CONCRETE MASONRY DESIGN MANUAL

CONCRETE MASONRY DESIGN MANUAL

Fourth Edition

BUILDING NEWS, INC.
LOS ANGELES 1981

ACKNOWLEDGEMENTS

Published For:

CONCRETE MASONRY ASSOCIATION OF CALIFORNIA AND NEVADA
83 Scripps Drive, Suite 303, Sacramento, California 95825 (916) 920-4414

Editorial Committee:
Stuart R. Beavers, Executive Director and Chairman
Donald T. Morton, PE, Co-Editor
James Misfeldt . . . Robert Balderree . . . Eugene Balsley . . . Arthur K. Rooks
Graphic Design: Robyn Raggio
Contributing Graphic Designer: Donalyn Sjostrand
Contributing Photographer: Patrick M. Jordan

Published By:

BUILDING NEWS, INC.
3055 Overland Avenue, Los Angeles, California 90034 (213) 870-9871

Staff for Building News, Inc.:

Sam Jaffe, Publisher and Co-Editor
Arlon Dorman, Co-Publisher
Roy Schramm, Graphic Design

The publishers acknowledge the co-operation of the Masonry Industry Advancement Committee of California and the American Society For Testing And Materials for the granting of reprint privileges for various technical materials reproduced in this manual.

The "Concrete Masonry Design Manual" has been prepared in keeping with the most current information and practice for the present state of the art of masonry design, engineering and construction. However, the writers, editors and all organizations and individuals who have contributed to this book are not responsible for any errors, omissions, negligence or any other deficiencies that may result from use of this manual.

TABLE OF CONTENTS

INTRODUCTORY

CHAPTER ONE — CONCRETE MASONRY UNITS

CHAPTER TWO — DESIGN

CHAPTER THREE — ENGINEERING TABLES

CHAPTER FOUR — ENERGY CONSERVATION

CHAPTER FIVE — NOISE CONTROL

CHAPTER SIX — REINFORCING STEEL

CHAPTER SEVEN — FIRE RESISTIVE CONSTRUCTION

CHAPTER EIGHT — WATERPROOFING

CHAPTER NINE — VENEER

CHAPTER TEN — GUIDE SPECIFICATIONS

CHAPTER ELEVEN — QUALITY CONTROL

CHAPTER TWELVE — STANDARDS

APPENDIX AND BIBLIOGRAPHY

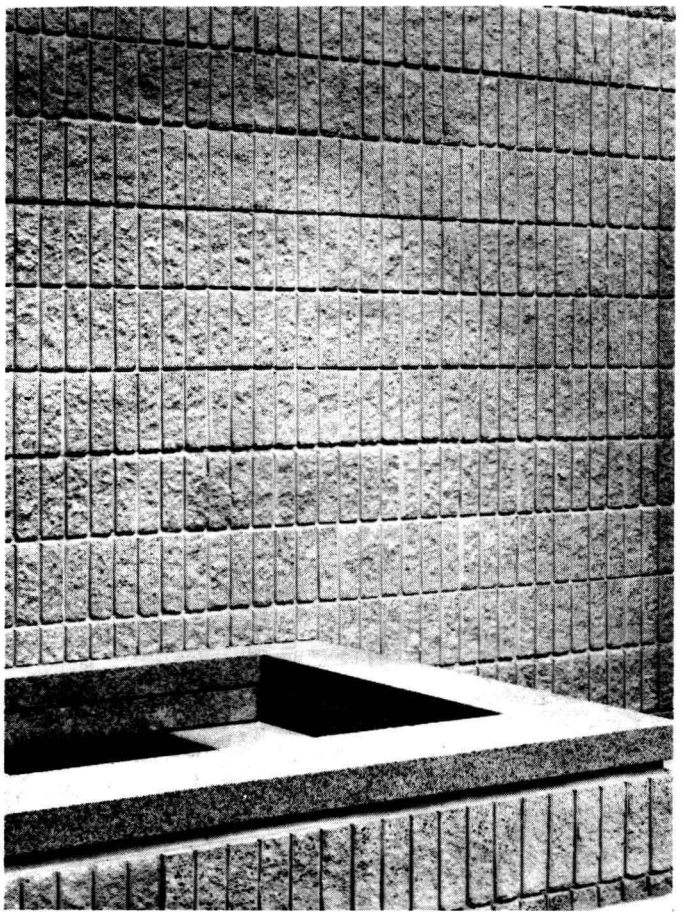
INTRODUCTION

Concrete masonry might well be described as the perfect building material! Its heritage is rich in time . . . with the sinews that bind it together – limestone, rock and sand – having lain locked in the earth since the dawn of antiquity. Yet, it is as modern as tomorrow . . . its development and proliferation tied inexorably to the discovery of the portland cement process and the coming of the machine age to the manufacture of unit masonry. This "young" building product, despite the fact that today it accounts for a vast amount of the world's construction, is still a long way from achieving its first century's birthday.

The infinite number of uses of concrete masonry are limited only to the imagination of the building designer. It is available in numberless choices of sizes, shapes, colors, textures and strengths. No other material has its fire-resistive qualities; few can match its structural strength. In a new era of great energy-saving consciousness it is finding much appreciation for its thermal-resistive properties, not to overlook its effective ability to act as a barrier to the transmission of sound. Architecturally, it has embellished the finest and most modern structures. With inflation leaping out of sight late in the twentieth century, concrete masonry's freedom from maintenance has underscored yet another benefit of this building material.

The West, with its pioneer spirit, has always been a leader in the development and use of concrete masonry. In 1946, when the California building industry began to come alive again after the four year dormancy of World War II, the concrete masonry plants of Southern California banded together to form a trade association to look out for its problems and to foster progress in their industry. This association was known as the Concrete Masonry Association of California. Three decades later this Southern California group was destined to merge with an upstate counterpart, the Northern California Concrete Masonry Association, and form a new organization which also embraced the neighboring state of Nevada – the Concrete Masonry Association of California and Nevada, best known in the industry as "CMACN."

JULIUS SHULMAN PHOTO



Meantime, the organization had moved a long way in underwriting the progress of its industry. Research and development had opened new vistas for the use of its product. The innovation of high lift grouting techniques, coupled with advanced engineering principles and modernization of building codes, opened up the world of high rise construction to concrete masonry. The introduction of pre-tensioned concrete plank systems for floors and ceilings, coupled with new engineering techniques for fastening these planks to walls of load-bearing concrete masonry, resulted in time saving economies in high rise construction never before dreamed of, particularly for apartment and condominium buildings.

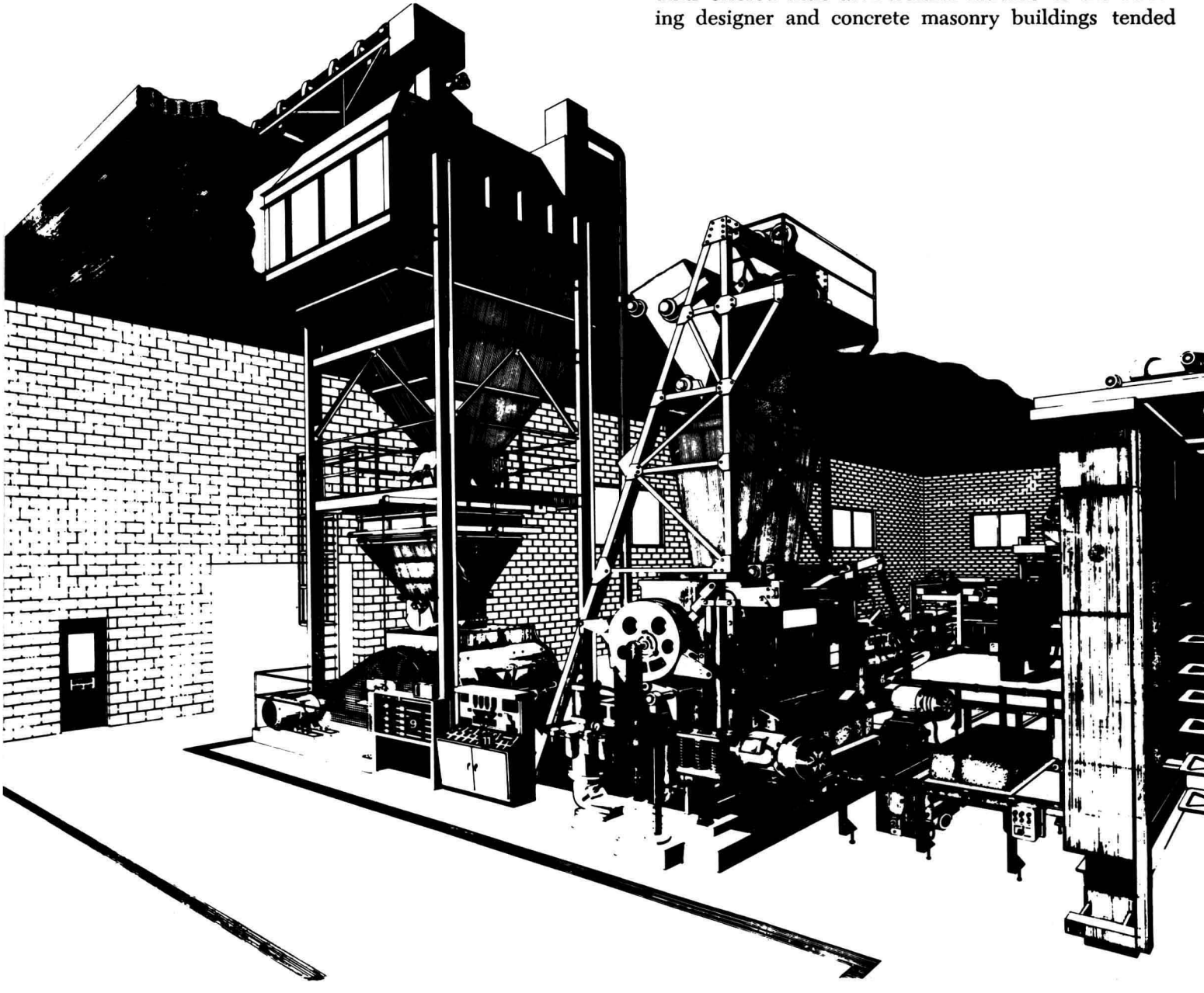
As the state of California became ribboned with miles of freeways in the postwar period and as mass housing projects sprung up along these heavy trafficked motor lanes, noise pollution became a major problem in the state and massive sound-barrier walls of

concrete masonry became the solution. Today, in the areas in and between the cities, wherever there is mass housing, concrete masonry sound walls parallel the concrete roadways mile for mile.

The year 1933 was a milestone in the history of the construction industry in the West. This was the year of the Long Beach earthquake, second in fame in the West only to the historic San Francisco quake of 1906. In the wake of the frightful loss of buildings and life of 1933 came the birth of modern building codes, based upon advanced engineering concepts designed to resist the strongest seismic forces.

Modern concrete masonry, coupled with reinforcing steel and high strength mortars, emerged as the ideal building material to meet the earthquake-resistive demands of the new codes, particularly for buildings in the medium height range. Schoolhouse designers quickly embraced concrete masonry for the vast program of schoolhouse construction and reconstruction in California that began after 1933 and has never ceased. And, in other fields of public and private buildings for industry and commerce, the story was the same. Concrete masonry became the favorite material for thousands of commercial, industrial, institutional and military buildings.

In their original concept concrete masonry units were of standard rectangular shapes, with flat surfaces, and produced in the single color of the familiar cement gray from the basic material of which they were made. Although highly utilitarian, the standard units offered little architectural latitude to the building designer and concrete masonry buildings tended



to present a montonous look of flat-planed, colorless walls.

To meet this architectural challenge, concrete masonry producers went into research and development to perfect techniques for mass machine production of quality architectural concrete masonry units.

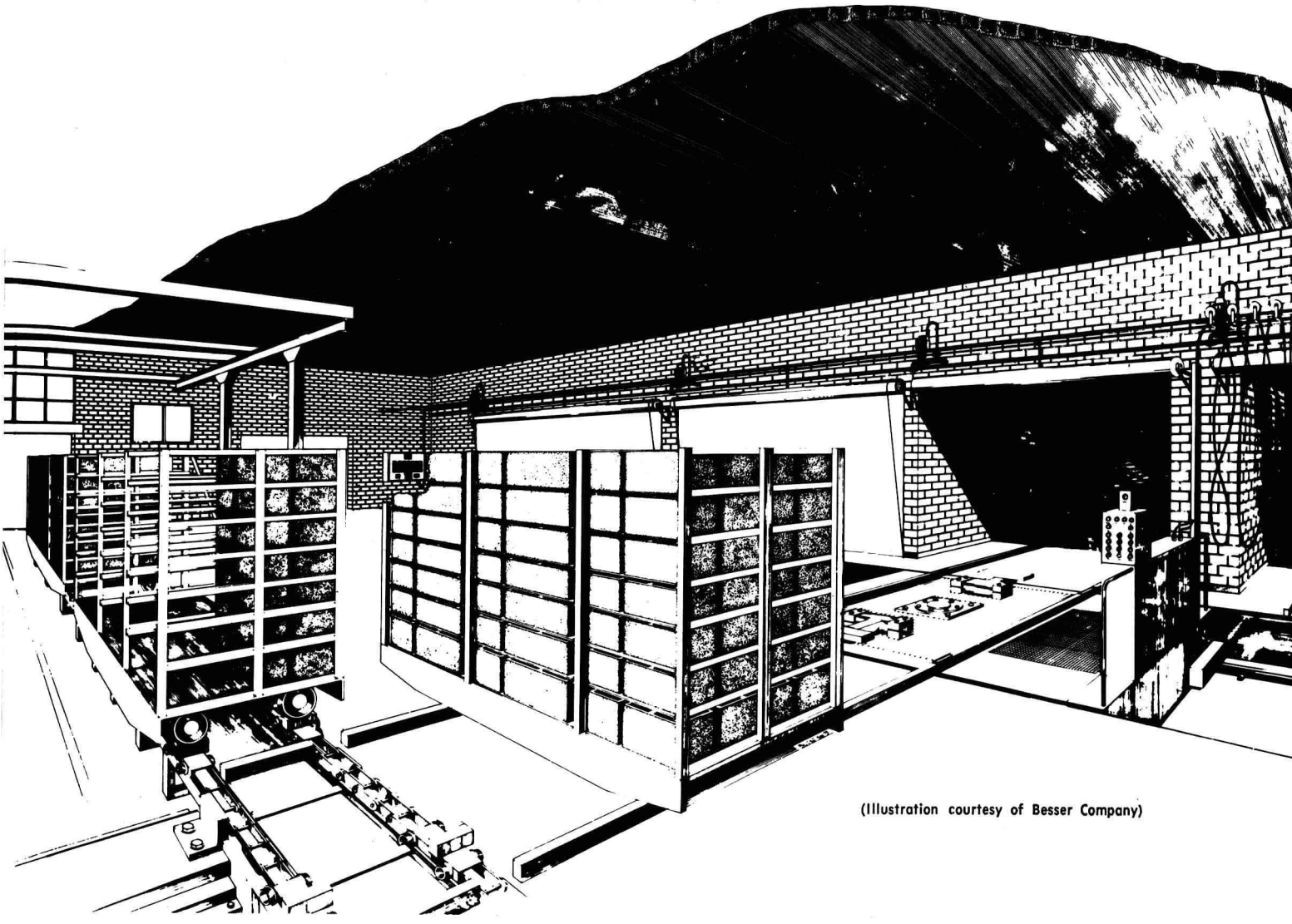
Screen blocks were developed, with a great variety of open web patterns for any possible design use. These eye-appealing concrete masonry units were used to add architectural flair to walls where the admission of air and light was needed in connection with the creation of separations of areas with semi-privacy. Not only were screen blocks used in every imaginative way on commercial and public structures, but they became highly popular in residences, to shield homes from street areas and to create patio and yard areas.

About the same time that screen blocks came upon the scene an ingenious Southern California block maker developed a technique for permitting concrete masonry units, after being molded and while the concrete was still in a plastic state, to assume an irregular, slumped effect on outside perpendicular surfaces. The purpose of manufacturing a block of this type was to simulate the look of adobe blocks, so popular throughout the Southwest since early pioneer days. Now the concrete masonry industry had developed a system of reviving this historically popular architectural look and made it available with the structural integrity of concrete.

Slumped concrete masonry is today one of the most popular architectural treatments for buildings of all types.

Meanwhile, another mechanical technique was de-

OVERALL view of modern, fully-automated, concrete masonry production plant.



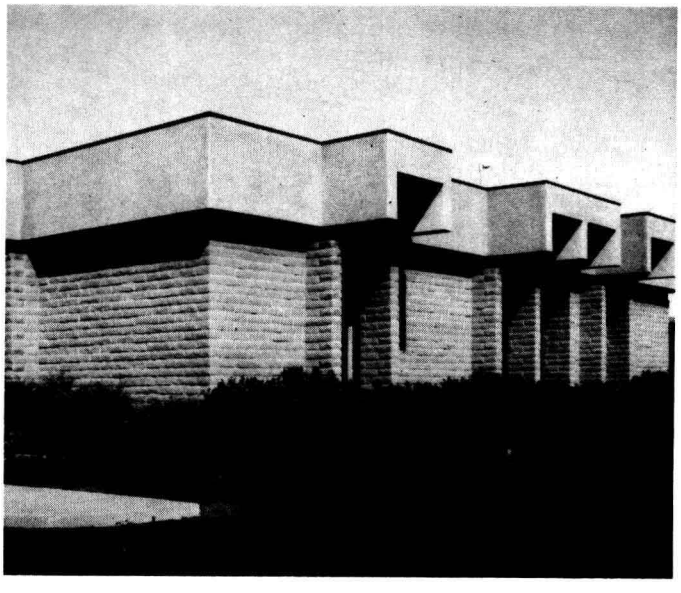
(Illustration courtesy of Besser Company)

veloped for cleaving concrete masonry units in two, after the molding process had been completed, in order to expose a rough, stone-like surface on the exterior of the block in lieu of the smooth, flat surface of the conventionally-molded product. Thus was born splitface block, another highly popular architectural unit, with all sorts of design possibilities and a third dimensional look. Another particular advantage of splitface surface is its freedom from maintenance and the ease in which undesired adornments can be removed by sandblasting. In the era of "American graffiti," when the youth of the land have felt strongly compelled to leave their mark upon walls, splitface concrete masonry construction has been highly embraced by schoolhouse designers.

Satisfying the architectural need for strong vertical and horizontal lines in wall design has been the development of concrete masonry units with molded-in scores and flutes.

Not only has the industry produced a kaleidoscope of shapes and textures in concrete masonry, but it has gone a long way with a third attribute, color. In addition to the conventional cement-gray color of concrete masonry, with which it is most commonly identified, the industry now offers a broad range of colors with which its product can readily be mixed and manufactured with inert oxide pigments that will endure as long as the block itself and never require painting. In addition, concrete is one of the best surfaces made for the acceptance of paint coatings. Because of the obvious problem of inventory, integrally colored block, other than those in the popular beige and tan tones, are not normally manufactured except on custom orders for appropriate quantities.

Behind all of this forward progress of the concrete masonry industry in the West has been the research, development and promotional effort of CMACN and its predecessor organizations. A most important part of that effort was the compilation and publishing of the original edition of this **Concrete Masonry Design Manual** in 1961. This manual pioneered the whole concept of modern engineering for concrete masonry structures. A distinguished California structural engineer, Albyn Mackintosh, was commissioned by the association to do the original engineering concepts and tables which went into this manual, most of which are still in use and accepted today.



The manual was designed to serve the needs of design professionals — architects, structural engineers, building designers, building officials, and others. In California it readily caught on and became accepted as the authoritative work in this regard. Subsequently, its fame and use spread nationally — and, ultimately, internationally — and the manual has achieved recognition and acceptance everywhere it has been put into use.

Originally published in loose-leaf form, the manual has been re-published three times in that format since its original publication in 1961. In this, the fourth updated printing, the content has been considerably expanded to include such contemporary subject matter as energy conservation and sound control and the binding has been switched from loose-leaf to hard cover, to implement its use in such areas as libraries as well as offices.

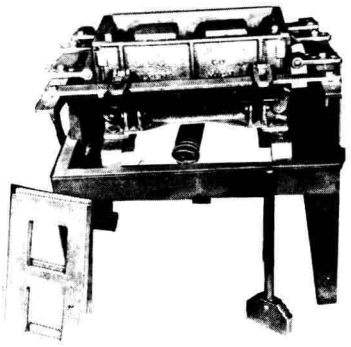
HISTORY OF CONCRETE MASONRY PRODUCTION

The history of concrete masonry traces itself back to colonial days in America, when a pair of enterprising masons named Foster and Van Derburgh sought for a way to make a precast building block larger than the clay brick then prevalent. After a great deal of experimentation they made the discovery that powdered quicklime and moist sand could be mixed together and molded by pressure into a usable building block, provided the finished product could be subjected to a steam treatment to hasten the slaking action. The natural mechanical heat thus generated formed a silicate of lime which turned out to become Foster and Van Derburgh's cement, holding their building blocks together.

These primitive blocks had serious drawbacks and in no way could compare with the machine-made products which were to follow a century later. They were solid, made entirely by hand in awkward wooden molds, oversized, very heavy and exceedingly hard to handle. Technically, too, they were not concrete blocks at all, inasmuch as the sand-lime mixture couldn't be truly rated as a cementing agent for concrete.

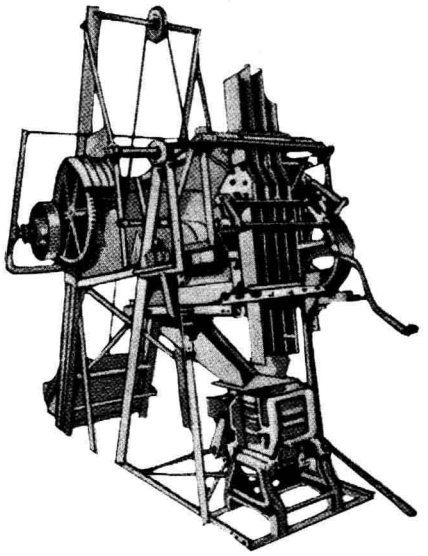
Faced with these shortcomings, the pioneering building blocks of Foster and Van Derburgh, although patented early in the 19th century, never caught on — and shortly thereafter the evolution of concrete block shifted to England.

The first recorded concrete block system was developed by a builder named Ranger, of Brighton, England, who patented his block in 1832. The concrete for this block was made of the unusual mix of sea gravel, broken flints, masons' chippings and other inert materials blended with powdered lime and boiling water.



EARLY model concrete block-making machine, 1904.

And so it went with a lot of early-day pioneers in this field, who produced hand-made blocks in cumbersome machines that required hand-tamping and had very limited production. The heavy, solid blocks, in unusual sizes up to 12″ x 9″ x 32″, weighed as much as 180 pounds and literally broke the backs of bricklayers, who objected to lifting such heavy weights. The development of hollow cells and lightweight aggregates in concrete blocks, to reduce weight, was still a long way in the future.

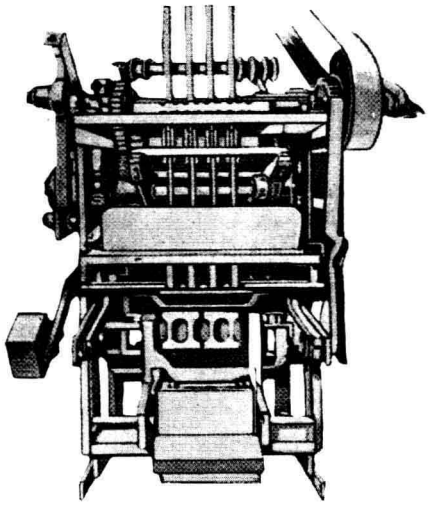


CONCRETE block-making machine, circa 1909.

The modern history of concrete masonry commences at the turn of the twentieth century and the beginnings of true automation in the manufacture of concrete block. A German immigrant, Herman Besser, is truly the "father" of the automated concrete block industry. In 1883 Besser moved his family from Buffalo, New York, to Alpena, Michigan, in the heartland of the lumbering industry at a time when wood was the principal building material.

After various approaches to the lumbering industry, Besser opened a stave and shingle mill in Alpena in 1897. Near the turn of the century, the once seemingly limitless supply of lumber was depleted, and the great lumbering industry began a sharp decline. By 1896 lumber production was down to half that of the peak year, 1889.

Meanwhile, in Pennsylvania, a revolutionary building product invented earlier in England, was first manufactured in this country. It was called "portland cement" and was immediately recognized for its strength as a building material. The first portland cement plant in the U.S. was established in 1871, and



CONCRETE block-making machine, circa 1914.

by 1898 there were 91 different formulas in use by manufacturers all over the country.

Singularly, it was the discovery of the portland cement process and the development of portland cement production in the United States which triggered and made possible the development of the modern concrete masonry industry which was to follow.

As the lumber industry fell off in Alpena, a fortunate discovery was made that the district was rich in limestone — the principal ingredient of portland cement. In 1898, Herman Besser joined hands with other lumber industry leaders in the area to establish the Alpena Portland Cement Co., to provide an alternate basic building material for the dwindling lumber supply.

Herman Besser's son, Jesse, went to work in the design shop of this new portland cement factory. The Alpena Portland Cement Company operated for only six years, then dissolved. But no matter how unsuccessful it might have been, it had served its purpose for Herman and Jesse Besser. Without it they never would have seen the need for a machine that would use cement in the manufacture of concrete or would they have had the opportunity to develop it.

In 1904, Herman Besser decided to purchase a hand-manufacture block machine as an additional service to the Alpena community. It was on that machine that Jesse Besser first tried his hand at engineering design. His ideas for improvement were so sound and practical that, shortly after, his father bought a foundry and machine shop and began manufacturing the block machines his son designed. Thus was the beginning of the Besser Company, pioneers in automation of concrete block manufacture, and foreleaders in an industry into which other major equipment manufacturers were to follow.

The first hand tamp block machine (circa 1904) which Besser produced had cast pallets with vertical cores and collapsible sides for block removal. Cement and aggregates were hand mixed, then shoveled into the mold and hand tamped around the core. The result was a 24" x 12" x 8" unit that varied in consistency and quality from unit to unit. Three men working at top speed could turn out 200 block in a 10-hour day on this first machine.

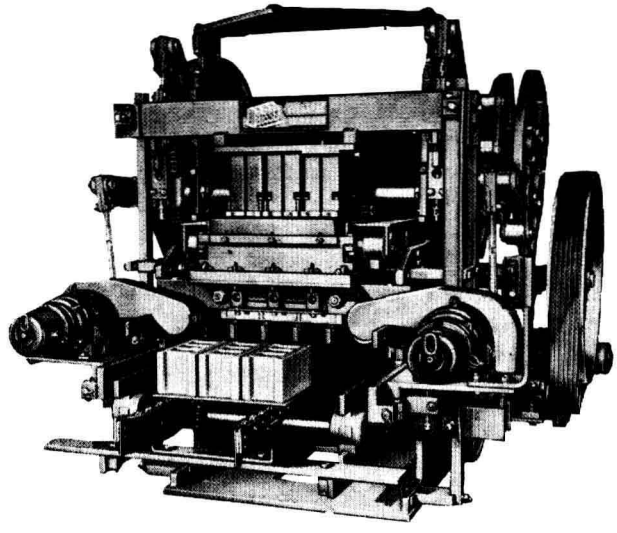
This contrasts to modern machines which produce 3-at-a-time block and delivers up to 2,000 block per hour!

Since the original 1904 machine there have been many generations of Besser block making machines, each of these improving the automation, production capability and quality control of the product.

The first big breakthrough came in 1909, when a machine was developed that featured power tamping and a self discharging mixer and skip loader, eliminating the laborious job of hand tamping.

Another big breakthrough came in 1939, when Besser introduced a radically new production method of "vibration under pressure," a system which eliminated costly wear on the facing liner of the machine caused by power tamping.

Today's fully automated block plants function on a

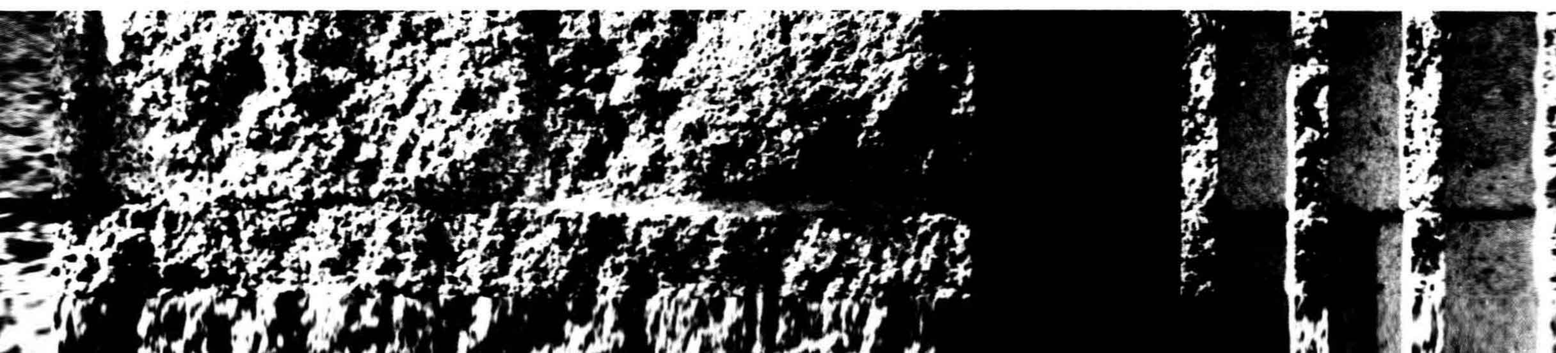


CONCRETE block-making machine, circa 1939.

totally automated production line basis for making and handling block — from raw-material receiving and handling systems; overhead bins; automatic batching control; automatic water control; automatic systems for controlling cure temperatures, pre-set time and soak periods in the kilns; to automatic palletizing and delivery.

Concrete masonry has, indeed, come a long way!

CONCRETE MASONRY UNITS



CONCRETE MASONRY UNITS

MASONRY

Since the beginning of mankind stone masonry has been the basic building material symbolic of permanence, protection and comfort. From that elementary conception evolved the concrete masonry industry. This modern industry takes basic raw materials and molds them into more workable dimensions and, like mother nature, embraces a broad variety of sizes, shapes, colors and textures

The present concrete masonry unit, with hollow cells, provides for seismic reinforcement. The cellular spaces will accommodate loose fill insulation to aid in achieving stringent energy requirements. The surface texture of concrete masonry units provides excellent sound absorption qualities. Through the careful selection and blending of natural materials and oxides the manufacturer can provide the designer with a broader range than that available from natural stone.

CONCRETE MASONRY UNITS

Consult your local manufacturers for available colors, sizes and textures. This Design Manual illustrates the basic precision units available from most manufacturers, in general produced in 12″, 10″, 8″, 6″ widths, non-load bearing 3″ and 4″ widths, and various veneer wall widths. Most manufacturers produce units 4″, 6″ and 8″ high. Some smaller heights may be available for veneer construction. From the architect and designer the concrete masonry unit has been "customized." Its split face and nearly limitless combination of scores, flutes, ribs, etc., has helped to expand flexibility in scale and design. The concrete block manufacturer encourages continued growth in the "customized masonry field."

DIMENSIONS

The industry standard is to specify unit widths (through the wall thickness) first, unit height next, unit length last. Example: 8 x 8 x 16 is 8 inches wide, 8 inches high and 16 inches long. The industry further speaks in modular dimensions. Actual sizes are ⅜ inch less to allow for mortar joints. Units depicted will conform to current code requirements insofar as minimum face shell thickness is concerned. This Design Manual will define dimensions for a standard unit in a given group and those dimensions will repeat for other units in the same group.

SLUMPED UNITS

A new, yet old, dimension with eye appeal, adobe-looking walls with the historic adobe look construction, is recreated through modern techniques. Slumped units are available in basic structural and veneer wall dimensions. Colors range beyond the typical adobe shade. The local manufacturer should be consulted for selection.

SPLIT FACE UNITS

An innovation to the earliest building material, split face units are a man-made product to simulate broken stone, the scale and appearance limited only to the designer and capabilities of present day machines.

VENEER UNITS

Depicted in this Design Manual are a wide range of veneer units. Beyond these, most face dimensions shown in structural or architectural units are available as veneer units.

SCREEN BLOCK

Screen wall units are presently available in a wide range of patterns and sculptured designs. These aesthetically-appealing units provide areas of shade and privacy. Most manufacturers stock screen wall units in one or more standard colors.

CAP UNITS

Cap units are manufactured in a variety of sizes and colors. They are used to cap walls and as patio and walkway pavers.

CONCRETE BRICK

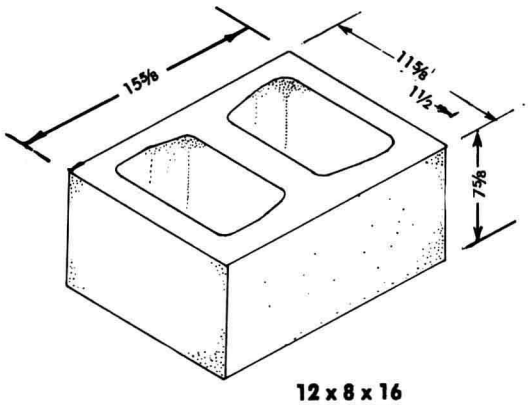
Brick is manufactured in a variety of sizes, textures and colors. They may be used as face brick, in a structural wall or as paving. Many manufacturers are now processing concrete brick to look like "used" brick.

PAVING UNITS

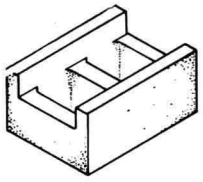
Vehicular concrete paving units are used for driveways, streets or other paving areas, highlighting an otherwise unattractive area.

STRUCTURAL PRECISION UNITS

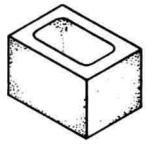
12x8x16



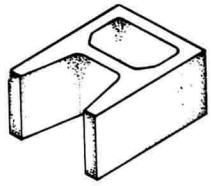
12 x 8 x 16
STANDARD



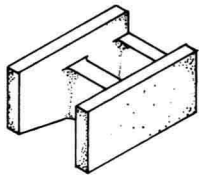
12 x 8 x 16
BOND BEAM



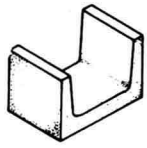
12 x 8 x 8
HALF



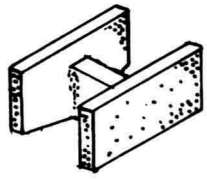
12 x 8 x 16
OPEN END
STANDARD



12 x 8 x 16
OPEN END
BOND BEAM

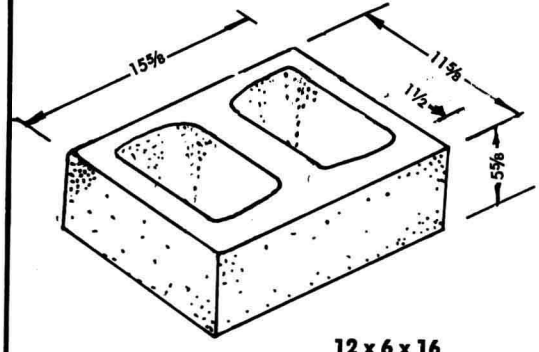


12 x 8 x 8
LINTEL

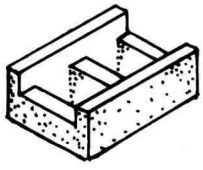


12 x 8 x 16
DOUBLE OPEN END
BOND BEAM

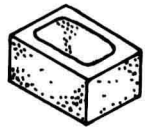
12x6x16



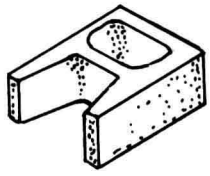
12 x 6 x 16
STANDARD



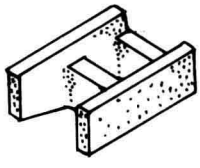
12 x 6 x 16
BOND BEAM



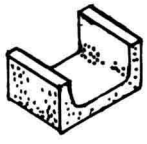
12 x 6 x 8
HALF



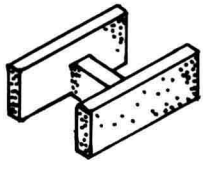
12 x 6 x 16
OPEN END
STANDARD



12 x 6 x 16
OPEN END
BOND BEAM



12 x 6 x 8
LINTEL



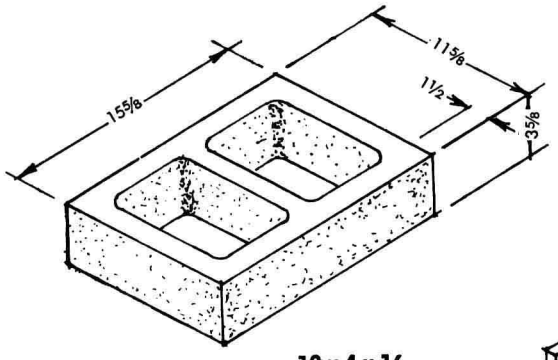
12 x 6 x 16
DOUBLE OPEN END
BOND BEAM

Note: Channels shown for bond beams are not to scale.

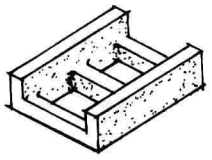
A local manufacturer should be consulted for information and availability on colors, sizes and shapes.

STRUCTURAL PRECISION UNITS (Continued)

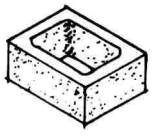
12x4x16



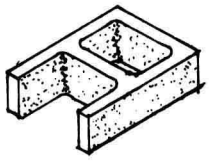
12 x 4 x 16
STANDARD



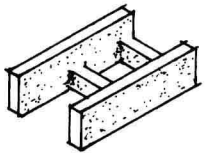
12 x 4 x 16
BOND BEAM



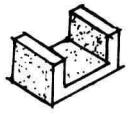
12 x 4 x 8
HALF



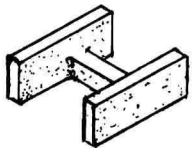
12 x 4 x 16
OPEN END
STANDARD



12 x 4 x 16
OPEN END
BOND BEAM

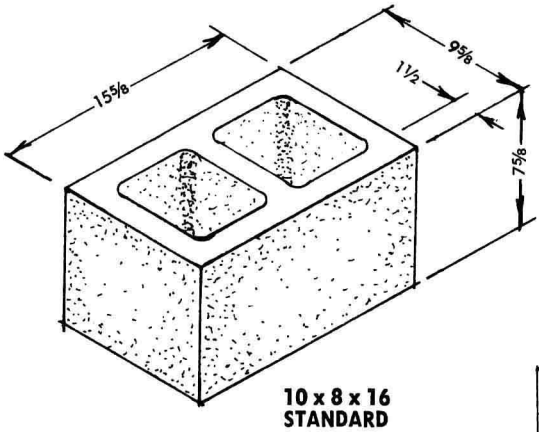


12 x 4 x 8
LINTEL

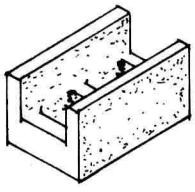


12 x 4 x 16
DOUBLED OPEN END
BOND BEAM

10x8x16

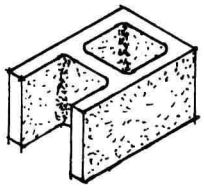


10 x 8 x 16
STANDARD

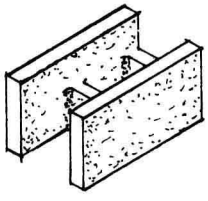


10 x 8 x 16
BOND BEAM

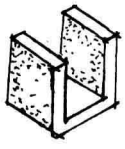
10 x 8 x 8
HALF



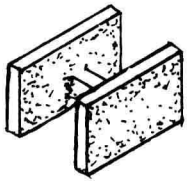
10 x 8 x 16
OPEN END
STANDARD



10 x 8 x 16
OPEN END
BOND BEAM



10 x 8 x 8
LINTEL



10 x 8 x 16
DOUBLE OPEN END
BOND BEAM

Note: Channels shown for bond beams are not to scale.

A local manufacturer should be consulted for information and availability on colors, sizes and shapes.