Aggregates for Concrete

Dr Peter Taylor, PE
Concrete

- Civilization would be stunted without it.
- Can be formed to any shape.
- It is fabricated on site.
- Using empirical QC tools.
- There is a lot of it.
- It's more complicated than you think.

The Concrete

- Gray ....................... ✓
- Hard ...................... ✓
- Cracked .................... ✓
What is Concrete?

640 m

30 mm

20 µm
The Perfect Material for Pavements

- Cost effective
- Easy to build with
- Get traffic on it fast
- Unbreakable
- Weather-proof
- Sustainable
- Resilient
### Life is changing

<table>
<thead>
<tr>
<th></th>
<th>1977</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of ingredients</td>
<td>Cement, water, rock, sand, AEA</td>
<td>Add SCMs, admixtures, int. aggregates, limestone…</td>
</tr>
<tr>
<td>Opening</td>
<td>Weeks</td>
<td>Days (or hours)</td>
</tr>
<tr>
<td>Curing</td>
<td>Weeks</td>
<td>Days</td>
</tr>
<tr>
<td>De-icing</td>
<td>Sand, NaCl</td>
<td>Other chlorides, formates, acetates</td>
</tr>
<tr>
<td>Design life</td>
<td>20 years</td>
<td>100 years</td>
</tr>
<tr>
<td>Knowledge base</td>
<td>In house</td>
<td>Contracted out</td>
</tr>
</tbody>
</table>
Sustainability

Getting what we need
• Capacity and Longevity for the minimum:
• Cost
• Energy & resources
• Pollutants
• Negative impact to society

Simply good engineering
(Getting more for less)
Sustainability

Tool No. 1
Consume less concrete for new structures

Sustainability

Tool No. 2
Consume less cement in concrete mixtures

Tool No. 3
Consume less clinker for making cements

Mehta, CI Feb. 2009
Proportioning

Filler
Gradation

Glue
What sort
How much
Aggregate Gradation

- Tarantula Curve

![Tarantula Curve Diagram]

*Greater than 15% on the sum of #8, #16 and #30
24-34% of fine sand (#30-200)*
Effect on Binder Content

![Graph showing the effect of binder content on VKelly Index for different aggregates.](image-url)
Effect of Proportioning
What Can Go Wrong?

- Alkali Aggregate Reaction
  - Reactive aggregates
  - Alkali hydroxides
  - Water
What Can Go Wrong?

- D-Cracking
  - Some limestone aggregates
  - Cold weather
What Can Go Wrong?

• Alkali Carbonate Reaction
  • A mystery
What Can Go Wrong?

• Popouts
  • Porous aggregates
A Better Specification

- AASHTO PP84 published in March
  - Guide Specification
  - “Deemed to satisfy”
  - Avoids bonus discussion – that is local
  - Provisional = meaning we can modify as we learn things

Delivering concrete to survive its environment
Require the things that matter

- Transport properties (everywhere)
- **Aggregate stability (everywhere)**
- Strength (everywhere)
- Cold weather resistance (cold locations)
- Shrinkage (dry locations)
- Workability (everywhere)
Closing

• We need to talk…