Scope of Work for
System-wide Life Cycle Benefits of Recycled Materials

I. Background and Problem Statement

RMRC and various governmental agencies have developed fact sheets on various recycled materials and industrial byproducts for their use in highway construction applications. These fact sheets typically have addressed the engineering properties and environmental suitability issues relevant to various applications and in some cases incorporated design guidelines and construction specifications. What is lacking is direct information on sustainability assessment characteristics, i.e., greenhouse emissions, energy and water consumption and life cycle cost benefits. Agencies may track system-wide use of quantities for major recycled materials such as fly ash in concrete, recycled asphalt pavement, recycled concrete aggregate, etc. (see Appendix), but they can not readily calculate the benefits accrued by substitution of these materials for conventional materials. Although state transportation departments have been in the forefront of introducing recycled materials, they have not been able to clearly convey the benefits in a quantitative and transparent manner using easily understood metrics.

II. Objectives

The first objective of this study is to develop/update factsheets on various recycled materials and industrial byproducts that are being used in highway construction. New information generated in recent years relative to their engineering properties and environmental impact questions will be added as well as relevant life cycle assessment data.

The second objective of this study is to develop a tool by which the state system-wide material use quantities can be used to calculate the life cycle benefits associated with the incorporation of recycled materials and industrial byproducts to highway pavement construction.

III. Scope of Work

Task 1: The research team will conduct a complete literature search of the topic, define a detailed plan of how to collect meaningful data sets in each RMRC-3G member state, and define an easily understandable approach to analyzing and presenting data and findings to a broad audience of end users. The RMRC-3G research team will also conduct a comprehensive literature search on the topic of use of recycled materials and industrial byproducts in transportation systems. They will start by reviewing the past RMRC reports, research final reports generated by the member DOTs (e.g., Wisconsin Highway Research Program), state and AASHTO specifications, FHWA reports, and the published literature relative to the use of these materials. One RMRC member state, Illinois, has recently published their annual report of recycled material use, (see example report http://www.dot.il.gov/materials/research/prr164.pdf from IDOT).

Task 2: Based upon the literature search and the discussion with the RMRC Executive Board, the Researcher shall develop updated data sheets on each material covering the nature and engineering properties of the material and their environmental suitability.

Task 3: Search and identify the most appropriate database for life cycle assessment parameters for each material. For instance, PALATE sponsored by RMRC is such a database as well as EPA databases and others. Incorporate the unit greenhouse gas emission reductions, energy, and water consumption reductions provided by use of each recycled material. Such reductions are the result of avoiding mining and production of conventional materials. Unit metrics for transportation and construction can also be incorporated. Determine if use of each recycled material is allowed in the states' current specification. See attached list of material definitions and member state reported use of various materials.

Task 4: Search and identify the most appropriate cost database for each material. For instance, RealCost by FHWA or each states records may provide such databases.

Task 5: Study how each member state maintains system-wide material quantity databases and how this information can be retrieved. For example, some states have a means of "querying" the information by careful selection of key words or bid items. Determine quantities for materials where information is available. For instance, use of fly ash in concrete can be tracked, but is not used in subgrade stabilization. Identify the challenges in this process and make recommendations to users on how usage information can be collected and retrieved for future reporting.

Task 6: Develop a computer-based tool that will make the necessary calculations once the system-wide material usage quantities are known for: a) life cycle assessment and b) benefits accrued from use of recycled materials and industrial by products in construction. This tool should be user friendly and lead to a brief report of the findings.

Task 7: Prepare a final report and formal presentation of the project to the RMRC-3G Executive Board and assist posting documentation and user manual on the RMRC website. The documentation should provide information on how to update the tool.

IV. Project Team

This research will be conducted under the supervision of the following co-Principle Investigators:

- Angela Pakes Ahlman, PE – co-PI
- Dr. Tuncer Edil, PE – co-PI

RECYCLED OR WASTE MATERIAL DEFINITIONS

- RECYCLED CONCRETE AGGREGATE/MATERIAL - Recycled concrete aggregate (RCA), or material (RCM), consists of high-quality, well-graded aggregates (usually mineral aggregates), bonded by a hardened cementitious paste.

- RECYCLED GLASS AGGREGATE OR GLASS BEADS - Glass is a product of the supercooling of a melted liquid mixture consisting primarily of sand (silicon dioxide) and soda ash (sodium carbonate) to a rigid condition, in which the supercooled material does not crystallize and retains the organization and internal structure of the melted liquid. When waste glass is crushed to sand-like particle sizes, similar to those of natural sand, it exhibits properties of an aggregate material.

- RECYCLED PORCELAIN AGGREGATE - crushed porcelain materials made primarily of clay, quartz and other materials. The porcelain can be glazed or unglazed from such things as tiles, toilets and insulators.

- TIRE DERIVED AGGREGATE (TDA) – TDA is aggregate made from shredded tires and used for a wide range of public works projects and other civil engineering applications.

- BOTTOM ASH – When pulverized coal is burned in a dry bottom boiler, about 20% of the unburned material is dry bottom ash. Bottom ash is a porous, glassy, dark gray material with a grain size similar to that of sand or gravelly sand.

- FLY ASH – Fly ash is produced from burning pulverized coal in a coal-fired boiler. It is a fine-grained, powdery particulate material that is carried off in the flue gas and usually collected by means of electrostatic precipitators, baghouses, or mechanical collection devices such as cyclones.

- WASTE-INCINERATION FLY ASH – Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials. Incineration of these materials converts the waste into heat, flu gas and other particulates, such as fly ash.

- ROAD OR CULVERT CLEANOUT DEBRIS/SWEEPINGS - Street sweepings and culvert or catch basin debris are materials such as sand, salt, leaves and debris removed from roads, parking lots and sidewalks to prevent these materials from being washed into storm sewers and surface waters, and to improve the appearance of public roadways.

- BY-PRODUCT LIME - Limestone (calcium carbonate) heated in a kiln drives off carbon dioxide and forms lime (calcium oxide). The kiln's exhaust gasses - filtered using electrostatic precipitators, baghouses, or other such methods - are collected and sold as by-product lime.

- MATERIAL – The substance or substances of which a thing is made or composed. Anything that serves as crude or raw matter to be used or developed.

- MICROSILICA – Also known as silica fume, microsilica is a non-crystalline polymorph of silicon dioxide, silica. It is an ultrafine powder consisting of spherical particles collected as a by-product of the silicon and ferrosilicon alloy production.

- RECLAIMED ASPHALT PAVEMENT - Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates.

- STEEL REINFORCEMENT: DOWEL BARS, REBAR, OR WELDED WIRE REINFORCEMENT – Reinforced concrete is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength and/or ductility. The reinforcement is usually steel reinforcing bars (rebar), dowel bars, or welded wire.

- CRUMB RUBBER – Crumb rubber is recycled rubber from automotive scrap tires.

- FOUNDRY SAND - Foundry sand is high-quality silica sand that is used to form molds for ferrous (iron and steel) and nonferrous (copper, aluminum, brass, etc.) metal castings.

- RECLAIMED ASPHALT SHINGLES - Recycled Asphalt Shingles (RAS) is a product that contains approximately 30% asphalt cement by mass weight. Sources of RAS include trimmings from shingle insulation and decommissioned shingle roofs.

- AIR-COOLED BLAST FURNACE AGGREGATE SLAG –Different forms of slag product are produced depending on the method used to cool the molten slag, such as air-cooled. If liquid slag is poured into beds and slowly cooled under ambient conditions, a crystalline structure is formed, and a hard, lump slag is produced, which can subsequently be crushed and screened.

- FOUNDRY SLAG FROM CASTING PROCESS – Foundries purchase new, virgin sand to make casting molds, and the sand is reused numerous times within the foundry. The foundry sand that is no longer reused is designated foundry slag from casting processes.

- GROUND GRANULATED BLAST FURNACE SLAG – The physical structure and gradation of granulated slag depend on the chemical composition of the slag, its temperature at the time of water quenching, and the method of production. When crushed or milled to very fine cement-sized particles, ground granulated blast furnace slag (GGBFS) has cementitious properties, which make a suitable partial replacement for or additive to Portland cement.

- IRON SLAG – During smelting, when iron ore is exposed to high temperatures, impurities within the natural ore are separated and removed from the molten metal. Iron slag is a collection of the removed compounds found in the impurities.

- STEEL SLAG – Steel slag, a by-product of steel making, is produced during the separation of the molten steel impurities from impurities in the steel-making furnaces. The slag occurs as a molten liquid me