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thesis entitled

DEVELOPMENT OF A DATABASE METHODOLOGY FOR COMPLIANCE WITH REGIONALLY AVAILABLE MATERIALS STANDARDS OF LEEDTM GREEN BUILDING RATING SYSTEM

presented by

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has been accepted towards fulfillment
of the requirements for the

Master of Science degree in Construction Management Program

Major Professor's Signature

8/4/2005

Date

DEVELOPMENT OF A DATABASE METHODOLOGY FOR COMPLIANCE WITH REGIONALLY AVAILABLE MATERIALS STANDARDS OF LEED™ GREEN BUILDING RATING SYSTEM

By

Sadiq Das

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Construction Management Program

2005

ABSTRACT

DEVELOPMENT OF A DATABASE METHODOLOGY FOR COMPLIANCE WITH REGIONALLY AVAILABLE MATERIALS STANDARDS OF LEED™ GREEN BUILDING RATING SYSTEM

By

Sadiq Das

Green building design is increasingly being considered by designers and builders across the United States. One strategy of green or sustainable design can be to use local or regionally manufactured and extracted materials for construction. The benefits of use of local materials are minimizing environmental and economic costs of transportation and supporting the local economy. This research developed a methodology for creating a database of regionally available materials which is applicable to universities and other large institutional owners and is targeted towards compliance with the "Leadership in Energy & Environmental Design" Green Building Rating System (LEED®). LEED is a sustainable design based system which entails certification processes for "green" buildings. LEED addresses regionally manufactured and extracted materials as well as numerous other sustainable practices. This methodology for development of a database is centered on compliance with the regionally available materials standards of LEED.

The researcher conducted interviews with LEED Accredited Professionals and construction managers, developed a building case study, created a sample database and created a framework outlining the process of developing a database. Additionally, the researcher outlined the process of complying with the regionally available materials standards of LEED and identified high-impact materials for typical institutional buildings.

I dedicate this thesis to my mother who has been the source of inspiration for every accomplishment in my life.

Acknowledgements

Working on this thesis has been an exciting and interesting experience. It was made possible by many individuals who affected my life and work in many different ways.

I am deeply indebted to my advisor Professor Timothy Mrozowski, for his knowledgeable input. Without his advice and help this work would not be possible. I would like to express my sincere thanks to the interviewees for their co-operation and valuable insight. I would like to thank the administrative staff of the Physical Plant Division of Michigan State University, for their time and co-operation and also my thesis committee members, Dr. Tariq Abdelhamid and Dr. David Johnson for their encouragement and expertise.

I would like to thank Nisha Nair for all her support during the highs and lows of this thesis research. I appreciate everything that you have done for me. I would like to acknowledge all my friends who listened to me during my times of frustration.

I would like to thank my parents for their continuous support in every aspect of my life. Lastly, I would like to thank my brother Kazim and his wife Abreez, for their love and encouragement. You always made me feel at home in spite of being thousands of miles away from home.

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CHAPTER 1

1.1 Introduction

Buildings have a significant impact on many of the environmental problems faced by our society and play an important part in shaping the lifestyle and health of its users. Sustainable or "green" design provides healthy and environmentally sensitive methods of building construction. "Green" or "sustainable" buildings use resources such as water, materials, energy and land more efficiently than buildings which are simply built to minimum code. "Green" buildings are sensitive to:

- "Environment
- Resource and energy consumption
- Impacts on people (quality and healthiness of work environment)
- Financial impact (cost effectiveness from a full financial cost-return perspective)
- The world at large" *(www.usgbc.org, date visited :January, 2005)*

One of the important methods of sustainable construction is using materials which are produced or extracted in close proximity to a project site and are based on the natural resources present within the region. The focus of this thesis is to develop a framework for development of a database of regionally manufactured materials for design and construction of institutional buildings.

Building construction undergoes frequent change with respect to building technology and improved building performance. Most of these changes are directed toward improving the quality of life of users through innovations in building design, efficient use of resources and creation of healthier environments. The need to build in order to accommodate the needs of populations has resulted in an increase in consumption of natural resources and production of waste which is harmful to the

environment. The resultant depletion of natural resources, large scale deforestation, pollution of air and rivers and destabilization of climate has made the construction industry explore new technologies and methods in order to build for a sustainable future.

1.2 Problem Statement

The life span of a building consists of its design, construction, operation and demolition or salvage. The decisions made at the first phase of building design and construction can significantly affect the costs and efficiencies of later phases. "Viewed over a 30 year period, initial building costs account for approximately two percent, operations and maintenance costs equal six percent while personnel costs equal 92 percent of the total costs incurred by the building" [Romm J., 1994].

A building goes through the following phases during its lifetime:

- Conceptualization phase
- Design phase
- Construction phase
- Occupancy phase
- Post occupancy phase

In order to construct energy-efficient "green" buildings, sustainability goals should be incorporated from the initial phases of conceptualization and design. Such an approach could result in innovations in construction techniques, material selection with environmental sensitivity and better all round efficiency in the construction process. "Careful selection of environmentally sustainable building materials is one way for architects and designers to begin incorporating sustainable design principles in buildings" [Jong-Jin Kim, et al., 1998].

1.3 Need Statement

"Green" design differs from conventional building design methods in terms of initial costs and the savings that are achieved over the life span of the building. Although building "green" could mean higher initial costs, the benefits of better building performance during operation of the building are considerable. "Minimal increases in initial costs of about 2% to support green design would, on average, result in life-cycle savings of 20% of total construction costs" [Kats G., et.al., Oct, 2003]. "Green buildings consume 10% to 50% less energy than traditionally constructed buildings" [Alvey J., 2003]. "The financial benefits of green buildings include reduced energy consumption and their associated costs, increased occupant productivity and worker retention, increased market values, and reduced health liability risks due to better indoor air quality" [Paumgartten P., 2003].

Use of locally produced materials during construction, siting a building on a location with existing infrastructure, efficient storm water drainage system, recycling used materials, efficient use of natural sources such as wind and sun for ventilation and heating respectively are examples of green building design.

Green building design is being considered as a part of the strategy for achieving sustainability goals at universities. Universities such as Carnegie Mellon University, Massachusetts Institute of Technology and the State University of New York at Buffalo are making an effort to incorporate sustainability goals in their respective environmental and building construction policies *(Refer to Appendix B)*.

Universities function as mini-cities consisting of office buildings, restaurants, retail shops, sports facilities, entertainment complexes, residential complexes and

schools. With the rise in enrollment along with an increase in energy costs and demands for better amenities such as air-conditioning, heating and ventilation, high-speed internet connection and healthy indoor environments, universities are continuously constructing new facilities to counter their growing needs. Figure 1.1 displays percent increase in education construction as compared to total non-residential construction from 1982 to 2002.

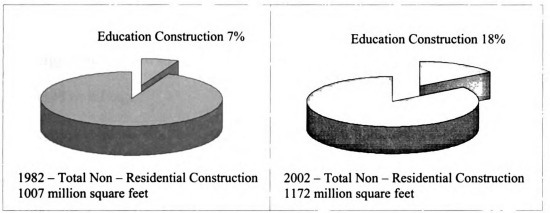

Figure 1.1 Increase in volume of Education Construction from 1982 to 2002
(source: McGraw Hill Construction Dodge's Special Sector Study)

In 1982, total education construction accounted for 7% of the 1,007 million square feet (msf) of the total non-residential construction in the US. In 2002, out of the 1,429 msf of non-residential construction total education construction has risen to 18% (McGraw Hill Construction, 2003). With these figures expected to grow with increasing number of enrollments, incorporating sustainability goals into their construction methods could prove to be beneficial for universities.

A number of sustainability guides and assessment and rating systems are available, which provide detailed performance standards for construction of buildings. A summary description of these performance standards and rating systems is provided in section 2.3 of this document. These standards emphasize integration of environmental

concerns with cost and other design criteria, in order to provide an energy efficient building. Careful selection of materials and their sources of origin is an important part of sustainable building design. Sustainable building materials can have the following characteristics,

- Durable
- Non-toxic
- Improve indoor environment quality
- Energy efficient or water efficient
- Reused or salvaged
- Recycled content
- Rapidly renewable
- Biodegradable or recyclable
- Locally manufactured

The selection of materials for any project depends upon the design criteria and climatic conditions prevalent at the building site. The selection of materials may depend upon the proximity of the jobsite to their manufacturing source as well. "Apart from reducing the significant environmental impacts of transporting materials over long distances, selecting local sources or vendors for building materials aids in development of a local economy" [Malin N., 1996]. Development and maintenance of information about building material alternatives, manufacturing sources and vendors could help builders employ sustainable materials in construction efficiently.

The United States Green Building Council (USGBC) developed the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™. The LEED

Rating System provides a detailed outline of suggested building and management techniques as standards which are required to be followed in order to obtain different levels of certification. Topics such as sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor air quality and innovative design have been addressed as sections containing standards for compliance.

The Materials and Resource section of the LEED™ Rating System includes credits MR 5.1 and 5.2 which require procurement of locally manufactured or extracted materials for building construction. In order to achieve certification for this credit, 20% of the total materials used for the project should be manufactured within 500 miles of the project site. 50% of those materials are required to be extracted within 500 miles to achieve credit 5.2.

LEED also requires the project team to submit documentation supporting the calculation of materials. "The documentation for LEED projects could cost up to $ 30,000 for project teams without experience in LEED certification" [Cooper G., 2002]. Developing frameworks which provide the methodology for achieving LEED credits could result in savings in management costs and time for the project team. This thesis provides a framework for development of a database of regional manufacturers in Michigan to aid in achieving the above mentioned credits for institutional buildings. Such a database can be used when specifying materials for a construction project. Manufacturers for materials are listed in the database according to CSI divisions. The incorporation of the database into the project during the conceptual planning stage could be helpful to the project team in making effective decisions early in the project. As shown in the Figure 1.2, the database would however, require periodic updating to reflect

changes in manufacturers or sources of building materials and equipment within the specified region.

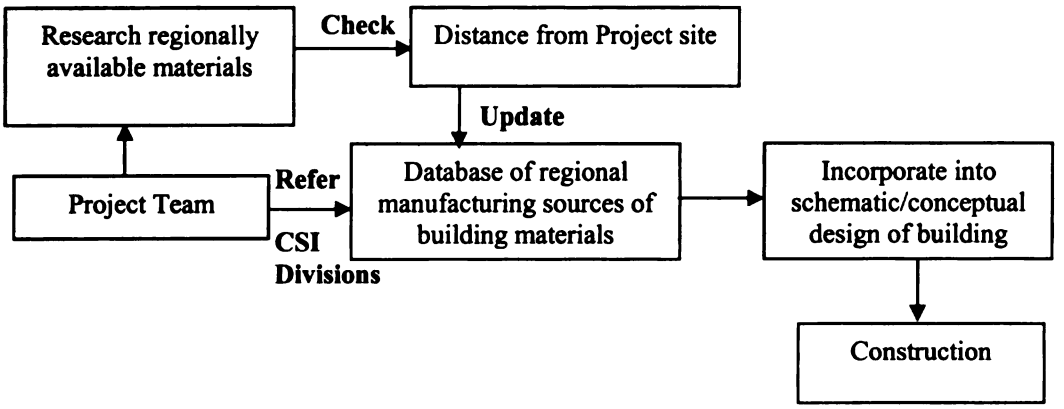

Figure 1.2 Utilization of Database during Construction

1.4 Research goals and objectives

1.4.1 Goals

The goal of this research is to facilitate the use of sustainable design processes by encouraging and aiding in the use of local materials in construction projects.

1.4.2 Objectives

The specific objectives of the research which were designed to aid in meeting the goals identified above were as follows:

- To create a framework for development of a database of locally manufactured materials which could aid in achieving compliance with credits MR 5.1 and 5.2 of the LEED Green Building Rating System™
- To develop recommendations for universities and other institutions for achieving compliance with MR 5.1 and 5.2 and creating their own database.

These objectives were accomplished by using the following procedures:

- Reviewed existing literature on LEED (Leadership in Energy and Environmental Design) Green Building Rating System™, LEED-NC Reference Guide, research papers and articles on LEED compliance
- Conducted interviews with LEED Accredited Professionals and construction managers who have been involved in LEED certification of buildings to obtain information about LEED certification practices
- Gained information about design and material procurement methods at universities through open-ended interviews with staff members from a case study university who are responsible for the administrative management of construction projects
- Procured building material data for a case study building (located on Michigan State University campus) in order to identify high impact materials when complying with LEED credits MR 5.1 and 5.2 for a typical institutional building
- Developed an example database of local manufacturers for building products and materials, within Michigan, using East Lansing, Michigan as the focal point in order to investigate appropriate methods of development of a database
- Developed a framework for development of a database for complying with LEED credits MR 5.1 and 5.2
- Developed recommendations for implementation of LEED certification criteria for MR credit 5.1 and MR credit 5.2 into with an emphasis on university construction

1.5 Research Scope

The research study developed an example database of regionally manufactured building materials classified according to the Construction Specification Institute (CSI)

format with East Lansing, Michigan as its focal point. The research used www.thebluebook.com, as the primary source of manufacturer or vendor information for calculation of distances from manufacturing locations for the database since MSU was used as the case study for the research. The researcher does not claim that the database contains every available manufacturer in Michigan. The information for location of extraction of materials was not available for a number of products. The data for location of extraction was included in the database wherever it was available.

CHAPTER 2

2.0 Introduction

In order to understand the importance of sustainability and energy conservation, it is essential to know about the impacts of modern day life on the environment. The literature review is divided into the following sections which provide an overview of sources of energy related problems, the measures that are being undertaken in response to those problems, green building rating systems and current research. The literature review addresses the following areas:

1) Levels of energy consumption
   - Global energy issues
   - United States of America energy consumption statistics
   - Impact of buildings
2) Green Buildings
   - Definition
   - Benefits of green building design
   - Procurement of regionally manufactured materials
   - Related studies and applicable research
3) Green Building Rating and Certification Systems
   - BREEAM - Building Research Establishment Environmental Assessment Method
   - Minnesota Sustainable Design Guide
   - The Green Building Challenge (GBC) assessment framework (GBTool)
   - LEEDTM – Leadership in Energy and Environmental Design
4) LEED 2.1 Rating System
   - Constituents

- Credits and points system

5) Related studies and applicable research

6) Description of Credit MR 5.1 and MR 5.2 of the LEED 2.1 Rating System

   - Intent
   - Requirements (Compliance and Document submittals)
   - Strategies for implementation of the credit

2.1 Levels of energy consumption

2.1.1 Global Issues

Energy consumption is a significant problem facing the world as it enters the 21st century. With large scale depletion of natural resources, deforestation and considerable destabilization of the environment, the need to co-exist with nature in order to preserve our surroundings has gained importance. Energy consumption throughout the world has increased during the past century with further increases estimated for the future.

2.1.2 Energy Consumption levels in the US

The United States consumes approximately 25 percent of the world's total energy even though it holds only 4.6 percent of the world's population as shown in Figure 2.1 below. Energy consumption is expected to grow at a higher rate due to increasing demands.

World Primary Energy Consumption and Population, Country/Region										
							Annual Growth Rate			
	Energy Consumption (Quad)			Population (million)			1990 - 2000		1990 - 2000	
Region/Country	1990	2000	2010	1990	2000	2010	Energy	Pop.	Energy	Pop.
United States	84.6	99.3	113.3	255	276	300	1.6%	0.8%	1.3%	0.8%
Western Europe (1)	59.9	66.8	72.1	377	389	391	1.1%	0.3%	0.8%	0.1%
Former Soviet Union	60.7	40.8	52.7	290	291	283	-3.9%	0.0%	2.6%	0.3%
Other Asia	22.1	36.6	45.8	808	977	1147	5.2%	1.9%	2.3%	1.6%
China	27.0	37	54.4	1155	1275	1366	3.2%	1.0%	3.9%	0.7%
Japan	17.9	21.8	23.8	124	127	128	2.0%	0.2%	0.9%	0.1%
Central & S. America	14.4	21	25.2	357	420	482	3.8%	1.6%	1.8%	1.4%
Middle East	13.1	20.3	25.0	191	242	295	4.5%	2.4%	2.1%	2.0%
Canada	11.0	13.2	15.3	28	31	33	1.8%	1.0%	1.5%	0.6%
India	7.8	12.7	16.9	845	1009	1164	5.0%	1.8%	2.9%	1.4%
Africa	9.3	11.9	14.4	619	794	997	2.5%	2.5%	1.9%	2.3%
Eastern Europe	15.6	11.3	13.1	122	121	119	-3.2%	-0.1%	1.5%	-0.2%
Mexico	5.0	6.2	8.6	83	99	113	2.2%	1.8%	3.3%	1.3%
World Total	348.4	398.9	480.6	5255	6049	6817	1.4%	1.4%	1.9%	1.2%
Notes: 1) Germany consumed (quads) 14.2, France 10.4, United Kingdom 9.8 and Italy 8.0										
Sources: EIA, Internation Energy Outlook, May 2003, Table A1, p.181 and Table A15, p. 196										

Figure 2.1: World Primary Energy Consumption and Population, by Country/ Region
(source: Office of Energy Efficiency and Renewable Energy Buildings Energy Databook, 2003)

2.1.3 Impact of Buildings

Due to the growth in population, the number of buildings being built every year is increasing. Buildings are responsible for the largest share of energy consumed in the US. As shown in Figure 2.2, commercial and residential buildings together, utilize approximately 40% of the total energy consumed in the US (DOE Energy Databook, 2003).

Buildings Share of U.S. Primary Consumption (percent) (1)							Total Consumption (quads)
	Residential	Commercial	Total Buildings	Industry	Transportn.	Total	
1980	20%	14%	34%	25%	25%	100%	74.5
1990	20%	15%	35%	27%	27%	100%	84.1
2000	21%	17%	38%	27%	27%	100%	99.4
2001	21%	18%	39%	28%	28%	100%	97.4
2005	21%	18%	39%	28%	28%	100%	103.2
2010	20%	18%	38%	29%	29%	100%	113.3
2020	19%	18%	37%	31%	31%	100%	130.2
2025	18%	18%	37%	32%	32%	100%	139.2

Note(s): 1) Buildings-related energy consumption in the industrial sector in 1991 was 1.96 of 31.76 quads; for comparison, 2001 industrial sector energy use was 32.67. 2) Renewables are not included in the 1980 data

Source(s): EIA, State Energy Data 2000, April 2003, Tables 8-12, p. 18-22 for 1980 and 1990; and EIA, Jan 2003, Table A2, p. 120-122 for 2000-2025 data and Table A18, p. 143 for non-marketed renewable energy.

Figure 2.2: Buildings Share of U.S. Primary Energy Consumption
(source: Office of Energy Efficiency and Renewable Energy Buildings Energy Databook, 2003)

Approximately 70% of the total electrical energy is consumed in buildings as shown in Figure 2.3. In the United States, construction and material production account for roughly 9 percent of energy use, and buildings operation accounts for approximately 30 percent of U.S. energy consumption [Abraham L., Agnello S., Ashkin S. et. al., 1996].

	Buildings Share of U.S. Electricity Consumption				
	Res	Com	Bldgs	Indtry	Trans
1980	34%	27%	61%	39%	0%
1990	34%	31%	65%	35%	0%
2000	35%	34%	68%	31%	1%
2001	35%	35%	70%	29%	1%
2010	35%	36%	71%	28%	1%
2020	34%	37%	71%	28%	1%
2025	33%	38%	71%	28%	1%

Figure 2.3: Building Share of U.S. Primary Electricity Consumption
(source: Office of Energy Efficiency and Renewable Energy Buildings Energy Databook, 2003)

In the United States, buildings also account for:

- 30% of greenhouse gas emissions
- 30% of raw materials use
- 30% of waste output/136 million tons annually
- 12% of potable water consumption

(www.usgbc.org, date visited: January, 2005)

"The construction industry constitutes the nation's largest manufacturing activity which contributes more than a trillion dollars to the U.S. economy" (US Census Bureau, 2004). Because of the building industry's significant impact on the national economy, even modest changes that promote resource efficiency in building construction and operations can make major contributions to economic prosperity and environmental performance.

The impact of buildings on the economy has prompted the construction industry to develop new technologies which enhance the performance of buildings. "Green" or sustainable design is being promoted as one of the solutions to counter the present energy problems. "With increased energy conservation and the adoption of diverse energy efficient technologies in areas such as transportation, residential energy use and the food system, the US economy could save approximately 33% of its current energy consumption which would save US citizens, approximately $438 billion per year" [Pimentel D., et.al., 2004]. An important step in achieving increased energy conservation is to construct buildings which consume less amounts of energy and sustain healthier environments for their occupants.

The Union Internationale des Architects/American Institute of Architects (UIA/AIA) World Congress of Architects recognized in its 1993 Declaration of Interdependence, that buildings and the built environment play a major role in the human impact on the natural environment and the quality of life. If sustainable design principles are incorporated into building projects, benefits can include resource and energy efficiency, healthy buildings and materials, ecologically and socially sensitive land use, transport efficiency, and strengthened local economies and communities [Abraham L., Agnello S., Ashkin S. et. al., 1996].

2.2 Green Building

"A "green" building is a design which performs more efficiently than traditionally designed buildings in methods of building construction, materials utilized during construction, building functionality and system performance, energy and water efficiency, quality of the indoor environment (air quality, thermal comfort, lighting), waste management and air emissions, site disturbance and storm water management, transportation options for occupants and longevity (durability, adaptability to changing building user needs)" [Paumgartten P., 2003]. "It's an open-ended definition that could include products made from recycled content, equipment that requires less energy to manufacture, products that improve indoor environmental quality by reducing toxic off-gassing or simply energy-efficient products or systems" [Posson D.G., 2003].

The life span of a building consists of various stages such as planning, design, construction and operation and the final stage of reuse or demolition. The main direct cost expenditures are realized during construction, renovation and operation while

indirect costs arise from building-related occupant health and productivities, as well as external costs such as air pollution, waste generation and habitat destruction.

Construction of green buildings might increase initial costs but the savings that are achieved over the life-span of the building can be considerable. "Many studies have shown that green building construction could increase upfront costs by as much as 2 percent with the resultant savings of 20 percent over the life-span of the building" [Kats G., et.al., 2003]. Designing buildings with green principles can result in savings in the areas of energy efficiency, water efficiency, waste reduction, construction, building operations and maintenance, insurance and liability and improves occupant health and productivity, building value and local economic development opportunities.

2.2.1 Green Building Benefits

"As much as 60 percent of the heating and cooling energy and 50 percent of the lighting energy consumed by U.S. buildings can be saved by using climate-sensitive design and available technologies" [Rodman D. and Lensen N., 1996]. Water-efficient appliances and fixtures, behavioral changes and changes in irrigation methods can reduce consumption by up to 30 percent or more [Abraham L., Agnello S., Ashkin S. et. al., 1996]. Efficient use of recyclable materials such as gypsum, glass, carpet, aluminum, steel, brick and recycling of debris can result in considerable waste reduction. Adaptive reuse of older structures instead of razing and construction of a new building can result in financial savings for users. Green buildings can result in lower operating expenses through reduced utility and waste disposal costs as well as lower building maintenance costs.

Selecting green building materials which have low to zero volatile organic compounds (VOC) emission, integrated ventilation systems, effective building envelopes and efficient management during construction or renovation are some of the measures that can help improve indoor air quality. "Recent studies have shown that buildings with good overall environmental quality, including effective ventilation, natural or proper levels of lighting, indoor air quality, and good acoustics, can increase worker productivity by six to 16 percent" [Romm J., 1994]. Consequently, a high level of performance and efficiency exhibited by green buildings can result in higher property values. Lower operating costs associated with more efficient systems can lead to higher building net income. "The value of a building is greatly increased for owners with rental premises, if the tenants view green properties as more desirable" [Abraham L., Agnello S., Ashkin S. et. al., 1996].

2.2.2 Procuring regionally manufactured materials

Use of local materials is an important strategy for sustainable design. Sustainable buildings are designed with the goal of developing a project which responds to conditions of the location at which the building is situated. Different locations have varying topography, soil type, mineral deposits, etc. which calls for building designs which are sensitive to these variations. Local materials are often better suited to climatic conditions. The economy of a region depends on the materials that are available within the region. Local manufacturers extract materials within the region and using these materials for construction supports local economies. Using local materials has the obvious benefit of reducing the significant environmental impacts of transporting materials long distances. "It has some less tangible benefits as well, such as encouraging vernacular building

styles, supporting the local economy, and connecting users directly with the impacts of their choices." [Malin N., October 1996]

Using locally produced materials has various environmental impacts which need to be considered while procuring materials. Section 2.3.1.4 includes literature on green building systems that have formulated standards for procurement of regional materials. The selection of a material for any project depends largely upon its performance throughout the life-cycle of the building. For some cases, the use of a locally manufactured material may not be the best possible option. Local manufacturers often produce materials in smaller quantities as compared to large centralized plants. Larger companies may employ better technologies during the manufacturing process which results in less waste material and more efficient use of raw materials. Designers need to consider these trade-offs before using local materials for projects. It is not always possible to use locally available materials in every aspect of a building project. "But if materials must be imported they should be used selectively and in as small volumes as possible" [Malin N., October 1996].

The key issues that need to be considered while using locally manufactured materials are,

- The feasibility of using the material over its life-cycle
- Checking the distances that the product has traveled from extraction to final installation
- Properties of material such as recycling, efficiency and performance standards, etc.

- Frequent trips between a project site and manufacturing location result in extra use of fuel. The delivery process should be consolidated to ensure fewer trips consisting of larger loads
- Ensure that vehicles operating for delivery are using optimum standards for fuel efficiency [Malin N., October 1996]

2.3 Green Building Rating and Certification Systems

"Green building rating and certification systems are intended to foster more sustainable building design, construction and operations by promoting and making possible a better integration of environmental concerns with cost and other traditional decision criteria" [Trusty W., Horst S., 2004]. This task is approached by various building assessment systems based on different parameters for measurement of performance and efficiency, with certain elements common among those systems. Green building rating and certification systems address aspects of design, construction and operation of buildings consisting of site selection and orientation, energy efficiency, water efficiency, waste management during construction and operations, selection of environmentally preferable materials, improved indoor environment and integrated management plans for buildings.

2.3.1 Rating and Certification Processes

Green building rating systems analyze construction methods, performance and efficiency of buildings for tasks carried out during the design and construction of the building. Some rating systems grade buildings based on a system of credit points. Individual buildings can achieve different levels of certification by gaining a certain number of credit points. These credits can be achieved by complying with the green

standards specified in the rating system. Based on the standards, one or more points can be allotted for every innovation or change that is made in the construction method of the building in order to gain compliance with green standards.

Some of the green building rating systems or green building assessment standards which have been developed over the past few years are listed below.

1) BREEAM - Building Research Establishment Environmental Assessment Method
2) Minnesota Sustainable Design Guide
3) The Green Building Challenge (GBC) assessment framework (GBTool)
4) LEED™ – Leadership in Energy and Environmental Design

2.3.1.1 BREEAM - Building Research Establishment Environmental Assessment Method

The BREEAM Assessment tool was developed by the Environmental Assessment Consortium (EAC) based in the United Kingdom. EAC is a multidisciplinary group of expert consultants that specialize in environmental design and energy efficiency. The BREEAM tool was developed by the EAC after conducting construction and environmental research carried out at the Building Research Establishment Ltd. (BRE), together with the input and experience of the construction and property industries, government and building regulators. "BREEAM is a tool that allows owners, users and designers of buildings to review and improve environmental performance throughout the life of a building" *(http://www.breeam.com/, date visited: October, 2004)*. The first version was developed in 1990 and was applicable for new office buildings. The subsequent versions incorporated standards which were applicable for other areas such as

new departmental stores and supermarkets, new homes, existing offices, new industrial units, etc. It is a scheme that sets a benchmark for environmental performance and provides a wide range of benefits.

Benefits that can be achieved through the use of the BREEAM tool are as follows,

- "Financial benefits - reduced energy and other running costs, improved staff productivity, making office buildings more lettable and potentially higher rental incomes
- Publicity benefits - making offices more attractive to potential customers or tenants, demonstrating environmental commitment or improving environmental performance
- Benefits to management - providing a thorough checklist for benchmarking building performance and property portfolios, setting realistic targets for improvement, providing support to wider corporate management strategies
- Benefits to staff and building users - creating a better place for people to work more productively, providing a healthier, more comfortable indoor environment"

(http://www.breeam.com/, date visited: October, 2004)

The method of assessment established by BREEAM begins before the design brief for the building is prepared. A BREEAM assessor becomes involved in the project during the early stages of the project in order to guide the design team through the design and management processes. Assessments are carried out by independent assessor organizations that are licensed and trained to complete assessments. Each assessment achieves a BREEAM rating and certificate on the basis of their performance against the standard.

"BREEAM is flexible and can be applied to provide a benchmark of environmental performance at any stage of the building's life cycle, through assessment against the three principal components of Design and Procurement, Core and Management and Operation" *(http://www.breeam.com/, date visited: October, 2004).*

During the Design and Procurement stage of the project, assessment of project commissioning, thermal comfort, predicted noise, building materials selection, re-use of facades and specification of thermal insulation materials is conducted. "It also includes an assessment of sub-elements of land-use (contaminated land, remediation, etc) and ecology (habitat diversity, habitat enhancement etc)" *(http://www.breeam.com/, date visited: October, 2004*). Core issues are addressed during both Design & Procurement and Management & Operation Assessments and cover essential elements of important environmental topic areas including health & well-being, energy, transport, water, materials and pollution.

The Management and Operation part of the assessment is carried out for buildings that are currently occupied and in operation. It provides professionals with an independent audit of the manner in which the existing building is being managed. "It includes an assessment of those elements that are considered to be of relevance to the management and operation of a building, such as environmental policies, environmental management systems (EMS), domestic hot water system design and maintenance, energy consumption, monitoring, targeting, heating system design and maintenance and transport policies" *(http://www.breeam.com/, date visited: October, 2004).*

2.3.1.1.1Use of Local materials

BREEAM uses the BRE Environmental Profiling methodology to measure environmental performance of a material through its life-cycle. The system has been developed by the BRE and it measures impacts of a material in 12 areas:

1) Climate change
2) Fossil fuel depletion
3) Ozone depletion
4) Human toxicity to air
5) Human toxicity to water
6) Waste disposal
7) Water extraction
8) Acid deposition
9) Ecotoxicity
10) Eutrophication
11) Summer smog
12) Minerals extraction [Lazarus N., 2002].

Material impact is evaluated by comparing with the average impact of a United Kingdom (UK) citizen and giving a score known as an 'Ecopoint' score. 100 Ecopoints represents the total environmental impact of an average UK citizen which is measured by dividing the impacts of UK by its population. A low Ecopoints score represents low environmental impact. The scores in each of the 12 areas are brought together using a subjective weighting system based on a consultation exercise with a broad range of interest groups.

The performance standards use a scale ranging from -2 to +5. A score of zero is the minimum acceptable performance as defined by regulations or industry standards within the region, while a score of 5 represents a performance target that is considerably better than of current practice. National teams are responsible for defining what this performance target represents but it should be one that is potentially achievable with current technologies, based on reasonable extrapolation from current practices, but without consideration of cost effectiveness. A score of -2 represents unsatisfactory performance which is clearly below accept industry standards.

2.3.1.2 Minnesota Sustainable Design Guide

The Minnesota Sustainable Design Guide (MSDG) is a tool which is designed to help people learn about sustainability, manage design decisions and integrate sustainable design into the building design and operation processes for new and renovated facilities. Like other green building rating and assessment tools, the MSDG specifies performance standards to guide the design and decision-making process. MSDG builds on other rating systems such as LEED™, Green Building Challenge '98 and BREEAM. The MSDG provides ecological resources and a step-by-step process to implement sustainable design practices.

The Design Guide provides 42 strategies that are organized according to six environmental design topics as follows,

- Site
- Water
- Energy
- Indoor environmental quality

- Materials
- Waste

(http://www.sustainabledesignguide.umn.edu, date visited: July, 2004)

Each topic contains a series of design strategies that address the related sustainable design issues. In addition, each strategy has performance indicators, which set the benchmarks that must be met in order to obtain credit for the strategy. The guide also contains a scoring system that enables the design team and building operators to evaluate building performance. Each strategy is awarded points based on specific performance indicators. One hundred points are distributed among the strategies according to the perceived environmental and human impacts as well as priorities of the Minnesota region. Since some strategies apply only to certain projects (i.e. renovations versus new construction, urban versus rural sites, etc.), the scoring system can be tailored to reflect the opportunities and constraints of the project. The system is designed to be used on web sites accessible to agency staff and architectural consultants, or as software distributed to project teams.

The goals of the Design Guide are to:

1) "Educate designers, building owners, operations staff, and occupants about the concepts, goals, and significance of sustainable design
2) Develop an orderly decision-making process with measurable outcomes along with a database of decisions and outcomes on each project
3) Provide flexibility in the way priorities are set and outcomes are measured within the system so it can be adapted for different clients or agencies, regions, and building types

4) Organize information in a hierarchy that permits users to easily understand the entire process but then allows them to go into more detailed information as needed to implement the system
5) Create a system that can easily grow and change as more experience and new information becomes available."

(http://www.sustainabledesignguide.umn.edu, date visited: July, 2004)

The major phases and sub-phases included in the MSDG during which sustainability guidance is provided to designers and building managers are as follows,

1) "Planning (Project Initiation, Programming, and Site Selection)
2) Design (Schematic Design, Design Development, and Construction Documents and Specifications)
3) Construction (Bidding and Award, Construction, and Commissioning)
4) Occupancy (Start-up, Operations and Maintenance, and Next Use). A checklist of actions required during each phase of the process is also provided."

(http://www.sustainabledesignguide.umn.edu, date visited: July, 2004)

The design team for an individual project will define a "target score" based on the building type, site, and other characteristics. The target score represents a feasible, yet ambitious, design goal. Since some strategies apply only to certain projects (i.e. renovations versus new construction, urban versus rural sites, etc.) it is important that the "target score" can be tailored to reflect the opportunities and constraints of the project.

2.3.2.1.1 Local materials standards

Strategy 5.5 of the Minnesota Sustainable Design Guide requires procuring materials from regional sources. The requirement of this credit is to procure 25% of total building materials from locations within 250-500 miles of the project site. The strategies proposed for implementation of the credits are as follows,

- "Research materials manufactured within a 250 - 500 mile radius of the project site. Include criteria for location of raw resources
- Develop design strategies that utilize locally manufactured materials
- Research and evaluate the environmental impacts of shipping products and materials. Various life-cycle phases of a material are Raw Material Extraction, Production, Distribution, Installation, Use, and Maintenance, and Eventual Reuse or Recycling. This strategy focuses on the Distribution Phase of the product's life
- Utilize lifecycle tools to study the environmental impacts of shipping
- Survey producers and manufacturers for data on transportation procedures."

(http://www.sustainabledesignguide.umn.edu, date visited: July, 2004)

2.3.1.3 Green Building Challenge Assessment Framework

Development of the Green Building Challenge Assessment method began in 1996 with 14 countries participating in the research and development process. The GBC process was initiated by Natural Resources Canada, but responsibility was handed over to the International Initiative for a Sustainable Built Environment (iiSBE) in 2002 *(http://greenbuilding.ca/, date visited: September, 2004)*. GBTool was developed as a software implementation of the Green Building Challenge (GBC). The system has been developed with a core component reflecting global issues which can be modified by

national teams to reflect energy, environmental and other priorities in specific countries and regions. During 1997 and 1998 it was tested by preparing detailed performance assessments of 34 green buildings from participating countries.

2.3.1.3.1 Features of GBTool *(http://greenbuilding.ca/, date visited: September, 2004)*

The following are the features of GBTool,

- Allows assessments to be carried out at all stages of the life-cycle and provides benchmarks suited to each phase
- Enables architects to carry out self-assessments of their designs, and enables third parties to provide certification of operational performance
- Allows third parties to establish weights to reflect the varying importance of issues by occupancy type in each region
- Allows generic benchmarks to be replaced by local ones, in local languages
- Handles up to three building types, separately or in a mixed-use project
- Handles new and existing construction, or a mix of the two
- Allows comparisons to be made with LEED.

This system is a building performance assessment tool that is designed to allow assessments to be carried out at various phases of the life cycle of a project. Parameters included within the system cover sustainable building issues within the three major areas of environment, social and economic sectors.

2.3.1.3.2 Performance by Phase

The GBT assessment can be carried out in the following four phases of the life-cycle of the building: Pre-Design, Design, Construction and Operations.

- The Pre-Design phase assessment is intended to demonstrate the sustainable performance of the project in the future, based on the information available at the end of the Pre-Design phase.
- The Design phase assessment is intended to indicate the future potential sustainable performance of the project, based on the information available at the end of the Design phase. The Pre-Design and Design phases are likely to undergo some changes during the evolution of the project. These two assessment modules are therefore, primarily intended for self-assessment purposes, and not for certification purposes.
- The Construction phase assessment is intended to provide a relatively factual assessment based on performance indicators available at the end of the construction and commissioning phase before occupancy.
- The Operations phase assessment is intended to provide an objective and factual indication of the actual performance of the project and the results may be useful for certification purposes. It is recommended that the projects should be occupied for a period of at least one year before the "Operations assessment" is carried out. *(http://greenbuilding.ca/, date visited: September, 2004)*

2.3.1.3.1 Local materials standards

GBtool was developed as a system which can be implemented in any region based on the requirements of the project and conditions of the region. "The method of assessment for materials used for any project is based on measuring the Embodied Energy Content (EEC) of the material using Life-cycle Assessment (LCA) procedures" [Lazarus N., 2002]. BREEAM, which is widely used in the United Kingdom, is based on the LCA method as well.

"The embodied energy of a material is the energy required to extract, process, manufacture and deliver it" [Lazarus N., 2002]. LCA examines the total environmental impact of a material from obtaining raw materials through manufacture, transport to a store, using it in the building and disposal or recycling. The analysis of materials using GBtool is carried out by calculating the embodied energy content of the material expressed in Giga-joules (GJ) using an assumed life-span of 75 years for the building. The energy content is measured for various stages of the life-cycle of the material from production through operation and disposal or recycling [Lazarus N., 2002].

2.3.1.4 Leadership in Energy and Environmental Design (LEED™)

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® was developed by the U.S. Green Building Council (USGBC) as a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. LEED standards are currently available or under development for:

- New commercial construction and major renovation projects (LEED-NC)
- Existing building operations (LEED-EB)
- Commercial interiors projects (LEED-CI)
- Core and shell projects (LEED-CS)
- Homes (LEED-H)
- Neighborhood Development (LEED-ND)

(www.usgbc.org, date visited: January, 2005)

LEED provides a framework for assessing building performance and meeting sustainability goals. LEED™ has defined analytical methods for evaluation of environmental performance of buildings. This evaluation is based on a table which allots

points for measures undertaken to achieve compliance with the set standards. LEED™ 2.1 system addresses six categories of evaluation:

- Sustainable Site
- Water Conservation
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation & Design Process

Within these categories the system contains minimum prerequisites that all projects must address and discretionary measures. LEED™ 2.1 contains seven prerequisites and sixty nine discretionary measures. A project is broken down based on these categories and allotted points according to the measures addressed by the design. Based on the total points accumulated by the design of the building which includes all the measures undertaken as prescribed by the LEED Rating System, the building is rated in the following levels of certification as shown in table 2.1.

Level of Certification	**LEED 2.1**
Total available measures	69
Basic Certification	26
Minimum for Silver	33
Minimum for Gold	49
Minimum for Platinum	52

Table 2.1: LEED™ Certification Levels

(source: www.usgbc.org, date visited: January,2005)

USGBC identifies the following as its goals for the creation of the LEED Rating System:

- "To define "green building" by establishing a common standard of measurement

- To promote integrated, whole-building design practices
- To recognize environmental leadership in the building industry
- To stimulate green competition
- To raise consumer awareness of green building benefits
- To transform the building market" *(www.usgbc.org, date visited: January, 2005)*

Various aspects of building design are addressed within the six categories of the LEED Rating System. The Sustainable Sites category includes erosion and sedimentation control, urban and brownfield redevelopment, modes of alternative transportation, storm-water management, heat island effect, etc. The Water Efficiency category addresses issues such as water efficient landscaping, innovative wastewater technologies and reduction in water use. The Energy and Atmosphere category includes building systems commissioning, minimum energy performance, cfc reduction in HVAC equipment, optimizing energy performance, use of renewable energy, ozone depletion and green power *(LEED 2.1 Rating System, November 2002).*

The Indoor Environmental Quality (IAQ) category addresses issues such as minimum IAQ performance, environmental tobacco smoke control, carbon dioxide monitoring, constriction IAQ management plan, low-emitting materials, controllability of perimeter and non-perimeter systems, thermal comfort compliant with ASHRAE 55-1992 and daylight access for spaces within the building. The Innovation and Design process category awards credits points for innovations in design *(LEED 2.1 Rating System, November 2002).*

The Materials and Resources category of the LEED Rating System deals with procurement of building materials. The prerequisite for this category of credits is

provision of a recycling and storage area in the building for collection and separation of waste such as paper, corrugated cardboard, glass, plastics and metals. Other credits cover building reuse, construction waste management, resource reuse, recycled content, local or regional materials, rapidly renewable materials and certified wood *(LEED 2.1 Rating System, November 2002).*

2.3.2 Related studies and applicable research

The LEED Rating System has been in use since June, 2001 when version 2.0 was released for assessment of buildings. This section of the literature review addresses previous research on the LEED Rating system.

California's Sustainable Building Task Force published a report in October, 2003 titled, "The Costs and Financial Benefits of Green Buildings" which analyzed the financial implications of using the LEED Rating System in the US. The study addressed by the report included an analysis of 33 LEED certified buildings consisting of 25 office buildings and 8 school buildings [Syphers G., Baum M., et.al., October, 2003].

The analysis compared the costs of constructing the 33 buildings using conventional design with the costs of constructing a LEED certified building. Several building representatives and architects were contacted to secure the cost of 33 green buildings which were compared to conventional designs for those buildings. "The average premium for the green buildings was slightly less than 2%, substantially lower than is commonly perceived. The majority of this cost is due to the increased architectural and engineering (A&E) design time necessary to integrate sustainable building practices into projects" [Syphers G., Baum M., et.al., October, 2003].

Figure 2.4 shows the cost premiums related to the level of certification of the buildings under consideration. "The cost of implementing LEED standards ranges from 0.66% to 6.5 %. The cost/square foot for commercial construction in California is $150 to $250 which would require a cost premium of $3 to $5 /square foot" [Syphers G., Baum M., et.al., October, 2003]. These costs when compared with the savings that can be achieved through the life-cycle of the building could prove to be minor increases. Although, these figures reflect the cost factors of building in the state of California, similar cost trends may be possible in other states. The cost of green design also tends to decline with experience in design and development.

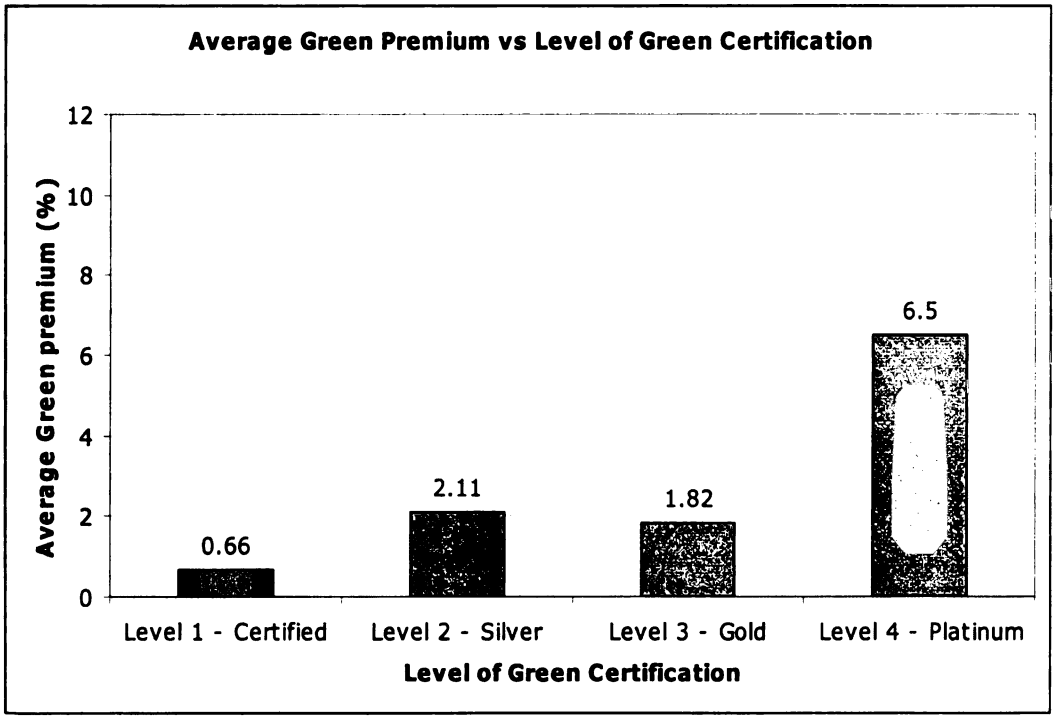

Figure 2.4: Cost Premium Percentage for LEED™ certification levels
(source: Syphers G., Baum M., et.al., October, 2003)

2.3.2.1 Influence of location on LEED cost

In order to study the impact of climate on cost and feasibility of LEED certified buildings, a research study was conducted which took the design of the Bren School

(LEED 1.0 Platinum) on University of California, Santa Barbara campus and placed it into five hypothetical settings around the country. For the purpose of the study, the base building design was kept constant instead of optimizing the design for different climates in order to minimize the variables.

The climates selected were:

- Mild Coastal – Santa Barbara and San Fransisco
- California Central Valley – Merced
- Gulf Coast – Houston
- Northeast Coast – Boston
- Rocky Mountains - Denver

[Langdon D., July 2004]

Table 2.2 displays initial additional cost as a percentage of starting budget to reach each specified level of LEED.

	Platinum	**Gold**	**Silver**
UCSB	7.8 %	2.7 %	1.0 %
San Fransisco	7.8 %	2.7 %	1.0 %
Merced	10.3 %	5.3 %	3.7 %
Denver	7.6 %	2.8 %	1.2 %
Boston	8.8 %	4.2 %	2.6 %
Houston	9.1 %	6.3 %	1.7 %

Table 2.2: Increase in Initial Cost for each Certification Level in Different Locations
(source: Langdon D., July 2004)

The research found that not only are the premiums different by location, but there is also a wide variation in the steps between levels. For example, Silver has a lower premium in Houston compared to Merced, but Gold has a higher premium. The study concluded that

when considering cost and feasibility for pursuing LEED certification of any building, it is important to:

- "Understand the feasibility of each point for the project
- Understand the factors affecting cost and feasibility"

[Langdon D., July 2004]

The cost to achieve LEED certification depends upon a variety of factors such as,

- "Type and size of project
- Timing of introduction of LEED as a design goal or requirement
- Level of LEED certification desired
- Composition and structure of the design and construction teams
- Experience and knowledge of designers and contractors or willingness to learn
- Process used to select LEED credits
- Clarity of the project implementation documents
- Base case budgeting assumptions."

[Syphers G., Baum M., et.al, 2003]

The cost of achieving compliance varies for each of the sections included in the LEED Rating System. The use of locally harvested and/or produced materials is usually neither difficult nor costly for most projects to achieve. "The difficulty of achieving this credit lies more with documentation than with the actual specification; once the contractor develops a documentation procedure, meeting the points becomes relatively straightforward" [Langdon D., 2004].

Research titled, 'Leadership in Energy and Environmental Design (LEEDTM) and Higher Education – Planning for Documentation and Communication' [Cooper G.,

2002] was conducted in 2003. The research conducted 27 surveys for registered and certified projects under the category of 'Higher Education'. The project teams for each of these projects were asked questions regarding their methods for achieving certification and the problems faced during the certification process. "LEED documentation was considered to be one of the most time consuming and confusing aspects of the certification process" [Cooper G., 2002].

The LEED 2.1 Rating System was introduced to reduce the burden of documentation on project teams using designed templates and software tools. Teams that are working on their first LEED project, often report costs in the range of $30,000 to $60,000. The new system was expected to reduce the documentation cost by half as a result of the version 2.1 updates [Cooper G., 2002]. An experienced design and construction team can complete documentation at a cost of $ 8,000 to $ 14,000 in additional fees [Gonchar, 2002].

A significant amount of effort during documentation goes into obtaining information that is required by LEED. LEED templates provide details about the submittals that are required for certification of each credit. It is important however, to include these requirements into the project outline at the beginning of the project. It could prove beneficial to develop system frameworks which address the problems that are faced by project teams during the documentation process.

2.3.3 LEED 2.1 Rating System – Credit MR 5.1

This credit addresses use of local materials during construction of a building. The credit is intended to promote development of the local economy and reduction in environmental impacts of transportation *(www.usgbc.org, date visited :January, 2005).*

2.3.3.1 Intent

The intent of this credit outlined by the LEED Rating System is to – "Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation" *(www.usgbc.org, date visited :January, 2005).*

2.3.3.2 Requirements

The main requirement for compliance with this credit as outlined by the LEED Rating System is to – "Use a minimum of 20% of building materials and products that are manufactured regionally within a radius of 500 miles" *(www.usgbc.org, date visited: January, 2005).*

"Manufacturing refers to the final assembly of components into the building product that is furnished and installed by the trade-workers. For example, if the hardware comes from Dallas, Texas, the lumber from Vancouver, British Columbia, and the joist is assembled in Kent, Washington; then the location of the final assembly is Kent, Washington" *(www.usgbc.org, date visited: January, 2005).*

Explanation: In order to achieve the credit, 20% of the total building materials and products used for the project must be manufactured within a radius of 500 miles from the project site. The calculation of the percentage of regionally procured materials is carried out using cost of materials. The cost information should include the price of the material only and exclude labor costs, cost of transportation and installation, taxes, etc. For products such as assemblies, the final place of assembly of the product constitutes the location of manufacture for that assembly.

2.3.3.3 Submittals

The following are the submittals required for this credit - provide the LEED Letter Template, signed by the architect or responsible party, declaring that the credit requirements have been met. Include calculations demonstrating that the project incorporates the required percentage of regional materials/products and showing their cost, percentage of regional components, distance from project to manufacturer, and the total cost of all materials for the project *(LEED version 2.1 Reference Guide, 2003).*

2.3.4 LEED 2.1 Rating System – Credit MR 5.2

2.3.4.1 Intent

The intent of this credit outlined by the LEED Rating System is to – "Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation" *(www.usgbc.org, date visited: January, 2005).*

2.3.4.2 Requirements

The main requirement for compliance with this credit as outlined by the LEED Rating System is – "Of the regionally manufactured materials documented for MR Credit 5.1, use a minimum of 50% of building materials and products that are extracted, harvested or recovered (as well as manufactured) within 500 miles of the project site" *(www.usgbc.org, date visited: January, 2005).*

Explanation: In order to achieve credit MR 5.2, 50% of the regionally manufactured materials and products used for credit MR 5.1 must be extracted, harvested or recovered within 500 miles of the project site. Location of extraction, harvest or recovery refers to

the place where the material was derived naturally. For example, a stone tile is manufactured and treated in Grand Rapids, Michigan before it is supplied to consumers. The stone, however, is quarried from Sandusky, Ohio. The location of extraction for the stone tile is Sandusky, Ohio *(www.usgbc.org, date visited: January, 2005)*.

2.3.4.3 Submittals

The following are the submittals required for this credit - provide the LEED Letter Template, signed by the architect or responsible party, declaring that the credit requirements have been met. Include calculations demonstrating that the project incorporates the required percentage of regional materials/ products and showing their cost, percentage of regional components, distance from project to manufacturer, and the total cost of all materials for the project. The calculation of regionally extracted materials is cost based as well *(LEED version 2.1 Reference Guide, 2003)*.

2.3.4.4 Strategies for implementation

This credit is based on procurement of materials for a building project within the region. In order to successfully implement the requirements of the credit, the incorporation of regional materials should be considered early in the conceptual design phase of the project. Regionally manufactured building materials should be checked for durability, performance and other environmental considerations. A current listing of regional manufacturers should be maintained which could be used for future projects. After the completion of the listing for regionally sourced manufactured building materials, appropriate building materials could be specified in the contract documents. It is also advisable to consider regionally manufactured materials with high recycled

content or materials which are rapidly renewable *(LEED version 2.1 Reference Guide, 2003).*

2.3.5 Draft proposal for LEED Rating System version 2.2

The revised version 2.2 of the LEED Rating System is currently under review and is scheduled to be usable by the beginning of the year 2006. The following parts of credit MR 5.1 requirements were proposed to be changed in the draft that was developed in October, 2004.

- Proximity limit for manufacturing and extraction locations changed to within 300 miles of project site
- Use a minimum of 10% of building materials or products for which at least 80% of the mass is extracted, processed and manufactured within 300 miles of the project site

  OR
- Specify a minimum of 10% of building materials or products for which at least 80% of the mass is extracted, processed, and manufactured within 1,000 miles of the project site, and shipped by rail or water.

  OR
- Specify a minimum of 10% of building materials or products that reflect a combination of the above extraction, processing, manufacturing and shipping criteria (e.g., 5% within 300 miles and 5% shipped by rail within 1,000 miles)

(LEED for New Construction Rating System version 2.2, 2005).

The following is changed draft language for credit MR 5.2 for version 2.2 of the LEED Rating System,

- Use a minimum of 20% of building materials or products for which at least 80% of the mass is extracted, processed and manufactured within 300 miles of the project site.

  OR

- Specify a minimum of 20% of building materials or products for which at least 80% of the mass is extracted, processed, and manufactured within 1,000 miles of the project site, and shipped by rail or water.

  OR

- Specify a minimum of 20% of building materials or products that reflect a combination of the above extraction, processing, manufacturing and shipping criteria (e.g., 10% within 300 miles and 10% shipped by rail within 1,000 miles)
- Calculation for credit MR 5.1 and 5.2 will be based on mass of the product or material under consideration instead of cost as used by the earlier version

(LEED for New Construction Rating System version 2.2, 2005).

2.4 Summary and conclusions

This chapter outlined literature which addressed green building benefits, green building rating systems, local materials standards for each of the rating systems that were listed, recent research and explanation of credit MR 5.1 and 5.2. The next chapter explains the methodology employed by the researcher to achieve the goals and objectives of this thesis.

CHAPTER 3

3.1 Methodology

The methodology used for this thesis is depicted in Figure 3.1 and consisted of the following core activities:

1) Literature review of various studies and current research, relevant to the thesis
2) Interviews were conducted with LEED Accredited Professionals, Construction Managers and Design and Construction Administration staff from Michigan State University's (MSU) Physical Plant Division, to gain insight on practical aspects of construction and compliance with LEED standards
3) Interviews were conducted with LEED Accredited Professionals to gain further information on the process of structuring a database
4) Sample building study of a typical institutional building was conducted to determine the materials which influence the certification of credit MR 5.1 and 5.2
5) An example database of regional manufacturers of construction materials was developed. Steps used to develop the sample database were as follows:

- Determination of materials which cause high cost impact on the certification process for credits MR 5.1 and 5.2
- Selection of manufacturers or vendors using commercial listings and classifying them based on Construction Specifications Institute format (CSI)
- Acquired Information regarding manufacturing and extraction locations of regionally available materials and products

6) Three LEED Accredited Professionals reviewed the final database and were interviewed in order to gain their opinions about the comprehensiveness and usability of the database

7) Development of a framework and recommendations for constructing a database of regional manufacturers which can be used by institutional organizations as well as for achieving certification of credits MR 5.1 and 5.2.

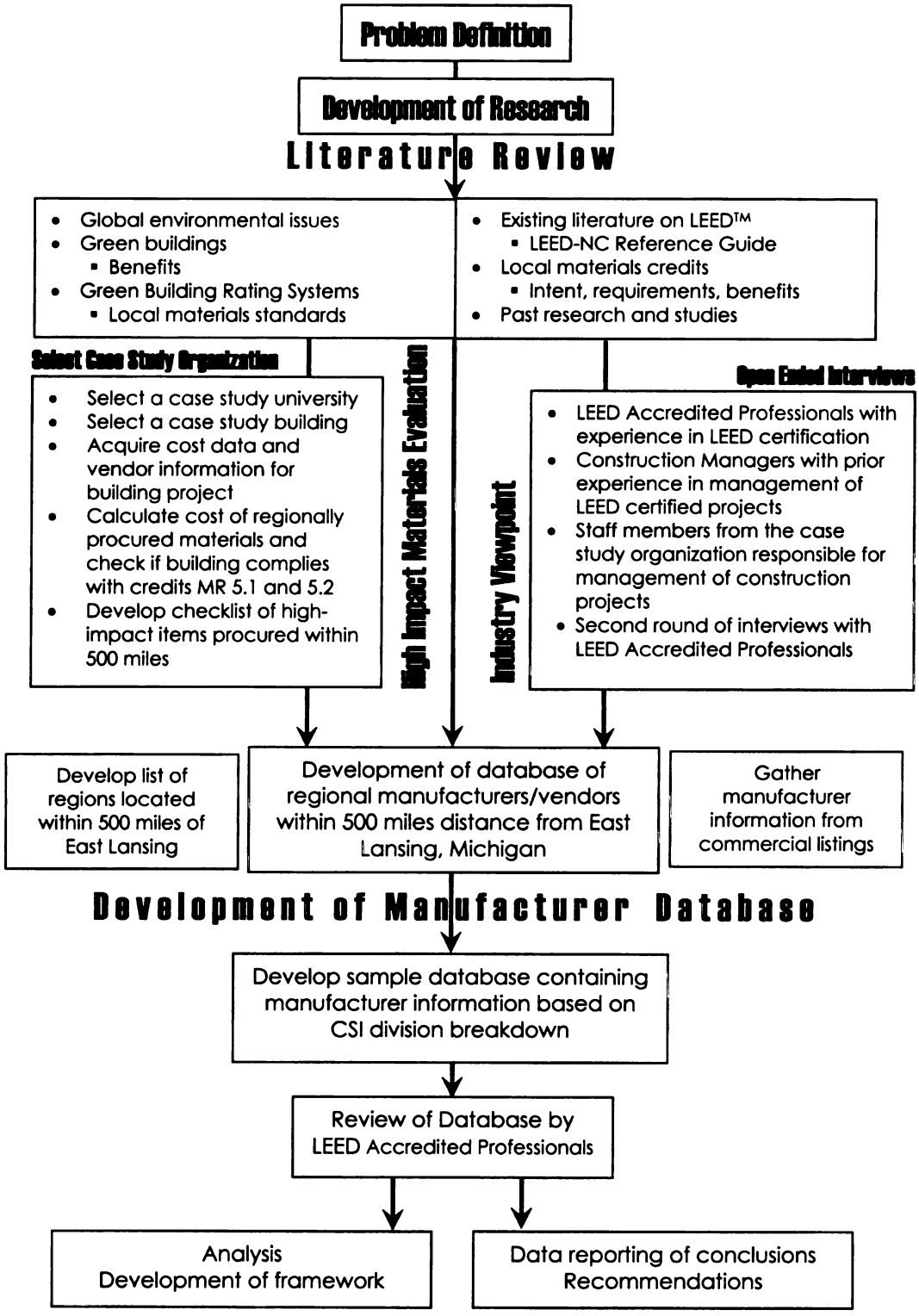

Figure 3.1: Thesis Methodology

3.1.1 Literature Review

Research was conducted on various green building standards that have been developed and are currently available for implementation. Recent research which addressed the LEED Green Building Rating System for its cost implications and documentation process were reviewed. The researcher studied the LEED Green Building Rating System with a focus on credit MR 5.1 and 5.2 which applies to procurement of regional materials for construction of buildings.

3.1.2 Case Study

In order to study the requirements of an institution, the researcher selected Michigan State University (MSU) as the case study organization. The researcher then selected the Cyclotron building located on MSU campus as a sample institutional building for the purpose of determining if a typical institutional building qualifies for LEED credits MR 5.1 and 5.2 or not. Detailed cost data for materials used in the selected building were not available hence, the researcher used the final schedule of values (Refer to Appendix E) and construction documents obtained from the Physical Plant Division for use in determining the percentage cost of materials as described below.

The data consisted of the final cost of various work items that were installed in the building and the total cost of the completed project. The schedule of values did not separate material cost from installation cost. Therefore, the researcher used a default value of 45% (allowable by LEED) of total cost of a process to derive the cost of material as prescribed by LEED for calculation of material percentages. The data did not display the sources for material procurement or manufacture. Structural steel was however, procured from a fabricator located within 10 miles of the project site. The researcher

conducted quantity takeoffs for concrete using building drawings and calculated the cost of concrete using RS Means data. For the project, concrete and gypsum (drywall) were assumed to have been procured from regional manufacturers. The researcher calculated the cost of the above materials and compared them with the total material cost of the project. The researcher also formulated a list of high-cost items which are presented in chapter 5 of this thesis.

3.1.3 Interviews

3.1.3.1 Method

Open-ended interviews were conducted with LEED Accredited Professionals (LAP), construction managers and staff personnel from Michigan State University's Physical Plant Division to obtain information on LEED documentation procedures and typical university construction procedures respectively. A second round of interviews was also conducted with the LAP to refine the process for developing the database and to help identify possible areas of emphasis. Because some products have little financial impact on the database, they could be eliminated from the database.

3.1.3.2 Participants

The target population and sample for the study were Michigan based LAP, construction managers and staff personnel from Michigan State University's Physical Plant Division involved in the design and management of construction projects on MSU campus.

The interviews with LEED Accredited Professionals were aimed at gathering information about the current practices in the LEED certification process and to gain a professional insight into the difficulties that a project team faces in developing and

maintaining the documents that are required to be submitted in order to achieve LEED certification. The goal of conducting interviews with Construction Managers was to gain the constructor's viewpoint of the LEED certification process. Open-ended interviews conducted with staff personnel from Michigan State University's Physical Plant Division, were directed towards gaining additional information about current MSU construction and design standards as well as material selection criteria.

3.1.3.3 Instrumentation

3.1.3.3.1 Procedure

Open ended interviews were conducted with four practicing LEED Accredited professionals, three construction managers and six MSU Physical Plant Division administrative staff members.

Interviewees were contacted to schedule interviews. At the interviewee's preference the interviews were conducted in person or by telephone. Interviewees had the option to submit written responses to the interview questions. Notes were taken during the interview by the researchers. No tape recordings were made. The researcher assigned a code number to each interviewee to document their responses for future identification purposes. Responses were then paraphrased and consolidated after the interviews, placed in tabular form and aggregated with responses from other interviewees. Paraphrased responses from the interviewees are presented in chapter four. For confidentiality purposes, interviewees were not identified in any reporting of the research. The process of interviewing was completed within one month.

The participation of the interviewees was voluntary. The interviewees had the option of refusing to participate in certain procedures or to answer certain questions, or

discontinue answering questions at any time without penalty. The interviewees were presented a consent form which explained their rights. The contents of the consent form and the questionnaire were reviewed by the University Committee on Research Involving Human Subjects prior to conducting the interviews. The questionnaires are included in Appendix A.

3.1.3.3.2 Selection and inclusion of subjects

Lists of LEED Accredited Professionals (LAP), construction managers and staff members from the Physical Plant Division at MSU were created. These lists served as target lists consisting of,

1) LEED Accredited Professionals located in the Midwest Region who have been involved in the LEED certification of building projects which are completed or are currently under construction
2) Construction managers who have been involved in construction of LEED certified projects and
3) Administrative staff from MSU Physical Plant who are responsible for design, construction and management of building construction projects on MSU campus.

The list of LAP from Michigan was obtained from the USGBC website. This list contained email addresses and organizations that each individual is affiliated with. The researcher contacted LAP from this list by email. The individuals were asked if they have been involved in the LEED certification of any building. Only the individuals who had practical experience in the LEED certification of buildings were asked for their willingness to participate in the interview. Appointments were scheduled for the interviews at their convenience.

A list of LEED certified construction projects in the Midwest region was obtained from USGBC website. The researcher contacted the companies responsible for the construction of those projects to obtain the contacts of construction managers involved in the management of those projects. The individuals were asked for their willingness to participate in the interview. Construction managers who were willing to participate were asked for an appointment for the interview at their convenience.

MSU staff from the Physical Plant Division that are responsible for the design, construction and administrative management of construction project on MSU campus were selected for the interviews.

3.1.4 LEED Accredited Professionals second round of telephone interviews

Telephone interviews were conducted with three LEED Accredited Professionals using an additional questionnaire. This questionnaire included questions about the details of the database such as CSI level of classification of materials, which divisions were high impact and those divisions with low impact that consequently make negligible contributions towards achieving credit MR 5.1 and 5.2. The purpose of the questionnaire was to reduce the size of the database in order to concentrate on only those materials which make larger contributions during cost calculations for credit MR 5.1 and 5.2. The questionnaire is included in Appendix A.

3.1.5 Analysis of Interview data

Data obtained from the interviews was recorded in a matrix and general themes regarding means for compliance and difficulties that could be faced by a project team

while endeavoring to make a project compliant with credit MR 5.1 and MR 5.2 were identified and reported *(Refer to Appendix C)*. These themes were used in developing a sample database and in preparing the final recommendations for compliance with LEED credits 5.1 and 5.2.

3.1.6 Development of database

As part of development of a database framework, a sample database of regional manufacturers was created to explore the information available and means which could be used to develop this type of database. The purpose of having a database is to aid in the process of selection of local building products for an institutional construction project. The sample database was based on methods prescribed by LEED for calculating the percentage of building materials procured within the range of 500 miles from a project site. The city of East Lansing, Michigan was selected as the reference point for the proximity limits criteria used by credit MR 5.1 and 5.2 of the LEED Rating System.

3.1.6.1 Selection of manufacturers for the sample database

The researcher developed a list of vendors and manufacturers of building construction materials which are located within a radius of 500 miles of the city in East Lansing. To measure the distance between the manufacturing unit of a vendor and East Lansing, online road mapping services including Mapquest (http://www.mapquest.com) and MSN Maps and Directions (www.mapblast.com) were used. The database is classified according to CSI division and includes the following information:

- CSI Division code
- Product name
- Vendor name, contact information

- Distance of manufacturing unit from East Lansing
- Distance of extraction of different components of the material from East Lansing (if available)

3.1.6.2 Source of data for database

Contact information of manufacturers was compiled from commercial listings provided on the website *www.thebluebook.com*. The researcher reviewed other sources such as the Michigan Chamber of Commerce, Yellow Pages and Sweets Commercial listings published by McGraw Hill but found them not to be as useful based on how they were organized.

The Michigan Chamber of Commerce hosts a website which allows access to a database of companies based in Michigan. The listing does not provide information about the products that are supplied by vendors or manufacturers which renders it difficult to classify manufacturers within the database. This source was therefore not considered for the database.

The 'Yellow Pages' is a common source for business listings. This source of commercial listings is not focused specifically on construction materials, therefore the search returns minimal results for regional vendors and manufacturers of construction materials.

The listings presented by *www.sweets.com* provide results based on the CSI format. The listings do not provide results based on regional vendors or manufacturers. This aspect of Sweets makes it difficult for a researcher to locate vendors or manufacturers within a particular region and was therefore not used for the database.

The 'Bluebook' hosts commercial listings on the website *www.thebluebook.com*, which was used for the database developed by the researcher. The Blue Book provides contact information of vendors or manufactures based on their location. Keywords of construction materials can be used for a state-wide search. The results provide a considerable amount of contact information of vendors and manufacturers including information on the products that they supply. The researcher searched for manufacturers within the state of Michigan for materials which have significant impact on construction costs.

3.1.6.3 Scope of Database

The researcher selected CSI divisions consisting of high cost materials and products to aid in achieving credit MR 5.1 of the LEED Rating System. The information included in the database is classified according to the CSI format. Mechanical and electrical equipment are not taken into consideration during calculation of materials for compliance with Credits MR 5.1 and 5.2 *(LAP interview, Appendix A)*. The researcher therefore, did not consider CSI divisions 15 and 16 for the database.

Because some products and CSI divisions only contribute a small portion of the overall cost of a project and in the certification process for credit MR 5, the researcher concentrated on those divisions within the CSI format which account for larger shares of project costs. A study of 16 MSU projects (Mrozowski, 2004), conducted an analysis of the cost of 16 institutional building projects on Michigan State University campus and showed that divisions 1, 2, 3, 4, 5, 7, 8, 9 and 11 each account for at least 2% of overall project costs in the building set. Since credit MR 5.1 and 5.2 of the LEED Rating System require calculation of material percentages based on cost, the researcher included the

above listed ten CSI divisions, in the initial database setup. This process eliminated divisions which do not make a large impact on the total cost of materials procured for a typical project. An aggregate schedule of values which depicts the percentage cost of each division for the 16 projects is shown in Table 3.1.

	CSI Divisions	%
1	General Conditions	6%
2	Site Work	9%
3	Concrete	7%
4	Masonry	8%
5	Metals	6%
6	Wood & Plastics	2%
7	Thermal & Moisture	3%
8	Windows & Doors	4%
9	Finishes	5%
10	Specialties	1%
11	Equipment	5%
12	Furnishings	0%
13	Special Construction	1%
14	Conveying Systems	1%
15	Mechanical	29%
16	Electrical	11%

Table 3.1: Percentage of Project Cost for 16 MSU Projects *(Mrozowski, 2004)*

In order to reduce the size of the database the researcher conducted additional telephone interviews with three LEED Accredited professionals and asked them to list the CSI divisions which made negligible contributions in achieving credits MR 5.1 and 5.2 in the projects on which they had worked *(Refer to Appendix A for questionnaire)*. The interviews suggested that CSI divisions 7, 10, 11, 12, 13 and 14 could be eliminated as well. Therefore, the final database focused on CSI divisions 2, 3, 4, 5, 6, 8 and 9. A list of materials from each of these divisions was formulated which was used to search for manufacturers for the database.

The CSI format contains divisions which are divided into sections which are further divided into sub-sections containing items. Figure 3.2 shows the the CSI coding levels. The researcher asked the LEED Accredited professionals about the level of CSI detail at which the database should be developed in order to make it useful for users.

Manufacturers, who cater to a given section generally provide products which cover most sub-items included in the section. The LAP suggested that level 2 was the appropriate level. Therefore, the researcher organized the database to this material level. The database contains lists of manufacturers based on levels 1 and 2 of the CSI format as displayed in Figure 3.2.

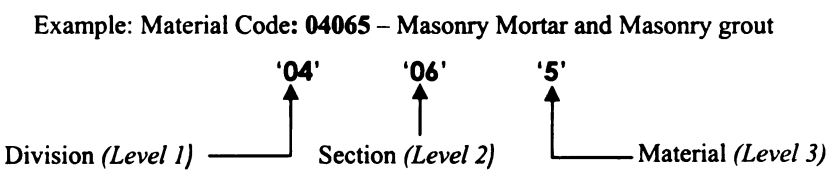

Figure 3.2: Construction Specification Institute (CSI) Coding System
(source: http://techn4.pcc.gov.tw/, date visited: February, 2005)

The researcher also referred to databases developed by various trade organizations. These organizations have websites which display information on manufacturers of products. The researcher selected those manufacturers which were located within the proximity limits of East Lansing, Michigan as prescribed by the LEED Rating System. The following is a list of organizations that were used by the researcher to obtain contact information of manufacturers:

- Great Lakes Fabricators and Erectors Association
- The Brick Industry Association
- Masonry Institute of America

- Gypsum Association
- The Carpet and Rug Institute

3.1.6.4 Keyword Selection process

In order to conduct searches for manufacturers of regional materials, the researcher developed a list of keywords for products to be included within the database. These keywords were selected from a list of materials that were expected to make high cost impacts on the calculations for credits MR 5.1 and 5.2. The list of keywords and the results that were returned after searches were conducted on the website www.bluebook.com, are presented in chapter 6 of this thesis.

3.1.6.5 Validation of Database

The framework for developing a database and the sample database developed during this thesis were presented to three LEED Accredited Professionals to ascertain its usefulness and comprehensiveness. A summary description of the structure of the database was presented to the LAP along with the contents of the database. The LAP were asked to review the following aspects of the database,

- Framework for development of a database
- Structure of sample database
- Method of data accumulation
- Usefulness of the sample database
- Ease of data retrieval
- Contents of Database

3.1.7 Data Reporting

The results of the keyword searches conducted by the researcher were documented and are presented in chapter 6 of this thesis. The searches were based on materials which are included in the database. The data presented in chapter 6 shows the examples of this process and the results that were generated after the keyword searches.

3.1.8 Conclusion

This chapter described the methodology that was used by the researcher to accomplish the goals and objectives of this thesis. The next chapter consists of interviewee responses presented in a paraphrased format.

CHAPTER 4

4.0 Interview Data and Analysis

This section of the thesis presents the interview data and its analysis. The analysis consists of identifying common themes from interview responses. The section includes the process for achieving compliance with credit MR 5.1 and 5.2, responsibilities of various project participants, management of documentation, flow of information between the architect, contractor and sub-contractors, difficulties that may be encountered during various phases of the project and a summary of suggestions from the interviewees for implementation of credit MR 5.1 and MR 5.2.

The researcher conducted open-ended interviews with LEED Accredited Professionals, construction managers and administrative and design staff from Michigan State University's Physical Plant Division. The goal of these interviews was to gain an insight into the building construction practices and LEED certification procedures during the implementation of credit MR 5.1 and MR 5.2 of the LEED Rating System.

4.1 Interview Data Report

This section is divided into three sub-sections:

- Question and responses summary of LEED Accredited Professional interviews
- Question and responses summary of construction manager interviews
- Question and responses summary of MSU Physical Plant administrative and design staff interviews.

Each sub-section presents the general theme expressed by the interviewees. The questionnaires used for the interviews are presented in Appendix A.

4.1.1 LEED Accredited Professional interviews

The researcher conducted open-ended interviews with 4 LEED Accredited Professionals. A LEED Accredited Professional (LAP) is an individual who has successfully completed the LEED® Professional Accreditation exam conducted by the U.S. Green Building Council. The purpose of this exam is to:

- "To ensure that a successful candidate has knowledge and skills necessary to participate in the design process, to support and encourage integrated design, and to streamline the application and certification process.
- To test understanding of green building practices and principles, and familiarity with LEED requirements, resources, and processes."

(www.usgbc.org, date visited: January, 2005)

A project can earn a point for a LAP being involved in the execution of the project. The LAP could be a part of the design or management team or hired as a consultant to oversee the LEED aspect of the project.

This thesis only included LAP who had previous or current experience with actual execution of a LEED certified building. The interviews consisted of a variety of closed and open-ended questions which are presented in this section.

4.1.1.1 LEED Accredited Professional Response Data

4.1.1.2 Demographic questions

The first two questions were intended to gain an understanding of the qualifications and background of the interviewees. The interviewees were asked about their educational and work experiences apart from being LEED Accredited Professionals and their experience in handling LEED certified projects.

All the interviewees were registered architects and had worked in the architectural and construction field from 8 to 40 years. Each of the interviewees indicated that they had a personal interest in sustainable design and construction. All interviewees had previously worked on LEED certified buildings and were currently involved in the design of buildings which had goals for LEED certification. The number of buildings handled by each of the interviewees for LEED certification ranged from 6 to 10 buildings. The buildings were either already certified or were under various stages of design or construction or LEED review.

4.1.1.3 LEED Certification questions

Interviewees were asked a variety of questions which were aimed at obtaining information about the cost of implementation of the LEED Rating System and procedures for obtaining compliance with credit MR 5.1 and credit MR 5.2. The responses are presented below in paraphrased form.

Interviewees were asked how buildings built to standard codes fare in terms of gaining LEED certification points even if they were not built with a goal of achieving LEED certification. The common response among the interviewees was that standard building codes are minimum standards and take care of the pre-requisites for LEED certification. Standard building codes differ from state to state. In some states such as California achieving basic certification is much easier than other states due to well developed building codes for sustainability.

Interviewees were asked to list the credits among the LEED credit rating system which are easily obtained for buildings without considerable increase in cost. All the interviewees said that credits which deal with simple design selection were achievable

without considerable increase in cost but the choices have to be made very early in the design. The following were listed as some of the credits which do not increase the cost of a project considerably,

- Site selection, urban redevelopment, alternative transportation with the exception of alternative fuel refueling, reduced site disturbance, storm-water management
- Water efficient landscaping
- Ozone depletion, recycled content and local/regional materials with respect to construction cost only (management costs for the credits may add to project cost), rapidly renewable materials, construction waste management if it is planned from the start
- Construction IAQ management plan during construction, use of low-emitting materials (adhesives and sealants, paints, carpets), daylight and views.

Several questions dealt with compliance with credit MR 5.1 and MR 5.2 and benefits of the above mentioned credits. The interviewees had used credit MR 5.1 in each of their previously LEED certified projects. The percentage of materials procured locally ranged from 60% to 90% for most projects. Projects located in the Mid-west region have a large number of products available within the region which are manufactured within 500 miles of the project site. Use of recycled materials for a project may also aid compliance with credit MR 5.2.

The benefits which were commonly cited by the interviewee responses were building the economy of the region, shipping of products over short distances reducing fuel consumption for transportation and reduction in lead time for delivery of materials through procurement from regional manufacturers. Working with local companies can

help find new partners for future work or receive discounts for bulk buys from a smaller producer.

When asked to outline the processes that they used for compliance with the requirements of credit MR 5 for regional materials each of interviewees responded with similar methods for compliance that can be summarized as follows. The process starts with selection of materials in the design phase based on the requirements of the project. Materials need to be researched and investigated before being incorporated into the specifications to ensure quality and performance. The next step is to incorporate those materials into the bid documents to make sure that the bidders have considered the availability of regional materials before bidding the project. The contractor needs to document materials which have been extracted or harvested within the 500 mile proximity limits as well. After completion of construction, the LEED AP needs to calculate whether the threshold for LEED credits has been achieved with information provided by the contractor.

One question asked the interviewees to describe the roles of the client, architect or designer, general contractor and sub-contractor in obtaining compliance with credits MR 5.1 and MR 5.2 and documentation procedures. The interviewees said that all individuals or organizations listed above need to have a clear understanding of the goals of the project.

The client is instrumental in selection of materials through the designer or architect by encouraging local product use and accepting the possibility of lesser known products for a project if they are manufactured locally and equal in quality to a more known name brand.

The design team needs to investigate products and locate sources for products to determine if materials of the required quality are available locally. The design team should incorporate products into specifications which meet the criteria for quality, performance standards and LEED credit MR5 proximity limits.

The general contractor is required to consider procurement of materials from local sources before a bidding project and to encourage sub-contractors and vendors to include regionally manufactured materials if they are feasible. The contractor is required to maintain a spreadsheet on total cost of project materials, individual costs of applicable local materials with names of companies and products and supporting documents from vendors verifying that the manufacturing location is within 500 mile radius of the project site. After bid and before construction the general contractor is required to provide appropriate submittals with signed letters certifying sources of manufacture, extraction and cost. LEED requires that all documents be stamped by the general contractor.

Sub-contractors should submit bids for projects using local materials if it is feasible, obtain information from the manufacturer and provide this information to the general contractor or construction manager. Additionally, sub-contractors must provide price of materials exclusive of labor charges, taxes, fees, etc. to the contractor.

The project should be registered with US Green Building Council. USGBC provides the template which should be used to document material or product information and can be obtained after registration of the project. The General Contractor and the sub-contractors should be informed about the documents that they need to maintain and the submittals that are required from them. Successful bidders should submit signed letters verifying sources of material prior to construction.

The general contractor should maintain a spreadsheet documenting materials that are procured regionally. The sub-contractor needs to submit cost of materials procured within 500 miles of the project site excluding labor or installation charges, taxes and other fees. The percentage of materials procured within the 500 mile radius is calculated by comparing cost of those materials with total cost of project materials. In order to achieve the credit the project should procure 20% of total project materials within 500 miles of the project site. The calculations and letter templates supported by material invoices and statements of manufacture location from manufacturers are required to be submitted for audit during the submittal process.

The documentation and submittal procedures for credit MR 5.2 are similar to credit MR 5.1. The percentage of raw materials within an assembly or product which are extracted regionally need to be calculated by weight. In order to achieve the credit, 50% of regionally manufactured materials should be extracted within the 500 mile radius. The submittal process for credit MR 5.2 requires calculations for percentage of individual raw materials by weight, letter templates from manufacturers and statements verifying location of extraction supported by invoices.

The interviewees were asked how they researched their list of manufacturers or vendors who are within the MR 5 proximity limits and if they had prepared a list of manufacturers/vendors related to projects located in Michigan or its border states for compliance with MR 5 limits. Constant research for products, Greenspec Directory [Wilson A., Malin N, et. al., 2003], previous experience with materials and interaction with vendors or manufacturers were listed as the common methods for selection of materials. Architecture and design firms generally use materials that are often repeated in

projects. Therefore, they commonly identify suitable products and their availability on an ongoing basis. Due to the nature of the construction industry credits MR 5 was usually achievable without extensive research for local products because certain high value products such as concrete and fabricated structural steel are readily available locally. The new LEED Rating System 2.2 draft reduces the proximity limit for local materials from 500 miles to 300 miles. This change may make credit MR 5 difficult to achieve. None of the interviewees had a comprehensive list of vendors or manufacturers which they used consistently. Specification writers have a list of preferred manufacturers based on quality and performance. Each of the interviewees had previous experience in preparing credit MR 5 documents.

Several questions asked the interviewees about the difficulties that a project team can face in achieving compliance with credits MR 5.1 and MR 5.2 for certification. The interviewees responded that the difficulty of achieving the credits changes from project to project. Credit MR 5.1 has been easily achievable until now due to the nature of the construction industry. It largely depends on the location of the project and the type of project. Some areas such as those on the coasts have some difficulty getting maximum benefit from any situation involving a radius from project site due to their proximity to oceans. Some regions do not have a broad range of materials manufactured within their region. The type of project can influence the level of difficulty as well because certain project types demand use of materials which have to be transported from distant locations. Overall, if the region is abundant with a variety of manufacturers and the project does not require special materials, MR5 credits are fairly easily achievable in terms of finding materials within the specified limits.

Achieving compliance with credit MR 5.2 can also depend on the use of materials with recycled content. It can be difficult to achieve credit MR 5.2 using virgin materials as the various components of a product may have been extracted outside the 500 mile radius of the project site.

The difficult activity in achieving credits MR 5.1 and MR 5.2 for any project is developing the documentation necessary to determine and the record location of manufacture, extraction and the distance, products are transported to the project site. Breaking down costs into specific material costs excluding labor, installation charges, taxes, etc. is difficult as well. There is some difficulty due to the lack of a database of regional materials for Michigan. The interviewees agreed that a database which contained information about location of manufacture of materials can be helpful in improving the efficiency of the current process.

The interviewees were asked how LEED Accredited Professionals reviewed certification documents for a building and the problems that they faced during the process. Two copies of documents are compiled and checked by LAP and submitted to the US Green Building Council. Consultant organizations which work with USGBC are responsible for the final reviews. Letter templates displaying the distance between manufacturing site and project site, certification documents from vendors or manufacturers signed and stamped by the general contracting firm and cost calculations are compiled by the LAP and submitted for review. The review is carried out by consultant organizations in two stages called the Preliminary and Final Review. After the Preliminary Review, a verdict on certified credits, credits held in abeyance and credits denied is issued. The project team is required to submit documents which support the

credits which have been denied before the Final Review is carried out. After the Final Review a project team can submit their appeals for the denied credits.

Several questions addressed methods employed by LAP for tallying project costs, costs of individual materials and calculation of percentages of components within an assembly or product with respect to their sources of extraction. The data for each material should be arranged in a spreadsheet with the mileage and source of manufacture and extraction specified in different columns. The project team should obtain letters certifying product information for source of manufacture and extraction to support the spreadsheet.

For calculation of source of extraction, the percentage of individual component of a product or assembly is calculated by weight. The documentation procedures for calculation for credit MR 5.2 are similar to credit MR 5.1. The most common problem that occurs during the process is lack of information from contractors. The processes of calculating mileage between a project site, manufacturing and extraction sources and contacting manufacturers for product information are time consuming.

The final question of the interview asked the interviewees for suggestions on how to develop a database framework for regional materials. All the interviewees suggested that information which displayed mileage between sources was important for the database. Other suggestions included providing links to online mapping websites such as *www.mapquest.com* which will save time for users. Because the LEED Rating System 2.2, which is currently under review, has a suggestion for reduction of proximity limits from 500 miles to 300 miles for credits MR 5, the interviewees suggested that the database should take into consideration the new requirement.

4.1.2 Construction Manager Interviews

The researcher obtained a list of LEED certified building projects for Michigan and contacted the construction companies that constructed the projects. The researcher selected three construction managers as the interviewees. Open ended interviews were conducted with the respondents all of whom had handled LEED certified building projects.

4.1.2.1 Construction Manager Responses

The following section presents themes expressed by the interviewees in a paraphrased format. The researcher has omitted references which would identify the interviewees without making any significant distortion in the responses.

4.1.2.2 Demographic questions

The interviewees were employees of established construction companies located in Michigan. The positions held by the interviewees at their respective companies ranged from estimators to construction managers or managers of pre-construction services. The interviewees had between 13-25 years of experience as construction professionals.

4.1.2.3 LEED certification questions

The interviewees expressed familiarity with the LEED Rating System for Green Building certification. Each of the interviewees had worked on 4 to 8 LEED certified projects which are either already constructed or are in various construction or planning stages. The roles played by the interviewees in the LEED certification process ranged from management of documentation for submittals to co-ordination with the design team and sub-contractors.

The interviewees were asked about the percentage increase in initial costs for a LEED certified building as compared to a similar sized building which was built without LEED certification goals. The interviewees agreed that the increase in project cost depends on the credits that are set as goals to be achieved by the project team. The increase in management costs of the project was said to be 1% to 3% and the overall construction cost increase ranged from 5% to 7% of the cost for a building built with standard building codes. The increase in costs however, is reducing as the LEED process is being streamlined for better efficiency.

The interviewees were asked to list the credits among the LEED Rating System which were easily achievable without considerable increase in project and administrative costs. The interviewees responded that costs of waste recycling are minimal if initial planning and space allocation for extra on-site dumpsters is conducted. Other credits which do not increase the cost of the project were indoor air quality compliance with ASHRAE 90.1, procuring regional materials depending on the location of the project, daylight and views credits, water-efficient landscaping and construction indoor air quality management plan.

The administrative costs for carrying out the LEED certification process have been dropping due to experience in handling similar projects. The documentation process has been streamlined with the recent updates to the LEED Rating System. The documentation process for certification requires maintaining templates which record items such as material manufacturing and extraction locations, mileage from the project site, measuring recycled waste quantities and types, low VOC emitting material procurement, etc.

The next two questions asked the interviewees about their familiarity with credit MR 5.1 and MR 5.2 and the benefits that are achieved by compliance with those credits. Each of the interviewees said that they had achieved compliance with credit MR 5.1 for every LEED certified project that they had worked on. Credit MR 5.2 is difficult to achieve for renovation project whereas it is easy to achieve for new building construction projects. The benefits listed by the interviewees for compliance with credits MR 5.1 and MR 5.2 were helping the growth of the regional economy and shorter lead times for material deliveries.

The interviewees were asked about the difficulties faced by the project team in the documentation process required for credit MR 5.1 and MR 5.2. The interviewees responded that getting information from sub-contractors regarding a product's manufacturing and extraction location was difficult. LEED requires submission of shop drawings with LEED templates for review which increases the burden on the project team. The interviewees however remarked that conditions vary between projects and that planning early can reduce the burden of documentation.

The final question asked the interviewees for suggestions on the development of a database framework. The interviewees agreed that such a database would be very helpful for credits MR 5.1 and MR 5.2. Research for new materials and sources of procurement on the internet and other product listing would be helpful in creating the database. The interviewees anticipated stricter guidelines for certification in the LEED 2.2 Rating System which will make it difficult to achieve the credit. The database will help improve the verification process for product information.

4.1.3 Physical Plant Administrative Staff Interviews

The researcher conducted open-ended interviews with six employees of the Physical Plant Division of Michigan State University (MSU). The goal of these interviews was to gain an insight into the typical building construction procedures of an institutional owner, use of sustainable practices in construction at MSU and their opinions on the use of the database methodology for future construction and LEED certification.

4.1.3.1 Physical Plant Administrative Staff Data

The responses obtained by the researcher during the interviews are presented below in a paraphrased form. As required by the interview protocol, the identities of the interviewees have been kept anonymous by omitting personal references within the responses without significant distortion of the responses.

4.1.3.2 Demographic questions

The interviewees were asked general questions regarding their qualifications and experience in order to gain an understanding of their backgrounds. The duties performed by the interviewees for the Physical Plant Division of MSU ranged from working with external design consultants, preparation of construction documents and project administration. The interviewees were design professionals and business management professionals with considerable experience in the construction industry.

4.1.3.3 MSU Construction and LEED certification questions

The first four questions of this section of the questionnaire asked the interviewees about their familiarity with the LEED Rating System and Michigan State University's general attitude towards use of sustainable practices for building construction on campus.

All the interviewees claimed to have fair knowledge of the LEED Rating System due to recent discussions with LEED consultants for implementation of the LEED Rating System for construction.

The interviewees agreed that Michigan State University is favorable towards use of sustainable practices on campus if the process is justified by Life-Cycle Cost *(LCC)* models. MSU has used LCC for analysis of products and systems on campus.

The interviewees were asked how products were selected for construction. The main criterion used for selection of a product or system for use at MSU was its life-cycle cost. Previous experience with products, low maintenance, reliability of product and servicing options provided by vendors or manufacturers also help in selecting a product.

During specification, manufacturers are suggested as a benchmark but contractors can propose substitutions with products of equal or better quality which meet performance standards, subject to review by the design staff.

The next question presented the MR 5.1 and MR 5.2 credit requirements to the interviewees and asked them about difficulties that they anticipate in complying with the credit. The interviewees indicated that MR 5.1 and MR 5.2 would lead to reduced competition and variety in product selection. Some manufacturers do not provide information about source of manufacture and extraction of the product which might make it difficult for certification.

The interviewees expressed that it will be difficult to obtain a break-down of product cost from the manufacturer which excludes labor, installation charges, taxes, etc. In an open-bid project, manufacturers are not willing to divulge the original price of the

products. The interviewees consider this as a hindrance in the documentation of information that is required for the credit.

4.1.4 Follow-up LEED Accredited Professional Interviews

The LEED Accredited Professionals were interviewed a second time to obtain information on the structure and emphasis areas of the database. The main objective of these interviews was to identify the CSI divisions which have the most influence on a project meeting the MR 5.1 and 5.2 requirements. The researcher contacted four LAP. One did not respond so the remaining three were interviewed.

4.1.4.1 Follow-up LEED Accredited Professional Interview response summary

The first question asked for suggestions on how the database should be organized. Each of the LAP agreed that the database should be classified according to CSI format. Throughout the industry construction professionals, including architects, engineers, contractors, and vendors or manufacturers are familiar with this system and it would help to make the database easily searchable and usable.

The next question explained the method employed by the researcher for classification of materials in the database starting with elimination of divisions 15 and 16. The LAP were asked to list the CSI divisions from 1 to 14 based on their experiences, which made negligible contributions towards calculations for credit MR 5.1 and 5.2 and could be eliminated without affecting the usability of the database. All the interviewees responded that divisions 11 to 14 do not typically make considerable contributions towards meeting MR 5.1 and 5.2 requirements. Division 1 is administrative and hence can be eliminated. One of the LAP suggested that division 7 can be eliminated as well.

The next question was developed to obtain information from the interviewees regarding the level at which the database should be classified *(Refer figure 3.2)*. Two of the interviewees suggested that the database should be classified at the root division level assuming that more detail on products could be added with future research. One interviewee suggested that the database should be classified to level 2 of the CSI classification. The option of classifying materials to further levels depends on the extent of detail required by the specifications writer.

The interviewees were asked to suggest methods for reducing the size of the database and how to focus on materials which heavily influence certification of credits MR 5.1 and 5.2. The response to this question was to focus on divisions 2 to 5 which consist of basic building materials which are typically procured from locations within close proximity to a project site. These divisions typically have high cost impacts and consist of materials which are readily available throughout the state of Michigan. Manufactured furniture is available regionally within the state of Michigan. In order to be considered for credit MR 5.1 and 5.2 requirements, it should also be incorporated into the calculations for all credits from MR 3 to MR 7.

The final question asked for suggestions on how to improve the usefulness of the database. The interviewees indicated that after classifying the manufacturers by CSI divisions, they could be organized alphabetically or by state or region. Other suggestions included linking the database to LEED credits for users who want to check credit MR 5 and search for manufacturers within 500 miles of the project site zip code. The database could be linked to an online mapping website such as *www.mapquest.com* which could

calculate the distance between a project site and manufacturing location for a user by entering zip codes.

4.1.5 Framework and Database Validation Interviews

The framework for developing a database and the example database were presented to three LEED Accredited Professionals to obtain their views on the usability, comprehensiveness, method of development, content and format of the database. The LAP were presented a summary description of the process used by the researcher to develop the database along with the example database, a questionnaire and the framework diagram presented in figure 6.1 of this thesis. The interviewees were asked to review the framework and the example database for the following:

- Framework for development of a database
- Structure of sample database
- Method of data accumulation
- Usefulness of the sample database
- Ease of data retrieval
- Contents of Database

4.1.5.1 Framework and Example Database Interview Response summary

The interviewees were asked how useful the database was in providing information for regional manufacturers in its current form. The interviewees were asked to rate the usability on a scale from 1 to 5, with 1 being 'very difficult' and 5 being 'very easy' to use. Two of the interviewees rated the database at 3 while 1 chose to rate it between 2 and 3. The interviewees suggested that the database could be more useful by including manufacturers outside the state of Michigan, located within 500 miles of the

focal point. The usefulness could also be improved by employing a user interface which responds to queries of the user. The interviewees also responded that the database was cumbersome to read due to arrangement of data in Microsoft Excel using rows and columns.

The next question addressed the comprehensiveness of the database in covering products or materials which aid in the certification of credits MR 5.1 and 5.2. The interviewees were asked to rate the database for its comprehensiveness on a scale of 1 to 5 with 1 being 'not comprehensive' and 5 being 'very comprehensive'. Each of the interviewees rated the database at 3 which denotes 'moderately comprehensive'. The interviewees responded that the database was comprehensive with respect to manufacturers based in Michigan but it would need more information considering the 500 mile radius requirement for credits MR 5.1 and 5.2.

The next question asked the interviewees if the database did not include any manufacturers that they were aware of. The interviewees responded that there were no manufacturers that they could name which were not included in the database.

The interviewees were asked to rate the overall content, format and method of development of the database on a scale of 1 to 5 with 1 denoting 'very bad' and 5 denoting 'very good'. The interviewees rated the database at 3 overall which denotes 'Ok'. The interviewees responded that the database had a good format and method of development but the content could be improved by including manufacturers from states other than Michigan.

The final question asked the interviewees to give suggestions regarding the content and form of development of the database. The interviewees responded that

special attention should be given to the ease of use of the database for the user. An interactive interface which responds to the queries of the user by retrieving data from the database could prove beneficial. The user interface should be attractive and easy to use. One interviewee responded that conducting telephone calls to ascertain manufacturing and extraction location may not be a cost effective method of obtaining information from manufacturers. But considering that such information is not available easily approaching the manufacturers through telephone calls seemed to be an easy method for obtaining information.

4.2 Process for compliance with LEED credits MR 5.1 and 5.2

Based on the LEED Accredited Professionals interviews, the process for compliance with credit MR 5.1 and 5.2 was outlined and described. This compliance process includes the following stages:

Stage 1: The project is required to be registered with the United States Green Building Council. USGBC provides templates which are required for documentation for LEED certification. Letter templates provided by USGBC for credit MR 5.1 and 5.2 should be used for documentation of the regional materials procurement credits. The project team should research materials and products within the region to ensure quality and performance standards. The development of a database could take place during this step of the process and is explained in section 6.4. Materials should be incorporated into the specifications before bidding the project. The project team must ascertain that bidders understand the requirements for achieving compliance with the above mentioned credits before submitting their bids. Figure 4.1 shows stage 1 of the process of certification for credits MR 5.1 and 5.2.

At the time of bid acceptance, bidders should submit signed letters certifying their sources of procurement of materials and products. For large builders and institutions such as universities and government agencies, a database containing a list of materials or products with manufacturing and extraction locations could prove helpful during this stage of certification.

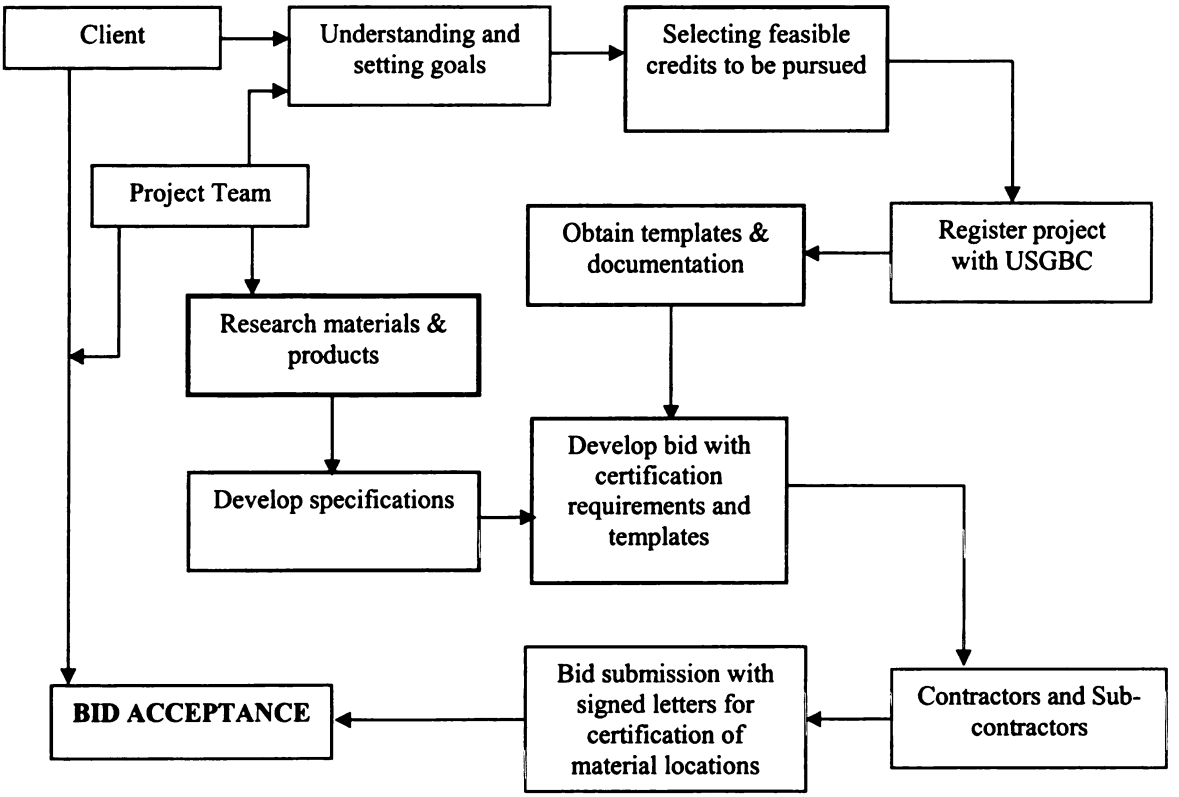

Figure 4.1 Stage 1: LEED Certification Process for credits MR 5.1 and 5.2
(source : LAP interviews)

The project team can obtain better pricing options on products from manufacturers that they have used in earlier projects. It would be easier to work with manufacturers who have previously supplied products for LEED certified buildings since they would be aware of the documentation that is needed for product certification.

Stage 2: The second stage of certification requires maintaining adequate documentation by responsible parties which is compiled towards the end of the project and submitted to the USGBC for review. The general contractor is required to maintain a spreadsheet containing records of materials and products with information about their location of manufacture and extraction. The distance between the location of manufacture and project site should be recorded in one column. The distance between location of extraction or harvest and project site must be recorded in a separate column on the spreadsheet. The spreadsheet must contain the following information,

- Product name
- Manufacturing location
- Distance of manufacturing location from project site
- Extraction location
- Distance of extraction location from project site

(LAP interviews)

Sub-contractors must submit material or product invoices with statements of manufacture and extraction obtained from the manufacturers. The general contractor is required to submit a spreadsheet, with product invoices and statement of manufacture bearing the general contracting company stamp, to the LEED Accredited Professional working on the project. The general contractor and the sub-contractors should make an attempt to use regional materials and products wherever feasible. The LEED Accredited Professional is required to carry out the calculations for material percentages based on the data provided by the general contractor. For product assemblies, percentage calculation must be executed using proportional weight of different constituents of the assembly. A

project may achieve additional certification points for exceeding the requirement prescribed by LEED for innovation.

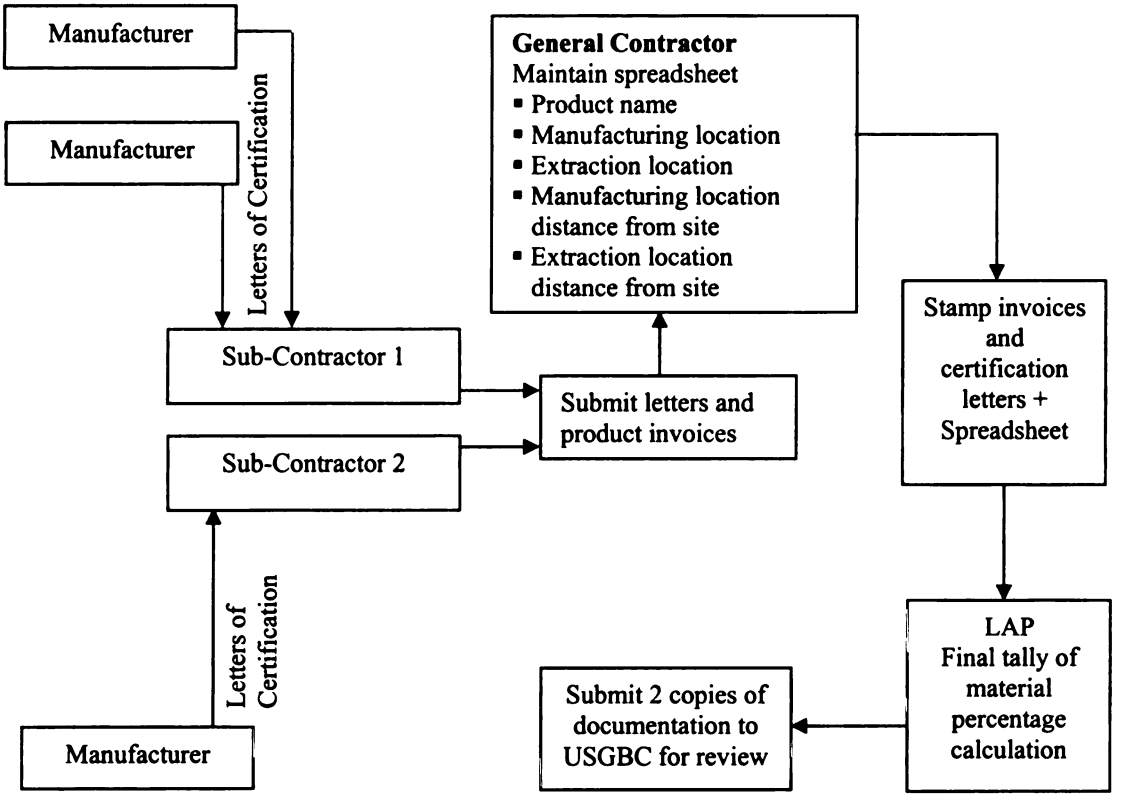

Figure 4.2 Stage 2: LEED certification process for credits MR 5.1 and 5.2
(source: LAP interviews)

Two separate copies of documentation consisting of certification letters, material or product invoices, spreadsheets with material information and final calculations of percentages should be submitted to USGBC for review.

Stage 3: This stage consists of reviews conducted by USGBC. These reviews are conducted by consultant organizations working with USGBC. After a Preliminary Review, the project team receives a verdict on certified credits, credits held in abeyance and credits denied. The project team is allowed to submit additional

supporting documentation for credits that are held in abeyance and the credits that were denied. After the Final Review, the project team has the option of submitting an appeal for the denied credits supported by more documentation as required.

4.3 Summary

This chapter consisted of responses from interviewees presented in a paraphrased format. Based on the responses from the interviewees the researcher outlined the LEED certification process. The next chapter contains analysis of the case study building on MSU campus.

CHAPTER 5

5.1 Sample Building Study

This thesis developed a general database framework which can be implemented by universities and can aid in achieving compliance with credits MR 5.1 and 5.2. In order to explore the types, quantities and cost of materials required for constructing a typical university building, the researcher selected a sample building for study. This part of research was conducted to determine the general feasibility of an institutional building constructed on a university campus for receiving certification for credit MR 5.1 and 5.2. Michigan State University was used as a case study for this purpose. The study also helped the researcher to derive a list of materials which influenced the cost calculations for the above mentioned credits. This list of materials was verified by comparing it with a list of high-value items developed by a GSA LEED™ cost study [Steve Winter Associates, October 2004]. The Cyclotron Addition Project, completed in 2004, was selected as the sample building for this phase of research.

5.2 Cyclotron Addition building

This project was constructed as an addition to the Cyclotron building which houses the National Superconducting Cyclotron Laboratory (NSCL). NSCL is a rare isotope research facility located on the campus of Michigan State University. The Cyclotron Addition project consisted of a 12,000 square feet office addition to the original Cyclotron laboratory building. The Cyclotron addition houses faculty offices, graduate student offices, two conference rooms and a reception area.

The building consists of two floors built on a steel framework. The exterior walls are concrete masonry block with brick veneer and cavity insulation on the outside. The

facade of the building consists of brick, punctured windows and a curved glass curtain wall.

5.3 LEED MR 5.1 and 5.2 calculations

The Physical Plant Division (PPD) of MSU is responsible for administration and supervision of construction on MSU campus. Cost data for the Cyclotron Addition project was obtained from the PPD. Because contractors do not provide detailed cost breakdown by material and labor the researcher used the Final Schedule of Values which listed work at the completion of the project (see Appendix D). The schedule of values contained a list of items, their cost at completion and name of company that supplied the item. The cost information obtained for the sample study building did not include detailed cost break-down of the work items into labor costs, transportation costs, taxes, material costs, etc. as is required by LEED. The researcher used the default, 45% of the total cost of an item, prescribed by the LEED Rating System as the cost of material for calculation of credit MR 5. Table 5.1 displays the list of high-cost items (including material, labor, indirect costs, etc.) for the Cyclotron project which cost at least 2% of total project cost.

Item	Cost
General Trades (includes Concrete)	366,519
Doors and Windows	120897
Doors, Frames, Hardware	65008
Drywall and Acoustical	234466
Hard Tile and Floor Fin.	82925
Masonry	274537
Roofing and sheet Metal	103571
Structural Steel	206597
All other items combined	1,958,049

Table 5.1: List of High-cost Items for Cyclotron Sample Building Study
(Source: Physical Plant Division, MSU)

The data procured from PPD did not contain breakout material cost or display information about the source of materials. Structural Steel was procured from a local

fabricator located in Lansing, Michigan which is 5 miles from the project site. Hence, it can be considered as a locally procured item. Several large gypsum board manufacturing facilities exist within 500 miles of project site, so drywall was assumed to have been procured from regional manufacturers. The researcher conducted quantity take-offs for concrete used in footings, below grade columns and concrete walls and slabs. Since, concrete is usually procured from local sources it can be assumed to be locally procured for the case study building.

Using RS Means cost data, the researcher calculated the cost of concrete material at the rate of $ 75/Cy for below grade concrete walls, piers, footings and slabs. Table 5.2 shows the calculations for concrete for the sample building and does not include steel reinforcing.

	Quantity	Cost
Footing	25.15 CY	1886.25
Slab	10157 sq. ft.	9310.58
Piers	6.52 CY	500
Below grade Walls	28.91 CY	2175
		13885

Table 5.2: Cost Calculations for Concrete for Sample Building
(Source: Physical Plant Division, MSU)

Table 5.3 shows the cost calculations required to achieve certification for credit 5.1. Table 5.4 shows estimated cost of materials assumed to be procured from regional manufacturers.

Total Project Cost	$3,412,569
Total Materials Cost for the project (45%)	$1,535,656
Required 20% benchmark	**$307,131**

Table 5.3: Required Total Cost of Regionally Procured Materials for MR 5.1 certification *(Source: Physical Plant Division, MSU)*

Concrete	$13,885
Structural Steel	$92,968
Drywall + Acoustical ceiling	$16,529
	$122,982

Table 5.4: Cost Calculations for Materials Assumed to be Regionally Procured
(Source: Physical Plant Division, MSU)

5.4 Conclusions of Sample Building Study

The calculations for the sample building study showed that the estimated cost of concrete, structural steel, drywall and acoustical ceiling tiles constituted approximately, 8% of the total material cost which is less than half of the percentage required to achieve certification. There are other materials such as reinforcement bars, fill, roof insulation, etc. which can be procured locally in Michigan but could not be included in the calculations due to unavailable information. The sample building could however qualify for certification of credit MR 5.1 if information about manufacturing sources of all materials was available. This shows that that a typical university building located within the state of Michigan likely could achieve MR5.1 certification if the project team included procurement of regional materials as a goal, early in the project planning process.

The conditions for institutional buildings located in regions other than Michigan may change based on the availability of materials which make significant impacts on the calculations for credit MR 5. The following items significantly impact total cost of materials for a project and offer opportunities for achieving MR 5 credits if obtained from local manufacturers and fabricators:

- Custom millwork
- Concrete

- Doors and windows
- Frames and Hardware
- Drywall and Acoustical tiles
- Hard tiles and Floor finishes
- Masonry
- Roofing and Sheet metal
- Structural Steel

The project was a relatively small project. Buildings built for universities are typically larger than the sample building, but the materials used are similar. These materials heavily influence material costs for any institutional building project.

This chapter presented the analysis of a case study building on the MSU campus. A case study building was used for the purpose of evaluating typical materials which are used, their costs and the likelihood that an institutional building would qualify for the criteria of MR 5.1. The next chapter contains results of the database research and the framework for development of the database.

CHAPTER 6

6.1 Development of a Sample Regional Manufacturers Database

In an effort to aid organizations in developing information on manufacturers who operate within a project region, the researcher created a sample database of regional manufacturers. The database was created based on the requirements for credit MR 5.1 and 5.2, responses from interviews of industry professionals and research conducted by the researcher to locate sources for manufacturer information available for users. This process enabled the researcher to:

a) Explore the information sources available and to consider their usefulness in developing a database of manufacturers
b) Explore the structure of a database
c) Identify the classes of products which have the most influence on compliance
d) Understand how to limit the scope of a database to make its development efficient and cost effective

The database consists of contact information of manufacturers of building materials located within the state of Michigan. The researcher used *http://www.thebluebook.com* as the primary source of information for vendors and manufacturers. Other sources such as Sweets Commercial listing published by McGraw Hill, the Chamber of Commerce of Michigan, *http://www.constructionmaterials.com* and *http://www.4specs.com* were considered for use in developing this database but were excluded because they did not provide options to search for regional products or the data did not contain information on materials produced by the manufacturers. Websites hosted by trade organizations which listed contact information of manufacturers of construction materials were also used. The research used keyword searches of *www.thebluebook.com*

to identify contact information for manufacturers and vendors of building materials. This keyword search process is presented below.

The researcher does not claim that the database contains every available manufacturer in Michigan, but instead was designed to explore a process for creating such a database.

6.1.1 Manufacturer/Vendor keyword search

The researcher conducted keyword searches for Michigan which focused on divisions 2, 3, 4, 5, 6, 8 and 9. These keywords were selected based on interview responses and database reduction methods explained in chapter 3. Table 6.1 shows the keywords that were used and are arranged according to CSI division,

CSI Division	Keyword - Building Material
Division 2	Aggregate Asphalt Cement Pavement / Pavers
Division 3	Concrete Concrete Reinforcement
Division 4	Masonry Unit Stone Brick
Division 5	Aluminum Metal Steel
Division 6	Wood Woodwork
Division 8	Window Door Glass
Division 9	Gypsum Tile Ceiling Flooring

Table 6.1: List of Keywords

Divisions 2, 3, 4 and 5 contain materials such as aggregates, concrete, concrete reinforcement, concrete masonry units, steel, metal, etc. which are usually procured within close proximity of a project site. Brick is also a high-value product that may be manufactured in Michigan. The researcher referred to the website hosted by the Brick Industry Association *(www.bia.org, date visited: April, 2005)* and located brick manufacturing plants located within 500 miles of the city of East Lansing, Michigan.

Michigan has a large number of manufacturers for products included within these divisions *(LAP interviews)*. The researcher conducted searches for various material manufacturers within the state of Michigan by using the keywords in *www.thebluebook.com* which provides a drop-down menu containing weblinks. These weblinks, when clicked, displayed webpages which had contact information of manufacturers and vendors. The researcher sorted and eliminated results which were not applicable for this research. For example, the search keyword 'woodwork' returned the following results for Michigan – Toledo, Ohio region.

Results	Listings
Architectural & Cabinet Woodwork	222
Cabinets - Kitchen	312
Millwork	219
Stairs - Wood	38

Table 6.2: Keyword search example

Since the current research is focused on commercial buildings and many of the firms listed were focused on residential kitchens, the results for 'cabinets-kitchen' were not considered. Many of the firms listed were "suppliers" or contractors rather than manufacturers, therefore contact information for suppliers, retailers and contractors were excluded from the database. The researcher verified company profiles on company

websites and by conducting telephone calls to determine if a firm was a supplier, contractor or manufacturer.

6.2 Keyword search

In order to conduct a precise search for materials, the researcher analyzed each division to select items which have high-cost impacts on projects. The results of the interviews, the building case study discussed in chapter 5 and high-value items listed by the GSA LEED Cost study [Steve Winter Associates, October 2004] were used to select items which have high-impact on the cost of a project. Items which deal with equipment, labor, installation costs, etc. were eliminated.

Typically, a CSI division consists of a variety of items which are associated with a process. For example, CSI code 4200 is used for masonry units while code 4210 includes clay masonry units and code 4220 includes concrete masonry units. The website search returned results for each of the three items since the search parameter that is used by the website search system is 'Masonry', which was common to each of the three items. In this case, the researcher selected 'Masonry' as the keyword to search for all types of masonry unit manufacturers. The researcher formulated a list of such keywords which were common among items included in each division. These keywords were used to search for manufacturers on the website.

6.3 Results of Keyword search

The results of the keyword searches conducted for the database have been organized by CSI division are presented below. The database is included in Appendix E.

6.3.1 Division 2 – Site Construction

Division 2 consists of site construction, earthwork, drainage, utility services, etc. which require use of equipment. Equipment costs cannot be considered for credit MR 5.1 and 5.2 as they are not installed in the building. Aggregates are readily available in every location in Michigan. Aggregates were therefore, not specifically included in the database. Materials such as asphalt and pavement were selected as the high-value building materials within division 2, as keywords. The keywords and results are shown below in table 6.3.

Region	Keyword	Results	Number of listings returned
Michigan	Paver	Pavers - Interlocking and unit	104
	Asphalt	Asphalt Profiling/ Recycling/ Scarifying	20
		Paving Materials	45

Table 6.3: Results for Division 2

Results such as road construction and contractors were eliminated since they do not apply to the requirements of the database. The total number of manufacturers listed in the database for this division is 15.

6.3.2 Division 3 – Concrete

Division 3 consists of items such as concrete reinforcement, concrete forms and accessories, cast-in place concrete, pre-cast concrete, etc. Concrete forms and accessories cannot be considered for this credit since they are not installed in the building. 'Concrete' was selected as the keyword for this division as the search returned manufacturer information for most types of concrete products included within this division. 'Concrete reinforcement' was used as the other keyword for this division. Since producers of ready-

mix concrete are readily available in close proximity to any location in the state of Michigan, the results for ready-mix concrete were not included in the database. Contact information of manufacturers was organized under categories such as concrete reinforcement, ready-mixed concrete, architectural concrete, mass concrete and pre-cast concrete. The keywords selected for division 3 and the results that were returned by the search are displayed in Table 6.4.

Region	Keyword	Results	Number of listings returned
Michigan	Concrete	Anchors - Masonry and Concrete	71
		Conc. Additives & Curing Compounds	84
		Conc. Blocks - Lt. Wt & glazed	68
		Concrete Lightweight	13
		Concrete - Post Tensioning	9
		Concrete - Precast Arch & Structural	86
		Concrete - Precast Sanitary, Drainage	34
		Concrete - Repair & Restoration Materials	87
		Floors - Seamless	32
		Floor - Underlayment	29
	Concrete Reinforcement	Reinforcing bars/ Wire mesh and Accessories	65

Table 6.4: Results for Division 3

The total number of manufacturers listed in the database within division 3 is 30.

6.3.3 Division 4 – Masonry

The material categories included within this division are masonry units, stone, masonry wall reinforcement, etc. The most commonly used masonry units in construction are concrete masonry units and clay masonry units. Michigan has a relatively small number of manufacturers of brick and related materials. Hence, the researcher referred to a list of manufacturers provided by the Brick Industry Association on its website

www.bia.org (date visited: April, 2005). The website hosts contact information and plant locations of brick manufacturers in the country. The researcher selected brick manufacturers who had manufacturing plants within a radius of 500 miles of East Lansing. The keyword selected for *www.thebluebook.com* search division 4 was 'Masonry' which produced results for masonry wall reinforcement and concrete masonry units. Table 6.5 shows the number of results that were returned for the search conducted for masonry in the state of Michigan. The total number of manufacturers listed in the database for this division is 38.

Region	Keyword	Results	Number of listings returned
Michigan	Masonry	Anchors - Masonry and Concrete	71
		Concrete blocks- lt. wt and glazed	69
		Masonry Wall Reinforcement	14
		Mason's Materials	43

Table 6.5: Results for Division 4

6.3.4 Division 5 – Metals

For the purpose of this search steel, metal and aluminum were used as keywords to locate regional manufacturers. USGBC issued a credit interpretation in February, 2004 which confirmed that the location at which steel assemblies are fabricated can be considered as the manufacturing location for those assemblies [Modern Steel Construction, May 2004]. Fabrication of structural steel entails cutting steel members to appropriate length, welding connection plates, punching or drilling holes, etc. Constructing steel trusses, frames or standard assemblies is carried out by fabricators as well. Steel manufactured by fabricators within 500 miles of the project site can be used for credit MR 5.1. Credit MR 5.2, however, requires tracing the location where the steel

was recycled as the place of extraction. It is difficult to trace the location of extraction of raw materials for steel since steel is recycled. Table 6.6 shows the results for the selected keywords.

Region	Keyword	Results	Number of listings returned
Michigan	Steel	Joists-Steel	22
		Pipe-Steel	39
		Roof Trusses-Steel	29
		Shelving Steel	102
		Steel Plate Fabricators	45
		Steel & Precast Concrete Erectors	43
		Structural Steel Detailers	29
		Structural Steel Fabricators	182
	Aluminum	Architectural Metals-Mfrs. & Distrs.	81
		Panel Systems	174
	Metal	Architectural Metals-Mfrs. & Distrs.	81
		Corrugated Metal	10
		Decking Metal	23
		Pipe-Corrugated Metal	11
		Stairs-Metal	43

Table 6.6: Results for Division 5

The researcher also referred to member listings provided by Great Lakes Fabricators and Erectors Association on the website *www.glfea.org (date visited: April, 2005)*. The member listings provide contact information of fabricators, erectors and other steel service providers. The researcher selected fabricators from the list and included them in the database. A total of 49 manufacturers or fabricators have been listed in the database within division 5.

6.3.5 Division 6 – Wood and Plastics

The items included in this division are wood framing, heavy timber construction, wood decking, finished carpentry, millwork, architectural woodwork, custom cabinets,

etc. The high-value materials or products in division 6 are finished carpentry consisting of millwork, casework, etc. and architectural woodwork such as cabinet woodwork, wood frames, etc [Steve Winter Associates, October 2004]. The fabrication shop where woodwork such as cabinets, shelving, etc. is built or assembled is considered the final location of manufacture. In-site reshaping and framing however, cannot be considered as manufacture (LAP interviews). The keywords used for this division to locate regional manufacturers were 'wood' and 'woodwork'. The results of the keyword searches are displayed in table 6.7 below. A total of 44 manufacturers of finished carpentry have been listed in the database for this division.

Region	Keyword	Results	Number of listings returned
Michigan	Wood	Building Materials	224
	Wood work	Architectural & Cabinet Woodwork	222
		Cabinets - Kitchen	312
		Millwork	219

Table 6.7: Results for Division 6

6.3.7 Division 8 – Doors and Windows

Division 8 includes items such as doors and frames, entrances and storefronts, windows, hardware, glazing, curtain walls, etc. The high-value materials or products in division 8 were windows, storefronts and curtain wall systems [Steve Winter Associates, October 2004]. The keywords used for this division were 'Window', 'Door' and 'Glass'. These keywords returned results which displayed manufacturer listings for all of the high-value items listed above. The final location where doors and windows are assembled is considered the manufacturing location. Products which are assembled on-site cannot be considered for calculations of regional materials credits unless all the components of the

assembly were manufactured at locations situated within the prescribed proximity limits (LAP interviews). The following results were returned for the keyword searches for division 8 which are displayed in table 6.8 below. A total of 54 manufacturers of doors and windows have been listed in the database within division 8.

Region	Keyword	Results	Number of listings returned
Michigan	Window	Glass Block	38
		Glass-Stained, Leaded & Art	55
		Millwork	219
		Storm Windows & Doors	25
		Windows - Metal	102
		Windows - Vinyl	172
		Windows - Wood	109
	Door	Doors - Access	34
		Doors - Alum., Bronze & Steel	59
		Doors - glass, heat tempered	14
		Doors - Hollow Metal Doors & Frames	102
		Doors - Sliding	34
		Doors - Wood, solid & Veneered	189
	Glass	Curtain Walls	43

Table 6.8: Results for Division 8

6.3.8 Division 9 – Finishes

This division includes items such as plaster, gypsum board, tiles, terrazzo, acoustical panels, carpet, paints and coatings, etc. The high-value items from this division consist of gypsum wallboard, carpet, resilient floor tiles, acoustical ceiling tiles and floor finishes [Steve Winter Associates, October 2004].

The manufacturers that produce gypsum board are typically large companies with manufacturing plants in a variety of locations in the US. The researcher used the website

www.gypsum.org (date visited: April, 2005) which is hosted by the Gypsum Association to research gypsum manufacturers. The researcher contacted gypsum manufacturers by telephone and obtained information about their manufacturing plants which are located in Michigan or close to it. The researcher included manufacturers with manufacturing plants located within 500 miles of East Lansing.

Carpets and resilient flooring were the other high impact materials from this division. The results returned by the searches conducted by the researcher consisted mainly of suppliers, distributors or retailers for carpet. The Carpet and Rug Institute (CRI) is the national trade association representing the carpet industry. Its members consist of manufacturers representing over 90% of all carpet produced in US *(www.carpet-rug.org, date visited: April, 2005)*. All the manufacturers listed by CRI were located outside the 500 mile radius used by this thesis. Hence, no manufacturers for carpet were included in the database. The researcher conducted searches for flooring in the state of Michigan. Table 6.9 shows the search keywords and the results that were returned while searching for manufacturers of items included in Division 9. The database contains 9 national manufacturers of resilient tile flooring and 4 manufacturers of gypsum products.

Region	Keyword	Results	Number of listings returned
Michigan	Flooring	Floor Treatment/Coating/Preservatives	139
		Floors - Resilient (Mfrs. & Distributors)	62
		Floors- Wood Finish/Parquet/Hardwood	250

Table 6.9: Results for Division 9

The researcher believes that other manufacturers are likely to exist within a region and that the development and maintenance of a database such as the sample database developed by this research should undergo continuous updating and focus on the classes of products and manufacturers used by a specific owner or design organization.

6.4 Development of Database Framework

Development of the sample database allowed the researcher to create a general framework which can be used by other institutional owners and designers in creating their own regional and organization specific database.. Figure 6.1 shows the flow diagram for material and product research and development of the database.

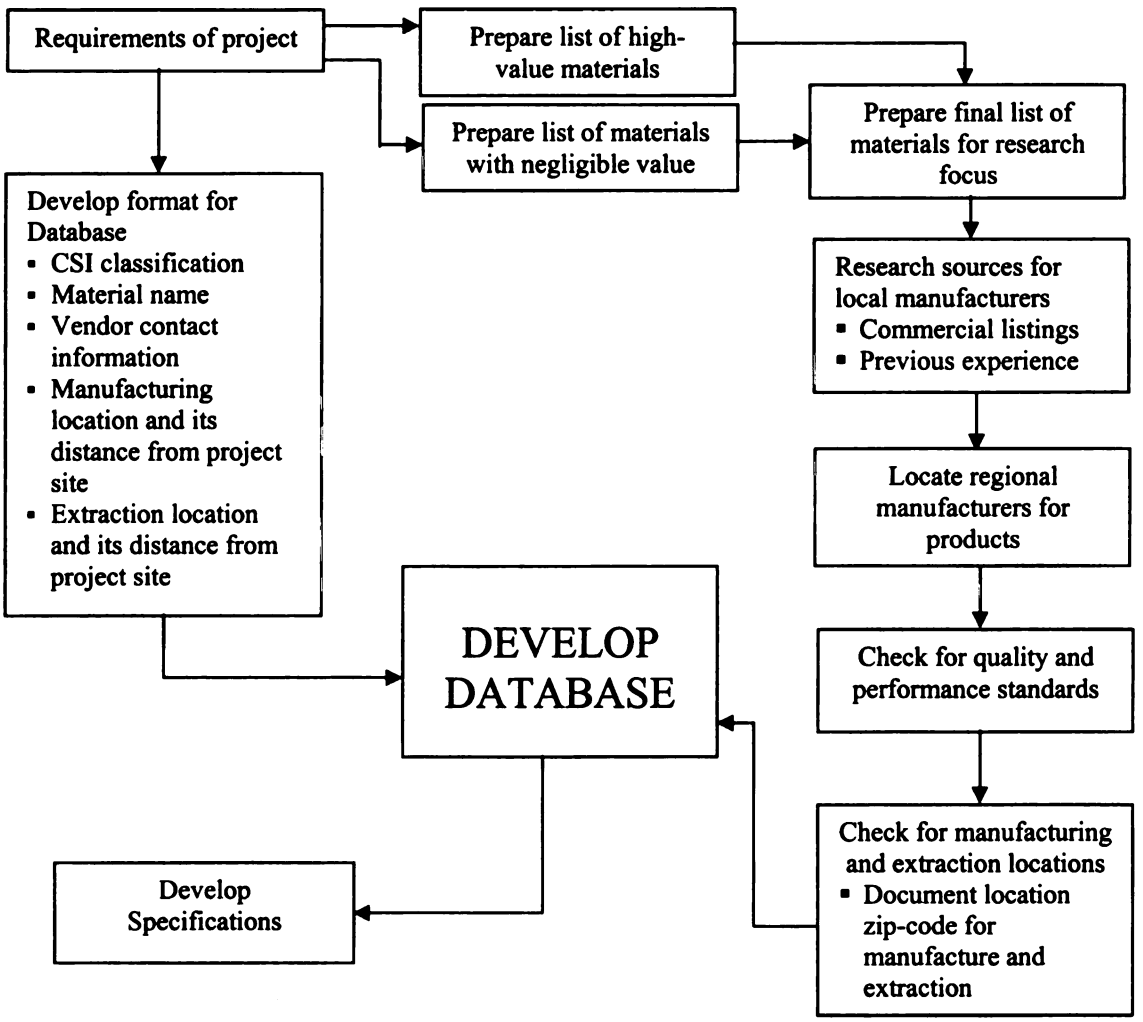

Figure 6.1: Research materials and development of database step

The development of a database can occur during the process of research for materials and products. The database format should be developed based on the CSI system. The process begins with listing the requirements of the owner's or designer's general project types such as office buildings, classroom buildings, medical facilities, etc. Requirements for material types, product finishes, assemblies, etc. should also be identified. The classification format and software for developing the database must be determined based on user requirements. The format should reflect the requirements of credit MR 5.1 and 5.2 such as,

- Product type
- Manufacturer contact information
- Manufacturing location and its distance from project site
- Extraction location and its distance from project site

A list of high-value materials should be developed, which make significant cost contributions to the total project cost. This list can be based on historical data for buildings similar in type and size to the project under consideration. A final list of materials should be used to research local manufacturers. This process helps in concentrating on only those items which have high impact on the cost of the project.

There are various sources for information on regional manufacturers. Some of these sources have been listed in section 7.3. These sources are in the form of online databases, product listing books, etc. Manufacturers and vendors should be contacted to gain information on the manufacturing and extraction locations of their products. This process also helps in eliminating retailers and other companies which do no manufacture the products. After locating regional manufacturers, checks for quality and performance

must be made in order to ascertain that products comply with the standards required for a project. The manufacturing and extraction locations of the materials should also be ascertained by obtaining relevant information from the vendors or manufacturers. Materials and manufacturers included within the database can be used while developing specifications for a project. Manufacturers can be included in the specifications as products which can be used by contractors for a project. The database should be updated regularly to include information of new manufacturers within the region. The following section explains influential divisions, materials or items for development of the database and scenarios for considering some of the items which have not been considered for the database.

6.5 Database research and analysis conclusions

The example database of regionally available materials was developed based on interviews conducted with LEED Accredited Professionals and the GSA LEED™ [Steve Winter Associates, October 2004] cost study. The broad conclusions derived from this process are presented below.

6.5.1 Influential CSI divisions for LEED MR 5.1 and 5.2 certification

The database was organized by focusing on divisions which make significant contributions to the total project cost. Based on the responses from the interviews conducted with LEED Accredited Professionals, divisions 7, 10, 11, 12, 13 and 14 are expected to make negligible contributions to project cost. Basic building materials such as concrete, steel, brick or block, earthwork, etc., belonging to CSI Divisions 2, 3, 4 and 5 are used in large quantities and add high value for most projects. Most of the items

included within these divisions are available within close proximity of any location in Michigan.

The following is a list of high-impact items which typically influence the cost of a project. The list was compiled from the GSA LEED™ Cost study [Steve Winter Associates, October 2004] which conducted cost calculations for two institutional buildings. The items included in the list are:

- Cast-in-place concrete
- Structural steel or metal
- Exterior cladding materials such as stone, brick, pre-cast concrete, metals, roof tiles etc.
- Masonry units
- Windows and curtain wall systems
- Gypsum wallboard
- Carpet
- Resilient flooring
- Ceiling tiles (Acoustical, specialty, etc.)
- Doors and frames
- Millwork and casework items

The state of Michigan has a large number of manufacturers for materials included in divisions 2, 3, 4 and 5. These materials have a high impact on total material cost and heavily influence compliance with credit MR 5.1 and 5.2. From the list of products stated above, items such as cast-in-place concrete, concrete masonry units, fabricated structural steel and gypsum wallboard tend to be manufactured within 500 miles of most

project sites. The proximity of manufacturers may vary for many of the other materials depending on the part of the country the project is located in. The 20 percent credit threshold can be attained by focusing on the above stated materials without extra cost beyond documentation costs. For projects with designs involving special materials or treatments which limit the number of manufacturers whose products can be specified in the project bids, a cost premium may be incurred in complying with credits MR 5.1 and 5.2.

6.5.2 Database presentation

The information collected by the researcher from www.bluebook.com was documented in Microsoft Excel spreadsheets. Each division was allotted separate work sheets. Manufacturers were classified according to the CSI format under material codes based on the products they manufacture. The database includes the following information:

- CSI code
- Name of product
- Description
- Manufacturer name
- Location of final assembly
- Distance between manufacturing location and East Lansing in miles
- Location of extraction
- Distance between extraction location and East Lansing in miles
- Mailing address of manufacturer
- Telephone and fax number

6.6 Scenarios for considering other materials

The following are scenarios for considering various materials for certification of credit MR 5.1 and 5.2 which have not been addressed in the sample database:

- Mechanical and Electrical equipment: Mechanical and Electrical equipment is not considered during calculations for certification of credits MR 5.1 and 5.2. These systems are assembled on the project site and in order to be considered for certification, the project team would have to document location of manufacturing for every component of the assembly. It is extremely difficult and arduous for the project team to document such information (LAP interviews)
- Elevators: Elevators are shipped to the project site as separate components which are assembled and installed in the building. In order to achieve certification for elevators, every component of the elevator assembly must be manufactured within the proximity limits prescribed by the LEED Rating System (LAP interviews)
- Manufactured furniture: Furniture can be included for new construction calculations, only if furniture is also included in the scope of work of the project and is calculated in every credit from MR 3 to 7. This condition entails incorporating furniture in calculations for credits for Resource reuse, Recycled content, Local or regional materials, Rapidly renewable materials and Certified wood (LAP interviews).

6.7 Conclusion

This chapter presented the framework for development of a database of regional manufacturers and the results of the sample database search conducted by the researcher.

The following chapter contains conclusions of this thesis and recommendations for implementation of the database methodology at universities.

CHAPTER 7

7.0 Summary and Recommendations

This chapter contains a summary of the research conducted by the researcher for this thesis. Section 7.1 includes an overview of the LEED Rating System. The final section of this chapter includes recommendations on a process for development of a database suitable for universities or other institutional organizations as well as suggestions for future areas of research.

7.1 Overview of LEED Rating System certification

The LEED Rating System offers a valuable assessment system for buildings designed and constructed with the goal of achieving better efficiency. Standard building codes address minimum standards and generally satisfy pre-requisites for LEED certification. Standard building codes vary by state and influence the conditions for achieving compliance with the LEED Rating System. It is easier to achieve basic certification in some states as compared to others which do not emphasize higher efficiency standards for buildings (LAP interviews).

One of the concerns of owners and builders in complying with green building standards is the increase in upfront costs of a project. The increase in initial costs of the project could range from 5% to 7% depending upon the level of certification that is achieved. The increase in management costs for LEED certification could range from 1% to 3% (CM interviews). In many states, basic LEED certification can be achieved with minor increase in initial costs. These costs are expected to decrease as better technologies are developed and the process for certification is streamlined [Cooper G., 2002].

Builders and developers that plan to achieve LEED certification for their buildings should understand the goals from the beginning of the project. In order to

achieve cost efficiency in management of documentation, project teams should clearly define their goals for achieving certification at the conceptual stage of the project. The process entails preparing a checklist of achievable credits. This allows ample time for the project team to conduct feasibility studies and design innovative methods and technologies to achieve the goals. All participants involved in the project must understand their responsibilities and their roles in achieving the goals as well. Larger institutions such as universities which are dedicated to achieving sustainability can work with USGBC to form partnerships that will lead to better implementation of LEED standards. Researchers and students from partner universities can also gain access to documentation and research developed by USGBC.

7.2 Possible difficulties during certification of credits MR 5.1 and 5.2

The nature of the construction industry makes it relatively easy to achieve credit MR 5.1. It is difficult, however, to achieve certification for credit MR 5.2 using virgin materials. The use of materials or products with recycled content helps in achieving credit MR 5.2 (LAP interviews). Overall, the difficulty in achieving these credits depends on the type of project and the location of the project. A project team may face the following difficulties in achieving the above mentioned credits:

- Certain types of projects require transporting special products over large distances
- Sub-contractors may not be able to provide manufacturing and extraction location for products
- LEED requires submission of some shop drawings with templates which increases the burden on the project team

- Sub-contractors may not prefer to disclose information about the price of material due to profit margins or competitive factors.

7.3 Benefits of credit MR 5.1 and 5.2

Achieving compliance with credit MR 5.1 and 5.2 can be beneficial in the following ways:

- Procuring materials and products regionally can help build the economy of the region
- Products shipped over short distances reduce fuel consumption for transportation
- There is a reduction in lead time for delivery of materials.

7.4 Conclusions and results of the database research

1) CSI format is used across the construction industry for specification of materials. A database based on the CSI format offers a system of classification which is applicable and familiar to users throughout the US
2) While constructing a database of regional materials for MR 5.1 and 5.2 certification, focus should be placed on materials which have a large impact on total project material costs. The following divisions were found to heavily influence total project costs for most projects.
   - Division 2 – Site work
   - Division 3 – Concrete
   - Division 4 – Masonry
   - Division 5 – Metals.

   In order to reduce the cost of database development it is also important to eliminate materials which are expected to make negligible contributions to the cost of projects. This elimination process can be based on historical cost data of materials for the types

of buildings under consideration by the organization. The contributions made by divisions may vary for different types of projects depending on their requirements. The elimination process enables the researcher to develop a database which is compact and comprehensive in covering only high-value items required for LEED certification

3) Although, Division 15 (Mechanical) and Division 16 (Electrical) make a combined contribution of 30% of a typical project, they are typically not considered for credit MR 5.1. In order to consider mechanical and electrical equipment for credits MR 5.1 and 5.2, each component of the equipment must be manufactured within the proximity limits prescribed for the credits (LAP interviews)
4) There are certain divisions within the CSI system which contain items that may be readily available within many locations across the country. For example, in Michigan, items such as aggregates, concrete, fabricated structural steel, etc. are usually procured from sources which are close to project sites. The availability of materials within close proximity of a project site however, depends on the region and its natural resources which can vary from one location to another
5) A large number of resources are available for contact information of vendors and manufacturers. These sources provide listings of regional businesses which cater to various requirements of the construction industry. The research found some limitations in each of the sources for business listings when developing a database of regional manufacturers. Some of the sources that were used or considered by this thesis were:

- Chamber of Commerce – (Michigan): The Michigan Chamber of Commerce hosts a website which contains a database of business entities located in the state of Michigan. The list however, contains contact information of only those businesses which are registered with the Michigan Chamber of Commerce. The listing does not provide information about the products that are supplied by vendors or manufacturers. It may also contain some defunct companies due to update schedules
- Yellow pages –This source of commercial listings is not focused specially on construction materials. Hence, the search does not show a large number of results for regional vendors and manufacturers of construction materials
- Sweets – The listings presented by *www.sweets.com* provide results based on CSI format. The listings do not provide results based on regional vendors or manufacturers. This aspect of Sweets makes it difficult for a researcher to locate vendors or manufacturers within a particular region
- Bluebook – The listings provided by *www.thebluebook.com* was used for the database presented by this thesis. The Blue Book provides contact information of vendors or manufactures based on their location. Keywords of construction materials can be used for a state-wide search. The results provide a sizeable amount of contact information of vendors and manufacturers including information on the products that they supply

6) The estimated time for completion of a database similar to the one compiled by this thesis is 2-3 weeks. This includes searching for different sources of commercial listings, short listing keywords applicable for the project, development of the database spreadsheet containing contact information of manufacturers, conducting

telephone calls to individual manufacturers to establish the location of manufacture and extraction of products

7) The type of database compiled by the methodology used by this thesis is feasible for institutions which can operate, design or construct buildings periodically within the same region. Large institutions such as universities which are continuously building new structures around the same campus area or government agencies involved in construction within a county or state can utilize a database more effectively than single building project developers. The cost for compiling a database could outweigh the benefits achieved by using the database for small developers
8) A database developed by an organization should be updated regularly whenever information for new manufacturers is obtained. Local manufacturers suggested by contractors, manufacturers listed in other commercial listings, etc., should be included in the database periodically
9) The utility of a database can be enhanced by developing data-management software which will retrieve data from the database according to the requirements of users. The design of the software could include an interactive computer interface which will allow users to type in queries such as CSI code, material names, zip code of project site, etc., and return results from the database which will help users in identifying the manufacturers that are located within the region
10) Finally, the sample database presented by this thesis does not claim to contain every vendor or manufacturer available within the region. The sample database contains information about manufacturers which have been listed by the commercial listing source used by the thesis.

7.6 Recommendations for Universities

The following recommendations are suggested by the researcher based on the framework developed by this thesis for compliance with credit MR 5.1 and 5.2, and are applicable to universities or institutional project owners, designers and constructors.

1) Incorporate procurement of regional materials criteria as a requirement in general construction standards and bid documents
2) Develop a list of manufacturers of products available within 500 miles of the organization. This framework for creating such a database of manufacturers of products available within the region is presented by this thesis
3) The structure of a database should reflect the requirements of credit MR 5.1 and 5.2. It should contain information such as distance between project site and location of manufacture and extraction respectively
4) CSI format is used throughout the construction industry for specification of materials. A database should be classified according to the CSI format.
5) A database should focus on high-value locally available materials. Divisions 2, 3, 4 and 5 from the CSI format consist of materials which are common to most construction projects and are regionally available for most regions in the US
6) The availability of materials or products from other divisions varies by location. Such materials may be included in the database according to the benchmark required by the standard and to achieve environmental and economic benefits based on regional considerations

7) A database could be made more effective by employing interactive software which retrieves data based on user requirements. A user interface could be designed which accepts user queries and returns data from the database

8) Data should be updated regularly to eliminate manufacturers which are no longer in business and to include new manufacturers

7.7 Findings and Contribution

The following are the major contributions of this thesis:

- Developed a framework for creating a database to aid in achieving LEED credits MR 5.1 and 5.2 which is applicable to universities or other institutional projects
- Identified a list of materials or items which make significant impacts on the cost of a project thereby aiding in the certification of LEED credits MR 5.1 and 5.2
- Documented the processes of LEED certification for credits MR 5.1 and 5.2 (Refer Figure 4.2). These processes were documented based on the responses obtained from open-ended interviews with LEED Accredited Professionals.
- This framework can help to make the process of identifying local materials more efficient for designers and owners

7.8 Limitations of the study

The database structure is based on the CSI format which is commonly used for construction material specifications. The database does not contain contact information for every manufacturer available in the state of Michigan for the products included in the database. The database contains only those manufacturers which were listed in commercial listings used by the researcher. There may be other sources of manufacturer information available which were not documented by the researcher. The database

methodology is feasible for organizations or large institutions such as universities which are continuously building new structures within a region. The database does not contain specifications for products. The database also does not have search options for users to retrieve specific data.

7.9 Areas for future research

The sample database is presented as a listing of manufacturers located in the region within 500 miles of the project site. Further research on individual product specifications and performance standards can be conducted in order to enhance the details of the database. Research can also be focused on VOC content of materials, recycled content, rapidly renewable materials, etc., which will enable a database to be useful for procuring materials which qualify for other credits included in the Materials and Resource section of the LEED Rating System as well. A database could then be combined with data retrieval software which employs a user friendly interface. Search criteria for products can be introduced within the software to return results as required by the user.

Appendix A

- **Consent Forms**
  - **LEED Accredited Professionals**
    - **First Consent Form**
    - **Revised Telephone Consent Form**
  - **MSU Physical Plant Administrative Staff**
  - **Construction Managers**
- **Interview Questionnaire**
  - **LEED Accredited Professionals**
    - **First questionnaire**
    - **Revised questionnaire**
  - **MSU Physical Plant Administrative Staff**
  - **Construction Managers**

Consent Form

Development of a Database Methodology for Compliance with Regionally Available Materials Standards of LEED™ Green Building Rating System

LEED Accredited Professional

I am a student of Michigan State University currently pursuing my master's degree in the Building Construction Management Program. I am studying the material related aspects of the LEED 2.1 Rating System specifications for certification of buildings and comparing them with the Construction and Design Standards followed by Michigan State University. The research will assess methods that could be undertaken for compliance with procurement of regional materials credit (MR 5.1 and MR 5.2), through my master's thesis research titled, "Development of a database methodology for compliance with Regionally Available Materials standard of LEED™ Green Building Rating System". The research is being conducted under the direction of Professor Tim Mrozowski, of the Construction Management Department at Michigan State University. This research is a master's thesis study and is not funded by an outside source or the university. As a part of the research, I am interviewing LEED Accredited Professionals. As an experienced industry participant, your insight into the building construction practices and LEED certification process will be very useful for my research. Your views and opinions are important to me. Your responses will help me to better understand the requirements and application methods of the LEED Rating System.

The interview consists of a variety of closed and open ended questions and is expected to last 40 minutes. Your participation is voluntary and you may choose not to participate at all, may refuse to participate in certain procedures or to answer certain questions, or may discontinue answering questions at any time without penalty. Your name will not be used in any reporting of the research and your rights will be protected to the maximum extent of the law. Your answers will be reported in paraphrased form and will be aggregated with others. You can exclude any information that you do not want to be reported in this form by initialing the interview question for the item you want to be excluded.

If you have any questions regarding this survey procedure or wish to make suggestions, please contact:

Professor Tim Mrozowski
Construction Management Program
School of Planning, Construction Management and Design,
212 Farrall Hall
Michigan State University
East Lansing, MI 48824
Phone: (517) 353-0781
Email: mrozowsk@egr.msu.edu

If you have any questions or concerns regarding your rights as a subject of this research please contact:

University Committee on Research Involving Human Subjects (UCRIHS)
Dr. Peter Vasilenko
Chair of UCRIHS
202 Olds Hall
Michigan State University
East Lansing, MI 48824
Phone: (517) 355-2180
Email: ucrihs@msu.edu

Telephone Interview Consent Form

Development of a Database Methodology for Compliance with Regionally Available Materials Standards of LEED™ Green Building Rating System

LEED Accredited Professional

I would like to thank you for the information that you provided me with during our earlier interview about the material procurement credits of the LEED 2.1 Rating System. During the interview, I had asked you various questions about the LEED Rating System and its implementation. I am currently developing the database of regional manufacturers and classifying them according to CSI format. The database contains divisions 1 to 14 and their respective sections. In order to reduce the size of the database, I am focusing on materials which make a larger impact on the calculations for achieving credit MR 5.1 and 5.2 and eliminating materials and sections which have little impact. Based on your prior experiences with LEED certified buildings, I would like to ask you some additional questions about selecting such high-impact divisions of the CSI system and eliminating divisions and sections which make negligible contributions to achieving credits MR 5.1 and 5.2.

The brief telephone interview consists of a few open ended questions and is expected to last 5-7 minutes. Your participation is voluntary and you may choose not to participate at all, may refuse to participate in certain procedures or to answer certain questions, or may discontinue answering questions at any time without penalty. Your name will not be used in any reporting of the research and your rights will be protected to the maximum extent of the law. Your answers will be reported in paraphrased form and will be aggregated with others. You can exclude any information that you do not want to be reported in this form by initialing the interview question for the item you want to be excluded.

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Consent Form

Development of a Database Methodology for Compliance with Regionally Available Materials Standards of LEED™ Green Building Rating System

MSU Physical Plant Administrative Staff

I am a master's student from the Building Construction Management Department at MSU. I am studying the LEED (Leadership in Energy and Environmental Design) standards for certification of green buildings and comparing them with the Construction and Design Standards followed by Michigan State University. Buildings which comply with the specified standards receive certification based on the level of green building strategies employed during the project. The research will assess methods that could be undertaken for compliance with procurement of regional materials credit (MR 5.1 and MR 5.2), through my master's thesis research titled, "Development of a database methodology for compliance with Regionally Available Materials standard of LEED™ Green Building Rating System". The research is being conducted under the direction of Professor Tim Mrozowski, of the Construction Management Department at Michigan State University. This research is a master's thesis study and is not funded by an outside source or the university. As a part of the research, I am interviewing Michigan State University Physical Plant Administrative staff. As an experienced MSU employee, your insight into the building construction practices followed by MSU, along with that of others will be very useful for my research. Your views and opinions are important to me. Your responses will help me to better understand the requirements of the university, in order to apply the LEED Rating System to a building constructed on Michigan State University campus.

The interview consists of a variety of closed and open ended questions and is expected to last 40 minutes. Your participation is voluntary and you may choose not to participate at all, may refuse to participate in certain procedures or to answer certain questions, or may discontinue answering questions at any time without penalty. Your name will not be used in any reporting of the research and your rights will be protected to the maximum extent of the law. Your answers will be reported in paraphrased form and will be aggregated with others. You can exclude any information that you do not want to be reported in this form by initialing the interview question for the item you want to be excluded.

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Consent Form

Development of a Database Methodology for Compliance with Regionally Available Materials Standards of LEED™ Green Building Rating System

Construction Manager

I am a student of Michigan State University currently pursuing my master's degree in the Building Construction Management Program. I am studying the material related aspects of the LEED (Leadership in Energy and Environmental Design) standards for certification of green buildings and comparing them with the Construction and Design Standards followed by Michigan State University. The research would assess methods that could be undertaken for compliance with procurement of regional materials credit (MR 5.1 and MR 5.2), through my master's thesis research titled, "Development of a database methodology for compliance with Regionally Available Materials standard of LEED™ Green Building Rating System". The research is being conducted under the direction of Professor Tim Mrozowski, of the Construction Management Department at Michigan State University. This research is a master's thesis study and is not funded by an outside source or the university. As a part of the research, I am interviewing construction managers who have been involved with building projects which have achieved LEED certification or are currently being constructed. As an experienced industry participant, your insight into the building construction practices and LEED certification process, along with that of others will be very useful for my research. Your views and opinions are important to me. Your responses will help me to better understand the process and impacts of regional materials use from a constructor's perspective.

The interview consists of a variety of closed and open ended questions and is expected to last 40 minutes. Your participation is voluntary and you may choose not to participate at all, may refuse to participate in certain procedures or to answer certain questions, or may discontinue answering questions at any time without penalty. Your name will not be used in any reporting of the research and your rights will be protected to the maximum extent of the law. Your answers will be reported in paraphrased form and will be aggregated with others. You can exclude any information that you do not want to be reported in this form by initialing the interview question for the item you want to be excluded.

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Interview Questionnaire for LEED Accredited Professional

■ Demographics

We will start out with a few background questions in order to put your statements into context. Are you ready to begin?

1) Apart from being a LEED Accredited Professional, what other work or educational experiences have you had for your current work?

2) How long have you been a LEED Accredited Professional and how many projects have you handled for LEED certification?

■ LEED certification

3) How do buildings built to standard codes fare in terms of gaining LEED certification points even if they are not built with a goal of achieving LEED certification?

4) Which credits among the LEED credit rating system are easily obtained for buildings without considerable increase in cost?

5) This research focuses on credit MR 5-Regional Building materials. How familiar are you with credit MR 5.1 and MR 5.2? Have you used these credits in any LEED certification of buildings that you have been involved with? Explain.

6) What are the benefits that can be attained by procuring of materials from regional manufacturer's and obtaining the LEED credit?

7) Please outline the processes, from design through construction completion, that you have used for compliance with the requirements of credit MR 5 for regional materials.

8) Please describe the roles of the following in obtaining compliance for credits MR 5.1 and MR 5.2

1) Client

2) Architect/ Designer

3) General Contractor

4) Sub contractors

9) What is the documentation process for compliance with the following credits?

MR5.1

MR5.2

10) How do you research/develop your list of manufacturers/vendors who are within the MR 5 proximity limits?

11) Have you prepared a list of manufacturers/vendors related to projects located in Michigan or Border States for compliance with MR 5 limits?

12) Have you prepared or reviewed MR 5 documents/submittals?

13) How difficult are credits MR 5.1 and MR 5.2 to achieve for certification?

14) What difficulties have you encountered or heard about in developing documentation for MR 5.1 and MR 5.2?

15) How is the documentation reviewed by LEED certified professionals like yourself? What problems have you encountered during the process?

16) Do you have a documentation and specification package for LEED that I can review?

17) Can you explain your method for tallying total project costs and costs of individual materials in compliance with the requirements for MR 5.1 and MR 5.2.

18) Credit MR 5.2 requires locating extraction sources of individual component materials of an assembly. What is the process followed by LEED Accredited Professionals for assessment of percentages of different materials in an assembly and calculating the distance between the location of extraction and project site?

19) What are the difficulties faced by a project team in calculation of material percentages within an assembly and their respective distances for credit MR 5.2?

20) Do you have any suggestions for me which will help me as I develop my framework for developing a database of regional materials?

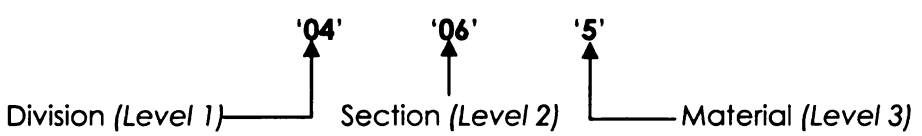
Revised Interview Questionnaire for LEED Accredited Professional

1) Do you have any suggestions on how the database of manufacturers should be organized?

2) The researcher initially selected divisions 1 to 14 for classification of manufacturers of construction materials. Divisions 15 and 16 were eliminated since credit MR 5.1 and 5.2 do not consider mechanical and electrical systems. From your experiences with LEED certified buildings, which divisions from 1 to 14 could be eliminated from the database because they make negligible contributions in achieving MR 5.1 and 5.2 credits?

3) Each CSI division consists of sections which are further divided into categories containing levels *(see example)*. To what level should the classification be maintained for the database in order to provide a comprehensive list of manufacturers which will help users in procurement of regional materials, efficiently?

Example: Material Code: **04065** – Masonry Mortar and Masonry grout



4) Do you have any suggestions for reducing the size of the database and keeping focused on materials and products which heavily influence gaining credit for MR 5.2 and 5.2?

5) Do you have any other suggestions for classification of manufacturer information in the database which would improve the usefulness of the database?

Interview Questionnaire for Michigan State University Physical Plant Construction Administrative Staff

Demographics

We will start out with a few background questions in order to put your statements into context. Are you ready to begin?

1) Describe your primary role in the building construction process carried out within MSU.

2) How long have you been in your current position? What other work or educational experiences have you had that provide background for you current position?

MSU construction and LEED Rating system

3) Are you familiar with the LEED credit rating system?

4) What is Michigan State University's general attitude towards sustainable construction?

5) Do MSU construction standards consider green building techniques as a priority for construction of buildings?

6) To what extent are green design principles implemented in construction on MSU campus?

7) This research deals with selection of regional materials/manufacturers for construction-

a. How does MSU develop standards for selection of a particular product for construction?

b. Does MSU specify/suggest vendors via specifications to contractors for procurement of materials?

8) Credit MR 5.1 of the LEED rating system requires usage of 20% of building materials procured from manufacturers/vendors within 500 miles of the project site. Credit 5.2 requires 50% of those materials to be extracted/harvested within a 500 miles radius of the same project site.

a. What difficulties do you think one may encounter, while trying to gain compliance with the standard stated above?

9) If this research suggested products which would enable MSU to use MR 5.1 and MR 5.2 – How should these products be evaluated? (eg. Cost, Durability, performance, specifications, vendors, etc.)

10) Does MSU have a general list of preferred manufacturers/vendors for materials used during construction?

Interview Questionnaire for Construction Managers

■ Demographics

We will start out with a few background questions in order to put your statements into context. Are you ready to begin?

1) What is your current position at your organization?

2) What work or educational experiences have you had for your current work?

■ Building Construction and LEED Certification

3) Are you familiar with the LEED Rating System for Green Building certification?

4) How many projects have you handled which had set goals for LEED certification?

5) What was your primary role in the LEED certification process during the construction of those buildings?

6) In the construction projects that you were involved with for LEED certification, what was the approximate percentage increase in upfront costs as compared to a building of similar size, built without LEED certification goals? How was this determined?

7) Which credits among the LEED credit rating system were easily managed by the building without considerable increase in cost

For the project-

Administrative cost to CM/AE -

8) This research focuses on credit MR 5-Regional Building materials. How familiar are you with credit MR 5.1 and MR 5.2? Have you used these credits in any of the LEED certified construction projects that you have been involved with?

9) What were the benefits that were achieved by your building project by conforming to the procurement of materials from regional manufacturer's credit?

10) What were the difficulties faced by your project team in the documentation process required for credit MR 5.1 and MR 5.2?

11) Do you have any suggestions for me which will help me as I develop my framework for developing a database of regional materials?

Appendix B

Environmental policies implemented by University of Buffalo

Environmental goals for Massachusetts Institute of Technology

UB Sustainable Energy Policy *(source: http://wings.buffalo.edu/ubgreen/, date visited July 04, 2004)*

The University at Buffalo's nationally recognized energy conservation program has a history exceeding twenty years. The program has documented annual energy dollar savings in excess of $9 million a year. In 1998, the $17 million demand side management project which the UB conducted with CES/Way International from 1994-1997 was awarded "Energy Project of the Year" from the Association of Energy Engineers.

UB is proud of its role as a national leader in campus energy conservation but we must not stand on our laurels. Our program must strive for continual improvement. Much more can be done.

UB commits to an energy conservation program based on continual improvement. The University will:

- Create and maintain appropriate organizational structures within facilities to enable on-going progress in the energy efficient operation of our campuses.
- Purchase only energy efficient equipment, consistent with performance and durability.
- Maintain or establish energy conservation and efficiency as priorities in facilities maintenance and operation.
- Consistently implement University heating and air conditioning policies.
- Continue the practice of identifying and implementing in-house conservation projects paid for out of University operations budgets.
- Evaluate prospective energy conservation and efficiency capital improvement projects on the basis of life cycle cost/benefit analysis.
- Explore methods for redirecting some portion of energy conservation dollar savings to fund additional conservation measures.
- Utilize creative funding mechanisms and energy service companies to accelerate action on larger energy conservation and efficiency projects which can be structured to pay for themselves.
- Continue efforts to raise energy awareness on campus.
- Reassess campus transportation needs and planning in light of the need to reduce energy use and energy-related emissions.
- Operate campus buses and campus fleet vehicles on natural gas or other clean alternative fuel beyond legally mandated levels.
- Strengthen its commitment to principles of environmentally sustainable green building design for all new construction and major renovations.
- Minimize SOX, NOX and CO2 emissions from campus fossil fuel burning equipment. Eliminate campus reliance on coal in the MacKay Power Plant.
- Develop a carbon dioxide emission reduction plan and measure annual progress. Seek reductions far in excess of Kyoto Global Warming Treaty requirements which call on the United States to reduce carbon dioxide emissions by 8% by 2010 (compared to 1990 levels).

- Explore and act on opportunities to employ renewable energy technologies.
- Seek effective implementation of UB's electricity purchasing policy to further promote efficiency, avoid dirty power purchases, and explore options for buying clean, renewable "green power."
- Provide support for clean energy research on campus.
- Provide support for community-based clean energy initiatives.

Our campus energy goal will be to reduce campus energy consumption by an additional 20% by the year 2010.

Endorsed by President William Greiner, May 2000

Environmental Goals for MIT

(source: http://web.mit.edu/environment/, date visited July 04, 2004)

MIT will become a leader in environmentally responsible operations, development of new and renewed facilities, and education. The initial, lifecycle and environmental costs and benefits of projects and programs will be considered in order to reduce the impact of the campus on the environment within realistic parameters. The Institute will achieve these goals, and seek continuously to improve upon them over time, through the broad participation of the faculty, students, and staff. To begin this process, the following goals are articulated. We will work toward quantifying these goals and measuring progress toward achieving them.

Included among MIT's important long-range environmental goals are to:

- Conserve energy, seeking continuous reductions in our per capita energy consumption
- Reduce campus air emissions, including those from transportation, of green house gasses and regulated pollutants
- Reduce material and resource consumption including office and laboratory supplies and water
- Increase the recycling and conservation of materials
- Increase the use of recycled-content products
- Reduce the volume of toxicity of our hazardous waste streams
- Improve our indoor environment, including both the indoor air quality and the comfort and productivity of our work and living spaces, by considering sustainability in our design, operations and maintenance policies
- Improve the urban environment, including landscape quality and the site and pedestrian environment
- Educate our students in sustainable concepts so that they may apply them in their professions
- Support community-wide and regional sustainability efforts

MIT is undertaking a significant capital projects program, presenting an immediate opportunity to make progress toward these goals in MIT buildings. Although many other projects and programs at MIT will work over time to achieve these goals, we will lose an important opportunity to make progress in MIT buildings if we do not act immediately in the capital projects program.

Consequently, as an interim measure to achieve a minimum standard and support progress toward these general environmental goals, MIT has determined that new projects (including, renovations and new construction) and programs will be designed to meet or exceed the "LEED Silver Plus"[1] standard. The LEED Silver Plus standard is the LEED Silver standard enhanced to reflect additional requirements that are necessary to support progress toward MIT's environmental goals. New projects and programs are projects or programs that are in early stages of design, are as yet to be designed, or are capable of being feasibly revised to meet MIT's environmental goals taking into account all factors and

circumstances. MIT actively encourages the pursuit of environmentally innovative projects and use of innovative technology. The LEED Silver Plus standard also will be revisited in the short term to determine whether further customization is necessary to meet MIT's long-term goals. MIT seeks to develop as quickly as possible a more performance-based standard that can be tailored to individual projects.

The total cost MIT incurs in any project involves funding from a variety of sources, including funding for initial capital development, for operating, repair and maintenance costs, and for replacements. MIT and the larger world of which we are a part also incur environmental costs from projects at every stage of development, use and replacement. In order to incur as little overall cost as possible both in the interim and under MIT's ultimate standard, MIT must make integrated decisions involving all constituencies with concern about any of these costs. During the interim and under any ultimate standard, initial investment and life cycle costs, as well as those environmental costs which do not translate well into either category (such as greenhouse gas emissions, indoor air quality and use of nonrenewable materials), will be taken into account throughout all stages of projects and programs.

It is a high priority for MIT to expeditiously develop a more comprehensive model for evaluating the total cost benefit of project/program components taking into account initial investment (including capital cost), lifecycle cost, performance, and environmental benefits and impacts.

MIT commits to undertaking consultation and review of projects among MIT experts, the MIT client team and designers at the very earliest stages of design concept development, and periodically throughout the design process, to incorporate objectives and mechanisms for achieving MIT's long-term environmental goals in projects and to evaluate total costs.

- Developed by the MIT Green Building Task Force, October 2001

Appendix C

Interview Transcripts

- **LEED Accredited Professional interviews**
- **Construction Manager Interviews**
- **MSU Physical Plant Division Administrative Staff Interviews**

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

LEED Accredited Professional

Q.No	Demographics	A	B
1)	Apart from being a LEED Accredited Professional, what other work or educational experiences have you had for your current work?	Omitted to maintain anonymity	Omitted to maintain anonymity
2)	How long have you been a LEED Accredited Professional and how many projects have you handled for LEED certification?	Omitted to maintain anonymity	Omitted to maintain anonymity
	LEED certification		
3)	How do buildings built to standard codes fare in terms of gaining LEED certification points even if they are not built with a goal of achieving LEED certification?	Building Codes take care of pre-requisites. Depends on firms. Some firms can get it. Other firms may not be able to get it.	Building codes are minimum standards, the bar has been raised a bit. Its different here in Michigan than in California where more buildings could gain certification.(Look at LEED EB)
4)	Which credits among the LEED credit rating system are easily obtained for buildings without considerable increase in cost?	Varies from project to project. All the credits are easily obtainable without considerable increase in cost except aggressive water reduction, energy saving credits, entire EA categories.	We charge a lot of money to our customers for implementation of LEED so it's a difficult question to answer. Using current sites won't cost anything. Business school at U of M is looking at cost factors of LEED. Different professionals handle different credits. Costs depend on that. Can you take the building to go above ASHRAE without increase in cost? No. Reduced energy savings - 28%. (look at the graph)

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

5)	This research focuses on credit MR 5- Regional Building materials. How familiar are you with credit MR 5.1 and MR 5.2? Have you used these credits in any LEED certification of buildings that you have been involved with? Explain.	Used all of them. At least 5.1; 5.2 not relied on heavily. Lowest percentage achieved on 5.1 is 60% (generally 60%-90%). You get innovation credit for doing twice as good.	Every project uses 5.1. Today everything can be bought within 500 miles. Recycled content gets the credit. Steel is recycled, glass- relatively easy to do.
6)	What are the benefits that can be attained by procuring of materials from regional manufacturers and obtaining the LEED credit?	Reduce lead time, Support the local economy, Reduced transportation (pollution). No real savings on transportation	Locally are good for regional economy, Less use of petroleum, Cost effective
7)	Please outline the processes, from design through construction completion that you have used for compliance with the requirements of credit MR 5 for regional materials.	The point is easy to get. If the design was unusual then we need to keep track of materials (flag unusual items). During construction all successful bidders should submit certified letters where the raw materials are coming from to decide the percentage of regional materials (getting paperwork for manufacturing)	We use the LEED charette. Decide initially. Set specifications according to the requirements. It is easy but everybody has to be aware of it. 5.2 is difficult to get. Design team meeting ------> LEED checklist------> Owner, Contractor, Architects measure it according to checklist ----------> specs ----------> Contractor and subs submittals

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

8)	Please describe the roles of the following in obtaining compliance for credits MR 5.1 and MR 5.2		
	a. Client	Not a lot. Designer notifies the client early about the availability of the credit point	Signs off on the selection of materials, through the design architect according to 5.1, unless client wants something from far off
	b. Architect/ Designer	If they are doing something unusual they need to make sure there aren't any implications	Everybody on the design team has to be involved.
	c. General Contractor	After bid and before construction, they are required to give appropriate submittals. Signed letters certifying sources and cost. LEED requires all documents to be stamped by the general contractor.	Once materials are selected, keeping a check on submittals. Cost of materials is to be recorded, not labor.
	d. Sub contractors		Make appropriate submittals
9)	What is the documentation process for compliance with the following credits?		
	MR5.1	After successful bid and prior to construction signed letters from sub-contractors	Submittals. Letter template, spreadsheet. To get template, get the project registered to get a template account.
	MR5.2	Signed letters from manufacturers about source of materials	
		Follows general submittal procedures.	
10)	How do you research/develop your list of manufacturers/vendors who are within the MR 5 proximity limits?	Don't have a list. Due to the nature of construction and the market we get the point easily. With 300 mi it might get difficult to get the point	Pure education, constant research, meeting and talking to vendors. Firms have a design outlook, consistent design types. Materials used are fairly consistent.

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

11)	Have you prepared a list of manufacturers/vendors related to projects located in Michigan or Border States for compliance with MR 5 limits?	No.	Its automatic. Spec writers have a list of vendors or preferred list of manufacturers based on quality and performance.
12)	Have you prepared or reviewed MR 5 documents/submittals?	Yes	Yes
13)	How difficult are credits MR 5.1 and MR 5.2 to achieve for certification?	5.1 is very easy to get. 5.2 depends on the project. The higher your recycled content makes it easier to achieve 5.2. Difficult for virgin materials.	5.1 is easy. 5.2 is somewhat harder (questionable)
14)	What difficulties have you encountered or heard about in developing documentation for MR 5.1 and MR 5.2?	5.1 never had any difficulty. Achieved credit for each project.	Have an invoice from all contractors for everything. Sometimes things are missing. 30% of documents are required with invoice.
15)	How is the documentation reviewed by LEED certified professionals like you? What problems have you encountered during the process?	Ill send them a letter showing miles (template), manufacture produced XX mile from site, source XX miles from site. Template with letter submittals. The key to keeping costs down is to get the templates done early during the project.	There are 7 contracted consultant firms which review the binders (2 binders, USGBC & consultants). Preliminary and Final review. Eg. 27 certified, 10 abeyance, 3 denied.----------> back-up materials -----> Final review ----------->Appeals.
16)	Do you have a documentation and specification package for LEED that I can review?	I will email it to you.	I saw the templates
17)	Can you explain your method for tallying total project costs and costs of individual materials in compliance with the requirements for MR 5.1 and MR 5.2.	Get letters from subs and general contractors. Arrange the mileage data in templates.	Working with AE responsible for design budget with feedback from contractor or contractor responsible for cost. Review with owner, wrt LEED credits based on optimizing energy

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

18)	Credit MR 5.2 requires locating extraction sources of individual component materials of an assembly. What is the process followed by LEED Accredited Professionals for assessment of percentages of different materials in an assembly and calculating the distance between the location of extraction and project site?	For Assembly the calculation is by cost of materials. For some products it goes by weight. If it gets too complicated then we don't bother.	Varies from firm to firm. Dependent on Material or system/assembly provider. Earlier getting information was difficult, now easy because of awareness amongst vendors.
19)	What are the difficulties faced by a project team in calculation of material percentages within an assembly and their respective distances for credit MR 5.2?	Contractors not giving information, If it happens after construction is completed and everybody is paid off, you will never get it.	Ask contractor to get information from vendors. People have more information available now.
20)	Do you have any suggestions for me which will help me as I develop my framework for developing a database of regional materials?	Make sure the mileage information is present. Look at version 2.2. Take care of 300 miles radius. It's a bigger issure in the west where there aren't many manufacturers.	Someone I know is putting together a website for regional materials. Archrecord.com and EBN are making databases too.

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

LEED Accredited Professional

Q.No.	Demographics	C	D
1)	Apart from being a LEED Accredited Professional, what other work or educational experiences have you had for your current work?	Omitted to maintain anonymity	Omitted to maintain anonymity
2)	How long have you been a LEED Accredited Professional and how many projects have you handled for LEED certification?	Omitted to maintain anonymity	Omitted to maintain anonymity
	LEED certification		
3)	How do buildings built to standard codes fare in terms of gaining LEED certification points even if they are not built with a goal of achieving LEED certification?	Depending on the state the building in question is in, the project could very easily make the jump to achieving at least a Certified level of LEED, as is the case in most states. Some states do not have well developed codes and for buildings in those states it may take more planning and thought before design gets too far along in order to comply with LEED standards and achieve at least a minimum of points.	They don't even compare. Building code is about achieving the minimum allowed by law to be acceptable. LEED is about achieving the maximum performance from a building. Buildings just built to code are far behind buildings built to LEED standards

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

4)	Which credits among the LEED credit rating system are easily obtained for buildings without considerable increase in cost?	Site selection, urban redevelopment, alternative transportation (all except alternative fuel refueling), reduced site disturbance (protect or restore open space), storm water management (both), ozone depletion, recycled content and local/regional materials (construction cost only – management costs for credits may add cost), rapidly renewable materials, construction IAQ management plan (during construction), low-emitting materials (adhesives and sealants, paints, carpets), daylight and views (possibility of both, dependent on type of project)	The credits that deal with simple design selection are always the easiest but these choices have to be made very early in the design. For instance, SS 4 is simply a matter of picking a site close to bus lines and transit. This is just a matter of selection. WE 1 is a simple task, EA 4 is a simple selection, EA 6 is a simple selection, MR 2 is one of the easiest if it is planned from the very start. Choosing to use recycled and regional materials is just a matter of selection. IEQ 4 can be easy if it is planned and executed properly.
5)	This research focuses on credit MR 5-Regional Building materials. How familiar are you with credit MR 5.1 and MR 5.2? Have you used these credits in any LEED certification of buildings that you have been involved with? Explain.	I am using these credits on the main project I am working on right now. Every project I have worked on has attempted to achieve these points. On one project we did have difficulty, but for the most part projects in the Midwest have an exceptional range of products to pull from that are within a 500 mile radius of their site.	Extremely familiar, I have used this credit in every one of my LEED projects. We chose materials based on their distance from our site for a number of reasons.
6)	What are the benefits that can be attained by procuring of materials from regional manufacturers and obtaining the LEED credit?	Benefits include reducing pollution (especially from trucks), working with local companies (possibly finding new partners to work with or receive discounts for bulk buys from a smaller producer), building economy in your area.	The benefit of buying materials locally is on several levels. One, it reduces the embodied energy in the product. If it doesn't have to be shipped from a long distance the fuel consumption for transportation is reduced. Thus making it a more sustainable product. Also on another scale, if you buy regional materials you are supporting your local economy.

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

7)	Please outline the processes, from design through construction completion that you have used for compliance with the requirements of credit MR 5 for regional materials.	In design the products need to be researched (to find new products) and investigated (to ensure quality) and then included in the specifications. Once included in the specifications, the contractor needs to attempt to procure products from regional manufacturers whenever possible. During construction the designer or, more likely, the contractor, needs to keep records of which products are manufactured from within the 500 mile radius and, of those, which also have their raw materials pulled from within that same radius. At completion of construction the LEED AP needs to run the calculations with that information to determine whether the threshold for LEED credits has been achieved.	The process starts in the design phase; you have to decide what materials the building is going to be built from. For instance our last LEED project we choose to use Insulated Concrete Forms instead of a steel frame because concrete is a regional material. I could also specify the use of fly ash in the concrete. Fly ash is a waste product from the coal burning electrical generation industry. It is considered recycled content. The next part is specifying the material's use in the bid documents and making sure the bidders have taken this into account in their bids. The last phase is having strong site supervision during construction to make sure the products you want are being installed.
8)	Please describe the roles of the following in obtaining compliance for credits MR 5.1 and MR 5.2		
	a. Client	Encouraging local product use and accepting the possibility of lesser name products on the job if they are local and equal in quality to a more known name brand.	The client must first understand the goals of the project and be passionate about them. If this happens, the project can go very smoothly.
	b. Architect/ Designer	Investigating products and doing the research to determine if local products are available and of a certain quality. Including local products in the specifications and other design documents.	The architect must have an understanding of sustainable practices and be able to specify the proper materials for the job. The architect should have an understanding of the practical application of the materials.

	c. General Contractor	Ensure bidding with subs and vendors includes local/regional products. Encourage subs and vendors to include local products whenever feasible. Note which products are being used that are within the 500 mile radius; keep spreadsheet on total cost of project materials, individual costs of applicable local materials (names of companies, products); get back up materials from vendors verifying that the manufacture location is within 500 mile radius	The general contractor must understand the goals of the architect and the client. The general contractor must also have an awareness of sustainable practices and the practical knowledge of how to apply them. The GC must also pay attention to the application of these processes to ensure they are done right.
	d. Sub-contractors	Bid projects with local materials whenever possible; ensure use of those materials by work teams on project; get information from manufacturer to give to GC or CM; break out price of materials from labor and taxes, fees, etc. in bid – give to GC or CM.	The sub contractors must also understand the goals of the architect and client. They must be able to take direction from the GC regarding proper procedure. They need to have an understanding of sustainable practices as it applies to their trade and have the integrity to do the job properly.
9)	What is the documentation process for compliance with the following credits?		
	MR5.1	Track materials that have been used on project that are manufactured within 500 mile radius. Break out costs between labor, materials, fees, etc – use only material costs in calculations. Calculate how much money was spent on local materials versus whole project materials. If meet 20% threshold, credit achieved. Submit calculations, letter template declaration – have back up showing info used for calculations and statements of manufacture location from manufacturers ready to go in case of audit during submittal process.	We use the LEED calculator provided by the USGBC

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

	MR5.2	Same as above, though once have list of manufacturers whose products come from within 500 mile radius, query them on where their materials for those products are drawn from...possibility the materials could help qualify for both 5.1 and 5.2 credits. For those products whose materials also come from within 500 mile radius, get letters of statement from manufacturers as well as cost of those raw materials versus cost of overall product. Use those raw materials cost numbers for calculation to verify half of all products noted in 5.1 also have materials qualifying for 5.2. Submit letter template declaration and calculations. Have back up info used for calculations and statement letters from manufacturers ready in case of audit during submission process.	Same
10)	How do you research/develop your list of manufacturers/vendors that are within the MR 5 proximity limits?	GreenSpec, online, word of mouth/networking with other professionals, work with contractors.	I use my subcontractors and suppliers to help supply information on this. I also do a fair amount of research on a daily basis to find products I need.
11)	Have you prepared a list of manufacturers/vendors related to projects located in Michigan or Border States for compliance with MR 5 limits?	Do not have a comprehensive list prepared now but could pull one together from spreadsheets assembled by contractors for LEED credit compliance and specifications from those projects.	I have some information regarding the products I've used in the past.
12)	Have you prepared or reviewed MR 5 documents/submittals?	I am in the midst of preparing documentation on MR5 credits now. Have not reviewed them from an official reviewer's perspective.	Yes, I have had to do both. We try to make sure our subcontractors get the information correct in the bidding process.

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

13)	How difficult are credits MR 5.1 and MR 5.2 to achieve for certification?	Depends on the location of the project in the country and the type of project being done. Some areas like those on the coasts (or more obviously – Hawaii) will have more of a difficulty getting the maximum benefit from any situation involving a radius from project site due to proximity to oceans. Some areas do not have varied types of materials being manufactured within their region. Types of projects can also influence the level of difficulty because certain project types are more demanding in their building requirements and may not have room to find or use local materials (i.e. clean rooms, high technology areas, surgical suites, etc.) Overall, if your area is abundant with a variety of manufacturers and you have a general project type (a commercial office building in Michigan or Ohio), you should be able to achieve the MR5 credits fairly easily in terms of finding and using materials. The more difficulty aspect, for any project anywhere, is keeping up with the paperwork of what was made where and with what material from where and how much it all costs. That is the more difficult part that could discourage a project from achieving these credits.	There is some difficulty here due to the lack of a database of regional materials for this area. If there were a database that I could plug in an address and it could tell me how far away a material is from me, my life would be much easier.
14)	What difficulties have you encountered or heard about in developing documentation for MR 5.1 and MR 5.2?	See above....documentation and keeping up with required numbers, materials, products, back up statements, etc.	The trouble is getting suppliers to get you the correct information. Sometimes it takes a few phone calls.

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

15)	How is the documentation reviewed by LEED certified professionals like you? What problems have you encountered during the process?	I have not reviewed a project for compliance with these credits. To my knowledge there are only five companies who do the official LEED reviews of projects. Reviewing materials to submit for a project (materials received from contractors, etc) have been difficult because it is a daunting task for everyone involved and oftentimes the contractors do not have someone dedicated to LEED only. Information can lag behind schedule and final assembly and review of info can be pushed to the last minute of a project, which makes it more difficult to add more products to the project if necessary or get the back up information needed from the manufacturers.	I feel that if you've been diligent in the process up to that point, documentation shouldn't be a problem.
16)	Do you have a documentation and specification package for LEED that I can review?	I have a sample spreadsheet the contractor has been keeping throughout the project that tracks materials for recycled content, local manufacture, etc. that you could look at. I would not want it shared without permission from the contractor. The specifications I can access and get to you, if needed. I do not have day to day access to them at this time.	I have some specifications that I can forward along
17)	Can you explain your method for tallying total project costs and costs of individual materials in compliance with the requirements for MR 5.1 and MR 5.2.	Everything is tied into the spreadsheet. Excel can help track and and add the project costs for materials very easily for you.	We use the LEED calculator that is provided by the USGBC

18)	Credit MR 5.2 requires locating extraction sources of individual component materials of an assembly. What is the process followed by LEED Accredited Professionals for assessment of percentages of different materials in an assembly and calculating the distance between the location of extraction and project site?	Location of extraction needs to be found from the manufacturer. Once that is known, the LEED AP needs to locate that city on a map and compare it to a 500 mile radius. Because the 500 mile radius is 'as the crow flies' one would only shortchange themselves to use something like Yahoo or Mapquest to calculate the distances as these programs use driving miles and rely on where actual roads are. For percentages of materials in an assembly, the easiest way I have found for the calculations is to ask the manufacturer to break down the cost of the various materials in the product. Then one can use those material costs and load those into the calculation directly instead of having to interpolate from percentage based product lists.	I haven't had to go to this much detail. We don't use many assemblies.
19)	What are the difficulties faced by a project team in calculation of material percentages within an assembly and their respective distances for credit MR 5.2?	Not taking the manufacturer's word on distance calculations as fact without checking the radius themselves – many manufacturers use the yahoo and mapquest programs and automatically count themselves out of the running for this credit when they could, in fact, be eligible. That takes time on the LEED AP's part to verify distances. Making the calls or requests to the manufacturers for their product materials lists also takes time and manufacturers may not be willing to give up that information or may not have it immediately accessible and ready to send out. More and more are becoming familiar with LEED requirements though and are starting to pull the information together so it is ready when their product is used on another LEED	See question 18

Interview Response Matrix – LEED Accredited Professional, 1st round of interviews

20)	Do you have any suggestions for me which will help me as I develop my framework for developing a database of regional materials?	Work with the folks out at GreenSpec and Environmental Building News. They have a database already started and they could help jump start your regional database with the information they already have on hand of products that could help a project meet other credit requirements.	Try to develop a distance calculation so I can easily see how far the material is away from my project. This may be as simple as a link to www.mapquest.com.

Interview Response Matrix – LEED Accredited Professional, 2nd round of interviews

Q.No	Second round of LAP interviews	A	
1)	Do you have any suggestions on how the database of manufacturers should be organized?	It should follow the CSI format or format of specifications. Its typical so that's why. Have some kind of cross reference to LEED credits.	
2)	The researcher initially selected divisions 1 to 14 for classification of manufacturers of construction materials. Divisions 15 and 16 were eliminated since credit MR 5.1 and 5.2 do not consider mechanical and electrical systems. From your experiences with LEED certified buildings, which divisions from 1 to 14 could be eliminated from the database because they make negligible contributions in achieving MR 5.1 and 5.2 credits?	10, 11, 12, 13, 14. There are elements within special construction which can be added into the recycled content credit.	
3)	Each CSI division consists of sections which are further divided into categories containing levels (see example). To what level should the classification be maintained for the database in order to provide a comprehensive list of manufacturers which will help users in procurement of regional materials, efficiently?	Keep it general. Don't go to the final level and as it builds you can add more detail. It's not too different for 5.1 or 5.2.	

Interview Response Matrix – LEED Accredited Professional, 2nd round of interviews

4)	Do you have any suggestions for reducing the size of the database and keeping focused on materials and products which heavily influence gaining credit for MR 5.2 and 5.2?	Since CSI is the basis, (haven't thought this out. What happens if you create a pre-amble of the CSI divisions? Data regarding the materials resides in the sections. Looking at it from LEED point of view. Is there a way to link-up the LEED credits to the database? If someone wants to check credit MR 5, the system shows that some company is in the area within 500 miles. Take zip code number which shows how far you are from the plant. A key that allows people to see their location from the manufacturing zip code.	
5)	Do you have any other suggestions for classification of manufacturer information in the database which would improve the usefulness of the database?	Not any. CSI system is the way to go for classification.	

Interview Response Matrix – LEED Accredited Professional, 2nd round of interviews

Q.No	Second round of LAP interviews	C	D
1)	Do you have any suggestions on how the database of manufacturers should be organized?	The most helpful way to organize a database of manufacturers would be by spec section or even CSI division. Building professionals, including architects, engineers, contractors, and vendors/manufacturers are all familiar with this system and it would be, in my opinion, a selling point to be part of a database that was easily searchable and usable.	The best way that I can think of is by CSI division. It is the most common classification system in construction. I think you're on the right track.
2)	The researcher initially selected divisions 1 to 14 for classification of manufacturers of construction materials. Divisions 15 and 16 were eliminated since credit MR 5.1 and 5.2 do not consider mechanical and electrical systems. From your experiences with LEED certified buildings, which divisions from 1 to 14 could be eliminated from the database because they make negligible contributions in achieving MR 5.1 and 5.2 credits?	Actually, division 1 is administrative only and will not have an effect on manufacturer location. Divisions 11-14 are not expected to contribute to the local/regional credit calculations. The most important divisions to achieving these credits are those that have high cost materials in them, like 2, 3, and 4. Basic building materials like steel, concrete, and brick or block as well as earthwork are generally large in quantity and cost on a project and will have more influence on the percentages required to achieve any of the credits in the MR section of LEED that are dependent on benchmarking against 'total materials cost'	Division 1 is general conditions I can't see how this would relate. Division 7 is questionable, as well as 10, 11, 13, & 14. Most of these items aren't available on a local or regional level.

Interview Response Matrix – LEED Accredited Professional, 2nd round of interviews

3)	Each CSI division consists of sections which are further divided into categories containing levels (see example). To what level should the classification be maintained for the database in order to provide a comprehensive list of manufacturers which will help users in procurement of regional materials, efficiently?	I think maintaining a database to the second level of CSI classification would be helpful enough. Going to the third level may be helpful, but sometimes the materials can be listed in several third level sections depending on who is writing the specs. Second level classification would also be quite enough work for anyone organizing and updating the database.	You could almost get down to just classifying them by the root CSI division. At this stage it may over complicate your database to go much further then that. How many companies are actually going into the database? I feel a root division classification would be sufficient.
4)	4) Do you have any suggestions for reducing the size of the database and keeping focused on materials and products which heavily influence gaining credit for MR 5.2 and 5.2?	Focus on the 2-5 divisions, not only because they generally have the higher costs on a project but also because, for the State of Michigan, there is a vast amount of manufacturers in our region that provide products in 2-5 – more so than the other divisions of products (excepting furniture, which doesn't count in this credit's calculations anyway).	See the answer above. I think it describes it.
5)	5) Do you have any other suggestions for classification of manufacturer information in the database which would improve the usefulness of the database?	Once the manufacturers are classified by CSI division and section, perhaps they could be organized by state and then in alphabetical order. Depending on where your project is within the state of Michigan, manufacturers in Illinois or Iowa may or may not help. Perhaps the contractor would find it helpful to work with manufacturers who are closer to the project site than others who may be a state away...perhaps it would help them negotiate costs due to reduced shipping or hauling?	Like I've said before, it would be nice to be able to judge distance from a particular job site. This could be as easy as link to mapquest.

Interview Response Matrix – Michigan State University Physical Plant Staff

Michigan State University Physical Plant Construction Administrative Staff

Q.No	Demographics	A	B
1)	Describe your primary role in the building construction process carried out within MSU.	Omitted to maintain anonymity	Omitted to maintain anonymity
2)	How long have you been in your current position? What other work or educational experiences have you had that provide background for you current position?	Omitted to maintain anonymity	Omitted to maintain anonymity

MSU construction and LEED Rating system

3)	Are you familiar with the LEED credit rating system?	Not in detail, just conceptually. Attended AIA presentation to members many times over years. Have not used LEED submittal process for certification.	Fairly familiar.
4)	What is Michigan State University's general attitude towards sustainable construction?	Favorable, if justified by life cycle cost model. We use materials and equipments that have long useful lives. We design buildings that protect mechanical and electrical equipment as well as occupants. We have maintenance programs that monitor & correct performance of systems.	View incorporation of sustainable construction as a positive development. We are in the process of getting familiar with it; It will lead to a design attitude to include sustainable designs as a matter of course.
5)	Do MSU construction standards consider green building techniques as a priority for construction of buildings?	Not currently, but as a priority for development of the next edition.	Not specifically. MSU construction standards have always emphasized low energy & life-cycle costs. Expanding on it.

Interview Response Matrix – Michigan State University Physical Plant Staff

6)	To what extent are green design principles implemented in construction on MSU campus?	Currently not part of our criteria for design. We look at it from the maintenance point of view.	Energy conservation has been a long standing policy. Using high quality materials, University views this as an issue which should be a university priority without substantial increase in cost.
7)	This research deals with selection of regional materials/manufacturers for construction-		
a.	How does MSU develop standards for selection of a particular product for construction?	1) Previous experience that is positive for performance and maintenance 2) Performance criteria	Focuses on life-cycle cost; Materials, devices or systems are selected to see if the function is completed. Lowest life-cycle cost/maintenance issues are important. First cost is never an issue.
b.	Does MSU specify/suggest vendors via specifications to contractors for procurement of materials?	Yes, but as an example of suppliers of products that meet the performance criteria of the specifications. Depending on the sophistication of the project for larger projects, hire consultants. Meet or exceed standards; lifecycle policy is followed.	Yes, standards in bid documents generally have a technical description that gives key minimum requirements for the materials. Lists 3-4 manufacturers based on experience. Contractor is given an option of giving new material which is subject to review
8)	Credit MR 5.1 of the LEED rating system requires usage of 20% of building materials procured from manufacturers/vendors within 500 miles of the project site. Credit 5.2 requires 50% of those materials to be extracted/harvested within a 500 miles radius of the same project site.		
a.	a. What difficulties do you think one may encounter, while trying to gain compliance with the standard stated above?	We live in a national and global economy. To procure our traditional building materials such as brick, limestone, glass and aluminum, from "local" producers could prove impossible or non-competitive. Vendor is possible, manufacturer is quite difficult.	The main problem - there aren't many suppliers who have this information; Construction material components are built all over the world.

Interview Response Matrix – Michigan State University Physical Plant Staff

9)	If this research suggested products which would enable MSU to use MR 5.1 and MR 5.2 – How should these products be evaluated? (eg. Cost, Durability, performance, specifications, vendors, etc.)	All of the above including maintenance costs	Cost is important. University is willing to pay premium for compliance (how much - not decided). Durability/performance will not be compromised - Equal to university standards or better. We review manufacturers, talk to users whom the vendor has sold it to.
10)	Does MSU have a general list of preferred manufacturers/vendors for materials used during construction?	MSU standards for construction include them by reference.	Appears in the standards by products. It's being refined and updated regularly.

Interview Response Matrix – Michigan State University Physical Plant Staff

Q.No.	Demographics	These were combined interviews with interviewess responses noted together.	
1)	Describe your primary role in the building construction process carried out within MSU.	Omitted to maintain anonymity	Omitted to maintain anonymity
2)	How long have you been in your current position? What other work or educational experiences have you had that provide background for you current position?	Omitted to maintain anonymity	Omitted to maintain anonymity

	MSU construction and LEED Rating system		
3)	Are you familiar with the LEED credit rating system?	Yes	Yes
4)	What is Michigan State University's general attitude towards sustainable construction?	"Say" they support it - no money yet. Not considered as a goal; for years been involved with LCC, sustainable practices have always been there. Distinguish between sustainable practices and LEED	Receptive but not yet a goal
5)	Do MSU construction standards consider green building techniques as a priority for construction of buildings?	No. Some people think we should consider it; Cost factor is important; As energy costs increase we need to see how these things conserve energy.	No
6)	To what extent are green design principles implemented in construction on MSU campus?	A lot in energy areas, meeting ASHRAE 90.1, Central building control, not a lot of motion detectors.	Somewhat in Mechanical/Electrical areas. Example: ASHRAE 90.1, Building Automated Systems.
7)	This research deals with selection of regional materials/manufacturers for construction-		
a.	How does MSU develop standards for selection of a particular product for construction?	Service space has doubled while staff numbers have gone down, servicing consideration. Life-cycle costs, experience, first cost. Staying with ones which have been	Life-cycle costs, experience, low maintenance, reliability, serviceability.

Interview Response Matrix – Michigan State University Physical Plant Staff

		effective. We do move into new systems/ A lot is historical experience/ company that supplies products and installs is important. A lot it also has to do with code issues. Support from dealers in important.	
b.	Does MSU specify/suggest vendors via specifications to contractors for procurement of materials?	We specify, 5 through 14 divisions, 4-5 manufacturers. We specify the product; Lot of cases where we do performance specifications. If you wan to substitute some product, you have to specify before bids. Very particular about certain products like fume hoods.	Yes, based on above criteria. Manufacturers are specified - not suppliers.
8)	Credit MR 5.1 of the LEED rating system requires usage of 20% of building materials procured from manufacturers/vendors within 500 miles of the project site. Credit 5.2 requires 50% of those materials to be extracted/harvested within a 500 miles radius of the same project site.		
a.	What difficulties do you think one may encounter, while trying to gain compliance with the standard stated above?	Reduced competition, reduced variety. Cost to track and certify it, expense in validating. Scope of specification reduced. We could only as manufacturer to certify.	Reduced competition, reduced variety, you can't find some products locally, time to certify and validate sources.
9)	If this research suggested products which would enable MSU to use MR 5.1 and MR 5.2 – How should these products be evaluated? (eg. Cost, Durability, performance, specifications, vendors, etc.)	same as 7 a	

Interview Response Matrix – Michigan State University Physical Plant Staff

10)	Does MSU have a general list of preferred manufacturers/vendors for materials used during construction?	Products we're currently using rate against 5.1 and 5.2. Need to see current benchmark and see how we fare. Difficult in our bidding system to get manufactured price & installed price; they won't give us real price. Would be interesting to see how soon can we ask for breakdown of price- during bid/later/earlier?	

Interview Response Matrix – Construction Manager

Construction Manager		A	B
Q.No.	**Demographics**		
1)	What is your current position at your organization?	Omitted to maintain anonymity	Omitted to maintain anonymity
2)	What work or educational experiences have you had for your current work?	Omitted to maintain anonymity	Omitted to maintain anonymity
	Building Construction and LEED Certification		
3)	Are you familiar with the LEED Rating System for Green Building certification?	Yes	Yes
4)	How many projects have you handled which had set goals for LEED certification?	Working on the 8th LEED project.	3 completed, working on 2, 3 in the pipeline
5)	What was your primary role in the LEED certification process during the construction of those buildings?	Varied by project; Most recently, the documentation process.	project coordinator, documentation
6)	In the construction projects that you were involved with for LEED certification, what was the approximate percentage increase in upfront costs as compared to a building of similar size, built without LEED certification goals? How was this determined?	Probably, 2% increase in management costs (hrs). Construction project - Depends on what points you're going after: 5-7 %; Its coming down.	It really depends on the type of project you're working on. Some projects demand more, others don't. depends on credits too. I would say, roughly, 1-3 % in man hours and around 6-8 % in construction costs.
7)	Which credits among the LEED credit rating system were easily managed by the building without considerable increase in cost		

Interview Response Matrix – Construction Manager

	For the project-	Waste Recycling very minimal IAQ compliant with ASHRAE LEED Accredited Professional Depending on project-regional materials Remodeling jobs have difficulty	Some site credits, regional materials, recycled content, IAQ management, We already follow ASHRAE. So those are easy.
	Administrative cost to CM/AE -	Costs minimal in recycled content	Design related credits. If there is paperwork to be processed then we have to put people on the job which costs money.
8)	This research focuses on credit MR 5-Regional Building materials. How familiar are you with credit MR 5.1 and MR 5.2? Have you used these credits in any of the LEED certified construction projects that you have been involved with?	5.1 - all the projects 5.2 - If its new, its not difficult; for renovation its difficult	5.1- is easy to get. We achieved that credit for all our projects. For 5.2 its difficult to get information because even manufacturers don't have that information.
9)	What were the benefits that were achieved by your building project by conforming to the procurement of materials from regional manufacturer's credit?	Helps regional economy, Typically most of the deliveries are down.	Sometimes you get good deals because you work with those people often, local economy flourishes. I guess we save fuel too. Not sure about that.
10)	What were the difficulties faced by your project team in the documentation process required for credit MR 5.1 and MR 5.2?	Getting the information from the subs, Requires LEED docs to be submitted with shop drawings, Much easier if started early, LEED certification varies by project.	The information is not available. These days some suppliers have the information but it takes time. But its changing as people are getting used to the requirements.
11)	Do you have any suggestions for me which will help me as I develop my framework for developing a database of regional materials?	Database would be very helpful, research on the internet. There is no current database which provides such information. It should speed verification process. With version 2.2, certification will be difficult.	It's a good approach and I think it would be helpful. It might save some time. I don't know of any method of doing this except if I would be able to search for items within the region; That would make our work much easier.

Interview Response Matrix – Construction Manager

Q.No.	Demographics	C	
1)	What is your current position at your organization?	Omitted to maintain anonymity	
2)	What work or educational experiences have you had for your current work?	Omitted to maintain anonymity	

	Building Construction and LEED Certification		
3)	Are you familiar with the LEED Rating System for Green Building certification?	Yes	
4)	How many projects have you handled which had set goals for LEED certification?	3 completed, working on 4 currently.	
5)	What was your primary role in the LEED certification process during the construction of those buildings?	Some part in documentation co-ordination, I deal with subs for information.	
6)	In the construction projects that you were involved with for LEED certification, what was the approximate percentage increase in upfront costs as compared to a building of similar size, built without LEED certification goals? How was this determined?	I cannot give you an exact figure for the increase in costs. I would say roughly 7-10% but it depends on the credits. If we're very ambitious then that cost can go up further. Difficult to estimate increase in management costs. Say, around 2-3%.	
7)	Which credits among the LEED credit rating system were easily managed by the building without considerable increase in cost		

Interview Response Matrix – Construction Manager

	For the project-	Some don't cost any money at all. The one that you're dealing with - regional materials, That is an easy credit to get. Construction waste, site credits, ASHRAE compliance which we already do.	
	Administrative cost to CM/AE -	Can't say credit wise because we've never conducted such an analysis.	
8)	This research focuses on credit MR 5-Regional Building materials. How familiar are you with credit MR 5.1 and MR 5.2? Have you used these credits in any of the LEED certified construction projects that you have been involved with?	Very familiar. Used it in every project until now.	
9)	What were the benefits that were achieved by your building project by conforming to the procurement of materials from regional manufacturer's credit?	It helps regional economy for one. It's supposed to reduce lead time too but that really depends on the suppliers.	
10)	What were the difficulties faced by your project team in the documentation process required for credit MR 5.1 and MR 5.2?	Information from subs - very difficult to get. Most of them don't really care. We have to put a person on the job at times just to get that information.	
11)	Do you have any suggestions for me which will help me as I develop my framework for developing a database of regional materials?	This database could be helpful if it gives the information which we need. You are going on the right track and I can't imagine how you could do this otherwise. Follow CSI format. I think that's about it.	

Framework and Database Validation

		A	B
1)	As a user, how useful is the database in providing you information for regional manufacturers, in its current form? You may choose to rate its usability on a scale or 1 to 5 (1 – very difficult, 2 – less difficult, 3 – moderately easy, 4 – easy, 5 – very easy). What are your suggestions?	The information that has been gathered is very good. It looks like for the most part you concentrated on Michigan companies. By LEED standards our 500 mile radius goes quite a bit farther then Michigan but I assume you didn't have the time to look into companies that far away. I think the usability of the database needs to be worked on a bit. It is a little cumbersome to work with. Maybe a better user interface may help a lot. Usability I'd rate between a 1 and 2.	Using the given scale I would rate it 3. Although the database seems to be quite useful as a user it might be difficult to retrieve data in this form. Looking through rows and columns manually is hard for someone like me.
2)	Looking at the contents of the database, does the database comprehensively cover the products/materials that aid certification for credits MR 5.1 and 5.2? You may choose to rate its comprehensiveness on a scale or 1 to 5 (1 – not comprehensive, 2 – less comprehensive, 3 – moderately comprehensive, 4 – quite comprehensive, 5 – very comprehensive). What are your suggestions?	As I said above, it looks like the main focus was on Michigan companies. What you have put together as a list of Michigan companies is great but our boundary goes a lot further then that. So if I were rating it based on Michigan companies I'd give it a 5, If we're talking about over the 500 mile radius I'd give it a 3.	I think the database has covered most divisions and materials which are important for the credit. However, it is Michigan based. Michigan has a large manufacturing base which makes it workable but the credit requirements say otherwise. I give a 3 as its rating for this aspect
3)	Are there any manufacturers that you know of that have not been included in the database?	There are no major omissions that stand out to me.	None that I can think of right now
4)	How would you overall rate the database for its content, format and method of development? You may choose to give an overall rating on a scale or 1 to 5 (1 – very bad, 2 – bad, 3 – Ok, 4 – good, 5 – very good). What are your suggestions?	Overall I'd give it a 3. The biggest thing would be to get the usability handled.	The database is useful with its format and your method. I would like to rate it between 3 and 4 because it provides helpful information but more information is needed. The task of collecting information such as this is phenomenal.

5)	Do you have any suggestions regarding the content and form of development of the database?	When you're doing a project like this you have to give special thought to how the end user is going to react to what you're doing. It may seem totally logical when you're working on it but someone else can look at it and say, I don't get it. Make the user interface attractive and simple to use. Couple that with the great information you have collected and you've got a stellar database.	I remember suggesting links within the database to mapquest. You have managed to document travel distances which are useful. The method that you have used has its pros and cons. On one hand, collecting information by conducting telephone calls does not seem feasible. However, such information is not available from any source. I guess this is one of the better ways of collecting information.

		C	
1)	As a user, how useful is the database in providing you information for regional manufacturers, in its current form? You may choose to rate its usability on a scale or 1 to 5 (1 – very difficult, 2 – less difficult, 3 – moderately easy, 4 – easy, 5 – very easy). What are your suggestions?	I was very impressed by the work that you have done. Within the given context, the database looks useful. It can be improved, however, by including more manufacturers. I still think the information can be used for a project satisfactorily but sometimes we prefer going further than Michigan based manufacturers to get better deals. It's difficult to use the database in the current form. So I'll rate it at 3.	
2)	Looking at the contents of the database, does the database comprehensively cover the products/materials that aid certification for credits MR 5.1 and 5.2? You may choose to rate its comprehensiveness on a scale or 1 to 5 (1 – not comprehensive, 2 – less comprehensive, 3 – moderately comprehensive, 4 – quite comprehensive, 5 – very comprehensive). What are your suggestions?	Most products that you have included in the database are, kind of, the ones which are useful for this credit. You have not included some concrete products and aggregates but the reasoning behind it is logical. They are locally available everywhere at least in Michigan. A rating of 3 is good for the database.	
3)	Are there any manufacturers that you know of that have not been included in the database?	There might be a few but I will have to look up our sources. Seems comprehensive enough though.	
4)	How would you overall rate the database for its content, format and method of development? You may choose to give an overall rating on a scale or 1 to 5 (1 – very bad, 2 – bad, 3 – Ok, 4 – good, 5 – very good). What are your suggestions?	For format and method of development - I will give it a 4. For content - maybe 3. Like I said before, Some information could be added. Considering a radius of 500 or 300 miles for the database will incorporate many more manufacturers.	

5)	Do you have any suggestions regarding the content and form of development of the database?	User interface needs to be developed. We have had suggestions for other green material databases for quick search methods. If that is combined with this database it will be a very valuable tool. Other than that, the methods that you have used seem to be reasonable and effective. I don't quite see any other way of collecting information for the database. The framework depicts a reasonable approach to the problem. I can't think of any other method right now that would work for this case.	

Appendix D

Sample building Study Schedule of Values

Sample building Study Schedule of Values – Cyclotron Addition Project

APPLICATION AND CERTIFICATE FOR PAYMEN

To Owner:
Michigan State University
Physical Plant
East Lansing, MI 48824

Project: 202418- MSU Cyclotron Additi

APPRC
PHYSI
ENGINEERIN
NAME

Via (Architect): Harley-Ell

From Contractor:
The Christman Company
408 Kalamazoo Plaza
Lansing MI 48933-1990

Contract For:

Contract Date:

CONTRACTOR'S APPLICATION FOR PAYMENT

Application is made for payment, as shown below, in connection with the Contact.
Continuation Sheet is attached.

1. Original Contract Sum		$3,205,108
2. Net Change By Change Order		$207,461
3. Contract Sum To Date		$3,412,569
4. Total Completed and Stored To Date		$3,412,569
5. Retainage :		
a. 0.00% of Completed Work	$0	
. 0.00% of Stored Material	$0	
Total Retainage		$0
6. Total Earned Less Retainage		$3,412,569
7. Less Previous Certificates For Payments		$3,403,060
8. Current Payment Due		$9,509
9. Balance To Finish, Plus Retainage		$0

CHANGE ORDER SUMMARY	Additions	Deductions
Total changes approved in previous months by Owner	$226,940	$0
Total Approved this Month	$0	$19,479
TOTALS	$226,940	$19,479
Net Changes By Change Order	$207,461	

Sample building Study Schedule of Values – Cyclotron Addition Project

CONTINUATION SHEET

Application and Certfication for Payment, containing
Contractor's signed certification is attached.
In tabulations below, amounts are stated to the nearest dollar.
Use Column I on Contracts where variable retainage for line items may apply.

Invoice # : **FINAL** **Contract : 202418- MSU Cyclotron Additio**

A	B	C	D
Item No.	Description of Work	Scheduled Value	Work Com From Previous Application (D+E)
02	Earthwork and Utilities W.P.M. Inc.	94,906	94,906
06	Bituminous Paving	0	0
07	Fencing DeWitt Fencing Co.	9,952	9,952
10	General Trades Christman Constructors	366,519	366,519
11A	Window Infill Schiffer Mason Contractors	9,750	9,750
11B	Masonry J & D Masonry	274,537	274,537
12	Structural Steel Douglas Steel	206,597	206,597
14	Roofing and Sheetmetal Mid-Michigan Roofing	103,571	103,571
15	Architectural Metals	8,530	8,530
18	Doors and Windows Aaron Glass	120,897	120,897
19	Caulking American Seal & Restoration	15,123	15,123
20A	Doors, Frames, Hardware Architectural Openings & Access	65,008	65,008
20B	Custom Millwork Welch Wood Products	28,144	28,144

Sample building Study Schedule of Values – Cyclotron Addition Project

CONTINUATION SHEET

Application and Certfication for Payment, containing
Contractor's signed certification is attached.
In tabulations below, amounts are stated to the nearest dollar.
Use Column I on Contracts where variable retainage for line items may apply.

Invoice # : **FINAL** **Contract : 202418- MSU Cyclotron Addition**

A	B	C	D
Item No.	Description of Work	Scheduled Value	Work Comp From Previous Application (D+E)
21	Drywall and Acoustical Wm. Reichenbach	234,466	234,466
23	Hard Tile and Floor Finishes Lansing Tile and Mosaic	82,925	82,925
24	Painting B & J Painting	39,386	39,386
25A	Misc Specialties Payne-Rosso	8,705	8,705
25B	Educational Specialties Advanced Specialties	5,826	5,826
26	Fire Protection Bay Fire Protection	37,390	37,390
27	Mechanical Systems Shaw-Winkler	967,593	967,593
28	Electrical Systems Lutz Electric Company	287,410	285,343
31	Window Treatments Creative Window	2,630	2,630
39	Construction Labor	180,458	177,938
40	Temporary Provisions	599	599
40A	General Conditions	55,935	55,935
41	Bonds	11,460	8,551
50	Preconstruction	25,440	25,440
60	CM Fee	156,000	154,440

Appendix E

Example database of Regional Manufacturers of Regional Materials

Concrete **Example Database of Manufacturers of Construction Materials In Michigan**

CSI Code	Name of product	Vendor/ Manufacturer name	Location of Final Assembly	Distance (mi) Manufacturing location - East Lansing	Location of Extraction	Distance (mi) Extraction location - East Lansing	Mailing Address of Vendor	Telephone and Fax number
3200	Concrete Reinforcement	Ambassador Steel	Lansing, MI	5	No Information		P.O. Box 21009, Lansing MI 48909	Tel#: 517-393-2780 Fax#:517-393-6917
		Concrete Accessory Mfg., Inc.	Ludington, MI	168	No Information		211 E. Dowland St. P.O. Box 603, Ludington MI 49431	Tel#: 800-338-0715 231-845-0546 Fax#:231-843-2259
		Dedoes	Not verified		No Information		29395 Wall St., Wixom MI 48 393	Tel#: 800-941-9450 248-449-8322 Fax#:248-449-8328
		HYMMCO	Saginaw, MI	80	No Information		6666 Bay Rd., Saginaw MI 48604	Tel#: 989-790-8001 Fax#:989-790-8015
		Metro Rebar, Inc.	Livonia, MI	73	No Information		12642 Richfield Ct., Livonia MI 48150	Tel#: 734-953-8887 Fax#:734-953-8919
		Polytorx	Jackson, MI	38	No Information		4861 Lone Oak Ct., Ann Arbor 48108	Tel#: 734-649-5663 Fax#: 734-661-0393

		Providence Steel & Building Supply Inc	Howell, MI	35	No Information		1200 Victory Dr., Howell MI 48843	Tel#: 517-545-4600 810-229-3310 Fax#:517-545-4933

3400	Precast Concrete	**Dura-Crete**	Warren, MI	85	No information		23350 Regency Park Drive, Warren, MI 48089	Tel#: 586-759-4286 Fax#: 586-759-4395
		Fabcon, LLC	Not verified		No information		518 Morgan Circle, Northville MI 48167	Tel#: 800-727-4444 248-349-1710 Fax#:248-349-5957
		Four Seasons Concrete Products	Roseville, MI	89	No information		29100 Groesbeck Hwy., Roseville 48066	Tel#: 586-777-3320 Fax#:586-777-3874
		Grand Valley Concrete Products	Grand Rapids, MI	72	No information		2500 3 Mile Rd., N.W., Grand Rapids MI 49544	Tel#: 616-453-9429 Fax#:616-453-7580
		Hollowcore, Inc.	Fairfield, OH	302	No information		P.O. Box 32996, Detroit MI 48232	Tel#: 313-962-9189 Fax#:519-737-6464
		Kerkstra/Spancrete Great Lakes	Grandville, MI	79	No information		1330 Chicago Dr., Jenison MI 49428	Tel#: 800-434-5830 616-224-6176 Fax#:616 224 2651

		Mack Inds. of Michigan	Whitelake, MI	57	No information		8265 White Lake Rd., White Lake MI	Tel#: 248-620-7400 Fax#:248-620-
		Marlette Concrete Products	Marlette, MI	102	No information		3372 Warner St., Marlette MI 48453	Tel#: 989-635-3575
		Metro Cast Corp.	Westland, MI	75	No information		6140 N. Hix Rd., Westland MI 48185	Ph#: (734) 728 0210 Fax#:(734) 728 5759
		Michigan Precast Concrete	Kawkawlin, MI	94	No information		2213 S. Huron Rd., Kawkawlin MI 48631	Tel#: 989-686-3618
		Micoff Precast	Peck, MI	113	No information		P.O. Box 86, Peck MI 48466	Tel#: 810-378-5525
		National Concrete Products Company	Plymouth, MI	72	No information		939 S. Mill St., Plymouth MI 48170	Tel#: 734-453-8448 Fax#:734-453-1890
		National Precast, Inc	Roseville, MI	89	No information		30066 Little Mack Ave., Roseville MI 48066	Tel#: 586-294-6430
		Precast Concrete Products, Inc.	Blissfield, MI	109	No information		7951 E. U.S. Hwy. 223, Blissfield MI 49228	Tel#: 517-486-4060 Fax#:517-486-2101
		The Prestressed Group	Detroit, MI	88	No information		P.O. Box 32996, Detroit MI 48232	Tel#: 519-737-1216 Fax#:519-737-6464

Div. 4 Masonry

Example Database of Manufacturers of Construction Materials In Michigan

CSI Code	Name of product	Vendor/ Manufacturer name	Location of Final Assembly	Distance (mi) Manufacturing location - East Lansing	Location of Extraction	Distance (mi) Extraction location - East Lansing	Mailing Address of Vendor	Telephone and Fax number
4080	**Masonry Anchorage Reinforcement** Masonry Reinforcement	**Best Block Co.**	Ann Arbor, MI	63	No information		6985 Jackson Rd., Ann Arbor MI 48103	Tel#: 734-663-3372 Fax#:734-663-5755
		Colonial Brick Co.	Detroit, MI	88	No information		12844 Greenfield Ave., Detroit MI 48227	Tel#: 734-665-8800 Fax#:734-665-9977
		Country Building Supply Co., Inc.	Novi, MI	60	No information		43755 Grand River Ave. P.O. Box 467, Novi MI 48376	Tel#: 248-349-7320 Fax#: 248-349-6775
		Dundee Mfg. Co.	Dundee, MI	88	No information		P.O. Box 143, Dundee MI 48131	Tel#: 734-529-2540 Fax#:734-529-3583
		EZ-Wall, Inc.	Grand Rapids, MI	72	No information		450 32nd St., S.W., Grand Rapids MI 49548	Tel#: 800-545-6704 Fax#:616-452-3835
		Masonpro, Inc.	Northville, MI	60	No information		43300 Seven Mile Rd., Northville 48167	Tel#: 248-347-3824 Fax#:248-347-1670

		Wall Anchor of Southwest Michigan	Kalamazoo, MI	80	No information		810 Bryant St., Kalamazoo MI 49001	Tel#: 269-345-5563

42 10	**Clay Masonry Unit** Facing Brick	**Belden Brick Sales Co.**	Canton, OH	274	Canton, OH	274	17092 Masonic Blvd., Fraser MI 48026	Tel#: 586-294-5400 Fax#:586-294-3977
		Belden - Plant	Strasburg, OH	292	Strasburg, OH	292	7666 Reed Road NW	
		Belden - Plant	Sugarcreek, OH	303	Sugarcreek, OH	303	375 Dover Road NW	
		Bowerston Shale Co.	Bowerston, OH	318	Bowerston, OH	318	P.O. Box 199	Phone:740-269-2921 Fax:740-269-5456
		Bowerston Shale Co.	Hanover, OH	276	Hanover, OH	276	P.O. Box 199	Phone:740-269-2921 Fax:740-269-5456
		General Shale Brick	Darlington, PA	314	Darlington, PA	314	602 Third & Morris Streets, P.O. Box 346	Phone:724-827-2700 Fax:724-827-2974
		General Shale Brick	Mooresville, IN	278	Mooresville, IN	278	Hwy 67 South P.O. Box 159	Ph:(317) 831-4614 Fax:(317) 831-2353
		Redland Brick Inc. - Harmar Plant	Cheswick, PA	348	Cheswick, PA	348	230 Rich Hill Road	Ph:(412) 828-8046 Fax:(412)

		Richards Brick Company	Edwardsville, IL	468	Edwardsville, IL	468	234 Springer Avenue	Ph:(618) 656-0230 Fax:(618) 656-0944
		Stark Ceramics, Inc.	Canton,OH	274	Canton,OH	274	P.O. Box 8880	Ph:(330) 488-1211 Fax:(330) 488-0333
		Watsontown Brick Company	Watsontown, PA	510	Watsontown, PA	510	P.O. Box 68 South Main Street	Ph:(570) 538-2555 Fax:(570) 538-5903
		Whitacre-Greer	Alliance, OH	277	Alliance, OH	277	1400 S. Mahoning Avenue	Ph:330 823-1610 Fax:330 823-5502
		Glen-Gery Corp.	Caledonia, OH	274	Caledonia, OH	274	37720 Hills Tech Dr., Farmington Hills MI 48331	Tel#: 248-489-9338 Fax#:248-489-8028
		Hanson Brick	Corunna, Mi	32	Corunna, Mi	32	PO Box 3820, Serr Road, Corunna, MI-48817	Tel#: 989-743-3444 Fax#- 989-743-3364
4220	**Concrete Masonry Unit**	**Acme Block & Supply Co.**	Saginaw, MI	80	Saginaw, MI	80	1506 Mackinaw St., Saginaw MI 48602	Tel #: 989-793-7331
	Concrete Brick	**Arlington Masonry Supply**	Shelby, MI	140	Shelby, MI	140	7500 Twenty Three Mile Rd., Shelby MI48316	Tel#: 586-731-5890 Fax#:586-731-3460
		Best Block Co.	Ann Arbor, MI	63	Ann Arbor, MI	63	6985 Jackson Rd., Ann Arbor MI 48103	Tel#: 734-663-3372

		Bosker Brick Co., Inc.	Battle Creek, MI	61	Battle Creek, MI	61	17 Springfield Dr., Battle Creek MI 49015	Tel#: 269-968-8181 Fax#:269-968-6960
		W Brewster Builders Supply Co.	Clawson, MI	85	Clawson, MI	85	890 N. Rochester Rd., Clawson MI 48017	Tel#: 248-588-2424 Fax#:248-588-2426
		Clark Block & Supply, Inc.	Canton, MI	74	Canton, MI	74	4930 Belleville Rd., Canton MI 48188	Tel#: 313-272-2160 Fax#:313-272-7850
		Country Building Supply Co., Inc.	Novi, MI	60	Novi, MI	60	43755 Grand River Ave. P.O. Box 467, Novi MI 48376	Tel#: 248-349-7320 Fax#: 248-349-6775
		Darling Builder's Supply Co.	Lansing, MI	5	Lansing, MI	5	1600 Turner St., Lansing 48906	Tel#: 517-484-5707 Fax#:517-484-4561
		Dix Block & Supply Co., Inc.	Lincoln Park, MI	91	Lincoln Park, MI	91	3250 Dix Hwy., Lincoln Park MI 48146	Tel#: 734-782-2404
		Fast Masonry Systems	Charlotte, MI	26	Charlotte, MI	26	P.O. Box 324, Charlotte MI 48813	Tel#: 517-543-0974 Fax#:517-543-5120
		Fendt Builders Supply, Inc	Farmington, MI	65	Farmington, MI	65	22005 Gill Rd., Farmington MI 48335	Tel#: 248-474-3211 Fax#:248-474-8110
		4-D, Inc.	Midland, MI	106	Midland, MI	106	426 River St. P.O. Box 592, Midland MI 48640	Tel#: 989-631-0400 Fax#:989-631-5070

		Gibraltar National Corporation	Detroit, MI	88	Detroit, MI	88	8951 Schaefer Hwy., Bldg. 4, Detroit MI 48228	Tel#: 800-442-7258 Fax#:313-491-5613
		Redford Building Supply Co	Redford, MI	76	Redford, MI	76	24949 Plymouth Rd., Redford MI 48239	Tel#: 313-534-5220 Fax#:313-534-6468
		South Monroe Block & Supply	Monroe, MI	106	Monroe, MI	106	6625 E. Dunbar Rd., Monroe MI 48161	Tel#: 734-457-1721 Fax#:734-457-2459
		Standard Supply & Lumber, Inc.	Ada, MI	63	Ada, MI	63	6566 E. Fulton, Ada MI 49301	Tel#: 616-676-2108 Fax#:616-676-8115
		Theut Products, Inc.	Chesterfield, MI	104	Chesterfield, MI	104	47875 Gratiot Ave., Chesterfield MI 48051	Tel#: 586-949-1300 Fax#:586-949-6620

Division 5 – Metals

Example Database of Manufacturers of Construction Materials In Michigan

CSI Code	Name of product	Vendor/ Manufacturer name	Location of Final Assembly	Distance (mi) Manufacturing location - East Lansing	Location of Extraction	Distance (mi) Extraction location - East Lansing	Mailing Address of Vendor	Telephone and Fax number
5100	Structural Metal Framing	Acme Wire & Iron Works	Detroit, MI	88	No Information		3527 E. Canfield Ave. Detroit MI 48207	Tel#: 313.923.7555 Fax#: 313.923.7557
	Metal Fabricators	Boryn Steel Joist, Inc	Detroit, MI	88	No Information		7611-A Lyndon St., Detroit MI 48238	Tel: 313 345-0842 800-959-0209
		Davis Iron Works	Walled Lake, MI	62	No Information		P.O. Box 900 MI 48089	Tel: 248 624.5960 Fax: 248 624.7030
		Douglas Steel Fabricating	Lansing, MI	5	No Information		P.O. Box 27277 Lansing MI 48909	Tel#: 517 322 2050 Fax#: 517.322.0050
		Ferguson Steel Inc.	Port Huron, MI	114	No Information		P.O. Box 610967 Port Huron 48061	Tel#: 810 985 5178 Fax#: 810.985.5129
		Ideal Steel and Builders' Supplies	Hamburg, MI	52	No Information		P.O. Box 310 10068 Industrial Drive Hamburg 48139	Tel#:810.231.1722 Fax#:810.231.9697

		Jaimes Industries	Southfield, MI	74	No Information		19270 W. 8 Mile Rd., Southfield MI	Tel#: 248-356-8600
		Jasman Truss & Panel Technologies	Whitmore Lake, MI	60	No Information		1175 E. North Territorial Rd., Whitmore Lake MI 48189	Tel#: 734-205-6800 Fax#:734-205-6815
		J.L. Peters Co.	Detroit, MI	88	No Information		12600 Norborne Detroit 48239	Tel#: 313 531 6680 Fax#: 313 531 8517
		Lincoln Welding Co., Inc.	Romulus, MI	83	No Information		27989 Van Born Rd., Romulus MI 48174	Tel#: 313-292-2299 Fax#:313-292-2229
		Michael Fabricating, Inc.	Brownstown Township, MI	101	No Information		21516 S. Telegraph Rd., Brownstown Township MI 48183	Tel#: 734-671-4960 Fax#:734-676-6970
		Nelson Iron Works Inc.	Detroit, MI	88	No Information		6350 Benham Detroit MI 48211	Tel#:313 925 5355 Fax#: 313 925 7544
		Ojibway Industrial LLC	Ecorse, MI	92	No Information		3720 High St. Ecorse MI 48229	Tel: 313.381.5444 Fax#: 313.928.6237
		Progressive Systems, Inc.	Zeeland, MI	95	No Information		8095 Riley St., Zeeland MI 49464	Tel#: 616-748-1384 Fax#: 616-748-1683
		Superior Steel Components, Inc.	Marne, MI	82	No Information		P.O. Box 68, Marne MI 49435	Tel#: 800-887-7133 616-677-6007 Fax#:800-

5120	Structural Steel Architecturally Exposed Structural Steel	**Aluminum & Architectural Metals**	NV				8711 Epworth St., Detroit MI 48204	Tel#: 313-895-2555 Fax#:313-895-2552
		C.A.S.S., Inc.	Detroit, MI	88	No Information		5641 Conner St., Detroit MI 48213	Tel#: 313-571-2277
		Can Art Handworks	Detroit, MI	88	No Information		2264 Wilkins St., Detroit MI 48207	Tel#: 313-392-0116 Fax#: 313-392-0202
		Delta Steel Inc.	NV				1410 Webber, Saginaw MI 48601	Tel#: 989 752 5129 Fax#: 989 752 7195
		Hollow Metal Fabricators, Inc.	Detroit, MI	88	No Information		616 E. State Fair St., Detroit MI 48203	Tel#: 313-892-2866 Fax#:313-892-3323
		Horizon Architectural Metal Products, Inc	NV				11007 Chicago Dr., Ste. 24, Zeeland 49464	Tel#: 616-393-8720 Fax#:616-393-8721
		Kalamazoo Custom Metal Works, Inc.	Kalamazoo, MI	80	No Information		904 Hotop Ave., Kalamazoo MI 49048	Tel#: 269-345-5411 Fax#:269-345-0792
		Century Truss Co.	Brighton, MI	43	No Information		7600, Kensington Ct, Brighton, MI-48116	Tel#: 248-486-4000 Fax#: 248-286-0880
		Michigan Glass & Metals	Not verified				604 S. 8th St., Kalamazoo MI 49009	Tel#: 269-375-6165 Fax#:269-375-6220

		O.I.K. Industries	Kalamazoo, MI	80	No Information		7882 Douglas Ave., Kalamazoo MI 49009	Tel#: 269-382-1210 Fax#:269-382-3102
		TNT Metal Fabrication, Inc.	Mount Clemens, MI	100	No Information		39 N. Rose St., Mount Clemens MI 48043	Tel#: 586-954-3320 Fax#:586-954-3520
5140	Structural Aluminum	A-1 Steel & Aluminum Supply Co. Metalworks, Inc.	Auburn Hills, MI	81	No Information		321 Collier Rd., Auburn Hills MI 48326	Tel#: 248-338-9000 Fax#:248-338-0000
	Architecturally	Lorin Industries	Muskegon, MI	111	No Information		1960 Roberts St., Muskegon MI 49442	Tel#: 800-654-1159 231-722-1631 Fax#:231-726-6186
	Exposed Structural	MCM Fixture Co.	Hazel Park, MI	80	No Information		21306 John R. Rd., Hazel Park MI 48030	Tel#: 248-547-9280 Fax#:248-547-9270
	Aluminum	R. J. Oldenkamp Assocs., Inc.	Not verified		Not verified		5674 Briar Glen Dr., Saline MI 48176	Tel#: 734-429-9480 Fax#:734-429-9490
		Sterling Sheet Metal, Inc.	Muskegon, MI	111	No Information		1569 Kingsley St., Muskegon MI 49442	Tel#: 231-777-7292 Fax#: 231-
		Unique Metal Products, Inc.	Ferndale, MI	79	No Information		1921 Hilton, Ferndale MI 48220	Tel#: 248-545-4566 Fax#:248-545-2767

5200	Metal Joist							
		Boryn Steel Joist, Inc	Detroit, MI	88	No Information		7611-A Lyndon St., Detroit MI 48238	Tel#: 313-345-0842 800-959-0209
		Cooper & Cooper, Inc	NV				P.O. Box 611107, Port Huron MI 48061	Tel#: 810-327-6247 Fax#:810-327-6015
		East Side Fabrication	Harrison Township, MI	101	No Information		42469 Irwin Rd., Harrison Township MI 48045	Tel#: 586-468-5222 Fax#:586-468-5222
		Bruce J. Havers Co., Inc.	Temperance, MI	105	No Information		130 Reed Dr., Temperance MI 48182	Tel#: 734-847-9232 Fax#:734-847-8543
		Lincoln Welding Co., Inc.	Romulus, MI	83	No Information		27989 Van Born Rd., Romulus MI 48174	Tel#: 313-292-2299 Fax#:313-292-2229
		MBM Fabricators Co., Inc.	Romulus, MI	83	No Information		36333 Northline Rd., Romulus MI 48174	Tel#: 734-941-0100 Fax#:734-941-6150
		Utica Steel	Chesterfield, MI	104	No Information		48000 Structural Dr., Chesterfield MI	Tel#: 586-949-1900 Fax#:586-
5210	Steel Joist	**Michigan Glass & Metals**	Not verified				604 S. 8th St., Kalamazoo MI 49009	Tel#: 269-375-6165 fax:269-375-6220

	Longspan Steel Joists	Lincoln Welding Co., Inc.	Romulus, MI	83	No Information		27989 Van Born Rd., Romulus MI 48174	Tel#: 313-292-2299 Fax:313-292-2229
5300	Metal Deck	Architectural Metal Fabricator, Inc.	Not verified		No Information		765 W. Kalamo Hwy., Charlotte MI 48813	Tel#: 517-543-2573 Fax#:517-543-2241
		Bruce J. Havers Co., Inc.	Temperance, MI	105	No Information		130 Reed Dr., Temperance MI 48182	Tel#: 734-847-9232 Fax#:734-847-8543
		MBM Fabricators Co., Inc.	Romulus, MI	83	No Information		36333 Northline Rd., Romulus MI 48174	Tel#: 734-941-0100 Fax#:734-941-6150
		Utica Steel	Chesterfield, MI	104	No Information		48000 Structural Dr., Chesterfield MI 48051	Tel#: 586-949-1900 Fax#:586-949-1284

5310	Steel Deck	Brown-Campbell Co.	Detroit, MI	88	No Information		14290 Goddard Ave., Detroit MI 48212	Tel#: 313-891-2390 Fax#:313-891-2903
	Composite Metal Deck	Bruce J. Havers Co., Inc.	Temperance, MI	105	No Information		130 Reed Dr., Temperance MI 48182	Tel#: 734-847-9232 Fax#:734-847-8543
		MBM Fabricators Co., Inc.	Romulus, MI	83	No Information		36333 Northline Rd., Romulus MI 48174	Tel#: 734-941-0100 Fax#:734-941-6150

		Utica Steel	Chesterfield, MI	104	No Information		48000 Structural Dr., Chesterfield MI 48051	Tel#: 586-949-1900 Fax#:586-949-1284
		Titus Welding Co.	Farmington Hills, MI	68	No Information		20750 Sunnydale St., Farmington Hills MI 48336	Tel#: 248-476-9366 Fax#:248-476-9223

Example Database of Manufacturers of Construction Materials In Michigan

Division 6 - Wood and Plastics

CSI Code	Name of product	Vendor/ Manufacturer name	Location of Final Assembly	Distance (mi) Manufacturing location - East Lansing	Location of Extraction	Distance (mi) Extraction location - East Lansing	Mailing Address of Vendor	Telephone and Fax number
6200	Finish Carpentry	Architectural Millwork Specialists Incorporated	Southfield, MI	74	No Information		20777 East St., Southfield MI 48034	Tel#: 248-352-3850 Fax#:248-352-0335
	Architectural Woodwork	BANCO Group	Not verified				44968 Ford Rd., Ste. L, Canton MI 48187	Tel#: 734-254-1070 Fax#:734-254-1906
	Millwork	B & B Heartwoods, Inc	AnnArbor, MI	62	No Information		5444 Whitmore Lake Rd., Ann Arbor MI 48105	Tel#: 734-332-9525
	Closet and Utility Wood Shelving	Barn Door Lumber Co.	Hemlock, MI	69	No Information		2020 N. Hemlock Rd., Hemlock MI 48626	Tel#: 989-642-8309 Fax#:989-642-2929
	Prefinished Paneling	Blackwell-Conway Co.	Dearborn, MI	86	No Information		14311 W. Warren Ave., Dearborn MI 48126	Tel#: 313-584-6370 Fax#:313-584-6373
	Board Paneling	Brifco, Inc.	Detroit, MI	88	No Information		24555 Southfield Rd., Ste. 109, Southfield MI 48075	Tel#: 248-424-9919 Fax#:248-424-9979
		Classic Storage	Howell, MI	35	No Info		10019 Bergin Rd., Howell MI	Tel#: 810-632-6024

		Co-Ordinated Systems, Inc.	New Baltimore, MI	108	No Information		47520 Jefferson Ave., New Baltimore MI 48047	Tel#: 586-949-1600 Fax#:586-949-0944
		Commercial Millwork & Interiors Corp.	Zeeland, MI	95	No Information		600 E. Washington, Zeeland 49464	Tel#: 616-772-2588 Fax:616-772-2544
		Custom Doors & Trim, Inc.	Holland, MI	100	No Information		4142 Blue Star Hwy., Holland MI 49423	Tel: 616-396-6335 Fax#:616-396-0435
		Dalek Woodworks	Sterling Heights, MI	91	No Information		40835 Mound Rd., Sterling Heights MI 48310	Tel#: 586-268-1144 Fax#:586-268-1184
		Dansville Millworks	Dansville, MI	23	No Information		1180 Mason St., Dansville MI 48819	Tel#: 517-623-6703
		Dimensional Millwork, Inc.	Chesterfield, MI	104	No Information		46571 Continental Dr., Chesterfield MI 48047	Tel#: 586-598-4161 Fax#:586-598-4162
		Doring Inc.	Troy, MI	90	No Information		1390 Piedmont, Troy MI 48083	Tel#: 248-524-9620 Fax:248-524-9628
		E & R Millwork	Dryden, MI	80	No Information		4677 Havens Rd., Dryden MI 48428	810-796-3290 Fax: 810-796-2971
		Elenbaas Millwork, Inc.	Grand Rapids, MI	72	No Information		3000 Wilson Dr., N.W., Grand Rapids MI 49544	Tel#: 419-693-5550 Fax#:419-693-5550

		Finished Carpentry Products	Canton, MI	73	No Information		30643 Schoolcraft Rd., Livonia MI 48150	Tel#: 734-523-6300 Fax#:734-523-1755
		Francesco Woodwork, Inc.	Sterling Heights, MI	91	No Information		40498 Mound Rd., Sterling Heights 48310	Tel: 586-264-0900Fax#:586-268-1261
		Greenia Custom Woodworking, Inc.	Reese, MI	89	No Information		2380 M-15 Vassar Rd., Reese 48757	Tel#: 989-753-0002Fax#:989-868-3274
		Harbor Millwork	Holland, MI	100	No Information		P.O. Box 8336, Holland MI 49422	800-426-4072 Fax: 616-393-8992
		Hengesbach, Albin, Carp. & Custom Cabs.	Westphalia, MI	29	No Information		P.O. Box 47, Westphalia MI 48894	Tel#: 989-587-4941 Fax#:989-587-3300
		Heritage Millworks Ltd.	Troy, MI	90	No Information		334 Minnesota Dr., Troy MI 48083	248-616-0011
		Iannuzzi Millwork, Inc.	Fraser, MI	90	No Information		33877 Doreka Dr., Fraser MI 48026	Tel#: 586-285-1000
		Mann's Custom Milling	Buchanan, MI	148	No Information		403 S. Oak St., Buchanan MI 49107	Tel#: 269-697-0305 Fax:269-697-0024
		Maplewood Custom Millwork, Inc.	Garden City, MI	77	No Information		6332 Middlebelt Rd., Garden City MI 48135	Tel#: 734-422-0660 Fax#:734-422-5428
		McClelland Millwork	Vassar, MI	81	No Information		581 N. Water St., Vassar MI 48768	989-823-7580

		McLaughlin, Doug, Millwork	Troy, MI	90	No Information		2826 Industrial Row Dr., Troy MI 48084	Tel#: 248 655 0570 Fax#:248 655 0572
		Midwest Millwork Co.	Waterford, MI	71	No Information		P.O. Box 300186, Waterford MI 48330	Tel#: 248-673-0808 Fax#:248-673-8760
		Mill Town Woodworks, Inc.	Baycity, MI	93	No Information		1111 S. Henry St., Bay City MI 48706	Tel#: 989 893 4570 Fax#:989 893 6643
		National Millwork, Inc.	Clawson, MI	85	No Information		150 N. Crooks Rd., Ste. B, Clawson 48017	248-435-2650
		Nelson-Mill Co.	Southfield, MI	74	No Information		23690 Telegraph Rd., Southfield MI 48034	Tel#: 248-354-8200 Fax#:248-354-4774
		North Oakland Trim & Millwork, Inc.	Clarkston, MI	70	No Information		4866 White Lake Rd., Clarkston MI 48346	Tel#: 248-922-9321 Fax#:248-922-9414
		Oakley's Wooden Things, Inc.	Monroe, MI	105	No Information		2520 N. Telegraph Rd., Monroe MI 48162	Tel#: 734-242-2433 Fax#:734-242-6685
		Public True Value Lumber Co.	Detroit, MI	88	No Information		1001 E. Seven Mile Rd., Detroit MI 48203	Tel#: 313-891-7125 Fax#:313-891-6670
		Sampeer Millworks	Avoca, MI	107	No Information		7654 Imlay City Rd., Avoca MI 48006	Tel#: 810-324-2449

		Specialty Cabinet Manufacturing, Inc.	Detroit, MI	88	No Information		5221 Trumbull St., Detroit MI 48208	313-894-6655
		Sterling Contrg. & Millwork, Inc.	Farmington Hills, MI	67	No Information		23350 Commerce Dr., Farmington Hills MI 48335	Tel#: 248-427-1400
		Taylor-Made Custom Woodworking	Bloomingdale, MI	106	No Information		14662 45th St., Bloomingdale MI 49026	Tel#: 269 521 4045 Fax#: 269 521 4045
		Weber Lumber & Millwork, Inc.	Vassar, MI	81	No Information		8586 W. Sanilac Rd., Vassar MI 48768	Tel#: 989-868-4175 Fax#:989-868-4841
		Wohlfert's, J. J., Custom Trim	Fowler, MI	31	No Information		10691 M-21, Fowler MI 48835	Tel#: 989 593 3283 Fax#:989-593-2121
		Wood Smiths, Inc., The	Kalamazoo, MI	80	No Information		1180 S. Eighth St., Kalamazoo MI 49009	Tel#: 269-372-6432 269-207-1081
		WoodMatic, Inc.	Holland, MI	100	No Information		684 Commerce Ct. P.O. Box 8069, Holland MI 49422	Tel#: 616-786-9663 616-784-7100 Fax#:616-786-

Division 8	Doors and Windows

Example Database of Manufacturers of Construction Materials In Michigan

CSI Code	Name of product	Vendor/ Manufacturer name	Location of Final Assembly	Distance (mi) Manufacturing location - East Lansing	Location of Extraction	Distance (mi) Extraction location - East Lansing	Mailing Address of Vendor	Telephone and Fax number
8100	Metal Doors and Frame	Bosker Brick Co., Inc.	Battle Creek, MI	61	No Information		17 Springfield Dr., Battle Creek MI 49015	Tel#: 269-968-8181 Fax#:269-968-6960
		Detroit Door & Hardware Co.	Madison Heights, MI	83	No Information		111 E. 12 Mile Rd., Madison Heights MI 48071	Tel#: 248-398-1200 Fax#:248-398-4734
		Pella Window & Door Co.	Pella, IA	517	No Information		33238 Woodward Ave., Birmingham MI 48009	Tel#: 248-624-8080 Fax#:248-624-7087
		State Wide Window & Door	Westland, MI	77	No Information		38391 Abruzzi Dr., Westland MI 48185	Tel#: 734-728-8785 800-955-5030 Fax#:734-728-9592
		Taylor Door & Builders, Inc.	Garden City, MI	79	No Information		30459 Ford Rd., Garden City MI 48135	Tel#: 734-261-7890 Fax#:734-261-8570
		U.S. Steel Door & Manufacturing	Garden City, MI	79	No Information		32401 Park Ln., Garden City MI 48135	Tel#: 734-522-2300 Fax#:734-522-2416

8110	Steel Doors and Frame	**American Industrial Doors, Inc.**	Canton, MI	76	No Information		8001 Ronda Dr., Canton MI 48187	Tel#: 734-459-3271 Fax#:734-459-8962
		Fox Brothers, Inc.	Lansing, MI	5	No Information		7320 Clyde Park, Byron Center MI 49315	Tel#: 616-455-5500 Fax#:616-455-5557
		Hoppe, R. K., Corp.	New Hudson, MI	56	No Information		P.O. Box 208, New Hudson MI 48165	Tel#: 248-437-7071 Fax#: 248-437-7852
		Overhead Door Company of Saginaw	Arthur, IL	365	No Information		8259 Tittabawassee Rd., Saginaw MI 48603	Tel#: 989-790-2538 Fax#:989-790-1984
		Quality Door & Lumber	Butler, IN	119	No Information		2894 Bay Rd., Saginaw MI 48603	Tel#: 989-792-9618 800-852-6468 Fax#:989-792-5737
		Taylor Door & Builders, Inc.	Garden City, MI	79	No Information		30459 Ford Rd., Garden City MI 48135	Tel#: 734-261-7890 Fax#:734-261-8570
		U.S. Steel Door & Manufacturing	Garden City, MI	79	No Information		32401 Park Ln., Garden City MI 48135	Tel#: 734-522-2300 Fax#:734-522-2416
8210	Wood Door	**Allegan Lumbertown Co.**	Grand Rapids, MI	73	No Information		730 River St., Allegan MI 49010	Tel#: 269-673-4470

		Custom Doors & Trim, Inc.	Holland, MI	95	No Information		4142 Blue Star Hwy., Holland MI 49423	Tel#: 616-396-6335 Fax#:616-396-0435
		Dearborn Door	No Information		No Information		10218 W. Warren Ave., Dearborn MI 48126	Tel#: 313-581-4050 Fax#:313-581-4299
		Detroit Door & Hardware Co.	Madison Heights, MI	83	No Information		111 E. 12 Mile Rd., Madison Heights MI 48071	Tel#: 248-398-1200 Fax#:248-398-4734
		Fingerle Lumber Co.	Ann Arbor, MI	64	No Information		P.O. Box 1167, Ann Arbor MI 48106	Tel#: 734-663-0581 734-741-4230 Fax#:734-663-1247
		Five Lakes Manufacturing, Inc.	Clinton Township MI	108	No Information		24400 Capital Blvd., Clinton Township MI 48036	Tel#: 586-463-4123
		Foster Finish Carpentry, Inc.	Not verified		No Information		19600 Sherwood St., Detroit MI 48234	Tel#: 313-368-4734 Fax#:313-368-4781
		Grand Rapids Sash & Door	Holt, MI	11	No Information		3909 Holt Rd., Holt MI 48842	Tel#: 517-694-2108 Fax#:517-694-5198
		Greenia Custom Woodworking, Inc.	Reese, MI	89	No Information		2380 M-15 Vassar Rd., Reese MI 48757	Tel#: 989-753-0002 Fax#:989-868-3274

		Karona, Inc.	Grand Rapids, MI	73	No Information		P.O. Box 888410, Grand Rapids MI 49588	Tel#: 800-829-9233
		Lifetime Doors, Inc.	Illinois	200	No Information		5410 Highland Rd., White Lake MI 48383	Tel#: 248-851-7700 Fax#:248-851-8534
		Michigan Lumber Co	Flint, MI	47	No Information		1919 Clifford St., Flint MI 48503	Tel#: 810-232-4108
		Portage Building Components, Inc.	Portage, MI	82	No Information		706 W. Melody Ave., Portage MI 49024	Tel#: 269-323-3986 Fax#:269-323-2590
		Quality Door & Lumber	Butler, IN	119	No Information		2894 Bay Rd., Saginaw MI 48603	Tel#: 989-792-9618 800-852-6468 Fax#:989-792-5737
		Raven, R. & J., Corp.	Grand Rapids, MI	73	No Information		255 Cottage Grove St., S.E., Grand Rapids MI 49507	Tel#: 616-245-5684 Fax#:616-245-4670
		Redi-Wood, Inc.	Not verified		No Information		P.O. Box 183, Grand Haven MI 49417	Tel#: 616-842-5860 Fax#: 616-842-5884
		Tailor Made Windows & Doors	East Pointe, MI	93	No Information		24460 Gratiot Ave., East Pointe MI 48021	Tel#: 586-773-3600 Fax#:586-773-7322
		Taylor Door & Builders, Inc.	Garden City, MI	79	No Information		30459 Ford Rd., Garden City MI 48135	Tel#: 734-261-7890 Fax#:734-261-8570

		U.S. Steel Door & Manufacturing	Garden City, MI	79	No Information		32401 Park Ln., Garden City MI 48135	Tel#: 734-522-2300 Fax#:734-522-2416
		Washtenaw Door & Trim, Inc.	Ypsilanti, MI	76	No Information		2502 E. Michigan Ave., Ypsilanti MI 48198	Tel#: 734-484-1250 Fax#: 734-484-7106
		WoodMatic, Inc.	Not verified		No Information		684 Commerce Ct. P.O. Box 8069, Holland MI 49422	Tel#: 616-786-9663 616-784-7100 Fax#:616-786-0811

8500	Metal Window	**All-Fab & Weld, Inc.**	Clio, MI	60	No Information		10508 N. Saginaw Rd., Clio MI 48420	Tel#: 810-687-1243 Fax#:810-687-1111
		Antcliff Aluminum Products Flint Door & Window Co.	Burton, MI	52	No Information		2417 E. Judd Rd., Burton MI 48529	Tel#: 810-742-5963
		Heritage Window & Door, Inc.	Detroit, MI	88	No Information		6141 Casmere St., Detroit MI 48212	Tel#: 313-893-2000 Fax#:313-893-2007
		Litex, Inc.	Hillsdale, MI	69	No Information		1675 W. Hamlin Rd., Rochester MI 48309	Tel#: 248-852-0661 248-852-0662 Fax#:248-852-0095
		Mayfield Co., Inc.	Not verified		No Information		18001 Mayfield Rd., Livonia MI 48152	Tel#: 734-425-9000 Fax#:734-425-3299

		Pella Window & Door Co.	Pella, IA	515	No Information		33238 Woodward Ave., Birmingham MI 48009	Tel#: 248-624-8080 Fax#:248-624-7087
		Peterson Window Corp.	Northville, MI	66	No Information		42975 Mill St., Northville MI 48167	Tel#: 800-521-7932 248-347-2400
		State Wide Window & Door	Westland, MI	77	No Information		38391 Abruzzi Dr., Westland MI 48185	Tel#: 734-728-8785 800-955-5030 Fax#:734-728-9592
		Wojan Window & Door	Coldwater, MI	74	No Information		340 Jay St., Coldwater MI 49036	Tel#: 517-278-2202 Fax#:517-279-9832

8500	Windows	**C & C Window Co.**	Clinton Township, MI	108	No Information		44766 Centre Court, Clinton Township MI	Tel#: 586-416-6800 Fax: 586-416-6801
		D & W Awning & Window Co.	Davison, MI	58	No Information		8068 E. Court St., Davison MI 48423	Tel#: 810-658-8777 810-742-0340 Fax#:810-658-1392
		Kaufmann Window & Door	Detroit, MI	88	No Information		12891 Mt. Elliot St., Detroit MI 48212	Tel#: 313-893-9500 Fax#:313-893-7897
		N R G, Inc.	Taylor, MI	93	No Information		22520 Ecorse Rd., Taylor MI 48180	Tel#: 313-295-4100 Fax#:313-295-3437

		Pella Window & Door Co.	Pella, IA	515	No Information		33238 Woodward Ave., Birmingham MI 48009	Tel#: 248-624-8080 Fax#:248-624-7087
		Polar Seal	Grand Rapids MI	73	No Information		625 Century Ave., S.W., Grand Rapids MI 49503	Tel#: 616-459-3463 Fax#:616-459-3469
		Raw Windows & Doors	Not verified		No Information		33103 Garfield Rd., Fraser MI 48026	Tel#: 586-296-7240 Fax#:586-296-7135
		State Wide Window & Door	Westland, MI	77	No Information		38391 Abruzzi Dr., Westland MI 48185	Tel#: 734-728-8785 800-955-5030 Fax#:734-728-9592
		Sunaire Window Manufacturing Co.	Brighton, MI	46	No Information		7936 Boardwalk Rd., Brighton MI 48116	Tel#: 248-437-5870 Fax#: 248-437-0642
		Sunrise Windows	Temperance MI	107	No Information		200 Enterprise Dr., Temporance MI 48182	Tel#: 734-847-8778 Fax#: 734-847-7758
		Tailor Made Windows & Doors	East Pointe, MI	93	No Information		24460 Gratiot Ave., East Pointe MI 48021	Tel#: 586-773-3600 Fax#:586-773-7322
		Ventaire Windows	Not verified		No Information		1100 E. Washington St., Ste. B, Freeland MI 48623	Tel#: 989-695-5026 Fax#: 989-695-5002

		Vinyl Tech Window Systems, Inc.	Holly, MI	60	No Information		P.O. Box 331, Holly MI 48442	Tel#: 248-634-8900 Fax#: 248-634-8933
		Weather King Windows & Doors	Farmington, MI	67	No Information		20775 Cheslay Dr., Farmington MI 48336	Tel#: 248-478-7788 Fax#:248-426-1293
		Windowcraft, Inc.	Wixom, MI	60	No Information		30687 Wixom Rd., Wixom MI 48393	Tel#: 248-669-1010 Fax#:248-669-2822
		Wojan Window & Door	Coldwater, MI	74	No Information		340 Jay St., Coldwater MI 49036	Tel#: 517-278-2202 Fax#:517-279-9832

Divisi on 9 Finishes

Example Database of Manufacturers of Construction Materials In Michigan

CSI Code	Name of product	Vendor/ Manufacturer name	Location of Final Assembly	Distance (mi) Manufacturing location - East Lansing	Location of Extraction	Distance (mi) Extraction location - East Lansing	Mailing Address of Vendor	Telephone and Fax number
9650	Resilient Flooring	Amtico International Inc.					6480 Roswell Road Atlanta 30328	Tel:404 267 1900 Fax:404 267 1901
		Altro Floors					224, Nazareth Pike Bethlehem, PA	Tel: 610-746 4324
		Armstrong Commercial Floors						1-877-276-7876 ext. 8278
		Centiva					1701 Mars Hill Rd. Florence, AL 35630	Phone:256-767-4990 Fax: 256-760-1763
		Congoleum Corporation						1-800-274-3266
		Dodge-Regupol, Inc					PO Box 989, (715 Fountain Ave) Lancaster, PA 17608	1-866-883-7780
		Fritz Industries					500 Sam Houston Road, Mesquite, Texas 75149	Ph:(972)285-5471 Fax:(972)270-0179

		TOLI International					55 Mall Drive Commack, NY 11725	800.446.5476 Fax:
		VPI Corporation					3123 South 9th Street P.O. Box 451 Sheboygan, WI 53082	Tel#:(920) 458-4664 (800) 874-4240 Fax#:(920) 458-1368

9680	Carpet and Rugs	**All listed manufacturers of carpets were located in GA or CA**	Not included in the database as the GA and CA lie beyond the 500 mile radius used by the database

9200	Gypsum	**National Gypsum**	National City, MI	147	National City, MI	147		704-365-7300
	Gypsum Products	**US Gypsum**	Detroit, MI	88	No Information			1-800 487 4431
		Georgia-Pacific	Wheatfield, IN	207	Point Hawkisbury, NS	1432		1-800-545 6302
		Temple Inland Inc.	Crawfortsville, IN	292	No Information			512-434-5800

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