

EARLY AGE AND LONG TERM STRENGTH
OF MIXES MADE WITH STALITE
LIGHTWEIGHT AGGREGATE

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RESEARCH LAB
GOLD HILL, NORTH CAROLINA



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On May 28, 2003 three concrete mixes were produced at Carolina Stalite's laboratory in Gold Hill, North Carolina. The mixes were similar to those recommend by Stalite for 3000, 4000 and 5000-psi concrete production. The mixes were labeled LW 1, which is a standard 3000 psi mix design recommended by Stalite, LW 2, which is a standard 3000 psi mix design recommended by Stalite, LW 3, which is a standard 3000 psi mix design recommended by Stalite, and NW which is a typical 3500 to 4000 psi normal weight mix design. The materials used for the mixes were Lafarge Type I/II cement, Hedrick concrete sand from Lilesville North Carolina, normal weight #67 stone from Vulcan Materials Cabarrus Quarry, Stalite ¾" to #4 rotary kiln expanded slate lightweight aggregate and local water. The mix proportions and fresh properties are list below.

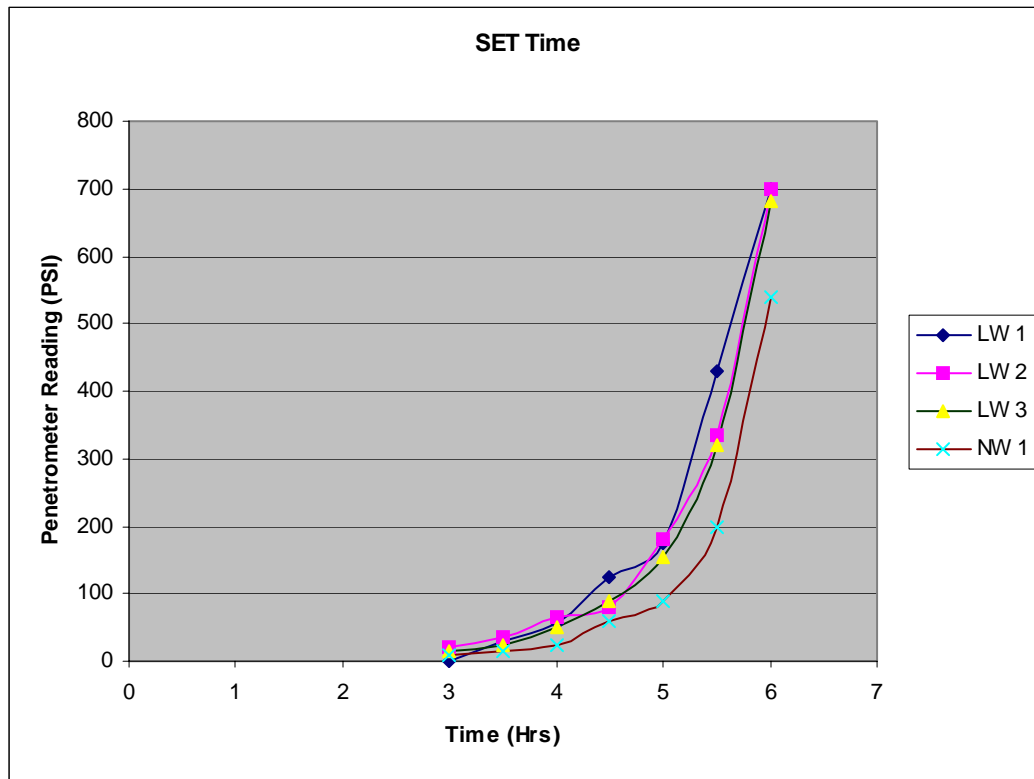
Mix Design				
Material	LW 1	LW 2	LW 3	NW 1
Cement	564	658	752	564
Stalite ¾" Lightweight	850	850	850	0
Normal weight Stone	0	0	0	1775
Natural Sand	1425	1347	1247	1180
Water	296	296	304	304
WRDA 35 oz/cmt	5.0	5.0	5.0	5.0
AEA 1400 oz/cmt	0.5	0.5	0.5	0.5

Fresh Properties				
Material	LW 1	LW 2	LW 3	NW 1
Slump (in.)	3.0	4.0	5.0	4.75
Air Content (%)	2.5	3.0	2.5	2.25
Temperature(° F)	77	79.7	76.2	76.2
Plastic Density (pcf)	121.8	119.8	120.3	151.3

The set time of the above concrete mixtures was determined in accordance with ASTM standards.

Set Time				
Time (Hours)	Penetrometer Reading (psi)			
	LW 1	LW 2	LW 3	NW 1
3	0	20	15	10
3.5	30	35	25	15
4	55	65	50	25
4.5	125	80	90	60
5	175	180	155	90
5.5	430	335	320	200
6	700	700	680	540

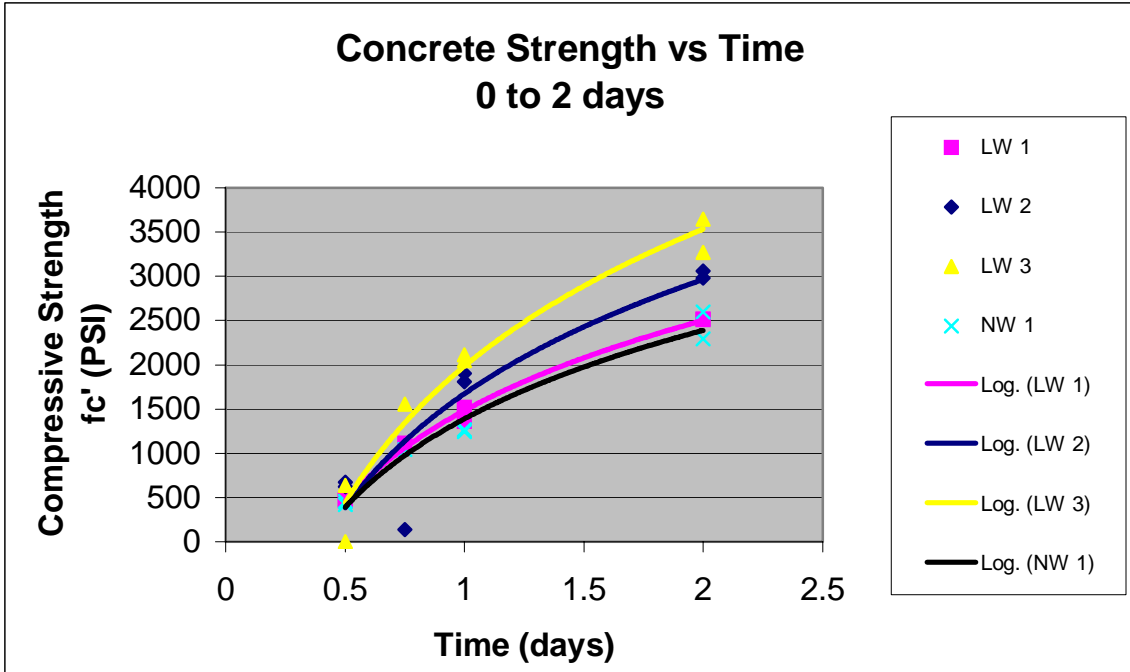
The results show a similar set time for the lightweight concrete mixtures and the normal weight comparison mixture.



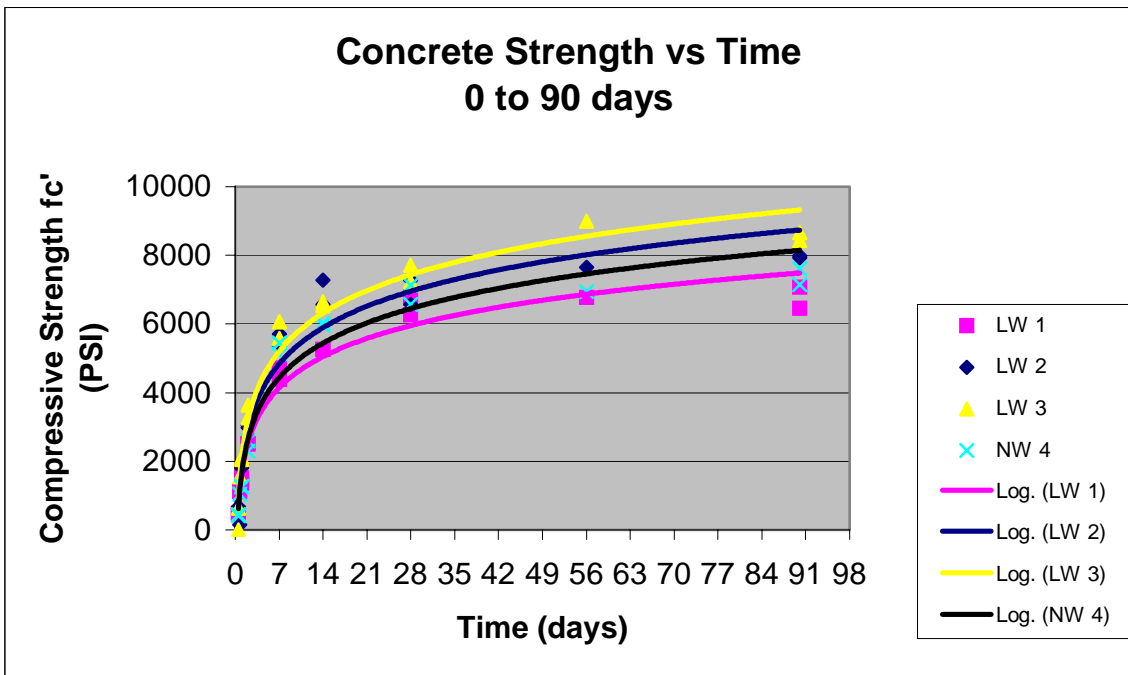
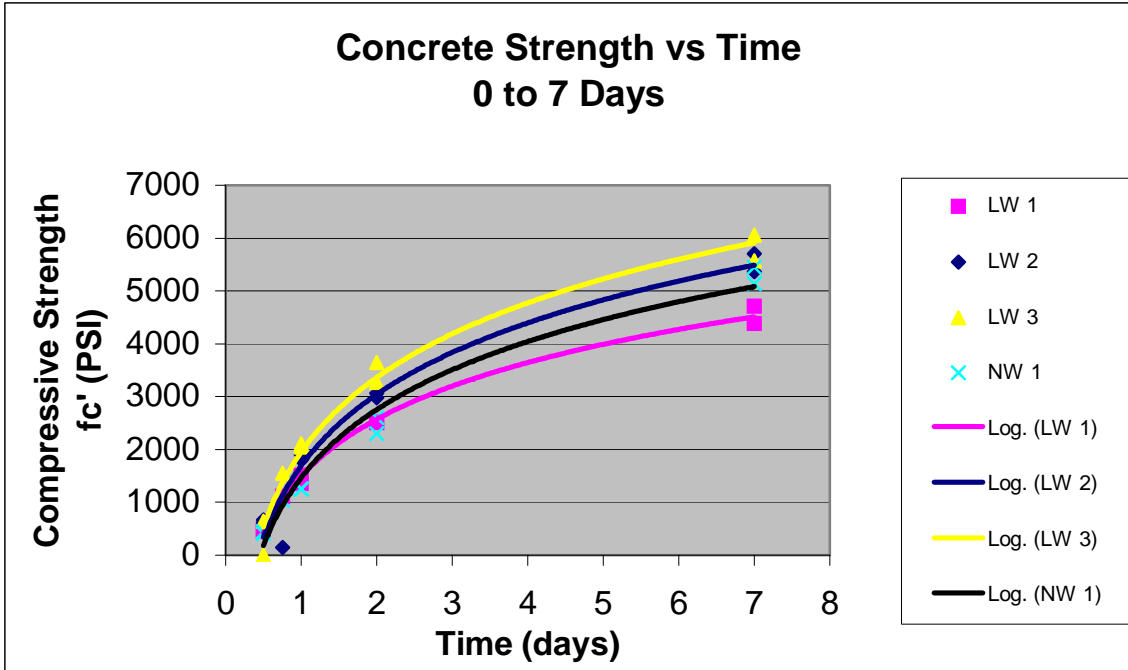
The compressive strength of the mixtures was determined in accordance with ASTM standards.

Compressive Strength (psi)				
Time	LW 1	LW 2	LW 3	NW 1
12 hr	460	622	648	417
12 hr	477	670	636	452
18 hr	1115	1141	1152	1038
24 hr	1362	1810	2047	1264
24 hr	1518	1899	2112	1247
48 hr	2509	2981	3644	2296
48 hr	2521	3060	3268	2600

The lightweight mixtures show compressive strengths similar to the normal weight comparison mixture at 48 hours. For precast/prestress applications this is important in determining bed turnaround times. With the lightweight concrete mixes tested using expanded slate lightweight aggregate the bed turnaround time can be estimated the same as for similar normal weight concrete mixtures.



Compressive Strength (psi)				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	4715	5704	6055	5138
28 DAYS	6817	5362	5575	5445
28 DAYS	6276	6565	7699	6575
56 DAYS	6764	7268	7229	7118
90 DAYS	7066	7642	8986	6946
90 DAYS	6454	7980	8658	7143
180 DAYS	6783	7925	8426	7615
180DAYS	7294	8406	8905	7502
365 DAYS	7592	7896	8572	7440
365 DAYS	7522	8019	8756	7350



The Modulus of elasticity of the concrete mixtures was determined in accordance with ASTM standards. The cylinders were moist cured until testing age. 4"x8" cylinders were tested at 7, 28, 56, 90, 180 and 365 days. The unit weight of the mixtures was determined in accordance with ASTM C567. The following tables show the concrete compressive strength, modulus of elasticity and density at ages of 7 to 365 days. The tables also show the calculated modulus of elasticity

based on the Georgia institute of technology document, the ACI 363 modified prediction model and the ACI 318 model referenced in ACI 213.

Modulus of Elasticity (psi)				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	2.81E+06	2.94E+06	3.10E+06	3.70E+06
28 DAYS	3.42E+06	2.87E+06	2.80E+06	3.99E+06
28 DAYS	3.18E+06	3.33E+06	3.58E+06	4.04E+06
56 DAYS	3.35E+06	3.60E+06	3.40E+06	3.95E+06
90 DAYS	3.53E+06	3.39E+06	3.46E+06	4.31E+06
90 DAYS	3.38E+06	3.50E+06	3.63E+06	4.49E+06
180 DAYS	3.74E+06	3.78E+06	3.70E+06	4.33E+06
180DAYS	3.70E+06	3.49E+06	3.87E+06	4.60E+06
365 DAYS	3.37E+06	3.61E+06	3.69E+06	4.73E+06
365 DAYS	3.47E+06	3.44E+06	3.71E+06	5.09E+06

The positive numbers in the variance charts below represent overestimation by the models and negative numbers represent underestimations by the models. The tables below show that the ACI 363 model is the most accurate prediction of modulus of elasticity for lightweight concrete with compressive strengths in the range tested. The testing showed that the ACI 318 model overestimated the modulus of elasticity for expanded slate lightweight aggregate concrete by about 10% on average. The testing showed the Georgia Institute of Technology model to be extremely accurate at strengths above 8000 psi.

Modulus of Elasticity Predicted by ACI 318				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	3.13E+06	3.42E+06	3.49E+06	4.42E+06
28 DAYS	3.71E+06	3.32E+06	3.35E+06	4.55E+06
28 DAYS	3.56E+06	3.63E+06	3.91E+06	4.96E+06
56 DAYS	3.65E+06	3.81E+06	3.79E+06	5.16E+06
90 DAYS	3.72E+06	3.89E+06	4.17E+06	5.07E+06
90 DAYS	3.56E+06	3.93E+06	4.08E+06	5.13E+06
180 DAYS	3.62E+06	3.92E+06	4.02E+06	5.30E+06
180DAYS	3.76E+06	4.00E+06	4.10E+06	5.21E+06
365 DAYS	3.82E+06	3.88E+06	4.02E+06	5.19E+06
365 DAYS	3.80E+06	3.90E+06	4.06E+06	5.16E+06

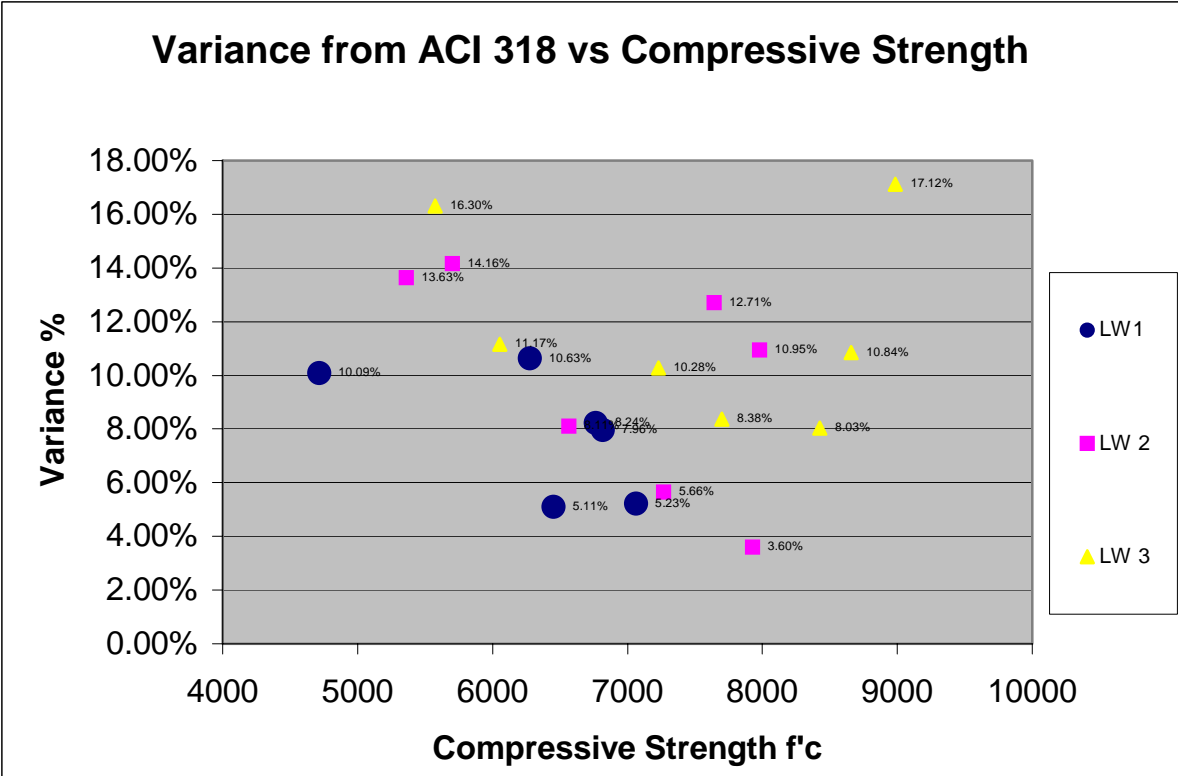
Modulus of Elasticity Variance from ACI 318				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	10.09%	14.16%	11.17%	16.22%
28 DAYS	7.96%	13.63%	16.30%	12.16%
28 DAYS	10.63%	8.11%	8.38%	18.47%
56 DAYS	8.24%	5.66%	10.28%	23.49%
90 DAYS	5.23%	12.71%	17.12%	14.91%
90 DAYS	5.11%	10.95%	10.84%	12.39%
180 DAYS	-3.33%	3.60%	8.03%	18.16%
180DAYS	1.40%	12.70%	5.55%	11.61%
365 DAYS	11.87%	6.82%	8.22%	8.90%
365 DAYS	8.70%	11.90%	8.51%	1.27%

Modulus of Elasticity Predicted by ACI 363 modified				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	2.96E+06	3.16E+06	3.20E+06	4.13E+06
28 DAYS	3.36E+06	3.09E+06	3.10E+06	4.22E+06
28 DAYS	3.25E+06	3.29E+06	3.48E+06	4.51E+06
56 DAYS	3.31E+06	3.42E+06	3.40E+06	4.64E+06
90 DAYS	3.35E+06	3.47E+06	3.66E+06	4.57E+06
90 DAYS	3.24E+06	3.49E+06	3.59E+06	4.61E+06
180 DAYS	3.28E+06	3.49E+06	3.55E+06	4.73E+06
180DAYS	3.37E+06	3.54E+06	3.60E+06	4.66E+06
365 DAYS	3.41E+06	3.45E+06	3.55E+06	4.65E+06
365 DAYS	3.40E+06	3.46E+06	3.57E+06	4.62E+06

Modulus of Elasticity Variance from ACI 363				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	5.06%	7.10%	3.15%	10.52%
28 DAYS	-1.77%	7.25%	9.67%	5.49%
28 DAYS	2.14%	-1.15%	-2.72%	10.24%
56 DAYS	-1.37%	-5.08%	0.13%	14.99%
90 DAYS	-5.22%	2.22%	5.53%	5.71%
90 DAYS	-4.25%	-0.22%	-1.23%	2.61%
180 DAYS	-14.18%	-8.42%	-4.12%	8.36%
180DAYS	-9.87%	1.18%	-7.56%	1.19%
365 DAYS	1.35%	-4.75%	-4.10%	-1.74%
365 DAYS	-2.08%	0.79%	-4.01%	-10.11%

Modulus of Elasticity Predicted by Georgia Tech Model				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	3.43E+06	3.55E+06	3.56E+06	3.56E+06
28 DAYS	3.65E+06	3.50E+06	3.51E+06	3.51E+06
28 DAYS	3.59E+06	3.62E+06	3.73E+06	3.73E+06
56 DAYS	3.62E+06	3.69E+06	3.68E+06	3.68E+06
90 DAYS	3.65E+06	3.72E+06	3.82E+06	3.82E+06
90 DAYS	3.58E+06	3.73E+06	3.78E+06	3.78E+06
180 DAYS	3.60E+06	3.72E+06	3.76E+06	3.76E+06
180DAYS	3.66E+06	3.75E+06	3.79E+06	3.79E+06
365 DAYS	3.68E+06	3.70E+06	3.76E+06	3.76E+06
365 DAYS	3.67E+06	3.71E+06	3.77E+06	3.77E+06

Modulus of Elasticity Variance from Georgia Tech Model				
Time	LW 1	LW 2	LW 3	NW 1
7 DAYS	18.05%	17.10%	13.01%	11.47%
28 DAYS	6.50%	18.18%	20.09%	5.49%
28 DAYS	11.44%	7.88%	3.92%	7.34%
56 DAYS	7.46%	2.53%	7.63%	10.97%
90 DAYS	3.27%	8.71%	9.62%	1.93%
90 DAYS	5.73%	6.07%	3.93%	-1.73%
180 DAYS	-3.88%	-1.49%	1.66%	3.17%
180DAYS	-1.27%	6.85%	-2.23%	-3.75%
365 DAYS	8.50%	2.35%	1.73%	-6.67%
365 DAYS	5.47%	7.35%	1.49%	-15.19%



E-Modulus vs Concrete Strength Lightweight Mixes

