The University of Wisconsin-Milwaukee's Center for By-Products Utilization (CBU) is one of the country's outstanding examples of a successful public/private partnership. Formed in 1988, by companies interested primarily in coal ash utilization, the CBU is dedicated to preserving the environment by finding practical uses for what was once considered waste. It does so through research on a variety of materials. The end result is the creation of cost effective products that satisfy existing needs, and a significant decrease in the volume of waste going to landfills. Finding beneficial uses of foundry by-products is the focus of CBU research funded by Wisconsin Department of Natural Resources and several Wisconsin-based foundries, including Falk Corporation, Maynard Steel Casting Co., Waupaca Foundry, and Badger Mining Corporation. Additional recent funding was also provided by the Solid Waste Research Council of the University of Wisconsin System.

As a result of increased pressure from environmental regulations to significantly reduce the amount of foundry waste disposed in landfills, the questions of what to do with these materials has reached a new, urgent stage. CBU at the University of Wisconsin-Milwaukee has been conducting the research for the past two years to develop practical ways of using discarded foundry sands and steel slag in construction materials.

Phase 1 of this research project was dedicated to the literature search and information gathering. The information about foundry processes, materials, waste generation, and potential uses of used foundry sand was collected, evaluated, and analyzed from worldwide sources. This information about the foundry industry, foundry by-products, and potential uses of foundry by-products from worldwide knowledge, was put together in a report. This report was published in February 1992.
Phase 2, and Phase 3 of this investigation were the laboratory study of used foundry sands and testing of construction products made from foundry sands.

Many different samples of used foundry sand, and air cooled slag, were received from different foundries for evaluation as potential construction products. A clean/new foundry sand from the Badger Mining Corporation was also utilized for control experiments. All sand samples were tested for their physical properties in order to establish base-line data for future use for quality control. It was observed that the used sands showed variation in their physical properties based on the type of equipment used, the size and shape of the casting made, and type and amount of binders used.

In general, all used foundry sand samples showed lower unit weight, lower fineness modulus, higher water absorption, lower specific gravity, and higher loss on wetting and drying in sodium sulfate solution, than the respective properties of regular concrete sand. Construction materials produced were tailored-made to take advantage of the properties of the used foundry sand. Based on the results of the physical properties, it was concluded that 100% of regular concrete sand probably cannot be replaced by used foundry sand. In order to design optimum cost-effective solution, it was decided to use as received foundry sand, i.e. no processing or cleaning of foundry sands was undertaken in this phase of the investigation. One sample from participating foundries was selected to make concrete, and several other different construction products.

In the Phase 3 of this research project, three different products, to utilize used foundry sand, were prepared at the Center for By-Products Utilization Laboratory. They were, portland cement concrete, masonry blocks, and paving stones. All of these products were tested, and evaluated for performance based upon applicable standards.
Many different types of concrete mixes were made in the CBU laboratories. In order to use as much of the foundry sand as possible, replacement levels of 25% and 35% were selected, in this initial investigation phase. Regular concrete sand were replaced with used foundry sands. One concrete mix was prepared with no foundry sand. Additional mixes were prepared with used foundry sand, replacing 25% and 35% of regular sand with used foundry sand. Similar mixes were prepared using clean/new foundry sand. All the mixes were designed as a high-performance concrete, readily acceptable for high-rise construction, as well as everyday construction. The performance of concrete was evaluated by testing for compressive strength, tensile strength, and modulus of elasticity. It was established that foundry sand is a good material to be used in making concrete. The concrete developed can be marketed for most needs without significant additional investment of research dollars.

Concrete masonry block mixture proportions were developed for bench-scale production. The size of the masonry block prepared in the laboratory was smaller than the normal size available in the market. However, its shape was proportionally reduced from a full-size block produced by a local block manufacturing company. All the masonry block mixtures were tested for their compressive strength, bulk density, and water absorption. The result indicated that the control mix, the mix with clean/new foundry sand, and other mixes with used foundry sand, reached about the same strength at the specified age. Bulk density and absorption of all the blocks were within ASTM requirements. Based on these test results it was concluded that block manufacturing on the large scale can be started. The level of used foundry sand can be fine-tuned based upon over-all performance requirements of a given market.

Paving stone mixes were also developed. One control mix, one mix with replacement of regular
sand with clean/new foundry sand, and additional mixes with regular aggregates replaced with used foundry sand, were designed and evaluated. The size of the paving stone prepared in the laboratory was the same size available in the market. Paving stones were tested for compressive strength, water absorption, resistance to abrasion, and freezing and thawing. Strength results of paving stone mixes with or without used foundry sand were lower than desirable. With the use of additives and/or admixtures the strength will be improved. ASTM requirements were met for water absorption and abrasion resistance.

The results of the concrete, masonry blocks, and paving stones, showed very promising possibilities available for foundry by-products. In general, the specified strength of normally used structural grade concrete is 3000 to 5000 psi. These strength levels were achieved with even 35% replacement of regular sand with used foundry sand. Modulus of elasticity for concrete made with used foundry sand showed similar results as the control mix without foundry sand. This property of concrete is very important to properly design reinforced concrete members for long-term serviceability. Masonry blocks passed all the requirements of ASTM for strength, water absorption, and bulk density. The bench-scale blocks produced were satisfactory for three different categories specified by ASTM, hollow load bearing blocks, hollow non-load bearing blocks, and solid non-load bearing blocks. Paving stones, with proper dosage of admixtures will reach the strength requirements of ASTM. Other requirements of absorption, bulk density, and resistance to abrasion were met, by paving stones with used foundry sands.

Initial test data indicate that used foundry sand can be used successfully for various construction products. Long-term performance data and parameters for mass production are being developed before production will be started for marketing these products. Additionally funded new-products design and testing is continuing. Additional partners for research and development phases are being
sought to bring these products to market. For more information write or call the Center for By-Products Utilization at the University of Wisconsin-Milwaukee.