

## Civil and Mechanical Engineering.

### THE RAISING OF THE GREAT GRAIN ELEVATOR BUILDING, AT MILWAUKEE, WIS.

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THIS building, situated on the banks of the Menomomee River, at the eastern terminus of the Milwaukee and St. Paul Railway, in the city of Milwaukee, is the largest, and by many persons conceded, the most convenient building in the world devoted exclusively to the receiving, storing and shipping of grain.

Its capacity is 1,250,000 bushels. Size, 280 feet long, 86 feet wide, and 130 feet high.

To a certain extent, a description of its construction is necessary, to properly understand the remarks which follow :

The plan of the storage bins, consists of dividing the length of the building into twenty-eight equal spaces, and the width into four parts, by partitions, constructed in the usual manner, of two-inch plank lying flat-wise on and breaking joints with each other, thoroughly spiked together, and thus built up to a height of sixty-one feet.

In the interior of the building, this work rests on a frame of oak beams, supported by clusters of posts, alternating two and four posts in each cluster, every ten feet apart from centre to centre, throughout the entire interior. The posts are 12 × 16 inches in size, 15 feet long, and rest on stone piers, built up from a pile foundation. The first or business floor, is at the top of the stone piers, on which the posts rest. The next floor is at the top of bins 76 feet above first floor. The foundation of the outside wall is piled, on which a stone wall 4 feet thick and 5 feet high rests. On this is placed the water-table, and then a brick wall 20 inches thick, and 15 feet high, to the under side of the frame work, supporting the wall of the bins. That portion of the building above the bins is built of frame, 40 feet wide, 270 feet long, four stories high, and is used for machinery, distributing and weighing grain, &c.

Notwithstanding this building rests on 9000 piles, averaging 30 feet long, it began to settle soon after it was completed, in the beginning of the year 1865, and in the summer of 1867 was found

to be so low, in several parts, as to preclude its being worked to its proper capacity, on account of many of the lower receiving hoppers being below the level of the water in the river. At this time, the greatest settlement at one point was  $2\frac{17}{100}$  feet. It appeared that this settlement was not caused by the piles slipping through the earth into which they were driven, as the surface earth had the same relative height to the building as when it was constructed, but was owing to the compression of the substratum. This was rendered apparent by the alteration of the heights of the railway tracks in the vicinity. One of my "bench-marks," used as a datum in taking levels, situated on a pile driven 30 feet into the ground, and distant 100 feet from the building, opposite where it had settled the least, went down three-fourths of one inch in twenty-eight months, with no weight upon it.

Judging from borings, it is believed that the substratum in which this compression takes place, consists of peat, intermixed with a large proportion of sand.

On the 20th of June, 1867, it was decided to raise the building, and by the 27th all grain in store was removed from it, and work commenced inside and out. It may be well to state, that prior to the commencement of the work, the party in charge stipulated to have the same completed in season to accommodate the grain traffic of the year, which would commence on or about the 20th of August.

The first work done, was the laying inside and outside of the outer wall of the structure, a foundation of timber on the earth. Cutting through the four feet thick stone wall, directly under the water-table, and inserting beams twelve inches square and ten feet long, each end projecting on either side of the wall, over the foundation timbers before mentioned, between which and the beams, screws were inserted. These beams were put through the wall as near to each other as practicable, and resulted in placing the weight of the outside walls entirely upon the screws. This process was simple, compared with the arrangement necessary in the interior. At each cluster of posts, the stone piers had a top area only a little larger than that covered by the posts. In a majority of instances, the pier projected only from four to six inches outside of the posts. To secure an even foundation for screws, that perforce had to be some distance apart, to prevent, in measure, settling of foundation, bringing a great strain upon a small number of screws, and thereby

crushing them, the plan was adopted of using these four and six-inch vacant parts of the pier tops, instead of the ground, as a foundation to work upon. To this end, timbers were laid across from pier to pier throughout, and bridged in a secure manner. On this the screws were placed. Between each cluster of posts, a frame was constructed of timber, 10 × 12 inches in size, consisting of three posts sill and caps resting on the screws, the posts extending from said sill to the under side of the beams, on which the structure above rested. The cluster of posts were made fast to the beams above, so that they would raise with the building. Levels had been taken on top of each pier to ascertain the proper height to raise, and thickness of pier caps to be introduced under posts.

When this height was less than one foot, cast iron cellular blocks were used. In all other cases, stone, in one piece of the requisite size. These were all provided, marked and numbered, each for its particular place beforehand. To provide, to a certain extent, for future settling of the structure, the rule was adopted to raise the building at all its parts one-quarter as much above the true plain of foundation, as such parts had settled below; that is to say, that where the subsidence was too feet, the rise should be  $2 + \frac{2}{4} = 2\frac{1}{2}$  feet. It must be understood that the building had not settled equally throughout all its parts. The south end settled but little, while the greatest depression was confined to the middle, west side, and north end, causing a curve sideways in the line of the top of the building, having a versed-sine of twenty-eight inches. The building was constructed of green lumber and timber; it settled and seasoned in this crooked state.

As the partitions of the bins are generally eight inches thick, of plank, and sixty-one feet high, one every twenty feet longitudinally, and one every ten feet transversely throughout, it can be conceived that in raising and giving a new or rather reverse form to the plain of the old foundation, unequal resistance to the action of the screws would result. Such was the fact. Had each screw to exert an equal force, then about six tons would have been the power required of each of the sixteen hundred and fifty (1650) used in raising. When the work of raising commenced, it was soon demonstrated that a force of sometimes nine tons was required to each screw in some of the lowest parts of the building, while at the higher parts comparatively little force was required; in fact, it was necessary in many places to carry the building from four to six inches higher

than intended, to be able to shove under the previously prepared pier caps on piers, twenty to forty feet distant. After all the screws were in place, the work of raising commenced, and after one week's labor, the structure was at the proper height to introduce the stone and iron pier caps. To do this, all timbers and screws had to be removed from the pier in hand. Other than that this process brought a great weight upon the adjoining screws, sometimes stripping them. No difficulty was encountered, of moment, in performing this portion of the work. This part done, the old floor was removed, and timber taken away that was used for the screw foundation, new floor laid at the right height, the fourteen iron hopper tanks raised to a proper height, screws and timbers removed from the outside walls, and the same bricked up under the water-table; seventy feet of the west brick wall which had crushed badly in settling, removed; shafting lined, scales leveled, and the whole building put in complete working order, on the stipulated day, the 20th of August, 1867, and in time for the fall business.

From over one thousand levels taken at different times, extending through a period of twenty-eight months, prior to the raising of the elevator, compared with an average load of 400,000 bushels of wheat, the monthly settlement was found to be .05855 feet. The building has now been raised six months, and under a similar average load, shows a monthly settlement of .03477 feet. So that it appears to have decreased from former monthly settlement, two-fifths nearly. There are strong grounds for believing that this monthly rate will rapidly decrease and soon vanish, rendering it unnecessary to raise the structure again.

The average number of men employed upon the work was one hundred and thirty.

Engineers' Office, Milwaukee and St. Paul Railway }  
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## THE SUEZ CANAL.

IN view of the commercial importance of this enterprise, as well as the diplomatic prominence which it has attained of late years, it may be interesting to note the present condition of the work, the prospects of its early completion, and the probabilities of its being maintained as one of the great highways of commerce.