(6) Proper proportioning of bitumen so that every particle of the aggregates are coated and no more.

(7) Heating of all the materials so that no moisture is present during the mixing and application.

(8) A thorough rolling so that the aggregates are squeezed together in a solid mass.

INFLUENCE OF TEMPERATURE ON THE STRENGTH OF CONCRETE.

THE general use of concrete in various kinds of construction and at all seasons of the year renders important a knowledge of the effect of temperature upon the strength of this material. It is of special economic importance to the contractor or the builder to be informed concerning the strength of concrete at early ages under different temperature conditions so that he may know when to remove forms and what loads may be safely applied to the different parts of a structure.

The subject of temperature influence is dealt with in a bulletin recently issued by the engineering experiment station of the University of Illinois. The author, Prof. A. B. McDaniel, of the department of civil engineering, presents the results of three groups of tests on (1) forty-five 6 x 6-in. cylinders; (2) fifty-one 6-in. cubes, and (3) sixty 8 x 16-in. cylinders, under such temperature conditions as were allowed by the facilities available. Professors A. N. Talbot and Ira O. Baker co-operated with Mr. McDaniel in planning the tests and in interpreting the data. The quality of the materials chosen is representative of the ingredients of concrete work in the middle west.

All the concrete was composed of 1 part cement, 2 parts sand, and 4 parts broken stone, by weight; corresponding to 1 part cement, 2.2 parts sand, and 3.6 parts broken stone, by volume. The materials for each specimen were weighed out separately and then mixed. The mixing of the concrete for Group I. was done with a trowel in a large galvanized iron pan. The cement and sand were first mixed dry to a uniform color and spread out in a layer of uniform thickness over the bottom of the pan. The stone was then added, and the whole mass given four complete turnings, which secured thorough incorporation of the dry materials. Water was added, and the material turned until thoroughly mixed. The concrete was gathered together in a compact mass, in one end of the mixing pan, so as to reduce evaporation losses to a minimum. The time of mixing of each specimen was kept as nearly constant as possible.

The concrete used in Groups II. and III. was mixed in similar manner to that of Group I., but was mixed on the concrete floor of the laboratory with shovels. The specimens were classified according to the form of test specimen and storage conditions, as shown in Table I.

Table I.—Description of Test Specimens.

Group	Set	Specimens		Number and Age of Specimens When Tested.
		Number	Form	
I	A	15	6 x 6-in. cylinders	5 specimens of each set; at 7, 14, and 28 days.
	B	15		
	C	15		
II	D	15	6-in. cubes	3 specimens of each set: at 4, 7, 11, 14, and 28 days.
	E	18		
	F	18		
III	G	15	8 x 16 in. cylinders	3 specimens of each set; at 3, 7, 10, 14, and 28 days.
	H	15		
	I	15		
	M	15		

The forms used for Group I. were sheet-iron cylinders 6 in. in diameter and 6 in. high. The specimens of Group II. were molded in three-gang cube forms made up of two 6-in. channels and plates placed 6 in. apart. The forms for the specimens of Group III. were sections of standard 8-in. wrought iron pipe, 16 in. long. The forms were removed from the specimens after a storage of two days. Table II. shows the weight of the dry materials, the per cent. of water in terms of the total dry materials, the temperature of the room and of the concrete, and the average time of molding.

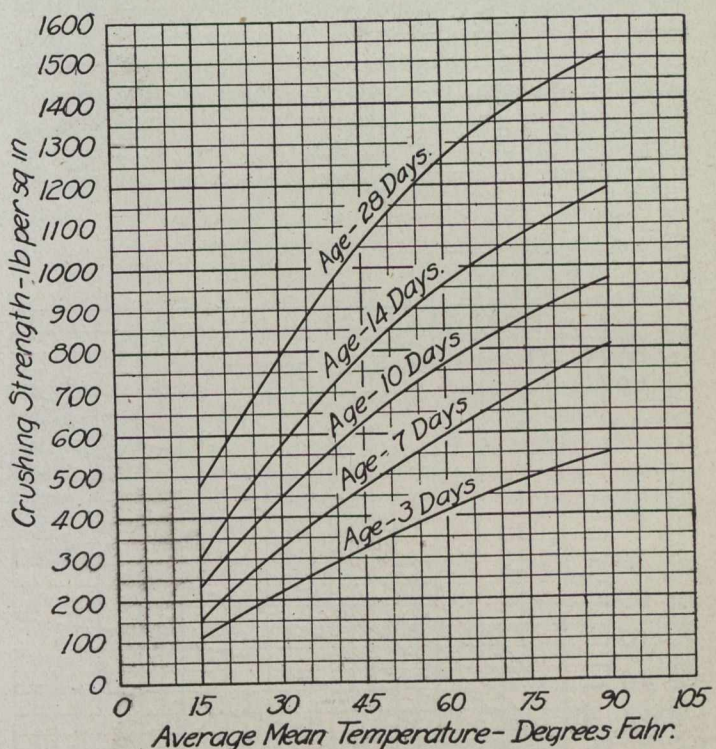

Fig. 1.—Relation of Strength to Temperature for Different Ages.

Prof. McDaniel draws the following general conclusions from the results obtained:

Under uniform temperature conditions, there was an increase of strength with age within the limits of the tests. For any temperature the rate of increase decreases with the age of the specimen; and this rate of increase is less correspondingly at the lower temperature conditions. For the specimens tested, under normal hardening temperature conditions of from 60 to 70° F., the compressive strength of the concrete subjected to a uniform temperature at the ages of 7, 14, and 21 days may be taken as approximately 50 per cent., 75 per cent. and 90 per cent.

Table II.—Data Concerning Molding of Specimens.

Type of Specimen	Set	Average Time of Molding, minutes	Average Temperature		Weights of Materials			Water per cent.
			Air	Concrete	Cement lb.	Sand, lb.	Stone, lb	
6-in. cylinders	A	8.5	32°F	70°F.	2.17	4.34	8.68	10.0
	B	8.5	65	71	2.17	4.34	8.68	10 0
	C	8.5	84	70	2.17	4.34	8.68	10 0
6 in. cubes	D	7.0	77	70	2.42	4.84	9.68	10.0
	E	7.0	75	70	2.42	4.84	9.68	11 0
	F	7.0	71	69	2 42	4.84	9.68	10.0
6-in. cylinders	G		68	69	10.2	20.4	40.8	9.3
	H							
	I							
	M							