Athena Sustainable Materials Institute

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A Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Manufactured by NRMCA Members – Version 3

This project report and its results are used to support the development of an industry average Environmental Product Declaration for the production of 72 concrete mix designs

Comissioner: National Ready Mixed Concrete Association (NRMCA)

EPD Program Operator: NSF International

Prepared by: The Athena Sustainable Materials Institute

November 2019

Updated February 20, 2020

Glossary of Terms

Based on ISO 14040/44:2006 – Terms and Definition Section.

Allocation: Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems.

Life Cycle: Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal.

Life Cycle Assessment (LCA): Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

Life Cycle Impact Assessment (LCIA): Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product.

Life Cycle Interpretation: Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations.

Life Cycle Inventory (LCI): Phase of Life Cycle Assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

Product system: Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product.

System boundary: Set of criteria specifying which unit processes are part of a product system. Note: the term system boundary is not used in this International Standard in relation to LCIA.

System expansion: Expanding the product system to include the additional functions related to the co-products, taking into account the requirements of 4.2.3.3.

Based on ISO 14021:1999(E)- Clause 7.8 Recycled content

Pre-consumer material: Material diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.

Post-consumer material: Material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product that can no longer be used for its intended purpose. This includes returns of material from the distribution chain.

Based on ISO 14025:2006- Clause 3 Terms and definitions

Type III Environmental Product Declaration (EPD): providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information
Note 1 the predetermined parameters are based on the ISO 14040 series of standards.
Note 2 the additional environmental information may be quantitative or qualitative.

Product Category Rules (PCR): set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories.

Based on ISO 21930:2017- Clause 3 Terms and definitions

Building product: goods or services used during the life cycle of a building or other construction works.

Declared unit: quantity of a building product for use as a reference unit in an EPD, based on LCA, for the expression of environmental information needed in information modules.

Information module: compilation of data to be used as a basis for a type III environmental declaration, covering a unit process or a combination of unit processes that are part of the life cycle of a product.

Reference service life: service life of a building product that is known or expected under a particular set, i.e., a reference set, of in-use conditions and that may form the basis of estimating the service life under other in-use conditions.

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Acronyms and Abbreviations

ACI	American Concrete Institute
CF	Characterization Factor
CFCs	Chlorofluorocarbons
CFC-11	Trichlorofluoromethane
CO_2	Carbon Dioxide
EPDs	Environmental Product Declarations
eq	Equivalent
FA	Fly ash
GWP	Global Warming Potential
IPCC	International Panel on Climate Change
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LEED	Leadership in Energy and Environmental Design
N	Nitrogen
NRMCA	National Ready Mixed Concrete Association
NO_x	Nitrogen Oxides
O_3	Ozone
PCR	Product Category Rules
$PM_{2.5}$	Particulate Matter less than or equal to 2.5 micrometers in diameter
PM_{10}	Particulate Matter less than or equal to 10 micrometers in diameter
RMC	Ready-mixed concrete
SCM	Supplementary cementing materials
SL	Slag cement
SO_2	Sulfur dioxide
TRACI	Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts
UNSPSC	United Nations Standard Products and Services Code
US EPA	United States Environmental Protection Agency
USGBC	U.S. Green Building Council
VOCs	Volatile Organic Compounds

1 General Study Aspects

Commissioner of the LCA project report and EPD	NRMCA NATIONAL READY MIXED CONCRETE ASSOCIATION
External LCA Practioner	Athena Sustainable Materials Institute
Date/version	November 2019, Version 3 Updated February 20, 2020

The LCA report is an update of the previously published Version 2.0. Updates to the LCA include additional study participants, more current background datasets, and compliance with a recently updated PCR for Concrete [15]. The LCA results in this document integrate the previous Version 2.0 participant data with the new participant data and updated model. This LCA document incorporates all of the content of the previous LCA and thus stands alone as the third party report for this project.

This study has been conducted in accordance with the requirements of the NSF International Product Category Rule (PCR) for Concrete Version 1 (February 22, 2019) [15]. This study was also conducted in accordance with ISO 14040:2006 [10], ISO 14044:2006 [11], and ISO 21930:2017 [12]. This study also complies with NSF's EPD Program Operator Instructions [14].

This project report has been commissioned with the intent to support a sector- or industry average Environmental Product Declaration (EPD) for ready-mixed concrete as produced by participating National Ready Mixed Concrete Association (NRMCA) members in accordance with ISO 14025:2006 [9] and the governing PCR [15].

This LCA project report was critically reviewed as per ISO 14040/44:2006 and the reference PCR requirements by Mr. Jack Geibig, President of Ecoform. The critical review report and responses to review comments are available from the NSF International upon request.

This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Name and affiliation: Jack Geibig - Ecoform

2 Study Goal

This is a sector-driven initiative by NRMCA and its members to develop an industry average EPD according to ISO 14025:2006 and specifically, the NSF PCR for ready-mix concrete. The goal of this study is to provide information to support the development of an EPD for 72 ready-mixed concrete product ranges covering a significant portion of NRMCA member production.

A corrolary goal of this LCA report is to enable NRMCA members, who participated in the IW-EPD, that have developed product specific third-party verified LCAs and/or EPDs to compare the environmental impacts of their products with industry average impacts. Appendix D presents region-specific inventory parameters and results indicators which can be used along with a company's own product-specific EPDs to demonstrate compliance with the following:

- LEED v4 and 4.1(beta) MR Credit Building Product Disclosure and Optimization
- Architecture 2030 Challenge for Products
- International Green Construction Code (IgCC)
- Green Globes for New Construction

Consult Appendix D for more information as to how the regional results have been developed and may be used for benchmarking.

2.1 Intended Applications

The EPD developed from this study is intended for use in Business to Business (B-to-B) communication.

2.2 Intended Audience

The intended audience for this LCA project report is NRMCA, its members and the verifier of the subsequent EPD. The intended audience for the EPD, for which this LCA project report serves as the reference document, include NRMCA member companies, their suppliers, architectural, engineering, and specifying professionals, LCA practitioners and tool developers, academia, governmental organizations, policy makers and other interested value chain parties who require reliable information on a range of ready-mixed concrete products.

Note: For purposes of USGBC LEEDv4 rating system EPD compliance only NRMCA member companies having participated in this industry average LCA and subsequent EPD may claim compliance with the rating system EPD contribution requirements. A list of NRMCA members and facilities participating in the development of this study is available from NRMCA at: https://www.nrmca.org/sustainability/EPDProgram/search/ .

2.3 Comparative Assertions

This LCA project report does not include comparative assertions; however, it and the subsequent EPD may lead to future comparative studies intended to be disclosed to the public. LCAs and EPDs not covering *all* life cycle stages or based on a different PCR are examples of studies and EPDs offering limited comparability.

3 Study Scope

3.1 Product Standard

Products covered by this report satisfy general purpose concrete as used in residential, commercial and public works applications in the US and Canada. This LCA project report assesses the impacts for a range of ready-mixed concrete products in accordance with ASTM C94: Standard Specification for Ready-Mixed Concrete [4], ACI 318: Buidling Code Requirements for Structural Concrete [3], CSA A23.1-09/A23.2-09 (R2014) - Concrete materials and methods of concrete construction/Test methods and standard practices for concrete [17], UNSPSC 30111500 Ready Mix, and ACI 211.1: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete [1]; and CSI MasterFormat Division 03-30-00: Cast-in-Place Concrete.

3.2 System Boundary

The system boundary for this study is limited to a cradle-to-gate focus. The following three life cycle stages as per the governing PCR are included in the study scope (see Figure 1):

A1- Raw material supply (upstream processes): extraction, handling, and processing of the raw materials and intermediate component products as well as fuels used in the production of concrete.
A2- Transportation: transportation of all input materials and fuels from the supplier to the gate of the concrete plant.
A3- Manufacturing (core process): the energy used to store, move, batch and mix the concrete and operate the concrete plant as well as the transportation and processing of wastes from these core processes.

Building Life Cycle Information Modules															
Product stage			Construction Process stage		Use stage							End-of-life stage			
Raw Material supply	Transport	Manufacturing	Transport	Construction/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport	Waste processing	Disposal
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4

Figure 1. Life cycle stage schematic – alpha-numeric designations as per NSF PCR (adapted from CEN 15978:2011)

Note: a significant portion of N. American concrete plants are truck-mixing (sometimes called transit mix) plants where the concrete mixing occurs within truck mixers after they are loaded and at the project site; for these operations a portion of the delivery truck's energy use that would typically be captured under "Construction and Process Stage" **A4-Transportation** (to site) is allocated to the mixing of concrete for truck-mixing plants and is captured in information module A3. This system boundary refinement addresses the difference between truck-mixing and central mix concrete plants where the latter plant type fully mixes the concrete in a stationary plant mixer prior to loading the concrete delivery trucks. See the allocation section for more details.

Except as noted above, all other life cycle stages as described in Figure 1 are excluded from the LCA study and EPD (the delivery portion of A4 for this transit mix plant, B1-7, and C1-4). The following processes are also excluded from the study:

- Production, manufacturer and construction of buildings' capital goods and infrastructure.
- Production and manufacture of concrete production equipment, concrete delivery vehicles, earthmoving equipment, and laboratory equipment.
- Personnel- related activities (travel, furniture, office supplies)
- Energy and water use related to company management and sales activities, which may be located either within the factory site or at another location.
- Water use in the placement and curing of concrete.

The ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017[1] was considered to determine the scope of various non LCIA metrics.

3.3 Declared Unit

The declared unit is **1 cubic meter (1 cubic yard)** of ready mixed concrete.

Environmental impacts are provided for 72 ready mixed concrete (RMC) products (mix designs). There are 100s if not 1,000s of possible RMC products (sometimes called mix designs, mixes, mixture compositions or mixtures), which ultimately balance the cost and performance of concrete for a wide variety of applications. For purposes of the NRMCA member industry average LCA and EPD, a conservative approach was taken to arrive at a workable list of 72 RMC products that could pragmatically represent a high proportion of the RMC produced by NRMCA members identified in the EPD. The typical process for developing mix designs is 1) a design professional or purchaser of concrete states a specified compressive strength and other performance criteria for the concrete, and 2) the concrete producer develops a mix design, or proportions, to meet the specified compressive strength and other performance criteria using an accepted mixture proportioning methodology such as the ACI recommended practice 211.1 [1] and 211.2 [2], the most common method used in North America.

For this LCA, NRMCA provided the mix designs using the ACI 211.1 process. For normal weight concrete, six different commonly specified compressive strengths were selected and 8 different mixture compositions were developed for each specified compressive strength. Further, 8

[1] https://aclca.org/aclca-iso-21930-guidance/

different mixture compositions were developed for three different compressive strengths of lightweight concrete mixes. The total number of products is thus 72.

Each RMC product considers 28-day strength, water to cementitious materials ratio to meet the specified compressive strength, air-entrainment admixture, water reducing and accelerating admixture, high range water reducing admixuture, coarse aggregate size and reactivity of supplementary cementitious materials as a percentage of portland cement reactivity. The key product variables are briefly described below:

- ***28-day strength*** – Six different specified compressive strengths were considered for normal weight concrete, 2,500 psi (17.3 MPa), 3,000 psi (20.7 MPa), 4,000 psi (27.6 MPa), 5,000 psi (34.5 MPa), 6,000 psi (41.3 MPa) and 8,000 psi (55.1 MPa); Three different specified compressive strengths were considered for lightweight concrete, 3,000 psi (20.7 MPa), 4,000 psi (27.6 MPa), and 5,000 psi (34.5 MPa);
- ***Water to cementitious materials ratio*** (w/cm) – Varies, but lower for higher strength concrete mixtures in accordance with ACI 211.1;
- ***SCM reactivity*** – assumes 75% reactivity for fly ash (FA) as compared to Portland cement and 100% reactivity of slag cement (SL) as compared to Portland cement based on NRMCA member feedback;
- ***Admixtures use*** – Products (mix designs) with specified compressive strength less than or equal to 5,000 psi (34.5 MPa) included an air entraining admixture since many of these concretes would be exposed to freezing and thawing. Products (mix designs) with specified compressive strength above 5,000 psi (34.5 MPa) did not include air entraining admixture since these higher strengths concretes are rarely exposed to freezing and thawing; water reducing and accelerating admixture used across all mixes; high range water reducer admixtures were assumed to be used in high strength mix designs (5,000psi (34.5 MPa) and above).
- ***Aggregate use*** – The normal weight concrete mixes contain natural and crushed coarse and fine aggregates that are of typical weight and composition. The lightweight concrete mixes substitute typical coarse aggregate with an expanded clay product that reduces the mass of aggregate for a given mix, and thus the overall mass of the lightweight mix concrete products. See Table 2: A1 Raw Material Supply.

Table 1 lists the 72 products (mix designs) considered in the LCA. They have been enumerated in ranges of mix design properties to cover a range of possible products and to conservatively estimate life cycle impact indicators; i.e., all product life cycle impacts are calculated at the upper bound of the strength range and lower bound of the indicated SCM percentage and thus, provide a conservative estimate the life cycle impacts associated with each product. The product name is represented by the specified compressive strength and the quantity (%) of portland cement and SCMs (either fly ash or slag cement or both) used to estimate the life cycle impact indicators and resource use metrics. Appendix B lists the mix design specifications and raw material quantitites considered for each RMC product.

The specified mixes are based on commonly available materials and thus any ready mixed concrete plant can produce any of the specified mixes. The A3 manufacturing energy for the declared mixes incorporates mixing energy that is assumed to be the same, regardless of the mix inputs (see Section 4.3 for more calculation methodology details). The A3 manufacturing energy input also includes region-specific facility operations energy (i.e. facility heating and cooling) that can not be separated from the mixing energy, and thus the A3 energy has been calculated on a region-specific basis. See Appendix D for region-specific energy consumption.

Table 1. Declared Product Range Classification

Specified Compressive Strength Range	SCM Range (%)	Product Name
0-2500 psi (0-17.24 MPa)	0-19% Fly Ash and/or Slag	2500-00-FA/SL
	20-29% Fly Ash	2500-20-FA
	30-39% Fly Ash	2500-30-FA
	40-49% Fly Ash	2500-40-FA
	30-49% Slag	2500-30-SL
	40-39% Slag	2500-40-SL
	≥50% Slag	2500-50-SL
	≥20% Fly Ash and ≥30% Slag	2500-50-FA/SL
2501-3000 psi (17.25-20.68 MPa)	0-19% Fly Ash and/or Slag	3000-00-FA/SL
	20-29% Fly Ash	3000-20-FA
	30-39% Fly Ash	3000-30-FA
	40-49% Fly Ash	3000-40-FA
	30-39% Slag	3000-30-SL
	40-49% Slag	3000-40-SL
	≥50% Slag	3000-50-SL
	≥20% Fly Ash and ≥30% Slag	3000-50-FA/SL
3001-4000 psi (20.69-27.58 MPa)	0-19% Fly Ash and/or Slag	4000-00-FA/SL
	20-29% Fly Ash	4000-20-FA
	30-39% Fly Ash	4000-30-FA
	40-49% Fly Ash	4000-40-FA
	30-39% Slag	4000-30-SL
	40-49% Slag	4000-40-SL
	≥50% Slag	4000-50-SL
	≥20% Fly Ash and ≥30% Slag	4000-50-FA/SL
4001-5000 psi (27.59-34.47 MPa)	0-19% Fly Ash and/or Slag	5000-00-FA/SL
	20-29% Fly Ash	5000-20-FA
	30-39% Fly Ash	5000-30-FA
	40-49% Fly Ash	5000-40-FA
	30-39% Slag	5000-30-SL
	40-49% Slag	5000-40-SL
	≥50% Slag	5000-50-SL
	≥20% Fly Ash and ≥30% Slag	5000-50-FA/SL

5001-6000 psi (34.48-41.37 MPa)	0-19% Fly Ash and/or Slag	6000-00-FA/SL
	20-29% Fly Ash	6000-20-FA
	30-39% Fly Ash	6000-30-FA
	40-49% Fly Ash	6000-40-FA
	30-39% Slag	6000-30-SL
	40-49% Slag	6000-40-SL
	≥50% Slag	6000-50-SL
	≥20% Fly Ash and ≥30% Slag	6000-50-FA/SL
6001-8000 psi (41.38-55.16 MPa)	0-19% Fly Ash and/or Slag	8000-00-FA/SL
	20-29% Fly Ash	8000-20-FA
	30-39% Fly Ash	8000-30-FA
	40-49% Fly Ash	8000-40-FA
	30-39% Slag	8000-30-SL
	40-49% Slag	8000-40-SL
	≥50% Slag	8000-50-SL
	≥20% Fly Ash and ≥30% Slag	8000-50-FA/SL
Lightweight 2501-3000 psi (17.25-20.68 MPa)	0-19% Fly Ash and/or Slag	LW-3000-00-FA/SL
	20-29% Fly Ash	LW-3000-20-FA
	30-39% Fly Ash	LW-3000-30-FA
	40-49% Fly Ash	LW-3000-40-FA
	30-39% Slag	LW-3000-30-SL
	40-49% Slag	LW-3000-40-SL
	≥50% Slag	LW-3000-50-SL
	≥20% Fly Ash and ≥30% Slag	LW-3000-50-FA/SL
Lightweight 3001-4000 psi (20.69-27.58 MPa)	0-19% Fly Ash and/or Slag	LW-4000-00-FA/SL
	20-29% Fly Ash	LW-4000-20-FA
	30-39% Fly Ash	LW-4000-30-FA
	40-49% Fly Ash	LW-4000-40-FA
	30-39% Slag	LW-4000-30-SL
	40-49% Slag	LW-4000-40-SL
	≥50% Slag	LW-4000-50-SL
	≥20% Fly Ash and ≥30% Slag	LW-4000-50-FA/SL
Lightweight 4001-5000 psi (27.59-34.47 MPa)	0-19% Fly Ash and/or Slag	LW-5000-00-FA/SL
	20-29% Fly Ash	LW-5000-20-FA
	30-39% Fly Ash	LW-5000-30-FA
	40-49% Fly Ash	LW-5000-40-FA
	30-39% Slag	LW-5000-30-SL
	40-49% Slag	LW-5000-40-SL
	≥50% Slag	LW-5000-50-SL
	≥20% Fly Ash and ≥30% Slag	LW-5000-50-FA/SL

3.4 Cut-off Criteria

The cut-off criteria for all activity stage flows considered within the system boundary conform with ISO 21930: 2017 Section 7.1.8. Specifically, the cut-off criteria were applied as follows:

- All inputs and outputs for which data are available are included in the calculated effects and no collected core process data are excluded.
- A one percent cut-off is considered for renewable and non-renewable primary energy consumption and the total mass of inputs within a unit process. The sum of the total negleted flows does not exceed 5% of all energy consumption and mass of inputs.
- All flows known to contribute a significant impact or to uncertainty (e.g. Portland cement and admixtures) are included;
- The cut-off rules are not applied to hazardous and toxic material flows – all of which are included in the life cycle flow inventory.

3.5 Waste Treatment

The A1-A3 product system includes the generation of waste in the form of product loss and anicillary materials and packaging that must be disposed. The calculated product loss in this study is presented in Appendix A (National Average) and Appendix D (Regional Benchmarks).

The polluter pays principle was followed in the inclusion of waste treatment processes in the system boundary. Waste processing of waste materials generated in A1-A3 (e.g. packaging material, waste water) is included in the product system.

Per the ACLCA ISO 21930 Guidance, the scope of waste treatment included in the LCA was limited to foreground data only, excluding upstream waste generated from A1 production processes (i.e. cement and aggregate production).

No regulated substances of very high concern are present in the product system.

4 Life Cycle Inventory Analysis

The material and unit process data underlying this study and the resultant EPD were derived from various sources. Secondary LCI data sources were generally used to compile material and energy flows (Module A1), while primary data were collected for process inputs (A2 and A3). This section qualitatively and quantitatively describes the various data sources used to compile the life cycle inventory metrics and subsequent life cycle impact assessment (LCIA) indicator results for the 72 declared RMC product designs.

4.1 Primary Data Sources

In 2014 NRMCA engaged the Athena Institute to develop a cradle-to-gate life cycle inventory questionnaire for the manufacture of ready mixed concrete and to survey a sub-population of its members to support the development of a life cycle assessment (LCA) and NRMCA member average environmental product declaration (EPD) for ready mixed concrete. In 2016, NRMCA re-engaged the Institute to capture additional member companies and plants that opted not to participate in the original 2014 effort and add them to the company and plant population such they are covered under an expanded and revised LCA and EPD (referred to as EPD Version 2). In 2019, a new NSF Concrete PCR was released and NRMCA once again engaged the Institute to re-survey and update the industry average LCA and EPD in accordance with this new PCR. This report is an intermediate work product describing the methods and revised summary statistics of the member LCI survey results, inclusive of the new plants and companies.

At the outset of this project the goal was to develop a “representative” statistical sample of NRMCA member plants with a 95% confidence level and a 5% margin of error. Based on NRMCA’s 2017 ready mixed concrete production data for the US and estimated average plant production by region, a distribution of ready-mix plants across NRMCA’s regions was estimated. There are approximately 8,000 plants across the US ready mixed concrete industry. NRMCA estimates that their membership represents 30% of all companies and 50% of all plants operating in 2017. Using a sample size calculator[2] it was determined that a minimum of 352 plants would need to be “sampled” to achieve the desired confidence level (95%) and margin of error (5%). However, because participation in the EPD project is voluntary and only reflects companies and their plants wishing to be included in the IW-EPD, the actual population is somewhat lower. After indicating willingness to participate each company provided a list of their plants by location, type and capacity. A total of 83 companies operating 1956 plants were included in the initial list, but due to inclusionary rules (e.g., plants operating less than 12 months, whether they were portable plants, etc.) a total 1772 plants were deemed eligible to be covered by the EPD. This new total became the new population and the sample size calculator was run again to determine the number of plants to sampled to achieve the 95% confidence level and a 5% margin of error. The sample size calculator returned a required sample size of 316 plants to satisfy the statistical “representative” goal.

[2] Sample size calculator – www.surveysystem.com

As this is the third iteration of this IW-EPD, the participating companies span various temporal versions of the EPD. Version 1 companies provided plant data for 2013, which according to the core ISO 21930:2017 PCR falls outside the "primary data vintage" of no more than 5 years (these data are 6 years old) and hence these data needed to be reviewed for "material change" and where appropriate updated. Previous analyses indicated that the major technosphere flows contributing to the impact of ready-mix plants included electricity, natural gas and diesel use (A3) as well as the transport of high mass inputs (A2) – aggregates. All version 1 companies indicating their continued participation in this third version of the IW-EPD were returned their 2013 plant questionnaire for review and updating. All plants provided updated production and fuel related input flows and some updated their mode and distance information concerning aggregates transportation if they were procuring these materials from new sources. Version 2 plants provided data for 2015 production year and being less than 5 years old did not need to provide more up to date data. Lastly, new companies wanting to participate in this third version provided both meta data and completed new plant surveys. Lastly, due to plants closing, divestitures and acquisitions a number of Version 1 and 2 companies also provided new complete plant surveys in addition to their previous plants' updates.

In total, 526 new or updated plant operations surveys were requested to support this third iteration of the IW-EPD. After completing mass/energy balance checks and following up with various companies concerning outliers and/or missing data a total of 489 were deemed usable. Based on a sample size of 489 plants and a total population of 1772 plants the achieved margin error was calculated to be 3.58%. The sample size represents approximately 6% of all US RMC plants (8000), 12% of NRMCA member's RMC plants (4000) and 28% of the total population (1772) eligible to be covered by the EPD.

The LCI data collection questionnaire is publically available from NRMCA. The resulting statistical summary report "NRMCA V3 LCI Data Collection Summary Statistics, June 2019" [5] (and supplementary data analysis) is confidential, but has been made available to NSF International to expedite the review of these primary data and this LCA project report. Appendix A summarizes the national average transportation modes and distances for high mass materials and presents the gate to gate manufacturing energy use. Appendix D presents the relevant inventory parameters for the various regions.

4.2 Secondary Data Sources

All upstream material, resource and energy carrier inputs have been sourced from various industry average datasets and literature. Many of these data sets are defaulted to those specified for use in the NSF PCR Version 1 (2019). Care was taken to fill known data gaps (dummies) as recorded in the US LCI database profiles. Per the NSF PCR, note that the municipal water input was modeled based on secondary data that includes the treatment and distribution processes.

Tables 2 to 4 describe each LCI data source for raw materials (A1), transportation by mode (A2) and the RMC core manufacture process (A3 and A4) as well as an assessment of data quality.

Table 2. A1 - Raw Material Supply			
Materials	**LCI Data Source**	**Year / Region**	**Data Quality Assessment**
USA Cement ***ASTM C150, C595, C1157***	Portland Cement Association EPD USA Portland Cement (2016) (Modeled with complete LCI to support ISO 21930:2017)	2016 USA	• **Technology:** very good • **Time:** very good • **Geography:** very good • **Completeness:** very good • **Reliability:** very good
CAN Cement ***ASTM C150, C595, C1157***	Cement Association of Canada EPD GU and GUL Cements (2016) (Modeled with complete LCI to support ISO 21930:2017)	2016 Canada	• **Technology:** very good • **Time:** very good • **Geography:** very good • **Completeness:** very good • **Reliability:** very good
Fly Ash ***ASTM C618***	None, no incoming burden, only transport is considered	N/A	• **N/A** • **Recovered material**
Silica Fume ***ASTM c1240***	None, no incoming burden, only transport is considered	N/A	• **N/A** • **Recovered material**
Slag Cement ***ASTM C989***	Slag Cement Association EPD of North America Slag Cement (2015) (Modeled with complete LCI to support ISO 21930:2017)	2015 North America	• **Technology:** very good • **Time:** very good • **Geography:** very good • **Completeness:** very good • **Reliability:** very good
Crushed Aggregates *coarse and fine* ***ASTM C33***	ecoinvent 3.4: "Gravel, crushed {RoW}| production | Cut-off, U" (2018) [18] Modified foreground process with region-specific electricity grid.	2001 World/ Regional	• **Technology:** very good • **Time:** poor • **Geography:** good • **Completeness:** very good • **Reliability:** very good
Natural Aggregates *coarse and fine* ***ASTM C330***	ecoinvent 3.4: "Gravel, round {RoW}| gravel and sand quarry operation | Cut-off, U" (2018) [18] Modified foreground process with region-specific electricity grid.	2001 World/ Regional	• **Technology:** very good • **Time:** poor • **Geography:** good • **Completeness:** very good • **Reliability:** very good
Manufactured Lightweight Aggregates	ecoinvent 3.4: Expanded clay {RoW}| production | Cut-off, U (2018) [18] Modified foreground process with United States average electricity grid	2000 World/ USA	• **Technology:** good Expanded clay is representative per: http://www.epa.gov/ttnchie1/ap42/ch11/final/c11s20.pdf • **Time:** poor • **Geography:** good • **Completeness:** very good • **Reliability:** very good

Table 2. A1 - Raw Material Supply			
Materials	**LCI Data Source**	**Year / Region**	**Data Quality Assessment**
Admixtures ***ASTM C494***	EFCA EPDs for Air Entrainers, Plasticisers and superplasticisers, Hardening Accelerators, Set Accelerators, Water Resisting Admixtures, and Retarders (2015) [8] Non-supported LCIA indicators estimated – adjusted using TRACI equivalents	2015 EU	• **Technology:** very good • **Time:** very good • **Geography:** fair • **Completeness:** good • **Reliability:** very good
Batch and Wash Water ***ASTM C1602***	ecoinvent 3.4: Tap water {RoW}| market for | Cut-off, U (2018) [18] Modified foreground process with United States average electricity grid	2011 World/ USA	• **Technology:** very good • **Time:** good • **Geography:** good • **Completeness:** very good • **Reliability:** very good

Table 3. A2 - Transportation			
Process	**LCI Data Source**	**Year / Region**	**Data Quality Assessment**
Ocean	USLCI 2014: Transport, ocean freighter, average fuel mix /US U (2014) [13]	2007 USA	• **Technology:** very good • **Time:** fair • **Geography:** very good • **Completeness:** very good • **Reliability:** very good
Rail	USLCI 2014: Transport, train, diesel powered /US U (2014) [13]	2007 USA	• **Technology:** very good • **Time:** fair • **Geography:** very good • **Completeness:** very good • **Reliability:** very good
Road	USLCI 2014: Transport, combination truck, short-haul, diesel powered/tkm/RNA (2014) [13] Adjusted for backhauls per NSF PCR 7.1.7.2	2010 USA	• **Technology:** very good • **Time:** good • **Geography:** very good • **Completeness:** very good • **Reliability:** very good

Table 4. A3 - Manufacturing			
Process	**LCI Data Source**	**Year / Region**	**Data Quality Assessment**
Electricity	ecoinvent 3.4: Electricity, low voltage {XX}| market for | Cut-off, U (2018) [18] NRMCA-specific electricity grids based on 2014 NERC regions.	2015 USA	• **Technology:** very good • **Time:** very good • **Geography:** very good • **Completeness:** very good **Reliability:** very good

Table 4. A3 - Manufacturing			
Process	**LCI Data Source**	**Year / Region**	**Data Quality Assessment**
Diesel	USLCI 2014: Diesel, combusted in industrial boiler /US U (2014) [13]	2007 USA	• **Technology:** very good • **Time:** fair • **Geography:** very good • **Completeness:** very good **Reliability:** very good
Gasoline	USLCI 2014: Gasoline, combusted in equipment /US U (2014) [13]	2007 USA	• **Technology:** very good • **Time:** fair • **Geography:** very good • **Completeness:** very good • **Reliability:** very good
Liquefied Propane Gas	USLCI 2014: Liquefied petroleum gas, combusted in industrial boiler /US U (2014) [13]	2007 USA	• **Technology:** very good • **Time:** fair • **Geography:** very good • **Completeness:** very good • **Reliability:** very good
Hazardous Solid Waste,	ecoinvent 3.4: Hazardous waste, for incineration {RoW}| treatment of hazardous waste, hazardous waste incineration | Alloc Rec, U (2018) [18] Modified foreground process with United States average electricity grid	2011 World/ USA	• **Technology:** very good • **Time:** good • **Geography:** good • **Completeness:** very good • **Reliability:** very good
Non-Hazardous Solid Waste	ecoinvent 3.4: Inert waste {RoW}| treatment of, sanitary landfill | Alloc Rec, U (2018) [18] Modified foreground process with United States average electricity grid	2011 World/ USA	• **Technology:** very good • **Time:** good • **Geography:** good • **Completeness:** very good • **Reliability:** very good

NRMCA Average Electricity Source Grid Breakdown	% of Average Grid
Electricity, low voltage {FRCC}| market for | Cut-off, U FRCC	11.22%
Electricity, low voltage {HICC}| market for | Cut-off, U HICC	0.51%
Electricity, low voltage {MRO}| market for | Cut-off, U MRO	5.65%
Electricity, low voltage {NPCC}| market for | Cut-off, U NPCC	4.34%
Electricity, low voltage {RFC}| market for | Cut-off, U RFC	12.13%
Electricity, low voltage {SERC}| market for | Cut-off, U SERC	24.81%
Electricity, low voltage {SPP}| market for | Cut-off, U SPP	1.87%
Electricity, low voltage {TRE}| market for | Cut-off, U TRE	9.59%
Electricity, low voltage {WECC}| market for | Cut-off, U WECC	29.89%

Electricity grid breakdown: The average electricity grid was developed based on total purchased electricity by surveyed plants weighted by RMC production in various NERC regions (see % contribution by NERC grid region above). For the regional benchmarks presented in Appendix D, the region-specific NERC region grid was applied.

4.3 Calculation Method

For purposes of calculating the requsite resource metrics and life cycle impact indicators (see Section 5 below), LCI datasets are created for each energy/fuel type as well as raw material (lb) and transportation mode (lb-miles), as specified by the RMC product mix design, in SimaPro (modules A1 and A2). With respect to purchased electricity, an average NRMCA electricity grid was developed based on the surveyed plants weighted by RMC production in the various NERC regions. (see % contribution by NERC grid region Table 4 above).

Similarly, a weighted-average manufacturing process LCI per cubic yard of concrete (module A3) is also created in SimaPro which reflects the weighted average mix of plant types and sizes as developed via the NRMCA plant survey. For each information module, the set of metrics and indicators are generated and exported to a project specific EPD calculator tool, where they are combined with the material quantities for the 72 RMC product mix designs to generate the total cradle-to-gate life cycle indicators and resource use metrics on a cubic yard basis. These results are then converted to a cubic meter basis for compliance reporting purposes as per the NSF PCR.

4.4 Allocation

The allocation of co-products or secondary flows cross the system boundary conforms with ISO 21930: 2017 Section 7.2.4. Specifically, the allocation criteria were applied as follows:

- Allocation was not applied to any of the gate-to-gate production facilities. For facilities that manufacture additional products (i.e. aggregate), the LCI flows at the facility specific to the concrete production were reported.
- The polluter pays principle is met. Waste processing of waste materials generated in A1-A3 (e.g. packaging material, waste-water) is included in the product system.
- For secondary data sources, the NSF PCR default allocation selection (i.e. “Cut-off” or “Alloc Rec”) was applied.
- The product category rules for this EPD recognize fly ash and silica fume as recovered materials and thus the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a concrete material input
- A portion (30%) of the reported fleet energy use for truck mixing plants was allocated to the mixing facility

4.5 Data Quality

Data quality requirements, as specified in the , as specified in ISO 21930:2017 Section 7.1.9 and the additional transparency requirements of the NSF PCR Section 7.1.9. are applied and reported in Tables 2 to 4. This section also describes the achieved data quality relative to the ISO 14044:2006 requirements. This LCA and resulting EPD was created using industry average data for upstream materials. Data variation can result from differences in supplier locations, manufacturing processes, manufacturing efficiency and fuel types used. Data quality is judged on the basis of its representativeness (technological, temporal, and geographical), completeness (e.g., unreported emissions), consistency and reliability.

All LCI data (Tables 2 to 4) are assessed on the basis of the five data quality indicators listed below. Each indicator is interpreted with respect to its key determining data parameters to provide clarity as to how the overall quality of each indicator is assessed and stated.

- ***Technical representativeness***: *The degree to which the data reflects the actual technology(ies) used.* Core manufacturing process technology is derived from very recent annual data covering a large number of plant sizes and types. These data are deemed to be reflective of typical or average technologies used within N. America in the production of ready-mixed concrete. Some background material and process data are European but deemed to be similar to technologies used in the US and Canada and are often cited as preferred "default data" in the governing NSF PCR.

  Overall quality - Good to very good

- ***Temporal representativeness***: *The degree to which the data reflects the actual time (e.g. year) or age of the activity.* Core manufacturing process data is recent. Secondary data sets are between 3 and 19 years old. For data sets older than 10 years more recent data sets were not available.

  Overall quality - Fair to very good

- ***Geographical representativeness***: *The degree to which the data reflects the actual geographic location of the activity (e.g. country or site).* Geographical coverage of core manufacturing processes is specific to the US. All energy profiles reflect US conditions. Some material (aggregates and admixtures) and process data are based on European sources. These data have been previously verified or listed in the governing PCR for default use.

  Overall quality - Fair to very good

- ***Completeness****: The degree to which the data are statistically representative of the relevant activity. Completeness includes the percentage of locations for which data is available and used out of the total number that relate to a specific activity.* Core manufacturing processes are very complete and were derived from a statistical sample with a 95% confidence interval and less than 5% error. These data reflect annual operations inclusive of seasonal and other normal annual fluctuations in operations. All relevant, specific processes, including inputs (raw materials, energy and ancillary materials) and outputs (emissions and production volume) were considered and modeled to represent the specified and declared RMC products. The relevant background materials and processes were taken from the US LCI Database (adjusted for known data placeholders); US system boundary adjusted ecoinvent v3.4 LCI databases and modeled in SimaPro software v8.5 [16]. Efforts were made to ensure that all data used was as complete as reasonably possible.

  Overall quality - Good to very good

- ***Reliability***: *The degree to which the sources, data collection methods and verification procedures used to obtain the data are dependable*. For core manufacturing processes the reliability of the information and data is deemed to be very good as these were derived from a large, statistically significant, survey of ready-mixed concrete producers and subsequently reviewed by the NRMCA for plausability. Similarly, the LCI data for Portland cement, at plant, reflects a very recent EPD. All missing process data (dummies) associated with the US LCI data have been consistently filled. All other LCI data have been incorporated in accordance with the default PCR requirements or derived from ecoinvent databases, which have been verified by ecoinvent.

  Overall quality - Fair to very good

Furthermore, the data quality is evaluated on the basis the precision, consistency and reproducibility.

Precision: The NRMCA participating member companies through measurement and calculation collected primary data on their annual production of RMC products. For accuracy the LCA team validated these plant gate-to-gate input and output data. A statistical analysis was completed and documented in a separate report – see Primary Data Sources section.

Consistency: To ensure consistency, the LCI modeling of the production weighted input and output LCI data for the declared products used the same modeling structure across the respective product systems, which consisted of input raw and ancillary material, energy flows, water resource inputs, product and co-products outputs, returned and recovered concrete materials, emissions to air, water and soil, and waste recycling and treatment. The same background LCI datasets from the NRMCA SimaPro LCI database were used across all RMC product systems LCI modeling. Crosschecks concerning the plausibility of mass and energy flows were continuously conducted. The LCA team conducted mass and energy balances at the plant and selected process level to maintain a high level of consistency.

Reproducibility: Internal reproducibility is possible since the data and the models are stored and available in a database (NRMCA SimaPro LCI database, 2019). A considerable level of transparency is provided throughout the report as the specifications and material quantity make-up for the declared RMC products are presented and key primary and secondary LCI data sources are summarized in Tables 2, 3 and 4. Several of the secondary data sources (Portland cement and Slag Cement) are based on EPD as opposed to an LCI database. We have thus added a supplemental data table in Appendix C to report the additional indicator results for those materials required to comply with the NSF PCR but not currently published in their respective EPDs.

5 Life Cycle Impact Assessment

Life cycle impact assessment (LCIA) is the phase in which the set of results of the inventory analysis – the inventory flow table – is further processed and interpreted in terms of environmental impacts[3] and resource use inventory metrics. As specified in the NSF PCR, the US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), version 2.1, 2012 [6] impact categories are used. Additionally, the PCR requires a set of inventory metrics to be reported with the LCIA indicators (see Table 5).

Table 5. Life Cycle Category Indicators and Inventory Metrics

Core Mandatory Impact Indicator	***Abbreviation***	**Unit**	**Method/Source**
Global warming potential	GWP	kg CO_2e	TRACI 2.1 V1.02
Depletion potential of the stratospheric ozone layer	ODP	kg CFC11e	TRACI 2.1 V1.02
Acidification potential of soil and water sources	AP	kg SO_2e	TRACI 2.1 V1.02
Eutrophication potential	EP	kg Ne	TRACI 2.1 V1.02
Formation potential of tropospheric ozone	SFP	kg O_3e	TRACI 2.1 V1.02
Abiotic depletion potential (ADPfossil) for fossil	ADPf	MJ, NCV	CML-IA Baseline V3.02
Abiotic depletion potential (ADPelements)	ADPe	kg Sbe	CML-IA Baseline V3.02
Fossil fuel depletion	FFD	MJ Surplus	TRACI 2.1 V1.02
Use of Primary Resources			
Renewable primary energy carrier used as energy	RPRE	MJ, NCV	CED V1.10 NCV
Renewable primary energy carrier used as material	RPRM	MJ, NCV	LCI Indicator
Non-renewable primary energy carrier used as	NRPRE	MJ, NCV	CED V1.10 NCV
Renewable primary energy carrier used as material	NRPRM	MJ, NCV	LCI Indicator
Secondary Material, Secondary Fuel and Recovered Energy			
Secondary material	SM	kg	LCI Indicator
Renewable secondary fuel	RSF	MJ, NCV	LCI Indicator
Non-renewable secondary fuel	NRSF	MJ, NCV	LCI Indicator
Recovered energy	RE	MJ, NCV	LCI Indicator
Mandatory Inventory Parameters			
Consumption of freshwater resources;	FW	m^3	LCI Indicator[A]
Calcination or carbonation emissions	CCE	kg CO_2e	LCI Indicator[B]
Indicators Describing Waste			
Hazardous waste disposed	HWD	kg	LCI Indicator
Non-hazardous waste disposed	NHWD	kg	LCI Indicator
High-level radioactive waste	HLRW	m^3	LCI Indicator
Intermediate- and low-level radioactive waste	ILLRW	m^3	LCI Indicator
Components for re-use	CRU	kg	LCI Indicator
Materials for recycling	MR	kg	LCI Indicator
Materials for energy recovery	MER	kg	LCI Indicator
Recovered energy exported from the product system	EE	MJ, NCV	LCI Indicator

Note A: Consumption of freshwater was calculated following ISO 14046 requirements for water footprint inventories.

Note B: It is noted that only upstream calcination in the production of clinker is considered in this measure. Downstream carbonation does not occur within the reported modules. A Cradle-to-Grave LCA of concrete would include carbonation and the subsequent reduction in global warming potential.

[3]Category indicators present possible or potential impacts and are based on environmental impacts that may be realized if the emitted chemical compound(s) actually follows the designated impact pathway and reacts accordingly in the receiving environment. Each potential impact pathway is calculated in isolation, and while a number of compounds may contribute to two or more pathways, no effort is made to partition individual chemical compound flows between impact pathways. As a result, LCIA results are only relative expressions of potentials and do not predict actual impacts, the exceeding of thresholds, safety margins or risks.

A short description of TRACI 2.1 impact categories (IC) and characterization factors (CF) is provided below. A characterization factor is a factor derived from a characterization model, which is applied to convert an assigned life cycle inventory analysis result to the common unit for the category indicator. The common unit allows calculation of the category indicator result.

- **Global warming (IC)** – TRACI calculates global warming potential (GWP), a midpoint CF metric proposed by the International Panel on Climate Change (IPCC), for the calculation of the potency of greenhouse gases relative to carbon dioxide (CO_2). The 100-year time horizons recommended by the IPCC and used by the US for policy making and reporting are adopted within TRACI. The methodology and science behind the global warming potential calculation is considered one of the most accepted LCIA categories. Within TRACI 2.1, current GWPs published by IPCC (2013) were used for each substance. GWP_{100} is expressed on equivalency basis relative to CO_2, that is, equivalent CO_2 mass basis.

- **Ozone depletion (IC)** – Stratospheric ozone depletion (ODP) is the reduction of the protective ozone within the stratosphere caused by emissions of ozone-depleting substances. International consensus exists on the use of ozone depletion potentials-ODPs (CF), a metric proposed by the World Meteorological Organization (WMO) for calculating the relative importance of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HFCs), and halons expected to contribute significantly to the breakdown of the ozone layer. Within TRACI 2.1, the most recent sources of ODPs (WMO 2003) were used for each substance, where chemicals are characterized relative to trichlorofluoromethane (CFC-11).

- **Acidification (IC)** – According to TRACI 2.1, acidification (AP) comprises processes that increase the acidity (hydrogen ion concentration, [H+]) within a local environment. This can be the result of the addition of acids (e.g., nitric acid and sulfuric acid) into the environment, or by the addition of other substances (e.g., ammonia) which increase the acidity of the environment due to various chemical reactions and/or biological activity, or by natural circumstances such as the change in soil concentrations because of the growth of local plant species. Acidification is a more regional rather than global impact affecting water and soil. Consistent with the focus on providing midpoint assessments, TRACI 2.1 uses an acidification model which incorporates the increasing hydrogen ion potential within the environment without incorporation of site-specific characteristics such as the ability for certain environments to provide buffering capability. Acidification is expressed in kg SO_2 equivalent.

- **Eutrophication (IC)** – In TRACI 2.1, eutrophication (EP) is defined as the fertilization of surface waters by nutrients that were previously scarce. This measure encompasses the release of mineral salts and their nutrient enrichment effects on waters – typically made up of nitrogen (N) and phosphorous (P) compounds and organic matter flowing into waterways. The result is expressed on an equivalent mass of nitrogen basis. The characterization factors estimate the eutrophication potential of a release of chemicals containing N or P to air or water, per kilogram of chemical released, relative to 1 kg N discharged directly to surface freshwater.

- **Photochemical ozone creation/smog (IC)** – Photochemical ozone formation potential (CF) – Under certain climatic conditions, air emissions from industry and transportation can be trapped at ground level where, in the presence of sunlight, they produce photochemical smog, a symptom of photochemical ozone creation potential (POCP). While ozone is not emitted directly, it is a product of interactions of volatile organic compounds (VOCs) and nitrogen oxides (NOx). The "smog" (POCP) indicator is expressed on a mass of equivalent ozone (O_3) basis.

5.1 Life Cycle Impact Assessment Results

This section presents the inventory metrics and life cycle impact indicator results for the 72 RMC product design mixes. These results are a function of LCI modeling and life cycle assessment as performed using SimaPro v8.5 with the LCI data sets as described in Section 4 of this report. Tables 6 to 14 summarize the LCA results for each of the eight product mix designs considered within each compressive strength class. The letter reference is as follows: a) cubic meter results b) cubic yard results. All product life cycle results are calculated at the upper bound of the strength class and lower bound of the indicated SCM percentage to conservatively estimate the life cycle impacts. Each table also reports the minimum and maximum indicator/inventory metric result within each compressive strength range.

Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories.

Table 6a. Summary Results (A1-A3): 0-2500 psi (0-17.2 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**0000-2500-00-FA/SL**	**0000-2500-20-FA**	**0000-2500-30-FA**	**0000-2500-40-FA**	**0000-2500-30-SL**	**0000-2500-40-SL**	**0000-2500-50-SL**	**0000-2500-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	195.52	310.65	310.65	267.96	244.94	220.69	241.70	218.81	195.85	195.52
ODP	kg CFC11e	6.04E-06	8.31E-06	8.31E-06	7.23E-06	6.65E-06	6.04E-06	7.60E-06	7.37E-06	7.13E-06	6.49E-06
AP	kg SO_2e	0.80	1.04	1.04	0.92	0.87	0.80	1.00	0.99	0.98	0.89
EP	kg Ne	0.29	0.42	0.42	0.37	0.34	0.31	0.35	0.32	0.30	0.29
SFP	kg O_3e	17.40	22.24	22.24	19.95	18.71	17.40	20.38	19.76	19.14	17.99
ADPf	MJ, NCV	1,438.72	1,941.80	1,941.80	1,720.40	1,601.76	1,477.55	1,671.54	1,583.43	1,493.84	1,438.72
ADPe	kg Sbe	2.05E-04	2.93E-04	2.93E-04	2.62E-04	2.46E-04	2.28E-04	2.40E-04	2.23E-04	2.05E-04	2.07E-04
FFD	MJ Surplus	123.40	148.76	148.76	136.52	130.07	123.40	143.56	142.12	140.46	131.47
Use of Primary Resources											
RPRE	MJ, NCV	60.59	88.63	88.63	76.76	70.40	63.70	73.16	68.08	62.94	60.59
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,614.02	2,109.63	2,109.63	1,873.28	1,746.63	1,614.02	1,869.25	1,791.21	1,711.61	1,623.22
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	59.74	119.48	119.48	100.61	90.42	79.65	83.63	71.69	59.74	62.88
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.61	2.84	2.84	2.45	2.24	2.02	2.10	1.86	1.61	1.67
CCE	kg CO_2e	61.73	123.45	123.45	103.96	93.42	82.30	86.42	74.07	61.73	64.98
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	2.25E-08	2.31E-08	2.31E-08	2.28E-08	2.27E-08	2.25E-08	2.30E-08	2.30E-08	2.30E-08	2.28E-08
ILLRW	m^3	3.04E-07	3.13E-07	3.13E-07	3.09E-07	3.06E-07	3.04E-07	3.13E-07	3.13E-07	3.12E-07	3.08E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6b. Summary Results (A1-A3): 0-2500 psi (0-17.2 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**0000-2500-00-FA/SL**	**0000-2500-20-FA**	**0000-2500-30-FA**	**0000-2500-40-FA**	**0000-2500-30-SL**	**0000-2500-40-SL**	**0000-2500-50-SL**	**0000-2500-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	149.48	237.51	237.51	204.87	187.27	168.73	184.79	167.29	149.74	149.48
ODP	kg CFC11e	4.62E-06	6.35E-06	6.35E-06	5.53E-06	5.08E-06	4.62E-06	5.81E-06	5.63E-06	5.45E-06	4.96E-06
AP	kg SO_2e	0.61	0.79	0.79	0.71	0.66	0.61	0.77	0.76	0.75	0.68
EP	kg Ne	0.22	0.32	0.32	0.28	0.26	0.24	0.26	0.25	0.23	0.22
SFP	kg O_3e	13.31	17.01	17.01	15.25	14.31	13.31	15.58	15.11	14.63	13.76
ADPf	MJ, NCV	1,099.98	1,484.61	1,484.61	1,315.34	1,224.63	1,129.67	1,277.99	1,210.62	1,142.12	1,099.98
ADPe	kg Sbe	1.57E-04	2.24E-04	2.24E-04	2.00E-04	1.88E-04	1.75E-04	1.84E-04	1.70E-04	1.57E-04	1.58E-04
FFD	MJ Surplus	94.35	113.73	113.73	104.38	99.44	94.35	109.76	108.66	107.39	100.52
Use of Primary Resources											
RPRE	MJ, NCV	46.32	67.76	67.76	58.69	53.82	48.70	55.94	52.05	48.12	46.32
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,234.00	1,612.93	1,612.93	1,432.23	1,335.39	1,234.00	1,429.14	1,369.48	1,308.62	1,241.04
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	45.67	91.35	91.35	76.92	69.13	60.90	63.94	54.81	45.67	48.08
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.23	2.17	2.17	1.87	1.71	1.54	1.61	1.42	1.23	1.28
CCE	kg CO_2e	47.19	94.39	94.39	79.48	71.43	62.92	66.07	56.63	47.19	49.68
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	1.72E-08	1.76E-08	1.76E-08	1.74E-08	1.73E-08	1.72E-08	1.76E-08	1.76E-08	1.76E-08	1.74E-08
ILLRW	m^3	2.32E-07	2.40E-07	2.40E-07	2.36E-07	2.34E-07	2.32E-07	2.39E-07	2.39E-07	2.39E-07	2.36E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7a. Summary Results (A1-A3): 2501-3000 psi (17.2-20.7 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**2501-3000-00-FA/SL**	**2501-3000-20-FA**	**2501-3000-30-FA**	**2501-3000-40-FA**	**2501-3000-30-SL**	**2501-3000-40-SL**	**2501-3000-50-SL**	**2501-3000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	215.98	346.49	346.49	298.11	271.94	244.44	268.27	242.31	216.36	215.98
ODP	kg CFC11e	6.60E-06	9.18E-06	9.18E-06	7.96E-06	7.30E-06	6.60E-06	8.38E-06	8.11E-06	7.84E-06	7.12E-06
AP	kg SO_2e	0.86	1.13	1.13	1.00	0.94	0.86	1.09	1.08	1.07	0.96
EP	kg Ne	0.32	0.46	0.46	0.40	0.37	0.34	0.38	0.35	0.32	0.32
SFP	kg O_3e	18.71	24.20	24.20	21.60	20.19	18.71	22.09	21.38	20.68	19.38
ADPf	MJ, NCV	1,555.87	2,126.93	2,126.93	1,875.85	1,739.68	1,598.54	1,818.81	1,718.57	1,618.33	1,555.87
ADPe	kg Sbe	2.17E-04	3.16E-04	3.16E-04	2.82E-04	2.63E-04	2.43E-04	2.57E-04	2.37E-04	2.17E-04	2.19E-04
FFD	MJ Surplus	129.93	159.01	159.01	145.11	137.54	129.93	152.83	151.14	149.45	139.27
Use of Primary Resources											
RPRE	MJ, NCV	66.58	98.39	98.39	84.94	77.66	70.06	80.80	75.02	69.25	66.58
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,742.52	2,306.59	2,306.59	2,038.56	1,893.20	1,742.52	2,032.20	1,943.36	1,854.51	1,754.36
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	67.69	135.39	135.39	114.01	102.45	90.26	94.77	81.23	67.69	71.26
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.77	3.17	3.17	2.73	2.49	2.23	2.33	2.05	1.77	1.84
CCE	kg CO_2e	69.95	139.89	139.89	117.80	105.86	93.26	97.92	83.94	69.95	73.63
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	2.23E-08	2.29E-08	2.29E-08	2.26E-08	2.25E-08	2.23E-08	2.29E-08	2.28E-08	2.28E-08	2.26E-08
ILLRW	m^3	2.99E-07	3.10E-07	3.10E-07	3.05E-07	3.02E-07	2.99E-07	3.10E-07	3.09E-07	3.09E-07	3.04E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7b. Summary Results (A1-A3): 2501-3000 psi (17.2-20.7 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**2501-3000-00-FA/SL**	**2501-3000-20-FA**	**2501-3000-30-FA**	**2501-3000-40-FA**	**2501-3000-30-SL**	**2501-3000-40-SL**	**2501-3000-50-SL**	**2501-3000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	165.13	264.91	264.91	227.92	207.91	186.88	205.10	185.26	165.42	165.13
ODP	kg CFC11e	5.05E-06	7.02E-06	7.02E-06	6.08E-06	5.58E-06	5.05E-06	6.40E-06	6.20E-06	6.00E-06	5.44E-06
AP	kg SO_2e	0.66	0.86	0.86	0.77	0.72	0.66	0.83	0.82	0.82	0.74
EP	kg Ne	0.24	0.35	0.35	0.31	0.28	0.26	0.29	0.27	0.25	0.24
SFP	kg O_3e	14.31	18.50	18.50	16.51	15.44	14.31	16.89	16.35	15.81	14.82
ADPf	MJ, NCV	1,189.55	1,626.15	1,626.15	1,434.19	1,330.08	1,222.17	1,390.58	1,313.94	1,237.30	1,189.55
ADPe	kg Sbe	1.66E-04	2.42E-04	2.42E-04	2.15E-04	2.01E-04	1.86E-04	1.96E-04	1.81E-04	1.66E-04	1.68E-04
FFD	MJ Surplus	99.34	121.57	121.57	110.95	105.15	99.34	116.85	115.56	114.27	106.48
Use of Primary Resources											
RPRE	MJ, NCV	50.90	75.22	75.22	64.94	59.37	53.56	61.77	57.36	52.94	50.90
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,332.25	1,763.51	1,763.51	1,558.59	1,447.46	1,332.25	1,553.73	1,485.80	1,417.88	1,341.30
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	51.76	103.51	103.51	87.17	78.33	69.01	72.46	62.11	51.76	54.48
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.36	2.42	2.42	2.08	1.90	1.71	1.78	1.57	1.36	1.41
CCE	kg CO_2e	53.48	106.96	106.96	90.07	80.94	71.30	74.87	64.17	53.48	56.29
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	1.71E-08	1.75E-08	1.75E-08	1.73E-08	1.72E-08	1.71E-08	1.75E-08	1.75E-08	1.75E-08	1.73E-08
ILLRW	m^3	2.29E-07	2.37E-07	2.37E-07	2.33E-07	2.31E-07	2.29E-07	2.37E-07	2.37E-07	2.36E-07	2.33E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 8a. Summary Results (A1-A3): 3001-4000 psi (20.7-27.6 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**3001-4000-00-FA/SL**	**3001-4000-20-FA**	**3001-4000-30-FA**	**3001-4000-40-FA**	**3001-4000-30-SL**	**3001-4000-40-SL**	**3001-4000-50-SL**	**6001-8000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	262.34	427.75	427.75	366.48	333.33	298.48	328.69	295.79	262.82	262.34
ODP	kg CFC11e	7.89E-06	1.11E-05	1.11E-05	9.60E-06	8.77E-06	7.89E-06	1.01E-05	9.80E-06	9.46E-06	8.54E-06
AP	kg SO_2e	1.01	1.34	1.34	1.18	1.10	1.01	1.29	1.28	1.26	1.13
EP	kg Ne	0.37	0.55	0.55	0.48	0.44	0.40	0.45	0.41	0.38	0.37
SFP	kg O_3e	21.68	28.62	28.62	25.33	23.55	21.68	25.95	25.06	24.17	22.52
ADPf	MJ, NCV	1,821.60	2,548.09	2,548.09	2,229.79	2,057.29	1,877.80	2,157.57	2,029.87	1,900.68	1,821.60
ADPe	kg Sbe	2.44E-04	3.69E-04	3.69E-04	3.26E-04	3.02E-04	2.77E-04	2.94E-04	2.69E-04	2.44E-04	2.46E-04
FFD	MJ Surplus	145.48	182.50	182.50	164.84	155.24	145.48	174.62	172.36	169.88	156.98
Use of Primary Resources											
RPRE	MJ, NCV	80.16	120.56	120.56	103.51	94.29	84.64	98.27	90.93	83.54	80.16
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2,039.10	2,754.65	2,754.65	2,414.86	2,230.72	2,039.10	2,406.82	2,293.49	2,178.60	2,051.78
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	85.71	171.42	171.42	144.35	129.72	114.28	119.99	102.85	85.71	90.22
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.15	3.91	3.91	3.35	3.05	2.73	2.85	2.50	2.15	2.24
CCE	kg CO_2e	88.56	177.12	177.12	149.16	134.04	118.08	123.99	106.27	88.56	93.22
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	2.18E-08	2.25E-08	2.25E-08	2.22E-08	2.20E-08	2.18E-08	2.25E-08	2.25E-08	2.24E-08	2.21E-08
ILLRW	m^3	2.89E-07	3.03E-07	3.03E-07	2.97E-07	2.93E-07	2.89E-07	3.02E-07	3.02E-07	3.02E-07	2.96E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 8b. Summary Results (A1-A3): 3001-4000 psi (20.7-27.6 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**3001-4000-00-FA/SL**	**3001-4000-20-FA**	**3001-4000-30-FA**	**3001-4000-40-FA**	**3001-4000-30-SL**	**3001-4000-40-SL**	**3001-4000-50-SL**	**3001-4000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	200.58	327.04	327.04	280.19	254.85	228.20	251.30	226.15	200.94	200.58
ODP	kg CFC11e	6.03E-06	8.52E-06	8.52E-06	7.34E-06	6.70E-06	6.03E-06	7.75E-06	7.49E-06	7.23E-06	6.53E-06
AP	kg SO_2e	0.77	1.03	1.03	0.90	0.84	0.77	0.99	0.98	0.96	0.87
EP	kg Ne	0.28	0.42	0.42	0.37	0.34	0.31	0.34	0.32	0.29	0.28
SFP	kg O_3e	16.57	21.88	21.88	19.37	18.01	16.57	19.84	19.16	18.48	17.22
ADPf	MJ, NCV	1,392.71	1,948.15	1,948.15	1,704.80	1,572.91	1,435.68	1,649.58	1,551.94	1,453.17	1,392.71
ADPe	kg Sbe	1.87E-04	2.82E-04	2.82E-04	2.49E-04	2.31E-04	2.12E-04	2.25E-04	2.06E-04	1.87E-04	1.88E-04
FFD	MJ Surplus	111.23	139.53	139.53	126.03	118.69	111.23	133.50	131.78	129.88	120.02
Use of Primary Resources											
RPRE	MJ, NCV	61.29	92.17	92.17	79.14	72.09	64.72	75.14	69.52	63.87	61.29
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,559.00	2,106.08	2,106.08	1,846.29	1,705.51	1,559.00	1,840.14	1,753.50	1,665.66	1,568.70
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	65.53	131.06	131.06	110.37	99.18	87.37	91.74	78.64	65.53	68.98
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.64	2.99	2.99	2.56	2.33	2.09	2.18	1.91	1.64	1.71
CCE	kg CO_2e	67.71	135.42	135.42	114.04	102.48	90.28	94.79	81.25	67.71	71.27
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	1.67E-08	1.72E-08	1.72E-08	1.70E-08	1.68E-08	1.67E-08	1.72E-08	1.72E-08	1.72E-08	1.69E-08
ILLRW	m^3	2.21E-07	2.32E-07	2.32E-07	2.27E-07	2.24E-07	2.21E-07	2.31E-07	2.31E-07	2.31E-07	2.26E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9a. Summary Results (A1-A3): 4001-5000 psi (27.6-34.5 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**4001-5000-00-FA/SL**	**4001-5000-20-FA**	**4001-5000-30-FA**	**4001-5000-40-FA**	**4001-5000-30-SL**	**4001-5000-40-SL**	**4001-5000-50-SL**	**4001-5000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	317.30	523.68	523.68	447.31	406.04	362.45	400.25	359.11	317.89	317.30
ODP	kg CFC11e	9.38E-06	1.34E-05	1.34E-05	1.15E-05	1.05E-05	9.38E-06	1.22E-05	1.18E-05	1.13E-05	1.02E-05
AP	kg SO_2e	1.17	1.59	1.59	1.39	1.29	1.17	1.53	1.51	1.49	1.33
EP	kg Ne	0.44	0.66	0.66	0.57	0.52	0.47	0.53	0.49	0.45	0.44
SFP	kg O_3e	25.23	33.89	33.89	29.79	27.57	25.23	30.56	29.45	28.34	26.28
ADPf	MJ, NCV	2,141.59	3,049.20	3,049.20	2,653.30	2,439.54	2,213.44	2,564.71	2,403.21	2,240.23	2,141.59
ADPe	kg Sbe	2.72E-04	4.29E-04	4.29E-04	3.74E-04	3.45E-04	3.13E-04	3.35E-04	3.04E-04	2.72E-04	2.75E-04
FFD	MJ Surplus	165.05	211.17	211.17	189.32	177.54	165.05	201.73	198.58	195.21	179.13
Use of Primary Resources											
RPRE	MJ, NCV	96.18	146.62	146.62	125.40	113.95	101.84	118.92	109.69	100.40	96.18
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2,394.79	3,286.98	3,286.98	2,864.35	2,636.15	2,394.79	2,855.88	2,712.18	2,566.92	2,408.74
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	106.91	213.81	213.81	180.05	161.80	142.54	149.67	128.29	106.91	112.53
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.58	4.79	4.79	4.09	3.71	3.31	3.47	3.02	2.58	2.69
CCE	kg CO_2e	110.46	220.93	220.93	186.04	167.19	147.28	154.65	132.56	110.46	116.28
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	2.07E-08	2.16E-08	2.16E-08	2.12E-08	2.09E-08	2.07E-08	2.16E-08	2.15E-08	2.15E-08	2.11E-08
ILLRW	m^3	2.73E-07	2.91E-07	2.91E-07	2.82E-07	2.78E-07	2.73E-07	2.90E-07	2.89E-07	2.89E-07	2.81E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9b. Summary Results (A1-A3): 4001-5000 psi (27.6-34.5 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**4001-5000-00-FA/SL**	**4001-5000-20-FA**	**4001-5000-30-FA**	**4001-5000-40-FA**	**4001-5000-30-SL**	**4001-5000-40-SL**	**4001-5000-50-SL**	**4001-5000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	242.59	400.38	400.38	341.99	310.44	277.11	306.01	274.56	243.05	242.59
ODP	kg CFC11e	7.17E-06	1.03E-05	1.03E-05	8.81E-06	8.01E-06	7.17E-06	9.31E-06	8.99E-06	8.67E-06	7.79E-06
AP	kg SO_2e	0.90	1.22	1.22	1.07	0.98	0.90	1.17	1.16	1.14	1.02
EP	kg Ne	0.33	0.51	0.51	0.44	0.40	0.36	0.41	0.37	0.34	0.33
SFP	kg O_3e	19.29	25.91	25.91	22.78	21.08	19.29	23.37	22.52	21.67	20.09
ADPf	MJ, NCV	1,637.36	2,331.28	2,331.28	2,028.59	1,865.16	1,692.30	1,960.86	1,837.38	1,712.78	1,637.36
ADPe	kg Sbe	2.08E-04	3.28E-04	3.28E-04	2.86E-04	2.63E-04	2.40E-04	2.56E-04	2.32E-04	2.08E-04	2.11E-04
FFD	MJ Surplus	126.19	161.45	161.45	144.74	135.74	126.19	154.23	151.83	149.25	136.95
Use of Primary Resources											
RPRE	MJ, NCV	73.54	112.10	112.10	95.88	87.12	77.86	90.92	83.86	76.76	73.54
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,830.95	2,513.07	2,513.07	2,189.95	2,015.48	1,830.95	2,183.48	2,073.61	1,962.55	1,841.62
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	81.73	163.47	163.47	137.66	123.71	108.98	114.43	98.08	81.73	86.04
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.97	3.66	3.66	3.13	2.84	2.53	2.65	2.31	1.97	2.06
CCE	kg CO_2e	84.45	168.91	168.91	142.24	127.82	112.61	118.24	101.35	84.45	88.90
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	1.58E-08	1.65E-08	1.65E-08	1.62E-08	1.60E-08	1.58E-08	1.65E-08	1.65E-08	1.65E-08	1.61E-08
ILLRW	m^3	2.09E-07	2.22E-07	2.22E-07	2.16E-07	2.12E-07	2.09E-07	2.21E-07	2.21E-07	2.21E-07	2.15E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 10a. Summary Results (A1-A3): 5001-6000 psi (34.5-41.4 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**5001-6000-00-FA/SL**	**5001-6000-20-FA**	**5001-6000-30-FA**	**5001-6000-40-FA**	**5001-6000-30-SL**	**5001-6000-40-SL**	**5001-6000-50-SL**	**5001-6000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	333.55	551.50	551.50	470.82	427.20	381.16	421.10	377.64	334.17	333.55
ODP	kg CFC11e	9.83E-06	1.41E-05	1.41E-05	1.21E-05	1.10E-05	9.83E-06	1.28E-05	1.23E-05	1.19E-05	1.07E-05
AP	kg SO_2e	1.23	1.67	1.67	1.46	1.35	1.23	1.61	1.59	1.57	1.40
EP	kg Ne	0.46	0.70	0.70	0.60	0.55	0.49	0.56	0.51	0.47	0.46
SFP	kg O_3e	26.39	35.54	35.54	31.21	28.86	26.39	32.02	30.85	29.68	27.50
ADPf	MJ, NCV	2,241.04	3,198.64	3,198.64	2,780.27	2,554.00	2,315.08	2,686.60	2,515.92	2,345.24	2,241.04
ADPe	kg Sbe	2.83E-04	4.48E-04	4.48E-04	3.90E-04	3.59E-04	3.26E-04	3.49E-04	3.16E-04	2.83E-04	2.86E-04
FFD	MJ Surplus	171.36	220.19	220.19	197.08	184.57	171.36	210.18	206.84	203.51	186.51
Use of Primary Resources											
RPRE	MJ, NCV	100.93	154.17	154.17	131.75	119.63	106.83	124.90	115.14	105.39	100.93
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2,503.18	3,446.39	3,446.39	2,999.77	2,758.23	2,503.18	2,990.74	2,838.86	2,686.98	2,519.89
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	112.93	225.86	225.86	190.19	170.92	150.57	158.10	135.51	112.93	118.87
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.71	5.04	5.04	4.30	3.90	3.48	3.64	3.17	2.71	2.83
CCE	kg CO_2e	116.69	233.37	233.37	196.52	176.61	155.58	163.36	140.02	116.69	122.83
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	2.08E-08	2.17E-08	2.17E-08	2.13E-08	2.10E-08	2.08E-08	2.17E-08	2.17E-08	2.16E-08	2.12E-08
ILLRW	m^3	2.74E-07	2.93E-07	2.93E-07	2.84E-07	2.79E-07	2.74E-07	2.92E-07	2.92E-07	2.91E-07	2.83E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 10b. Summary Results (A1-A3): 5001-6000 psi (34.5-41.4 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**5001-6000-00-FA/SL**	**5001-6000-20-FA**	**5001-6000-30-FA**	**5001-6000-40-FA**	**5001-6000-30-SL**	**5001-6000-40-SL**	**5001-6000-50-SL**	**5001-6000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	255.02	421.65	421.65	359.97	326.62	291.42	321.96	288.72	255.49	255.02
ODP	kg CFC11e	7.52E-06	1.08E-05	1.08E-05	9.25E-06	8.41E-06	7.52E-06	9.78E-06	9.44E-06	9.10E-06	8.17E-06
AP	kg SO_2e	0.94	1.28	1.28	1.12	1.03	0.94	1.23	1.21	1.20	1.07
EP	kg Ne	0.35	0.53	0.53	0.46	0.42	0.38	0.43	0.39	0.36	0.35
SFP	kg O_3e	20.18	27.17	27.17	23.86	22.07	20.18	24.48	23.59	22.69	21.03
ADPf	MJ, NCV	1,713.40	2,445.54	2,445.54	2,125.67	1,952.68	1,770.01	2,054.05	1,923.56	1,793.06	1,713.40
ADPe	kg Sbe	2.16E-04	3.42E-04	3.42E-04	2.98E-04	2.75E-04	2.49E-04	2.67E-04	2.42E-04	2.16E-04	2.19E-04
FFD	MJ Surplus	131.01	168.34	168.34	150.68	141.12	131.01	160.69	158.14	155.59	142.60
Use of Primary Resources											
RPRE	MJ, NCV	77.17	117.87	117.87	100.73	91.46	81.68	95.49	88.03	80.57	77.17
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,913.82	2,634.95	2,634.95	2,293.49	2,108.82	1,913.82	2,286.58	2,170.46	2,054.34	1,926.60
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	86.34	172.68	172.68	145.41	130.68	115.12	120.88	103.61	86.34	90.88
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.07	3.85	3.85	3.29	2.98	2.66	2.78	2.43	2.07	2.16
CCE	kg CO_2e	89.21	178.43	178.43	150.25	135.02	118.95	124.90	107.06	89.21	93.91
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	1.59E-08	1.66E-08	1.66E-08	1.63E-08	1.61E-08	1.59E-08	1.66E-08	1.66E-08	1.66E-08	1.62E-08
ILLRW	m^3	2.10E-07	2.24E-07	2.24E-07	2.17E-07	2.14E-07	2.10E-07	2.23E-07	2.23E-07	2.23E-07	2.16E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 11a. Summary Results (A1-A3): 6001-8000 psi (41.3-55.1 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**6001-8000-00-FA/SL**	**6001-8000-20-FA**	**6001-8000-30-FA**	**6001-8000-40-FA**	**6001-8000-30-SL**	**6001-8000-40-SL**	**6001-8000-50-SL**	**6001-8000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	385.23	642.02	642.02	546.99	495.61	441.31	488.43	437.16	385.97	385.23
ODP	kg CFC11e	1.13E-05	1.63E-05	1.63E-05	1.39E-05	1.26E-05	1.13E-05	1.47E-05	1.42E-05	1.37E-05	1.23E-05
AP	kg SO_2e	1.39	1.91	1.91	1.66	1.53	1.39	1.83	1.81	1.78	1.58
EP	kg Ne	0.52	0.80	0.80	0.69	0.63	0.56	0.64	0.58	0.53	0.52
SFP	kg O_3e	29.69	40.47	40.47	35.36	32.60	29.69	36.32	34.94	33.56	31.00
ADPf	MJ, NCV	2,538.60	3,669.01	3,669.01	3,175.83	2,909.13	2,626.05	3,065.27	2,862.54	2,661.29	2,538.60
ADPe	kg Sbe	3.13E-04	5.07E-04	5.07E-04	4.39E-04	4.03E-04	3.64E-04	3.91E-04	3.52E-04	3.13E-04	3.17E-04
FFD	MJ Surplus	188.70	246.57	246.57	219.29	204.52	188.70	234.67	230.48	226.51	206.50
Use of Primary Resources											
RPRE	MJ, NCV	116.11	178.90	178.90	152.49	138.20	123.07	144.41	132.86	121.36	116.11
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2,833.43	3,946.80	3,946.80	3,420.32	3,135.61	2,833.43	3,409.41	3,228.71	3,049.58	2,852.84
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	132.98	265.96	265.96	223.96	201.26	177.30	186.17	159.57	132.98	139.98
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	3.12	5.87	5.87	5.00	4.52	4.03	4.22	3.67	3.12	3.26
CCE	kg CO_2e	137.40	274.81	274.81	231.42	207.96	183.21	192.37	164.88	137.40	144.64
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	2.02E-08	2.13E-08	2.13E-08	2.08E-08	2.05E-08	2.02E-08	2.13E-08	2.12E-08	2.12E-08	2.07E-08
ILLRW	m^3	2.63E-07	2.85E-07	2.85E-07	2.75E-07	2.69E-07	2.63E-07	2.84E-07	2.84E-07	2.83E-07	2.73E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 11b. Summary Results (A1-A3): 6001-8000 psi (41.3-55.1 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**6001-8000-00-FA/SL**	**6001-8000-20-FA**	**6001-8000-30-FA**	**6001-8000-40-FA**	**6001-8000-30-SL**	**6001-8000-40-SL**	**6001-8000-50-SL**	**6001-8000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	294.53	490.86	490.86	418.20	378.92	337.40	373.43	334.24	295.09	294.53
ODP	kg CFC11e	8.61E-06	1.25E-05	1.25E-05	1.06E-05	9.66E-06	8.61E-06	1.13E-05	1.09E-05	1.05E-05	9.38E-06
AP	kg SO_2e	1.06	1.46	1.46	1.27	1.17	1.06	1.40	1.38	1.36	1.21
EP	kg Ne	0.39	0.61	0.61	0.53	0.48	0.43	0.49	0.45	0.40	0.39
SFP	kg O_3e	22.70	30.94	30.94	27.04	24.93	22.70	27.77	26.71	25.66	23.70
ADPf	MJ, NCV	1,940.90	2,805.16	2,805.16	2,428.10	2,224.19	2,007.76	2,343.56	2,188.57	2,034.70	1,940.90
ADPe	kg Sbe	2.39E-04	3.88E-04	3.88E-04	3.36E-04	3.08E-04	2.78E-04	2.99E-04	2.69E-04	2.39E-04	2.42E-04
FFD	MJ Surplus	144.27	188.52	188.52	167.66	156.37	144.27	179.42	176.22	173.18	157.88
Use of Primary Resources											
RPRE	MJ, NCV	88.77	136.78	136.78	116.58	105.66	94.09	110.41	101.58	92.78	88.77
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2,166.31	3,017.54	3,017.54	2,615.02	2,397.35	2,166.31	2,606.68	2,468.53	2,331.57	2,181.15
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	101.67	203.34	203.34	171.23	153.88	135.56	142.34	122.00	101.67	107.02
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.39	4.49	4.49	3.82	3.46	3.08	3.23	2.81	2.39	2.49
CCE	kg CO_2e	105.05	210.11	210.11	176.93	159.00	140.07	147.07	126.06	105.05	110.58
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	1.54E-08	1.63E-08	1.63E-08	1.59E-08	1.57E-08	1.54E-08	1.63E-08	1.62E-08	1.62E-08	1.58E-08
ILLRW	m^3	2.01E-07	2.18E-07	2.18E-07	2.10E-07	2.06E-07	2.01E-07	2.17E-07	2.17E-07	2.16E-07	2.09E-07
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 12a. Summary Results (A1-A3): 0-3000 psi Lightweight (0-20.7 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**LW-3000-00-FA/SL**	**LW-3000-20-FA**	**LW-3000-30-FA**	**LW-3000-40-FA**	**LW-3000-30-SL**	**LW-3000-40-SL**	**LW-3000-50-SL**	**LW-3000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	416.67	596.09	596.09	512.64	467.62	497.83	425.53	468.88	416.67	439.94
ODP	kg CFC11e	1.48E-05	2.05E-05	2.05E-05	1.77E-05	1.61E-05	1.90E-05	1.48E-05	1.87E-05	1.65E-05	1.84E-05
AP	kg SO_2e	2.02	2.70	2.70	2.36	2.18	2.58	2.02	2.57	2.29	2.56
EP	kg Ne	0.72	0.99	0.99	0.86	0.79	0.88	0.72	0.84	0.75	0.81
SFP	kg O_3e	29.23	38.42	38.42	33.93	31.50	35.46	29.23	34.68	31.21	33.90
ADPf	MJ, NCV	3,122.24	4,218.66	4,218.66	3,675.73	3,383.15	3,774.20	3,122.24	3,659.74	3,273.85	3,545.28
ADPe	kg Sbe	2.71E-04	3.95E-04	3.95E-04	3.43E-04	3.15E-04	3.24E-04	2.88E-04	3.02E-04	2.71E-04	2.80E-04
FFD	MJ Surplus	219.90	282.18	282.18	251.29	234.69	269.23	219.90	266.86	241.48	264.49
Use of Primary Resources											
RPRE	MJ, NCV	266.37	367.31	367.31	316.27	288.78	333.87	266.37	327.35	290.13	320.83
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	3,400.37	4,586.11	4,586.11	3,998.57	3,681.95	4,169.08	3,400.37	4,067.06	3,632.01	3,965.04
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	75.08	150.16	150.16	126.45	113.63	105.11	100.10	90.09	79.03	75.08
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.17	3.73	3.73	3.20	2.92	2.79	2.62	2.48	2.22	2.17
CCE	kg CO_2e	77.58	155.15	155.15	130.66	117.41	108.61	103.44	93.09	81.66	77.58
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	5.06E-08	6.35E-08	6.35E-08	5.68E-08	5.32E-08	6.10E-08	5.06E-08	6.10E-08	5.58E-08	6.10E-08
ILLRW	m^3	1.60E-06	2.10E-06	2.10E-06	1.84E-06	1.70E-06	2.00E-06	1.60E-06	2.00E-06	1.80E-06	2.00E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 12b. Summary Results (A1-A3): 0-3000 psi Lightweight (0-20.7 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**LW-3000-00-FA/SL**	**LW-3000-20-FA**	**LW-3000-30-FA**	**LW-3000-40-FA**	**LW-3000-30-SL**	**LW-3000-40-SL**	**LW-3000-50-SL**	**LW-3000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	318.57	455.74	455.74	391.95	357.52	380.62	325.34	358.49	318.57	336.36
ODP	kg CFC11e	1.13E-05	1.57E-05	1.57E-05	1.35E-05	1.23E-05	1.45E-05	1.13E-05	1.43E-05	1.26E-05	1.41E-05
AP	kg SO_2e	1.55	2.07	2.07	1.81	1.67	1.98	1.55	1.96	1.75	1.95
EP	kg Ne	0.55	0.76	0.76	0.66	0.60	0.67	0.55	0.65	0.58	0.62
SFP	kg O_3e	22.35	29.38	29.38	25.94	24.08	27.11	22.35	26.51	23.86	25.92
ADPf	MJ, NCV	2,387.13	3,225.39	3,225.39	2,810.29	2,586.60	2,885.58	2,387.13	2,798.07	2,503.03	2,710.56
ADPe	kg Sbe	2.07E-04	3.02E-04	3.02E-04	2.62E-04	2.41E-04	2.47E-04	2.20E-04	2.31E-04	2.07E-04	2.14E-04
FFD	MJ Surplus	168.12	215.74	215.74	192.13	179.43	205.84	168.12	204.03	184.63	202.22
Use of Primary Resources											
RPRE	MJ, NCV	203.65	280.83	280.83	241.81	220.79	255.27	203.65	250.28	221.82	245.29
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2,599.77	3,506.33	3,506.33	3,057.12	2,815.05	3,187.49	2,599.77	3,109.49	2,776.87	3,031.49
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	57.40	114.80	114.80	96.68	86.88	80.36	76.53	68.88	60.42	57.40
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.66	2.85	2.85	2.45	2.23	2.13	2.00	1.89	1.70	1.66
CCE	kg CO_2e	59.31	118.62	118.62	99.89	89.77	83.04	79.08	71.17	62.43	59.31
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	3.87E-08	4.86E-08	4.86E-08	4.34E-08	4.07E-08	4.67E-08	3.87E-08	4.66E-08	4.27E-08	4.66E-08
ILLRW	m^3	1.22E-06	1.60E-06	1.60E-06	1.41E-06	1.30E-06	1.53E-06	1.22E-06	1.53E-06	1.38E-06	1.53E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 13a. Summary Results (A1-A3): 3001-4000 psi Lightweight (20.7-27.6 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**LW-4000-00-FA/SL**	**LW-4000-20-FA**	**LW-4000-30-FA**	**LW-4000-40-FA**	**LW-4000-30-SL**	**LW-4000-40-SL**	**LW-4000-50-SL**	**LW-4000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	475.10	690.86	690.86	595.41	540.36	576.35	487.83	539.70	475.10	498.48
ODP	kg CFC11e	1.63E-05	2.29E-05	2.29E-05	1.98E-05	1.80E-05	2.15E-05	1.63E-05	2.12E-05	1.84E-05	2.06E-05
AP	kg SO_2e	2.19	2.97	2.97	2.61	2.39	2.89	2.19	2.87	2.52	2.82
EP	kg Ne	0.80	1.11	1.11	0.96	0.88	0.98	0.80	0.94	0.83	0.89
SFP	kg O_3e	32.65	43.58	43.58	38.44	35.47	40.37	32.65	39.38	35.07	38.14
ADPf	MJ, NCV	3,453.82	4,727.84	4,727.84	4,130.57	3,777.49	4,252.64	3,453.82	4,107.72	3,632.50	3,922.37
ADPe	kg Sbe	3.05E-04	4.56E-04	4.56E-04	3.95E-04	3.60E-04	3.70E-04	3.26E-04	3.43E-04	3.05E-04	3.13E-04
FFD	MJ Surplus	238.57	310.82	310.82	276.94	256.91	299.49	238.57	296.50	265.14	291.16
Use of Primary Resources											
RPRE	MJ, NCV	285.38	397.51	397.51	345.26	312.84	367.19	285.38	358.93	313.63	345.12
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	3,753.24	5,129.18	5,129.18	4,484.25	4,102.43	4,697.28	3,753.24	4,568.10	4,031.95	4,394.54
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	95.06	190.12	190.12	160.10	143.87	133.08	126.75	114.07	100.06	95.06
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.59	4.56	4.56	3.91	3.55	3.38	3.17	2.99	2.66	2.59
CCE	kg CO_2e	98.22	196.45	196.45	165.43	148.66	137.51	130.96	117.87	103.39	98.22
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	5.05E-08	6.41E-08	6.41E-08	5.78E-08	5.37E-08	6.31E-08	5.05E-08	6.30E-08	5.68E-08	6.20E-08
ILLRW	m^3	1.61E-06	2.13E-06	2.13E-06	1.89E-06	1.73E-06	2.09E-06	1.61E-06	2.09E-06	1.85E-06	2.05E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 13b. Summary Results (A1-A3): 3001-4000 psi Lightweight (20.7-27.6 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**LW-4000-00-FA/SL**	**LW-4000-20-FA**	**LW-4000-30-FA**	**LW-4000-40-FA**	**LW-4000-30-SL**	**LW-4000-40-SL**	**LW-4000-50-SL**	**LW-4000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	363.24	528.20	528.20	455.22	413.14	440.65	372.97	412.63	363.24	381.12
ODP	kg CFC11e	1.25E-05	1.75E-05	1.75E-05	1.51E-05	1.37E-05	1.65E-05	1.25E-05	1.62E-05	1.41E-05	1.57E-05
AP	kg SO_2e	1.68	2.27	2.27	1.99	1.83	2.21	1.68	2.19	1.93	2.16
EP	kg Ne	0.61	0.85	0.85	0.74	0.67	0.75	0.61	0.72	0.63	0.68
SFP	kg O_3e	24.96	33.32	33.32	29.39	27.12	30.86	24.96	30.11	26.81	29.16
ADPf	MJ, NCV	2,640.64	3,614.69	3,614.69	3,158.05	2,888.09	3,251.38	2,640.64	3,140.58	2,777.24	2,998.86
ADPe	kg Sbe	2.33E-04	3.49E-04	3.49E-04	3.02E-04	2.75E-04	2.83E-04	2.49E-04	2.62E-04	2.33E-04	2.39E-04
FFD	MJ Surplus	182.40	237.64	237.64	211.74	196.42	228.98	182.40	226.69	202.71	222.61
Use of Primary Resources											
RPRE	MJ, NCV	218.19	303.92	303.92	263.97	239.18	280.73	218.19	274.42	239.79	263.86
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	2,869.56	3,921.54	3,921.54	3,428.46	3,136.53	3,591.32	2,869.56	3,492.57	3,082.65	3,359.87
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	72.68	145.36	145.36	122.41	110.00	101.75	96.90	87.21	76.50	72.68
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	1.98	3.49	3.49	2.99	2.71	2.58	2.43	2.28	2.03	1.98
CCE	kg CO_2e	75.10	150.19	150.19	126.48	113.66	105.14	100.13	90.12	79.05	75.10
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	3.86E-08	4.90E-08	4.90E-08	4.42E-08	4.10E-08	4.82E-08	3.86E-08	4.82E-08	4.34E-08	4.74E-08
ILLRW	m^3	1.23E-06	1.63E-06	1.63E-06	1.44E-06	1.32E-06	1.60E-06	1.23E-06	1.60E-06	1.41E-06	1.57E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 14a. Summary Results (A1-A3): 4001-5000 psi Lightweight (27.6-34.5 MPa) RMC product mix design, per cubic meter											
		Minimum	**Maximum**	**LW-5000-00-FA/SL**	**LW-5000-20-FA**	**LW-5000-30-FA**	**LW-5000-40-FA**	**LW-5000-30-SL**	**LW-5000-40-SL**	**LW-5000-50-SL**	**LW-5000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	517.88	771.41	771.41	659.35	594.46	634.28	534.08	592.38	517.88	543.62
ODP	kg CFC11e	1.75E-05	2.53E-05	2.53E-05	2.16E-05	1.94E-05	2.34E-05	1.75E-05	2.30E-05	1.98E-05	2.22E-05
AP	kg SO_2e	2.34	3.26	3.26	2.82	2.56	3.12	2.34	3.10	2.70	3.03
EP	kg Ne	0.86	1.22	1.22	1.05	0.95	1.06	0.86	1.02	0.89	0.96
SFP	kg O_3e	35.23	48.02	48.02	41.98	38.48	44.01	35.23	42.88	37.92	41.37
ADPf	MJ, NCV	3,717.43	5,220.09	5,220.09	4,511.33	4,090.32	4,621.91	3,717.43	4,456.22	3,907.21	4,229.87
ADPe	kg Sbe	3.30E-04	5.06E-04	5.06E-04	4.34E-04	3.94E-04	4.05E-04	3.55E-04	3.73E-04	3.30E-04	3.38E-04
FFD	MJ Surplus	254.40	339.68	339.68	299.44	275.53	323.55	254.40	320.12	283.94	313.18
Use of Primary Resources											
RPRE	MJ, NCV	302.39	436.90	436.90	373.61	334.17	394.71	302.39	385.26	332.70	367.50
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	4,035.00	5,658.68	5,658.68	4,892.89	4,437.34	5,104.64	4,035.00	4,956.95	4,337.72	4,742.68
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	108.69	217.37	217.37	183.05	164.50	152.16	144.92	130.42	114.41	108.69
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.88	5.15	5.15	4.40	3.98	3.79	3.55	3.34	2.97	2.88
CCE	kg CO_2e	112.30	224.61	224.61	189.14	169.97	157.23	149.74	134.76	118.21	112.30
Indicators Describing Waste											
HWD	kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
NHWD	kg	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
HLRW	m^3	5.12E-08	6.79E-08	6.79E-08	6.01E-08	5.49E-08	6.54E-08	5.12E-08	6.54E-08	5.80E-08	6.39E-08
ILLRW	m^3	1.64E-06	2.28E-06	2.28E-06	1.98E-06	1.78E-06	2.18E-06	1.64E-06	2.18E-06	1.90E-06	2.13E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 14b. Summary Results (A1-A3): 4001-5000 psi Lightweight (27.6-34.5 MPa) RMC product mix design, per cubic yard											
		Minimum	**Maximum**	**LW-5000-00-FA/SL**	**LW-5000-20-FA**	**LW-5000-30-FA**	**LW-5000-40-FA**	**LW-5000-30-SL**	**LW-5000-40-SL**	**LW-5000-50-SL**	**LW-5000-50-FA/SL**
Core Mandatory Impact Indicator											
GWP	kg CO_2e	395.95	589.79	589.79	504.11	454.50	484.94	408.33	452.91	395.95	415.63
ODP	kg CFC11e	1.34E-05	1.93E-05	1.93E-05	1.65E-05	1.49E-05	1.79E-05	1.34E-05	1.76E-05	1.52E-05	1.70E-05
AP	kg SO_2e	1.79	2.49	2.49	2.16	1.96	2.39	1.79	2.37	2.06	2.32
EP	kg Ne	0.65	0.94	0.94	0.80	0.72	0.81	0.65	0.78	0.68	0.73
SFP	kg O_3e	26.94	36.71	36.71	32.10	29.42	33.65	26.94	32.78	28.99	31.63
ADPf	MJ, NCV	2,842.18	3,991.04	3,991.04	3,449.16	3,127.27	3,533.71	2,842.18	3,407.02	2,987.28	3,233.97
ADPe	kg Sbe	2.52E-04	3.87E-04	3.87E-04	3.32E-04	3.01E-04	3.10E-04	2.71E-04	2.85E-04	2.52E-04	2.59E-04
FFD	MJ Surplus	194.50	259.70	259.70	228.94	210.66	247.37	194.50	244.75	217.09	239.45
Use of Primary Resources											
RPRE	MJ, NCV	231.19	334.04	334.04	285.65	255.49	301.77	231.19	294.56	254.37	280.97
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	3,084.97	4,326.37	4,326.37	3,740.88	3,392.59	3,902.78	3,084.97	3,789.86	3,316.43	3,626.03
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy											
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	83.10	166.19	166.19	139.95	125.77	116.34	110.80	99.72	87.47	83.10
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters											
FW	m^3	2.21	3.94	3.94	3.36	3.04	2.90	2.72	2.55	2.27	2.21
CCE	kg CO_2e	85.86	171.72	171.72	144.61	129.95	120.21	114.48	103.03	90.38	85.86
Indicators Describing Waste											
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m^3	3.91E-08	5.19E-08	5.19E-08	4.59E-08	4.20E-08	5.00E-08	3.91E-08	5.00E-08	4.44E-08	4.88E-08
ILLRW	m^3	1.26E-06	1.75E-06	1.75E-06	1.52E-06	1.36E-06	1.67E-06	1.26E-06	1.67E-06	1.46E-06	1.62E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6 Interpretation

Contribution analysis is an analytical method used to support the interpretation of LCA results and to facilitate the comprehension and the reader's understanding of the environmental profile. Table 15 summarizes the results of a cradle-to-gate percent contribution analysis (for the minimum and maximum product mix design) for each compressive strength class by information module.

Table 15 shows the percent contribution of the raw materials production (A1), transportation (A2) and RMC manufacturing core processes (A3) for the global warming potential (GWP) impact indicator and Non-renewable primary energy consumed as energy (NRPRE) inventory metric. Global warming potential and non-renewable energy were selected as representative indicators as it is generally understood that the primary driver of impacts in the ready-mix concrete product system is the consumption of energy resources in the production of the cement, the transport of high-mass materials to the ready-mix producer, as well as the emissions from cement calcination that is incorporated in the A1 GWP impacts. The contribution analysis confirms our understanding of the concrete impacts.

Table 15: Contribution Analysis by Information Module for GWP and NRPRE

Specified Compressive Strength	Minimum & Maximum	Global Warming Potential (GWP) percent contribution by module			Non-renewable primary energy consumed as energy (NRPRE) percent contribution by module		
		A1	A2	A3	A1	A2	A3
2500 psi 17.2 MPa	Min.	84%	11%	5%	71%	20%	9%
	Max.	89%	8%	3%	76%	17%	7%
3000 psi 20.7 MPa	Min.	85%	11%	4%	72%	19%	8%
	Max.	90%	7%	3%	78%	16%	6%
4000 psi 27.6 MPa	Min.	87%	9%	4%	77%	17%	7%
	Max.	92%	6%	2%	81%	14%	5%
5000 psi 34.5 MPa	Min.	89%	8%	3%	78%	16%	6%
	Max.	93%	5%	2%	83%	13%	4%
6000 psi 41.4 MPa	Min.	89%	8%	3%	79%	16%	6%
	Max.	93%	5%	2%	83%	13%	4%
8000 psi 55.1 MPa	Min.	90%	7%	2%	80%	14%	5%
	Max.	94%	5%	1%	85%	12%	4%
LW-3000 psi 20.7 MPa	Min.	92%	6%	2%	87%	10%	4%
	Max.	94%	5%	2%	88%	9%	3%
LW-4000 psi 27.6 MPa	Min.	93%	5%	2%	87%	9%	3%
	Max.	94%	4%	1%	89%	8%	3%
LW-5000 psi 34.5 MPa	Min.	93%	5%	2%	88%	9%	3%
	Max.	95%	4%	1%	89%	8%	3%

Overall, upstream materials production (A1) accounts for the largest proportion of the GWP (84% to 95%) and non-renewable primary energy consumption (71% to 90%) associated with the production of ready-mixed concrete. Materials transportation (A2) contributes the next highest proportion of GWP (4% to 11%) and NRPRE (8% to 20%) with RMC manufacturing (A3) accounting for the remaining and smallest portion of the overall GWP and energy consumption across all compressive strengths.

As one moves from the minimum to the maximum impact mix design in a compressive strength class, it is evident that upstream materials account for a larger share of the GWP and consumed energy. This is due to the fact that the highest impact mix design is the 100% Portland cement mix design as the manufacture of Portland cement has the highest GWP and energy consumption of any of the material inputs used in the production of ready-mixed concrete.

6.1 Study Limitations

This study does not report all of the environmental impacts due to manufacturing of RMC. During the LCI data collection stage a number of RMC manufacturers reported other emissions (e.g., particulate matter) that are not reflected in the impact indicators or inventory metrics. These reported emissions might impact human and/or ecosystem health. In order to assess the local impacts of product manufacturing on human health, land use and local ecology, additional analysis is required.

This project reports the results of an industry average ‘cradle-to-gate’ LCA of RMC in order to benchmark the manufacture of RMC only. No environmental claim regarding the superiority or equivalence of RMC relative to a competing product that performs the same function is implied. An EPD does not make any statements that the product covered by the EPD is better or worse than any other product. LCIA results are only relative expressions of potentials and do not predict actual impacts, the exceeding of thresholds, safety margins or risks.

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Appendix A: NRMCA National Production Data Summary

Table A1-NRMCA National Production Data Summary		
Number of Plants	489	
% Transit Mix Plants	81%	
% Central Mix Plants	19%	
% Batch Waste	0.20%	
	yd3	m3
Average Production	62,207	47,561
Total Production	30,419,087	23,257,054
Minimum Production	263	201
Maximum Production	412,066	315,047

Table A2-NRMCA National Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	75.1	61.7	33.8	24.5	21.7	6.7	40.0
Rail	mi	45.1	30.5	6.5	30.5	6.0	15.0	2.1
Ocean	mi	249.5	29.5	390.5	6.6	8.5	0.0	29.6
Barge	mi	41.9	0.0	25.9	6.1	0.4	2.7	2.7

Table A3- NRMCA National Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	3.22	4.21
Natural Gas	cuft	11.98	15.66
Secondary Fuels - Liquid (waste solvents, etc.)	lb	0.00	0.00
Secondary Fuels - Solid (tires, etc.)	tn.sh	0.00	0.00
Fuel Oil (other than diesel)	gal	0.01	0.01
Diesel	gal	0.32	0.42
Gasoline	gal	0.00	0.00
LPG (Liquified Propane Gas)	gal	0.01	0.01
Other	gal	0.00	0.00
Process water consumption	gal	23.03	30.12
Hazardous Solid Waste	lbs	0.02	0.03
Non-Hazardous Solid Waste	lbs	6.95	9.09

Appendix B: Mix design specifications and raw material quantitites per 1 cubic yard ready mix concrete

	Comp. Strength	w/cm	FA	SL	Air Ent	Cement	Fly Ash	Slag	Batch Water	Crushed Coarse Agg.	Nat. Coarse Agg.	Crushed Fine Agg.	Nat. Fine Agg.	Air Ent Adm	Wat Red Adm	High Wat Red Adm	Acc Adm
	(psi)		%	%	(Y/N)	(lb)	(lb)	(lb)	(lb)	lbs	lbs	lbs	lbs	(oz)	(oz)	(oz)	(oz)
2500-00-FA/SL	2500	0.61	0%	0%	Y	429	0	0	261	1125	552	164	1244	1	3	0	20
2500-20-FA	2500	0.61	20%	0%	Y	361	90	0	261	1125	552	155	1181	1	3	0	25
2500-30-FA	2500	0.61	30%	0%	Y	325	139	0	261	1125	552	151	1147	1.5	3	0	30
2500-40-FA	2500	0.61	40%	0%	Y	286	191	0	261	1125	552	146	1111	1.5	3	0	40
2500-30-SL	2500	0.61	0%	30%	Y	300	0	129	261	1125	552	163	1236	1	3	0	30
2500-40-SL	2500	0.61	0%	40%	Y	257	0	172	261	1125	552	162	1233	1	3	0	40
2500-50-SL	2500	0.61	0%	50%	Y	215	0	215	261	1125	552	162	1230	1	3	0	45
2500-50-FA/SL	2500	0.61	20%	30%	Y	226	90	135	261	1125	552	154	1172	1	3	0	45
3000-00-FA/SL	3000	0.54	0%	0%	Y	486	0	0	261	1125	552	158	1202	1	3	0	15
3000-20-FA	3000	0.54	20%	0%	Y	409	102	0	261	1125	552	149	1131	1	3	0	20
3000-30-FA	3000	0.54	30%	0%	Y	368	158	0	261	1125	552	144	1092	1.5	3	0	20
3000-40-FA	3000	0.54	40%	0%	Y	324	216	0	261	1125	552	138	1052	1.5	3	0	30
3000-30-SL	3000	0.54	0%	30%	Y	340	0	146	261	1125	552	157	1193	1	3	0	20
3000-40-SL	3000	0.54	0%	40%	Y	292	0	194	261	1125	552	157	1190	1	3	0	30
3000-50-SL	3000	0.54	0%	50%	Y	243	0	243	261	1125	552	156	1187	1	3	0	40
3000-50-FA/SL	3000	0.54	20%	30%	Y	256	102	154	261	1125	552	148	1121	1	3	0	40
4000-00-FA/SL	4000	0.42	0%	0%	Y	616	0	0	261	1125	552	146	1108	1	3	0	10
4000-20-FA	4000	0.42	20%	0%	Y	518	130	0	261	1125	552	134	1017	1	3	0	15
4000-30-FA	4000	0.42	30%	0%	Y	466	200	0	261	1125	552	127	969	1.5	3	0	15
4000-40-FA	4000	0.42	40%	0%	Y	410	274	0	261	1125	552	121	917	1.5	3	0	25
4000-30-SL	4000	0.42	0%	30%	Y	431	0	185	261	1125	552	144	1096	1	3	0	15
4000-40-SL	4000	0.42	0%	40%	Y	369	0	246	261	1125	552	144	1092	1	3	0	25
4000-50-SL	4000	0.42	0%	50%	Y	308	0	308	261	1125	552	143	1089	1	3	0	30

4000-50-FA/SL	4000	0.42	20%	30%	Y	324	130	194	261	1125	552	132	1005	1	3	0	30
5000-00-FA/SL	5000	0.35	0%	0%	Y	768	0	0	270	1032	507	147	1118	1	3	4	0
5000-20-FA	5000	0.35	20%	0%	Y	647	162	0	270	1032	507	132	1005	1	3	4	10
5000-30-FA	5000	0.35	30%	0%	Y	581	249	0	270	1032	507	124	944	1.5	3	4	15
5000-40-FA	5000	0.35	40%	0%	Y	512	341	0	270	1032	507	116	880	1.5	3	4	20
5000-30-SL	5000	0.35	0%	30%	Y	537	0	230	270	1032	507	145	1103	1	3	4	15
5000-40-SL	5000	0.35	0%	40%	Y	461	0	307	270	1032	507	145	1098	1	3	4	20
5000-50-SL	5000	0.35	0%	50%	Y	384	0	384	270	1032	507	144	1094	1	3	4	20
5000-50-FA/SL	5000	0.35	20%	30%	Y	404	162	242	270	1032	507	130	990	1	3	4	20
6000-00-FA/SL	6000	0.36	0%	0%	N	811	0	0	293	1032	507	151	1151	0	3	4	0
6000-20-FA	6000	0.36	20%	0%	N	683	171	0	293	1032	507	136	1032	0	3	4	10
6000-30-FA	6000	0.36	30%	0%	N	614	263	0	293	1032	507	127	967	0	3	4	15
6000-40-FA	6000	0.36	40%	0%	N	541	360	0	293	1032	507	118	899	0	3	4	20
6000-30-SL	6000	0.36	0%	30%	N	568	0	243	293	1032	507	149	1135	0	3	4	15
6000-40-SL	6000	0.36	0%	40%	N	487	0	324	293	1032	507	149	1130	0	3	4	20
6000-50-SL	6000	0.36	0%	50%	N	406	0	406	293	1032	507	148	1125	0	3	4	25
6000-50-FA/SL	6000	0.36	20%	30%	N	427	171	256	293	1032	507	134	1015	0	3	4	25
8000-00-FA/SL	8000	0.31	0%	0%	N	955	0	0	293	1032	507	138	1046	0	3	4	0
8000-20-FA	8000	0.31	20%	0%	N	804	201	0	293	1032	507	119	905	0	3	4	10
8000-30-FA	8000	0.31	30%	0%	N	723	310	0	293	1032	507	109	830	0	3	4	15
8000-40-FA	8000	0.31	40%	0%	N	637	424	0	293	1032	507	99	750	0	3	4	15
8000-30-SL	8000	0.31	0%	30%	N	669	0	287	293	1032	507	135	1028	0	3	4	15
8000-40-SL	8000	0.31	0%	40%	N	573	0	382	293	1032	507	134	1022	0	3	4	15
8000-50-SL	8000	0.31	0%	50%	N	478	0	478	293	1032	507	134	1016	0	3	4	20
8000-50-FA/SL	8000	0.31	20%	30%	N	503	201	302	293	1032	507	117	886	0	3	4	20
LW-3000-00-FA/SL	3000	0.54	0	0%	Y	539	0	0	290	0	0	165	1254	1	3	0	0
LW-3000-20-FA	3000	0.54	0.2	0%	Y	454	114	0	290	0	0	178	1356	1	3	0	0

LW-3000-30-FA	3000	0.54	0.3	0%	Y	408	175	0	290	0	0	186	1411	1.5	3	0	0
LW-3000-40-FA	3000	0.54	0.4	0%	Y	359	240	0	290	0	0	189	1436	1.5	3	0	0
LW-3000-30-SL	3000	0.54	0	30%	Y	377	0	162	290	0	0	173	1313	1	3	0	0
LW-3000-40-SL	3000	0.54	0	40%	Y	324	0	216	290	0	0	172	1310	1	3	0	0
LW-3000-50-SL	3000	0.54	0	50%	Y	270	0	270	290	0	0	172	1307	1	3	0	0
LW-3000-50-FA/SL	3000	0.54	0.2	30%	Y	284	114	170	290	0	0	181	1373	1	3	0	0
LW-4000-00-FA/SL	4000	0.42	0	0%	Y	683	0	0	290	0	0	147	1121	1	3	0	0
LW-4000-20-FA	4000	0.42	0.2	0%	Y	575	144	0	290	0	0	156	1188	1	3	0	0
LW-4000-30-FA	4000	0.42	0.3	0%	Y	517	221	0	290	0	0	164	1246	1.5	3	0	0
LW-4000-40-FA	4000	0.42	0.4	0%	Y	455	303	0	290	0	0	167	1272	1.5	3	0	0
LW-4000-30-SL	4000	0.42	0	30%	Y	478	0	205	290	0	0	149	1136	1	3	0	0
LW-4000-40-SL	4000	0.42	0	40%	Y	410	0	273	290	0	0	149	1132	1	3	0	0
LW-4000-50-SL	4000	0.42	0	50%	Y	341	0	341	290	0	0	152	1156	1	3	0	0
LW-4000-50-FA/SL	4000	0.42	0.2	30%	Y	359	144	216	290	0	0	158	1203	1	3	0	0
LW-5000-00-FA/SL	5000	0.35	0	0%	Y	781	0	0	275	0	0	128	973	1	3	4	0
LW-5000-20-FA	5000	0.35	0.2	0%	Y	657	164	0	275	0	0	140	1068	1	3	4	0
LW-5000-30-FA	5000	0.35	0.3	0%	Y	591	253	0	275	0	0	151	1146	1.5	3	4	0
LW-5000-40-FA	5000	0.35	0.4	0%	Y	520	347	0	275	0	0	155	1178	1.5	3	4	0
LW-5000-30-SL	5000	0.35	0	30%	Y	546	0	234	275	0	0	135	1028	1	3	4	0
LW-5000-40-SL	5000	0.35	0	40%	Y	468	0	312	275	0	0	135	1023	1	3	4	0
LW-5000-50-SL	5000	0.35	0	50%	Y	390	0	390	275	0	0	139	1060	1	3	4	0
LW-5000-50-FA/SL	5000	0.35	0.2	30%	Y	411	164	246	275	0	0	146	1108	1	3	4	0

* All aggregate used in lightweight mixes was modeled as manufactured lightweight aggregate.

Appendix C:

Modeled A1 Indicator Results for Portand Cement and Slag Cement (per tonne)

			Portland Cement		Slag Cement	
	Indicator	Unit	Result	Notes	Result	Notes
Global warming potential	GWP	kg CO2e	1040.00	EPD	146.60	EPD
Depletion potential of the stratospheric ozone layer	ODP	kg CFC11e	2.61E-05	EPD	1.69E-05	EPD
Acidification potential of soil and water sources	AP	kg SO2e	2.45	EPD	2.10	EPD
Eutrophication potential	EP	kg PO4e	1.22	EPD	0.27	EPD
Formation potential of tropospheric ozone	SFP	kg O3e	48.80	EPD	26.50	EPD
Abiotic depletion potential (ADPfossil) for fossil resources;	ADPf	MJ, NCV	5250.00	Estimated as NRPE-F	1820.19	Calculated from LCI model
Abiotic depletion potential (ADPelements) ;	ADPe	kg Sb	7.21E-04	Estimated based on CAC Cement LCA	3.84E-05	Calculated from LCI model
Fossil fuel depletion	FFD	MJ Surplus	269.85	Estimated based on weighted average FFD factor (relative to NRPE-F Factors) of 0.0514 per ratios of fossil fuels in A1-A3 reported in Quantis background report	216.69	Calculated from LCI model
Renewable primary energy carrier used as energy	RPRE	MJ, NCV	292.00	Estimated by combining NPRE-O and RPRE-B in EPD	88.79	Calculated from LCI model
Non-renewable primary energy carrier used as energy	NRPRE	MJ, NCV	5595.00	Estimated by combining NRPRE-F and NRPRE-N in EPD	2562.46	Calculated from LCI model
Consumption of freshwater resources;	FW	m3	9.70	EPD	0.03	EPD
Non-hazardous waste disposed	NHW	kg	0.00	Only accounted in A3 Foreground per ACLCA Guidance	0.00	Only accounted in A3 Foreground per ACLCA Guidance
Hazardous waste disposed	HW	kg	0.00	Only accounted in A3 Foreground per ACLCA Guidance	0.00	Only accounted in A3 Foreground per ACLCA Guidance
High-level radioactive waste	HLRW	m3	Not able to estimate		0.00	Calculated from LCI model
Intermediate- and low-level radioactive waste	ILLRW	m3	Not able to estimate		0.00	Calculated from LCI model
Calcination carbon emissions	CCE	kg CO2e	484.05	Per Quantis background report	0.00	Calculated from LCI model
Non-renewable secondary fuel	NRSF	MJ	468.46	Per Quantis background report	0.00	Calculated from LCI model

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Appendix D: NRMCA Member National and Regional LCA Benchmark (Industry Average) Report – Version 3

Summary: Appendix D is intented for use by NRMCA members, who participated in the IW-EPD, that have developed product specific third-party verified LCAs and/or EPDs to compare the environmental impacts of their products with industry average impacts.

November 2019

Updated February 20, 2020

The users of this benchmark report can use this appendix, along with their own product-specific EPDs to demonstrate compliance with the following:

LEED v4 and 4.1(beta) MR Credit Building Product Disclosure and Optimization
A company with product-specific EPDs can demonstrate impact reductions below industry average in LEED v4. The following is an excerpt from LEEDv4 MR Credit Building Product Disclosure and Optimization – Environmental Product Declarations – Option 2 Multi-Attribute Optimization (1 point).

> "*Third party certified products that demonstrate impact reduction below industry average in at least three of the following categories are valued at 100% of their cost for credit achievement calculations.*
>
> - *global warming potential (greenhouse gases), in CO2e;*
> - *depletion of the stratospheric ozone layer, in kg CFC-11;*
> - *acidification of land and water sources, in kg SO2;*
> - *eutrophication, in kg nitrogen or kg phosphate;*
> - *formation of tropospheric ozone, in kg O_3; and*
> - *depletion of nonrenewable energy resources, in MJ.* "

Architecture 2030 Challenge for Products
A company with product-specific EPDs can use the document to demonstrate progress toward meeting the Architecute 2030 Challenge for Products which asks architects to specify products with carbon footprint 35% below industry average in 2015 and increasing to 50% below industry average by 2030.

International Green Construction Code (IgCC)
A company with product-specific EPDs can meet the new Material Selection and Properties section of the 2015 International Green Construction Code. As one option under 505.3 Multi-attribute material declaration and certification, not less than 55 percent of the total building materials used in the project, based on mass, volume or cost, shall have an EPD comply with the provisions of ISO 14025 and ISO 21930 and be externally verified.

Green Globes For New Construction
Companies use the Industry average EPD or product specific EPDs to meet the EPD requirement in Green Globes. The following is an exerpt from Section 3.5 Materials and Resources, 3.5.1.2 Path B: Prescriptive Path for Building Core and Shell (up to 20 points).

> *Based upon the appropriate application and specification of comparable materials and products, what percentage of the products selected for the building core and shell (based upon cost) have:*
>
> *Environmental Product Declarations (EPDs) that utilize recognized Product Category Rules, conform to ISO standards, and minimally includes cradle-to-gate scope:*
>
> - *Industry Wide (Generic) EPD: Products specified for the building core and shell shall include Type III Environmental Product Declaration (EPD)?*

and/or

- *Product Specific EPD: Products specified for the building core and shell shall include Type III Environmental Product Declaration (EPD) , where the EPDs are specific to particular products from identified manufacturers*

Designing Low Impact Concrete Mixtures

Finally, a company can use the document to help it design products that have lower environmental impacts than industry and regonal average by comparing the environmental impacts of its mix designs with those of the industry average.

Companies claiming compliance with LEED v4 and Architecture 2030 Challenge for Products and other standards should reference this document.

How this benchmark document is structured

This document presents the key life cycle impact assessment indicators for both the U.S. national and eight NRMCA regions for nine benchmark ready mixed concrete products, which vary by compressive strength and cementitious material content. The benchmark concrete products also include three lightweight mix designs in each region. Each NRMCA region is represented in a separate section and the results are presented so companies with third-party verified LCAs and/or EPDs can benchmark their products against the regional benchmarks. For each region (see Figure 1 for a definition of each NRMCA region) a production summary is provided indicating the number and type of plants the benchmark is based on and the average, minimum and maximum production per plant (Table A).

The regional report then presents the six normal weight benchmark ready mixed concrete products by compressive strength (2,500 psi, 3,000 psi, 4,000 psi, 5,000 psi, 6,000 psi, and 8,000 psi) as well as three lightweight compressive strengths (3,000 psi lightweight, 4,000 psi lightweight, and 5,000 psi lightweight). The mixture proportions of each concrete product is also shown for reference purposes and these vary by region (Table B). For more on how these benchmark mix designs were determined, see the mix design methodology section below.

The report then shows the weighted average transportation mode and distance for high mass materials (Table C). While truck transportation is the dominant mode a number of raw materials and intermediate product inputs arrive via more than one mode.

Next, the report lists the weighted average plant (gate-to-gate) energy and water use as well as solid wastes produced per cubic yard and cubic meter of ready mixed concrete for each region (Table D). These values reflect the weighted average product by region – i.e., the batch water and hence total water consumption will vary by mix design, but the results displayed here only reflect the weighted average mix design. These plant/facility level data are a good reference point for NRMCA members wishing to compare their individual products manufactured at their facilities with the regional benchmarks.

Next, the LCA results for the nine benchmark concrete products are presented on a cubic yard basis (Table E).

Benchmark mix design methodology

The ACI 211 compressive strength to water to cementitious materials ratio (w/cm) relationship is assumed to apply across all regions. To calculate the cementitious materials (CM) content for each region, an average strength is calculated for a region based on the regional w/cm and average material quantities reported in the respective regional plant surveys. To estimate mixture proportions above and below the regional average strength level the change in strength is assumed to follow the typical strength to w/cm ratio relationship defined in ACI 211. The following are some broad assumptions:

- The regional Supplementary Cementitious Materials (SCM) to total CM ratio is maintained across all compressive strengths.
- The ratio of fine to coarse aggregate is maintained across all compressive strengths for normal weight concrete. The ratio of fine to coarse aggregate for lightweight concrete is adjusted to maintain a target unit weight for concrete.
- Water demand for higher strength concretes (above 5000 psi) will increase because of increased paste content and the use of smaller coarse aggregate size.
- Water reducing admixtures (and high range water reducing admixtures) are assumed to be used as the strength level is increased to impact a change in the mixing water content and is reflected in an assumed change in water content across different compressive strengths.
- It is assumed that the volume of concrete remains constant regardless of material quantities so the specific gravities of coarse and fine aggregate are adjusted for each region to maintain this volume.
- As the paste content changes, some change in the total aggregate content is assumed – decreased as paste volume is increased for higher strength. The percent change in aggregate content is adjusted up or down to maintain volume.

Calculation steps

1. Identify the average material quantities used for each region from the plant survey.
2. Determine the average total batching water for the region by taking the average batch water reported and adding moisture content of 1% for coarse aggregate and 5% for fine aggregate.
3. Determine the total aggregate content for a region by totalling the average coarse aggregate, fine aggregate and other aggregate for the region.
4. Calculate the Saturated Surface Dry (SSD) coarse aggregate content by taking the average coarse aggregate content and dividing by 101%.
5. Calculate the SSD fine aggregate content by taking the average fine aggregate content and dividing by 105%.
6. Calculate the average w/cm for the region by taking the average total batching water and dividing by the total CM (cement + fly ash + slag).

7. Calculate the average compressive strength for each region based on average material quantities and average w/cm using ACI 211 w/cm curves.
8. Adjust the specific gravity of coarse and fine aggregate to maintain volume for the average mix.
9. For each specified compressive strength class (2500, 3000, 4000, 5000, 6000 and 8000 psi) identify the w/cm from ACI 211. Use air entrainment for mixes 5000 psi and less, use no air entrainment for mixes above 5000 psi.
10. Adjust mixing water up by the same percentage as was used in the Industry-Wide EPD based on strength level. Calculate the CM content by dividing the water content by the w/cm.
11. Calculate the average fly ash percentage by taking the average fly ash use and dividing by the total CM use.
12. Calculate the average slag percentage by taking the average slag use and dividing by the total CM use.
13. Adjust aggregate content up or down by a certain percentage to adjust volume up or down to maintain volume.
14. Calculate the adjusted coarse and fine aggregate based on the ratio of average coarse and fine aggregate average from the region.
15. Adjust the fine to coarse aggregate ratio to maintain a target unit weight of 118 lb/ft3 (1890 kg/m3) for lightweight concrete mixes.
16. Assume the same admixture content as was used in the original mix designs for the Industry-Wide EPD.

The following section presents the U.S. national and regional LCA benchmarks results. NRMCA regions are defined in Figure F1.

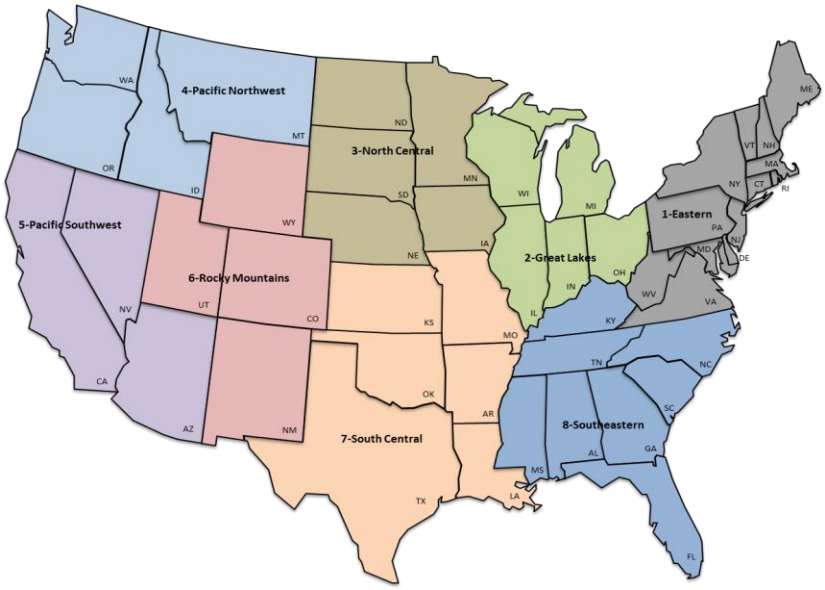

Figure D1-NRMCA Regions

The regional results are presented in ascending order as follows:

1. National NRMCA average
2. Eastern Region
3. Great Lakes Midwest Region
4. North Central Region
5. Pacific Northwest Region
6. Pacific Southwest Region
7. Rocky Mountains Region
8. South Central Region
9. South Eastern Region

D-1 : NRMCA U.S. National

Table A1-NRMCA U.S. National Production Data Summary		
Number of Plants	489	
% Transit Mix Plants	81%	
% Central Mix Plants	19%	
% Batch Waste	0.20%	
	yd3	m3
Average Production	62,207	47,561
Total Production	30,419,087	23,257,054
Minimum Production	263	201
Maximum Production	412,066	315,047

Table B1-NRMCA U.S. National Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	354	394	475	576	610	719	394	475	556
Fly Ash	lbs	62	69	83	101	107	126	69	83	97
Slag Cement	lbs	17	19	23	28	30	35	19	23	27
Mixing Water	lbs	305	305	305	315	341	341	308	308	308
Crushed Coarse Aggregate	lbs	1,126	1,115	1,083	1,029	1,061	1,018	0	0	0
Natural Coarse Aggregate	lbs	553	547	531	505	521	499	0	0	0
Crushed Fine Aggregate	lbs	169	167	162	154	159	152	161	149	136
Natural Fine Aggregate	lbs	1,282	1,270	1,233	1,171	1,208	1,159	1,225	1,130	1,035
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	980	990	1,000
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,867	3,886	3,895	3,878	4,037	4,049	2,178	2,168	2,159

Table C1-NRMCA U.S. National Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	75.1	61.7	33.8	24.5	21.7	6.7	40.0
Rail	mi	45.1	30.5	6.5	30.5	6.0	15.0	2.1
Ocean	mi	249.5	29.5	390.5	6.6	8.5	0.0	29.6
Barge	mi	41.9	0.0	25.9	6.1	0.4	2.7	2.7

Table D1-NRMCA U.S. National Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	3.22	4.21
Natural Gas	cuft	11.98	15.66
Fuel Oil (other than diesel)	gal	0.01	0.01
Diesel	gal	0.32	0.42
Gasoline	gal	0.00	0.00
LPG (Liquified Propane Gas)	gal	0.01	0.01
Water Consumption (excluding batch water)	gal	23.03	30.12
Hazardous Solid Waste	lbs	0.02	0.03
Non-Hazardous Solid Waste	lbs	6.95	9.09

Table E1- NRMCA U.S. National LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	203.24	222.44	261.83	310.59	328.03	380.56	397.94	438.78	479.93
ODP	kg CFC11e	5.63E-06	6.11E-06	7.07E-06	8.26E-06	8.71E-06	1.00E-05	1.46E-05	1.57E-05	1.67E-05
AP	kg SO2e	0.72	0.77	0.88	1.01	1.07	1.21	1.98	2.10	2.21
EP	kg Ne	0.28	0.30	0.35	0.40	0.43	0.49	0.71	0.76	0.81
SFP	kg O3e	15.46	16.56	18.77	21.44	22.58	25.52	26.53	28.80	31.07
ADPf	MJ, NCV	1,241.81	1,342.56	1,548.62	1,804.84	1,902.93	2,178.87	2,895.87	3,116.47	3,341.73
ADPe	kg Sbe	2.00E-04	2.13E-04	2.37E-04	2.66E-04	2.80E-04	3.13E-04	2.61E-04	2.86E-04	3.12E-04
FFD	MJ Surplus	106.27	112.05	123.82	138.65	145.07	160.97	203.36	215.98	229.30
Use of Primary Resources										
RPRE	MJ, NCV	58.70	63.92	74.63	88.03	92.84	107.17	274.92	287.82	300.96
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,443.65	1,551.32	1,771.32	2,044.67	2,150.27	2,444.86	3,248.27	3,484.49	3,725.75
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	75.35	83.79	101.15	122.62	129.91	153.03	83.94	101.13	118.32
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	2.00	2.18	2.54	2.98	3.15	3.63	2.39	2.75	3.11
CCE	kg CO2e	77.86	86.58	104.51	126.70	134.23	158.12	86.73	104.49	122.26
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	1.79E-08	1.77E-08	1.74E-08	1.68E-08	1.71E-08	1.67E-08	5.10E-08	5.12E-08	5.13E-08
LLRW	m3	2.43E-07	2.41E-07	2.35E-07	2.26E-07	2.32E-07	2.24E-07	1.70E-06	1.71E-06	1.72E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

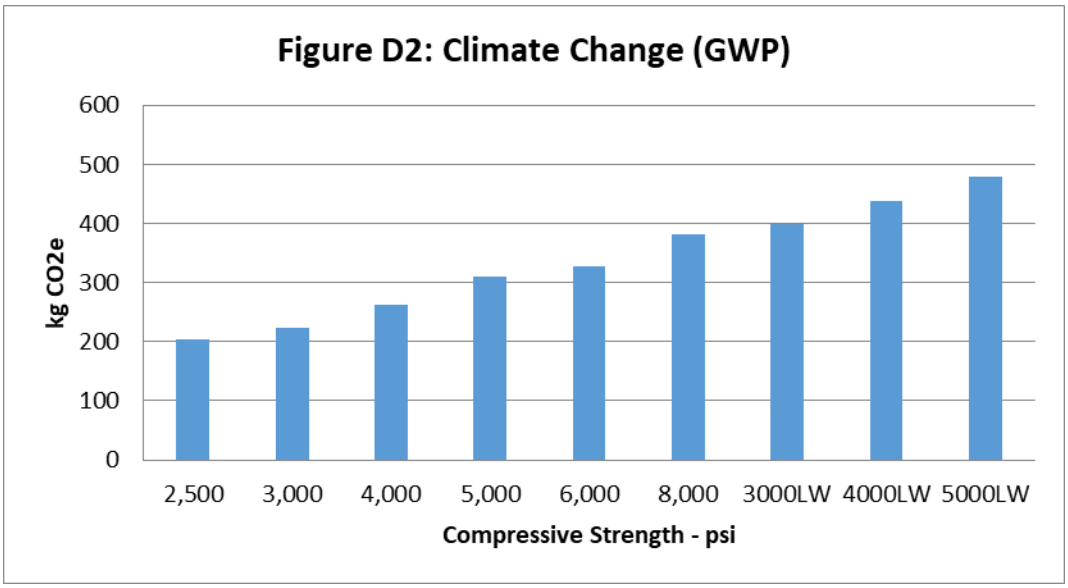
Figure D2: Climate Change (GWP)
600
500
400
300
200
100
0
kg CO2e
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

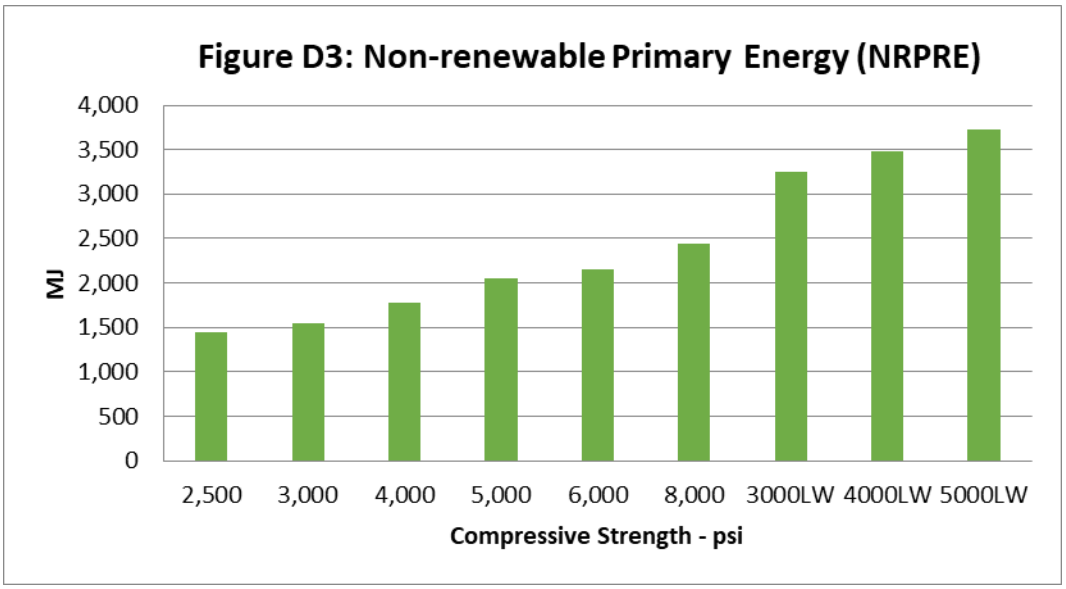
Figure D3: Non-renewable Primary Energy (NRPRE)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
MJ
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-2: Eastern Region

Table A2-Eastern Production Data Summary		
Number of Plants	65	
% Transit Mix Plants	63%	
% Central Mix Plants	37%	
% Batch Waste	0.25%	
	yd3	m3
Average Production	59,453	45,455
Total Production	3,864,451	2,954,584
Minimum Production	1,734	1,326
Maximum Production	307,863	235,378

Table B2-Eastern Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	345	387	475	585	620	746	393	481	572
Fly Ash	lbs	35	39	47	59	62	75	41	51	60
Slag Cement	lbs	60	67	82	101	107	129	60	73	87
Mixing Water	lbs	289	289	289	299	324	324	292	292	292
Crushed Coarse Aggregate	lbs	1,391	1,364	1,324	1,258	1,298	1,232	0	0	0
Natural Coarse Aggregate	lbs	325	319	310	294	304	288	0	0	0
Crushed Fine Aggregate	lbs	186	182	177	168	173	165	182	164	149
Natural Fine Aggregate	lbs	1,227	1,203	1,168	1,110	1,145	1,086	1,201	1,086	982
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	990	1,010	1,020
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,857	3,850	3,873	3,874	4,034	4,044	2,169	2,147	2,142

Table C2-Eastern Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	106.3	100.5	116.8	16.2	23.9	33.8	40.7
Rail	mi	39.1	7.9	0.3	14.3	0.0	5.4	11.3
Ocean	mi	62.4	0.0	0.0	16.2	0.0	0.0	0.0
Barge	mi	22.3	0.0	51.0	1.9	0.9	0.2	8.8

Table D2-Eastern Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	4.90	6.41
Natural Gas	cuft	10.36	13.55
Secondary Fuels - Liquid (waste solvents, etc.)	lb	0.01	0.01
Fuel Oil (other than diesel)	gal	0.03	0.04
Diesel	gal	0.29	0.37
LPG (Liquified Propane Gas)	gal	0.01	0.01
Water Consumption (excluding batch water)	gal	26.25	34.33
Hazardous Solid Waste	lbs	0.01	0.01
Non-Hazardous Solid Waste	lbs	9.03	11.81

Table E2-Eastern LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	202.80	223.22	266.65	321.35	339.48	401.40	416.94	464.19	511.26
ODP	kg CFC11e	6.18E-06	6.71E-06	7.83E-06	9.23E-06	9.73E-06	1.13E-05	1.52E-05	1.65E-05	1.78E-05
AP	kg SO2e	0.74	0.80	0.93	1.08	1.14	1.32	2.19	2.34	2.48
EP	kg Ne	0.29	0.31	0.36	0.42	0.45	0.52	0.73	0.79	0.85
SFP	kg O3e	15.20	16.37	18.90	22.02	23.20	26.77	30.87	33.59	36.26
ADPf	MJ, NCV	1,265.08	1,373.38	1,607.93	1,904.99	2,009.56	2,345.75	3,156.93	3,426.55	3,690.83
ADPe	kg Sbe	2.09E-04	2.21E-04	2.47E-04	2.80E-04	2.94E-04	3.31E-04	2.63E-04	2.93E-04	3.22E-04
FFD	MJ Surplus	110.37	116.71	130.94	149.24	156.35	176.98	239.57	256.09	272.57
Use of Primary Resources										
RPRE	MJ, NCV	58.39	63.99	75.99	91.25	96.29	113.47	278.27	294.74	309.66
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,515.88	1,632.50	1,885.47	2,205.42	2,319.70	2,681.97	3,558.28	3,849.41	4,134.54
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	73.57	82.45	101.17	124.70	132.14	158.80	83.65	102.41	121.78
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	1.99	2.17	2.55	3.04	3.21	3.76	2.40	2.79	3.19
CCE	kg CO2e	76.02	85.20	104.54	128.85	136.53	164.09	86.43	105.81	125.84
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	5.16E-08	5.09E-08	5.00E-08	4.85E-08	4.94E-08	4.78E-08	7.01E-08	7.02E-08	6.98E-08
LLRW	m3	3.93E-07	3.87E-07	3.79E-07	3.66E-07	3.74E-07	3.60E-07	1.80E-06	1.82E-06	1.83E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

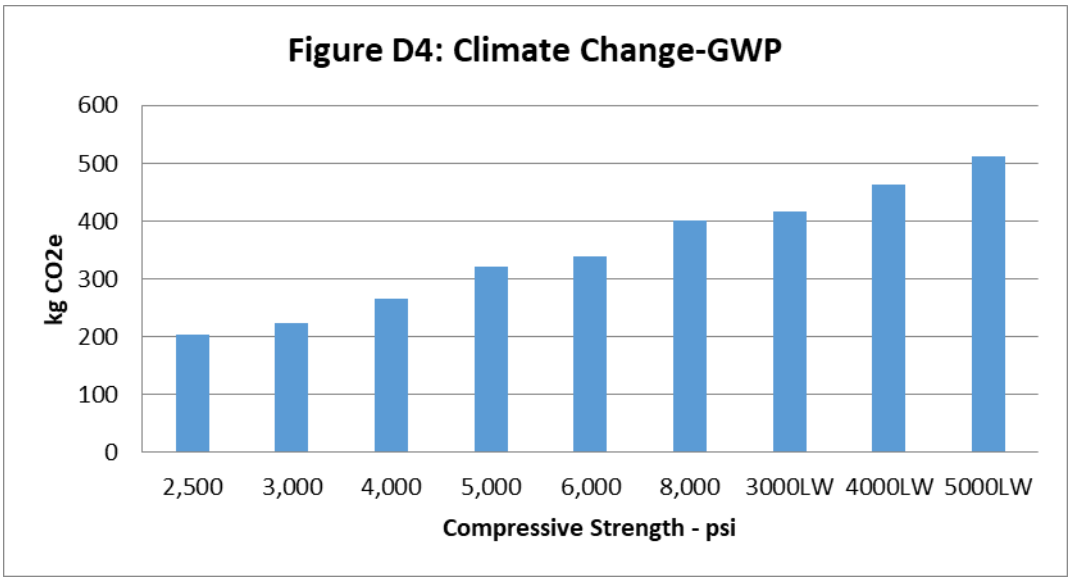
Figure D4: Climate Change-GWP
600
500
400
300
200
100
0
kg CO2e
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

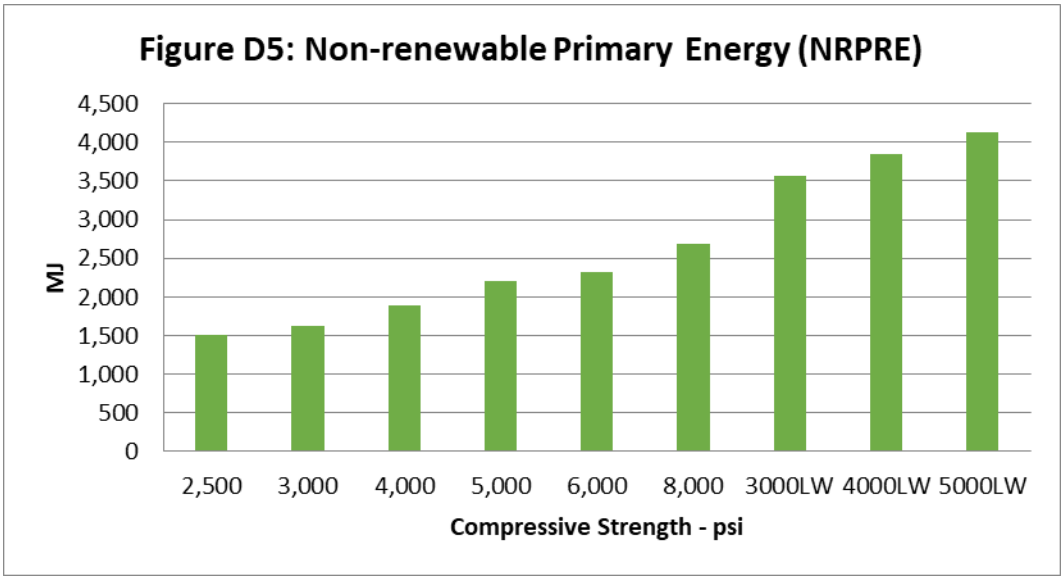
Figure D5: Non-renewable Primary Energy (NRPRE)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
MJ
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-3: Great Lakes Midwest Region

Table A3-Great Lakes Midwest Production Data Summary		
Number of Plants	69	
% Transit Mix Plants	66%	
% Central Mix Plants	34%	
% Batch Waste	0.08%	
	yd3	m3
Average Production	73,876	56,482
Total Production	5,097,459	3,897,286
Minimum Production	1,263	966
Maximum Production	412,066	315,047

Table B3-Great Lakes Midwest Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	341	382	468	576	611	733	383	468	556
Fly Ash	lbs	39	44	54	67	71	85	44	54	64
Slag Cement	lbs	24	27	33	41	44	52	27	33	40
Mixing Water	lbs	267	267	267	276	300	300	271	271	271
Crushed Coarse Aggregate	lbs	1,517	1,489	1,445	1,387	1,431	1,373	0	0	0
Natural Coarse Aggregate	lbs	245	240	233	224	231	221	0	0	0
Crushed Fine Aggregate	lbs	14	14	14	13	14	13	14	12	11
Natural Fine Aggregate	lbs	1,460	1,432	1,390	1,335	1,376	1,321	1,371	1,248	1,138
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	1,050	1,070	1,080
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,908	3,895	3,905	3,919	4,076	4,098	2,110	2,087	2,080

Table C3-Great Lakes Midwest Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	42.9	66.3	44.2	25.1	18.5	1.3	29.6
Rail	mi	27.5	0.0	24.3	5.2	0.0	0.7	0.0
Ocean	mi	23.7	0.0	54.5	0.0	0.0	0.0	0.0
Barge	mi	167.4	0.0	116.6	22.6	0.4	0.0	8.5

Table D3-Great Lakes Midwest Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	3.12	4.08
Natural Gas	cuft	38.76	50.70
Fuel Oil (other than diesel)	gal	0.00	0.01
Diesel	gal	0.26	0.33
Gasoline	gal	0.00	0.01
LPG (Liquified Propane Gas)	gal	0.01	0.01
Water Consumption (excluding batch water)	gal	15.45	20.21
Non-Hazardous Solid Waste	lbs	0.84	1.10

Table E3-Great Lakes Midwest LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	197.04	216.41	257.59	309.58	326.96	385.62	402.59	447.19	491.54
ODP	kg CFC11e	5.61E-06	6.09E-06	7.13E-06	8.43E-06	8.89E-06	1.04E-05	1.51E-05	1.64E-05	1.75E-05
AP	kg SO2e	0.69	0.74	0.84	0.98	1.03	1.18	2.01	2.14	2.27
EP	kg Ne	0.30	0.32	0.37	0.43	0.45	0.51	0.73	0.79	0.84
SFP	kg O3e	13.79	14.81	16.99	19.73	20.78	23.90	25.32	27.69	30.03
ADPf	MJ, NCV	1,185.19	1,282.67	1,494.10	1,764.25	1,860.36	2,164.85	2,929.35	3,174.37	3,414.40
ADPe	kg Sbe	2.05E-04	2.17E-04	2.42E-04	2.75E-04	2.89E-04	3.25E-04	2.59E-04	2.88E-04	3.16E-04
FFD	MJ Surplus	100.82	105.90	117.42	132.60	138.60	155.60	203.16	216.89	230.73
Use of Primary Resources										
RPRE	MJ, NCV	52.73	58.08	69.53	84.14	88.92	105.31	286.02	301.89	316.15
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,422.57	1,526.59	1,752.58	2,041.30	2,145.44	2,470.95	3,314.86	3,578.14	3,835.71
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	72.50	81.21	99.54	122.56	129.89	155.89	81.43	99.57	118.27
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	1.88	2.06	2.44	2.92	3.08	3.62	2.28	2.66	3.05
CCE	kg CO2e	74.91	83.91	102.85	126.64	134.21	161.08	84.14	102.89	122.21
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	2.51E-08	2.48E-08	2.43E-08	2.36E-08	2.41E-08	2.34E-08	5.57E-08	5.62E-08	5.63E-08
LLRW	m3	3.28E-07	3.23E-07	3.15E-07	3.05E-07	3.13E-07	3.02E-07	1.83E-06	1.85E-06	1.86E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

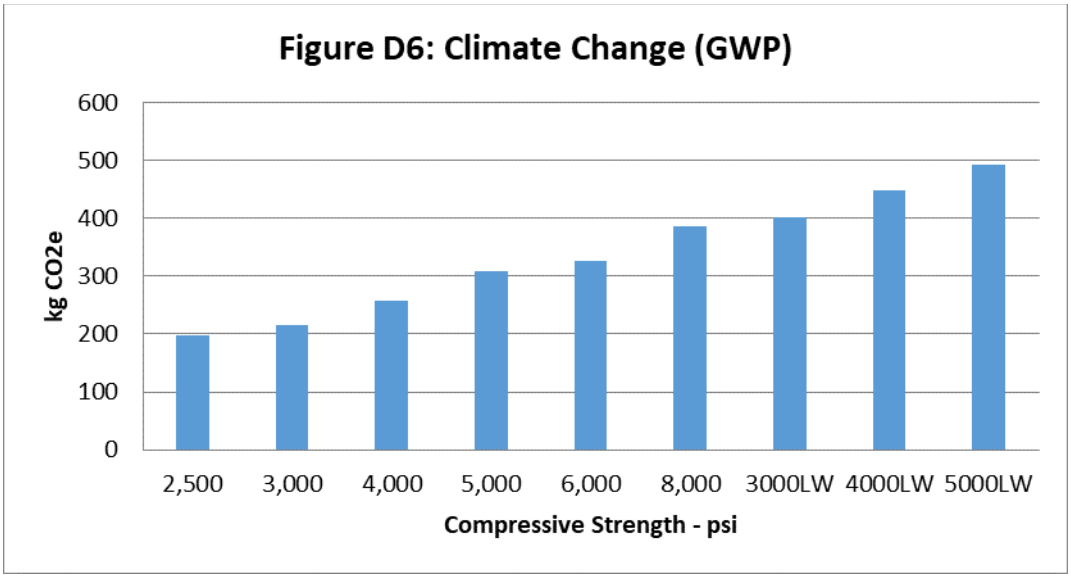
Figure D6: Climate Change (GWP)
600
500
400
300
200
100
0
kg CO2e
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

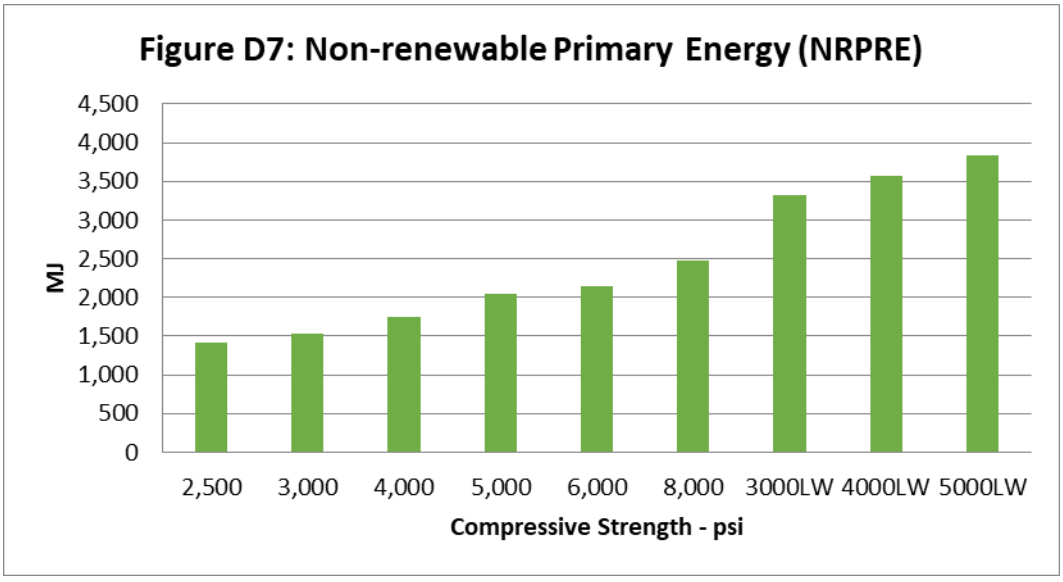
Figure D7: Non-renewable Primary Energy (NRPRE)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
MJ
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-4: North Central Region

Table A4-North Central Production Data Summary		
Number of Plants	28	
% Transit Mix Plants	61%	
% Central Mix Plants	39%	
% Batch Waste	0.07%	
	yd3	m3
Average Production	46,057	35,213
Total Production	1,289,592	985,964
Minimum Production	2,834	2,167
Maximum Production	172,000	131,503

Table B4-North Central Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	352	392	476	579	615	728	393	476	559
Fly Ash	lbs	65	73	88	107	114	135	73	88	103
Slag Cement	lbs	4	4	5	7	7	8	4	5	6
Mixing Water	lbs	291	291	291	301	327	327	294	294	294
Crushed Coarse Aggregate	lbs	784	769	747	709	739	709	0	0	0
Natural Coarse Aggregate	lbs	932	914	888	843	879	843	0	0	0
Crushed Fine Aggregate	lbs	222	218	212	201	210	201	219	203	183
Natural Fine Aggregate	lbs	1,211	1,188	1,154	1,096	1,142	1,096	1,195	1,105	1,000
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	980	990	1,010
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,862	3,850	3,860	3,843	4,032	4,047	2,179	2,172	2,147

Table C4-North Central Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	204.8	132.3	118.3	44.6	17.2	2.7	16.2
Rail	mi	82.0	186.3	0.0	0.0	2.1	0.0	2.1
Ocean	mi	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barge	mi	188.9	0.0	0.0	0.0	0.0	0.0	0.0

Table D4-North Central Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	2.69	3.52
Natural Gas	cuft	17.47	22.85
Diesel	gal	0.12	0.15
Water Consumption (excluding batch water)	gal	18.76	24.54
Non-Hazardous Solid Waste	lbs	2.42	3.17

Table E4-North Central LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	201.49	221.31	262.71	314.22	332.90	389.28	392.31	435.37	480.88
ODP	kg CFC11e	5.18E-06	5.64E-06	6.61E-06	7.81E-06	8.27E-06	9.59E-06	1.43E-05	1.54E-05	1.65E-05
AP	kg SO2e	0.72	0.78	0.90	1.05	1.11	1.28	1.94	2.08	2.23
EP	kg Ne	0.30	0.32	0.37	0.42	0.45	0.51	0.72	0.77	0.82
SFP	kg O3e	15.22	16.49	19.14	22.39	23.70	27.31	25.83	28.60	31.49
ADPf	MJ, NCV	1,255.73	1,362.99	1,590.59	1,875.78	1,985.36	2,298.25	2,847.51	3,093.28	3,361.53
ADPe	kg Sbe	1.90E-04	2.02E-04	2.27E-04	2.57E-04	2.72E-04	3.06E-04	2.62E-04	2.88E-04	3.15E-04
FFD	MJ Surplus	101.84	108.59	123.30	142.06	149.73	170.29	191.10	207.22	225.11
Use of Primary Resources										
RPRE	MJ, NCV	60.63	65.69	76.39	89.82	94.91	109.58	275.56	288.48	303.89
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,416.71	1,530.77	1,772.95	2,076.29	2,193.70	2,526.63	3,160.55	3,422.69	3,709.38
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	74.90	83.45	101.16	123.14	130.73	154.77	83.64	101.19	118.88
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	1.96	2.14	2.50	2.96	3.13	3.63	2.35	2.72	3.09
CCE	kg CO2e	77.39	86.22	104.52	127.24	135.08	159.92	86.43	104.55	122.84
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	1.14E-08	1.12E-08	1.10E-08	1.06E-08	1.09E-08	1.06E-08	4.81E-08	4.83E-08	4.89E-08
LLRW	m3	1.96E-07	1.93E-07	1.88E-07	1.81E-07	1.87E-07	1.81E-07	1.67E-06	1.69E-06	1.71E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

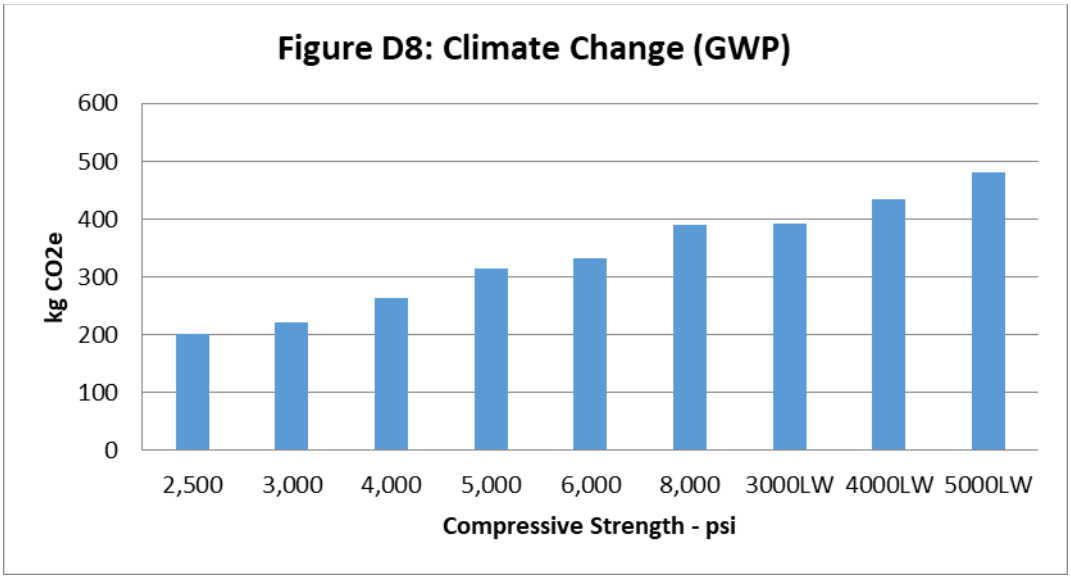
Figure D8: Climate Change (GWP)
600
500
400
300
200
100
0
kg CO2e
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

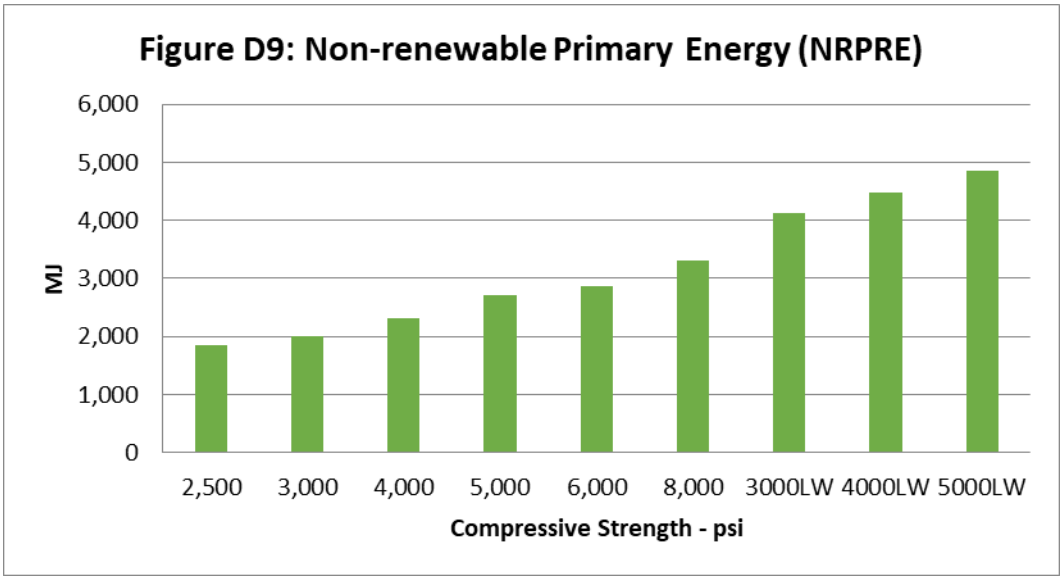
Figure D9: Non-renewable Primary Energy (NRPRE)
6,000
5,000
4,000
3,000
2,000
1,000
0
MJ
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-5: Pacific Northwest Region

Table A5-Pacific Northwest Production Data Summary		
Number of Plants	32	
% Transit Mix Plants	60%	
% Central Mix Plants	40%	
% Batch Waste	0.78%	
	yd3	m3
Average Production	61,404	46,947
Total Production	1,964,932	1,502,298
Minimum Production	1,652	1,263
Maximum Production	136,600	104,438

Table B5-Pacific Northwest Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	362	406	500	619	655	791	407	500	597
Fly Ash	lbs	93	105	129	159	169	204	105	129	154
Slag Cement	lbs	11	13	16	19	21	25	13	16	19
Mixing Water	lbs	302	302	302	313	339	339	306	306	306
Crushed Coarse Aggregate	lbs	135	133	129	121	125	117	0	0	0
Natural Coarse Aggregate	lbs	1,695	1,663	1,614	1,518	1,566	1,469	0	0	0
Crushed Fine Aggregate	lbs	79	78	75	71	73	69	71	63	56
Natural Fine Aggregate	lbs	1,340	1,315	1,277	1,200	1,238	1,162	1,200	1,072	956
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	1,060	1,070	1,070
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	4,018	4,014	4,042	4,019	4,186	4,176	2,101	2,085	2,088

Table C5-Pacific Northwest Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	37.8	75.4	11.5	9.0	10.4	1.9	10.5
Rail	mi	123.6	46.1	0.0	1.3	3.5	13.7	3.5
Ocean	mi	1,308.4	0.0	1,680.4	0.0	2.1	0.1	2.1
Barge	mi	11.6	0.0	0.0	0.0	0.0	11.1	0.4

Table D5-Pacific Northwest Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	3.61	4.72
Natural Gas	cuft	10.87	14.22
Diesel	gal	0.27	0.35
LPG (Liquified Propane Gas)	gal	0.04	0.05
Water Consumption (excluding batch water)	gal	22.38	29.27
Hazardous Solid Waste	lbs	0.36	0.47
Non-Hazardous Solid Waste	lbs	29.73	38.89

Table E5-Pacific Northwest LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	200.12	222.32	269.49	329.12	347.85	415.86	418.57	467.06	515.91
ODP	kg CFC11e	5.46E-06	5.98E-06	7.11E-06	8.51E-06	8.98E-06	1.06E-05	1.55E-05	1.67E-05	1.79E-05
AP	kg SO2e	0.71	0.78	0.93	1.12	1.19	1.41	2.12	2.29	2.44
EP	kg Ne	0.26	0.29	0.34	0.41	0.43	0.51	0.75	0.81	0.86
SFP	kg O3e	15.81	17.41	20.84	25.13	26.54	31.46	28.90	32.39	35.91
ADPf	MJ, NCV	1,163.24	1,284.29	1,542.44	1,870.21	1,975.31	2,346.32	3,040.57	3,311.77	3,581.54
ADPe	kg Sbe	1.70E-04	1.83E-04	2.13E-04	2.50E-04	2.63E-04	3.05E-04	2.71E-04	3.01E-04	3.31E-04
FFD	MJ Surplus	94.23	101.90	118.34	139.45	146.43	169.93	208.59	225.76	243.28
Use of Primary Resources										
RPRE	MJ, NCV	64.55	70.35	82.76	98.46	103.62	121.40	300.55	314.95	327.90
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,331.69	1,460.86	1,736.43	2,086.23	2,198.71	2,594.65	3,390.53	3,680.51	3,968.48
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	77.48	86.97	107.10	132.50	140.32	169.41	87.15	107.09	127.83
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	2.03	2.23	2.64	3.17	3.35	3.95	2.48	2.89	3.32
CCE	kg CO2e	80.06	89.87	110.66	136.91	144.99	175.05	90.05	110.65	132.09
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	6.29E-09	6.22E-09	6.12E-09	5.92E-09	6.03E-09	5.82E-09	4.99E-08	5.02E-08	5.00E-08
LLRW	m3	1.58E-07	1.56E-07	1.52E-07	1.45E-07	1.49E-07	1.42E-07	1.80E-06	1.81E-06	1.81E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

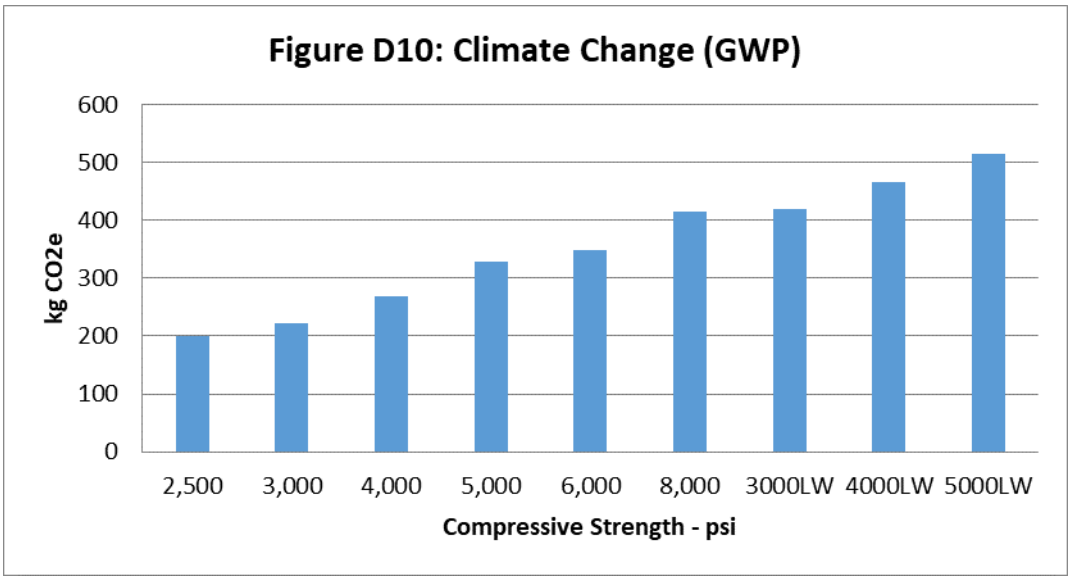
Figure D10: Climate Change (GWP)
600
500
400
300
200
100
0
kg CO2e
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

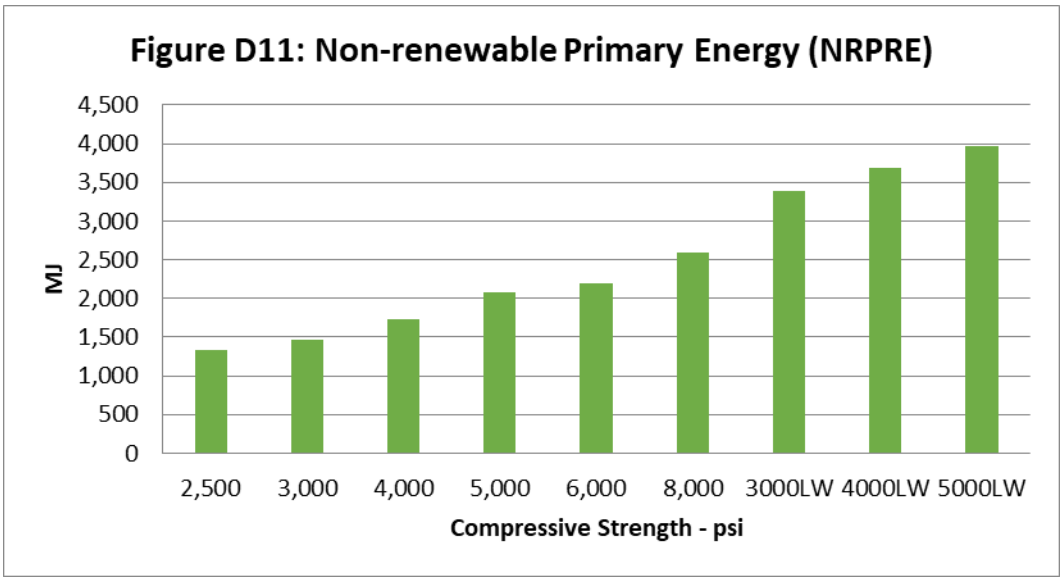
Figure D11: Non-renewable Primary Energy (NRPRE)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
MJ
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-6: Pacific Southwest Region

Table A6-Pacific Southwest Production Data Summary		
Number of Plants	51	
% Transit Mix Plants	66%	
% Central Mix Plants	34%	
% Batch Waste	1.03%	
	yd3	m3
Average Production	97,308	74,397
Total Production	4,962,694	3,794,251
Minimum Production	7,561	5,781
Maximum Production	403,143	308,225

Table B6-Pacific Southwest Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	379	419	497	594	632	731	419	498	573
Fly Ash	lbs	55	61	73	87	92	107	61	73	84
Slag Cement	lbs	0	0	0	0	0	0	0	0	0
Mixing Water	lbs	328	328	328	340	369	369	332	332	332
Crushed Coarse Aggregate	lbs	780	772	750	719	742	712	0	0	0
Natural Coarse Aggregate	lbs	742	735	713	684	706	677	0	0	0
Crushed Fine Aggregate	lbs	186	184	178	171	177	169	179	167	153
Natural Fine Aggregate	lbs	1,318	1,305	1,267	1,216	1,254	1,203	1,269	1,183	1,084
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	900	910	930
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,789	3,804	3,807	3,811	3,972	3,968	2,260	2,252	2,227

Table C6-Pacific Southwest Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	81.4	38.8	12.9	13.4	40.6	8.2	48.2
Rail	mi	36.0	105.3	0.0	77.3	0.6	73.4	0.6
Ocean	mi	317.4	181.1	402.6	0.2	51.1	0.1	180.4
Barge	mi	0.0	0.0	0.0	0.0	1.6	0.0	1.6

Table D6-Pacific Southwest Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	2.79	3.65
Natural Gas	cuft	0.06	0.08
Diesel	gal	0.32	0.42
LPG (Liquified Propane Gas)	gal	0.01	0.01
Water Consumption (excluding batch water)	gal	21.62	28.28
Non-Hazardous Solid Waste	lbs	37.23	48.70

Table E6-Pacific Southwest LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	217.67	236.74	274.85	321.62	341.25	389.12	405.22	444.74	485.27
ODP	kg CFC11e	5.66E-06	6.12E-06	7.04E-06	8.16E-06	8.65E-06	9.80E-06	1.41E-05	1.51E-05	1.62E-05
AP	kg SO2e	0.82	0.87	0.97	1.09	1.15	1.27	2.04	2.15	2.27
EP	kg Ne	0.28	0.30	0.35	0.40	0.42	0.48	0.69	0.74	0.79
SFP	kg O3e	18.63	19.68	21.73	24.21	25.53	28.08	30.39	32.47	34.60
ADPf	MJ, NCV	1,346.02	1,445.74	1,643.08	1,887.73	1,997.76	2,245.16	2,963.76	3,174.72	3,400.81
ADPe	kg Sbe	1.98E-04	2.10E-04	2.34E-04	2.63E-04	2.78E-04	3.08E-04	2.63E-04	2.89E-04	3.14E-04
FFD	MJ Surplus	115.17	120.85	131.84	145.83	153.06	166.78	216.01	227.71	240.76
Use of Primary Resources										
RPRE	MJ, NCV	68.32	73.45	83.64	96.29	101.77	114.56	266.21	278.59	293.07
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,513.38	1,619.52	1,829.49	2,089.84	2,207.32	2,470.54	3,283.83	3,508.96	3,750.83
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	81.44	89.86	106.79	127.46	135.71	156.99	90.05	106.81	123.07
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	2.14	2.31	2.66	3.10	3.28	3.72	2.52	2.87	3.21
CCE	kg CO2e	84.15	92.85	110.34	131.70	140.22	162.22	93.04	110.36	127.16
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	6.92E-09	6.87E-09	6.73E-09	6.54E-09	6.70E-09	6.51E-09	4.28E-08	4.31E-08	4.39E-08
LLRW	m3	1.72E-07	1.71E-07	1.66E-07	1.61E-07	1.65E-07	1.60E-07	1.55E-06	1.57E-06	1.59E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

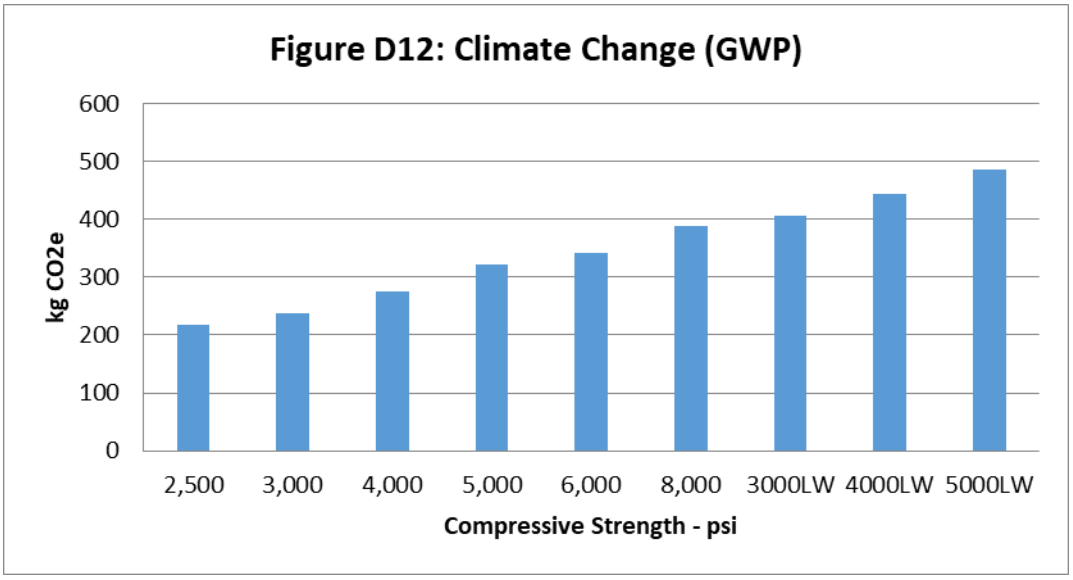
Figure D12: Climate Change (GWP)
kg CO2e
600
500
400
300
200
100
0
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

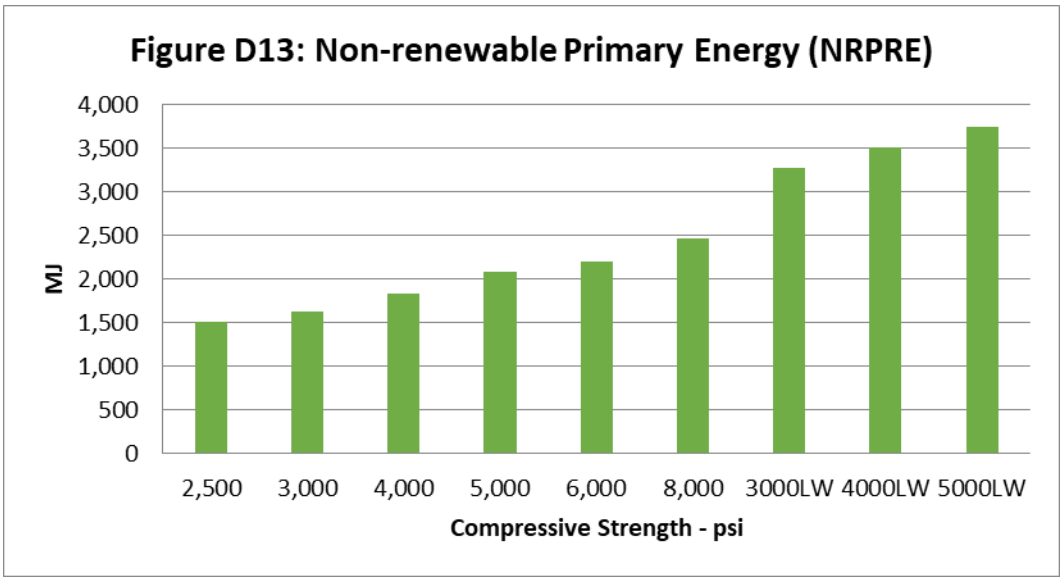
Figure D13: Non-renewable Primary Energy (NRPRE)
MJ
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-7: Rocky Mountains Region

Table A7-Rocky Mountains Production Data Summary		
Number of Plants	22	
% Transit Mix Plants	55%	
% Central Mix Plants	45%	
% Batch Waste	0.01%	
	yd3	m3
Average Production	105,461	80,631
Total Production	2,320,132	1,773,868
Minimum Production	6,778	5,182
Maximum Production	325,595	248,935

Table B7-Rocky Mountains Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	362	402	486	588	625	736	403	486	568
Fly Ash	lbs	69	77	93	112	119	141	77	93	109
Slag Cement	lbs	0	0	0	0	0	0	0	0	0
Mixing Water	lbs	303	303	303	314	341	341	307	307	307
Crushed Coarse Aggregate	lbs	929	920	893	849	875	840	0	0	0
Natural Coarse Aggregate	lbs	826	818	794	754	778	747	0	0	0
Crushed Fine Aggregate	lbs	19	19	19	18	18	17	19	18	16
Natural Fine Aggregate	lbs	1,369	1,356	1,316	1,250	1,290	1,237	1,360	1,254	1,147
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	990	1,000	1,010
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,877	3,895	3,904	3,886	4,047	4,058	2,167	2,157	2,147

Table C7-Rocky Mountains Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	61.1	159.5	0.0	20.4	16.7	0.0	28.9
Rail	mi	24.2	18.5	0.0	0.0	0.0	0.0	0.0
Ocean	mi	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barge	mi	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table D7-Rocky Mountains Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	3.04	3.97
Natural Gas	cuft	19.84	25.95
Diesel	gal	0.23	0.30
LPG (Liquified Propane Gas)	gal	0.01	0.01
Water Consumption (excluding batch water) Batching water consumption	gal	24.25	31.72
Non-Hazardous Solid Waste	lbs	0.10	0.13

Table E7-Rocky Mountains LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	197.53	216.79	256.41	305.53	323.69	376.73	391.66	432.80	474.23
ODP	kg CFC11e	5.33E-06	5.80E-06	6.76E-06	7.94E-06	8.40E-06	9.68E-06	1.45E-05	1.56E-05	1.66E-05
AP	kg SO2e	0.62	0.67	0.77	0.89	0.94	1.07	1.85	1.96	2.07
EP	kg Ne	0.26	0.28	0.33	0.38	0.41	0.47	0.70	0.74	0.79
SFP	kg O3e	12.83	13.83	15.87	18.35	19.38	22.10	23.00	25.09	27.18
ADPf	MJ, NCV	1,164.93	1,263.10	1,466.06	1,719.62	1,818.54	2,092.92	2,791.47	3,010.37	3,233.81
ADPe	kg Sbe	1.91E-04	2.04E-04	2.29E-04	2.59E-04	2.73E-04	3.07E-04	2.59E-04	2.85E-04	3.12E-04
FFD	MJ Surplus	93.73	98.99	109.98	124.03	130.11	145.32	184.35	196.42	209.17
Use of Primary Resources										
RPRE	MJ, NCV	66.57	71.71	82.27	95.43	100.63	114.85	280.62	293.47	306.56
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,324.58	1,429.08	1,645.03	1,914.77	2,020.45	2,312.39	3,108.71	3,342.31	3,580.81
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use of Primary Resources										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	76.90	85.49	103.18	125.04	132.84	156.43	85.66	103.18	120.70
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
FW	m3	2.03	2.21	2.57	3.03	3.20	3.69	2.43	2.79	3.16
CCE	kg CO2e	79.46	88.34	106.61	129.21	137.26	161.64	88.51	106.62	124.72
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	7.17E-09	7.12E-09	6.98E-09	6.74E-09	6.89E-09	6.70E-09	4.60E-08	4.63E-08	4.67E-08
LLRW	m3	1.58E-07	1.57E-07	1.53E-07	1.46E-07	1.50E-07	1.45E-07	1.66E-06	1.68E-06	1.69E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

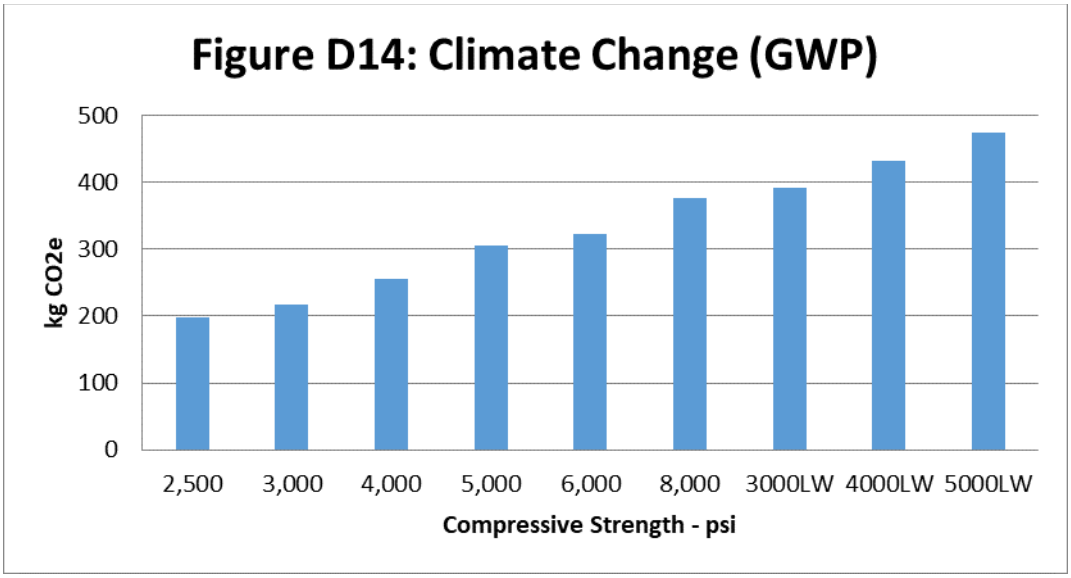
Figure D14: Climate Change (GWP)
500
400
300
200
100
0
kg CO2e
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

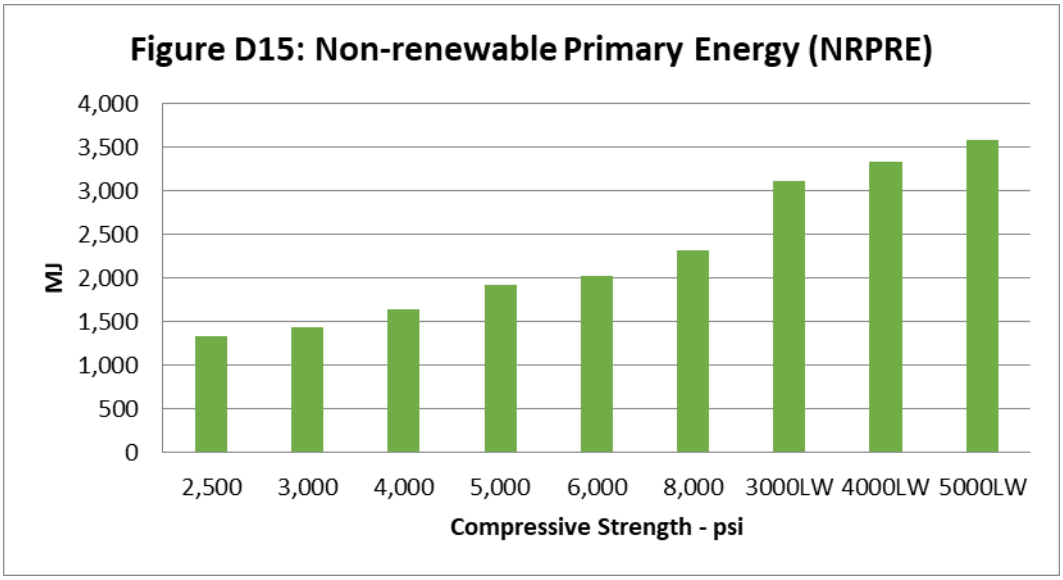
Figure D15: Non-renewable Primary Energy (NRPRE)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
MJ
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-8: South Central Region

Table A8-South Central Production Data Summary		
Number of Plants	91	
% Transit Mix Plants	80%	
% Central Mix Plants	20%	
% Batch Waste	0.04%	
	yd3	m3
Average Production	49,568	37,897
Total Production	4,510,685	3,448,665
Minimum Production	263	201
Maximum Production	232,476	177,741

Table B8-South Central Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	328	364	438	528	561	658	365	437	510
Fly Ash	lbs	61	68	82	99	105	123	68	82	95
Slag Cement	lbs	1	1	1	1	1	2	1	1	1
Mixing Water	lbs	279	279	279	289	314	314	283	283	283
Crushed Coarse Aggregate	lbs	1,276	1,264	1,227	1,190	1,227	1,177	0	0	0
Natural Coarse Aggregate	lbs	428	424	412	399	412	395	0	0	0
Crushed Fine Aggregate	lbs	21	21	20	20	20	19	21	20	18
Natural Fine Aggregate	lbs	1,423	1,409	1,367	1,326	1,367	1,312	1,441	1,348	1,239
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	980	990	1,010
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,818	3,830	3,826	3,852	4,008	4,001	2,179	2,171	2,147

Table C8-South Central Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	58.8	55.1	1.3	33.0	15.2	3.5	42.2
Rail	mi	47.6	0.5	6.4	48.3	6.0	0.0	2.1
Ocean	mi	169.6	0.0	0.0	0.0	0.0	0.0	0.0
Barge	mi	8.2	0.0	0.0	1.5	0.0	0.0	0.0

Table D8-South Central Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	3.33	4.35
Natural Gas	cuft	5.98	7.83
Diesel	gal	0.37	0.49
Gasoline	gal	0.00	0.01
Water Consumption (excluding batch water)	gal	21.29	27.85
Non-Hazardous Solid Waste	lbs	1.53	2.00

Table E8-South Central LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	190.49	207.65	242.52	285.94	302.70	348.49	377.49	413.86	451.98
ODP	kg CFC11e	5.20E-06	5.61E-06	6.45E-06	7.50E-06	7.93E-06	9.03E-06	1.41E-05	1.50E-05	1.60E-05
AP	kg SO2e	0.66	0.71	0.80	0.90	0.95	1.07	1.85	1.95	2.06
EP	kg Ne	0.27	0.29	0.33	0.38	0.40	0.45	0.68	0.73	0.78
SFP	kg O3e	14.28	15.18	16.98	19.22	20.26	22.61	23.67	25.55	27.50
ADPf	MJ, NCV	1,169.25	1,257.63	1,435.49	1,661.33	1,754.63	1,988.11	2,734.37	2,927.10	3,138.07
ADPe	kg Sbe	1.92E-04	2.03E-04	2.24E-04	2.52E-04	2.65E-04	2.93E-04	2.46E-04	2.70E-04	2.95E-04
FFD	MJ Surplus	101.65	106.52	116.09	128.84	134.80	147.36	187.53	197.96	209.82
Use of Primary Resources										
RPRE	MJ, NCV	51.21	55.92	65.51	77.60	82.15	94.75	268.07	279.83	293.92
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,362.36	1,456.36	1,645.38	1,885.59	1,985.54	2,233.66	3,073.99	3,279.69	3,505.43
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	69.73	77.38	93.01	112.28	119.35	139.89	77.53	92.99	108.32
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	1.85	2.01	2.33	2.74	2.90	3.32	2.22	2.54	2.87
CCE	kg CO2e	72.05	79.95	96.11	116.02	123.32	144.55	80.11	96.08	111.93
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	1.28E-08	1.27E-08	1.25E-08	1.22E-08	1.25E-08	1.21E-08	4.81E-08	4.84E-08	4.91E-08
LLRW	m3	2.13E-07	2.11E-07	2.06E-07	2.01E-07	2.06E-07	1.99E-07	1.67E-06	1.69E-06	1.71E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

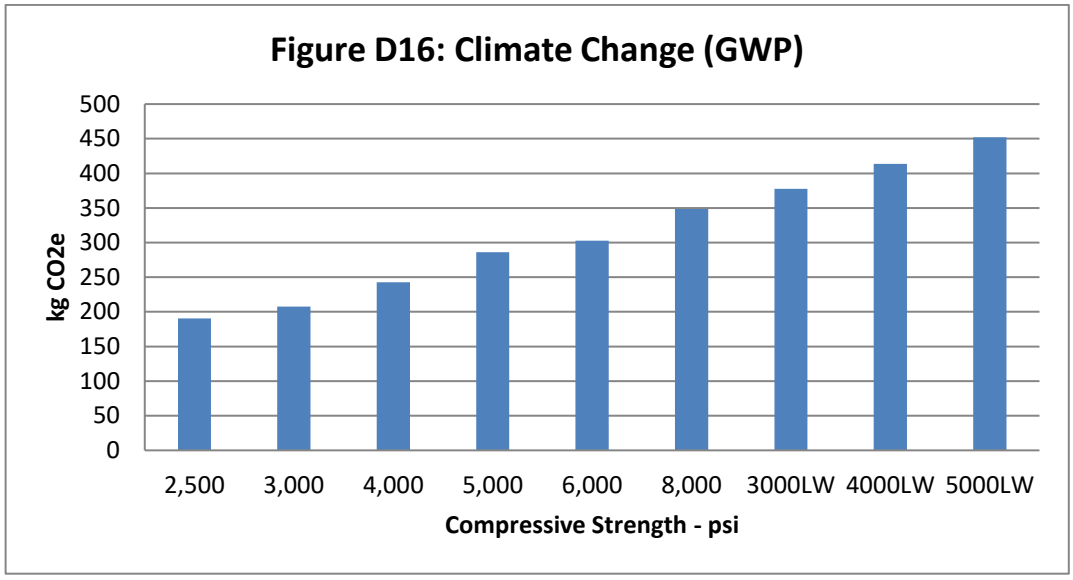
Figure D16: Climate Change (GWP)
kg CO2e
500
450
400
350
300
250
200
150
100
50
0
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

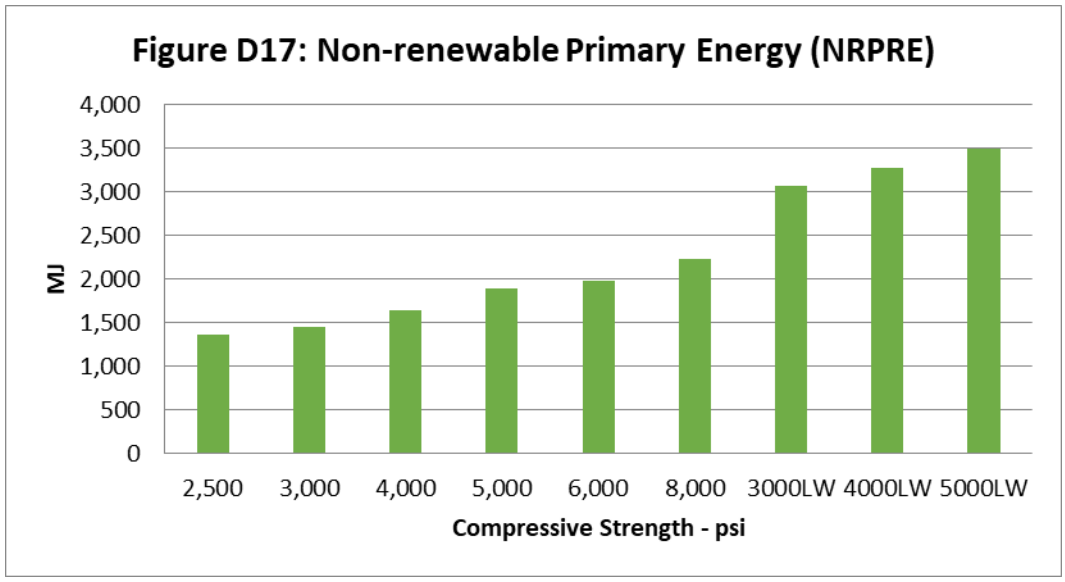
Figure D17: Non-renewable Primary Energy (NRPRE)
MJ
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

D-9: South Eastern Region

Table A9-South Eastern Production Data Summary		
Number of Plants	131	
% Transit Mix Plants	82%	
% Central Mix Plants	18%	
% Batch Waste	0.40%	
	yd3	m3
Average Production	48,925	37,406
Total Production	6,409,141	4,900,138
Minimum Production	1,354	1,035
Maximum Production	253,110	193,516

Table B9-South Eastern Benchmark Mix Designs (per cubic yard)										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	354	391	465	555	591	684	390	462	533
Fly Ash	lbs	85	93	111	133	141	163	94	111	128
Slag Cement	lbs	22	24	29	34	36	42	24	29	33
Mixing Water	lbs	347	347	347	359	390	390	351	351	351
Crushed Coarse Aggregate	lbs	1,330	1,304	1,266	1,202	1,240	1,189	0	0	0
Natural Coarse Aggregate	lbs	290	284	276	262	270	259	0	0	0
Crushed Fine Aggregate	lbs	419	411	399	378	390	374	395	364	339
Natural Fine Aggregate	lbs	1,046	1,026	996	946	976	936	988	911	848
Man.Lightweight Aggregate	lbs	0	0	0	0	0	0	920	930	930
Air %	%	6%	6%	6%	6%	6%	0	6%	6%	2%
Air Entraining Admixture	oz	1	1	1	1	1	1	1	1	0
Plasticizer & Superplasticizer	oz	3	3	3	7	3	3	3	7	7
Set Accelerator	oz	25	20	15	10	25	20	15	10	10
Total Weight	lbs	3,892	3,881	3,888	3,868	4,035	4,037	2,241	2,227	2,231

Table C9-South Eastern Transportation Modes and Distances - High Mass Materials								
Transportation Mode	Units	Portland Cement	Fly Ash	Slag Cement	Crushed Coarse Aggregate	Natural Coarse Aggregate	Crushed Fine Aggregate	Natural Fine Aggregate
Truck	mi	80.4	58.0	21.9	31.9	18.0	14.6	55.3
Rail	mi	48.8	0.9	6.9	40.3	22.3	8.7	1.7
Ocean	mi	372.3	0.0	982.9	24.9	0.0	0.0	0.0
Barge	mi	6.6	0.0	5.5	0.0	0.0	0.0	0.0

Table D9-South Eastern Gate to Gate Manufacturing Energy Use			
		per yd3	per m3
Purchased Electricity	kWh	2.59	3.39
Natural Gas	cuft	1.47	1.93
Diesel	gal	0.46	0.60
LPG (Liquified Propane Gas)	gal	0.00	0.01
Water Consumption (excluding batch water)	gal	30.05	39.30
Non-Hazardous Solid Waste	lbs	14.64	19.15

Table E9-South Eastern LCA Results (per cubic yard)										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
Core Mandatory Impact Indicator										
GWP	kg CO2e	209.17	226.87	262.74	306.52	325.03	370.15	387.10	424.12	458.62
ODP	kg CFC11e	5.93E-06	6.35E-06	7.23E-06	8.28E-06	8.77E-06	9.87E-06	1.42E-05	1.52E-05	1.60E-05
AP	kg SO2e	0.77	0.82	0.92	1.04	1.10	1.22	1.90	2.01	2.11
EP	kg Ne	0.29	0.31	0.35	0.40	0.42	0.47	0.68	0.72	0.76
SFP	kg O3e	16.72	17.73	19.81	22.27	23.53	26.13	25.96	28.09	30.07
ADPf	MJ, NCV	1,307.52	1,399.79	1,588.77	1,819.92	1,925.67	2,162.96	2,802.91	3,003.82	3,188.41
ADPe	kg Sbe	2.15E-04	2.25E-04	2.47E-04	2.72E-04	2.87E-04	3.14E-04	2.61E-04	2.83E-04	3.05E-04
FFD	MJ Surplus	117.28	122.52	133.49	147.02	154.16	167.89	200.31	211.88	222.96
Use of Primary Resources										
RPRE	MJ, NCV	52.83	57.73	67.62	79.88	84.83	97.28	258.78	270.72	280.41
RPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRPRE	MJ, NCV	1,530.27	1,628.65	1,830.40	2,076.89	2,191.00	2,444.28	3,158.80	3,373.97	3,571.31
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Secondary Material, Secondary Fuel and Recovered Energy										
SM	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ, NCV	75.54	83.37	99.12	118.35	126.01	145.84	83.14	98.62	113.64
RE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mandatory Inventory Parameters										
FW	m3	2.09	2.25	2.58	2.98	3.16	3.56	2.44	2.76	3.07
CCE	kg CO2e	78.05	86.14	102.41	122.29	130.20	150.70	85.91	101.91	117.42
Indicators Describing Waste										
HWD	kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NHWD	kg	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
HLRW	m3	1.88E-08	1.85E-08	1.81E-08	1.74E-08	1.78E-08	1.72E-08	4.86E-08	4.87E-08	4.84E-08
LLRW	m3	2.72E-07	2.68E-07	2.61E-07	2.50E-07	2.57E-07	2.48E-07	1.61E-06	1.62E-06	1.62E-06
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

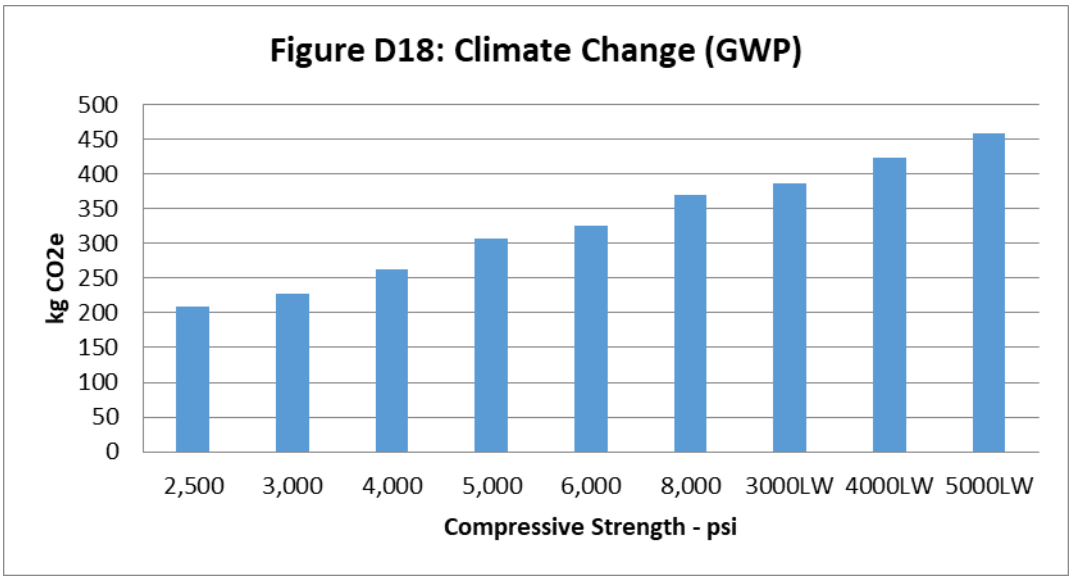
Figure D18: Climate Change (GWP)
kg CO2e
500
450
400
350
300
250
200
150
100
50
0
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi

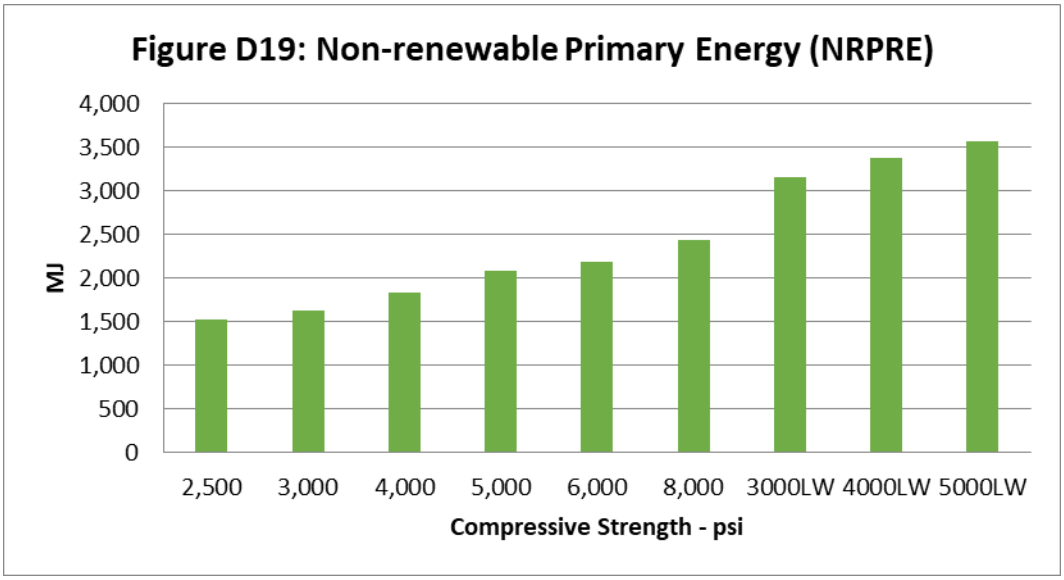
Figure D19: Non-renewable Primary Energy (NRPRE)
MJ
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2,500
3,000
4,000
5,000
6,000
8,000
3000LW
4000LW
5000LW
Compressive Strength - psi