MUNICIPAL DEPARTMENT

THE ACTION OF HEAT ON CEMENT.*

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The modern tendency towards large and high buildings, with a skeleton structure of steel, has made the question of fire prevention and protection one of the most vital importance to architects, manufacturers, engineers, and builders in general. Countless experiments have been made to devise some means of preventing iron and steel columns and girders from buckling under great heat. Plainly, the only way this can be done is by so protecting the metal that heat cannot come into contact with the metal surface.

Experiments have also been made, and numerous schemes introduced, to devise some means of making a floor between the girders that will withstand the action of fire, and so prevent a fire, even if started, from spreading from one flat to another. Hollow tile, brick, and terra cotta have been tried with indifferent success; and at present the tendency is towards using Portland cement or concrete as a protection for ironwork.

It is not the purpose of this paper to propose or condemn any scheme, or to introduce any new one; but rather to show what really may be expected from a mass of concrete or cement when subjected to great heat. The writer has carefully examined all available literature upon the subject, including books and trade catalogues; and while many give tests which are claimed to be eminently satisfactory, still, in almost every case, the accounts give such meagre information about the tests themselves as to be almost useless, as far as information is concerned, and certainly so as far as comparisons with each other are concerned. The information as to the action of the cement itself is, in every case, very meagre; and all the information given refers only to the conduct of the system tested, and no information whatever is given as to its condition afterwards.

In making these tests three brands of cement were used—two Canadian brands: "Star," manufactured at Deseronto, and "Samson," from Owen Sound; one foreign brand, "Jossen," of Belgium manufacture. These cements were thoroughly tested for fineness, strength, and "blowing," before using, and were found to be first-class. The "Star" and "Jossen" were comparatively slow-setting, and the "Samson" set very rapidly.

Tests were made upon neat briquettes and sand briquettes, mixed in proportions of one sand to one cement, two sand to one cement, and three sand to one cement. The age of the briquettes varied from two months to about four years. Over two hundred briquettes were used in making the tests.

The briquettes were heated in a small assay furnace, heated by a large gas burner, and which gave a range of temperatures of from about 650° Fahrenheit to about 1775° Fahrenheit.

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The temperatures were determined by means of a water calorimeter; the temperature of the furnace being obtained from the rise in temperature of a pint of water, in which had been immersed an iron ball of known weight, and which was heated to the temperature of the furnace. The temperatures given are approximately correct. The calorimeter gave good results—different readings, under the same conditions, rarely differing by more than 10° or 15°, which is very close for such high temperatures.

On heating the briquette and removing from the furnace, the first thing noticed was a loss in weight in the briquette; and almost all neat briquettes showed cracks, some large and some small. Some sand briquettes also showed cracks, but not to the same extent as in the neat briquettes; but there was no exception to the change in weight. This loss in weight is due to the fact that the hardened cement is a compound of hydrated crystals of aluminum silicate and calcium silicate, and the heat drives off the water of crystallization, and the loss in weight corresponds to the amount of water of crystallization driven off by the heat. Now, since the crystals depend upon the water for their formation, it is evident that when the water is removed the crystals are destroyed, and the cement ruined. Such was found to be the case in every instance.

The briquettes, after cooling sufficiently to allow handling, were broken in the testing machine, the load being applied at the rate of about 400 pounds per minute. The result showed a marked decrease in the tensile strength, as reference to Tables I. and II. will show; and, under the best conditions, this loss in tensile strength showed an approximate proportion to the loss in weight. Briquettes which lost 19 or 20 per cent. of weight, which is practically the amount of water required for proper crystallization, were practically unable to resist any load whatever, and in very few cases possessed 10 per cent. of their original strength.

The effect of different temperatures was rather peculiar. Briquettes placed immediately into a temperature of about 1775° Fahrenheit showed a very great loss in strength for a very small loss in weight, and did not appear to follow this law of proportion between losses of weight and strength, at least not nearly so well as briquettes treated differently. When the briquettes were gradually heated, however, and allowed to slowly rise to the temperature of the furnace, this law was followed quite closely, as reference to tables will show. The plotted curves give a good idea of the effect of slow and rapid heating on the relation of the cement to this law. This is accounted for by the fact that the cold briquette, on being placed in the furnace at such a great heat, is immediately subjected to very considerable internal stresses, due to the expansion of the outside of the briquette before any water of crystallization at all is driven off. Briquettes, heated gradually, were not subjected to these internal stresses to nearly the same extent as those which were heated very suddenly.

An attempt was made to discover, if possible, a critical temperature to which it would be possible to subject the cement without danger of injury to the crystals, and where the cement would retain its cohesive powers. It was found that, if such a temperature existed, it was below the lowest temperature generated by the furnace, which was considerably below red heat. The lowest temperature had the same effect as the highest, excepting, of course, that with the lower temperature a longer time was required to effect the same reduction of weight than with a higher one. The lowest temperature necessary to destroy the cement was not determined, but it is probably quite low.

The following quotation from Heath's "Manual of Lime and Cement" is interesting regarding this. "Even good Portland cement concrete, if exposed to the weather during a hot, dry summer, with no supply of moisture available, will probably be found covered with a network of innumerable hair-like cracks, which are signs of the beginning of disintegration, the natural and inevitable result of the loss of the water of hydration of the cement." (Heath's "Manual of Lime and Cement," page 75.)

The only neat briquettes which were not cracked by the heat were some very old ones, about four years old, which were tested. Most of these were uncracked, although some that were very suddenly heated cracked somewhat. All the newer briquettes cracked, the cracks being very large in most cases.

After cooling, the briquettes were found to be quite soft, and could easily be crushed between the fingers. This was especially noticeable in the case of those briquettes which had lost the most water of hydration. These briquettes were like lumps of dry mud or clay, and a very slight pressure was sufficient to crush them completely. Briquettes which had not lost so much water were harder, while those which had lost only about one or two per cent. of water were quite hard. Of this latter class, however, those briquettes which had been heated suddenly were much the softer.

Briquettes which were cracked on removing from the furnace showed the cracks much distended and widened out on cooling, and most of those which had not cracked in the furnace showed cracks on standing for a day or two.

All sand briquettes, whether cracked in the furnace or not, entirely disintegrated on standing in air for a time, the cementing material having been entirely destroyed. Those sand briquettes which had lost most of their water of hydration disintegrated first, and those that had lost less followed soon after. Six briquettes of two sand to one cement were placed suddenly in the most intense heat, and left for about three minutes and removed. They lost from three to four per cent. in weight, and two of them which were broken showed a complete loss of tensile strength; one breaking before any load was applied, and the other going at about eight pounds. The remaining four were set away, and in a couple of days commenced to crumble, the edges going first, and leaving an irregular mass in the centre. This, however, resisted for some time, but in about three weeks they also were completely disintegrated. It was thought that the sudden application of very intense heat would cause the water of hydration to be removed from the outside only, and that the inside would remain solid, and resist weathering. The results, however, showed that although the outer part of the briquettes suffered most, as is shown by the rapid disintegration, still the heat also affected the inner part, and caused its ultimate disintegration. These briquettes were too hot to be handled comfortably when weighed, after removal from the furnace, and it is quite probable that the heat still remaining in the outer portion caused a still further loss of water of hydration in the parts in the centre of the mass. The low tensile strength of these two briquettes was probably caused by the sudden heat causing great internal stresses in the briquettes. The parts of the two broken briquettes also behaved in the same manner as the unbroken ones.

(To be Continued.)

Mr. J. MacFarlane, Dominion analyst, has gone to England, for the purpose of investigating and reporting upon the utilization of city sewage in Europe for the purpose of fertilization.