In many instances, parts of this wall above low water are faced with granite blocks. This is a noted example of what can be expected in the way of using mass concrete in sea water if properly made, though perhaps some repair work has been necessary in order to maintain the excellent condition of the wall.

In some of the earlier sections of this wall the concrete was placed "*en-mass*-in-site," but, since 1876, most of the wall has been built by the concrete block method. Only under specially favorable conditions is it possible to place concrete successfully *in situ* under (sea) water, as it becomes disintegrated "through the chemical action of the sulphate of magnesia on fresh concrete or through the resulting porosity of concrete due to the impossibility of tamping under water";* the viscosity and weight of the mass not being sufficient to produce such a dense material as obtained in block work.

To discuss an opposite case in New York Harbor, viz., Dry Dock No. 2, New York Navy Yard, originally built of timber in 1890, the history of which it is not necessary to relate here: In 1900 this dock was rebuilt, concrete being used very extensively. During 1913 a large sum was expended in repairing and replacing the concrete altars and floors. As it has been stated that the difficulties of using concrete in sea water have been so great at this yard as to indicate that this is not a permanent material for use in sea water structures, it would be of deep interest to learn the facts as to the chemical composition of the cement used, of the sand and stone, as to the mixture thereof, and the precautions taken in mixing and placing; also as to whether the dock is kept flooded when not in use, especially during the winter. If, as has been stated, the concrete "has deteriorated and disintegrated to such an extent that it was possible to use a pick and shovel in removing it," it is apparent that it was lacking in one or more of the essential features that are deemed absolutely necessary for a successful use of concrete in sea water structures.

Whether any of the concrete pile docks on the Great Lakes have shown any signs of deterioration due to frost action, the writer does not know, but trusts that some facts covering this question will be brought out in the discussion. As the water level is practically the same all through the winter, only a very short length of the pile would be affected, and not some 10 ft., as in Boston Harbor.

One of the first concrete docks built in San Francisco is said to have failed in part due to poor construction. The early method of building the concrete columns of San Francisco concrete docks was to use a wooden cylinder, strongly built, as a column form, into which, it has been stated, the concrete was poured, apparently without any attempt to pump out the cylinder. As long as the wooden cylindrical forms remained in place around the supposedly concrete column, the dock was pronounced a success. When the teredo had finally destroyed the forms, the columns began to collapse and the dock became a pronounced failure, because, in pouring the concrete, the heavier material—the stone or gravel—settled first, then the sand, and finally the cement. The result was that throughout the length of the concrete columns there were alternate layers of uncemented stone and sand, with the cement in between the sand of one batch and the stone of the following one. Concrete can be and is successfully dropped through a height of 50 ft.—and even up to 100 ft. in one noted case in Arizona—but, if the receptacle into which it is dropped is full of water, disaster alone awaits the unfortunate engineer.

In another of the San Francisco docks, where wooden piles supported the concrete columns, the concrete was not carried down below the mud line a sufficient distance to prevent the teredo from destroying the piles below the concrete.

The question has been raised: Has any deterioration taken place in concrete structures standing in sea water in the harbors of the Southern States, where frost action is unknown? The most prominent concrete structure thus situated is the famous viaduct across the Florida Keys, built of Alsen cement, imported from Germany. It is possible that some of the members of this society are in a position to give complete information regarding the action of salt water and the waves of the Gulf on this structure.

In order to guard against the disintegration (irrespective of its cause) of mass concrete placed *in situ* above low water, or to repair any damage that has been done, besides the cement gun process, various methods have been used, all based on the fundamental principle of using an impermeable material for the facing of the structure. Below low water, properly made block work has given most satisfactory results. Carefully made, fully cured pre-moulded concrete piles seem to resist the action of the sea and frost successfully. In Holland, hard, impermeable brick have been used to prevent any further damage to one of the breakwaters above low water. In England, the upper parts of massive breakwaters are mostly faced with granite or some other hard suitable stone. In Nova Scotia, both brick and pre-moulded blocks of concrete of small size were placed on the face of a concrete sea wall after the disintegrated concrete had been removed. A still more recent device is the use of hollow, vitrified, salt-glazed tile blocks filled with concrete after being put in place. Experiments thus far seem to have proved that:

"Vitrified salt-glazed tile is impervious to any deteriorating action of sea water, and has an effective structure against the battering of ice; it is so dense as to preclude the possibility of any water entering and freezing in it to the consequent destruction of the tile."

Though oiled concrete is being used as a waterproof material in certain cases, it is possible that the refuse, oil, gases, etc., discharged from certain classes of buildings, etc., might have a destructive effect on the concrete foundation piles or other parts of the building, especially in sea water heavily charged with sewage. It is a well-known fact that concrete sewers will not perform their duty properly for any length of time unless they have a brick lining invert, over which flows the heavy sludge. In time of flood the surface water is so great as to dilute the sewage and prevent injurious effects. The writer would be pleased to hear opinions on this point, as it is possible that a destructive effect might have been caused by sewage in connection with one of the most seriously affected cases in Boston.

Although poor results seem to have attended quite a number of the reinforced concrete structures standing in sea water in America, the opposite appears to have been true in foreign countries. Still, a few failures are on record as having occurred in England and Germany, due mostly to permeable concrete.

*This subject is discussed further by the writer in an article entitled "Chemistry of Salt Water Cement," Metallurgical and Chemical Engineering, January and February, 1914.