

Determining Factors that Affect Concrete Strength

Emily Conrad

10/16/2021

A. Purpose of Study

The purpose of this study is to determine which factors affect concrete strength. The factors examined in this study include Blast Furnace Slag, Fly Ash, Water, Super Plasticizer, Coarse Aggregate, Fine Aggregate, Age and Strength. By determining which factors have the strongest correlation or relationship with concrete strength we can conclude with factors are more closely related to the overall concrete strength.

H_0 : No relationship exists between factors and strength

H_A : A relationship does exist between a factor and strength

B. Analysis Plans

The analysis plans for this study will include running a descriptive statistical analysis on each factor, running a linear regression analysis to determine significance and correlation between a factor and concrete strength, and plotting the scatterplots for each factor and strength to look for linear trends. The significance level of 0.05 will help us to determine if a relationship exists between factors and concrete strength.

C. Descriptive Statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
Strength	35.8180	16.70574	1030
BlastFurnaceSlag	73.896	86.2793	1030
FlyAsh	54.188	63.9970	1030
Water	181.567	21.3542	1030
Superplasticizer	6.205	5.9738	1030
CoarseAggregate	972.919	77.7540	1030
FineAggregate	773.580	80.1760	1030

Assumptions of Linear Regression:

- Linear relationship
- Multivariate normality
- No or little multicollinearity
- Homoscedasticity

Case Summaries^a

	BlastFurn aceSlag	Fly Ash	Water	Super plastic izer	Coarse Aggreg ate	FineA ggreg ate	Age	Strength
1	.0	.0	162.0	2.5	1040.0	676.0	28	79.99
2	.0	.0	162.0	2.5	1055.0	676.0	28	61.89
3	142.5	.0	228.0	.0	932.0	594.0	270	40.27
4	142.5	.0	228.0	.0	932.0	594.0	365	41.05
5	132.4	.0	192.0	.0	978.4	825.5	360	44.30
6	114.0	.0	228.0	.0	932.0	670.0	90	47.03
7	95.0	.0	228.0	.0	932.0	594.0	365	43.70
8	95.0	.0	228.0	.0	932.0	594.0	28	36.45
9	114.0	.0	228.0	.0	932.0	670.0	28	45.85
10	.0	.0	228.0	.0	932.0	594.0	28	39.29
11	132.4	.0	192.0	.0	978.4	825.5	90	38.07
12	132.4	.0	192.0	.0	978.4	825.5	28	28.02
13	47.5	.0	228.0	.0	932.0	594.0	270	43.01
14	190.0	.0	228.0	.0	932.0	670.0	90	42.33
15	76.0	.0	228.0	.0	932.0	670.0	28	47.81
16	.0	.0	228.0	.0	932.0	670.0	90	52.91
17	209.4	.0	192.0	.0	1047.0	806.9	90	39.36

18	38.0	.0	228.0	.0	932.0	670.0	365	56.14
19	95.0	.0	228.0	.0	932.0	594.0	90	40.56
20	.0	.0	228.0	.0	932.0	594.0	180	42.62
21	47.5	.0	228.0	.0	932.0	594.0	180	41.84
22	209.4	.0	192.0	.0	1047.0	806.9	28	28.24
23	209.4	.0	192.0	.0	1047.0	806.9	3	8.06
24	209.4	.0	192.0	.0	1047.0	806.9	180	44.21
25	.0	.0	228.0	.0	932.0	670.0	365	52.52
26	.0	.0	228.0	.0	932.0	670.0	270	53.30
27	95.0	.0	228.0	.0	932.0	594.0	270	41.15
28	38.0	.0	228.0	.0	932.0	670.0	180	52.12
29	47.5	.0	228.0	.0	932.0	594.0	28	37.43
30	.0	.0	228.0	.0	932.0	594.0	7	38.60
31	76.0	.0	228.0	.0	932.0	670.0	365	55.26
32	114.0	.0	228.0	.0	932.0	670.0	365	52.91
33	132.4	.0	192.0	.0	978.4	825.5	180	41.72
34	.0	.0	228.0	.0	932.0	594.0	270	42.13
35	190.0	.0	228.0	.0	932.0	670.0	365	53.69
36	237.5	.0	228.0	.0	932.0	594.0	270	38.41
37	237.5	.0	228.0	.0	932.0	594.0	28	30.08
38	142.5	.0	228.0	.0	932.0	594.0	90	37.72
39	.0	.0	228.0	.0	932.0	594.0	90	42.23
40	237.5	.0	228.0	.0	932.0	594.0	180	36.25
41	38.0	.0	228.0	.0	932.0	670.0	90	50.46
42	47.5	.0	228.0	.0	932.0	594.0	365	43.70

43	237.5	.0	228.0	.0	932.0	594.0	365	39.00
44	.0	.0	228.0	.0	932.0	670.0	180	53.10
45	47.5	.0	228.0	.0	932.0	594.0	90	41.54
46	47.5	.0	228.0	.0	932.0	594.0	7	35.08
47	.0	.0	192.0	.0	1047.0	806.9	3	15.05
48	95.0	.0	228.0	.0	932.0	594.0	180	40.76
49	237.5	.0	228.0	.0	932.0	594.0	7	26.26
50	95.0	.0	228.0	.0	932.0	594.0	7	32.82
51	142.5	.0	228.0	.0	932.0	594.0	180	39.78
52	190.0	.0	228.0	.0	932.0	670.0	180	46.93
53	237.5	.0	228.0	.0	932.0	594.0	90	33.12
54	76.0	.0	228.0	.0	932.0	670.0	90	49.19
55	209.4	.0	192.0	.0	1047.0	806.9	7	14.59
56	132.4	.0	192.0	.0	978.4	825.5	7	14.64
57	.0	.0	228.0	.0	932.0	594.0	365	41.93
58	132.4	.0	192.0	.0	978.4	825.5	3	9.13
59	76.0	.0	228.0	.0	932.0	670.0	180	50.95
60	142.5	.0	228.0	.0	932.0	594.0	28	33.02
61	76.0	.0	228.0	.0	932.0	670.0	270	54.38
62	114.0	.0	228.0	.0	932.0	670.0	270	51.73
63	.0	.0	192.0	.0	971.0	850.6	3	9.87
64	190.0	.0	228.0	.0	932.0	670.0	270	50.66
65	114.0	.0	228.0	.0	932.0	670.0	180	48.70
66	38.0	.0	228.0	.0	932.0	670.0	270	55.06
67	209.4	.0	192.0	.0	1047.0	806.9	360	44.70

68	142.5	.0	228.0	.0	932.0	594.0	7	30.28
69	190.0	.0	228.0	.0	932.0	670.0	28	40.86
70	.0	.0	146.0	.0	1120.0	800.0	28	71.99
71	189.2	.0	170.1	10.1	926.1	756.7	3	34.40
72	262.2	.0	175.5	8.6	1046.9	611.8	3	28.80
73	106.3	.0	153.5	16.5	852.1	887.1	3	33.40
74	106.3	.0	151.4	18.6	936.0	803.7	3	36.30
75	93.8	.0	126.6	23.4	852.1	992.6	3	29.00
76	118.8	.0	181.1	8.9	852.1	781.5	3	37.80
77	117.2	.0	137.8	32.2	852.1	840.5	3	40.20
78	106.3	.0	153.5	16.5	852.1	887.1	3	33.40
79	97.1	.0	157.9	12.1	852.1	925.7	3	28.10
80	.0	.0	141.8	28.2	852.1	893.7	3	41.30
81	106.3	.0	153.5	16.5	852.1	887.1	3	33.40
82	212.5	.0	155.7	14.3	852.1	880.4	3	25.20
83	94.7	.0	147.4	11.4	946.8	852.1	3	41.10
84	189.0	.0	164.9	11.6	944.7	755.8	3	35.30
85	282.8	.0	183.8	10.3	942.7	659.9	3	28.30
86	151.2	.0	153.9	15.9	1134.3	605.0	3	28.60
87	189.0	.0	164.9	11.6	944.7	755.8	3	35.30
88	200.9	.0	144.7	11.2	1004.6	803.7	3	24.40
89	189.0	.0	164.9	11.6	944.7	755.8	3	35.30
90	177.0	.0	186.0	11.1	884.9	707.9	3	39.30
91	189.0	.0	145.9	22.0	944.7	755.8	3	40.60
92	189.0	.0	164.9	11.6	944.7	755.8	3	35.30

93	189.0	.0	174.9	9.5	944.7	755.8	3	24.10
94	189.2	.0	170.1	10.1	926.1	756.7	7	46.20
95	262.2	.0	175.5	8.6	1046.9	611.8	7	42.80
96	106.3	.0	153.5	16.5	852.1	887.1	7	49.20
97	106.3	.0	151.4	18.6	936.0	803.7	7	46.80
98	93.8	.0	126.6	23.4	852.1	992.6	7	45.70
99	118.8	.0	181.1	8.9	852.1	781.5	7	55.60
100	117.2	.0	137.8	32.2	852.1	840.5	7	54.90
Total	100	100	100	100	100	100	100	100

D. Results and Conclusions

Value of Pearson Correlation Coefficient and Strength

Absolute Value of r

$r < 0.3$

$0.3 < r < 0.7$

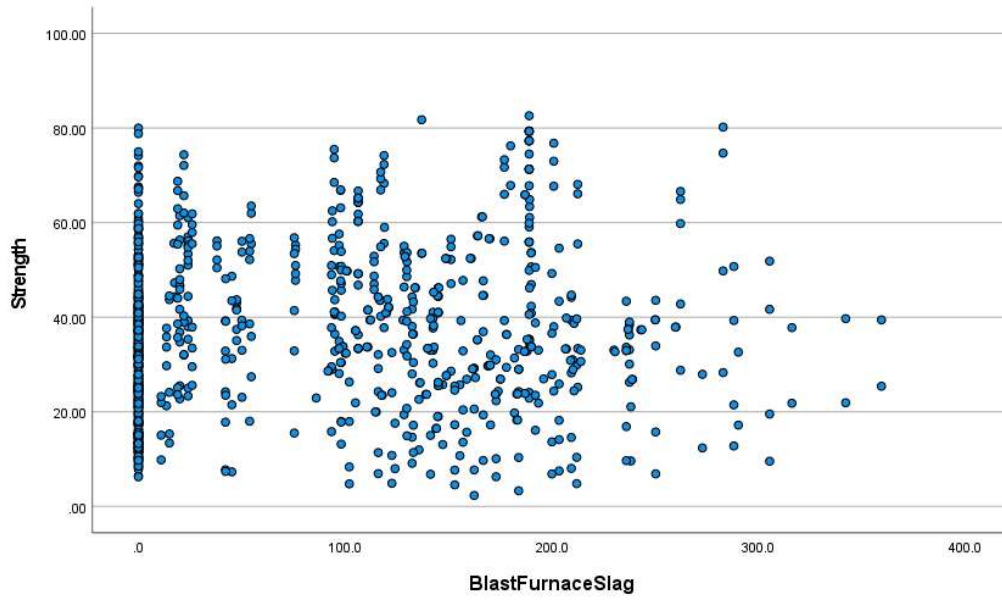
$r > 0.7$

Strength of Relationship

None or very weak

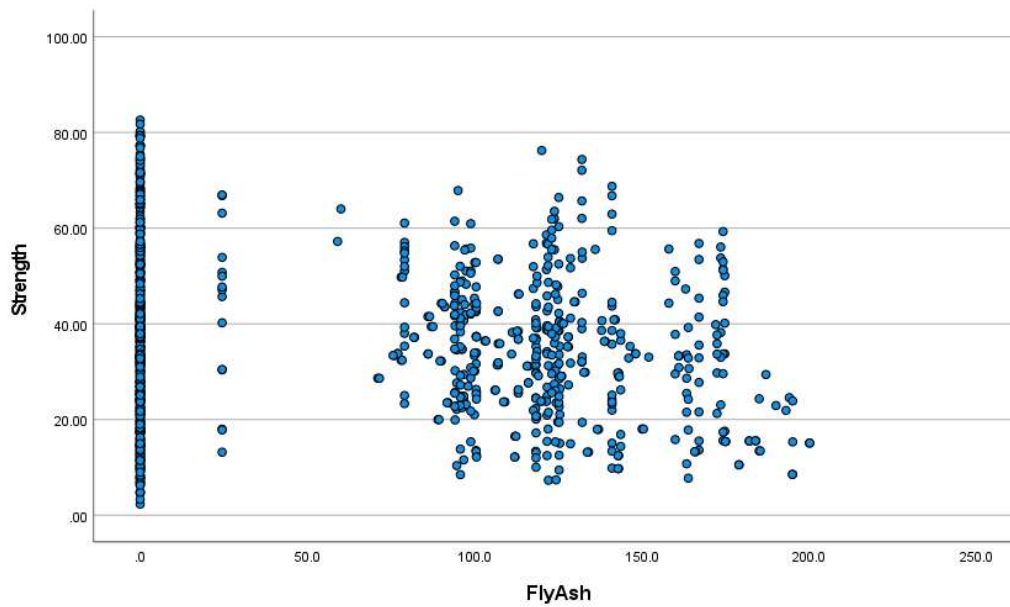
Moderate

Strong



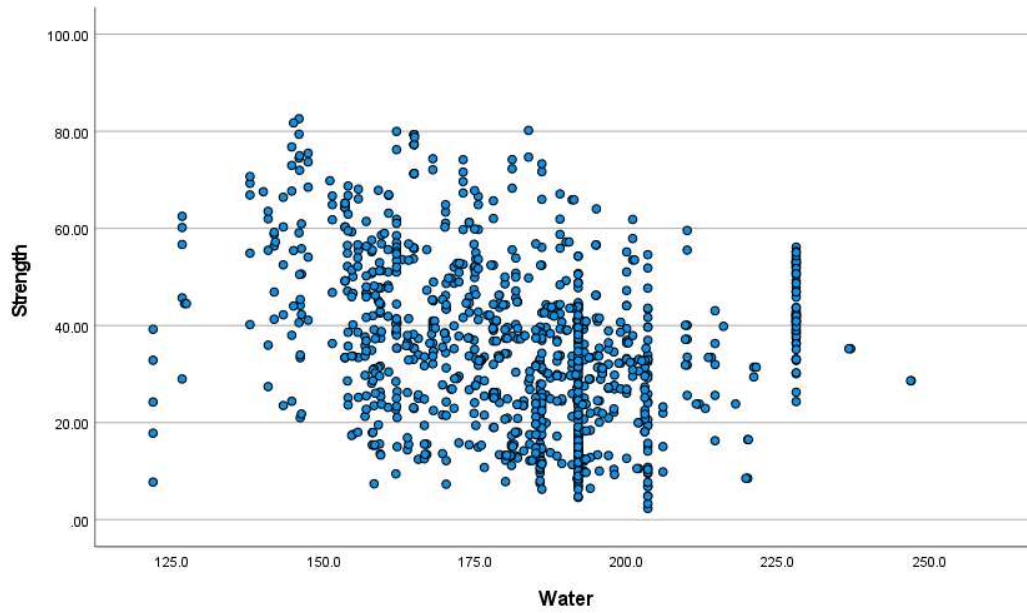
$r = 0.135 \rightarrow$ weak relationship

p-value = 0.000



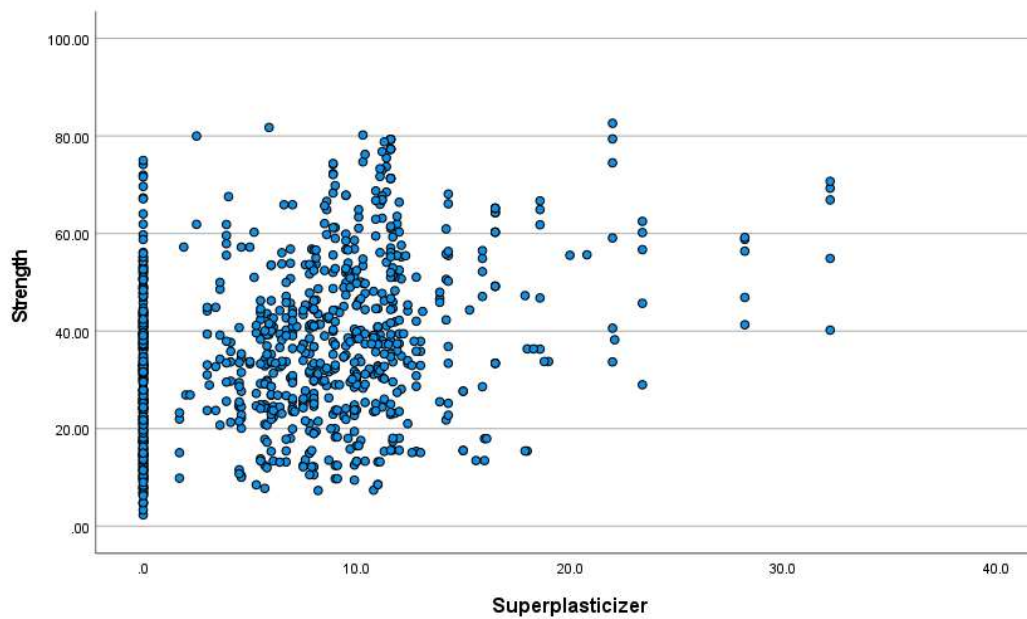
$r = -0.106 \rightarrow$ weak relationship

p-value = 0.001



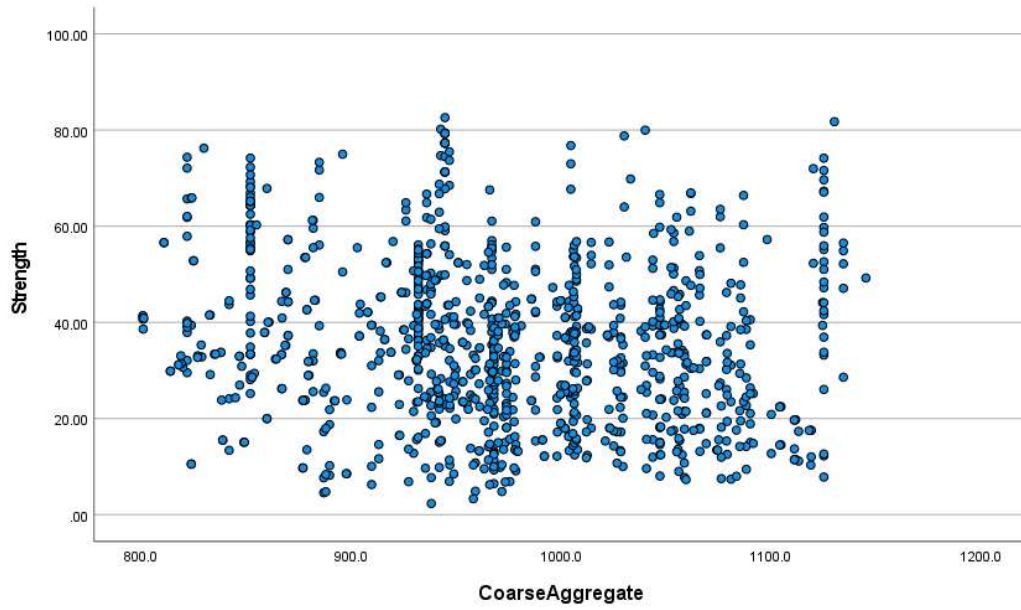
$r = -0.290 \rightarrow$ moderate relationship

p-value = 0.000



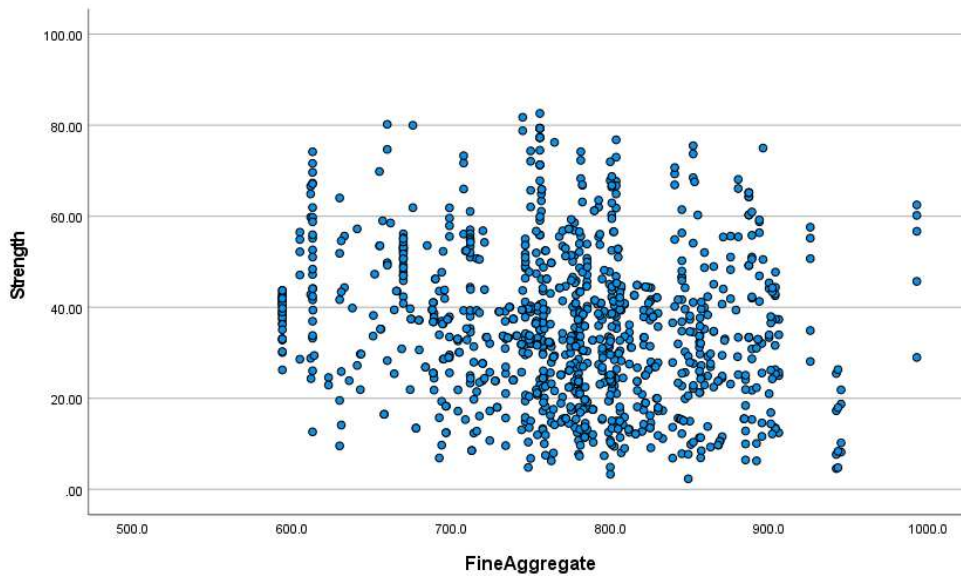
$r = 0.366 \rightarrow$ moderate relationship

p-value = 0.000



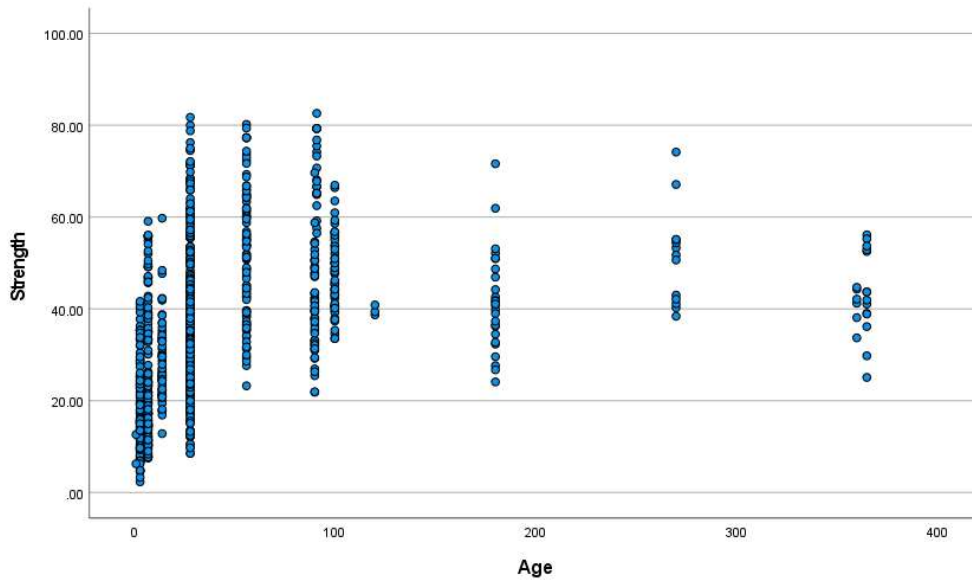
$r = -0.165 \rightarrow$ weak relationship

p-value = 0.000



$r = -0.167 \rightarrow$ weak relationship

p-value = 0.000



$r = 0.329 \rightarrow$ moderate relationship

p-value =

Correlations

		Strength	BlastFurnaceSlag	FlyAsh	Water
Pearson Correlation	Strength	1.000	.135	-.106	-.290
	BlastFurnaceSlag	.135	1.000	-.324	.107
	FlyAsh	-.106	-.324	1.000	-.257
	Water	-.290	.107	-.257	1.000
	Superplasticizer	.366	.043	.378	-.658
	CoarseAggregate	-.165	-.284	-.010	-.182
	FineAggregate	-.167	-.282	.079	-.451
Sig. (1-tailed)	Strength	.	.000	.000	.000
	BlastFurnaceSlag	.000	.	.000	.000
	FlyAsh	.000	.000	.	.000
	Water	.000	.000	.000	.
	Superplasticizer	.000	.083	.000	.000
	CoarseAggregate	.000	.000	.375	.000
	FineAggregate	.000	.000	.006	.000
N	Strength	1030	1030	1030	1030
	BlastFurnaceSlag	1030	1030	1030	1030

	FlyAsh	1030	1030	1030	1030
	Water	1030	1030	1030	1030
	Superplasticizer	1030	1030	1030	1030
	CoarseAggregate	1030	1030	1030	1030
	FineAggregate	1030	1030	1030	1030

Correlations

		Superplasticizer	CoarseAggregate	FineAggregate
Pearson Correlation	Strength	.366	-.165	-.167
	BlastFurnaceSlag	.043	-.284	-.282
	FlyAsh	.378	-.010	.079
	Water	-.658	-.182	-.451
	Superplasticizer	1.000	-.266	.223
	CoarseAggregate	-.266	1.000	-.178
	FineAggregate	.223	-.178	1.000
Sig. (1-tailed)	Strength	.000	.000	.000
	BlastFurnaceSlag	.083	.000	.000
	FlyAsh	.000	.375	.006
	Water	.000	.000	.000
	Superplasticizer	.	.000	.000
	CoarseAggregate	.000	.	.000
	FineAggregate	.000	.000	.
N	Strength	1030	1030	1030
	BlastFurnaceSlag	1030	1030	1030
	FlyAsh	1030	1030	1030
	Water	1030	1030	1030
	Superplasticizer	1030	1030	1030
	CoarseAggregate	1030	1030	1030
	FineAggregate	1030	1030	1030

All the factors included in this study have some type of relationship with the final strength of concrete. The three factors that have the strongest relationship with strength include age, water, and superplasticizer. Age and superplasticizer have positive correlation coefficients so as we increase the age or amount of superplasticizer the concrete strength increases. Water has a negative correlation coefficient so as we increase water the strength of the concrete decreases. Therefore, less water correlates with increased concrete

strength. To maximize strength, it might make sense to design an experiment that optimizes these three factors or water, age, and superplasticizer to find the optimal parameter levels that maximize concrete strength.