front of which is cut diamondwise; and as will be noticed in the cross-section, the two keystones are connected by a rod of iron, which does not injure the solidity of the vault. The simple and elegant profile of the arches and the piers will commend the design to all bridge builders. The piers batter to a pleasing proportion, and are faced with courses 0·20 in height, and crowned by a capping of ashlar. The abutments have this moulding carried through to the banks at the same level, thus connecting in effect the piers and the abutments.

The total cost of the bridge was 1,345,000fr. for 438 metres. Our readers will be enabled to study for themselves the details of these two excellent examples of bridges, as all the dimensions are given, and the several radii of the arches in the last described structure are indicated. We are no less charmed with the scientific distribution of material and construction than with the graceful elegance and simplicity in the lines and profiles of these two bridges. Our own London Bridge over the Thames only is comparable with these in the extreme simplicity and elegance of proportions between the opening and solids.

The two designs are instructive also as showing two distinct modes of reducing the weight on the foundations. In the first instance we see a backing of rubble masonry over the vault, the filling being of lighter material; in the latter case the weight is discharged by a small arch over the pier, and a considerable saving of solid masonry is effected. The designer of a bridge must use his own judgment as to which plan it is desirable for him to adopt. The main consideration should be the nature of the foundation or bed of the river. If this is at all doubtful, or if the formation is of a compressible soil, or if of rock full of cracks, the less weight on the foundation the better; if it is unyielding, the designer may adopt bold proportions for his openings. Perhaps no better foundation for a pier of a bridge can be found than that shown in our sections. Here we have no bearing piles supporting the pier, but a solid mass of concrete "in a shell," in the one case 5·03 m. deep and 6·40 m. wide, extending throughout the whole length of the pier. This mass of beton is supported while in the process of setting by the piles, and further protected from the scouring action of the river by stones thrown in all round.

In treating of foundations, a writer in the 9th edition of the "Encyclopædia Britannica" makes some very apt remarks, and as our purpose is now to give practical information with respect to the site and foundations of bridges, we may here refer to these observations in the course of our remarks. As regards site, the engineer must satisfy himself by borings at convenient distances. A solid rock is, of course the best if homogeneous, but if cracks are found, it cannot be relied upon, and is inferior to such formations as uniform gravel, chalk, and some kinds of sand and clay. A squeezable foundation is the worst, as it would allow of subsidence when the piers were loaded. Even more objectionable than a compressible foundation is one of unequal bearing power. When softer materials are found they should be removed, and the inequalities filled up with concrete.

Referring more particularly now to foundations under water, the action of the scour is one of the chief difficulties in the way of a lasting foundation against which the engineer has to contend. We may allude in passing to the subsidence of Waterloo bridge over the Thames as an instance of this. Little did its engineer, Rennie, think that in little more than half a century symptoms of failure of the foundations from this cause would have shown themselves. Many other bridges have failed by the gradual undermining of the piers, and we may have to say something about the action in a future article.

There are several methds adopted in the laying of foundations of bridges to which we may briefly refer. We have naturally first to speak of the system of cofferdams, and for the benefit of our younger readers we may say the cofferdam consists of a double row of sheet piles tied together by wales and cross beams inclosing a vertical wall of clay puddle. Its width is determined by the pressure or head of water, and sometimes it equals the head unless inside strutting can be adopted, from side to side of the inclosed area. The *Cours de Ponts*, as used at the school of *Ponts et Chaussées*, remarks that a cofferdam need not be made of greater thickness than from 4ft. to 6ft. The water being pumped out, the necessary excavations can then be proceeded with.

Another system of laying foundations is by making caissons: these may be of timber or wrought-iron plates bolted together in sections and sunk. One mode was by driving piles, cutting them off level at a certain depth, and then sinking a caisson or box filled with masonry on the proposed site. As the scour of the river has been found to injure this method of procedure, it has been generally abandoned. Another and preferable form of caisson is to construct it of wrought-iron plates ½in. to ⅝in. thick in circular segments or rings, bolted together so as to form sections of a manageable diameter and depth. The lower section is made with a cutting edge to penetrate the soil. These sections are sometimes sunk between guide piles, and the joints made watertight. After being sunk by their own and additional weight the ground within is excavated and the water kept down by chain and bucket or other kind of pump. Sometimes mechanical dredgers are used. Sometimes a frame is floated to the site of pier and then sunk, the inside soil is then excavated or concrete is shot within it, which sets undisturbed. These hollow timber frames without a bottom are particularly adapted for bridge pier building. They can be made watertight after being lowered, and can be used in water from 5ft. to 20ft. of depth. This mode of laying foundations will be effectual wherever a good rocky bed is found. When the frame is in position, it is allowed to remain as a protection for the concrete, and in such a case should be surrounded by a rubble embankment or "toe." The same plan has been used by the French engineers in the bridges we have described, and is called "concrete in a shell." This mode depends on the valuable property of hydraulic concrete of setting into a solid mass under water. The area of site is inclosed by piling or a shell of timber or iron. The soil inside is dredged out by a mechanical excavator until the foundation is reached, and concrete or beton is then shot or run in from a height of about 10ft. and rammed in layers. The rubble stones heaped up outside protect the shell or casing of piles against the scour of the current.—*The Building News.*

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Japanese napkins folded in the shape of fans and put in glasses at each end of the top shelf on the sideboard are light and ornamental.

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## EXPERIMENTS ON AMERICAN WOODS.

BY PROF. S. P. SHARPLES, BOSTON, MASS.

*(Read at the Boston Meeting, February, 1883.)*

Under the act providing for the taking of the Tenth Census the superintendent was authorized to appoint experts to inquire into special industries. Under this act Professor Charles S. Sargent was appointed to gather statistics in relation to the forest industries.

As chief of the Department of Forestry of the Tenth Census he has been busily engaged in this work since the Fall of 1869. Soon after his appointment he became convinced that it would be desirable to make an examination of the fuel-value of the various woods of the United States, and this work was placed in my hands.

At the same time I made the suggestion that while we had the opportunity, it would be well to test also the strength of these woods. The suggestion was adapted and Professor Sargent at once set his agents to work in various parts of the country to collect specimens of all the trees growing in their localities, employing as a rule botanists who were familiar with the flora of the region in which they were at work. The result of this work was the collection of over thirteen hundred specimens of wood, comprising over four hundred species and varieties, nearly one hundred of which had not before been described as trees existing in the United States.

The ash and specific gravity of every specimen in this collection has been determined, in most cases in duplicate. About 2,600 ash and 2,000 specific gravities have been determined, about 325 species were further tested for transverse strength and resistance to crushing. In this series about 1,800 specimens were tested. As each of these was tested in three different ways, it made in all about 3,900 tests. The specific gravity of each specimen in this last series was also determined, thus making in all about 10,600 tests that were made on the specimens. Many of these tests, however, included not only a single test, but often a series of tests that required at least ten entries on the final report, as I shall explain further in this paper.

In addition to to the tests already spoken of, 70 tests were of the carbon and hydrogen in a number of specimens.

These tests have already, so far as the results of the ash and specific gravity of the dry wood is concerned, been published in *Forestry Bulletin* No. 22. The carbon and hydrogen deter-