OFFICIAL PUBLICATION OF
IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

Vol. XIV. March 20, 1916 No.31

CONCRETE SIDEWALK CONSTRUCTION

BULLETIN 21

ENGINEERING EXTENSION DEPARTMENT
TECHNICAL SERVICE

Ames, Iowa

Published Tri-Monthly by the Iowa State College of Agriculture and Mechanic Arts. Entered as Second-Class matter, at the Post Office at Ames, Iowa under the Act of Congress of August 24, 1912.

THE TECHNICAL SERVICE BUREAU.

The Technical Service Bureau is maintained jointly by the Engineering Extension Department and the Engineering Experiment Station for the purpose of making more widely available the services of these departments to the industrial interests of Iowa.

In order to present technical information so that it will be of value to those who are not engineers, yet deal with technical problems, there are issued from time to time bulletins of special interest to the municipalities, industries and trades of the state. These bulletins are the results of investigations and tests; lectures or papers given during conventions or Extension Department short courses; or valuable information from other sources.

The Bureau also furnishes to the municipalities and industries special information and preliminary expert advice.

CONCRETE SIDEWALK CONSTRUCTION

By R. W. Crum, Assoc. Prof. Experimental Engineering.

The function of a sidewalk is to provide an even, clean and dry path for pedestrians. The necessary qualities which a sidewalk must possess in order to fulfill the above functions are permanence and solidity. Portland cement concrete sidewalks, when properly constructed, meet these conditions in a very satisfactory manner.

The purpose of this bulletin is to present the correct methods to be used in building concrete sidewalks, and to point out wherein the violation of well known principles will result in failure.

DESIGN

The considerations mentioned above require that the walk be so designed and built that it will be solid, dry and permanent. To be solid the slab must be hard enough to resist wear and thick enough to support the loads it will have to carry. To be dry, the walk must be so placed that the water will run off. To be permanent, the walk must be made of durable materials and must be laid upon a foundation which will provide a uniform and unchanging support.

Walks are constructed according to two different plans. There are two course walks and one course walks. Walks laid in two courses consist of a base layer of medium rich concrete covered with a layer of rich mortar ½″ to 1″ thick. The one course walk is a single layer of first-class concrete. The former is probably the better for very heavy traffic if properly and carefully constructed, since the top can be made very hard and wear resisting. The one course walk is more simple to construct and cheaper and, if well made, is entirely satisfactory for most locations.

Line and Grade.—Both line and grade should be kept unbroken for as long a distance as possible for the sake of appearance. Lines and grades for sidewalks usually conform to the street lines and grades, but it should be borne in

The line and grade of a sidewalk should be kept unbroken for as long a distance as possible for the sake of appearance.

mind that lot lines are only imaginary and that it is not necessary for the walks to follow them absolutely. Some slight deviations from the lot lines for the purpose of straightening out the kinks may be permissible and will greatly improve the appearance of the street.

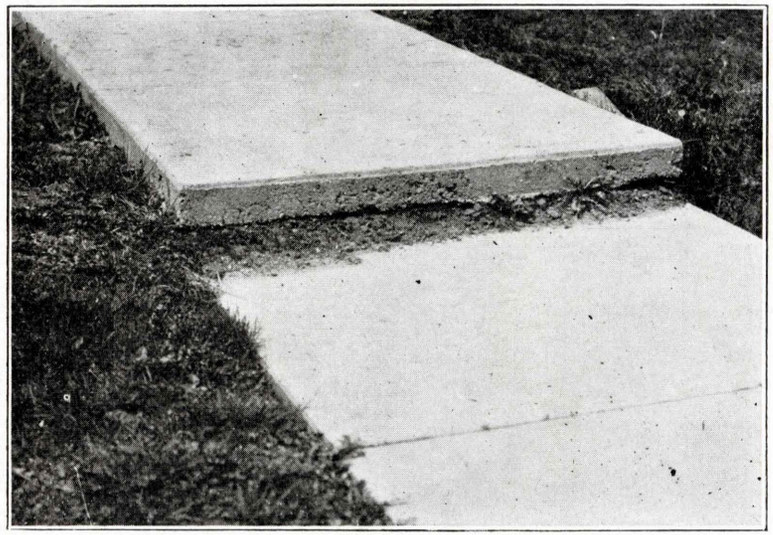
Wherever possible, slight changes in direction should be made at the top of the grade. A slight kink which would not be noticed at the top of a hill might cause a very unsightly street if located at the foot or on the side of the hill.

Changes in grade should be made gradually by means of vertical curves. Abrupt changes in the grade, on which a person might stumble, should not be tolerated.

Width.—Walks for residence streets should be at least 4′ wide; in business districts from 8′ to 20′. A walk less than 4′ wide is very unsatisfactory.

Thickness—Most concrete walks in light traffic residence districts are made 4″ thick. On heavy traffic streets, adjacent to the business district, the walks should be 4½″ or 5″ thick and in business districts 6″ thick.

Surface Drainage.—The top of the walk should be



A very poor way of making a change in the grade. In this case the higher walk is at grade and the lower walk is to be replaced at some future date. The cost of sloping a slab of the lower walk to meet the end of the new walk would be trifling.

placed at least three inches above the sod and should have a slope of ¼ inch to the foot toward the street.

Foundation—A firm support for the walk is an absolute necessity. Where the soil is firm and hard and the walk so placed that drainage is complete and there is no danger of water being retained under the walk, the walk may be laid directly upon the soil. It is somewhat better practice, however, to lay the walk upon a 1″ or 2″ layer of wet sand.

In locations where the natural drainage away from the walk is not good a sub-base of cinders, at least 8″ thick, should be used. The cinder foundation will be worse than useless, however, unless an outlet is provided for the water which it collects. In other words, the principal function of the cinders is to provide under drainage. Each low place must be provided with an outlet.

A fill upon which a sidewalk is to be built must be thoroughly compacted before the walk is laid. If compacted by hand, it should be tamped in layers not over six inches thick.

MATERIALS.

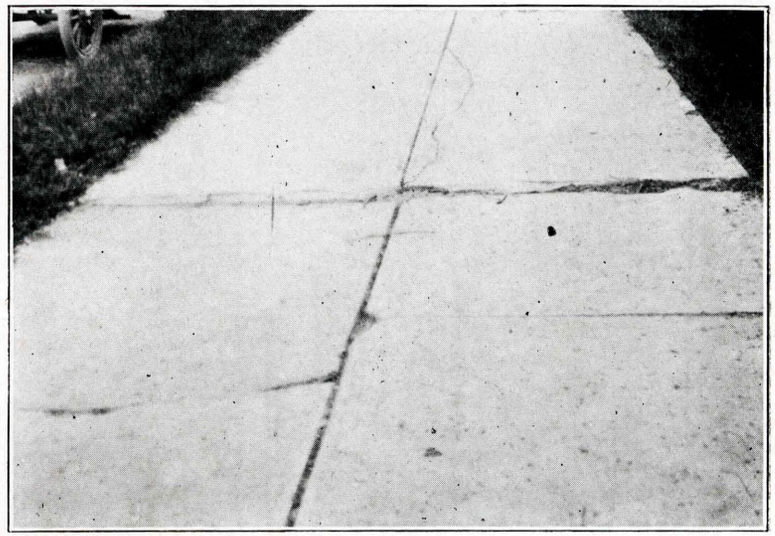
Cement.—Fresh cement, which is known to pass the requirements of the American Society for Testing Materials or the U. S. Government Specifications for Portland Cement, should be used. Cement deteriorates when stored for a long time, even though stored in a dry room. Nearly all of the Portland cement made in the United States today is uniform and of good quality, but when buying cement it is certainly wise to insure against the use of the questionable cement, which is occasionally found on the market, by having the cement tested at a reliable laboratory.

Aggregate.—Aggregate may be defined as the material mixed with water and cement to make concrete.

Sand.—Sand may be defined as that part of the aggregate, all of which will pass a No. 4 screen. Sand for use in sidewalks must be clean and composed of hard, durable materials. It should be graded in size from the finest particles up to particles which will pass a No. 4 screen. The bad effects of silt, clay or loam in the sand are more apparent in walks and pavements than in any other form of concrete construction. Limestone screenings should not be used in the top coat of two course walks nor in one course walks.

Material of an organic nature, such as animal matter or vegetable loam, will cause the disintegration of concrete when present in as small amounts as one-tenth of one per cent. Clay, if present as a film around the sand grains, may prevent the hardening of the concrete as a whole, due to lack of adhesion between the grains. If the clay is present, as finely divided dust, it will not cause disintegration, but will cause the walk to show decided lack of good wearing quality. Although strong concrete can be made with limestone screenings, they are soft and wear away rapidly under traffic. A walk, like any other structure, is no better than its weakest part, and if it does not wear well, the walk is a failure in spite of strong concrete and good foundation.

Coarse Aggregate.—Coarse aggregate may be defined as the material ranging in size between ¼" and the maximum size specified.



The cracks running lengthwise of this walk were caused by settlement due to poor foundation. Another fault is that the slabs are not completely separated, so that the cracks did not follow the surface markings.

The coarse aggregate should consist of hard particles graded in size up to material that will pass a 1" ring. It should be free from dust.

Crushed limestone and sandstone may be used in the base course of two piece walks. On account of their lack of wearing quality under traffic, they should not be used in one course work. Only pebbles, such as are found in natural gravel pits, or such material as crushed granite should be used in one course walks.

Gravel.—While unscreened natural gravel is often used for sidewalk construction, it is not to be recommended for the best class of work. It should be screened into sand and coarse aggregate and remixed in the proper proportions.

Proportions.—Two Course Walk—base, 1 sack cement to 2½ cu. ft. sand to 5 cu. ft. coarse aggregate; top coat, 1 sack cement to 2 cu. ft. of sand.

One course Walk—1 sack cement to 1½ cu. ft. sand to 3 cu. ft. coarse aggregate.

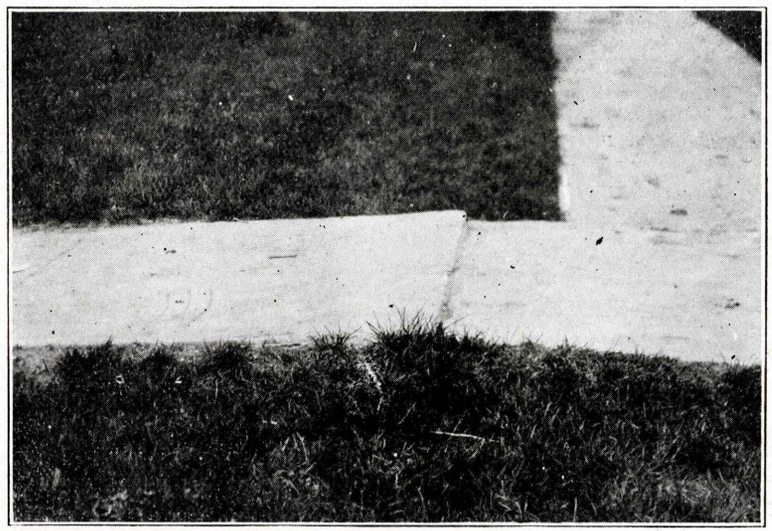
When considerations of cost require the use of un-

screened gravel, good work may be accomplished, if great care is practiced in arranging the proportion of cement to gravel. It should be understood first of all that such deposits are never uniform and that gravels taken from different levels or different parts of the same pit will have very different characteristics. On this account, the proportions to be used should be redetermined for each pile of material.

In sampling pit run gravel, care should be taken to get a good average of the pile. A rule that will yield good concrete for a one course sidewalk is as follows: Use one-half as much cement as there is material in the gravel which will pass a No. 4 sieve. The analysis may be easily made as follows: Use a straight sided vessel of any size, say 18″ high. Fill the vessel with gravel well settled by jarring, then 18″ represents the amount of gravel in the sample by measure. Separate the gravel into two sizes by screening over a No. 4 sieve, put the material passing the screen back into the vessel and measure its height in the vessel. Suppose it comes to 10″, then 10 represents the amount of sand in the gravel. The rule stated above gives us 5 to represent the necessary amount of cement. This maks the relation of cement to gravel as 5 to 18. That is, the proportion should be 5 sacks of cement to 18 cubic feet of gravel. This is the same as 1 sack of cement to 3.6 cu. ft. of gravel. As it is not usually practicable to measure as closely as this, we would use the next richer proportion, which could be conveniently measured, in this case 1 to 3½. For a complete discussion of the use of such material, the reader is referred to Bulletin No. 34, Engineering Experiment Station, Iowa State College.

However, a better method of using this kind of material is to screen it all into the two sizes and remix in the proper proportions.

Proportioning cement to pit gravel without reference to the relation of sand to coarse aggregate therein, by the arbitrary assignment of such proportions as 1 to 3, or 1 to 5, etc., is wrong. For instance, the writer had occasion not long ago to test the compressive strength of two specimens of pit gravel concrete. Both specimens were made at the same time and under the same conditions, the gravel in each case



No provision was made for expansion in his case. When expansion did take place, buckling of the slabs followed.

coming from the same pit, and the proportions in each case were 1 part cement to 5 parts gravel. One stood a load of 1,600 pounds per square inch, the other stood 240 lbs. per square inch. The only difference in the two specimens was that the gravel in the first contained 40% sand, and in the second contained 95% sand.

CONSTRUCTION.

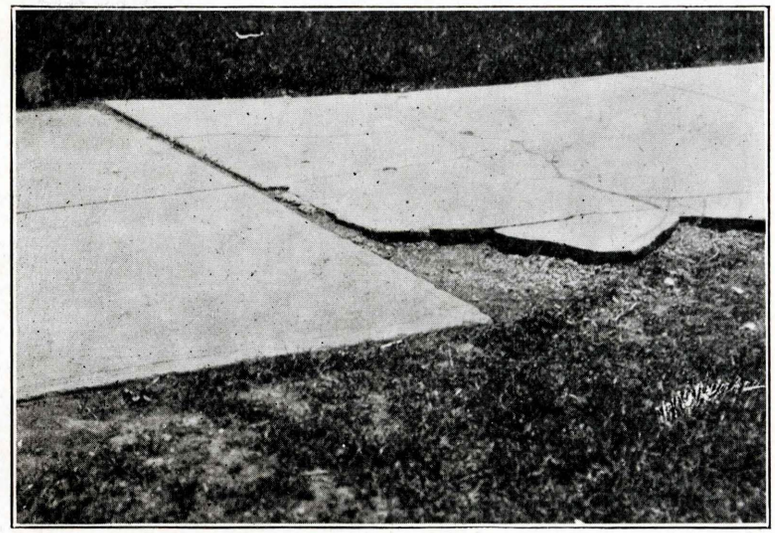
The first step in constructing the walk is the staking out of the work. Stakes marking the line and grade should be set 1 foot from the edge of the walk, not more than 25 feet apart. Line and grade should be established by an engineer. If the walk is to conform to the surface of the ground and alignment does not require the running of land lines by a surveyor, it is possible for an experienced foreman to set stakes without the use of an instrument.

The alignment is usually marked by a tack in the top of the stake, and the number of inches the top of the stake is above or below grade is marked upon the stake or upon a nearby marker.

Forms.—The forms usually consist of 2″x4″ lumber, fastened securely to stakes. The top is set to conform to the finished grade and the inside is the line of the walk. Metal cross forms should be placed across the walk at regular intervals to divide the walk into separate slabs, as some provision must be made to allow for expansion and contraction of the concrete. These intervals should not exceed 6 feet. If ⅛″ metal cross forms are used, no other provision need be made for expansion and contraction. If the walk is made in this way, unsightly cracks and buckling will not occur. Merely marking the top in squares will not prevent irregular cracks. It is necessary that the slabs be not too large and that they be absolutely separate. The method mentioned will insure this. A satisfactory joint can also be made by using a 2″x4″ cross form and laying the walk in alternate slabs. Form lumber should be straight and smooth on top and inside.

Measuring Material.—The ideal way and, indeed, the only accurate way to measure the materials for concrete, is to weigh them. This method is being adopted on large work and in cement products plants, but has not been much used as yet on sidewalk construction. The materials, excepting the cement, are measured by loose volume. Cement must never be measured loose in a box, since a bag of cement will yield all the way from ¾ to 1½ cubic feet, depending upon the way it is placed in the box. However, we have a useful unit of measurement in the bag as packed by the manufacturer. On this class of work it is customary to consider a bag of cement to be 1 cubic foot. The aggregates may be measured in any vessel of definite capacity. A rectangular box, holding an even number of cubic feet, is best. If the measuring is done in wheelbarrows, the size of the loads permissible with a given amount of cement must be frequently determined by checking with a cubic foot box.

Mixing.—The materials must be thoroughly mixed. Modern research has proven beyond a doubt that much of the trouble with faulty concrete has been due to insufficient mixing. Of the machine mixers, the batch type is to be preferred for the reasons that better mixing is secured and the



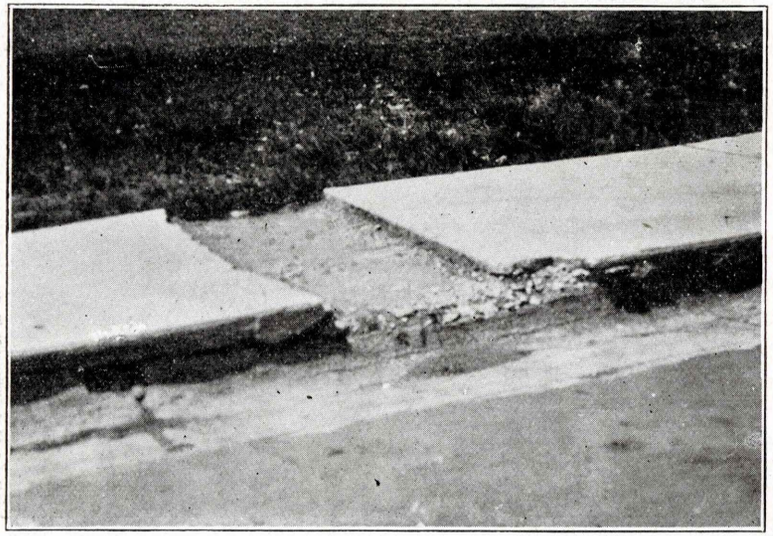
Effect of expansion combined with poor concrete. The concrete in the base course was very poor, and separation of the two courses followed.

materials can be more accurately measured than is possible in the case of continuous mixers.

The materials should all be placed in the mixer dry and turned over a few times before the water is added. The mixing time for each batch should be from two to three minutes.

Hand mixing is simply a matter of intelligent, hard work. Mix the cement and sand dry, then add the stone and mix; then add the water slowly, as the mix proceeds, using a watering can or spraying nozzle. The mixing should be done on a water-tight platform with shovels. Shovel the mass over and over until the color and consistency are uniform. Then continue to mix for about as long again.

It is somewhat difficult to prescribe the exact amount of water that should be used in mixing, as this depends somewhat upon the weather and upon the amount of mixing. Continued mixing has the effect of making the concrete more fluid. In general, the concrete should be of such a consistency that it will just flow when dumped into the form.



This figure shows the breaking up of the top due to poor concrete in the base and careless workmanship in placing the top course.

Wet concrete will be porous when set and will require much more time for finishing. Dry concrete will require heavy tamping. The concrete should be wetter in hot weather than in cool weather. The consistency recommended will not rquire tamping to compact the concrete, but will need puddling in order to drive out the air and force the larger stones below the surface, and make the structure of the concrete uniform. Before the concrete is placed the base should be thoroughly wetted. If wet concrete is placed on a dry, porous base, the base will absorb so much water from the concrete that there will not be enough left for the chemical action in the bottom layers.

After the concrete is placed it should be struck off even with the tops of the forms and left until ready for the finishing process. For one course work the concrete should be lightly tamped after leveling off, in order to flush mortar to the surface. This will be a great advantage in finishing the surface.

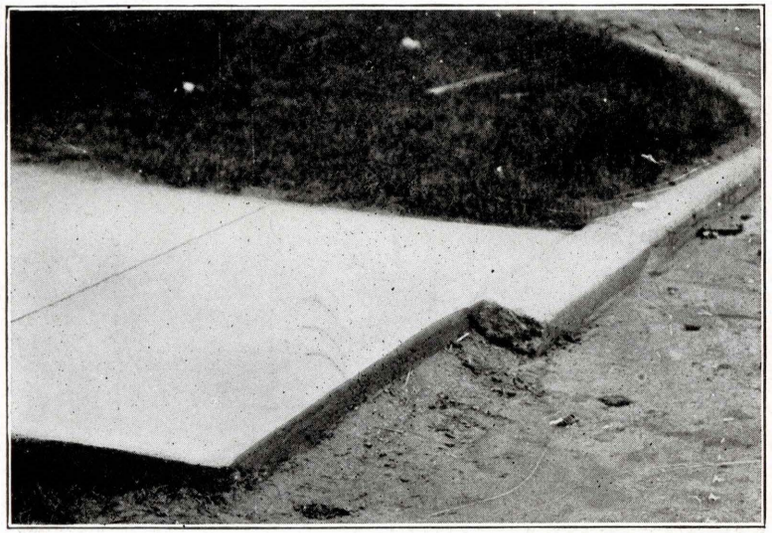
The proper time to finish the surface is just after the cement has begun to set. The true setting of the cement

This walk appears to be of very poor concrete throughout.

must not be confused with the drying out of the surface due to the evaporation of the water. In warm weather the surface water evaporates, sometimes before the cement has a chance to set. Under such circumstances, best results will follow if the walk is protected from wind and sun. Sprinkling neat cement upon the surface merely takes up the surplus water and does not hasten the setting.

The surface of either a one course or a two course walk may be finished to any degree of smoothness desired. For a rough finish, a wooden float is all that is necessary. For a smooth finish, the surface should first be evened up with the wooden float and then troweled smooth with a metal finishing trowel. For most purposes a medium rough finish should be used, as it helps prevent the walk from becoming slippery in the winter. After the surface is finished, the edges and cross lines should be trued up with the edgers and groovers made for that purpose.

For proper curing the conditions necessary are even temperature throughout the thickness of the slab and an excess of water. The walk should be kept wet and covered

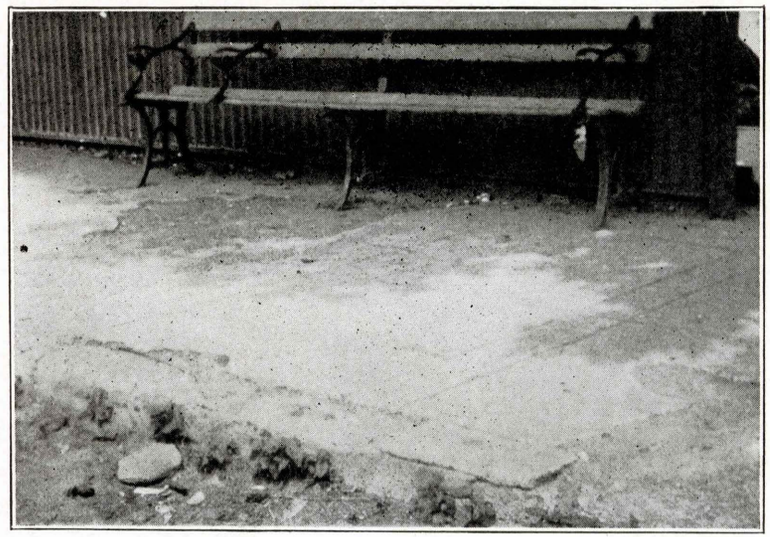


Lack of provision for expansion of the walk caused the curb to be broken off. This is a very common occurrence, which can be prevented by a simple expansion joint.

with canvas, straw, sawdust or earth, for at least two days after finishing.

DEFECTS IN SIDEWALKS.

If the foregoing principles are carried out, concrete walks can be made which will last indefinitely, free from defects. On the other hand, the neglect of some of the smallest items may result in a walk damaged beyond repair. The defects in sidewalks arise from three sources, poor design, poor foundations or poor concrete. Walks may fail due to poor design, cncerning such points as width, thickness, drainage and provision for expansion and contraction. Poor foundations are frequent causes of failure. The usual evidences are cracks, due to unequal supporting power of the soil, or to the action of frost in heaving and breaking the walk. If proper provision is made for drainage, the latter is not likely to occur. In the case of a poorly compacted fill, the foundation may even slip away from beneath the walk altogether.



Appearance of a walk laid in freezing weather. If proper precautions had been taken to prevent freezing, this job might have been made a success. However, laying sidewalks in freezing weather is usually not to be recommended.

For the construction of good walks, of course, good concrete must be made, but the manufacture of good concrete requires close attention to the simplest details. Poor concrete may result from (1) poor materials, (2) poor proportioning, or (3) poor workmanship. The evidences are a multitude of surface cracks in all directions, rapid wear as shown by a dusty surface, disintegration of the top and complete breaking up of the walk.

The effect of frost upon the concrete may be justly charged to poor workmanship. If a concrete walk is allowed to freeze before it has completely set, the surface will always scale off, and frequently the concrete will fail to harden.

If necessity compels the laying of walks in freezing weather, the concrete must be kept warm for a long time, and even then the results to be expected will be in doubt.

The illustration on the cover shows a walk on the Iowa State College campus, in the construction of which attention was paid to the various factors discussed in this paper. This

walk has been in service for seven years and is still in perfect condition.

In conclusion, attention is directed to the following summary of the principal factors bearing upon successful sidewalk construction:

(1) The careful selection of clean, well graded aggregate.

(2) A firm foundation.

(3) Provision for expansion.

(4) Proper curing. This includes protection from the rays of the sun in summer and from frost in winter.

(5) Proper finish. The troweling should be done at such a time as to bring neither neat cement nor uncoated sand grains to the surface.

NATIONAL ASSOCIATION OF CEMENT USERS
STANDARD SPECIFICATIONS
FOR
PORTLAND CEMENT SIDEWALKS

REVISED MAY 15, 1912.

MATERIALS.

1. The cement shall meet the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials and adopted by this association. (Standard No. 1.)

2. The aggregates shall be clean, coarse, hard, durable materials and shall be free from dust, soft, flat or elongated particles, loam, vegetable or other deleterious matter. In no case shall aggregate containing frost or lumps of frozen material be used.

(a) **Fine Aggregate.**—Fine aggregate shall consist of sand, crushed stone or gravel screenings preferably of silicious material, graded from fine to coarse and passing, when dry, a screen having one-quarter (¼) inch diameter holes, and not more than three (3) per cent shall pass a sieve having one hundred (100) meshes per linear inch.

Fine aggregate shall be of such quality that mortar composed of one (1) part Portland cement and three (3) parts fine aggregate by weight, when made into briquettes will show a tensile strength at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and Standard Ottawa sand.

(b) **Coarse Aggregate.**—Coarse aggregate shall consist of inert materials such as crushed stone or gravel, graded in size, retained on a screen having one-quarter (¼) inch diameter holes and the maximum size shall be such as to pass a one and one-quarter (1¼) inch ring.

(c) **Natural Mixed Aggregates.**—Natural mixed aggregates shall not be used as they come from the deposit, but shall be screened and remixed to agree with the proportions specified.

3. Only clean, hard, suitable material, not exceeding

four (4) inches in the largest dimension, shall be used in the sub-base*.

4. Water shall be clean, free from oil, acid, alkali or vegetable matter.

5. If artificial coloring material is required, only mineral colors shall be used.

6. The reinforcing metal shall meet the requirements of the Standard Specifications for Steel Reinforcement adopted March 16, 1910, by the American Railway Engineering Association.

7. The expansion joint fillers shall be a suitable elastic water-proof compound that will not become soft and run out in hot weather, nor hard and brittle and chip out in cold weather.

SUB-GRADE*.

8. **Slope.**—The sub-grade shall have a slope toward the curb of not less than one-half (½) inch per foot.

9. **Depth*.**—(a) The sub-grade shall not be less than eleven (11) inches below the finished surface of the walk.

(b) The sub-grade shall not be less than five (5) inches below the finished surface of the walk.

10. **Preparation.**—All soft and spongy places shall be removed and all depressions filled with suitable material, which shall be thoroughly compacted in layers not exceeding six (6) inches in thickness.

11. **Deep Fills.**—When a fill exceeding one (1) foot in thickness is required to bring the work to grade, it shall be made in a manner satisfactory to the engineer. The top of all fills shall extend beyond the walk on each side at least one (1) foot, and the sides shall have a slope not greater than one (1) on one and one-half (1½).

12. **—Drainage.**—When required, a suitable drainage system shall be installed and connected with sewers or other drains indicated by the engineer.

*NOTE—When a sub-base is required, eliminate paragraph 9 (b). When a sub-base is not required, eliminate paragraphs 3 and 9 (a), 13 and 14. Unless paragraph 9 (a) is eliminated, 9 (b) is void.

SUB-BASE.

13. **Width—Thickness**—On the sub-grade shall be spread a suitable material as hereinbefore stated, which shall be thoroughly rolled or tamped to a surface at least five (5) inches below the finished grade of the walk. On the fills, the sub-base shall extend the full width of the fill and the sides shall have the same slope as the sides of the fill.

14. **Wetting.**—While compacting the sub-base, the material shall be kept thoroughly wet and shall be in that condition when the concrete is deposited.

FORMS.

15. **Materials.**—Forms shall be free from warp and of sufficient strength to resist springing out of shape.

16. **Setting.**—The forms shall be well staked or otherwise held to the established lines and grades and their upper edges shall conform to the established grade of the walk.

17. **Treatment.**—All wood forms shall be thoroughly wetted and metal forms oiled before depositing any material against them. All mortar and dirt shall be removed from forms that have been previously used.

CONSTRUCTION.

18. **Size of Slabs.**—The slabs or independently divided blocks when not reinforced shall have an area of not more than thirty-six (36) square feet and shall not have any dimension greater than six (6) feet. Large slabs shall be reinforced as hereinafter specified.

19. **Thickness of Walk.**—The thickness of the walks should not be less than five (5) inches for residence districts, and not less than six (6) inches for business districts.

20. **Width and Location of Joints.**—A one-half (½) inch expansion joint shall be provided at least once in every fifty (50) feet.

21. **Protection of Edges.**—Unless protected by metal, the upper edges of the concrete shall be rounded to a radius of one-half (½) inch.

MEASURING AND MIXING.

22. **Measuring.**—The method of measuring the materials for the concrete, including water, shall be one which will insure separate uniform proportions at all times. A bag of Portland cement (94 lbs. net) shall be considered one (1) cubic foot.

23. The ingredients of the concrete or mortar shall be thoroughly mixed dry, sufficient water added to obtain the desired consistency, and the mixing continued until the materials are uniformly distributed and the mass is uniform in color and homogeneous.

(a) **Machine Mixing.**—When the conditions will permit, a machine mixer of a type that insures the uniform proportioning of the materials throughout the mass shall be used.

(b) **Hand Mixing.**—When it is necessary to mix by hand, the mixing shall be on a water-tight platform and the materials shall be turned until the mass is uniform in color and homogeneous.

24. **Retempering,** that is, remixing mortar or concrete that has partially hardened with additional water, will not be permitted.

TWO-COURSE WALK.

BASE.

25. **Proportions.**—The concrete shall be mixed in the proportion by volume of one (1) part Portland cement, two and one-half (2½) parts fine aggregate and five (5) parts coarse aggregate.

26. **Consistency.**—The materials shall be mixed wet enough to produce a concrete of a consistency that will flush readily under slight tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.

27. **Placing.**—After mixing, the concrete shall be handled rapidly and the successive batches deposited in a continuous operation, completing individual sections. Under no circumstances shall concrete be used that has partially hardened. The forms shall be filled and the concrete struck off and tamped to a surface the thickness of the wearing course below the established grade of the walk. After the concrete has been thoroughly tamped against the cross forms, they shall be removed and the material or the adjoining slab deposited so as to preserve the joint. Workmen shall not be permitted to walk on freshly laid concrete, and if sand or dust collects on the base it shall be carefully removed before the wearing course is applied.

28. Slabs having an area of more than thirty-six (36) square feet, or having any dimension greater than six (6) feet, shall be reinforced with wire fabric or with plain or deformed bars. The cross-sectional area of metal shall amount to at least 0.041 sq. in. per lin. ft. The reinforcement shall be placed upon and slightly pressed into the concrete base immediately after the base is placed. Reinforcement shall not cross joints and shall be lapped sufficiently to develop the strength of the metal.

WEARING COURSE.

29. **Proportions.**—The mortar shall be mixed in the manner hereinbefore specified in the proportion by volume of one (1) part Portland cement, and not more than two (2) parts fine aggregate.

30. **Consistency.**—The mortar shall be of a consistency that will not require tamping, but which can be easily spread into position.

31. **Thickness.**—The wearing course of the walk in residence districts shall have a minimum thickness of three-quarters (¾) of an inch, and in business districts a minimum thickness of one (1) inch.

32. **Placing.**—The wearing course shall be placed immediately after mixing and in no case shall more than fifty (50) minutes elapse between the time the concrete for the base is mixed and the time the wearing course is placed.

33. **Finishing.**—After the wearing course has been brought to the established grade, it shall be worked with a wood float in a manner that will thoroughly compact it. When required, the surface shall be troweled smooth, but ex-

cessive working with a steel trowel shall be avoided. The slab markings shall be made in the wearing course directly over the joints in the base with a tool which will completely separate the wearing course of adjacent slabs. If excessive moisture occurs on the surface, it must be taken up with a rag or mop and in no case shall dry cement or a mixture of dry cement and sand be used to absorb this moisture or to hasten the hardening. Unless protected by metal, the surface edges of all slabs shall be rounded to a radius of about one-half (½) inch.

34. If artificial coloring is used, it must be incorporated with the entire wearing course and shall be mixed dry with the cement and aggregate until the mixture is of uniform color. In no case shall the amount of coloring used exceed five (5) per cent of the weight of the cement.

ONE COURSE WALK.

Th general requirements of the specifications covering two-course work will apply to one-course work with the following exceptions:

35. **Proportions.**—The concrete shall be mixed in the proportion of one (1) part Portland cement, one and one-half (1½) parts fine aggregate and three (3) parts coarse aggregate passing a one (1) inch ring.

36. **Placing and Finishing.**—The forms shall be filled, the concrete struck off and the coarse particles forced back from the surface, and the work finished as specified under Two-Course Work.

37. **Reinforcement.**—When a single course walk is to be reinforced, the metal shall be placed two (2) inches from the finished surface. The minimum amount of metal shall be as specified in Paragraph 28.

PROTECTION.

38. **Treatment.**—When completed, the work shall be kept moist and protected from traffic and the elements for at least three days, and shall not be opened to traffic until the engineer so directs.

39. **Temperature below 35 Degrees F.**—If at any time

during the progress of the work the temperature is, or in the opinion of the engineer will within twenty-four (24) hours drop to thirty-five (35) deg. Fahrenheit, the water and aggregates shall be heated and precautions taken to protect the work from freezing for at least five (5) days. In no case shall concrete be deposited upon a frozen subgrade or sub-base.