buildings," 111.

In addition to warehouses and hangars, deployable buildings could also be utilized as housing. A particularly notable experiment in deployable housing in this period came from the private sector, when, in 1965, Dr. Jaakko Hiidenkari of Finland had an idea for a ski cabin that could be moved from mountain to mountain via helicopter. Hiidenkari soon commissioned architect Matti Suuronen to design his cabin. Suuronen came back with a design similar to a flying saucer, with an elliptical-spherical shape and elliptical windows around the center of the house. It was positioned on a four-footed metal frame which allowed for the trapdoor entrance to fold down from the center of the house (Figure 169). It was called the “Futuro House.” In order to keep the weight low enough for air transportation, the Futuro House used fiberglass reinforced plastic for the exterior and polyurethane insulation. To heat the house, an electrical heating system that could raise the internal temperatures of the house from -20° to 60° F in 30 minutes was used. The first prototype was built by the Helsinki-based company Polykem in early 1968. Only about 100 Futuro Houses were manufactured, and production permanently ended in 1973 with the onset of the Oil Crisis, which roughly tripled the production cost of Futuro Houses.[189]

[189] Craig Barnes, “Futuro History,” FuturoHouse.co.uk, accessed Sept. 5, 2019, http://www.futurohouse.co.uk/futuro-history.html.

Figure 169. A Futuro house being transported by helicopter, Sweden, 1969 (Craig Barnes, "Futuro History," accessed Sept. 5, 2019, "http://www.futurohouse.co.uk/futuro-history.html).


### 2.4.9 Hardened Metal Structures

The same properties that made deep-corrugated self-framing structures appealing to the agricultural market, namely their stability under vertical and lateral forces, led them to be looked at by the military as potential battlefield hangars or other storage. These would be "hardened" structures, or structures designed to withstand nearby explosions and enemy fire. At Holloman AFB in Otero County, New Mexico, a prototype hardened hangar was constructed using a deep-corrugated self-framing structure as the basis for their design, with embankments built-up along each side of the structure for additional protection (Figure 170 and Figure 171).[190]

Figure 170. A prototype hardened aircraft hangar under construction at Holloman Air Force Base, Otero County, New Mexico, Feb. 1968 (NARA College Park RG 342-B).

Figure 171. A prototype of a protective aircraft structure being tested by the Air Force at Holloman AFB, Otero County, New Mexico, Feb. 1968 (NARA College Park RG 342-B).

190 Photograph 29228, Feb. 1968, Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, Box 933, National Archives at College Park, College Park, MD; Photograph 29229, Feb. 1968, Records of Air Force Commands, Activities, and Organizations, Record Group 342-B, Box 933, National Archives at College Park, College Park, MD.

### 2.4.10 Pole Barns

Pole barn building was simple enough that do-it-yourself literature for their construction had spread by the Vietnam War. For example, "Low Cost Pole Buildings Construction: the Complete 'How-To' Book" cost $4.95 and came completely illustrated with 40 special plans for structures.[191] Despite their simplicity, both component and complete building manufacturers sought to produce prefabricated pole barns. PCI Pole Buildings of Southern Illinois is one company that manufactured complete pole barns using pre-engineered parts and their own team of builders to erect their structures (Figure 172). Automated Building Components, Inc., by contrast, manufactured roof trusses as a component for pole barns.[192]

Both do-it-yourself and manufactured pole barns maintained many of the qualities of prefabricated metal structures that had made prefabricated structures attractive options for commercial, agricultural, and warehousing uses. These capabilities are highlighted by a 1977 advertisement for Alabama/Tennessee Post Builders demonstrating various uses for their pole barns (Figure 173).[193]

[191] "Low-Cost Pole Building Construction: The Complete 'How-To' Book," *Agricultural Engineering* 92 (1977): n.p.

[192] "Engineered Agri-Business Structures Are Success Key at PCI Buildings," *Automation in Housing and Building System News* (Oct. 1980): 38.

[193] Alabama/Tennessee Post Builders, "Farm Buildings: Anywhere in Alabama," *Progressive Farmer* 92 (1977): n.p.

Figure 172. Alabama/Tennessee Post Builders building options, 1977 (Alabama/Tennessee Post Builders, "Farm Buildings: Anywhere in Alabama," *Progressive Farmer* 92 (1977): n.p.).


Figure 173. A pole barn erected by the PCI Pole Buildings in Carrollton, Illinois, 1980 ("Engineered Agri-Business Structures Are Success Key at PCI Buildings," Automation in Housing and Building System News (Oct. 1980): 38).

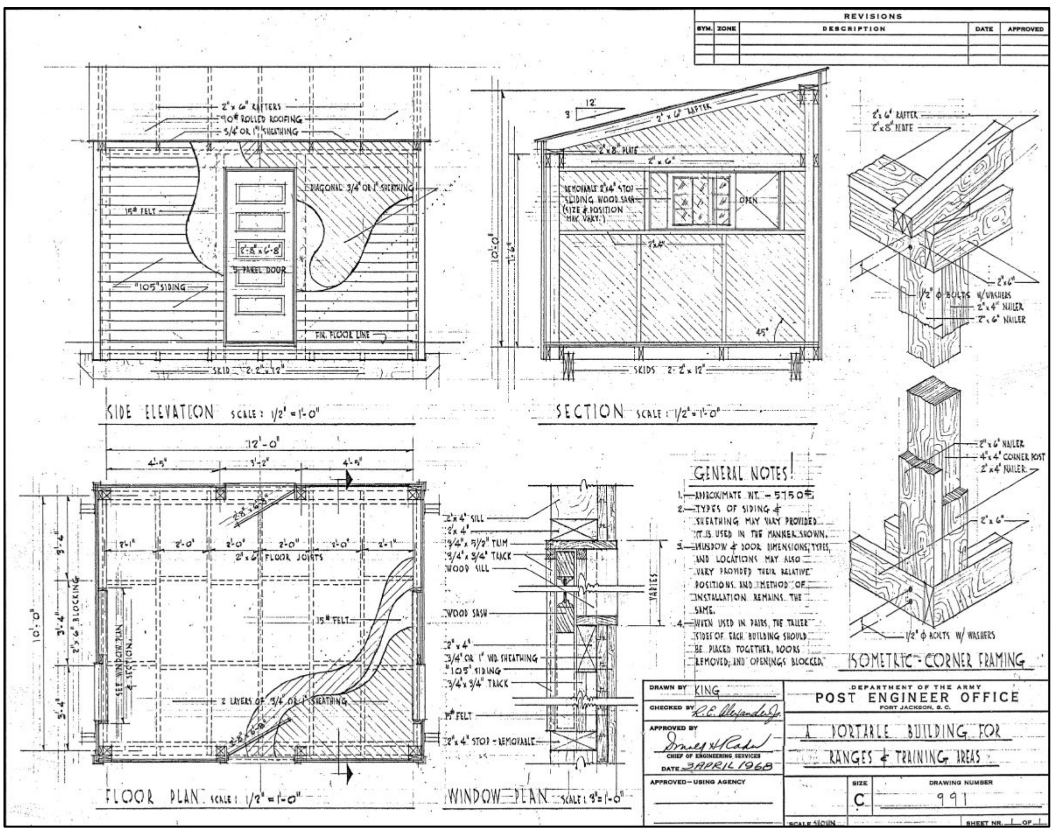
### 2.4.11 Wood Construction

The use of wood in DoD construction continued throughout the Vietnam War. Semi-permanent buildings, on installations both domestic and abroad, were constructed of wood (Figure 174);[194] however, the majority of the wood used during this period (70% of lumber and 85% of plywood) was used for facilitating purposes, such as to form concrete. In 1962, 35.1 million square feet of plywood and 69 million board feet of lumber were

194 Mel Schenck, "The Largest Military Construction Project in History," *The New York Times*, Jan. 16, 2018, https://www.nytimes.com/2018/01/16/opinion/the-largest-military-construction-project-in-history.html; H.N. Wallin, W. Stuart Potter, and J.H. Hottenroth, "TME Looks Back: Vietnam – 'Military Construction in Vietnam,'" Society of American Military Engineers, accessed August 16, 2021, https://samenews.org/tme-looks-back-vietnam-military-construction-in-vietnam/.

used by the military. By the end of the 1970s, the military's use of lumber had decreased significantly, with only 10 million square feet of plywood and 21 million board feet of lumber being used. This was likely due to technological advances, such as the invention and use of resin-coated or impregnated plywood, which allowed a single piece of plywood to be used as formwork for numerous concrete pours. Despite the general decrease in wood use, though, the use of lumber and plywood by the military for structural purposes increased between 1962 and 1978.[195]

Figure 174. Portable wood utilitarian building at Fort Jackson, South Carolina, 1968 (Adam D. Smith and Sunny E. Adams, "Fort Jackson range architectural inventory," ERDC/CERL SR-04-7, Champaign, IL: Engineer Research and Development Center-Construction Engineering Research Laboratory).




## 2.4.12 Concrete Construction

As evidenced by the use of wood for facilitating purposes during the 1960s and 1970s, concrete was a widely used building material during the Vietnam War era. By 1969, modular precast panels were the most

195 William H. Reid and David B. McKeever, *Wood Products Used in Military Construction in the United States, 1962 and 1978*, Madison, WI: Forest Products Laboratory, US Forest Service, 1980.

commonly used concrete building system by the DoD. Precast and prestressed or post-tensioned concrete posts and beams were also commonly used;[196] however, cast-in-place concrete and concrete block construction systems were more common than other systems for the speedy construction of housing and other utilitarian buildings.[197] During this period, the military conducted experiments to determine if bamboo could be used as reinforcement for concrete structures constructed under field conditions. While it was determined that bamboo could be used as the reinforcing material for light, semipermanent concrete military structures, it is unclear if any buildings were constructed using this method.[198]

## 2.5 Late Cold War and Gulf War Era

### 2.5.1 Metal Building Systems

During the mid-twentieth century, the American metal building industry had been undergoing a slow evolution from prefabricated kits to custom designed structures. Companies began to develop their own distinct building methods for different systems, which ranged from complete building systems to component systems for roofing, structural, and/or wall systems. Armco's Steelox was an early example of a metal component building system that architects could choose to incorporate into their designs. The development of computers allowed for complex force calculations to be done quickly, providing more customization and design possibilities than previously possible. By the late Cold War, two distinct fields of the metal building industry developed: prefabricated kit manufacture (Figure 175 and Figure 176) and metal building system manufacture.[199]

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[196] Gordon Ray, "Concrete Building Systems for Military Use," *The Military Engineer* 61, no. 402 (July – Aug. 1969): 253-255, 254.

[197] Ibid; Wallin, Potter, and Hottenroth, "TME Looks Back: Vietnam – 'Military Construction in Vietnam.'"

[198] Kenneth L. Saucier, "Bamboo Reinforcement for Concrete," *The Military Engineer* 60, no. 393 (Jan. – Feb. 1968): 22-24.

[199] Arco Steel Buildings, "Steel Buildings Stock Reduction Sale," *Progressive Farmer* 98 (Jan.–June 1983): 83; Arco Steel Buildings, "Steel Building Spring Sale," *Progressive Farmer* 101 (Jan.–June 1986): n.p.; Arco Steel Buildings, "Steel Building Winter Sale," *Progressive Farmer* 104 (Jan.–June 1989): n.p.

Figure 175. Prefabricated metal bleachers cover at Fort Jackson, South Carolina from 1985 (Adam D. Smith and Sunny E. Adams, "Fort Jackson range architectural inventory," ERDC/CERL SR-04-7, Champaign, IL: Engineer Research and Development Center-Construction Engineering Research Laboratory).

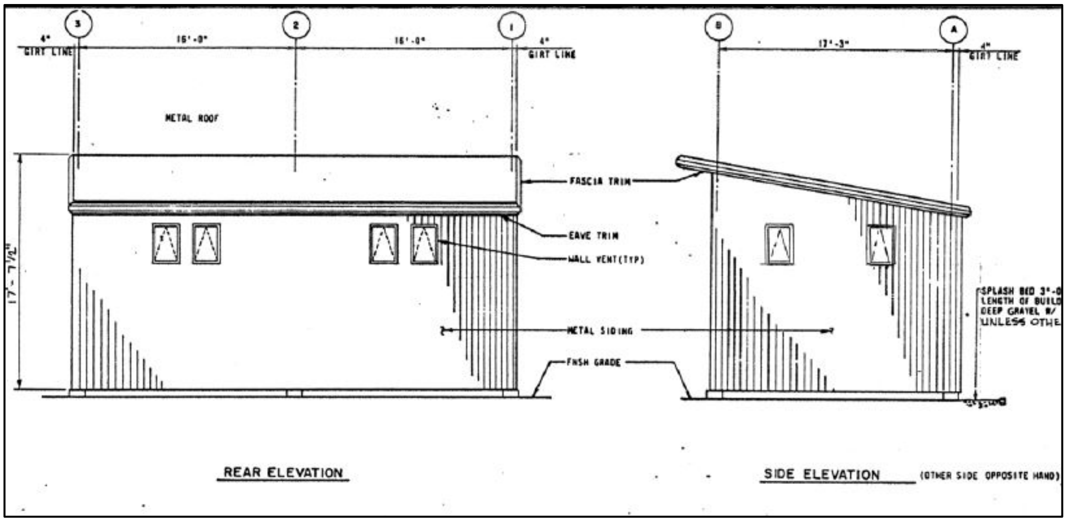
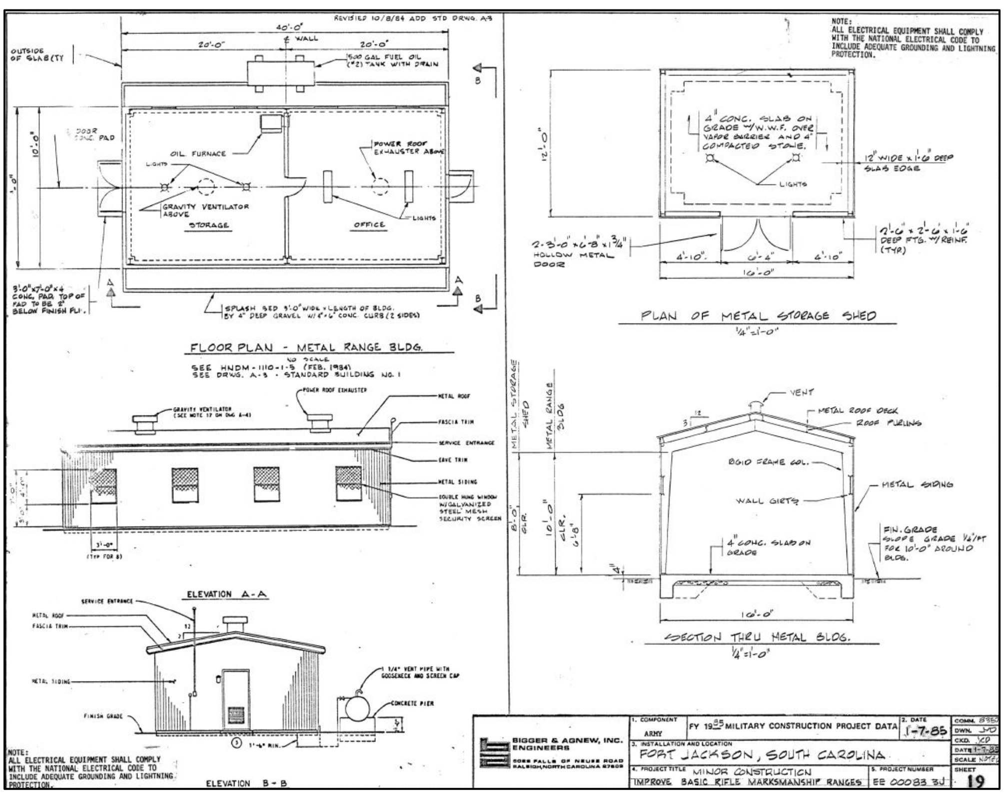



Figure 176. Prefabricated administrative building at Fort Jackson, South Carolina from 1985 (Adam D. Smith and Sunny E. Adams, "Fort Jackson range architectural inventory," ERDC/CERL SR-04-7, Champaign, IL: Engineer Research and Development Center-Construction Engineering Research Laboratory).



### 2.5.2 Housing

As the DoD began to transition to a volunteer military, the provision of good family housing became a priority. The need for this was perhaps best summarized by General E.R. Heilberg, III, the Chief Engineer of the US Army, in a 1986 *Military Engineer* article discussing the changing goals of the Army Corps of Engineers: “We recruit the soldier, but we retain the family.”[200] The Army Corps of Engineers had been building housing for the Air Force since the 1940s, and their housing construction program, particularly for the Army, expanded dramatically during the early 1980s.[201] In 1982, Congress directed the construction of 200 premanufactured two-story, two-bedroom housing units with attached garages at Fort Irwin, California. These units averaged 950 square ft and cost about $49,000 each.[202] By 1986, the Army Corps of Engineers had a manufactured housing program that constructed 1,500 buildings at installations in the US and abroad. Many of these houses were of a modular design (Figure 177).[203]

Figure 177. A modular section of housing being lifted into place by crane, Fort Ord, California, 1986 (E.R. Heiberg, III, “The Corps of Engineers: Leaders in Customer Care,” *The Military Engineer* 78, no. 505 (Jan.–Feb. 1986): 6–9).

[200] E.R. Heiberg, III, “The Corps of Engineers: Leaders in Customer Care,” *The Military Engineer* 78, no. 505 (Jan.–Feb. 1986): 6–9.

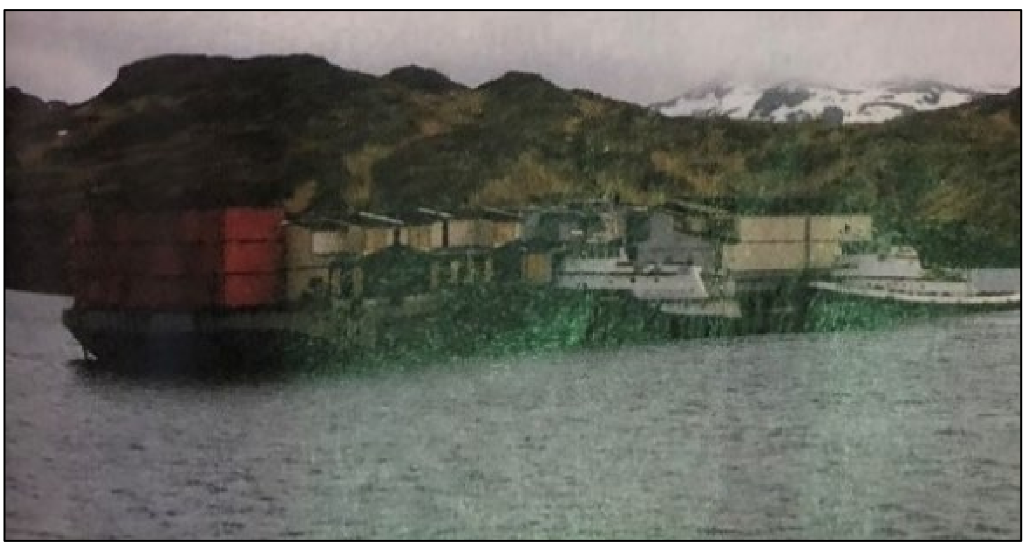
[201] Ibid; US Army Corps of Engineers, “A Brief History of the Corps: Introduction,” History, accessed Aug. 16, 2021, https://www.usace.army.mil/about/history/brief-history-of-the-corps/introduction/.

[202] Newman, “Overseas Housing Strategies.”

[203] Heiberg, III, “The Corps of Engineers: Leaders in Customer Care.”

Modular premanufactured homes were well-suited to military use as they could be erected on-site with far fewer workers and in less time than traditional housing. This was particularly useful in remote locations such as Adak Island, Alaska, where large crews and long erection times were undesirable. To develop the Adak Naval Operating Base, the Navy contracted J. A. Jones Company. The company constructed offices and two large metal warehouses on 14 riverfront acres in Portland, Oregon. One warehouse produced components for the first floors of housing, while the other produced second floors; all floors were constructed in a traditional, stick-built design. Upon completion, the components were stacked on reinforced, continuous-grade beams cast in the yard. A large, flat-decked derrick barge transported these structures to two ocean-going barges. Finally, in April 1986, a tugboat left Portland's harbor on a seven-day, 3,000-mile voyage carrying 43 completed housing units to Adak Island, Alaska (Figure 178). Two additional trips transported 30 and 22 housing units, respectively.[204]

Figure 178. Tugboats bringing a barge with Navy housing units into the port at Adak Island, Alaska, 1986 (James F. Howell, Sr., "Building Houses in a Different Way," *The Military Engineer* 80, no. 525 (Nov.–Dec. 1988): 581–582).



The houses were offloaded at Adak, at times in the face of 80–100 mph winds. At one point, a 7.74 earthquake stopped operation. Once they were offloaded, the units were transported one mile to their destination via two welded-together trailers. They were then lifted onto concrete foundations and joined in groups of two, three, and four (Figure 179). The buildings

[204] James F. Howell, Sr., "Building Houses in a Different Way," *The Military Engineer* 80, no. 525 (Nov.–Dec. 1988): 581-582.

were completely furnished and "each unit feature[d] a 'greenhouse' over every patio that provide[d] natural light to an enclosed area so residents [could] enjoy greenery that is scarce on Adak Island."[205]

Figure 179. A graphic depiction of several housing units combined into a complex at Adak Island, Alaska, 1988 (James F. Howell, Sr., "Building Houses in a Different Way," *The Military Engineer* 80, no. 525 (Nov.–Dec. 1988): 581–582).

### 2.5.3 Kelly Klosure Systems

Kelly Industries' building division, Kelly Klosure Systems, offered small-span buildings of clear span widths up to 24 ft and eave heights up to 12 ft (Figure 180). The Kelly Klosure System used pre-structured panels that provided enough structural support that independent framing was not required. These panels came both pre-insulated and uninsulated, and the exterior came in painted or plain galvanized finishes (Figure 181). These buildings were noncombustible and weather-tight, as well as easily relocatable.[206]

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[205] Howell, Sr., "Building Houses in a Different Way."

[206] Kelly Industries, Inc., "You've asked, We're responding…" *The Military Engineer* 87, no. 570 (April – May 1995): 49; Kelly Industries, Inc., "Simple enough to build yourself," *The Military Engineer* 88, no. 577 (April – May 1996): 43; Kelly Industries, Inc., "Preengineered Buildings," *The Military Engineer* 89, no. 582 (Jan. 1997): 21.

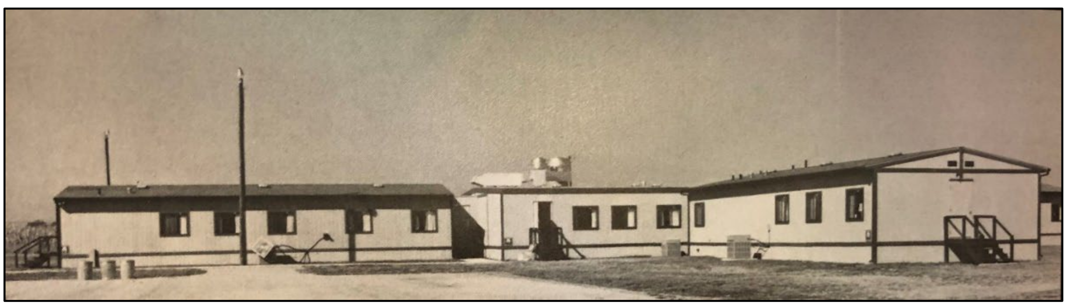
Figure 180. A Kelly Klosure System building that was erected as a classroom for the 440th Tactical Air Wing in Milwaukee, Wisconsin, 1997 (Kelly Industries, Inc., “Preengineered Buildings,” *The Military Engineer* 89, no. 582 (Jan. 1997): 21).

Figure 181. Kelly Klosure Systems advertisement showing a typical structure on the top right, as well as cross sectional view of their pre-insulated structured panels on the bottom left, 1995 (Kelly Industries, Inc., “You’ve asked, We’re responding…” The Military Engineer 87, no. 570 (April–May 1995): 49).

### 2.5.4 Modular Relocatable Buildings

Beginning in the 1980s, prefabricated, modular structures were delivered to sites fully constructed by companies such as Modulaire Industries (Modulaire) and Williams Mobile Offices (Figure 182, Figure 183, and Figure 184). These structures served as temporary or permanent field offices, living quarters, and even clean-rooms, complete with showers and an air filtration system (Figure 185). Most structures were single story, though two story options were available. They were easily adaptable and often arranged in multi-sectional complexes joined by enclosed hallways. Modulaire offered delivery from 17 points across the US, while Williams Mobile Offices had five.[207] Built, Inc., of Blairsville, Georgia, also manufactured modular, relocatable office buildings. These could serve as both exterior and in-plant offices, which indicates that they would have been constructed on-site, though there is no definitive evidence of this (Figure 186).[208]

Figure 182. A series of modular buildings premanufactured by Modulaire and arranged together in a complex, 1982 (Modulaire Industries, "Call to Quarters," *The Military Engineer* 74, no. 482 (Sept.–Oct. 1982): 420).



[207] Modulaire Industries, "Call to Quarters," *The Military Engineer* 74, no. 482 (Sept. – Oct. 1982): 420; Williams Mobile Offices, "The company behind these buildings is Williams," *The Military Engineer* 76, no. 492 (March – April 1984): 129.

[208] Panel Built, Inc. "A better way to create space," *The Military Engineer* 90 (1997): n.p.

Figure 183. Several buildings manufactured by Modulaire. In the rear of the photo are many modular buildings connected end to end to make two long buildings. On the bottom left is an interior view of a modular office, many of which came pre-furnished, 1984 (Williams Mobile Offices, "The company behind these buildings is Williams," *The Military Engineer* 76, no. 492 (March–April 1984): 129).

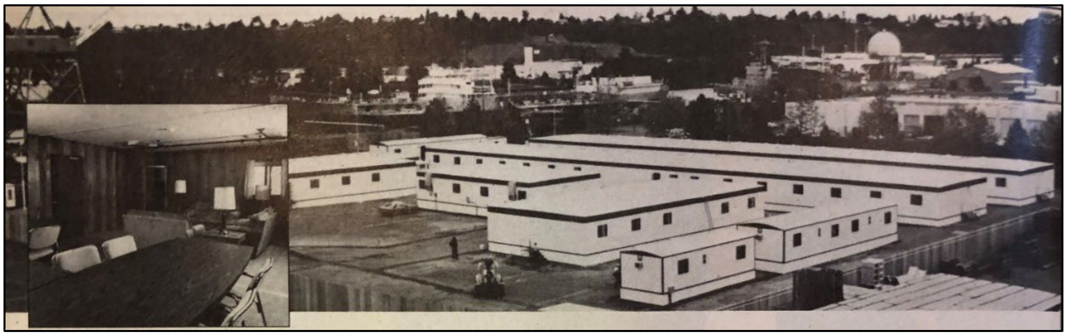


Figure 184. Williams Mobile Offices advertisement showing different models of modular structures, as well as a view of a typical interior, 1984 (Williams Mobile Offices, "The company behind these buildings is Williams," *The Military Engineer* 76, no. 492 (March–April 1984): 129.

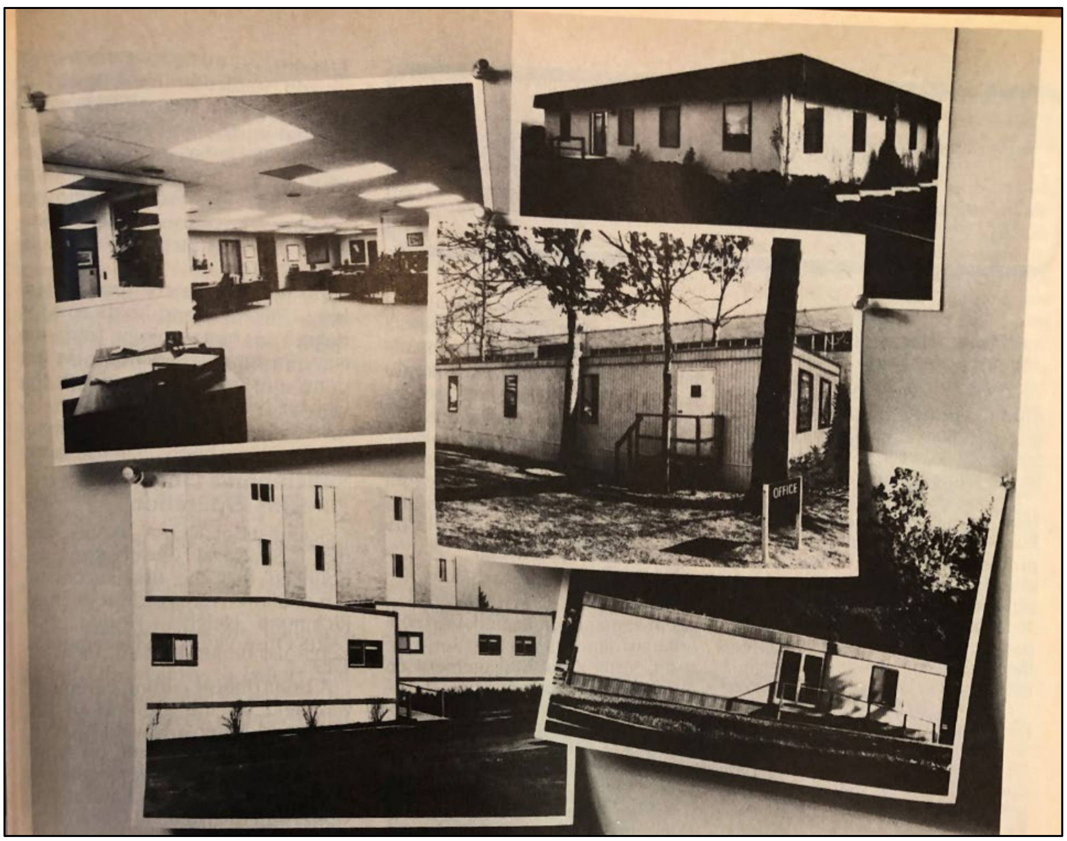
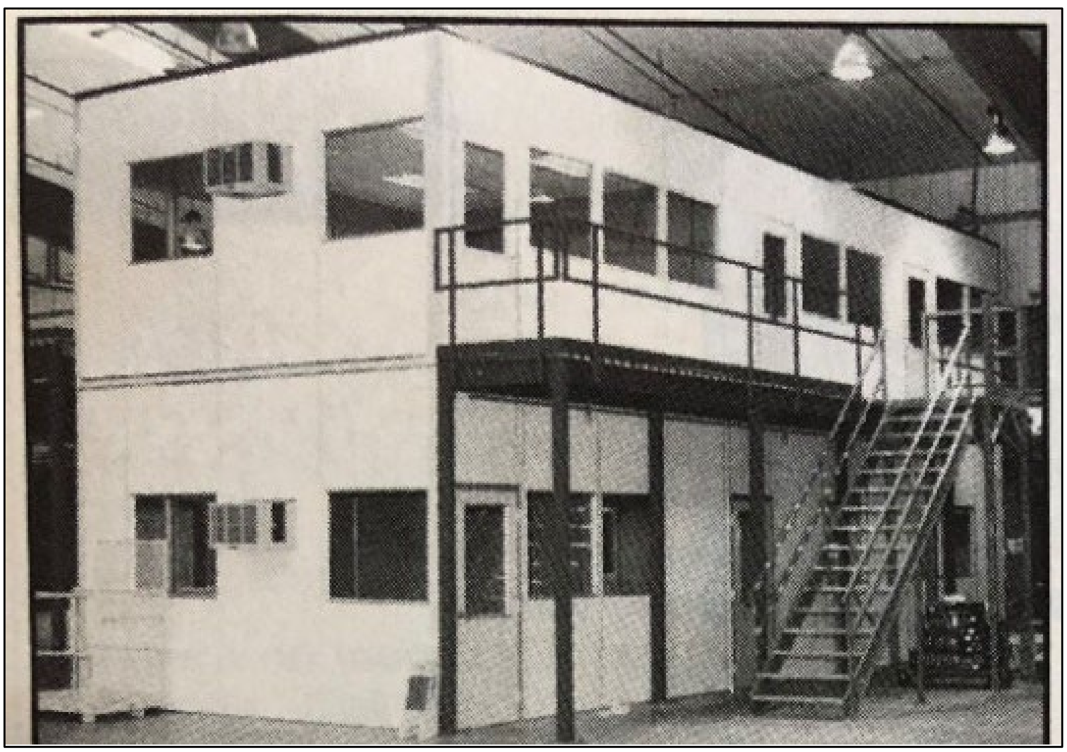


Figure 185. An arched-roofed modular clean-room manufactured by Williams Mobile Offices. It had toilets, showers, lockers, HVAC systems, and an air filtration system, 1984 (Williams Mobile Offices, "The company behind these buildings is Williams," *The Military Engineer* 76, no. 492 (March–April 1984): 129).

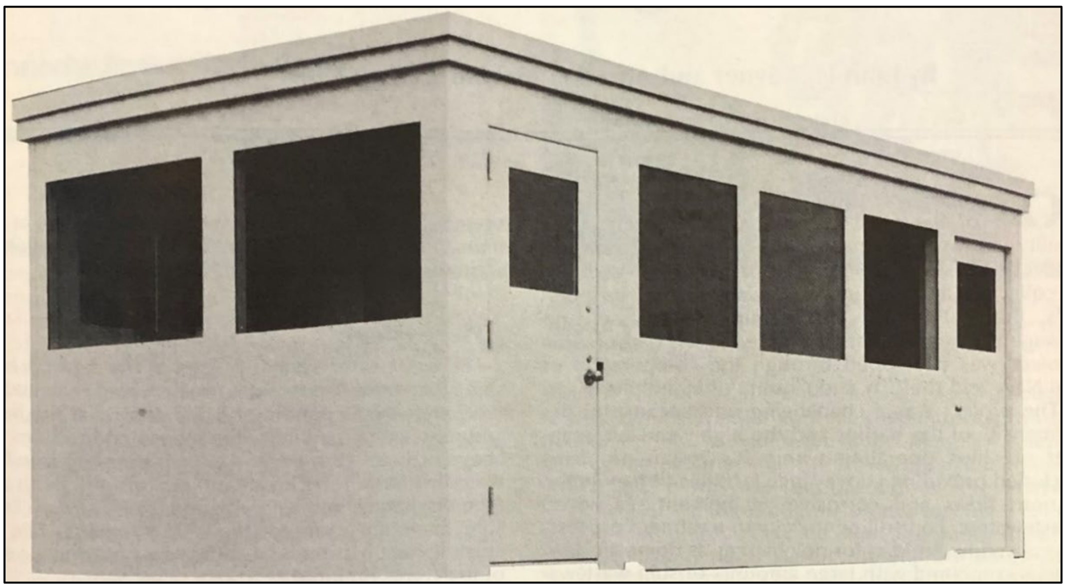
Figure 186. A two-story in-plant office structure manufactured by Panel Built, Inc., with multiple entrances on both the first and second stories, 1997 (Panel Built, Inc. "A better way to create space," *The Military Engineer* 90 (1997): n.p.).



### 2.5.6 Armored Guard Stations

For hardened, defensive structures necessary at base entrances, companies manufactured prefabricated modular buildings that were bulletproof and met Nuclear Regulatory Commission (NRC) regulations. Overly Manufacturing Company marketed prefabricated armored guard stations, sally ports, and armored towers that would be delivered in completed form to the site (Figure 187).[209]

Figure 187. A two-door bulletproof sally-port manufactured by Overly Manufacturing Company, 1982 (Overly Manufacturing Company, "Stops Bullets. Also Invaders," *The Military Engineer* 74, no. 478 (March 1982): 99).



### 2.5.7 Hazardous Material Storage

Prefabricated structures were particularly useful for hazardous material storage, which became a higher priority during the late Cold War. Prior to the introduction of stringent environmental regulations, traditional prefabricated structures were used for the storage of hazardous material (Figure 188); however, these were unable to safely contain some types of hazardous material. Environmental Products, Inc., sold a completely prefabricated metal structure known as a "Rust-Guard," which was designed for the sole purpose of storing hazardous materials. The building had an electrostatically applied, corrosion-resistant coating on both sides of the stainless steel panels. It also used corrosion-resistant fasteners.

[209] Overly Manufacturing Company, "Stops Bullets. Also Invaders," *The Military Engineer* 74, no. 478 (March 1982): 99.

There was no ground-to-metal contact, which protected against contamination (Figure 189).[210] While the "Rust-Guard" was a more permanent solution for hazardous materials storage, prefabricated structures were also used for decontamination because they could be erected quickly and moved when decontamination was finished. P & D Systemtechnic, Inc., sold a modular, environmentally safe relocatable hazardous materials storage and containment warehouse. The roof was made of a polycarbonate that allowed for 75–80% of sunlight to pass through. These buildings had secondary containment sumps for spills, and had four corridor width options, allowing completely enclosed corridors that could fit forklift and/or truck traffic to be created between warehouses.[211]

Figure 188. A metal prefabricated building in which a barrel of radioactive Americium 241 was discovered in 1986. The structure appears to be a Mesker Building due to the truss design combined with the pre-framed doorway and sidewalls, Wright Patterson AFB, Ohio, 1991 (Richard A. Phelps, "Environmental Management Offices: Key to the Air Force's Future Viability," *The Military Engineer* 83, no. 543 (July 1991): 44–46, 45).

[210] Environmental Products, Inc., "Stop rust from putting holes in your environmental containment plans," *The Military Engineer* 85, no. 556 (May - June 1993): 47.

[211] "Random Rubble: Modular HazMat Warehouses," *The Military Engineer* 85, no. 560 (Nov.–Dec. 1993): 71.

Figure 189. An example of a Rust-Guard building manufactured by Environmental Products, Inc., 1994 (Environmental Products, Inc., “Stop rust from putting holes in your environmental containment plans,” *The Military Engineer* 85, no. 556 (May–June 1993): 47).


In certain instances, traditional prefabricated metal buildings could be used for hazardous materials storage. For example, a self-framing building was deployed by the Army Corps of Engineers in 1995 to clear the site of Camp American University, which had been used for chemical weapons testing during WWI. Camp American University in Washington, DC, was leased in 1917 and was used as a site for the chemical research of 250 gases in temporary structures. “By 1921, the installation was closed, its earthworks filled, and the wooden buildings burned.” In 1993, a backhoe found a cache of chemical munitions, so the Army Corps of Engineers deployed a deep-corrugated, straight-sided self-supporting steel prefabricated building for containment (Figure 190).[212]

[212] Craig A. Crotteau, “Cleaning Up Chemical Munitions,” *The Military Engineer* 87, no. 573 (Oct. – Nov. 1995): 38-41.

Figure 190. Pictured is straight sided deep-corrugated self-framing structure used by the Army Corps of Engineers to contain hazardous materials, note the metal frame at the base of the structure with slots for the deep-corrugated side walls, Camp American University, Washington, DC, 1995 (Craig A. Crotteau, "Cleaning Up Chemical Munitions," *The Military Engineer* 87, no. 573 (Oct.–Nov. 1995): 38–41).

Construction of the vapor containment structure.

### 2.5.8 Quonset Huts

Many extant Quonset huts continued to be used through the end of the Cold War. Consequently, many needed to be refurbished or otherwise repaired to allow continued use. In *Military Engineer*, Curveline, Inc., marketed replacement curved panels as "an attractive cost-effective way to refurbish aging Quonset huts."[213] These were applied either by adding 24-

[213] Curveline, Inc., "New Products & Services: Curved Panels," *The Military Engineer* 88, no. 581 (Dec. 1996): 68.

gauge panels directly over top of existing panels or stripping off existing panels and replacing them with 20-gauge curved panels (Figure 191).[214]

Figure 191. A Quonset hut being rehabilitated by Curveline, Inc., unknown location, 1996 (Curveline, Inc., "New Products & Services: Curved Panels," *Military Engineer* 88, no. 581 (Dec. 1996): 68).

### 2.5.9 Automatic Building Machine (ABM) System

M.I.C Industries of Virginia introduced the Automatic Building Machine (ABM) System in the late 1980s as a method for building self-framing structures. The ABM consisted of an onsite metal fabricator on a trailer, called a K-Span Mobile Factory, where sheet metal would be formed into curved panels which were then crimped together with an automatic seaming machine that rode over the buildings, providing a weatherproof and permanent structure that required no bolts or screws (Figure 192 and Figure 194). These buildings could also be de-seamed, moved, and reused elsewhere. The two qualities of this building system most important to military users were its erection speed and low cost. The ABM System allowed a crew of seven to 14 men to erect 5,000 to 10,000 square ft of coverage in a single day for only four to six dollars per square foot, a "cost that is competitive with tents."[215] This system was extremely flexible, as ABM could make straight-walled structures with flat or peaked roofs, as

[214] Ibid.

[215] Forrest T. Gay, "Steel Buildings – On the Double," *The Military Engineer* 82, no. 535 (May–June 1990): 53–54.

well as addition to more traditional "half-round" structures with widths ranging from 12 to 120 ft and any length. Additionally, these structures could be insulated by placing a building within a building (Figure 195). The Army Corps of Engineers Construction Engineering Research Laboratory, tested this building system's structural integrity and performance, clearing them for use in mobilization.[216]

Figure 192. ABM System advertisement for portable metal forming machine showing ABM buildings in military use, 1993 (M.I.C. Industries, Inc., "Build metal structures in one day," *The Military Engineer* 82, no. 535 (May–June 1990): 52).


[216] Gay, "Steel Buildings – On the Double;" M.I.C. Industries, Inc., "Build metal structures in one day," *The Military Engineer* 82, no. 535 (May–June 1990): 52.

Figure 193. The final components of an ABM structure are being hoisted into place by crane. The structure is fitted with a large utility door, as well as a personnel door on the far right of the structure, 1990 ((M.I.C. Industries, Inc., “Build metal structures in one day,” *The Military Engineer* 82, no. 535 (May–June 1990): n.p.).

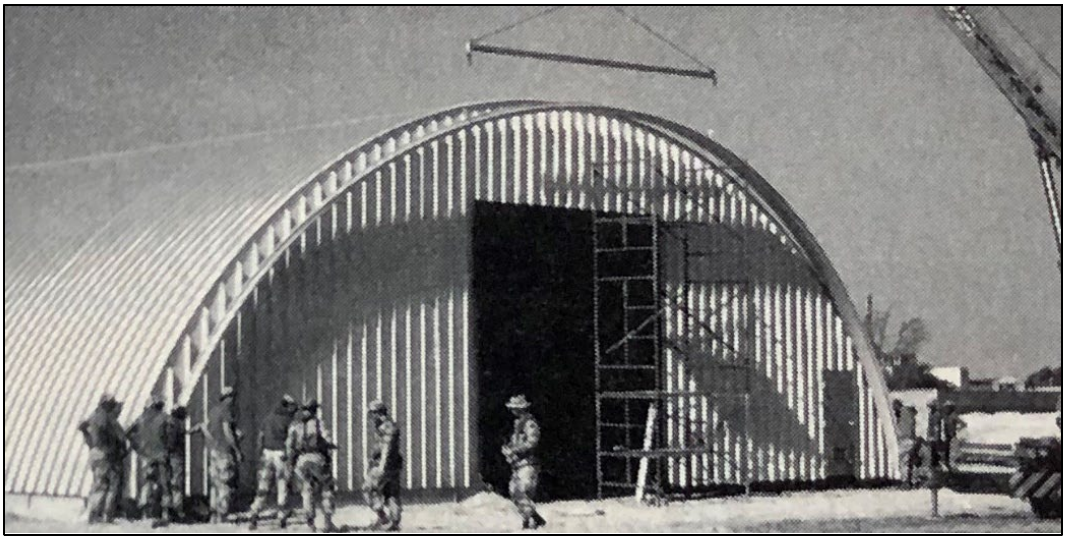
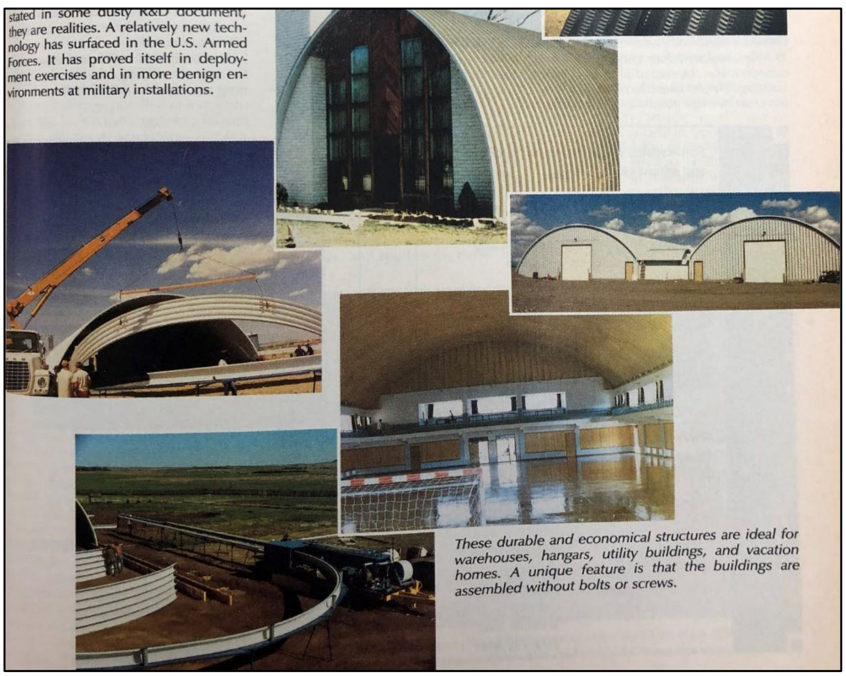


Figure 194. The seam of an ABM structure is being crimped by the automatic seaming machine as it works its way up the side of the structure, 1990 (Forrest T. Gay, “Steel Buildings – On the Double,” *The Military Engineer* 82, no. 535 (May–June 1990): 53–54).

ABM buildings were used by the DoD as early as 1987, when they were deployed with engineering units in exercise "Bright Star" in Egypt. They were also used domestically that year at Holloman AFB, New Mexico; Fort Lewis, Washington; and Fort Stewart, Georgia. The ABM System was used by all branches of the DoD during Operation Desert Storm, as this was the first time the Seabees employed the technology (Figure 196). Seventeen buildings were erected in Saudi Arabia within 40 days; 29 ABM buildings were used in total. Six were used on the flight line, while 17 served as ammunition storage. The types of AMBs used in Desert Storm were the basic Model MIC-120 K-Span, the Model MIC-240 Type Super-Span, and the MIC-160 Ekonospan.[217] New ABM systems were introduced, such as the UBM-2000, which featured a computer-controlled K-Span machine (Figure 197 and Figure 198).[218]

Figure 195. Images of ABM System structures showing both the construction method for and versatility of this building system, 1990 (Forrest T. Gay, "Steel Buildings – On the Double," *The Military Engineer* 82, no. 535 (May–June 1990): 53–54).




[217] Joe Morales, "Random Rubble: ABMs Used in Operation Desert Storm," *The Military Engineer* 83, no. 542 (May–June 1991): 37.

[218] "Random Rubble: MIC's UBM-2000," *The Military Engineer* 85, no. 540 (Nov.–Dec. 1993): 71; "New UBM," *The Military Engineer* 89, no. 582 (Jan. 1997): 346.

Figure 196. An ABM building being erected in Saudi Arabia during Operation Desert Storm, 1991 (Joe Morales, “Random Rubble: ABMs Used in Operation Desert Storm,” *The Military Engineer* 83, no. 542 (May–June 1991): 37).

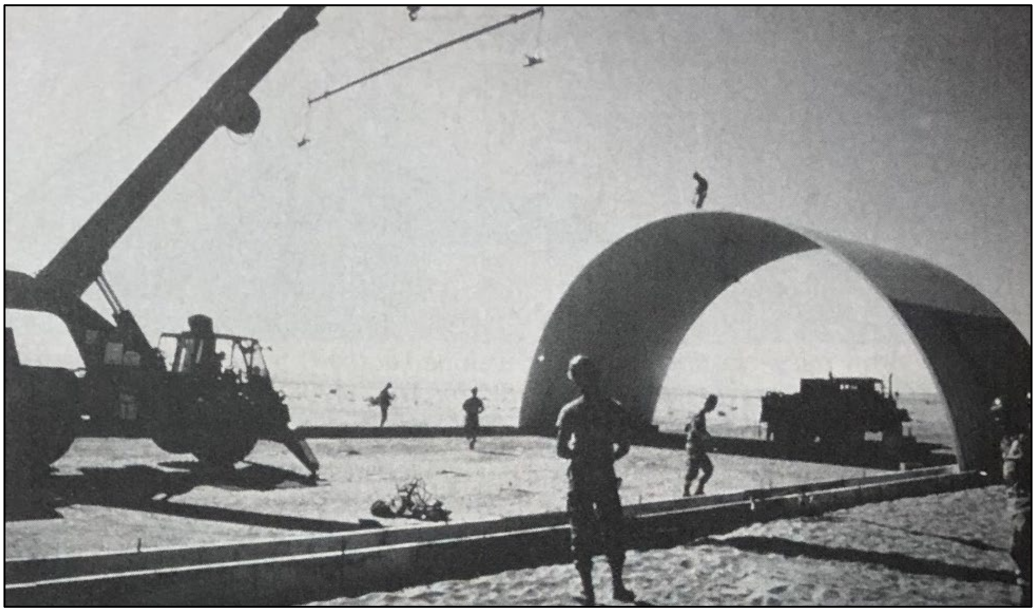


Figure 197. A section constructed using the UBM-2000 as part of a demonstration for “scores of observers representing construction, military, and foreign government sectors,” 1993 (“Random Rubble: MIC’s UBM-2000,” *The Military Engineer* 85, no. 540 (Nov.–Dec. 1993): 71).

Figure 198. One of four ABMs erected by the Air National Guard using the UBM-2000 at their Regional Training Center, North Carolina, 1997 ("New UBM," *The Military Engineer* 89, no. 582 (Jan. 1997): 346).

### 2.5.10 Fabric Deployable Structures

Several companies began marketing metal-framed fabric deployable structures for military use during the mid-1980s. The most notable of these companies was Rubb, Inc. of Sanford, Maine. Rubb's earlier fabric structures had 10 ft to 82 ft spans, but they could span up to 260 ft by 1997 (Figure 199 and Figure 200). They could be made any length and required minimal site preparation. They were also compactly shipped and, therefore, could be distributed by air.[219]

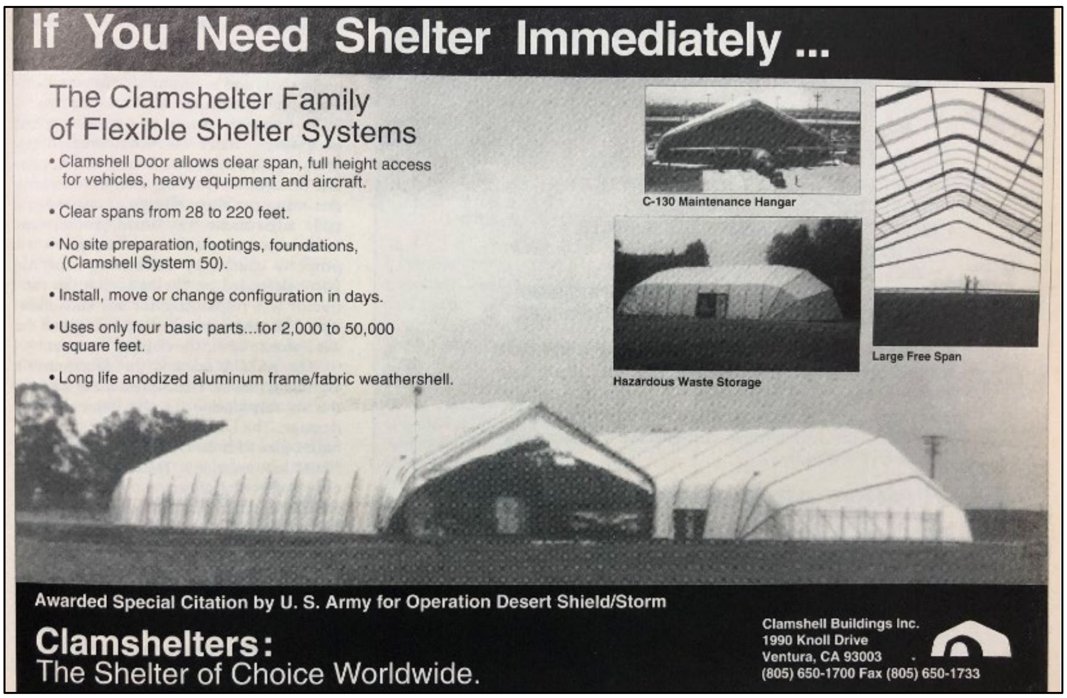
[219] Rubb, Inc., "Fabric Engineering-War Zone Tested," *The Military Engineer* 89, no. 583 (Feb. – Mar. 1997): 26; Rubb, Inc., "Deployable Buildings for the Army, Navy, Airforce & Marines," *The Military Engineer* 78, no. 505 (Jan. – Feb. 1986): 88.

Figure 199. Advertisement for Rubb fabric structures, 1986 (Rubb, Inc., “Deployable Buildings For the Army, Navy, Airforce & Marines,” *The Military Engineer* 78, no. 505 (Jan.–Feb. 1986): 88).


Figure 200. Advertisement for Rubb fabric structures, 1997 (Rubb, Inc., “Fabric Engineering-War Zone Tested,” *The Military Engineer* 89, no. 583 (Feb.–Mar. 1997): 26).

Other companies that made similar structures included Clamshell Buildings, Inc., which used an anodized aluminum frame to cover 28–220 ft clear spans, allowing buildings from 2,000–50,000 square ft to be constructed. These buildings, which saw deployment in the Gulf War, required no foundation and featured a clam door, which spanned the entire height of the building, allowing for easy access for heavy equipment and aircraft (Figure 201).[220] Another similar company was Big Top Manufacturing, which produced structures similar to those designed by Rubb (Figure 202).[221]

Figure 201. Advertisement for Clamshell Buildings, Inc., 1993 (Clamshell Buildings, Inc., "If you need shelter immediately...," *The Military Engineer* 85, no. 557 (July 1993): 23).




[220] Clamshell Buildings, Inc., "If you need shelter immediately...," *The Military Engineer* 85, no. 557 (July 1993): 23.

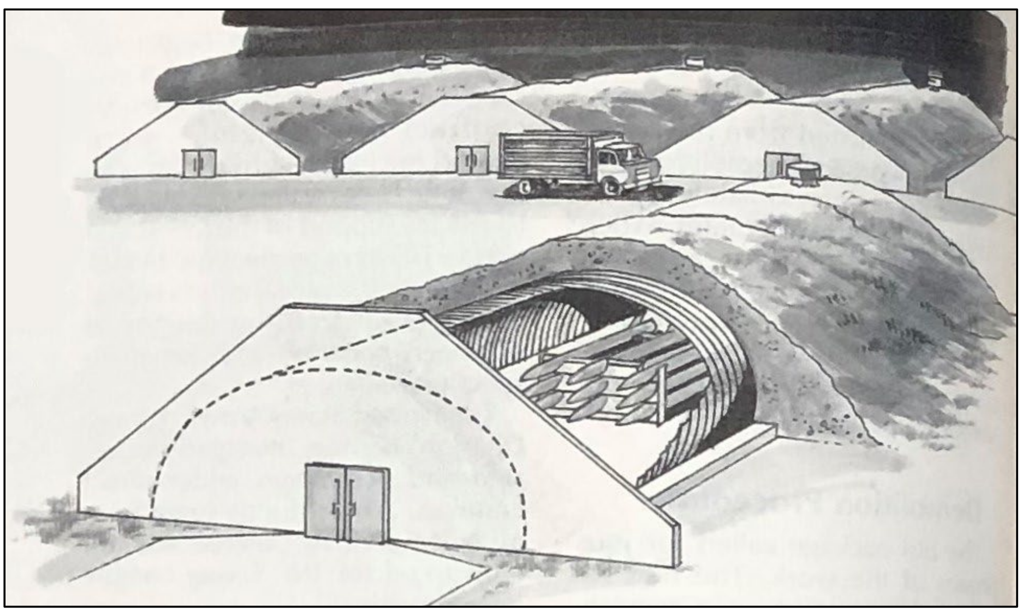
[221] Big Top Shelters, "Relocatable Shelters," *The Military Engineer* 88 (1996): 21.

Figure 202. Advertisement for Big Top Shelters, 1996 (Big Top Shelters, "Relocatable Shelters," *The Military Engineer* 88 (1996): 21).

### 2.5.11 Hardened Steel Structures

By the end of the Cold War, the prototypes of hardened, deep-corrugated steel buildings that were tested in the 1960s had developed into marketable structures. Syro Steel Company's corrugation pattern for their hardened structures, called DEEP COR©, consisted of 5-1/2-in. by 15 in. corrugations. Syro offered "ordnance storage igloos" which required earth covering for additional protection and could cover spans up to 60 ft (Figure 203). Forty-foot-wide versions of these igloos were installed at Hickam AFB, Hawaii. Similar structures were available for a variety of applications such as "instrumentation bunkers, armories, barracks, command/communication, emergency and maintenance vehicle shelters [and] housing" (Figure 204).[222] Syro's DEEP COR© was strong enough that it was the deep corrugation chosen by NATO for their Third Generation Hardened NATO shelters. Sections of this shelter received ballistic testing at Kirtland AFB, New Mexico. The advertised width of Syro's hardened aircraft shelters had up to 210 ft spans, which was enough to accommodate an E-3A surveillance aircraft (Figure 205).[223]

Figure 203. Cross-section of a prefabricated Ordnance Storage Igloo which is covered in dirt for added protection (Syro Steel Company, "Syro Communique: Military Applications Addressed by Syro Steel," *The Military Engineer* 82 (1990): n.p.).



[222] Syro Steel Company, "Syro Communique: Military Applications Addressed by Syro Steel," *The Military Engineer* 82 (1990): n.p.

[223] Syro Steel Company, "Syro Communique: Military Applications Addressed by Syro Steel."

Figure 204. A Syro prefabricated hardened structure, depicted with three ventilators to provide air flow to the underground structure (Syro Steel Company, "Syro Communique: Military Applications Addressed by Syro Steel," *The Military Engineer* 82 (1990): n.p.).

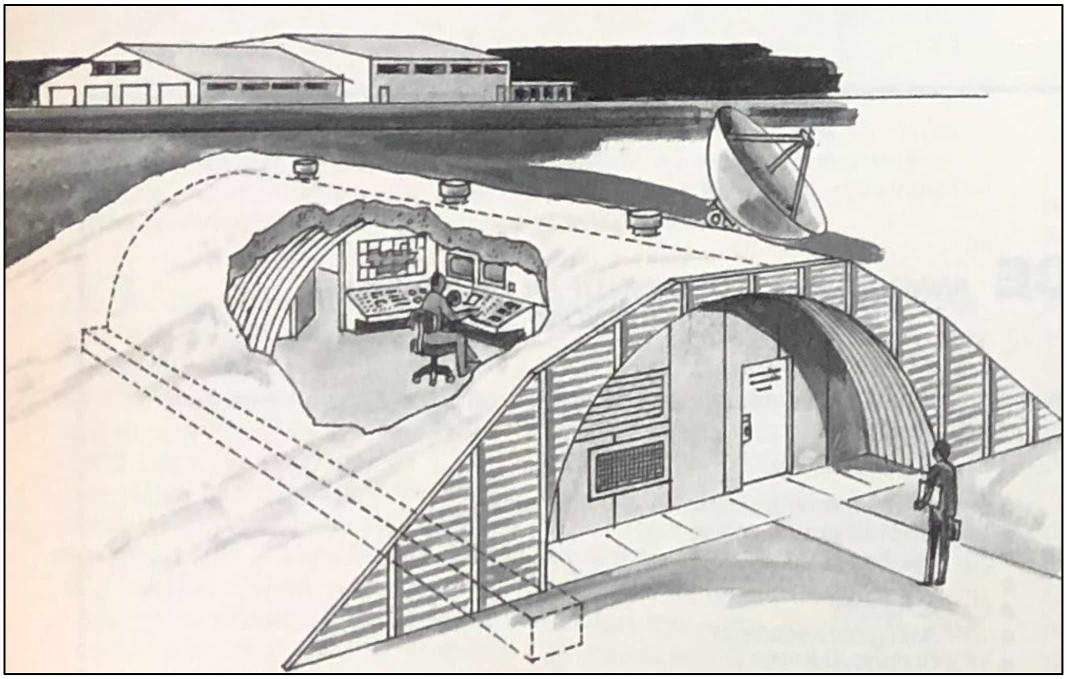
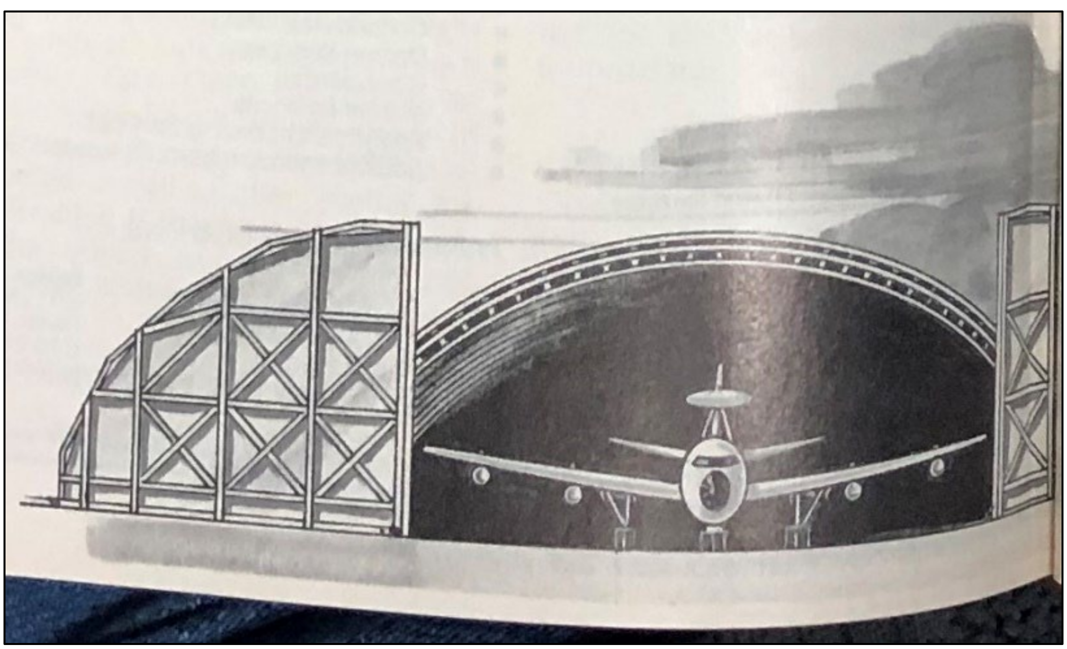


Figure 205. A Syro hardened airplane hangar, which could span up to 210 ft (Syro Steel Company, "Syro Communique: Military Applications Addressed by Syro Steel," *The Military Engineer* 82 (1990): n.p.).



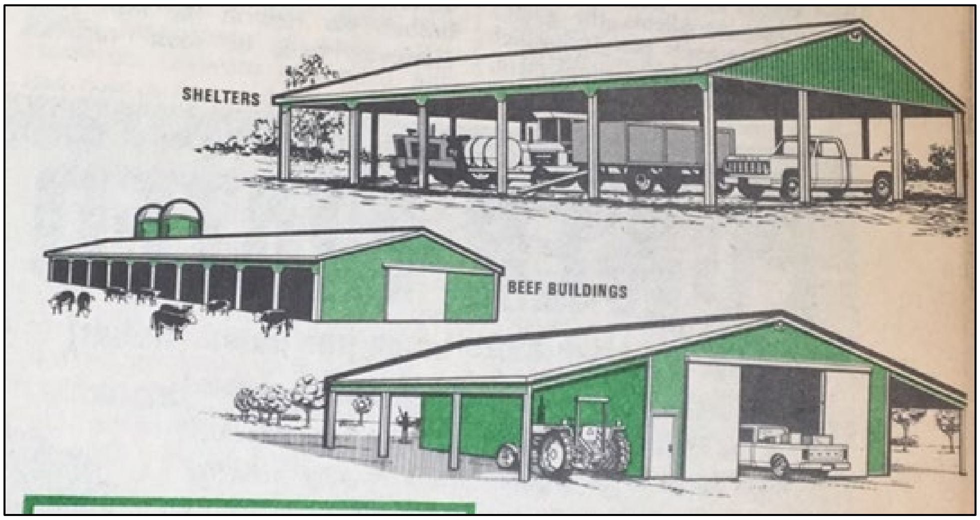
### 2.5.12 Wood Construction

By the late Cold War, several companies began marketing wooden prefabricated structures that had a metal exterior. These hybrid structures first gained popularity for agricultural use but gained popularity in the DoD for similar applications as pole barns. Buildings of this type almost exclusively featured trusses as roof support. Wickes Buildings, based in Huntsville, Alabama; Macon, Georgia; and Jackson, Tennessee, was an early company manufacturing such structures. Wickes' exteriors could be either steel or aluminum. They also came in a variety of designs ranging from warehouse-sized barns to open-walled shelters (Figure 206 and Figure 207). Wickes did not operate under the dealer system, but instead marketed directly to buyers and used crews of Wickes workers to erect buildings.[224]

Figure 206. A typical Wickes Building. This design, intended for machine storage, was one of many standard models and designs offered by this company, 1977 (Wickes Buildings, "The Peak of Excellence," *Progressive Farmer* 92 (Jan. 1977): n.p.).

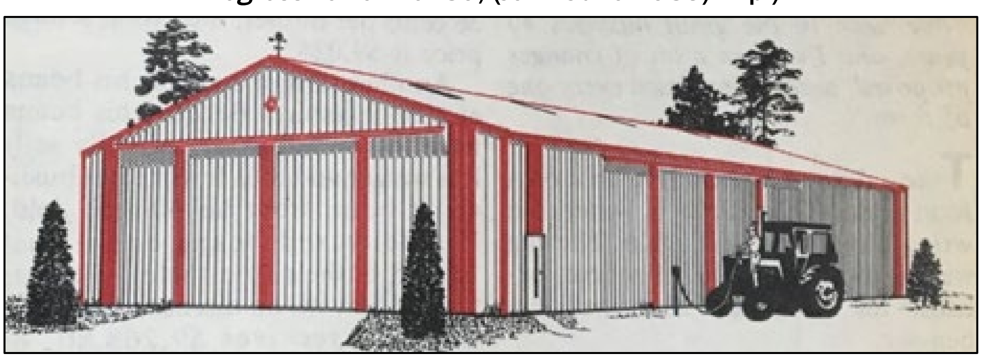

[224] Wickes Buildings, "The Peak of Excellence," *Progressive Farmer* 92 (Jan. 1977): n.p.

Figure 207. Several varieties of Wickes Buildings offered, including open walled shelters, January 1977 (Wickes Buildings, "The Peak of Excellence," *Progressive Farmer* 92 (Jan. 1977): n.p.).




Morton Buildings of Morton, Illinois, was another manufacturer of wood framed structures with sheet metal exteriors (Figure 208 and Figure 209). Morton offered customization of their buildings, with optional concrete floors, insulation, windows, skylights, and huge doors. Like Wickes, they used their own crews to erect buildings and marketed directly to buyers, with local sales offices serving over 40 states. This national marketing allowed Morton to maintain a directory of over 75,000 Morton Building owners across the country offering tours of their buildings.[225]

Figure 208. A typical Morton Building. Listed advantages included the use of 0.020 in. thick galvanized steel, with 0.9 oz minimum of zinc galvanization per square foot, and a silicone polyester paint system, 1983 (Morton Buildings, [Advertisement], *Progressive Farmer* 89, (Jan.–June 1983): n.p.).



[225] Morton Buildings, "Is a lifetime investment worth a half-hour tour?" *Progressive Farmer* 95 (Jan.–June 1980): 57; Morton Buildings, "Weather or Weather Not…You're Covered," *Progressive Farmer* 104 (Jan. – June 1989): n.p.

Figure 209. A "Basic Machine Storage" building by Morton Buildings, measuring 54 ft by 13 ft by 75 ft with 7 ft-6 in. truss and column spacing. It came complete with gutters and downspout, a 50-year snow warranty, and a five-year wind warranty for $20,494, 1995 (Morton Buildings, [Advertisement], *Progressive Farmer* 110 (1995): n.p.).

Hybrid wood and steel construction was also used during this period for roofing systems. TrusWal Systems, Inc., of Troy, Michigan, used metal SpaceJoist Webs to make flat chord trusses with two-by-fours, supplemented by either wood truss or steel purlins (Figure 210).[226]

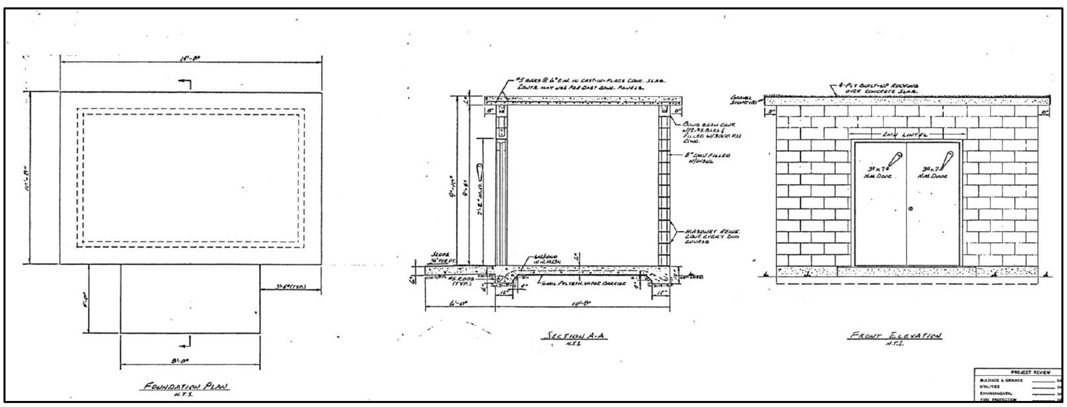
Figure 210. The frame of a building erected by TrusWal Systems Inc. showing the SpaceJoist Webs in the flat chord truss (Jack N. Schmidt, "Schmidt: Truss Business Will Double in Next 10 Years," *Automation in Housing and Building System News* (Feb. 1979): 55).

[226] Jack N. Schmidt, "Schmidt: Truss Business Will Double in Next 10 Years," *Automation in Housing and Building System News* (Feb. 1979): 55.

### 2.5.13 Concrete Construction

While the DoD continued to use concrete for utilitarian construction both on installations and in theater through the end of the twentieth century, the methods of construction did not change from those utilized during WWII and the early Cold War period. During this period, the DoD primarily used CMU construction, rather than the pre-cast or cast-in-place methods that were common during the Vietnam War era. The use of CMU construction for housing also decreased during this period, with CMU construction instead being primarily for utility buildings (Figure 211).

Figure 211. Example of a concrete block utility building at Fort Jackson, South Carolina from 1982 (Adam D. Smith and Sunny E. Adams, “Fort Jackson range architectural inventory,” ERDC/CERL SR-04-7, Champaign, IL: Engineer Research and Development Center-Construction Engineering Research Lab).



# 3 DoD Real Property Assets Database Analysis

## 3.1 Background

In order to meet this project's objective of providing documentation of Cold War era facilities constructed from 1946 to 1991 that could be classified as utilitarian in the DoD RPAD, researchers analyzed the types of facilities classified as such within the database. The DoD RPAD is a DoD-wide database of real property, or land and improvements to land including buildings and structures, which is compiled annually by OSD from inventories conducted by the Armed Services. The first level of collection occurs at individual installations, which have their own real property databases.

There is no existing definition of or typology for utilitarian as it applies to DoD RPAD. Given that the ultimate goal of this research is to define a "utilitarian" typology for the DoD based on existing DoD RPAD entries in an effort to provide the empirical background for a program alternative to Section 106, the research team developed a tentative definition of utilitarian to narrow their scope when reviewing DoD RPAD entries in order to proceed with this study.

In collaboration with the DoD Cultural Resources Program (CRP) and Legacy Program staff, ERDC-CERL researchers developed tentative parameters for defining utilitarian facilities during the proposal period for this project. The proposal for this project thus established that, for a preliminary search through the DoD RPAD, utilitarian facilities are those that are less than 1,000 square ft and provide some utilitarian purpose on a DoD installation such as (but not limited to) miscellaneous storage, hazardous waste storage, wash racks, overhead covers, and pavilions. Properties that directly support or supported mission activities or are part of utility service infrastructure, such as (but not limited to) sewage lift stations, well covers, and electrical substations, were not considered utilitarian for the purposes of this report.

ERDC-CERL, DoD CRP, and Legacy Program staff also crafted a general construct for the proposal of this project of how the definition of temporary, semi-permanent, and permanent intersected with the actual facilities across the DoD. The definition of temporary facilities are those that have a life span of less than five years; the group hypothesized that this category would primarily consist of small-scale wood buildings and structures. Semi-permanent facilities are defined as those that have a life span greater than five years but less than 25 years; the group hypothesized that this category would primarily consist of metal buildings and structures. Finally, permanent facilities are those defined as having a life span greater than 25 years; researchers hypothesized that this category would primarily consist of buildings and structures constructed out of concrete block.

In 2018, after the proposal for this project—including the tentative definition of utilitarian outlined above—was accepted by the Legacy Program , the Department of Veterans Affairs (VA) and the ACHP released a NHPA Section 106 Program Comment for Vacant and Underutilized Properties. In this Program Comment, the VA and ACHP defined utilitarian resources as:

> building[s] or structure[s] of practical design, usually without much architectural ornamentation, utilizing traditional construction materials, with functions primarily limited to industrial and storage needs. VA's utilitarian properties tend to have standardized plans and little architectural design, complexity, or uniqueness, were constructed quickly, and have been determined by VA to have minor or no historic significance and/or diminished or no integrity. Utilitarian properties in VA's inventory could include, but are not limited to, warehouses, garages and carports, storage sheds, sewage plants, transformer buildings, incinerators, smoking shelters, pump houses, trailers, boiler/power plants, barns, Quonset structures, laundry facilities, golf shacks, gate houses, guard stations, connecting corridors, greenhouses, fallout shelters, maintenance shops (e.g., machine, paint, vehicle repair, housekeeping), animal research laboratories, and associated research sheds or ancillary buildings.[227]

Upon the Program Comment's release, the research team for this project sought to re-evaluate their tentative definition of utilitarian resources based on the VA and ACHP definition prior to analyzing the DoD RPAD entries for resources that could be considered utilitarian. The VA and ACHP definition was not definitively

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[227] Fowler, "Notice of Issuance of the US Department of Veterans Affairs Program Comment for Vacant and Underutilized Properties," 54123.

adopted by ERDC-CERL researchers while conducting research for this report, as this report seeks to define utilitarian based on DoD-owned real property; however, it did provide researchers with additional parameters for defining utilitarian resources. In particular, the VA and ACHP definition of utilitarian provided that utilitarian buildings and structures are defined by their lack of architectural features and the speed of their construction. This definition also provided researchers with a basis for analyzing the historical integrity of utilitarian resources in the DoD RPAD.

Based on both the definition of utilitarian tentatively developed by ERDC-CERL, DoD CRP, and Legacy Program staff and that released by the VA and ACHP in their Program Comment, ERDC-CERL researchers developed the following hypothetical definition of DoD real property utilitarian resources: buildings and structures of less than 1,000 square ft with a utilitarian purpose on DoD installations that have minimal architectural ornamentation; are wood, metal, or concrete construction; and were prefabricated, used prefabricated materials, or were constructed based on standardized plans. The researchers further hypothesized that these buildings and structures would be primarily of metal (rather than wood or concrete block) and semi-permanent (rather than temporary or permanent) construction.

## 3.2 DoD RPAD Data Collection

The DoD provided the ERDC-CERL research team with raw data from the DoD RPAD. The DoD's data collection parameters included all buildings or structures classified as temporary, all buildings or structures classified as semi-permanent, all buildings or structures of less than 1,000 square ft classified as permanent; the parameters excluded land, all facilities constructed before January 1, 1946, and after December 31, 1991, all disposed facilities, and all assets located outside of the United States and its territories. DoD provided buildings and structures larger than 1,000 square ft for both the temporary and semi-permanent categories to validate the hypothesis that the facilities in those two categories were indeed utilized for primarily utilitarian purposes regardless of size.

For DoD RPAD entries that met the above parameters, the DoD provided the following data elements concerning location and ownership: historic status; construction date; current and previous use(s); condition;

construction type, material, and status (temporary, semi-permanent, or permanent); and size. See Appendix B for a complete list of the parameters used for data collection and the data elements utilized.

## 3.3 Historic Status Codes

As ERDC-CERL researchers sought to identify utilitarian structures' eligibility for the NRHP (based on the VA and ACHP's definition of utilitarian structures as having minor or no significance and integrity), the data collected from the DoD RPAD system includes a data element entitled "RPA Historic Status Code," wherein "RPA" is an acronym for "Real Property Asset." Historic Status Codes (HSCs) are related to the RPA's NRHP eligibility status and are defined as "a code used to identify the current historical status of a real property asset."[228] The DoD uses thirteen HSCs, listed and defined in Table 1.

Table 1. Definitions of DoD HSCs.

| HSC | Definition | Description |
|---|---|---|
| DNE | Determined Not Eligible | A facility that has been evaluated for historic status and determined to be not eligible for listing on the NRHP. |
| DNR | NHLI/NHLC/NREI/NREC National Register Property—Designation rescinded | A facility formerly classified as an NHLI, NHLC, NREI, or NREC which has been determined to lack the integrity necessary to continue to be designated a historic property. |
| ELPA | Eligible for Purposes of a Program Alternative | An individual facility that is treated as eligible for listing on the NRHP by consensus of the relevant Federal Preservation Office, relevant State Historic Preservation Office, and ACHP during the development of a program alternative. |
| FCHR | FGHN Historic and Cultural Resource | An asset of a Foreign Government/Host Nation (FGHN) that the responsible DoD Component manages as a historic real property asset. This real property asset meets the definition of "Historic and Cultural Resources" in accordance with section G.2 of DoDM 4715.05-V1, DoD "Overseas Environmental Baseline Guidance Document (OEBGD): Conservation," June 29, 2020. In consultation with the FGHN, the DoD Component's cultural resources staff or its delegated trusted agents are responsible for identifying and evaluating historic and cultural real property assets in accordance with definitions and |

[228] Office of the Under Secretary of Defense, *Alternative Valuation Methodology for Establishing Opening Balances for Buildings, Structures, and Linear Structures* by Mark E. Easton (Washington, DC: GPO, 2016), https://comptroller.defense.gov/Portals/45/documents/fmr/archive/04arch/04_06_2016-01-19_RP_Opening_Bal_Val.pdf.

| | | |
|---|---|---|
| | | other requirements in the relevant Final Governing Standards (FGS), or OEBGD where no FGS exists. |
| NAR | Not Assessed Routinely | An asset that is not routinely planned to be evaluated for National Register of Historic Places (NRHP) eligibility. While not routinely assessed, these individual assets should be evaluated pursuant to 54 USC §306108 and 36 CFR Part 800 if there is a potential to affect historic properties. For purposes of physical inventory, assets assigned the Historic Status Code value NAR are not considered historic. The appropriate assignment of the RPA Historic Status Code value NAR is determined at the national level and Facility Analysis Category codes (FACCODES) appropriate for NAR value assignment are provided. If an asset has been previously assigned a Historic Status Code value other than NEV, the value remains unchanged and NAR should not be assigned. The value NAR should only be assigned to assets previously having a value of NEV. |
| NCE | Non-Contributing Element | An individual facility within the boundaries of a NRHP-listed or eligible historic district or National Historic Landmark District that has been evaluated and determined to not contribute to the historic or architectural significance of the district. |
| NEV | Not Evaluated | A facility that has not yet been evaluated for historic status. |
| NHLC | Contributing Element to a National Historic Landmark District | An individual facility that is identified as a contributing element of a historic district that is both listed on the NRHP and designated a National Historic Landmark by the Secretary of the Interior based on its significance to the nation's history. |
| NHLI | Individual National Historic Landmark | An individual facility which is individually listed on the NRHP and has further been declared to be a National Historic Landmark by the Secretary of Interior based on its significance to the nation's history. |
| NREC | Contributing Element to a District Determined Eligible for Listing on the NRHP | An individual facility that is identified as a contributing element of a historic district that has been determined eligible for listing on the NRHP but that has not been formally listed on the NRHP. |
| NREI | Individual National Register Eligible | An individual facility that has been determined to meet the NRHP criteria for eligibility but has not been formally listed on the NRHP. |
| NRLC | Contributing Element to a Listed NRHP District | An individual facility that is identified as a contributing element of a historic district that is formally listed on the NRHP. |

| | | |
|---|---|---|
| NRLI | Individual National Register Listed | An individual facility that has been determined to meet the NRHP criteria for eligibility and has been formally individually listed on the NRHP.[229] |

## 3.4 DoD RPAD Data Minimization and Analysis

In 2015, the DoD provided ERDC-CERL researchers with an Excel spreadsheet containing 129,538 RPAs that fit the criteria for collection discussed in section 3.2. All of the data contained in this spreadsheet is For Official Use Only (FOUO)[230] as defined when the data was given to ERDC-CERL at the end of FY 2016 and cannot be included verbatim in this report; however, the resources were generally classified as having uses such as (but not exclusive to) public restrooms or showers, firing range facilities, roads, sidewalks, pads, parking lots, athletic fields, athletic support and storage buildings, overhead covers, hazardous materials storage, oil storage, light poles, observation towers, and bridges.

The ERDC-CERL architectural historian and data science intern conducted data minimization—reducing the amount of data collection to just that which needed to be analyzed—by removing entries that were not buildings or structures (for example, roads, sidewalks, parking lots, and bridges), that were directly related to mission activities (for example, firing ranges, range support structures, ammunition storage facilities, and mission-related fuel tanks), and research and development facilities. This list is not inclusive of all items removed from entries removed during data minimization.

The ERDC-CERL architectural historian and data science intern also removed all National Guard, Air Guard, and Reserve facilities, with the exception of large training locations due to the higher number of RPAs in the data set than expected. This exclusion allowed for a more manageable data set; however, the analysis is applicable to the Air and Army National Guard as well as Reserve facilities.

[229] This table has been adapted from Joanna Hall, *A Look at Historic Real Property Inventory in the DoD*, Legacy Program 07-376 (Washington, DC: GPO, 2007), https://usarsustainabilitydotcom.files.wordpress.com/2017/11/materials-usar-cr-historic-property-guidance-final23nov16.pdf.

[230] The FOUO classification system was replaced by the Controlled Unclassified Information system in 2020, but the original RPAD spreadsheets were not reclassified as CUI by the originator and remain FOUO.

Upon the completion of data minimization, the data science intern had reduced the 129,358 entries to approximately 28,000 entries for analysis. These entries encompassed all facilities identified as utilitarian based on the preliminary definition presented in section 3.1. As a preliminary step of analysis, the intern classified the facilities by installation and date of construction (Table 2).

Table 2. The 25 DoD installations with the greatest number of utilitarian buildings as defined in section 3.1.

| Location | Date of Construction | Number of Facilities |
|---|---|---|
| White Sands Missile Range, New Mexico | | 241 |
| | 1946–1949 | 1 |
| | 1950–1959 | 147 |
| | 1960–1969 | 56 |
| | 1970–1979 | 14 |
| | 1980–1989 | 18 |
| | 1990–1991 | 5 |
| Naval Air Weapons Station China Lake, California | | 235 |
| | 1946–1949 | 3 |
| | 1950–1959 | 62 |
| | 1960–1969 | 90 |
| | 1970–1979 | 40 |
| | 1980–1989 | 19 |
| | 1990–1991 | 21 |
| Naval Support Activity, South Potomac, Washington, DC | | 203 |
| | 1946–1949 | 1 |
| | 1950–1959 | 33 |
| | 1960–1969 | 86 |
| | 1970–1979 | 34 |
| | 1980–1989 | 28 |
| | 1990–1991 | 21 |
| Camp Ripley, Minnesota | | 131 |
| | 1946–1949 | 0 |
| | 1950–1959 | 45 |
| | 1960–1969 | 20 |
| | 1970–1979 | 1 |
| | 1980–1989 | 7 |
| | 1990–1991 | 58 |
| Naval Base Ventura County, California | | 119 |
| | 1946–1949 | 0 |
| | 1950–1959 | 28 |
| | 1960–1969 | 27 |

| Location | Date of Construction | Number of Facilities |
|---|---|---|
| | 1970–1979 | 31 |
| | 1980–1989 | 20 |
| | 1990–1991 | 13 |
| Marine Corps Base Camp Lejeune, North Carolina | | 109 |
| | 1946–1949 | 1 |
| | 1950–1959 | 7 |
| | 1960–1969 | 14 |
| | 1970–1979 | 28 |
| | 1980–1989 | 44 |
| | 1990–1991 | 15 |
| Fort Bliss, Texas | | 106 |
| | 1946–1949 | 0 |
| | 1950–1959 | 36 |
| | 1960–1969 | 39 |
| | 1970–1979 | 9 |
| | 1980–1989 | 20 |
| | 1990–1991 | 2 |
| Joint Base Pearl Harbor-Hickam, Hawaii | | 105 |
| | 1946–1949 | 0 |
| | 1950–1959 | 28 |
| | 1960–1969 | 12 |
| | 1970–1979 | 38 |
| | 1980–1989 | 24 |
| | 1990–1991 | 3 |
| Joint Base Lewis-McChord, Washington | | 86 |
| | 1946–1949 | 0 |
| | 1950–1959 | 18 |
| | 1960–1969 | 9 |
| | 1970–1979 | 11 |
| | 1980–1989 | 44 |
| | 1990–1991 | 4 |
| Fort Polk, Louisiana | | 84 |
| | 1946–1949 | 0 |
| | 1950–1959 | 3 |
| | 1960–1969 | 5 |
| | 1970–1979 | 12 |
| | 1980–1989 | 33 |
| | 1990–1991 | 31 |
| Fort Rucker, Alabama[231] | | 82 |

231 This installation was Fort Rucker during the research for this project; DoD renamed it Fort Novosel in 2023.

| Location | Date of Construction | Number of Facilities |
|---|---|---|
| | 1946–1949 | 0 |
| | 1950–1959 | 3 |
| | 1960–1969 | 15 |
| | 1970–1979 | 25 |
| | 1980–1989 | 36 |
| | 1990–1991 | 3 |
| Naval Air Station Patuxent River, Maryland | | 69 |
| | 1946–1949 | 0 |
| | 1950–1959 | 11 |
| | 1960–1969 | 20 |
| | 1970–1979 | 15 |
| | 1980–1989 | 16 |
| | 1990–1991 | 7 |
| Naval Base Coronado, California | | 63 |
| | 1946–1949 | 1 |
| | 1950–1959 | 16 |
| | 1960–1969 | 13 |
| | 1970–1979 | 16 |
| | 1980–1989 | 14 |
| | 1990–1991 | 3 |
| Patrick Space Force Base, Florida | | 62 |
| | 1946–1949 | 0 |
| | 1950–1959 | 16 |
| | 1960–1969 | 18 |
| | 1970–1979 | 10 |
| | 1980–1989 | 14 |
| | 1990–1991 | 4 |
| Letterkenny Army Depot, Pennsylvania | | 62 |
| | 1946–1949 | 0 |
| | 1950–1959 | 2 |
| | 1960–1969 | 37 |
| | 1970–1979 | 18 |
| | 1980–1989 | 4 |
| | 1990–1991 | 1 |
| Fort Hood, Texas[232] | | 62 |
| | 1946–1949 | 0 |
| | 1950–1959 | 6 |
| | 1960–1969 | 18 |
| | 1970–1979 | 9 |

[232] This installation was Fort Hood during the research for this project; DoD renamed it Fort Cavazos in 2023.

| Location | Date of Construction | Number of Facilities |
|---|---|---|
| | 1980–1989 | 23 |
| | 1990–1991 | 6 |
| Marine Corps Base Camp Pendleton, California | | 60 |
| | 1946–1949 | 0 |
| | 1950–1959 | 12 |
| | 1960–1969 | 4 |
| | 1970–1979 | 11 |
| | 1980–1989 | 28 |
| | 1990–1991 | 5 |
| Naval Supply Depot Monterey | | 58 |
| | 1946–1949 | 0 |
| | 1950–1959 | 3 |
| | 1960–1969 | 45 |
| | 1970–1979 | 4 |
| | 1980–1989 | 6 |
| | 1990–1991 | 0 |
| Fort Benning, Georgia[233] | | 58 |
| | 1946–1949 | 1 |
| | 1950–1959 | 4 |
| | 1960–1969 | 15 |
| | 1970–1979 | 27 |
| | 1980–1989 | 11 |
| | 1990–1991 | 0 |
| Eglin Air Force Base, Florida | | 58 |
| | 1946–1949 | 0 |
| | 1950–1959 | 13 |
| | 1960–1969 | 17 |
| | 1970–1979 | 19 |
| | 1980–1989 | 5 |
| | 1990–1991 | 3 |
| Edwards Air Force Base, California | | 55 |
| | 1946–1949 | 1 |
| | 1950–1959 | 11 |
| | 1960–1969 | 10 |
| | 1970–1979 | 10 |
| | 1980–1989 | 14 |
| | 1990–1991 | 9 |
| Camp Minden, Louisiana | | 53 |
| | 1946–1949 | 2 |

233 This installation was Fort Benning during the research for this project; DoD renamed it Fort Moore in 2023.

| Location | Date of Construction | Number of Facilities |
|---|---|---|
| | 1950–1959 | 14 |
| | 1960–1969 | 15 |
| | 1970–1979 | 11 |
| | 1980–1989 | 7 |
| | 1990–1991 | 4 |
| Louisiana National Guard | | 52 |
| | 1946–1949 | 0 |
| | 1950–1959 | 1 |
| | 1960–1969 | 3 |
| | 1970–1979 | 5 |
| | 1980–1989 | 32 |
| | 1990–1991 | 11 |
| Fort Stewart, Georgia | | 51 |
| | 1946–1949 | 0 |
| | 1950–1959 | 9 |
| | 1960–1969 | 13 |
| | 1970–1979 | 6 |
| | 1980–1989 | 19 |
| | 1990–1991 | 4 |
| Fort Bragg, North Carolina[234] | | 50 |
| | 1946–1949 | 0 |
| | 1950–1959 | 4 |
| | 1960–1969 | 3 |
| | 1970–1979 | 14 |
| | 1980–1989 | 22 |
| | 1990–1991 | 7 |

This analysis demonstrated that most facilities listed in the DoD RPAD that may qualify as utilitarian were constructed in the early Cold War period and Vietnam War eras. Further analysis of the DoD RPAD data disproved the hypothesis that small-scale wood buildings would be classified as temporary construction, metal buildings would be classified as semi-permanent construction, and concrete buildings would be classified as permanent construction.[235] Rather, the data element Construction Material was frequently either not provided or classified as "Not Applicable." When Construction Material information was available, researchers were not able to identify a significant association between

[234] This installation was Fort Bragg during the research for this project; DoD renamed it Fort Liberty in 2023.

[235] A building's status as temporary, semi-permanent, or permanent was provided by the Construction Type data element included in data collection. See Appendix B for more information.

wood and metal buildings and Construction Type (temporary, semi-permanent, or permanent). Concrete construction, however, exhibited a correlation with permanent construction.

The final step of data analysis consisted of identifying the uses and eligibility status of the buildings and structures identified as utilitarian. Uses were determined through Design Use Facility Analysis Category (FAC) Titles, which categorize and briefly describe real property assets.[236] These titles may serve as a list of utilitarian facility types within the DoD. A complete list of Design Use FAC Titles found in the data, along with the number of facilities per title and number of buildings and structures constructed prior to 1975 and therefore eligible for NRHP evaluation as of 2016 is available in Table 3. Key findings from this analysis include:

- 71.7% (21,094) of the facilities included in the collected data were permanent; 19.2% (5,649) were semi-permanent; and 9% (2,663) were temporary.
- 47.8% (14,055) of the facilities included in the collected data were 50 years of age or less.
- 75.6% (22,224) of the buildings had not yet been evaluated for historic status.
- 24.4% (7,182) of the buildings had been evaluated for historic status.
    - Of those evaluated, 82.9% (5,955 buildings of 7,182 evaluated; 20.3% of the total buildings in the data collected) had been determined not eligible for listing in the NRHP and 3.5% (258) had been determined non-contributing elements of an eligible historic district.
    - Of those evaluated, 7.3% (522 buildings of the 7,182 evaluated; 1.8% of the total buildings in the data collected) were determined eligible for listing in the NRHP for the purposes of a program alternative.

[236] Each Design Use FAC Title is associated with a FOUO Category Code. These Category Codes were provided by ERDC-CERL to OSD in late FY 2016.

- Of those evaluated, 6.2% (443 buildings of the 7,182 evaluated; 1.5% of the total buildings in the data collected) had been determined eligible for listing in the NRHP.

- Of the buildings determined eligible for listing on the NRHP, 87.3% (387 buildings of the 443 determined eligible; 21.7% of those evaluated and 1.3% of the total collected) were built between 1950 and 1969.

A complete tabulation of the non-FOUO data used to produce these numbers is available in Appendix C.

Table 3. Utilitarian facility uses, the number of facilities per use, and the number of facilities per use constructed prior to 1975 and eligible for historic status evaluation.

| Design Use FAC Title | Number of Facilities | Number of Facilities Constructed Before 1975* |
|---|---|---|
| Aircraft Washing Pad, Surfaced | 93 | 45 |
| Ambulance Shelter | 18 | 8 |
| Boathouse | 29 | 23 |
| Car Wash Facility | 11 | 2 |
| Central Vehicle Wash Facility | 38 | 3 |
| Cold Storage, Depot | 1 | 1 |
| Cold Storage, Installation | 17 | 6 |
| Controlled Humidity Storage, Depot | 102 | 87 |
| Controlled Humidity Storage, Installation | 20 | 15 |
| Covered Storage Building, Depot | 119 | 90 |
| Covered Storage Building, Installation | 2,861 | 1,604 |
| Covered Storage Shed, Depot | 28 | 11 |
| Covered Storage Shed, Installation | 1,175 | 463 |
| Exchange Support Facility | 7 | 3 |
| Exchange Warehouse | 21 | 15 |
| Facility Engineer Maintenance Facility | 10 | 1 |
| Facility Engineer Maintenance Shop | 718 | 414 |
| Family Housing Storage Facility | 1,148 | 338 |
| Hazardous Materials Storage, Depot | 55 | 35 |
| Hazardous Materials Storage, Installation | 1,945 | 932 |
| Hazardous Waste Storage or Disposal Facility | 275 | 50 |
| Helium Storage Facility | 2 | 1 |
| Incinerator | 20 | 14 |
| Industrial Waste Treatment | 240 | 90 |
| Installation Support Equipment Maintenance Shed | 90 | 49 |
| Installation Support Vehicle Maintenance Shop | 205 | 94 |

| Design Use FAC Title | Number of Facilities | Number of Facilities Constructed Before 1975* |
|---|---|---|
| Latrine/Shower Facility | 291 | 145 |
| Laundry/Dry Cleaning Facility | 14 | 10 |
| Liquid Fuel Loading/Unloading Facility | 405 | 235 |
| Liquid Oxygen Storage | 95 | 42 |
| Loading Platform/Ramp | 988 | 469 |
| Marine Fueling Facility | 21 | 13 |
| Marine Maintenance Shop | 51 | 20 |
| Marine Maintenance Support Facility | 41 | 7 |
| Marine Operating Fuel Storage | 2 | 0 |
| Medical Warehouse | 22 | 11 |
| Miscellaneous MWR Facility | 8 | 5 |
| Miscellaneous MWR Support | 328 | 164 |
| Miscellaneous Personnel Shelter | 1,234 | 426 |
| Miscellaneous UPH Support Building | 118 | 48 |
| Miscellaneous Utility Facility | 1,837 | 623 |
| Open Storage, Depot | 31 | 22 |
| Open Storage, Installation | 448 | 242 |
| Operations Supply Building | 379 | 174 |
| Overhead Cover | 406 | 126 |
| Parking Garage/Building | 19 | 7 |
| Pavilion | 1,223 | 419 |
| Public Restroom/Shower | 1,416 | 679 |
| Refuse Collection and Recycling Facility | 121 | 54 |
| Sanitary Landfill | 94 | 47 |
| Septic Lagoon and Settlement Ponds | 20 | 9 |
| Septic Tank and Drain Field | 839 | 504 |
| Training Aids Support Building | 76 | 44 |
| Training Support Structure | 546 | 184 |
| Transient and Recreational Lodging Support Facility | 18 | 6 |
| Utility Building | 4,972 | 3,085 |
| Vehicle Fueling Facility | 553 | 233 |
| Vehicle Maintenance Facility | 3,240 | 1,502 |
| Vehicle Maintenance Shop, Depot | 8 | 3 |
| Vehicle Operating Fuel Storage | 294 | 103 |
| **Total** | **29,406** | **14,055** |
| *At the time of research initiation, 1975 had reached the DoD's 45-year benchmark for evaluating real property for historic status. The DoD uses a 45-year benchmark to encourage installations to preemptively evaluate their real property for historic status. | | |

This data demonstrates that nearly half of the facilities identified as utilitarian by this study were less than 50 years of age and will need to be evaluated for NRHP-eligibility via Section 110 planning surveys or under Section 106 as applicable. Even more buildings will be in need of evaluation in the coming years. Finally, most utilitarian buildings that have been determined eligible for listing on the NRHP were built during the height of the Cold War, and likely served a mission critical function.

## 3.5 Utilitarian Definition Summary

The data analysis demonstrated that buildings gathered through DoD RPAD data collection based on a preliminary definition of utilitarian are primarily concrete and permanent construction. Additionally, they have primarily not yet been evaluated for the NRHP, and those that have been evaluated have primarily been determined not eligible for listing. Considering these conclusions and the historic context produced for this report, ERDC-CERL researchers developed the following definition for utilitarian buildings built for the Cold War between 1946 and 1991 and included in the DoD RPAD:

> buildings or structures of practical design with minimal architectural ornamentation that were constructed utilizing traditional construction materials (typically concrete, but also wood or metal).

The DoD's utilitarian properties typically were prefabricated, or used prefabricated materials, or were constructed based on standardized plans. They typically feature little architectural design, complexity, or uniqueness and were constructed quickly. Utilitarian properties were constructed to meet basic needs, not to directly support mission activities. As such, utilitarian buildings within the DoD are defined by both their use and their design and construction process—they meet basic, industrial needs that are not mission critical and were prefabricated or standardized. Most utilitarian properties still in use by the DoD primarily have functions limited to industrial and storage needs. Utilitarian properties in the DoD's inventory may include, but are not limited to, warehouses, vehicle shelters, storage buildings and sheds, maintenance facilities, support buildings, fueling facilities, latrines, and septic and landfill facilities.

# 4 Utilitarian Buildings on DoD Installations

Following DoD RPAD data analysis and the development of a definition for utilitarian buildings in the DoD based on the history of these structures and the qualities of extant utilitarian structures in the DoD RPAD, ERDC-CERL researchers conducted six visits to DoD installations. During site visits, researchers intended to obtain information on building uses and types, installation history, and utilitarian building manufacturer plans. References to specific prefabricated building manufacturers and their building plans were not available at the site visits.

Per the proposal for this project, the goal of the field investigations was to produce case studies with a level of historical and physical detail that will assist installation CRMs in their identification and management of utilitarian buildings and structures. However, facility number information from the DoD RPAD was not provided to ERDC-CERL researchers. Due to this, ERDC-CERL researchers were unable to correlate DoD RPAD information with the actual facility numbers on buildings and structures on each installation. This chapter therefore presents facilities identified as utilitarian by installation CRMs in an effort to further refine the definition of utilitarian.

This chapter begins with an explanation of site selection. The installations visited are then discussed in alphabetical order. Due to the FOUO status of DoD RPAD data and lack of individual building identification information, this chapter discusses general characteristics of buildings identified as utilitarian by installation CRMs rather than individual structures and their historic status designation.

## 4.1 Installation Selection

ERDC-CERL researchers did not include specific installations for field visits in the proposal for this project, as the intention was to choose sites based on the data collection, minimization, and analysis. Instead, ERDC-CERL researchers provided Table 2 as a list of potential installations for visitation to the DoD CRP. The DoD CRP then provided ERDC-CERL with a short list of installations to contact to request permission for use in the study.

Installations were ultimately chosen on geographic spread and type of service—for example, if installations for multiple services were geographically near each other, those installations were chosen over others that were geographically isolated. The final criteria for selection was installation permission: if an installation did not respond to ERDC-CERL researchers' request for visitation or replied in the negative, that installation was not visited. The installations visited by researchers included:

- Fort Polk, Louisiana[237]
- Marine Corps Air Ground Combat Center Twentynine Palms, California
- Marine Corps Base Hawaii, Kaneohe Bay, Hawaii
- Naval Air Weapons Station China Lake, California
- White Sands Missile Range, New Mexico
- Wright-Patterson Air Force Base, Ohio

The following three installations, Marine Corps Base Kaneohe Bay, Hawaii; Marine Corps Air Ground Combat Center Twentynine Palms, California; and Wright-Patterson Air Force Base, Ohio, were not included in the list of the 25 installations with the largest number of utilitarian buildings but were added by ERDC-CERL and the DoD CRP due to members of the research team visiting them for other Legacy Program projects.

## 4.2 Fort Polk, Louisiana

The ERDC-CERL cultural geographer and architectural historian visited Fort Polk, Louisiana, in September 2016 to conduct an in-person evaluation of buildings that were identified as utilitarian by the installation CRM. The CRM provided the ERDC-CERL research team with an installation map and a list of buildings to evaluate but did not accompany the team during their visit.

### 4.2.1 Historical Summary

Fort Polk is a United States Army installation located in central Louisiana in Vernon Parish, approximately ten miles east of Leesville, Louisiana, and

[237] This installation was Fort Polk during the research for this project; DoD renamed it Fort Johnson in 2023. This report will refer to the installation as Fort Polk to reflect the time when research was conducted for this project in 2016.

30 miles north of DeRidder in Beauregard Parish, Louisiana. The post encompasses approximately 198,000 acres. The Department of the Army owns 100,000 acres, while the US Forest Service owns 98,125 acres.

Fort Polk is utilized by the Joint Readiness Training Center (JRTC) to train Brigade Combat Teams and Security Force Assistance Brigades to conduct large scale operations on a decisive action battlefield against a near-peer threat with multi-domain capabilities. Training conducted at Fort Polk enables US Army Forces Command units to increase readiness and support globally deployable missions.

Fort Polk was first established as Camp Polk in 1941 during the Great Louisiana Maneuvers. Thousands of soldiers trained for WWII at the camp during these maneuvers, which tested troops' mobilization and mechanization capabilities. After the war, 16 armored divisions were created using soldiers trained at Camp Polk. It continued to serve the 1st Armored Division through the Korean War, after which the camp was deactivated.[238]

The camp was temporarily reactivated as Fort Polk in the 1950s but did not become permanently reactivated until 1961. At that time, Fort Polk was reactivated in response to the Berlin Crisis. The next year, it became and infantry training center—the nation's largest—and provided advanced training for Vietnam-style combat through the 1960s and 1970s.[239] In the 1970s and 1980s, Fort Polk hosted the 5th Infantry Division (Mechanized), and it hosted the 2nd Armored Cavalry Regiment in the 1990s. It hosted the 1st Maneuver Enhancement Brigade and the 162nd Infantry Brigade in the 2000s. Fort Polk, renamed Fort Johnson in 2023, is currently home to the JRTC; the 3rd Brigade Combat Team, 10th Mountain Division; and the 115th Combat Support Hospital, US Army Garrison and Bayne-Jones Army Community Hospital.[240]

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238 Fort Polk Housing, "Fort Polk, LA History," accessed November 7, 2020, https://www.fortpolkhousing.com/history.

239 Fort Polk Housing, "Fort Polk, LA History;" Army.mil, "History," US Army JRTC and Fort Polk, accessed November 18, 2022, https://home.army.mil/polk/index.php/about/history.

240 ArmyBases.org, "Fort Polk, LA (Louisiana)," accessed November 7, 2020, https://armybases.org/fort-polk-la-louisiana/.

### 4.2.2 Utilitarian Facilities at Fort Polk

The DoD RPAD data collection and analysis identified 84 utilitarian buildings and structures constructed at Fort Polk between 1951 and 1991.[241] Eighty-seven percent of these facilities (73) were constructed between 1976 and 1991 (Table 4).[242]

Table 4. Utilitarian facilities at Fort Polk, Louisiana, by construction date.

| Date of Construction | Number of Facilities |
|---|---:|
| 1946–1949 | 0 |
| 1950–1959 | 3 |
| 1960–1969 | 5 |
| 1970–1979 | 12 |
| 1980–1989 | 33 |
| 1990–1991 | 31 |
| 1990–1991 | 6 |

Per the DoD RPAD data, utilitarian facilities at Fort Polk covered the entire range of Construction Types (permanent, semi-permanent, and temporary) and Construction Materials (metal, wood, concrete) evaluated for this study. At the time of data collection, two of the facilities were classified as DNE, one was classified as ELPA, and 81 were classified as NEV.

The buildings and structures at Fort Polk evaluated by ERDC-CERL researchers reflected this distribution of construction type and material. HSCs could not be correlated with individual buildings. The buildings were also typically support or storage structures. A representative sample of utilitarian facilities—as identified by the CRM—is shown in images Figure 212–Figure 216. Additional photographs are available in Appendix D.

[241] No utilitarian structures listed in the DoD RPAD were constructed at Fort Polk between 1946 and 1950.

[242] Buildings constructed in 1976 were, at the time of writing, 45 years of age and therefore in need for historic status evaluation per DoD guidance.

Figure 212. Buildings 749 and 750 at Fort Polk (ERDC-CERL 2016).


Figure 213. Building 2654 at Fort Polk (ERDC-CERL 2016).

Figure 214. Building 3334 at Fort Polk (ERDC-CERL 2016).

Figure 215. Building 3411 at Fort Polk (ERDC-CERL 2016).

Figure 216. Building 4768 at Fort Polk (ERDC-CERL 2016).


## 4.3 Marine Corps Air Ground Combat Center Twentynine Palms, California

The ERDC-CERL cultural geographer and architectural historian visited Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms in November–December 2016 to conduct an in-person evaluation of buildings that were identified as utilitarian by the installation CRM. The CRM provided the ERDC-CERL research team with an installation map but did not accompany the team during their visit.

### 4.3.1 Historical Summary

MCAGCC Twentynine Palms, also referred to as 29 Palms, is the largest United States Marine Corps base. Located adjacent to the city of Twentynine Palms, San Bernadino County, California, the base encompasses 1,100 square miles of the Mojave Desert. Its mission is to host live-fire combined arms training to promote operational force readiness.[243]

MCAGCC was originally founded between 1941 and 1942 as the Twentynine Palms Air Academy, an Army Air Forces glider training facility. The Army Air Forces used the installation for glider and fighter training through 1944, when the Navy took control of the base and began using the airfield—Condor Field—as a gunnery and bombing range. While the Navy operated the installation, it was called Twentynine Palms Naval Auxiliary Air Station.[244]

Following the end of WWII, the Navy transferred ownership of the installation to San Bernadino County. As Marines returned to nearby Camp Pendleton, California, though, they found that they needed more space for artillery and rocket training. Consequently, Base Headquarters at Camp Pendleton reopened Twentynine Palms as Camp Detachment, Marine Corps Training Center, Twentynine Palms on August 20, 1952.[245] The first live-fire field training exercise at the base was held in December of that year.[246]

By 1957, the installation was redesignated as Marine Corps Base, Twentynine Palms.[247] It continued to serve as a Marine Corps field training center through the 1960s and early 1970s. In 1976, a new airfield opened at Twentynine Palms.[248] The installation was subsequently redesignated as Marine Corps Air Ground Combat Training Center (MCAGCC) on February 16, 1979.[249] The installation soon began hosting

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243 Military One Source, "Twentynine Palms (MCAGCC) In-depth Overview," Military Installations, accessed November 20, 2022, https://installations.militaryonesource.mil/in-depth-overview/twentynine-palms-mcagcc#:~:text=In%201952%2C%20the%20Marine%20Corps,Corps%20Air%20Ground%20Combat%20Center; Chris La Porte, "MCAGCC 29 Palms: In-Depth Welcome Center (2022 Edition), My Base Guide, accessed November 20, 2022, https://mybaseguide.com/installation/twentynine-palms/community/mcagcc-29-palms-welcome-center/.

244 29 Palms, California, "A Brief History of MCAGCC," Marine Corps Base 29 Palms, accessed November 22, 2022, https://visit29.org/historic-29/marine-corps-base-29-palms/.

245 29 Palms, California, "A Brief History of MCAGCC."

246 Denise Goolsby, "History: Twentynine Palms Marines base emerges in 1950s," *Desert Sun*, updated May 2, 2015, https://www.desertsun.com/story/news/2015/04/28/history-twentynine-palm-marine-base/26538047/.

247 Goolsby, "History."

248 It is unclear when Condor Field was closed and if this new airfield was merely a reopening of Condor Field; Twentynine Palms Housing, "MCAGCC Twentynine Palms, CA History," accessed November 7, 2020, https://www.twentyninepalmshousing.com/history.

249 29 Palms, California, "A Brief History of MCAGCC."

Combined Arms Exercises at an unprecedented scale. The Marine Corps also opened a Tactical Exercise Control Center at the installation to control, instruct, and critique the exercises.[250]

Twentynine Palms' role as a Marine Corps training center continued to grow through the end of the twentieth century and, on October 1, 2000, it gained an additional mission as Marine Air Ground Task Force Training Command. This mission, in addition to its air ground combat training mission, is ongoing.[251]

### 4.3.2 Utilitarian Facilities at MCAGCC Twentynine Palms

The DoD RPAD data collection and analysis identified 31 utilitarian buildings and structures constructed at MCAGCC between 1953 and 1991.[252] Eighty-four percent of these facilities (26) were constructed between 1976 and 1991 (Table 5). [253]

Table 5. Utilitarian facilities at MCAGCC Twentynine Palms, CA, by construction date.

| Date of Construction | Number of Facilities |
|---|---:|
| 1946–1949 | 0 |
| 1950–1959 | 4 |
| 1960–1969 | 1 |
| 1970–1979 | 1 |
| 1980–1989 | 20 |
| 1990–1991 | 5 |

The utilitarian facilities at MCAGCC covered the entire range of Construction Types (permanent, semi-permanent, and temporary) and Construction Materials (metal, wood, concrete) evaluated for this study. At the time of data collection, 24 of the facilities were classified as DNE and seven were classified as NEV.

The buildings and structures at MCAGCC evaluated by ERDC-CERL researchers reflected this distribution of construction type and material.

[250] Andrea Zittel and James Trainor, "29 Palms Marine Base," High Desert Test Sites, accessed November 22, 2022, https://highdeserttestsites.com/programs/publications/desert-destination-log/twentynine-palms.

[251] Visit29, "Marine Corps Base 29 Palms."

[252] No utilitarian structures listed in the DoD RPAD were constructed at MCAGCC between 1946 and 1950.

[253] Buildings constructed in 1976 were, at the time of writing, 45 years of age and therefore in need for historic status evaluation per DoD guidance.

HSCs could not be correlated with individual buildings. The buildings were also typically support or storage structures. A representative sample of utilitarian buildings—as identified by the MCAGCC CRM—is shown in images Figure 217–Figure 221. Additional photographs are available in Appendix D.

Figure 217. Building 478 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 218. Building 0690R1 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 219. Building 1092 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 220. Building 1097Y1 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 221. Building 1101 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

## 4.4 Marine Corps Base Hawaii, Kaneohe Bay, Hawaii

The ERDC-CERL architectural historian and landscape architect visited MCB Hawaii (MCBH) in October 2016 to conduct an in-person evaluation of buildings that were identified as utilitarian by the installation CRM . The CRM provided the ERDC-CERL research team with an installation map and a list of buildings to evaluate but did not accompany the team during their visit.

### 4.4.1 Historical Summary

MCBH is a 2,951-acre Marine Corps facility and air station located on the Mokapu Peninsula of O’ahu between Kailua and Kāne’ohe. It is approximately 12 miles northeast of Honolulu, and encompasses two classified conservation areas: the Ulupa’U Crater area (northeast peninsula) and the Nu’upia Pond area (at Mokapu Road).[254]

MCBH was first commissioned as the 332-acre Fort Kuwaaohe Army Military Reservation in 1918. Fort Kuwaaohe, later renamed Fort Hase, was a defense battalion of the Windward Coastal Artillery Command; however, its role greatly increased during WWII, beginning in 1939. That year, the Navy began construction of Naval Air Station Kaneohe Bay. At the time, a Marine Corps security detachment reported to the Naval Air Station with a mission to protect construction materials aboard the air station.[255]

On December 7, 1941, Japan launched an attack on Pearl Harbor. Just nine minutes before that attack, though, the Imperial Japanese Navy aerial striking force targeted Naval Air Station Kaneohe Bay to disable American aircraft that could have prevented the attack. The Imperial Japanese Navy was largely successful, as 27 of the 36 PBY Catalinas (a type of amphibious aircraft) stationed at the base were destroyed. Eighteen sailors were killed in the attack.[256]

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[254] Marine Corps Base Hawaii, *2022 Secretary of Defense Environmental Award* (Oahu, Hawaii: MCBH, 2022), https://www.denix.osd.mil/awards/2022secdef/natural-resources-conservation-small-installation/marine-corps-base-hawaii/1%20Nomination%20Narrative%20USMC%20NRC-SI_MCB%20Hawaii.pdf.

[255] US Marine Corps, “Mission & History,” Marine Corps Base Hawaii, accessed November 7, 2020, https://www.mcbhawaii.marines.mil/Unit-Home/Mission/.

[256] Mark Loproto, “Other Targets: Naval Air Station Kaneohe Bay,” PearlHarbor.org, June 1, 2018, https://pearlharbor.org/other-targets-naval-air-station-kaneohe-bay/.

The Navy decommissioned Naval Air Station Kaneohe Bay In 1949. After the former landowner refused to accept the property, the Marine Corps subsequently assumed control of both Kaneohe Bay and Fort Hase. Kaneohe Bay was officially commissioned as Marine Corps Air Station Kaneohe Bay by 1952. Through the early 1990s, Kaneohe Bay was home to a number of Marine Corps fighters. In 1994, the Marine Corps consolidated all of its installations and facilities in Hawaii under a single command, MCBH. Several other realignments occurred during the early twenty-first century. [257]

### 4.4.2 Utilitarian Facilities at MCBH

The DoD RPAD data collection and analysis identified 33 utilitarian buildings and structures constructed at MCBH between 1952 and 1991.[258] Sixty-one percent of these buildings and structures (20) were constructed between 1976 and 1991 (Table 6). [259]

Table 6. Utilitarian facilities at MCBH by construction date.

| Date of Construction | Number of Facilities |
|---|---|
| 1946–1949 | 0 |
| 1950–1959 | 4 |
| 1960–1969 | 4 |
| 1970–1979 | 9 |
| 1980–1989 | 16 |
| 1990–1991 | 0 |

The utilitarian facilities at MCBH covered the entire range of Construction Types (permanent, semi-permanent, and temporary) and Construction Materials (metal, wood, concrete) evaluated for this study. At the time of data collection, all 33 facilities were classified as NEV. The facilities were typically support or storage structures. A representative sample of utilitarian buildings and structures—as identified by the MCBH CRM—is shown in

[257] US Marine Corps, "Mission & History," Marine Corps Base Hawaii, accessed November 7, 2020, https://www.mcbhawaii.marines.mil/Unit-Home/Mission/.

[258] No utilitarian structures listed in the DoD RPAD were constructed at MCBH between 1946 and 1952.

[259] Buildings constructed in 1976 were, at the time of writing, 45 years of age and therefore in need for historic status evaluation per DoD guidance.

Figure 222–Figure 226. Additional photographs are available in Appendix D.

Figure 222. Building 138 at MCBH (ERDC-CERL 2016).


Figure 223. Building 283 at MCBH (ERDC-CERL 2016).

Figure 224. Building 302 at MCBH (ERDC-CERL 2016).


Figure 225. Building 390 at MCBH (ERDC-CERL 2016).

Figure 226. Building 697 at MCBH (ERDC-CERL 2016).


## 4.5 Naval Air Weapons Station China Lake, California

The ERDC-CERL cultural geographer and architectural historian visited Naval Air Weapons Station (NAWS) China Lake in December 2016 to conduct an in-person evaluation of buildings that were identified as utilitarian by the installation CRM. The installation's staff archaeologist identified utilitarian buildings and accompanied the team on their visit.

### 4.5.1 Historical Summary

NAWS China Lake is located approximately 150 miles north of Los Angeles in the Western Mojave Desert Region of California. It provides and maintains land, facilities, and other assets that support the Navy's research, development, acquisition, testing, and evaluation (RDAT&E) efforts. NAWS is the Navy's largest single landholding, covering more than 1.1 million acres.[260]

[260] Navy Life, "Welcome to NAWS China Lake," Navy Life SW, accessed November 7, 2020, https://chinalake.navylifesw.com/.

In the mid-1930s, Trans-Sierra Airlines sought to develop a route between Fresno, California, and Phoenix, Arizona. The Civilian Air Administration granted the request, so long as an emergency landing field was constructed near the small town of Inyokern, California. The Works Progress Administration subsequently built the field, and it officially opened in 1935.[261]

The Army Air Forces took over the airfield in September 1942 for use as a training facility. This use did not come to fruition, however, and the Navy took it over the following year to serve as a rocket testing facility—a need which had been established in the 1930s.[262]

The Navy designated the facility as the Naval Ordnance Test Station (NOTS) in November 1943 with a mission of research and development of weapons, as well as offering training for the weapons developed. Testing began in December, and an existing relationship between the Navy and the California Institute of Technology resulted in the cooperative development of weapons by soldiers and scientists.[263] Also around this time, a community larger than Inyokern called China Lake formed near NOTS. NOTS subsequently became known as NOTS China Lake.[264]

In July 1967, the Navy combined NOTS China Lake and the Naval Ordnance Laboratory in Corona, California, and redesignated the facility as the Naval Weapons Center. Two years later, the mission and functions of the National Parachute Test Range located in El Centro, California, were also moved to the Naval Weapons Center.[265]

In January 1992, the Navy disestablished the Naval Weapons Center, as well as the Pacific Missile Test Center in Point Mugu, California, and joined their missions and functions with naval units at Albuquerque and White Sands, New Mexico, as a single command. This command was

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261 M.L. Shetle, "Naval Air Facility, Inyokern," MilitaryMuseum.org, accessed November 21, 2022, https://www.militarymuseum.org/NAFInyokern.html.

262 Shetle, "Naval Air Facility, Inyokern."

263 Naval Air Weapons Station China Lake, "History," accessed November 7, 2020, https://cnrsw.cnic.navy.mil/Installations/NAWS-China-Lake/About/History/.

264 China Lake Museum Foundation, "A Brief Overview of the History of China Lake," Brief History, accessed November 21, 2022, https://chinalakemuseum.org/brief-history.

265 Naval Air Weapons Station China Lake, "History."

called the Naval Air Warfare Center Weapons Division, and the facilities at China Lake were redesignated as a Naval Air Weapons Station.[266]

### 4.5.2 Utilitarian Facilities at NAWS China Lake

The DoD RPAD data collection and analysis identified 235 utilitarian buildings and structures constructed at NAWS China Lake between 1946 and 1991. Nineteen percent of these facilities (45) were constructed between 1976 and 1991 (Table 7).[267]

Table 7. Utilitarian facilities at NAWS China Lake by construction date.

| Date of Construction | Number of Facilities |
|---|---|
| 1946–1949 | 3 |
| 1950–1959 | 62 |
| 1960–1969 | 90 |
| 1970–1979 | 40 |
| 1980–1989 | 19 |
| 1990–1991 | 21 |
| 1990–1991 | 3 |

The utilitarian facilities at NAWS China Lake covered the entire range of Construction Types (permanent, semi-permanent, and temporary) and Construction Materials (metal, wood, concrete) evaluated for this study. At the time of data collection, 44 of the facilities were classified as DNE, one was DNR, three were ELPA, two were NCE, six were NHLC, and the remaining 161 were NEV. The facilities were typically support or storage structures. A representative sample of utilitarian buildings and structures—as identified by the NAWS China Lake CRM—is shown in images Figure 227–Figure 231. Additional photographs are available in Appendix D.

[266] Naval Air Weapons Station China Lake, "History."

[267] Buildings constructed in 1976 were, at the time of writing, 45 years of age and therefore in need for historic status evaluation per DoD guidance.

Figure 227. Building 00558 at NAWS China Lake (ERDC-CERL 2016).

Figure 228. Building 00991 at NAWS China Lake (ERDC-CERL 2016).

Figure 229. Building 00991A at NAWS China Lake (ERDC-CERL 2016).


Figure 230. Building 01093 at NAWS China Lake (ERDC-CERL 2016).

Figure 231. Building 01104 at NAWS China Lake (ERDC-CERL 2016).


## 4.6 White Sands Missile Range, New Mexico

The ERDC-CERL cultural geographer and architectural historian visited White Sands Missile Range (WSMR) in November 2016 to conduct an in-person evaluation of buildings that were identified as utilitarian by the installation CRM. The installation's staff historic architect identified utilitarian buildings and accompanied the team on their visit.

### 4.6.1 Historical Summary

WSMR is the US' largest military installation, covering approximately 3,200 square miles. It is located in southern New Mexico, and is equipped with facilities for research, development test, and evaluation (RDT&E), experimentation, and training. It is also home to the location of the world's first atom bomb test in 1945.[268]

[268] Army Technology, "White Sands Missile Range," accessed November 7, 2020, https://www.army-technology.com/projects/white-sands-range/.

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Following Germany's successful launch of their V-2 rocket, the US military began to consider establishing a land-based test range for rockets and missiles.[269] The area that is now the Trinity nuclear test site, part of WSMR and the site of the world's first nuclear bomb test, was subsequently selected for this purpose in November 1944.[270]

The Secretary of War sanctioned the establishment of White Sands Proving Ground, which encompassed the future Trinity nuclear test site, in February 1945.[271] The world's first nuclear bomb was detonated at the Trinity site on June 16, 1945.[272] In April 1946, the Army Air Forces launched the first successful US-adapted V-2 missile, the first high-altitude missile that was controlled in-flight.[273]

In 1959, White Sands Proving Ground was redesignated as WSMR. Rocket and missile development and testing continued to be WSMR's mission through the end of the century, and WSMR served as a key site for NASA's space launch vehicle development in the 1960s. Today, WSMR continues to play a role in the US space launch research and activities.[274]

### 4.6.2 Utilitarian Facilities at WSMR

The DoD RPAD data collection and analysis identified 241 utilitarian buildings and structures constructed at WSMR between 1949 and 1991.[275] Twelve percent of these facilities (28) were constructed between 1976 and 1991 (Table 8).[276]

Table 8. Utilitarian facilities at WSMR by construction date.

| Date of Construction | Number of Facilities |
|---|---|
| 1946–1949 | 1 |

[269] Army Technology, "White Sands Missile Range."

[270] Army Technology, "White Sands Missile Range."

[271] National Park Service, "White Sands Missile Range," White Sands National Park New Mexico, accessed November 21, 2022, https://www.nps.gov/whsa/learn/historyculture/white-sands-missile-range.htm.

[272] Army Technology, "White Sands Missile Range."

[273] Army Technology, "White Sands Missile Range."

[274] White Sands Missile Range Public Affairs Office, *White Sands Missile Range: More than Missiles* (White Sands Missile Range, New Mexico: White Sands Missile Range, 2022), https://www.nasa.gov/pdf/449089main_White_Sands_Missile_Range_Fact_Sheet.pdf.

[275] No utilitarian structures listed in the DoD RPAD were constructed at NAWS China Lake between 1946 and 1949.

[276] Buildings constructed in 1976 were, at the time of writing, 45 years of age and therefore in need for historic status evaluation per DoD guidance.

| Date of Construction | Number of Facilities |
|---|---|
| 1950–1959 | 147 |
| 1960–1969 | 56 |
| 1970–1979 | 14 |
| 1980–1989 | 18 |
| 1990–1991 | 5 |
| 1990–1991 | 1 |

The utilitarian facilities at WSMR covered the entire range of Construction Types (permanent, semi-permanent, and temporary) and Construction Materials (metal, wood, concrete) evaluated for this study. At the time of data collection, 72 of the facilities were classified as DNE, one was ELPA, eight were NREI, and the remaining 160 were NEV. The buildings were typically support or storage structures. A representative sample of utilitarian buildings and structures—as identified by the WSMR CRM—is shown in images Figure 232–Figure 236. Additional photographs are available in Appendix D.

Figure 232. Building 1128 at WSMR (WSMR 2016).

Figure 233. Building 1710 at WSMR (WSMR 2016).


Figure 234. Building 1713 at WSMR (WSMR 2016).

Figure 235. Buildings 1727 (right) and 1732 (left) at WSMR (WSMR 2016).


Figure 236. Building 1729 at WSMR (WSMR 2016).

## 4.7 Wright-Patterson Air Force Base, Ohio

The ERDC-CERL cultural geographer and architectural historian visited Wright-Patterson Air Force Base (AFB), Ohio, in February 2017 to conduct an in-person evaluation of buildings that were identified as utilitarian by the installation CRM. The CRM accompanied the team on their visit.

### 4.7.1 Background

Wright-Patterson AFB is located northeast of Dayton, Ohio, in Greene and Montgomery Counties.[277] It encompasses 8,000 acres divided into two areas, Area A and Area B, which are separated by Ohio State Road 444.[278] The installation's origins lie with Orville and Wilbur Wright, who developed the Wright Flyer from 1904 to 1906 at the Huffman Prairie Flying Field, which is now a part of Wright-Patterson AFB. From 1910 to 1916, the Wright brothers operated a flying school at Huffman Prairie Flying Field.[279]

By the start of WWI, the Wright brothers and others in the Dayton, Ohio, community had turned Dayton into the United States' premier location for flying expertise, engineering, and supply. Consequently, the Army purchased Huffman Field, as well as the nearby Wright and McCook Fields, in 1917. The Army turned Wright Field into a combat training center, with schools for armorers and aviation mechanics, and established the Fairfield Aviation General Supply Depot adjacent to the fields.[280]

By the end of WWI, Dayton, Ohio, held not only the greatest concentration of flying expertise, engineering, and supply, but also the greatest concentration of military aviation infrastructure. The Army therefore continued to utilize and invest in the three airfields. As aviation technology continued to develop, the Army closed McCook Field, which was too small for the airplanes of the 1920s and 1930s. The Army also merged the original Wright Field and the Fairfield Depot into the Fairfield Air Depot

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[277] Wright-Patterson AFB, "Wright-Patterson Air Force Base," November 8, 2019, https://www.wpafb.af.mil/Welcome/Fact-Sheets/Display/Article/1146061/wright-patterson-air-force-base/.

[278] Military One Source, "Wright-Patterson AFB In-depth Overview," Wright-Patterson AFB, accessed November 7, 2020, https://installations.militaryonesource.mil/in-depth-overview/wright-patterson-afb; Wright-Patterson AFB, "Wright-Patterson Air Force Base."

[279] Wright-Patterson AFB, "Wright-Patterson Air Force Base."

[280] Wright-Patterson AFB, OH, "Wright-Patterson AFB, OH History," accessed November 7, 2020, https://www.wrightpattersonhousing.com/history.

and renamed the entire installation—the Fairfield Air Depot and Huffman Field—as Wright Field.[281]

Following the United States' entry into WWII, the Army significantly expanded Wright Field. In 1947, the Air Force was established as a separate service, and Wright Field became an Air Force Base. Wright Field was renamed Wright-Patterson AFB in 1948, and it continued to serve as a center of Air Force aviation technology development through the Cold War. Today, its missions encompass supply and logistics, research and development, and aviation education.[282]

### 4.7.2 Utilitarian Facilities at Wright-Patterson AFB

The DoD RPAD data collection and analysis identified 29 utilitarian buildings and structures constructed at Wright-Patterson AFB between 1952 and 1987.[283] Forty-eight percent of these facilities (14) were constructed between 1976 and 1991 (Table 9).[284]

Table 9. Utilitarian facilities at Wright-Patterson AFB by construction date.

| Date of Construction | Number of Facilities |
|---|---:|
| 1946–1949 | 0 |
| 1950–1959 | 4 |
| 1960–1969 | 6 |
| 1970–1979 | 9 |
| 1980–1989 | 10 |
| 1990–1991 | 0 |

The utilitarian facilities at Wright-Patterson AFB covered the entire range of Construction Type (permanent, semi-permanent, and temporary) and Construction Material (metal, wood, concrete) evaluated for this study. Notably, at least two of the facilities identified as utilitarian by the Wright-Patterson AFB CRM were constructed of brick. At the time of data collection, ten of the facilities were classified as DNE, two were NCE, and the remaining 17 were NEV. The buildings and structures were typically support or storage structures. A representative sample of utilitarian

[281] Wright-Patterson AFB, OH, "Wright-Patterson AFB, OH History."

[282] Wright-Patterson AFB, OH, "Wright-Patterson AFB, OH History."

[283] No utilitarian structures listed in the DoD RPAD were constructed at Wright-Patterson AFB between 1946 and 1952 or between 1987 and 1991.

[284] Buildings constructed in 1976 were, at the time of writing, 45 years of age and therefore in need for historic status evaluation per DoD guidance.

buildings and structures—as identified by the Wright-Patterson AFB CRM—is shown in Figure 237–Figure 240. Additional photographs are available in Appendix D.

Figure 237. Building 16 at Wright–Patterson AFB (ERDC-CERL 2017).

Figure 238. Building 23 at Wright–Patterson AFB (ERDC-CERL 2017).

Figure 239. Buildings 107 (right), 111 (middle), and No Number (left) at Wright–Patterson AFB (ERDC-CERL 2017).

Figure 240. Building 117 at Wright–Patterson AFB (ERDC-CERL 2017).

## 4.8 Utilitarian Definition Revisited

Due to a lack of identifying information provided to ERDC-CERL for the buildings in the DoD RPAD, the ERDC-CERL research team was unable to evaluate the buildings identified as utilitarian by the DoD RPAD analysis presented in Chapter 3 as originally intended. Instead, the ERDC-CERL research team evaluated buildings that the installation CRMs themselves identified as utilitarian. This allowed the ERDC-CERL research team to further refine the definition of utilitarian based on the understanding of installation CRMs—the individuals primarily conducting typological assessments of these buildings.

The buildings identified as utilitarian by installation CRMs largely featured the same characteristics as those expected by the researchers at the start of the project but not identified by the DoD RPAD analysis—metal, concrete block, or wood construction that was temporary, semi-permanent, or permanent with minimal architectural ornamentation. They primarily served as support and storage facilities. However, the buildings identified as utilitarian by installation CRMs also included the occasional brick building. Considering this, the ERDC-CERL researchers refined the definition of utilitarian buildings built during the Cold War period between 1946 and 1991 in Chapter 3 to the following final definition:

> buildings or structures of practical design with minimal architectural ornamentation that were most frequently constructed utilizing traditional construction materials (typically concrete block, but also wood and metal). The use of non-traditional construction materials (materials other than concrete block, wood, and metal) does not preclude a building or structure from being classified as utilitarian. The DoD's utilitarian properties typically were prefabricated, or used prefabricated materials, or were constructed based on standardized plans. They typically feature little architectural design, complexity, or uniqueness and were constructed quickly.

NRHP-eligibility does not preclude a building or structure from being classified as utilitarian. Utilitarian properties were constructed to meet basic needs and not directly to support mission activities. As such, utilitarian buildings within the DoD are defined by both their use and their design and construction process—they meet basic, industrial needs that are not mission critical and were prefabricated or standardized. Most utilitarian structures still in use by the DoD primarily have functions limited to industrial and storage needs. Utilitarian properties in the DoD's inventory may include, but are not limited to, warehouses, vehicle shelters, storage buildings and sheds, maintenance facilities, support buildings, fueling facilities, latrines, and septic and landfill facilities.

# 5 Conclusion and Recommendations

This report's objective was to enhance the management of prefabricated temporary and semi-permanent buildings constructed during the Cold War period from 1946 to 1991 through the documentation of utilitarian resources. Given that there is neither an official DoD definition of utilitarian resources nor any federal guidance regarding the criteria for eligibility of utilitarian resources for listing on the NRHP, this project instead sought to develop a definition of utilitarian buildings for the DoD based on data in the DoD RPAD—the DoD-wide database of real property—and resources identified by installation CRMs as utilitarian. Thus, this project intended to define utilitarian buildings and provide parameters for classifying them in the DoD RPAD to aid in the development of future NHPA Section 106 program alternatives.

Prior to beginning research, the ERDC-CERL team, DoD CRP, and Legacy Program staff hypothesized that most Cold War-era utilitarian resources would be semi-permanent, prefabricated metal buildings and that approximately 6,000 buildings in the DoD RPAD would meet these parameters and be able to be classified as utilitarian. However, the historic context created for this report revealed that, while many utilitarian buildings were metal, construction also included wood, concrete, and other building materials. Further, research for the historic context also revealed that utilitarian buildings, when defined broadly as buildings constructed quickly to meet a basic, non-mission critical need, were constructed based on standardized plans and/or of prefabricated materials in addition to being prefabricated. The historical research conducted for this report therefore clarified that utilitarian buildings could be of any material but were defined by their use, as well as their design and construction processes.

This finding of the historical research was reiterated by the findings of the DoD RPAD analysis, which identified 28,668 data entries in the DoD RPAD. These data entries were identified using criteria developed and presented in Chapter 3, as there is not an existing category code specific for utilitarian buildings. Instead, utilitarian buildings are categorized by use (such as oil storage, hazardous waste storage, or picnic pavilion) rather than a utilitarian code with subgroupings for use. The data entries gathered encompassed resources made of metal, wood, and concrete block, as well as buildings classified as temporary, permanent, and semi-permanent. These construction types and materials did not correlate with use—for example, one hazardous materials storage building may be permanent concrete construction while another may be semi-permanent metal construction. These findings proved false the hypothesis that utilitarian buildings would be semi-permanent, prefabricated metal construction. Instead, most of the utilitarian resources listed in DoD RPAD were permanent, concrete construction, though the full range of utilitarian resources encompassed many construction materials and types.

While analyzing the DoD RPAD data, the ERDC-CERL research team also analyzed the historic status—based on the HSC—of utilitarian structures. The goal of this analysis was to take the first step toward easing the management of these resources by understanding the historic significance and integrity of those that had been evaluated. This was a particularly important step in the research, as more than half (52.2%) of the buildings included in data collection were not yet eligible for historic status evaluation, meaning that the evaluation and management of utilitarian buildings as historic or potentially historic resources will be increasing through at least 2041.[285] The majority (75.6%) of data entries assessed for this report represented buildings that had not yet been evaluated for listing on the NRHP, further demonstrating the importance of this research.

Of the 24.4% of the resources that had been evaluated for NRHP-eligibility, 86.4% were determined not eligible for listing on the NRHP or non-contributing elements of an eligible historic district.[286] Further, 7.3% of those evaluated were NRHP-eligible for the purposes of a program alternative, meaning they were determined to meet NRHP eligibility criteria when considered as resources that could be managed by an existing program alternative to Section 106. Thus, only 7.3% of the buildings that had been evaluated were able to be managed via an existing program alternative, demonstrating the potential value of developing a program alternative to NHPA Section 106 for utilitarian buildings. Altogether, this data demonstrates that resources in the DoD RPAD identified as utilitarian by this report primarily have not been evaluated

[285] The final year of construction evaluated for this report was 1991. Buildings typically become eligible for evaluation or listing on the NRHP at 50 years of age. For buildings constructed in 1991, 50 years of age will be reached in 2041.

[286] Of those evaluated, 82.9% were not eligible and 3.5% were non-contributing elements of an eligible historic district. The sum of those percentages is 86.4%.

for NRHP-eligibility, likely do not have the level of significance or integrity required for NRHP-eligibility and are not currently able to be efficiently managed via an existing program alternative to NHPA Section 106.

The final step of research for this project proposed by ERDC-CERL researchers was visits to DoD installations to conduct in-person evaluations of utilitarian buildings. Due to an inability to correlate the provided DoD RPAD data with individual buildings on the installations, however, the ERDC-CERL research team adjusted the aim of their installation visits to instead understand the criteria used by installation CRMs to identify utilitarian buildings. Through six site visits, the ERDC-CERL research team determined that installation CRMs largely identify utilitarian resources as buildings and structures constructed and utilized to serve a basic need—such as support and storage—with little architectural ornamentation. The buildings identified by installation CRMs covered a similar spread of construction type (temporary, semi-permanent, and permanent) and material (concrete, wood, and metal) as the data entries in DoD RPAD; however, installation CRMs also identified brick buildings as utilitarian. This indicates that the people evaluating these structures have a broader understanding of construction material used for utilitarian buildings than just those materials that were specifically identified in the DoD RPAD analysis (concrete, wood, and metal). This reflects the findings of the historical research conducted for this report, which, as stated above, found that utilitarian buildings could be constructed of any material.

## 5.1 A Definition of Utilitarian Buildings for a Potential NHPA Section 106 Program Alternative

The VA and ACHP released a Program Comment defining utilitarian buildings as follows:

> building[s] or structure[s] of practical design, usually without much architectural ornamentation, utilizing traditional construction materials, with functions primarily limited to industrial and storage needs. VA's utilitarian properties tend to have standardized plans and little architectural design, complexity, or uniqueness, were constructed quickly, and have been determined by VA to have minor or no historic significance and/or diminished or no integrity. Utilitarian properties in VA's inventory could include, but are not limited to, warehouses, garages and carports, storage sheds, sewage plants, transformer buildings,

> incinerators, smoking shelters, pump houses, trailers, boiler/power plants, barns, Quonset structures, laundry facilities, golf shacks, gate houses, guard stations, connecting corridors, greenhouses, fallout shelters, maintenance shops (e.g., machine, paint, vehicle repair, housekeeping), animal research laboratories, and associated research sheds or ancillary buildings.[287]

At the point of this VA Program Comment definition's release, research for this DoD report was already underway; however, ERDC-CERL researchers adopted this definition as a basis for understanding utilitarian buildings going forward in their research.

The VA Program Comment definition of utilitarian does not provide a general period during which utilitarian resources were constructed, and this lack of provision of a historic period is supported by this report. Historical research conducted for this report demonstrated no direct association between the designs of most utilitarian buildings and any national event. Therefore, utilitarian buildings cannot be categorized into historic periods as required by *National Register Bulletin #15: How to Apply the National Register Criteria for Evaluation* for significance under Criterion A for association with "events that have made a significant contribution to the broad patterns of our history."[288] This is notable, as the development of some prefabricated buildings types, such as Quonset huts and housing, were directly associated with mission activities, such as the WWII war effort and Cold War research efforts. Therefore, prefabricated construction alone does not classify a resource as utilitarian. Instead, utilitarian buildings lack ornamentation or other architectural characteristics that would allow architectural historians to identify their period of construction by in-person evaluation that is not aided by historical research. This lack of defining architectural characteristics may be the result of standardized construction, prefabrication, or the use of prefabricated materials; however, construction that does not fall into these parameters does not preclude a building from being utilitarian.

Given that previous DoD NHPA Section 106 program alternatives have been based upon specific category codes (such as ammunition storage or housing) and a specific range of dates (such as 1946–1974) or period (such

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[287] Fowler, "Notice of Issuance of the US Department of Veterans Affairs Program Comment for Vacant and Underutilized Properties," 54123.

[288] NPS, *National Register Bulletin #15: How to Apply the National Register Criteria for Evaluation*, 2.

as Interwar), and that utilitarian buildings currently neither have a category code nor association with a specific range of dates or historical period, a program alternative to NHPA Section 106 will need to:

1. Feature a list of DoD RPAD category codes that is developed and vetted to ensure that all types of utilitarian buildings identified by this report are incorporated;

2. Consult with the ACHP, relevant State Historic Preservation Officers (SHPOs), the National Conference of State Historic Preservation Officers, and the National Association of Tribal Historic Preservation Officers regarding this list;

3. Define a range of dates or historic period for the definition that applies to the historic properties covered by the Program Alternative.

The DoD RPAD Analysis chapter (Chapter 3) provides a list of building types studied for this report that may be utilized as a list of DoD RPAD category codes for utilitarian buildings for purposes of a Program Alternative. This list will still require consultation with the ACHP, relevant SHPOs , the National Conference of State Historic Preservation Officers, and the National Association of Tribal Historic Preservation Officers.

Further, the ERDC-CERL research team developed the date range of 1946 to 1991 for this report based on similar studies that have previously been conducted, such as the UPH historic context and ammunition storage historic context. It is important to note, however, that, while the development and widespread use of standardized and prefabricated building technologies may have associations with specific conflicts—for example, the development and use of prefabricated panel construction by the DoD for housing is related to the Cold War—buildings using these types of construction for support, storage, or other utilitarian purposes are typically not directly related to any conflict that the DoD has participated in. Further, a utilitarian building's construction during a specific conflict or historical period does not necessarily indicate significance in relation to that conflict or period.

Therefore, utilitarian buildings often serve a basic need that is not necessarily inherently related to a significant conflict or period in DoD history. As such, they are defined by their both their use—a structure that meets a basic need rather than a structure that meets a mission-critical need—and their design and construction processes—a resource that was prefabricated, constructed using prefabricated materials, or constructed based on a standardized plan to preclude the building or structure from having character defining features.

Based on this information, ERDC-CERL presents the following definition of utilitarian buildings that may be utilized for the development of a program alternative: buildings or structures of practical design with minimal architectural ornamentation that were most frequently, *but not always*, constructed utilizing traditional construction materials (concrete block, wood, and metal).

Historically, the DoD most frequently used concrete block for the construction of utilitarian buildings. The use of non-traditional construction materials (materials other than concrete block, wood, and metal) does not preclude a building or structure from being classified as utilitarian. The DoD's utilitarian resources typically were prefabricated, used prefabricated materials, or were constructed based on standardized plans. They typically feature little architectural design, complexity, or uniqueness; were constructed quickly; and repeatedly have been determined ineligible for listing in the NRHP due to having minor or no historic significance and/or diminished or no integrity. However, eligibility for listing in the NRHP does not preclude a building or structure from being classified as utilitarian. Utilitarian buildings and structures were constructed to meet a basic need and not to directly support mission activities.

As such, the DoD's utilitarian resources are defined by both their use and their design and construction processes—they meet basic, industrial needs that are not mission critical and were prefabricated or otherwise standardized. Most utilitarian structures still in use by the DoD primarily have functions limited to industrial and storage needs. Utilitarian properties in the DoD's inventory may include, but are not limited to, warehouses, vehicle shelters, storage buildings and sheds, maintenance facilities, support buildings, fueling facilities, latrines, and septic and landfill facilities. This definition does not apply to buildings and structures constructed prior to 1946.

## 5.2 Recommendation and Conclusion

Based on the fact that 52.2% of the buildings included in data collection for this report were not yet of age for NRHP-eligibility evaluation, and that 75.6% of the buildings included had not yet been evaluated for NRHP-eligibility, it is the recommendation of this report that the DoD pursue a program alternative to Section 106 of the NHPA from the ACHP for the management of these resources. Based on the commonality of uses, construction materials, and construction types for utilitarian buildings as discussed in Chapters 3 and 4, this report recommends the development of a Program Comment similar to that issued by the ACHP for the VA in 2018. A Program Comment issued by the ACHP would be the best option of all program alternatives since it would cover all aspects of Section 106 as defined during the Program Comment development and potentially would not have an expiration date that would also be defined during the Program Comment development. Other program alternatives would not have the broad reach of a Program Comment to cover an entire class of facilities and generally other program alternatives have short sunset expiration dates that would not help the agency with mitigating their obligations under Section 106 of the NHPA. The definition of utilitarian buildings presented above may serve as the basis for this Program Comment or for other program alternatives.

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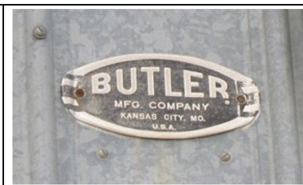
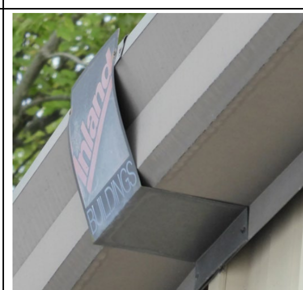
# Appendix A: Information Related to Prefabricated Building Manufacturers

This appendix provides a list of prefabricated building manufacturers and histories of metal corrugation and metal roofing to provide installation CRMs with information that may help identify prefabricated and metal building construction dates and manufacturers. This may aid in the management of utilitarian structures, particularly in the case of the development of a program alternative, by helping installation CRMs quickly identify whether or not resources fall into the 1946–1991 period for utilitarian building construction recommended by this report.

## A.1 Prefabricated Building Manufacturers

| Company Name | Location | Period Active in Market | Product Details | Logo |
|---|---|---|---|---|
| A&M Building Systems, Inc. | Clovis, New Mexico | Unknown | |   |
| Alliance Steel | Oklahoma City, Oklahoma | 1970s-Present | Metal buildings constructed on site |     |

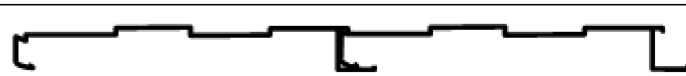
| | | | | |
|---|---|---|---|---|
| American Buildings Company | Eufaula, Alabama | 1964-Present | Metal buildings constructed on site; acquired by Nucor in 2007. |   |
| Arco Building Systems | Tucker, Georgia | 1979-Present | Pre-engineered metal building systems | |
| Armco Drainage and Metal Products, INC | Middletown, Ohio | 1950s-1970s | Subsidiary of Armco Steel Corporation; main product was STEELOX building system of interlocking self-framing panels. |     |
| Automated Building Components, Inc. | North Baltimore, OH | 1960s | Roof truss system for building pole | |
| Behlen Manufacturing | Columbus, Nebraska | 1950s-Present | Metal buildings constructed on site; building system incorporated self-framing walls with large corrugations. | |
| Butler Manufacturing | Kansas City, Missouri | 1909-Present | Metal buildings constructed on site |   |

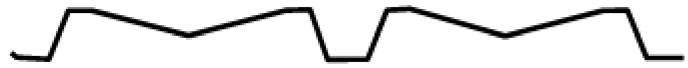
| | | | | |
|---|---|---|---|---|
| | | | |  |
| Chief Buildings | Grand Island, Nebraska | 1966-Present | Metal buildings constructed on site |  |
| Gulf States Manufacturing | Starksville, Mississippi | Unknown-2017 | Metal buildings constructed on site; acquired by Nucor at some point and merged with Kirby in 2017 |  |
| H. H. Robertson Company (now Robertson Building Systems) | Washington D.C. | 1917-Present | Architectural metal manufacturing and installation | |
| Inland Buildings (A.k.a. INRYCO from 1974-1984) | Cullen, Alabama (1974-Present) | 1910-Present | Metal buildings constructed on site |  |
| Kelly Klosure Systems | Fremont, Nebraska | 1968-Present | Reusable prefabricated and insulated steel panels | |
| Kirby Building Systems | Portland, Tennessee | 1959-Present | Metal buildings constructed on site; purchased by Nucor in 2007 | |
| Luria Standardized Buildings (a division of Luria Engineering Company, formerly Luria Steel and Trading | Haverstraw, New York (formerly Georgia) | 1948-Present | Steel prefabricated aircraft hangars | |

| | | | | |
|---|---|---|---|---|
| Corporation, now Luria Corp.) | | | | |
| Lustron Corporation | Columbus, Ohio | 1947-1950 | Manufactured homes made of enameled steel | |
| M.I.C Industries | Reston, Virginia | 1981-Present | Metal buildings constructed on site; known for Automatic Building Machine System | |
| Geo. L. Mesker & Company | Evansville, Indiana | 1885-c.1960 | Complete storefronts, steel roof trusses, and prefabricated steel buildings | |
| Morgan Buildings | Ft. Worth, Texas | 1961-Present | Wood framed buildings with wood or steel exterior; delivered on site in modular components |   |
| Morton Buildings | Morton, Illinois | 1965-Present | Metal and steel pole barn buildings | |
| Nucor Building Systems | Waterloo, Indiana | 1988-Present | Metal buildings constructed on site |   |
| Parkersburg Building Division | Parkersburg, West Virginia | 1930s-1981 | Metal buildings constructed on site; began as subsidiary of Parkersburk Rig and Reel Company; Parkline, Inc currently owns the manufactures the building system |  |

| | | | | |
|---|---|---|---|---|
| Star Manufacturing | Oklahoma City, Oklahoma | 1930s-Present | Metal buildings constructed on site |  |
| Stran-Steel Corporation (now a subsidiary of US Steel) | Detroit, Michigan | 1929-Present | Metal buildings constructed on site; subsidiary of National Steel; known for Quonset huts |  |
| Wickes, Inc. (formerly Wickes Lumber Co.) | Vernon Hills, Illinois | 1854-Present | Wood buildings with prefabricated metal exteriors | |
| Wonder Building Corporation | Chicago, Illinois | 1949-Present | Corrugated steel half-round structures ("Wonder Buildings") | |

## A.2 Evolution of Corrugation in Metal Buildings

| Trends: | Examples: |
|---|---|
| Standard Corrugation | Figure 241 (Pictured: Generic) |
| 1840s—1930s |  |
| Deep Corrugation | Figure 242 (Pictured: Generic) |
| 1930s—1960s |  |
| Corrugated Rib | Figure 243 (Pictured: Generic) |
| 1940s—1950s |  |
| Flat-crimp Reinforced Corrugated Rib | Figure 246 Figure 244, Figure 245 and (Pictured: "Deep-drawn Corrugated Panel" – Butler 1945) |
| 1940s—1960s |  |
| Box Rib | Figure 247 (Pictured: Unnamed Box Rib – Mesker 1958) |
| 1940s—1960s |  |
| Flat-crimp-reinforced Box Rib | Figure 248 (Pictured: "Butlerib" – Butler 1958) |
| 1950s—1980s |  |
| Crimp–reinforced Box Rib | Figure 249 (Pictured: "Butlerib II" – Butler 1969) |
| 1960s—Present |  |
| Angular-Crimp Box Rib | Figure 250 and Figure 251 (Pictured: "Strongpanel" – Granite City Steel 1974) |
| 1970s—Present |  |
| Flat-Crimp Corrugation | Figure 252 (Pictured: "StylWall Fluted Panel" – Butler 1980s) |
| 1980s— 1990s? |  |

| Angular-Crimp Inverse Box Rib | Figure 253 (Pictured: “Shadowall Panel” – Butler mid-1990s) |
|---|---|
| 1990s—Present |  |

### A.2.1 Standard and Deep Corrugation

Perhaps, the single most important development for the construction of metal buildings was corrugation, first seen in England in the 1840s. Corrugating sheet metal provided stability in the direction perpendicular to the corrugation. Early corrugation remained simple, with uniformed corrugation depth and spacing (Figure 241).[289] This form of corrugation was used extensively by the DoD during both World Wars and was an essential component in the construction of Nissen huts and Quonset huts. Over time, it was discovered that larger and deeper corrugations could provide additional strength, and corrugation size began to increase by the 1930s (Figure 242).[290] This same principle would go on to be the main impetus for the self-framing Wonder Building, which was popular in the late 1950s and 1960s. While standard corrugations of varying depths are still used today, it has slowly lost popularity as newer forms of corrugation entered the market beginning in the 1940s.[291]

[289] Simon Holloway and Adam Mornement, *Corrugated Iron: Building on the Frontier*, New York: W.W. Norton & Co., 2007, Ch. 1.

[290] Ibid, Ch. 4; Chiei and Decker, *Quonset Hut*; Garner, *World War II Temporary Buildings*.

[291] Wonder Trussless Building, Inc., "Wonder Building Assembly and Specification Manual," Chicago, IL: Wonder Trussless Building, Inc., 1958.

Figure 241. An illustration of a corrugated sheet marketed by Mesker in their catalog, offering a variety of lengths and gauges, but with the same size corrugation patterns, 1914 (Geo. L. Mesker & Co., "Store Fronts," Evansville, IN: 1914, https://digital.lib.uh.edu/collection/aapamphlets/item/954).

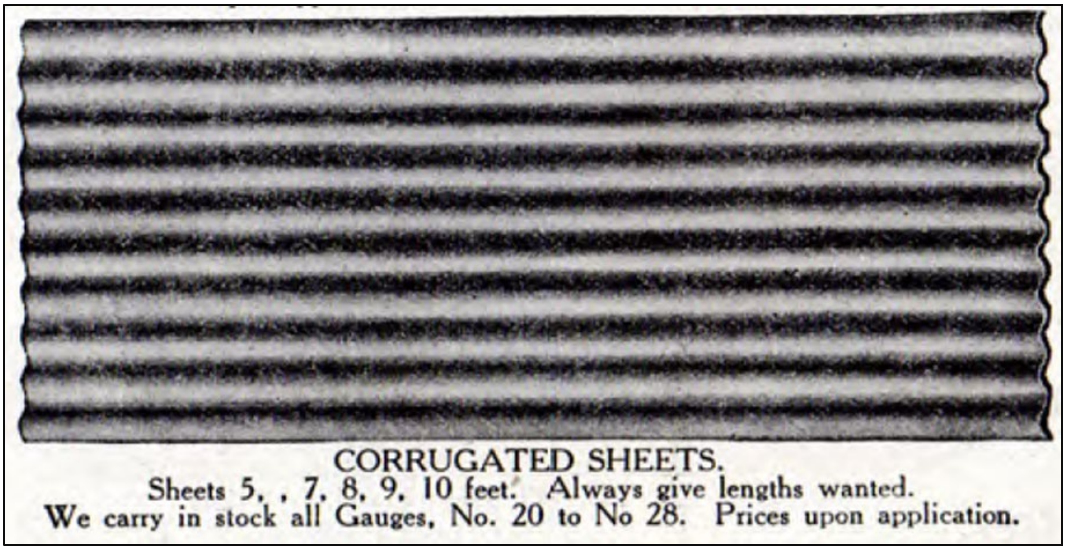
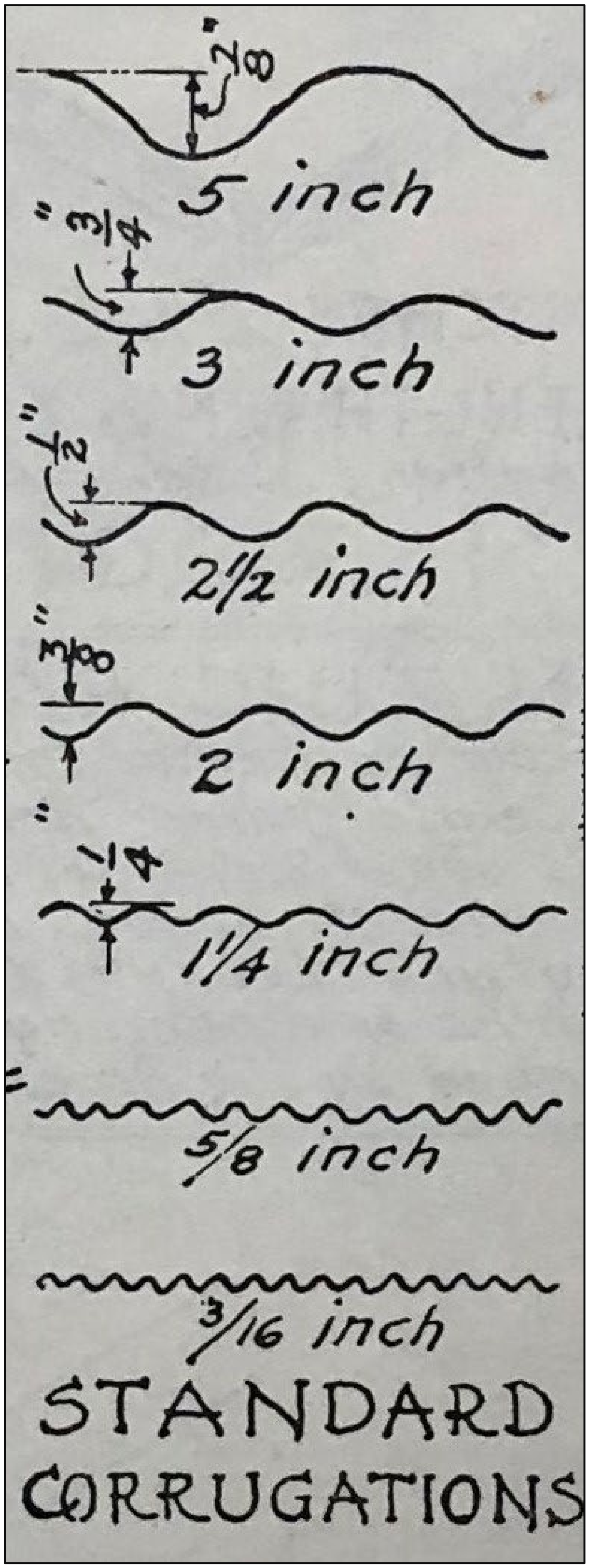


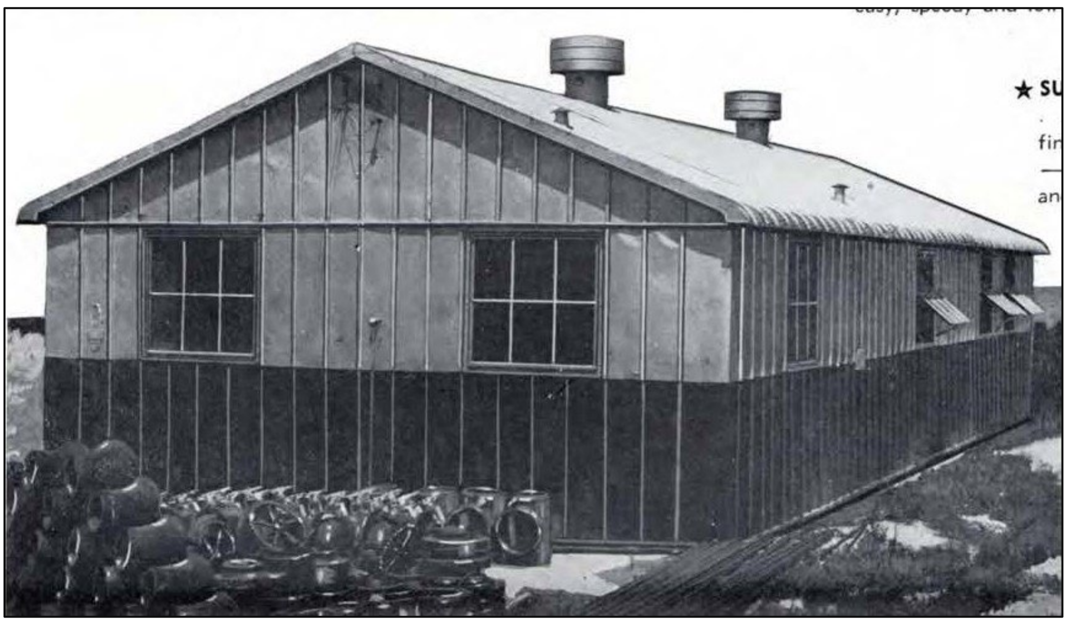
Figure 242. “Standard Corrugations” listed in the Architectural Graphic Standards with sizes ranging from 3/16” to 5”, 1946 (Charles Ramsey and Harold Sleeper, *Architectural Graphic Standards, 3rd Ed.*, New York: John Wiley & Sons, 1946).



### A.2.2 Corrugated Rib

One of the earliest adaptations to the typical standard corrugation was the addition of flat sections in between the corrugations. This type of corrugation began to be referred to as ribs. Corrugated rib panels grew in popularity in the 1940s and continued in use into the 1950s (Figure 243).[292] Rib panels maintained the rigidity created by the corrugations while using less metal. These corrugations were often deeper than normal corrugations to add strength that would counteract any loss of strength from the reduced quantity of individual corrugations.[293]

Figure 243. A prefabricated metal building manufactured by Mesker, which utilizes corrugated rib panels, 1958 (Geo. L. Mesker Steel Corporation, "Catalog E," Evansville, IN: Geo. L. Mesker Steel Corporation, 1948, https://www.dropbox.com/s/janqyw1yshqoeuk/1948%20Geo%20L%20Mesker%20Steel%20Corp%20Catalog%20E.pdf?dl=0).



### A.2.3 Flat-Crimp Reinforced Corrugated Rib

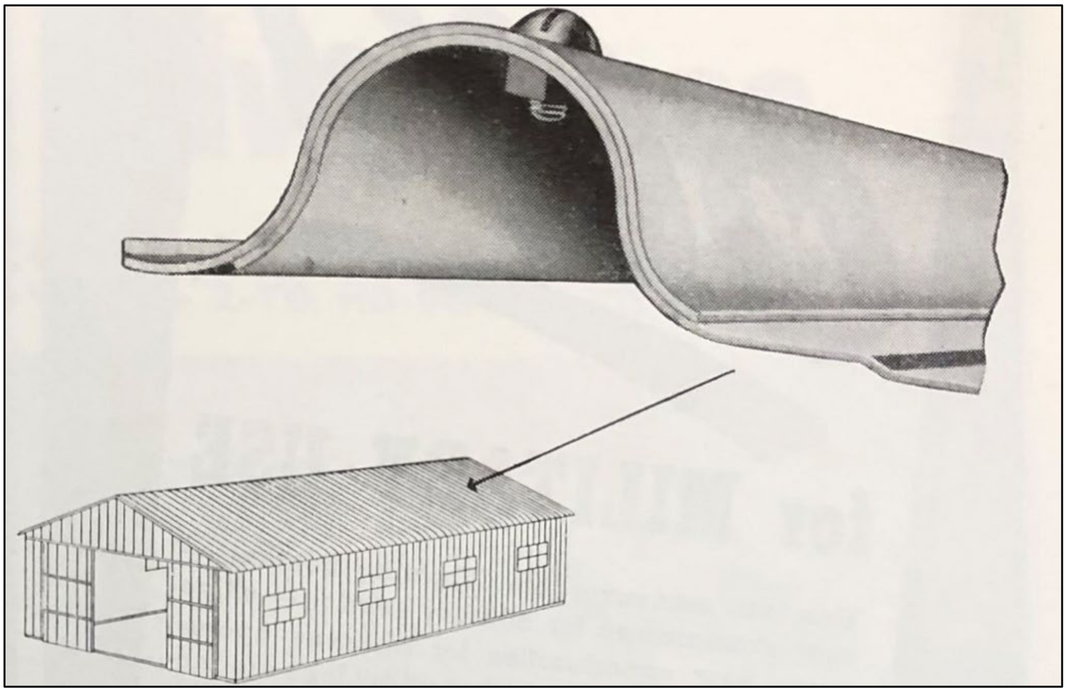
Butler's "Deep-Drawn Corrugation" greatly strengthened the corrugated rib panel design by adding deeper corrugations and using small angular crimps on either side of the rib (Figure 244 and Figure 245). This panel

[292] Geo. L. Mesker Steel Corporation, "Catalog E," Evansville, IN: Geo. L. Steel Corporation, 1948, https://www.dropbox.com/s/janqyw1yshqoeuk/1948%20Geo%20L%20Mesker%20Steel%20Corp%20Catalog%20E.pdf?dl=0.

[293] Wonder Steel Buildings, "Special Factory Offer;" Southeastern Steel Buildings, "Our Buildings Will Save You Thousands;" Simon Holloway and Adam Mornement, *Corrugated Iron: Building on the Frontier*, New York: W.W. Norton & Co., 2007.

was featured as the roofing and siding for most Butler buildings from the 1940s through the 1960s, including their rigid-frame warehouses and the Butler huts, the replacement selected by the DoD for the Quonset hut during the Vietnam War (Figure 246).[294]

Figure 244. A close up on the joint between two “deep-drawn corrugated panels” which is intened to highlight the increased weather-tightness of the connection, May-June 1952 (Butler Manufacturing Company, [Advertisement], *The Military Engineer* 44, no. 299 (May – June 1952): n.p.).



[294] Butler Manufacturing Company, [Advertisement], The Military Engineer 44, no. 299 (May – June 1952): n.p.; Butler Manufacturing Co., “Obsolete BRI Profile,” Obsolete Butler Panels, accessed Aug. 17, 2021, https://butlerpartsonline.com/obsolete-butler-panels/; Butler Manufacturing Company, “U.S. Navy rigid frame utility warehouse building erection instructions.”

Figure 245. A detailed design of Butler's "deep-drawn corrugations" showing the center and outside corrugations. Of note are the crimp-reinforcements added directly on either side of the corrugations to provide added strength, 1949 (Butler Manufacturing Company, "Obsolete BRI Profile," Obsolete Butler Panels, accessed Aug. 17, 2021, https://butlerpartsonline.com/obsolete-butler-panels/).

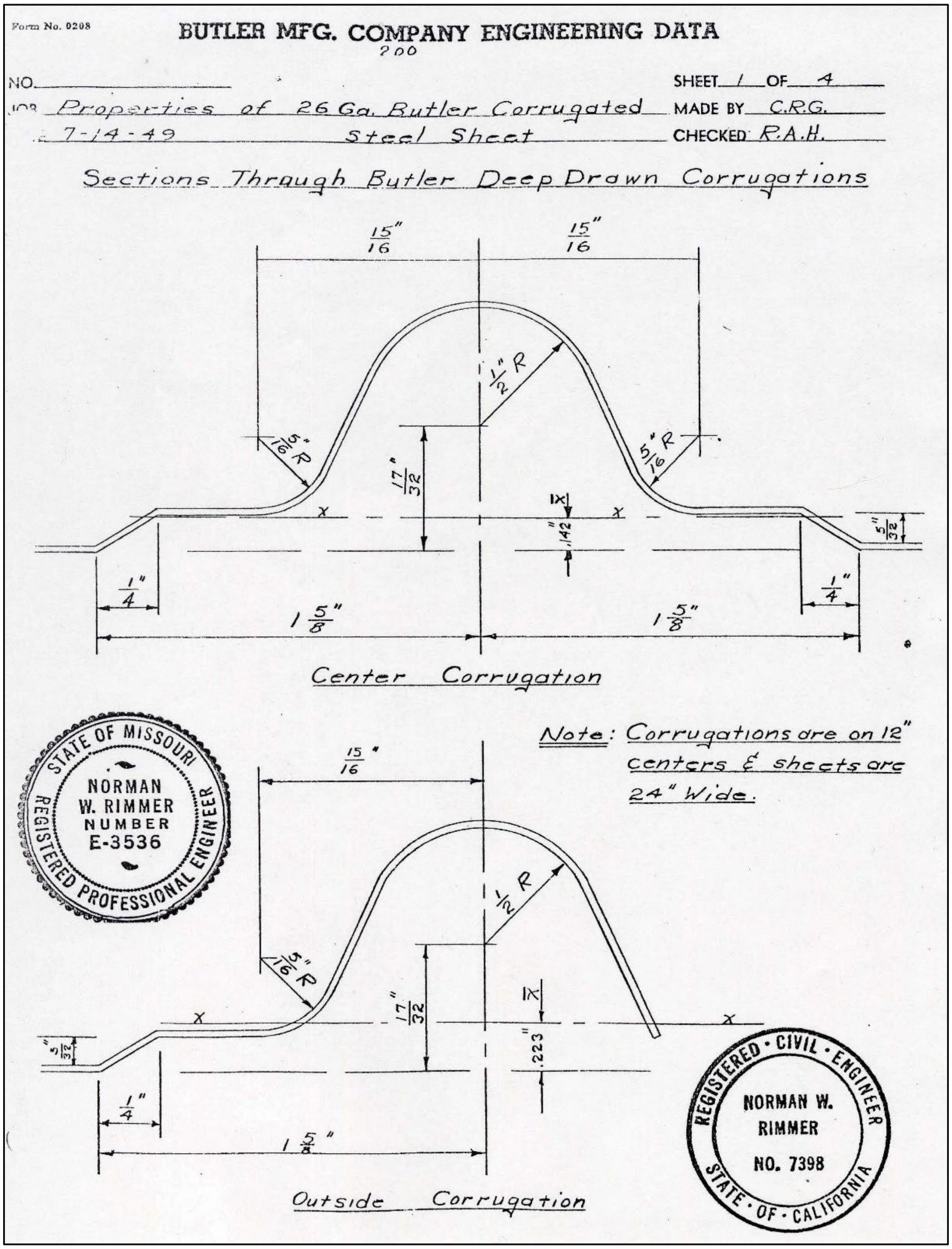


Figure 246. A "Deep-drawn Corrugated Panel" used by Butler in as both roofing and siding for many of their structures from the 1940s to the 1960s, 1945, (Butler Manufacturing Company, "U.S. Navy rigid frame utility warehouse building erection instructions for the 40' 0" x 100' 0" building," Kansas City, MO: Butler Manufacturing Company, 1945).


### A.2.4 Box Rib and Flat-Crimp Reinforced Box Rib

Beginning in the 1950s, as crimping techniques improved, companies started manufacturing box ribbed panels, in which ribs were created using crimping rather than single deep corrugations (Figure 247).[295] Similar to small crimps added to strengthen Butler's "Deep-Drawn Corrugated Panels," Butler's version of the box rib had low profile crimps added, with the effect of adding two small ribs between every large box rib. Butler's box rib was known as the "Butlerib" and released in 1958 (Figure 248).[296]

[295] Geo. L. Mesker & Co., [Catalog], Evansville, IN: Geo. L. Mesker Steel Corporation, 1960; Butler Manufacturing Company, "Butler Rib Cross Section Profile," Obsolete Butler Panels, accessed Aug. 17, 2021, https://butlerpartsonline.com/obsolete-butler-panels/).

[296] Butler Manufacturing Company, "Butler Rib Cross Section Profile;" Butler Manufacturing Company, "Would you buy a Butler building just to get this panel?"

Figure 247. A typical example of a box rib panel, with this particular model being used by Mesker in their line of prefabricated steel buildings as both siding and roofing. These panels could be made out of galvanized steel or in translucent plastic and came in lengths up to 8 feet, 1960 (Geo. L. Mesker & Co., [Catalog], Evansville, IN: Geo. L. Mesker Steel Corporation, 1960).

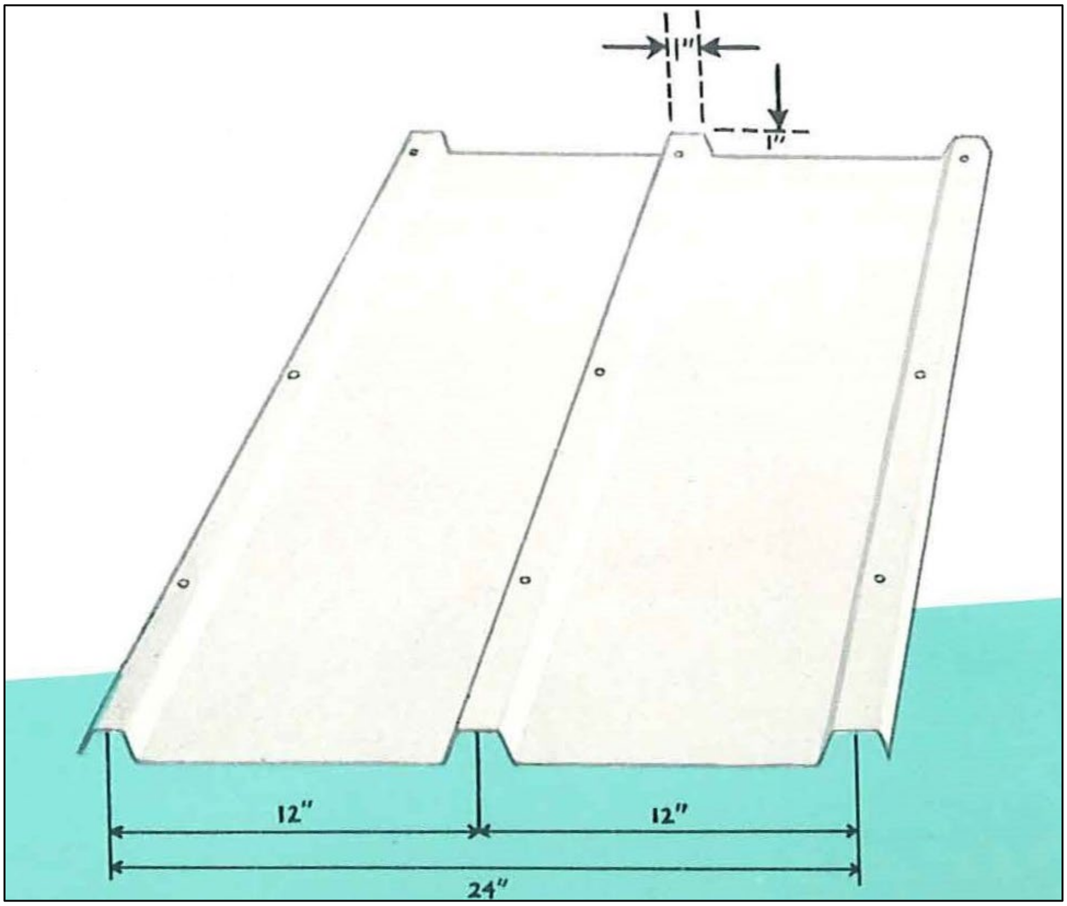
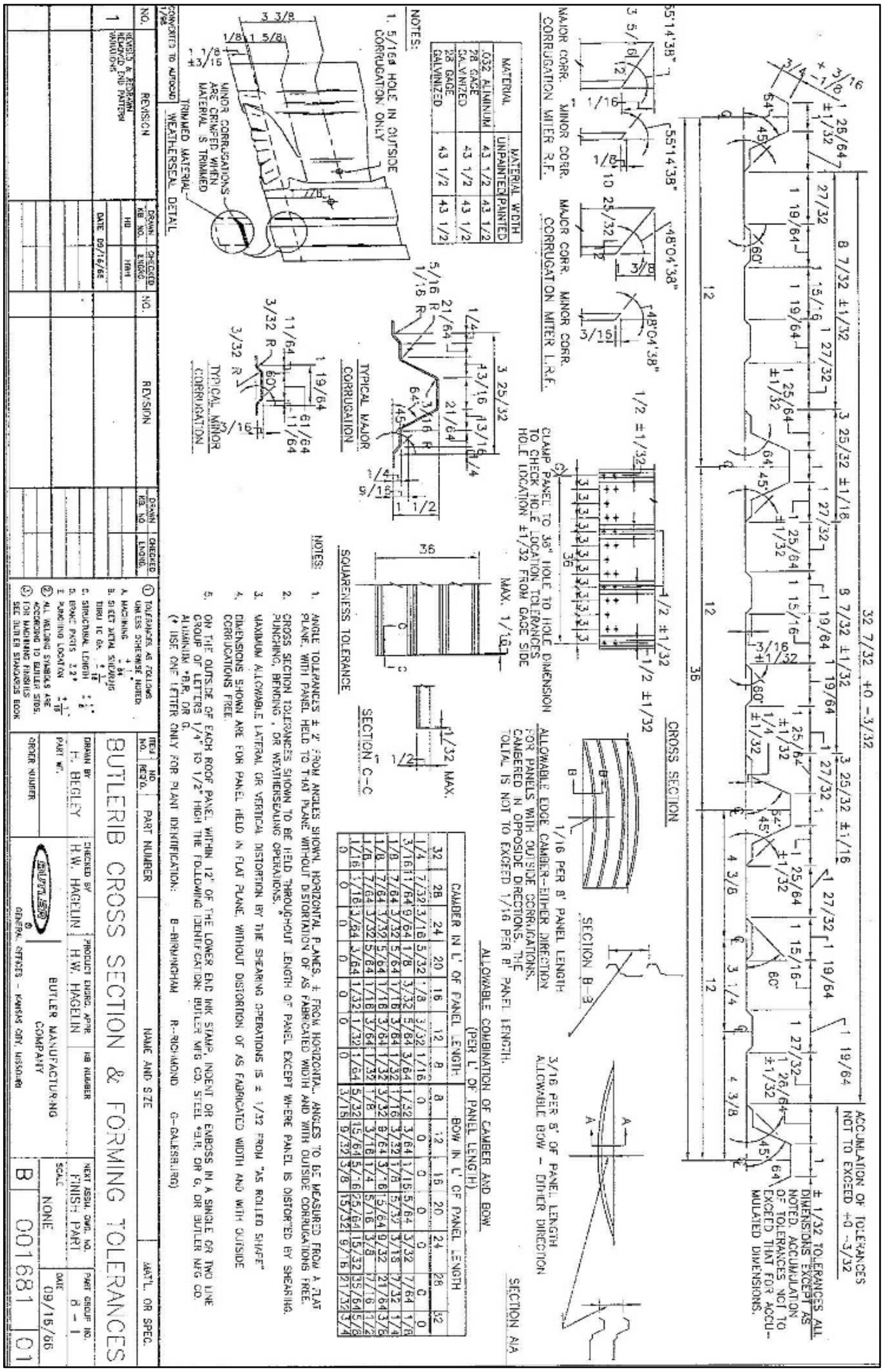


Figure 248. The cross section of the Butlerib, released in 1958, which shows the low profile ribs added between the larger box ribs, 1966 (Butler Manufacturing Company, "Butler Rib Cross Section Profile," Obsolete Butler Panels, accessed Aug. 17, 2021, https://butlerpartsonline.com/obsolete-butler-panels/).

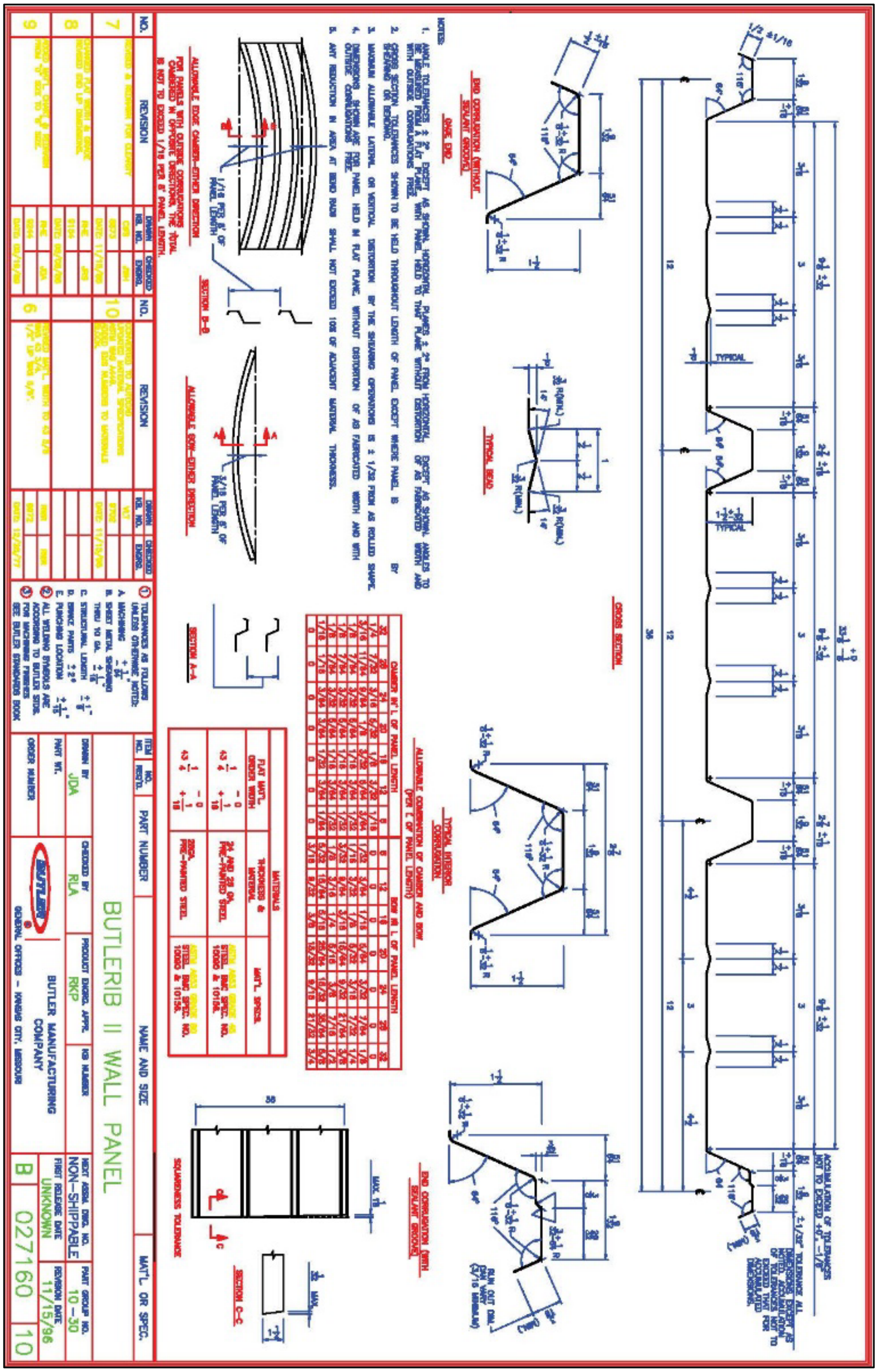


### A.2.5 Crimp Reinforced Box Rib

By the early 1970s, companies began to realize that simple crimping patterns were enough to give sheet metal stability. The early signs of this shift are seen in 1969 when the second iteration the Butlerib, the Butlerib II (Figure 249), was released. This improved upon the original Butlerib by doing away with the miniature box ribs and replacing them with very slight v-crimps. The Butlerib II is still used widely today in roofing and siding of Butler Buildings.[297]

[297] Butler Manufacturing Company, "BRII Wall Profile," BRII Wall Profile, accessed Aug. 17, 2021, https://butlerpartsonline.com/product/brii-wall-panel.

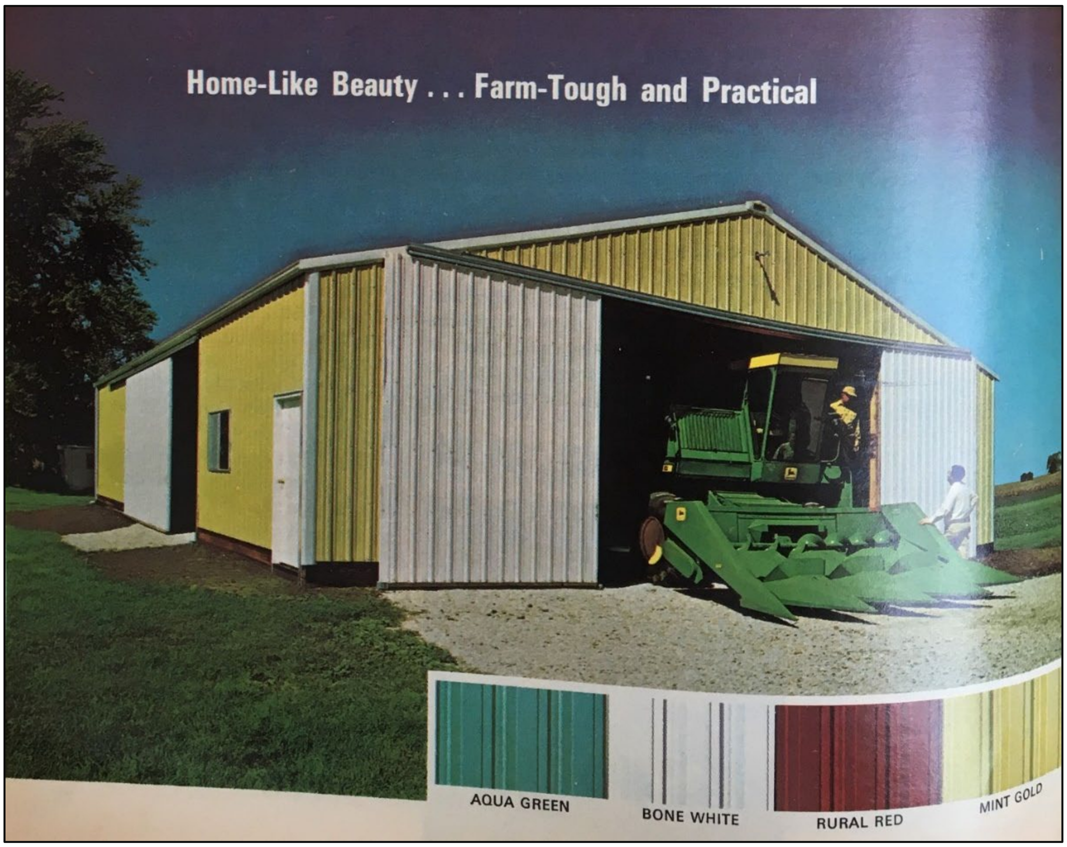
Figure 249. The cross section of the Butlerib II, originally released in 1969, which shows the replacement of the low profile box ribs with small v-crimps, 1996 (Butler Manufacturing Company, “BRII Wall Profile,” BRII Wall Profile, accessed Aug. 17, 2021, https://butlerpartsonline.com/product/brii-wall-panel/).



### A.2.6 Angular-Crimp Box Rib

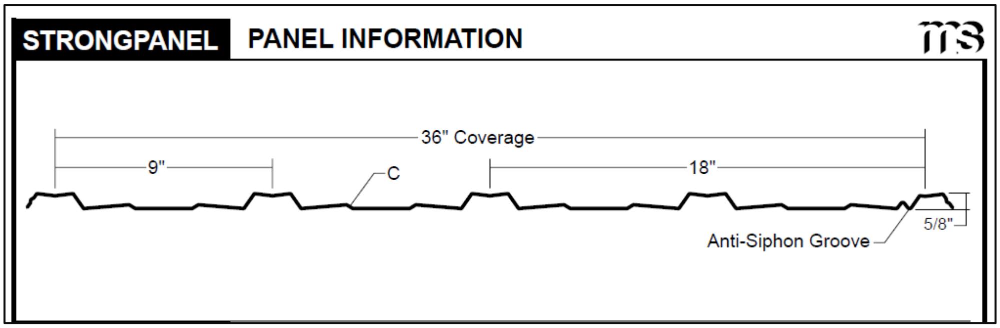
Similarly, Granite City Steel Company realized that the v-crimps could be added to the box rib itself, rather than between the ribs. Their Strongpanel, released in the early 1970s, featured ribs with v-crimps (Figure 250 and Figure 251).[298]

Figure 250. An advertisement by Granite City Steel for the Strongpanel, which came with the color already applied, 1974 (Granite City Steel, [Advertisement], *Progressive Farmer* 89 (1974): n.p.).




[298] Granite City Steel, [Advertisement], *Progressive Farmer* 89 (1974): n.p.; Metal Sales Manufacturing Co., Strongpanel Install Guide, PDF, https://www.buildsite.com/pdf/metalsales/StrongPanel-Installation-Instructions-1871429.pdf.

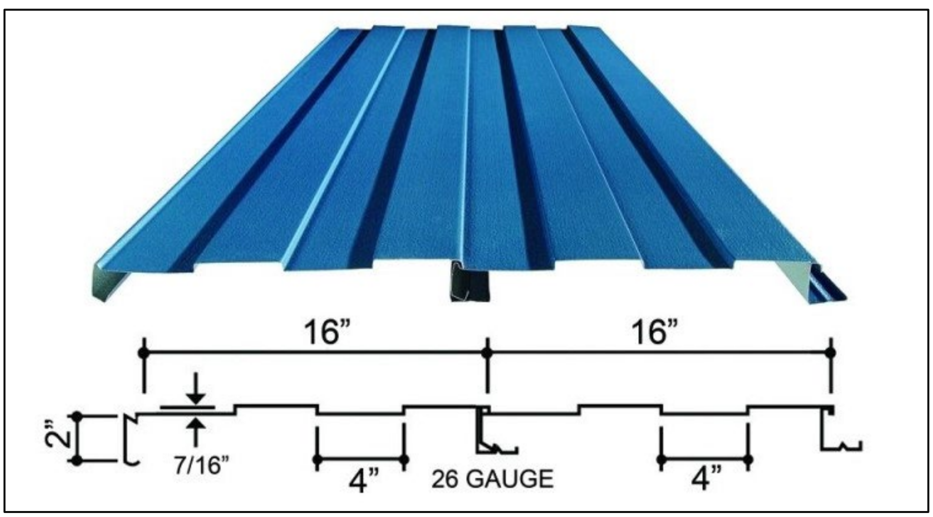
Figure 251. A cross section of a Strongpanel, notice the anti-siphon groove added to the end of the panel, 2015 (Metal Sales Manufacturing Co., *Strongpanel Install Guide*, PDF, https://www.buildsite.com/pdf/metalsales/StrongPanel-Installation-Instructions-1871429.pdf, 7).




### A.2.7 Flat-Crimp Corrugation

Taking the idea of low-profile ribs further, Butler released the StylWall Panel in mid-1980s. This panel's exterior was exclusively made up of flat-crimp corrugations that resembled the Butlerib's low-profile box ribs while being continuous across the panel (Figure 252). This panel also had interlocking ends for the panels to clip together, allowing it to be manufactured with a completely flat surface, as well. [299]

Figure 252. Two of Butler's StylWall Panels connected together showing seamless connection provided, unknown, (Butler Manufacturing Co., "StylWall II Fluted," StylWall II Wall System, accessed Aug. 17, 2021, https://butlerpartsonline.com/product/stylwall-fluted/).



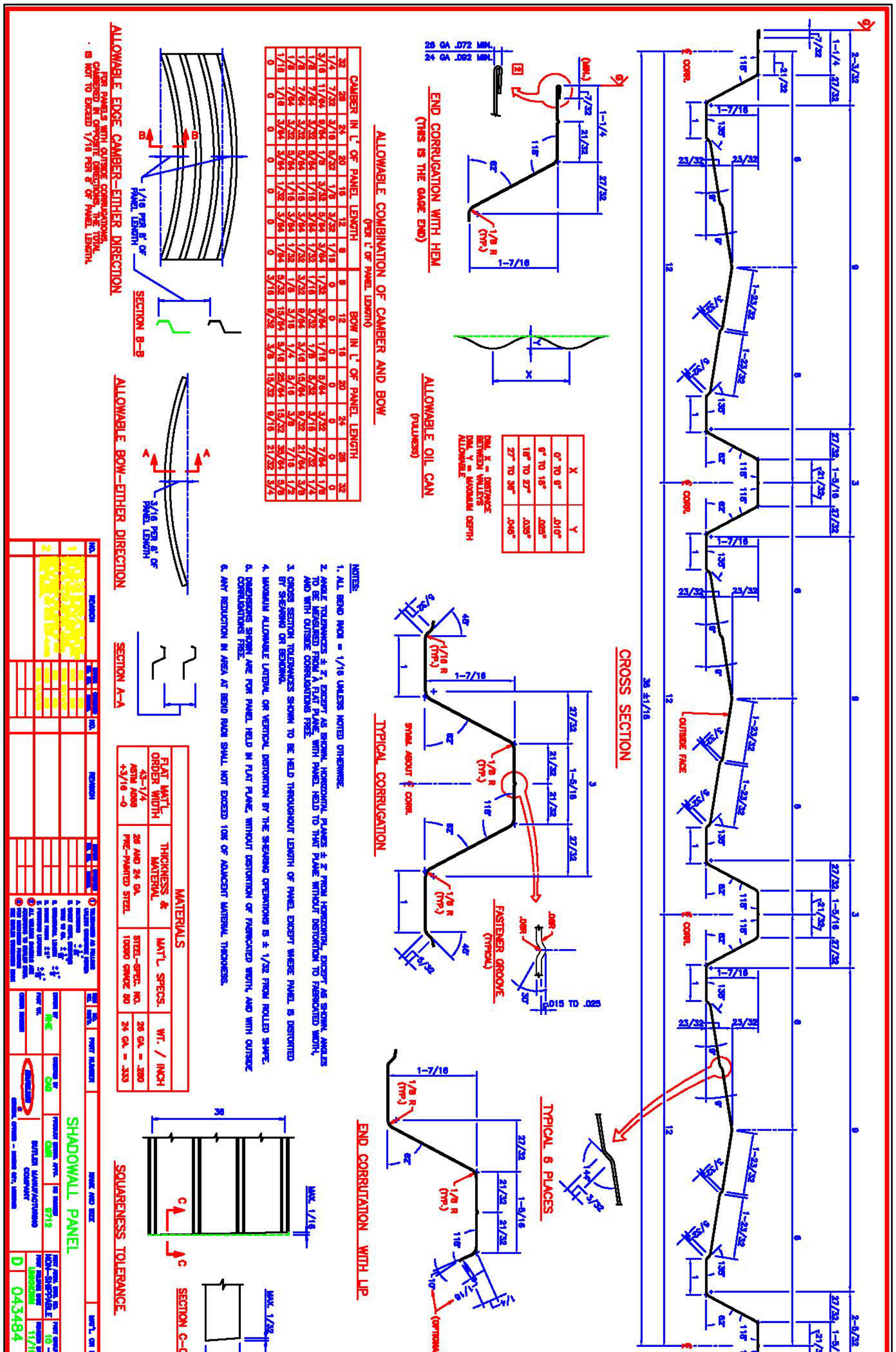

[299] Butler Manufacturing Co., "StylWall II Fluted," StylWall II Wall System, accessed Aug. 17, 2021, https://butlerpartsonline.com/product/stylwall-fluted/.

### A.2.8 Angular-Crimp Inverse Box Rib

Using a similar principle to the v-crimps added to the Butlerib II, Butler's Shadowall panels replaced the entire space between ribs with one large v-crimp (Figure 253). This greatly reduced the amount of metal used but required the reversal of the panel. The box ribs thus protruded toward the interior rather than the exterior, as in previous box ribs. This created a large pocket of air that could be easily insulated. Shadowall panels were advertised for their ability to be applied directly on top of existing siding or roofing, making it ideal for quick renovations.[300]

[300] Butler Manufacturing Co., "Shadowall Profile," Shadowall Panel, accessed Aug. 17, 2021, https://butlerpartsonline.com/product/shadowall-panel/).

Figure 253. A cross section of the Shadowall Panel, manufactured by Butler, notice the low profile crimps added to the larger v-crimp for further stability, 1998 (Butler Manufacturing Company, "Shadowall Profile," Shadowall Panel, accessed Aug. 17, 2021, https://butlerpartsonline.com/product/shadowall-panel/).



## A.3 Evolution of Metal Roofing

In the metal building industry, corrugated sheets of metal have been used as both siding and roofing, and the information in the previous section will apply to most corrugated roofing (Figure 254); however, there was some metal roofing that developed independently of corrugated siding and saw use in both metal buildings and traditional structures. By the early 1900s, sheet metal was being shaped specifically as roofing.[301]

Figure 254. Corrugated sheets were listed in Mesker's 1900 catalog (Geo. L. Mesker & Co., "Geo L. Mesker & Co. Architectural Iron Works," Evansville, IN: Geo. L. Mesker Steel Corporation, 1900, https://archive.org/details/Geo.L.MeskerCo.ArchitecturalIronWorksModernStoreFrontsHandsome, 38).

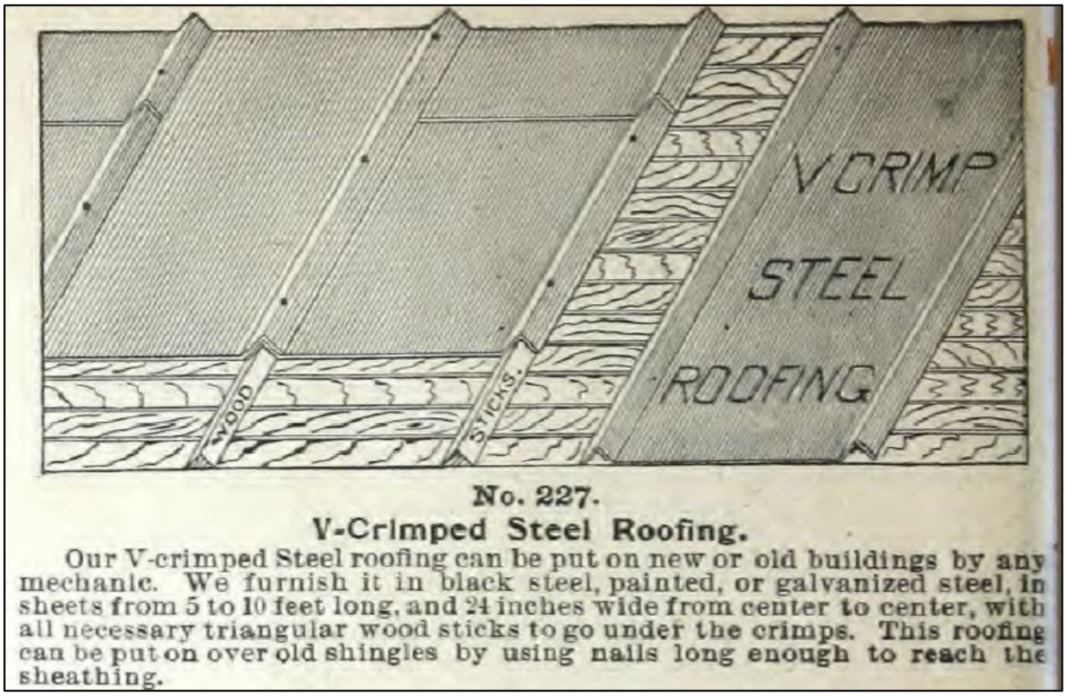

### A.3.1 V-Crimp and Double V-Crimp

An early important design was the v-crimp metal roof. V-crimp metal roof sheets featured v-crimps along both sides of the sheet so that they could be laid in an overlapping pattern. This developed around the turn of the nineteenth century (Figure 255). Wood nailing strips were placed under

[301] Geo. L. Mesker & Co., "Geo. L. Mesker & Co. Architectural Iron Works," Evansville, IN: Geo. L. Mesker Steel Corporation, 1900, https://archive.org/details/Geo.L.MeskerCo.ArchitecturalIronWorksModernStoreFrontsHandsome, 38.

the crimps.[302] By the 1940s, it was found that adding additional v crimps provided added weatherproofing properties for steeper roofs, leading to double v-crimp panels growing in popularity (Figure 256).[303] This method is still used, though it has been eclipsed by the standing seam roof in the non-corrugated metal roofing market.[304]

Figure 255. An early version of V-Crimp steel roofing manufactured by Mesker, 1900 (Geo. L. Mesker & Co., "Geo L. Mesker & Co. Architectural Iron Works," Evansville, IN: Geo. L. Mesker Steel Corporation, 1900, https://archive.org/details/Geo.L.MeskerCo.ArchitecturalIronWorksModernStoreFrontsHandsome, 38).

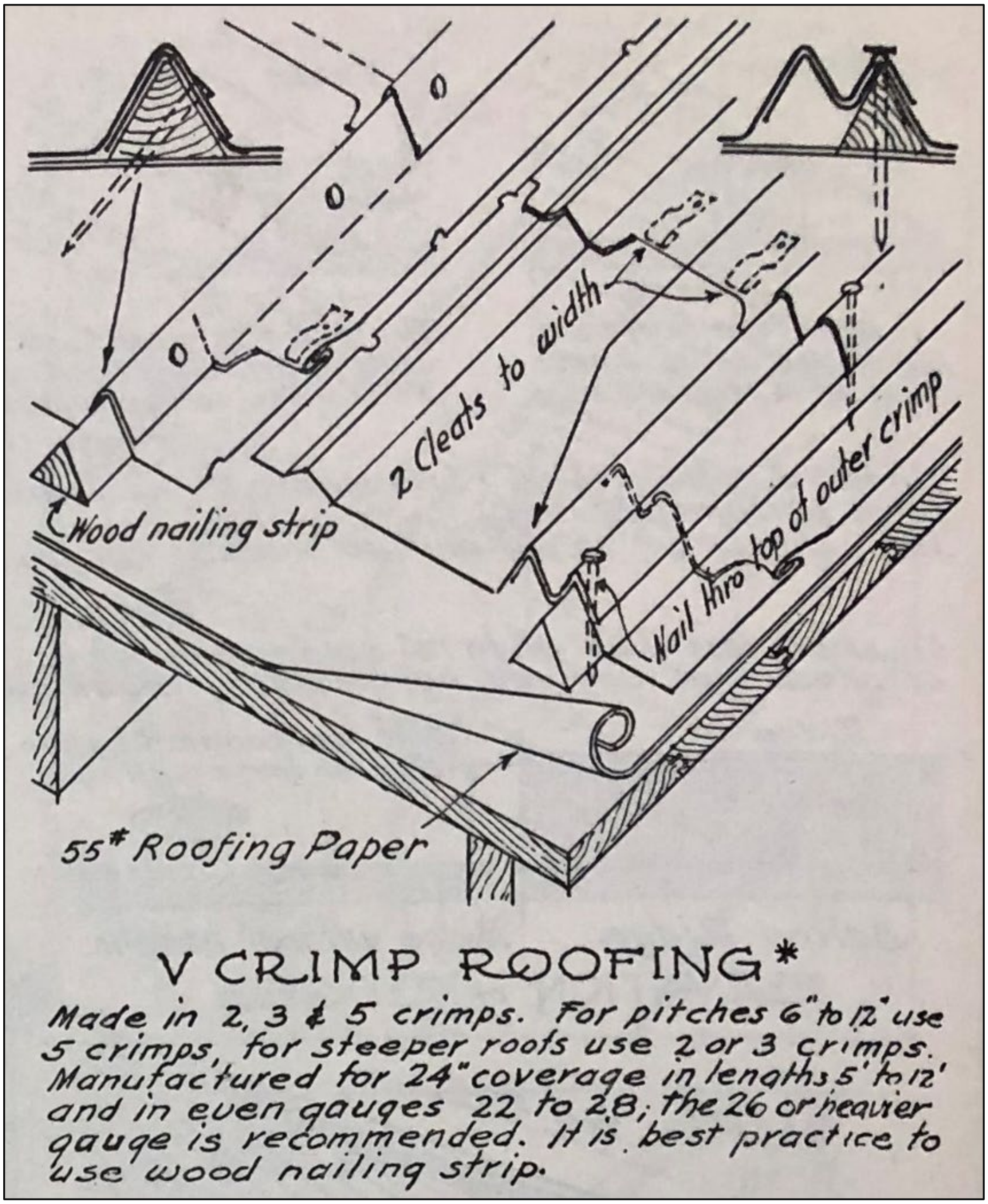



302 Ibid.

303 Charles Ramsey and Harold Sleeper, Architectural Graphic Standards, 3rd Ed., New York: John Wiley & Sons, 1946.

304 Sea Island Builders, "Standing Seam Vs. Crimp Roof," News, accessed Aug. 24, 2021, https://seaislandbuilders.com/news/standing-seam-vs-crimp-roof-1.

Figure 256. An installation guide for different V-Crimp roofing panels, 1946 (Charles Ramsey and Harold Sleeper, *Architectural Graphic Standards, 3rd Ed.*, New York: John Wiley & Sons, 1946).




### A.3.2 Standing Seam

Standing seam roofs date to the turn of the century and have always been known as the most weatherproof metal roof. The standing seam is the upright joint formed when two flat panels interlock. These joints could be pressed tightly or clipped to provide a watertight seal (Figure 257, Figure 258, and Figure 259).[305]

Figure 257. Pressed Standing Seam Steel Roofing advertised in Mesker's 1900 catalog, showing the use of clamps over the standing seam created by the joining of two panels, 1900 (Geo. L. Mesker & Co., "Geo L. Mesker & Co. Architectural Iron Works," Evansville, IN: Geo. L. Mesker Steel Corporation, 1900, https://archive.org/details/Geo.L.MeskerCo.ArchitecturalIronWorksModernStoreFrontsHandsome, 38).

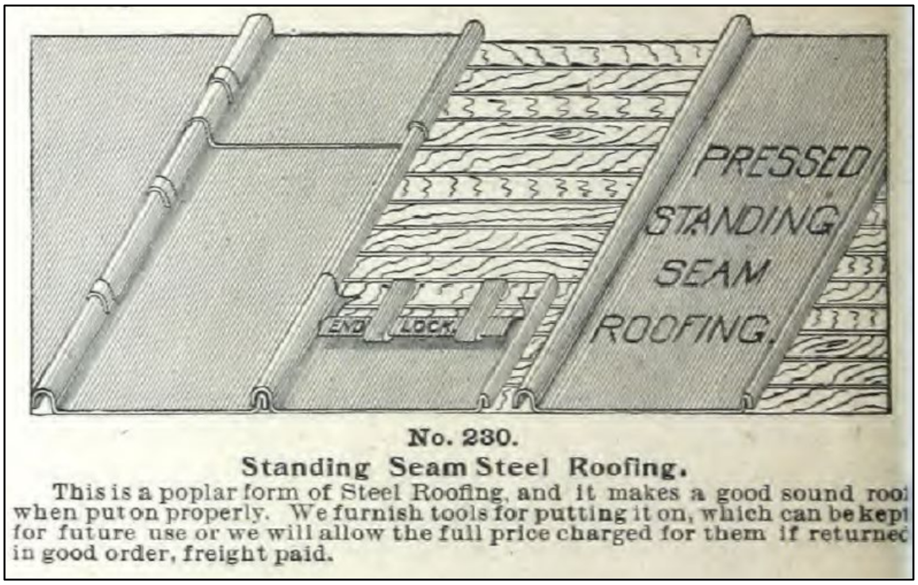
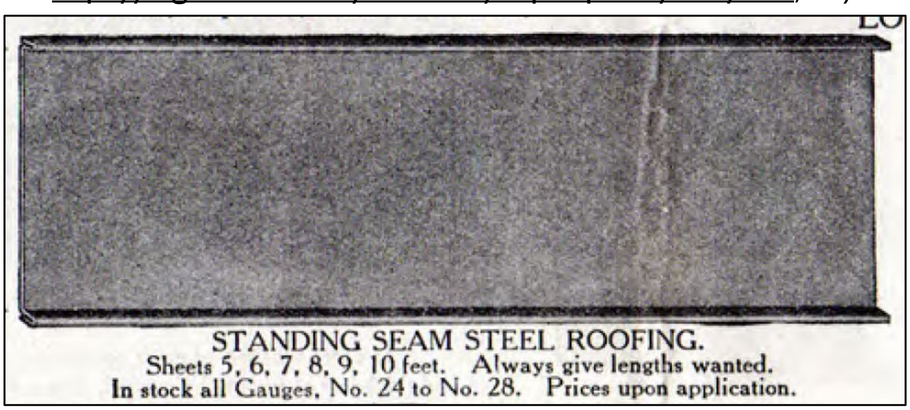
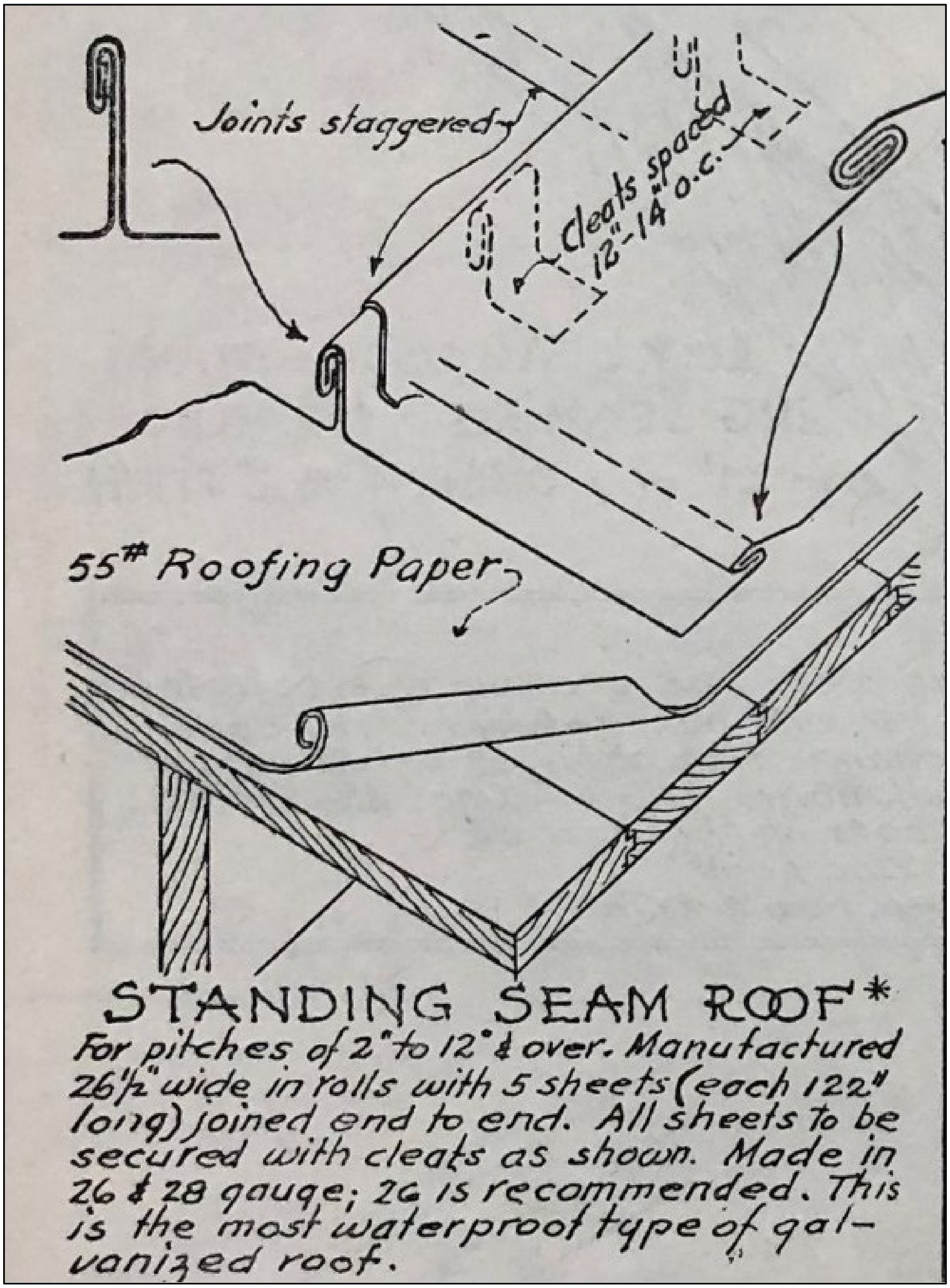



Figure 258. An example of a Standing Seam Steel Panel manufactured by Mesker, notice the seam improvement in just 14 years, as well as the options provided in gauge and length, 1914 (Geo. L. Mesker & Co., "Store Fronts," Evansville, IN: 1914, https://digital.lib.uh.edu/collection/aapamphlets/item/954, 15).




[305] Geo. L. Mesker & Co., "Geo L. Mesker & Co. Architectural Iron Works;" Geo. L. Mesker & Co., "Store Fronts;" Ramsey and Sleeper, *Architectural Graphic Standards*.

Figure 259. Installation guides for a typical standing seam roof, 1946 (Charles Ramsey and Harold Sleeper, *Architectural Graphic Standards, 3rd Ed.*, New York: John Wiley & Sons, 1946).




While the basic technology of the standing seam has changed little, improvements have been made in the application process. Forming the seams at the worksite was an early improvement that led to a tighter seam when compared to the interlocking of preformed seams (Figure 260).[306] The MR-24 roof, released in 1969 by Butler, was a breakthrough development for non-corrugated metal roofing. It is still one of Butler's top recommended roofing systems with "more than 3.2 billion square feet . . . installed since 1969."[307] The MR-24 featured an exclusive Pittsburgh double lock standing seam, which is the same seam used for the closure of metal barrels (Figure 261). This meant that upright metal seam was bent inward a full 360 degrees, providing a weatherproof seal.[308] Most significant about this roofing system was the patented "Roof Runner" roll-forming machine, which is fixed along the seam at one end of the roof and uses 4,000 pounds of pressure to fold the seam as it rolls across the roof, decreasing installation time and increasing the strength of the seal (Figure 262).[309] The MR-24 system's double-locked seams have been tested under 6 inches of water and even have with-stood battering from baseball-sized hailstones without leaking. This is partly achieved by the merging of a box rib with the standing seam, which provides structural benefits in addition.[310] When originally released, Butler guaranteed 10-year warranties although this has now been increased to 25 years.[311]

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[306] Ramsey and Sleeper, *Architectural Graphic Standards*; Linda Mastaglio, "Auctioning Giant-Sized Merchandise," *Building Profit* (Fall/Winter 2007): 11-15, https://www.butlermfg.com/wp-content/uploads/2018/02/2007-FallWinter.pdf.

[307] Butler Manufacturing Company, "MR-24: Celebrating 50 Years of Superior Performance," Product Performance, accessed Aug. 24, 2021, https://www.butlermfg.com/corporate/mr-24-celebrating-50-years-of-superior-performance/.

[308] Ibid.

[309] Butler Manufacturing Company, "Why the Roof Runner Helps Make the Butler MR-24 Roof System the Best in the Industry," Butler Parts Online, accessed Aug. 24, 2021, https://butlerpartsonline.com/why-the-roof-runner-helps-make-the-butler-mr-24-roof-system-the-best-in-the-industry/.

[310] Simmons Construction, Inc., "Butler 360° Pittsburgh double-lock seam," accessed Aug. 16, 2021, https://www.simmonsgc.com/Butler/b_bm_d.htm.

[311] Cowles, Butler Company History; Butler Manufacturing Co., "Building Division Warranty," Warranties, accessed Aug. 16, 2021, https://www.butlermfg.com/warranties/

Figure 260. Two methods for forming standing seams provided in an architectural guidebook, 1994 ((Charles Ramsey and Harold Sleeper, *Architectural Graphic Standards, 9th Ed.*, New York: John Wiley & Sons, 1994).

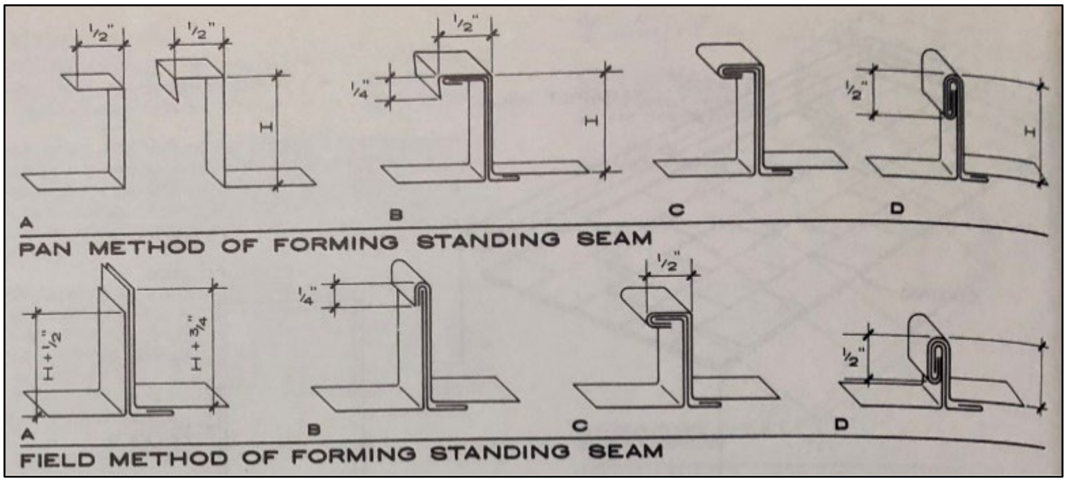



Figure 261. Ad advertisement for Butler's MR-24 roof, emphasizing the exclusive use of the 360-degree double-lock seam, notice how the seams of the MR-24 resembles a box rib and provides similar structural benefits, Unknown (Simmons Construction, Inc., "Butler 360° Pittsburgh double-lock seam," accessed Aug. 16, 2021, https://www.simmonsgc.com/Butler/b_bm_d.htm).

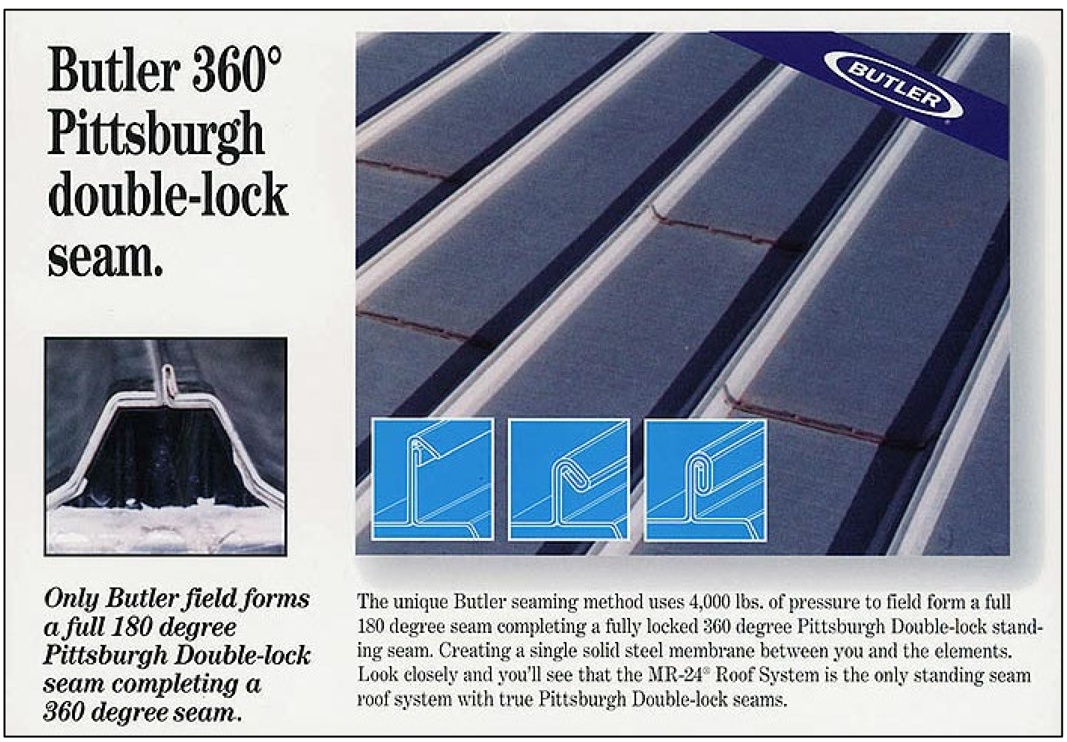
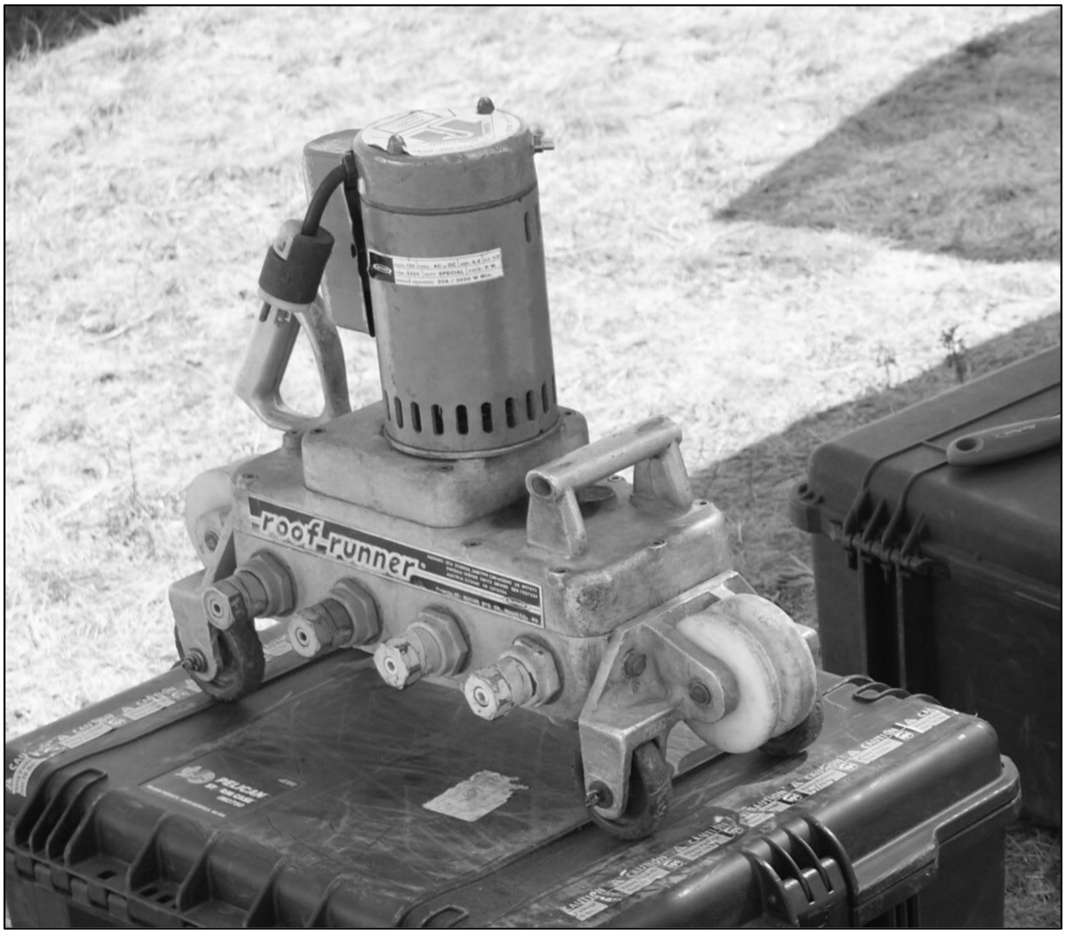


Figure 262. A "Roof Runner" machine used in the installation of the MR-24 roof, 2011 (Rider di, https://en.wikipedia.org/wiki/Roof_seamer#/media/File:Roof_runner.jpg).



# Appendix B: DoD RPAD Data Elements

This appendix provides the exact collection criteria and data elements supplied to ERDC-CERL by the DoD. Researchers utilized the following collection criteria to collect records from the DoD RPAD for this report:

- Exclude Land
- Facility Build Date: Include all properties with a date of construction Jan. 1, 1946–Dec. 31, 1991;
- Exclude disposed (Disposal Completion Date null)
- Assets located in the US and Territories
- Include:
    - All buildings/structures classified as Temporary
    - All buildings/structures classified as Semi-permanent
    - All buildings/structures 1,000 square feet or less classified as Permanent.

The data provided would include the following DoD RPAD elements:

- Installation Name
- DoD Organization
- Accountable Organization
- RPA Name
- State
- Real Property Unique Identifier
- RPA Historic Status Code
- Facility Built Date
- RPA Predominant Current Use FAC Code
- RPA Predominant Current Use FAC Title
- RPA Predominant Design Use FAC Code
- RPA Predominant Design Use FAC Title
- RPA CATCODE & CATCODE Long Name/Title
- Asset Condition (Facility Condition Index)
- Construction Type
- Construction Material
- Square Feet
- Status (Temporary, Semi-Permanent, Permanent)
- Structure or Building (S or B)
- Category Code (if not captured by other data elements)
- Category Description (if not captured by other data elements)

- Current use (if not captured by other data elements)
- Previous use/s (if not captured by other data elements).

# Appendix C: Facility Information

This appendix provides a complete tabulation of the non-FOUO data used to produce the analysis presented in Chapter 3.

Table 10. Number of permanent, semi-permanent, and temporary buildings per Design Use FAC Title.

| Design Use FAC Title | Construction Type | | | Total |
|---|---|---|---|---|
| | Permanent | Semi-Permanent | Temporary | |
| Aircraft Washing Pad, Surfaced | 82 | 8 | 3 | 93 |
| Ambulance Shelter | 10 | 7 | 1 | 18 |
| Boathouse | 8 | 18 | 3 | 29 |
| Car Wash Facility | 5 | 5 | 1 | 11 |
| Central Vehicle Wash Facility | 37 | 0 | 1 | 38 |
| Cold Storage, Depot | 0 | 1 | 0 | 1 |
| Cold Storage, Installation | 7 | 8 | 2 | 17 |
| Controlled Humidity Storage, Depot | 46 | 48 | 8 | 102 |
| Controlled Humidity Storage, Installation | 7 | 12 | 1 | 20 |
| Covered Storage Building, Depot | 25 | 84 | 10 | 119 |
| Covered Storage Building, Installation | 1,345 | 1,070 | 446 | 2,861 |
| Covered Storage Shed, Depot | 8 | 17 | 3 | 28 |
| Covered Storage Shed, Installation | 606 | 353 | 216 | 1175 |
| Exchange Support Facility | 1 | 3 | 3 | 7 |
| Exchange Warehouse | 3 | 14 | 4 | 21 |
| Facility Engineer Maintenance Facility | 9 | 1 | 0 | 10 |
| Facility Engineer Maintenance Shop | 215 | 385 | 118 | 718 |
| Family Housing Storage Facility | 518 | 22 | 608 | 1,148 |
| Hazardous Materials Storage, Depot | 47 | 8 | 0 | 55 |
| Hazardous Materials Storage, Installation | 1,515 | 297 | 133 | 1,945 |
| Hazardous Waste Storage or Disposal Facility | 212 | 60 | 3 | 275 |
| Helium Storage Facility | 2 | 0 | 0 | 2 |
| Incinerator | 13 | 6 | 1 | 20 |
| Industrial Waste Treatment | 228 | 8 | 4 | 240 |
| Installation Support Equipment Maintenance Shed | 45 | 40 | 5 | 90 |
| Installation Support Vehicle Maintenance Shop | 73 | 108 | 24 | 205 |
| Latrine/Shower Facility | 216 | 66 | 9 | 291 |

| Design Use FAC Title | Construction Type | | | Total |
|---|---|---|---|---|
| | Permanent | Semi-Permanent | Temporary | |
| Laundry/Dry Cleaning Facility | 9 | 4 | 1 | 14 |
| Liquid Fuel Loading/Unloading Facility | 378 | 24 | 3 | 405 |
| Liquid Oxygen Storage | 77 | 15 | 3 | 95 |
| Loading Platform/Ramp | 935 | 41 | 12 | 988 |
| Marine Fueling Facility | 19 | 2 | 0 | 21 |
| Marine Maintenance Shop | 11 | 40 | 0 | 51 |
| Marine Maintenance Support Facility | 7 | 31 | 3 | 41 |
| Marine Operating Fuel Storage | 2 | 0 | 0 | 2 |
| Medical Warehouse | 14 | 6 | 2 | 22 |
| Miscellaneous MWR Facility | 1 | 7 | 0 | 8 |
| Miscellaneous MWR Support | 196 | 94 | 38 | 328 |
| Miscellaneous Personnel Shelter | 796 | 299 | 139 | 1,234 |
| Miscellaneous UPH Support Building | 86 | 23 | 9 | 118 |
| Miscellaneous Utility Facility | 1,772 | 43 | 22 | 1,837 |
| Open Storage, Depot | 17 | 6 | 8 | 31 |
| Open Storage, Installation | 231 | 131 | 86 | 448 |
| Operations Supply Building | 247 | 109 | 23 | 379 |
| Overhead Cover | 320 | 67 | 19 | 406 |
| Parking Garage/Building | 9 | 10 | 0 | 19 |
| Pavilion | 669 | 385 | 169 | 1,223 |
| Public Restroom/Shower | 901 | 377 | 138 | 1,416 |
| Refuse Collection and Recycling Facility | 96 | 24 | 1 | 121 |
| Sanitary Landfill | 81 | 12 | 1 | 94 |
| Septic Lagoon and Settlement Ponds | 8 | 6 | 6 | 20 |
| Septic Tank and Drain Field | 738 | 89 | 12 | 839 |
| Training Aids Support Building | 31 | 38 | 7 | 76 |
| Training Support Structure | 265 | 194 | 87 | 546 |
| Transient and Recreational Lodging Support Facility | 8 | 6 | 4 | 18 |
| Utility Building | 4,356 | 466 | 150 | 4,972 |
| Vehicle Fueling Facility | 510 | 34 | 9 | 553 |
| Vehicle Maintenance Facility | 2,781 | 361 | 98 | 3,240 |
| Vehicle Maintenance Shop, Depot | 5 | 3 | 0 | 8 |
| Vehicle Operating Fuel Storage | 235 | 53 | 6 | 294 |
| **Total** | **21,09421,094** | **5,649** | **2663** | **29,406** |

Table 11. Number of buildings classified under each HSC per Design Use FAC Title.

| Design Use FAC Title | HSC | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DNE | DNR | ELPA | FCHR | NAR | NCE | NEV | NHLC | NHLI | NREC | NREI | NRLC | NRLI | |
| Aircraft Washing Pad, Surfaced | 23 | | | | | | 70 | | | | | | | 93 |
| Ambulance Shelter | | | | | | | 18 | | | | | | | 18 |
| Boathouse | 2 | | 1 | | | | 26 | | | | | | | 29 |
| Car Wash Facility | 2 | | | | | | 9 | | | | | | | 11 |
| Central Vehicle Wash Facility | 5 | | | | | | 33 | | | | | | | 38 |
| Cold Storage, Depot | 1 | | | | | | | | | | | | | 1 |
| Cold Storage, Installation | 2 | | | | | | 14 | | | 1 | | | | 17 |
| Controlled Humidity Storage, Depot | 40 | | | | | | 42 | | | 18 | 2 | | | 102 |
| Controlled Humidity Storage, Installation | 7 | | | | | | 10 | | | 3 | | | | 3 |
| Covered Storage Building, Depot | 25 | | 2 | | | 1 | 89 | 2 | | | | | | 119 |
| Covered Storage Building, Installation | 708 | | 82 | | | 30 | 1,935 | 5 | | 55 | 46 | | | 101 |
| Covered Storage Shed, Depot | 8 | | | | | 1 | 19 | | | | | | | 20 |
| Covered Storage Shed, Installation | 269 | | 20 | | | 12 | 851 | | | 17 | 5 | 1 | | 23 |
| Exchange Support Facility | 1 | | | | | | 6 | | | | | | | 7 |
| Exchange Warehouse | 3 | | | | | | 18 | | | | | | | 21 |
| Facility Engineer Maintenance Facility | 2 | | | | | | 8 | | | | | | | 10 |

| Design Use FAC Title | HSC | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DNE | DNR | ELPA | FCHR | NAR | NCE | NEV | NHLC | NHLI | NREC | NREI | NRLC | NRLI | |
| Facility Engineer Maintenance Shop | 277 | | 20 | | | 8 | 403 | | | 7 | 1 | 2 | | 718 |
| Family Housing Storage Facility | 93 | | 93 | | | | 962 | | | | | | | 1,148 |
| Hazardous Materials Storage, Depot | 14 | | 3 | | | | 38 | | | | | | | 55 |
| Hazardous Materials Storage, Installation | 435 | | 32 | | | 17 | 1,437 | 2 | | 13 | 8 | 1 | | 1,945 |
| Hazardous Waste Storage or Disposal Facility | 32 | | 1 | | | 3 | 239 | | | | | | | 275 |
| Helium Storage Facility | | | | | | 1 | 1 | | | | | | | 2 |
| Incinerator | 5 | | | | | 1 | 14 | | | | | | | 20 |
| Industrial Waste Treatment | 52 | | 20 | | | 1 | 163 | | | 4 | | | | 240 |
| Installation Support Equipment Maintenance Shed | 12 | | 6 | | | 1 | 69 | | | 2 | | | | 90 |
| Installation Support Vehicle Maintenance Shop | 70 | | 3 | | | 2 | 125 | | | 4 | 1 | | | 205 |
| Latrine/Shower Facility | 115 | | 25 | | | | 151 | | | | | | | 291 |
| Laundry/Dry Cleaning Facility | 2 | | | | | | 11 | | | 1 | | | | 14 |
| Liquid Fuel Loading/Unloading Facility | 130 | | 2 | | | 8 | 260 | | 1 | 1 | 3 | | | 405 |
| Liquid Oxygen Storage | 27 | | | | | | 67 | | | 1 | | | | 95 |
| Loading Platform/Ramp | 153 | | 22 | | | 2 | 807 | 2 | | 2 | | | | 988 |

| Design Use FAC Title | HSC | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DNE | DNR | ELPA | FCHR | NAR | NCE | NEV | NHLC | NHLI | NREC | NREI | NRLC | NRLI | |
| Marine Fueling Facility | 2 | | 3 | | | | 16 | | | | | | | 21 |
| Marine Maintenance Shop | 5 | | | | | | 45 | 1 | | | | | | 51 |
| Marine Maintenance Support Facility | 2 | | | | | 7 | 32 | | | | | | | 41 |
| Marine Operating Fuel Storage | | | | | | | 2 | | | | | | | 2 |
| Medical Warehouse | 6 | | | | | | 16 | | | | | | | 22 |
| Miscellaneous MWR Facility | 3 | | | | | | 5 | | | | | | | 8 |
| Miscellaneous MWR Support | 99 | | | | | 4 | 222 | | | 2 | 1 | | | 328 |
| Miscellaneous Personnel Shelter | 151 | | 18 | | | 13 | 1,049 | 1 | | 1 | | 1 | | 1,234 |
| Miscellaneous UPH Support Building | 7 | | 16 | | | | 95 | | | | | | | 118 |
| Miscellaneous Utility Facility | 323 | | 10 | | | 28 | 1,468 | | | 2 | 6 | | | 1,837 |
| Open Storage, Depot | 4 | | 1 | | | | 26 | | | | | | | 31 |
| Open Storage, Installation | 119 | | 1 | | | 6 | 317 | 2 | | | 3 | | | 448 |
| Operations Supply Building | 23 | | 2 | | | 2 | 344 | 2 | | 2 | 1 | 3 | | 379 |
| Overhead Cover | 14 | | | | | 1 | 391 | | | | | | | 406 |
| Parking Garage/Building | | | | | | | 19 | | | | | | | 19 |
| Pavilion | 157 | | | | | 6 | 1,056 | 3 | | | 1 | | | 1,223 |
| Public Restroom/Shower | 345 | | 43 | | | | 1,020 | | | 5 | 1 | 2 | | 1,416 |
| Refuse Collection and Recycling Facility | 29 | | | | | 4 | 85 | | | | 3 | | | 121 |

| Design Use FAC Title | HSC | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DNE | DNR | ELPA | FCHR | NAR | NCE | NEV | NHLC | NHLI | NREC | NREI | NRLC | NRLI | |
| Sanitary Landfill | 9 | | 1 | | | | 80 | | | | 4 | | | 94 |
| Septic Lagoon and Settlement Ponds | 1 | | | | | | 19 | | | | | | | 20 |
| Septic Tank and Drain Field | 98 | | 14 | | | 11 | 713 | | | 2 | 1 | | | 839 |
| Training Aids Support Building | 14 | | 1 | | | 1 | 60 | | | | | | | 76 |
| Training Support Structure | 60 | | | | | | 486 | | | | | | | 546 |
| Transient and Recreational Lodging Support Facility | 3 | | | | | | 15 | | | | | | | 18 |
| Utility Building | 1,142 | | 78 | | | 78 | 3,515 | 3 | | 69 | 57 | 29 | 1 | 4,972 |
| Vehicle Fueling Facility | 95 | | | | | 7 | 446 | | | 1 | 4 | | | 553 |
| Vehicle Maintenance Facility | 668 | | 2 | | | 2 | 2,548 | 1 | | 7 | 12 | | | 3,240 |
| Vehicle Maintenance Shop, Depot | | | | | | | 7 | | | 1 | | | | 8 |
| Vehicle Operating Fuel Storage | 61 | | | | | | 233 | | | | | | | 294 |
| **Total** | **5,95561** | **0** | **522** | **0** | **0** | **258** | **22,224** | **25** | **1** | **222** | **160** | **38** | **1** | **25,469** |

Table 12. Date of construction of buildings determined eligible for the NRHP.

| Design Use FAC Title | Date of Construction | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | 1946–1949 | 1950–1959 | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1991 | |
| Cold Storage, Installation | | | | | | 1 | 1 |
| Controlled Humidity Storage, Depot | | 1 | 17 | 1 | | | 19 |
| Controlled Humidity Storage, Installation | | 3 | | | | | 3 |
| Covered Storage Building, Depot | | | 2 | | | | 2 |
| Covered Storage Building, Installation | 1 | 73 | 24 | 4 | 2 | 2 | 106 |
| Covered Storage Shed, Installation | | 10 | 6 | 2 | 5 | | 23 |
| Facility Engineer Maintenance Shop | | 5 | 4 | | 1 | | 10 |
| Hazardous Materials Storage, Installation | | 15 | 6 | 1 | 2 | | 24 |
| Industrial Waste Treatment | | 3 | 1 | | | | 4 |
| Installation Support Equipment Maintenance Shed | | 2 | | | | | 2 |
| Installation Support Vehicle Maintenance Shop | | 5 | | | | | 5 |
| Laundry/Dry Cleaning Facility | | | 1 | | | | 1 |
| Liquid Fuel Loading/Unloading Facility | | 2 | 3 | | | | 5 |
| Liquid Oxygen Storage | | | 1 | | | | 1 |
| Loading Platform/Ramp | | 2 | 1 | 1 | | | 4 |
| Marine Maintenance Shop | | 1 | | | | | 1 |
| Miscellaneous MWR Support | 1 | 1 | 1 | | | | 3 |
| Miscellaneous Personnel Shelter | | 1 | | | | 1 | 2 |
| Miscellaneous Utility Facility | | 5 | 1 | 1 | 1 | | 8 |
| Open Storage, Installation | | 5 | | | | | 5 |
| Operations Supply Building | 1 | 6 | | | 1 | | 8 |
| Pavilion | | 2 | | | 2 | | 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Public Restroom/Shower | | 2 | 3 | 1 | 2 | | 8 |
| Refuse Collection and Recycling Facility | | 1 | | 1 | 1 | | 3 |
| Sanitary Landfill | | 4 | | | | | 4 |
| Septic Tank and Drain Field | | 3 | | | | | 3 |
| Utility Building | 2 | 51 | 94 | 9 | 3 | 1 | 160 |
| Vehicle Fueling Facility | 1 | 3 | 1 | | | | 5 |
| Vehicle Maintenance Facility | 2 | 12 | 3 | | | 1 | 18 |
| Vehicle Maintenance Shop, Depot | | | | | 1 | | 1 |
| **Total** | **8** | **218** | **169** | **21** | **21** | **6** | **443** |

# Appendix D: Additional Photos Collected

This appendix provides additional photos of utilitarian buildings collected by ERDC-CERL researchers during field visits for use by installation CRMs as comparative images when identifying utilitarian buildings and structures.

## D.1 Fort Polk, Louisiana

Figure 263. Building 2613 at Fort Polk (ERDC-CERL 2016).

Figure 264. Building 2651 at Fort Polk (ERDC-CERL 2016).


Figure 265. Building 2653 at Fort Polk (ERDC-CERL 2016).

Figure 266. Building 2656 at Fort Polk (ERDC-CERL 2016).


Figure 267. Building 2748 at Fort Polk (ERDC-CERL 2016).

Figure 268. Building 2822 at Fort Polk (ERDC-CERL 2016).


Figure 269. Building 2849 at Fort Polk (ERDC-CERL 2016).

Figure 270. Building 2852 at Fort Polk (ERDC-CERL 2016).

Figure 271. Building 3121 at Fort Polk (ERDC-CERL 2016).

Figure 272. Building 3313 at Fort Polk (ERDC-CERL 2016).

Figure 273. Building 3314 at Fort Polk (ERDC-CERL 2016).

Figure 274. Building 3323 at Fort Polk (ERDC-CERL 2016).


Figure 275. Building 3327 at Fort Polk (ERDC-CERL 2016).

Figure 276. Building 3456 at Fort Polk (ERDC-CERL 2016).

Figure 277. Building 3711 at Fort Polk (ERDC-CERL 2016).

Figure 278. Building 3715 at Fort Polk (ERDC-CERL 2016).

Figure 279. Building 3804 at Fort Polk (Fort Polk 2016).

Figure 280. Building 4765 at Fort Polk (Fort Polk 2016).


Figure 281. Building 4775 at Fort Polk (ERDC-CERL 2016).

Figure 282. Building 9519 at Fort Polk (ERDC-CERL 2016).


Figure 283. Building 9668 at Fort Polk (ERDC-CERL 2016).

Figure 284. Building 9787 at Fort Polk (ERDC-CERL 2016).


Figure 285. Building 9790 at Fort Polk (ERDC-CERL 2016).

Figure 286. Building 9792 at Fort Polk (ERDC-CERL 2016).


Figure 287. No Number at Fort Polk (ERDC-CERL 2016).

Figure 288. No Number at Fort Polk (ERDC-CERL 2016).


Figure 289. No Number at Fort Polk (ERDC-CERL 2016).

## D.2 Marine Corps Air Ground Combat Center Twentynine Palms, California

Figure 290. Building 1102T1 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 291. Building 1103 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 292. Building 1103T2 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 293. Building 1108T1 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 294. Building 1108T2 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 295. Building 1116 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 296. Building 1118 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 297. Building 1119 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 298. Building 1121 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 299. Building 1129T2 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 300. Building 1132T2 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 301. Building 1262 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 302. Building 1278Y1 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 303. Building 1481 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 304. Building 1498 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 305. Building 1572 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 306. Building 1958 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 307. Building 2085 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 308. Building 2296 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 309. Building 2297 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 310. Building 2297 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 311. Building 2298 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 312. Building 2318 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 313. Building 3815 at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 314. Building 5300 at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 315. Buildings 5303 (left), 5304 (middle), and 5305 (right) at MCAGCC Twentynine Palms (ERDC-CERL 2016).


Figure 316. No Number at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 317. No Number at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 318. No Number at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 319. No Number at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 320. No Number at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 321. No Number at MCAGCC Twentynine Palms (ERDC-CERL 2016).

Figure 322. No Number at MCAGCC Twentynine Palms (ERDC-CERL 2016).

## D.3 Marine Corps Base Hawaii, Kaneohe Bay, Hawaii

Figure 323. Building 265 at MCBH (ERDC-CERL 2016).

Figure 324. Building 266 at MCBH (ERDC-CERL 2016).


Figure 325. Building 1175 at MCBH (ERDC-CERL 2016).

Figure 326. Building 1362 at MCBH (ERDC-CERL 2016).


Figure 327. Building 1368 at MCBH (ERDC-CER 2016).

Figure 328. Building 1371 at MCBH (ERDC-CERL 2016).


Figure 329. Building 1628 at MCBH (ERDC-CERL 2016).

Figure 330. Building 1631 at MCBH (ERDC-CERL 2016).


Figure 331. Building 3083 at MCBH (ERDC-CERL 2016).

Figure 332. Building 4042 at MCBH (ERDC-CERL 2016).


Figure 333. Building 6079 at MCBH (ERDC-CERL 2016).

Figure 334. Building 6516 at MCBH (ERDC-CERL 2016).

Figure 335. No Number at MCBH (ERDC-CERL 2016).

Figure 336. No Number at MCBH (ERDC-CERL 2016).

Figure 337. No Number at MCBH (ERDC-CERL 2016).

## D.4 Naval Air Weapons Station China Lake, California

Figure 338. Building 00023 at NAWS China Lake (ERDC-CERL 2016).

Figure 339. Building 00576 at NAWS China Lake (ERDC-CERL 2016).

Figure 340. Building 00989 at NAWS China Lake (ERDC-CERL 2016).

Figure 341. Building 00992 at NAWS China Lake (ERDC-CERL 2016).

Figure 342. Building 01077 at NAWS China Lake (ERDC-CERL 2016).

Figure 343. Building 01096 at NAWS China Lake (ERDC-CERL 2016).

Figure 344. Building 01112 at NAWS China Lake (ERDC-CERL 2016).

Figure 345. Building 01188 at NAWS China Lake (ERDC-CERL 2016).

Figure 346. Building 01198 at NAWS China Lake (ERDC-CERL 2016).

Figure 347. Building 01344 at NAWS China Lake (ERDC-CERL 2016).

Figure 348. Building 01481 at NAWS China Lake (ERDC-CERL 2016).

Figure 349. Building 02313 at NAWS China Lake (ERDC-CERL 2016).


Figure 350. Building 02325 at NAWS China Lake (ERDC-CERL 2016).

Figure 351. Buildings 02612 (left) and 02614 (right) at NAWS China Lake (ERDC-CERL 2016).

Figure 352. Building 02615 at NAWS China Lake (ERDC-CERL 2016).

Figure 353. Building 02682 at NAWS China Lake (ERDC-CERL 2016).


Figure 354. Building 02708 at NAWS China Lake (ERDC-CERL 2016).

Figure 355. Building 02750 at NAWS China Lake (ERDC-CERL 2016).


Figure 356. Building 08683 at NAWS China Lake (ERDC-CERL 2016).

Figure 357. Building 10625 at NAWS China Lake (ERDC-CERL 2016).


Figure 358. Building 10656 at NAWS China Lake (ERDC-CERL 2016).

Figure 359. Building 10705 at NAWS China Lake (ERDC-CERL 2016).


Figure 360. Buildings 10857 and 10858 at NAWS China Lake (ERDC-CERL 2016).

Figure 361. Building 11170 at NAWS China Lake (ERDC-CERL 2016).


Figure 362. Building 11531 at NAWS China Lake (ERDC-CERL 2016).

Figure 363. Building 11614 at NAWS China Lake (ERDC-CERL 2016).


Figure 364. Building 11615 at NAWS China Lake (ERDC-CERL 2016).

Figure 365. Building 11640 at NAWS China Lake (ERDC-CERL 2016).


Figure 366. Building 11683 at NAWS China Lake (ERDC-CERL 2016).

Figure 367. Building 11685 at NAWS China Lake (ERDC-CERL 2016).


Figure 368. Building 11691 at NAWS China Lake (ERDC-CERL 2016).

Figure 369. Building 11693 at NAWS China Lake (ERDC-CERL 2016).


Figure 370. Building 11701 at NAWS China Lake (ERDC-CERL 2016).

Figure 371. Building 14554 at NAWS China Lake (ERDC-CERL 2016).


Figure 372. Building 15960 at NAWS China Lake (ERDC-CERL 2016).

Figure 373. Building 30929 at NAWS China Lake (ERDC-CERL 2016).

Figure 374. Building 31515 at NAWS China Lake (ERDC-CERL 2016).

Figure 375. Building 31604 at NAWS China Lake (ERDC-CERL 2016).

Figure 376. Building 1198 at NAWS China Lake (ERDC-CERL 2016).

Figure 377. No Number at NAWS China Lake (ERDC-CERL 2016).

Figure 378. No Number at NAWS China Lake (ERDC-CERL 2016).

Figure 379. No Number at NAWS China Lake (ERDC-CERL 2016).

Figure 380. No Number at NAWS China Lake (ERDC-CERL 2016).

Figure 381. No Number at NAWS China Lake (ERDC-CERL 2016).

Figure 382. No Number at NAWS China Lake (ERDC-CERL 2016).

## D.5 White Sands Missile Range, New Mexico

Figure 383. Building 28 at WSMR (ERDC-CERL 2016).

Figure 384. Building 65 at WSMR (ERDC-CERL 2016).

Figure 385. Building 174A at WSMR (ERDC-CERL 2016).

Figure 386. Building 302 at WSMR (ERDC-CERL 2016).

Figure 387. Building 302A at WSMR (ERDC-CERL 2016).

Figure 388. Building 312 at WSMR (ERDC-CERL 2016).

Figure 389. Building 1748 at WSMR (ERDC-CERL 2016).

Figure 390. Building 1756 at WSMR (ERDC-CERL 2016).


Figure 391. Building 1764 at WSMR (ERDC-CERL 2016).

Figure 392. Buildings 1764A and 1764B at WSMR (ERDC-CERL 2016).


Figure 393. Building 1767 at WSMR (ERDC-CERL 2016).

Figure 394. Building 1800 at WSMR (ERDC-CERL 2016).


Figure 395. Building 1804 at WSMR (ERDC-CERL 2016).

Figure 396. Buildings 1849 and 1850 at WSMR (ERDC-CERL 2016).


Figure 397. Buildings 1852 and 1854 at WSMR (ERDC-CERL 2016).

Figure 398. Building 1860 at WSMR (ERDC-CERL 2016).

Figure 399. Building 1862 at WSMR (ERDC-CERL 2016).

Figure 400. Building 4170 at WSMR (ERDC-CERL 2016).

Figure 401. Building 5027 at WSMR (ERDC-CERL 2016).

Figure 402. Building 07417 at WSMR (ERDC-CERL 2016).

Figure 403. Building 14179 at WSMR (ERDC-CERL 2016).

Figure 404. Building 19351 (concrete block) and no number (metal) at WSMR (ERDC-CERL 2016).


Figure 405. Building 19464 at WSMR (ERDC-CERL 2016).

Figure 406. Building 20506 at WSMR (ERDC-CERL 2016).


Figure 407. Building 20510 at WSMR (ERDC-CERL 2016).

Figure 408. Building 21244 at WSMR (ERDC-CERL 2016).


Figure 409. Building 21538 at WSMR (ERDC-CERL 2016).

Figure 410. Building 21731 at WSMR (ERDC-CERL 2016).

Figure 411. Building 21732 at WSMR (ERDC-CERL 2016).

Figure 412. Building 22700 at WSMR (ERDC-CERL 2016).


Figure 413. Building 22895 at WSMR (ERDC-CERL 2016).

Figure 414. Building 23101 at WSMR (ERDC-CERL 2016).

Figure 415. Building 23310 (left) and No Number building (right) at WSMR (ERDC-CERL 2016).

Figure 416. Buildings 23514 (left) and 23511 (right) at WSMR (ERDC-CERL 2016).

Figure 417. Building 23652 at WSMR (ERDC-CERL 2016).

Figure 418. Building 25101 at WSMR (ERDC-CERL 2016).

Figure 419. Building 27108 at WSMR (ERDC-CERL 2016).

Figure 420. Building 27164 at WSMR (ERDC-CERL 2016).

Figure 421. Building 27165 at WSMR (ERDC-CERL 2016).

Figure 422. Building 27171 at WSMR (ERDC-CERL 2016).


Figure 423. Building 27176 at WSMR (ERDC-CERL 2016).

Figure 424. Building 27181 at WSMR (ERDC-CERL 2016).

Figure 425. Building 27184 at WSMR (ERDC-CERL 2016).

Figure 426. Building 27185 at WSMR (ERDC-CERL 2016).

Figure 427. Building 27186 at WSMR (ERDC-CERL 2016).

Figure 428. Building 27206 at WSMR (ERDC-CERL 2016).

Figure 429. Building 27911 at WSMR (ERDC-CERL 2016).

Figure 430. Building 630742 at WSMR (ERDC-CERL 2016).


Figure 431. No Numbers at WSMR (ERDC-CERL 2016).

Figure 432. No Number at WSMR (ERDC-CERL 2016).

Figure 433. No Number at WSMR (ERDC-CERL 2016).

Figure 434. No Number at WSMR (ERDC-CERL 2016).

Figure 435. No Numbers at WSMR (ERDC-CERL 2016).

Figure 436. No Number at WSMR (ERDC-CERL 2016).


Figure 437. No Number at WSMR (ERDC-CERL 2016).

Figure 438. No Number at WSMR (ERDC-CERL 2016).

Figure 439. No Number at WSMR (ERDC-CERL 2016).

Figure 440. No Number at WSMR (ERDC-CERL 2016).

Figure 441. No Number at WSMR (ERDC-CERL 2016).

Figure 442. No Numbers at WSMR (ERDC-CERL 2016).

Figure 443. No Numbers at WSMR (ERDC-CERL 2016).

Figure 444. No Number at WSMR (ERDC-CERL 2016).

Figure 445. Building No Number at WSMR (ERDC-CERL 2016).

Figure 446. No Number at WSMR (ERDC-CERL 2016).

Figure 447. No Number at WSMR (ERDC-CERL 2016).

Figure 448. No Numbers at WSMR (ERDC-CERL 2016).

Figure 449. No Number at WSMR (ERDC-CERL 2016).

## D.6 Wright-Patterson Air Force Base, Ohio

Figure 450. Building 17 at Wright-Patterson AFB (ERDC-CERL 2017).


Figure 451. Building 55 at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 452. Building 68 at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 453. Building 85 at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 454. Building 138 at Wright-Patterson AFB (ERDC-CERL 2017).


Figure 455. Building 352 at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 456. Building 897 at Wright-Patterson AFB (ERDC-CERL 2017).


Figure 457. Building 4044 at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 458. Building 4047 (right) and No Number (left) at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 459. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 460. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 461. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 462. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 463. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 464. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 465. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

Figure 466. No Number at Wright-Patterson AFB (ERDC-CERL 2017).

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This report is an investigation into the history and types of utilitarian buildings and structures on DoD installations from 1946 through 1991. Utilitarian buildings and structures are those of practical design. They are typically prefabricated or follow a standardized plan and construction process, and they typically serve basic, industrial, non-mission critical functions. They are thus defined by both their design and construction process and their use.

In the US, many utilitarian buildings and structures have reached or are reaching 50 years of age, the benchmark at which typical buildings and structures are considered eligible for the NRHP. This report contains a historic context for utilitarian buildings and structures conducted during the twentieth century, an investigation into the DoD Real Property Database, the results of typology examinations in the field, and an account of the evolution of metal construction. This report will provide DoD cultural resource managers (CRMs) with a basis for identifying and evaluating potentially historic utilitarian buildings and structures that have reached 50 years of age and may be eligible for the NRHP. It may also provide the foundation for the creation of a program alternative to the Section 106 process for undertakings that impact these buildings and structures.

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