

they gave him enough food to last the party for three meals.

Meanwhile Col. Harding, with the assistance of his medicine chest, posed as a quack. He announced that he was prepared to prescribe for any who were sick, and the astonished natives soon produced a vast number of the afflicted. Many were suffering from only petty complaints and his cures of their ailments earned him the gratitude of the village, so that food was soon obtained in abundance.

In this manner the expedition pushed forward, and at last, after weeks of suffering, hardships, and the surmounting of innumerable difficulties they gained their goal—the source of the Zambesi River. It rises in a number of springs in the interior of Barotseland, in the midst of a jungle. The trees are most luxuriant and are interlaced with thick creepers. The soil is unusually fertile, the bracken, plants, and fungi thriving in the shady hollow in abundance. The head of the river was thoroughly surveyed and considerable scientific and topographical data was secured. The expedition then retraced their steps, completing their survey and mapping out the numerous tributaries between the source and the Victoria Falls, as well as the Kaapenda or Makes Rapids.

#### MANUFACTURE AND USE OF CONCRETE PILES.\*

By HENRY LONGCOPE.

ALL of us have frequently seen piling used in many ways, and if my own experience is a criterion few of us have ever given this matter serious consideration and have taken the whole subject as a matter of course; but when we go into closer investigation we find that piling has an ancient and honorable history, beginning with the prehistoric race of Lake Dwellers, who at one time inhabited one portion of Europe, and traces of their ancient foundations have been discovered from time to time, showing that the pile played an important part in their social economy. It is probable they drove their piles with crude instruments, some distance from the shore, in order to protect themselves from land attacks by their enemies. Through the natural course of evolution, the crude idea was perfected by engineers, who saw that wooden piles were subject to decay and the attacks of the teredo worm, and as a consequence sought a material that was more substantial.

The first innovation was the sand pile, produced by driving a wooden form in the ground and withdrawing the same, the hole being filled with moist sand well rammed. The next method adopted was to drive a metal form into the ground and after withdrawal to fill the hole with concrete; but this was not successful, as it was open to the serious objection that on withdrawing the form the ground would collapse before the concrete could be inserted. Still another method was introduced, which consisted of dropping a cone-shaped piece of metal, weight five tons, a number of times from a considerable height, in order to form a hole, which was afterward filled with concrete. This method never passed the experimental stage. Later a plan was devised to mold a pile, using concrete, reinforcement sometimes also being used. This pile was allowed to stand until perfectly hard, when it was driven in a similar manner as now in vogue. To prevent the concrete pile from injury, a drive-head or cap was so arranged as to deaden the force of the hammer blow. Gilbreth uses a molded taper pile, cast with a core hole the entire length of the pile, which is jetted down by a water jet and finally settled by hammer blows. Still another method is used by Raymond. Under this system piles are usually put in by either of two methods, the jetting method or the pile core method. The water jet system is used only where the material penetrated is sand, quicksand, or soft material that will dissolve and flow up inside the pile when the water is forced through the pipe, thus causing the shell to settle until it comes in contact with the next shell, and so on until the desired depth has been reached. The shells are filled with concrete simultaneously with the sinking process, and when necessary spreaders are attached to keep the hole in perfect line with the pipe. The ½-inch pipe is left in the center of the pile and gives it greatly increased lateral strength. If desired, the lateral strength may be further increased by inserting rods near the outer surface of the concrete. By this method, piles of any size up to two feet in diameter at the bottom and four feet at the top can be put through any depth of water and to a suitable penetration in sand or silt (water sediment).

The pile-core method is the one most generally used for foundation work and consists of a collapsible steel pile core, conical in shape, which is incased in a thin, tight-fitting metal shell. The core and shell are driven into the ground by means of a pile driver. The core is so constructed that when the desired depth has been reached it is collapsed and loses contact with the shell, so that it can be easily withdrawn, leaving the shell or casing in the ground, to act as a mold or form for the concrete. When the form is withdrawn, the shell or casing is filled with carefully mixed Portland cement concrete, which is thoroughly tamped during the filling process.

The simplex system uses another method in which the driving form consists of a strong steel tube, the lower end of which is fitted with powerful tooth jaws, which close together tightly, with a point capable of penetrating the soil when driven and also capable of opening automatically to the full diameter of the tube while being withdrawn. The point of the form closely

resembles the jaws of an alligator, and was so named by the colored laborers. At the same time the form is being withdrawn, the concrete is deposited. The form, as carried out in actual practice, is constructed as follows: A stock length (about 20 feet) of 15 inches outer diameter pipe ½-inch metal is reinforced at the upper end by means of a band of ½-inch boiler steel, 18 inches wide, rolled into a cylinder to fit tightly around the pipe and riveted to it by means of three rows of 1-inch rivets, 8 rivets to the row. The rivets are countersunk and have slightly oval shaped heads. This band has been found necessary to prevent the upsetting action of the hammer, and its depth, 18 inches, has been found by practice to be the minimum to prevent the buckling of the tube, although it seems well nigh impossible to construct a form which will entirely resist the repeated blows of the heavy hammer, the only solution being to build all of the apparatus of such rugged nature as to reduce the punishment to a minimum. Four large holes are bored 90 degrees apart through the band and pipe, to accommodate the 2-inch pins which connect the pulling tackle to the form.

The lower end of the pipe is riveted to a cast steel sleeve, having the same inside diameter as the pipe, but of 1½ inches thick metal, making the outside diameter 17 inches; the pipe is turned off true and fits with a driving fit into an 8-inch deep socket turned into the sleeve. Two rows of twelve 1-inch countersunk rivets with flattened heads connect the sleeve to the pipe. To this sleeve are attached two cast-steel jaws in such a manner as to permit them to swing freely. These jaws are segments of a true cylinder, the same size as the sleeve, namely, 14 inches inside diameter and 17 inches outside diameter, formed by two planes cutting in at approximately 30 degrees to the axis, and the second at right angles to the first and intersecting a little short of the axis. When brought together they form a clam shell point, absolutely tight and well adapted for penetrating the soil, but when hanging open they form a true cylinder of the full opening of the pipe. The interlocking of the jaws binds them together so that they act as one solid piece. The jaws are usually closed together and held by two small tapered pins, or a small clamp, which is destroyed during the driving and comes off when pulling the form from the ground.

The driving form consists of a stock length about 22 feet of large diameter pipe, reinforced with a band and fitted at the bottom with an alligator point. Additional lengths can be easily coupled by means of a band and rivets.

The pile driver used generally is similar to that used in driving ordinary wooden piles. A sliding purchase cap is arranged near the top of the driver and from it is suspended the pulling tackle, consisting of a quadruple steel block and a quintuple steel fall rove with a ⅝-inch plow steel wire rope, which runs over a single steel block and thence to the engine.

The hammer weighs 3,000 pounds, and the engine is any style of an approved type hoisting engine.

On the top of the driver are mounted three sheaves, the middle one for the 1½-inch hammer line and one on either side for the bucket line and the rammer line, respectively.

The pile is produced in this way: the driving form is swung up into the leads, with closed jaws; it is then lowered until it rests on the ground and has buried its nose in the soil. The pins are removed, the pressure of the soil holding the jaws together. On the top of the form is placed a steel drive-head with a tenant underneath to engage the pipe and provided on the top with an oak block to take the shock of the blow. The form is then driven to the required depth; the hammer with the drive-head attached is raised to the top of the leads, and toggled by swinging out the purchase cap carrying the pulling tackle. The fall is connected to the driving form and made ready for pulling it out of the ground. The rammer is a cylinder of cast iron 6 inches in diameter and weighs 30 pounds. This is lowered to the bottom of the form and a target is fastened in the rope flush with the top of the form. The rammer is raised half way up in the tube and a bucketful of concrete, which makes about 4 feet of pile, is hoisted in a bucket having a falling bottom, and emptied down the tube, striking the bottom with considerable impact. The rammer is lowered until it rests on the concrete, which would show the target about 4 feet above the top of the form; the form is pulled up until the target on the rammer line is 1 foot above the top of the form, which indicates that the jaws have opened and the concrete has passed through with the exception of a 1-foot head of concrete left in the form to prevent any particle of soil from getting into the concrete; the rammer is raised and let fall frequently to insure perfect ramming; then the rammer is raised half way up in the tube as before, and a second bucketful of concrete is emptied and the process is repeated until the hole has been filled and the form withdrawn.

The concrete used consists of 1 part Portland cement, 2½ sand and 5 parts broken stone, graded.

A modification of the method just described is to fill the form with the required amount of concrete, sufficient to make a complete pile, and a ramrod, which is merely a piston head with a rod fastened to it, upon which the hammer is lowered, but not struck; the form is then pulled and the hammer gradually settles, showing that the concrete is spreading out below, as the form is withdrawn, or, in other words, filling up the entire space previously occupied by the form.

In order to prevent voids another precaution is taken by furnishing the men with comparative tables,

indicating the amount of concrete which should be inside the form, in order to make the required length of finished pile. If, on raising the form, the concrete should slop over, it would show that voids existed, and therefore the personal equation would be present here, as it is in all other operations.

In certain conditions of soil, such as deep fills of rubbish, cinders, or light, loose materials, a cast-iron point, generally of a similar shape to the alligator point, is used. There is no sleeve or jaws whatever on the end of the form, there being nothing but the plain length of pipe. The cast iron pipe is located on the proper center, on the ground where the hole is to be driven, the pipe form is lowered over this point and driven to the required depth; the method of withdrawing the form and filling is exactly the same as the method before described for alligator points, except in the case of the cast iron point, which remains in the ground, as obviously it cannot be withdrawn.

It is so evident that concrete is vastly superior to wood in the construction of piles that it is almost superfluous to mention the points of superiority. Concrete is not subject to rot or the ravages of the teredo worm, neither can the piles constructed of concrete be destroyed by fire, and no cost is attached for repairs. While it is not possible to give accurate statistics as to the life of a wooden pile, as it varies so much under different conditions, yet we know that in some cases they are rendered worthless in a very few years, especially when the material which surrounds them is composed of rotted vegetation, or where the pile is exposed by the rise and fall of tides. It is also impossible to state the exact cost of a concrete pile, as it varies also according to conditions. Ordinarily speaking, a concrete pile will cost from one and one-half times to two times as much as a wooden pile; but in order to illustrate where a saving can be made, the following extract from a letter to the Raymond Concrete Pile Company, under date of May 24, 1905, relative to the piles which they drove at the United States Naval Academy at Annapolis, Md., is given, viz.:

"The original plans called for 3,200 wooden piles cut off below low water with a capping of concrete. To get down to the low water level required sheet piling, shoring and pumping, and the excavating of nearly 5,000 cubic yards of earth. By substituting your concrete piles, the work was reduced to driving 850 concrete piles, excavating 1,000 cubic yards of earth and placing of 1,000 cubic yards of concrete."

In the work mentioned, the first estimate for wooden piles placed the cost at \$9.50 each, while the estimate for concrete piles was placed afterward at \$20 each, yet the estimate based on the use of wood piles aggregated \$52,840, while the estimate based on the use of concrete piles was \$25,403, or a total saving in favor of concrete of over \$27,000.

One question which arose in my mind when I first started my investigation was whether the pile when completed was one solid mass, or whether it was full of voids or soil. In several instances the piles were uncovered to their full depth, and they were found to be perfectly sound in every particular. By surrounding the operation with the safeguards provided, it is almost impossible to make a faulty pile. The concrete is made as wet as good practice will allow. Constant ramming and dropping the concrete from a considerable height tend to the assurance of a solid mass, then the target on the ramming line or the introduction of an electric light into the form shows what is being done at the bottom of the form.

#### ARTIFICIAL GEMS.

THE production of artificial gems has been a favorite pursuit of many intelligent chemists and physicists since the most ancient times. The great material value of precious stones was always an incentive to the imitation of these, but practice remained far behind theory, and few positive results were obtained. Now, as reported in the Paris papers, certain French chemists have at last succeeded in discovering a new and more practical method of manufacturing artificial gems, particularly rubies. We are familiar with the epoch-making analyses and experiments of Moissan, and his artificial diamonds; but the tiny crystals produced in the electric furnace, from coal, are so small that they are of no practical use, and jewelers as well as goldsmiths agree that their actual value is null. In addition to this, the cost of production is so great that the experiment is seldom made, and when undertaken is more for scientific than for practical purposes. The case is different with artificial rubies, and the "Geneva rubies," so called, have attained general popularity. The makers have endeavored to keep the process of their manufacture a strict secret, but not with entire success. We are told that in the "machine" constructed by a Parisian chemist for manufacturing artificial rubies, there is a blow pipe, similar to a glass-blower's pipe, and a heating pipe. Into the latter are sifted finely pulverized alumina and chromium oxides, alternately, to form a deposit in strata, and in the shape of a pointed sugar-loaf. This formation makes gradual heating possible, the mass takes a spherical form, and on hardening, the crystalline character of the ruby appears. Great care is taken to let it cool slowly, in order that the formation of the crystals shall be regular and the stones clear. With this quite simple apparatus three or four rubies are made at a time, and they can be distinguished from natural, mechanically-cut rubies only by skilled experts. They often weigh from 13 to 16 carats, and have a cross section of 6 or 7 millimeters. The greatest care is needed to prevent the formation of bubbles.—Edelmetall Industrie.

\* Paper read before the Cement Users' Association.