Manufactured Sand in Concrete

VULCAN MATERIALS COMPANY:

KEVIN VAUGHAN, PE

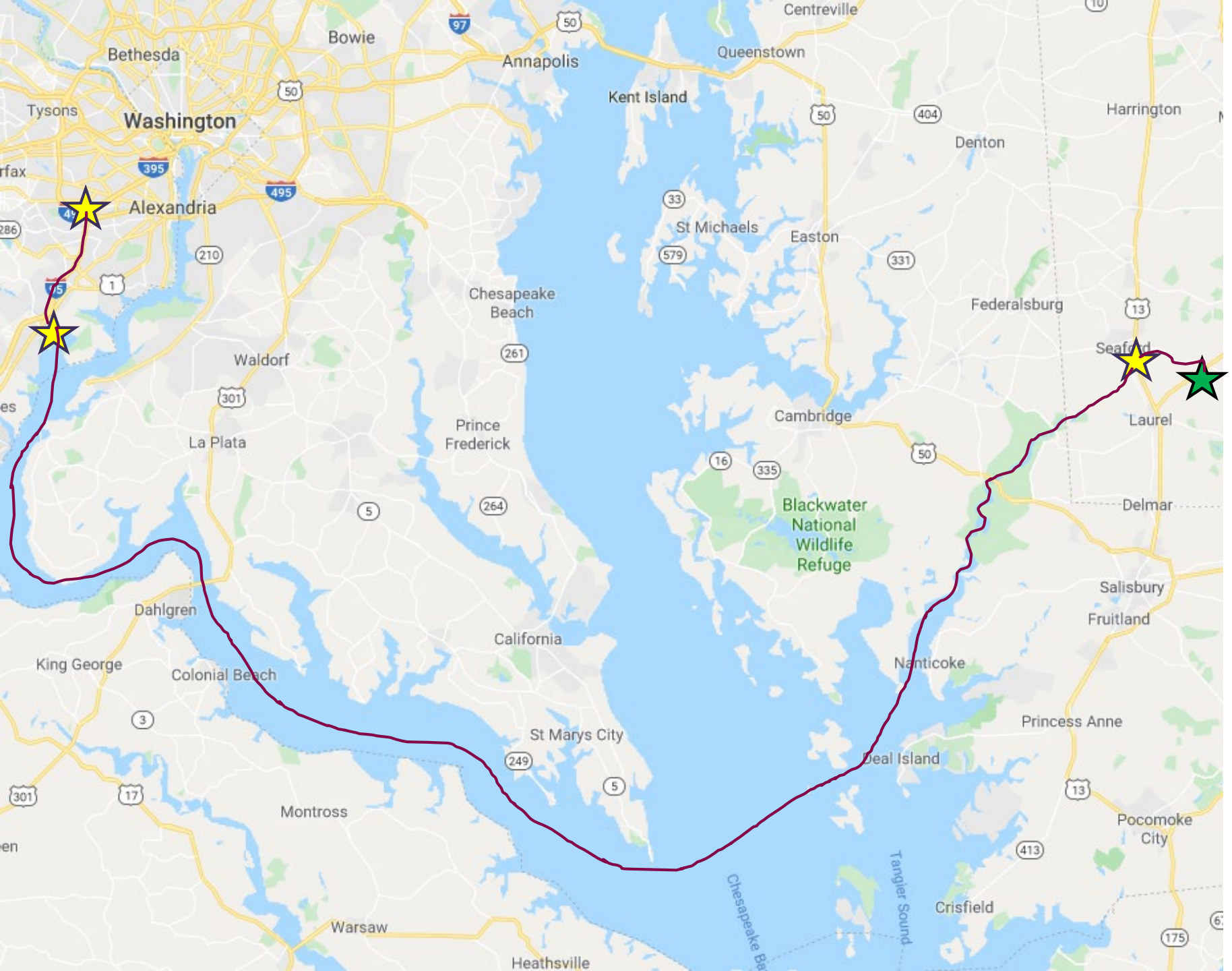
TECK L CHUA, PE

Manufactured Sand in Concrete

- Issues with availability of natural sand vs. manufactured sand
- How manufactured sand differs from natural sand
- Different methods of manufactured sand production
- Designing concrete with manufactured sand
- Production of concrete with manufactured sand
- Placement of concrete with manufactured sand
- Example projects that have been completed

Natural Sand Sources

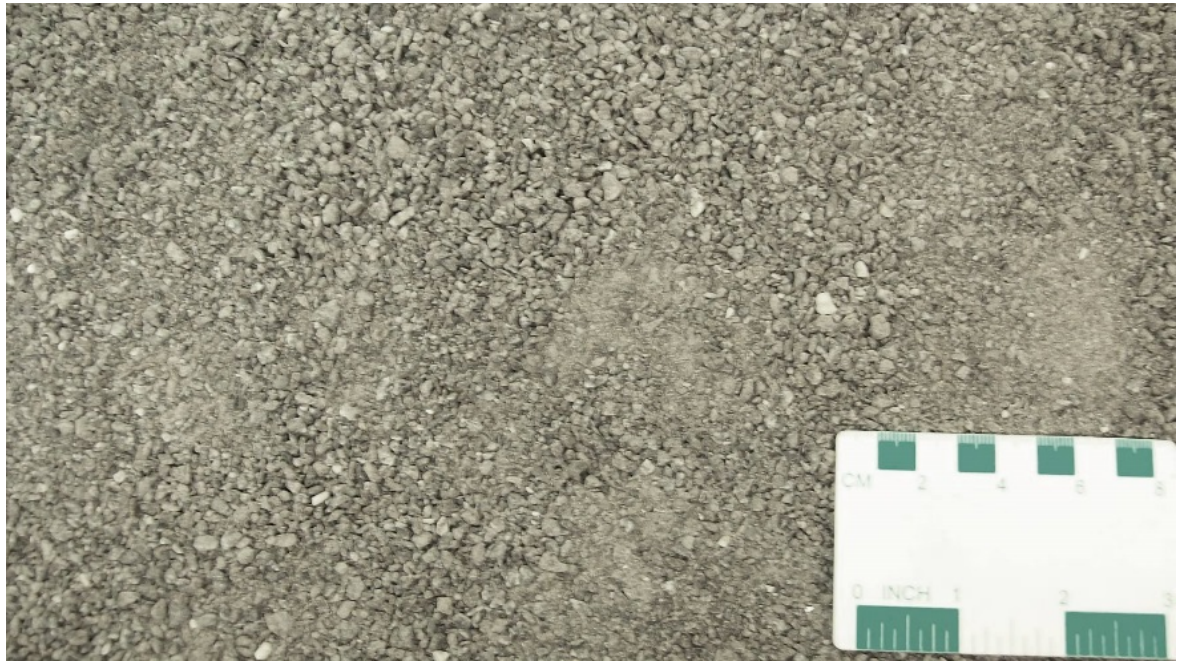
- Natural sand sources are not readily available in certain areas
  - Northern Virginia
  - Central & Western North Carolina
  - Atlanta, GA
- How do you supply natural sand to concrete producers in these markets?
  - Lots of transportation cost



- Truck 9 miles from Sand Source to Sales Yard
- Barge 160 miles from Sales Yard to Sales yard
- Truck 12 miles from Sales Yard to Concrete Plant
- 181 Miles of Transportation

Manufactured Sand

- When we crush stone to make coarse aggregate for concrete
  - We also make fine aggregate
  - This fine aggregate can be used as manufactured sand
- Benefits
  - More readily available and closer to the concrete plants
  - Can save on transportation costs
  - Makes use of a locally available material



Man Sand vs. Natural Sand

Sieve Size	Manufactured Sand	Natural Sand
3/8"	100	100
#4	99	97
#8	76	93
#16	52	81
#30	48	48
#50	22	9
#100	11	1
#200	3.9	0.5

Man Sand vs. Natural Sand

Sieve Size	Manufactured Sand	Natural Sand	ASTM C33
3/8"	100	100	100
#4	99	97	95-100
#8	76 Coarse	93	80-100
#16	52 Coarse	81	50-85
#30	48	48	25-60
#50	22	9	5-30
#100	11 Fine	1	0-10
#200	3.9 Fine	0.5	0-3*

*For manufactured sand, may be raised to 5% for concrete subject to abrasion and 7% for all other concrete

Manufactured Sand Specifications

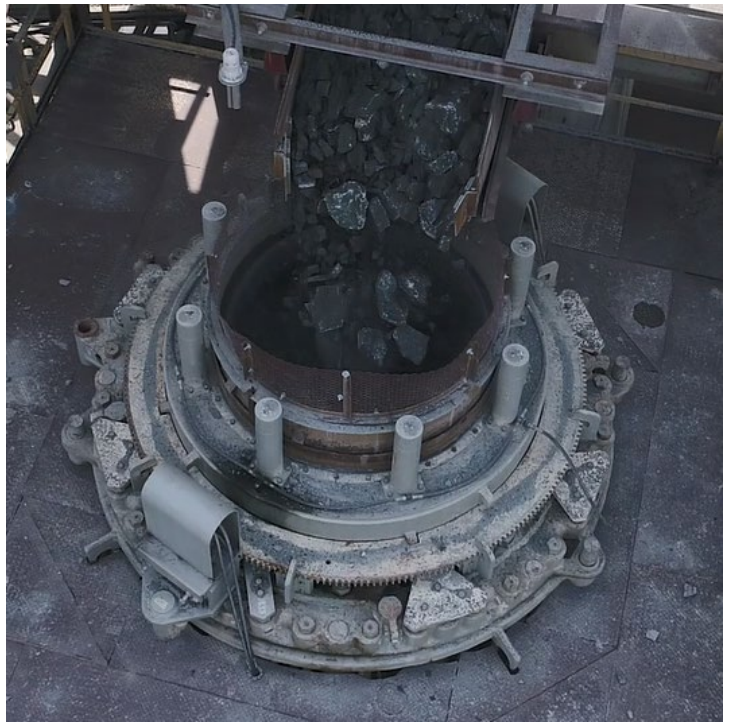
- Several Issues with typical sand specifications
- C33 was really designed for natural sand
  - Gradation doesn't fit man sand
  - Doesn't mean man sand gradation is bad
  - ASTM C33 allows alternate gradations
- The language about minus #200 and concrete subject to abrasion
  - Minus #200 in man sand is not clay or clay like
  - International Center for Aggregate Technology found that man sand with up to 18% minus #200 performed very well in abrasion

Manufactured Sand

- Definition from ASTM C 125 – fine aggregate produced by crushing rock, gravel, iron blast-furnace slag, or hydraulic-cement concrete
- Manufactured sands are made by
  - Blast → Crush → Screen
  - Other options include
    - Impact crushing to change particle shape
    - Washing to reduce minus #200

Crushing & Screening Man Sand

- Quarries typically use compression crushers (cones and jaws)
- Aggregate then screened to separate into coarse and fine
- Man Sand is typically the minus 3/8" material
- Man Sand may then be washed to remove minus #200



Sand Screw For Washing

Impact Crushing

- Some plants may also use an “impact” crusher to improve the particle shape
  - Horizontal or Vertical Shaft Impact Crushers (HSI or VSI)
- This can be helpful, but is not always necessary

Manufactured Sand In Concrete

- Concrete producers may use 100% manufactured sand
- May use a blend
  - In some areas we pre-blend natural and manufactured sand
- How do concrete producers proportion/use manufactured sand?

Manufactured sand: Adoption barriers

- Concrete finishers hate it
  - difficult to “close” with a trowel.
  - like rubbing on stone with a trowel
- Pump operator hates it
  - High pump pressure – more wear/tear
- Ready mixed guy hates it
  - Higher water demand

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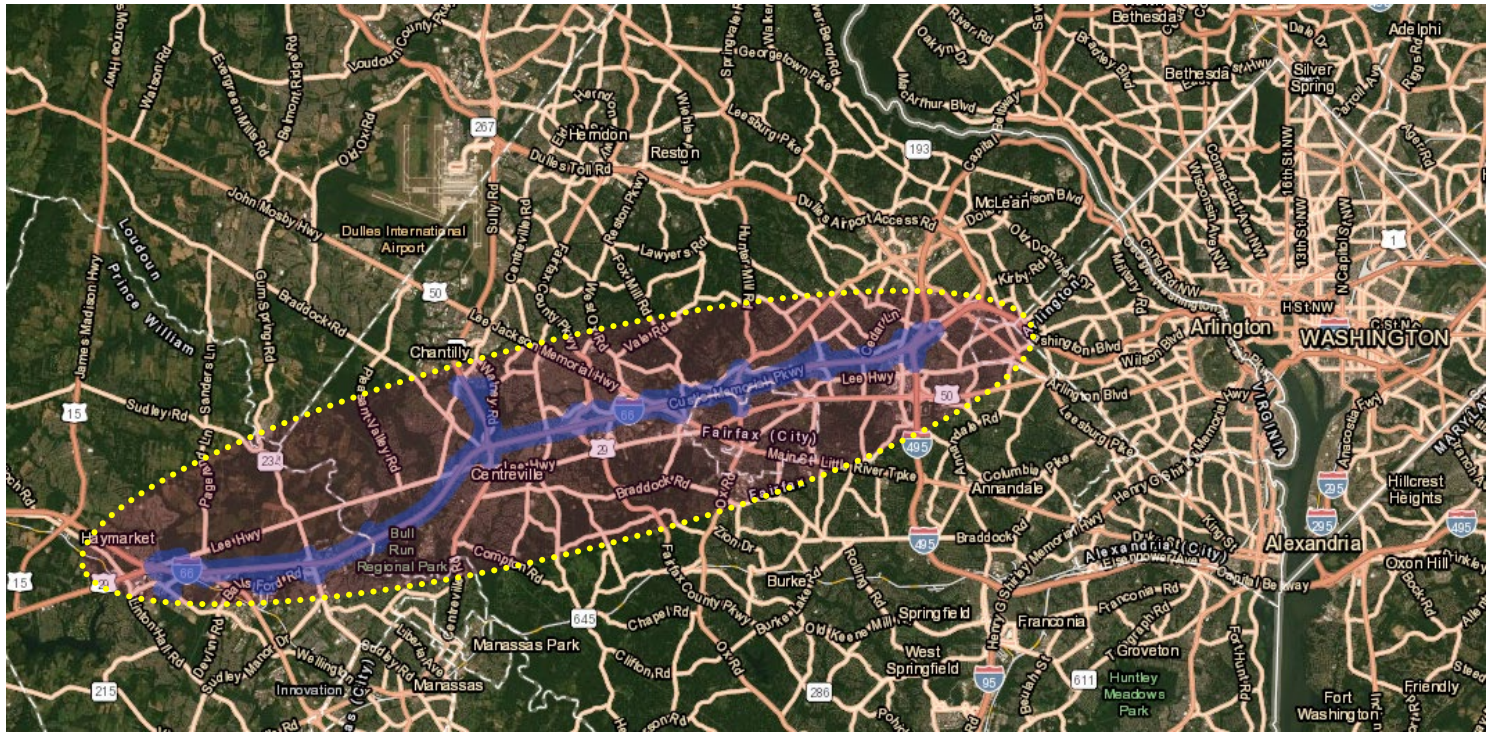
All True, when poorly proportioned!

Vulcan's Success in Using Manufactured sand since 2011

INFRASTRUCTURES

Transform I-66 Outside the Beltway (current)



- 60% manf sand
- $3.7 billion project
- Two express lanes, 22.5 mi both direction, I-495 to Haymarket.
- VMC share: 70% of 400,000cy

http://outside.transform66.org/about_the_project/maps_plans.asp

WMATA Silver Line Phase 2

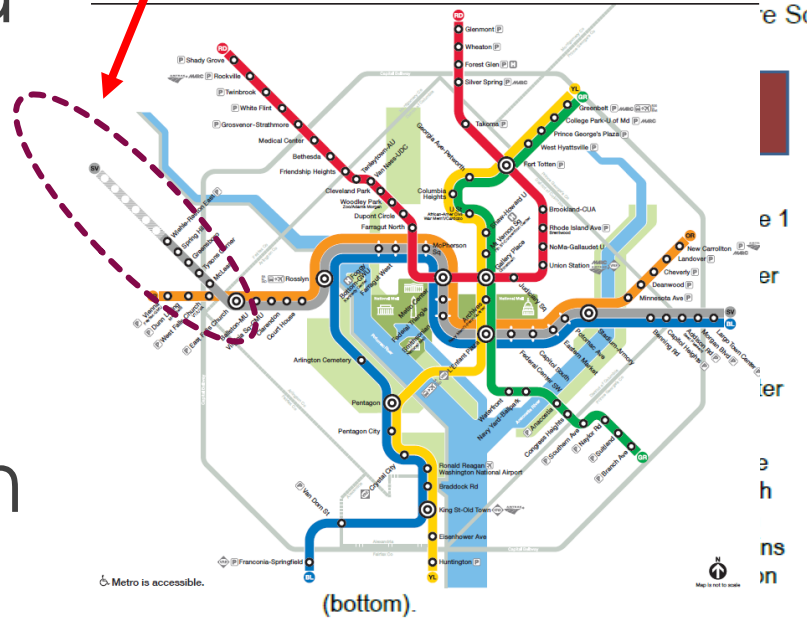
- 75% manf sand in concrete exposed to view
- Pump placed
- $2.8 billion project
- 11.4 mile extension

http://www.dullesmetro.com/silver-line-stations/dulles-airport1/

DULLES CORRIDOR METRORAIL PROJECT

Dulles Airport Metrorail Station

The Dulles Airport Metrorail Station is being constructed by Capital Rail Constructors, a joint venture of Clark
e South Co., as part of Phase 2 of the Silver Line extension to Dulles



(bottom).

I-495 Express Lanes: Springfield to Tysons

- 40% manf sand
- $2 billion PPTA project
- 180,000 cy
- 50+ bridges in 14-mile stretch

Reagan National Airport (DCA)
R 1-19 Improvement Paving (2012)

- 100% manf sand
- FM = 2.85

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Reagan National Airport (DCA) Runway 1-19 Improvement

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Vulcan's Experience Using Manufactured sand

Buildings

High Performance Computing Center 2 (2014) National Security Agency (NSA), MD

- 100% manf sand
- Pump placed
- $565 mil project
- 40,000 cy

https://www.nab.usace.army.mil/Portals/63/docs/BusinessWithUs/MMSAME_Industry%20Day_PDF.pdf?ver=2018-07-24-162644-310

East Campus Building 2
Fort Meade, MD

- 100% manf sand
- 10-floor Building & Garage
- Pump placed
- 90,000 cy

https://www.wileywilson.com/project/ecb2/

Rosslyn Commons, Arlington, VA

http://www.macfarlanepartners.com/projects/rosslyn-commons/

ROSSLYN COMMONS

Arlington, Virginia

Market: Washington, D.C.
Type: Multifamily Residential
Role: Development Partner
Status: Under construction

Mid-rise apartment community being developed in the heart of Rosslyn, one of Arlington's "urban villages," approximately half a mile from the Potomac River.

Size

- 474 rental apartments
- 12,900 square feet of retail space

Contractor's Onsite Plant

100% manufactured sand, FM = 3.66

Rosslyn Commons, Arlington, VA

Placed Oct 26, 2011

Pictures courtesy of Swope Associates

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Tysons Corner Center, Tysons, VA

http://www.washingtonpost.com/business/capitalbusiness/macerich-starting-mixed-use-tysons-corner-project-in-early-2012/2011/06/22/AGz5YXjH_story.html

- high-end office building, a 400-unit apartment tower and a four-star hotel

Tysons Corner Center

- 70% manf sand, 30% natural sand
- Placed September 14-15, 2012

Mix proportioning techniques for manufactured sand

- Standard ACI 211 proportioning
- Manf sand Fineness Modulus (FM): 2.8 to 3.7
- VDOT Spec: 2.3 <FM<3.1
- Blend with natural sand
- Composite FM: 2.3 <FM<3.1

Stone Volume Per ACI 211

Table 6.3.6 – Volume of coarse aggregate per unit of volume of concrete

Nominal maximum size of aggregate, in.	Volume of oven-dry-rodded coarse aggregate* per unit volume of concrete for different fineness moduli of fine aggregate+			
	2.40	2.60	2.80	3.00
3/8	0.50	0.48	0.46	0.44
1/2	0.59	0.57	0.55	0.53
3/4	0.66	0.64	0.62	0.60
1	0.71	0.69	0.67	0.65
1 1/2	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.80	0.78	0.76
6	0.87	0.85	0.83	0.81

FM

*Volumes are based on aggregates in oven-dry-rodded condition as described in ASTM C 29.

These volumes are selected from empirical relationships to produce concrete with a degree of workability suitable for usual reinforced construction. For less workable concrete, such as required for concrete pavement construction, they may be increased about 10 percent. For more workable concrete see Section 6.3.6.1.

+See ASTM C 1.36 for calculation of fineness modulus.

Composite FM: M_sand + N_sand

	Manf sand	Natural sand	Combined Fine Agg (by weight)							ASTM C33 VDOT
			Manf sand	*90%*	*80%*	*70%*	*60%*	*50%*	*40%*	*30%*	
			Natural sand	*10%*	*20%*	*30%*	*40%*	*50%*	*60%*	*70%*	
3/8"	100.0	100%		100%	100%	100%	100%	100%	100%	100%	100
#4	97.7	96%		98%	97%	97%	97%	97%	97%	97%	95-100
#8	63.8	87%		66%	68%	71%	73%	75%	78%	80%	80-100
#16	33.9	76%		38%	42%	47%	51%	55%	59%	63%	50-85
#30	19.5	56%		23%	27%	30%	34%	38%	41%	45%	25-60
#50	10.2	25%		12%	13%	15%	16%	18%	19%	21%	5-30
#100	4.4	4%		4%	4%	4%	4%	4%	4%	4%	0-10
#200	2.2	1.8%		2%	2%	2%	2%	2%	2%	2%	0-5
FM	3.71	2.56		3.59	3.48	3.36	3.25	3.13	3.02	2.90	
S.G.	2.93	2.60		2.90	2.86	2.83	2.80	2.77	2.73	2.70	
abs	0.85	0.75		0.84	0.83	0.82	0.81	0.80	0.79	0.78	

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Another example

Form TL-27MC (Revised 1/07)

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION

STATEMENT OF HYDRAULIC CEMENT CONCRETE MIX DESIGN

Submit one copy to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This mix design is approved for all projects of the Department for the class of concrete shown: Calendar Year 2020 Mix Design No. 9020-T-20

Producer Vulcan Materials Plant Location Centreville Phone 703-713-3100
Type of Mix: Ready Mix Job Mix Date 12/31/2019

VCC Mix No: 40-111334 Mix Design - One Cubic Yard (Meter) Based on SSD Condition

Class of Concrete (Q) A4 General (E) Slump/ 2 - 7 In. Air Content 6.5 +-1.5 %
(Low Permeability) Flow

Material		Quantities				Code	Source Name	
Cement	Type 2	330	lbs.	196	kg.	10	Lehigh	
Min Admix 1	Slag	330	lbs.	196	kg.	703	Lehigh	
Chaney-Sussex	40%	512	lbs.			9071	Chaney Sussex	
Luck Stone	60%	765	lbs.		kg.	9010	Luck Stone	
Sand (2)	4.0% adjust	1277	lbs.	758	kg.		40%Chaney /60%Luck	
No. 57	Stone (1)	1883	lbs.	1118	kg.	9003	Luck Stone	
Gr./No.	Aggr. (1)		lbs.		kg.			
Water (2)	275 lbs.	33.0	gal.	163	L.		well/city/pond	
Admixture (AE) (3)	AEA 14	varies	oz.	varies	ml.	66	Sika Corp.	Lyndhurst, NJ
*Admixture (Retarder) (3)	SikaTard 440	varies	oz.	varies	ml.	272	Sika Corp.	Lyndhurst, NJ
Admixture (Other) (3)	ViscoCrete 250	varies	oz.	varies	ml.	446	Sika Corp.	Lyndhurst, NJ
Admixture (Other) (3)	ViscoCrete 2100	varies	oz.	varies	ml.	190	Sika Corp.	Lyndhurst, NJ

NOTES: *Admx not used together; Admix dosage is oz/cwt or ml/kg of cementitious.

Weight at 0% adjustment: sand = 1226 57 Stone (1) = 1933

(1) The quantities of fine and coarse aggregates necessary to conform to specifications in regard to consistency and workability shall be determined by the method described in "Recommended Practice for Selecting Proportions for Normal Weight Concrete" (ACI-211.1) and the actual quantities used shall not deviate more than plus or minus 5 percent from such quantities.

(2) To provide minimum slump permissible in Table II-17 while satisfying placement and finishing requirements. A separate design shall be submitted for each slump desired.

(3) The quantity of admixture will not be approved or disapproved since it varies considerably and must be initially established by trial and error by the producer or contractor with subsequent adjustment during batching to maintain the desired results within the range specified.

Mineral Admixture #1 - sp.gr.	2.94	
Chaney-Sussex Sand - Abs.	0.5	
Sand - F.M.	*2.67*	
Sand - sp.gr.	*2.61*	
Luck Stone Sand - Abs.	0.5	
Sand - F.M.	*3.0*	
Sand - sp.gr.	*3.10*	
Compsite Sand - F.M.	2.9	
Composite Sand - sp.gr.	2.88	
C.A. #1 - Abs.	0.58	
C.A. #1 - sp.gr.	2.94	
C.A. #1 Unit mass	108 lbs./C.F.	/ kg/C.M.
2nd F.A./C.A.-F.M./u.wt.	/	/
	R	M
Design W/C Ratio	0.42	

Contractor _____ (Name of Company) By Sean Murnane (Certified Technician Preparing Form)

Producer Technician's Expiration Date # 2022 (Do Not Use Social Security Number)

FOR DEPARTMENT USE ONLY

Remarks: OK (mix design approved w/7" max slump using HRWR & w/4% adjustment already made)

Copies: District Materials Engineer
Project Inspector
Plant Inspector
Sub- Contractor and / or R.M. Producer

Checked by B.Kimmer

Approved by _____ District Materials Engineer
For David Shiells 1/6/2020

Approved tentatively subject to the production of material meeting the requirements of the Specifications and Special Provisions.

N sand

M sand

Chaney-Sussex	40%	512	lbs.
Luck Stone	60%	765	lbs.

N sand

M sand

Mineral Admixture #1 - sp.gr.	2.94	
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C.A. #1 Unit mass	108 Lbs./C.F.	/ kg/C.M.

M_sand with high fines + N_ sand

- VDOT 2016 Road & Bridge Spec Section 202.03.(e)

Material	% by Weight	AASHTO Test Method
Clay lumps	0.25	T112
Shale, mica, coated grains, soft or flaky particles	1.0	T113
Organic material	0	T21
Total material passing No. 200 sieve by washing[1]		T11 and T27
For use in concrete subject to abrasion	3	
For other concrete	5	

[1]In the case of stone sand, if the material passing the No. 200 sieve is dust of fracture, essentially free from clay and shale, the percentages shown for use in concrete subject to abrasion and in other concrete may be increased to 5.0 percent and 7.0 percent, respectively.

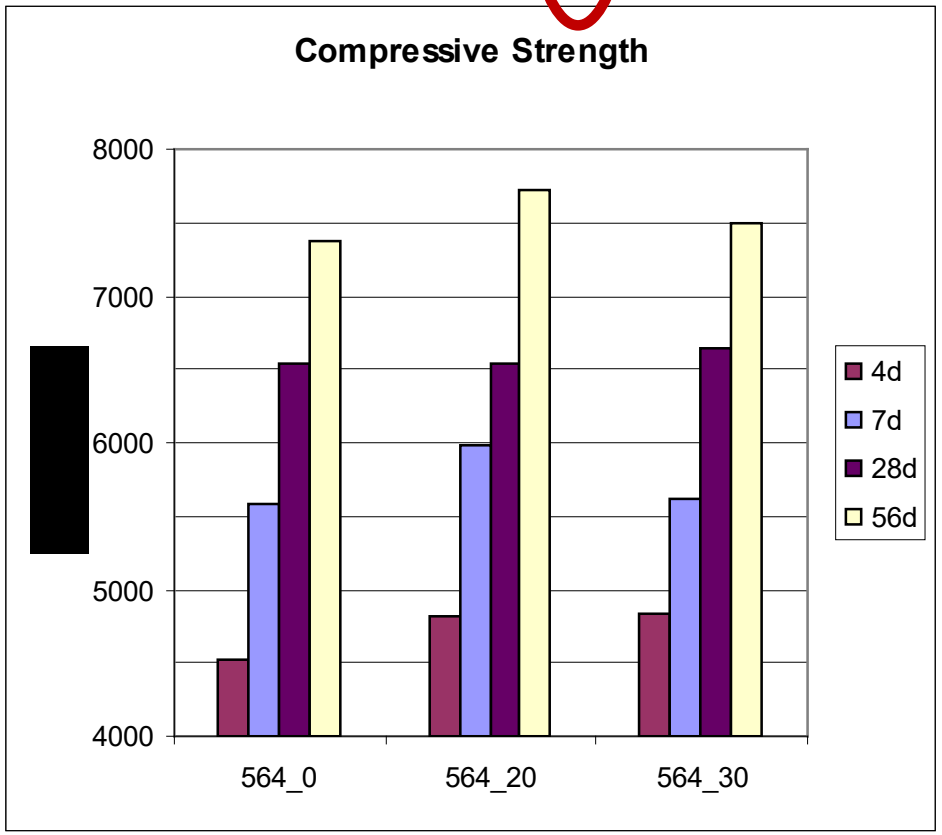
(for) stone sand . . . (if) minus #200 sieve is dust of fracture . . . use in concrete subject to abrasion and in other concrete may be increased to 5.0 % and 7.0%, respectively.

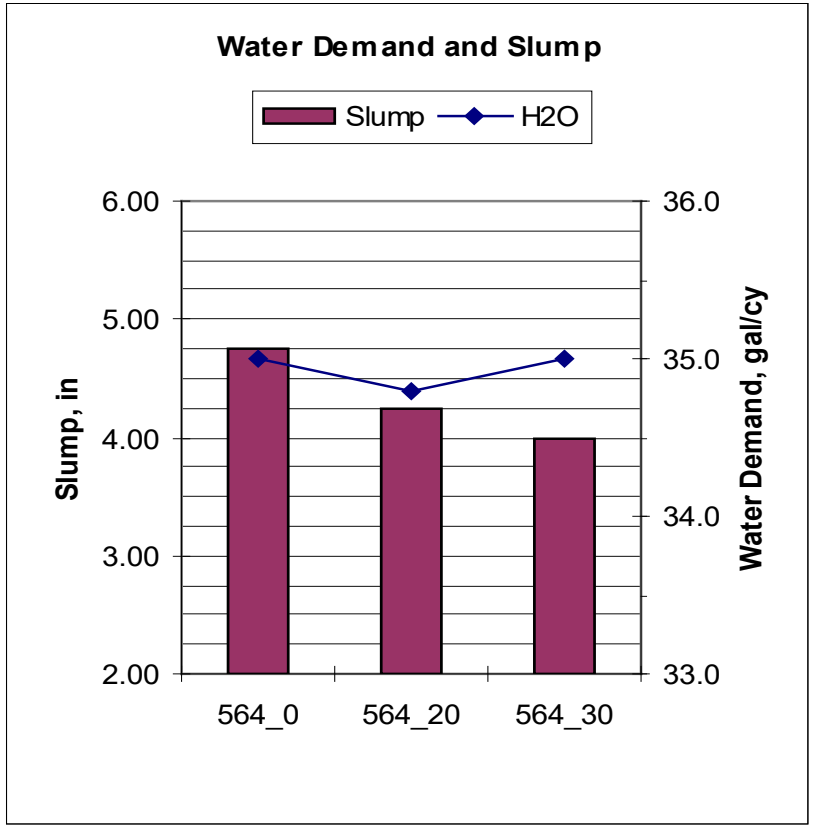
M_sand with high fines + N_ sand

	M_sand Screenings 7/'10	N_sand natural sand '10	Combined Fine Agg (by weight)				ASTM C33 VDOT
			M_sand	*40%*	*30%*	*25%*	*20%*	
			N_sand	*60%*	*70%*	*75%*	*80%*	
3/8"	100.0	100%		100%	100%	100%	100%	100
#4	96.8	98%		97%	97%	97%	97%	95-100
#8	76.0	81%		***79%***	***79%***	80%	80%	80-100
#16	52.8	67%		61%	63%	63%	64%	50-85
#30	39.1	48%		44%	45%	45%	46%	25-60
#50	29.7	17%		22%	21%	20%	20%	5-30
#100	24.2	4%		***12%***	10%	9%	8%	0-10
#200	**18.9**	0.5%		***8%***	***6%***	5%	4%	0-5
FM	2.81	2.87		2.85	2.85	2.86	2.86	
S.G.	2.77	2.64		2.69	2.68	2.67	2.67	
abs	0.69	1.00		0.88	0.91	0.92	0.94	

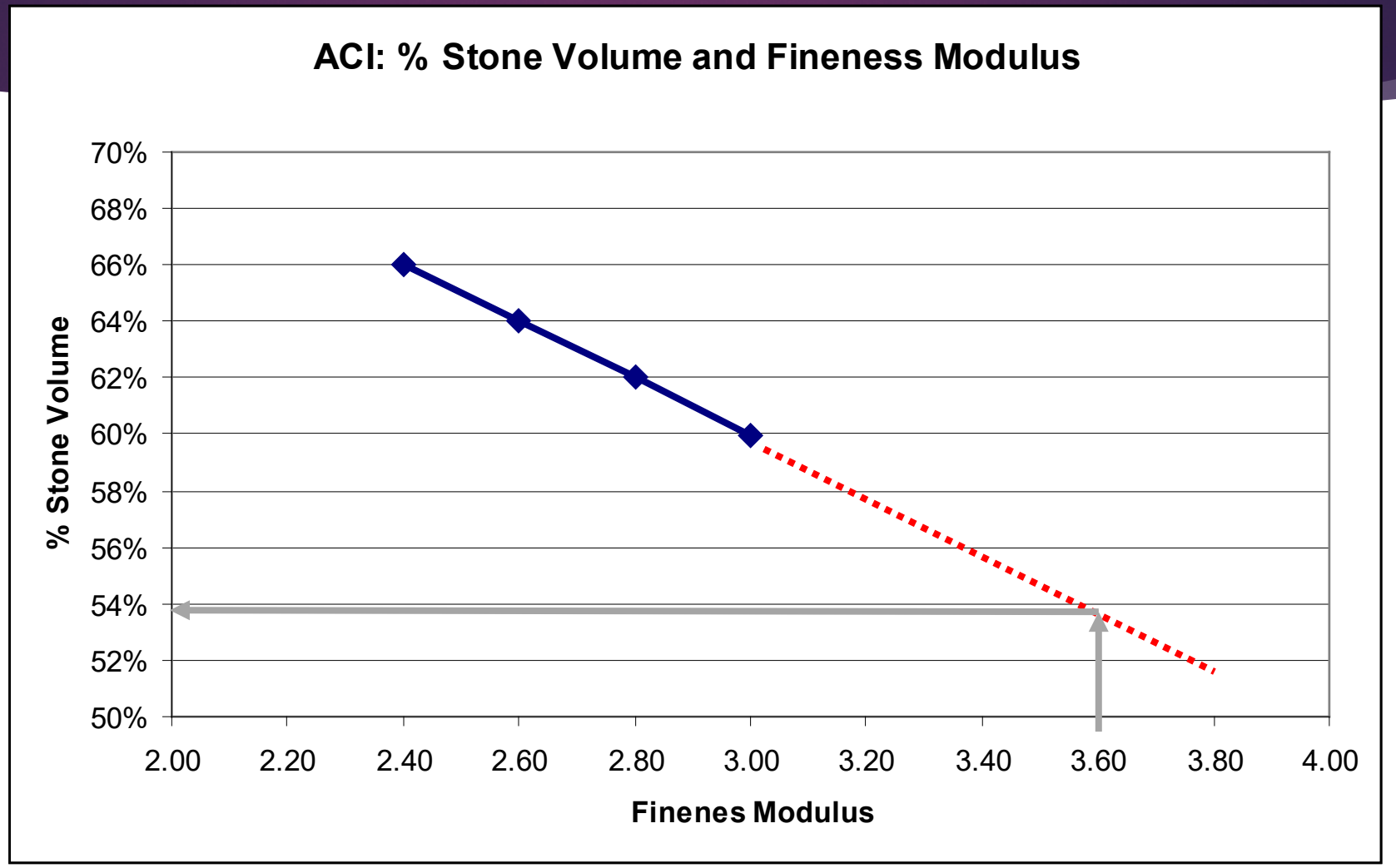
Mideast Concrete Division

Sampl ID	w/c	SL, in	air, %	unit wt, pcf	Yld, cf	H2O, gal	Temp, F		***compressive strength averages (psi or %), (day)				Designed weights, pcy				WR, oz per	
							conc	air	4	7	28	56	#57	NS	PC	MS	cwt	cy
564_0	0.516	4.75	3.4	152.2	26.9	35.0	72	70	4530	5575	6533	7370	1850	1393	564	0	3	16.9
564_20	0.511	4.25	3.0	154.0	26.7	34.8	72	70	4810	5990	6533	7730	1850	1130	564	279	3	16.9
564_30	0.521	4.00	2.4	156.1	26.4	35.0	73	70	4830	5615	6650	7500	1850	998	564	418	3	16.9





FM > 3.1



Mideast Concrete Division

Rosslyn Commons, Arlington, VA

http://www.macfarlanepartners.com/projects/rosslyn-commons/

ROSSLYN COMMONS

Arlington, Virginia

Market: Washington, D.C.
Type: Multifamily Residential
Role: Development Partner
Status: Under construction

Mid-rise apartment community being developed in the heart of Rosslyn, one of Arlington's "urban villages," approximately half a mile from the Potomac River.

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Contractor's Onsite Plant

100% manufactured sand, FM = 3.66

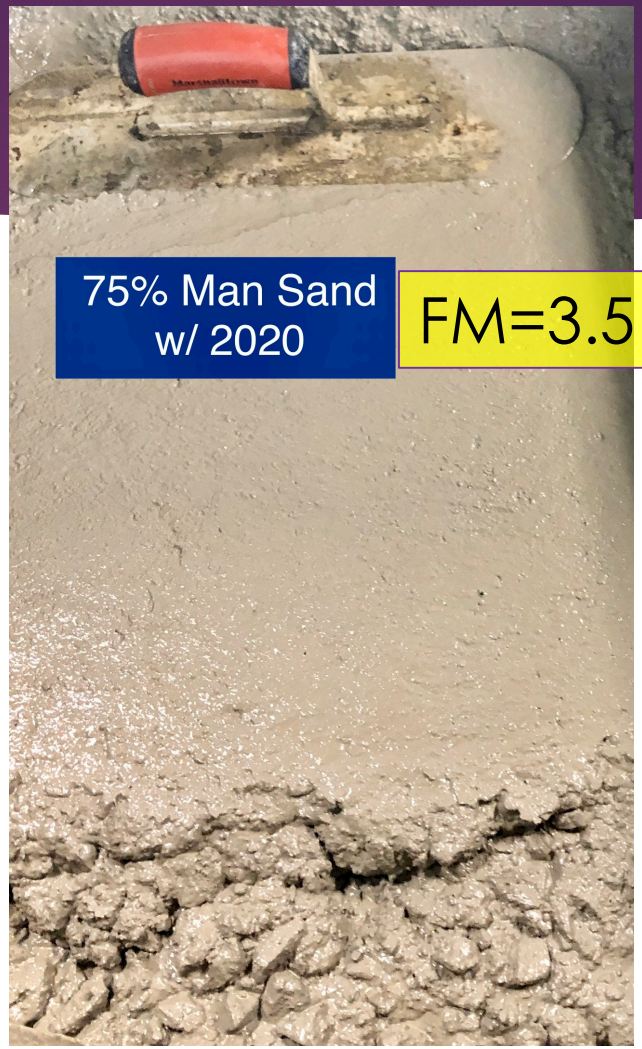
Rosslyn Commons, Arlington, VA

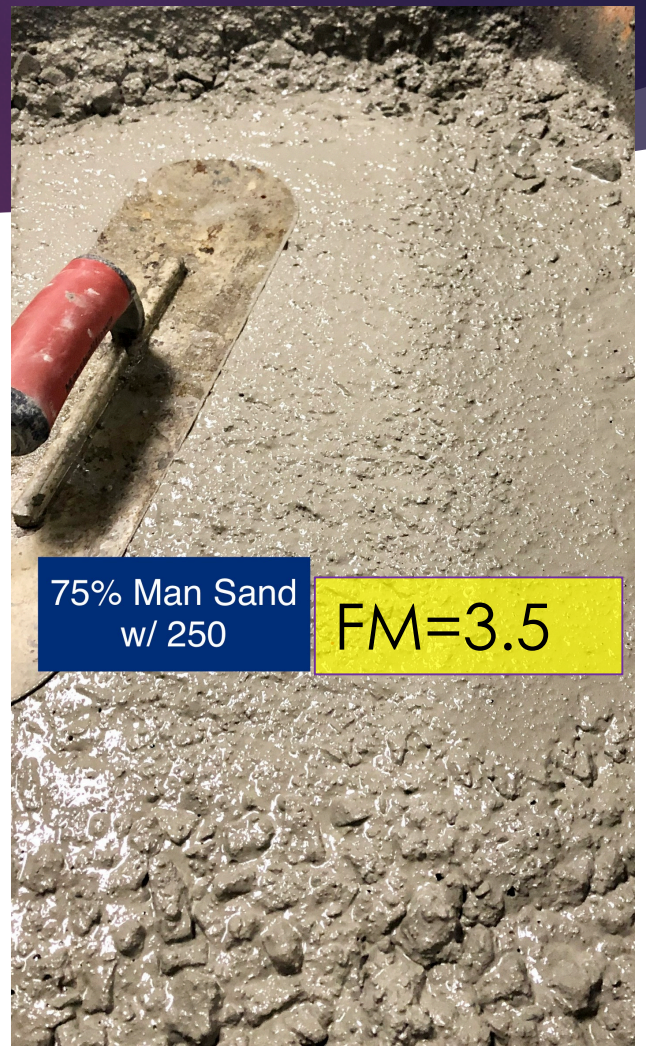
Placed Oct 26, 2011

Pictures courtesy of Swope Associates

Mideast Concrete Division

ASSISTANCE FROM CERTAIN ADMIXTURES





BUILDING TRUST

Questions?