241

MICHIGAN
STATE HIGHWAY DEPARTMENT
G. Donald Kennedy
State Highway Commissioner

CURING OF CONCRETE

BY

CALCIUM CHLORIDE INTEGRAL MIXED

By

E.A. Finney

Research Project 39 B-11 (2e)

Research Laboratory
Testing and Research Division
Report No. 31
April 1, 1942

In compliance with your request of April 20, 1942, we are submitting herein a brief summary of our experiences concerning calcium chloride as a curing agent when incorporated in concrete mixtures.

The subject will be discussed in the following order; workability and finishing, strength, durability, water retention and resistance to sealing.

CALCIUM CHLORIDE INTEGRAL MIXED

Workability and finishing: Observations on the Test Road indicate that the addition of 2 pounds of calcium chloride per barrel of cement produces good workability, reduces segregation of the aggregates and subsequent bleeding and laitance and gives fair finishing characteristics. The mixture is slightly more plastic than ordinary concrete. No indications were noted in which the time of set was materially reduced because of meteorological conditions plus the accelerative effect of the calcium chloride itself. However, it is to be noted that the air temperature at the time of laying the calcium chloride section on the Test Road was 60°F. Therefore, the above results should be considered with this low temperature in mind. Under higher temperatures which will be encountered during summer construction operations there is no doubt but what the quantity of calcium chloride might have to be reduced or eliminated entirely.

In the event that calcium chloride and Orvus are used together, a different condition may result. A short section was tried on the Test Road including 1 percent calcium chloride integral mixed with the Orvus. The temperature was 70°F. and no unusual difficulties were experienced. The Construction Division has had experience on several projects where calcium chloride was used with Orvus during cold weather construction. Temperature seems to be the main factor in the use of these materials in the same mixture.

Strength: Tables I and II contain data pertaining to comparative compressive strengths and modulus of rupture values for several types of concrete. It is to be noted that the values for concrete containing calcium chloride are approximately on a par with plain concrete at the 28-day period.

Durability: Table III contains results from the comparative durability study of several different concretes from the Test Road. It is to be noted that in this case, the concrete containing calcium chloride has the lowest ra ting of the group.

Water Retention: An approximation of what might be expected of the water retention characteristic of calcium chloride as compared with other types of curing mediums is illustrated in Figure I. These curves represent the relative moisture condition of the top 1 inch of the slab during a 7 day curing period under practically similar conditions.

The moisture gradient of the calcium chloride treated section shows that such a curing method may produce results analogic in character to those obtained by the membrane curing agents.

Durability of concrete surface: Scaling studies have been conducted on the several concretes of the Michigan Test Road during the last two winter seasons. Some of the results from this study are presented in Table IV. The results indicate that calcium chloride integrally mixed in the concrete seems to improve the resistance of the concrete to scaling over that of plain concrete. However, if calcium chloride is used with Orvus, no doubt the resistance of the concrete to scaling will be approximately equivalent to that of concrete containing Orvus alone.

CALCIUM CHLORIDE SURFACE TREATMENT

No experiments were conducted on the Test Road in which calcium chloride was applied to the surface of the slab for curing purposes.

We have no data to prove that one application of 1 percent to 2 percent of calcium chloride spread over the surface of the slab will materially harm the concrete or will act as an accelerator to surface scaling. The damage seems to be caused by repeated applications of calcium chloride over a period of time.

Although specifications for surface curing with calcium chloride appears in the A.S.T.M. Standards and in the current specifications of several highway departments, it is our belief that it is being used only in very special cases.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the data presented herein, we feel that there is no apparent reason why calcium chloride, when integrally mixed in the concrete for the purpose of curing, should not be retained in the present Michigan State Highway Department specifications.

Flake calcium chloride was used for the experiments on the Test Road. In case the present specifications are continuing in force, it is suggested that the specifications be revised to the effect that the calcium chloride be used in solution form. If used in this manner, uniform dispersion of the chloride throughout the concrete mixture will be assured regardless of the form in which the chloride is purchased.

Since the data on concrete curing by surface treatments of calcium chloride is rather vague, we would recommend, for the present at least, that this method of curing should not be included in the proposed supplemental specifications until such time that it can be definitely proven by further research, both physically and chemically, that calcium chloride surface treatments for curing are not detrimental to the slab surface.

TABLE I

28-day Compressive Strength Tests - Standard Pavement Concrete

Project F 18-20, C3

Specimen No.	Cement	Coarse Aggregate	Fine Aggregate	Curing Method	6"x12" cyl. strength lbs. per sq. inch
1	Petoskey	Hersey	Hersey	Wet straw	3990
2					4170
3					3820
4					5130
5					5050
6					6010
7					3890
8					4840
9					3780
10					4530
1				$CaCl_2$ Integral	4490
2					5190
3					4880
4					4240
1				Paper	5860
1				Wet earth	4950
1				Rite-Cure	3430
1				Cut-back Asphalt	4525
2					4670
3					4280
4					4980
5					3960
1	Aetna	Hersey	Hersey	Wet Straw	4170
2					4590
3					4950
4					3980
5					4590
1	Petoskey	Inland	Inland	Wet Straw	3533
2					3890
3					4340
4					4940

No compressive strength tests on projects F 18-20, C4 and F 67-37, C6

TABLE II

MODULUS OF RUPTURE TESTS
MICHIGAN TEST ROAD

Admixture and Curing	Cement	2-day	7-day	28-day
$CaCl_2$ 2% Int. mixed	Petoskey	267	445	605
Orvus $CaCl_2$ 1%	Petoskey	—	328	489
None	Aetna	387	511	686
Vinsol Resin 1% $CaCl_2$	Petoskey	391	449	—
Natural Cement	Petoskey	399	515	626
None	Petoskey	410	507	586
Plastiment	Petoskey	367	465	807
Orvus	Petoskey	457	—	587

NOTE: These figures represent breaks by the three point method and are approximately 20% below the values which would be obtained on the Standard Michigan Beam Breaker.

TABLE III

RESULTS ON LABORATORY DURABILITY TESTS
Freezing and Thawing of 3 x 6 x 15" Specimens
From Michigan Test Road

Cement	Admixture	Cycles for Failure in Freezing and Thawing
Petoskey	Modified Sand	110
Petoskey	Limestone Dust	107
Petoskey	Orvus	104
Petoskey	Vinsol Resin + 1% $CaCl_2$	96
Petoskey	Orvus + 1% $CaCl_2$	94
Petoskey	Orvus	89
Petoskey	None	83
Aetna	Vinsol Resin	82
Petoskey	Natural + Grinding Aid	76
Aetna	None	75
Petoskey	Limestone Dust	74
Petoskey	Silica Dust	74
Petoskey*	$CaCl_2$ 2% Integral mixed	43

NOTE: Beams were made from concrete that had stood in rain for at least one hour. The concrete had a partial initial set. This may account for low result.

TABLE IV

RESULTS OF SCALING STUDIES
MICHIGAN TEST ROAD

Cement	Curing	1940 - 1941 Cycle	1940 - 1941 % Scaling	1941 - 1942 Cycle	1941 - 1942 % Scaling
Petoskey	Wet Straw	13	100	9	100
Petoskey	Wet Straw	33	61	41	100
Petoskey	Asphalt Emulsion	27	61	—	—
Petoskey	Wet Earth	28	33	—	—
Petoskey	Ponding	28	28	—	—
Petoskey	$CaCl_2$ Integral mixed	24	17	61	71
Petoskey	Double Burlap	24	14	—	—
Petoskey	Paper	28	3.0	—	—
Petoskey	24-hr. Burlap + Paper	28	Trace	47	100
Petoskey	Rite Cure	28	None	61	9

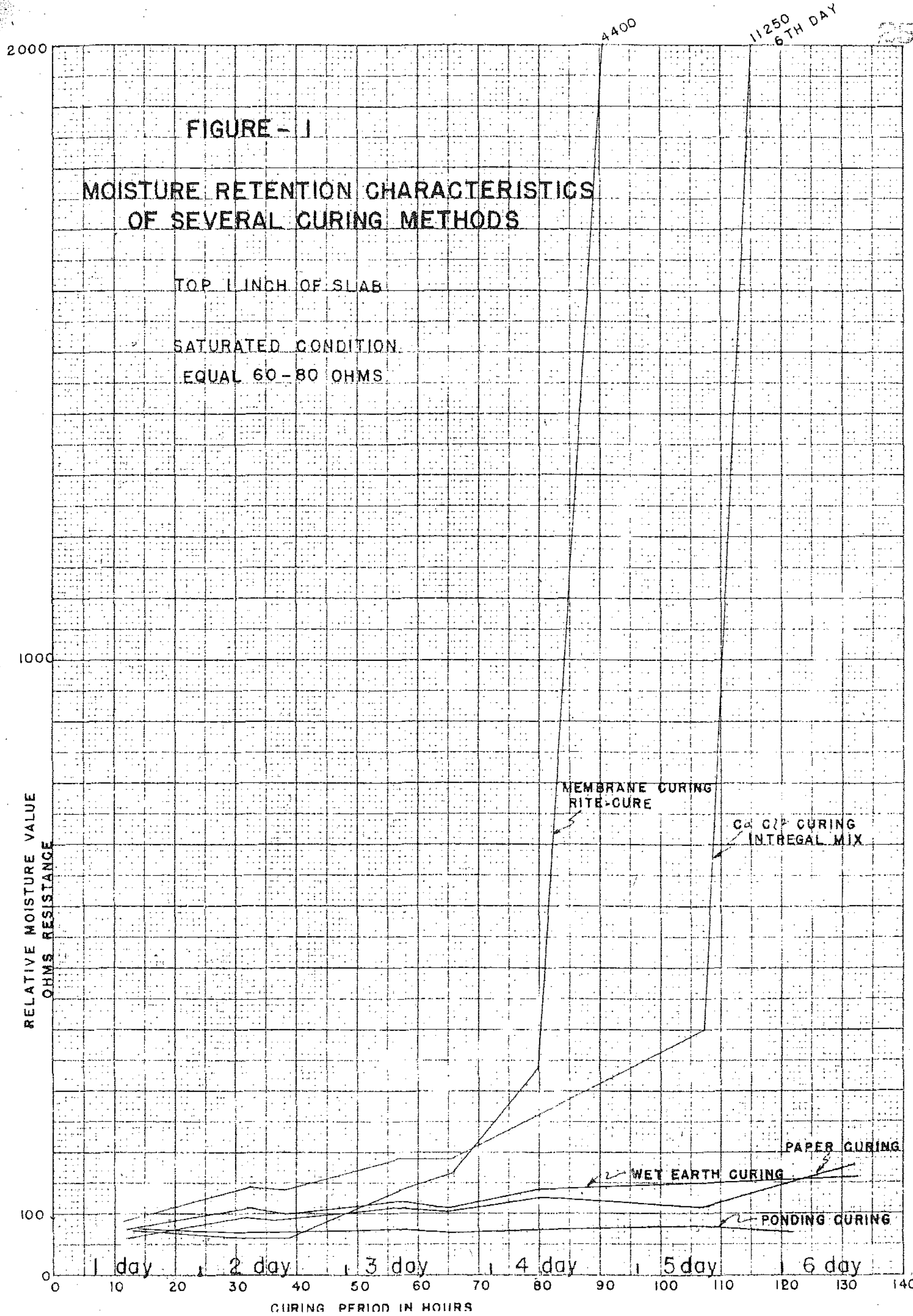

FIGURE - I
MOISTURE RETENTION CHARACTERISTICS
OF SEVERAL CURING METHODS
TOP 1 INCH OF SLAB
SATURATED CONDITION
EQUAL 60 - 80 OHMS
4400
11250
6TH DAY
MEMBRANE CURING
RITE-CURE
Ca Cl2 CURING
INTREGAL MIX
PAPER CURING
WET EARTH CURING
PONDING CURING
RELATIVE MOISTURE VALUE
OHMS RESISTANCE
2000
1000
100
0
1 day
2 day
3 day
4 day
5 day
6 day
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
CURING PERIOD IN HOURS