# CONCRETE PIPE HANDBOOK

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HOWARD F. PECKWORTH
*Managing Director*
American Concrete Pipe Association

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# PREFACE

This Concrete Pipe Handbook has been prepared by the American Concrete Pipe Association for the users and producers of concrete pipe. It contains engineering data and technical information pertaining to concrete pipe which is not readily available and which has never before been collected together in one useful volume.

Insofar as possible the most important matters are included herein, although to be fully complete it would fill many volumes.

Construction practices vary widely in different parts of the country. Thus, in most cases where one practice is presented it does not mean that others are not equally effective. An attempt has been made to present the most acceptable method.

In a way this Handbook speaks for the Industry in that it was prepared at the request of the Board of Directors of the American Concrete Pipe Association, reviewed in general by the Board, and reviewed and criticized in detail by the Technical Problems Committee and the Executive Committee.

For further information about any matter having to do with concrete pipe, please address your inquiry to the Managing Director in Chicago or to your local concrete pipe manufacturer.

HOWARD F. PECKWORTH
*Managing Director*
Chicago, Illinois
February 1951

# ACKNOWLEDGMENTS

Collected in this Handbook in concentrated form is a small part of the experience record and data of a large, important and complicated industry. Many people have been connected in one way or another with its preparation. Their help is greatly appreciated even though they are not mentioned here by name.

The idea of the book was conceived by the Board of Direction of the American Concrete Pipe Association during 1945 and succeeding Boards have endorsed the idea and aided its formation. The various Technical Problems Committees of the American Concrete Pipe Association likewise have aided in the preparation of the book over the last five years. In addition, many individual members of the industry have supplied data, suggestions and ideas.

Practicing consulting civil engineers, engineers in the Federal, State and Municipal governmental services and users of concrete pipe, both in this country and abroad have contributed lavishly of material and ideas. Their help is greatly appreciated and throughout the text care has been taken to mention, whenever possible, the sources from which the material was collected. My assistants on the staff of the American Concrete Pipe Association have been most helpful throughout the process of writing this book. John G. Hendrickson, Jr., Research Engineer, prepared the original draft of several of the chapters and did the necessary research on other chapters. William A. Haley III, Assistant to the Managing Director, did much of the editing and Marjorie L. Congleton was responsible for the format and makeup.

Every effort possible has been made to be accurate, factual, concise and honest. Many thanks to all those who have contributed.

HOWARD F. PECKWORTH
Chicago, Illinois
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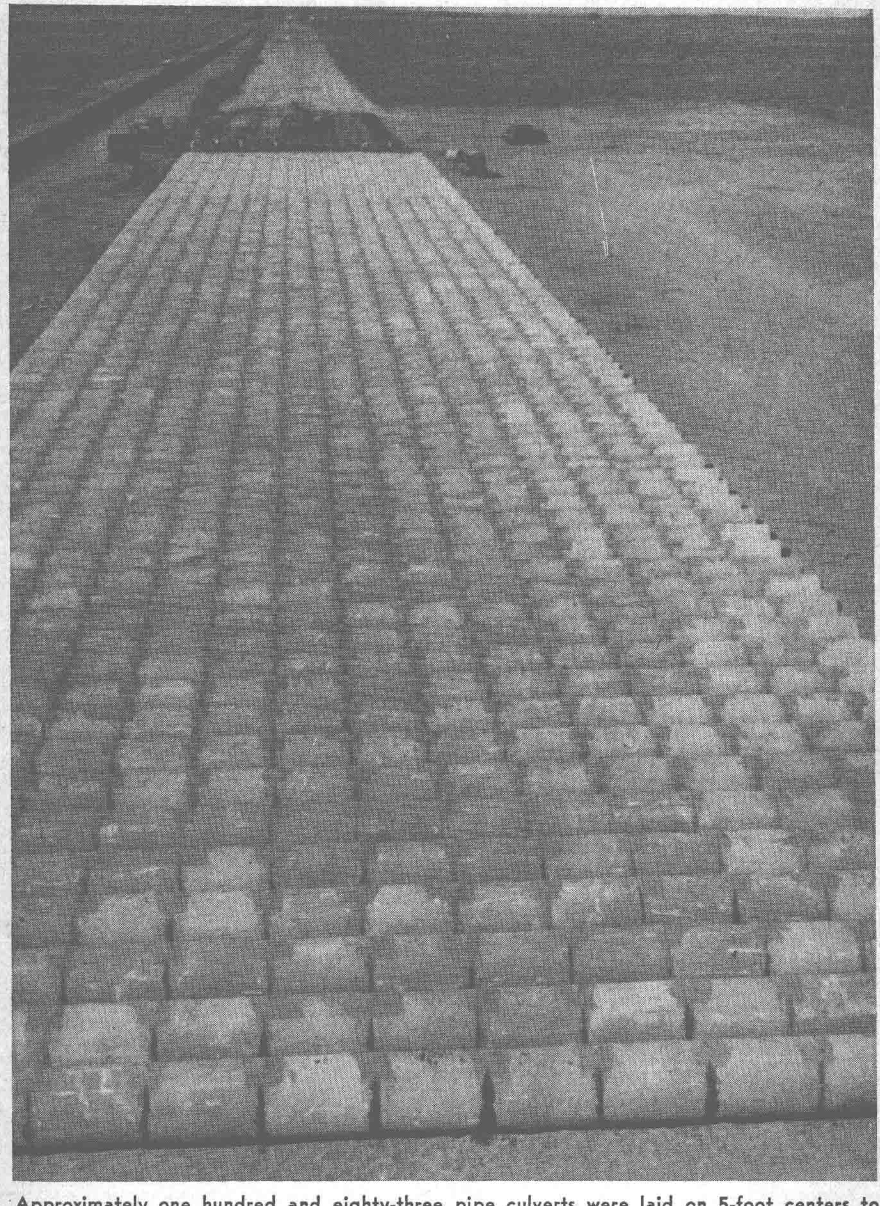


Approximately one hundred and eighty-three pipe culverts were laid on 5-foot centers to provide for drainage in the event of flash floods on an important cross-country highway in New Mexico.

## 1.1—INTRODUCTION

Throughout the world Concrete Pipe is the accepted commodity for irrigation, drainage, sewerage projects, culverts and pressure water supply mains.

Concrete pipe is made of concrete, either plain or reinforced. The concrete is different than conventional concrete in that it is special high strength concrete manufactured by several different unique processes. Made of local materials by local labor in local manufacturing plants it is available in all parts of the United States and Canada and in nearly all foreign countries.

## 1.2—INDUSTRY DEVELOPMENT

Natural cement concrete was used in building the Cloaca Maxima or main sewer in Rome in 800 B.C., portions of which are in service today. A rammed concrete water line constructed by the Romans in the year 80 delivered water from the Eiffel Mountains to Colonia Agrippina (Cologne, Germany) up until 1928 or a period of one thousand eight hundred and forty-eight years.

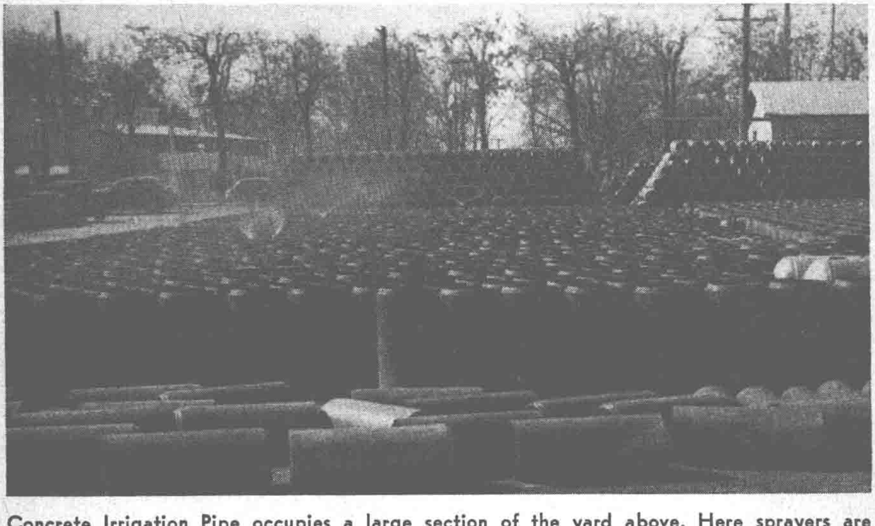
In this country the concrete pipe industry has grown up with the growth of the country. Concrete pipe sanitary sewers developed in the 1840's. Concrete drain tile and storm sewers also were first used in the 1840's followed by a great period of expansion in the Midwest in the 1890's and 1900's. Concrete irrigation pipe was used in California and the west shortly after the Gold Rush in 1849. The railways pioneered the concrete pipe culvert directly after the Civil War. The great highway development from 1915 to the present carried on this development of concrete pipe highway culverts. Concrete pressure water pipe lines of great lengths to withstand high internal pressures have been designed and built extensively during the last fifty years because of the demands of large cities for adequate supplies of drinking water.

About 350 relatively small plants comprise the extent of the concrete pipe industry in the United States supplying some 8,000,000 tons of pipe each year in the irrigation, drain tile, storm sewer, sanitary sewer, culvert and pressure water pipe fields. Concrete pipe plants are located in every State in the Union and in every province in Canada and in Alaska, Hawaii and Puerto Rico. In general they are locally owned and locally managed. They use local materials, local labor and local capital to supply a commodity in local demand all over the country.

## 1.3—CONCRETE IRRIGATION PIPE

It is an argumentative point whether irrigation was made possible by the development of concrete irrigation pipe or whether concrete irrigation pipe developed because of the irrigation demands. The fact is that in our western states there are many times as many miles of concrete irrigation pipe lines as there are primary and secondary roads, many of them in service over 75 years.

In the irrigation field concrete pipe is used in the larger sizes to convey the irrigation water from the storage dams in the mountains to the farm lands. At the site of the homestead the water is carried by smaller size concrete conduits to distribute the water throughout the ranch so that it can be turned on or off like a drinking water system whenever the farmer or rancher needs water for his crops or stock. Thus, irrigation pipe ranges in the larger sizes up to fifteen feet in diameter and in the smaller sizes it serves right on down to four inches. Concrete pipe in this function conserves the water which is lost by evaporation from open ditches; it conserves the land because the conduit is buried below the surface out of sight; it conserves the water normally lost to the non-profitable weeds and vegetation which grow up around open ditches and so far as is known it is permanent.



Concrete Irrigation Pipe occupies a large section of the yard above. Here sprayers are used to throw a fine spray of water over the pipe to aid in its curing.

## 1.4—CONCRETE DRAIN TILE AND CONCRETE STORM SEWERS

In the drainage field concrete pipe is used for the small 4-inch open joint farm drains, for the large 108-inch concrete pipe lines used to divert streams in new housing developments and in all sizes in between. The small size concrete pipe farm drain tile was produced first in New England and later in the middle west where a tremendous market developed shortly before the turn of the century. The rolling prairies of the midwest by the nature of the contours contain pockets needing drainage to make it completely productive. In the improvement of the land, farmers need a continuous supply of this small size drain tile. Concrete farm drain tile increases the available farm acreage, increases the quality and quantity of farm products, decreases farm labor, decreases overhead and cost of production and increases the value of the farmland.

In the larger sizes concrete pipe is used for all drainage problems such as diverting streams, drainage of manufacturing sites, airports, ball fields and parks.

The success or failure of an airfield depends on the way it is drained. Because of its generally flat nature, it is necessary to carry off drainage water from airfields quickly to avoid interruptions in traffic. In recent years there has been a great increase in airport construction and it has been estimated that probably 90% of all the airports in the country are drained using concrete drainage pipe.

## 1.5—CONCRETE PIPE SANITARY SEWERS

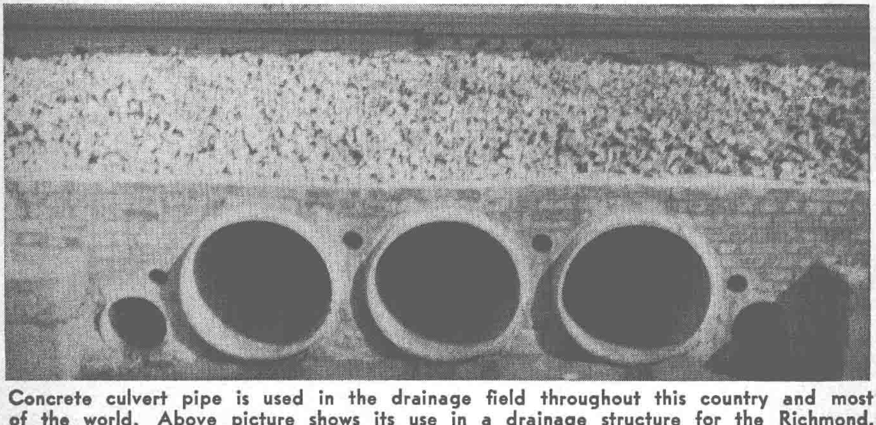
Concrete sanitary sewer pipe developed to meet the demand for sewerage systems which in turn made possible the growth of our large cities. Concrete sewer pipe, either exclusively or in part, is used in the sewerage systems of almost every city in the United States. They have been used in Mohawk, New York, since 1842; Newark, New Jersey, since 1867; Savannah, Georgia, since 1870 and so on in locations too numerous to mention. Thirty-seven cities have concrete pipe sanitary sewers more than fifty years old. Twenty-eight cities have concrete pipe sanitary sewers more than fifty miles long and several over 500 miles long.

The sizes range from the small 4-inch house connections to the large 12-foot diameter trunk sewers in our large cities.

Concrete sanitary sewer pipe prior to installation on a housing development in Memphis, Tennessee.

## 1.6—CONCRETE PIPE CULVERTS

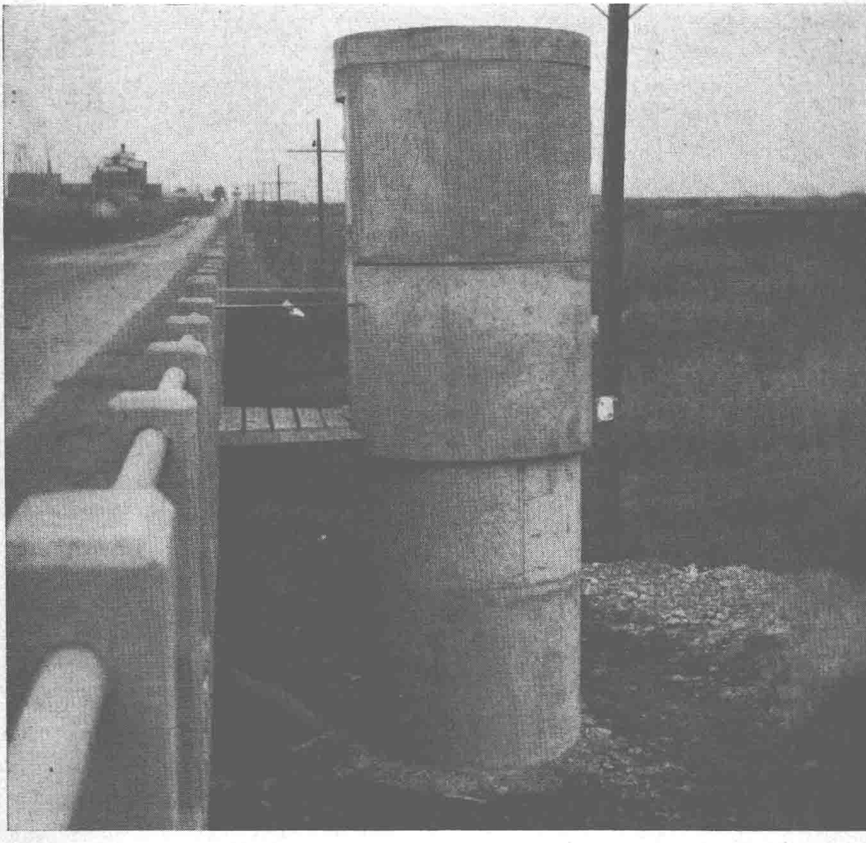
Because of its ruggedness and long length of life, concrete culvert pipe is used by every State Highway Department and every railway in the country . . . its use for culverts having been developed early in our history during the great expansion of railroad construction. Properly bedded and backfilled concrete pipe is being used under embankments of unlimited height and in our western states fills of over 100 feet in height are commonplace. Under both highway and railway fills with both minimum and maximum cover conditions, concrete pipe culverts have a life expectancy of 100 years or more. In this field, concrete pipe can be jacked under embankments without disturbing the traffic on the top of the embankment.



Concrete culvert pipe is used in the drainage field throughout this country and most of the world. Above picture shows its use in a drainage structure for the Richmond, Fredericksberg and Potomac Railway System.

## 1.7—CONCRETE PRESSURE WATER PIPE

For pressure drinking water mains and irrigation systems, concrete pressure pipe is used for pressures up to 600 feet head or 260 pounds per square inch. It is made either plain or reinforced, either with or without a steel cylinder, either with or without prestressing, each different design depending on the demands to be made on the conduit both internally and externally. This concrete pressure water pipe is carrying drinking and irrigation water across our countryside, and under rivers and bays to deliver a tremendous quantity of clear, pure water.



**This unusual use of concrete pipe is a river gage house at Belle Fourche, South Dakota. The top door sections are 54 inches in diameter while the lower sections are 48 inches.**

## 1.8—SPECIAL USES FOR CONCRETE PIPE

In addition to the conventional uses of concrete pipe, there are many special adaptations. Some of these adaptations are:

Concrete pipe at random in pastures to hinder landing of enemy airplanes.
Concrete pipe bomb proof shelters in wartime.
Concrete pipe cattle passes.
Concrete pipe cattle watering troughs.
Concrete pipe grease traps.
Concrete pipe obstacles or tunnels for children in public playgrounds.
Concrete pipe piles.
Concrete pipe river gauging stations.
Concrete pipe sections set on end filled with sand and used as ash trays at airports.
Concrete pipe sentry boxes for railways.
Concrete pipe septic tanks.
Concrete pipe sewer manholes.
Concrete pipe silos.
Concrete pipe underpasses for pedestrians.
Concrete pipe underpinning.
Concrete pipe wells.
Half round sections of concrete pipe for open side drainage of highways.
Perforated concrete pipe for draining the downstream side of earth, sand and gravel dams.
Porous concrete pipe for draining the construction joints in concrete dams.

CHAPTER II

# HOW CONCRETE PIPE IS MANUFACTURED

Concrete is transported from the mixer to the forms by means of a crane and bucket in this particular operation.

## 2.1—THE CONCRETE

An extremely dry mix of cement, sand and gravel or broken stone, and water with or without additions such as fly-ash, and or air entraining agents is used in the manufacture of concrete pipe. In the cast and vibrated pipe the slump often approaches zero as determined by ASTM Designation: C143 "Standard Method of Slump Test For Consistency of Portland-Cement Concrete." In the machine made Packerhead and Tamped Pipe, the slump is often less than zero, meaning, of course, that there is less water in the mix than required to give zero slump. In centrifugated pipe the water is forced out by centrifugal action to give whatever water-cement ratio desired, the result generally being a slump near zero. Thus, in all methods of making concrete pipe the resultant mix has a very, very low water cement ratio.

Density, in the case of the cast and vibrated pipe, is obtained by means of high speed vibrators attached to the outside of the form or applied directly inside the form, or both. Modern high speed vibrators are used with very small amplitude and very high speeds. Often the speeds are in excess of 8000 rpm, and this high speed is obtained electrically or by using air activated vibrators operated by 100 pounds per square inch or more of air pressure.

Density in the cases of the machine made Packerhead or Tamped Pipe is obtained by actual mechanical compaction of the mix when in the machine. By adjusting the mechanisms the desired mechanical compaction can be obtained.

Density in the case of the centrifugated pipe is obtained by centrifugal action, the result being determined by adjusting the speed of rotation and the method of manufacture.

The weight per cubic foot as a measure of density indicates that where conventional concrete might weigh 145 pounds per cubic foot, the concrete pipe with the same aggregates might weigh as high as 160 and even 165 or more pounds per cubic foot.

Compressive strength of conventional concrete is determined by ASTM Specification Designation C39 "Standard Method of Test for Compressive Strength of Molded Concrete Cylinders"; ASTM Specification Designation C192 "Tentative Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Laboratory"; and ASTM Specification Designation C3 "Standard Method of Making and Curing Concrete Compression and