CON FORMS

Minnesota Concrete Council – 1/28/21

Concrete Pumping 101

Jim Bury
Director – Placing Equipment & Support Services
Construction Forms

1

Concrete Pumping & Placement






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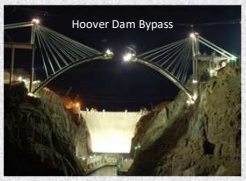
Sensational Achievements – Generational Projects



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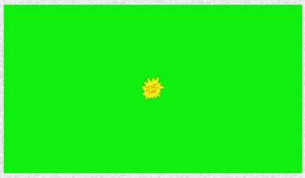
World Records in Concrete Pumping

Burj Khalifa tower (Dubai) – 1988 ft vertical

Le Refrain in Haut Doubs, France – 1.25 mi horizontal



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Concrete Pumping & Placement Success

Success Depends Upon:

Environmental/Jobsite Conditions

Mix Designed For Pumpability

Equipment Capabilities

Mix Creation & Delivery

Planning & Execution

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Concrete Pumping Dependency

Mix and Environmental Factors

- Aggregate gradation
- Aggregate roughness
- Aggregate porosity
- Aggregate moisture
- Aggregate max. size
- Aggregate shape
- Sand fineness modulus
- Sand roughness
- Sand moisture
- Sand proportion
- Cement type
- Cement proportion
- Water proportion
- Fly ash type
- Fly ash proportion
- Silica fume type
- Silica fume proportion
- Slag type
- Slag proportion
- Water reducer usage
- Viscosity modifier usage
- Accelerator usage
- Decelerator usage
- Total mortar content
- Total fines content
- Fiber type & size
- Fiber content
- Age of concrete
- Batching quality control
- Material storage QC
- Temperature
- Component suspension
- On-site water addition

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Concrete Pumping Dependency

Equipment & Application Limiting Factors

- Volume output
- Vertical pumping distance
- Horizontal pumping distance
- Number of elbows
- Elbow radius and angle
- Number of reducers
- Length & diameter of pipeline
- Pipeline pressure rating
- Water-tight pipeline (no leaks)
- Dent free pipeline
- Steel pipe vs. rubber hose
- Available engine power
- System power losses
- Hydraulic pressure capability
- Condition of wear items
- Hopper configuration
- Hopper agitator effectiveness
- Vibrator location
- Delivery cylinder size & length
- Delivery cylinder inside surface
- Delivery path continuity
- Boom arm configuration
- Heat added by equipment

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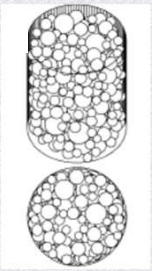
Concrete (Artificial Rock)



Aggregates

Smaller Grains < 2mm (sand)

Artificial fillers (fibers, spheres)

Cementitious Materials (cement, fly ash, silica fume, slag)

Water

Admixtures (water reducers, accelerators, decelerators, viscosity modifiers, colorants)

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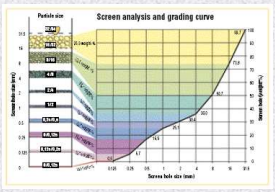
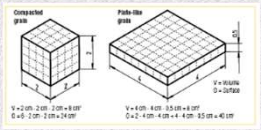
Aggregates / Sand





- Gradation
- Absorption/Porosity
- Shape & Smoothness
- Abrasiveness

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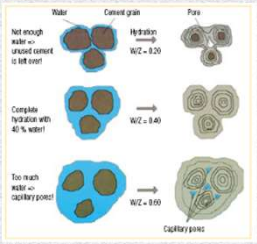
Water



No one is happy unless the quantity of water used is right for the recipe:

- Too Little Water
  - Some cement not hydrated causing many issues
  - Not enough liquids to coat the pipe wall causing extreme wear and blockages
- Too Much Water
  - Weak concrete, finishing issues
  - Liquid flows past the aggregate (instead of suspending it) causing a blockage

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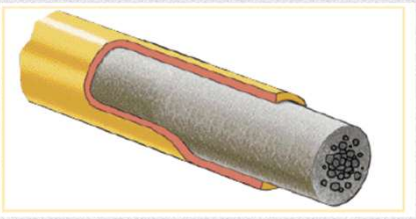
Concrete Pumping - Delivery



Mix Distribution

- Center
  - ❖ Aggregate Rich
  - ❖ Freedom of Movement
  - ❖ Shear Flow
- Boundary Layer
  - ❖ Aggregate Free – Mortar Rich
  - ❖ Friction avoidance

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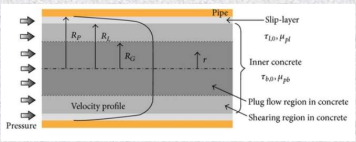
Concrete Pumping - Delivery



Mix Distribution

- Increasing freedom of movement moving away from the center line
- Fibers affect this equilibrium

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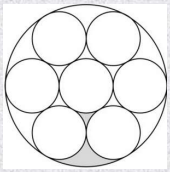
Concrete Pumping - Delivery



- Maximum Size (1/3 Rule)

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Concrete Pumping

Hopper
- Reservoir
- Flow Assistance/Manager
- Isolation

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Concrete Pumping

Delivery Cylinders
- Pull From Hopper
- Initial Pumping Cross-Section
- Push Into Rest of Pipe System

Distribution Valve
- Cylinder-to-Delivery Lines
- Refinement of Cross-Section

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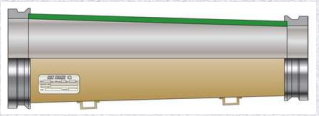
Disruptions to Flow

Reducers
Elbows
Gaps, Dents, and Edges



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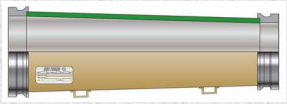
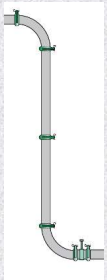
Resistance to Pumping





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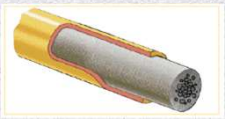
Mortar & Fine Matter Content

Mortar Content Ratio
(Mix ingredients < 2mm size)
Suspension and Transport Media
Minimum 50% by volume

Water/Cementitious Ratio
(Traditional Indicator)
Flow enabler
Cement: Minimum 0.40 (40% water)
Cementitious: Depends on mix



Fine Matter Content
(Mix ingredients < 0.125mm size)
Friction Fighter
Minimum 400 lbs/yd³

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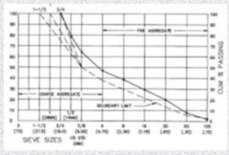
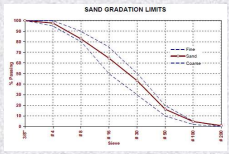
Example Mix Design & Analysis

Material	Weight (lbs)	Lbs/ft³	Volume (ft³)
Cement	384	197	1.95
Fly Ash	50	144	0.35
#2 Natural Sand	1075	100	10.75
#57 Limestone	1100	162	6.79
#4 Limestone	600	162	3.70
Water	200	62	3.23
Air	1.0%	0	0.27
	3409	Total	27

Criteria	Actual	Req'd	Status
W/C (by weight)	.46	.40	OK
Mortar volume (ft³)	16.5	>13.5 ft³	OK
Fines (by weight)	434	>400 lbs/yd³	OK

The Good





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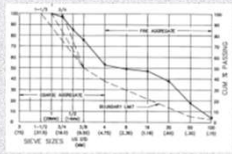
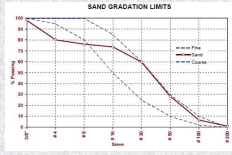
Example Mix Design & Analysis

Material	Weight (lb)	lbs/ft³	Volume (yd³)
cement	265	197	1.35
fly ash	115	144	0.80
slag	325	181	1.80
silica fume	20	144	0.14
sand	1430	162	8.83
aggregate - #57	1170	172	6.80
aggregate - #8	500	172	2.91
water	225	62	3.61
air	3.0%	0	0.81
	4050	Total	27.0

Criteria	Actual	Req'd	Status
W/C (by weight)	0.31	.40	Very Low
Mortar volume (ft³)	17.3	>12.1 ft³	OK
Fines (lbs)	725	>400 lbs/yd³	OK but high

The Bad





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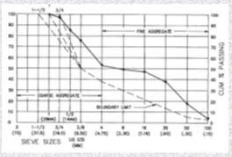
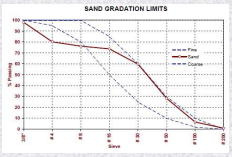
Example Mix Design & Analysis

Material	Weight (lb)	lbs/ft³	Volume (yd³)
cement	685	197	3.48
fly ash	300	175	1.71
silica fume	30	144	0.21
sand	1375	162	8.49
aggregate - #57	1080	175	6.17
aggregate - #8	450	175	2.57
water	250	62	4.01
air	1.5%	0	0.41
	4170	Total	27.0

Criteria	Actual	Req'd	Status
W/C (by weight)	0.25	.40	Extremely low
Mortar volume (ft³)	18.3	>12.1 ft³	OK
Fines (lbs)	1015	>400 lbs/yd³	Very High

The Unpumpable





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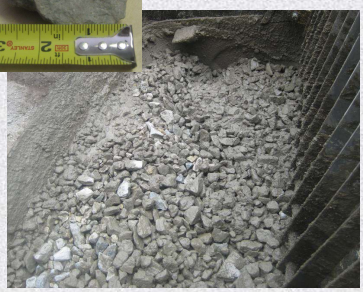
Mix Consistency



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Resources

ACI 304.2R – Placing Concrete by Pumping Methods

ACI 211-9R – Proportioning for Pumpable Concrete

ACI 238 – Workability of Fresh Concrete

University Civil Engineering Departments

Equipment Manufacturers

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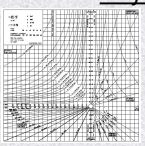
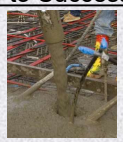
Keys to Success – Planning & Execution





Jobsite Specs:
- Horizontal Length
- Vertical Length

Equipment Specs:
- Engine Power
- Line Pressure
- Volume Output

Misc. Parameters:
- Pipe Diameter
- Mix Design
- Environmental Extremes

Pre-Pour Meetings:
- All stakeholders
- Responsibilities
- Plan Addresses All Concerns Early

Mix Supply:
- Travel Routes
- Direct Line Communication to Jobsite
- Supply Pumpable Mix at Staged Intervals

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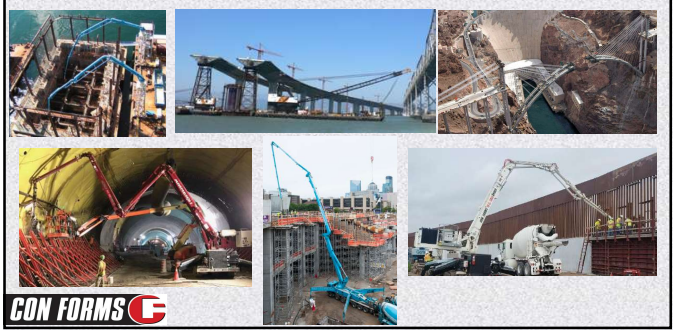
Thank You



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