Recyclable Fine Aggregates in Concrete

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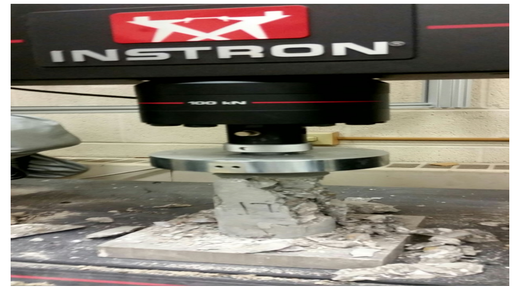
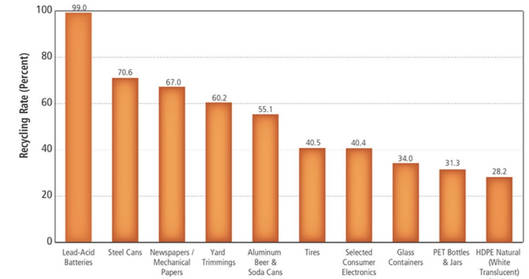


Introduction

In 2013, the U.S. generated an estimated 254 million tons of trash but only recycled 87 million tons of the total amount which is equivalent to about 34.3 percent. The material that are the least recycled the least were plastics at 13 percent, metal at 9 percent, and glass at 5 percent. With all the material that was recycled during that year it has reduced the amount of waste that put into landfills. Since the 1980's recycling materials has increased by 15 million tons and has lead to 186 million metric tons reduction of carbon dioxide emissions in the air. This is equivalent to about 39 million cars being removed off the road.[1]

Concrete is another material that is categorized as a waste and is recycled as well. Concrete is gathered after a demolition project of a structure and often sent to a crushing plant where concrete is fed into a crusher and the final product can come in various sizes. Typically the concrete can be crushed to the same size of normal aggregates which allows the recycled concrete to be replaced instead of the same size rocks and pebbles. Recycling concrete has benefits which allows to reduce construction costs and not put the old material into landfills.[2]



Methodology

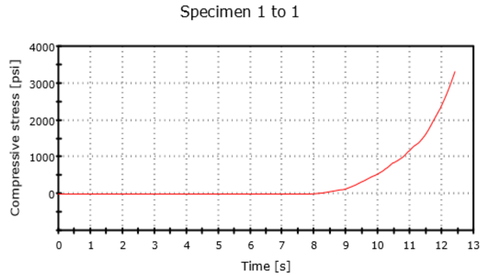
The research project focuses on being able to substitute a percentage of the fine aggregate (sand) with a recycled material such as : glass, metal, and plastic. The project was broken down into various steps in order to create a proper concrete mix:

- Slump Test (between 1-2 inches)
- Sieve Analysis for each material (Fineness moduli of fine aggregate and nominal maximum size of coarse aggregate)
- Amount of mixing water
- Amount of entrapped air (ignored)
- Desired Strength (3000 psi)
- Water-cement ratio by weight (0.68)
- Weight of cement
- No pozzolanic materials used (regular mix design)
- Unit weight of coarse aggregate
- Weight of coarse aggregate
- First estimate of concrete weight (lb/yd^3)
- Weight of fine aggregate
- Moisture contents
- No chemical admixture added
- Adjusted mix water
- Ingredient of concrete batch
- Mix design and pouring the concrete into 3 in. diameter cylinders
- Performing 7th & 28th day compression test

Project Breakdown & Overview

Case No.	Materials Used	Avg. Strength 7th Day (psi)	Avg. Strength 28th day (psi)
Case 1	Coarse Aggregate + Fine Aggregate	3143	4332
Case 2	ReC. Coarse Aggregate + Fine Aggregate	2598	3305
Case 3	Coarse Aggregate + ReC Fine Aggregate	2546	2492
Case 4	ReC. Coarse Aggregate + ReC. Fine Aggregate	1416	1517
Case 5	Coarse Aggregate + Fine Aggregate (glass)	1914	To be tested
Case 6	Coarse Aggregate + Fine Aggregate (plastic)	711	To be tested
Case 7	Coarse Aggregate + Fine Aggregate (metal)	716	To be tested

Compression Test

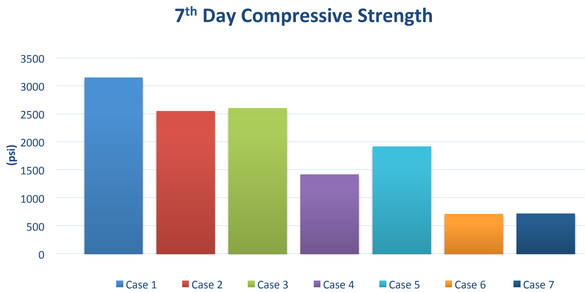


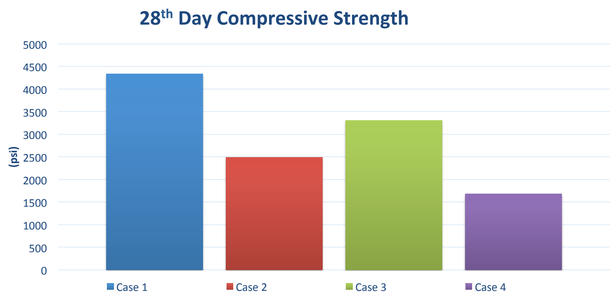
	Maximum Load [lbf]	Compressive extension at Maximum Load [in]	Load at Break (Standard) [lbf]	Compressive strain (Extension) at Break (Standard) [in/in]
1	23377.95	12.97526	23377.95022	2.16254
Coefficient of variation	-----	-----	-----	-----
Mean	23377.95	12.97526	23377.95022	2.16254
Standard deviation	-----	-----	-----	-----

Conclusions

- The mix designs were created for an proposed strength of 3000 psi and cases 2, 3, and 5 which included recycled materials seem to be good options to reduce construction costs.
- Mix cases with plastic and metals do not provide appropriate strength to be used as civil engineering materials.
- Further work will include fixing the mix design with different recycled material proportions to reach the projected goal.
- By doing this every structure that is being built will be able to reduce the amount of recycled material that would have gone into landfills

Compressive Strength Comparison





7th & 28th Day Results

Case Measurements

	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
1.7.1	3.79	3.04	3.10	3.07	5.90	5.96	5.93	43.83	149.50	22530.36	3047.67
1.7.2	3.83	3.04	3.05	3.05	5.95	5.98	5.97	43.47	152.05	23377.95	3208.17
1.7.3	3.92	3.03	3.03	3.03	6.03	6.03	6.03	44.13	153.59	23389.22	3196.06
1.7.4	3.80	3.06	3.06	3.06	5.94	5.91	5.93	43.49	150.83	22904.76	3120.63
										Avg:	3143.13

	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
2.7.1	3.64	3.08	3.03	3.06	6.01	6.00	6.01	44.10	142.67	19687.65	2681.46
2.7.2	3.59	3.03	3.08	3.06	5.98	5.98	5.98	43.82	141.58	18380.77	2507.56
2.7.3	3.58	3.06	3.07	3.06	5.95	5.95	5.95	43.85	141.16	17730.41	2405.43
2.7.4	3.59	3.03	3.03	3.03	6.05	6.07	6.06	44.19	140.38	18890.18	2589.78
										Avg:	2546.05

	Weight(lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
3.7.1	3.56	3.06	3.05	3.06	6.04	6.02	6.03	44.09	139.50	20110.39	2749.82
3.7.2	3.68	3.06	3.02	3.04	6.06	6.03	6.04	43.82	145.02	23505.00	3241.54
3.7.3	3.58	3.05	3.06	3.05	5.93	6.03	5.98	43.79	140.51	14908.70	2035.89
3.7.4	3.56	3.04	3.08	3.05	5.90	5.91	5.90	43.22	142.20	17308.73	2364.40
										Avg:	2597.91

	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
4.7.1	3.38	3.07	3.05	3.06	6.00	6.02	6.01	44.09	132.54	15577.22	2124.40
4.7.2	3.33	3.03	3.05	3.04	6.00	5.99	5.99	43.57	132.23	6670.42	917.52
4.7.3	3.31	3.01	3.08	3.05	5.99	6.04	6.02	44.07	129.83	10098.32	1378.27
4.7.4	3.32	3.03	3.04	3.03	6.02	6.02	6.02	44.06	130.06	10638.70	1453.27
										Avg:	1418.12

7 Day Glass	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
1	3.29	3.03	3.02	3.02	6.00	6.02	6.01	43.13	131.78	14750.00	2056.43
2	3.25	3.02	3.02	3.02	6.00	6.00	6.00	42.91	131.00	12500.00	1747.96
3	3.35	3.02	3.04	3.03	6.01	6.00	6.00	43.34	133.47	14000.00	1939.01
										Avg:	1914.28

7 Day Plastic	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
1	3.04	3.02	3.03	3.03	6.00	6.00	6.00	43.12	121.64	5000.00	695.71
2	2.97	3.02	3.03	3.02	6.00	6.00	6.00	42.97	119.55	5200.00	725.94
										Avg:	710.82

7 Day AL	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
1	3.47	3.06	3.06	3.06	6.04	6.02	6.03	44.42	134.86	5500.00	766.66
2	3.45	3.02	3.02	3.02	6.01	6.02	6.02	43.58	136.80	4750.00	655.93
3	3.34	3.03	3.05	3.04	6.02	6.03	6.02	43.70	132.20	5400.00	744.22
4	2.93	3.03	3.04	3.04	5.59	5.58	5.58	40.61	125.29	5300.00	732.99
										Avg:	715.60

	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
1.28.1	3.855	3.051	3.045	3.048	5.988	5.983	5.9855	43.67	152.53	36500.00	5002.34
1.28.2	3.8705	3.039	3.053	3.046	6.036	6.03	6.033	43.96	152.13	28250.00	3876.76
1.28.3	3.865	3.048	3.054	3.051	5.94	6.01	5.975	43.68	152.89	36000.00	4924.12
1.28.4	3.87	3.076	3.034	3.055	6.01	5.995	6.0025	44.00	151.99	30750.00	4195.01
										Avg:	4331.96

	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
2.28.1	3.576	3.08	3.038	3.059	6.018	6.012	6.015	44.21	139.78	20425.45	2779.22
2.28.2	3.616	3.035	3.083	3.059	5.99	5.97	5.98	43.95	142.17	16690.62	2271.03
2.28.3	3.5595	3.063	3.065	3.064	5.952	5.956	5.954	43.90	140.11	18697.93	2535.86
2.28.4	3.5555	3.037	3.064	3.0505	6.043	6.05	6.0465	44.19	139.03	17421.41	2383.70
										Avg:	2492.45

	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
3.28.1	3.61	3.042	3.064	3.053	5.998	6.036	6.017	44.05	141.62	23500.00	3210.14
3.28.2	3.6735	3.058	3.042	3.05	6.031	5.979	6.005	43.87	144.68	21000.00	2874.28
3.28.3	3.4405	3.045	3.039	3.042	5.917	5.884	5.9005	42.88	138.63	26000.00	3577.38
3.28.4	3.643	3.04	3.048	3.044	5.931	5.994	5.9625	43.39	145.08	22750.00	3126.10
										Avg:	3304.54

	Weight (lbs)	Diameter in"	Diameter 2	Average diameter	Height in"	Height 2 in"	Avg Height	Vol.	Density	Load	Strength
4.28.1	3.4345	3.058	3.049	3.0535	5.995	6.014	6.0045	43.97	134.97	11352.62	1550.28
4.28.2	3.398	3.038	3.057	3.0475	6.005	5.99	5.9975	43.75	134.22	10707.94	1468.01
4.28.3	3.3345	3.023	3.054	3.0385	5.992	6.04	6.016	43.62	132.09	15674.19	2161.61

References

[1] "Advancing Sustainable Materials Management: Facts and Figures." EPA. Environmental Protection Agency, n.d. Web. 13 Sept. 2016.http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_3.pdf

[2] Admin, Member Clicks. "Good Economic Sense." Concrete Recycling Home. n.p., n.d. Web. 14 Sept. 2016.

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