



## Appendix D: NRMCA Member National and Regional LCA Benchmark (Industry Average) Report – V 3.0

**Summary:** Appendix D is intended 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



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 CO<sub>2</sub>e;*
- *depletion of the stratospheric ozone layer, in kg CFC-11;*
- *acidification of land and water sources, in kg SO<sub>2</sub>;*
- *eutrophication, in kg nitrogen or kg phosphate;*
- *formation of tropospheric ozone, in kg O<sub>3</sub>; 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 Architecture 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-Wide EPD or product-specific EPDs to meet the EPD requirement in Green Globes. The following is an excerpt 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 regional 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/ft<sup>3</sup> (1890 kg/m<sup>3</sup>) 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**

<b>Table A1-NRMCA U.S. National Production Data Summary</b>		
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

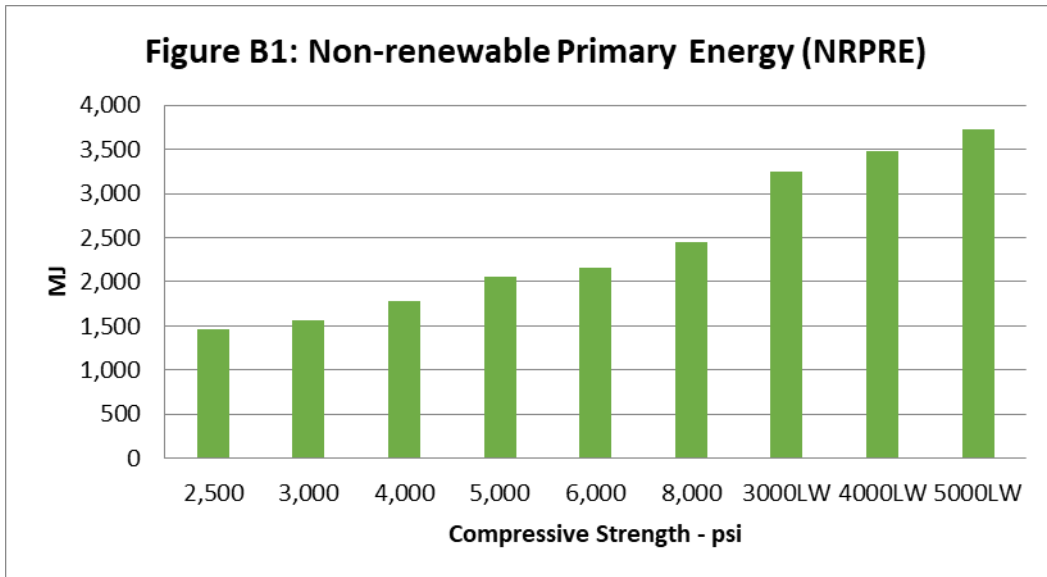
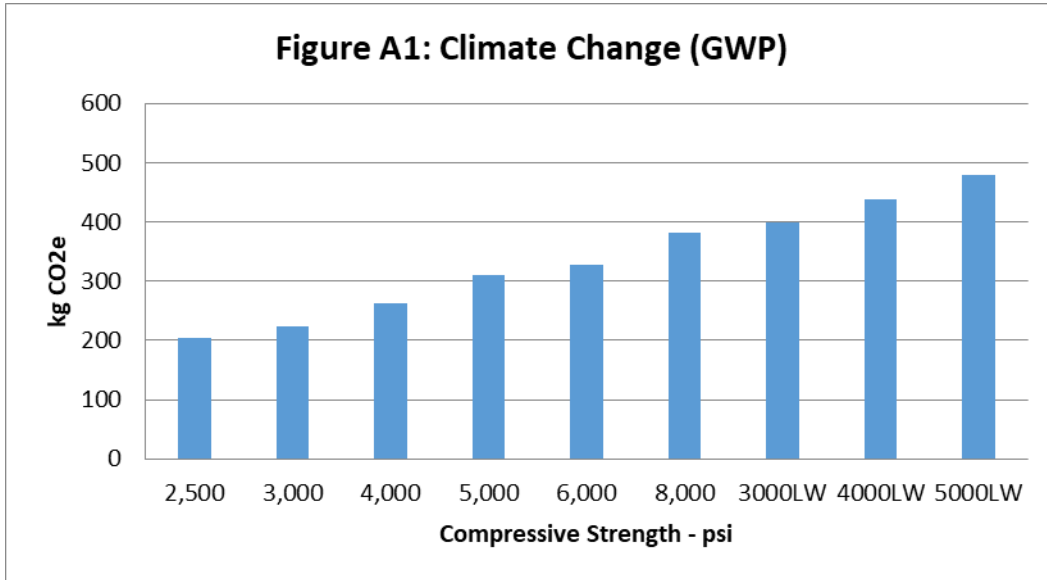
<b>Table B1-NRMCA U.S. National Benchmark Mix Designs (per cubic yard)</b>										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	354	394	475	576	610	719	394	475	556
Fly Ash	lbs	62	69	83	101	107	126	69	83	97
Slag Cement	lbs	17	19	23	28	30	35	19	23	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 yd <sup>3</sup>	per m <sup>3</sup>
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	204.39	223.39	262.55	311.07	328.55	381.03	398.07	438.86	479.94
ODP	kg CFC11e	5.78E-06	6.25E-06	7.22E-06	8.41E-06	8.88E-06	1.02E-05	1.48E-05	1.58E-05	1.69E-05
AP	kg SO2e	0.72	0.77	0.88	1.01	1.06	1.20	1.97	2.09	2.21
EP	kg Ne	0.28	0.31	0.35	0.41	0.43	0.49	0.71	0.76	0.81
SFP	kg O3e	15.29	16.37	18.55	21.20	22.32	25.23	26.29	28.53	30.77
ADP <sub>f</sub>	MJ, NCV	1,052.19	1,143.26	1,334.84	1,575.76	1,663.92	1,925.71	2,662.22	2,873.29	3,088.59
ADP <sub>e</sub>	kg Sbe	2.02E-04	2.14E-04	2.39E-04	2.68E-04	2.82E-04	3.14E-04	2.62E-04	2.88E-04	3.14E-04
FFD	MJ Surplus	108.93	114.09	125.19	139.30	145.73	161.51	202.90	215.44	228.62
Use of Primary Resources										
RPRE	MJ, NCV	59.97	65.05	75.62	88.89	93.76	108.09	275.50	288.40	301.52
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,466.89	1,570.11	1,785.38	2,053.80	2,159.92	2,453.74	3,249.42	3,485.05	3,725.32
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	2.99	3.16	3.52	4.00	4.27	4.75	3.38	3.74	4.10
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	1.85E-08	1.84E-08	1.80E-08	1.74E-08	1.79E-08	1.74E-08	5.17E-08	5.18E-08	5.20E-08
LLRW	m3	2.49E-07	2.47E-07	2.41E-07	2.32E-07	2.38E-07	2.30E-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



**D-2: Eastern Region**

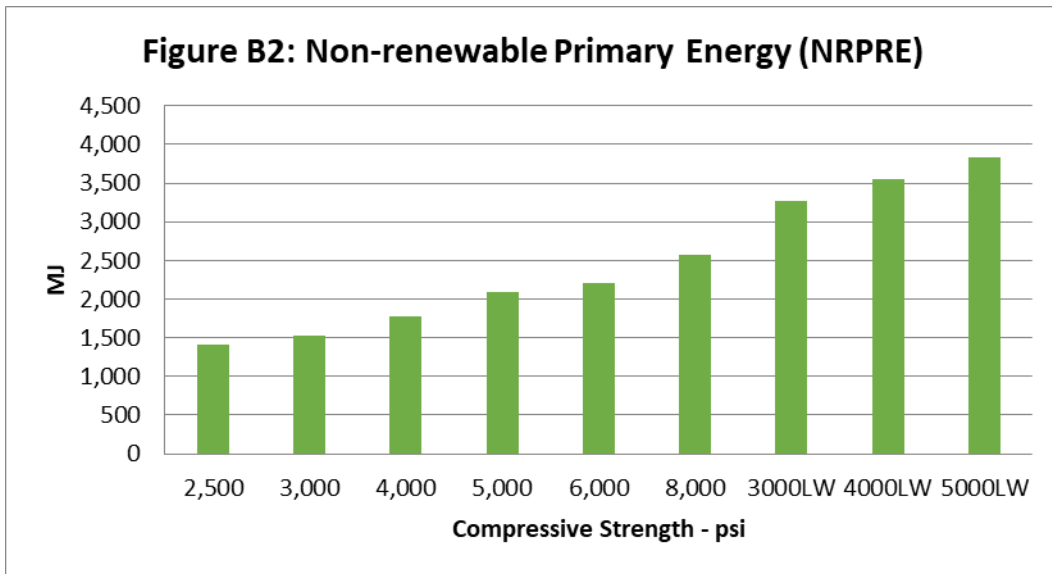
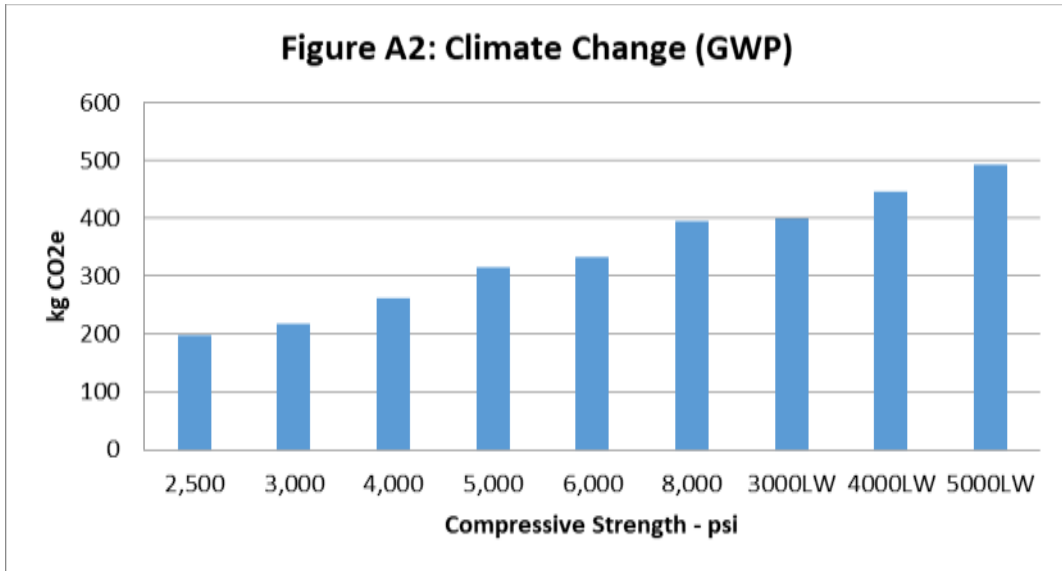
Table A2-Eastern Production Data Summary		
Number of Plants	65	
% Transit Mix Plants	63%	
% Central Mix Plants	37%	
% Batch Waste	0.25%	
	yd3	m3
Average Production	59,453	45,455
Total Production	3,864,451	2,954,584
Minimum Production	1,734	1,326
Maximum Production	307,863	235,378

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

<b>Table E2-Eastern LCA Results (per cubic yard)</b>										
Strength	psi @28 days	2,500	3,000	4,000	5,000	6,000	8,000	3000LW	4000LW	5000LW
<b>Core Mandatory Impact Indicator</b>										
GWP	kg CO2e	197.62	217.93	261.21	315.77	333.82	395.70	399.18	446.19	493.10
ODP	kg CFC11e	5.54E-06	6.08E-06	7.22E-06	8.65E-06	9.14E-06	1.08E-05	1.49E-05	1.62E-05	1.75E-05
AP	kg SO2e	0.73	0.79	0.92	1.07	1.13	1.31	2.01	2.16	2.30
EP	kg Ne	0.24	0.26	0.32	0.38	0.40	0.47	0.69	0.75	0.81
SFP	kg O3e	15.38	16.53	19.02	22.10	23.28	26.80	26.65	29.28	31.89
ADP <sub>f</sub>	MJ, NCV	1,018.95	1,119.19	1,337.10	1,615.74	1,708.01	2,024.94	2,692.12	2,946.04	3,195.38
ADP <sub>e</sub>	kg Sbe	2.04E-04	2.16E-04	2.43E-04	2.75E-04	2.89E-04	3.27E-04	2.62E-04	2.91E-04	3.20E-04
FFD	MJ Surplus	107.34	113.22	126.85	144.45	151.45	171.72	205.45	221.29	237.31
<b>Use of Primary Resources</b>										
RPRE	MJ, NCV	53.00	58.59	70.62	85.99	90.98	108.35	275.41	291.98	306.98
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,406.89	1,521.36	1,771.68	2,089.63	2,201.85	2,564.29	3,268.75	3,556.52	3,839.60
NRPRM	MJ, NCV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Secondary Material, Secondary Fuel and Recovered Energy</b>										
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
<b>Mandatory Inventory Parameters</b>										
FW	m3	2.85	3.03	3.42	3.95	4.21	4.77	3.29	3.69	4.09
CCE	kg CO2e	76.02	85.20	104.54	128.85	136.53	164.09	86.43	105.81	125.84
<b>Indicators Describing Waste</b>										
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	1.19E-06	1.18E-06	1.16E-06	1.12E-06	1.14E-06	1.11E-06	6.83E-07	6.65E-07	6.48E-07
LLRW	m3	1.31E-06	1.29E-06	1.26E-06	1.22E-06	1.25E-06	1.21E-06	2.29E-06	2.30E-06	2.29E-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



**D-3: Great Lakes Midwest Region**

<b>Table A3-Great Lakes Midwest Production Data Summary</b>		
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

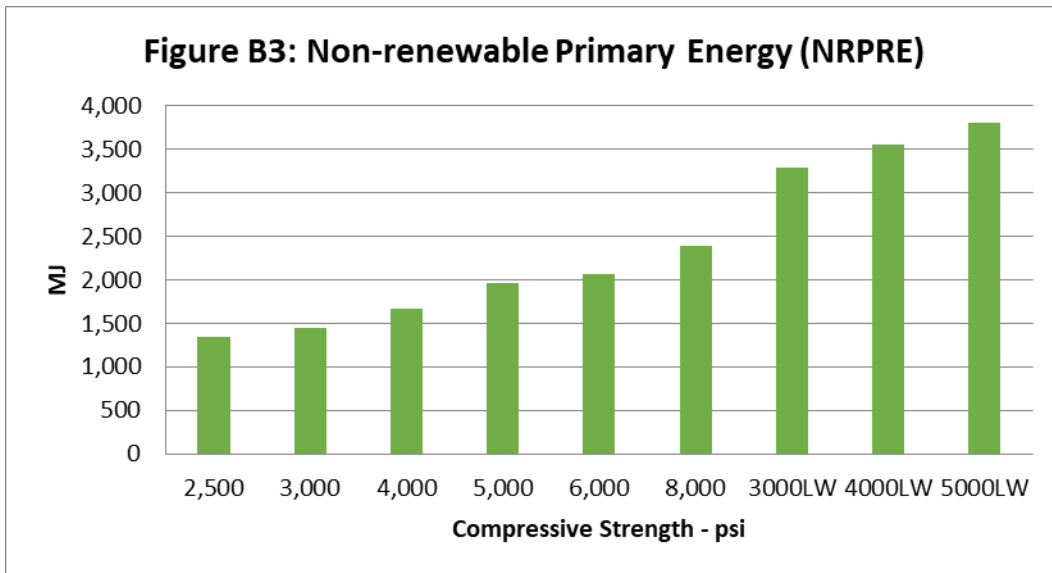
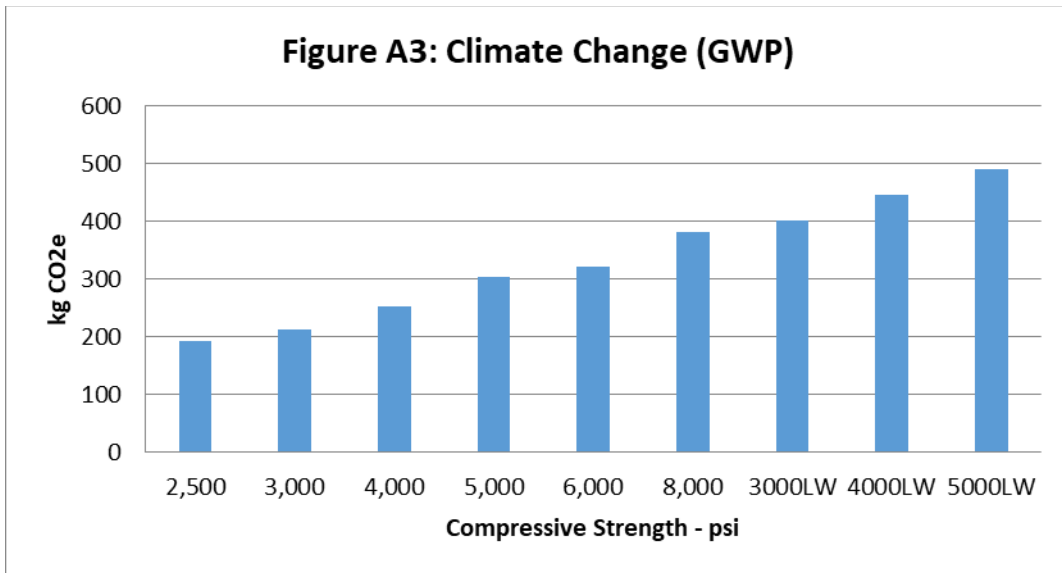
<b>Table B3-Great Lakes Midwest Benchmark Mix Designs (per cubic yard)</b>										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	341	382	468	576	611	733	383	468	556
Fly Ash	lbs	39	44	54	67	71	85	44	54	64
Slag Cement	lbs	24	27	33	41	44	52	27	33	40
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	192.43	211.66	252.63	304.40	321.68	380.19	401.57	445.91	489.97
ODP	kg CFC11e	5.17E-06	5.66E-06	6.71E-06	8.03E-06	8.49E-06	9.98E-06	1.50E-05	1.63E-05	1.74E-05
AP	kg SO2e	0.68	0.73	0.84	0.97	1.02	1.16	2.02	2.15	2.27
EP	kg Ne	0.23	0.25	0.30	0.36	0.38	0.45	0.71	0.76	0.82
SFP	kg O3e	14.22	15.17	17.22	19.80	20.83	23.76	25.81	28.01	30.18
ADP <sub>f</sub>	MJ, NCV	978.01	1,071.94	1,276.27	1,538.32	1,625.82	1,922.96	2,732.57	2,972.04	3,205.97
ADP <sub>e</sub>	kg Sbe	2.01E-04	2.13E-04	2.39E-04	2.71E-04	2.85E-04	3.22E-04	2.58E-04	2.87E-04	3.16E-04
FFD	MJ Surplus	103.35	107.87	118.62	132.88	138.87	155.27	205.50	218.55	231.68
Use of Primary Resources										
RPRE	MJ, NCV	50.60	55.92	67.34	81.96	86.74	103.20	285.25	301.16	315.44
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,349.29	1,450.64	1,673.13	1,958.14	2,060.62	2,384.52	3,295.44	3,555.14	3,808.81
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	2.73	2.90	3.28	3.80	4.06	4.59	3.16	3.54	3.93
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	1.03E-06	1.01E-06	9.90E-07	9.61E-07	9.83E-07	9.54E-07	4.79E-07	4.65E-07	4.53E-07
LLRW	m3	1.14E-06	1.12E-06	1.10E-06	1.06E-06	1.09E-06	1.06E-06	2.17E-06	2.19E-06	2.19E-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



**D-4: North Central Region**

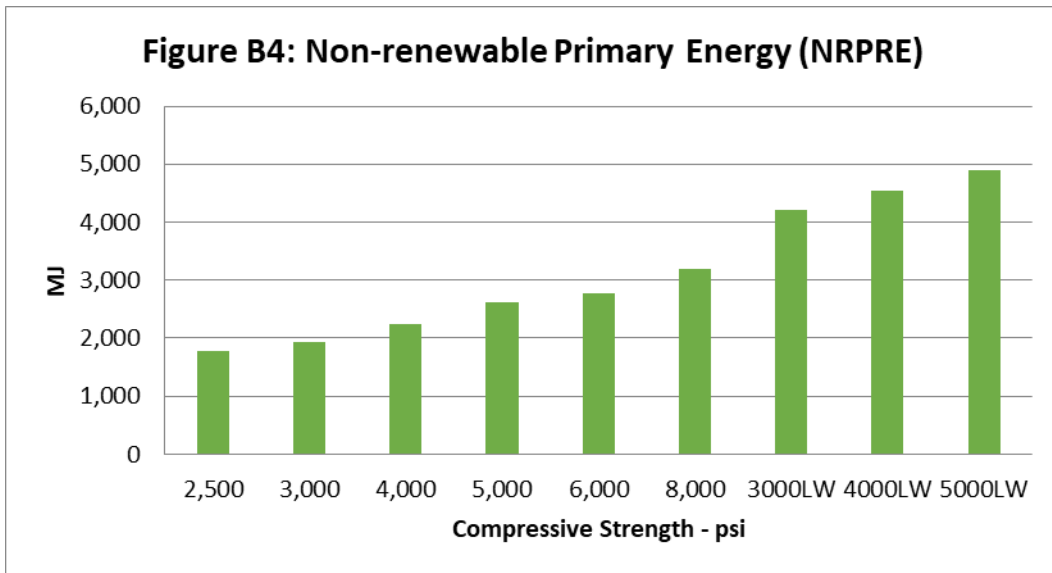
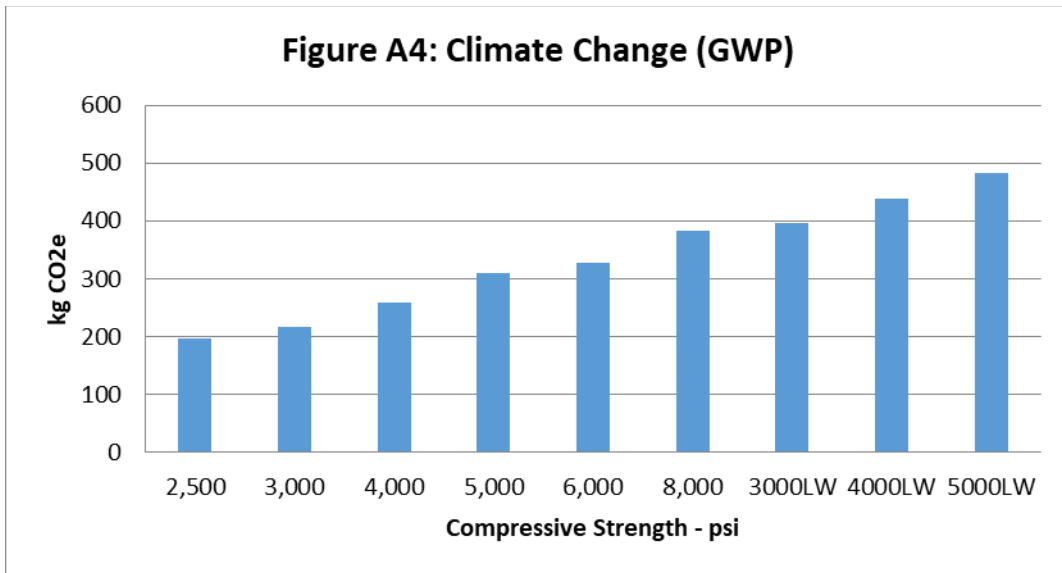
Table A4-North Central Production Data Summary		
Number of Plants	28	
% Transit Mix Plants	61%	
% Central Mix Plants	39%	
% Batch Waste	0.07%	
	yd3	m3
Average Production	46,057	35,213
Total Production	1,289,592	985,964
Minimum Production	2,834	2,167
Maximum Production	172,000	131,503

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	197.21	216.78	257.74	308.75	327.27	383.21	395.42	437.97	482.96
ODP	kg CFC11e	5.03E-06	5.50E-06	6.47E-06	7.68E-06	8.15E-06	9.48E-06	1.43E-05	1.54E-05	1.65E-05
AP	kg SO2e	0.71	0.77	0.88	1.03	1.09	1.24	1.99	2.11	2.25
EP	kg Ne	0.23	0.25	0.30	0.36	0.38	0.44	0.68	0.73	0.79
SFP	kg O3e	15.57	16.72	19.15	22.12	23.40	26.71	26.92	29.41	32.02
ADP <sub>f</sub>	MJ, NCV	981.01	1,073.13	1,270.08	1,519.30	1,609.86	1,884.01	2,631.78	2,847.82	3,085.79
ADP <sub>e</sub>	kg Sbe	1.86E-04	1.98E-04	2.23E-04	2.54E-04	2.68E-04	3.03E-04	2.60E-04	2.87E-04	3.14E-04
FFD	MJ Surplus	105.72	111.67	125.14	142.32	149.94	169.27	204.46	219.33	235.89
Use of Primary Resources										
RPRE	MJ, NCV	51.17	56.29	67.12	80.83	85.70	100.65	270.55	283.66	299.28
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,363.83	1,473.32	1,708.38	2,003.57	2,118.72	2,445.23	3,215.48	3,470.31	3,749.39
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	2.88	3.05	3.42	3.92	4.19	4.69	3.30	3.66	4.03
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	3.27E-07	3.23E-07	3.16E-07	3.05E-07	3.14E-07	3.05E-07	2.18E-07	2.12E-07	2.05E-07
LLRW	m3	4.33E-07	4.27E-07	4.18E-07	4.02E-07	4.15E-07	4.03E-07	1.80E-06	1.81E-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



**D-5: Pacific Northwest Region**

<b>Table A5-Pacific Northwest Production Data Summary</b>		
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

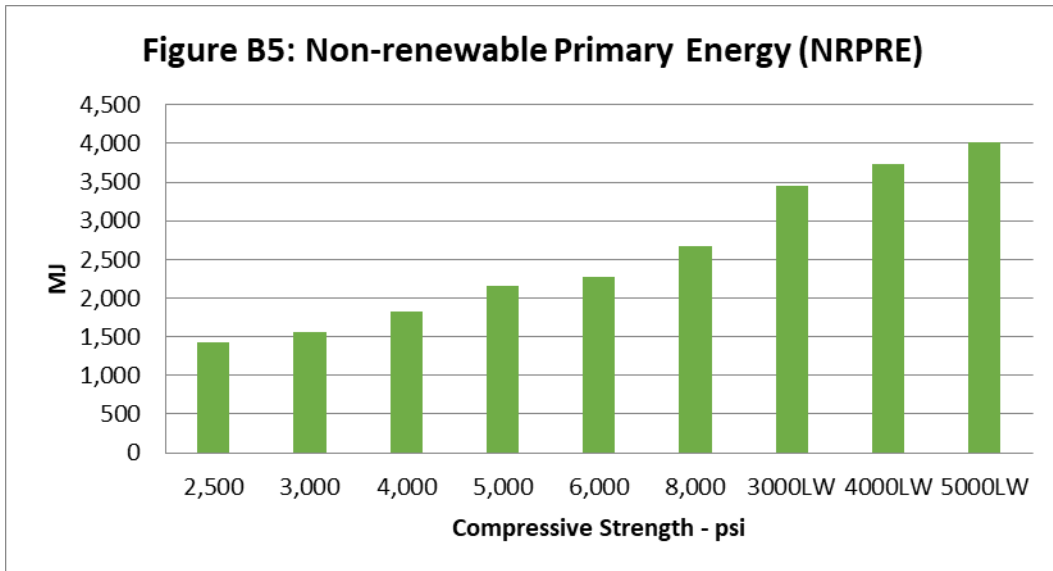
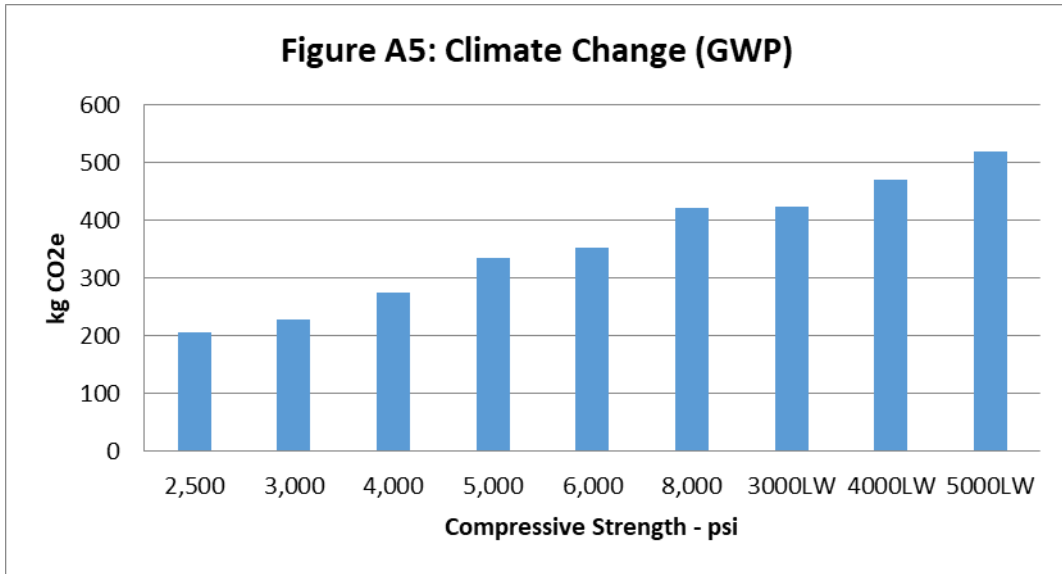
<b>Table B5-Pacific Northwest Benchmark Mix Designs (per cubic yard)</b>										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	362	406	500	619	655	791	407	500	597
Fly Ash	lbs	93	105	129	159	169	204	105	129	154
Slag Cement	lbs	11	13	16	19	21	25	13	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	206.60	228.38	275.04	333.94	352.88	420.39	422.99	470.97	519.31
ODP	kg CFC11e	5.38E-06	5.90E-06	7.03E-06	8.44E-06	8.93E-06	1.05E-05	1.55E-05	1.67E-05	1.79E-05
AP	kg SO2e	0.80	0.87	1.02	1.20	1.26	1.48	2.20	2.35	2.50
EP	kg Ne	0.25	0.27	0.33	0.40	0.42	0.50	0.74	0.80	0.85
SFP	kg O3e	18.17	19.70	23.01	27.09	28.56	33.27	30.84	34.13	37.46
ADP <sub>f</sub>	MJ, NCV	1,023.81	1,127.17	1,352.81	1,641.73	1,734.77	2,066.89	2,826.32	3,069.97	3,310.97
ADP <sub>e</sub>	kg Sbe	1.68E-04	1.82E-04	2.11E-04	2.48E-04	2.62E-04	3.04E-04	2.70E-04	3.00E-04	3.31E-04
FFD	MJ Surplus	111.82	118.34	133.40	152.60	159.99	182.35	219.27	235.30	251.68
Use of Primary Resources										
RPRE	MJ, NCV	56.42	62.14	74.52	90.35	95.43	113.52	294.85	309.47	322.60
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,436.29	1,557.63	1,823.77	2,160.90	2,276.48	2,665.06	3,454.85	3,737.27	4,017.59
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	3.00	3.19	3.61	4.18	4.46	5.06	3.45	3.87	4.30
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	1.51E-06	1.50E-06	1.47E-06	1.42E-06	1.45E-06	1.40E-06	1.03E-06	9.99E-07	9.68E-07
LLRW	m3	1.62E-06	1.61E-06	1.58E-06	1.53E-06	1.55E-06	1.50E-06	2.76E-06	2.74E-06	2.70E-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



**D-6: Pacific Southwest Region**

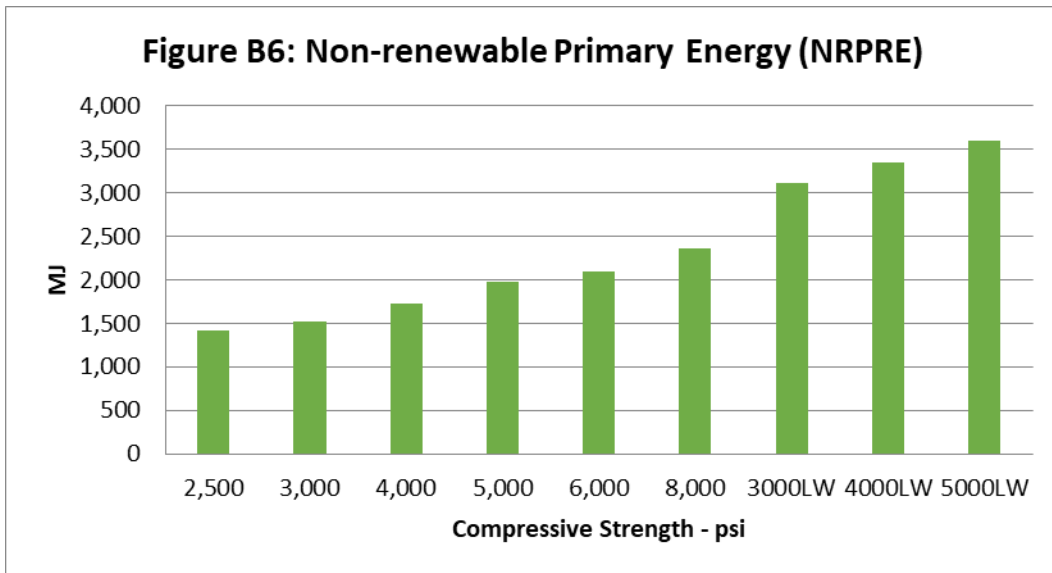
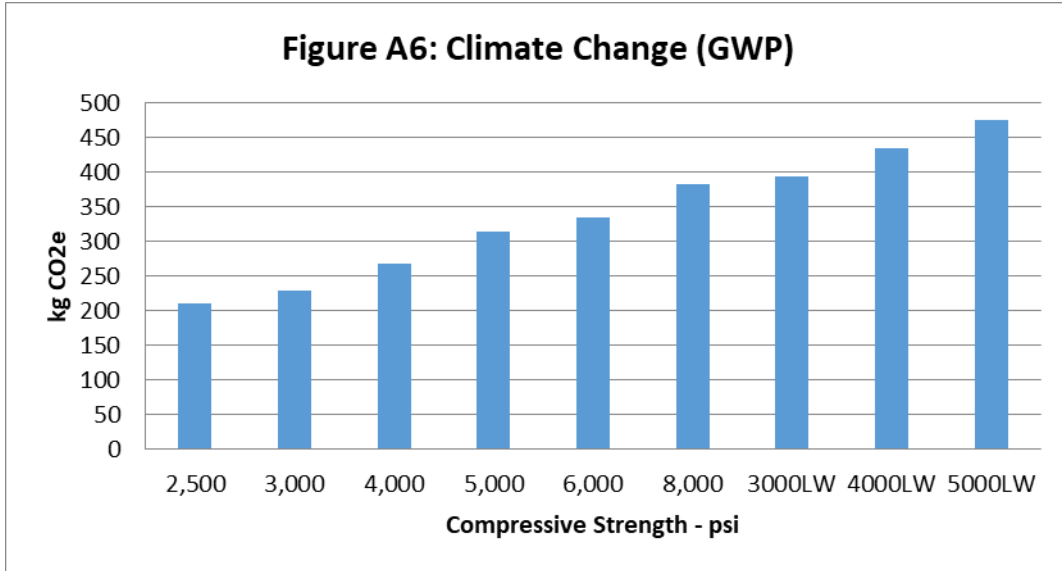
<b>Table A6-Pacific Southwest Production Data Summary</b>		
Number of Plants	51	
% Transit Mix Plants	66%	
% Central Mix Plants	34%	
% Batch Waste	1.03%	
	yd3	m3
Average Production	97,308	74,397
Total Production	4,962,694	3,794,251
Minimum Production	7,561	5,781
Maximum Production	403,143	308,225

<b>Table B1-NRMCA U.S. National Benchmark Mix Designs (per cubic yard)</b>										
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	210.24	229.14	267.24	314.08	333.54	381.72	394.02	433.80	474.53
ODP	kg CFC11e	5.52E-06	5.98E-06	6.91E-06	8.04E-06	8.54E-06	9.70E-06	1.41E-05	1.51E-05	1.62E-05
AP	kg SO2e	0.71	0.76	0.87	0.99	1.05	1.17	1.89	2.00	2.12
EP	kg Ne	0.25	0.27	0.32	0.37	0.40	0.45	0.67	0.72	0.77
SFP	kg O3e	15.66	16.74	18.85	21.43	22.66	25.31	26.11	28.30	30.52
ADP <sub>f</sub>	MJ, NCV	1,055.54	1,145.35	1,330.23	1,561.35	1,657.81	1,896.42	2,582.51	2,786.98	3,006.16
ADP <sub>e</sub>	kg Sbe	1.96E-04	2.08E-04	2.32E-04	2.61E-04	2.76E-04	3.06E-04	2.63E-04	2.88E-04	3.14E-04
FFD	MJ Surplus	104.66	109.71	120.33	134.03	140.93	155.17	194.50	206.66	220.04
Use of Primary Resources										
RPRE	MJ, NCV	59.15	64.16	74.39	87.15	92.49	105.57	260.98	273.54	288.21
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,414.27	1,516.14	1,724.12	1,983.48	2,098.46	2,366.22	3,119.23	3,348.06	3,592.88
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	3.20	3.37	3.72	4.20	4.50	4.94	3.60	3.95	4.29
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	1.66E-06	1.65E-06	1.61E-06	1.57E-06	1.60E-06	1.56E-06	9.48E-07	9.21E-07	8.90E-07
LLRW	m3	1.77E-06	1.76E-06	1.72E-06	1.68E-06	1.71E-06	1.66E-06	2.43E-06	2.42E-06	2.42E-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



**D-7: Rocky Mountains Region**

<b>Table A7-Rocky Mountains Production Data Summary</b>		
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

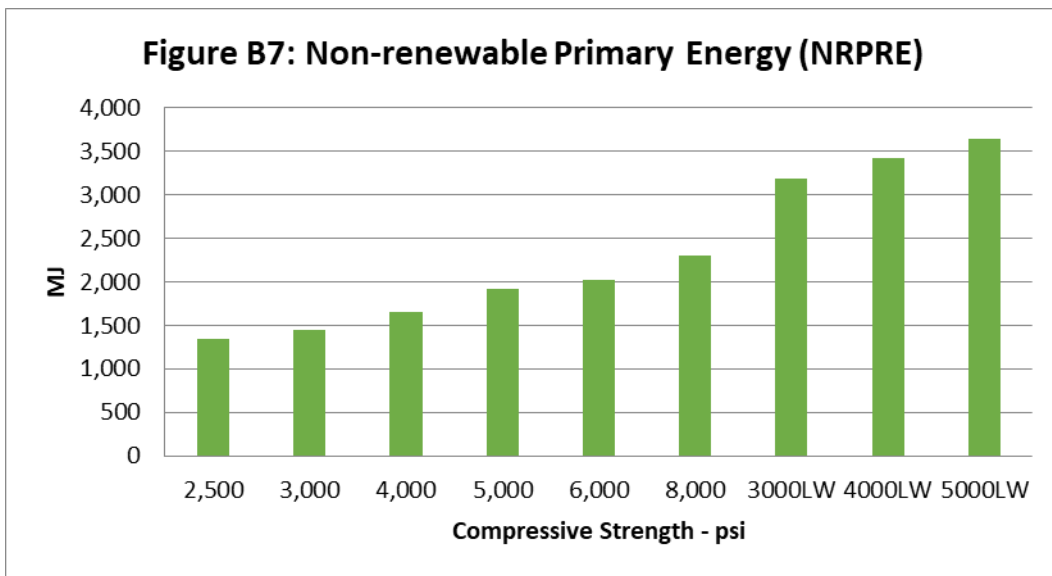
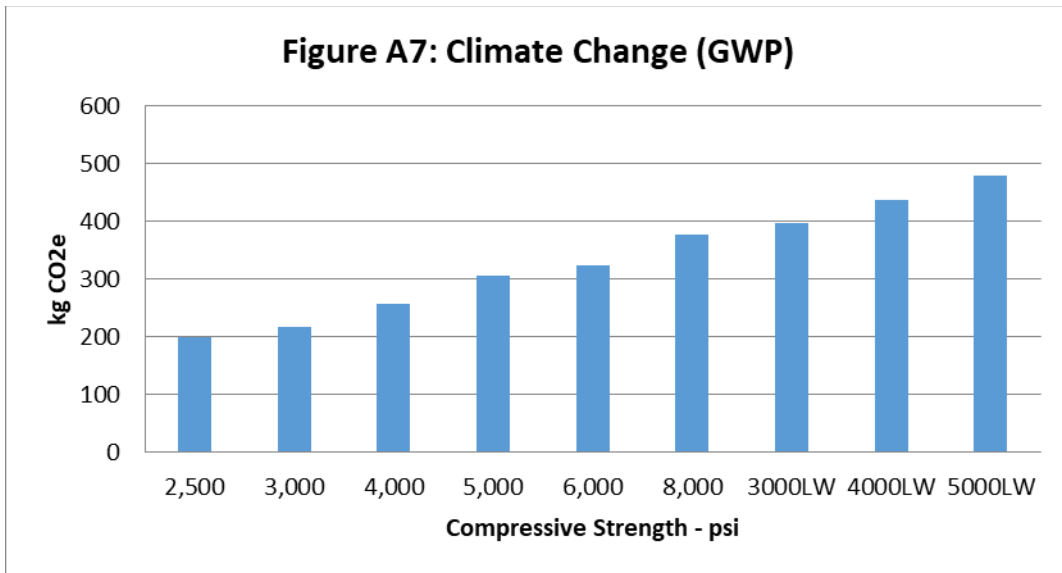
<b>Table B7-Rocky Mountains Benchmark Mix Designs (per cubic yard)</b>										
Compressive Strength	psi	2500	3000	4000	5000	6000	8000	3000 LW	4000 LW	5000 LW
Portland Cement	lbs	362	402	486	588	625	736	403	486	568
Fly Ash	lbs	69	77	93	112	119	141	77	93	109
Slag Cement	lbs	0	0	0	0	0	0	0	0	0
Mixing Water	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	198.51	217.55	256.84	305.55	323.75	376.48	396.94	437.81	478.95
ODP	kg CFC11e	5.21E-06	5.68E-06	6.64E-06	7.84E-06	8.31E-06	9.60E-06	1.45E-05	1.56E-05	1.66E-05
AP	kg SO2e	0.66	0.71	0.81	0.92	0.97	1.10	1.93	2.04	2.15
EP	kg Ne	0.24	0.26	0.31	0.36	0.38	0.45	0.69	0.74	0.79
SFP	kg O3e	14.13	15.10	17.04	19.38	20.44	23.04	25.28	27.26	29.25
ADP <sub>f</sub>	MJ, NCV	1,002.13	1,093.45	1,285.85	1,528.28	1,619.10	1,882.40	2,658.41	2,870.01	3,085.74
ADP <sub>e</sub>	kg Sbe	1.89E-04	2.01E-04	2.26E-04	2.57E-04	2.71E-04	3.05E-04	2.58E-04	2.85E-04	3.12E-04
FFD	MJ Surplus	99.40	104.06	114.16	127.06	133.20	147.68	196.49	207.94	220.03
Use of Primary Resources										
RPRE	MJ, NCV	56.38	61.51	72.20	85.65	90.70	105.21	275.64	288.65	301.87
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,339.62	1,440.11	1,650.22	1,912.97	2,019.00	2,306.43	3,185.30	3,414.93	3,649.11
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	2.97	3.15	3.52	4.01	4.29	4.78	3.39	3.76	4.12
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	1.76E-06	1.75E-06	1.71E-06	1.65E-06	1.69E-06	1.64E-06	9.16E-07	8.92E-07	8.67E-07
LLRW	m3	1.86E-06	1.85E-06	1.81E-06	1.75E-06	1.79E-06	1.74E-06	2.51E-06	2.50E-06	2.49E-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



**D-8: South Central Region**

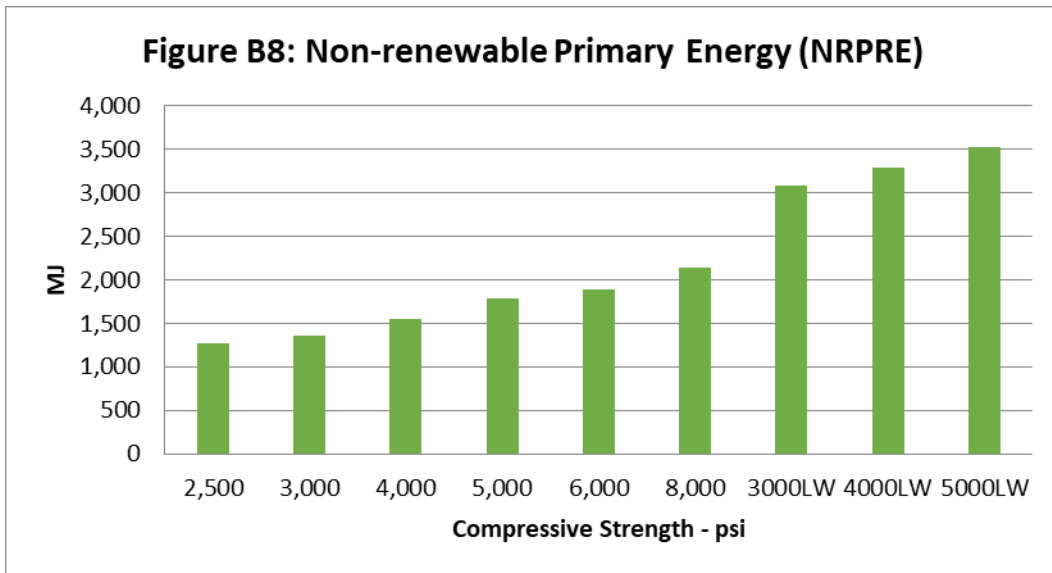
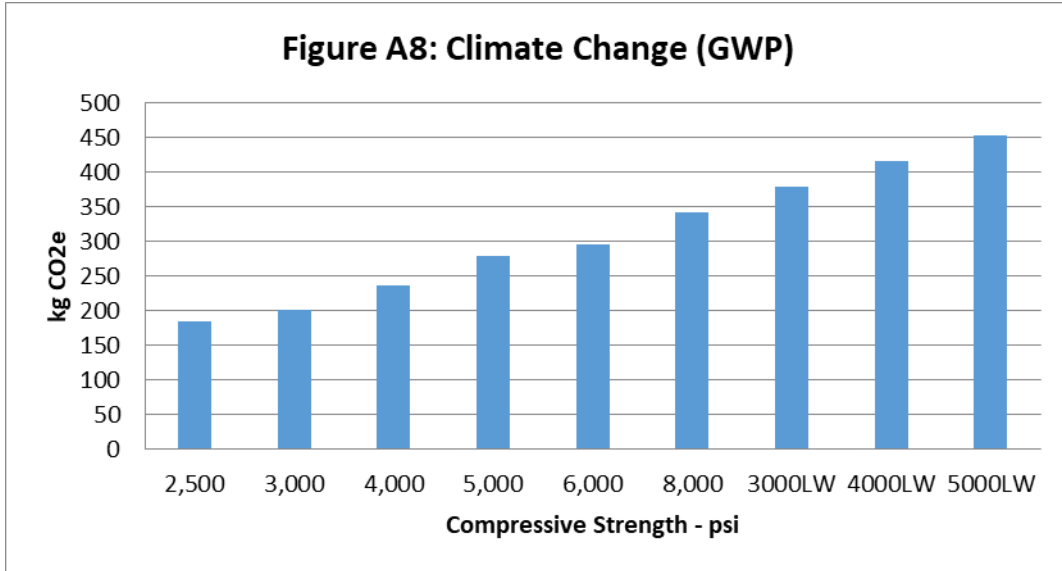
Table A8-South Central Production Data Summary		
Number of Plants	91	
% Transit Mix Plants	80%	
% Central Mix Plants	20%	
% Batch Waste	0.04%	
	yd3	m3
Average Production	49,568	37,897
Total Production	4,510,685	3,448,665
Minimum Production	263	201
Maximum Production	232,476	177,741

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	183.92	200.90	235.73	279.11	295.76	341.81	378.53	415.02	453.30
ODP	kg CFC11e	4.78E-06	5.20E-06	6.06E-06	7.12E-06	7.55E-06	8.67E-06	1.40E-05	1.49E-05	1.59E-05
AP	kg SO2e	0.64	0.69	0.77	0.88	0.93	1.05	1.89	1.99	2.10
EP	kg Ne	0.22	0.24	0.28	0.33	0.35	0.40	0.66	0.71	0.76
SFP	kg O3e	14.00	14.91	16.71	18.98	20.01	22.39	24.96	26.84	28.81
ADP <sub>f</sub>	MJ, NCV	921.21	1,002.02	1,171.76	1,387.02	1,469.78	1,699.26	2,552.44	2,741.72	2,949.73
ADP <sub>e</sub>	kg Sbe	1.88E-04	1.99E-04	2.20E-04	2.48E-04	2.61E-04	2.90E-04	2.45E-04	2.69E-04	2.93E-04
FFD	MJ Surplus	97.54	101.72	110.76	122.96	128.80	141.65	193.34	203.94	216.00
Use of Primary Resources										
RPRE	MJ, NCV	47.83	52.40	61.90	73.91	78.43	91.15	266.32	278.13	292.27
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,269.65	1,359.33	1,545.96	1,783.78	1,881.92	2,133.98	3,088.04	3,295.64	3,523.71
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	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	2.72	2.88	3.20	3.64	3.90	4.32	3.12	3.44	3.76
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	7.68E-07	7.63E-07	7.47E-07	7.32E-07	7.47E-07	7.27E-07	4.07E-07	3.99E-07	3.90E-07
LLRW	m3	8.75E-07	8.69E-07	8.51E-07	8.33E-07	8.52E-07	8.27E-07	1.99E-06	2.00E-06	2.02E-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



**D-9: South Eastern Region**

<b>Table A9-South Eastern Production Data Summary</b>		
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

<b>Table B9-South Eastern Benchmark Mix Designs (per cubic yard)</b>										
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	200.70	218.32	254.18	298.13	316.46	361.90	383.85	421.14	455.83
ODP	kg CFC11e	5.41E-06	5.85E-06	6.74E-06	7.83E-06	8.31E-06	9.43E-06	1.40E-05	1.50E-05	1.59E-05
AP	kg SO2e	0.72	0.76	0.86	0.99	1.04	1.17	1.89	2.00	2.10
EP	kg Ne	0.24	0.26	0.30	0.35	0.38	0.43	0.66	0.70	0.74
SFP	kg O3e	15.50	16.52	18.62	21.13	22.34	24.98	25.75	27.90	29.90
ADP <sub>f</sub>	MJ, NCV	1,015.96	1,100.21	1,275.65	1,494.44	1,586.29	1,813.36	2,549.64	2,743.22	2,919.56
ADP <sub>e</sub>	kg Sbe	2.12E-04	2.22E-04	2.44E-04	2.69E-04	2.84E-04	3.11E-04	2.60E-04	2.83E-04	3.04E-04
FFD	MJ Surplus	106.73	111.45	122.02	135.36	142.18	156.38	195.83	207.84	219.21
Use of Primary Resources										
RPRE	MJ, NCV	52.68	57.42	67.17	79.33	84.31	96.81	258.62	270.59	280.29
RPRM	MJ, NCV	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
NRPRE	MJ, NCV	1,398.72	1,494.35	1,694.63	1,942.29	2,053.27	2,311.74	3,102.88	3,322.41	3,522.76
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	3.15	3.31	3.64	4.09	4.38	4.79	3.53	3.85	4.16
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	1.14E-06	1.12E-06	1.10E-06	1.06E-06	1.08E-06	1.05E-06	5.83E-07	5.61E-07	5.43E-07
LLRW	m3	1.26E-06	1.24E-06	1.21E-06	1.16E-06	1.19E-06	1.15E-06	2.09E-06	2.08E-06	2.06E-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

