



Virginia Concrete Conference 2008



## Optimized Mix Design Proportioning Procedures COMPASS

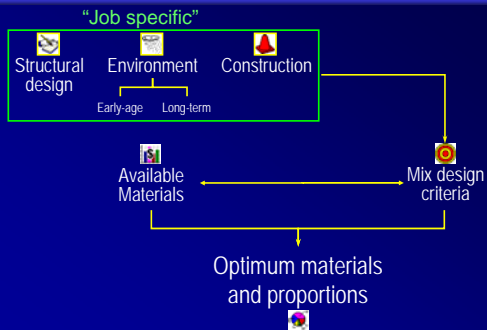


Presented by:  
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The Transtec Group

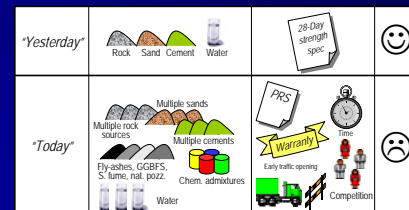
## FHWA CPTP Task 64

- Develop computer-based guidelines for job-specific optimization of paving concrete
- Considerations:
  - Used by concrete pavement engineers, materials engineers, and paving concrete suppliers
  - Balance practical and reliable
  - For JPCP, CRCP, and patch/repair mixtures
  - Conventional concrete-making materials

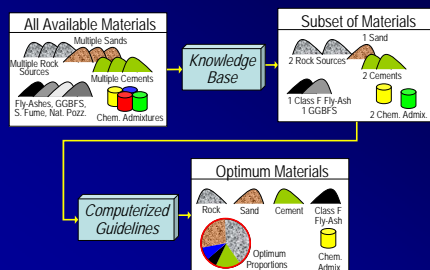
## Job-specific optimization



## Why optimize?



## How to Optimize?



## COMPASS

1. Mix Expert
2. Gradation optimization
3. Initial proportioning
4. Proportioning optimization

## Mix Expert

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**Site Specific Conditions**

- Project Type
- Design & Construction Info
- Climate
- Exposure



**Design Criteria Recommendations**

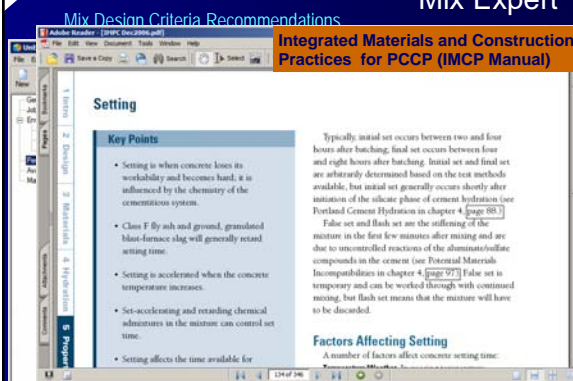
- Important PCC Properties
- Recommended Test Methods
- Recommended Materials

## Mix Expert

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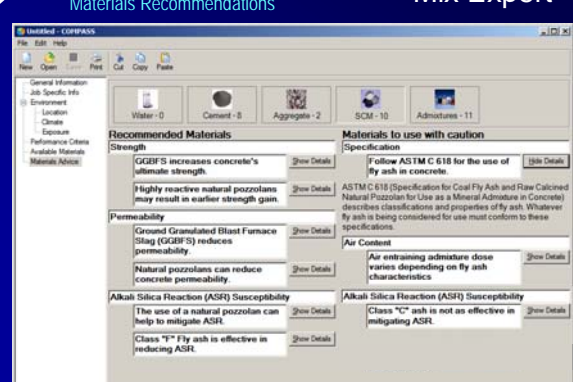
Mix Design Criteria Recommendations

Integrated Materials and Construction Practices for PCCP (IMCP Manual)



## Materials Recommendations

## Mix Expert





## COMPASS

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## Aggregate Gradation Optimization

- Purpose: *to determine optimal proportioning of available aggregates to...*
  - Improve durability
  - Maximize strength potential
  - Achieve workability requirements for paving applications
  - Minimize cost

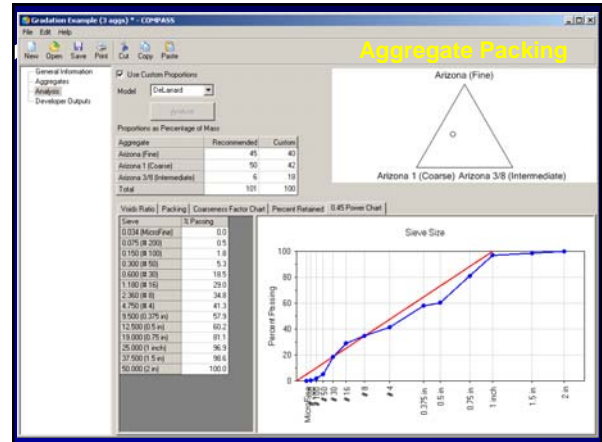
Gap-Graded Mixture
Well-Graded Mixture

## Aggregate Packing

- Packing Models Identified
  - Dewar - Theory of Particle Mixtures
  - De Larrard - Compressible Packing Model
  - Toufar (SHRP)
- Characteristics
  - Volumetric models
  - Minimize voids in aggregate structure
  - All validated with actual mix data

# Aggregate Packing

- “Reality Checks”
  - Application of practical principles learned from construction practice
  - Aggregate gradation for PCC mixtures
    - Coarseness Factor Chart
    - 0.45 Power Chart (Asphalt Industry)
    - Percent Retained (8-18 Chart)



# COMPASS

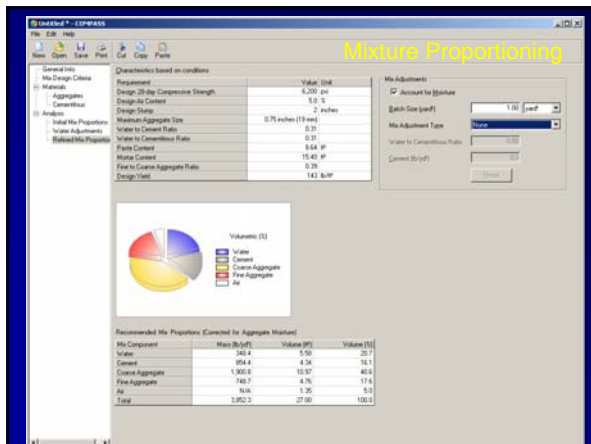
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# Water Content

Water adjustment	Water adjustment range	Adjustment Percentage Selected
1. <b>Aggregate shape &amp; texture</b> Baseline = cubic crushed stone • Rounded deduct 0.3% • Elongated add 0.3%	(-5 to +5%)	
2. <b>Combined aggregate grading</b> (0 for ACI 211.1 Assumptions)	(-10 to +10%)	
3. <b>Air retaining admixture</b> Effect varies with higher air content and other factors. Zero at 2% air, 10% for about 6% air	(-10 to 0%)	
4. <b>Normal range water reducing admixture</b>	(-10 to -5%)	
5. <b>Mid range water reducing admixture (MRWRA)</b>	(-1.5 to -8%)	
6. <b>High range water reducing admixture (HRWRA - Superplasticizer)</b>	(-30 to -12%)	
7. <b>Mineral Admixtures</b> Flyash to Silica Fume	(-10 to +15%)	
8. <b>Other factors such as w/c, cement fineness, temperature</b>	(-10 to +10%)	
9. <b>Cumulative adjustment percentage</b> = sum of all values		= sum
10. <b>Suggested maximum reduction</b> recognizing overlapping effects of multiple factors		-30%
11. <b>Water Adjustment Factor</b>		= 1.00 (w/cm/100)

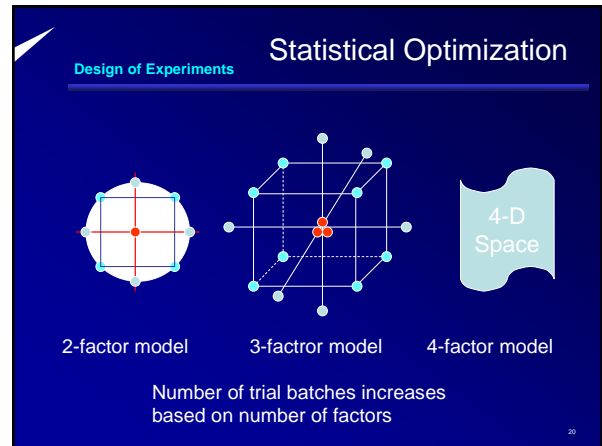
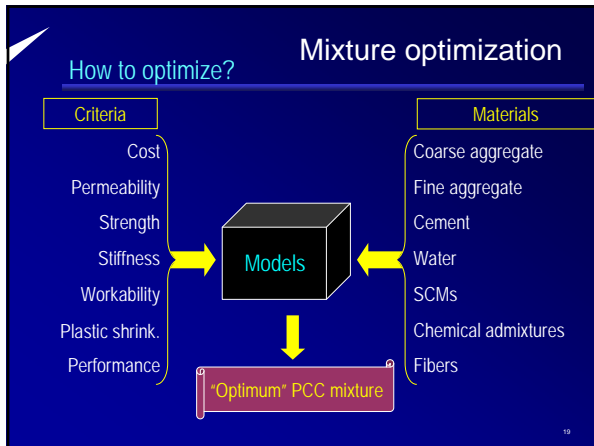
(taken from Hover 2001)

# Mixture Proportioning

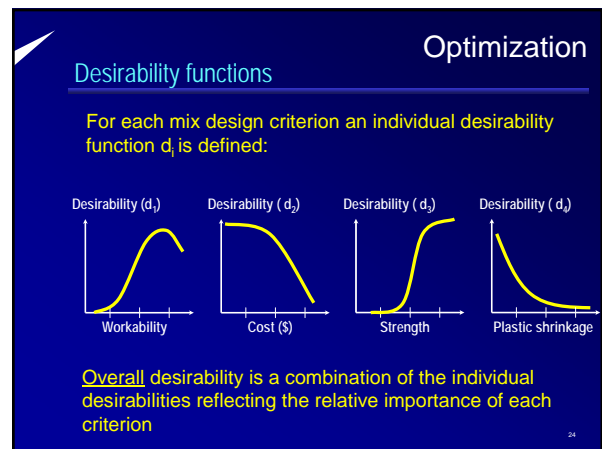
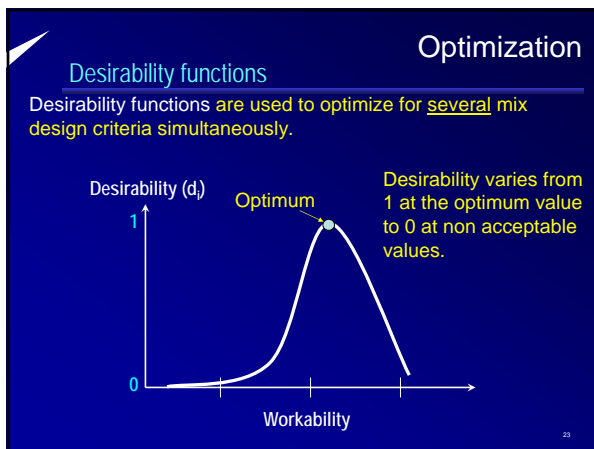
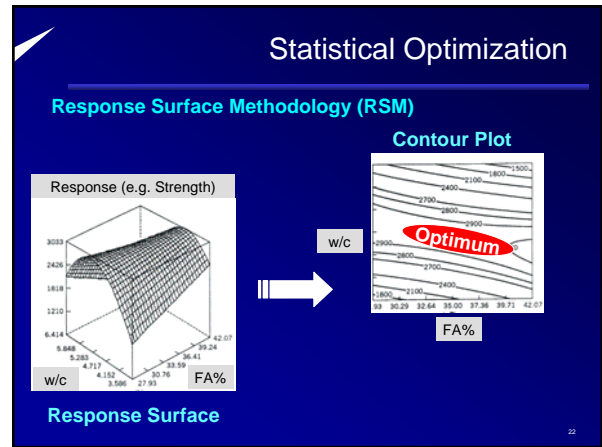


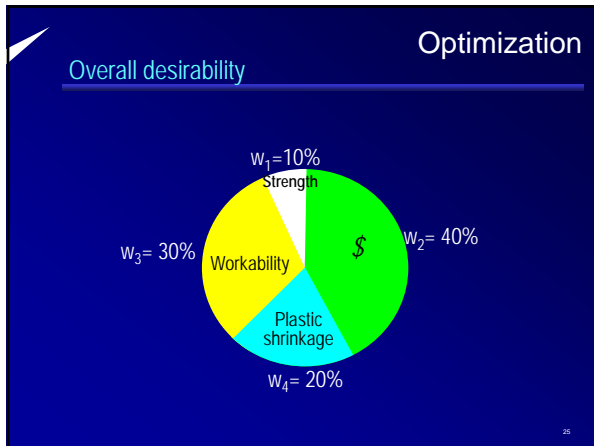
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- ### Response Models
- In general, a response is a property of interest that can be expressed in terms of one or more factors
  - For concrete, response models relate the materials proportions to concrete properties (mix design criteria)





- ### Optimization process
1. Define mix design criteria
  2. Define initial set of trial mixtures
  3. Develop response models
  4. Predict properties from response models for extended set of mixtures
  5. Identify optimal mix using desirability functions

### Material Factors

The Material Factors window shows a list of factors and their ranges. The 'Aggregate and Fiber Limit' is set to '% Volume'. The 'Range Values' section includes a 'Fixed Factor' checkbox, a 'Unit' dropdown set to '% Volume', and input fields for 'Fixed Value' (50), 'Minimum' (65), and 'Maximum' (72). The 'Properties' section includes 'Aggregate Type' (Coarse), 'Bulk Specific Gravity' (2.70), and 'Cost' (0.006 \$/ton).

### Trial Batches

The Trial Batches window displays a pie chart for 'Batch ID 3' and a table of trial batches. The pie chart shows the volumetric composition: Blended Agg (71.26%), Cement (18.88%), and Water (9.86%). The table below lists 13 trial batches with their respective material quantities and costs.

Batch ID	Yielder (B(yd))	Cement (B(yd))	Blended Agg (B(yd))	Total (B(yd))	Total Cost (B(yd))
3	224.4	953.6	3,243.1	4,021.1	39.94
10	249.0	622.6	3,117.4	3,989.0	41.74
11	261.5	502.0	3,117.4	3,961.4	40.24
2	287.5	647.1	2,991.7	3,926.6	41.89
5	255.7	601.6	3,117.4	3,974.7	40.96
12	289.5	681.1	2,968.1	3,938.7	42.95
7	255.7	601.6	3,117.4	3,974.7	40.96
1	233.5	925.0	3,243.1	4,001.6	38.88
8	255.7	601.6	3,117.4	3,974.7	40.96
6	255.7	601.6	3,117.4	3,974.7	40.96
9	255.7	601.6	3,117.4	3,974.7	40.96
4	276.6	682.5	2,991.7	3,950.8	43.20
13	221.9	822.2	3,276.7	4,020.8	38.98

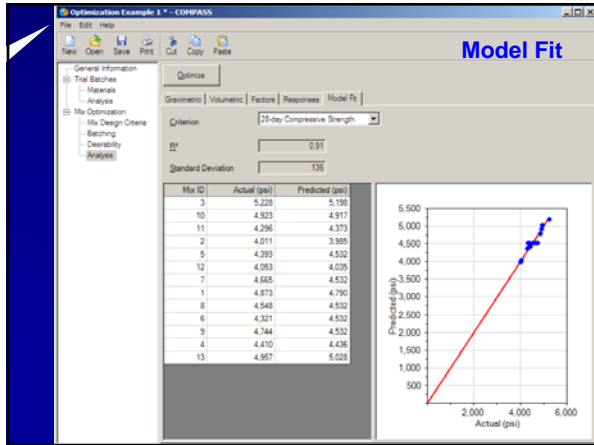
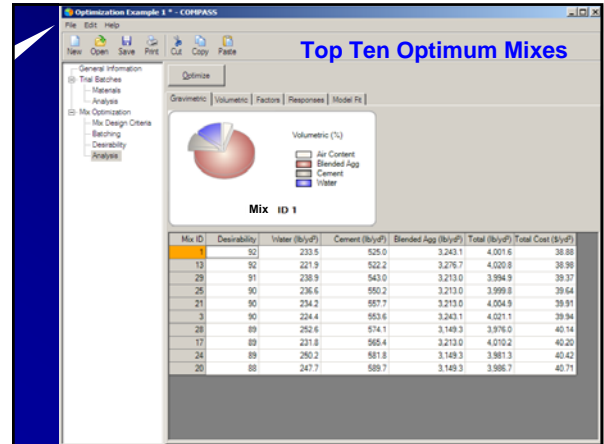
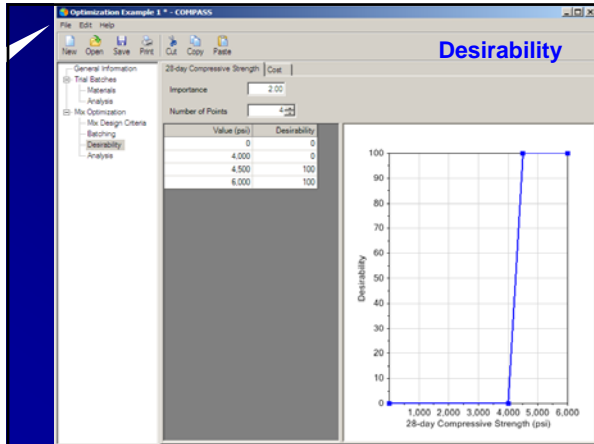
### Mix Design Criteria

The Mix Design Criteria window shows a list of criteria. The '28-day Compressive Strength' is selected with a source of 'Lab Testing'. The 'Cost' criterion is selected with a source of 'Virtual Batching'. The 'Maximum Aggregate Size' is set to a dropdown menu.

### Batching Results

The Batching Results window displays a table of mix IDs and their properties, along with a bar chart of 28-day compressive strength. The table shows the 28-day compressive strength and cost for 13 mix IDs. The bar chart shows the 28-day compressive strength for each mix ID, with values ranging from approximately 4,000 to 5,000 psi.

Mix ID	28-day Compressive Strength (psi)	Cost (B(yd))
3	5,221	39.94
10	4,529	41.74
11	4,796	40.24
2	4,011	41.89
5	4,393	40.96
12	4,163	42.95
7	4,665	40.96
1	4,673	38.88
8	4,560	40.96
6	4,321	40.96
9	4,744	40.96
4	4,410	43.20
13	4,973	38.98



U.S. Department of Transportation  
**Federal Highway Administration**

[www.PCCMix.com](http://www.PCCMix.com)

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