

**EVALUATION OF CONCRETE PATCHING MIXES
AND
OPENING TIME
USING
THE MATURITY CONCEPT**

**Final Report
for
MLR-93-7**

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Highway Division
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DISCLAIMER

The contents of this report reflect the views of the authors and do not necessarily reflect the official views of the Iowa Department of Transportation. This report does not constitute a standard, specification or regulation.

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ABSTRACT

This report summarizes the findings of a research which was intended to evaluate the concrete strength and opening time for the full depth patching projects in Iowa under cold weather and whether or not cold water could be allowed in the mix. This research was performed both in the laboratory and in the field. The results indicated that with the present specification the concrete strength after five hours for two-lane patches which requires hot water and calcium chloride is about 1,600 psi. Hence, if a higher strength is desired, a longer curing time is required. Hot water will have to be used and water reducer is not recommended for two-lane patches. On the other hand, the concrete strength for multi-lane patches with either hot or cold water approaches 4,000 psi in less than 24 hours. There was only a slight difference in compressive strengths between the 24-hour and 36-hours curing times.

INTRODUCTION

The State of Iowa is nationally known for the portland cement concrete (PCC) highway system. However, this PCC pavement has been in service for so long that some deterioration has occurred. Full depth patching is needed to improve the smoothness and extend the service life of the pavement. According to the Iowa Department of Transportation specifications, an M mix without calcium chloride shall be used with the curing time of 36 hours or an F mix without calcium chloride with curing time of 24 hours on multi-lane sections. On the other hand, an M mix with calcium chloride or FF mix without calcium chloride shall be used with a minimum of five hours of curing time on two-lane sections. The Supplemental Specifications 5105 (SS-5105) for construction projects dated August 3, 1993 added the temperature requirement of 75°F (24°C) for the materials delivered to the job site. The latter requirement may be difficult to meet during early spring or late fall unless hot water is used. Some ready mix plants have access to the hot water but some do not. When hot water is not available, long hauling of the concrete to the job site has to be done. It is not cost effective and sometimes there is a compliance problem with transit mixing requirements. However, heating must be done to make sure that the concrete is mature enough or the concrete strength is high enough before the patches are open to traffic. Since the gain in concrete strength is

largely controlled by time and temperature, the concrete temperature and curing time are important. It is speculated that our specification requirements are adequate. Could specifications be modified so that the concrete temperature could be lower or curing time could shorter? What concrete strength are we getting with our present specifications?

This research is intended to answer these questions by using five different M mixes both in the laboratory and in the field so that a better understanding of concrete maturity and strength based on time and temperature may be obtained.

RESEARCH OBJECTIVE

The objectives of this research were:

1. To review the present specifications regarding the curing time and temperature requirements.
2. To estimate the concrete strength based on the present specifications.
3. To evaluate the possibility of lowering our requirements.

EXPERIMENTAL DESIGN

Objective

The objective of the research is to develop a strength and temperature-time factor relationship in the laboratory and use this relationship to predict the strength of the concrete in the field with the temperature and time available.

Materials

For this research, five different M mixes were used. They were:

Mix #1: Cold water without calcium chloride.

Mix #2: Cold water with calcium chloride.

Mix #3: Cold water with calcium chloride and water reducer.

Mix #4: Hot water without calcium chloride.

Mix #5: Hot water with calcium chloride.

Procedure

In order to obtain the data for the research both laboratory and field testings were done.

Laboratory Mixing and Testing

A batch of 13 cylinders with dimensions of $4\frac{1}{2}$ " x 9" was made for each of the M-mixes (see appendix for mix proportions). A thermocouple was placed in one these cylinders to monitor the temperature of the concrete. For the mixes with calcium

chloride, three cylinders were used to determine the compressive strength at 3, 4, 5, and 7 hours. A similar procedure was followed for the mixes without calcium chloride except the compressive strength was determined at 7, 24, 30, and 36 hours.

The function that probably best correlates with the strength of concrete is the Nurse-Saul expression (1):

$$\text{Maturity } (^{\circ}\text{C} \times \text{days or hrs}) = \sum a_t(T + 10) \quad (1)$$

Where:

a_t : Time of curing in days or hours.

T : Temperature in $^{\circ}\text{C}$.

The datum temperature which is the temperature point from which the temperature is measured for Nurse-Saul expression is assumed to be -10°C . That is the reason why there is a 10 in the equation.

According to ASTM C-1074-87, "Standard Practice for Estimating Concrete Strength by the Maturity Method", a datum temperature of 0°C is assumed (2). Thus, Equation 1 is changed as follows:

$$M(t) = \sum (T_a - T_o) \Delta t \quad (2)$$

or

$$M(t) = \sum (T_a) \Delta t \quad (3)$$

Where:

$M(t)$: Temperature-time factor, deg.-hr or deg.-day

T_a : Average concrete temperature during time interval, $^{\circ}\text{C}$

T_o : Datum temperature, $^{\circ}\text{C}$

Δt : A time interval, hr or day

With the temperature, time and compressive strength information a compressive strength versus temperature-time factor was developed.

Field Testing

The same materials used in the lab were used for the full depth patching projects on the westbound of I-80 from Mile Post 225 to Mile Post 215. A thermocouple was placed down to six inches in the patch and about two feet from the edge to record the temperature of the concrete every 15 minutes. The daytime temperature during the field testing was about 45°F and the nighttime temperature was down to 38°F. The weather conditions were excellent to study the concrete maturity and opening time during cold weather.

RESULTS

Laboratory Testing Results

Table 1. Initial concrete temperature, maturity, curing time, and compressive strength of the mixes in the laboratory (please see page 4 for mix descriptions)

| | Mix #1 | Mix #2 | Mix #3 | Mix #4 | Mix #5 |
|----------------------------|--------|--------|--------|--------|--------|
| Initial Temperature (°F) | 62 | 57 | 62.5 | 74.9 | 77 |
| Maturity (deg-hr) | 164.7 | 63.9 | 70.5 | 188.6 | 80.0 |
| Time, hrs | 7 | 3 | 3 | 7 | 3 |
| Compressive Strength (psi) | 340 | 50 | 30 | 960 | 200 |
| Maturity (deg-hr) | 787.3 | 91.8 | 94.8 | 843.5 | 113.5 |
| Time, hrs | 24 | 4 | 4 | 24 | 4 |
| Compressive Strength (psi) | 3780 | 170 | 70 | 4110 | 600 |
| Maturity (deg-hr) | 993.3 | 122.7 | 122.7 | 1059.6 | 150.1 |
| Time, hrs | 30 | 5 | 5 | 30 | 5 |
| Compressive Strength (psi) | 4050 | 470 | 260 | 4020 | 1040 |
| Maturity (deg-hr) | 1177.8 | 191.1 | 188.1 | 1258.9 | 229.1 |
| Time, hrs | 36 | 7 | 7 | 36 | 7 |
| Compressive Strength (psi) | 4200 | 1160 | 970 | 4140 | 1890 |

Field Testing Results

Table 2. Initial concrete temperature, maturity, curing time, and predicted compressive strength

| | Mix #1 | Mix #2 | Mix #3 | Mix #4 | Mix #5 |
|--------------------------------------|--------|--------|--------|--------|--------|
| Initial Temperature (°F) | 66.7 | 68.9 | 70.0 | 86.0 | 84.8 |
| Maturity (deg-hr) | 785.7 | 139.0 | NA | 860.0 | 202.0 |
| Time, hrs | 22.5 | 5 | NA | 18 | 5 |
| Estimated Compressive Strength (psi) | 3780 | 640 | NA | 4110 | 1600 |

NA: Not available

The information for Mix #3 was not available because there were only three microloggers and one maturity meter available for the research.

The compressive strength and maturity or temperature-time factor in the laboratory were also used to obtain Figures 1 to 5. From these figures the field maturity information was used to predict the field compressive strength of the mixes.

STRENGTH & TEMP.-TIME FACTOR
COLD WATER W/O CaCl₂
(Mix #1)

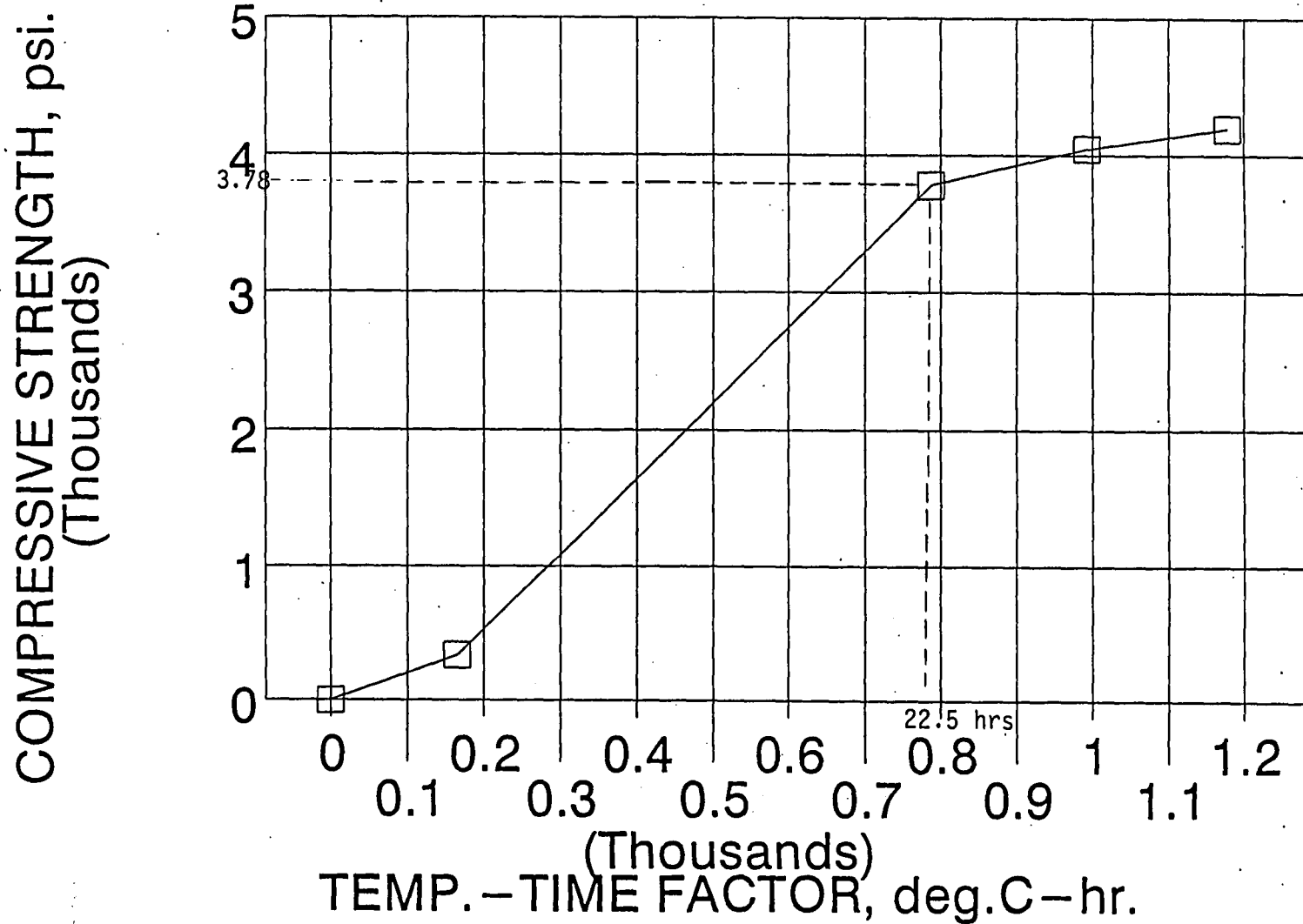


Figure 1. Cold water without calcium chloride

STRENGTH & TEMP.-TIME FACTOR COLD WATER W/ CALCIUM CHLORIDE (Mix #2)

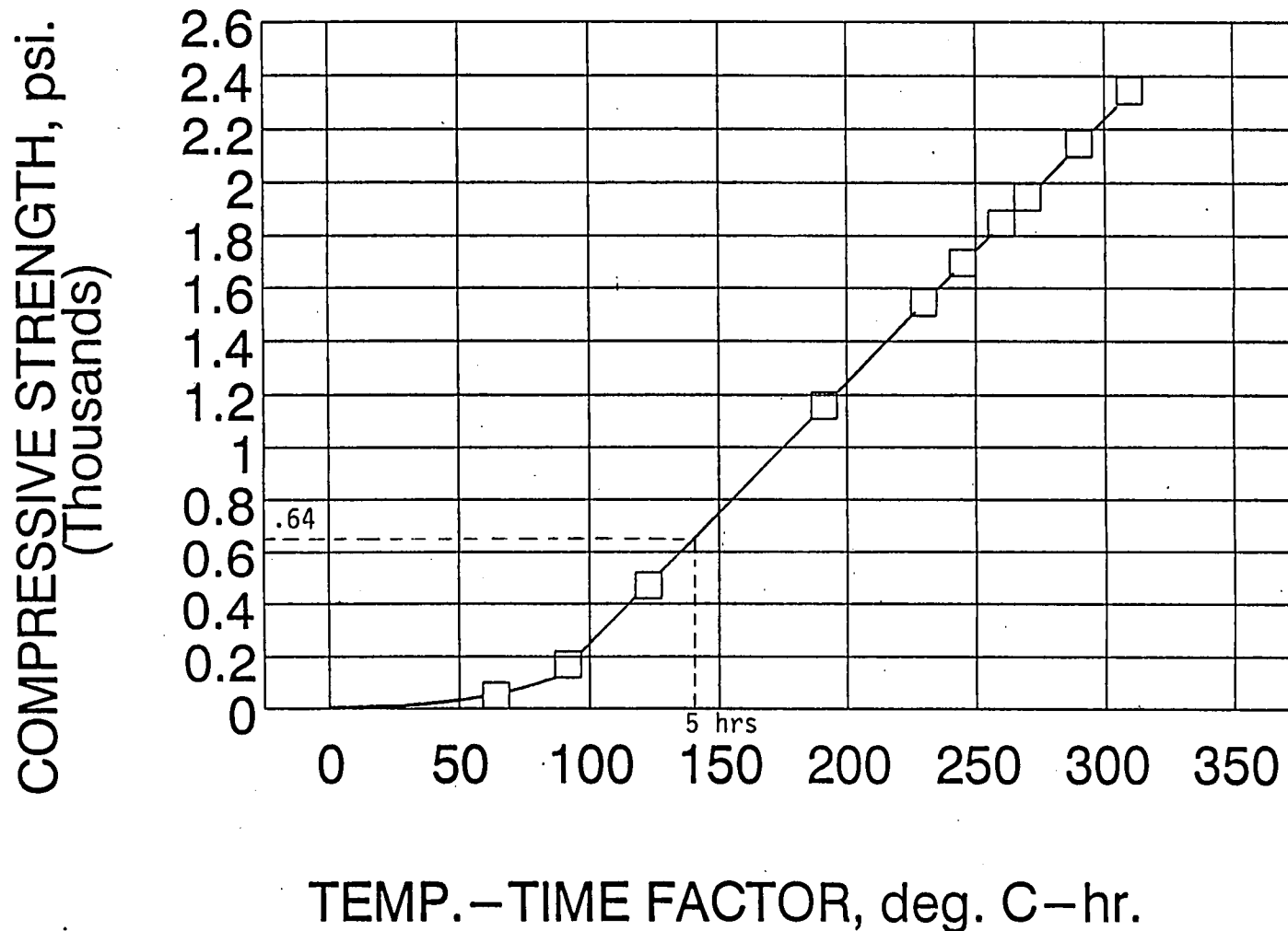


Figure 2. Cold water with calcium chloride

STRENGTH & TEMP.-TIME FACTOR
COLD WATER W/ CaCl₂ & WR
(Mix #3)

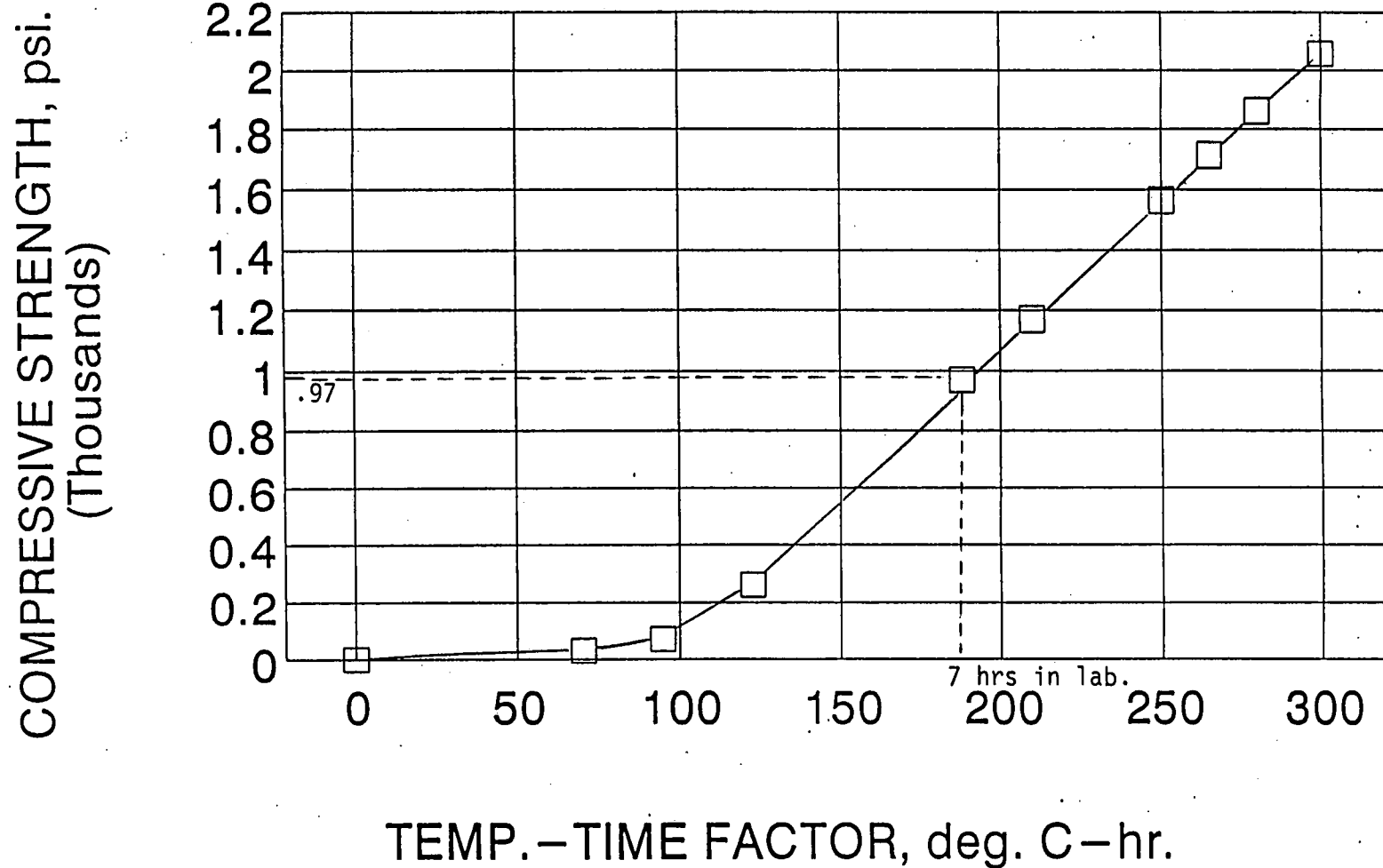


Figure 3. Cold water with calcium chloride and water reducer

STRENGTH & TEMP.-TIME FACTOR WARM WATER W/O CaCl₂ (Mix #4)

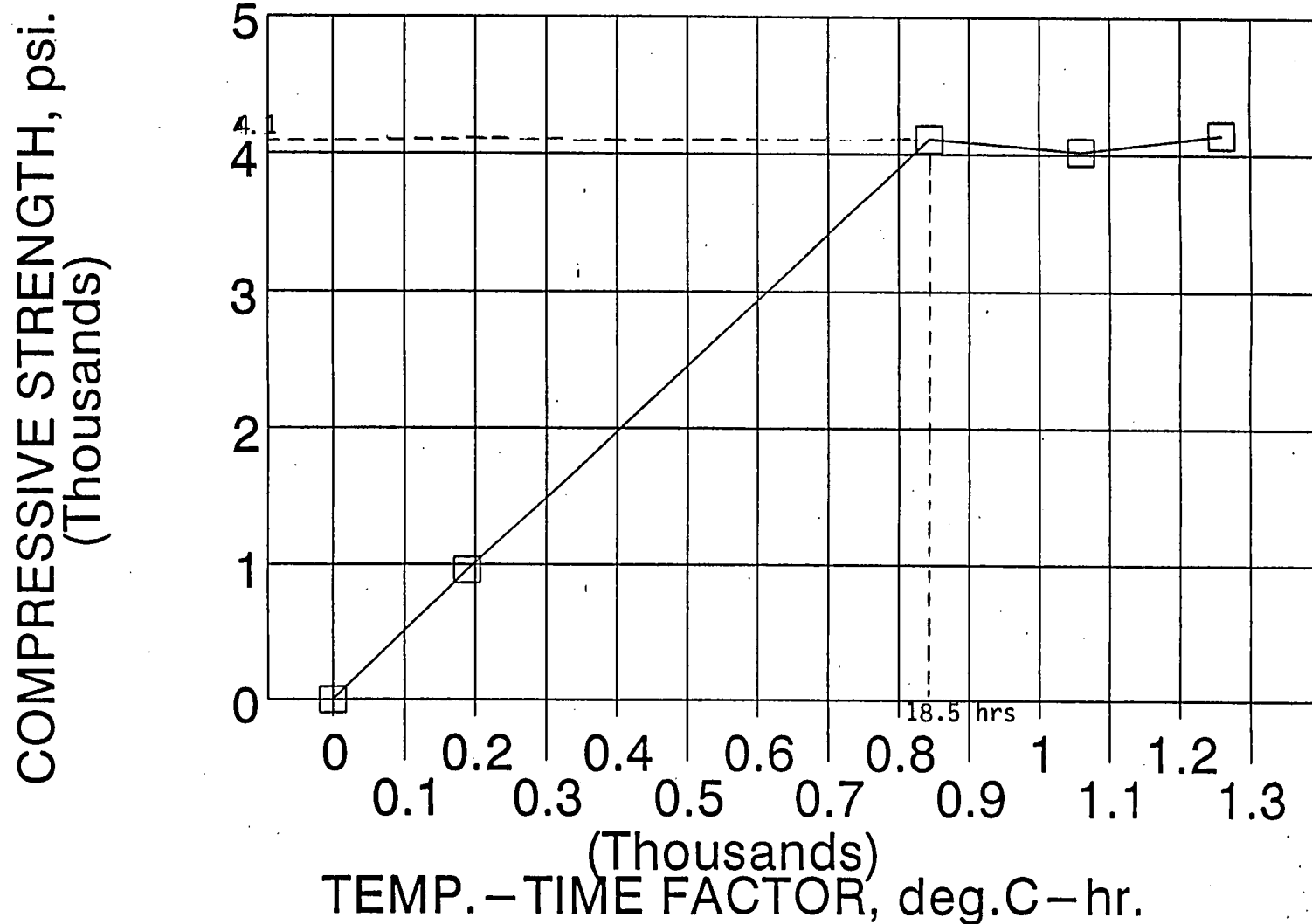


Figure 4. Warm water without calcium chloride

STRENGTH & TEMP.—TIME FACTOR HOT WATER W/ CALCIUM CHLORIDE (Mix #5)

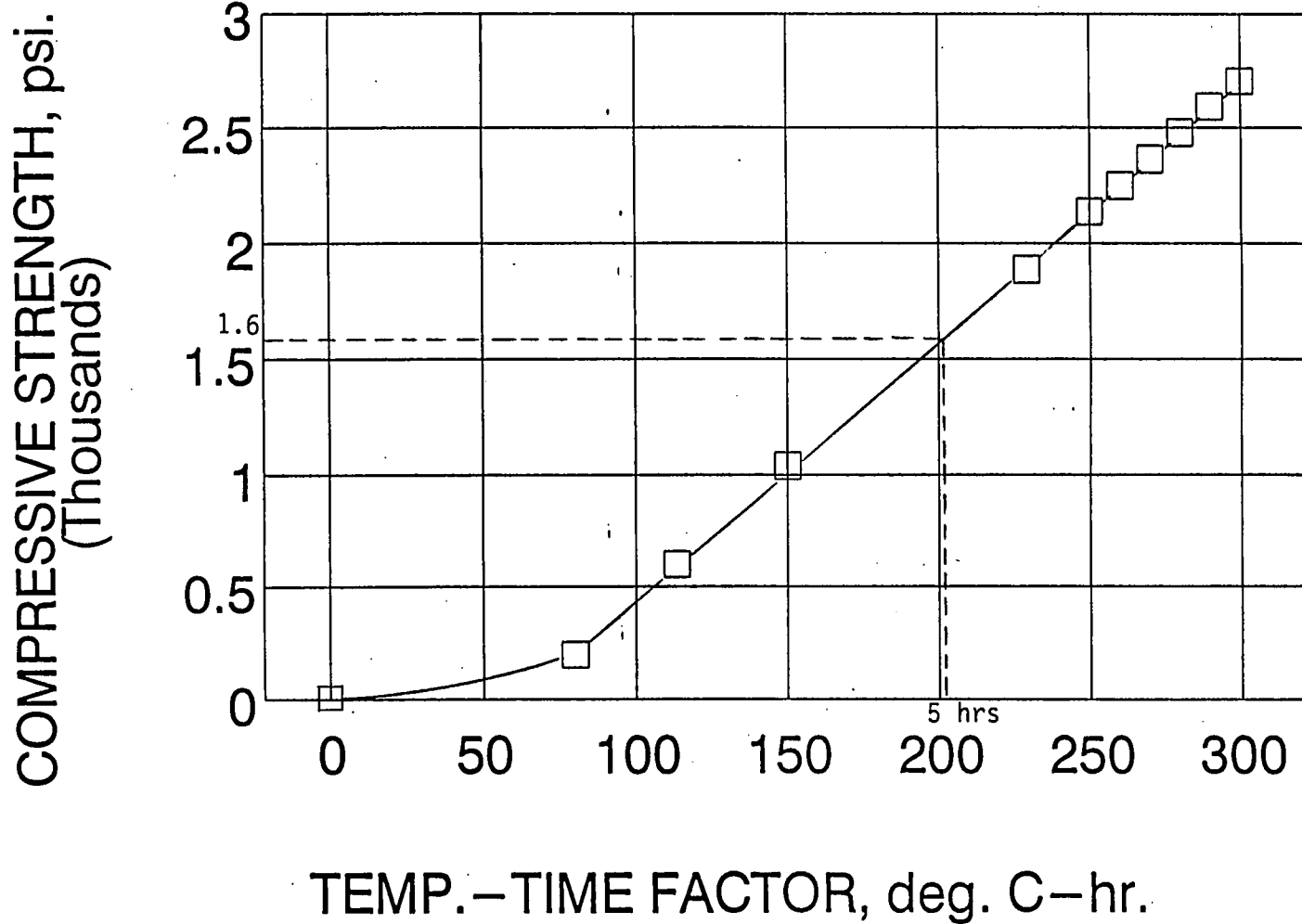


Figure 5. Hot water with calcium chloride

ANALYSIS OF RESULTS

Laboratory Results

Since the water used in the laboratory was only warm, the initial concrete temperature was much lower than expected. This, however, should not have affected the maturity calculation and compressive strength-maturity relationship.

The compressive strength of Mixes #1 & #4 appeared to reach the maximum point after 24 hours. It was only a slight difference in strength between the concrete with cold water and warm water. This concrete is intended to be used for 36-hour curing so there was no calcium chloride in the mix. Also, there was only a slight difference in compressive strengths between the 24-hour and 36-hour curing times.

The compressive strength of concrete with calcium chloride was low after 5 hours of curing. With the warm water the compressive strength was only 1,040 psi. With the cold water the compressive strength was 470 psi. With the cold water and water reducer the compressive strength was only 260 psi.

The compressive strength and maturity relationship for the concrete with calcium chloride appeared to be linear during the first seven hours.

Field Results

The concrete temperature in the field was much higher than that in the laboratory. This produced a much higher maturity in

the same time interval. Using the compressive strength and maturity relationship developed in the laboratory, the following predictions were obtained on curing time and compressive strength.

For the concrete with cold water and no calcium chloride the a compressive strength of almost 4,000 psi could be achieved in 22.5 hours.

For the concrete with cold water and with calcium chloride the compressive strength after five hours of curing was 640 psi.

For the concrete with cold water, calcium chloride, and water reducer there was no data available. However, it is speculated that the compressive strength after five hours would be lower than 640 psi.

For the concrete with hot water and calcium chloride the compressive strength is predicted to be around 1,600 psi after 5 hours.

For the concrete with hot water and no calcium chloride a compressive strength of about 4,100 psi could be achieved in 18 hours.

DISCUSSION

In the laboratory, the compressive strength of the concrete with calcium chloride and warm water was higher than that of the cold water and much higher than that of the cold water and water reducer. The water reducer in this case was acting as a retarder. Therefore, the compressive strength was lower. It seemed to be valid that warmer water provided higher maturity and as a result, higher compressive strength. Based on what was obtained in the laboratory and in the field, water reducer is not recommended and hot water must be used for five-hour patches. The predicted compressive strength of concrete with cold water and calcium chloride after five hours was about 640 psi and that of the concrete with the addition of water reducer would be much lower than 640 psi. The field data indicated that even with hot water and calcium chloride the predicted compressive strength after five hours was about 1,600 psi. This suggested that our present specification may be adequate for two-lane section full depth patches. However, if a higher compressive strength is desired during cold weather, a longer curing time is required. Figure 5 showed that a curing time of almost six hours is required to obtain a compressive strength of 2,000 psi.

Since there was not a significant difference in compressive strength between the concrete with cold and hot water, the cold water may be used for 36-hour curing on multi-lane section patches. The laboratory testing indicated that the compressive

strength was sufficient after 24 hours. Once again, because the concrete temperature in the field was higher, this strength could be obtained in less than 24 hours. Therefore, our present specification which requires 36 hours of curing time is more than adequate. The compressive strength of the concrete with cold or hot water could attain more than 4,000 psi after 36 hours under cold weather.

CONCLUSIONS AND RECOMMENDATIONS

From the data collected in the research, the following conclusions and recommendations were made:

1) The present specifications regarding the curing time and concrete temperature for two-lane full depth patches may be adequate. Hot water must be used when cold weather is expected. The specifications for multi-lane full depth patches are more than adequate.

2) The compressive strength for concrete with hot water and calcium chloride is predicted to be about 1,600 psi after five hours and that with hot or cold water and no calcium chloride is predicted to be more than 4,000 psi after 36 hours. However, if a higher compressive strength is desired for two-lane full depth patches, longer curing time is required. Based on the data, a curing time of six hours would provide a compressive strength of 2,000 psi.

3) The water reducer should not be used for two-lane full depth patches because it behaves like a retarder for a short duration.

4) The compressive strength for concrete with cold water and calcium chloride is predicted to be about 640 psi after five hours. Thus, cold water is not recommended for two-lane patches.

5) Since there is only a slight difference in compressive strength between the concrete with cold and hot water after 36 hours of curing, the present specification requiring a minimum of

75°F for concrete temperature may be eliminated for 36-hour patches.

6) An adequate compressive strength of the concrete mixes without calcium chloride may be obtained in 24 hours or less.

7) Based on research data for 5-hour patches, from both laboratory and field, it is recommended that the curing time for these patches be extended to 6 hours during the cold weather.

RECOMMENDATIONS FOR FURTHER STUDY

This is the first time this research is performed and during this research, it was found that water reducer was acting like a retarder during the early stage. Therefore, the compressive strength was low during the early hours even though the calculated maturity was high. From what was found in Mix #3 the concrete strength was affected by admixtures. Actually, when an admixture is used, the datum temperature used to calculate the maturity must be changed. However, there is no information on what it should be changed to. Also, during the research the compressive strength in the field was only predicted based on the relationship developed in the lab. No actual field compressive strength was obtained due to projects being too far away from the laboratory. Hence, the following recommendations are made for further study:

1. Repeat the same research with the full depth patching projects near Ames so that more information on field compressive strength and maturity is obtained.
2. Perform the research at different seasons (early spring, summer, and late fall, etc.) to investigate the temperature effect on the concrete curing time.
3. Evaluate the influence of admixtures on concrete strength and derive the datum temperature for the admixtures in the maturity calculation.

REFERENCES

1. S. A. Mindess and J. F. Young. Concrete. Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1981.
2. 1992 Annual Book of ASTM Standards, Volume 04.02, "Concrete and Aggregates", Philadelphia, PA, 1992.

APPENDIX

PROJECT TITLE

Evaluation of Concrete Patching Mixes and Opening Time
Using the Maturity Concept.

PRINCIPAL INVESTIGATORS

Champ L. Narotam & John H. Vu

PURPOSE

For full-depth concrete patching projects, the Iowa Department of Transportation specification requires a minimum curing time of five (5) hours before opening to traffic. This is required regardless of calendar date. Nevertheless, the hydration of cement is greatly affected by both the time and the temperature during hydration. Thus, the gain in strength of the concrete is also controlled by these two factors. By specifying only the curing time of five hours, the concrete may be strong enough during the summer but may not be during the fall due to the temperature difference. Therefore, a better understanding of concrete strength for our patching project may be helpful in determining the opening time.

The following questions should be answered:

1. What strength are we getting in five hours?
Is it high enough?
2. Could the curing time be shorter than five hours during the summer but longer during the fall?

OBJECTIVE

The objective of the study is to determine the maturity of M-mix with calcium chloride for full-depth patching and the time it takes to provide adequate strength for opening to traffic.

PROCEDURE

An M-mix is used to make 13 cylinders (4½" X 9"). One of these cylinders will be used with a thermocouple in the center to check for temperature at different time. Three cylinders will be used to determine compressive strength at 1 hr, 3 hrs, 5 hrs, and 7 hrs. The compressive strength, concrete temperature, and time

data will be used to determine the relationship between strength and maturity. This relationship will then be used to determine the opening time for full-depth patching project with the field available concrete temperatures.

Based on the laboratory information, field testing will be performed to predict the concrete strength and opening time.

RESPONSIBILITIES

- * Jim Grove, P.C. Concrete Engineer, will obtain the materials for our study and schedule the field testing with the contractors through the appropriate resident engineer.
- * The Cement and Concrete Section will perform the mixing and testing.
- * John H. Vu will be responsible for preparation of a final report.

IOWA DEPARTMENT OF TRANSPORTATION

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TO OFFICE: Central Materials DATE: October 20, 1993
ATTENTION: Champ Narotam & John Vu REF. NO.:
FROM: Jim Grove
OFFICE: Materials
SUBJECT: MLR-93-7
 Evaluation of Concrete Patching Mixes and Opening Time
 Using to Maturity Concept

I talked with Dick Fratzke from Cedar Falls Construction yesterday, Tuesday, October 19, 1993, about working with us on this research. He is very willing to help us with this work. The Story County I-35 patching job was completed yesterday. They will be moving to I-80, MP 215 to 225, at the end of this week. We agreed that the I-80 project should work okay for this research.

The concrete will come from Marengo Ready Mix out of their Williamsburg plant. He will arrange for samples of the material to be brought to the lab this week, at least by Friday. He feels Wednesday would be the best day to test. They may be done by Friday or not be allowed to patch that day since the next day will be a home football game in Iowa City.

We talked about four patches for testing. All would be constructed on the interstate, even the chloride ones. That would allow a longer monitoring time in case strength was not achieved after five hours. The four patches would be:

1. Standard five hour patch with PCC at 75°, as per the current specification.
2. Standard five hour patch, with PCC at current temperature with no heated water.
3. Standard 36 hour patch with PCC at 75°.
4. Standard 36 hour patch with PCC at current temperature.

Patches normally take about one half of a truck load of concrete so he'll plan to place two patches with each concrete mix discussed above. We may want to monitor both, depending on our equipment and procedure.

I will try to contact Dick on Friday to confirm these details. Since I will be out next week with the PCC rating team, I would ask that you make arrangements for the personnel and equipment that will be needed to conduct the research.

JG:tlm

cc: B. Brown
M. Bortle
K. Yanna
R. Boulet



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IOWA CONCRETE PAVING ASSOCIATION

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 FAX (515) 278-6587

| | | |
|--|--------------------------------|----------------|
| Post-It™ brand fax transmittal memo 7671 | | # of pages • / |
| To: <i>Dick Vu</i> | From: <i>Lori Tiefenthaler</i> | |
| Co. <i>IDOT</i> | Co. <i>ICPA</i> | |
| Dept. | Phone # <i>515-278-0608</i> | |
| Fax # <i>239-1092</i> | Fax # | |

10/22/93

Memorandum to: Jim Grove P.E., IDOT
 Champak Narotam P.E., IDOT
 John Vu P.E., IDOT
 Dick Fratzke, Cedar Falls Construction
 Todd Clancy, IRMCA

From: Lori Tiefenthaler

RE: PATCHING RESEARCH - MATURITY CONCEPT: MLR-93-7

Five different types of concrete patch mixtures will be monitored, the order of these mixes will need to be coordinated in the field between the contractor, the ready mix producer and IDOT testing personnel.

1. M-4 Current temperature w/o Cal. - 36 hour patch.
(target 60-65 degrees)
2. M-4 Current temperature with Cal. 5 hour patch.
(target 60-65 degrees)
3. M-4-WR Current temperature with Cal. 5 hour patch.
(target 60-65 degrees)
Discuss with the contractor if the Water Reducer
had any negative affects on workability.
4. M-4 75 degree temperature w/o Cal. (Hot Water)
36 hour patch.
5. M-4 75 degree temperature with Cal. (Hot Water)
5 hour patch.

CONCRETE MIX DESIGN

PROJECT NO.: MLR-93-7

PROJECT TITLE: PATCHING MIXES, USING MATURITY CONCEPT

MIX TYPE: M-4

MIX NO.: MIX NO.1 W/O CACL2 (60-65 DEG.F) DATE: 10\25\93

MATERIALS:

Cement: 0 Specific Gravity= 3.14
 Fine Aggregate: RURAL MARENGO
 *** Specific Gravity= 2.63
 Coarse Aggregate: CONKLIN QUARRY, IOWA CITY
 *** Specific Gravity= 2.66
 Air Entraining Agent: PROTEX 0.8 Oz./94 lbs. cement
 Design W/C = 0.356

| ITEM | ABS. VOLUME, lb./1.0 ft3 | lb./ 1.25 ft3 |
|--|---------------------------------|---------------|
| Cement: 825.0 lb./yd3 | 0.1559 X 3.14 X 62.4 = 30.56 | 38.2 |
| Water: 293.7 lb./yd3 | 0.1743 X 1 X 62.4 = 10.88 | 13.6 |
| Fine Aggregate: 1339.8 lb./yd3 | 0.3024 X 2.63 X 62.4 = 49.62 | 62.0 |
| Coarse Aggregate: 1355.1 lb./yd3 | 0.3024 X 2.66 X 62.4 = 50.19 | 62.7 |
| Air Entraining Agent: 0.8 Oz./94 lbs. cement | 30.56 X 0.009 X 29.57 = 7.69 cc | 9.6 cc |

Date Mixed: Slump: 1 AND in. +/- 4 in. max.
 Air: 6.5 % +/- 1.5 %

| | |
|--------------------------|---------------------------|
| First Trial: Slump-_____ | Second Trial: Slump-_____ |
| Air-_____ | Air-_____ |
| Unit Wt.-_____ | Unit Wt.-_____ |
| Water Used-_____ | Water Used-_____ |

Notes: Make 13 cylinders, 4.5"X 9. Break 3 cylinders
 at 1, 3, 5, and 7 hrs. at

| | | | |
|---------|---------------|---------------|---------------|
| | SIZE/WT. BAT. | SIZE/WT. BAT. | SIZE/WT. BAT. |
| COARSE: | 3/4 ***** | 3/8 ***** | #8 ***** |
| | 1/2 ***** | #4 ***** | -#200 ***** |

 Vol. Ck = ERR

CONCRETE MIX DESIGN

PROJECT NO.: MLR-93-7

PROJECT TITLE: PATCHING MIXES, USING MATURITY CONCEPT

MIX TYPE: M-4

MIX NO.: MIX NO.2 WITH CACL2 (60-65 DEG.F) DATE: 10\25\93

MATERIALS:

Cement: 0 Specific Gravity= 3.14

Fine Aggregate: RURAL MARENGO
*** Specific Gravity= 2.63Coarse Aggregate: CONKLIN QUARRY, IOWA CITY
*** Specific Gravity= 2.66

Air Entraining Agent: PROTEX 0.7 Oz./94 lbs. cement

Design W/C = 0.356

| ITEM | ABS. VOLUME, lb./1.0 ft3 | | | | lb./ 1.25 ft3 | | | |
|------------------------|--------------------------|---|-------|---|---------------|---|---------|--------|
| Cement: | 0.1559 | X | 3.14 | X | 62.4 | = | 30.56 | 38.2 |
| 825.0 lb./yd3 | | | | | | | | |
| Water: | 0.1743 | X | 1 | X | 62.4 | = | 10.88 | 13.6 |
| 293.7 lb./yd3 | | | | | | | | |
| Fine Aggregate: | 0.3099 | X | 2.63 | X | 62.4 | = | 50.85 | 63.6 |
| 1373.0 lb./yd3 | | | | | | | | |
| Coarse Aggregate: | 0.3099 | X | 2.66 | X | 62.4 | = | 51.43 | 64.3 |
| 1388.7 lb./yd3 | | | | | | | | |
| Air Entraining Agent: | 30.56 | X | 0.007 | X | 29.57 | = | 6.73 cc | 8.4 cc |
| 0.7 Oz./94 lbs. cement | | | | | | | | |

Date Mixed: Slump: *1 and 2 in.* *3 in. Max.*
~~1 AND in.~~ +/- ~~3 IN.in.~~
 Air: 5 % +/- 2 %

First Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Second Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Notes: Make 13 cylinders 4.5" X 9". Break 3 cylinders at 1, 3, 5, and 7 hrs.

| | | | | | |
|---------|--------------|--|--------------|--|--------------|
| | SIZE/WT.BAT. | | SIZE/WT.BAT. | | SIZE/WT.BAT. |
| COARSE: | 3/4 ***** | | 3/8 ***** | | #8 ***** |
| | 1/2 ***** | | #4 ***** | | -#200 ***** |

CONCRETE MIX DESIGN

PROJECT NO.: MLR-93-7
 PROJECT TITLE: PATCHING MIXES, USING MATURITY CONCEPT
 MIX TYPE: M-4
 MIX NO.: MIX NO.3 WITH CACL2 AND WR (60-65 DEGDATE: 10\25\93)

MATERIALS:

Cement: 0 Specific Gravity= 3.14
 Fine Aggregate: RURAL MARENGO
 *** Specific Gravity= 2.63
 Coarse Aggregate: CONKLIN QUARRY, IOWA CITY
 *** Specific Gravity= 2.66
 Air Entraining Agent: PROTEX 0.7 Oz./94 lbs. cement
 Water Reducer: N-3 3 Oz./100 lbs. cement
 Design W/C = 0.356

| ITEM | ABS. VOLUME, lb./1.0 ft3 | | | | | | lb./ 1.25 ft3 |
|-------------------------|--------------------------|---|-------|---|-------|------------|---------------|
| Cement: | 0.1559 | X | 3.14 | X | 62.4 | = 30.56 | 38.2 |
| 825.0 lb./yd3 | | | | | | | |
| Water: | 0.1743 | X | 1 | X | 62.4 | = 10.88 | 13.6 |
| 293.7 lb./yd3 | | | | | | | |
| Fine Aggregate: | 0.3099 | X | 2.63 | X | 62.4 | = 50.85 | 63.6 |
| 1373.0 lb./yd3 | | | | | | | |
| Coarse Aggregate: | 0.3099 | X | 2.66 | X | 62.4 | = 51.43 | 64.3 |
| 1388.7 lb./yd3 | | | | | | | |
| Air Entraining Agent: | 30.56 | X | 0.007 | X | 29.57 | = 6.73 cc | 8.4 cc |
| 0.7 Oz./94 lbs. cement | | | | | | | |
| Water Reducer: | 30.56 | X | 0.030 | X | 29.57 | = 27.11 cc | 33.9 cc |
| 3.0 Oz./100 lbs. cement | | | | | | | |

Date Mixed: Slump: 1 AND in. +/- 3 IN.in.
 Air: 5 % +/- 2 %

First Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Second Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Notes: Make 13 cylinders 4.5" X 9". Break 3 cylinders at 1, 3, 5, and 7 hrs.

| | | | |
|---------|--------------|--------------|--------------|
| | SIZE/WT.BAT. | SIZE/WT.BAT. | SIZE/WT.BAT. |
| COARSE: | 3/4 ***** | 3/8 ***** | #8 ***** |

CONCRETE MIX DESIGN

PROJECT NO.: MLR-93-7

PROJECT TITLE: PATCHING MIXES, USING MATURITY CONCEPT

MIX TYPE: M-4

MIX NO.: MIX NO.4 W/O CACL2 (75 DEG.F)

DATE: 10\25\93

MATERIALS:

Cement: 0 Specific Gravity= 3.14
 Fine Aggregate: RURAL MARENGO
 *** Specific Gravity= 2.63
 Coarse Aggregate: CONKLIN QUARRY, IOWA CITY
 *** Specific Gravity= 2.66
 Air Entraining Agent: PROTEX 0.8 Oz./94 lbs. cement
 Design W/C = 0.356

| ITEM | ABS. VOLUME, lb./1.0 ft3 | lb./ 1.25 ft3 |
|---|--------------------------|---------------|
| Cement: 0.1559 X 3.14 X 62.4 = 30.56 | 38.2 | |
| 825.0 lb./yd3 | | |
| Water: 0.1743 X 1 X 62.4 = 10.88 | 13.6 | |
| 293.7 lb./yd3 | | |
| Fine Aggregate: 0.3024 X 2.63 X 62.4 = 49.62 | 62.0 | |
| 1339.8 lb./yd3 | | |
| Coarse Aggregate: 0.3024 X 2.66 X 62.4 = 50.19 | 62.7 | |
| 1355.1 lb./yd3 | | |
| Air Entraining Agent: 30.56 X 0.009 X 29.57 = 7.69 cc | 9.6 cc | |
| 0.8 Oz./94 lbs. cement | | |

Date Mixed: Slump: 1 AND in. +/- 4 in. max.
 Air: 6.5 % +/- 1.5 %

First Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Second Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Notes: Make 13 cylinders 4.5" X 9". Break 3 cylinders at

| | SIZE/WT.BAT. | SIZE/WT.BAT. | SIZE/WT.BAT. |
|---------|--------------|--------------|--------------|
| COARSE: | 3/4 ***** | 3/8 ***** | #8 ***** |
| | 1/2 ***** | #4 ***** | -#200 ***** |

 Vol. Ck = ERR

CONCRETE MIX DESIGN

PROJECT NO.: MLR-93-7

PROJECT TITLE: PATCHING MIXES, USING MATURITY CONCEPT

MIX TYPE: M-4

MIX NO.: MIX NO.5 WITH CACL2 (75 DEG.F)

DATE: 10\25\93

MATERIALS:

Cement: 0 Specific Gravity= 3.14
 Fine Aggregate: RURAL MARENGO Specific Gravity= 2.63

 Coarse Aggregate: CONKLIN QUARRY, IOWA CITY
 *** Specific Gravity= 2.66
 Air Entraining Agent: PROTEX 0.7 Oz./94 lbs. cement
 Design W/C = 0.356

| ITEM | ABS. VOLUME, lb./1.0 ft3 | | | | | | lb./ 1.25 ft3 |
|------------------------|--------------------------|---|-------|---|-------|-----------|---------------|
| Cement: | 0.1559 | X | 3.14 | X | 62.4 | = 30.56 | 38.2 |
| 825.0 lb./yd3 | | | | | | | |
| Water: | 0.1743 | X | 1 | X | 62.4 | = 10.88 | 13.6 |
| 293.7 lb./yd3 | | | | | | | |
| Fine Aggregate: | 0.3099 | X | 2.63 | X | 62.4 | = 50.85 | 63.6 |
| 1373.0 lb./yd3 | | | | | | | |
| Coarse Aggregate: | 0.3099 | X | 2.66 | X | 62.4 | = 51.43 | 64.3 |
| 1388.7 lb./yd3 | | | | | | | |
| Air Entraining Agent: | 30.56 | X | 0.007 | X | 29.57 | = 6.73 cc | 8.4 cc |
| 0.7 Oz./94 lbs. cement | | | | | | | |

Date Mixed: Slump: 1 AND in. +/- 3 in. max.
 Air: 5 % +/- 2 %

First Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Second Trial: Slump-_____
 Air-_____
 Unit Wt.-_____
 Water Used-_____

Notes: Make 13 cylinders 4.5" X 9". Break 3 cylinders at
 1, 3, 5, and 7 hrs.

| | SIZE/WT.BAT. | SIZE/WT.BAT. | SIZE/WT.BAT. |
|---------|--------------|--------------|--------------|
| COARSE: | 3/4 ***** | 3/8 ***** | #8 ***** |
| | 1/2 ***** | #4 ***** | -#200 ***** |

Maturity Concept**In Lab Testing****Assume datum temp. is 0 deg. Celcius.****Wednesday 11/3/93**

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Mix #1: Cold water w/o calcium chloride.

| Mix #1 Conc. T. (deg. F) | Mix #1 Conc. T. (deg. C) | Mix #1 Maturity (deg. -hr) | Mix #1 Comp. Str (psi) | Hours |
|---|---|---|---------------------------------------|--------------|
| 70.8 | 21.6 | 5.4 | | |
| 76.2 | 24.6 | 11.5 | | |
| 80.6 | 27.0 | 18.3 | | |
| 65.44 | 18.6 | 22.9 | | |
| 66.54 | 19.2 | 27.7 | | 1-hr |
| 67.12 | 19.5 | 32.6 | | |
| 67.49 | 19.7 | 37.5 | | |
| 67.84 | 19.9 | 42.5 | | |
| 68.2 | 20.1 | 47.5 | | 2-hrs |
| 68.54 | 20.3 | 52.6 | | |
| 68.92 | 20.5 | 57.7 | | |
| 69.33 | 20.7 | 62.9 | | |
| 69.77 | 21.0 | 68.2 | | 3-hrs |
| 70.2 | 21.2 | 73.5 | | |
| 70.7 | 21.5 | 78.8 | | |
| 71.2 | 21.8 | 84.3 | | |
| 71.8 | 22.1 | 89.8 | | 4-hrs |
| 72.4 | 22.4 | 95.4 | | |
| 73.1 | 22.8 | 101.1 | | |
| 73.8 | 23.2 | 106.9 | | |
| 74.6 | 23.7 | 112.9 | | 5-hrs |
| 75.4 | 24.1 | 118.9 | | |
| 76.2 | 24.6 | 125.0 | | |
| 77.2 | 25.1 | 131.3 | | |
| 78.1 | 25.6 | 137.7 | | 6-hrs |
| 79 | 26.1 | 144.2 | | |
| 80.1 | 26.7 | 150.9 | | |
| 81.2 | 27.3 | 157.7 | | |
| 82.4 | 28.0 | 164.7 | 340 | 7-hrs |
| 83.6 | 28.7 | 171.9 | | |
| 84.8 | 29.3 | 179.2 | | |
| 86 | 30.0 | 186.7 | | |
| 87.2 | 30.7 | 194.4 | | 8-hrs |
| 88.5 | 31.4 | 202.3 | | |
| 89.7 | 32.1 | 210.3 | | |
| 91 | 32.8 | 218.5 | | |
| 92.1 | 33.4 | 226.8 | | 9-hrs |
| 93.3 | 34.1 | 235.3 | | |
| 94.4 | 34.7 | 244.0 | | |
| 95.4 | 35.2 | 252.8 | | |
| 96.3 | 35.7 | 261.7 | | 10-hrs |

Maturity Concept**In Lab Testing****Assume datum temp. is 0 deg. Celcius.****Page 2****Wednesday 11/3/93****Page 34****Mix #1: Cold water w/o calcium chloride.**

| <i>Mix #1 Conc. T. (deg. F)</i> | <i>Mix #1 Conc. T. (deg. C)</i> | <i>Mix #1 Maturity (deg. -hr)</i> | <i>Mix #1 Comp. Str (psi)</i> | <i>Hours</i> |
|---|---|---|---------------------------------------|--------------|
| 97.1 | 36.2 | 270.8 | | |
| 97.8 | 36.6 | 279.9 | | |
| 98.4 | 36.9 | 289.1 | | |
| 98.9 | 37.2 | 298.4 | | 11-hrs |
| 99.3 | 37.4 | 307.8 | | |
| 99.7 | 37.6 | 317.2 | | |
| 99.9 | 37.7 | 326.6 | | |
| 100.1 | 37.8 | 336.1 | | 12-hrs |
| 100.3 | 37.9 | 345.6 | | |
| 100.4 | 38.0 | 355.1 | | |
| 100.5 | 38.1 | 364.6 | | |
| 100.5 | 38.1 | 374.1 | | 13-hrs |
| 100.5 | 38.1 | 383.6 | | |
| 100.5 | 38.1 | 393.1 | | |
| 100.6 | 38.1 | 402.6 | | |
| 100.6 | 38.1 | 412.2 | | 14-hrs |
| 100.7 | 38.2 | 421.7 | | |
| 100.7 | 38.2 | 431.2 | | |
| 100.7 | 38.2 | 440.8 | | |
| 100.7 | 38.2 | 450.3 | | 15-hrs |
| 100.6 | 38.1 | 459.9 | | |
| 100.6 | 38.1 | 469.4 | | |
| 100.6 | 38.1 | 478.9 | | |
| 100.5 | 38.1 | 488.4 | | 16-hrs |
| 100.5 | 38.1 | 497.9 | | |
| 100.4 | 38.0 | 507.4 | | |
| 100.4 | 38.0 | 516.9 | | |
| 100.3 | 37.9 | 526.4 | | 17-hrs |
| 100.3 | 37.9 | 535.9 | | |
| 100.2 | 37.9 | 545.4 | | |
| 100.1 | 37.8 | 554.8 | | |
| 100.1 | 37.8 | 564.3 | | 18-hrs |
| 100 | 37.8 | 573.7 | | |
| 100 | 37.8 | 583.2 | | |
| 99.9 | 37.7 | 592.6 | | |
| 99.8 | 37.7 | 602.0 | | 19-hrs |

| Mix #1 Conc. T. (deg. F) | Mix #1 Conc. T. (deg. C) | Mix #1 Maturity (deg. -hr) | Mix #1 Comp. Str (psi) | Hours |
|--------------------------------|--------------------------------|----------------------------------|------------------------------|--------|
| 99.7 | 37.6 | 611.4 | | |
| 99.7 | 37.6 | 620.8 | | |
| 99.6 | 37.6 | 630.2 | | |
| 99.5 | 37.5 | 639.6 | | 20-hrs |
| 99.4 | 37.4 | 649.0 | | |
| 99.2 | 37.3 | 658.3 | | |
| 99.1 | 37.3 | 667.6 | | |
| 99 | 37.2 | 676.9 | | 21-hrs |
| 98.9 | 37.2 | 686.2 | | |
| 98.8 | 37.1 | 695.5 | | |
| 98.7 | 37.1 | 704.8 | | |
| 98.6 | 37.0 | 714.0 | | 22-hrs |
| 98.5 | 36.9 | 723.2 | | |
| 98.3 | 36.8 | 732.5 | | |
| 98.2 | 36.8 | 741.7 | | |
| 98.1 | 36.7 | 750.8 | | 23-hrs |
| 98 | 36.7 | 760.0 | | |
| 97.8 | 36.6 | 769.1 | | |
| 97.5 | 36.4 | 778.2 | | |
| 97.4 | 36.3 | 787.3 | 3780 | 24-hrs |
| 97.1 | 36.2 | 796.4 | | |
| 96.8 | 36.0 | 805.4 | | |
| 96.5 | 35.8 | 814.3 | | |
| 96.2 | 35.7 | 823.2 | | 25-hrs |
| 95.9 | 35.5 | 832.1 | | |
| 95.6 | 35.3 | 840.9 | | |
| 95.3 | 35.2 | 849.7 | | |
| 95 | 35.0 | 858.5 | | 26-hrs |
| 94.7 | 34.8 | 867.2 | | |
| 94.4 | 34.7 | 875.9 | | |
| 94.1 | 34.5 | 884.5 | | |
| 93.8 | 34.3 | 893.1 | | 27-hrs |
| 93.5 | 34.2 | 901.6 | | |
| 93.3 | 34.1 | 910.1 | | |
| 93 | 33.9 | 918.6 | | |
| 92.7 | 33.7 | 927.0 | | 28-hrs |
| 92.4 | 33.6 | 935.4 | | |
| 92.2 | 33.4 | 943.8 | | |
| 92 | 33.3 | 952.1 | | |
| 91.8 | 33.2 | 960.4 | | 29-hrs |

Maturity Concept**In Lab Testing****Assume datum temp. is 0 deg. Celcius.****Page 4****Wednesday 11/3/93****Page 36****Mix #1: Cold water w/o calcium chloride.**

| <i>Mix #1 Conc. T. (deg. F)</i> | <i>Mix #1 Conc. T. (deg. C)</i> | <i>Mix #1 Maturity (deg. -hr)</i> | <i>Mix #1 Comp. Str (psi)</i> | <i>Hours</i> |
|---|---|---|---------------------------------------|--------------|
| 91.5 | 33.1 | 968.7 | 4050 | 30-hrs |
| 91.3 | 32.9 | 976.9 | | |
| 91.1 | 32.8 | 985.1 | | |
| 90.9 | 32.7 | 993.3 | | |
| 90.7 | 32.6 | 1001.5 | | |
| 90.5 | 32.5 | 1009.6 | | 31-hrs |
| 90.1 | 32.3 | 1017.7 | | |
| 89.7 | 32.1 | 1025.7 | | |
| 89.3 | 31.8 | 1033.6 | | |
| 89 | 31.7 | 1041.5 | | |
| 88.7 | 31.5 | 1049.4 | 4200 | 32-hrs |
| 88.4 | 31.3 | 1057.2 | | |
| 88 | 31.1 | 1065.0 | | |
| 87.8 | 31.0 | 1072.8 | | |
| 87.5 | 30.8 | 1080.5 | | |
| 87.2 | 30.7 | 1088.2 | | 33-hrs |
| 87 | 30.6 | 1095.8 | | |
| 86.8 | 30.4 | 1103.4 | | |
| 86.5 | 30.3 | 1111.0 | | |
| 86.3 | 30.2 | 1118.5 | | |
| 86.1 | 30.1 | 1126.0 | 4200 | 34-hrs |
| 85.9 | 29.9 | 1133.5 | | |
| 85.6 | 29.8 | 1141.0 | | |
| 85.5 | 29.7 | 1148.4 | | |
| 85.3 | 29.6 | 1155.8 | | |
| 85 | 29.4 | 1163.2 | | 35-hrs |
| 84.8 | 29.3 | 1170.5 | | |
| 84.6 | 29.2 | 1177.8 | | |
| 84.4 | 29.1 | 1185.1 | | |
| 84.2 | 29.0 | 1192.3 | | |

Maturity Concept

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Wednesday 10/27/93

M-4

Cold water without calcium chloride. (Mix # 1)

Field data

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Assume datum temperature is 0 degree Celcius.

| Time | Mach. T. (deg. C) | Conc. T. (deg. F) | Conc. T. (deg. C) | Maturity (deg.-hr) | Hours (hrs) |
|------|----------------------|----------------------|----------------------|-----------------------|----------------|
| 1430 | 13.15 | 67.3 | 19.6 | 4.9 | |
| 1445 | 14.44 | 67.03 | 19.5 | 9.8 | |
| 1500 | 14.72 | 67.27 | 19.6 | 14.7 | |
| 1515 | 14.82 | 67.6 | 19.8 | 19.6 | |
| 1530 | 14.96 | 67.96 | 20.0 | 24.6 | 1 |
| 1545 | 15.11 | 68.41 | 20.2 | 29.7 | |
| 1600 | 15.23 | 68.93 | 20.5 | 34.8 | |
| 1615 | 15.28 | 69.51 | 20.8 | 40.0 | |
| 1630 | 15.27 | 70.1 | 21.2 | 45.3 | 2 |
| 1645 | 15.16 | 70.9 | 21.6 | 50.7 | |
| 1700 | 15.08 | 71.6 | 22.0 | 56.2 | |
| 1715 | 14.89 | 72.4 | 22.4 | 61.8 | |
| 1730 | 14.55 | 73.2 | 22.9 | 67.5 | 3 |
| 1745 | 14.02 | 74.1 | 23.4 | 73.4 | |
| 1800 | 13.24 | 75.1 | 23.9 | 79.4 | |
| 1815 | 12.14 | 76 | 24.4 | 85.5 | |
| 1830 | 10.98 | 76.9 | 24.9 | 91.7 | 4 |
| 1845 | 9.84 | 77.9 | 25.5 | 98.1 | |
| 1900 | 8.8 | 78.9 | 26.1 | 104.6 | |
| 1915 | 7.93 | 80 | 26.7 | 111.3 | |
| 1930 | 7.23 | 81.1 | 27.3 | 118.1 | 5 |
| 1945 | 6.705 | 82.3 | 27.9 | 125.1 | |
| 2000 | 6.29 | 83.7 | 28.7 | 132.3 | |
| 2015 | 5.988 | 85 | 29.4 | 139.6 | |
| 2030 | 5.755 | 86.4 | 30.2 | 147.2 | 6 |
| 2045 | 5.553 | 87.8 | 31.0 | 154.9 | |
| 2100 | 5.369 | 89.3 | 31.8 | 162.9 | |
| 2115 | 5.178 | 90.8 | 32.7 | 171.0 | |
| 2130 | 5.04 | 92.2 | 33.4 | 179.4 | 7 |
| 2145 | 4.934 | 93.6 | 34.2 | 188.0 | |
| 2200 | 4.86 | 94.9 | 34.9 | 196.7 | |
| 2215 | 4.85 | 96.2 | 35.7 | 205.6 | |
| 2230 | 4.839 | 97.3 | 36.3 | 214.7 | 8 |
| 2245 | 4.818 | 98.4 | 36.9 | 223.9 | |
| 2300 | 4.807 | 99.3 | 37.4 | 233.3 | |
| 2315 | 4.807 | 100.1 | 37.8 | 242.7 | |
| 2330 | 4.839 | 100.8 | 38.2 | 252.3 | 9 |
| 2345 | 4.881 | 101.5 | 38.6 | 261.9 | |
| 0 | 4.913 | 102 | 38.9 | 271.6 | |
| 15 | 4.913 | 102.5 | 39.2 | 281.4 | |
| 30 | 4.913 | 102.8 | 39.3 | 291.3 | 10 |

Maturity Concept

I-80

Wednesday 10/27/93

Page 2

M-4

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Cold water without calcium chloride.

Assume datum temperature is 0 degree Celcius.

Mix # 1, Field Data

| Time | Mach. T. (deg. C) | Conc. T. (deg. F) | Conc. T. (deg. C) | Maturity (deg.-hr) | Hours (hrs) |
|------|----------------------|----------------------|----------------------|-----------------------|----------------|
| 45 | 4.924 | 103.1 | 39.5 | 301.1 | 11 |
| 100 | 4.924 | 103.4 | 39.7 | 311.1 | |
| 115 | 4.966 | 103.6 | 39.8 | 321.0 | |
| 130 | 5.051 | 103.8 | 39.9 | 331.0 | |
| 145 | 5.104 | 103.9 | 39.9 | 341.0 | |
| 200 | 5.146 | 104.1 | 40.1 | 351.0 | 12 |
| 215 | 5.188 | 104.2 | 40.1 | 361.0 | |
| 230 | 5.231 | 104.2 | 40.1 | 371.0 | |
| 245 | 5.273 | 104.3 | 40.2 | 381.1 | |
| 300 | 5.284 | 104.4 | 40.2 | 391.1 | |
| 315 | 5.316 | 104.4 | 40.2 | 401.2 | 13 |
| 330 | 5.39 | 104.4 | 40.2 | 411.2 | |
| 345 | 5.485 | 104.4 | 40.2 | 421.3 | |
| 400 | 5.591 | 104.4 | 40.2 | 431.3 | |
| 415 | 5.697 | 104.4 | 40.2 | 441.4 | |
| 430 | 5.782 | 104.4 | 40.2 | 451.5 | 14 |
| 445 | 5.867 | 104.3 | 40.2 | 461.5 | |
| 500 | 5.931 | 104.3 | 40.2 | 471.5 | |
| 515 | 6.009 | 104.2 | 40.1 | 481.6 | |
| 530 | 6.094 | 104.2 | 40.1 | 491.6 | |
| 545 | 6.169 | 104.1 | 40.1 | 501.6 | 15 |
| 600 | 6.243 | 104 | 40.0 | 511.6 | |
| 615 | 6.297 | 103.9 | 39.9 | 521.6 | |
| 630 | 6.339 | 103.9 | 39.9 | 531.6 | |
| 645 | 6.382 | 103.8 | 39.9 | 541.6 | |
| 700 | 6.435 | 103.7 | 39.8 | 551.5 | 17 |
| 715 | 6.499 | 103.6 | 39.8 | 561.5 | |
| 730 | 6.552 | 103.5 | 39.7 | 571.4 | |
| 745 | 6.616 | 103.4 | 39.7 | 581.3 | |
| 800 | 6.701 | 103.2 | 39.6 | 591.2 | |
| 815 | 6.85 | 103.1 | 39.5 | 601.1 | 18 |
| 830 | 7.05 | 103 | 39.4 | 610.9 | |
| 845 | 7.36 | 102.8 | 39.3 | 620.8 | |
| 900 | 7.71 | 102.7 | 39.3 | 630.6 | |
| 915 | 8.01 | 102.6 | 39.2 | 640.4 | |
| 930 | 8.63 | 102.5 | 39.2 | 650.2 | 19 |
| 945 | 9.73 | 102.3 | 39.1 | 659.9 | |
| 1000 | 10.78 | 102.1 | 38.9 | 669.7 | |
| 1015 | 11.72 | 102 | 38.9 | 679.4 | |
| 1030 | 12.57 | 101.9 | 38.8 | 689.1 | |

Maturity Concept

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Wednesday 10/27/93

M-4

Cold water without calcium chloride.

Assume datum temperature is 0 degree Celcius.

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Mix #1, Field Data

| Time | Mach. T. (deg. C) | Conc. T. (deg. F) | Conc. T. (deg. C) | Maturity (deg.-hr) | Hours (hrs) |
|------|----------------------|----------------------|----------------------|-----------------------|----------------|
| 1045 | 13.18 | 101.8 | 38.8 | 698.8 | 21 |
| 1100 | 13.71 | 101.7 | 38.7 | 708.5 | |
| 1115 | 14.02 | 101.7 | 38.7 | 718.2 | |
| 1130 | 14.3 | 101.7 | 38.7 | 727.8 | |
| 1145 | 15.16 | 101.6 | 38.7 | 737.5 | |
| 1200 | 15.45 | 101.5 | 38.6 | 747.2 | 22 |
| 1215 | 15.53 | 101.4 | 38.6 | 756.8 | |
| 1230 | 15.92 | 101.4 | 38.6 | 766.4 | |
| 1245 | 16.3 | 101.2 | 38.4 | 776.1 | |
| 1300 | 16.54 | 101.2 | 38.4 | 785.7 | |
| 1315 | 16.68 | 101.1 | 38.4 | 795.3 | 23 |
| 1330 | 16.72 | 101 | 38.3 | 804.8 | |
| 1345 | 16.72 | 101 | 38.3 | 814.4 | |
| 1400 | 16.78 | 100.8 | 38.2 | 824.0 | |
| 1415 | 17.26 | 100.7 | 38.2 | 833.5 | |
| 1430 | 17.91 | 100.4 | 38.0 | 843.0 | 24 |
| 1445 | 18.14 | 99.8 | 37.7 | 852.4 | |
| 1500 | 18.2 | 99.1 | 37.3 | 861.8 | |
| 1515 | 18.25 | 98.7 | 37.1 | 871.0 | |
| 1530 | 18.36 | 98.4 | 36.9 | 880.3 | |
| 1545 | 18.44 | 98.2 | 36.8 | 889.4 | 25 |
| 1600 | 18.49 | 98.1 | 36.7 | 898.6 | |
| 1615 | 18.52 | 98 | 36.7 | 907.8 | |
| 1630 | 18.53 | 97.9 | 36.6 | 916.9 | |
| 1645 | 18.48 | 97.7 | 36.5 | 926.1 | |
| 1700 | 18.38 | 97.6 | 36.4 | 935.2 | 26 |
| 1715 | 18.04 | 97.5 | 36.4 | 944.3 | |
| 1730 | 17.45 | 97.4 | 36.3 | 953.4 | |
| 1745 | 17.12 | 97.2 | 36.2 | 962.4 | |
| 1800 | 16.63 | 97 | 36.1 | 971.4 | |
| 1815 | 15.91 | 96.9 | 36.1 | 980.5 | 27 |
| 1830 | 14.95 | 96.7 | 35.9 | 989.4 | |
| 1845 | 14 | 96.5 | 35.8 | 998.4 | |
| 1900 | 13.13 | 96.2 | 35.7 | 1007.3 | |
| 1915 | 12.35 | 96 | 35.6 | 1016.2 | |
| 1930 | 11.63 | 95.7 | 35.4 | 1025.1 | 28 |
| 1945 | 10.98 | 95.4 | 35.2 | 1033.9 | |
| 2000 | 10.37 | 95.1 | 35.1 | 1042.6 | |
| 2015 | 9.8 | 94.8 | 34.9 | 1051.3 | |
| 2030 | 9.24 | 94.5 | 34.7 | 1060.0 | |

Maturity Concept

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Wednesday 10/27/93

M-4

Cold water without calcium chloride.

Assume datum temperature is 0 degree Celcius.

Mix #1, Field Data

| Time | Mach. T. (deg. C) | Conc. T. (deg. F) | Conc. T. (deg. C) | Maturity (deg. -hr) | Hours (hrs) |
|------|----------------------|----------------------|----------------------|------------------------|----------------|
| 2100 | 8.26 | 94 | 34.4 | 1068.6 | |
| 2115 | 7.84 | 93.6 | 34.2 | 1077.2 | |
| 2130 | 7.44 | 93.3 | 34.1 | 1085.7 | 31 |
| 2145 | 7.04 | 93.1 | 33.9 | 1094.2 | |
| 2200 | 6.588 | 92.8 | 33.8 | 1102.6 | |
| 2215 | 6.137 | 92.5 | 33.6 | 1111.0 | |
| 2230 | 5.691 | 92.2 | 33.4 | 1119.4 | 32 |
| 2245 | 5.267 | 91.9 | 33.3 | 1127.7 | |
| 2300 | 4.86 | 91.6 | 33.1 | 1136.0 | |
| 2315 | 4.49 | 91.3 | 32.9 | 1144.2 | |
| 2330 | 4.099 | 90.9 | 32.7 | 1152.4 | 33 |
| 2345 | 3.757 | 90.6 | 32.6 | 1160.6 | |
| 0 | 3.494 | 90.3 | 32.4 | 1168.7 | |
| 15 | 3.283 | 90 | 32.2 | 1176.7 | |
| 30 | 3.041 | 89.7 | 32.1 | 1184.7 | 34 |
| 45 | 2.731 | 89.5 | 31.9 | 1192.7 | |
| 100 | 2.426 | 89.1 | 31.7 | 1200.6 | |
| 115 | 2.142 | 88.9 | 31.6 | 1208.5 | |
| 130 | 1.932 | 88.5 | 31.4 | 1216.4 | 35 |
| 145 | 1.77 | 88.3 | 31.3 | 1224.2 | |
| 200 | 1.623 | 88 | 31.1 | 1232.0 | |
| 215 | 1.455 | 87.7 | 30.9 | 1239.7 | |
| 230 | 1.308 | 87.4 | 30.8 | 1247.4 | 36 |
| 245 | 1.182 | 87.1 | 30.6 | 1255.1 | |
| 300 | 1.067 | 86.8 | 30.4 | 1262.7 | |
| 315 | 0.978 | 86.5 | 30.3 | 1270.3 | |
| 330 | 0.905 | 86.2 | 30.1 | 1277.8 | 37 |
| 345 | 0.873 | 86 | 30.0 | 1285.3 | |
| 400 | 0.926 | 85.7 | 29.8 | 1292.7 | |
| 415 | 0.968 | 85.4 | 29.7 | 1300.2 | |
| 430 | 0.968 | 85.2 | 29.6 | 1307.5 | 38 |
| 445 | 0.947 | 84.9 | 29.4 | 1314.9 | |
| 500 | 0.926 | 84.7 | 29.3 | 1322.2 | |
| 515 | 0.863 | 84.4 | 29.1 | 1329.5 | |
| 530 | 0.842 | 84.2 | 29.0 | 1336.7 | 39 |
| 545 | 0.842 | 83.9 | 28.8 | 1343.9 | |
| 600 | 0.779 | 83.7 | 28.7 | 1351.1 | |
| 615 | 0.548 | 83.4 | 28.6 | 1358.3 | |
| 630 | 0.286 | 83.2 | 28.4 | 1365.4 | 40 |

In Lab Testing
Tuesday 10/26/93

Assume datum Temperature is 0 deg. C!

Mixes #2 & #5

Mix #2: Low temp. with calcium chloride.

Mix #5: High temp. with calcium chloride.

| Time | Mach. T. (deg. C) | Mix #2 Conc. T. (deg. F) | Mix #5 Conc. T. (deg. F) | Mix #2 Conc. T. (deg. C) | Mix #5 Conc. T. (deg. C) | Mix #2 Maturity (deg.-hr) | Mix #5 Maturity (deg.-hr) | Mix #2 Comp. Str (psi) | Mix #5 Comp. Str (psi) |
|------|----------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|---------------------------------|---------------------------------|------------------------------|------------------------------|
| 815 | 23.46 | 63.76 | 77.3 | 17.6 | 25.2 | 0.0 | 0.0 | | |
| 830 | 23.69 | 64.73 | 75.9 | 18.2 | 24.4 | 4.5 | 6.1 | | |
| 845 | 23.78 | 65.52 | 75.9 | 18.6 | 24.4 | 9.2 | 12.2 | | |
| 900 | 23.85 | 66.3 | 76.1 | 19.1 | 24.5 | 14.0 | 18.3 | | |
| 915 | 23.92 | 67.14 | 76.6 | 19.5 | 24.8 | 18.8 | 24.5 | | |
| 930 | 23.97 | 68.09 | 77.2 | 20.1 | 25.1 | 23.9 | 30.8 | | |
| 945 | 24.08 | 69.07 | 78 | 20.6 | 25.6 | 29.0 | 37.2 | | |
| 1000 | 24.12 | 70.3 | 79.2 | 21.3 | 26.2 | 34.3 | 43.7 | | |
| 1015 | 24.15 | 71.5 | 80.6 | 21.9 | 27.0 | 39.8 | 50.5 | | |
| 1030 | 24.23 | 73 | 82.3 | 22.8 | 27.9 | 45.5 | 57.5 | | |
| 1045 | 24.31 | 74.6 | 84.2 | 23.7 | 29.0 | 51.4 | 64.7 | | |
| 1100 | 24.34 | 76.2 | 86.1 | 24.6 | 30.1 | 57.6 | 72.2 | | |
| 1115 | 24.39 | 77.9 | 88 | 25.5 | 31.1 | 63.9 | 80.0 | 50 | 200 |
| 1130 | 24.45 | 79.7 | 89.8 | 26.5 | 32.1 | 70.6 | 88.0 | (3-hr) | (3-hr) |
| 1145 | 24.52 | 81.3 | 91.4 | 27.4 | 33.0 | 77.4 | 96.3 | | |
| 1200 | 24.53 | 82.9 | 93.1 | 28.3 | 33.9 | 84.5 | 104.8 | | |
| 1215 | 24.52 | 84.4 | 94.6 | 29.1 | 34.8 | 91.8 | 113.5 | 170 | 600 |
| 1230 | 24.57 | 85.8 | 96 | 29.9 | 35.6 | 99.2 | 122.4 | (4-hr) | (4-hr) |
| 1245 | 24.64 | 87.1 | 97.3 | 30.6 | 36.3 | 106.9 | 131.4 | | |
| 1300 | 24.7 | 88.3 | 98.5 | 31.3 | 36.9 | 114.7 | 140.7 | | |
| 1315 | 24.73 | 89.4 | 99.7 | 31.9 | 37.6 | 122.7 | 150.1 | 470 | 1040 |
| 1330 | 24.71 | 90.4 | 100.7 | 32.4 | 38.2 | 130.8 | 159.6 | (5-hr) | (5-hr) |
| 1345 | 24.71 | 91.4 | 101.7 | 33.0 | 38.7 | 139.0 | 169.3 | | |
| 1400 | 24.7 | 92.3 | 102.5 | 33.5 | 39.2 | 147.4 | 179.1 | | |
| 1415 | 24.7 | 93.2 | 103.2 | 34.0 | 39.6 | 155.9 | 189.0 | | |
| 1430 | 24.68 | 94 | 103.7 | 34.4 | 39.8 | 164.5 | 198.9 | | |
| 1445 | 24.68 | 95 | 104.2 | 35.0 | 40.1 | 173.3 | 209.0 | | |
| 1500 | 24.67 | 95.9 | 104.4 | 35.5 | 40.2 | 182.1 | 219.0 | | |
| 1515 | 24.67 | 96.6 | 104.3 | 35.9 | 40.2 | 191.1 | 229.1 | 1160 | 1890 |
| 1530 | 24.74 | 96.9 | 104.1 | 36.1 | 40.1 | 200.1 | 239.1 | (7-hr) | (7-hr) |

Maturity

I-80

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M-4

Low temperature with calcium chloride.

Assume datum temperature is 0 deg. Celcius.

Mix # 2, Field Data

| Time | Mach. T. (deg. C) | Conc. T. (deg. F) | Conc. T. (deg. C) | Maturity (deg.-hr) | |
|------|----------------------|----------------------|----------------------|-----------------------|-------|
| 1445 | 13.27 | 69.03 | 20.6 | 5.1 | |
| 1500 | 14.23 | 68.9 | 20.5 | 10.3 | |
| 1515 | 14.99 | 69.25 | 20.7 | 15.4 | |
| 1530 | 15.54 | 69.87 | 21.0 | 20.7 | |
| 1545 | 15.82 | 70.6 | 21.4 | 26.1 | 1-hr |
| 1600 | 15.96 | 71.5 | 21.9 | 31.5 | |
| 1615 | 16.1 | 72.4 | 22.4 | 37.2 | |
| 1630 | 16.12 | 73.7 | 23.2 | 43.0 | |
| 1645 | 15.74 | 74.9 | 23.8 | 48.9 | 2-hrs |
| 1700 | 15.6 | 76.3 | 24.6 | 55.1 | |
| 1715 | 15.37 | 77.9 | 25.5 | 61.4 | |
| 1730 | 14.97 | 79.6 | 26.4 | 68.0 | |
| 1745 | 14.46 | 81.4 | 27.4 | 74.9 | 3-hrs |
| 1800 | 13.63 | 83.2 | 28.4 | 82.0 | |
| 1815 | 12.6 | 85.1 | 29.5 | 89.4 | |
| 1830 | 11.51 | 86.9 | 30.5 | 97.0 | |
| 1845 | 10.45 | 88.7 | 31.5 | 104.9 | 4-hrs |
| 1900 | 9.47 | 90.6 | 32.6 | 113.0 | |
| 1915 | 8.61 | 92.5 | 33.6 | 121.4 | |
| 1930 | 7.87 | 94.4 | 34.7 | 130.1 | |
| 1945 | 7.36 | 96.4 | 35.8 | 139.0 | 5-hrs |
| 2000 | 6.976 | 98.4 | 36.9 | 148.3 | |
| 2015 | 6.667 | 100.5 | 38.1 | 157.8 | |
| 2030 | 6.398 | 102.5 | 39.2 | 167.6 | |
| 2045 | 6.197 | 104.4 | 40.2 | 177.6 | 6-hrs |
| 2100 | 6.006 | 106.1 | 41.2 | 187.9 | |
| 2115 | 5.889 | 107.6 | 42.0 | 198.4 | |
| 2130 | 5.794 | 108.9 | 42.7 | 209.1 | |
| 2145 | 5.716 | 110.1 | 43.4 | 220.0 | 7-hrs |
| 2200 | 5.674 | 111.2 | 44.0 | 231.0 | |
| 2215 | 5.663 | 112.1 | 44.5 | 242.1 | |
| 2230 | 5.653 | 113 | 45.0 | 253.3 | |
| 2245 | 5.642 | 113.7 | 45.4 | 264.7 | 8-hrs |
| 2300 | 5.631 | 114.4 | 45.8 | 276.1 | |
| 2315 | 5.642 | 115 | 46.1 | 287.6 | |
| 2330 | 5.674 | 115.5 | 46.4 | 299.2 | |
| 2345 | 5.695 | 116 | 46.7 | 310.9 | 9-hrs |

*Maturity Concept
In Lab Testing*

Assume datum temp. is 0 deg. Celcius.

Mix #3: Cold water w/ calcium chloride and WR.
Wednesday 11/3/93

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| <i>Time</i> | <i>Mach. T. (deg. C)</i> | <i>Conc. T. (deg. F)</i> | <i>Conc. T. (deg. C)</i> | <i>Maturity (deg. -hr)</i> | <i>Comp. Str. (psi)</i> |
|-------------|------------------------------|------------------------------|------------------------------|--------------------------------|-----------------------------|
| 830 | 22.35 | 74.4 | 23.6 | 5.9 | |
| 845 | 22.97 | 74.5 | 23.6 | 11.8 | |
| 900 | 23.22 | 77.6 | 25.3 | 18.1 | |
| 915 | 23.41 | 67.2 | 19.5 | 23.0 | |
| 930 | 23.54 | 68.0 | 20.0 | 28.0 | |
| 945 | 23.67 | 68.4 | 20.2 | 33.1 | |
| 1000 | 23.84 | 68.9 | 20.5 | 38.2 | |
| 1015 | 23.96 | 69.3 | 20.7 | 43.4 | |
| 1030 | 24.08 | 69.8 | 21.0 | 48.6 | |
| 1045 | 24.12 | 70.4 | 21.3 | 54.0 | |
| 1100 | 24.16 | 71.0 | 21.7 | 59.4 | |
| 1115 | 24.19 | 71.8 | 22.1 | 64.9 | |
| 1130 | 24.22 | 72.7 | 22.6 | 70.5 | 30 |
| 1145 | 24.27 | 73.7 | 23.2 | 76.3 | |
| 1200 | 24.3 | 74.9 | 23.8 | 82.3 | |
| 1215 | 24.31 | 76.3 | 24.6 | 88.4 | |
| 1230 | 24.33 | 77.9 | 25.5 | 94.8 | 70 |
| 1245 | 24.33 | 79.6 | 26.4 | 101.4 | |
| 1300 | 24.29 | 81.4 | 27.4 | 108.3 | |
| 1315 | 24.29 | 83.1 | 28.4 | 115.4 | |
| 1330 | 24.35 | 84.8 | 29.3 | 122.7 | 260 |
| 1345 | 24.41 | 86.4 | 30.2 | 130.3 | |
| 1400 | 24.42 | 87.9 | 31.1 | 138.0 | |
| 1415 | 24.45 | 89.2 | 31.8 | 146.0 | |
| 1430 | 24.52 | 90.4 | 32.4 | 154.1 | |
| 1445 | 24.56 | 91.6 | 33.1 | 162.4 | |
| 1500 | 24.6 | 92.7 | 33.7 | 170.8 | |
| 1515 | 24.6 | 93.8 | 34.3 | 179.4 | |
| 1530 | 24.6 | 94.5 | 34.7 | 188.1 | 970 |

3 hrs

4 hrs

5 hrs

7 hrs

Maturity Concept**In Lab Testing****Assume datum temp. is 0 deg. Celcius.****Wednesday 11/3/93****Page 44****Mix #4: Warm water w/o calcium chloride.**

| <i>Mix #4 Conc. T. (deg. F)</i> | <i>Mix #4 Conc. T. (deg. C)</i> | <i>Mix #4 Maturity (deg. -hr)</i> | <i>Mix #4 Comp. Str (psi)</i> | <i>Hours</i> |
|---|---|---|---------------------------------------|--------------|
| 71.5 | 21.9 | 5.5 | | |
| 74.2 | 23.4 | 11.3 | | |
| 74.3 | 23.5 | 17.2 | | |
| 75.1 | 23.9 | 23.2 | | |
| 78.7 | 25.9 | 29.7 | | 1-hr |
| 75.2 | 24.0 | 35.7 | | |
| 75.2 | 24.0 | 41.7 | | |
| 75.2 | 24.0 | 47.7 | | |
| 75.2 | 24.0 | 53.7 | | 2-hrs |
| 75.3 | 24.1 | 59.7 | | |
| 75.4 | 24.1 | 65.7 | | |
| 75.6 | 24.2 | 71.8 | | |
| 75.9 | 24.4 | 77.9 | | 3-hrs |
| 76.2 | 24.6 | 84.0 | | |
| 76.6 | 24.8 | 90.2 | | |
| 77.1 | 25.1 | 96.5 | | |
| 77.6 | 25.3 | 102.8 | | 4-hrs |
| 78.3 | 25.7 | 109.3 | | |
| 79 | 26.1 | 115.8 | | |
| 79.8 | 26.6 | 122.4 | | |
| 80.6 | 27.0 | 129.2 | | 5-hrs |
| 81.5 | 27.5 | 136.0 | | |
| 82.5 | 28.1 | 143.1 | | |
| 83.6 | 28.7 | 150.2 | | |
| 84.7 | 29.3 | 157.5 | | 6-hrs |
| 85.9 | 29.9 | 165.0 | | |
| 87.2 | 30.7 | 172.7 | | |
| 88.5 | 31.4 | 180.5 | | |
| 89.8 | 32.1 | 188.6 | 960 | 7-hrs |
| 91 | 32.8 | 196.8 | | |
| 92.3 | 33.5 | 205.1 | | |
| 93.6 | 34.2 | 213.7 | | |
| 94.8 | 34.9 | 222.4 | | 8-hrs |
| 96 | 35.6 | 231.3 | | |
| 97 | 36.1 | 240.3 | | |
| 98 | 36.7 | 249.5 | | |
| 98.8 | 37.1 | 258.8 | | 9-hrs |
| 99.5 | 37.5 | 268.2 | | |
| 100.2 | 37.9 | 277.6 | | |
| 100.7 | 38.2 | 287.2 | | |
| 101.1 | 38.4 | 296.8 | | 10-hrs |

*Maturity Concept**In Lab Testing**Assume datum temp. is 0 deg. Celcius.**Page 2**Page 45**Wednesday 11/3/93**Mix #4: Warm water w/o calcium chloride.*

| <i>Mix #4 Conc. T. (deg. F)</i> | <i>Mix #4 Conc. T. (deg. C)</i> | <i>Mix #4 Maturity (deg. -hr)</i> | <i>Mix #4 Comp. Str (psi)</i> | <i>Hours</i> |
|---|---|---|---------------------------------------|--------------|
| 101.4 | 38.6 | 306.4 | | |
| 101.7 | 38.7 | 316.1 | | |
| 101.9 | 38.8 | 325.8 | | |
| 102.1 | 38.9 | 335.5 | | 11-hrs |
| 102.2 | 39.0 | 345.3 | | |
| 102.4 | 39.1 | 355.1 | | |
| 102.5 | 39.2 | 364.8 | | |
| 102.6 | 39.2 | 374.7 | | 12-hrs |
| 102.7 | 39.3 | 384.5 | | |
| 102.8 | 39.3 | 394.3 | | |
| 102.8 | 39.3 | 404.1 | | |
| 102.8 | 39.3 | 414.0 | | 13-hrs |
| 102.9 | 39.4 | 423.8 | | |
| 103 | 39.4 | 433.7 | | |
| 103.1 | 39.5 | 443.6 | | |
| 103.2 | 39.6 | 453.4 | | 14-hrs |
| 103.2 | 39.6 | 463.3 | | |
| 103.2 | 39.6 | 473.2 | | |
| 103.3 | 39.6 | 483.1 | | |
| 103.3 | 39.6 | 493.0 | | 15-hrs |
| 103.3 | 39.6 | 502.9 | | |
| 103.2 | 39.6 | 512.8 | | |
| 103.2 | 39.6 | 522.7 | | |
| 103.2 | 39.6 | 532.6 | | 16-hrs |
| 103.1 | 39.5 | 542.5 | | |
| 103.1 | 39.5 | 552.3 | | |
| 103 | 39.4 | 562.2 | | |
| 103 | 39.4 | 572.1 | | 17-hrs |
| 103 | 39.4 | 581.9 | | |
| 103 | 39.4 | 591.8 | | |
| 103 | 39.4 | 601.7 | | |
| 102.9 | 39.4 | 611.5 | | 18-hrs |
| 102.9 | 39.4 | 621.3 | | |
| 102.8 | 39.3 | 631.2 | | |
| 102.8 | 39.3 | 641.0 | | |
| 102.7 | 39.3 | 650.8 | | 19-hrs |

Maturity Concept

In Lab Testing

Wednesday 11/3/93

Mix #4: Warm water w/o calcium chloride.

Page 3

Assume datum temp. is 0 deg. Celcius.

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| <i>Mix #4 Conc. T. (deg. F)</i> | <i>Mix #4 Conc. T. (deg. C)</i> | <i>Mix #4 Maturity (deg. -hr)</i> | <i>Mix #4 Comp. Str (psi)</i> | <i>Hours</i> |
|---|---|---|---------------------------------------|--------------|
| 102.6 | 39.2 | 660.6 | | |
| 102.5 | 39.2 | 670.4 | | |
| 102.4 | 39.1 | 680.2 | | |
| 102.3 | 39.1 | 690.0 | | 20-hrs |
| 102.2 | 39.0 | 699.7 | | |
| 102.1 | 38.9 | 709.5 | | |
| 102 | 38.9 | 719.2 | | |
| 101.8 | 38.8 | 728.9 | | 21-hrs |
| 101.7 | 38.7 | 738.6 | | |
| 101.6 | 38.7 | 748.2 | | |
| 101.4 | 38.6 | 757.9 | | |
| 101.2 | 38.4 | 767.5 | | 22-hrs |
| 101.1 | 38.4 | 777.1 | | |
| 100.9 | 38.3 | 786.6 | | |
| 100.8 | 38.2 | 796.2 | | |
| 100.6 | 38.1 | 805.7 | | 23-hrs |
| 100.4 | 38.0 | 815.2 | | |
| 100.2 | 37.9 | 824.7 | | |
| 99.9 | 37.7 | 834.1 | | |
| 99.7 | 37.6 | 843.5 | 4110 | 24-hrs |
| 99.5 | 37.5 | 852.9 | | |
| 99.2 | 37.3 | 862.2 | | |
| 99 | 37.2 | 871.5 | | |
| 98.7 | 37.1 | 880.8 | | 25-hrs |
| 98.4 | 36.9 | 890.0 | | |
| 98.2 | 36.8 | 899.2 | | |
| 97.9 | 36.6 | 908.4 | | |
| 97.7 | 36.5 | 917.5 | | 26-hrs |
| 97.5 | 36.4 | 926.6 | | |
| 97.3 | 36.3 | 935.7 | | |
| 97.1 | 36.2 | 944.7 | | |
| 96.9 | 36.1 | 953.7 | | 27-hrs |
| 96.6 | 35.9 | 962.7 | | |
| 96.4 | 35.8 | 971.6 | | |
| 96.2 | 35.7 | 980.6 | | |
| 96 | 35.6 | 989.4 | | 28-hrs |
| 95.8 | 35.4 | 998.3 | | |
| 95.6 | 35.3 | 1007.1 | | |
| 95.4 | 35.2 | 1015.9 | | |
| 95.2 | 35.1 | 1024.7 | | 29-hrs |

Maturity Concept

Page 4

In Lab Testing

Assume datum temp. is 0 deg. Celcius.

Wednesday 11/3/93

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Mix #4: Warm water w/o calcium chloride.

| Mix #4 Conc. T. (deg. F) | Mix #4 Conc. T. (deg. C) | Mix #4 Maturity (deg.-hr) | Mix #4 Comp. Str (psi) | Hours |
|--------------------------------|--------------------------------|---------------------------------|------------------------------|--------|
| 95 | 35.0 | 1033.5 | 4020 | 30-hrs |
| 94.8 | 34.9 | 1042.2 | | |
| 94.6 | 34.8 | 1050.9 | | |
| 94.4 | 34.7 | 1059.6 | | |
| 94.2 | 34.6 | 1068.2 | | |
| 94 | 34.4 | 1076.8 | | 31-hrs |
| 93.7 | 34.3 | 1085.4 | | |
| 93.5 | 34.2 | 1093.9 | | |
| 93.3 | 34.1 | 1102.4 | | |
| 93.1 | 33.9 | 1110.9 | | |
| 92.9 | 33.8 | 1119.4 | 4140 | 32-hrs |
| 92.7 | 33.7 | 1127.8 | | |
| 92.5 | 33.6 | 1136.2 | | |
| 92.3 | 33.5 | 1144.6 | | |
| 92.1 | 33.4 | 1152.9 | | |
| 91.9 | 33.3 | 1161.2 | | 33-hrs |
| 91.7 | 33.2 | 1169.5 | | |
| 91.5 | 33.1 | 1177.8 | | |
| 91.3 | 32.9 | 1186.0 | | |
| 91.1 | 32.8 | 1194.2 | | |
| 91 | 32.8 | 1202.4 | 4140 | 34-hrs |
| 90.8 | 32.7 | 1210.6 | | |
| 90.5 | 32.5 | 1218.7 | | |
| 90.3 | 32.4 | 1226.8 | | |
| 90.1 | 32.3 | 1234.9 | | |
| 89.9 | 32.2 | 1242.9 | | 35-hrs |
| 89.7 | 32.1 | 1251.0 | | |
| 89.5 | 31.9 | 1258.9 | | |
| 89.2 | 31.8 | 1266.9 | | |
| 89 | 31.7 | 1274.8 | | |

Maturity Concept

Hot water without calcium chloride. M-4

Wednesday 10/27/93

Assume datum temperature is 0 degree Celcius.

Mix #4, ^{Page 48} Field Data

| <i>Hour (hr)</i> | <i>Conc. T. (deg. C)</i> | <i>Maturity (deg. -hr)</i> |
|----------------------|------------------------------|--------------------------------|
| 0 | 31 | 0 |
| 1 | 33 | 33 |
| 2 | 37 | 70 |
| 3 | 42 | 112 |
| 4 | 46 | 158 |
| 5 | 49 | 207 |
| 6 | 50 | 257 |
| 7 | 51 | 308 |
| 8 | 51 | 359 |
| 9 | 51 | 410 |
| 10 | 51 | 461 |
| 11 | 51 | 512 |
| 12 | 51 | 563 |
| 13 | 50 | 613 |
| 14 | 50 | 663 |
| 15 | 50 | 713 |
| 16 | 49 | 762 |
| 17 | 49 | 811 |
| 18 | 49 | 860 |
| 19 | 48 | 908 |
| 20 | 48 | 956 |
| 21 | 47 | 1003 |
| 22 | 47 | 1050 |
| 23 | 46 | 1096 |
| 24 | 46 | 1142 |
| 25 | 45 | 1187 |
| 26 | 45 | 1232 |
| 27 | 44 | 1276 |
| 28 | 43 | 1319 |
| 29 | 43 | 1362 |
| 30 | 42 | 1404 |
| 31 | 41 | 1445 |
| 32 | 40 | 1485 |
| 33 | 40 | 1525 |
| 34 | 39 | 1564 |
| 35 | 38 | 1602 |
| 36 | 37 | 1639 |
| 37 | 37 | 1676 |
| 38 | 36 | 1712 |
| 39 | 35 | 1747 |
| 40 | 35 | 1782 |
| 41 | 34 | 1816 |

Maturity Concept

M-4

75 degrees with calcium chloride.

5-hour patching.

Wednesday 10/27/93

Assume datum temperature is 0 deg. Celcius.

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Mix #5,

Field Data

| <i>Time</i> | <i>Mach. T. (deg. C)</i> | <i>Conc. T. (deg. F)</i> | <i>Conc. T. (deg. C)</i> | <i>Maturity (deg.-hr)</i> | |
|-------------|------------------------------|------------------------------|------------------------------|-------------------------------|-------|
| 1500 | 14.65 | 85.1 | 29.5 | 7.4 | |
| 1515 | 14.45 | 85.7 | 29.8 | 14.8 | |
| 1530 | 14.46 | 86.7 | 30.4 | 22.4 | |
| 1545 | 14.32 | 87.7 | 30.9 | 30.2 | |
| 1600 | 14 | 88.5 | 31.4 | 38.0 | 1-hr |
| 1615 | 13.68 | 89.3 | 31.8 | 46.0 | |
| 1630 | 13.32 | 90.1 | 32.3 | 54.0 | |
| 1645 | 13 | 92.1 | 33.4 | 62.4 | |
| 1700 | 12.82 | 94.4 | 34.7 | 71.1 | 2-hrs |
| 1715 | 12.4 | 96.7 | 35.9 | 80.0 | |
| 1730 | 11.8 | 99.2 | 37.3 | 89.4 | |
| 1745 | 11.08 | 101.9 | 38.8 | 99.1 | |
| 1800 | 10.1 | 104.7 | 40.4 | 109.2 | 3-hrs |
| 1815 | 9.09 | 107.6 | 42.0 | 119.7 | |
| 1830 | 8.2 | 110.6 | 43.7 | 130.6 | |
| 1845 | 7.38 | 113.3 | 45.2 | 141.9 | |
| 1900 | 6.685 | 115.5 | 46.4 | 153.5 | 4-hrs |
| 1915 | 6.105 | 117.2 | 47.3 | 165.3 | |
| 1930 | 5.69 | 118.7 | 48.2 | 177.4 | |
| 1945 | 5.403 | 120 | 48.9 | 189.6 | |
| 2000 | 5.224 | 121.1 | 49.5 | 202.0 | 5-hrs |
| 2015 | 5.014 | 122.1 | 50.1 | 214.5 | |
| 2030 | 4.853 | 123.1 | 50.6 | 227.1 | |
| 2045 | 4.727 | 124 | 51.1 | 239.9 | |
| 2100 | 4.622 | 124.7 | 51.5 | 252.8 | 6-hrs |
| 2115 | 4.57 | 125.4 | 51.9 | 265.8 | |
| 2130 | 4.507 | 126.1 | 52.3 | 278.8 | |
| 2145 | 4.507 | 126.6 | 52.6 | 292.0 | |
| 2200 | 4.517 | 127.2 | 52.9 | 305.2 | 7-hrs |
| 2215 | 4.517 | 127.7 | 53.2 | 318.5 | |
| 2230 | 4.496 | 128.1 | 53.4 | 331.8 | |
| 2245 | 4.465 | 128.4 | 53.6 | 345.2 | |
| 2300 | 4.465 | 128.7 | 53.7 | 358.6 | 8-hrs |
| 2315 | 4.528 | 129 | 53.9 | 372.1 | |
| 2330 | 4.58 | 129.2 | 54.0 | 385.6 | |
| 2345 | 4.611 | 129.4 | 54.1 | 399.1 | |
| 0 | 4.601 | 129.5 | 54.2 | 412.7 | 9-hrs |

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Mix No. Mix 1 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-185-190

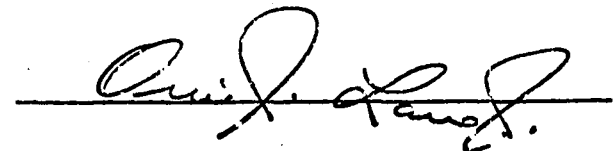
Remarks 60-65°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | | | Rural Marango | Concklin gr. | Protex 8oz/94lb | |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | 62.0 | 62.7 | | |
| | | | Actual 14.3 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|-------------------------------------|---------------|-------|------|-----------|--------|------|------------|------------|
| | | | | | | | | Date | Days | | |
| 185 | | | 4 1/2 X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-2 | 7hr | 5450 | 340 |
| 186 | | | 4 1/2 X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-2 | 7hr | 5600 | 350 |
| 187 | | | 4 1/2 X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-2 | 7hr | 5350 | 340 |
| | | | 4 1/2 X 9 Cyl | | | | | | | Avg. | 340 |
| 188 | | | 4 1/2 X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 24hr | 60600 | 3810 |
| 189 | | | 4 1/2 X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 24hr | 58800 | 3700 |
| 190 | | | 4 1/2 X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 24hr | 60800 | 3820 |
| | | | | | | | | | | Avg. | 3780 |
| | | | Temperature at 7 hr 83°F | | | | | | | | |
| | | | Temperature at 24 hr 97.1°F | | | | | | | | |
| | | | Temperature at Rest Period was 58°F | | | | | | | | |
| | | | Temperautre at molding was 62°F | | | | | | | | |
| | | | | | | | | | | | |

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Testing Engineer



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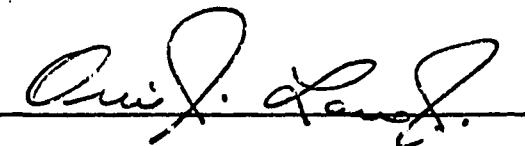
Mix No. Mix 1 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-191-196

Remarks 60-65°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | | | Rural Marengo | Concklin Gr. | Prtex 8oz/94lb | |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | 62.0 | 62.7 | | |
| | | | Actual 14.3 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|-------------------------------------|---------------|-------|------|-----------|--------|-------|------------|------------|
| | | | | | | | | Date | Days | | |
| 191 | | | 4½ X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 30 hr | 64000 | 4020 |
| 192 | | | 4½ X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 30 hr | 63000 | 3960 |
| 193 | | | 4½ X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 30 hr | 66400 | 4180 |
| | | | 4½ X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 30 hr | Avg. | 4050 |
| 194 | | | 4½ X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 36 hr | 68800 | 4330 |
| 195 | | | 4½ X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 36 hr | 67000 | 4210 |
| 196 | | | 4½ X 9 Cyl | 6.2 | 2.75 | .374 | 11-2-93 | 11-3 | 36 hr | 64400 | 4050 |
| | | | | | | | | | | Avg. | 4200 |
| | | | | | | | | | | | |
| | | | Temperature at Rest Period was 58°F | | | | | | | | |
| | | | Temperature at molding was 62°F | | | | | | | | |
| | | | Temperature at 30 hr was 90.6°F | | | | | | | | |
| | | | Temperature at 36 hr was 84.2°F | | | | | | | | |

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Mix No. Mix 2 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-197-202

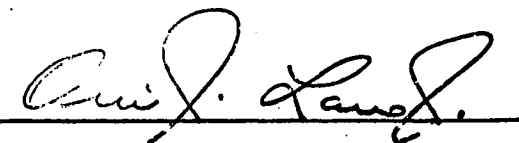
Remarks Cacl₂ 60-65°F° MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | None | | Rural Marengo | Concklin gr. | Protex .7oz/94lb | |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | 63.6 | 64.3 | | |
| | | | Actual 13.6 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|---|---------------|-------|------|-----------|--------|------|------------|------------|
| | | | | | | | | Date | Days | | |
| 197 | | | 4 1/2 x 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 3 hr | 750 | 47 |
| 198 | | | 4 1/2 X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 3 hr | 800 | 50 |
| 199 | | | 4 1/2 X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 3 hr | 780 | 49 |
| | | | 4 1/2 X 9 Cyl | | | | | | | Avg. | 50 |
| 200 | | | 4 1/2 X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 4 hr | 2640 | 170 |
| 201 | | | 4 1/2 X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 4 hr | 2740 | 170 |
| 202 | | | 4 1/2 X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 4 hr | 2850 | 180 |
| | | | | | | | | | | Avg. | 170 |
| | | | Temperature at 3 hr 73.3°F° | | | | | | | | |
| | | | Temperature at 4 hr 79.8°F° | | | | | | | | |
| | | | Temperature of Concrete at Rest Period was 52°F Before Calcium Chloride | | | | | | | | |
| | | | Temperature of Concrete at molding was 57°F | | | | | | | | |
| | | | Slump was 2.25' Before Calcium Chloride was added | | | | | | | | |
| | | | Air was 6.0% before Calcium Chloride was added | | | | | | | | |

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Testing Engineer



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Mix No. Mix 2 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-203-208

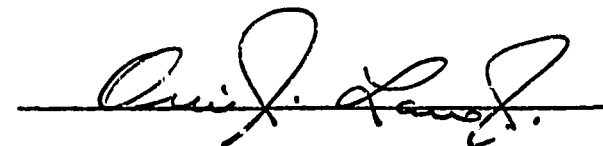
Remarks Cacl₂ 60-65°F° MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | None | | Rural Marengo | Concklin gr. | Protex .70z/94lb | |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | 63.6 | 64.3 | | |
| | | | Actual 13.6 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|---|---------------|-------|------|-----------|--------|------|------------|------------|
| | | | | | | | | Date | Days | | |
| 203 | | | 4½ X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 5 hr | 7630 | 480 |
| 204 | | | 4½ X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 5 hr | 7350 | 460 |
| 205 | | | 4½ X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 5 hr | 7650 | 480 |
| | | | 4½ X 9 Cyl | | | | | | | Avg. | 470 |
| 206 | | | 4½ X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 7 hr | 18050 | 1140 |
| 207 | | | 4½ X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 7 hr | 18950 | 1190 |
| 208 | | | 4½ X 9 Cyl | 6.0 | 2.25 | .366 | 10-26-93 | 10-26 | 7 hr | 18350 | 1150 |
| | | | | | | | | | | Avg. | 1160 |
| | | | Temperature at | 5 hr 85.4°F° | | | | | | | |
| | | | Temperature at | 7 hr 93.7°F° | | | | | | | |
| | | | Temperature of concrete at rest period was 52°F before calcium chloride was added | | | | | | | | |
| | | | Temperature of concrete at molding was 57°F | | | | | | | | |
| | | | Slump was 2.25 before Calcium chloride was added | | | | | | | | |

Air was 6.0% before calcium chloride was added

Testing Engineer



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Mix No. Mix 3 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-209-214

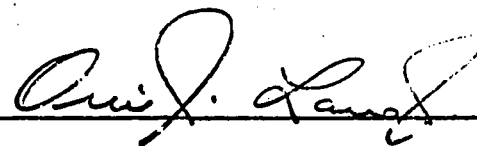
Remarks Calcium Chloride and Prokrete N-3 water reducer temperature 66-65°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | | | Rural Marengo | Concklin gr. | Protex .7oz/94lb | Prokrete N.3 |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | 30z/100lb |
| Batch Wt. | 38.2 | | Design 13.6 | 63.6 | 64.3 | | |
| | | | Actual 13.7 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|---|---------------|-------|------|-----------|--------|------|------------|------------|
| | | | | | | | | Date | Days | | |
| 209 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 3 hr | 500 | 30 |
| 210 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 3 hr | 500 | 30 |
| 211 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 3 hr | 500 | 30 |
| | | | | | | | | | | Avg. | 30 |
| 212 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 4 hr | 1050 | 70 |
| 213 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 4 hr | 1050 | 70 |
| 214 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 4 hr | 1100 | 70 |
| | | | | | | | | | | Avg. | 70 |
| | | | Temperature at rest period was 58°F before Calcium Chloride was added | | | | | | | | |
| | | | Temperature at molding was 62.5°F | | | | | | | | |
| | | | Temperature at 3 hr was 72.3°F | | | | | | | | |
| | | | Temperature at 5 hr was 77.2°F | | | | | | | | |
| | | | Slump & Air was Run before Calcium Chloride was added | | | | | | | | |

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Mix No. Mix 3 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-215-220

Remarks Calcium Chloride and Prokrete N-3 water reducer temperature 60-65°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | | | Rural Marengo | Concklin gr. | Protex .7oz/94lb | Prokrete N-3 |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | 3oz/100lb |
| Batch Wt. | 38.2 | | Design 13.6 | 63.6 | 64.3 | | |
| | | | Actual 13.7 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|---|---------------|-------|------|-----------|--------|------|------------|------------|
| | | | | | | | | Date | Days | | |
| 215 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 5 hr | 3800 | 240 |
| 216 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 5 hr | 4150 | 260 |
| 217 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 5 hr | 4350 | 270 |
| | | | 4 1/2 X 9 Cyl | | | | | | | Avg. | 260 |
| 218 | | | 4 1/2 X 9 cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 7 hr | 14550 | 910 |
| 219 | | | 4 1/2 x 9 cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 7 hr | 15900 | 1000 |
| 220 | | | 4 1/2 X 9 Cyl | 7.0 | 2.25 | .358 | 11-3-93 | 11-3 | 7 hr | 16000 | 1010 |
| | | | | | | | | | | Avg. | 970 |
| | | | Temperature at test period was 58°F before Calcium Chloride was added | | | | | | | | |
| | | | Temperature at molding was 62.5°F | | | | | | | | |
| | | | Temperature at 5 hr was 84.0°F | | | | | | | | |
| | | | Temperature at 7 hr was 94.2 °F | | | | | | | | |
| | | | Slump & Air was run before calcium chloride was added | | | | | | | | |

Testing Engineer

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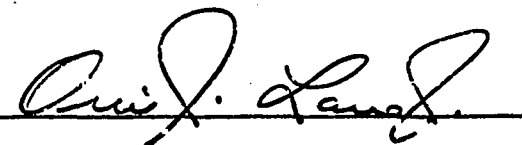
Mix No. Mix 4 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-221-226

Remarks 75°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | | | Rural Marengo | Concklin Gr. | Protex .8oz/94Lb | |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | 62.0 | 62.7 | | |
| | | | Actual 14.2 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|-------------------------------------|---------------|-------|------|-----------|--------|-------|------------|------------|
| | | | | | | | | Date | Days | | |
| 221 | | | 4 1/2 X 9 Cyl | 5.6 | 2.75 | .371 | 11-2-93 | 11-2 | 7 hr | 15150 | 950 |
| 222 | | | 4 1/2 X 9 Cyl | 5.6 | 2.75 | .371 | 11-2-93 | 11-2 | 7 hr | 15400 | 970 |
| 223 | | | 4 1/2 X 9 Cyl | 5.6 | 2.75 | .371 | 11-2-93 | 11-2 | 7 hr | 15350 | 970 |
| | | | | | | | | | | Avg. | 960 |
| 224 | | | 4 1/2 X 9 Cyl | 5.6 | 2.75 | .371 | 11-2-93 | 11-2 | 24 hr | 65600 | 4120 |
| 225 | | | 4 1/2 X 9 Cyl | 5.6 | 2.75 | .371 | 11-2-93 | 11-2 | 24 hr | 64800 | 4070 |
| 226 | | | 4 1/2 X 9 Cyl | 5.6 | 2.75 | .371 | 11-2-93 | 11-2 | 24 hr | 65800 | 4140 |
| | | | | | | | | | | Avg. | 4110 |
| | | | Temperature at rest period was 74°F | | | | | | | | |
| | | | Temperature at molding was 74.9°F | | | | | | | | |
| | | | Temperature at 7 hr was 92.9°F | | | | | | | | |
| | | | Temperature at 24 hr was 98.8°F | | | | | | | | |

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Mix No. Mix 4 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-227-232

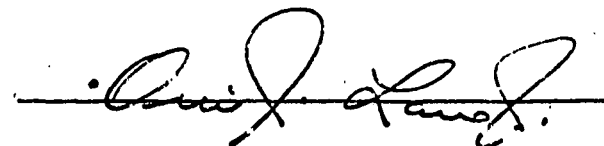
Remarks 75°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | | | Rural Marengo | Concklin Gr. | Prtex 80x/94lb | |
| Sp. Gr. | 3.14 | | | 2.63 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | 62.0 | 62.7 | | |
| | | | Actual 14.3 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|-------------------------------------|---------------|-------|------|-----------|--------|-------|------------|------------|
| | | | | | | | | Date | Days | | |
| 227 | | | 4½ X 9 Cyl | 5.6 | 2.75 | .375 | 11-2-93 | 11-3 | 30 hr | 66400 | 4180 |
| 228 | | | 4½ X 9 Cyl | 5.6 | 2.75 | .375 | 11-2-93 | 11-3 | 30 hr | 62400 | 3920 |
| 229 | | | 4½ X 9 Cyl | 5.6 | 2.75 | .375 | 11-2-93 | 11-3 | 30 hr | 63200 | 3970 |
| | | | | | | | | | | Avg. | 4020 |
| 230 | | | 4½ X 9 Cyl | 5.6 | 2.75 | .375 | 11-2-93 | 11-3 | 36 hr | 66000 | 4150 |
| 231 | | | 4½ X 9 Cyl | 5.6 | 2.75 | .375 | 11-2-93 | 11-3 | 36 hr | 65200 | 4100 |
| 232 | | | 4½ X 9 Cyl | 5.6 | 2.75 | .375 | 11-2-93 | 11-3 | 36 hr | 66200 | 4160 |
| | | | | | | | | | | Avg. | 4140 |
| | | | Temperature at rest period was 74°F | | | | | | | | |
| | | | Temperature at molding was 74.9°F | | | | | | | | |
| | | | Temperature at 30 hr was 93.8°F | | | | | | | | |
| | | | Temperature at 36 hr was 88.6°F | | | | | | | | |
| | | | | | | | | | | | |

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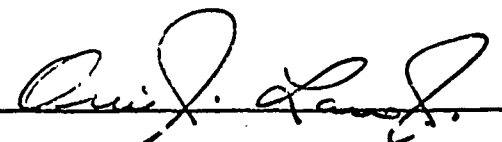
Mix No. Mix 5 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-233-238
Remarks Cacl 2 75°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | None | | Rural Marengo | Concklin gr | Protex 7oz/94lb | |
| Sp. Gr. | 31.4 | | | 2.63 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | 63.8 | 64.3 | | |
| | | | Actual 13.6 | | | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|--|---------------|-------|------|-----------|--------|------|------------|------------|
| | | | | | | | | Date | Days | | |
| 233 | | | 4½ x 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 3 hr | 2980 | 190 |
| 234 | | | 4½ x 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 3 hr | 3150 | 200 |
| 235 | | | 4½ x 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 3 hr | 3360 | 210 |
| | | | | | | | | | | Avg. | 200 |
| 236 | | | 4½ x 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 4 hr | 9900 | 620 |
| 237 | | | 4½ x 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 4 hr | 9300 | 580 |
| 238 | | | 4½ x 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 4 hr | 9650 | 610 |
| | | | | | | | | | | Avg. | 600 |
| | | | Temperature at 3 hr was 86.0°F | | | | | | | | |
| | | | Temperature at 4 hr was 93.0 °F | | | | | | | | |
| | | | Temperature of Concrete at rest period was 52.°F before Calcium Chloride was added | | | | | | | | |
| | | | Temperature of concrete at molding was 57°F | | | | | | | | |
| | | | Slump was 2.25" Before calcium Chloride was added | | | | | | | | |

Air was 6.0% before calcium chloride was added

Testing Engineer



IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

Misc Concrete
C. Narotam
J. Vu

Office of Materials
Concrete Section

Mix No. Mix 5 Mix Class M-4 Date Reported 11-4-93 Lab Number ACC3-239-244

Remarks Cac12 75°F MLR-93-7

| | Cement | Fly Ash | Water | Fine Aggregate | Coarse Aggregate | Air Entraining Agent | Water Reducer |
|--------------|--------|---------|-------------|----------------|------------------|----------------------|---------------|
| Source/Brand | | None | | Rural Marengo | Concklin gr. | Protex .7oz/94lb | |
| Sp. Gr. | 3.14 | | | 2.36 | 2.66 | | |
| Batch Wt. | 38.2 | | Design 13.6 | | | | |
| | | | Actual 13.6 | 63.3 | 64.3 | | |

| Lab No. | Speciman No. | Mold No. | Description | % Air Content | Slump | W/C | Date Made | Tested | | Total Load | Lb./sq.in. |
|---------|--------------|----------|---|---------------|-------|------|-----------|--------|------|------------|------------|
| | | | | | | | | Date | Days | | |
| 239 | | | 4½ x 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 5 hr | 16200 | 1020 |
| 240 | | | 4½ X 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 5 hr | 16350 | 1030 |
| 241 | | | 4½ X 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 5 hr | 17250 | 1080 |
| | | | | | | | | | | Avg. | 1040 |
| 242 | | | 4½ X 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 7 hr | 28950 | 1820 |
| 243 | | | 4½ X 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 7 hr | 30600 | 1920 |
| 244 | | | 4½ X 9 Cyl | 5.8 | 2.25 | .366 | 10-26-93 | 10-26 | 7 hr | 30850 | 1940 |
| | | | | | | | | | | Avg. | 1890 |
| | | | Temperature at 5 hr was 98.3°F | | | | | | | | |
| | | | Temperature at 7 hr was 104.4°F | | | | | | | | |
| | | | Temperature of concrete at rest period was 52°F before calicum chloride was added | | | | | | | | |
| | | | Temperature of concrete at loading was 57°F | | | | | | | | |
| | | | Slump was 2.25" before calicum cholride was added | | | | | | | | |

Air was 6.0% before before calicum cholride was added

Testing Engineer

