

length, with the larger diameter of 6 inches. These values, substituted in the equation, will give

$$y = \frac{94.5}{31.5 + x}$$

Let us take a line,  $ab$ , of  $31\frac{1}{2}$  inches in length, divided into inches. At the points of division, let us raise perpendiculars to  $ab$ , and then, in the last equation, successively make  $x = 0$ ;  $x = 1$ ;  $x = 2$  . . .  $x = 31\frac{1}{2}$ . Let us carry the corresponding values for  $y$  that result therefrom to the perpendiculars marked 0, 1, 2, 3 . . .  $31\frac{1}{2}$ ; and then, through the extremities, pass an unbroken line. This line,  $a'b'$ , will be the profile required. As it is necessary to leave a little margin to the belt, we have increased the length by one inch at each end.

This profile is to be very carefully traced upon a piece of well planed and thick sheet iron, which will serve to guide the instrument that shapes the cone in the lathe.

**Shifting of the Belt.**—We have said above that the carriage, on reaching one of the ends of its travel, abuts against an apparatus that shifts the cone belt the desired distance. We shall show the arrangement of this apparatus.

A horizontal axle,  $A$  (Fig. 7), at right angles with the direction of the frame through which it passes, carries two wheels—one of them a ratchet wheel,  $R$ , and the other a pulley,  $G$ , with a helicoidal channel. Around this pulley runs a chain, which is fixed to the vertical rod,  $T$ . Another chain fixed to this same rod passes over two small pulleys,  $p, p'$ . The pulley,  $p$ , revolves on an axle fixed to the frame, while the pulley,  $p'$ , is fixed to the interior of a weight,  $Q$ . The chain is afterward fixed to the frame at the point,  $K$ . The rod,  $T$ , is provided at each extremity with a piece,  $m$ , that slides with slight friction upon the horizontal bars,  $B$ , which are parallel with the frame. The rod,  $T$ , carries two forks,  $f, f'$ , between the branches of which runs the cone belt. Two clicks,  $C, C'$ , engage with the teeth of the ratchet wheel,  $R$ . The upper one of these acts by its own weight, and the lower one by the weight of its opposite extremity. These clicks are so arranged that when one of them engages with a tooth, the extremity of the other enters a tooth directly opposite. A vertical rod,  $s$ , carries two little tappets,  $t, t'$ , and two stationary rings,  $b, b'$ , spaced a distance apart equal to the travel of the carriage. This rod passes through a stop,  $u$ , fixed to the carriage and placed between the rings,  $b, b'$ . The figure represents the carriage at about the end of its upward travel. At this moment, the stop abuts against the upper ring, and, through the tappet,  $t$ , lifts the click,  $C$ . The tooth,  $d$ , of the ratchet wheel is thus disengaged. The weight,  $Q$ , exerting a tension on the chain, causes the belt to advance toward the left, and at the same time makes the entire system of the axle,  $A$ , revolve. But, as the wheel,  $R$ , has revolved by half a tooth, it is stopped at the tooth,  $d'$ , by the click,  $C'$ , and does not move again until the moment when the stop,  $u$ , pressing against the lower ring, disengages the tooth,  $d'$ . The extremity of the upper click is then in the center of the tooth,  $d$ . The wheel,  $R$ , then revolves by half a tooth again, allowing the belt to move forward the same distance as before, and so on at every travel. As for the number of teeth in the wheel,  $R$ , that is variable, and depends upon the displacement to be given the belt, and that in turn depends upon the size of the cord. When the bobbin is full, a wheel,  $M$ , called a Mendoza pulley, permits of moving the belt back to its initial position, in order to begin another bobbin.—*L'Industrie Textile*.

#### ACCIDENTS DUE TO THE USE OF MAGNESIAN CEMENTS IN MASONRY.

By MM. LEON DURAND-CLAYE, Chief Engineer, and DELRAY, Engineer (*Ponts et Chaussées*).

In a circular dated July 18, 1876, the Chief Administration (of *Ponts et Chaussées*) notified the engineers in chief of the Lower Loire and neighboring departments that after experiments made in the harbor of St. Nazaire, as well as in the *Ecole des Ponts et Chaussées* they felt able to authorize, in such structures as bridges, locks, quay walls, etc., in fresh water or in open air, as well as in parts of sea works that are above the high-water mark, the use of Portland cement made in a recently opened factory at Campbon (Lower Loire). On account of this circular, the Bureau of Construction of the work of building a railroad from Questembert to Ploermel accepted the Campbon Works on the same footing as the Longuey Works, at Boulogne sur Mer, or the Famelon Works, at Desvres, as regarded the furnishing of cement for building the arches, of about 14 meters span, of three skew bridges, projected for the river Oust. Because it was near the scene of operations, the Campbon factory supplied the cement used in the arches of these structures.

About the end of 1882, that is to say, one year after the beginning of work on the line from Questembert to Ploermel, movements that were quite abnormal were observed in the arches of these bridges. Fissures were produced parallel to the face; the face courses were separated from the body of the arch; the arch was divided into several parts; the coping stones of the tympanons were raised and thrown outside of and to the right of the keystone of each of the arches, and at the same time the abutments rotated above the springing of the arch.

The vibrations due to the passage of trains had only served to increase these disturbances. The fissures widened to 0.01 m. and more, and reached the piers and abutments about a year after they affected the arches. From this time the destruction of the bridges was inevitable. In spite of the presence of iron bars that had been used to bind the tympanons, the arches completely disintegrated, were weakened by their own weight, and separated from the tympanons by fissures several centimeters wide. It became necessary to support them by very resistant centers, until a final decree should order the demolition of the masonry vaults, and the substitution, as the work on the road continued, of metallic girders for masonry bridges.

The engineers who were called upon to study these phenomena attributed them to a swelling of the Portland cement used in building the arches. We give the description of the movements as detailed by Engineer Resal, in charge of the building of the new Orleans lines, in a letter of June 6, 1885, addressed to the President of the Cement Commission:

"On account of the swelling of the cement, the joints of the arch, N C, Fig. 1, enlarged as they broke, and, consequently, have increased the development of the intrados and extrados; the arch necessarily rose at the keystone, C, where a fissure, naturally larger on the extrados than on the intrados, was produced. Another was naturally produced at the springing, N, of reverse direction. In general, this fissure is small, the upper angles, O, of the springer and of the first voussoir being broken and chipped. The same fact is observable in several arches, in the horizontal joints of the intrados of the upper voussoirs, just as shown in the figure. The body, T, of the tympanon, carried by the arch, followed its movement of rotation around the point, O, which produced the following results:

1. A general break at the line of separation, O P, between the tympanon and the arch is apparent, the lower part of the tympanon not having undergone the same deformation as the arch.

2. The plinth of the bridge in the middle of each arch was driven upward. (This rise, which amounts to several centimeters, is quite visible on crossing the bridge.)

3. The joints at the summit of the arch were opened, and the central fissure of the arch extends into the tympanon.

4. In general, the tympanons show no other ruptures. Nevertheless, in some cases, the middle part between O and P showed disruption.

We have seen that the tympanon, T, has rotated around the point, O. It follows that the vertical joint, R Q, has shifted to R Q', driving back the pier, M, of the abutment, which has been forced outward. The vertical joint, S V, was naturally displaced, and took

M. Resal, engineer in charge of the work, to whom we are indebted for these particulars, observed that the appearance of the transverse elevation indicated a rupture, due to a simple enlargement of the foundation without any sinking. In effect, the transverse dimension of the pier was increased several centimeters, and the fissures were of uniform size above and below. The courses of stone had preserved their horizontality, and the joints of the plinth remained rectilinear.

Finally, the largest fissure, which was opened to an extent of four centimeters, penetrated into the quay wall.

M. Resal adds: "The movement of expansion of the foundations could not be transmitted evenly and in its entirety to the springing courses of the metallic part; the resistance of the bridge was enough to keep almost intact the mass of masonry into which the arches were rabbeted.

"A complete rupture between these springing courses and the foundation ensued. The upper portions of the structure, resting on these springers, for this reason has not suffered as much as has the foundation.

"As for the wing walls of the pier, they have only undergone a limited movement; the drawings of this part of the work show clearly that the known fissures are due to the movement of the first courses, which have dilated, as they lifted vertically the upper part of the wing walls, and pressed them a little back. The fissure followed, in effect, visibly the line of this discharging arch.

"In the right hand pier this last phenomenon alone was manifested, Campbon cement in this pier having only been used for the discharging arch, and not in the foundations.

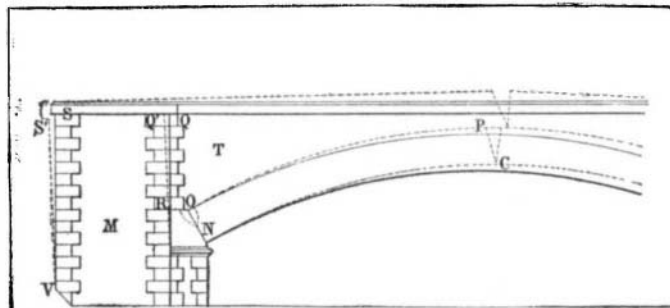


FIG. 1.—BRIDGE OVER THE OUST.

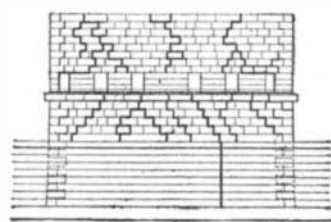


FIG. 2.—BRIDGE OVER THE ETIER DE MAUVES.  
FRONT ELEVATION OF THE LEFT PIER.

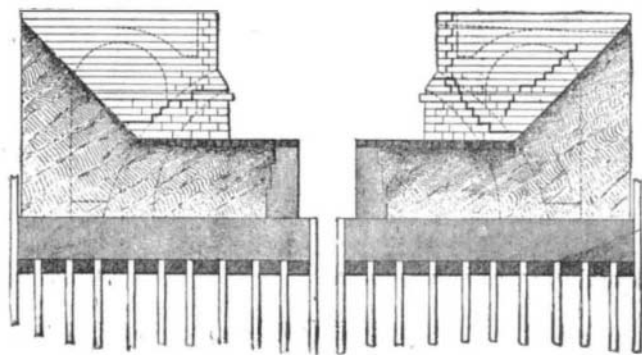


FIG. 3.—SIDE ELEVATIONS OF PIERS OF SAME.

#### ACCIDENTS DUE TO THE USE OF MAGNESIAN CEMENTS IN MASONRY.

in general a direction, S' V, parallel to R Q'. The inclination of this joint is shown in almost all the structures by the successive projection of the stones, the horizontal joints of the abutment pier having been broken; this is very easily seen. All these movements are shown only in such parts as the arch could act upon. This explains why the foundations have not suffered."

Portland cement from Campbon was also employed on the connecting line from Nantes, for a bridge of 20 meters span, with metallic arches, built over the Etier de Mauves, Figs. 2 and 3.

The metallic arches rest upon springing courses, whose mortar is made of Campbon cement. The springing courses form part of the stone abutments laid in hydraulic cement resting on piling. The ends of the stones for the left hand pier are bedded in a mass 0.50 m. thick of Campbon cement concrete; for the left hand pier in a mass of Doue hydraulic lime. These lower layers of concrete are covered with a layer 2.35 m. thick of hydraulic concrete for both right and left hand.

The masonry of the left hand pier, begun on June 1, 1882, was completed in May, 1883. That of the right hand pier, begun in September, 1882, was completed in July, 1883. The rubble work of the approaches had been finished a little earlier than this, and the metallic part was completed between October 8, 1883, and January 10, 1884.

The work seemed to behave most satisfactorily, until, in the month of April, 1884, two fissures appeared in the left hand abutment.

From this time the fissures continually multiplied and enlarged, until the month of March, 1885, when the situation was such as is represented in Figs. 2 and 3.

"The fissures in the left hand pier having apparently remained unchanged for a certain time, a very liquid grouting of cement of proper quality was injected therein. At first this operation seemed to produce good results, and for nearly a month the face of the abutment remained intact; then all the joints reopened, and the overturning movement went on as before, although with less intensity.

"In the month of October, 1885, the right hand pier presented the same appearance as it did at the beginning of the year, and before the injections. Only, if the number of fissures was almost the same, their average width was only one half as great. Finally, a concluding visit, made during the month of January last, showed that the fissures, closed by new injections, had only opened an insignificant amount, about a half millimeter in three months, and, under these conditions, it was decided to throw open the bridge to travel.

"The phenomena observed in the masonry of the Etier de Mauves bridge can unhesitatingly be attributed to the use of Campbon cement. The hypothesis of a movement in the foundation piles must be abandoned, as it is proved that there was not—in the right hand abutment—any vertical sinking or horizontal displacement in any direction whatever, nor any angular movement around an axis of rotation. Moreover, the piles had been driven until they were immovable."

We have also collected numerous examples of analogous accidents produced in other works of art or in constructions of civil engineering, due to the use of Campbon cement.

Without speaking of inclosure walls completely wrecked by a pointing on one face of Campbon cement; of tombstones in the cemetery of St. Nazaire, joined

