Implementation of Portland Limestone Cements

Larry Sutter
Michigan Tech Transportation Institute
Background

• Type 1L cements have been adopted
  – ASTM C595 in June 2012
  – AASHTO M 240 in August 2012

• A major step change in the goal of improving the sustainability of portland cement concrete
2109: All sentences are just the word "sustainable" repeated over and over.

2061: "Sustainable" occurs an average of once per sentence.

2036: "Sustainable" occurs an average of once per page.

2020: "Sustainable" occurs an average of once per year.

Present day: "Sustainable" occurs an average of once per month.

1960: "Sustainable" occurs an average of once per decade.

Frequency of use of the word "sustainable" in US English text, as a percentage of all words, by year.

Source: Google ngrams.
CO₂ emissions from clinker production as a function of kiln efficiency

Herfort, 2012
CO₂ emissions from clinker production as a function of kiln efficiency

Herfort, 2012
Why do I care?

• As an “academic” I am a neutral observer

• I can study problems and offer opinions/solutions without an agenda… but I do have an agenda…

• I am a tax payer so I want good roads

• I have a 17 year old daughter that deserves to be left a world not on the brink
PLC Implementation

• Informal survey was conducted to gauge the DOTs attitude towards adoption of PLCs

• Intent was to see what efforts might be needed to facilitate implementation

• Results indicate:
  – DOTs are generally supportive of PLCs
  – NCC can facilitate by providing information exchange
In the foreseeable future, is your agency planning to include the use of Type IL cements in pavement construction?

8 - Yes

2 - No

3 - We will consider it after more testing, either laboratory or field testing, or both

3 - Other (provide comments)
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11 – Yes (Those replying other were yes with caveats)

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Q1 Other Comments

- For the most part supportive
  - We would allow it if a cement company decides to produce it, but meetings with various Associations would be needed to discuss mix design parameters.
  - Our agency is currently doing a research study to evaluate the effects of increased limestone dust in cements. This will probably be completed next year. It is important to note that our agency has not seen the use of any blended cements for road or bridge work.
  - Probably require a special provision to clarify
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National Concrete Consortium Cement Task Force

About the NCC Task Force on C595 and C1157 Cements

The NCC Task Force on C595 and C1175 Cements was initiated in order to develop an electronic forum for documenting and exchanging information about the performance characteristics of ASTM C595 / AASHTO M240 and ASTM C1175 cements in concrete for paving and transportation structures.

Objectives

The objectives of the NCC Cement Task Force are to

- Establish an electronic resource (website)
  - Share state experience with projects that have used ASTM C595/AASHTO M240 and ASTM C1175 cement specifications
  - Share testing and project data from cement manufacturers and other laboratories
  - Post or link to relevant research
  - Develop and post Frequently Asked Questions
- Identify technology transfer needs and meet those needs
- Report to NCC on task force activities and recommendations

Resources

- Field Trials of Concretes Produced with Portland Limestone Cement by Michael D.A. Thomas, Doug Hooton, Kevin Cail, Brenton A. Smith, John De Wal, and Kenneth G. Kazanis (1.4 mb pdf)
- Use of Performance Specified (ASTM C1157) Cements in Colorado Transportation Projects: Case Studies by Thomas J. Van Dam and Brooke W. Smartz (206 kb pdf)
- Performance Enhancing by Thomas J. Van Dam, Brooke W. Smartz, and Todd Laker (4.74 mb pdf)
- Use of Performance Cements in Colorado and Utah: Laboratory Durability Testing and Case Studies by Todd Laker, Brooke W. Smartz, and Thomas J. Van Dam (2.3 mb pdf)

Task Force Documents

- Report for TTCC/NCC Task Force on C595 and C1157 Cements by John Melander (797 kb ppt)
- Minutes from the Cement Task Force July 2010 meeting (18 kb doc)

Members of the Task Force

- Peter Taylor, National Concrete Pavement Technology Center
- John Melander, Portland Cement Association
- Al Innis, Holcim, U.S.
- Nick Popoff, St. Marys Cement Group
- Tommy Nantung, Indiana DOT
- John Staton, Michigan DOT
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Lost Creek Road Morgan, Utah

- Rural County Road
  - Constructed 2009
  - Major Truck Traffic
  - Construction Limitations
  - Mountain weather issues

- Performance System
  - 10% Limestone Cement
  - 20% Class F fly ash

- Compressive strength
  - design 4000 psi, average 5120 psi

- Flexural strength
  - design 650 psi, average 720 psi
104th South, Salt Lake City, Utah

- Pooled Fund Ternary Study (2009)
  - University of Utah* (Tikalsky)
    - 10% Limestone Cement
    - 25% Class F Fly ash
- Single days production
- Control Section Strength*
  - Compressive 4454 psi
  - 28Day
- Actual Test Section Strength*
  - Compressive 5396 psi
  - 28Day
SR 201, Salt Lake City, Utah

- Eastbound lanes paved August 2009 with ASTM C150 Type II/V
- **Westbound lanes paved October 2009 with ASTM C1157 10% portland-limestone cement**
  - Both mixes contained 25% Class F fly ash
- Eastbound Strength
  - Compressive ~5000 psi
  - Average Concrete Temp ~70 °F
- Westbound Strength
  - Compressive ~4500 psi
  - Average Concrete Temp ~50 °F
City of Denver Concrete Paving

- Aligns with Denver Greenprint Program
  - 20% Class C fly ash
  - No noticeable performance differences
  - Winter construction
  - 25% Class C fly ash
US HW 287 Near Lamar, CO

- 7 Miles PCCP (2008)
  - Hot dry summer construction
- Ports to Plains US Highway route
  - Heavy truck traffic
- 20% Class F fly ash
- 695 psi average 28-day flexural strength
- Contractor received quality incentive per CDOT specifications
- Used in concrete paving on a regular basis in Colorado
Over 100 miles of paving in Colorado and Utah
Do you feel the need for additional laboratory and field testing of these materials, or do you think ample testing has been performed but the results need to be accumulated into a single report for review by your agency?

1 - Need more laboratory testing

2 - Need more field testing

3 - Need both more laboratory and field testing

4 - Enough testing has been performed; it needs to be assembled into a single document for our agencies review.

6 - Other (provide comments)
• There is not much information on using this cement with cementitious materials to address alkali-silica reaction.

• Not having seen all the documentation it is difficult to rule out further testing in the field and lab. It would be helpful if in there was one location that assembled all research documents that would be available online to agencies for review.

• Our agency has seen very little data for Type 1L blended cement making it difficult to determine if enough testing has been performed. Our agency has conducted limited testing involving permeability and strength.
Our agency is currently doing a research study to evaluate the effects of increased limestone dust in cements. This will probably be completed next year. We implemented a testing protocol to compare base cement with the IL cement.

Our DOT has had several projects ASTM C1157 cement with positive results.

Need more field testing – Which we plan to do on real time projects.
• Between what is in this document and the references cited in this document, there is ample information on laboratory testing of PLC

• NCC should approach PCA about putting this document on the Cement Task Force web page for distribution to all stakeholders

**State-of-the-Art Report on Use of Limestone in Cements at Levels of up to 15%**

by P. D. Tennis, M. D. A. Thomas, and W. J. Weiss
What do you see as the biggest hurdle(s) to implementing Type IL cement in your agency’s specifications? (Please comment.)
The time necessary to implement new specification language is our only hurdle.

It will take some time to work out the mix design parameters which must include mitigation measures for alkali-silica reaction.

No large hurdles. With a confidence level gained through lab testing we would likely allow implementation. We already allow ASTM C595 cements with some restrictions.

There is none. It is in AASHTO M 240, therefore it is in our specification.
• **Proving the savings achieved, which limestone producers (for Type IL Cement) use as a major selling point.**

• None – we have allowed.

• Unsure as at the moment as our agency does not allow any blended cements.

• **Biggest hurdle is getting the states to accept it for AASHTO. No more testing is required to implement Type IL cements.**
• Transferring knowledge to concrete suppliers, contractor, and DOT field personnel about the materials and its potential advantages and disadvantages (if any) so they gain a comfort level with using the material.

• No major obstacles other than acceptable performance using Type 1L blended cement.

• There has to be a market for blended cement. To date I have not seen any interest by paving contractors or ready-mix producers to use any blended cement for work in our state, let alone a Type 1L.
Another concern is addressing potential forms of sulfate attack when using high limestone containing cements such as Type IL cement. Recommendations and reports on mitigating this risk would be helpful. Current research available appears to be limited on the potential of sulfate attack on Type IL cement.

Biggest hurdle is usually because it is new and different from what engineers are used to. Although it is common practice here to use ternary mixes, there are still some who will not implement the use.
Another concern is addressing potential forms of sulfate attack when using high limestone containing cements such as Type IL cement. Recommendations and reports on mitigating this risk would be helpful. Current research available appears to be limited on the potential of sulfate attack on Type IL cement.

- The new specifications do not permit use in a sulfate environment
- Significant research has been done showing performance in a sulfate environment to be comparable to OPC
- Additional research will be conducted to confirm these findings.
• Our Standard Specifications for portland cement do not explicitly require C150 Type I cement, nor do they explicitly prohibit C595 cements for all applications. <edit> Hence, if all concerns are successfully addressed relative to the performance of C595 Type IL, we will probably opt to provide clarification to our cement specifications via special provision.

• We do not see any large hurdles. We plan an interim implementation period with a nominal limit of 10% limestone content, followed by eventually increasing our spec to the full 15% allowed in the ASTM spec if performance at 10% is satisfactory.
Take Aways

• Information exchange on in-place PLC is needed
  – NCC should have Utah and Colorado discuss their experiences at the next meeting

• Information needs to be passed down to the contractors
  – Associations, NCC, and CP Tech all have a role

• But what you never thought you’d hear an academic say – neutral or not…
No more research is needed!
• The time is **now** for all stakeholders to work together to implement this new technology

• This represents a step change in the sustainability game

• Lets embrace it
Questions?