The Tennant Avenue Bridge
Built with Environmentally Friendly Concrete

Speaker
Mike Donovan, P.E.
Director of Project Management
Owner – City of Morgan Hill
Designer – Mark Thomas and Company
CM – CSG (for Caltrans)
GC – Top Grade Construction
Concrete Sub – Viking Construction
Concrete Sub foundation – Malcolm Drilling
Concrete Supplier – Central Concrete Supply
California – Bay Area

THE NEW RESOURCE FOR GREEN CONSTRUCTION
SCM % Replacement History

- 2005: 18.6%
- 2006: 23.5%
- 2007: 28.9%
- 2008: 32.6%
- 2009: 33.4%
- 2010: 33.7%
## Average Cementitious

<table>
<thead>
<tr>
<th></th>
<th>Central Concrete</th>
<th>National</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005  2006  2007  2008  2009</td>
<td>2007  2030</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>441  426  402  379  384</td>
<td>450  310</td>
<td></td>
</tr>
<tr>
<td>Fly Ash</td>
<td>85  90  97  100  108</td>
<td>60  168</td>
<td></td>
</tr>
<tr>
<td>Slag</td>
<td>16  41  66  83  79</td>
<td>18  50</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>542  557  565  562  570</td>
<td>628  528</td>
<td></td>
</tr>
</tbody>
</table>
AB 32: The California Global Warming Solutions of 2005

GHG reduction targets:

- Reduce to 1990 levels by 2020
- Reduce to 80% below 1990 levels by 2050

*Equals approximately 60 million tons emission reduction, 11% below business as usual

**Equals approximately 174 million tons emission reduction, 29% below business as usual
Climate Action Teams

Government’s Office

California Environmental Protection Agency

Air Resources Board

- Agriculture
- Forests
- Energy
- Cement Concrete
- Water
- Transportation
- High GWP Gases
- Recycling and Waste Management
- State Gov’t
US Concrete’s Partner in Carbon Footprinting
$$$ = GHG
Top 10 - Greenhouse Gas Breakdown

100% = 300,000 tons-CO$_{2}$eq

- Cement 65%
- Coarse Aggregate 17%
- Diesel Combustion 5%
- Fly Ash 4%
- Slag Cement 3%
- Fine Aggregate 3%
- Plant-Washout Disposal 2%
- Other Ad Mixture 2%
- Lightweight Aggregate 2%
- Delivery-Truck fuel 1%
- Other 6%

FIGURE 1: GHG Emissions breakdown by Account.
The New Carbon Calculator

Carbon Footprint Report

Mix Code... 11H1C9F1
Mix Label... Mat Foundation, Core Walls, Columns
Location Code... 004W
Location City... San Jose

132.5 kgCO2eq / cyd (mix)
12.5 kgCO2eq / cyd (location overhead)
145.0 kgCO2eq / cyd (total)
319.0 lbsCO2eq / cyd (total)

kg CO2eq / cyd

0 20 40 60 80 100 120 140 160 180 200 220

Overhead
Chemical
Chemical
Water
Slag
Fly Ash
Cement II/V
Aggregate
Aggregate
Aggregate

kgCO2eq / cyd
Caltrans moving toward performance:

- No Minor Concrete Categories
- Lower Cementitious required
- Limit on Cement
- Mandatory SCM design
- Extended Time for Strength Requirements
90-2.01C Required Use of Supplementary Cementitious Materials

General
A. Any combination of portland cement and at least one SCM, satisfying Equations (1) and (2)

Equation (1)

\[
\frac{(25 \times UF) + (12 \times FA) + (10 \times FB) + (6 \times SL)}{MC} > X
\]

\(X = 1.8\) for innocuous aggregate, 3.0 for all other aggregate

Equation (2)

\[MC - MCSM - PC > 0\]
Caltrans 2008 SCM study (slag)

Compressive strength, psi

Age, days

C=100%

C=75%, FAf=25% (control)

C=40%, S=60%

C=50%, S=50%

C=100%
<table>
<thead>
<tr>
<th>Mix Code</th>
<th>Mix Description</th>
<th>Quantity Placed</th>
<th>Lb $\text{CO}_2\text{eq}$,</th>
<th>Total Lb $\text{CO}_2\text{eq}$</th>
<th>Lb $\text{CO}_2\text{eq}$,</th>
<th>Total Lb $\text{CO}_2\text{eq}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDJSL9U3</td>
<td>CIDH 675 lbs 50% SCM</td>
<td>384</td>
<td>406</td>
<td>155,904</td>
<td>502</td>
<td>192,768</td>
</tr>
<tr>
<td>F01138P8</td>
<td>CDF 88% FA</td>
<td>15</td>
<td>130</td>
<td>1,950</td>
<td>130</td>
<td>1,950</td>
</tr>
<tr>
<td>D15SL9EA</td>
<td>Class 1 675 lbs 25% FA</td>
<td>359.5</td>
<td>504</td>
<td>181,188</td>
<td>504</td>
<td>181,188</td>
</tr>
<tr>
<td>D24SL9QA</td>
<td>Class 2 590 lbs 70% SCM</td>
<td>1005</td>
<td>283</td>
<td>284,415</td>
<td>450</td>
<td>52,250</td>
</tr>
<tr>
<td>S29100EX</td>
<td>3-Sack Sand Slurry 25% FA</td>
<td>18</td>
<td>249</td>
<td>4,482</td>
<td>249</td>
<td>4,482</td>
</tr>
<tr>
<td><strong>Total lbs of $\text{CO}_2\text{eq}$</strong></td>
<td></td>
<td></td>
<td><strong>627,939</strong></td>
<td></td>
<td></td>
<td><strong>832,638</strong></td>
</tr>
</tbody>
</table>
Compressive Strength Comparisons

28 Day Compressive Strength

psi

Cementitious (lbs.)

- 25%
- 20%
- 15%
- 100%
- EFv2
Rapid Chloride Permeability Tests
Per ASTM C 1202 at 56 Day Standard Cure

<table>
<thead>
<tr>
<th>Charge Passed</th>
<th>Chloride Ion Penetrability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 4,000</td>
<td>High</td>
</tr>
<tr>
<td>2,000 - 4,000</td>
<td>Moderate</td>
</tr>
<tr>
<td>1,000 - 2,000</td>
<td>Low</td>
</tr>
<tr>
<td>100 - 1,000</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

The chart shows the chloride permeability test results for different cementitious mixes. The x-axis represents the total cementitious (lbs), and the y-axis represents the charge passed (coulombs).

- **100% Cement**: Shows significant chloride ion penetrability, especially at higher concentrations of cement.
- **25% Fly Ash**: Exhibits lower chloride ion penetrability compared to pure cement, indicating a more resistant material.
- **EF V2 50%**: Demonstrates intermediate chloride ion penetrability, suggesting a balance between high performance and cost-efficiency.
- **EF V2 70%**: Offers lower penetrability, indicating potential for use in environments where chloride resistance is crucial.

The chart highlights the effectiveness of the different mixes in resisting chloride penetration, which is crucial for green construction projects aiming to increase durability and environmental sustainability.
Other Sustainable Strategies
In Summary

- The Tennant Avenue bridge is a typical overpass design.
- Normal construction schedule.
- 25% lower carbon footprint.
- The specifications by which the concrete mixes were allowed to be used represent a dramatic change that provides a glimpse into the future sustainable design and construction of the infrastructure.
The Future of Concrete is Green.

Questions?