Pervious Concrete Fall 2008 Construction LRRB 879

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A failure to plan is a plan to fail… Sage Unknown

Outline

- Sub Surface Exploration
- Location Allocation
- Pavement Design
- Instrumentation
- Construction Sequence
- As Built
- Monitoring
- Initial Test Results
- Conclusion

Links

- Reports are in ftp site:

  ftp://ftp2.dot.state.mn.us/

  Under file Login as:

  mrlresearchftp

Password: private098

Navigate: pub/share/materialslab/research/LRRBPERVIOUSCONCRETE/

  - Construction Report
  - Hydrologic Evaluation Report
  - Concrete Testing Report Cells 39, 85 & 89

POROUS CELL LAYOUT

7 inches	Pervious PCC
	12" Drainable Base
	Sand Clay

Pervious HMA on Sand (Cell 86)

Pervious PCC on Sand (Cell 85)

Pervious Control (Cell 87)

Pervious PCC on clay (Cell 89)

Pervious HMA on Clay(Cell 88)

2008 PERVIOUS INITIATIVES- LOCATION ALLOCATION

PSC CODE	FINISHING	Cell/ Location Allocation	Performance Specification
Perv C	Pervious Concrete	85, 89	Porosity shall be 18 to 22 % and communicating void ratio shall be 20 to 25%. The surface shall be void of laitance or slurry and should guarantee uniform porosity through the depth of the concrete. The matrix should be resistant to undesirable raveling and weathering. This shall be established during the trial mixing process. Unit weight may not exceed 125 pcf unless if by improved practice or otherwise, contactor achieves desired porosity while attaining 7-day flexural strength of 300psi. Mix design Modification: 6 % Sand
PERV OL	Pervious Concrete Overlay	37	Specified by Iowa State University. Unique Porous mix Contains Fibers and 6% sand. Mixture is self consolidating and slip-formable Poly Olefin / Polypropylene Fibers + cellulosic fibers included. (Contacts: Prof Vern Shaeffer, Dr John Kevern, Mr Paul Wiegand)
Perv B	Pervious Asphalt	86,88	The oil content, VMA unit weight and porosity shall meet the industry standard prevailing at the time of paving or as designed and specified by others.
PERV BC	Pervious Control cell	87	Non- Porous HMA

Location Of Foundation and CPT Probes

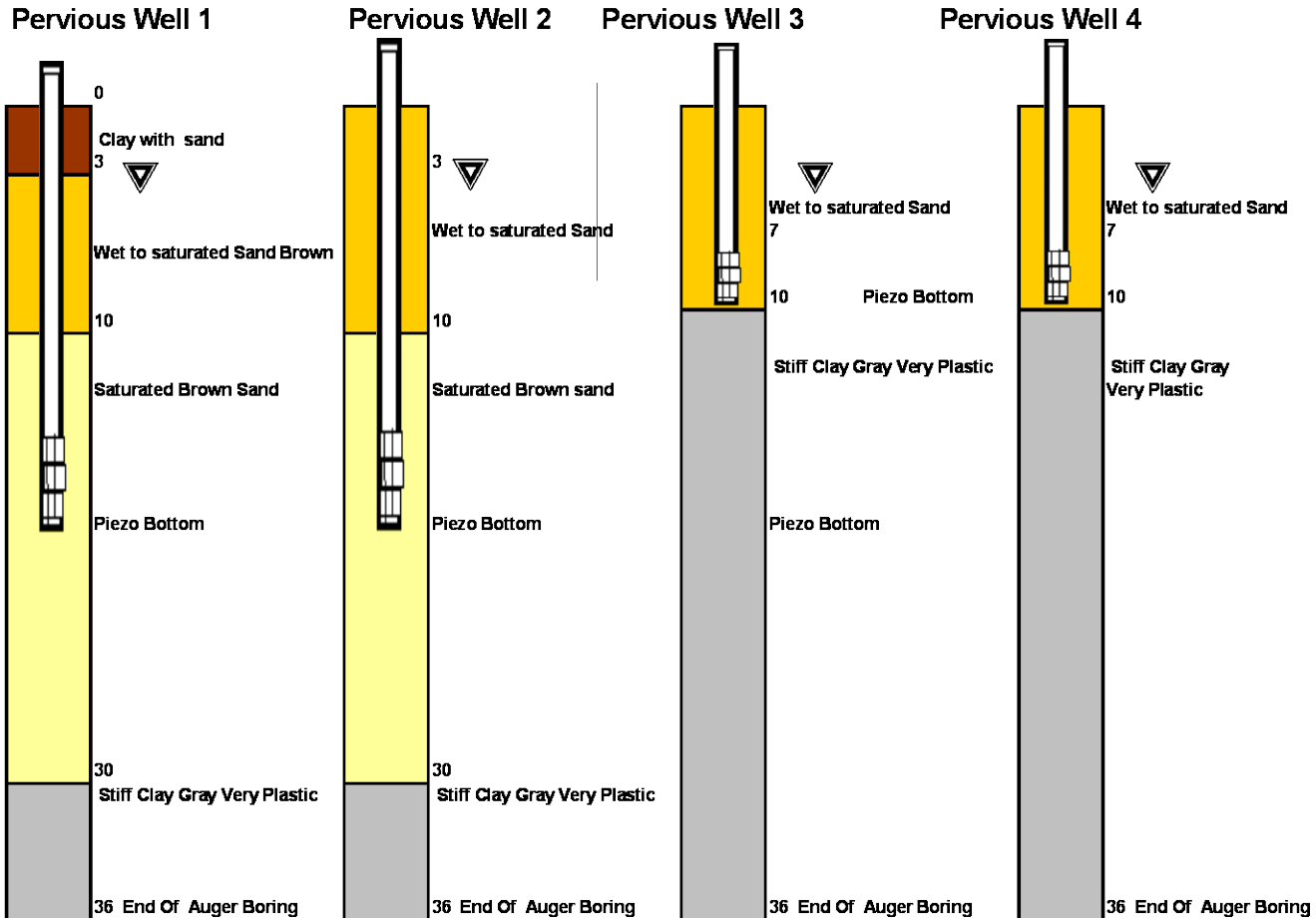
SUBSURFACE EXPLORATION STRATEGY

- Mn/DOT Geotechnical Section obtained Geotechnical borings from the project and install piezometers.
- Geotechnical section to use the Cone Penetrometer equipment to ascertain descriptive hydrogeological features such as extent of granular / cohesive layers, true phreatic surface and soil characterization. (4 Probes)

- Foundations section Provided 4 piezometers equipped borings in the low volume road

- MnROAD Auger Borings and Piezo installation (4)

MnROAD CREW Piezometer Borings 11/07/07

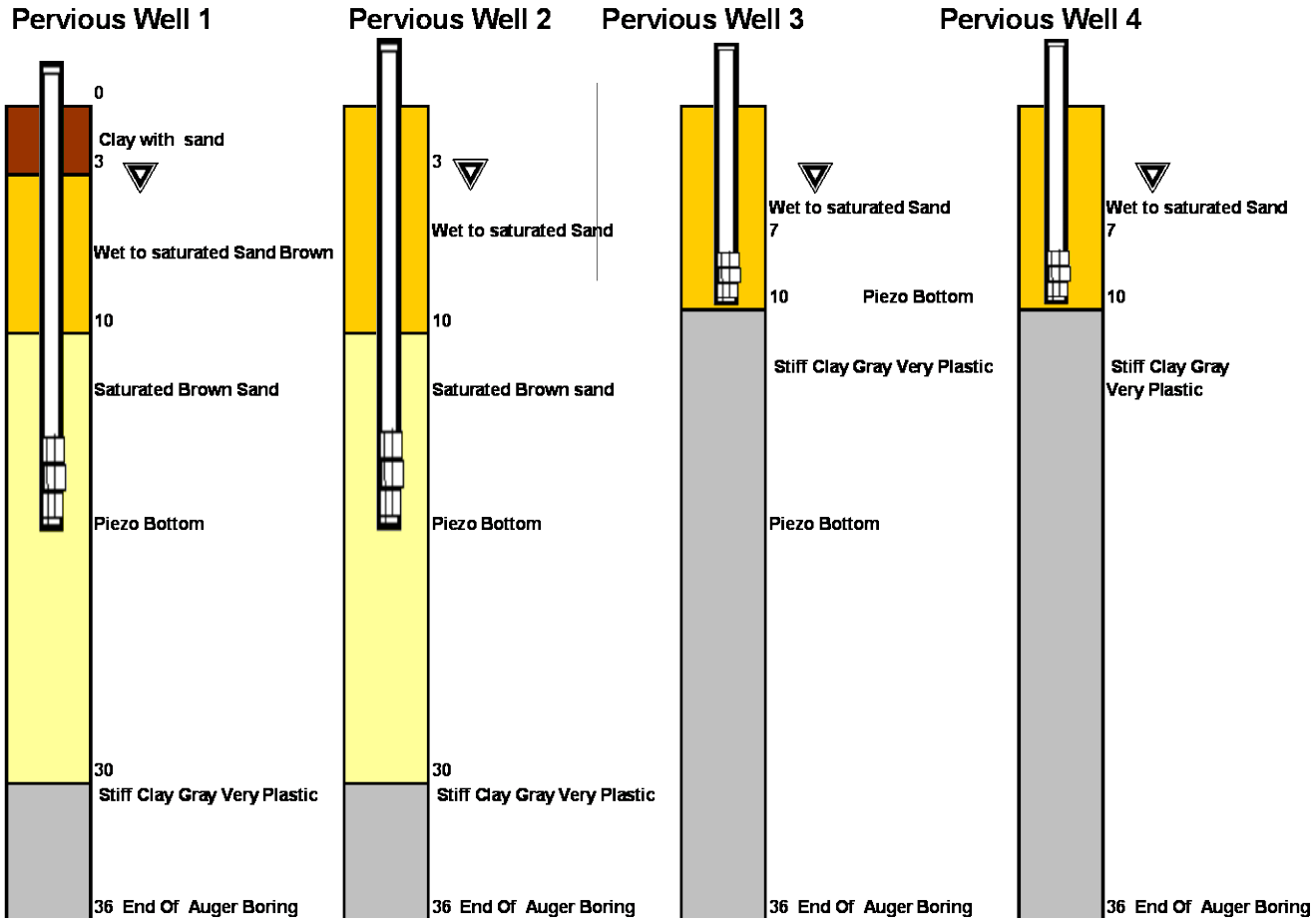


Granular Soils Encountered Under Cell 85

AQUIFEROUS GRANULAR MATERIAL7-32ft

AQUICLUDE FAT CLAY

MnROAD CREW Piezometer Borings 11/07/07



Cohesive Soils In the Aquiclude

ESAL COMPUTATION FOR PERVIOUS CONCRETE

		(Given)	Load Eqv Factor	ESAL	Load Eqv Facto	ESAL
SINGLE AXLE						
5000-6999	6	9	0.015	0.135	0.01	0.09
7000-8999	8	10	0.046	0.46	0.032	0.32
9000-10999	10	62	0.11	6.82	0.085	5.27
11000-12999	12	156	0.221	34.476	0.176	27.456
13000-14999	14	54	0.395	21.33	0.341	18.414
15000-16999	16	65	0.646	41.99	0.604	39.26
17000-18999	18	4	1	4	1	4
TANDEM AXLE						
14000-17999	16	4	0.065	0.26	0.082	0.328
18000-21999	18	12	0.151	1.812	0.206	2.472
22000-25999	20	68	0.302	20.536	0.444	30.192
26000-29999	22	97	0.541	52.477	0.85	82.45
30000-33999	24	108	0.888	95.904	1.49	160.92
34000-37999	26	32	1.38	44.16	2.43	77.76
38000-41999	28	12	2.045	24.54	3.75	45
TOTAL ESALs				348.9		493.932
TRUCK FACTOR				1.54		2.19

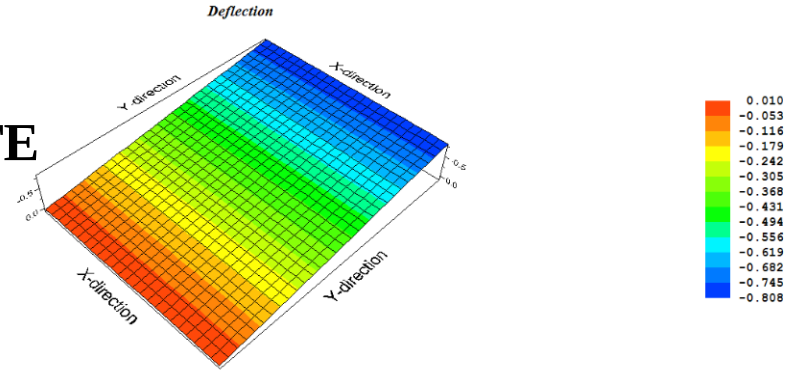
Case 1,80 kips 3 times a week
Average load = 85/5=17k per axle

LANE	LVR CONFIG	# axles	Daily repetitions	Repetitions/year Inside lane Days weekly	Repetitions/year Inside lane 84/day Weekly	Repetitions/year Cumulative 10 years	Load Range lb/axle	Avg Load (Kips)	Repetition (Given)	Flexible Pavement SN = 3.5 Load Eqv	Flexible Pavement SN = 3.5 ESAL	Rigid Pavement Load Eqv	Rigid Pavement ESAL
Inside	80	5	80	4	16697	166971		21000	166971	2.3	384034	3.73	622803
Outside	102	5	80	1	4174	41743	18	18888	41743	7.6	317246	11.65	486304
New Config	80	5	80	5	20871	208714		21000	208714	2.3	480043	3.73	778504

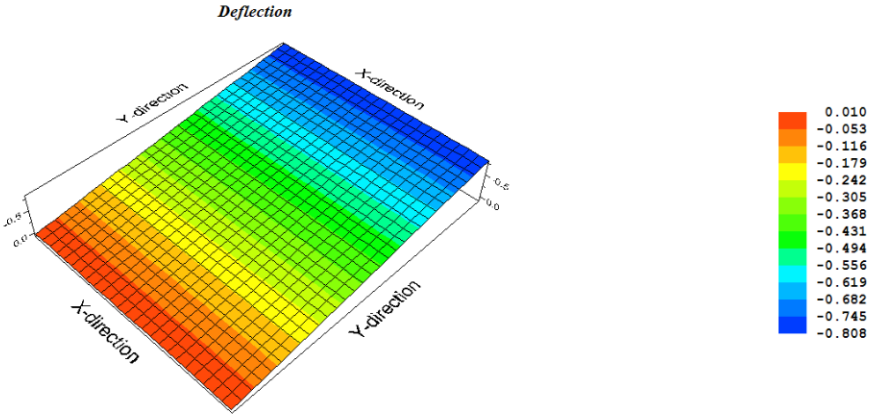
I-SLAB ANALYSIS COMPARISON
Deflection in Upper Layer

Deflection in upper layer

NORMAL CONCRETE

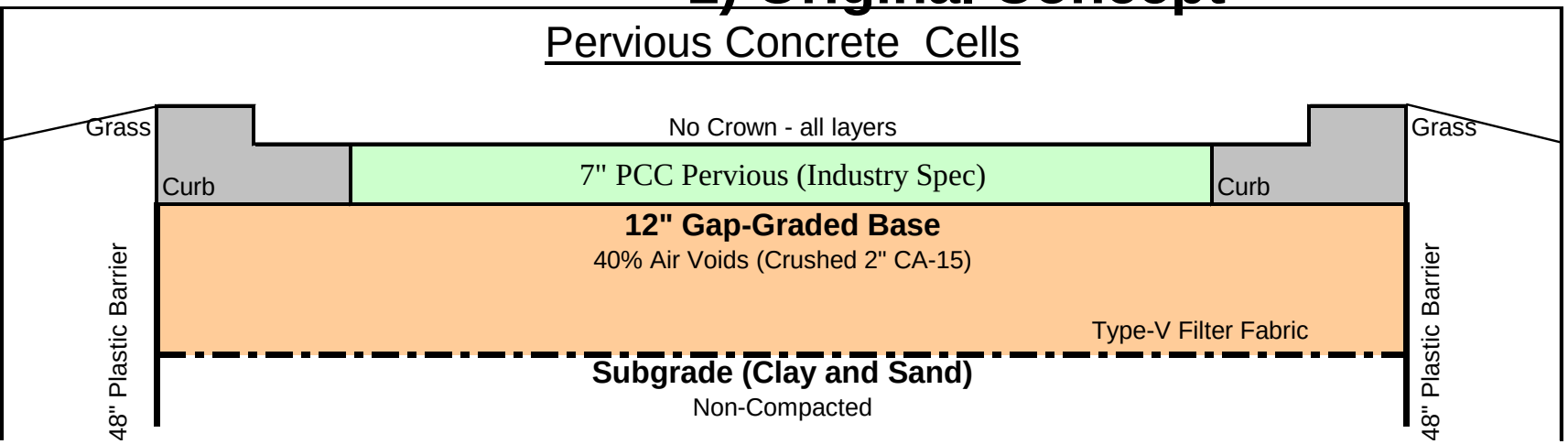


PERVIOUS CONCRETE



ON-SITE DESIGN MODIFICATIONS

1) Original Concept



Pavement Design Layout: Subgrade in Cell 85 is Sand and Subgrade in Cell 89 is Clay

2) On-Site Modifications

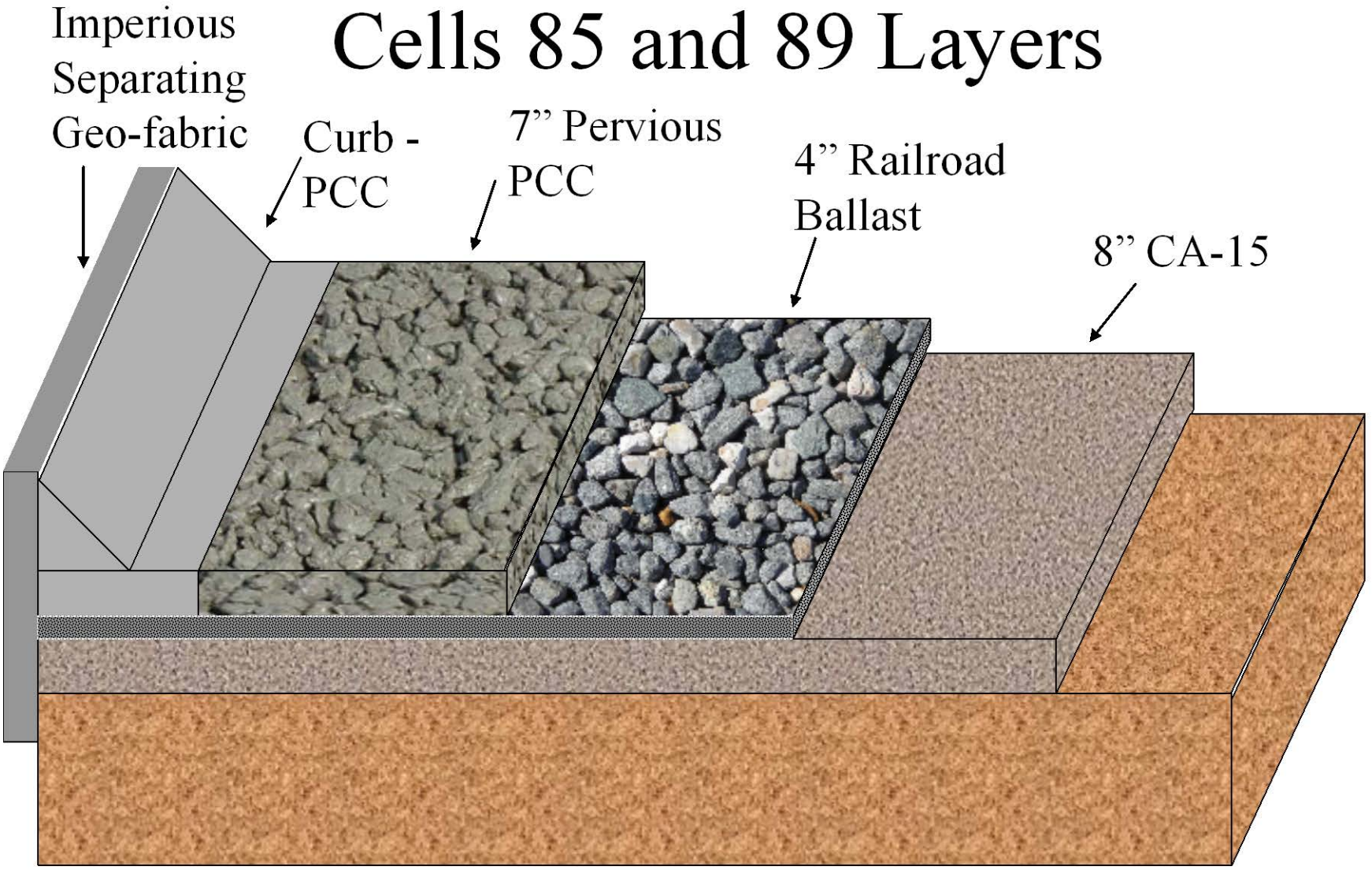
Design Modification To Allow Construction Traffic

- **7 inch pervious concrete**
- **4 inch Base of Angular Rail Road ballast 3 inch Nominal Size**
- **8 Inches Subbase of Design CA 15 Aggregate**
- **Fairly compacted Sand subgrade Cell 85**
- **Stiff clay Subgrade Cell 89. Detailed Geotechnical Report prior to design is available.**

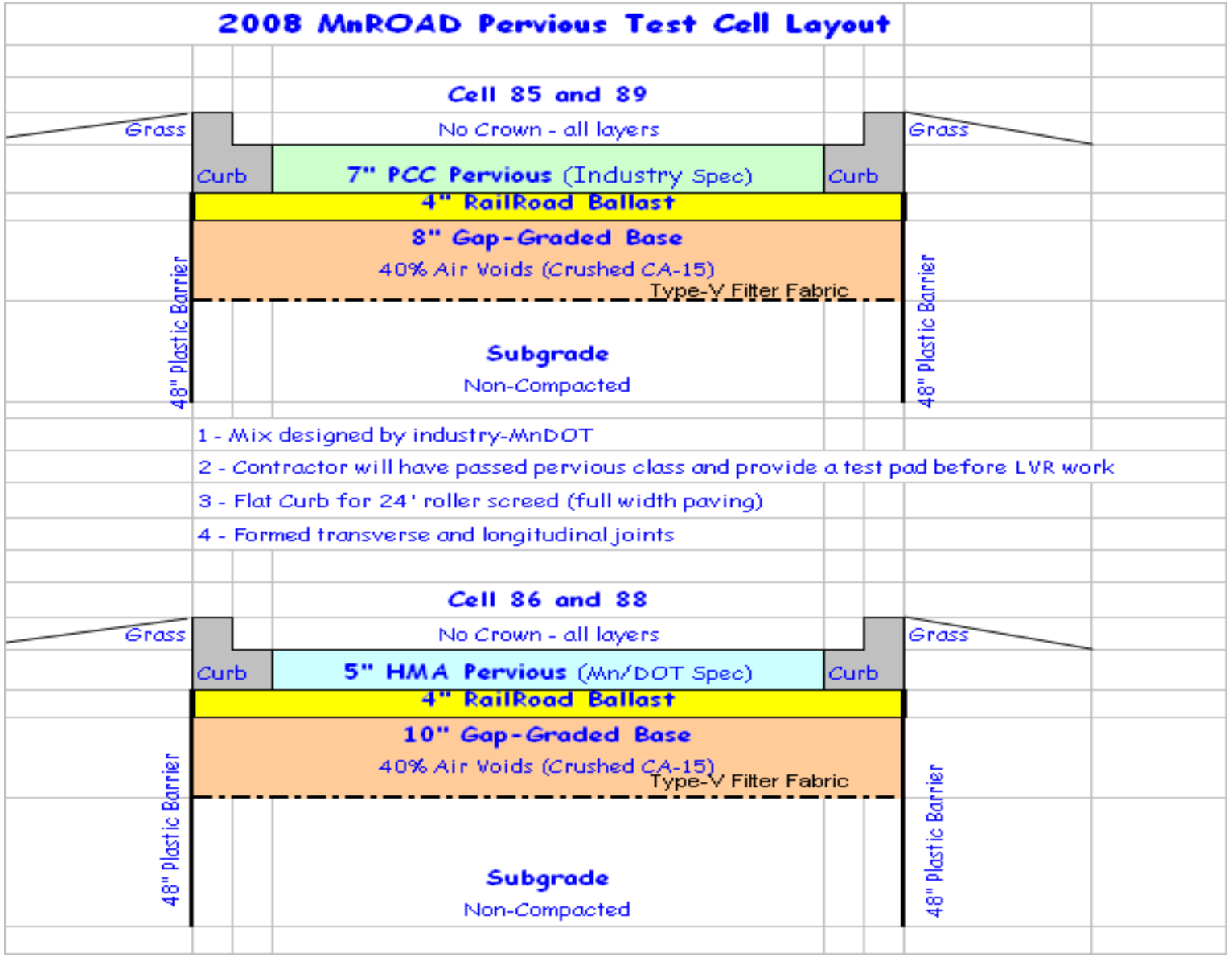
Design Modification for Sawcut Efficiency

- **20 ft Joints---------→ 10 ft Joint- Spacing to Match Curb**

Cells 85 and 89 Layers



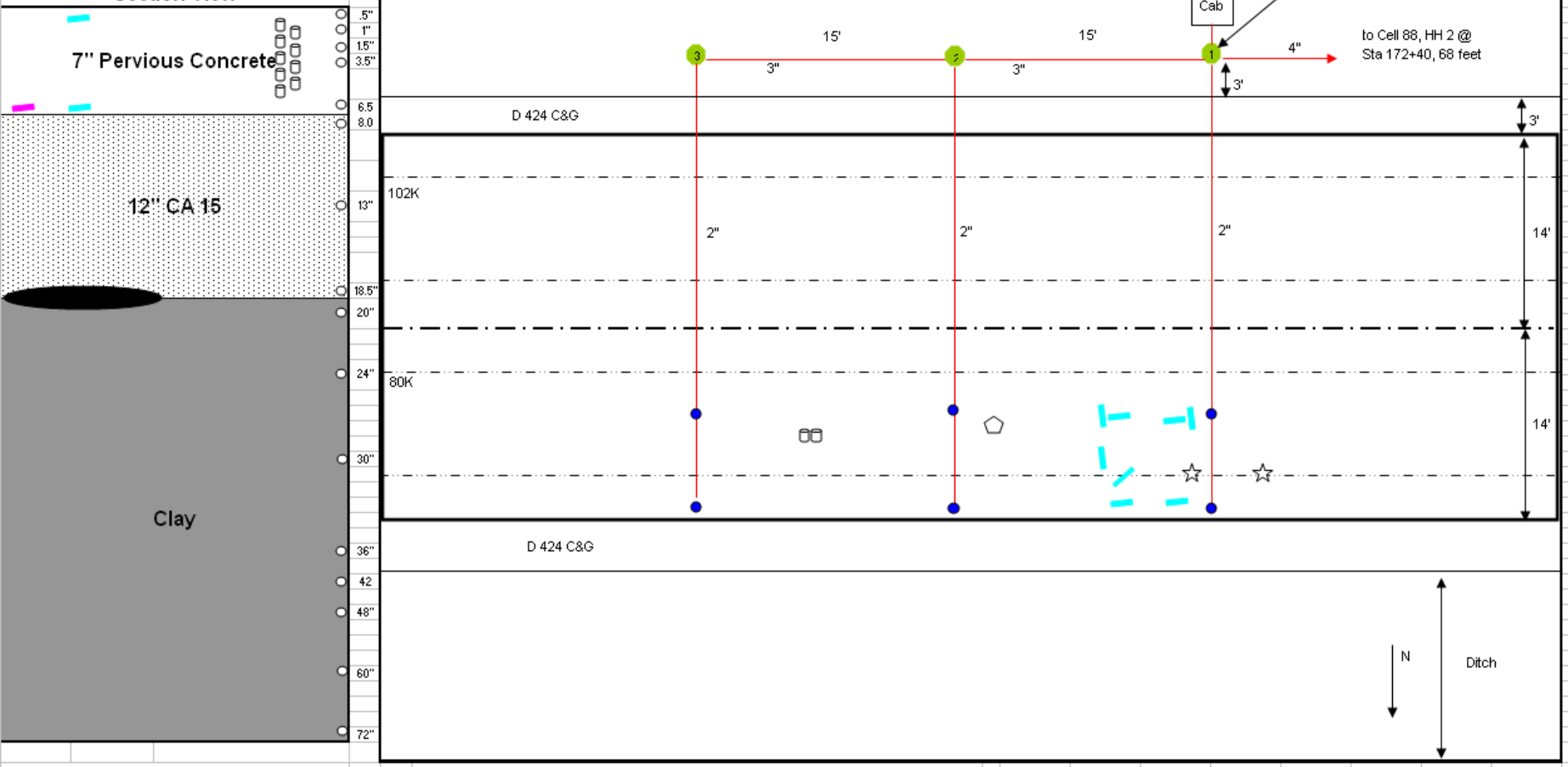
AS BUILT X-SECTIONS



MnROAD Instumentation Summary, Pervious PCC over Clay

Cell	89
Project	8680-157

Section View



Sensor Requirement

Code	Number	Sensor	Description
TC	8	ThermoCouple (Temperature)	Measures Temperature - Installed in a Thermal Couple Tree to a depth of 8' from the surface
EC		EcH2O-TE (Moisture)	Measure volmetric moisture content, temperature, electric conductivity
PG	2	PG Sensor	Measures normal stress at base/subgrade interface
IK	9	Maturity	Wireless Maturity Sticks
CE	8	Embedded Strain Gauge	Dynamic Strain Measurement (Longitudinal and Transverse)
VW	16	Vibrating Wire Strain Gauge	Static (Environmental) Strain

Legend			
	Risers		Wheelpath (9.5' offset from CL)
	Centerline		Conduit
	LE Sensors		TC Sensors
	TE Sensors		EC Sensors
	PG Sensor		Maturity
	TC/ M Sensor		CE sensor
	Handhole		VW Sensors

INSTRUMENTATION OF CELL 89

PAVING PROCESS

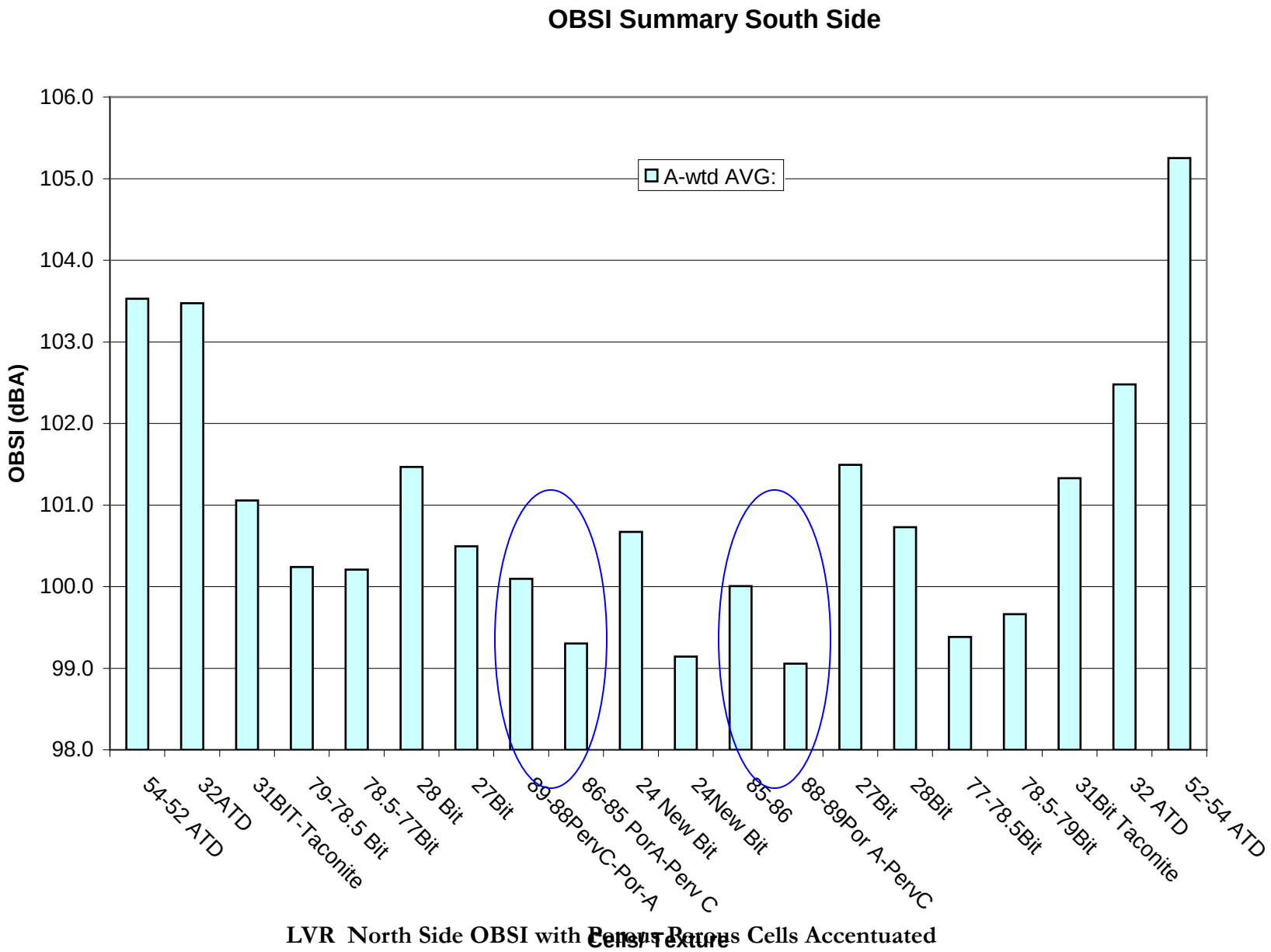
PAVING PROCESS

JOINT ESTABLISHMENT (PIZZA-CUT) COINCIDENT WITH CURB

CURING

RAILROAD BALLAST B/W 85 &86 PRIOR TO TRANSVERSE DRAINS

OBSI RESULTS



LVR North Side OBSI with Porous-Porous Cells Accentuated

Mechanical Properties

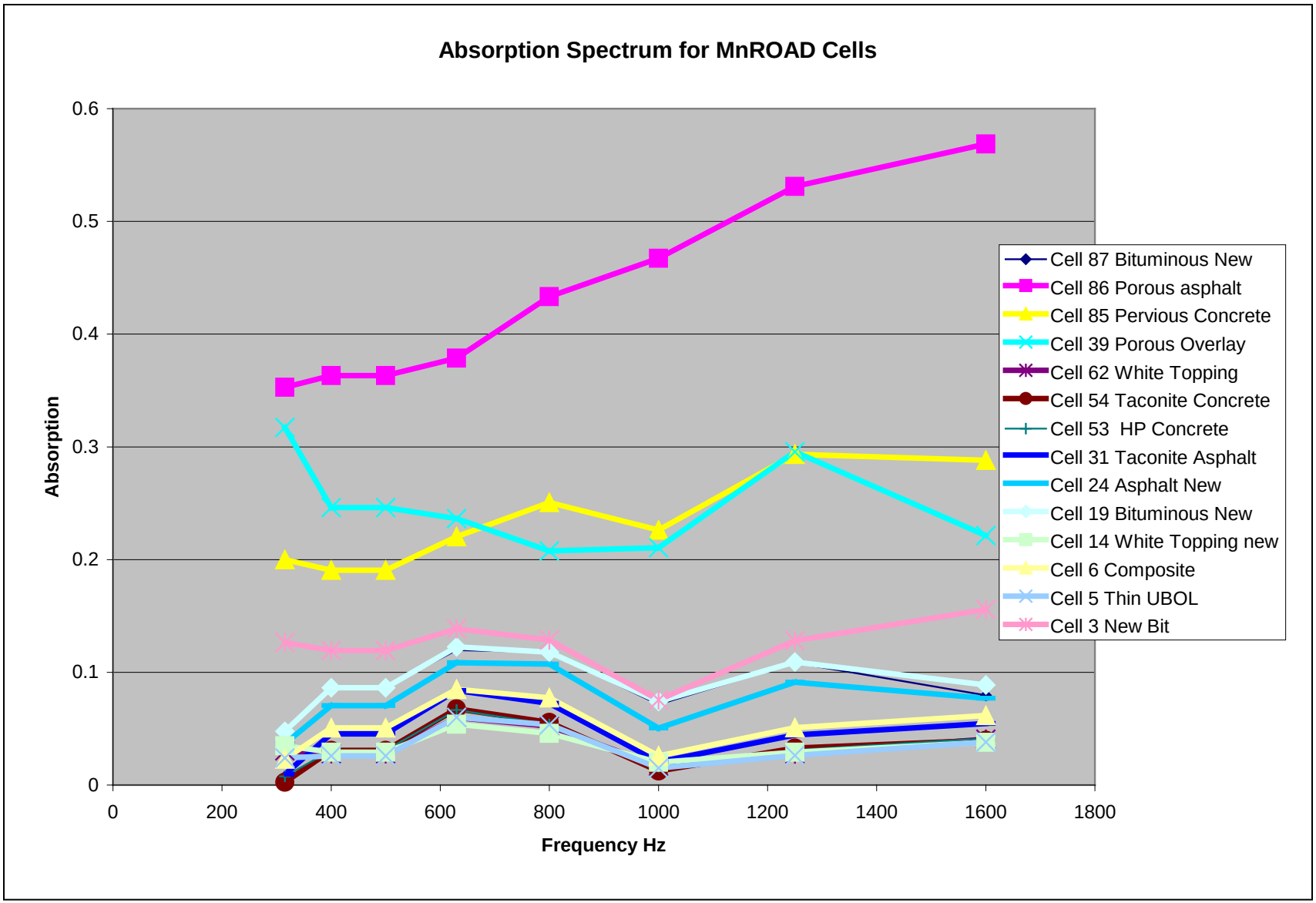
Average Flexural Strength @ 28 Days(psi):					
Cell	Number of Specimens	Average Strength	Standard Deviation	High	Low
Trail Batch					
5	4	930	87.3	1010	830
6					
13-14					
39 Inside Lane	2	855	N/A	890	820
39 Outside Lane	2	465	N/A	470	460
53 Inside Lane	2	1115	N/A	1150	1080
53 Outside Lane					
85 Inside Lane	2	325	N/A	330	320
85 Outside Lane	2	490	N/A	520	460
89 Inside Lane	2	490	N/A	520	450
89 Outside Lane	2	440	N/A	460	410

Average Compressive Strength @ 28 Days(psi):					
Cell	Number of Specimens	Average Strength	Standard Deviation	High	Low
Trial Batch					
5	4	5200	85	5300	5100
6	2	5670	N/A	5750	5580
13-14	2	5030	N/A	5130	4920
39 Inside Lane	2	4750	N/A	4780	4720
39 Outside Lane	2	4020	N/A	4060	3980
53 Inside Lane	2	5895	N/A	5950	5840
85 Inside Lane	2	3850	N/A	3880	3810
85 Outside Lane	2	5200	N/A	5240	5150
89 Inside Lane	2	4290	N/A	4330	4240
89 Outside Lane	2	4250	N/A	4300	4200

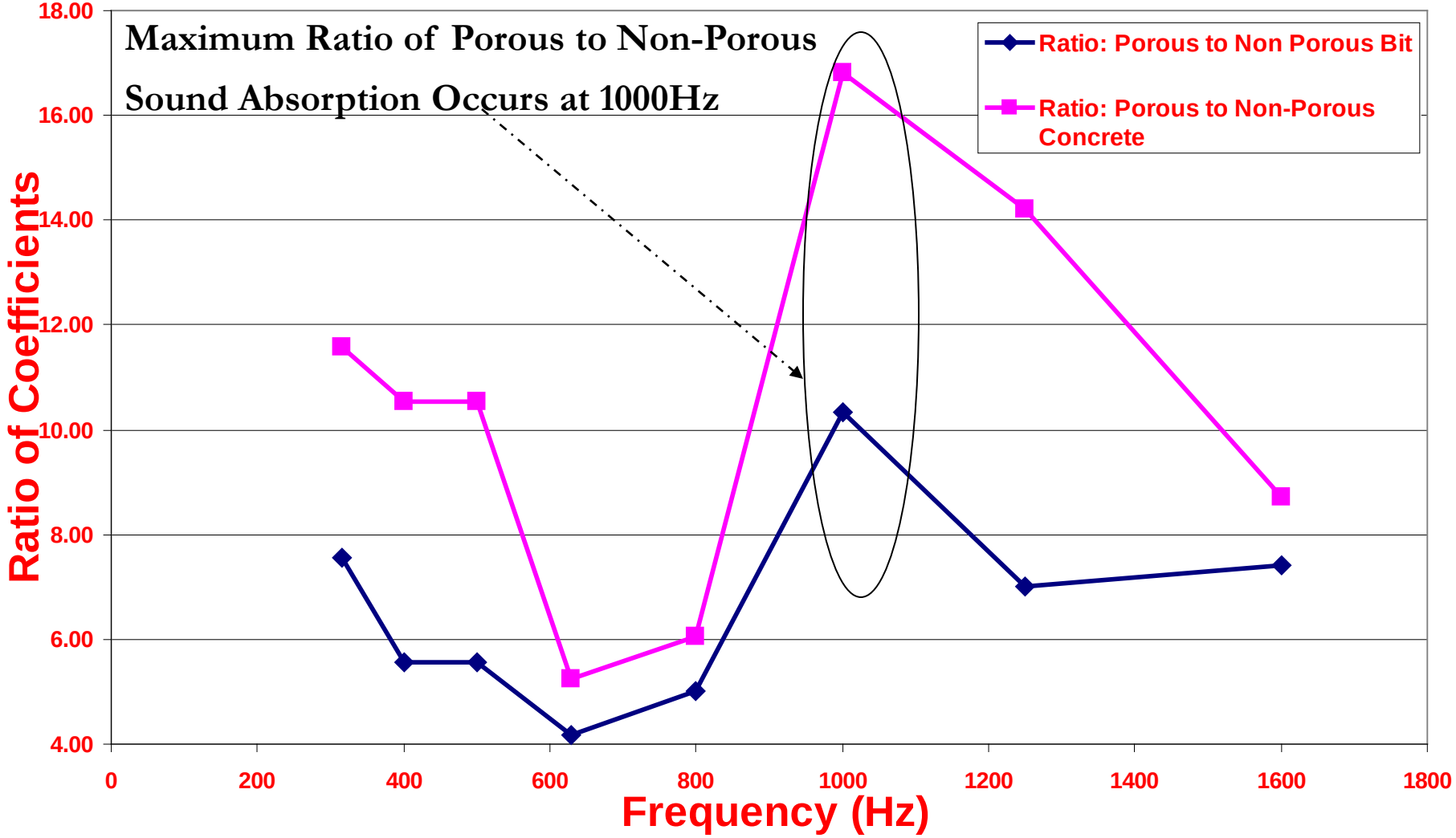
TANSVERSE DRAINS

For Hydrological Evaluation

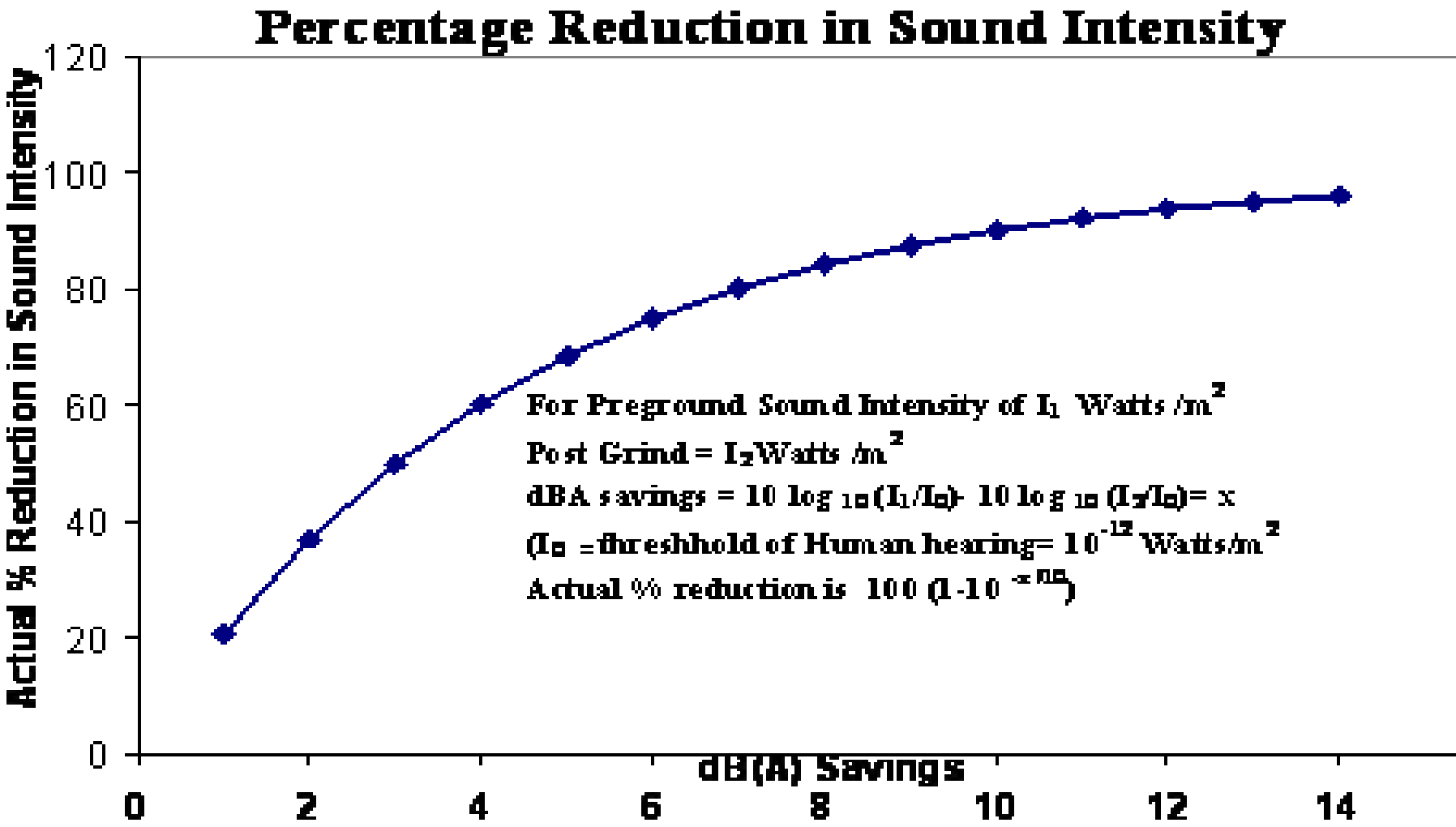
Sound AbsorptionSOUND_~1.WMV

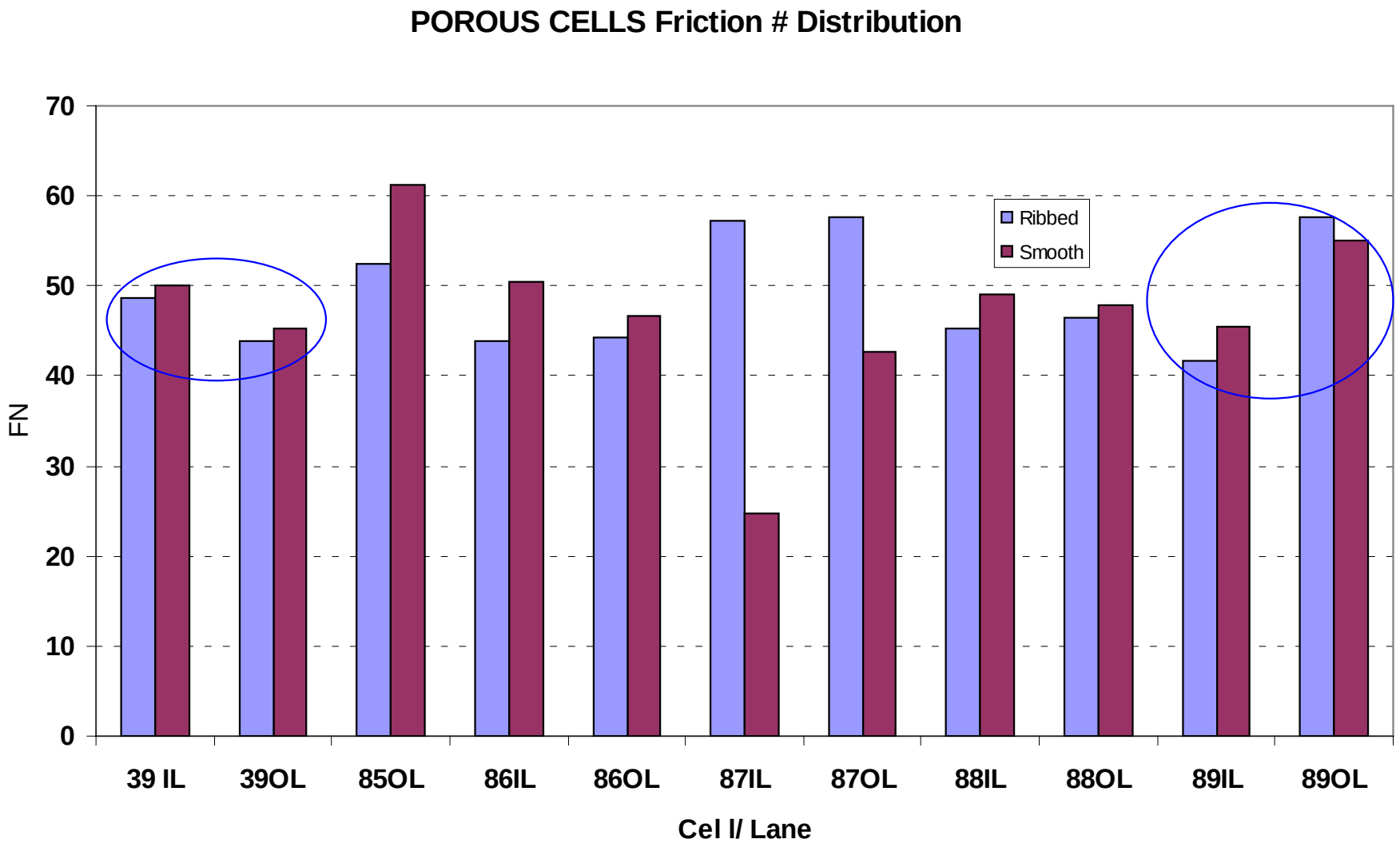


Ratio of Porous to Non-Porous Sound Absorption Coefficients



QUIET PAVEMENT NOISE REDUCTION

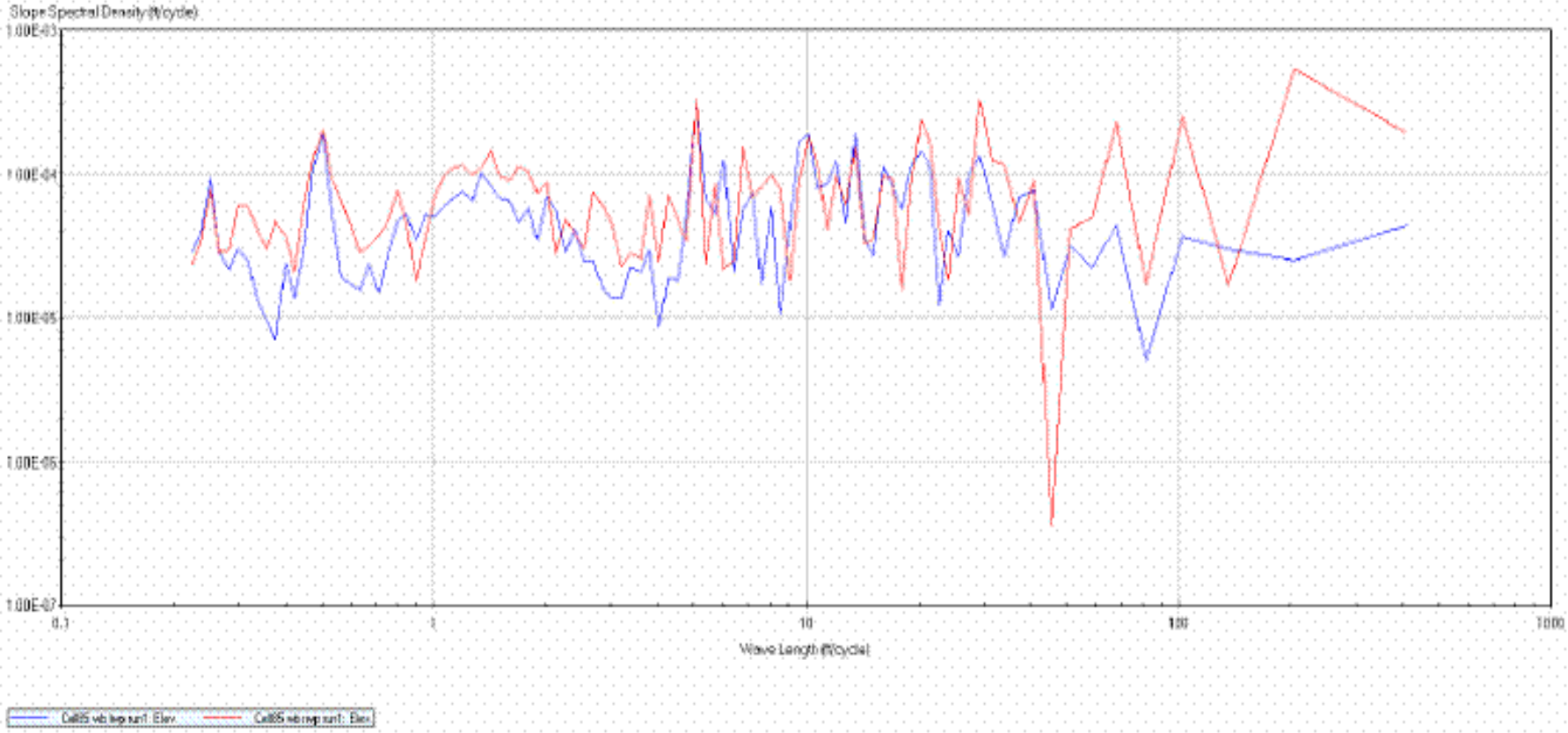



POROUS CELLS Friction # Distribution
70
60
50
40
30
20
10
0
FN
Ribbed
Smooth
39 IL
39OL
85OL
86IL
86OL
87IL
87OL
88IL
88OL
89IL
89OL
Cel l/ Lane

Ride Quality IRI inches/ mile

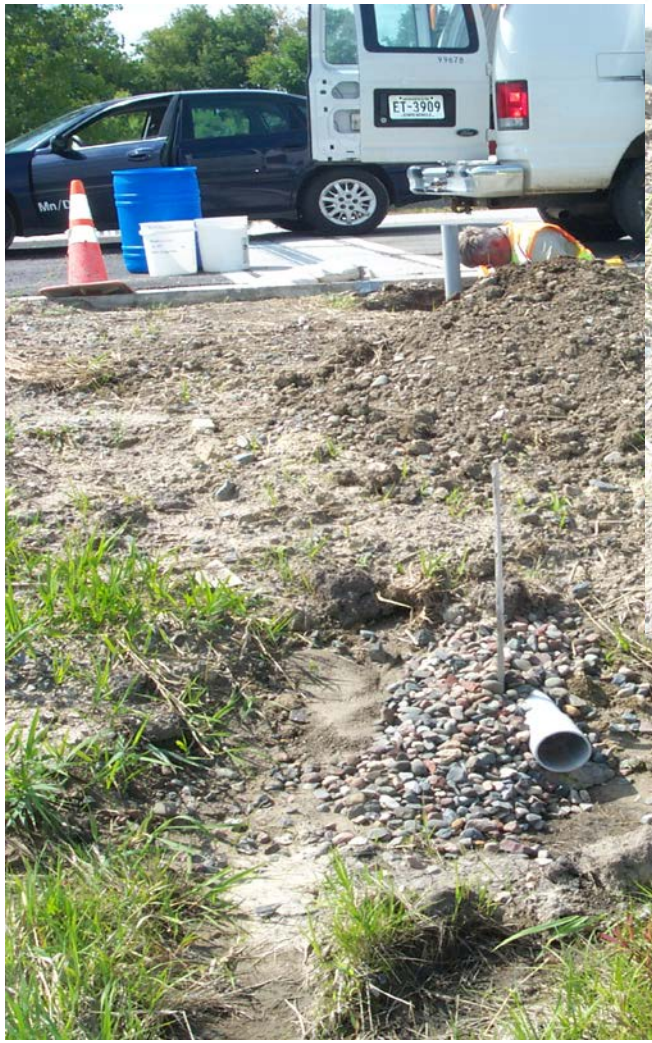
CELL WP AVG	RUN1	RUN2	RUN 3	Aver
39 9-APR EB LWP	211.8	214.4	213.1	212.7
39 9-APR EB RWP	208.5	216.1		212.3
39 9-APR WB LWP	227.5	227.9	227.7	233.3
39 9-APR WB RWP	240.2	237.6		238.9
85 9-APR EB LWP	184.3	202.1	193.2	213.9
85 9-APR EB RWP	235.4	233.6		234.5
85 9-APR WB LWP	253.6	255	254.3	254.3
85 9-APR WB RWP	265.6	270.9		268.3
86 9-APR EB LWP	134.2	131.1	128	129
86 9-APR EB RWP	127.9	125.9		126.9
86 9-APR WB LWP	213.8	202.7	172.8	208.3
86 9-APR WB RWP	139.4	135.1		137.3
87 9-APR EB LWP	144.8	147.9	146.4	145
87 9-APR EB RWP	146.1	141.2		143.7
87 9-APR WB LWP	163	162.9	162.7	147.4
87 9-APR WB RWP	135.1	128.8		132
88 9-APR EB LWP	198	206.6	202.3	168.8
88 9-APR EB RWP	134.4	136.3		135.4
88 9-APR WB LWP	194.6	188	191.3	177
88 9-APR WB RWP	168	157.2		162.6
89 9-APR EB LWP	181.7	182.2	182	200.5
89 9-APR EB RWP	215. 7	222.4		219.1
89 9-APR WB LWP	241.7	235	238.4	282.5
89 9-APR WB RWP	328.8	326.6		324.4

Cell 85 PSD – 80K lane



SOUND ABSORPTION MEASUREMENT

FLOW MEASUREMENTS



FLOUTS…. AN INNOVATIVE METERING SYSTEM

MINNESOTA DEPARTMENT OF TRANSPORTATION

FLOW TIME MEASUREMENTS

Cell	Type	Base	Location		Lane	Head Drop (in)	Time (s)
88	HMA	Clay	104.7' from East end	30" from South Curb	Environmental	8 to 0	3.49
88	HMA	Clay	104.7' from East end	30" from South Curb	Environmental	8 to 0	3.18
88	HMA	Clay	104.7' from East end	7 ft. from South Curb	Environmental	8 to 0	3.31
88	HMA	Clay	104.7' from East end	7 ft. from South Curb	Environmental	8 to 0	3.47
88	HMA	Clay	104.7' from East end	30" from North Curb	Traffic	8 to 0	3.76
88	HMA	Clay	104.7' from East end	30" from North Curb	Traffic	8 to 0	4.09
88	HMA	Clay	29.6' from West end	30" from South Curb	Environmental	8 to 0	3.54
88	HMA	Clay	29.6' from West end	30" from South Curb	Environmental	8 to 0	4.19
88	HMA	Clay	29.6' from West end	7 ft. from South Curb	Environmental	8 to 0	2.46
88	HMA	Clay	29.6' from West end	7 ft. from South Curb	Environmental	8 to 0	2.75
88	HMA	Clay	29.6' from West end	30" from North Curb	Traffic	8 to 0	3.57
88	HMA	Clay	29.6' from West end	30" from North Curb	Traffic	8 to 0	3.94
86	HMA	Sand	117.7' from West end	30" from South Curb	Environmental	8 to 0	2.12
86	HMA	Sand	117.7' from West end	30" from South Curb	Environmental	8 to 0	2.49
86	HMA	Sand	117.7' from West end	7 ft. from South Curb	Environmental	8 to 0	4.7
86	HMA	Sand	117.7' from West end	7 ft. from South Curb	Environmental	8 to 0	4.82
86	HMA	Sand	117.7' from West end	30" from North Curb	Traffic	8 to 0	1.94
89	Concrete	Clay	35.5' from East end	30" from South Curb	Environmental	8 to 0	8.64
89	Concrete	Clay	35.5' from East end	30" from South Curb	Environmental	8 to 0	8.4
89	Concrete	Clay	35.5' from East end	6 ft. from North Curb	Traffic	8 to 0	8.08
89	Concrete	Clay	35.5' from East end	6 ft. from North Curb	Traffic	8 to 0	8.02
89	Concrete	Clay	35.5' from East end	30" from North Curb	Traffic	8 to 0	5.21
89	Concrete	Clay	35.5' from East end	30" from North Curb	Traffic	8 to 0	5.92
89	Concrete	Clay	87.5' from East end	30" from South Curb	Environmental	8 to 0	11.05
89	Concrete	Clay	87.5' from East end	30" from South Curb	Environmental	8 to 0	10.88
89	Concrete	Clay	87.5' from East end	6 ft. from North Curb	Traffic	9 to 0	7.03
89	Concrete	Clay	87.5' from East end	6 ft. from North Curb	Traffic	9 to 0	6.99
89	Concrete	Clay	87.5' from East end	30" from North Curb	Traffic	8 to 0	5.21
89	Concrete	Clay	87.5' from East end	30" from North Curb	Traffic	8 to 0	5.5
85	Concrete	Sand	34' from East end	30" from South Curb	Environmental	8 to 0	7.69
85	Concrete	Sand	34' from East end	30" from South Curb	Environmental	8 to 0	7.61
85	Concrete	Sand	34' from East end	6 ft. from North Curb	Traffic	8 to 0	3.63
85	Concrete	Sand	34' from East end	6 ft. from North Curb	Traffic	8 to 0	3.61
85	Concrete	Sand	34' from East end	30" from North Curb	Traffic	8 to 0	2.27
85	Concrete	Sand	34' from East end	30" from North Curb	Traffic	8 to 0	2.46
85	Concrete	Sand	34' from East end	30" from North Curb	Traffic	8 to 0	2.1
85	Concrete	Sand	94.2' from West end	30" from South Curb	Environmental	8 to 0	5.02
85	Concrete	Sand	94.2' from West end	30" from South Curb	Environmental	8 to 0	5.08
85	Concrete	Sand	94.2' from West end	6 ft. from North Curb	Traffic	8 to 0	3.87
85	Concrete	Sand	94.2' from West end	6 ft. from North Curb	Traffic	8 to 0	4.09
85	Concrete	Sand	94.2' from West end	30" from North Curb	Traffic	8 to 0	7.86
85	Concrete	Sand	94.2' from West end	30" from North Curb	Traffic	8 to 0	7.59

CONCLUSIONS

- Mechanical Properties:
  - » Adequate Flexural and Compressive
  - » Variability (More insitu tests) Cores, etc
  - » Density 120 PCF mean
  - » FWD to be analyzed
  - » Friction>= Normal Concrete Turf Drag of same age
- Surface Characteristics
  - » Excellent Sound Absorption Properties
  - » Excellent OBSI
  - » Very Poor Ride Quality
- Continuous Monitoring
  - » SA, OBSI, GT, DSH,FWD, FLOW, Piezo.

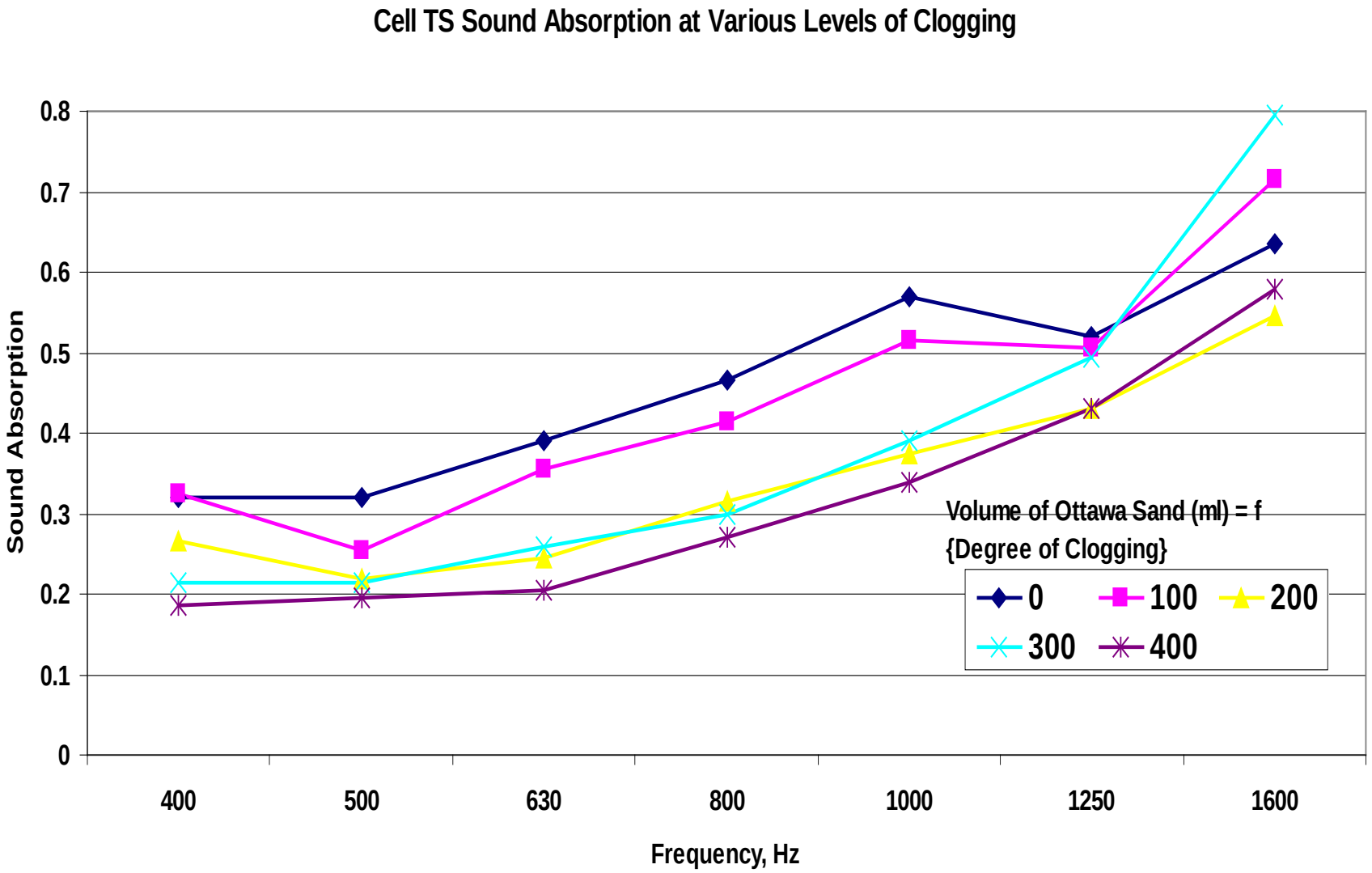
Food For Thought

- Slip Form Paving
- Clogging Effect

  SA of Cell 89 & 88 = 0.35 at 1000Hz

  SA of cell 64 = 0.1 at 1000Hz

- Invest in Vacuuming at the right time


Cell TS Sound Absorption at Various Levels of Clogging
Sound Absorption
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
400
500
630
800
1000
1250
1600
Frequency, Hz
Volume of Ottawa Sand (ml) = f {Degree of Clogging}
0
100
200
300
400