Adiabatic Calorimeter Results

BACKGROUND

The cement degree of hydration is related to the development of mechanical properties in the concrete such as strength and modulus of elasticity. The degree of hydration is also related to the rate of internal heat generated in the concrete. HIPERPAV considers the degree of hydration and total heat of hydration information for a given concrete mix to determine the PCC tensile strength, modulus of elasticity, and temperature development in the concrete. Set time can also be estimated at a specific point during the degree of hydration of the cement.[1]

The degree of hydration and total heat of hydration can be determined through adiabatic calorimetry.

For the materials collected during each instrumentation site (MN, NE, AZ, TX, and NC), three adiabatic tests were performed to determine the heat of hydration, degree of hydration, and the hydration shape and time parameters.[2,3] As its name implies, the hydration parameters determine the shape of the hydration curve for a specific mix design.

OBJECTIVE

The purpose of this study was to outline the data reduction and results from the adiabatic calorimeter tests.

RESULTS

The hydration curves for each test are combined and used to generate one theoretical hydration curve with one set of hydration parameters. The hydration curves were determined for the States of Minnesota, Nebraska, Arizona, and North Carolina.

A parametric study was performed on the hydration parameters to see their effect on the hydration curves. This parametric study shows how each of the hydration parameters affects the size and shape of the hydration curve. The findings from the parametric study can be used to compare the hydration curves between the different mixes used.

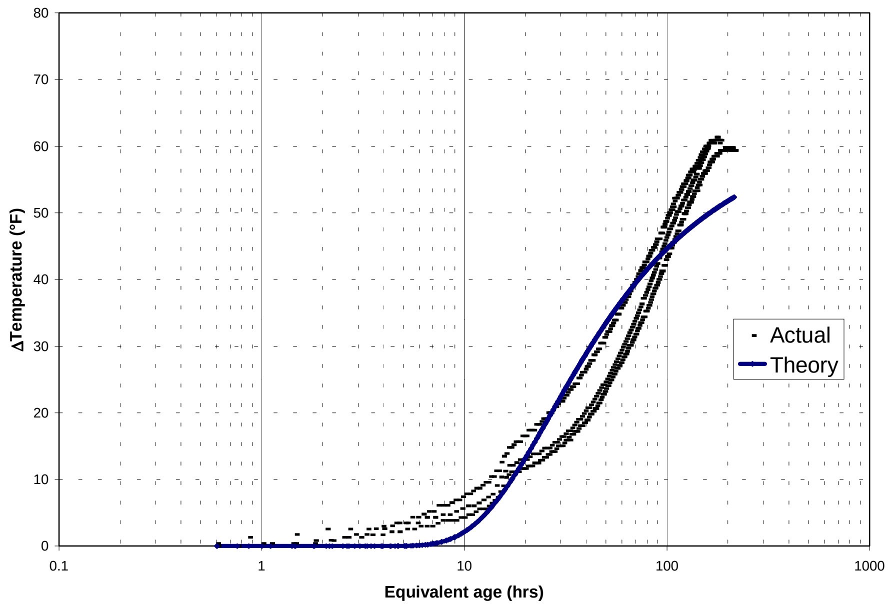

Figure 1. Hydration curve for the Minnesota concrete mix.

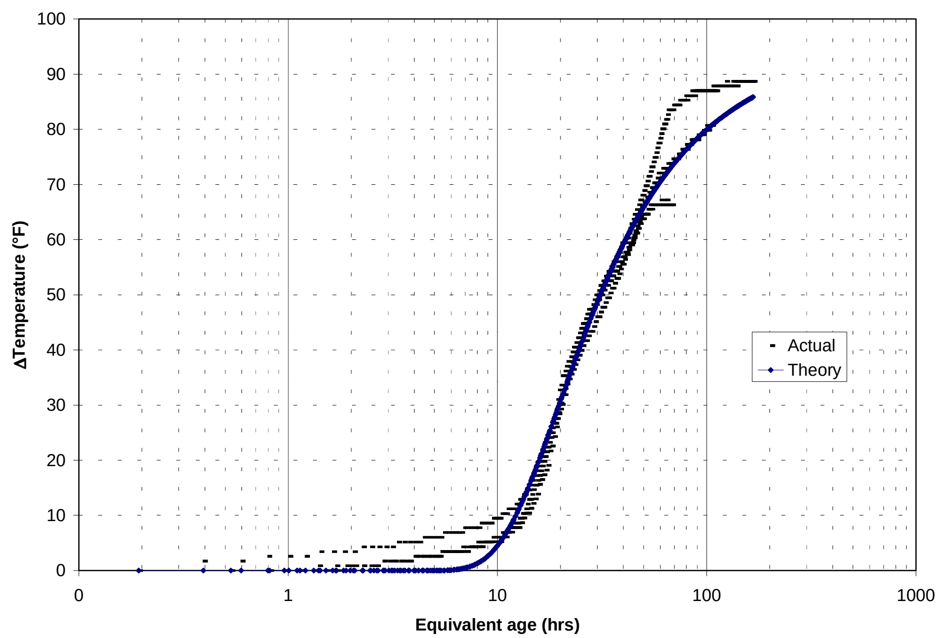

Figure 2. Hydration curves for Nebraska concrete mix.

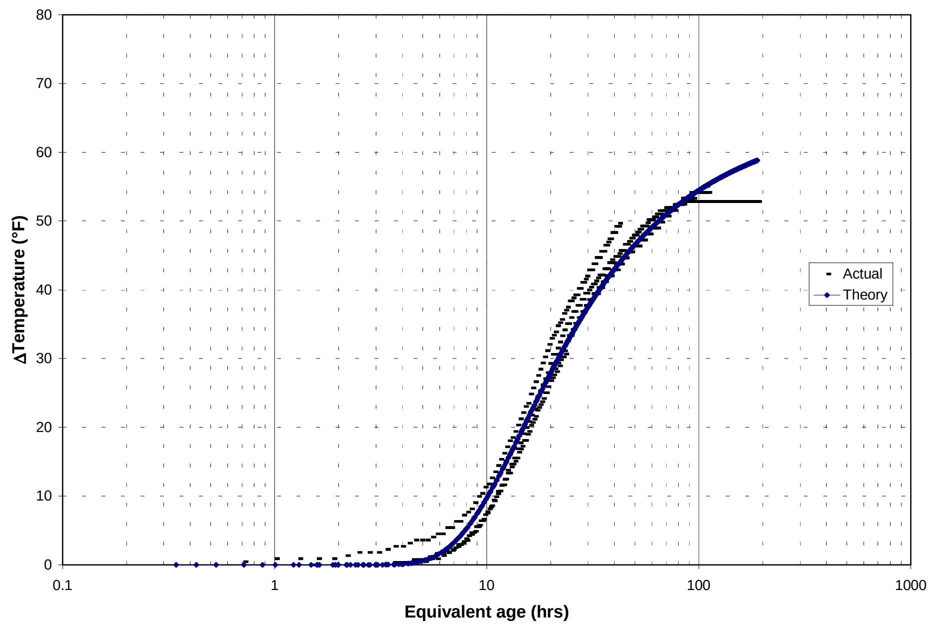

Figure 3. Hydration curves for Arizona concrete mix.

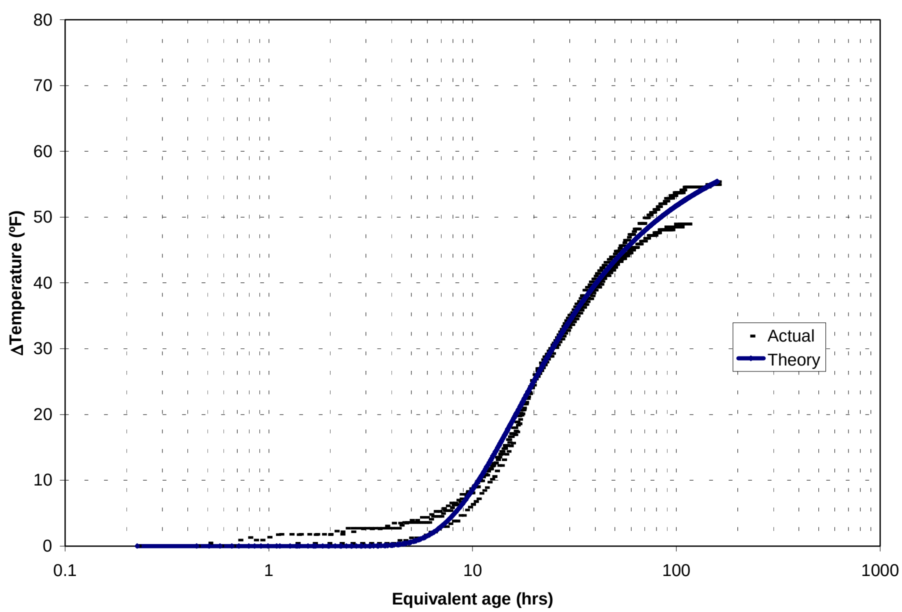

Figure 4. Hydration curves for North Carolina concrete mix.

REFERENCES

(1) Jan Byfors, Plain Concrete at early ages, CBI, 1980.

APPENDIX A:

HYDRATION CURVES

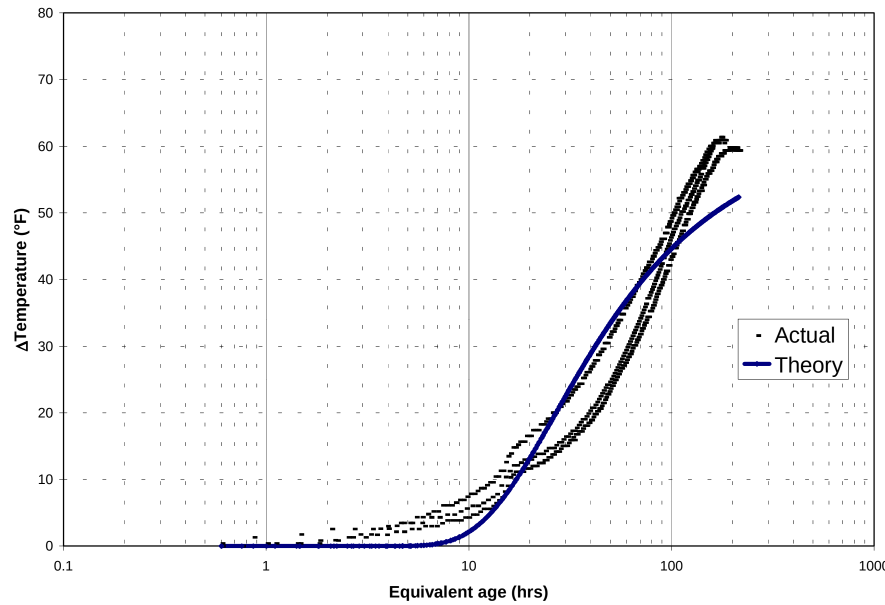

Figure A1. Hydration Curve for the Minnesota Concrete Mix

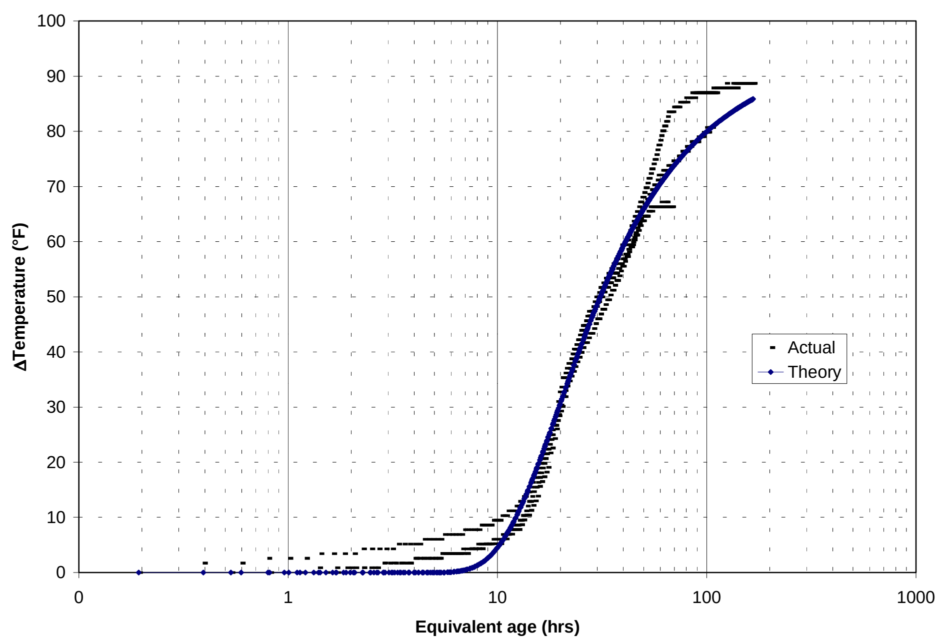

Figure A2. Hydration Curves For Nebraska Concrete Mix

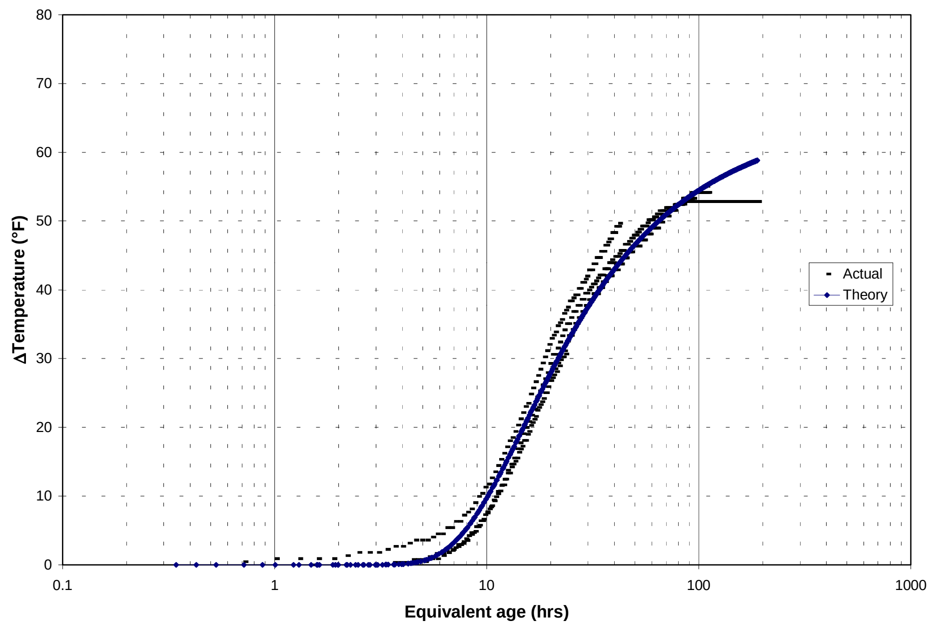

Figure A3. Hydration Curves For Arizona Concrete Mix

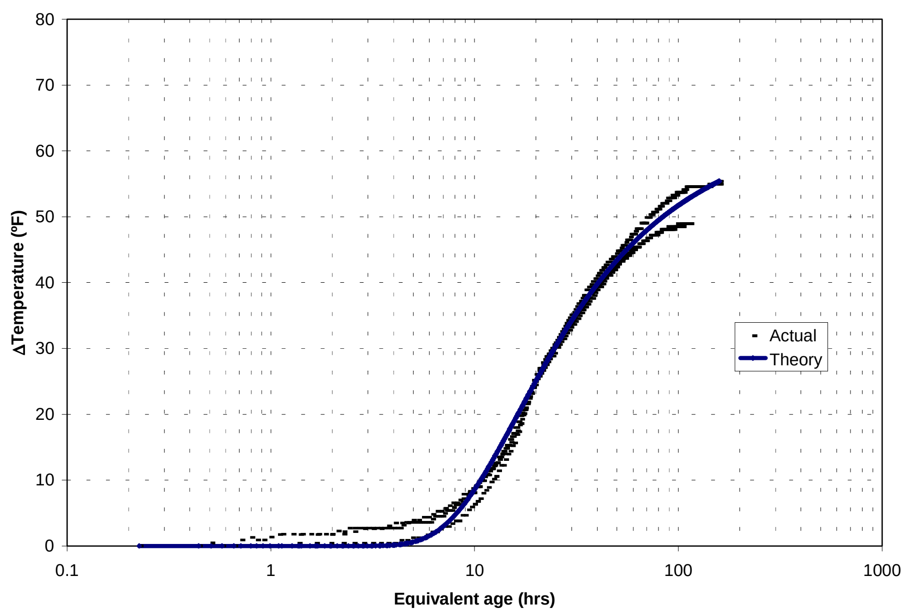

Figure A4. Hydration Curves For North Carolina Concrete Mix

APPENDIX B:

HYDRATION CURVES

PARAMETRIC STUDY FOR DEGREE OF HYDRATION

In this study the heat of hydration parameters are changed one at a time to determine the effect that they have on the development of the degree of hydration. The following heat of hydration relationship is used:

$$\alpha = e^{-\lambda\left(\ln\left(1+\frac{t}{t_1}\right)\right)^{-\kappa}}$$

For the parameter κ the values 0.5, 1.0 and 5.0 are used. The parameters t_1 and λ are held constant to a value of 1.0. The following graph shows the change in slope for the degree of hydration curve by changing this parameter. The functions of the degree of hydration g(t), f(t), and h(t) correspond to k values 0.5,1.0, and 5.0 respectively.

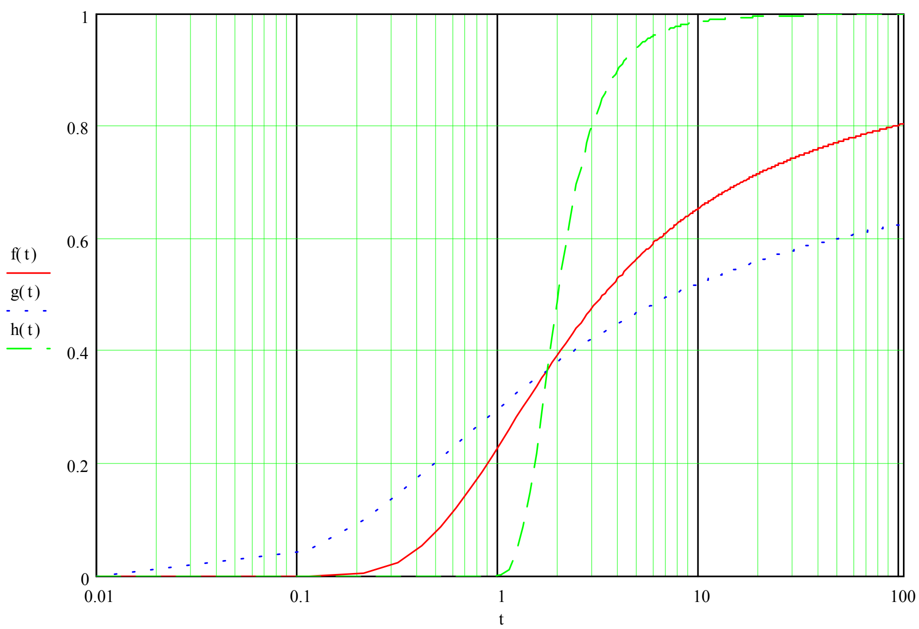

Figure 1, Change in slope of the hydration curve for a change in the parameter k

For the parameter t_1 the values 0.3, 1.0 and 5.0 are used. The parameters κ and λ are held constant to a value of 1.0. The following graph shows the shift in time when the degree of hydration curve starts to develop by changing this parameter. The functions of the degree of hydration g(t), f(t), and h(t) correspond to t_1 values 0.3,1.0, and 5.0 respectively.

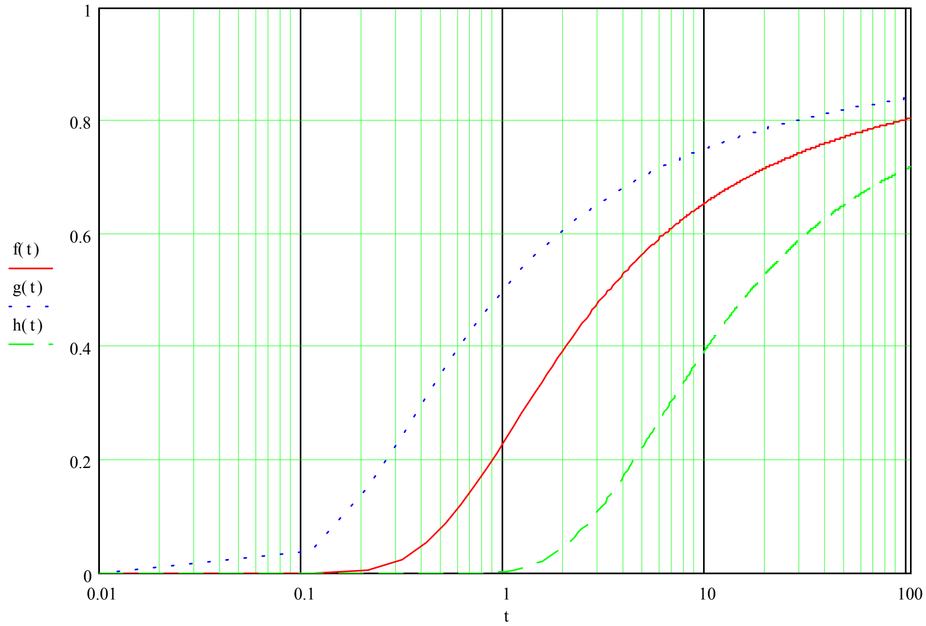

Figure 2, Change in time when hydration starts to develop for a change in the parameter t_1.

For the parameter λ the values 0.5, 1.0, and 2.0 are used. The parameters t_1 and λ are held constant to a value of 1.0. In a similar fashion as t_1, changing this parameter shifts the starting time when the degree of hydration curve starts to develop. The functions of the degree of hydration g(t), f(t), and h(t) correspond to λ values 0.5,1.0, and 2.0 respectively.

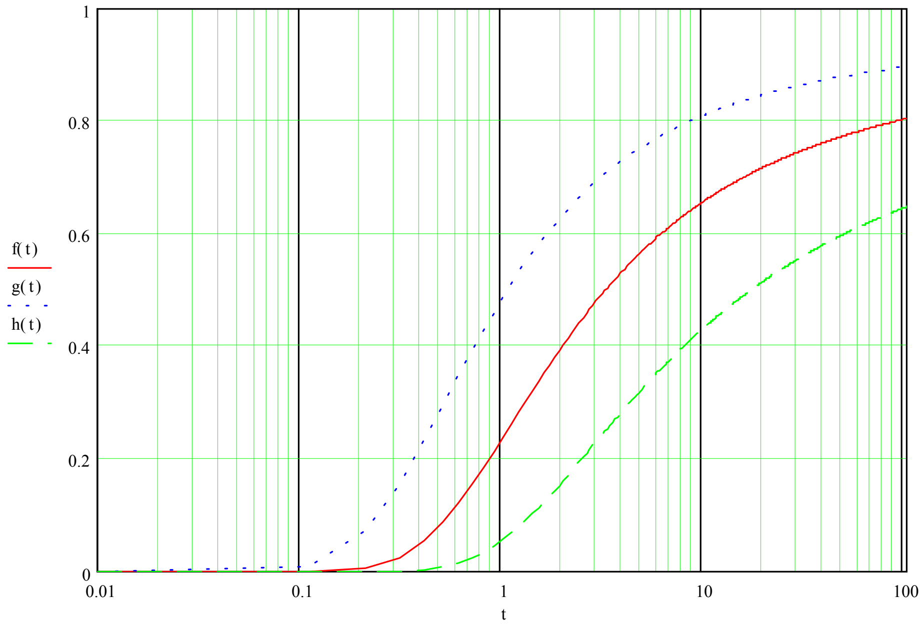

Figure 3, Change in time when hydration starts to develop for a change in the parameter λ.

The above study shows how t_1 and λ cause a similar effect on the time when the degree of hydration starts to develop. This may indicate that for a given degree of hydration curve either t_1 or λ can be fixed while κ and the other parameter are changed in order to determine the best fit for that curve.

For the tests performed on this project, λ was left constant at 1.0 while t_1 and κ where varied to obtain the best fit for the hydration curves.