ANNUAL PROJECT REPORT
AS OF DECEMBER 2003

1. PROJECT SPONSOR:
CONSOL Energy Inc.
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South Park, PA 15129-9566

2. PRINCIPAL INVESTIGATOR:
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3. OCDO GRANT NO. CDO/D-95-2

4. PROJECT UPDATE _ OR
FINAL REPORT X

5. PROJECT TITLE: Aggregate Production From Wet Lime FGD Sludge

6. PROJECT TERM: FROM: 11/01/1996 **TO:** 05/30/2003

7. BUDGET :

CO-SPONSORS NAME	COST-SHARE
OCDO	$ 195,158
CONSOL ENERGY Inc.	$ 198,277
The Garick Corp.	$ 3,000
Walden Industries Inc.	$ 9,874
Turmbull Corp.	$ 16,405
TOTAL PROJECT COST:	$ 422,714

I. ABSTRACT

8. OVERVIEW OF PROJECT & OBJECTIVES:

The objectives of this project are to determine the technical and economic feasibility of producing construction-grade aggregates from the solid by-products of lime-based flue gas desulfurization (FGD) units, and to determine their performance in field trials as masonry units and highway construction aggregates. The aggregates are produced via CONSOL's patented disk pelletization technology.

Lime-based FGD units are the most common type used in Ohio and in the Ohio coal marketing region. Utilization (as opposed to landfill disposal) of the FGD sludge could reduce the cost of flue gas desulfurization by an equivalent of $2-9/ton of coal. This would provide a substantial incentive to scrub rather than switch to low-sulfur coal. Lowering FGD operating costs would improve the competitive position of Ohio medium- and high-sulfur coals, thus promoting the Ohio coal industry and Ohio coal mining employment.

9. WORK DONE AND CONCLUSIONS:

The test program that began in late 1996 was completed in 2003. Forty-one semi-continuous bench-scale pelletization tests were conducted using AEP Gavin and Cinergy Zimmer Station solids to evaluate manufactured aggregate mix formulations. Based on the results of these tests large quantities of aggregates were produced for field demonstrations. Two and one-half ton of crushed road construction aggregates and two ton of lightweight aggregates for concrete block production were produced using bench-scale equipment.

The road construction aggregates were made from AEP Gavin Station sulfite FGD sludge, Gavin fly ash, hydrated lime and a proprietary component. The aggregates met the American Association of State Highway and Transportation Officials (AASHTO) M-283 Class A aggregate specifications. These aggregates were blended 50/50 with natural aggregate material and used in an asphalt mix to pave a 72'x11'x1.5" section of highway in Warren, Trumbull County, Ohio. As a control, a similar section of road was paved with asphalt made with natural conventional aggregates only. The road sections were then monitored for almost five years to evaluate the performance of the test patches under highway traffic conditions.

The lightweight aggregates were made from Cinergy Zimmer Station FGD sludge, Beckjord Station fly ash and hydrate lime. The Beckjord fly ash was used to reduce the density of the aggregates. These aggregates met the American Society for Testing and Materials (ASTM) C-331 combined aggregate specifications for unit weight, clay lumps, grain size, and staining for lightweight aggregates for concrete masonry units. Walden Industries in Tiltonsville, Ohio used the crushed manufactured aggregates in their commercial scale equipment to produce lightweight concrete blocks. These blocks were then used to build a 6' high by 25' long outdoor concrete block wall section. For comparison, other sections of the wall were made with commercial normal weight, medium weight, and lightweight blocks. To check the performance of the various test sections, the wall construction was monitored over almost a five year period.

The work demonstrated the technical feasibility of producing construction aggregates from coal combustion by-products (wet lime FGD scrubber sludge and fly ash) using CONSOL Energy's manufactured aggregate process. It outlined the economic feasibility of aggregate production and demonstrated the use of the materials in concrete masonry and highway construction field trials. Based on the test program results the following observations and conclusions are made:

- The use of manufactured aggregates made from AEP Gavin Station wet lime FGD scrubber sludge and fly ash presents no handling problems for commercial asphalt road construction equipment.

- The asphalt highway test patch field demonstration showed that manufactured aggregates can perform about as well as conventional aggregates in asphalt paving. Both the test patch made with a 50/50 coarse blend of manufactured and conventional aggregates and the test patch made with 100 percent conventional aggregates maintained good structural integrity over the approximately five years of test program monitoring. There was no rutting or cracking of the test pavements.

- Some delamination of the manufactured aggregate from the surface layer of the test patch pavement was observed during the winter months of 1999 and 2000. The delamination is thought to be caused by a combination of freeze/thaw conditions and the use of de-icing agents, such as, sodium chloride salt and slag on the pavement. In a separate study from this Grant Agreement, CONSOL Energy and Universal Aggregates identified a mix design additive that significantly improves the manufactured aggregate resistance to disintegration by repeated freezing and thawing in sodium chloride solution. However, the additive increased the aggregate production costs by $7-$14/ton. The use of this additive makes production of manufactured road aggregate currently un-economical for Ohio since natural aggregate that meets AASHTO Class A specification typically sells for $6.50 /ton to $9.50/ton.

- The use of lightweight manufactured aggregates made form Zimmer Station FGD sludge and Beckjord Station fly ash caused no problems in commercial block production equipment. These results indicate that with respect to handling properties manufactured lightweight aggregates should be readily acceptable to block producers.

- The outdoor wall construction demonstrates that lightweight blocks made from the manufactured aggregates perform as well as the commercial normal weight, commercial medium weight, and commercial lightweight concrete blocks that were used for comparison. Nearly five years of monitoring the wall revealed no structural deterioration with no cracks and no separation of mortar joints. These results indicate that there is good potential for the use of manufactured aggregates by the concrete block industry.

- There is now no interest in producing lightweight aggregate using Zimmer Station FGD sludge and Beckjord fly ash since the Zimmer Station FGD was recently converted to gypsum production for sale to a wallboard manufacturer. Of the five coal-fired power plant in Ohio that have FGD scrubbers, the AEP Conesville Station was identified as the most likely site for a commercial lightweight aggregate production facility. In a separate OCDO program, the manufacture and use of lightweight manufactured aggregates made with Conesville FGD

sludge was demonstrated[§]. The lightweight concrete block production results were encouraging with the exception that drying shrinkage of the blocks made by all manufacturers was higher than ASTM specifications. In other research programs that are not part of the current Grant Agreement, CONSOL Energy is studying how to overcome the drying shrinkage problem. A decision to proceed with a lightweight manufacturer aggregate facility at Conesville cannot go forward until this issue is resolved.

10. PLANS FOR COMING YEAR:

The test program has ended and no additional work will be preformed. The final report will be issued.

II. HIGHLIGHTS/ACCOMPLISHMENTS

11. Field demonstration monitoring of the Trumbull, county road test patches was completed in June 2003 and final inspection of the Tiltonsville concrete block wall was made in July 2003. This ended the test program. A draft of the final report was prepared and forwarded to OCDO for review. The major highlights and accomplishments for the program are:

- Based on the results of 41 bench-scale tests, manufactured aggregate mix designs were successfully identified for the production of test quantities of road construction aggregates and lightweight aggregates for concrete block manufacture.

- Successfully produced aggregates that met AASHTO M-283 Class A aggregate specifications.

- Successfully produced lightweight aggregates for concrete masonry units that met ASTM C-331 specifications.

- Large test quantities of manufactured road construction aggregates (2.5 ton) and lightweight aggregates for concrete block production (2.0 ton) were successfully prepared using semi-continuous bench-scale equipment.

- A field demonstration of the use of manufactured aggregates in asphalt road construction was successfully completed. The results of the testing showed that a test patch made with a 50/50 coarse blend of manufactured aggregates with conventional aggregates in an asphalt mix preformed nearly as well as a test patch made with conventional aggregates only. After nearly five years of use on a northern Ohio county road both test batches remained structurally sound.

[§] McCoy, D. C., Wu, M. M., "Demonstration of the Production of Manufactured Aggregates From AEP Gavin and Conesville Station FGD Sludges," OCDO Final Report, DCO/D-98-17, May 31, 2003.

- A field demonstration of the use of the use of lightweight concrete blocks made with lightweight weight manufactured aggregates was successfully completed. The concrete blocks were used in the construction of a section of an outdoor concrete wall. Nearly five years of monitoring the concrete wall revealed no difference in structural integrity between the section made with lightweight manufactured aggregate concrete block and the sections made with conventional normal weight, medium weight and lightweight weight concrete blocks.

III. ARTICLES/PRESENTATIONS

12.

- Wu, M. M.; McCoy, D. C.; Fenger, M. L.; Scandrol, R. O.; Winschel, R. A.; Withum, J. A.; Statnick, R. M. "Production of Manufactured Aggregates from Coal Combustion By-Products", Presented at the 1999 International Ash Symposium, Lexington, KY, October 1999.

- Wu, M. M.; McCoy, D. C.; Fenger, M. L.; Scandrol, R. O.; Winschel, R. A.; Withum, J. A.; Statnick, R. M. "Production of Manufactured Aggregates from Coal Combustion By-Products", Presented at the Sixteenth Annual International Pittsburgh Coal Conference, Pittsburgh, PA, October 1999.

- Wu, M. M.; McCoy, D. C.; Fenger, M. L.; Scandrol, R. O.; Winschel, R. A.; Withum, J.A.; Statnick, R. M. "Production of Manufactured Aggregates from Coal Combustion By-Products", presented at the 13th U. S.-Korea Joint Workshop on Energy and the Environment, Reno, NV, September 1999.

- Wu, M. M.; Winschel, R. A.; Hasenfus, G. J. "Production of Manufactured Aggregates from Coal Combustion By-Products", presented at the ACAA Thirteenth International Symposium on Ash Management and Use of Coal Combustion By-Products, Orlando, FL, January 1999.

- Wu, M. M.; Winschel, R. A.; Hasenfus, G. J. "Production of Manufactured Aggregates from Coal Combustion By-Products", presented at the DOE Advanced Coal-Based Power and Environmental Systems '98 Conference, Morgantown, WV, July 1998.