Report of: Asphalt Mix Design and Testing Using Fox River Sediment Glass Aggregates

Minergy

December 22, 2003

OMNNI Prj. T0868A03-003

ENGINEERING • ARCHITECTURE • ENVIRONMENTAL

OMNNI ASSOCIATES

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REPORT OF: ASPHALT MIX DESIGN AND TESTING

PROJECT: Fox River Sediment Glass Aggregate Asphalt Mix Designs

OMNNI PROJECT NO. T0868A03-003

CLIENT: Mr. Tom Bauduin
Minergy
1512 S. Commercial Street
Neenah, WI 54956

DATE: December 22, 2003

INTRODUCTION

This report presents the results of asphalt mix design and testing using glass aggregate produced by Minergy. Glass aggregate from the Minergy Winneconne Pilot Plant produced from sediments dredged from the Fox River was used in the design and testing. Two sizes of glass aggregates were used in the asphalt mix designs. One size has a gradation that is naturally produced by the plant during the incineration process. The other size consisted of glass aggregate crushed to meet ASTM: C33 gradation requirements for concrete fine aggregate. These glass aggregates were incorporated into an existing Wisconsin Department of Transportation (WisDOT) verified; 19 mm, E-1 asphalt mix currently being produced by a local asphalt mix supplier. The purpose of this testing and evaluation was to compare the physical properties of the asphalt paving mixtures containing a glass aggregate component to a similar mix composed exclusively of locally available, naturally occurring aggregates and recycled asphalt pavement (RAP). Both physical properties of the asphalt mixes and the effect of moisture on the ability of the asphalt binder to adhere to the aggregate of the mixtures containing the glass aggregate were compared to the traditional asphalt mix design obtained from the asphalt supplier and the Wisconsin Department of Transportation specifications.

The scope of our work consisted of the following tasks:

- Mobilize technicians to the asphalt plant site located in the Green Bay area to obtain aggregate and recycled asphalt pavement (RAP) to be used in performing asphalt mix designs. Obtain asphalt binder from the asphalt binder supplier.

- Perform two asphalt mix designs (WisDOT 1559-01) using aggregate blends containing a Fox River sediment glass aggregate component in a mixture with locally available, naturally occurring aggregates and recycled asphalt pavement (RAP). One of the designs would incorporate the glass aggregate that has a gradation that is naturally produced by the plant during the incineration process. The second design would use glass aggregate that has been crushed to a finer gradation, meeting the ASTM: C33 concrete fine aggregate grading specification. The mix design aggregate proportions would be based on an existing asphalt mix design that uses the same naturally occurring aggregates and RAP. The mix designs will include aggregate gradations, bulk specific gravities and absorptions, elongated particles, fine aggregate angularity, sand equivalency, % fractured faces in the coarse aggregate, bulk mix density (Gmb), maximum theoretical specific gravity (Gmm), total voids, voids in mineral aggregate (VMA), voids filled with binder (VFB), dust/binder ratio, and tensile strength ratio testing.

- Compare the physical properties of an asphalt mix using the glass aggregate to the existing

mix design that did not include the glass aggregate. Also compare the effect of moisture on the ability of the asphalt binder to adhere to the aggregate of the mixture containing the glass aggregate to the existing mix design and the Wisconsin Department of Transportation specifications.

- Prepare a report summarizing our findings.

MATERIALS

A local asphalt mix producer's 19 mm, E-1 mix design was used to incorporate the glass aggregates into and to provide a standard asphalt mix to which mix properties could be compared. A copy of the mix design report is included in Appendix B. The mix components as listed on this design were used to perform our work. The following materials were used in designing and testing the asphalt mixes:

1.	Aggregates:	7/8" x 5/8" Chip 5/8" x ½" Chip ½" x ¼" Chip Washed Manufactured Sand Natural Sand Crushed Recycled Asphalt Pavement (RAP) Glass Aggregate – Minergy, Winneconne (Fox River sediments)
2.	Asphalt Binder	PG 58-28 – Koch Pavement Solutions, Green Bay Terminal

Naturally occurring aggregates, recycled asphalt pavement (RAP) and asphalt binder were supplied by an asphalt mix supplier located in the Green Bay area. Aggregates and RAP were sampled from the plant stockpiles and the asphalt binder was obtained from Koch Pavement Solutions, who had sampled it from the Green Bay terminal. The crushed stone chips and manufactured sand are produced from Silurian age dolomitic limestone from the Niagara Formation in Brown County, Wisconsin. The natural sand is composed predominantly of quartz sand and is mined from a glacial outwash deposit in Brown County, Wisconsin. Minergy personnel delivered glass aggregates from the Winneconne pilot plant to our laboratory.

The naturally occurring aggregates used in the asphalt supplier's mix design were obtained from Wisconsin DOT qualified aggregate sources. Aggregate sources are qualified through the WisDOT Central Laboratory in Madison and the aggregate qualification typically involves the DOT testing them for Sodium Sulfate Soundness (AASHTO T104), LAR Wear (AASHTO T96) and Freeze-Thaw (AASHTO T103). The glass aggregate provided for this work has not been qualified by the WisDOT Central Laboratory. However, the testing for soundness, wear and freeze-thaw are performed on coarse aggregates only and would not be required for the glass

aggregate for it to be used as a fine aggregate (passing the #4 sieve) component in a WisDOT verified mix design.

TEST METHODS

Asphalt mixes were designed to meet the current Wisconsin Department of Transportation's requirements as specified in section 460 of the WisDOT Standard Specifications for Highway and Structure Construction, 2003 Edition. Aggregate and asphalt mix tests were performed in accordance with test methods specified by WisDOT Procedure 1559-01.

The glass aggregates generally consisted of very angular, sand sized particles with very little passing the #200 sieve. Glass aggregate test reports have been included in Appendix D.

Aggregate from the naturally occurring aggregates and RAP sampled from the asphalt supplier's plant stockpiles were tested for gradation, specific gravity and fine aggregate angularity. Asphalt binder content of the RAP was also determined. All test results were compared to the results reported on the asphalt supplier's mix design report to verify that they were reasonably close to the aggregate components used during the design.

To assess the effect of using glass aggregate as a mix aggregate component, OMNNI Associates mix design #903003 was performed using the asphalt supplier's mix design and substituting the washed manufactured sand with the uncrushed glass aggregate. The washed manufactured sand was replaced because the gradation and angularity was most similar to the glass aggregates. OMNNI Associates mix design #902903 was performed using the asphalt supplier's mix design and substituting the washed natural sand with the crushed glass aggregate. For each mix design, a series of test blends were prepared in the laboratory to determine the aggregate blend percentages that would result in a mix that contained approximately 13-14% Voids in Mineral Aggregate (VMA) at the predicted optimum asphalt binder content. When this blend percentage was determined, further laboratory batching and testing was performed for each mix design to determine the optimum asphalt binder content, $\%G_{mm}$ at $N_{initial}$ and $\%G_{mm}$ at N_{max}, and Tensile Strength Ratio (TSR). Mix design reports were prepared and are included in Appendix C.

The TSR test was also performed on the existing contractor's mix design using aggregates and asphalt binder from the current sampling so that a direct comparison with the glass aggregate mix designs could be obtained. The aggregates and asphalt binder were blended using the blend percentages reported in the original mix design report.

A summary of all test results is included in Appendix A.

DISCUSSION AND CONCLUSIONS

Test results indicate that the substitution of the washed manufactured sand and washed natural sand with the glass aggregates generally resulted in an increase in the amount of recycled asphalt

pavement (RAP) that could be included in the mix and a decrease in the amount of natural and manufactured sands needed. It is our opinion that this is because the high angularity of the glass aggregate helps to build voids in mineral aggregate (VMA) into the mix, allowing the addition of more fines (passing #200 sieve) and requiring less sand to be used in the mix.

Because the aggregates substituted into the asphalt supplier's existing asphalt mix are considered to be glass, the possibility of an increased susceptibility to stripping was an item for which we tested using each of the glass aggregates. The Tensile Strength Ratio (TSR) test is the test that is currently used by the Wisconsin DOT to predict the susceptibility of the asphalt binder to strip away from the aggregates when subjected to the presence of water and general weathering. TSR results for the mixes using the glass aggregates were 81 for design #902903 and 78 for design #903003, which are very close to the TSR result of 78 obtained from the mix consisting of aggregates and asphalt binder that were blended in accordance with the asphalt producer's mix design report. These test results indicate that the mixes containing the glass aggregates are also not susceptible to stripping.

Based on the results of our testing, it is our opinion that the Fox River sediment glass aggregate included in these asphalt mixes can be successfully used as an aggregate component in WisDOT verified asphalt mix designs as well as commercial asphalt mix designs. The grading and high angularity of the glass aggregate helps to build VMA into the mix, allowing for an increased percentage of RAP and a decrease in the percentages of natural and manufactured sands used in the mix, which should produce a highly economical asphalt mix. Prior to full-scale use of asphalt mix containing a glass aggregate, producers and users may elect to produce the mix and place it in a test area where it can be monitored for long term susceptibility to stripping, and/or other concerns that they may have. However, the results of all testing performed on these glass aggregate mixes to-date indicate that the mixes will perform very well.

If you have any questions regarding this report, please contact us.

Sincerely,

Paul R. Eggen
Program Manager – Materials Testing

ASPHALT AGGREGATE AND MIX PROPERTIES SUMMARY

Minergy, Prj. T0868A03-003

December 22, 2003

	Asphalt Mix Supplier's Mix Design	Mix Using Crushed Glass Agregate Design #902903	Mix Using Uncrushed Glass Agregate Design #903003	WisDOT Section 460 Specifications 19 mm, E-1
Mix Blend Percentages				
7/8"x 5/8" Chip (%)	16	20	20	
5/8"x 1/2" Chip (%)	11	10	10	
1/2"x 1/4" Chip (%)	5	9	10	
Washed Man Sand (%)	30	25	-	
Natural Sand (%)	26	-	23	
RAP (%)	12	14	15	
Uncrushed Glass Aggregate (%)	-	-	22	
Crushed Glass Aggregate (%)	-	22	-	
Asphalt Binder - Added (%)	4.10	3.95	3.70	
Asphalt Binder - Total (%)	4.50	4.63	4.43	
Blended Aggregate Properties				
1" (25.0 mm)	100	100	100	100
3/4" (19.0 mm)	100	99.9	99.9	90-100
1/2" (12.5 mm)	89.9	89.9	89.9	90 max
3/8" (9.5 mm)	76.4	73.3	73.2	
#4 (4.75 mm)	61.5	57.3	56.6	
#8 (2.36 mm)	45.2	45.2	45.4	23-49
#16 (1.18mm)	33.7	30.2	28.7	
#30 (0.60mm)	25.1	17.7	20.4	
#50 (0.30mm)	14.7	10.4	12.1	
#100 (0.15mm)	6.5	6.3	5.5	
#200 (0.075mm)	4.6	4.6	4.1	2-8

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ASPHALT AGGREGATE AND MIX PROPERTIES SUMMARY

Minergy, Prj. T0868A03-003
December 22, 2003

	Asphalt Mix Supplier's Mix Design	Mix Using Crushed Glass Agregate Design #902903	Mix Using Uncrushed Glass Agregate Design #903003	WisDOT Section 460 Specifications 19 mm, E-1
Fine Aggregate Angularity (%)	45.7	46.2	45.3	40 Min
Bulk Specific Gravity (GSB)	2.736	2.765	2.753	
Apparent Specific Gravity (GSA)	2.814	2.834	2.816	
Effective Specific Gravity (GSE)	2.788	2.828	2.805	
Absorption	-	0.91	0.91	
Mix Properties				
Total Voids	4.0	4.0	4.0	4.0
Voids in Mineral Aggregate (VMA)	13.3	13.4	13.1	13.0 Min
Voids Filled w/ Binder (VFB)	69.9	70.1	69.5	65-78
Maximum Specific Gravity (G_{mm})	2.589	2.617	2.606	
Bulk Specific Gravity (G_{mb})	2.485	2.512	2.502	
% G_{mm} @ $N_{initial}$	90.3	89.9	91.0	< 90.5[1]
% G_{mm} @ N_{max}	96.3	96.7	96.7	$\leq$ 98.0
Tensile Strength Ratio (TSR)	75[2]	81	78	70 Min
Dust to Effective Binder Ratio	1.2	1.2	1.1	1.2 Max
Film Thickness Estimate (Microns)	-	7.77	7.77	

[1] The percent maximum density at initial compaction is only a guideline.

[2] A TSR test result of 78 was obtained by OMNNI Associates using aggregates and asphalt binder sampled for mix designs #902903 and #903003.

REPORT OF SUPERPAVE VOLUMETRIC ASPHALTIC MIX DESIGN

(AASHTO PP-28, ASTM D4867)

TYPE . . . . . E-1, 19 mm
DESIGN ESALS. . . 1.0E+06
JOB NUMBER . . . .

DESIGN NUMBER: Supplier Design

AGGREGATE SOURCE

SPL NO.	TEST NO.	MATERIAL
1	A-55-02	7/8" x 5/8" Chip
2	A-56-02	5/8" x 1/2" Chip
3	A-57-02	1/2" x 1/4" Chip
4	A-67-02	Washed Manufactured Sand
5	A-60-02	Natural Sand
6	B-7-02	Crushed RAP

AGGREGATE GRADATION (% PASSING):

SPL NO.	*1*	*2*	*3*	*4*	*5*	*6*			
BLEND %	16	11	5	30	26	12	BLEND	JOB MIX	SPEC.
25mm (1.0")	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19mm (3/4")	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90-100
12.5mm (1/2")	53.2	76.5	100.0	100.0	100.0	100.0	89.9	89.9	0-90
9.5mm (3/8")	12.5	20.6	92.2	100.0	100.0	96.1	76.4	76.4	--
4.75mm (#4)	1.9	4.8	9.9	88.6	93.2	78.2	61.5	61.5	---
2.36mm (#8)	1.9	3.7	5.0	53.0	80.3	62.5	45.2	45.2	23-49
1.18mm (#16)	1.8	3.1	4.3	29.3	69.2	50.3	33.7	33.7	---
0.60mm (#30)	1.8	2.8	4.0	15.9	56.3	40.8	25.1	25.1	---
0.30mm (#50)	1.8	2.7	3.9	9.4	28.8	29.7	14.7	14.7	---
0.15mm (#100)	1.8	2.6	3.8	5.8	5.9	20.4	6.5	6.5	---
0.075mm (#200)	1.6	2.4	3.4	3.0	2.6	14.9	4.1	4.1	2-8
G_{sb}	2.740	2.743	2.708	2.790	2.697	2.693	2.736		
FAA				48.7	41.4	47.4			

FOR JMF AS USED IN LABORATORY TRIAL MIXES:

SOUNDNESS	= 0.5	ELONGATED PARTICLES =	1%
L.A. WEAR =	3.8 (100) 28.9 (500)	UNCOMPACTED VOIDS - F.A.=	45.7%
FREEZE/THAW	= --	BULK AGG. SP. GR. =	2.736
SAND EQUIVALENT	= 91.7	APPARENT AGG. SP. GR. =	2.814
CRUSH	= 95.8/1F, 98.5/2F	EFFECTIVE AGG. SP. GR. =	2.788

BINDER DATA

TYPE . . . . . PG 58-28
SOURCE . . . . . Koch
SP. GR. (77/77F) . 1.031

RAP DATA

(ASTM D2171, D1856, D5)
% BINDER = 3.54

AVERAGE TEST DATA (60 GYRATIONS AT 275F)

BINDER CONT. (% OF MIX) ADDED	- - - - % 'VOIDS - - - - MIX	VMA	VFB	TH. MAX. SP. GR. (G_{mm})	BULK SP. GR. (G_{mb})
3.70	5.3	13.5	60.7	2.606	2.467
4.20	3.7	13.2	72.0	2.585	2.490
4.70	2.0	12.8	84.4	2.565	2.513
5.20	0.8	12.9	93.8	2.545	2.524

THE TEST DATA SHOWN ON THIS REPORT PERTAIN ONLY TO THE MATERIAL SUBMITTED FOR DESIGN
AASHTO PP28 MODIFIED TO MEET CUSTOMER REQUIREMENTS

REPORT OF SUPERPAVE VOLUMETRIC ASPHALTIC MIX DESIGN

(AASHTO PP-28, ASTM D4867)

TYPE . . . . . E-1, 19 mm
DESIGN ESALS. . . 1.0E+06
JOB NUMBER . . . .

DESIGN NUMBER: Supplier Design

FOR: $N_{initial}$ 7
N_{design} 60
N_{max} 75

RECOMMENDED OPTIMUM BINDER CONTENT = 4.10 % ADDED 4.50 *% TOTAL*

DESIGN DATA AT OPTIMUM BINDER CONTENT:

MIX VOIDS (%)	=	4.0
VMA (%)	=	13.3
VFB (%)	=	69.9
TH. MAX. SP. GR. (G_{mm})	=	2.589
BULK SP. GR. (G_{mb})	=	2.485
UNIT WEIGHT (lbs/ft^3)	=	154.7
$\%G_{mm}$ @ $N_{initial}$	=	90.3
$\%G_{mm}$ @ N_{max}	=	96.3
TSR N= 20	=	75.2
RECOMMENDED MIXING TEMP.	=	275-300
DUST TO P_{be} RATIO	=	1.2

COMMENTS:

THE TEST DATA SHOWN ON THIS REPORT PERTAIN ONLY TO THE MATERIAL SUBMITTED FOR DESIGN

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REPORT OF SUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

TYPE . . . . . E1-19.0 mm
DESIGN ESALS. . . 1.0E+06
JOB NUMBER T0868A03-003

DESIGN NUMBER: 903003
DATE: 12/11/2003

AGGREGATE SOURCE

SPL NO.	TEST NO.	MATERIAL
1	24790	7/8 x 5/8 Chip
2	24890	5/8 x 1/2 Chip
3	24990	1/2 x 1/4 Chip
4	25190	Washed Nat. Sand
5	25490	Glass Aggregate
6	25290	Crushed RAP

AGGREGATE GRADATION (% PASSING):

SPL NO.	*1*	*2*	*3*	*4*	*5*	*6*			
BLEND %	20	10	10	23	22	15	BLEND	JOB MIX	SPEC.
25mm (1.0")	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100
19mm (3/4")	99.3	100.0	100.0	100.0	100.0	100.0	99.9	99.9	90-100
12.5mm (1/2")	60.5	80.8	100.0	100.0	100.0	98.1	89.9	89.9	0-90
9.5mm (3/8")	12.9	20.1	95.9	100.0	100.0	93.4	73.2	73.2	--
4.75mm (#4)	3.3	4.3	5.2	93.9	99.9	76.3	56.6	56.6	---
2.36mm (#8)	2.9	3.6	3.6	76.9	79.6	59.3	45.4	45.4	23-49
1.18mm (#16)	2.7	3.2	3.4	64.2	26.3	46.6	28.7	28.7	---
0.60mm (#30)	2.6	3.1	3.3	52.1	7.9	37.1	20.4	20.4	---
0.30mm (#50)	2.5	3.0	3.2	27.3	2.5	27.5	12.1	12.1	---
0.15mm (#100)	2.5	2.9	3.1	6.0	0.7	18.9	5.5	5.5	---
0.075mm (#200)	2.2	2.6	2.8	2.8	0.1	13.2	3.6	4.1	2-8
G_{sb}	2.751	2.746	2.736	2.680	2.878	2.698	2.753		
Absorption (%)	1.07	1.09	1.29	1.19	0.30	0.79	0.91		
FAA				41.9	50.5	42.9			

FOR JMF AS USED IN LABORATORY TRIAL MIXES:

SOUNDNESS = 0 (217-24-2002)
L.A. WEAR = 4.9 (100) 24.3 (500)
FREEZE/THAW = 0.2
SAND EQUIVALENT = 88
CRUSH = 1F/100 2F/99

ELONGATED PARTICLES = 0.0%
UNCOMPACTED VOIDS - F.A.= 45.3
BULK AGG. SP. GR. = 2.753
APPARENT AGG. SP. GR. = 2.820
EFFECTIVE AGG. SP. GR. = 2.805

BINDER DATA

TYPE . . . . . PG 58-28
SOURCE . . . . . Koch
SP. GR. (77/77F) . 1.031

RAP DATA

(ASTM D2171, D1856, D5)
% BINDER = 4.87

AVERAGE TEST DATA (75 GYRATIONS AT 275F)

BINDER CONT. (% OF MIX) ADDED	- - - - % 'VOIDS - - - - MIX	VMA	VFB	TH. MAX. SP. GR. (G_{mm})	BULK SP. GR. (G_{mb})
3.17	5.7	13.4	57.8	2.629	2.480
3.67	4.1	13.2	68.8	2.608	2.501
4.17	2.3	12.7	82.0	2.587	2.528
4.67	1.0	12.7	91.8	2.567	2.540

THE TEST DATA SHOWN ON THIS REPORT PERTAIN ONLY TO THE MATERIAL SUBMITTED FOR DESIGN
AASHTO PP28 MODIFIED TO MEET CUSTOMER REQUIREMENTS

REPORT OF SUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

TYPE . . . . . E1-19.0 mm — DESIGN NUMBER: 903003
DESIGN ESALS. . . 1.0E+06
JOB NUMBER . . . . T0868A03-003 — DATE: 12/11/2003

FOR: $N_{initial}$ 7
N_{design} 60
N_{max} 75

RECOMMENDED OPTIMUM BINDER CONTENT = 3.70 % ADDED 4.43 *% TOTAL*

DESIGN DATA AT OPTIMUM BINDER CONTENT:

MIX VOIDS (%)	=	4.0
VMA (%)	=	13.1
VFB (%)	=	69.5
TH. MAX. SP. GR. (G_{mm})	=	2.606
BULK SP. GR. (G_{mb})	=	2.502
UNIT WEIGHT (lbs/ft^3)	=	155.8
$\%G_{mm}$ @ $N_{initial}$	=	91.0
$\%G_{mm}$ @ N_{max}	=	96.7
TSR N= 18	=	78
RECOMMENDED MIXING TEMP.	=	275-300
DUST TO P_{be} RATIO	=	1.1

COMMENTS:

P-0.075 INCREASED 0.5% TO SIMULATE AGGREGATE BREAKDOWN DURING MIX PRODUCTION.

OMNNI ASSOCIATES

PAUL R. EGGEN
WISCONSIN CERTIFIED ASPHALTIC TECHNICIAN III

OMNNI ASSOCIATES
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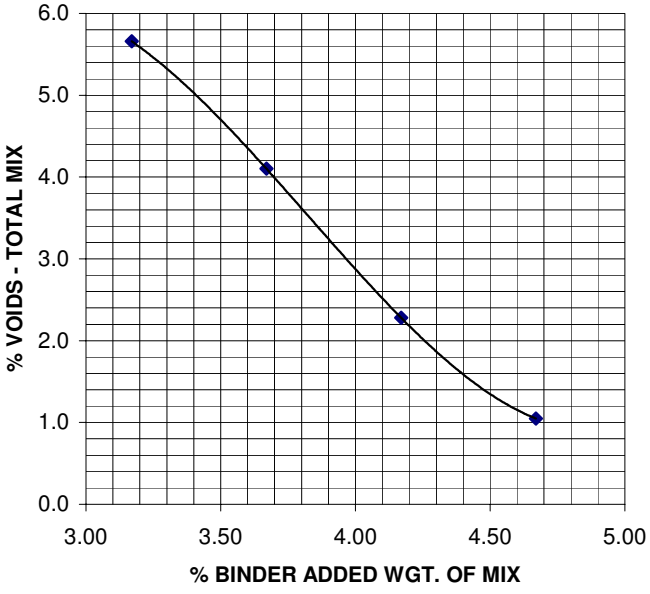
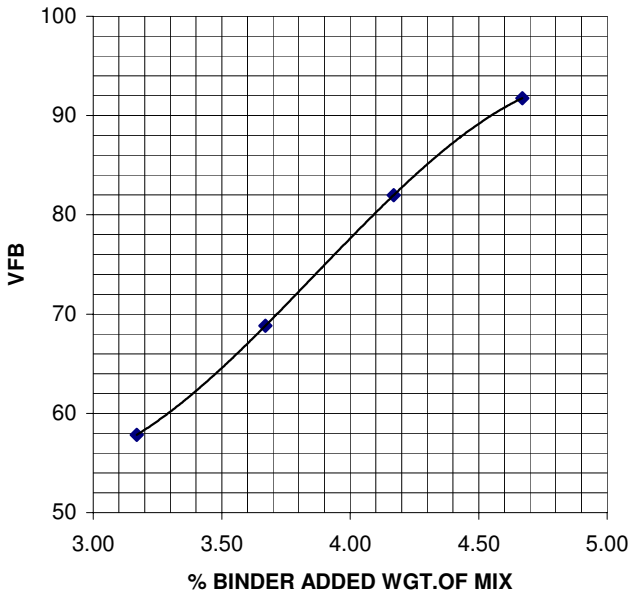
(920) 735-6900

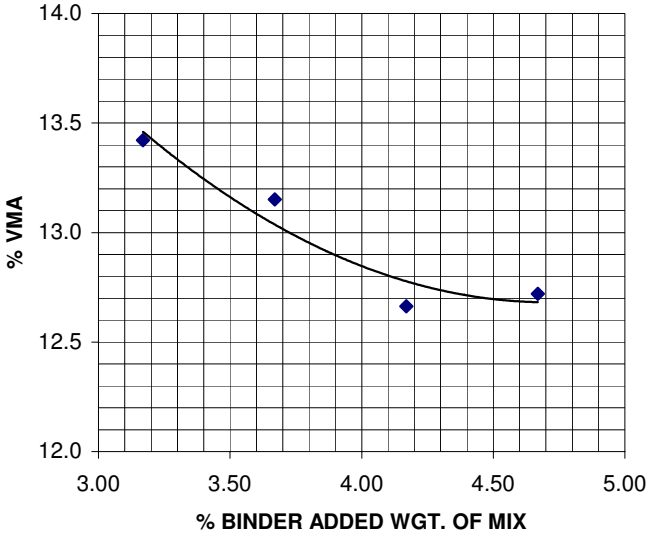
REPORT OFSUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

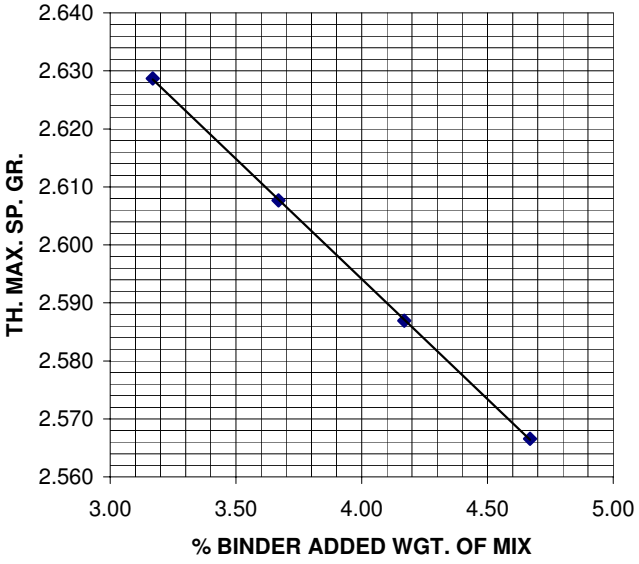
TYPE . . . . . E1-19.0 mm
DESIGN ESALS. . . 1.0E+06
JOB NUMBER T0868A03-003

DESIGN NUMBER: 903003
DATE: 12/11/03







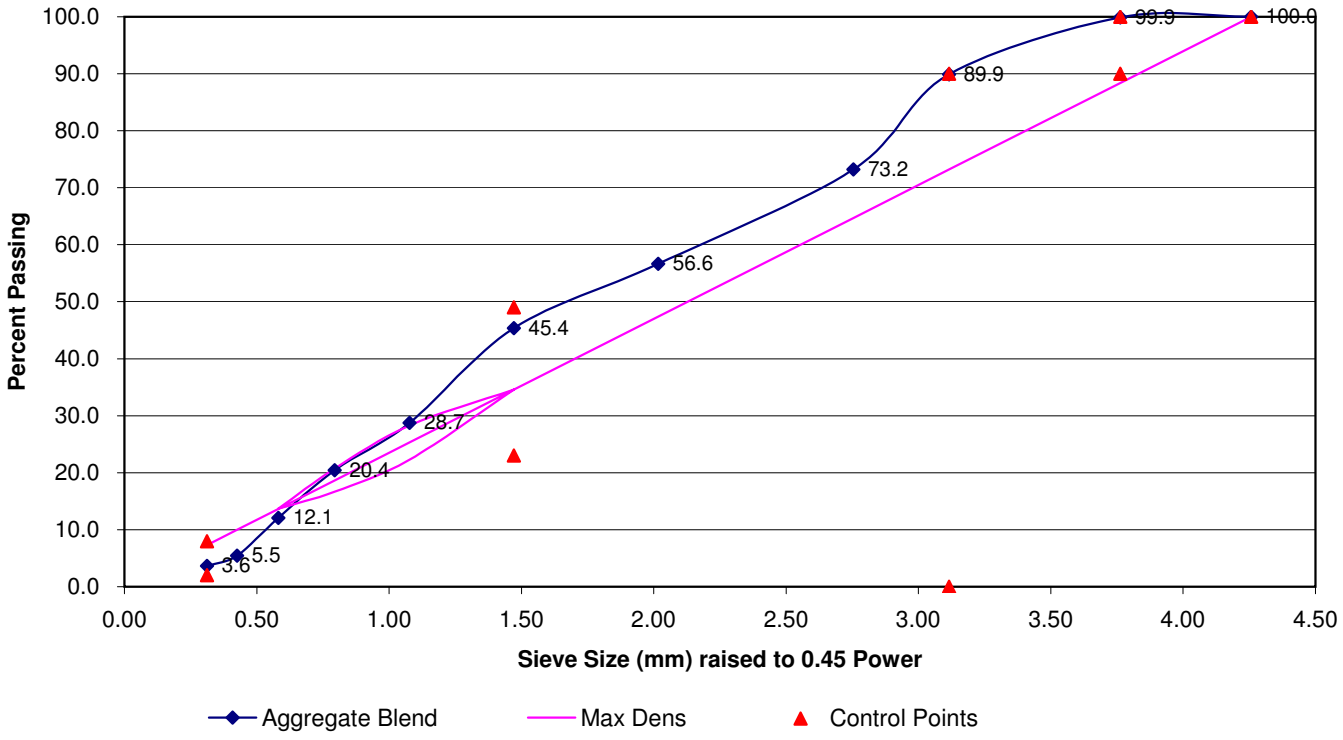


AGGREGATE BLEND

OMNNI ASSOCIATES
ONE SYSTEMS DRIVE
APPLETON, WI 54914
(920) 735-6900

REPORT OFSUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

TYPE	E1-19.0 mm	DESIGN NUMBER:	903003
DESIGN ESALS. . .	1.0E+06		
JOB NUMBER	T0868A03-003	DATE:	12/11/03



COMPACTION CURVE

OMNNI ASSOCIATES
ONE SYSTEMS DRIVE
APPLETON, WI 54914
(920) 735-6900

REPORT OF SUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

TYPE . . . . . E1-19.0 mm
DESIGN ESALS. . . 1.0E+06
JOB NUMBER T0868A03-003

DESIGN NUMBER: 902903
DATE: 12/211/03

AGGREGATE SOURCE

SPL NO.	TEST NO.	MATERIAL
1	24790	7/8 x 5/8 Chip
2	24890	5/8 x 1/2 Chip
3	24990	1/2 x 1/4 Chip
4	25090	Washed Mfg'd Sand
5	25390	Crushed Glass Aggregate
6	25290	Crushed RAP

AGGREGATE GRADATION (% PASSING):

SPL NO.	*1*	*2*	*3*	*4*	*5*	*6*			
BLEND %	20	10	9	25	22	14	BLEND	JOB MIX	SPEC.
25mm (1.0")	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100
19mm (3/4")	99.3	100.0	100.0	100.0	100.0	100.0	99.9	99.9	90-100
12.5mm (1/2")	60.5	80.8	100.0	100.0	100.0	98.1	89.9	89.9	0-90
9.5mm (3/8")	12.9	20.1	95.9	100.0	100.0	93.4	73.3	73.3	--
4.75mm (#4)	3.3	4.3	5.2	92.3	100.0	76.3	57.3	57.3	---
2.36mm (#8)	2.9	3.6	3.6	57.4	96.6	59.3	45.2	45.2	23-49
1.18mm (#16)	2.7	3.2	3.4	33.6	64.3	46.6	30.2	30.2	---
0.60mm (#30)	2.6	3.1	3.3	19.8	29.2	37.1	17.7	17.7	---
0.30mm (#50)	2.5	3.0	3.2	12.2	11.0	27.5	10.4	10.4	---
0.15mm (#100)	2.5	2.9	3.1	7.6	3.1	18.9	6.3	6.3	---
0.075mm (#200)	2.2	2.6	2.8	4.5	1.0	13.2	4.1	4.6	2-8
G_{sb}	2.751	2.746	2.736	2.727	2.886	2.698	2.765		
Absorption (%)	1.07	1.09	1.29	1.40	0.06	0.79	0.91		
FAA					48.0	42.9			

FOR JMF AS USED IN LABORATORY TRIAL MIXES:

SOUNDNESS = 0.5
L.A. WEAR = 3.8 (100) 28.9 (500)
FREEZE/THAW = 0
SAND EQUIVALENT = 76
CRUSH = 1F/100 2F/100

ELONGATED PARTICLES = 0.0%
UNCOMPACTED VOIDS - F.A.= 46.2
BULK AGG. SP. GR. = 2.765
APPARENT AGG. SP. GR. = 2.834
EFFECTIVE AGG. SP. GR. = 2.828

BINDER DATA

TYPE . . . . . PG 58-28
SOURCE . . . . . Koch
SP. GR. (77/77F) . 1.031

RAP DATA

(ASTM D2171, D1856, D5)
% BINDER = 4.87

AVERAGE TEST DATA (75 GYRATIONS AT 275F)

BINDER CONT. (% OF MIX ADDED)	- - - - % 'VOIDS - - - - MIX	VMA	VFB	TH. MAX. SP. GR. (G_{mm})	BULK SP. GR. (G_{mb})
3.62	5.1	13.6	62.6	2.631	2.497
4.12	3.4	13.2	74.3	2.609	2.521
4.62	1.9	13.0	85.4	2.589	2.539
5.12	1.0	13.4	92.5	2.568	2.542

THE TEST DATA SHOWN ON THIS REPORT PERTAIN ONLY TO THE MATERIAL SUBMITTED FOR DESIGN
AASHTO PP28 MODIFIED TO MEET CUSTOMER REQUIREMENTS

REPORT OF SUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

TYPE . . . . . E1-19.0 mm — DESIGN NUMBER: 902903
DESIGN ESALS. . . 1.0E+06
JOB NUMBER . . . . T0868A03-003 — DATE: 12/211/03

FOR: $N_{initial}$ 7
N_{design} 60
N_{max} 75

RECOMMENDED OPTIMUM BINDER CONTENT = 3.95 % ADDED 4.63 *% TOTAL*

DESIGN DATA AT OPTIMUM BINDER CONTENT:

MIX VOIDS (%)	=	4.0
VMA (%)	=	13.4
VFB (%)	=	70.1
TH. MAX. SP. GR. (G_{mm})	=	2.617
BULK SP. GR. (G_{mb})	=	2.512
UNIT WEIGHT (lbs/ft^3)	=	156.4
$\%G_{mm}$ @ $N_{initial}$	=	89.9
$\%G_{mm}$ @ N_{max}	=	96.7
TSR N= 23	=	81
RECOMMENDED MIXING TEMP.	=	275-300
DUST TO P_{be} RATIO	=	1.2

COMMENTS:

P-0.075 INCREASED 0.5% TO SIMULATE AGGREGATE BREAKDOWN DURING MIX PRODUCTION.

OMNNI ASSOCIATES

PAUL R. EGGEN
WISCONSIN CERTIFIED ASPHALTIC TECHNICIAN III

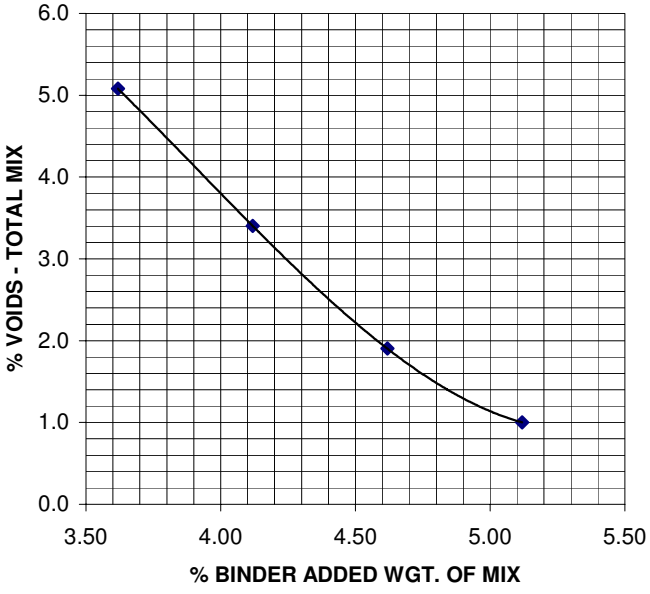
THE TEST DATA SHOWN ON THIS REPORT PERTAIN ONLY TO THE MATERIAL SUBMITTED FOR DESIGN

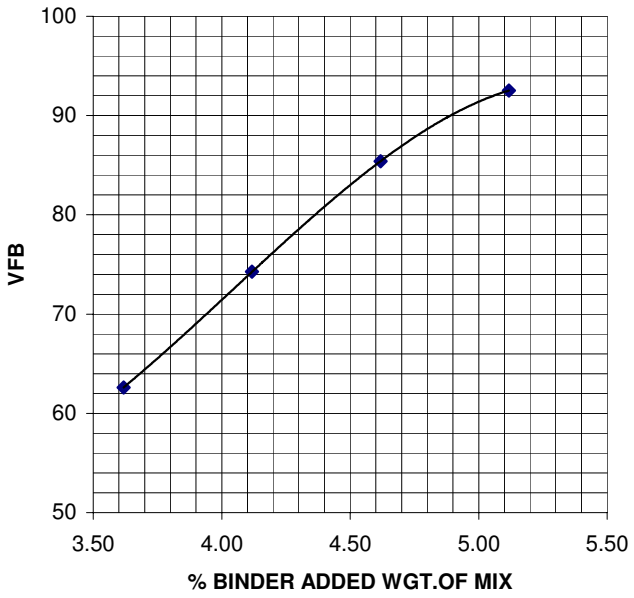
OMNNI ASSOCIATES
ONE SYSTEMS DRIVE
APPLETON, WI 54914
(920) 735-6900

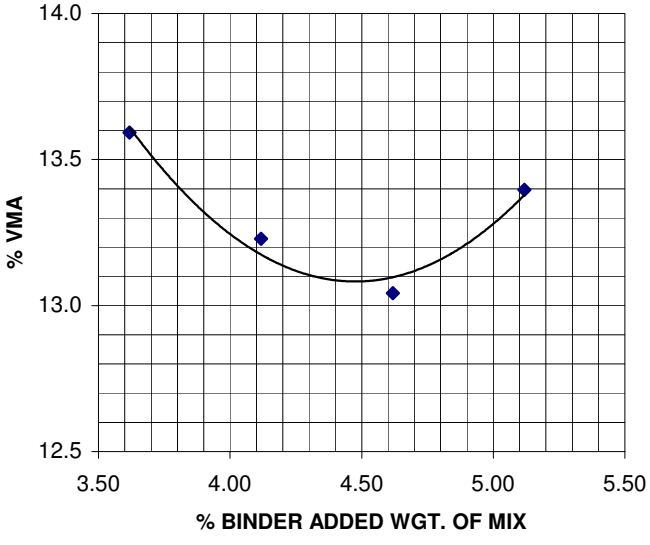
REPORT OFSUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

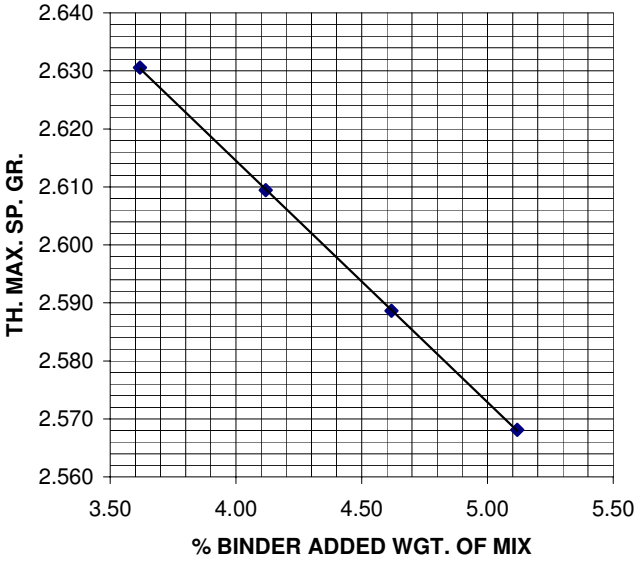
TYPE . . . . . E1-19.0 mm
DESIGN ESALS. . . 1.0E+06
JOB NUMBER T0868A03-003

DESIGN NUMBER: 902903
DATE: 12/211/03







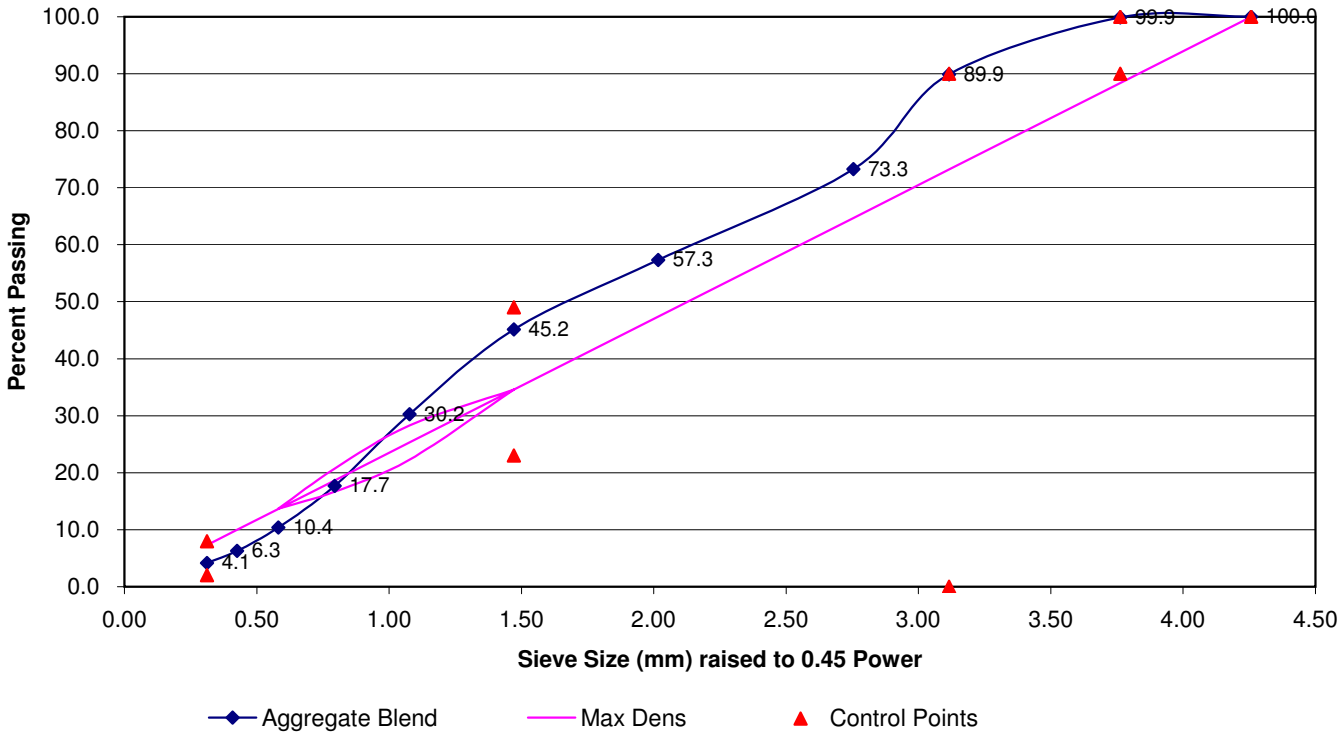


AGGREGATE BLEND

OMNNI ASSOCIATES
ONE SYSTEMS DRIVE
APPLETON, WI 54914
(920) 735-6900

REPORT OFSUPERPAVE ASPHALTIC MIX DESIGN
(AASHTO PP-28, ASTM D4867)

TYPE	E1-19.0 mm	DESIGN NUMBER:	902903
DESIGN ESALS. . .	1.0E+06		
JOB NUMBER	T0868A03-003	DATE:	12/211/03



COMPACTION CURVE

GLASS AGGREGATE PROPERTIES SUMMARY

Minergy, Prj. T0868A03-003

December 22, 2003

	Fox River Sediment Uncrushed Glass Aggregate	Fox River Sediment Crushed Glass Aggregate	Neenah Glass Aggregate
Gradation			
3/4" (19.0 mm)	100.0	100.0	100.0
1/2" (12.5 mm)	100.0	100.0	99.5
3/8" (9.5 mm)	100.0	100.0	93.3
#4 (4.75 mm)	99.9	100.0	52.9
#8 (2.36 mm)	79.6	96.6	19.3
#16 (1.18mm)	26.3	64.3	6.9
#30 (0.60mm)	7.9	29.2	2.6
#50 (0.30mm)	2.5	11.0	1.0
#100 (0.15mm)	0.7	3.1	0.4
#200 (0.075mm)	0.1	1.0	0.3
Fine Aggregate Angularity (%)	50.5	48.0	51.7
Bulk Specific Gravity (GSB)	2.878	2.886	2.787
Apparent Specific Gravity (GSA)	2.903	2.891	2.804
Absorption	0.30	0.06	0.60

One Systems Drive, Appleton, WI 54914 Ph. 920/735-6900, Fax 920/830-6100, Website: www.omnni.com

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OMNNI ASSOCIATES, INC.
ONE SYSTEMS DRIVE
APPLETON, WI 54914-1654
TEL: 920-735-6900

REPORT OF: LABORATORY TESTS OF AGGREGATE

PROJECT: Fox River Glass Aggregate Mix Design and Testing **OMNNI PROJECT NO.** T0868A03

CLIENT: Minergy **DATE:** 12/22/03

Sample Number: 25390
Date of Sample: 8/03
Sample Source: Minergy
Sample Location: Pilot Plant - Winneconne
Tests Performed: Grain Size Analysis, Specific Gravity, Fine Aggregate Angularity

TEST RESULTS;

Aggregate Description: Crushed Fox River Sediment Glass Aggregate

Grain Size Analysis (ASTM:C136)

SIEVE SIZE	% PASSING	ASTM C33 SPECIFICATION
3/8"	100.0	100
#4	100.0	95-100
#8	96.6	80-100
#16	64.3	50-85
#30	29.2	25-60
#50	11.0	5-30
#100	3.1	0-10
#200	1.0	0-3

Specific Gravity and Absorption (ASTM: C128)

Bulk Specific Gravity	2.886
Apparent Specific Gravity	2.891
Absorption (%)	0.06

Fine Aggregate Angularity (ASTM: C1252, Method A)

Fine Aggregate Angularity (%)	48.0

REMARKS: The above sample was delivered to our laboratory by Minergy personnel.

Reviewed By: *Paul R. Eggen*

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REPORT OF: LABORATORY TESTS OF AGGREGATE

PROJECT: Fox River Glass Aggregate Mix Design and Testing **OMNNI PROJECT NO.** T0868A03

CLIENT: Minergy **DATE:** 12/22/03

Sample Number: 25490
Date of Sample: 8/03
Sample Source: Minergy
Sample Location: Pilot Plant - Winneconne
Tests Performed: Grain Size Analysis, Specific Gravity, Fine Aggregate Angularity

TEST RESULTS;

Aggregate Description: Fox River Sediment Glass Aggregate

Grain Size Analysis (ASTM:C136)

SIEVE SIZE	% PASSING
3/8"	100.0
#4	99.9
#8	79.6
#16	26.3
#30	7.9
#50	2.5
#100	0.7
#200	0.1

Specific Gravity and Absorption (ASTM: C128)

Bulk Specific Gravity	2.878
Apparent Specific Gravity	2.903
Absorption (%)	0.30

Fine Aggregate Angularity (ASTM: C1252, Method A)

Fine Aggregate Angularity (%)	50.5

REMARKS: The above sample was delivered to our laboratory by Minergy personnel.

Reviewed By: *Paul R. Eggen*