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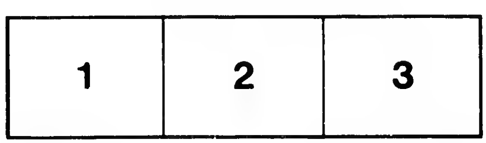

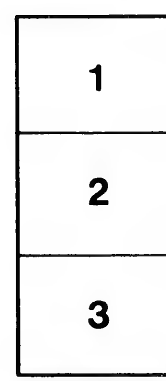

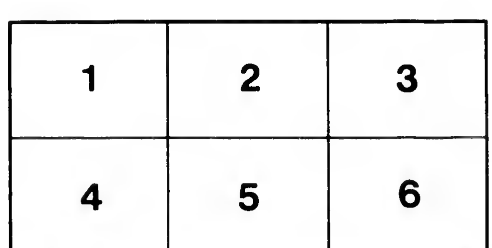

DAWSON

ON

THE PAROY RESERVOIR.

THE

PAROY RESERVOIR.

BY

WILLIAM BELL DAWSON, M.A.,

Assoc. M. Inst. C.E.

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THE INSTITUTION OF CIVIL ENGINEERS.

SECT. II.—OTHER SELECTED PAPERS.

(*Paper No. 1767.*)

"The Paroy Reservoir."

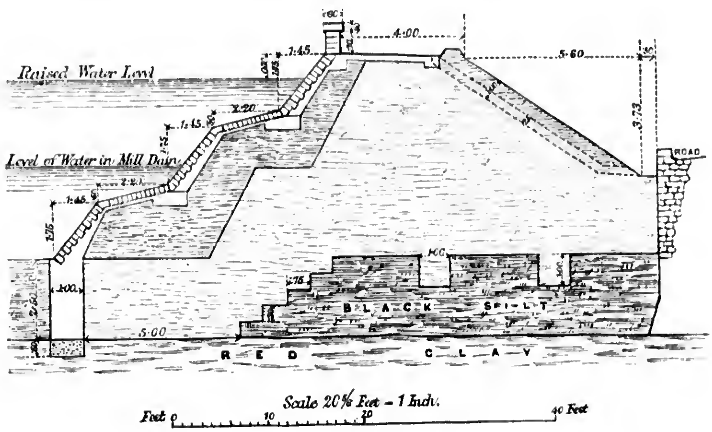
By WILLIAM BELL DAWSON, M.A., Assoc. M. Inst. C.E.

THE Marne-Rhine canal, which connects Paris with Strassburg, has two summits on its course; one where it passes from the head-waters of the Marne to the valley of the Moselle, the other in crossing the Vosges mountains before descending towards the valley of the Rhine. The latter is lower and wider than the other, and the summit-reach is rather more than 18 miles in length. This reach derives its supply from the head-waters of the Sarre, and from the Gondrexange pond, through which it passes, and of which the level has been raised to increase its capacity. From the summit-reach water is drawn off for the supply of the canal on both slopes, and also for a length of 12 miles on a branch from this point northward, through the coalfields of the valley of the Sarre. On the slope towards the Moselle the head-water has to do duty as far as the Réchicourt pond, of which the capacity has also been artificially increased, to afford storage for any surplus from the Gondrexange pond that may reach it along the canal, in addition to the rainfall of its own basin. Its capacity is 880,000,000 gallons, and it has to furnish the water necessary for the working of the canal as far as Dombasle, a length of about 24 miles. From this point an ample supply is derived from the Meurthe, a tributary of the Moselle, near to which the canal runs for a considerable distance.

The supply on this part of the canal was never more than barely sufficient, and a scheme had been elaborated some twelve years ago for supplementing it. The events of 1870–71 made a fundamental change in the data of the problem, as the position of the new frontier cut off from France the summit-reach of the Vosges, together with the Gondrexange and Réchicourt ponds, and upon these the supply of the slope towards the Moselle depended, of which the greater part still remained in France. By the International Convention of May 1873 however, Germany agreed to furnish sufficient water to maintain the depth of 5 feet 3 inches, which the canal had at that time. Subsequently, the French Government decided, by the Decree of the 8th of November, 1877, to increase the depth of water to 6 feet 6 inches; to carry this into effect an additional quantity of water had to be obtained. From an examination of the country, it was evident that no streams of importance could be made available as a source of supply, and that the best means of securing it would be by the construction of a reservoir which should depend entirely upon the rainfall on its own basin. This solution had the additional advantage of being independent of the political relations with a neighbouring country. It was not difficult to obtain the site for such a reservoir. At 4½ miles from the frontier, close to the canal, there was a mill-pond of considerable extent, situated in a valley consisting entirely of clay and marl, and whose sides sloped up uniformly to a considerable height. The east side of the valley, which is rather steeper than the other, consists of variegated marls lying almost horizontally. The lime in these marls has separated from the general mass, and occurs as thin layers of calcite, 2 or 3 inches in thickness, leaving between them beds of red, blue, and grey clay, of a consistency not affected by contact with standing water, and sufficiently compact and tenacious to form a good foundation for masonry structures. On the west side of the valley there is a heavy bed of rather soft red clay, which crumbles into flakes when exposed to the air. In the central part of the valley a deposit of black silt, 25 or 30 feet thick, occurs in the middle, thinning off towards the sides. This silt is soft and compressible at the surface, but firmer below. On exposure to the air it becomes as tough as brick clay, and shrinks into little cubes as it dries. These are homogeneous and fine-grained, and while moist are somewhat greasy.

The mill-pond that existed here was retained by an embankment of earth, which also served to carry across the valley the road from Dombasle to Sarrebourg. The level of the water was 4 feet 5 inches above that of the surface of the canal opposite. This level could be raised only 9 feet, otherwise the village of Bures, at the upper end of the valley, would be inundated. The volume contained between the level of the water in the reach opposite and this new level was found to be 350,000,000 gallons. The first point to be determined was, therefore, whether a reservoir with this available capacity would be sufficient to store the rainfall of its own basin, and meet the demand on the length of canal which it would be required to supply. No direct observations of a satisfactory character were available; but as the conditions of the Gondrexange pond had been studied for fourteen years, a comparison with it was thought admissible, as it is distant only 15 miles. The rainfall and evaporation, respectively, were assumed to be equal at the two places, and the differences in the nature and character of the two basins were taken into account. The volume of water required for the supply of the canal being known, the problem presented no special difficulty. Tables were drawn up of the receipts and expenditure of the reservoir as they would have been during the fourteen years. From these it appeared that, during the driest season, there would have been one week (in the month of November, 1858), when the available quantity would have fallen to 3,000,000 gallons, after which the reservoir would have been replenished by the winter rains. This result was considered satisfactory, and as affording sufficient guarantee for the future.

Fig. 1.



Cross Section of the Embankment.

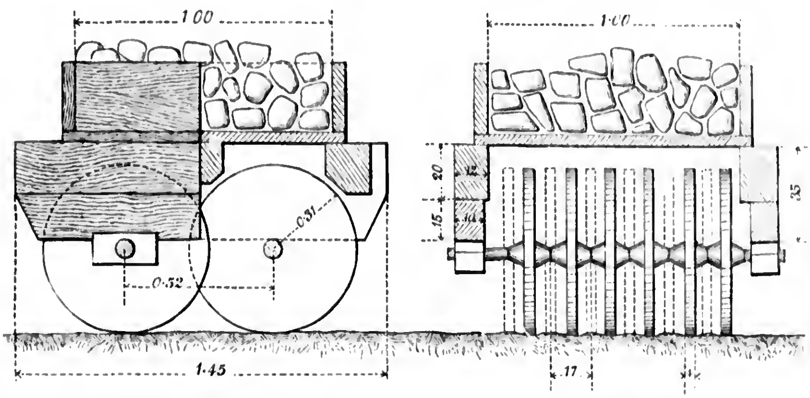
A suitable position for the retaining dam was indicated by the bank of the mill-pond. It was thought better to place the new dam in front of the old one rather than to modify the profile and height of the existing bank, to avoid the reconstruction of the roadway on its summit, and the interruption to the traffic which would necessarily result. The incorporation of a mass of earthwork of uncertain quality in the body of the new work was also obviated, and a much larger base was secured to the dam without additional expense. The profile of the dam (Fig. 1) is one which had been adopted before at the reservoirs of Montaubry and Mittersheim. The earthwork is stepped on the water side and faced with masonry, so designed that if any settlement does occur in the earthwork, it can only cause the angles between the successive steps to become slightly more obtuse, without producing cracks in the masonry. The earthwork on the water side is thus enabled to stand at an average slope of about 1½ to 1, which reduces the length of the slope to nearly one-half of what it would be at the ordinary inclination of 3 to 1. This again allows a layer of puddle of sufficient thickness to be placed on the water slope, as the reduction in its length brings down the volume of the puddle to an admissible quantity. It is protected by the masonry, and is in a position to perform its duty much more certainly and effectively than if placed in the centre of the dam as a puddle wall. It can also be carried down as far as necessary in a trench along the toe of the slope. The cost of the masonry facing is counterbalanced to some extent by a corresponding saving in the volume of the earthwork, and this becomes greater in proportion as the dam is of greater height. The crest of the dam rises 2 feet 3 inches above the water level.

To take advantage of the good foundation on the east side of the valley, the waste weir and outlet works were combined into one structure. According to observation the maximum storm rainfall amounts to 40,000 gallons per minute for the basin. The length of the overflow was calculated so that this quantity of water entering the reservoir for a period of thirty-six hours would not raise the water more than 8 inches above the crest of the waste weir, supposing the outlet gates to remain closed. The water from the reservoir passes into an intermediate basin, from which it can be admitted to the canal or be turned into a waste-water channel. This basin was placed on the site of an old borrow-pit made during the construction of the canal.

The material for the body of the dam was selected from among the marls and clays at the sides of the valley. The puddle for the inner side of the work was obtained from a natural deposit of sandy clay situated at a distance of 1000 yards from the works. This was mixed with one-tenth of its volume of slaked lime before being used. It was originally intended to carry up the earthwork as far as possible during the first complete working season, to allow the reservoir to fill with water during the succeeding winter to complete the settlement and consolidation of the work, and to construct the masonry facing in the summer following. After the contract was let it was abandoned, on account of the difficulties met with in excavating the silt in the central part of the valley; and the work was carried on by day labour under the supervision of the engineer in charge. The delay occasioned in reorganizing the work made it impracticable to conform to this plan without an unwarrantable increase in the time occupied in its execution. To secure the same advantages, it was decided to keep the earthwork constantly wet by a small force-pump, and to pay special attention to its consolidation.

To prepare a seat for the bank it was necessary to remove a large quantity of the silt occupying the bottom of the valley. After the water of the mill-pond was let out, an excavation in the silt, 16 feet wide measured back from the toe of the water slope, was commenced at the centre of the valley. This was carried down

Fig. 2.



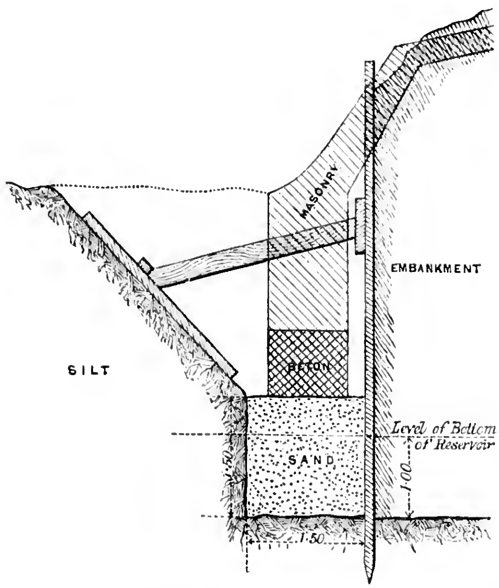
Half elevation. Half section. Transverse section.

Compression-Roller.

Scale $\frac{1}{30}$ of real size.

till the silt was found sufficiently compact to resist a pressure of $2\frac{1}{2}$ tons on the square foot (2·60 kilogrammes per square centimetre) without yielding appreciably. A depth of 13 feet satisfied this condition. From the lower side of this excavation the silt was stepped back toward the road. A small hand-pump was sufficient to keep it free from water. The earth, in filling in, was spread in layers 10 inches in thickness, and was carried up so as to leave a trench 5 feet in width between it and the upper side of the excavation. This trench was destined to receive the masonry wall along the toe of the water slope; but it was found necessary to fill it temporarily with sand, which was carefully punned and brought up to the natural surface of the ground to support the silt which would not stand alone. As the excavation extended from the centre toward the sides of the valley, sufficiently firm ground was found at a less depth; and it soon became possible to remove the silt entirely, and to seat the earthwork on the clay below. After the excavation had been filled in to the natural surface of the ground, the work presented less difficulty. The puddle on the water slope was carried up at the same time with the earthwork of the body of the dam. The successive layers were partly consolidated by the passage of the carts in which the material was brought. In addition, a compression-roller was used. It was of the design shown in Fig. 2, and weighed, when empty, 25 cwt. An additional load of 16 cwt. of stone could be placed in the box. It was drawn by four horses, and the pole was attached

Fig. 3.



Foundation of the masonry facing in the central part of the valley, as actually built. Scale $\frac{1}{100}$ of real size.

to an iron hoop running in guides at the four corners of the box, to avoid turning the roller before commencing the return trip. The final measurements showed that the earthwork had become so thoroughly packed as to occupy nearly the same volume as that of the borrow-pits from which it had been taken. This method of consolidation cost $\frac{1}{2}d.$ per cubic yard of earthwork. Near the masonry of the overflow and outlet works maidens of cast-iron, weighing 35 lbs., were used, and of hemispherical form below, to prevent fouling.

As the dam rose in height, the toe of the water-slope advanced slightly. The amount nowhere exceeded 6 inches, and when the full height was reached the movement ceased. During the latter part of the same season in which the earthwork was completed, the masonry facing was commenced. In building the wall along the toe of the water-slope, light sheet piling was driven on the side next the bank, and the temporary sand-filling was taken out to a depth of 8 feet. The silt on the other side was sloped back and the opening shored, as shown in Fig. 3. By the end of the season the masonry was brought up to about one-half the height of the dam, and during the following winter the reservoir was partially filled. In the spring the facing was carried up to the full height of the dam, and the whole of the works were completed by the autumn of 1878.

SUMMARY of COST.

	£.	£.
The Paroy Mill Pond, including the old dam, the mill, &c.	8,000	
Land up to the contour line at 1 foot above the normal water-level of the reservoir	5,400	
Indemnities	200	
Total purchases		13,600
Earthwork, and excavation in the foundations	3,320	
Masonry facing	2,400	
Overflow and outlet works	1,340	
Accessories	140	
Extras, estimated at schedule prices	600	
Total for construction		7,800
Grand total		21,400

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