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THE ACTION OF HEAT ON CEMENT.

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(Concluded.)

A number of briquettes were heated, and rapidly cooled by being immersed in cold water, after being heated for different lengths of time at different temperatures. In every case the briquettes cracked when immersed; and, it they were red-hot before immersion, they completely disintegrated—in most cases being reduced to a heap of soft mud. The sand briquettes acted precisely similarly to the neat ones; and it appears conclusive that if cement or concrete is allowed to become red-hot, and is then immersed in cold water, the effect would be ruinous in the extreme. Some briquettes were also heated, and, instead of being immersed, were placed under a small stream of water flowing at the rate of about two litres a minute. The results were the same. Red-hot cement completely disintegrated. In some cases, when heat had not been applied sufficiently long to heat the briquette through and through, and where the edges only glowed, the glowing parts chipped off when water was applied, leaving an irregular mass comprising that part of the briquette which had not been heated so much. Even when not completely disintegrated, this central mass showed cracks, was very soft, and had no strength to resist any pressure.

From these experiments, then, the following conclusions may be drawn:

(1) While there is no doubt that a covering of Portland cement concrete will afford some protection to a metal column or girder, still there appears to be no doubt that the concrete itself will be ruined by the action of the fire, and will have to be removed as soon as the fire is subdued. The concrete covering may remain upon the ironwork during a fire, but the heat will damage it to such an extent that it will disintegrate afterwards. The impression appears to exist that the concrete will be in as good condition after a fire as before. This is a mistake, as a fire of ordinary intensity is sufficient to ruin, completely, a very large covering of concrete.

(2) The concrete covering, if heated, will not stand the action of water; all the experiments show that water applied to hot cement is extremely ruinous. This is a very important point, when we come to consider the immense amount of water thrown into a building during a conflagration. The cement is certain to become red-hot; and then, when the hose is turned on, the water strikes the protecting covering, and it breaks off, leaving the ironwork bare and filling the air with a shower of dangerous falling pieces. In a fireproofed building the usual construction is to have a system of concrete arches and slabs between the joists and girders. The walls are of concrete, and have metal doors to confine the fire, if started, to one spot as much as possible. The floor is usually cemented over, or boarded with thin flooring, and is, therefore, more or less water-tight. The ceiling, or under part, might be exposed to intense heat, while immense quantities of water were being poured upon the upper portion, causing an immense strain on the concrete, not from the weight of water, but from the opposite strains which the cement would undergo, on account of one side being expanded by the intense heat, while the other side is kept cold by the water upon it. All this time the fire below is eating away the strength of the cement, and a collapse is the result.

(3) In calculating for the design of the columns and girders, and especially for floors, no allowance should be made for the strength of the concrete, but the cement covering should be considered as so much extra load on the system. It is the usual custom, in designing a fireproof system, to consider that the concrete bears its share of the loads upon the girder; and, in a great many cases, the girder is designed on that assumption. If no fire occurs, this is all right; but, during a severe fire, the concrete loses its cohesive properties, both on account of its water of hydration, and on account of the great internal strains caused by the expansion of one side under heat, and, consequently, becomes unable to resist any stress anywhere near what it was originally able to bear, and in most cases would not even be self-supporting. The experiments have shown that sudden heating is extremely ruinous, much more so than heat suddenly applied; and, in the average fire, a very high temperature is generated in an incredibly short time, and concrete subjected to its action would, in a very short time, be unable to bear any strain whatever.

It appears from this that, in a fireproof building, floor should never be constructed of slabs of cement, forming short spans or arches from girder to girder, without any support. If no load were placed on the floor, and it were subjected to heat, it might possibly retain its form, provided water was not thrown upon it; but if loaded, as any floor would be a collapse is inevitable. Concrete, then, should always have a metal system of some sort imbedded in it, sufficiently to bear the weight of the concrete itself, and all external loads which may come upon it.

The great advantages possessed by cement or concrete, as a fire-protecting material, are its low heat-conducting power and its very small expansion under heat. These advantages, however, are entirely off-set by the fact that it loses its strength under heat, is ruined by water applied during a fire, and will disintegrate after a fire, if not during the fire itself. These experiments tend to show, therefore, that the value of concrete as a fire-protecting material has been greatly over-estimated, and that disastrous results may follow from confidence in a building protected with such a material.

TABLE I.—RESULTS OF 26 BRIQUETTES HEATED SUDDENLY. Temp., 1775° Fah. (approx.)

Weight in Grammes.		Per Cent. Lost.	Tensile Strength.		Per Cent. Lost.
Before.	After.		Before.	After.	
§140.02	125.57	10.4	530	190	64.1
§139.28	117.47	15.4	"	200	62.3
§140.06	115.75	17.3	"	185	65.1
§139.07	113.72	18.6	"	53	90.0
§140.46	125.99	11.6	"	180	66.1
§140.98	132.87	5.7	"	235	55.7
§139.23	137.68	1.1	"	330	37.7
§140.11	120.89	13.7	"	140	73.6
§139.47	133.57	2.9	"	280	47.1
§139.21	112.07	19.5	"	15	97.1
§140.17	121.17	13.4	"	155	70.7
§138.71	119.70	13.7	"	145	72.7
§135.77	131.70	2.9	930	0	100.0
†133.75	118.85	11.1	"	20	97.8
†132.75	dropped from tongs, and broke on floor.				
†131.16	123.05	6.2	930	50	94.6
†132.76	118.95	10.4	"	20	97.8
†134.15	128.70	4.8	"	23	97.5
‡139.22	125.72	9.7	515	85	83.5
‡138.41	128.39	7.2	"	75	85.4
‡140.00	134.23	4.1	"	122	76.3
‡137.35	135.54	1.3	"	200	61.2
‡138.47	131.38	5.1	"	97	81.1
‡138.21	135.68	1.8	"	185	64.1
‡140.04	112.87	19.4	"	0	100.0
‡137.26	113.24	17.5	"	10	98.1

§ "Star" Brand. † Briquettes, 4 years old, brand unknown. ‡ "Jossen" Brand.

TABLE II.—RESULTS OF TWENTY-ONE BRIQUETTES HEATED VERY GRADUALLY AND BROKEN. Maximum Temperature, 1000°—1025° Fah.

Weight in Grammes.		Per Cent. Lost.	Tensile Strength.		Per Cent. Lost.
Before.	After.		Before.	After.	
*139.27	132.34	4. 9	530	395	25.6
*138.31	130.16	5. 9	"	390	26.3
*140.26	128.32	8. 5	"	348	34.3
*140.06	129.16	7. 8	"	351	33.7
*138.07	126.23	8. 6	"	327	38.2
*139.04	120.13	12. 9	"	152	71.2
*139.26	116.27	16. 5	"	73	84.3
*138.35	113.31	18. 1	"	29	94.5
*140.21	119.26	14. 9	"	110	79.0
*139.32	125.34	10.04	"	237	55.2
†137.79	129.32	6. 1	515	348	32.3
†139.42	130.26	6. 6	"	348	32.3
†140.31	133.58	4. 8	"	398	22.6
†139.27	127.31	9. 3	"	232	49.0
†140.32	120.15	14. 3	"	182	64.7
†138.37	136.32	1. 5	"	440	14.7
†139.46	134.31	3. 7	"	400	22.3
†140.07	121.31	13. 4	"	195	62.3
†139.36	117.26	15. 8	"	130	74.6
†140.21	122.31	12. 5	"	193	62.4
†139.36	112.60	19. 2	"	10	98.0

* "Star" Brand. † "Jossen" Brand.