Maturity in Iowa: A Construction Perspective

Kevin Merryman – PCC Field Engineer

Iowa Department of Transportation

Maturity

- Accelerated construction technique?

A Little Perspective

- Iowa does not use strength in the acceptance process for concrete paving
- Strength is only used to determine time of opening
- Contractors are responsible for repair of random cracking unless design related

When Is It Okay to Drive On?

- What strength is needed?
- How do we measure?

Time for Opening Standard Class C Concrete

Pavement Thickness (in.)	Min. Flexural Strength, (psi MOR-CPL)	Min. Time (Days)
>9	500	5
<9	500	7

Both strength and time conditions must be met.

At contractor's option, maturity method to determine time for opening based on strength requirement only.

A Little History on Maturity

- Option to use since 1997
- Used on most PCC paving projects
- Only time not used is when paving with ready mix out of plant with no maturity curve – VERY RARE

Maturity Concept

- **Time Temperature Factor: TTF**
  - Relationship between thermal history and strength of a concrete
- **ASTM C 1074 – Iowa Materials IM 383**
  - **Nurse•Saul Equation**
  - $M\ (°C \cdot hrs) = \Sigma[(T - T_0)\Delta t]$
    - *where* $T_0 = (-10\ °C)$
  - **Time × Temperature = Maturity (TTF)**

Factors of Safety

- Iowa uses 500 psi opening
  - Only 300 psi needed

Required Opening Strength

Thickness		k -value		Required Flexural Strength (MOR-TPL) in Mpa (psi) Estimated ESAL's from Time of Opening to Design Strength									
mm	in	Mpa/m	pci	100		500		1000		2000		5000	
200	8	27	100	2.55	370	2.82	410	2.96	430	3.10	450	3.24	470
		54	200	2.14	310	2.34	340	2.41	350	2.55	370	2.69	390
		136	500	2.07	300	2.07	300	2.07	300	2.07	300	2.14	310
215	8.5	27	100	2.34	300	2.55	370	2.62	380	2.78	400	2.96	430
		54	200	2.07	300	2.07	300	2.20	320	2.07	330	2.41	350
		136	500	2.07	300	2.07	300	2.07	300	2.48	300	2.07	300
230	9	27	100	2.07	300	2.27	330	2.41	350	2.07	360	2.69	390
		54	200	2.07	300	2.07	300	2.07	300	2.07	300	2.20	320
		136	500	2.07	300	2.07	300	2.07	300	2.27	300	2.07	300
240	9.5	27	100	2.07	300	2.07	300	2.20	320	2.07	330	2.41	350
		54	200	2.07	300	2.07	300	2.07	300	2.07	300	2.07	300
		136	500	2.07	300	2.07	300	2.07	300	2.07	300	2.07	300
250	10	27	100	2.07	300	2.07	300	2.07	300	2.07	300	2.20	320
		54	200	2.07	300	2.07	300	2.07	300	2.07	300	2.07	300
		136	500	2.07	300	2.07	300	2.07	300	2.07	300	2.07	300
265 or greater	10.5	27	100	2.07	300	2.07	300	2.07	300	2.07	300	2.07	300
		54	200	2.07	300	2.07	300	2.07	300	2.07	300	2.07	300
		136	500	2.07	300	2.07	300	2.07	300	2.07	300	2.07	300

Cole, Lawrence & Okamoto, Paul, Flexural Strength Criteria for Opening Concrete Roadways to Traffic, TRB paper 950222

Factors of Safety

- Iowa uses 500 psi opening
  - Only 300 psi needed (Table previous slide)
- Curve established on concrete with higher air content
- Require curve development at highest w/c ratio expected
  - Iowa allows w/c to change 0.02 higher
- Field maturity tested near edge
  - Temperature lower than at mid slab

Any Strength Issues?

- No known incidences of random cracking due to inadequate strength

Factors Affecting TTF

- Cement
- Fly Ash
- Admixtures
- w/c ratio
- Mix Type
- Aggregates

A curve validation can be used to allow some changes without establishing a new curve

QC/QA Monthly Validation

- Cast & Cure 3 Beams
- Monitor Maturity until approximate required opening TTF is reached
- Test all 3 beams and average
- Average Strength should be within ±50 psi of opening strength at TTF
  - >50 psi okay, more conservative
  - <50 psi must develop new curve

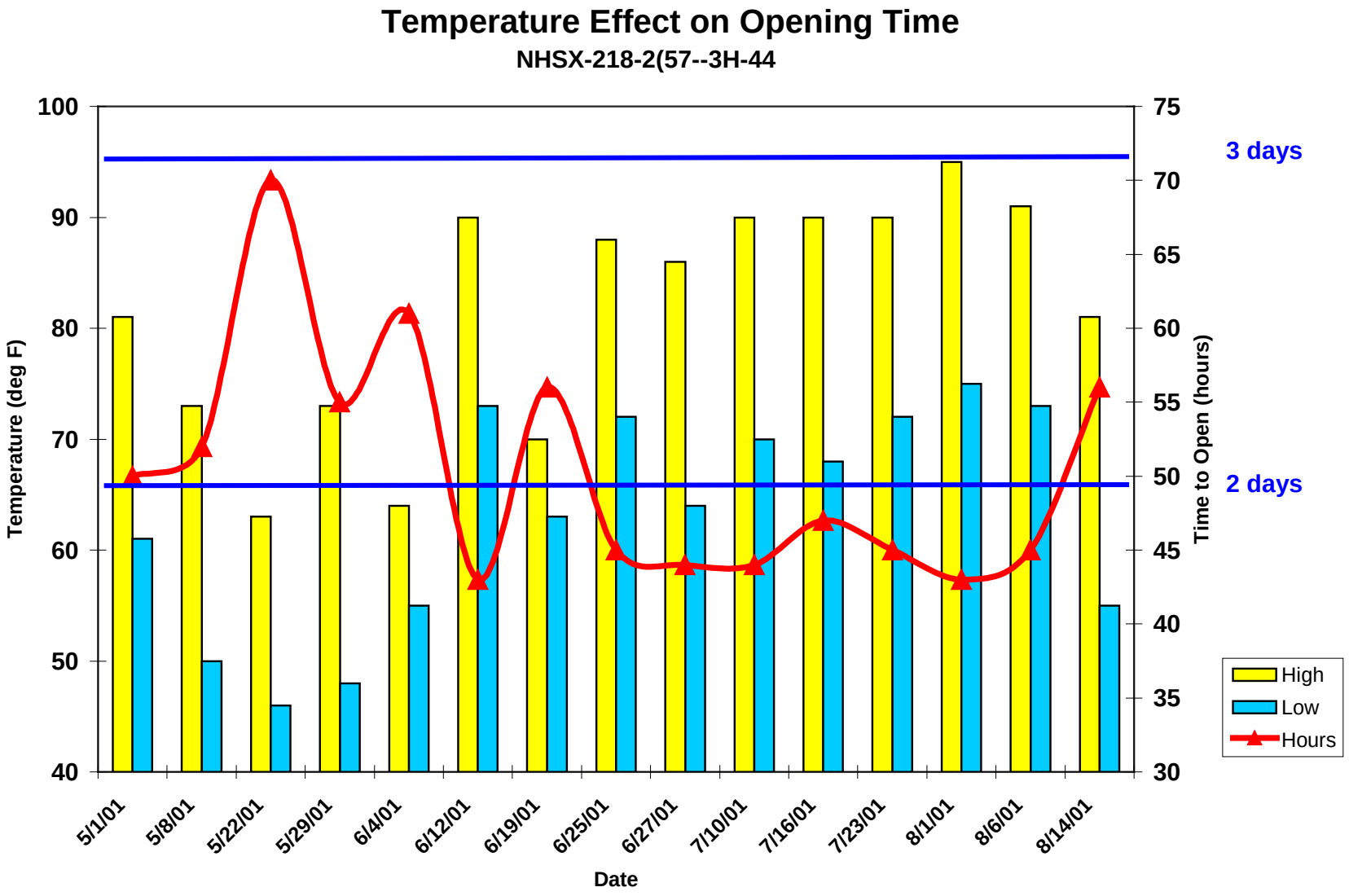
Monthly Curve Validation

Assured same basic mix being placed

Maturity - Typical Opening Times

- Summer (>80 °F) 24-48 hours
- Fall/Spring (>55 °F) 36-72 hours
- Late Fall/Early Spring (<50 °F) 48-144 hours

Seasonal Changes



Opening Times Utilizing Maturity

- Extreme late opening
  - US 20 Hamilton County
  - TTF = 3200+
- Accelerated construction?

MATURITY - STRENGTH DEVELOPMENT

CURVE #: 1
PROJ. #: NHS-520-4(43)--19-40

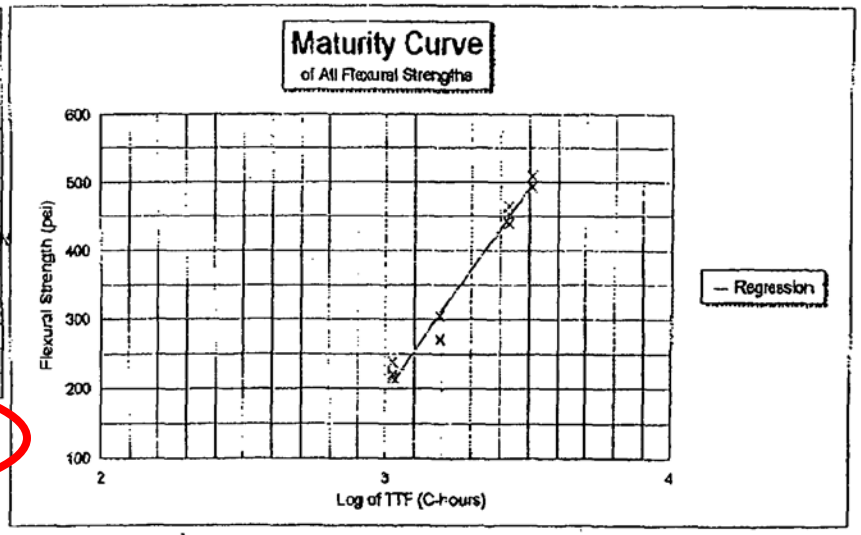
MONITOR: JERRY HINDERS
REP/CONTRACTOR: FRED CARLSON CO

INSPECTOR: JEFFREY L. BOLSINGER
DATE: 10/19/99

BEAM #	INDICATED LOAD (lbs)	ACTUAL LOAD (lbs)	BREAK LOCATION (in)	DEPTH (in)	WIDTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF
	Enter	*Enter*	*Enter*	*Enter*	*Enter*			*Enter*	*Enter*	*Enter*	
1	1700	1740	0.5	6.00	5.94	0.126263	220	40.5	1099	1011	1055
2	1800	1840	0.75	5.94	5.91	0.129480	238	40.5	1099	1011	1055
3	1600	1640	0	5.82	6.06	0.131536	216	40.5	1099	1011	1055
4	2100	2140	1.25	5.91	6.09	0.126932	272	63.5	1595	1503	1549
5	2000	2040	1.25	5.82	6.00	0.132852	271	63.5	1595	1503	1549
6	2400	2440	0.25	5.94	6.12	0.125037	305	63.5	1595	1503	1549
7	3500	3550	1	5.97	5.94	0.127535	453	136	2714	2616	2665
8	3400	3440	1.75	5.88	6.12	0.127602	439	136	2714	2616	2665
9	3500	3550	1	5.88	5.97	0.130808	464	136	2714	2616	2665
10	3900	3950	1	5.88	6.06	0.128865	509	168	3261	3149	3205
11	3800	3850	0.25	5.88	5.91	0.132136	509	168	3261	3149	3205
12	3700	3750	0.5	5.85	6.00	0.131492	493	168	3261	3149	3205

MIX INFORMATION	*Enter*
AIR:	9.2 %
SLUMP:	1.5
W/C:	.449
INITIAL TEMPERATURE OF BEAMS:	22
MIX NUMBER:	HH1
FLY ASH SOURCE:	PORT NEAL #4
CEMENT SOURCE:	HOLNAM 1S
COARSE AGGREGATE SOURCE:	MARTIN MARIETTA/ALDEN
FINE AGGREGATE SOURCE:	MARTIN MARIETTA/ANDERSON
WATER REDUCER BRAND:	
ADD. RATE:	
AIR ADMIXTURE BRAND:	DARAVAIR 1400
ADD. RATE:	22.2 OZ/CY
METHOD OF DEVELOPMENT:	MATURITY
Required Flexural Strength (MOR):	500 psi

REQUIRED TTF: 3240



NE116

Certified Maturity Contractor Representative - Jeffrey L Bolsinger
Signature

Maturity Curve Reviewed - John H. Lee
T.C. Materials Engineer

Comments:

cc: RCE, TCME, Central Materials, Pavement Materials Engineer, Contractor

Opening Times Utilizing Maturity

- Extreme early opening
  - 24th Street in Council Bluffs
  - TTF = 880 = opening in approx. 9 hours
- Accelerated construction?

MATURITY - STRENGTH DEVELOPMENT MOR-CPL

COUNTY: POTT.
CURVE #: CV47BIPF
PROJ. #: ALL

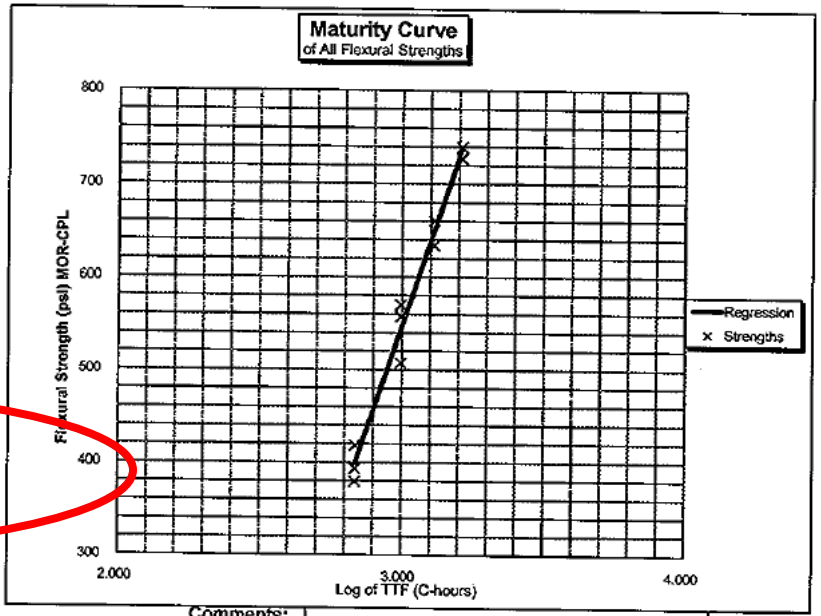
MONITOR: ATLANTIC
REP/CONTRACTOR: ALL

INSPECTOR: STEVE FORBES
DATE: 04/23/08

BEAM #	LOAD AT BREAK (lbs)	TABLE VALUE (lbs)	BREAK LOCATION (in)	WIDTH (in)	DEPTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH CPL (psi)	AGE AT BREAK (days)	TTF CH 1	TTF CH 2	AVERAGE TTF	BEAM TEMP (AVG)
	Enter	*Enter*	*Enter*	*Enter*	*Enter*			*Enter*	*Enter*	*Enter*		*Enter*
1	3300	3140	cl	5.98	6.00	0.125418	394	27	683.1	683.1	683	17
2	3500	3340	cl	5.98	6.00	0.125418	419	27	683.1	683.1	683	17
3	3200	3030	cl	5.98	6.00	0.125418	380	27	683.1	683.1	683	17
4	4200	4050	cl	5.98	6.00	0.125418	508	39	986.7	986.7	987	13
5	4600	4450	cl	5.98	6.00	0.125418	558	39	986.7	986.7	987	13
6	4700	4550	cl	5.98	6.00	0.125418	571	39	986.7	986.7	987	13
7	5400	5270	cl	5.98	6.00	0.125418	661	51	1292.1	1292.1	1292	18
8	5400	5270	cl	5.98	6.00	0.125418	661	51	1292.1	1292.1	1292	18
9	5200	5060	cl	5.98	6.00	0.125418	635	51	1292.1	1292.1	1292	18
10	5900	5800	cl	5.98	6.00	0.125418	727	63	1612.5	1612.5	1613	16
11	6000	5900	cl	5.98	6.00	0.125418	740	63	1612.5	1612.5	1613	16
12	6000	5900	cl	5.98	6.00	0.125418	740	63	1612.5	1612.5	1613	16

MIX INFORMATION	*Enter*
AIR:	6.00%
SLUMP:	3.00"
w/c:	0.43
MIX:	CV47BIPF
FLY ASH SOURCE:	
GGBFS SOURCE:	
CEMENT SOURCE:	PC008
COARSE AGGREGATE SOURCE:	ANE002
INTERM. AGGREGATE SOURCE:	
FINE AGGREGATE SOURCE:	ANE504
WATER REDUCER BRAND:	POZZ.322N
Add. Rate:	3OZ/100#
AIR ADMIXTURE BRAND:	DARAVAIR1400
Add. Rate:	3OZ/YARD
METHOD OF DEVELOPMENT:	
Desired Flexural Strength (MOR-CPL):	500 psi

REQUIRED TTF:	883



Certified Contractor Representative - _____
Signature

Maturity Curve Reviewed - _____
Testing Engineer

Comments:

cc: RCE, DME, Central Materials, Contractor

Maturity Advantages

- Use new pavement as haul road

CHEVROLET

Maturity Advantages

- Use new pavement as haul road
- Early entry sawing
  - 100% of joints cracked and working

Maturity Advantages

- Expedite sub-drain and shouldering

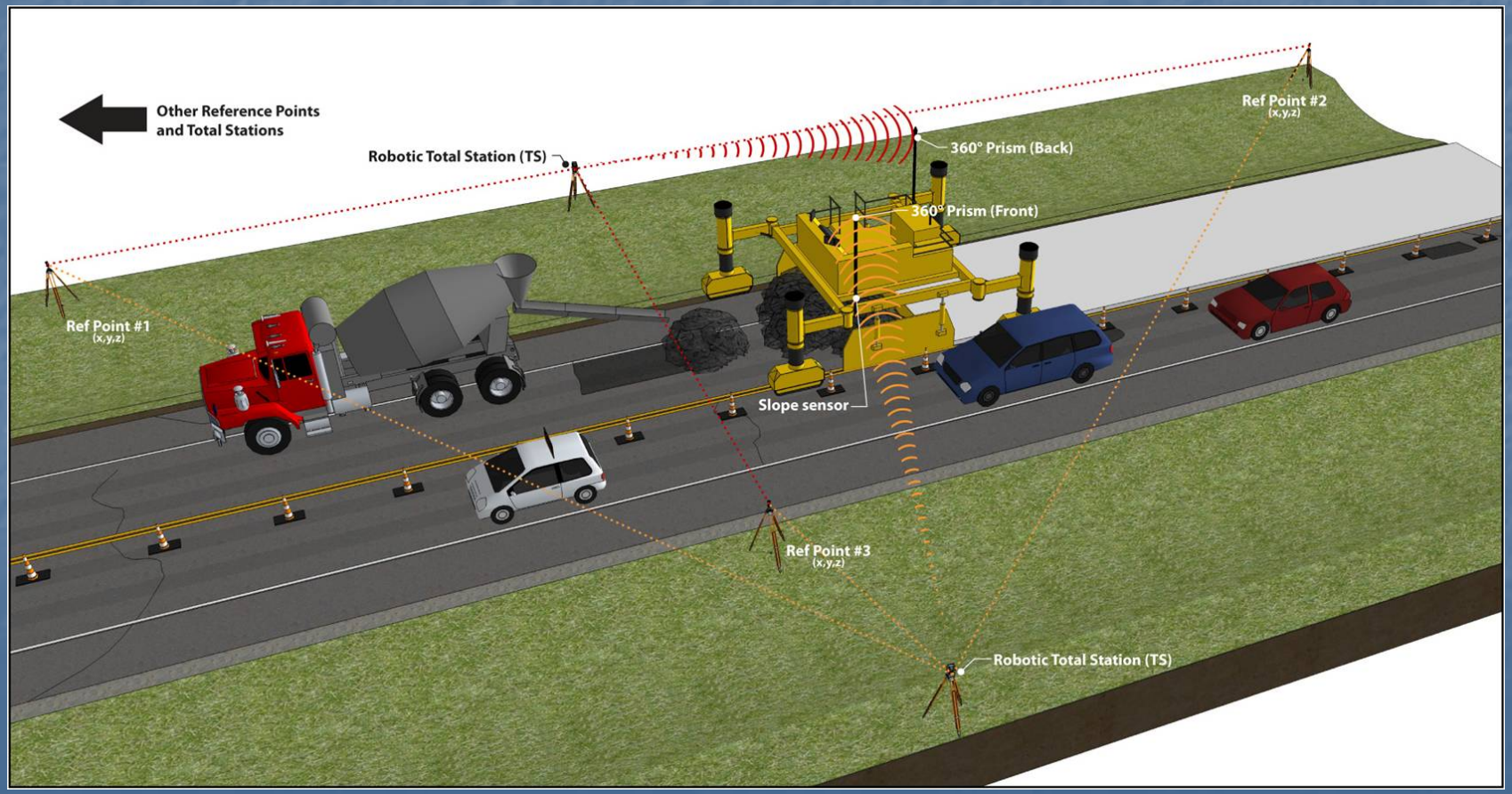
Maturity Advantages

- Accelerate staged construction

Budweiser

Maturity Advantages

- PCC overlays under traffic – staging

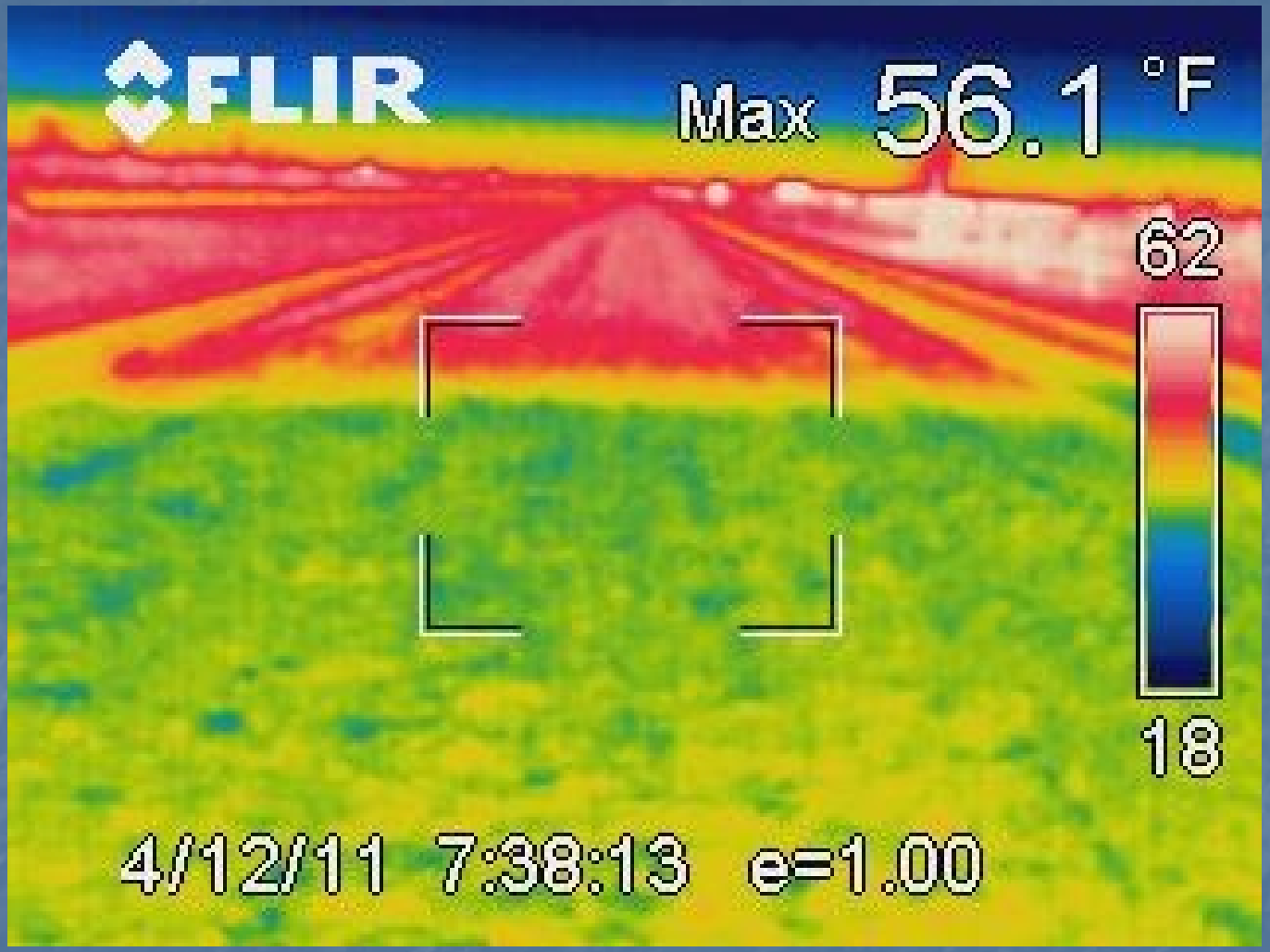


Maturity Advantages

- Provide local access
- Reduced construction time and cost

Conclusions

- Is use of maturity an accelerated construction technique?
  - Peer pressure approach – Everyone is using it……
  - Practical approach – “Time is money”
  - 2010 average prices
    - 10” QM-C pavement $25.49 (500k SY)
    - 12” QM-C pavement $32.97 (250k SY)
- Bottom line – it depends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Questions????