square inch, and there is no tension. The cost of the structure was $8000, which is equivalent to about $3.00 per square foot of the roadway.

Walnut Lane Bridge, Philadelphia. A notable structure in concrete is the Walnut Lane Bridge built as it is with a clear span of 233 feet. The arch was completed in 1908 under the direction of the Bureau of Surveys, Mr. George S. Webster, Chief Engineer and Mr. Henry H. Quimby, Assistant Engineer. The principal arch consists of two ribs, upon which rest cross walls connected by small longitudinal arches of 20 feet span carrying the spandrel wall supporting the I-beams of the floor.

A fine photograph of the arch is shown in Fig. 156, page 532, and cross sections illustrating the design in Fig. 185, page 592. The balustrade is entirely of concrete, the posts being molded on the ground and the surface washed off with water to reveal the aggregate.

Other Notable Bridges. For references to other bridges built in recent years, see Chapter XXXI.

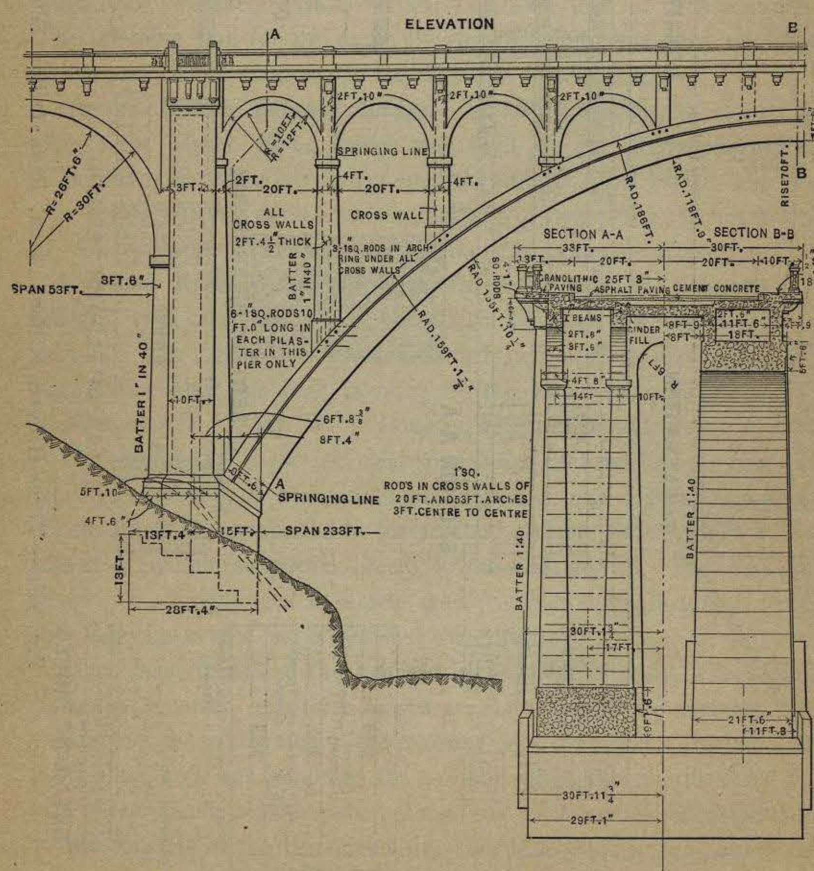

FIG. 185 Walnut Lane Bridge, Philadelphia. (*See p.* 592.)

CHAPTER XXIII

SIDEWALKS, BASEMENT FLOORS AND PAVEMENTS

The introduction of reliable American Portland cements has rendered concrete available for sidewalks and other similar purposes at a price not more than two-thirds of that previous to 1890, when German and English cements were used. Portland cement being thus commercially within reach of builders, masons have become familiar with its use, and concrete sidewalks, because of their economy and durability, are supplanting those of other materials.

Street pavements are also being made of concrete, and with apparent success,* by methods similar to those which obtain in sidewalk construction.

The essentials for a good concrete sidewalk are an artificial foundation of firm but porous material, through which the rain water may percolate, a base of good strong concrete, and a wearing surface of rich mortar, troweled to a smooth, dense surface. The walk must be divided into blocks, with the joints between them forming lines of weakness, so that if any cracks occur through shrinkage, settlement, or frost, they will occur at the joints and thus not be noticeable.

Vault light construction in concrete requires even greater skill than ordinary walks, and should never be attempted by inexperienced constructors.

The construction of basement floors is similar to sidewalk work except that in dry ground an artificial foundation is not always necessary, and, there being less danger of settlement and frost, the blocks of such a floor may be of larger size, having occasional joints to provide for contraction from changes in temperature.

Floors above the ground level in buildings whose design is considered in Chapter XXIV, page 609, may be surfaced with mortar in a manner similar to the wearing surface of walks, or the concrete may be floated without the extra coating of mortar.

MATERIALS FOR CONCRETE SIDEWALKS

The selection of a first-class Portland cement is an absolute necessity.† Natural cements will not stand the wear, and Puzzolan cements are liable

*Engineering News, Jan. 28, 1904, p. 84.
†See Cement Specifications, p. 29.

to surface deterioration from the action of the weather. Walks have been built with a Natural cement concrete base, and a wearing surface of Portland cement mortar, but the results have been unsatisfactory, for even if the surface coat is laid before the Natural cement concrete base has set the Portland cement does not adhere strongly and is likely to scale off.

Mr. Harry T. Buttolph* suggests that the breaking up of the surface appears to be due to the difference in expansion of Natural and Portland cement. He has noticed that the surface of such slabs sometimes curls up like a sheet of paper.

For the foundation, by which is meant the prepared surface underneath the concrete, any porous material such as broken stone, gravel (preferably with sand screened out), or cinders may be employed.

For the base, which consists of a layer of concrete from 3 to 5 inches thick, ordinary materials, such as broken stone and sand, screened gravel and sand, or gravel as it comes from the bank without screening, may be used for the aggregate. Unscreened gravel is not generally advisable, however, because a more uniform mixture can be obtained by screening the gravel and remixing the sand with it in definite proportions. (See p. 112.) The proportions frequently used in our large cities for the concrete base are 1 part Portland cement to 2 parts sand to 5 parts stone, based in some localities upon the volume of cement as packed in the barrel, and in others upon the volume loose, although the resulting proportions obtained in the two cases are very different. (See p. 218.) In many cases these proportions are richer than is necessary. In Germany,† proportions 1:3:6 are recommended for heavy duty, and 1:5:10 for light work, while for ordinary requirements 1:4:8 are specified. The last two proportions appear rather lean for ordinary conditions, but 1:3:6, if the relative volumes are based on a unit of 3.8 cu. ft. to the barrel, should be satisfactory for ordinary conditions, with 1:2½:5 for more important construction, or for pavements to be subjected to severe usage, such as teaming. If the proportions are based upon the volume of cement measured loose, the required parts of sand and stone must be decreased by about 10%; thus 1:3:6 would become about 1:2¾:5½.

The wearing surface, whose thickness varies in different specifications from ½ to 1 inch, should be laid with the same first-class Portland cement as is the base. Customary proportions are equal parts of cement and aggregate. Either sand, or fine crushed rock, or a mixture of the two,

*Personal correspondence.

†"How to Use Portland Cement," translated from the German of L. Golinelli by Spencer B. Newberry, p. 26.

may be used to form the mortar. If crushed rock is used, — and good crushed rock is usually preferable to sand, — it should be of a texture such as granite or trap, which will break into cubical, rather than flat or laminated fragments. The size of crushed stone specified by the majority of engineers is that which will pass a ¼-inch sieve, although a few cities require finer material, Chicago, for example, specifying* torpedo sand ranging from ⅛-inch down. Such sand is too fine to give a strong mortar. On the other hand, some cities, including Omaha, Neb.,† require crushed stone which will pass a ½-inch mesh sieve.

The requirements in various cities throughout the United States in 1900 are shown in the following table:

Requirements in Various Cities.‡ (*See p.* 595.)

City.	Foundation.		Base.		Wearing Surface.		Dry Coating.	Size of Blocks.	Guarantee.
	Thickness.	Material.	Thickness.	Proportions.	Thickness.	Proportions. Cement. Sand.	Proportions. Cement. Sand.		
	Inch		Inch		Inch				Yr.
Boston	12	Broken stone, gravel or cinders	3	1:2:5	1	1:1	...	3½ to 6 ft. sq.	10
Rochester ..	6	Sand, gravel, broken stone or cinders.....	‖	1:5	1	2:3	...	....	3
Philadelphia	3	Sand, gravel, broken brick, stone or cinders	3	.....	2	1:2	1:1	....	..
Washington	0		4	1:2:5	1	2:3	1:1	....	5
Chicago ...	12§	Cinders..............	4¼	1:2:5	¾	1:1	...	5 ft. x 6 ft.	10
Milwaukee .	4	Cinders or broken stone	2½	1:3:5	1	1:1	...	24 to 36 sq. ft.	...
St. Louis...	8	Cinders..............	3½	1:3	½	1:1	...	....	1
Omaha	4	Gravel, slag or stone...	3	1:2:4	1	1:2	3:1	....	5

Coloring Matter. The appearance of a walk is improved by being slightly colored. The following formulas are recommended by Mr. L. C Sabin:¶

*1899 Specifications.

†1898 Specifications.

‡From Typical Concrete Sidewalk Specifications, by Sanford E. Thompson, in *Cement*, July, 1900, p. 85.

§No foundation required where the soil is clean sand.

‖Specified for each contract.

¶Sabin's "Cement and Concrete", 2nd Edition, p. 382.

Colors for 1 : 2 Mortar. By Louis C. Sabin (*see p.* 595)

MATERIAL.	½ LB. PER 100 LB. CEMENT.	4 LB. PER 100 LB. CEMENT.	COST PER LB.
Lamp Black	Light slate	Dark blue slate	15 cents
Prussian Blue	Light green slate	Bright blue slate	50 "
Ultra Marine Blue		Bright blue slate	20 "
Yellow Ochre	Light green	Light buff	3 "
Burnt Umber	Light pinkish slate	Chocolate	10 "
Venetian Red	Slate, pink tinge	Dull pink	2½ "
Red Iron Ore	Pinkish slate	Light brick red	2½ "

NOTE: Colors vary with quantity of material added. Cost is per lb. of coloring matter. Colors are apt to fade unless formed by color of crushed rock.

Quantity of Materials Required. The volumes of materials required to cover a certain area of surface are determined by the thickness of the walk or floor, the proportions in which the materials are mixed, and the character of the materials.

The following table gives the approximate quantity of materials necessary for 100 square feet of surface for walks of various thicknesses of base and wearing surface. It is assumed in compiling the table that the coarse aggregate of the base contains about 45% voids, and that the stone and

Materials for 100 Square Feet of Concrete Sidewalks. (*See p.* 596.)
Proportions based on a barrel unit of 3.8 cubic feet.

	Base.						Wearing Surface.						
	Proportions. 1:2½:5			Proportions. 1:3:6				Proportions. 1:1		Proportions. 1:1½		Proportions. 1:2	
Thickness.	Cement.	Sand.	Stone.	Cement.	Sand.	Stone.	Thickness.	Cement.	Sand.	Cement.	Sand.	Cement.	Sand.
in.	bbl.	cu. yd.	cu. yd.	bbl.	cu. yd.	cu. yd.	in.	bbl.	cu. yd.	bbl.	cu. yd.	bbl.	cu. yd
2½	1.10	0.39	0.78	0.94	0.40	0.80	½	0.85	0.12	0.68	0.14	0.56	0.16
3	1.33	0.47	0.94	1.13	0.48	0.96	¾	1.28	0.18	1.02	0.21	0.85	0.24
3½	1.55	0.55	1.10	1.32	0.56	1.12	1	1.70	0.24	1.36	0.29	1.13	0.32
4	1.77	0.63	1.25	1.51	0.64	1.28	1¼	2.13	0.30	1.70	0.36	1.41	0.40
4½	1.99	0.70	1.41	1.70	0.72	1.44	1½	2.56	0.36	2.04	0.43	1.69	0.47
5	2.21	0.78	1.56	1.89	0.80	1.60	2	3.41	0.48	2.72	0.57	2.26	0.63

NOTE.—Select and add together the quantities of each material corresponding to the required thickness and proportions of base and wearing surface.

sand are measured loose by shoveling into boxes or barrels, on the basis of the volume of a cement barrel of 3.8 cubic feet. For example, proportions 1: 3: 6 are equivalent to 1 barrel Portland cement, 11.4 cu. ft. of sand and 22.8 cu. ft. of broken stone or gravel, while proportions 1: 2 are equivalent to 1 barrel of Portland cement to 7.6 cu. ft., or one bag of Portland cement to 1. 9 cu. ft. of sand or crushed stone. The variation in volume of mortar produced with sand and crushed stone of different fineness may affect the quantities for wearing surface by at least 10%, but to provide for such variation, and to allow for waste, 10% has been added, in computing the values, to the quantities in the table on page 231.

Since the volumes are given separately for the base and wearing surface, the quantities required for walks of other thicknesses may be readily estimated, as illustrated in the following example:

Example: — What materials will be required for a walk 8 ft. in width and 150 ft. long, the base to be 3 in. thick, of concrete in proportions 1: 3: 6, and the wearing surface one inch thick, in proportions 1 part cement to 1 part sand?

Solution: — Referring to the table we find directly that for 100 sq. ft. of base 3 in. thick, 1.13 bbl. Portland cement, 0.48 cu. yd. sand, and 0.96 cu. yd. broken stone or gravel are required. Similarly, for 100 sq. ft. of the wearing surface one inch thick we should require 1.70 bbl. cement and 0.24 cu. yd. sand. For each 100 sq. ft. of completed walk there would therefore be needed 2.83 bbl. cement, 0.72 cu. yd. sand, and 0.96 cu. yd. broken stone or gravel; and since there are 1 200 sq. ft. in an area of 150 by 8 ft., for both base and wearing surface we should require 34 bbl. Portland cement, 9 cu. yd. sand, and 12 cu. yd. broken stone or gravel.

TOOLS

The following implements are required in ordinary concrete walk construction:

Mortar box for mixing the materials for wearing surface.

Platform about 12 ft. square for mixing concrete* (see Fig. 7, p. 22).

One or more iron wheelbarrows for handling the materials and the concrete (see Fig. 4, p. 18).

Square-pointed shovels (see Fig. 3, p. 18).

Hoe.

2-inch scantling of a width corresponding to the thickness of the walk.

⅞-inch stuff of same width as scantling, for curved forms.

Steel square.

*Sometimes unnecessary.

Spirit level.
Straight-edge long enough to extend across the walk.
Two rammers about 5 inches square, with handles about 4 feet long (see Fig. 99, p. 281).
Wooden stakes.
Iron pins and twine for stretching line.
Mason's trowel.
Pointing trowel.
Plasterer's steel trowel (see Fig. 186, p. 601).
Plasterer's wood float.
Groover (see Fig. 187, p. 601).
Edging trowel (see Fig. 188, p. 602).
Dot roller (see Fig. 189, p. 602.)

METHOD OF LAYING SIDEWALKS

Successful sidewalk construction is as dependent upon careful attention to small details which have been proved essential to good workmanship, as upon adherence to the more general directions given in any set of specifications. The full description of methods to be employed in laying a walk are given for the benefit of those who are unable to take advantage of the experience of specialists in this line. Experienced contractors often can perform such work better and cheaper than it can be done by day labor.

Thickness of Walk. A total thickness of 4 inches of concrete and mortar laid upon a 10-inch foundation of porous material gives excellent results for ordinary sidewalks, although 5 inches is often required for public works. In locations subject to wide changes in temperature, as Boston and vicinity, a thickness of 4 inches has proved satisfactory, while in some cities 3½ inches only is required. For a 4-inch walk it is advisable to make the base 3 or 3¼ inches and the wearing surface 1 or ¾ inch thick. The slope of surface often adopted is ¼ or ⅜ inches to the foot.

Driveways or walks which are subjected to excessive wear may be 5 or 6 inches thick, the upper 1 or 1½ inches constituting the wearing surface.

Foundation. The construction of the foundation is as important as the laying of the concrete. For out-of-door construction the foundation should generally be from 6 to 12 inches thick, depending upon the character of the soil. In localities unaffected by frost and having soil sufficiently porous to carry off surface water, the foundation may be omitted entirely, and the concrete laid upon natural ground excavated to the required depth.

In Washington, D. C.,* no foundation is specified, and even in Chicago* it is not required where the soil is clean, porous sand. For basement or cellar floors which are not to be subjected to frost, the concrete may usually be placed directly upon the soil; but in compact ground, or where surface water is troublesome, blind drains of pipe or of cobble stones, carefully rammed, should be laid at various points.

The materials for a foundation, where such is required, may be broken stone, gravel, cinders, or coarse sand. In order to make it more porous, broken stone or gravel should be screened. Whatever material is employed it must be thoroughly rammed so as to present a firm and unyielding surface. Cinders or sand should be thoroughly wet when being rammed.

Concrete Base of Walk. The coarse concrete constituting the main body of the walk is generally called the base. Before this coarse concrete of the base is placed, the surface must be carefully laid off into squares or blocks. Such divisions are absolutely essential, since the joints furnish lines of weakness along which cracks will occur if the concrete is affected by the freezing of the soil beneath tree-roots, unequal settlement, or temperature changes, and also facilitates the replacing of a block if one is injured from any cause.

There are three distinct methods of forming separate blocks: (*a*) laying the blocks alternately, and then filling in between them; (*b*) allowing the scantling of the forms o remain in place until after the concrete is laid, and then filling the spaces they occupied with lean mortar or sand; (*c*) placing tarred paper between the blocks. The first method is usually preferable.

The size of the blocks depends upon the width and shape of the walk or floor. Blocks nearly but not quite square have a better appearance than those which are distinctly oblong. The limit of size for a 4-inch walk is generally placed at 6 feet square. In 5-inch work this may be safely increased to 8 feet square. Joints should be placed around trees and about 6 inches from buildings, manholes, or other adjacent structures.

After ramming and leveling the foundation, if there is no curb to be formed, strips of scantling 2 inches thick, and of a width corresponding to the thickness of the walk, are placed on edge along the back and front lines of the walk, and held in place by stakes driven behind them. These strips should have notches cut in them to designate the location of the dividing line between the blocks. Other strips, located by these notches, are placed across the walk, which is now ready for the concrete.

The concrete materials in the specified proportions are mixed as de-

*Specifications for 1899.

scribed on page 20. If the surface of the road is hard and smooth, the mixing may be done upon it without any platform. In any case, it must be very thorough, some contractors employing a man to rake each shovelful as it is turned by the two shovelers. Enough water should be added to produce a jelly-like consistency, the mortar rising to the surface when lightly rammed. The surface of the coarse concrete must be below the level of the top of the forms so as to give room for the finishing coat, or wearing surface.

If the walk or floor is laid in alternate blocks by the first method (*a*), described above, the forms around each block are left in until after the top coat or wearing surface has been placed, and has slightly stiffened, when they may be removed and the alternate blocks laid. The latter must be placed on the same day, however, to avoid difficulty in forming the surface joints between the stones. If a filler is placed between the blocks, the forms are lifted soon after the concrete of the base is laid, and before the wearing surface is spread, and the joints filled with sand or, in some cases, by a "separator" of lean mortar mixed, say, 1 part cement to 4 or 5 parts sand. Whatever the material used, it must be weaker than the concrete.

Wearing Surface. As soon as a few of the blocks of concrete base have been laid, and before they have set, the mortar for the wearing surface must be placed. This surface, as described on page 594, consists of a mixture of cement and sand, cement and fine crushed stone, or cement and a mixture of sand and stone. The materials should be very exactly proportioned, so as to give a uniform color. The cement must not be mixed with the sand long in advance of its use because the natural moisture in the sand will cake the cement. If the work is progressing so slowly that the cement must be measured by pailfuls, a determination must first be made of the number of pails of loose cement in a bag or barrel of packed cement, and the number of pails of sand in a barrel of loose sand, then the relative volumes calculated to allow for the increase in bulk of the loose over the packed cement. Each pail must be filled in exactly the same way, so that one measure will not be more densely packed than the next. The sand and cement must be mixed dry until the color is absolutely uniform, when, if coloring matter is used, it is added to this dry material. Water is added to give about the consistency employed by a mason in laying brick, so that it can be readily leveled off with a straight-edge. This mortar is carried from the mortar box to the walk in pails, and smoothed off with a straight-edge guided by the tops of the forms.

The surface is roughly floated with a plasterer's trowel, shown in Fig. 186.

soon after leveling with the straight-edge, but the final floating is not performed until the mortar has been in place from two to five hours and has partially set. The final floating is done first with a wooden float and afterwards with a metal float or plasterer's trowel. Just before the floating, a very thin layer of "dryer," consisting of dry cement and sand, mixed in proportions 1:1 or even richer, is frequently spread over the surface, but this is generally undesirable as it tends to make a glassy walk.

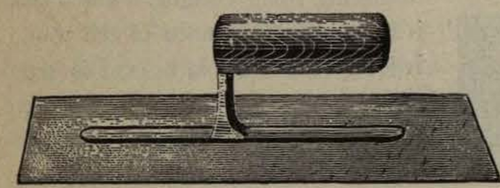

FIG. 186.—Plasterer's Trowel, or Metal Float. (*See p.*600.)

The surface is now ready to groove, for by this time the intermediate stones should be in place. As has been stated, the cross joints are in line with notches in the outside forms. The mason can thus locate the joints between the blocks of base concrete. To find the line exactly, he runs his small pointing-trowel down through the upper layer, and feels for the joint below. With the ends of the joints thus marked, he lays a straight-edge flat across the walk against these marks, and, walking across on the straight-edge, marks the line and also cuts through the partially set mortar and concrete by running his small pointing-trowel to the full length of the blade. Moving the straight-edge back a fraction of an inch, he runs his groover (see Fig. 187) along the line cut by the trowel, using the straight-edge for a rule. Both edges of the walk are rounded off by the edging trowel (see Fig. 188), which is a small float with one of its edges curved. The entire surface is finally gone over once more with the metal float to erase any marks or scratches which may have been made. A dot roller (see Fig. 189) or grooved roller may be employed to relieve the smoothness.

FIG. 187.—Groover. (*See p.*601.)

The exact time at which the surface should be floated depends upon the setting of the cement, and must be determined by the mason. Considerable skill is required in this troweling to prevent the formation of hair cracks by over-troweling, and to insure a surface which will not wear rough as a result of insufficient troweling.

If the walk is exposed to the hot sun it may be necessary to cover it with a wood or canvas frame, or with moist sand, for several days after its completion, as it is absolutely necessary that it shall not dry out too quickly

Effect of Frost upon New Concrete Sidewalks. If concrete sidewalks are exposed to frost before thoroughly hard and dry, the surface is likely to blister and scale off in patches about $\frac{1}{16}$ inch thick. It is best, therefore, to avoid sidewalk construction in freezing weather.

Concrete Curbing. Concrete curbing for artificial sidewalks is largely displacing stone curbing. The curb is built just in advance of the walk. It is divided into blocks and is separated from the walk by joints similar to the joints between the blocks. The soil is excavated, and a foundation of porous materials of the same thickness as that employed under the walk proper is placed and rammed. In Boston* a layer of ordinary concrete 12 inches wide and 8 inches deep is placed upon this foundation to underlie the curb. The curb proper is 12 inches deep and 8 inches wide at the bottom, tapering on the outside to a width of 7 inches at the top, with its inside face vertical. At least one inch of the face and of the surface consists of mortar or granolithic, like the wearing surface of the walk. A typical sidewalk and curb is shown in Fig. 190. The back of the curb is formed against a temporary plank. For the face mold, a 12-inch planed plank is set on edge to the proper batter and may be held in place by driving stakes about 4 inches out from it, and nailing strips from the top of these stakes to the top edge of the plank, so that they can be knocked up and the plank loosened without disturbing the face of the curb. When ready to place the concrete for the curb, which should be laid before the layer of concrete underlying it has set, a 1-inch board is placed on edge just inside of the 12-inch plank, with occasional thin strips or wedges between it and the plank. The coarse concrete of the curb is then placed back of this board, and thoroughly rammed so that its surface is one inch

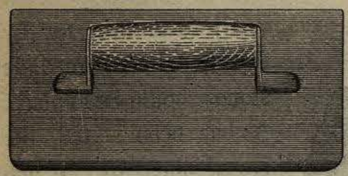

FIG. 188.—Edging Trowel. (*See p.* 601.)

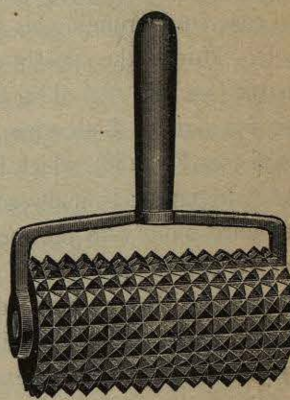

FIG. 189.—Dot Roller. (*See p.* 601.)

*Specifications for 1899.

below the top of the forms, and when sufficiently hard, the 1-inch board is drawn up from the face, and with the aid of a trowel its place is filled with wearing surface material. The outside form is generally allowed to remain over night, and in the morning the outside surface is floated. A ruled joint like that between the blocks is formed between the curb and the remainder of the walk.

A metal corner is sometimes laid in the exposed edge of the curb to protect it from wear.

Combined Curb and Gutter. One of the advantages of a concrete walk lies in the ease with which it is adapted to special construction. A gutter 5 or 6 inches thick, with a pitch corresponding to the crown of the street, is often laid in combination with the curb. It is underlaid with a porous

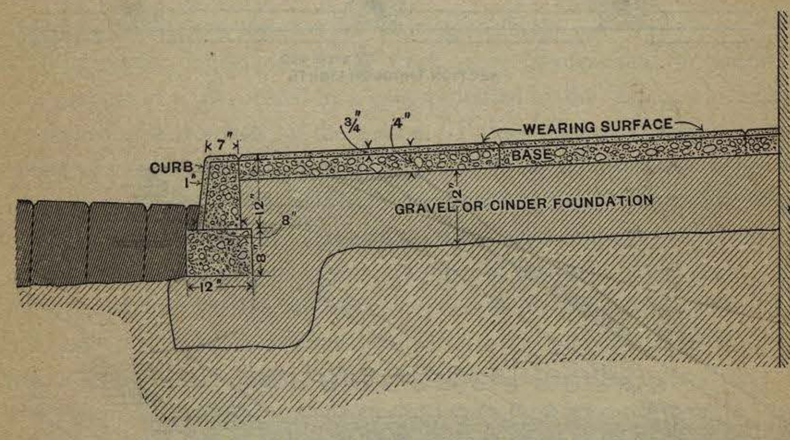

FIG. 190.—Typical Concrete Sidewalk and Curb. (*See p.* 602.)

foundation, and in some cases by a sub-soil tile drain. The blocks forming the combined gutter and curb are made about 6 feet in length, and are in alternate sections so as to form definite cross joints, but each section of the curb and gutter must be built together, with no longitudinal joint between them.

Vault Light Construction. Sidewalk lights over basement areas or subways are formed of circular lights of plate glass, set in reinforced concrete slabs, supported by steel or reinforced concrete beams. Steel rods about $\frac{3}{16}$ inch diameter are interlaced in both directions between all of the rows of glass discs. The width of the slab between beams is governed by the thickness of the slab, a customary width being 3 to 4 feet. The dimensions of the beams and girders, whether of steel or reinforced concrete, depend upon their loading and span. (See table, p. 508.) A typical vault light construction supported by steel girders and stiffened by concrete ribs as designed by Mr. Ross F. Tucker, is illustrated in Fig. 191.

If concrete beams or stiffeners are used, they must be laid at the same time as the slabs are placed, so as to be in the same piece with them, but contraction joints must be provided as shown. In laying the slabs, the position of the glass discs may be located by an iron plate with holes of the size of the glass discs. On top of this iron form, a layer of oiled paper is

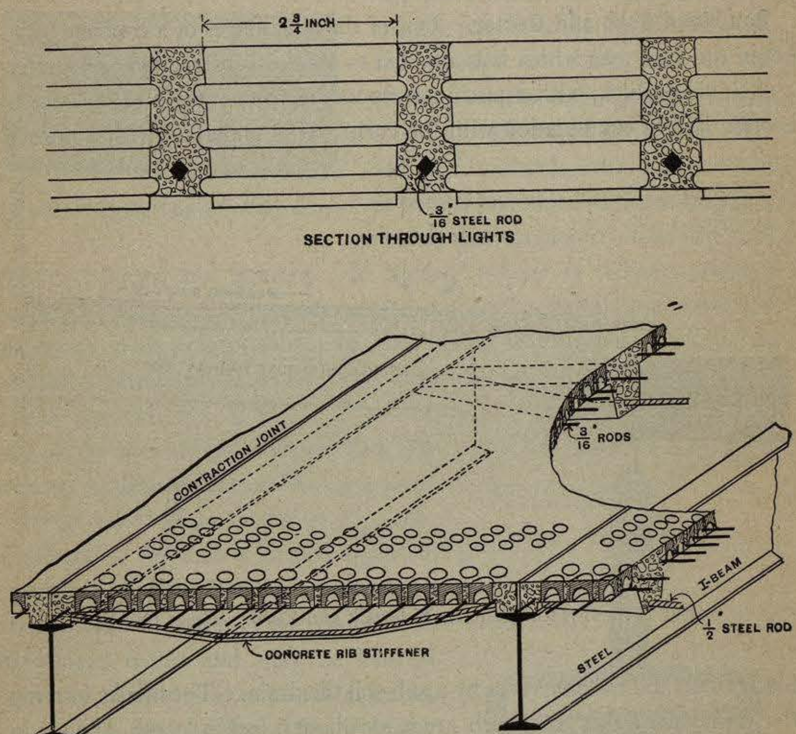

FIG. 191.—Typical Vault Light Construction. (*See p.* 602.)

spread to prevent the cement sticking to it, the lenses are set upon the paper over the holes, the reinforcing rods placed, and the mortar poured around the glass, and its surface troweled after partially setting, same as the surface of a granolithic walk. After the mortar has become thoroughly hard, the metal plate and the paper may be removed.

COST AND TIME OF SIDEWALK CONSTRUCTION

The cost of concrete sidewalk or basement floor construction is extremely variable. The job at any one location is likely to be small, not occupying

more than a few days, so that the time and expense of transporting men and materials, and the time getting started upon the work, constitute an important item. The skill of the men employed in placing and finishing the concrete affects the cost still more, since an experienced gang may easily lay three times as much surface of walk in a day as inexperienced men, even if the latter are accustomed to ordinary concrete work. Excavation is another variable item, depending upon the quantity of earth to be removed and the character of the material.

A gang of convenient size consists of —

One mason.

One man to assist the mason in placing forms, and to level and ram the concrete.

Three men mixing and placing coarse concrete for base.

One man mixing top dressing for wearing surface.

If excavation is included in the work, more laborers may be needed. The amount of walk covered by a gang is limited by the surface which can be floated and troweled by the mason. Unless he works overtime, the laying of concrete must stop about the middle of the afternoon in order that the wearing surface may have opportunity to set. Meanwhile, the concrete gang may prepare and ram the foundation and get everything in readiness to begin concreting promptly the next morning. With a gang of the size suggested a foreman adds considerable to the expense, and it is often advantageous to so arrange the work as to make the mason responsible for its quantity and quality. A bonus paid for an excess over a certain area of surface covered is an effective incentive for a good day's work. In order to properly fix such a bonus the employer must know the relative times required for plain sidewalk and curb. The size of the blocks must also be considered, since the labor upon the joints forms a prominent division of the work.

Under average conditions a mason skilled in this class of work should float and trowel a surface of 600 to 700 square feet in eight hours, if no allowance is made for time which is necessarily lost between jobs and in commencing work. This lost time will lower the average by an amount varying with the size of the job. If the excavation is ready, five men working with the mason should prepare the foundation and place the base concrete and the mortar for the wearing surface for a walk 4 to 4½ inches thick. For a thicker walk, one more man may be required in the gang to keep up with the mason, since a thick walk requires more concrete or mortar.

The contract price for a granolithic or artificial walk from 4 to 5 inches in thickness, with Portland cement at about $2.00 per barrel, varies from $0.22 to $0.30 per square foot. The cost of curbing runs about $0.75 to $1.00 per linear foot without a metal strip, and 25 to 50 cents higher with it.

DRIVEWAYS

For driveways the concrete is laid similarly to that in sidewalk construction. The total thickness may be 5 inches for light travel, or 6 to 7 inches for heavy teaming. Grooving the surface in 6-inch squares affords foothold for the horses.

CONCRETE STREET PAVEMENTS

Concrete pavements in alley ways, constructed like sidewalks except marked off into small blocks, have been in successful use in Boston and elsewhere, since 1894. In 1896 a street pavement built in Richmond, Ind., by Mr. H. L. Weber, proved so successful that many other concrete pavements have been laid there, and the use has been extended to other cities. Results have been satisfactory where traffic is not too heavy, and where the very best of materials and workmanship have been employed.

The construction of concrete street pavements is similar to sidewalk construction but even greater care must be used to be sure that it is monolithic from top to bottom so that there can be no separation of layers. Unless the soil is very porous so as to drain off the water and at the same time form a non-compressible foundation, a porous material like broken stone or screened gravel thoroughly compacted and rolled should be laid for a depth of about 5 to 6 inches. Sometimes a 6-inch concrete foundation is also advisable. After laying the foundation a concrete base 4 inches to 6 inches thick is laid in proportions of about 1 : 2½ : 5 and the wearing surface must be placed at the same time or immediately following it so as to make one solid layer. The construction of the wearing surface is the most critical part of the work, for upon it depends the durability of the pavement. The best aggregate is crushed granite or trap or a mixture of this and sand. It must be free from dust and a considerable proportion of it should be as large as ¼ in. in size. Instead of using 1 : 1½ or 1 : 2 mortar, it is still better to form a true concrete, using proportions of about one part cement to one and one-half parts sand to two parts of crushed screenings. This is laid wet and may be troweled and divided into small blocks, or may be given a rough finish to afford a good foothold for horses. Expansion joints should be made along the curbs and across the street about every 30 feet apart.

CHAPTER XXIV

CONCRETE BUILDING CONSTRUCTION

The rapid development of the use of concrete both in the United States and Europe is the best evidence of its adaptability for a building material. This is exemplified in numerous structures which, not only from an engineering standpoint but architecturally as well, are models of the builder's art.

In work above ground, concrete is most extensively employed in the building of floors and roofs. Its especial availability for this class of construction has been made possible by the introduction of numerous systems of metal reinforcement, the application of which has resulted in the reduction of the thickness and brittleness of the slabs.

The fire-resisting qualities of Portland cement concrete when composed of first-class materials, such as sand, and gravel, hard broken stone, or cinders, appear both from experimental and actual fire tests to be equal or superior to those by any other material. (See Chapter XVIII, p. 327.) Moreover, its strength and permanence, when it is carefully laid and properly reinforced, are unquestioned, and by employing a wet mixture the mortar in the concrete surrounds and effectually prevents the corrosion of the metal with which it is reinforced.

Its fire-resisting quality has led to the adoption of reinforced concrete for stairways, for columns and girders, and finally for entire buildings. The growing confidence in its utility for office buildings seems to promise for it successful competition with steel fireproof construction and a wide use in this class of structures. The cost of the reinforced concrete for an office building built of this material in 1904, based on actual construction records, with cement at $2.00 per barrel delivered on the work, was about 20% less than the estimated cost of the steel and tile of ordinary fireproof construction. As the concrete portion constituted about one-fifth of the total cost of the building, the net saving is reduced to about 4%, a very considerable sum, however, when figured on a fifteen-story office building. There is also an additional saving in other materials due to the reduction in height of the building because of the thin concrete floors, and to the fewer coats of plaster, with omission of furring, on walls and ceilings.

The Ingalls Building, designed by the Ferro-Concrete Construction Company and erected in Cincinnati, O., in 1903, was the first notable