

Burj Khalifa

A new high for high performance SCC

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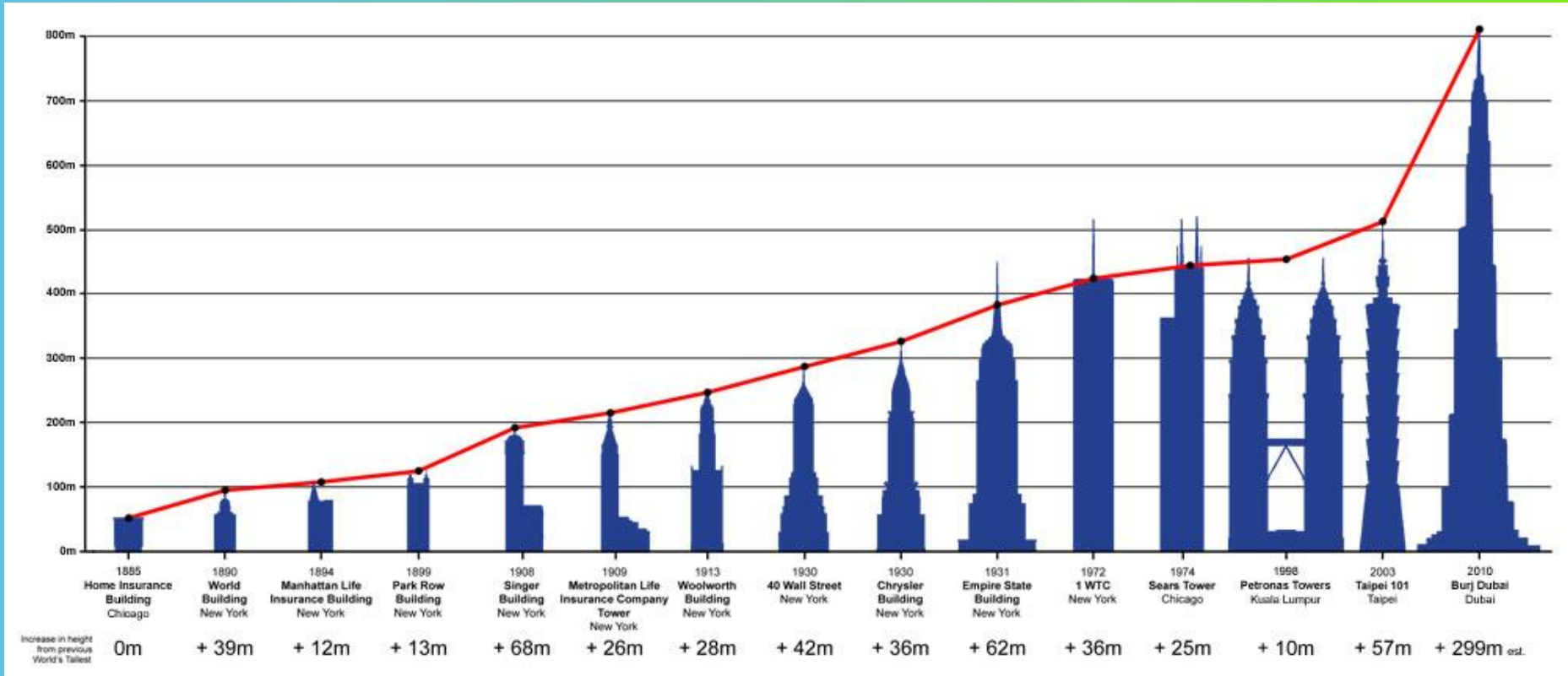
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Why build supertall buildings? Isn't it unsustainable?



Holders of the Title of “World’s Tallest Building”



Burj Khalifa

Piling:

- 60 MPa SCC

Raft:

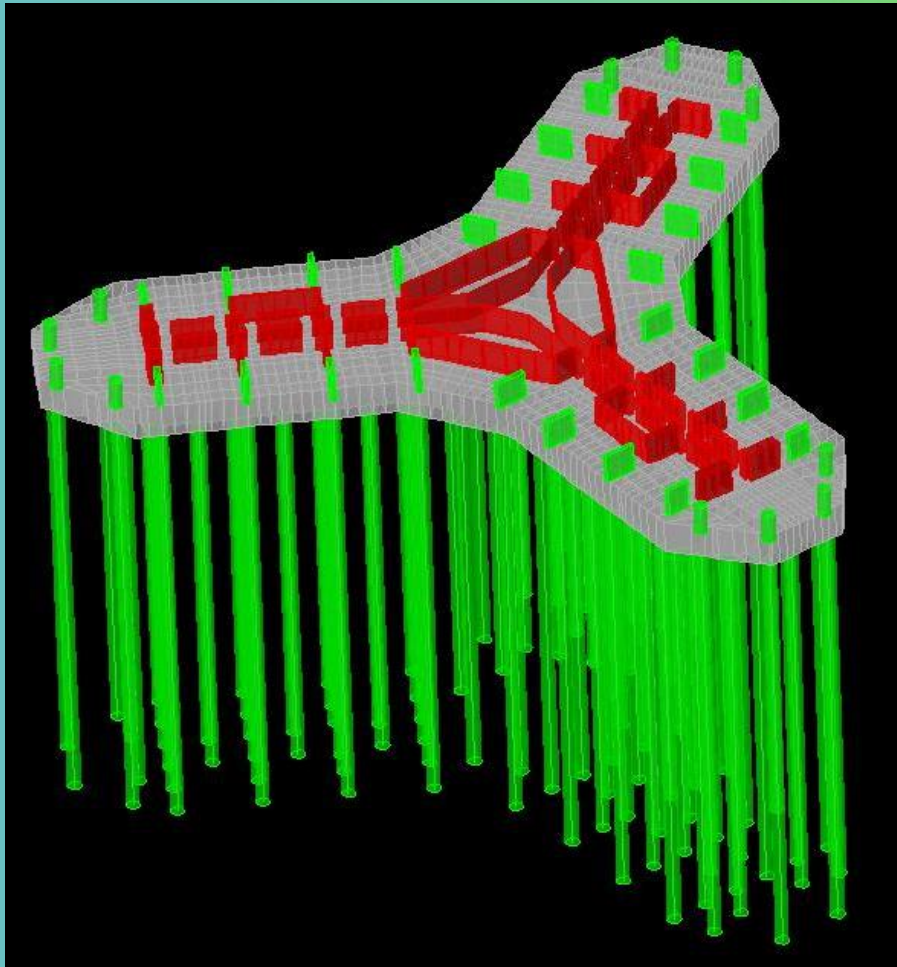
- 50 MPa SCC

Tower:

- 80 MPa to 440 metres
- 60 MPa to 581 metres
- 80 MPa to 585 metres
- 60 MPa to 605 metres



Burj Khalifa – Tower Foundations

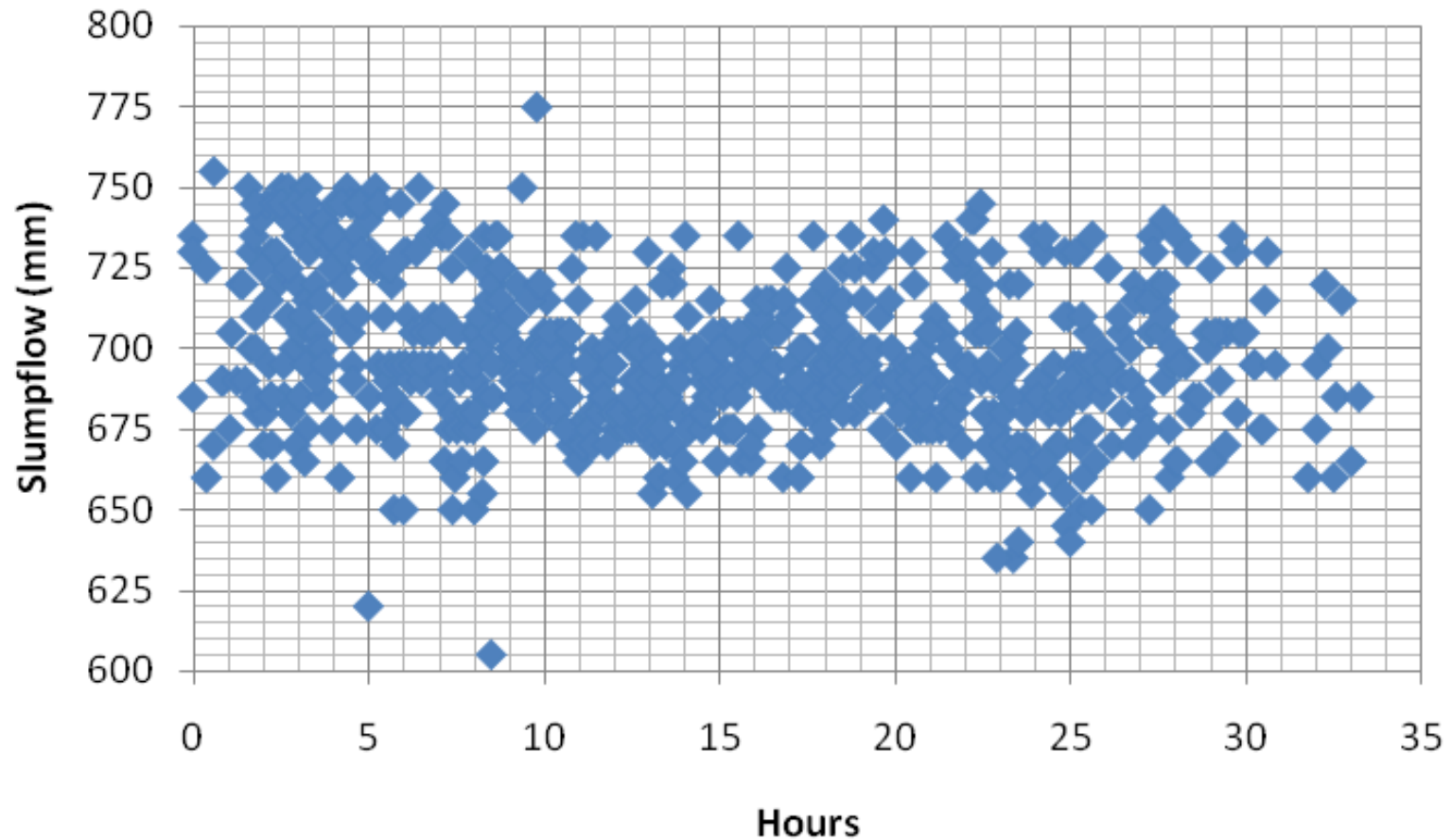


Mix Design for raft

(Temperature and durability considerations)

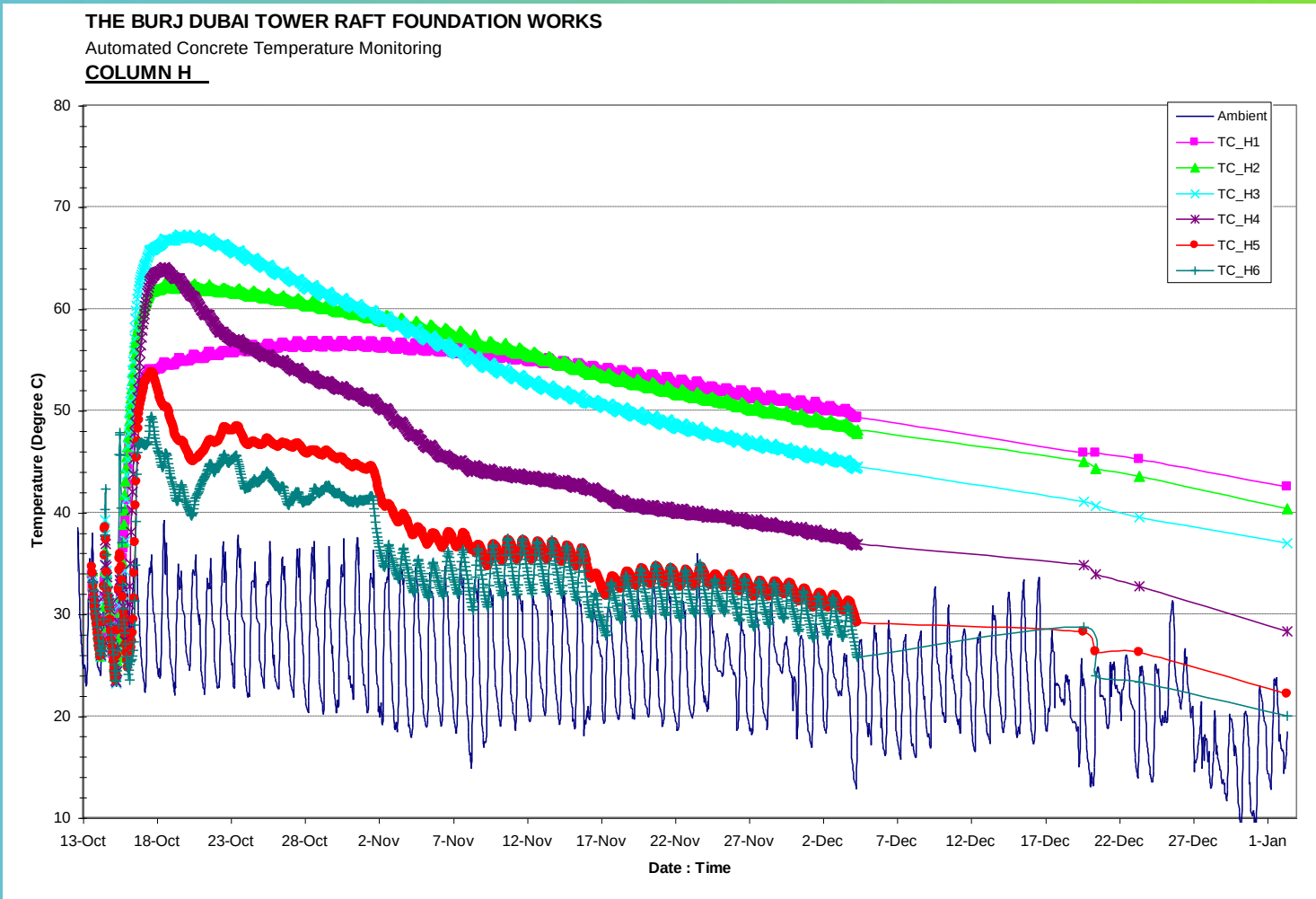
Cement (MSRPC)	252 kg/m ³
Fly Ash	168 kg/m ³
Silica fume	30 kg/m ³
Aggregate (20 mm)	368 kg/m ³
Aggregate (10 mm)	368 kg/m ³
Washed crushed sand (0-5 mm)	552 kg/m ³
Dune Sand (0 – 0.6 mm)	552 kg/m ³
Fine Aggregate Component	60%
Polycarboxylate SP	4 - 6 L/m ³
VMA	1 - 1.5 L/m ³
w/cm	0.32

Slumpflow during production (Approx 5000 m³)

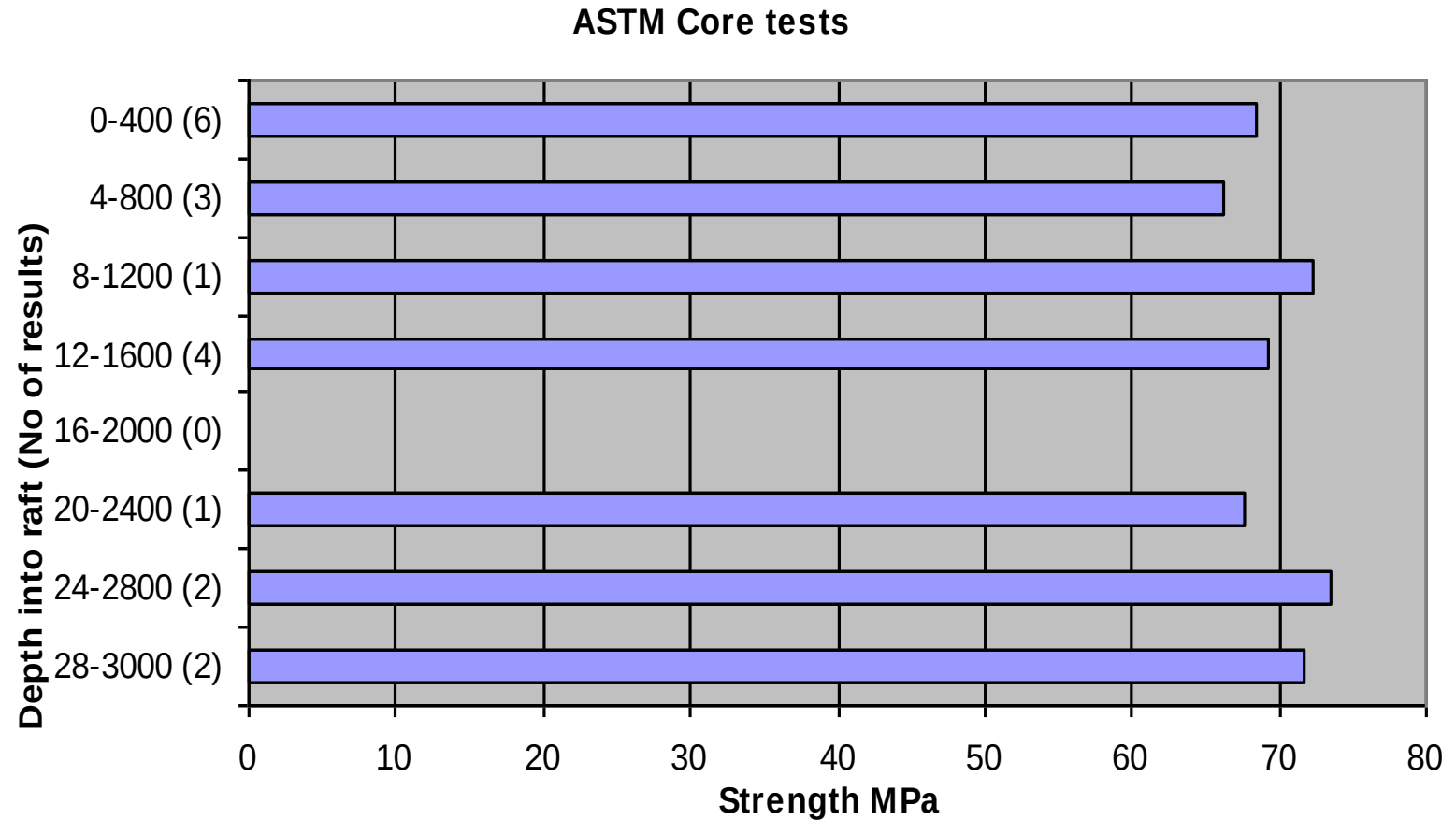


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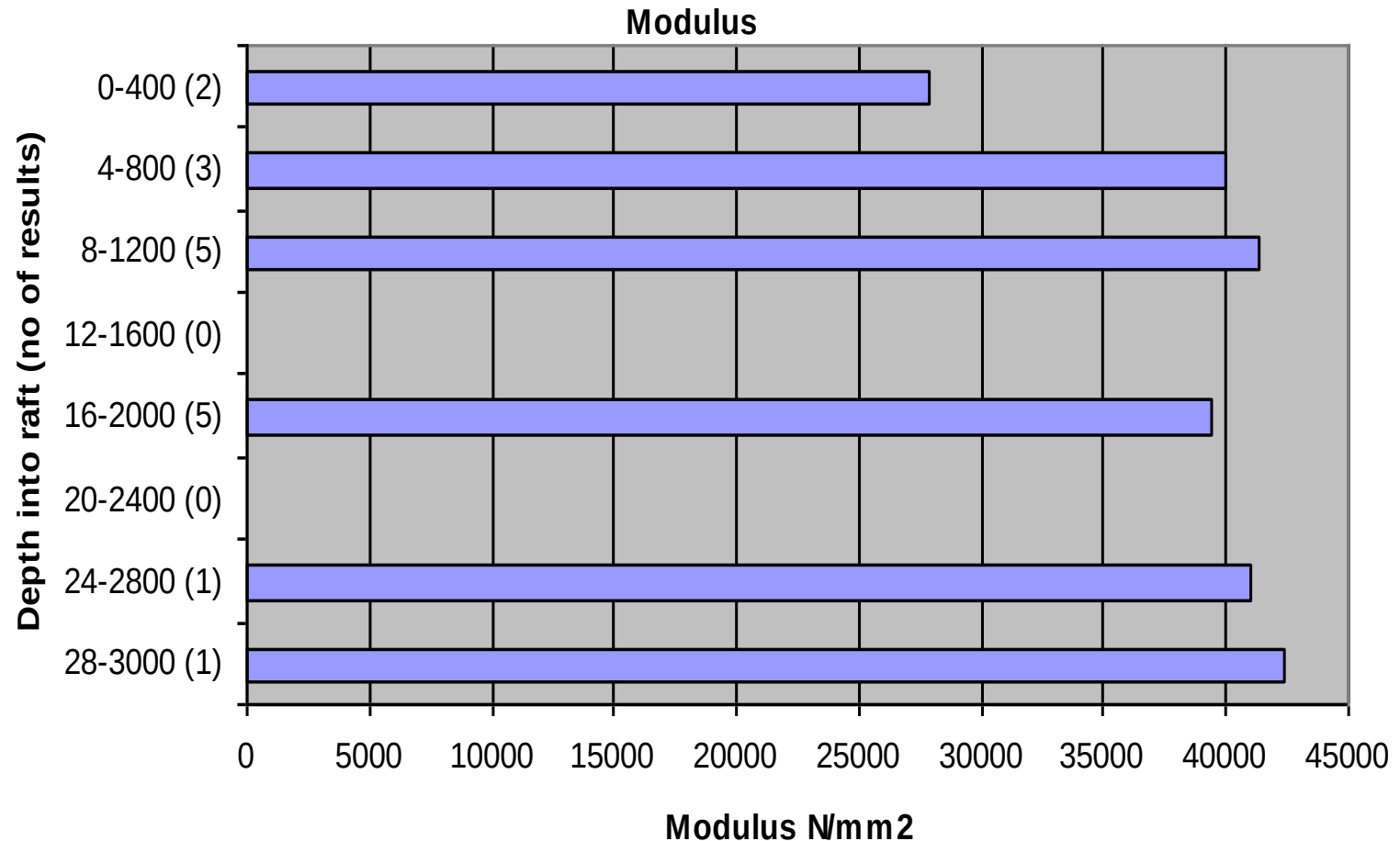
Temperature rise in centre of tower raft



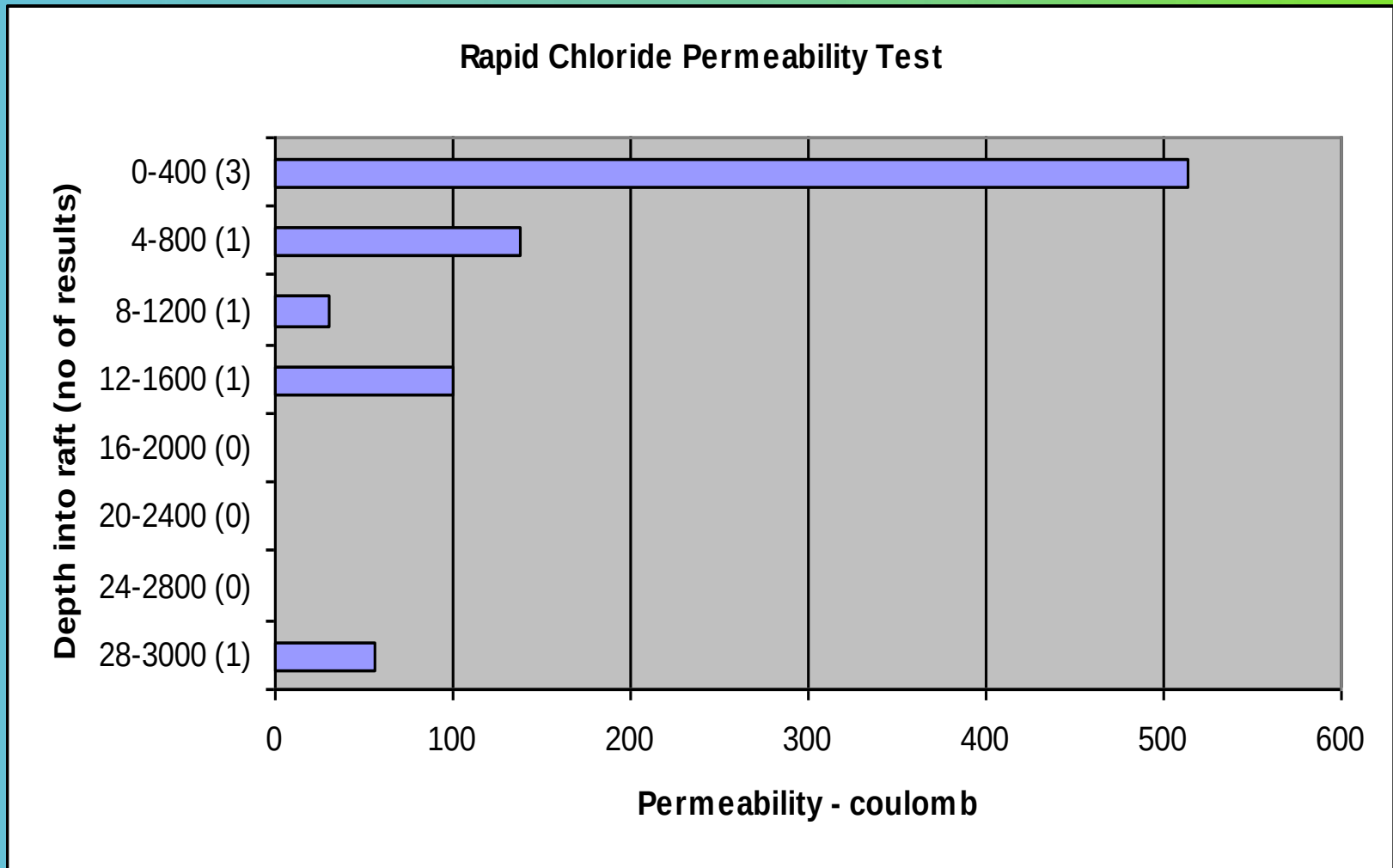
Compressive strength of cores (ASTM C39)



Modulus of cores (ASTM C469)



Coulomb values (ASTM C 1202)

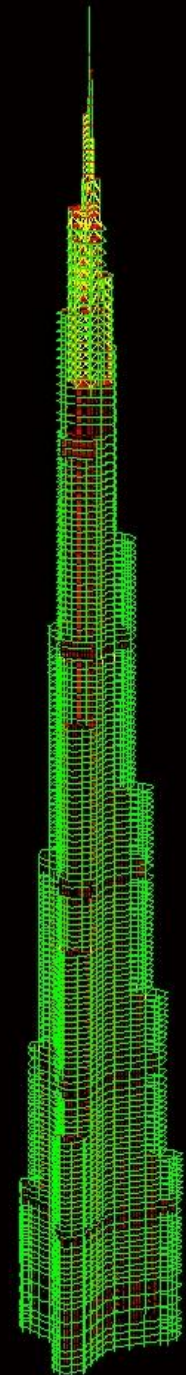


Burj Khalifa - Structural System Description

Steel Braced Frame
spire, communication

Reinforced Concrete Core Wall System
hotel / residential / office

Pile Supported Raft Foundation



Mixture proportions

Code	C80-20	C80-14	C80-10	C60-10	C50-20	C50-14
Max.Agg	20	14	10	10	20	14
w/cm	0.27	0.30	0.29	0.35	0.36	0.36
OPC	380	384	400	376	328	338
FA	60	96	100	94	82	112
SF	44	48	50	25	25	25
F.Agg %	50	49	49	51	49	50

Pumping Trial



Reductions in slumpflow during pumping trials

Pipe Length(m)	Concrete grade	Slumpflow(mm)			
		At plant	Before pumping	After pumping	Loss /100m
250	C80-20	600	580	495	34
450	C80-14	600	545	475	16
	C80-10	630	560	415	32
	C80-20	600	540	420	27
600	C50-14	630	580	480	17
	C60-10	620	560	395	28
	C80-14		600	410	32

Concrete pressure during trials

Pipe Length(m)	Concrete grade	Output (m ³ /hr)	Friction factor	Concrete pressure (bars)			
				Hopper	250m	450m	600m
250	C80-20	29	5.3	119	21	-	-
450	C80-14	29	2.3	88	43	10	-
	C80-10	33	2.0	90	47	11	-
600	C50-14	30	1.6	88	51	27	8
	C60-10	27	1.9	99	63	34	11

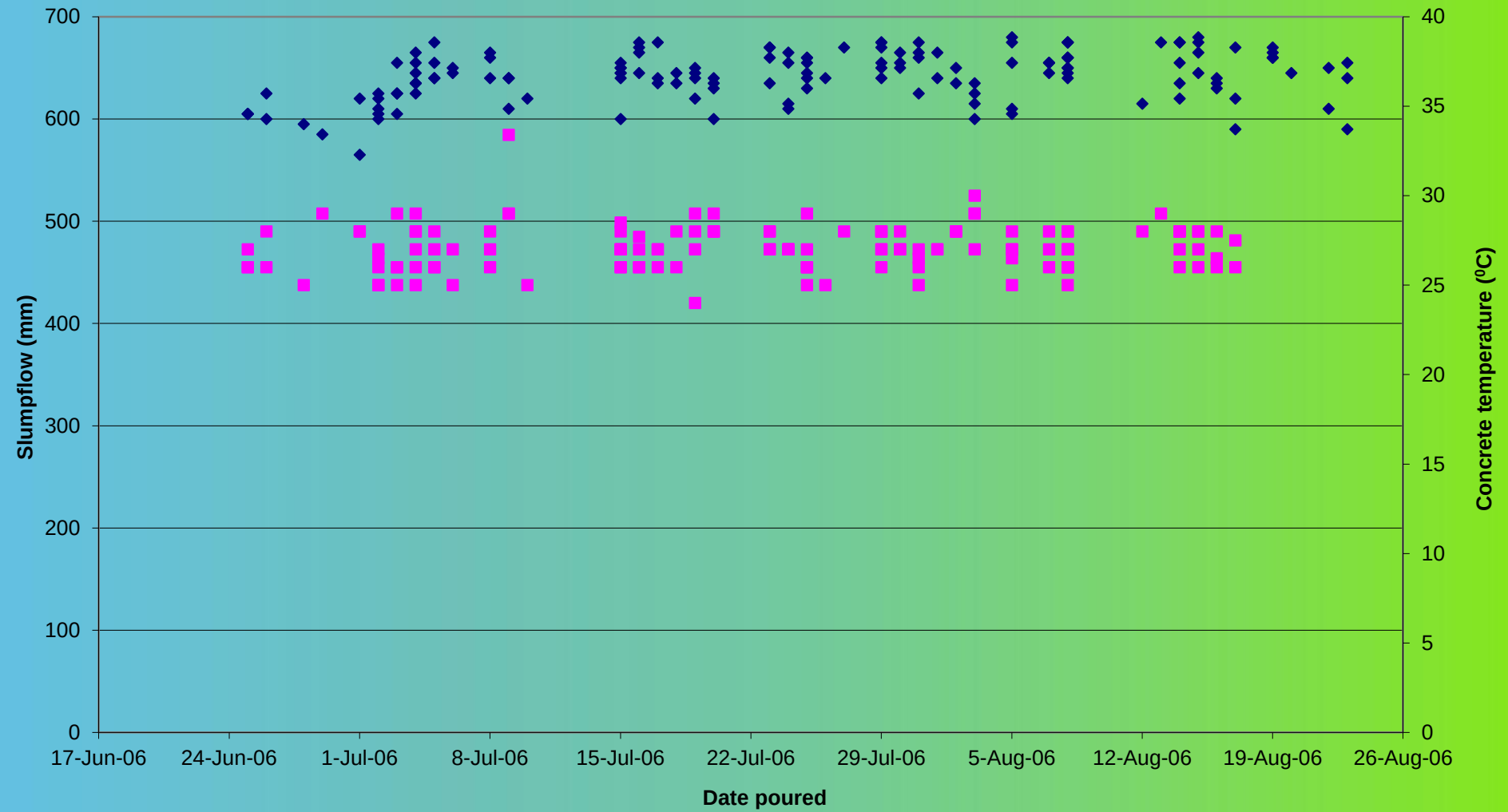
Increases in temperature during pumping trials

Pipe Length(m)	Concrete grade	Temperature (°C)			
		At plant	Before pumping	After pumping	Increase /100m
250	C80-20	26	27	30	1.2
450	C80-14	25	25	29	0.9
	C80-10	28	27	32	1.1
	C80-20	27	28	37	2.0
600	C50-14	26	27	33	1.0
	C60-10	27	28	35	1.2
	C80-14		29	35	1.0

Pump Station at ground level



C80A - Slumpflow and temperature data









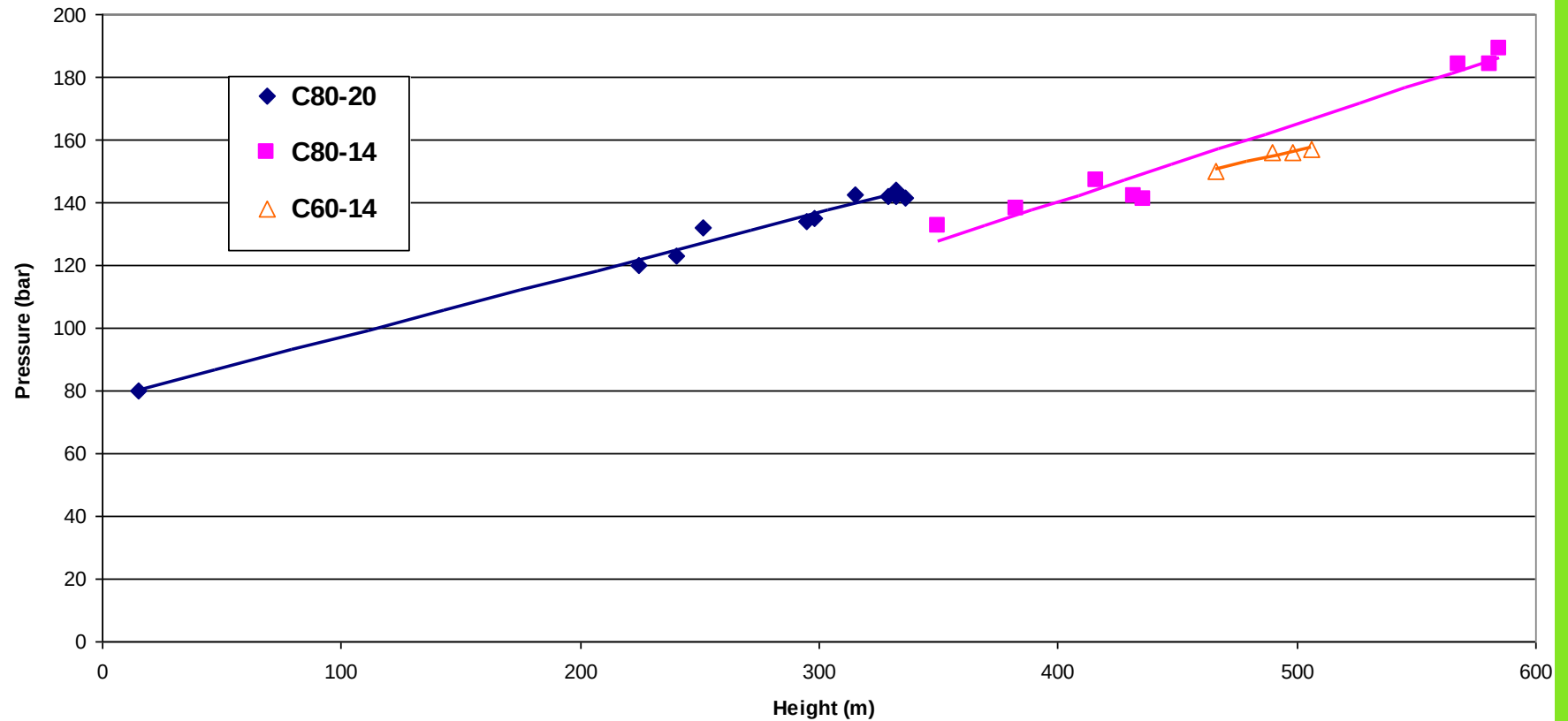




Measuring Pressure



Pumping pressure vs height



Concrete Rheology – Key to High Pressure Pumping



Effect of pumping on fresh concrete properties

Grade of concrete	C60/14				C80/14						C80/20 (5inch)	
Level	L126		L129		L115-1		L115-2		L125		L102	
Sampling	before pumping	after pumping	before pumping	after pumping	before pumping	after pumping	before pumping	after pumping	before pumping	after pumping	before pumping	after pumping
Slump Flow (mm)	640	545	620	570	710	635	640	620	570	550	690	600
T-500 (sec)	2.4	2.5	2.6	2.0	3.5	3.1	4.7	3.9	9.2	4.1	4.3	6.9
Temperature (°C)	25.0	29.0	25.0	28.0	25.0	27.0	25.0	26.5	28.0	31.0	24.0	26.0
Plastic viscosity (Pa.s)	24.0	12.7	24.7	13.0	39.8	29.7	40.9	16.0	51.4	26.9	93.4	45.8
Dynamic Yield Stress (Pa)	56.8	116.8	61.5	125.4	12.1	37.1	62.6	92.4	85.4	116.0	18.5	48.3





Kingdom Tower

Tower Height: 1,000+ meters

Number of floors: 240 +

Estimated Concrete: 250,000 m³

- 85 MPa to L98 170,000 m³
- 75 MPa to L168 70,000 m³
- 65 MPa to 975m 10,000 m³



Conclusions

- Concrete has now replaced steel as the material of choice for supertall building construction.
- Self consolidating concrete provides for rapid and high quality construction which can be pumped great distances.
- Good quality control to maintain consistent concrete properties is important to ensuring continuous uninterrupted concrete pumping at high pressure.
- Ensuring a cohesive slurry to prime the pipeline is important to prevent segregation and blockage, especially in pumping highly workable concrete.

Thank You

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