The New Indianapolis Airport Parking Garage
- Sustainable Concrete to Produce a 70-Year Design Life.

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Director, Silica Fume Association
Sustainable design; to meet the needs of the present without compromising the ability of future generations to meet their needs.
~120AD
Sustainable?

LEED credits - 0
Indianapolis Airport Parking

- $118M Engineer’s estimate.
- 1100 Rental, 5900 Public Parking.
- 70-year designed service life.
• ATM-like ticketing kiosks.
• Electronic mapping system.
• Mid-field Terminal & Garage entirely funded by user fees.
• Parking generates +$20M annually for the airport.
Indianapolis Airport Parking
7000 spaces
$12,500 / space, $87.5M
16-mo. construction
70-yr. design service life

SILICA-FUME CONCRETE
Better, Economical, *Green*
Customer Safety
Lighting
Stairwells and elevators
60 x 54ft bays
12ft height
Deck & Girders - 6000 psi
Columns - 8000 psi
Indy- PT Parking Deck HPC Proportions

- Cement 611 pcy
- Fly ash, F 100 pcy
- Silica Fume 50 pcy
- Water 289 pcy (w/cm 0.375)
- CA 1800 pcy
- FA 1150 pcy
- CA + FA min. 17.7 cft/cy (6)
- HRWR 6-8 oz/cwt.

- Strength 3000psi @20hrs, (9-10,000psi @ 28d)
- Air 4-6%
- Slump 6-8in
- Permeability <1000 coulombs.
100% Pre-consumer waste.

Guide for the Design of Durable Parking Structures

Reported by ACI Committee 362

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The guide is a summary of practical information regarding design of parking structures for durability, and it also includes information about design issues related to parking structure construction and maintenance.

The guide is intended for use in establishing criteria for the design and construction of concrete parking structures. It is written to specify the necessary aspects of parking structures that are different from those of other buildings or structures.

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Table 3.2 — Cast-in-place post-tensioned concrete (Recommended minimum considerations for durability. The recommendations in these tables assume drainage as noted in Section 3.2.2, cover tolerance as specified in ACI 318, and maintenance as noted in Chapter 5b)

<table>
<thead>
<tr>
<th>Design elementb</th>
<th>Durability zone (see Fig. 3.1)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Note cracks and construction joints to be sealed to prevent leakage</td>
<td>I</td>
<td>II/CC-I</td>
</tr>
<tr>
<td>Concrete</td>
<td>Strength, psi</td>
<td>3500</td>
</tr>
<tr>
<td>Air, percentb</td>
<td>Not required</td>
<td>6½ ± 2</td>
</tr>
<tr>
<td>W/C ratio (maximum)</td>
<td>0.45</td>
<td>0.40</td>
</tr>
<tr>
<td>Reinforcement cover, in. in. and protectionc</td>
<td>Slab top</td>
<td>1½</td>
</tr>
<tr>
<td>2-in. cover recommended for #6 through #18 bars</td>
<td>Slab bottom</td>
<td>¾</td>
</tr>
<tr>
<td></td>
<td>Beam</td>
<td>1¼</td>
</tr>
<tr>
<td></td>
<td>Column</td>
<td>1½</td>
</tr>
<tr>
<td></td>
<td>Walls (exterior face)</td>
<td>1½</td>
</tr>
<tr>
<td>PTI tendons</td>
<td>—</td>
<td>PTI Spec</td>
</tr>
<tr>
<td>Sealerd</td>
<td>—</td>
<td>Roof only</td>
</tr>
</tbody>
</table>

a) Nonconcrete: PTI Spec = minimum requirements of PTI specifications for unbonded single strand tendons; ENCAP = encapsulated tendons per PTI specifications; W/C = water/cementitious.
b) These recommendations are for thick slab structural systems as described in Chapter 2 and are not intended for slabs on grade. (If thin slab systems are used, a membrane is recommended for all exposure conditions.)
c) Fire resistive considerations may require greater bottom cover than noted herein.
d) Sealer should meet the criteria developed in NCHRP Report 244. Abrasion resistance and skid resistance should be considered in addition to NCHRP 244 criteria.
e) If a corrosion inhibitor or epoxy coated nonprestressed reinforcement is used, the cover can be reduced to 1¼ in. and bottom slab cover may be reduced to ¾ in.
f) Silica fume may be used in lieu of sealer application if the permeability of that concrete is determined to be low by acceptable standards.
g) Only required where freezing occurs. Measure at the point of placement. Target air content for ¾ in. aggregate. See Section 3.3.3.4.
h) Additional protection is recommended for mixed use structure and when maintenance is unlikely.
Relative Reduction in Penetration Coefficients with Silica Fume (w/cm = 0.35)
FIGURE 5. A generalized relation between efficiency index and silica fume content of concrete.
Life-365™
Life-365 Service Life Prediction Model™
for Reinforced Concrete Exposed to Chlorides

Version 2.0

Life-365 Service Life Prediction Model and Life-365
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To accurately capture the costs of your alternative concrete mix designs, you need to input the actual concrete costs of the mixes in your area. There are two types of mixes that need costs: (1) the basic mix, which has the concrete cost listed in the Default Concrete and Repair Costs tab above, and (2) an alternative mix that includes SCMs and inhibitors. If you have an alternative mix, you need to input the "ready mix" cost of this concrete in the Set Concrete Costs table to the left.

By default, the Set Concrete Costs table lists the cost of each mix design as the basic mix cost. To input the "ready mix" cost of an alternative mix, click on the listed value of that cost in the center column of the table. If you need to reset this cost to the basic mix cost, uncheck the box key to the right of the cost.

### Costs for Each Alternative Mix Design

#### Construction and Repair Costs for CI + sealer

<table>
<thead>
<tr>
<th>Cost name</th>
<th>Start year</th>
<th>End year</th>
<th>Intserv</th>
<th>Amount</th>
<th>units</th>
<th>$/sq. ft</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction cost</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,250,000</td>
<td>sq. ft</td>
<td>5.51</td>
<td>$23,395,798</td>
</tr>
<tr>
<td>Barrier cost</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>4,250,000</td>
<td>sq. ft</td>
<td>0.85</td>
<td>$3,722,530</td>
</tr>
<tr>
<td>Repair cost</td>
<td>53.7</td>
<td>70</td>
<td>10</td>
<td>425,000</td>
<td>sq. ft</td>
<td>300.00</td>
<td>$127,500,000</td>
</tr>
</tbody>
</table>

#### Cost Timeline for Alternative: CI + sealer

- **Construction cost**
  - 0
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60
  - 70

- **Barrier cost**
  - 0
  - 5

- **Repair cost**
  - 0
  - 10
Portland Cement Impact
1# Cement produced = 1# CO$_2$ emitted.
Sustainable Concrete Technology is HPC

Optimize the use of SCMs.
(100% pre-consumer waste material)
- Reduced permeability.
- ASR control.
- Less shrinkage - less cracking.
- Reduced heat of hydration.
- Lower CO₂ impact of concrete.
CALTRANS SCM Spec. - Reduce CO₂, Control ASR.

90.2.01C. Required Use Of Supplementary Cementitious Materials

General

The amount of portland cement and SCM used in portland cement concrete shall conform to the minimum cementitious material content provisions in Section 90-1.01, "Description," or Section 90-4.05, "Optional Use of Chemical Admixtures," and these specifications. The SCM content in portland cement concrete shall conform to one of the following.

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

Equation (1)

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

Where:

- \( UF \) = Silica fume, metakaolin, or UFFA, including the amount in blended cement, pounds per cubic yard.
- \( PA \) = Fly ash or natural pozzolan conforming to the requirements in AASHTO Designation M 295, Class F or N with a CaO content up to 10 percent, including the amount in blended cement, pounds per cubic yard.
- \( FB \) = Fly ash or natural pozzolan conforming to the requirements in AASHTO Designation M 295, Class F or N with a CaO content up to 15 percent, including the amount in blended cement, pounds per cubic yard.
- \( SL \) = GGBFS, including the amount in blended cement, pounds per cubic yard.
- \( MC \) = Minimum amount of cementitious material specified, pounds per cubic yard.
- \( X \) = 1.8 for instantaneous aggregate, 3.0 for all other aggregate.
<table>
<thead>
<tr>
<th>Component</th>
<th>Ref.</th>
<th>CALTRANS</th>
<th>CO₂ effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cem.III</td>
<td>611</td>
<td>535</td>
<td>-76 lbs</td>
</tr>
<tr>
<td>Fly ash</td>
<td>76</td>
<td>120</td>
<td>+0.44 lbs</td>
</tr>
<tr>
<td>SF</td>
<td></td>
<td>20</td>
<td>+0.32 lbs</td>
</tr>
<tr>
<td>CA</td>
<td>1530</td>
<td>1530</td>
<td></td>
</tr>
<tr>
<td>FA</td>
<td>1470</td>
<td>1470</td>
<td></td>
</tr>
<tr>
<td>HRWA</td>
<td>53oz</td>
<td>53oz</td>
<td></td>
</tr>
<tr>
<td>Set NC, 1d, psi</td>
<td></td>
<td>110oz</td>
<td>110oz</td>
</tr>
<tr>
<td>Water</td>
<td>282</td>
<td>110oz</td>
<td>80oz</td>
</tr>
<tr>
<td>Flow, in.</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1d, psi</td>
<td>4000*</td>
<td></td>
<td>3600</td>
</tr>
<tr>
<td>7d</td>
<td>5000</td>
<td></td>
<td>7240</td>
</tr>
<tr>
<td>90d</td>
<td>7800</td>
<td></td>
<td>10260</td>
</tr>
</tbody>
</table>
HPC - Parking Deck Construction

Fast track construction - one pass finishing and immediate cure.
Summary

Delivered $2500/space ($15M) below Engineer’s estimate.

Customer safety by-design.

Sustainable properties:
- Recycled SCMs.
- 4:1- SF substitution.
- 100% local materials.

Reduced maintenance.
- 70-yr. Service life decks.

Additional info -
[www.life-365.org](http://www.life-365.org)
[www.silicafume.org](http://www.silicafume.org)
Thank you. Questions?