CHAPTER XXIX

MISCELLANEOUS STRUCTURES.

The more important structures are treated with considerable detail in preceding chapters. The uses of concrete and reinforced concrete are now so numerous and are increasing so rapidly that only brief reference can be made to a few of the smaller and of the less common structures.

In railroad work, not only for the more important structures like piers, abutments and arches, but for the numberless smaller details like telegraph poles, ties, bumping posts, and signal posts, is reinforced concrete being employed. Roundhouses, stations and terminal warehouses are being designed either exclusively or in part of this material.

In power development, not only the dams are of concrete, but the canals, penstocks, flumes, and the power stations themselves.

In water-works construction the use of concrete has extended to reservoirs, filter basins, tanks and conduits, and, in some of the recent works, concrete with its imbedded steel for reinforcement is almost the only structural material.

Even the farmer and the householder are utilizing concrete in various ways for barns, garages, chicken houses, floors, fences, silos, tanks, troughs, drains and many other of the small details which make for economy, durability and convenience. By mixing and placing the concrete according to the directions laid down in Chapter II and using sufficient reinforcement (in some cases ordinary fence wire is suitable), many an inexperienced man has built permanent structures of pleasing appearance. For reinforced concrete work such as floors, roofs and stairs, an engineer should be called upon to design the dimensions and reinforcement.

Telegraph Poles. Wooden poles are being replaced in many localities by poles of reinforced concrete because of their greater durability. The Pennsylvania lines west of Pittsburg* have installed poles from 20 to 28 feet high, 8 inches square at the bottom, tapering to 6 inches square at the top, with corners chamfered 2 inches. Holes are left in the pole for the brace and cross-arm bolts and also for the climber steps. The reinforcement may be greatest at the bottom and reduced above to allow for the lessening stress.

* Concrete Engineering, July 1908, p. 189.

In 1907 Mr. Robert A. Cummings* made comparative tests of reinforced concrete and white cedar poles. The former were 13 inches square at the butt and 7 inches at the top, reinforced to withstand the weight of 50 wires all coated with ice to a diameter of one inch. These were stronger than the wooden poles of substantially the same size. After breaking, the ends of the concrete poles were held in a slightly inclined position by the reinforcement, while the wooden poles broke square off and fell to the ground.

Ties. Concrete ties of varied designs† have proved satisfactory for slow speed traffic, especially in yards and on turnouts. They also have been used to a certain extent on high speed track. One of the most important features is the connection with the rail which is generally made through a cushion block of wood. If the tie supports both rails, it must be reinforced in the center at the top to resist the negative bending moment. The ends of the ties should also be well reinforced to prevent breakage in case of derailment.

Road Beds. For tunnels, concrete roadbeds have been found economical because of the very great saving in maintenance expense.

Roundhouses. Reinforced concrete affords a durable and inflammable material for the structural portions and the roofs of roundhouses, while the walls may be built either of concrete or of brick.

Cinder and Ash Pits. Concrete will stand as high temperature as will be given to it by hot ashes and cinders.

Grain Elevators. By building of reinforced concrete the danger from fire is avoided as well as the necessity for constant repairs.

Coal Pockets. For coal storage the strength and fireproofness of reinforced concrete is bringing about its general adoption.

Boiler Settings. Reinforced concrete boiler settings have been in successful use in several plants for a number of years. The initial cost is probably not less than brick but greater durability and freedom from repairs is claimed by the users of concrete settings.

Double walls are required with an air space between. The inner wall may be about 5 inches thick and the outer about 6 inches, both thoroughly reinforced to prevent as far as possible the development of cracks. Bars ⅜-inch diameter, spaced 6 inches apart both ways, afford effective reinforcement. The walls may be tied together at intervals with bars. The reinforcement permits building the setting to any shape over the boiler, although wherever it comes in contact with the boiler, a 3-inch layer of mineral wool should be introduced to allow for variation in expansion.

* *Cement Age*, Aug. 1907, p. 84.

† *Concrete Review*, 1908, published by the Association of American Portland Cement Manufacturers.

A fire-brick lining must be used. A thickness of 8 or 9 inches is more economical than a $4\frac{1}{2}$-inch lining because it can be replaced without disturbing the concrete. Spaces must be left at the ends of the fire-brick lining to allow for expansion.

The concrete should be as rich as 1 : 2 :4 and the best aggregates are quartz sand and trap rock about $\frac{3}{4}$ inch maximum size. For high temperatures gravel and limestone aggregates should be avoided. Cinders of first-class quality should make durable walls when mixed with sand and cement in rich proportions.

Fences. Fences have been built of solid concrete, of mortar plastered on wire lath, of concrete rails set in concrete posts, and of concrete posts with galvanized fence wire between them. The last plan is the most common. For farm or division fences the length of posts may be 7 feet, allowing 3 feet of this to set into the ground, and the size may be 5 or 6 inches square at the bottom and 4 or 5 inches square at the top with $\frac{1}{4}$-inch rods in each corner. Forms are easily made singly or so as to mold several posts at once.

Silos. Silos of solid monolithic concrete built in circular forms may have walls 6 inches thick reinforced with $\frac{1}{2}$-inch bars bent to circles and placed 12 inches apart. Occasional vertical bars are also necessary. The concrete must be mixed wet and placed very carefully so as to give a perfectly smooth interior surface, so solid and dense that the ensilage will not be dried out next to the wall.

Greenhouses. Greenhouses themselves, as well as the floors, tables, water troughs, hotbeds, and minor appurtenances, are being built of concrete. The directions throughout the various chapters in this treatise for structures of different classes will be found to apply to these details.

House Chimneys. Chimneys for residences may be of concrete if heavily reinforced, but the expense of forms usually will make them more costly than brick.

Chimney caps of concrete should be well reinforced to prevent cracking.

Residences. Residences are built of solid reinforced concrete; concrete blocks (see p. 629); concrete tile, plastered (see p. 629); and mortar plastered on metal lath (see p. 627).

Solid or monolithic concrete is especially adapted to fine residences and permits unique architectural treatment. Eventually with the development and consequent reduction in cost of form construction, reinforced concrete may be more generally employed for dwellings of small and moderate size.

CHAPTER XXX

CEMENT MANUFACTURE

This chapter contains a short historical sketch followed by a brief outline of the processes of modern cement manufacture, illustrated with views of typical machinery.

HISTORICAL

Lime must have been used by the Egyptians thousands of years before Christ, as the stones in the pyramids apparently were laid in mortar of common lime and sand. It is even thought by some that these ancients understood the principle of mixing lime and clay together to make a real cement.

Concrete was made by the Romans as early as several centuries before Christ. For most of their work, they used lime mixed with sand and stone, but understanding the value of puzzolana or volcanic ashes to render lime hydraulic, they employed these two materials in combination with the sand and stone for marine construction. For less important work, they often mixed lime and coarsely powdered brick with the aggregate. Vitruvius, writing in the first century, describes methods of making concrete with lime alone, and also gives as the formula for making it of slaked lime and Italian puzzolana:

12 parts of puzzolana, well pulverized.
6 parts of quartz sand, well washed.
9 parts of rich lime, recently slaked; to which is added
6 parts or fragments of broken stone, porous and angular, when intended for a "pise" or a filling in.

In the Middle Ages concrete was employed, after the Roman fashion, for both walls and foundations. In the former it was generally laid as a core faced with stone masonry. Large stones were often imbedded in the mass.

The fact that clay contained in certain limes rendered them hydraulic was discovered by John Smeaton, when studying the designs for the third Eddystone Lighthouse, about 1750. Early in the following century, Vicat, by his extended scientific researches in France, earned for himself the name of the founder of hydraulic chemistry.