Material Science & Engineering Journal

Research Article
Published: 28 Jun, 2019

Modeling Strain Development of Concrete Strength Modified with Fly Ash and Super Plasticizer

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Abstract

The study purpose of this Study is to monitor the growth rate of strain from modification of concrete with fly ash and super plasticizer, the study express the behavior of strain under the influences of these additive's, the research work provided the platform whereby the strain can be monitored considering some predominant concrete characteristics such as void ratios, porosity and water cement ratios. These are reflected on the variation of strain as expressed from the figures, linear trend were observed, but variation of strain were also experienced in various figures, the study observed the behavior of strain in concrete, such subjection of stress are through an applied load that generates cracks on concrete when tensile strain exceed its capacity. Measuring the deformation of these materials is though the applied load, the study has experienced strain behavior on concrete when combined with materials characteristic modulus. These condition were observed on the study through the developed model modified with fly ash and super plasticizer, the results express how these parameters affect strain from mixed designed concrete, predictive values were simulated numerically to determine the strain at every twenty four hours, this were to monitor strain increase within twenty four hours to the optimum values recorded at ninety days, predictive values were subjected to validation, and both parameters generated best fits correlation.

Keywords: Modeling Strain; Fly ash; Super plasticizers

Introduction

High-Strength Concrete Mechanical properties (HSC) can be separated in two groups as short-term these are mechanical properties and long-term mechanical properties. Concrete stress strain from HSC depends on the design mode that determined the behavior of the material parameters, these includes aggregate type and experimental parameters such as age at testing, strain level including its interaction between specimen and testing machine. The stress-strain model applied for NSC cannot be lengthy for application in HSC through nature of the loading curve changes significantly [1-3]. Rising of steeper sudden develop drop in strength after maximum value presents difficulty in numerical modeling of stress-strain behavior of HSC. Aitcin recommends that HSC performs like a real composite material and its equivalents of stress-strain can be drawn to the behavior applied in rock mechanic [4,5]. it is investigated reported that there is less internal micro cracking in HSC than NSC for the same axial strain imposed, HSC are observed to experience less lateral strain, and consequently efficiency of internment on compressive strength of HSC is frequently limited compared to NSC. Reducing w/c ratio increases the strength of concrete [6]. Nevertheless, the strength of hydrated cement is low associated with the strength of coarse aggregates. Comparing two strengths it become necessary obvious that decreasing w/c ratio doesn't increase the strength significantly, strength of HSC developed better performances, it necessary that strength and quality of coarse aggregates should experiences increased, in addition to other factors. Typically, w/c ratios between 0.2 to 0.4 are used for HSC. Further it observed that Low w/c ratio reduces the workability. Observed that an influence of silica fume on strength development of HSC is most prominent during 7 to 28 days after mixing [7]. Measured compressive strength of HSC is determined based on testing variables, namely, mold type, specimen size, end conditions and strain rate. 4 × 8 in. (102 mm × 204 mm) cylinder specimens have been shown to produce [8,9]. Defines the secant modulus of elasticity as the ratio of stress and strain at 40% of the compressive strength. As strength of concrete increases, its modulus of elasticity increases as well. Poisson's ratio is not affected by compressive strength, curing method and age of concrete [10-15].

Theoretical Background

$$\frac{dc}{dx} + A_{(x)}C_{(d)} = K_{(x)}C_d{}^n ; n \geq 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

OPEN ACCESS

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Received Date: *20 May 2019*
Accepted Date*: 25 Jun 2019*
Published Date*: 28 Jun 2019*

Citation:
Eluozo SN. Modeling Strain Development of Concrete Strength Modified with Fly Ash and Super Plasticizer. Mater Sci Eng J. 2019; 2(1): 1008.

Table 1: Predictive and Experimental Values of Strain-Stress at Different Curing Age.

Curing Age	Predictive Strain-Stress Values	Experimental Strain-Stress Values
7	8.59E-04	0.000703
8	9.81E-04	0.000803
9	1.10E-03	0.000903
10	1.27E-03	0.001003
11	1.35E-03	0.001103
12	1.47E-03	0.001203
13	1.60E-03	0.001303
14	1.71E-03	0.001403
15	1.84E-03	0.001503
16	1.96E-03	0.001603
17	2.09E-03	0.001703
18	2.21E-03	0.001803
19	2.33E-03	0.001903
20	2.45E-03	0.002003
21	2.58E-03	0.002103
22	2.70E-03	0.002203
23	2.82E-03	0.002303
24	2.94E-03	0.002403
25	3.07E-03	0.002503
26	3.19E-03	0.002603
27	3.31E-03	0.002703
28	3.44E-03	0.002803
29	3.56E-03	0.002903
30	3.68E-03	0.003003
31	3.80E-03	0.003103
32	3.93E-03	0.003203
33	4.05E-03	0.003303
34	4.17E-03	0.003403
35	4.29E-03	0.003503
36	4.42E-03	0.003603
37	4.54E-03	0.003703
38	4.66E-03	0.003803
39	4.79E-03	0.003903
40	4.91E-03	0.004003
41	5.03E-03	0.004103
42	5.15E-03	0.004203
43	5.28E-03	0.004303
44	5.40E-03	0.004403
45	5.52E-03	0.004503
46	5.64E-03	0.004603
47	5.77E-03	0.004703
48	5.89E-03	0.004803
49	6.01E-03	0.004903
50	6.14E-03	0.005003
51	6.26E-03	0.005103
52	6.38E-03	0.005203
53	6.50E-03	0.005303
54	6.63E-03	0.005403
55	6.75E-03	0.005503
56	6.87E-03	0.005603
57	6.99E-03	0.005703
58	7.12E-03	0.005803
59	7.24E-03	0.005903
60	7.36E-03	0.006003

Table 2: Predictive and Experimental Values of Strain-Stress at Different Curing Age.

Curing Age	Predictive Strain-Stress Values	Experimental Strain-Stress Values
7	0.000703	0.000702
8	0.000803	0.000802
9	0.000903	0.000902
10	0.001003	0.001002
11	0.001103	0.001102
12	0.001203	0.001202
13	0.001303	0.001302
14	0.001403	0.001402
15	0.001503	0.001502
16	0.001623	0.001602
17	0.001713	0.001702
18	0.001813	0.001802
19	0.001913	0.001902
20	0.002113	0.002002
21	0.002123	0.002102
22	0.002213	0.002202
23	0.002323	0.002302
24	0.002423	0.002402
25	0.002523	0.002502
26	0.002613	0.002602
27	0.002713	0.002702
28	0.002833	0.002802
29	0.002933	0.002902
30	0.003113	0.003002
31	0.003123	0.003102
32	0.003203	0.003202
33	0.003323	0.003302
34	0.003433	0.003402
35	0.003533	0.003502
36	0.003623	0.003602
37	0.003753	0.003702
38	0.003863	0.003802
39	0.003943	0.003902
40	0.004113	0.004002
41	0.004123	0.004102
42	0.004233	0.004202
43	0.004333	0.004302
44	0.004423	0.004402
45	0.004523	0.004502
46	0.004623	0.004602
47	0.004713	0.004702
48	0.004823	0.004802
49	0.004943	0.004902
50	0.005113	0.005002
51	0.005133	0.005102
52	0.005243	0.005202
53	0.005323	0.005302
54	0.005463	0.005402
55	0.005553	0.005502
56	0.005653	0.005602
57	0.005743	0.005702
58	0.005833	0.005802
59	0.005923	0.005902
60	0.006123	0.006002

Table 3: Predictive and Experimental Values of Strain-Stress at Different Curing Age.

Curing Age	Predictive Strain-Stress Values	Experimental Strain-Stress Values
7	8.59E-04	0.0007
8	9.82E-04	0.0008
9	1.10E-03	0.0009
10	1.23E-03	0.001
11	1.35E-03	0.0011
12	1.47E-03	0.0012
13	1.60E-03	0.0013
14	1.72E-03	0.0014
15	1.84E-03	0.0015
16	1.96E-03	0.0016
17	2.09E-03	0.0017
18	2.21E-03	0.0018
19	2.33E-03	0.0019
20	2.45E-03	0.002
21	2.58E-03	0.0021
22	2.70E-03	0.0022
23	2.82E-03	0.0023
24	2.94E-03	0.0024
25	3.07E-03	0.0025
26	3.19E-03	0.0026
27	3.31E-03	0.0027
28	3.44E-03	0.0028
29	3.56E-03	0.0029
30	3.68E-03	0.003
31	3.80E-03	0.0031
32	3.93E-03	0.0032
33	4.05E-03	0.0033
34	4.17E-03	0.0034
35	4.29E-03	0.0035
36	4.42E-03	0.0036
37	4.54E-03	0.0037
38	4.66E-03	0.0038
39	4.79E-03	0.0039
40	4.91E-03	0.004
41	5.03E-03	0.0041
42	5.15E-03	0.0042
43	5.28E-03	0.0043
44	5.40E-03	0.0044
45	5.52E-03	0.0045
46	5.64E-03	0.0046
47	5.77E-03	0.0047
48	5.89E-03	0.0048
49	6.01E-03	0.0049
50	6.13E-03	0.005
51	6.26E-03	0.0051
52	6.38E-03	0.0052
53	6.50E-03	0.0053
54	6.63E-03	0.0054
55	6.75E-03	0.0055
56	6.87E-03	0.0056
57	6.99E-03	0.0057
58	7.12E-03	0.0058
59	7.24E-03	0.0059
60	7.36E-03	0.006

Table 4: Predictive and Experimental Values of Strain-Stress at Different Curing Age.

Curing Age	Predictive Strain Values	Predictive Strain-Stress Values	Experimental Strain-Stress Values
7	0.0086098	0.008403	8.58E-03
8	0.0098128	0.009603	9.81E-03
9	0.0110162	0.010803	1.14E-02
10	0.01222	0.012003	1.27E-02
11	0.0134242	0.013203	1.35E-02
12	0.0146288	0.014403	1.47E-02
13	0.0158338	0.015603	1.60E-02
14	0.0170392	0.016803	1.72E-02
15	0.018245	0.018003	1.84E-02
16	0.0194512	0.019203	1.96E-02
17	0.0206578	0.020403	2.09E-02
18	0.0218648	0.021603	2.21E-02
19	0.0230722	0.022803	2.33E-02
20	0.02428	0.024003	2.45E-02
21	0.0254882	0.025203	2.58E-02
22	0.0266968	0.026403	2.67E-02
23	0.0279058	0.027603	2.82E-02
24	0.0291152	0.028803	2.94E-02
25	0.030325	0.030003	3.07E-02
26	0.0315352	0.031203	3.19E-02
27	0.0327458	0.032403	3.31E-02
28	0.0339568	0.033603	3.44E-02
29	0.0351682	0.034803	3.56E-02
30	0.03638	0.036003	3.56E-02
31	0.0375922	0.037203	3.68E-02
32	0.0388048	0.038403	3.93E-02
33	0.0400178	0.039603	4.04E-02
34	0.0412312	0.040803	4.17E-02
35	0.042445	0.042003	4.29E-02
36	0.0436592	0.043203	4.42E-02
37	0.0448738	0.044403	4.54E-02
38	0.0460888	0.045603	4.66E-02
39	0.0473042	0.046803	4.79E-02
40	0.04852	0.048003	4.91E-02
41	0.0497362	0.049203	5.03E-02
42	0.0509528	0.050403	5.15E-02
43	0.0521698	0.051603	5.28E-02
44	0.0533872	0.052803	5.40E-02
45	0.054605	0.054003	5.52E-02
46	0.0558232	0.055203	5.66E-02
47	0.0570418	0.056403	5.77E-02
48	0.0582608	0.057603	5.89E-02
49	0.0594802	0.058803	6.01E-02
50	0.0607	0.060003	6.14E-02
51	0.0619202	0.061203	6.26E-02
52	0.0631408	0.062403	6.38E-02
53	0.0643618	0.063603	6.50E-02
54	0.0655832	0.064803	6.63E-02
55	0.066805	0.066003	6.75E-02
56	0.0680272	0.067203	6.87E-02
57	0.0692498	0.068403	6.99E-02
58	0.0704728	0.069603	7.12E-02
59	0.0716962	0.070803	7.24E-02
60	0.07292	0.072003	7.31E-02

Table 5: Predictive and Experimental Values of Strain-Stress at Different Curing Age.

Curing Age	Predictive Strain Values	Predictive Strain-Stress Values	Experimental Strain-Stress Values
7	0.008423	0.0097147	0.0095
8	0.009633	0.0109192	0.0107
9	0.011613	0.0121243	0.0119
10	0.013203	0.01333	0.0131
11	0.014223	0.0145363	0.0143
12	0.016413	0.0157432	0.0155
13	0.016613	0.0169507	0.0167
14	0.017713	0.0181588	0.0179
15	0.018033	0.0193675	0.0191
16	0.019223	0.0205768	0.0203
17	0.022423	0.0217867	0.0215
18	0.023603	0.0229972	0.0227
19	0.024803	0.0242083	0.0239
20	0.025103	0.02542	0.0251
21	0.026213	0.0266323	0.0263
22	0.026413	0.0278452	0.0275
23	0.027623	0.0290587	0.0287
24	0.028843	0.0302728	0.0299
25	0.031203	0.0314875	0.0311
26	0.031303	0.0327028	0.0323
27	0.033403	0.0339187	0.0335
28	0.034603	0.0351352	0.0347
29	0.035813	0.0363523	0.0359
30	0.036113	0.03757	0.0371
31	0.037223	0.0387883	0.0383
32	0.038423	0.0400072	0.0395
33	0.039623	0.0412267	0.0407
34	0.040813	0.0424468	0.0419
35	0.042113	0.0436675	0.0431
36	0.043223	0.0448888	0.0443
37	0.044423	0.0461107	0.0455
38	0.045623	0.0473332	0.0467
39	0.046813	0.0485563	0.0479
40	0.048113	0.04978	0.0491
41	0.049223	0.0510043	0.0503
42	0.050423	0.0522292	0.0515
43	0.051613	0.0534547	0.0527
44	0.052823	0.0546808	0.0539
45	0.054223	0.0559075	0.0551
46	0.055223	0.0571348	0.0563
47	0.056413	0.0583627	0.0575
48	0.057623	0.0595912	0.0587
49	0.058833	0.0608203	0.0599
50	0.061233	0.06205	0.0611
51	0.061213	0.0632803	0.0623
52	0.062423	0.0645112	0.0635
53	0.063623	0.0657427	0.0647
54	0.064823	0.0669748	0.0659
55	0.066113	0.0682075	0.0671
56	0.067223	0.0694408	0.0683
57	0.068423	0.0706747	0.0695
58	0.069623	0.0719092	0.0707
59	0.070823	0.0731443	0.0719
60	0.072113	0.07438	0.0731

Table 6: Predictive and Experimental Values of Strain-Stress at Different Curing Age.

Curing Age	Predictive Strain-Stress Values	Experimental Strain-Stress Values
7	8.53E-03	0.007604
14	1.71E-02	0.017516
21	2.56E-02	0.027036
28	3.41E-02	0.036164
60	7.31E-02	0.0729
90	9.75E-02	0.0999

Where U(X) and K(X) are function of y

Divides (1) through by Cd-n, we obtained

$$C_d^{-n}\frac{dc}{dx} + A_{(x)}C_d^{1-n} = K_{(x)} \quad \text{..................} \quad (2)$$

Let $\beta = C_d^{1-n}$ .... (2b)

Differentiate (2b) wrt x gives this implies that;

$$\frac{d\beta}{dx} = (1-n)C_d^{-n}\frac{dc}{dx} \quad \text{..........................} \quad (3)$$

$$C_d^{-n}\frac{dc}{dy} = \left(\frac{1}{1-n}\right)\frac{d\beta}{dx} \quad \text{..........................} \quad (4)$$

Put equation (2) and (4) into equation (1) and multiply through by (1-n) yields

$$\frac{d\beta}{dx} + (1-n)U_{(x)}\beta = (1-n)K_{(x)} \quad \text{..............} \quad (5)$$

Let $U_{(x)} = \frac{K_{(x)}}{2}$ .... (6)

Substitute (6) into (5) gives:-

$$\frac{d\beta}{dx} + (1-n)\frac{K_{(x)}}{2}\beta = (1-n)K_{(x)} \quad \text{..........................} \quad (7)$$

Simplifying (7) and integrate both sides of the yielded equation gives:

$$\beta = 2 - D\exp\left[-2(1-n)\int K_{(x)}dx\right] \quad \text{...........} \quad (8)$$

But $\beta = C_d^{1-n}$

Hence equation (8), becomes:-

$$C_d^{1-n} = 2 - D\exp\left[(2n-2)\int K_{(x)}dx\right] \text{.....................} (9)$$

$$C_d^{1-n} = D\exp[(2n-2)K_{(x)}X] \text{.......................} (10)$$

Material and Methods

Gravel concrete like any other materials are to certain extends elastic as such stresses and strain induced in any structural members. The standard procedure for making and testing concrete cylinders for static young modulus of elasticity as per ASTM C469 (1975) were adopted in this investigation. Capped gravel concrete cylinders of 30cmx 15 cm Diameter were made with Various mix proportion by weight and recommended water cement ratio of [0.23,0.30,0.35,0.40] cured and tested after [7 to 90] days under compression in a compression machine. Demech mechanical strain garage was used to measured strain at middle of the specimen height. Strains recorded were taken immediately after loading. The modulus of elasticity E is the proportionality constant defined as the ratio of stress to strain. The relationship between Ec and Fcu normal dense concrete according to British standard is given as Ec=9.1 f1/3 [KN/mm^3].

Figures 1 to 6 explained the growth rate of strain at different curing age, linear trend was observed in the figures, the study monitor the behavior of strain under the influences of modifiers with fly ash and super plasticizer, the design were applied to determine the

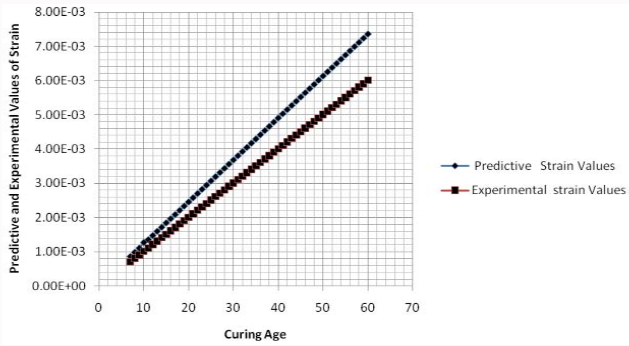

Figure 1: Predictive and Experimental Values of Strain –Stress at Different Curing Age.

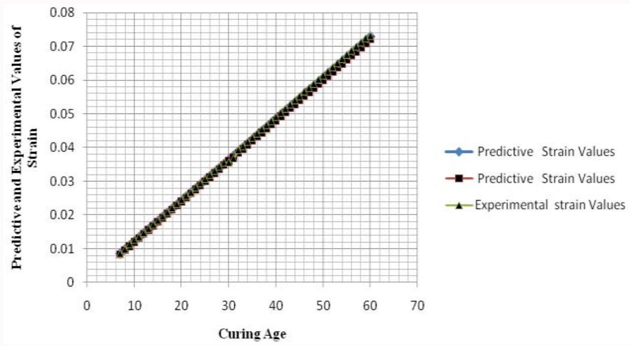

Figure 4: Predictive and Experimental Values of Strain –Stress at Different Curing Age.

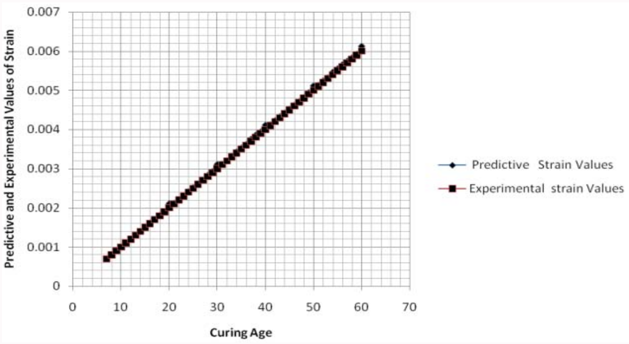

Figure 2: Predictive and Experimental Values of Strain –Stress at Different Curing Age.

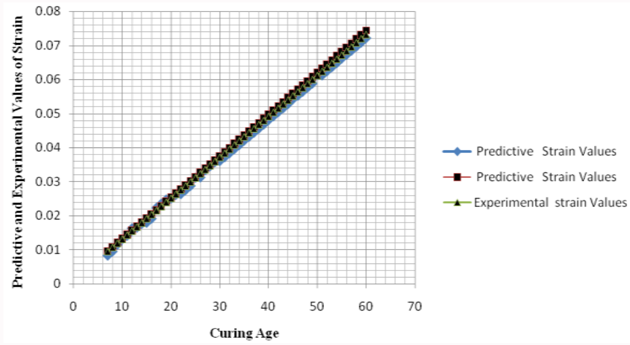

Figure 5: Predictive and Experimental Values of Strain –Stress at Different Curing Age.

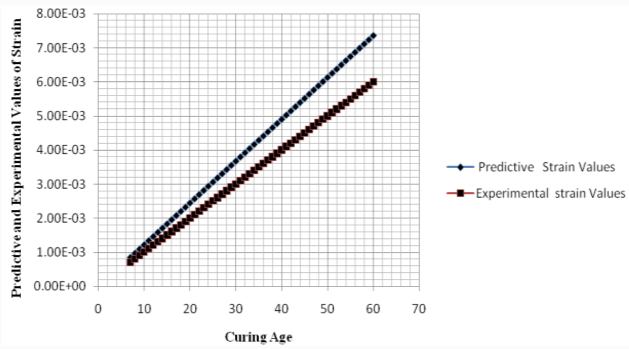

Figure 3: Predictive and Experimental Values of Strain –Stress at Different Curing Age.

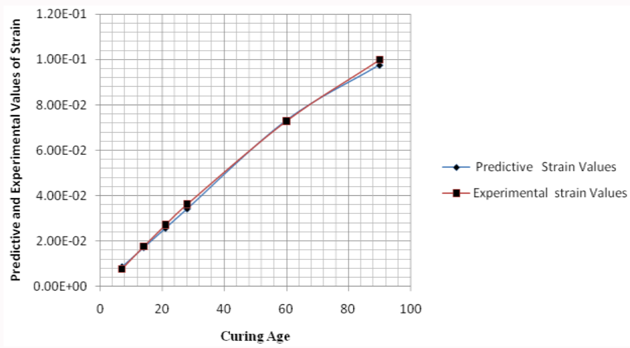

Figure 6: Predictive and Experimental Values of Strain –Stress at Different Curing Age.

strain development of the concrete, the strain establish the overall behavior of model reinforced concrete in tension, these definitely include combined cracking effect and slippage at cracks along the reinforcement, since strain is change in length when compared to original length, it definitely that develop variation, but in concrete strain known to be the reduction of concrete volume that changes in strain when load are applied, this condition mean that the concrete will experience change in concrete volume, the figure observed change in strain applying different load on concrete modified with fly ash and super plasticizer measuring the concrete strain. The dosage and variation of water cement ratios can be attributing to the variation of concrete strain, because the figures experienced variation of concrete strain despite the linear trend observed from the figures. The strain growth rate reflected mention concrete characteristics in its structure, compaction of concrete were by porosity can be determined also pressured the variation of concrete strain, the developed simulation values considered these variables in the system, these parameters express their effect on the strain behavior in all the figures, the predictive values were subjected to model validation, and both parameters developed favourable fits.

Conclusion

The study has definitely express the behavior of modifiers such as fly as hand super plasticizer content in concrete generating strain at different curing age. The study has explain the growth rate of strain from concrete design with modification the addictive, the behavior of concrete strain express the reflection of this addictive based on different dosage and curing age, concrete characteristics such as porosity void ratios were observed to determine the variation of strain at different curing age, water cement ratios mixed proportion through mixed design also pressured the growth rate variation of concrete strain, the variation in volume through the reduction of concrete when there an applied load, the study has observed the reaction of these two addictive on the mixed design developed to determine concrete strain, such condition explain total behavior of strain modified with fly ash and super plasticizer, the subjection of stress through an applied load thus generates cracks are on concrete were expressed when tensile strain exceed it capacity, measuring the deformation of this materials are though the applied load, the study has experienced strain behavior on concrete when combined with materials characteristic modulus. The derived model was subjected to model validation with experimental values, and both parameters developed best fit correlation.

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