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# Mix Proportioning for Concrete Pavements

Road Pavements Forum

November 2019

B Perrie

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# Outline

- Introduction
- Requirements
- Specification
- Material selection
- Proportioning
- Assessment of mixes
- Conclusion

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# Requirements

- Fresh concrete
  - Surface finish
  - Riding quality
  - Must be compatible with equipment
  - Workable enough to ensure full compaction
  - Resist flow on grades and crossfalls

# Requirements

- Hardened concrete
  - Strength, both compressive and flexural
  - Shrinkage important in undowelled pavements
  - Abrasion resistance
  - Durable
- Must meet specification

# Specifications for Concrete Pavements

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# Introduction

- COTO Chapter 6: Concrete Layers
- Project specifications

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# Materials

- Cement
  - SANS 50197-1 as appropriate
  - GGBS/GGCS to SANS 55167-1
  - Fly ash to SANS 50450-1
  - Blends with cement and GGBS/GGCS or flyash < 20%

# Materials

- Water
  - Comply with SANS 51008
- Admixtures
  - Comply with SANS 50934, ASTM C494 or AASHTO M194
  - No $CaCl_2$
  - Combinations to be tested

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# Materials

- Aggregates
  - SABS 1083
  - 10% Fact Dry 210 kN, Wet 160 kN
  - Acid insolubility of fine > 40%
  - FM of fine not to vary > 0,20
  - Flakiness Index < 35
  - ASR testing
  - 37,5 + 19,0; 13,2; 9,5 or 26,5 or 19,0

# Materials

- Aggregates (Additional when instructed)
  - Presence of sugar
  - Soluble deleterious materials
  - Low density
  - Soluble salts
  - Sulfates
  - Shell material

# Materials

- Jointing materials
  - Preformed compression to SABS 1023
  - Filler to AASHTO 153
  - Silicone see COLTO 7102 e iii
- Curing compound
  - ASTM C 309 and BS 7542
  - Efficiency index > 90% at 0,2 l/$m^2$

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# Concrete

- Water:cement < 0.53
- Cementious content > 320 kg/$m^3$
- Strength: Highest of
  - 35 MPa
  - 0,85 $f_{c1}$ — $f_{c1}$ is compressive strength at flexure of 4,2 MPa
  - 0,85 $f_{c2}$ — $f_{c2}$ is compressive strength at w:c of 0,53
  - 0,85 $f_{c3}$ — $f_{c3}$ is compressive strength at cement content of 320 kg/$m^3$

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# Concrete

- Trial mixes
  - Relationship between $f_c$ and $f_f$ at three w:c's; 0.48, 0.53 and 0.58
  - 6 cubes
  - 6 beams
  - Three water contents on consistence
  - Drying shrinkage on three mixes

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# Mix Proportioning

# Material selection

- Cement
  - Large range of cements available
  - Affect on early strength gain and durability
  - High extender contents may improve some properties and adversely affect others
  - Major effect is on early age strength gain (VIP for cutting)

# Material selection

- Cement (cont.)
  - High extender contents increase vulnerability to poor curing
  - Adverse effects worse in cold weather
  - May be advantageous in hot weather
  - Recommend high early strength

**Table 1.1: Common cements: SABS EN 197-1**

| Main types | Notation of products (types of common cement) | | Composition, percentage by mass[a] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Clinker | Blast-furnace slag | Silica fume | Pozzolana | | Fly ash | | Burnt shale | Limestone | | Minor additional constituents |
| | | | | | | natural | natural calcined | siliceous | calcareous | | | | |
| | | | K | S | D[b] | P | Q | V | V | T | L | LL | |
| CEM I | Portland cement | CEM I | 95 - 100 | - | - | - | - | - | - | - | - | - | 0 - 5 |
| CEM II | Portland-slag cement | CEM II A-S | 80 - 94 | 6 - 20 | - | - | - | - | - | - | - | - | 0 - 5 |
| | | CEM II B-S | 65 - 79 | 21 - 35 | - | - | - | - | - | - | - | - | 0 - 5 |
| | Portland-silica fume cement | CEM II A-D | 90 - 94 | - | 6 - 10 | - | - | - | - | - | - | - | 0 - 5 |
| | Portland-pozzolana cement | CEM II A-P | 80 - 94 | - | - | 6 - 20 | - | - | - | - | - | - | 0 - 5 |
| | | CEM II B-P | 65 - 79 | - | - | 21 - 35 | - | - | - | - | - | - | 0 - 5 |
| | | CEM II A-Q | 80 - 94 | - | - | - | 6 - 20 | - | - | - | - | - | 0 - 5 |
| | | CEM II B-Q | 65 - 79 | - | - | - | 21 - 35 | - | - | - | - | - | 0 - 5 |
| | Portland-fly ash cement | CEM II A-V | 80 - 94 | - | - | - | - | 6 - 20 | - | - | - | - | 0 - 5 |
| | | CEM II B-V | 65 - 79 | - | - | - | - | 21 - 35 | - | - | - | - | 0 - 5 |
| | | CEM II A-W | 80 - 94 | - | - | - | - | - | 6 - 20 | - | - | - | 0 - 5 |
| | | CEM II B-W | 65 - 79 | - | - | - | - | - | 21 - 35 | - | - | - | 0 - 5 |
| | Portland-burnt shale cement | CEM II A-T | 80 - 94 | - | - | - | - | - | - | 6 - 20 | - | - | 0 - 5 |
| | | CEM II B-T | 65 - 79 | - | - | - | - | - | - | 21 - 35 | - | - | 0 - 5 |
| | Portland-limestone cement | CEM II A-L | 80 - 94 | - | - | - | - | - | - | - | 6 - 20 | - | 0 - 5 |
| | | CEM II B-L | 65 - 79 | - | - | - | - | - | - | - | 21 - 35 | - | 0 - 5 |
| | | CEM II A-LL | 80 - 94 | - | - | - | - | - | - | - | - | 6 - 20 | 0 - 5 |
| | | CEM II B-LL | 65 - 79 | - | - | - | - | - | - | - | - | 21 - 35 | 0 - 5 |
| | Portland-composite cement[c] | CEM II A-M | 80 - 94 | ◄---------- | | | | 6 - 20 | | ---------- | | | 0 - 5 |
| | | CEM II B-M | 65 - 79 | ◄---------- | | | | 21 - 35 | | ---------- | | | 0 - 5 |
| CEM III | Blastfurnace cement | CEM III A | 35 - 64 | 36 - 65 | - | - | - | - | - | - | - | - | 0 - 5 |
| | | CEM III B | 20 - 34 | 66 - 80 | - | - | - | - | - | - | - | - | 0 - 5 |
| | | CEM III C | 5 - 19 | 81 - 95 | - | - | - | - | - | - | - | - | 0 - 5 |
| CEM IV | Pozzolanic cement[c] | CEM IV A | 65 - 89 | - | ◄---------- | | 11 - 35 | | ---------- | | - | - | 0 - 5 |
| | | CEM IV B | 45 - 64 | - | ◄---------- | | 36 - 55 | | ---------- | | - | - | 0 - 5 |
| CEM V | Composite cement[c] | CEM V A | 40 - 64 | 18 - 30 | - | ◄-- | 18 - 30 | | --- | - | - | - | 0 - 5 |
| | | CEM V B | 20 - 39 | 31 - 50 | - | ◄-- | 31 - 50 | | --- | - | - | - | 0 - 5 |

**Notes**

(a) The values in the table refer to the sum of the main and minor additional constituents.

(b) The proportion of silica fume is limited to 10%.

(c) In portland-composite cements CEM II A - M and CEM II B - M, in pozzolanic cements CEM IV A and CEM IV B, and in composite cements CEM V A and CEM V B the main constituents other than clinker shall be declared by designation of the cement.

# Nomenclature (cont.)

- Strength grade

| Strength Class | Compressive strength, MPa | | | |
|---|---|---|---|---|
| | Early strength | | Standard strength | |
| | 2 days | 7 days | 28 days | |
| 32,5N | - | ≥16,0 | ≥32,5 | ≤52,5 |
| 32,5R | ≥10,0 | - | | |
| 42,5N | ≥10,0 | - | ≥42,5 | ≤62,5 |
| 42,5R | ≥20,0 | - | | |
| 52,5N | ≥20,0 | - | ≥52,5 | - |
| 52,5R | ≥30,0 | - | | |

# Material selection

- Admixtures
  - Used to improve properties and/or effect savings
  - Air entrainers
  - Water  reducers/plasticisers
  - Acceleraters and retarders
- Combinations of cement and admixtures
  - Important to determine effect of combinations

# Proportioning

- Information required
  - Placing method
  - Grades crossfalls etc
  - Most appropriate consistence
  - Insertion of dowels and tiebars
  - Texturing
  - Climatic conditions
  - Available materials and cost.

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# Proportioning

- Mix design
  - C&CI method
  - ACPA method
  - Caltrans
  - SA envelope

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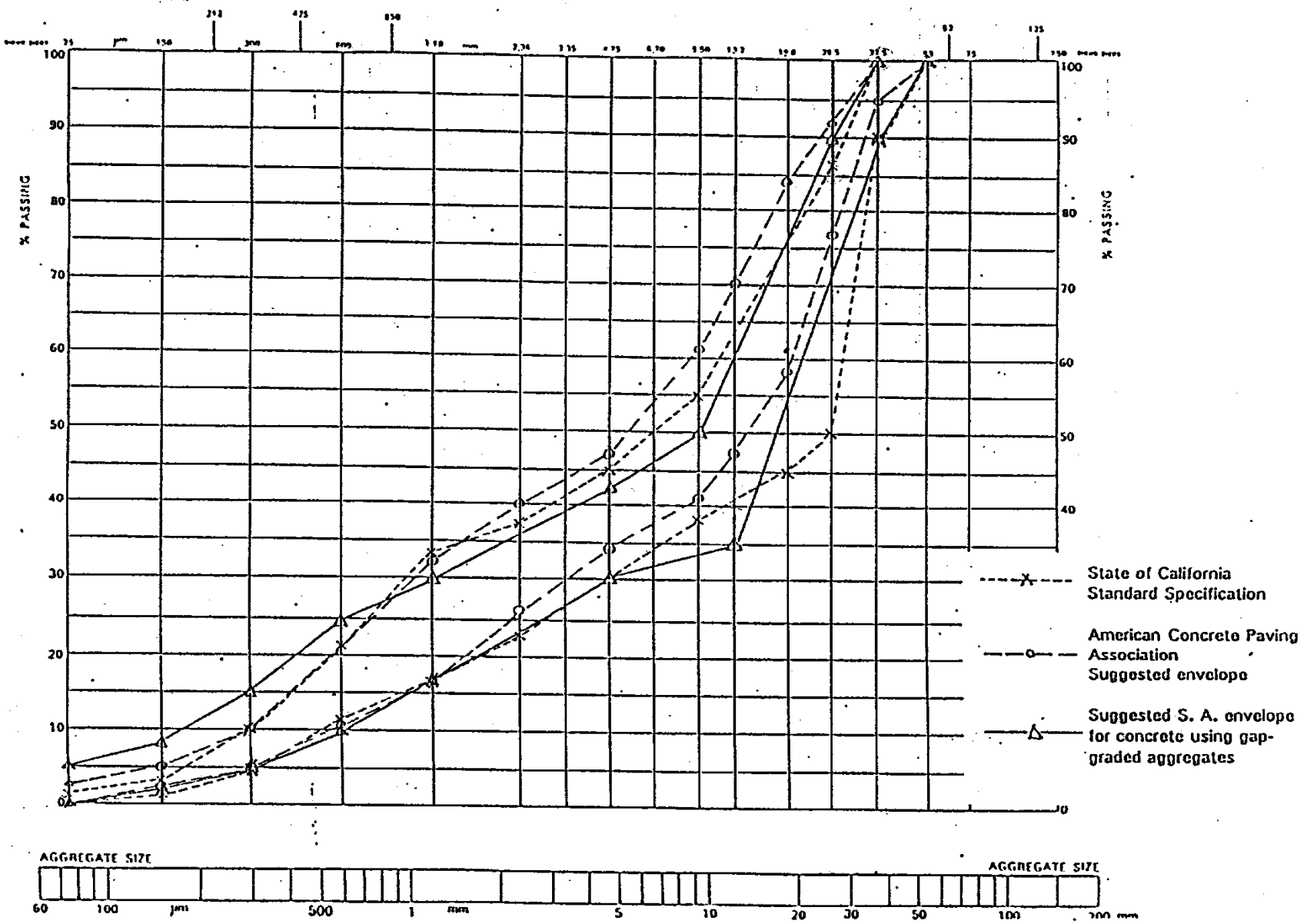
## APPENDIX A - SUGGESTED ENVELOPES OF OVERALL AGGREGATE GRADING

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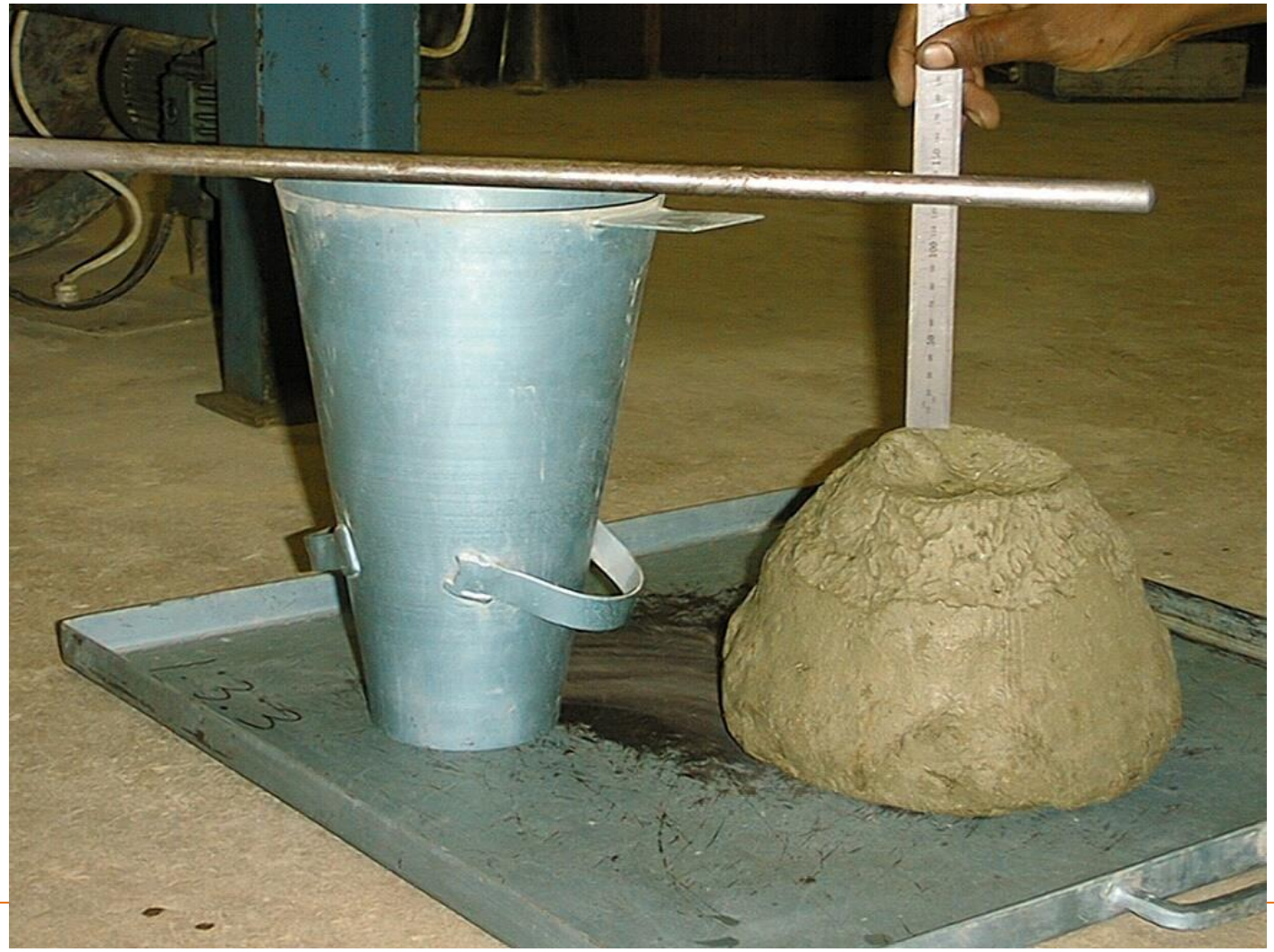
# Plastic properties

- Workability should allow full compaction without segregation
- Concrete should be free of excessive bleeding

# Workability

- Usually slump test
- Doesn’t measure workability but consistence
- For stiff mixes use Vebe test

# Workability



# Workability

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# Workability

- Slipform - 25 to 35 mm
- Sideform - 35 to 50 mm
- Hand work - 50 to 70 mm

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# Assessment of mixes

- Bleeding
- Dowel and tiebar insertability


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# Assessment of mixes

- Texturability

# Assessment of mixes

- Sawability

| Aggregate Type | Strength |
|---|---|
| Granite, Quartzite | 3 - 5 MPa |
| Dolerite, Andesite | 4 - 6 MPa |
| Felsite | > 8 MPa |

# Assessment of mixes

- Strength
- Shrinkage

# Trial Pavement

- Essential to test compatibility of mix with equipment

*Questions?*

*Thank you*

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