Concrete makes sanitary sewers
Concrete is permanent
Concrete will solve all sewer problems
CONCRETE SEWERS

General

Along with the increasing use of concrete in other fields has come a growing preference for concrete in sewer construction. No doubt this is due to the fact that concrete possesses a number of distinctive advantages, among which are permanence and efficiency, to which may be added comparative cheapness and adaptability to a variety of building requirements. Regardless of the type of construction, most of the materials of which concrete is made can be obtained practically anywhere, which means that the greater portion of the money necessary for any project in which it is used is spent at home, while if other materials are employed they would have to be shipped in, often a considerable distance.

The fact that concrete pipe can be formed of practically any desired cross section, can be made uniform in size throughout and with joints that are self-centering and smooth, thus preventing obstructions in the sewer line, are advantages peculiar to concrete pipe. If concrete sewers are built of monolithic construction the work permits the use of much rela-
CONCRETE SEWERS

vitely unskilled labor, provided competent supervision is used. This results in reducing the cost of the work to such an extent that monolithic concrete sewers of large size are beyond successful price competition from other materials.

When concrete sewer pipe were first made and used, little was known of the requirements of manufacture as compared with those recognized and observed in present-day practice; therefore, it is perhaps surprising that the early concrete pipe sewers of which there is record gave the great degree of satisfaction which they did in practically all cases. Natural cement was used in most of the sewer pipe first made in this country, and although this is inferior to Portland cement the early concrete pipe rendered remarkably satisfactory service, and many sewers constructed of this early product are still in use.

Early Use

Records show that Brooklyn, N. Y., used concrete sewer pipe exclusively for a long period of years. The first sewers of this kind were laid about 1850. Since then concrete pipe has been in the specifications of that borough where a total of over 400 miles of concrete pipe is in use. In 1850 concrete sewers were built in Paris, France, also. Now there are over 300 miles of concrete sewers in Paris. In many other European cities concrete pipe have been and are still being used very extensively in sewer construction. These early uses of and experiences with concrete pipe are mentioned because many have not had experience with concrete pipe or have not had an opportunity to investigate their exceptional merits. More than 400
of the largest cities in the United States and Canada are now using concrete for sewers, either in the form of pipe, concrete block, or monolithic construction.

**CITY OF ALTOONA**
**Pennsylvania**

DEPARTMENT OF STREETS AND PUBLIC IMPROVEMENTS
P. E. {

BUREAU OF ENGINEERING. JAMES W. WHILES CITY ENGINEER.

Altoona, Pa., July 29th, 1915.

Mr. Harry Whipple,

Vis. Editor, Concrete Cement Age,

Detroit, Mich.

Dear Sir:

In reply to your communication of the 22nd inst., relative to concrete sewers in this City we would answer your questions as follows:

1st. Concrete has been used to some extent in constructing sewers in this City since the year 1904. The majority of sewers of a size of 24 inches in diameter or larger laid since 1904 are constructed of concrete block. Reinforced concrete poured in place, or reinforced concrete pipe. There is now in service some 3500 lin. ft. of concrete block sewers, about 3700 ft. of reinforced concrete storm sewers and 15,300 ft. of reinforced concrete pipe sewers.

2nd. The reasons for adopting concrete for sewers were the employment of local labor, the saving in the cost of the sewer, the ease in changing the cross-section to properly meet the existing conditions, and for sanitary sewers the reinforced concrete pipe has fewer joints and may be constructed to greatly reduce the quantity of infiltration.

3rd. The sewers constructed of concrete are entirely satisfactory.

4th. Last year, James Perry & Sons Co., Inc. of Baltimore laid some 6,000 lin. ft. of 34 inch pipe made by the Lock Joint Pipe Co., where the level of the ground water was from two to five feet above the top of the pipe and the amount of infiltration water was less than one-half the quantity stated as allowable in the specifications.

Yours truly,

P. E. {

Altoona, Pennsylvania, recognizes that concrete sewer work keeps local labor employed and much of the money expended at home.

Some years ago Richard L. Humphrey, the well-known consulting engineer, made an extensive investigation of concrete sewers in Philadelphia,
Minneapolis, Brooklyn and elsewhere, and summarized his findings in the following remarks:

"There does not seem to be any reason why concrete does not form one of the most admirable materials for the construction of sewers. I have seen concrete sewers in which the discharge waters of manufacturing plants have flowed through them containing a great quantity of acids and one would reasonably suppose that the surface of that sewer would be softened and disintegrated, but there seems to be a saving grace for the sewer in that the oily matters and scum that is to be found in sewage coats the surface of the sewer and renders it immune against action. In most of the sewers that I have examined, the original surface was intact and in a better state than when originally laid."

The late J. P. Sherer, when connected with the Milwaukee (Wis.) Board of Public Works, made the following remarks on the subject of concrete sewer pipe:

"Few people realize the extent to which concrete sewer pipe is used. Out of 300 miles of sewers in Milwaukee, as nearly as I can learn, over 200 miles are made of concrete, which speaks well for a product of that kind. In all places where we had to replace the sewers that were put in in the early history of Milwaukee, we found the concrete pipe to be intact. For instance: Only recently we were required to take up 12-inch pipe to replace it with 20-inch, and for the entire length that pipe was found to be in elegant condition, very much harder than when first placed there. There was no defect or flaw from one end to the other and there were 1,400 or 1,500 feet on that line of pipe."

Milwaukee is still using concrete for sewers.

Reinforced Concrete Pipe Sewers

Many types of reinforced concrete sewer pipe are manufactured. These differ, however, principally in the methods used to form joints and in the manner of reinforcing the pipe. Some types of pipe are circular in form, some egg shape, some have a combination of egg shape section and flat base. Various methods, some of which are patented, are used to form joints. Some pipe have bell and spigot ends, others have plain ends which
interlock in various ways, provided for when the pipe are manufactured. Which type or types should be used is largely a matter of individual preference.

Regardless of form or type, the value of concrete sewer pipe lies largely in its quality.

While cement inspector for Kansas City, Mo., E. S. Wallace read a paper before the Illinois Society of Engineers and Surveyors (January 30, 1914) in which he said:

"Our tests have shown conclusively that there are three things essential to the manufacture of good concrete pipe: (1) The pipe must be composed of proper materials; (2) It must be made right; and (3) It must be cured right."

Kansas City, Mo., is one of the many cities which has made very extensive use of concrete pipe in sewer work. In 1912 Kansas City laid over

![Pipe yard where concrete pipe were manufactured at Salt Lake City for the City sewers.](image)

30,000 lineal feet of plain concrete pipe and 65,000 additional linear feet in 1913, all ranging in size from 8 to 24 inches. As a result of following proper specifications for the manufacture of sewer pipe, Kansas City has had no failures of its concrete pipe sewers.

**Concrete**

Concrete for reinforced concrete pipe and monolithic concrete sewers should be made of 1 part Portland cement (to meet the requirements of the American Society for Testing Materials), 2 parts of clean, well graded
sand, all of which shall pass a screen of 4 meshes per lineal inch (no sand should contain more than 5 per cent of loam), 4 parts of coarse aggregate, consisting of gravel, crushed granite, trap rock or hard limestone; 100 per cent of the coarse aggregate should pass a screen of \( \frac{3}{4} \) -inch mesh and be retained on a screen of \( \frac{1}{4} \) -inch mesh. All parts are by volume.

Experience has shown that cleanliness of the sand and pebbles or broken stone, which means freedom from clay, loam or crusher dust, has a great influence on the quality of concrete. No compromise should be made in the matter of clean, well-graded materials; it is just as important as requiring that the cement used shall meet standard specifications. When the material to be used comes from a gravel bank or similar deposit, it should be examined to determine cleanliness and grading. The natural run of such material is not to be relied upon. It must be screened and the sand and pebbles remixed in the proper proportions. If the fine aggregate contains more than 5 per cent by volume, matter ordinarily classed as dust, silt or clay, the presence of such material will invariably lower the quality of the resulting concrete. If crushed stone is used, it also must meet the requirements of grading and cleanliness mentioned for pebbles. The tendency to use an excess of fine material is particularly to be avoided because of the consequent reduction in strength of the finished pipe.

In reinforced concrete pipe enough water must be used in the concrete mixture to make certain that there will be a perfect bond between concrete and reinforcing metal. In general, the concrete should be of a quicky con-
Concrete should be deposited evenly around the mold in thin layers and thoroughly spaded.

Low Cost

Reinforced monolithic concrete on account of its low cost has, for some years, been practically above competition in the construction of large sewers. The same holds true of reinforced concrete pipe in large sizes. In the manufacture of concrete sewer pipe of large size, the use of steel reinforcing proves economical and advantageous.

REPRESENTATIVE MANUFACTURERS OF REINFORCED CONCRETE PIPE

California Glazed Cement Pipe Co. Security Building
Los Angeles, Cal.
Canada Lock Joint Pipe, Limited Union Bank Building
Winnipeg, Canada
Concrete Pipe Works Board of Trade Building
Portland, Ore.
Core Joint Concrete Pipe Co. Munsey Building
Baltimore, Md.
Independent Concrete Pipe Co. 201 North West Street
Indianapolis, Ind.
Lock Joint Pipe Co. 165 Broadway
New York, N. Y.
C. F. Massey Co. Peoples Gas Building
Chicago
Pacific Lock Joint Pipe Co. Tacoma, Wash.
Western Reinforced Concrete Pipe Co. Los Angeles, Cal.
Shearman Concrete Pipe Co. Athens, Tenn.
Utah Lock Joint Pipe Co. Salt Lake City, Utah
Wilson Concrete Co. Red Oak, Iowa
Specifications for Reinforced Concrete Pipe

Boulder, Colo., Kansas City, Mo., New York, N. Y., Philadelphia, Pa., Baltimore, Md., Albany, N. Y., Buffalo, N. Y., and Salt Lake City, Utah, are some cities which have prepared good and comprehensive specifications for concrete pipe and other ways of using concrete in sewer work. No doubt engineers or others interested can secure a copy of these specifications by addressing the Department of Sewers of the cities mentioned. The various manufacturers of reinforced concrete pipe will be glad to furnish copies of their specifications on request.

Plain Concrete Pipe

Although a committee of the American Society for Testing Materials, known as Committee C-4, has been charged with the duty of preparing a standard specification for concrete pipe, the results of this committee's labors will not be available until after June, 1918. However, the specifications for tests will be similar to the specifications adopted by the American Society for Testing Materials' Committee C-6, 1916.

In general, the following recommendations will be found a safe guide in the manufacture of concrete pipe by machine. These recommendations are offered to concrete pipe manufacturers in the belief that if followed the resulting product will be of a uniformly high quality.
RECOMMENDATIONS TO BE FOLLOWED IN THE MANUFACTURE OF MACHINE-MADE CONCRETE SEWER PIPE

I. MATERIALS


2. Fine Aggregate. Fine aggregate shall consist of sand, fine gravel, graded from fine to coarse, and passing when dry a screen having 4 meshes

City of Tulsa, Oklahoma

April 6, 1916.

Mr. C. W. Wood,
113 Washington Street,
Chicago, Illinois.

Dear Sir:--

We have been laying sewer pipe made of concrete in Tulsa, for about five years. There must be fifty miles of it in use by this time. During this time we have had no vitrified pipe.

Yours truly,

E. H.
City Engineer.

Fifty miles of concrete pipe sewers in Tulsa, Oklahoma, show the city's preference per linear inch, and shall be of siliceous material, clean, free from dust, soft particles, loam, vegetable or other similar foreign matter. Not more than 20 per cent shall pass a sieve having 50 meshes per linear inch. The fine aggregate shall be of such quality that mortar composed of 1 part Portland cement and 3 parts fine aggregate by weight, when made into briquets, will show a tensile strength equal to or greater than the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand. In no case shall fine aggregate containing frost or lumps of frozen material be used; neither should fine aggregate containing more than 5 per cent by volume of clay or loam, or other soluble matter, as determined by washing, be used.
3. **Coarse Aggregate.** Coarse aggregate shall consist of inert material, as pebbles or crushed stone, graded in size, retained on a screen having 4 meshes per linear inch. It shall be clean, hard and durable, free from dust, vegetable or other foreign matter, and shall contain no soft or flat particles. In no case shall coarse aggregate containing frost or lumps of frozen material be used. The maximum size of coarse aggregate shall be no greater than one-half the wall thickness of the pipe, and in no case should the coarse aggregate exceed $\frac{3}{4}$ inch.

4. **Natural Mixed Fine and Coarse Aggregate.** Natural mixed aggregates shall not be used as they are received from the deposit. They shall be screened over a $\frac{3}{4}$-inch screen and mixed to agree with proportions specified.

5. **Proportions to be Used.** For the manufacture of concrete pipe up to and including those of 12-inch internal diameter, concrete shall be mixed in the proportions of 1 sack of cement to not more than 3 cubic feet of fine aggregate. For the manufacture of pipe above 12 inches internal diameter, concrete shall be mixed in the proportions of 1 sack of Portland cement to not more than 3 cubic feet of fine and coarse aggregate measured separately.

**II. WORKMANSHP**

6. **Measuring Materials.** A sack of Portland cement (94-lb. net) shall be considered 1 cubic foot. The method of measuring the various materials for the concrete shall be one which will insure separate and uniform
proportions of each of the materials at all times. When cement in bulk is used, the cement shall be accurately measured in such a manner as to ensure that the quantity of cement used as the equivalent of 1 sack in the proportions specified above shall be 94 pounds.

7. Mixing. The concrete materials shall be mixed to the desired consistency in a batch mixer of approved type. The mixing shall continue for at least one minute after all materials, including water, are in the mixer.

City of Boston,
Public Works Department,
Sewer and Water Division.

Boston, July 22, 1915.

Mr. Edward P. Murphy,
Commissioner of Public Works.

Dear Sir:

I return herewith the letter of Mr. Harvey Whipple, Managing Editor of the Concrete-Cement Age, Detroit, Mich., dated July 17, 1915, stamped 15-745, with answers to his four questions, seriatim:

1. Since 1906, generally in place of brick.
2. Economy.
3. No cause has appeared up to date for dissatisfaction with concrete (monolithic) sewers.
4. The use of concrete, reinforced with steel, has made feasible the box section type of sewer, admirably adapted to cases of lack of headroom, sometimes accompanied by lack of side room. The rebuilding of Old Story Brook is the best type of this form of construction.

By the use of steel longitudinally in the invert and side walls many sewers have been built in questionable ground, the sewer being practically a concrete girdle, spanning the soft spots, and avoiding pile driving.

Neither of the above devices would be practicable in brick.

Yours respectfully,

Joseph L. Dool
Office Engineer Sewer Service.

Boston, Massachusetts, recognizes many advantages for concrete in sewer work.

8. Retempering. Retempering of mortar or concrete which has partly hardened, that is, remixing with additional materials or with water, shall not be permitted.

9. Consistency. Concrete shall be mixed as wet as can be used and at the same time permit the immediate removal of the outer casing or form
from the pipe. As an indication of the required consistency, the pipe should show on the outer surface web-like markings of watermarks, indicating free moisture after the removal of the jackets. Interior surfaces of the pipe should show marks caused by free water coming to the surface under the troweling action of the revolving packer head or core, in case such is used.

10. Forming. Pipe shall be made in such manner as to insure a dense and uniformly compacted product with smooth ends and inner surfaces. Each pipe shall be of a cylindrical section, the size being designated by the interior diameter. The thickness of the pipe should be practically uniform throughout and be not less than one-twelfth of the diameter, with a minimum thickness of five-eighths inch. The diameter shall not vary more than 1 per cent from that specified.
11. Precautions. No pipe shall be made when the temperature of the atmosphere surrounding the machine is lower than 50 degrees Fahrenheit. Aggregates and water shall be heated when the temperature of either is lower than 50 degrees Fahrenheit.

III. HARDENING

12. Steam Hardening. Within 60 minutes after removing the outer casings from the pipe they shall be placed in a curing room, where the temperature is not lower than 50 degrees Fahrenheit, and be protected from drafts of air or other influences which would tend to cause evaporation of moisture from the concrete. Within 10 hours after removing the pipe from the machine the temperature in the hardening room shall be raised to at least 100 degrees Fahrenheit, and an atmosphere saturated with wet steam shall be maintained by introducing wet steam into the hardening room.

(a) During a certain season of the year when the outside temperature during the day does not fall below 50 degrees Fahrenheit the pipe shall be steam hardened as described above for not less than 48 hours, after which they may be removed from the hardening room and piled out of doors. They shall, however, then be sprinkled not fewer than three times daily for 7 days. They may be shipped after having been stored out of doors not fewer than 14 days.

(b) When the temperature of the outside atmosphere falls below 50 degrees Fahrenheit during the day the pipe shall be steam hardened for not fewer than 96 hours, after which they may be piled out of doors. They
then require no further treatment, but shall remain in storage for not fewer than 14 days before shipment.

13. Water Hardening. It is sometimes found impracticable to introduce steam into the hardening room. The pipe should, however, be handled in the same manner as previously described under steam hardening until they have become sufficiently hardened so that when water is sprayed upon them they are not injured. The pipe shall then be kept constantly wet on the surface by sprinkling with water in the form of a fine spray or mist, for not fewer than 7 days, and the temperature shall be maintained at not less than 70 degrees Fahrenheit in the hardening room. After removing from this room the pipe shall be treated as described above for steam hardening.

14. Steam and Water Hardening. It is sometimes desirable or advantageous to use a combination of the steam and water hardening processes
as outlined herein. The pipe in this case shall be hardened in the steam room under conditions already described for steam hardening until such time as they are sufficiently hard to permit being piled one upon the other.

IV. HANDMADE CONCRETE PIPE

Sewer pipe of large size, especially those above 24 inches in diameter, are usually manufactured by hand—often at the site of the work. The forms usually consist of properly-shaped steel plates with the inner form so placed within the outer one that the shell of the finished pipe will be of the desired or required thickness. The forms are kept clean and free from rust by removing any particles of adhering concrete each time after use and by wiping the forms with oil-soaked waste, particularly just before again using them. Depending upon the size of pipe to be manufactured, both inner and outer forms are constructed of two or more pieces properly stiffened and fitted with necessary fastening and clamping devices. Usually inner and outer forms are so arranged that the inner form when set up with the outer one becomes self-centering.

In the manufacture of concrete pipe by hand, a somewhat arbitrary rule has been more or less recognized with reference to the thickness of the shell of such pipe. Handmade pipe should have a wall thickness of not less than one-tenth the diameter.

The concrete mixture to be used in the manufacture of pipe by hand should be as specified on page 12. Concrete should be mixed for not less than one minute in a suitable batch mixer.
In filling forms the concrete should be deposited in layers around the entire section between inner and outer forms and be well spaded while placing to insure that the concrete will be settled to maximum density and that coarse particles will be forced back from form faces, thus increasing the density and watertightness of the pipe.

Forms shall not be removed from the pipes until 24 hours shall have elapsed after filling the mold. Pipe shall remain on pallets or base rings.
Mr. Harvey Whipple, Managing Editor,  
Concrete-Cement Age,  
67-698 Fort St., West,  
Detroit, Mich.

Dear Sirs—

Your letter of July 23rd. to City Engineer, Curtis  
Hill, was referred to this department for answer.

We have been using concrete pipe in sewers for  
about three years in sizes from 8" to 24" in plain concrete.  
For sewers of larger sizes we use reinforced concrete pipe  
and reinforced monolithic concrete. From January, 1913 to  
January, 1916 we constructed about 35 miles of concrete sewers,  
including the plain concrete, reinforced concrete pipe  
and reinforced monolithic concrete.

Concrete pipe was admitted to our specifications  
to produce competition and this advantage was gained as expected. This competition has also resulted in our getting  
much better vitrified pipe than was turned out previously to  
admitting concrete pipe.

Concrete pipe in sewer construction has given sat-  
sisfaction in this city. The only difficulty we experience  
is in getting the reinforcing rods properly bent and placed  
in their proper position. This, I believe, is due to the class  
of labor that is employed for this work.

We have no especially interesting sewer work going  
on at the present time. Yours very truly,

[Signature]

Engineer-Sewer Division

Concrete pipe in Kansas City sewer work forced higher standards for competing materials. Many  
miles of satisfactory and efficient concrete pipe sewers are in service in Kansas City.

for 72 hours. If they are hardened by the water process, they should be  
kept moist for a period of at least 7 days after forms have been removed.  
Proper hardening is very important to securing a high-grade product and  
has great influence on the ultimate success of the pipe.
V. GENERAL REMARKS

A deficiency in fine material in the aggregate causes difficulty in the manufacturing process, loss of pipe when removed from the casing, rough surfaces, stone pockets, and pinholes through which water may be forced when the pipe is subjected to internal water pressure. A deficiency of fine material within certain limits does not decrease the strength of the finished product. Excess of fine material causes low strength in the finished pipe, and with ordinary mixtures tends to produce a pipe which will show seepage under internal pressure. There is a marked tendency to use an excess of fine material in the aggregate, and this should be particularly guarded against. Unless pipe are tested, the manufacturer may be deceived as to the quality of the product which he is making, owing to the smooth and (to the uninitiated) workman-like appearance of the pipe in which aggregate containing an excess of fine material has been used.

There are two indications of good quality in pipe:

1. High supporting strength.
2. Low percentage of absorption.

Pipe showing a small percentage of absorption are in every respect preferable to those in which the percentage of absorption is high. In investigating and determining the absorption it is necessary to dry the pipe at a temperature of 212 degrees Fahrenheit until they show no further
loss in weight. Pipe will absorb their full capacity of water within 24 hours after immersion. Tests have clearly shown that high strength and low absorption go hand in hand.

The quantity of water to be used in each batch of concrete is something upon which the uniformity of the product more or less depends.

In connection with the steam hardening process, two requirements deserve particular emphasis, because if neglected they sometimes cause improper hardening of the pipe.

(1) The steam hardening room must be sufficiently tight to prevent circulation of air and the consequent existence of a heated atmosphere not thoroughly saturated with water vapor, which would result in evaporation of water from the pipe walls.

(2) In no case should steam be allowed to enter the hardening chamber under pressure in such a manner as to strike directly upon the green pipe. The effect of this is to heat them quickly, causing evaporation of water from the interior of the pipe and the destruction of the product. In the manufacture of high standard and uniform concrete pipe, proper curing is absolutely essential.

Specifications usually require that concrete pipe shall meet certain test requirements. Such tests are made to determine the crushing strength of the pipe, their impermeability, and their resistance to internal pressure, which would tend to burst them. All tests which have been made on properly-constructed concrete pipe when compared with similar tests of pipe made of other materials have demonstrated the superior quality of con-
Concrete pipe and show that they possess strength far in excess of that necessary to meet the conditions under which generally used.

Obviously, it would be impossible in the limited space of this booklet to publish a complete list of the many manufacturers of concrete pipe in the United States. The Cement Products Bureau of the Portland Cement Association will be glad to furnish complete lists of manufacturers of concrete pipe to those interested.

CITIES USING CONCRETE SEWERS

At the present time considerably over 400 cities in the United States and Canada have concrete sewers. Among these are the following:

Atlanta, Ga.
Altoona, Pa.
Aberdeen, Wash.
Alameda, Cal.
Albany, N. Y.
Atlantic City, N. J.
Adrian, Mich.
Ann Arbor, Mich.
Ampere, N. J.
Alhambra, Cal.
Albuquerque, N. Mex.
Akron, Ohio
Bakersfield, Cal.
Baltimore, Md.

Batavia, N. Y.
Bellingham, Wash.
Bethlehem, Pa.
Beverly, Mass.
Beverly, Wash.
Boulder, Col.
Birmingham, Ala.
Boise, Idaho
Boston, Mass.
Brantford, Canada
Bridgeport, Conn.
Brooklyn, N. Y.
Buffalo, N. Y.
Bayonne, N. J.
Belleville, N. J.
Bloomfield, N. J.
Binghamton, N. Y.
Borough of Queens, New York City
Cambridge, Mass.
Cleveland, Ohio
Cincinnati, Ohio
Columbia, S. C.
Canton, Ohio
Columbus, Ohio
Corvallis, Ore.
Colorado Springs, Colo.
Chicago, Ill.
Chattanooga, Tenn.
Chalmette, La.
Chicago Junction, Ill.
Crafton, N. J.
Clifton, N. J.
Crystal Falls, Mich.
Chicago Heights, Ill.
Commission, N. J.

Detroit, Mich.
Dover, Del.
Dowagiac, Mich.
Duluth, Minn.
Dixville Notch, N. H.

East Orange, N. J.
Erie, Pa.
Elkhart, Ind.
Edmonton, Alberta, Canada
Eburne, B. C.
Everett, Wash.
East Deerfield, Mass.
Essex County, N. J.

Ford City, Mich.
Fort Smith, Ark.
Fort Worth, Tex.
Forest Hill, N. Y.

Galveston, Tex.
Goderich, Canada
Grand Rapids, Mich.
Green Bay, Wis.
Greenfield, Mass.

Hillsboro, Ore.
Haverford, Pa.
Small concrete pipe in the storage yard, Kansas City, Missouri. Well-made concrete pipe will stand any amount of exposure to the elements.

Hamilton, Canada
Harrisburg, Pa.
Hot Springs, S. Dak.
Hartford, Conn.
Havana, Cuba
Haverstraw, N. Y.
Hemet, Cal.
Holland, Mich.
Houston, Tex.
Indianapolis, Ind.
Iron Mountain, Mich.
Irvington, N. J.

Jackson, Mich.
Janesville, Wis.
Jersey City, N. J.

Knoxville, Tenn.
Kansas City, Mo.
Kalamazoo, Mich.
Kent, Wash.
Kitchener, Ont.

Lake City, S. C.
Lancaster, Ohio
Lebanon, Pa.
Lewiston, Ind.

Lincoln, Nebr.
Longmont, Colo.
Los Angeles, Cal.
Louisville, Ky.
Lorain, Ohio
La Porte, Ind.
Lansing, Mich.

Medford, Mass.
Michigan City, Ind.
Milburn, N. J.
Milwaukee, Wis.
Montclair, N. J.
McKeesport, Pa.
Minneapolis, Minn.
Mishawaka, Ind.
Montreal, Que.
Mobile, Ala.
Moline, Ill.
Modesto, Cal.
Monterey, Cal.
Monrovia, Cal.
Muscatine, Iowa
Marion, N. J.

New Bedford, Mass.
Newburgh, Ohio
Newark, N. J.
New Haven, Conn.  
Norfolk, Va.  
New Orleans, La.  
New Westminster, B. C.  
New York, N. Y.  
Niagara Falls, N. Y.  
New York State Barge Canal  
North Milwaukee, Wis.  
Oakland, Cal.  
Oakwood, Pa.  
Ogden, Utah  
Omaha, Nebr.  
Oswego, N. Y.  
Oshkosh, Wis.  
Pacific Grove, Cal.  
Paterson, N. J.  
Puyallup, Wash.  
Pawtucket, R. I.  
Peachland, Canada  
Pensacola, Fla.  
Perth Amboy, N. J.  
Phoenix, Ariz.  
Pittsburgh, Pa.  
Portland, Ore.  
Portland, Me.  
Providence, R. I.  
Pueblo, Colo.  
Reading, Pa.  
Regina, Canada  
Reno, Nev.  
Richmond, Va.  
Richmond, Ind.  
River Rouge, Mich.  
Sacramento, Cal.  
Salem, Ore.  
Salt Lake City, Utah  
St. Louis, Mo.  
St. Paul, Minn.  
St. Joseph, Mo.  
San Bernardino, Cal.  
San Diego, Cal.  
San Francisco, Cal.  
San Jose, Cal.  
Santa Clara, Cal.  
Santa Monica, Cal.  
Curing or hardening chamber where concrete pipe are kept moist by sprinkling until the required degree of hardness has been attained to permit storing them out of doors.
City of Oshkosh

Henry Whipple Eats
Concrete Cement Age
Detroit, Mich.

Dear Sir:

The city of Oshkosh has over 50 miles of cement sewers. The first cement sewers were laid here in 1884 and these are still in good condition. Some sewer pipe was laid about 1879 or 1880 and since then the satisfactory pipe has been used until this year. We are now laying in both kinds of pipe, and I believe the cement pipe is the best for large pipe. If cement pipe is properly made, they are perfectly satisfactory to me. I have tried both kinds of pipe and find that both may be used. My experience on the whole has been that cement pipe is superior to vitrified for pipe over 12 in. in diameter.

Yours truly,

J. H. Randall
Executive Engineer

Oshkosh, Wisconsin, made an early start in concrete sewer work. Since 1884, 50 miles of concrete sewers have been laid in that city.
CONCRETE SEWERS

Toledo, Ohio
Toronto, Canada
Tulsa, Okla.
Two Harbors, Minn.
Transcona, Man.

Union City, Ind.
Vancouver, B. C.
Ventura, Cal.
Vinita, Okla.
Victoria, B. C.
Vincennes, Ind.
Vailburgh, N. J.

Washington, D. C.
Watsonville, Cal.
Waukegan, Ill.
West Newton, Mass.
Wichita, Kans.
Wilmington, Del.
Winnipeg, Canada
Wyandotte, Mich.
Wallingford, Conn.
Watertown, N. Y.
York, Pa.
Yorkton, Saskatchewan

Considering the fact that the greater portion of concrete pipe sewers now in existence in this country and elsewhere has given long years of satisfactory service, often in spite of the fact that the methods by which pipe were manufactured in the past did not approach present-day high standards, it is reasonable to assume that the very superior product of today will meet every requirement exacted from it in sewer work. The same holds true of concrete in monolithic sewer construction.

Such isolated cases as have been brought to notice of the disintegration of concrete when subjected to sewage have invariably been traced to poor materials or methods of workmanship. If the methods outlined in the recommendations previously given are followed to the letter, concrete sewer pipe may be relied upon to meet the most exacting conditions imposed upon them in modern sewer practice.

MONOLITHIC CONCRETE SEWERS

When concrete is used for sewer work in the form of monolithic construction it is, of course, necessary that specifications shall be prepared for the work with particular reference to the conditions that are to be met on each individual job. Owing, therefore, to the difference in designs which will naturally be adopted to best meet local conditions, it is impossible to present an invariable specification for monolithic concrete sewer work.

A 1:2:4 concrete is to be recommended for all reinforced and plain concrete sections in monolithic sewer construction. A leaner mixture may be and usually is used for any necessary mass work such as foundations. Cement, sand and pebbles or crushed stone used in monolithic concrete sewers are subject to the same general specification requirements that govern in all other first-class concrete work. Concrete should be mixed in an approved machine of the batch type. Accurate measuring devices should be used for proportioning the mixtures so that each batch will be uniform. No concrete should be used after hardening has started and no remixed or retempered concrete should be used under any conditions. Mixtures should be of a quaky or jelly-like consistency so that they may
be readily spaded around reinforcement, yet should not be wet enough to cause a separation of sand-cement mortar and coarse aggregate. After mixing, the concrete should be transported rapidly to the place where it is to be placed. It should be spaded thoroughly around reinforcement,

pipes, or other shapes built into the work, especially on surfaces which are to be exposed to the interior of the sewer so that the sand-cement mortar may be brought to the face, thus producing a dense, watertight surface.

With the use of a concrete of the consistency described, carefully placed in smooth, watertight forms, satisfactory surfaces are obtained for the interior of the sewer. If monolithic concrete sewer construction is properly performed, the same satisfactory results will follow as in all other correct uses of concrete.
Leading sanitary and municipal engineers give unqualified endorsement to concrete in sewer construction.

It is significant of the merits of this material that over 400 cities in the United States and Canada favor concrete in sewer work.

If you are interested in any other use of concrete, write to

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