Design Considerations for Efficiency and Performance

2019 Municipal Streets Seminar

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Iowa State University University - Ames

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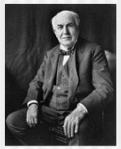
Count on Concrete

COMMON SENSE

- Can't be bought
- Can it be taught?
- Do your best to use it
- "The three great essentials to achieve anything worthwhile are, first, hard work; second, stick-to-itiveness; third, common sense."
  – Thomas A. Edison



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Really?

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Specs & References

- Iowa – SUDAS
- Iowa – DOT
- MN – DOT
- MN – LRRB Flatwork
- ACPA, NRMCA, ACI, IGGA etc

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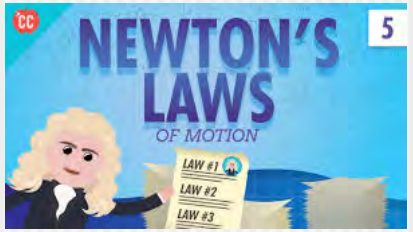
Two People I have Learned not to Argue With



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Jointing

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Rule Number 1

- CONCRETE CRACKS!!!

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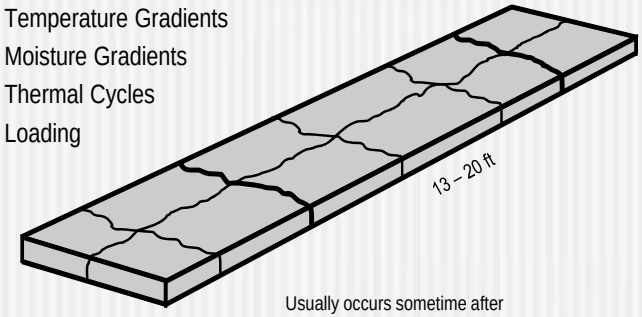
Natural Crack Development

- Temperature Gradients
- Moisture Gradients
- Thermal Cycles
- Loading



Usually occurs sometime after 12 hours and may take months

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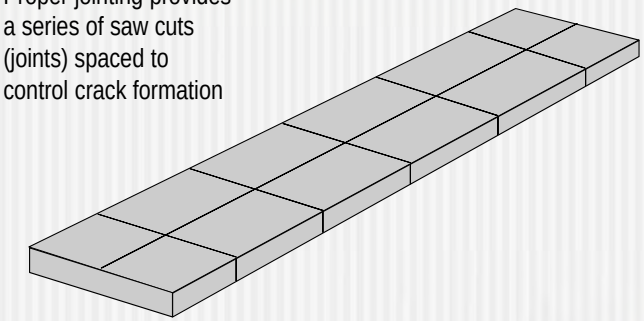
Natural Crack Development

- Proper jointing provides a series of saw cuts (joints) spaced to control crack formation



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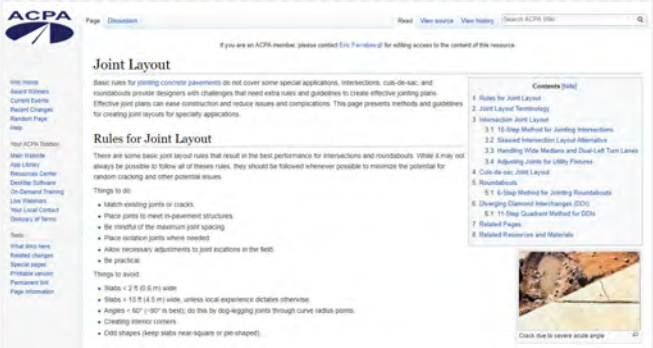
ACPA WikiPave

- http://www.acpa.org/wikipave-org/



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Joint Spacing

- 2 x Thickness (in inches)
- 1.75 x Thickness (in inches)

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Things to Ensure

- Match existing joints or cracks
- Square or rectangular panels
- Reduce/eliminate crack risks
  - Develop a jointing plan
  - Watch timing
  - Understand joint location
    (make field adjustments & be open to suggestions from the contractor)

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Things to Avoid

- Slabs < ~~3~~ 4 ft. wide
- Slabs > 15 ft. wide
- Long narrow slabs
- Angles < 60º (≈90º is best)
- Include 'Stopper Bars' if acute angles are formed or if terminating a joint at another slab without isolation material. (WikiPave)

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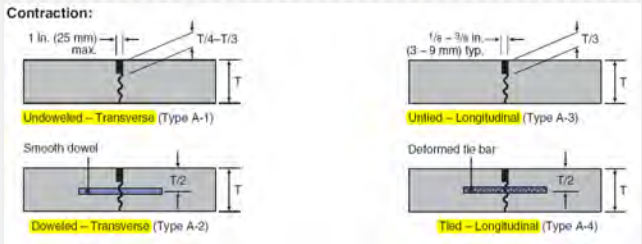
Contraction Joint (sawed/tooled)



- (https://iowadot.gov/erl/current/RS/content_eng/pv101.pdf)

ACPA Publication TB019P – "Concrete Intersections: A Guide for Design and Construction"

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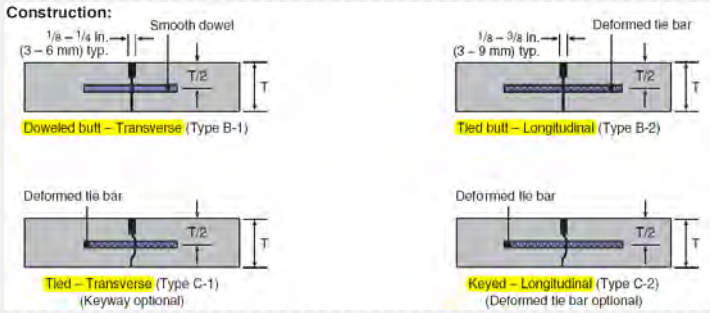
Construction Joint (butt)



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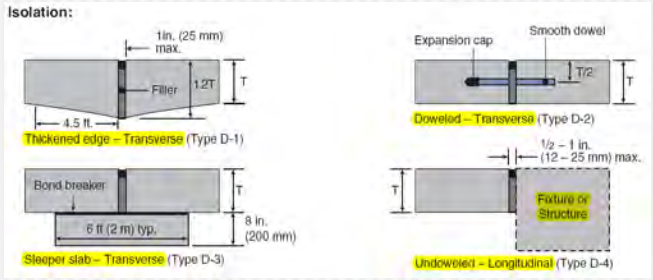
Isolation Joint (expansion)



- (not all allowed/offered in Iowa)

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Difference between Expansion and Isolation Joints

- Expansion Joints
  - For structures within the pavement (bridges)
  - *Not needed in the mainline pavement at regular intervals*
- Isolation Joints
  - At intersections
  - Small in-pavement objects
  - For structures adjacent to the pavement

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Intersection Jointing

- Develop a jointing plan
  - Bird's eye view
- Follow ACPA's 10-step method
- Be practical!

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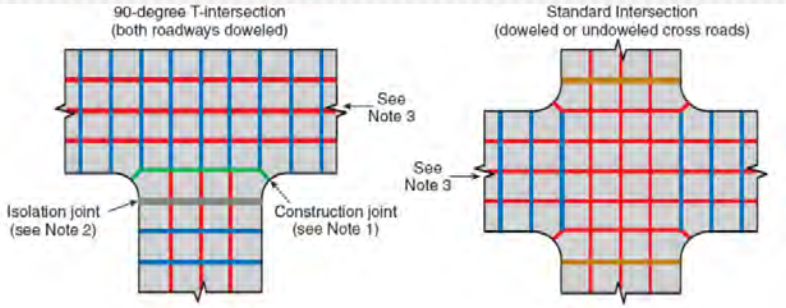

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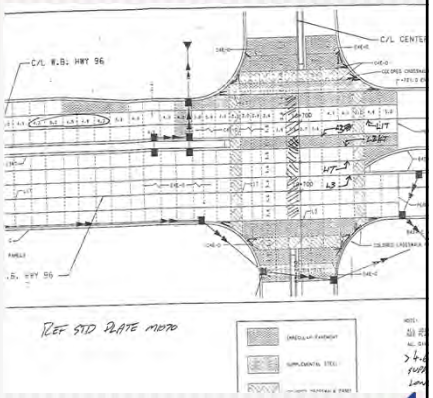
Jointing Options

- Match joints
- Isolate intersection to eliminate having to match



Isolating Intersections

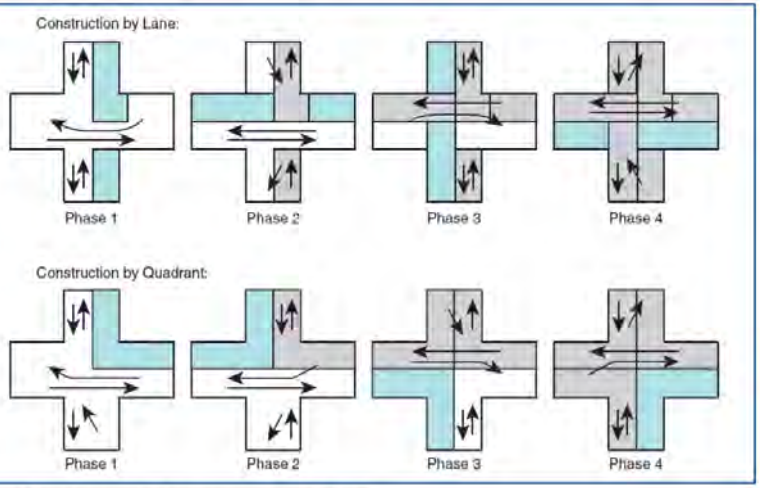
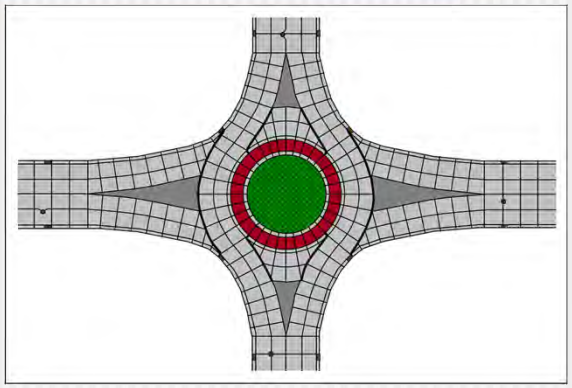


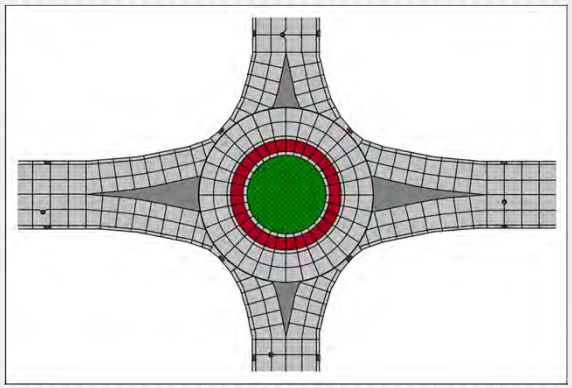
Figure 8. Possible options for phasing construction under traffic.

ACPA Publication TB019P – "Concrete Intersections: A Guide for Design and Construction"

Roundabout – Pave Through

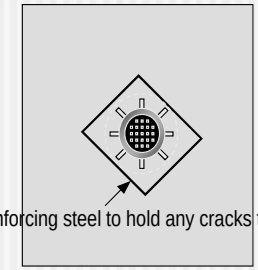


Roundabout – Isolate Circle



In-Pavement Objects

Locate in Mid-Panel



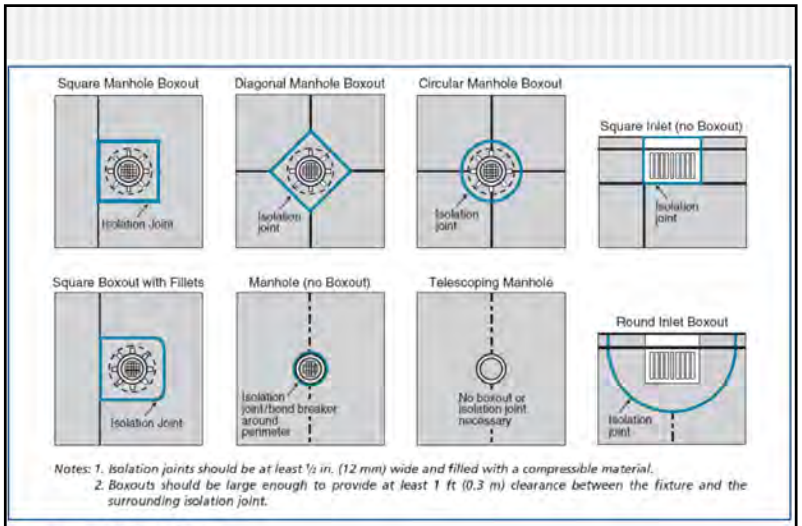


Figure 6. Details for boxing out fixtures.

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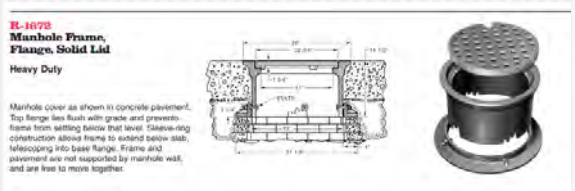
Telescoping Manholes

- Easier than boxouts
- No jointing - moves with pavement
- Neenah Types:
  - R-1672, R-1673, R-1673-A ?



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Intersecting Side Streets

- Consider continuing concrete out of turning and/or stopping zones to minimize bump/rut

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Construction and Timing

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Construction Considerations

Staging

- The more often the paving crew is required to return the higher the costs for mobilization.
- Minimize the number of holes/exceptions to maintain continuity. Holes require forming and hand work at both ends.
- The less the paver needs to return, the more uniform the pavement and better the ride.

Construction Considerations

Staging

- If there are multiple projects due in the same basic time frame, try to pave projects together. Obviously, the unit costs will be lower for larger projects, but it is also a more efficient use of personnel

Construction Considerations

Set-up

- The more variable width of pavement, the more paver set-ups required, the higher the cost per square yard.
- Most efficient if paver can set up and go. Uniform widths require less set-ups
- Best idea for urban paving is 12' width intervals

- Allow integral curb whenever possible

Figure 13. Slipform pavement with integral curb.

ACPA Publication TB019P – "Concrete Intersections: A Guide for Design and Construction"

Construction Considerations

Set-up

- Maintain uniform lane widths. Ramps, loops, acceleration, deceleration, turn lanes, radius', etc. are better off squaring off rather than tapering.
- Median noses have less issues when uniform width vs taper or rounded.

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Use bid items required

- Separate Bid Item for Each Thickness
  - 7" Concrete Pavement
  - 6" Concrete Pavement
- Dowels & Reinforcing Steel
- Incidental items vs contractor risk (money)

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Pavement Steel

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Use ~~MnDOT~~ IA DOT Approved Materials

- Cement
- Water
- Fine Aggregate
- Coarse Aggregate
- Admixtures
- Joint Sealers

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Construction Considerations

Timing

- The more restrictive the contract, as far as working days and/or completion date, the higher the costs.
- Paving contractors are usually in high demand in the fall. (Grading vs OL)
- If there is any way of varying the time requirements or grade first year and pave the following year, the costs will be lower

Construction Considerations

Timing

- Project let in early fall or winter tend to have more competitive prices due to scheduling and materials costs.
- An open time period will reduce costs by allowing the contractor to fit project in their schedule.
- Let grading and paving portions separately.

Construction Considerations

Specifications

- Uniform specifications from District to District, County to County and City to City would stabilize pricing greatly.

Construction Considerations

Miscellaneous

- COMMON SENSE Joint and lane layouts, design, accessibility, and staging should all be well thought out. Simpler is usually better. If you or yours are not familiar with certain aspects, call ICPA, IRMCA or the contractors.

DOT Specs

- 'Highway' specs not residential specs
- IA DOT vs SUDAS

A Little Math

- Typical Mn/DOT C&G mix
  - 280 lb water (16.6% by volume)
  - 1.5 ft^3 air (5.5%)
  - 500 lb cement (9.4%)
  - 90 lb fly ash (2.0%)
  - 1190 lb sand (26.7%)
  - 1800 lb rock (39.8%)

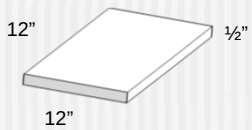
    (100.0%)

A Little Math

- Typical Mn/DOT C&G mix
  - 3.5% deleterious material, by weight, allowed by spec in the rock
  - 1800# x 0.035 = 63#/cy of deleterious material

A Little Math

- 12" x 12" x ½" section = 0.0015 CY
- 63# x 0.00154 = 0.097# = 1.6 oz
- If a ½" diameter rock weighs 0.2 oz that is 8 pop-outs / sf or
- 72 pop-outs per SY



Maturity (Specification ~~2461.3.C.6~~ IM 383)

What is Maturity?

- Maturity describes a relationship between time and temperature
- Measured in "Celsius-degrees-hours" (C°H)
- Represents a "rate of change"
- "Simple" to calculate – area under the time & temperature curve (calculus)
- "Discovered" (described) by Nurse and Saul in 1950's
  - Concrete of the same mix at the same maturity has approximately the same strength whatever combination of temperature and time go to make up that maturity" (Saul 1951)

Maturity Benefits

- Provides a better representation of in situ concrete strength gain than laboratory or field cured specimens
- Enables anytime in situ strength measurements
- Provides better timing for strength dependent construction activities
- Saves time and money compared to conventional strength testing procedures
- Enables in situ strength measurements at lowest strength locations
- Enables in situ strength measurements at critical strength locations

Speaking of Strength…

- When Can We Allow traffic on New Concrete?
  - 7 Days?
  - 3 Days?
  - 1 Day?

Table 7010.01: Minimum Age and Tested Strength of Pavement Before Opening

Class of Mix	Type of Cement	Minimum Age For Opening[1]	Minimum Compressive Strength (psi)	Minimum Flexural Strength Center Point (psi)
C	Type I	7 Days[2]	3,000	575
M	Type I			

[1] Opening without testing only allowe
[2] Five calendar days for concrete 9 i

Table 2301.03- 3: Minimum Flexural Strength

Strength Class of Concrete	Minimum Age	psi
A	14 calendar days[(a)]	500
B	14 calendar days	400
C	7 calendar days[(b)]	500
M	48 hours[(c)]	500

(a) 10 calendar days for concrete 8 inches thick or more.
(b) 5 calendar days for concrete 9 inches thick or more.
(c) Pavement may be opened for use prior to 48 hours when minimum flexural strength requirements are met.

Opening Strength

Early loading of Cells 124-424

4,000 lb axle vs 14,000 lb axle loads (1st Cell @ 3hrs)

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The Experiment

Concrete Age:

3 hrs. | 5-3/4 hrs. | 8-1/3 hrs. | 10-1/2 hrs. | No Load

124 | 224 | 324 | 424 | 524

Cell x24 Early Loading Sequence		
Maturity (Deg-Hr)	Flexural (psi)	Loads applied to lanes
100	73	1st Load on Cell 124 (forward and back)
200	196	1st Load on Cell 224, 2nd load on Cell 124
300	267	1st Load on Cell 324, 2nd load on Cell 224, 3rd load on Cell 124
400	318	1st Load on Cell 424, 2nd load on Cell 324, 3rd load on Cell 224, 4th load on Cell 124

Starting Day 2, 5 passes per day for first week

Burnham - NCC 2017

3 hours

https://www.youtube.com/watch?v=A7n-CaONIwU

- https://www.youtube.com/watch?v=ZyNy2UA9mSs

MnROAD – Early Opening

- https://www.youtube.com/watch?v=fn-bd4RVXWQ

Thank You
Questions?

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