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PREDICTIVE MODEL TO MONITOR VARIATION OF STRESS –STRAIN RELATIONSHIP OF 3/8 GRAVEL CONCRETE WITH WATER CEMENT RATIO [0.45] AT DIFFERENT LOAD

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Abstract- Stress- strain relationship are normally established in concrete to monitor various rate of compression of strength, higher concrete strength has been generated from other type of aggregates size, but the application of locally occurring 3/8 gravel has not been thoroughly evaluated to determine its strength rate, the effectiveness of these materials are determined on the way it is used in construction projects, the study of monitoring it stress –strain relationship were carried out to express the developed compressive strength applying these local material, the rate of its effective in construction will determined it economic values to maximize cost in project, when it has attained higher concrete strength like others. The study of monitoring these relationship were carried out through experimental set up, the generated values were also calibrated to generate model equation, the resolved equations generated theoretical values, these results were compared with measured values, both parameters express best fits validating the model, the stress – strain relationship express its values base on the mix proportions, designed variations including curing methods and age. These condition influences the behaviour of the stress –strain relationship as it is express in all the graphical representation.

Keywords*: *predictive model, stress-strain relationship,3/8 gravel, and load

1. Introduction

It has been observed that when concrete is subjected to loading, it display a linear stress-strain connection to elastic range. The ratio through linear portion of the relationship known to the slope is known as the modulus of elasticity (Boris, 2009). The elastic limit is "the maximum stress which a material is competent of sustaining without any divergence from proportionality of stress to strain (Hooke's law)." As it is express from previous section, the modulus of elasticity is the ratio stuck between stress and the reversible strain. When a load is applied to concrete, it will distort depend on the extent of the load thus its rate of application. The value of strain is of immense significance since it represents the inflexibility of the structural design, thus the stress at which the concrete will observe lasting deformation if exceeded. Most structures are subject matter to cyclic loading thus imperative to know the elastic portion for design purposes, particularly the quantity of steel required for reinforcement (Boris, 2009). According to the Canadian Portland Cement Association (CPCA), the elastic modulus of concretes will be influenced by the properties of different aggregate types with different elastic moduli. Previous researchers have express Stress-Strain relation curves for aggregate, concrete, and cement paste, this are for stress-strain relations on cement paste, aggregate and concrete, it has been observed that aggregate has a substantially at larger elastic modulus compared to concrete and cement paste, so it is could be guessed that aggregate and aggregate content has a important pressure on the elastic modulus of concrete. Parrot (1979) generating an equation that can predict the elastic modulus of concrete; it must be Mechanical properties of High-Strength Concrete (HSC) can be divided in two groups as short-term mechanical properties and long-term mechanical properties (Eluozo and Ode 2015a, Eluozo and Ode 2015b, Eluozo and Ode 2015c). The ascending branch of stress-strain is more linear and steeper for HSC. Strain at maximum strength is greater and descending part becomes steeper compared to NSC. Stress-strain behaviour of HSC depends on material parameters such as aggregate type and experimental parameters that include age at testing, strain rate and interaction between specimen and testing machine. The stress-strain model used for NSC cannot be extended for use in HSC as the nature of loading curve changes significantly. Steeper rise and sudden drop in strength after maximum value presents difficulty in numerical modelling of stress-strain behaviour of HSC. Aītcin (1998) suggests that HSC behaves like a real composite material and parallels can be drawn to the stress-strain behaviour used in rock mechanics (Ode 2004). Smooth river gravel produces weaker concrete. Smallest size of coarse aggregate produces highest strength concrete owing to its high specific surface area. Addition of silica fume decreases the requirement of low w/c to achieve high compressive strength. Iravani (1996) noted that effect of silica fume on strength development of HSC is most prominent during 7 to 28 days after mixing. Hence, most of the empirical formulations express modulus of elasticity as a function of compressive strength. The equation suggested in ACI-318 overestimates elastic modulus of HSC and ACI 363 (ACI, 2010) suggest a different equation for HSC based on studies done by Carrasquillo *et al.* (1981) that have been shown to produce conservative values for normal-density concrete (Shah and Ahmad, 1994): Data on Poisson's ratio of concrete is very limited, especially for HSC. Poisson's ratio of HSC is constant in the linear zone but increases in the non-linear zone as a function of axial strain. In the linear range, Poisson's ratio is not affected by compressive strength, curing method and age of concrete (Logan *et al.*, 2009 Ephraim and Ode 2006).

2. Materials and Method

3/8 gravel concrete like any other materials is to a certain extend 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 3/8 gravel concrete cylinders of 30cmx 15cm Diameter were made with 1:1:6:2:9 mix proportion by weight and recommended water cement ratio of 0.45, cured and tested after 28 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 $E_{c\,=\,9.1}\ f^{1/3}$[KN/mm^3]

3. Results and Discussion

Results and discussion are presented in tables including graphical representation of compressive strength of concrete.

Table: 1 Stress relationship at Different Load

Load [KN	Stress [N/mm]
30	1.69
60	3.396
90	5.093
120	6.791
150	8.489
180	10.187
210	11.885
240	13.582
270	15.28
300	16.978
310	17.544
320	18.11
330	18.676

340	**19.242**
350	**19.808**
380	**20.374**
400	**22.637**

Table: 2 Predictive and Measured Values of Stress Relationship at Different Load

Load [KN	Predictive Values Stress N/mm^2	Measured Values Stress N/mm^2
30	1.61	1.64
60	3.385	3.398
90	5.0902	5.097
120	6.809	6.891
150	8.515	8.689
180	10.206	10.197
210	11.882	11.885
240	13.544	13.552
270	15.192	15.283
300	16.825	16.988
310	17.366	17.444
320	17.906	18.111
330	18.444	18.576
340	18.98	19.842
350	19.515	19.408
380	21.109	20.574
400	22.17	22.537

Table: 3 Strain relationships at Different Load

Load [KN	Vertical Strain X [1.99E10-5] N/mm^2
30	1.10E-05
60	1.90E-05
90	2.10E-05
120	3.10E-05
150	4.00E-05
180	4.10E-05
210	4.30E-05
240	4.50E-05
270	6.20E-05
300	7.31E-05
310	7.51E-05

320	**8.21E-05**
330	**8.30E-05**
340	**8.40E-05**
350	**8.60E-05**
380	**1.26E-05**
400	**1.28E-05**

Table: 4 Predictive and Measured Values of Strain Relationship at Different Load

Load [KN	Predictive Values vertical Strain	Measured Values Vertical Strain
30	**2.90E-06**	**1.10E-06**
60	**1.24E-05**	**1.50E-05**
90	**2.59E-05**	**2.14E-05**
120	**3.76E-05**	**3.50E-05**
150	**4.75E-05**	**4.50E-05**
180	**5.56E-05**	**4.90E-05**
210	**6.90E-05**	**5.30E-05**
240	**6.64E-05**	**5.50E-05**
270	**6.91E-05**	**6.60E-05**
300	**7.00E-05**	**7.11E-05**
310	**6.99E-05**	**7.13E-05**
320	**6.96E-05**	**7.21E-05**
330	**6.91E-05**	**7.30E-05**
340	**6.84E-05**	**7.40E-05**
350	**6.75E-05**	**7.60E-05**
380	**7.56E-05**	**5.26E-05**
400	**6.00E-05**	**5.28E-05**

Table: 5 Strain relationships at Different Load

Load [KN	Horizontal Strain X [1.99E-05]
30	**6.60E-05**
60	**5.70E-05**
90	**6.10E-05**
120	**9.40E-05**
150	**1.12E-05**
180	**1.13E-05**
210	**1.25E-05**
240	**1.36E-05**
270	**1.83E-05**
300	**2.56E-05**

310	**2.70E-05**
320	**3.03E-05**
330	**2.66E-05**
340	**2.68E-05**
350	**3.18E-05**
380	**4.92E-05**
400	**5.20E-05**

Table: 6 Predictive and Measured Values of Strain Relationship at Different Load

Load [KN	Predictive Values Horizontal Strain	Measured Values Horizontal Strain
30	**7.32E-05**	**6.70E-05**
60	**6.52E-05**	**5.90E-05**
90	**5.68E-05**	**5.90E-05**
120	**6.28E-05**	**7.40E-05**
150	**4.10E-05**	**3.12E-05**
180	**3.49E-05**	**3.23E-05**
210	**3.09E-05**	**1.25E-05**
240	**2.97E-05**	**2.66E-05**
270	**3.18E-05**	**2.83E-05**
300	**3.80E-05**	**3.56E-05**
310	**4.11E-05**	**3.27E-05**
320	**4.48E-05**	**4.03E-05**
330	**4.88E-05**	**3.96E-05**
340	**5.36E-05**	**5.68E-05**
350	**5.90E-05**	**5.18E-05**
380	**7.91E-05**	**6.92E-05**
400	**9.60E-05**	**8.90E-05**

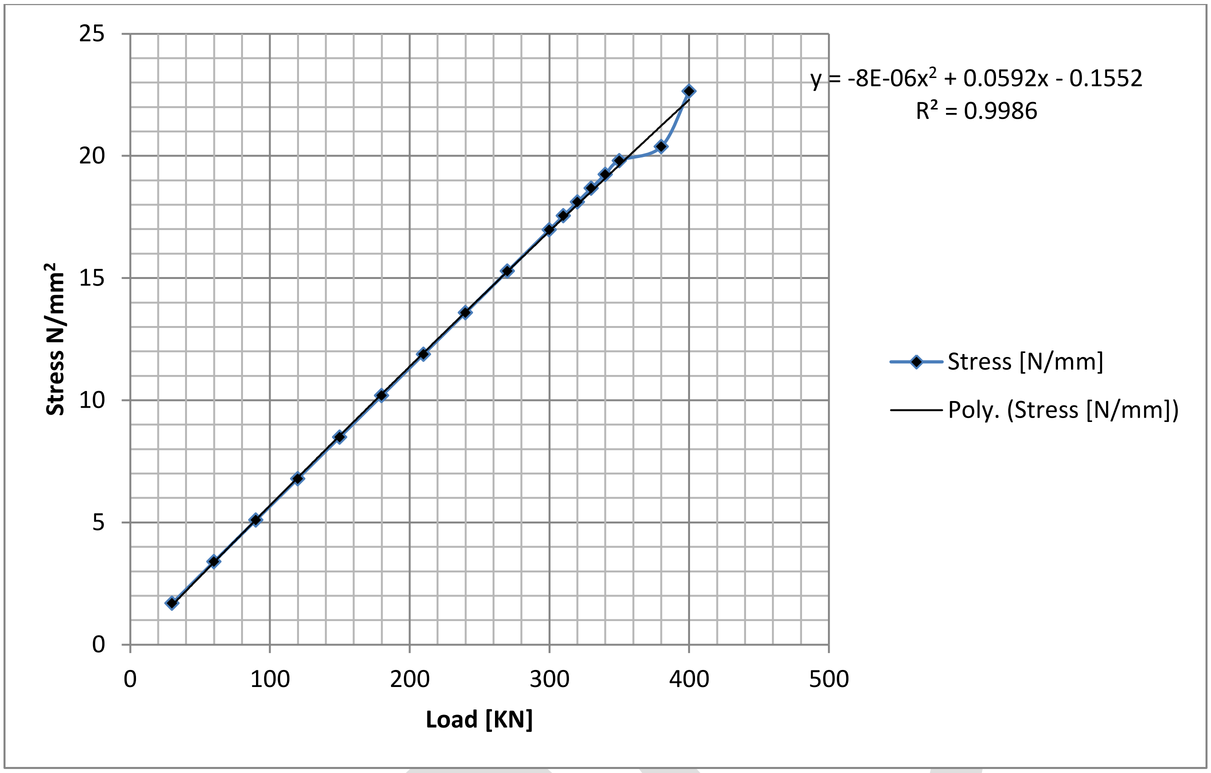

Figure 1: Stress relationships at Different Load

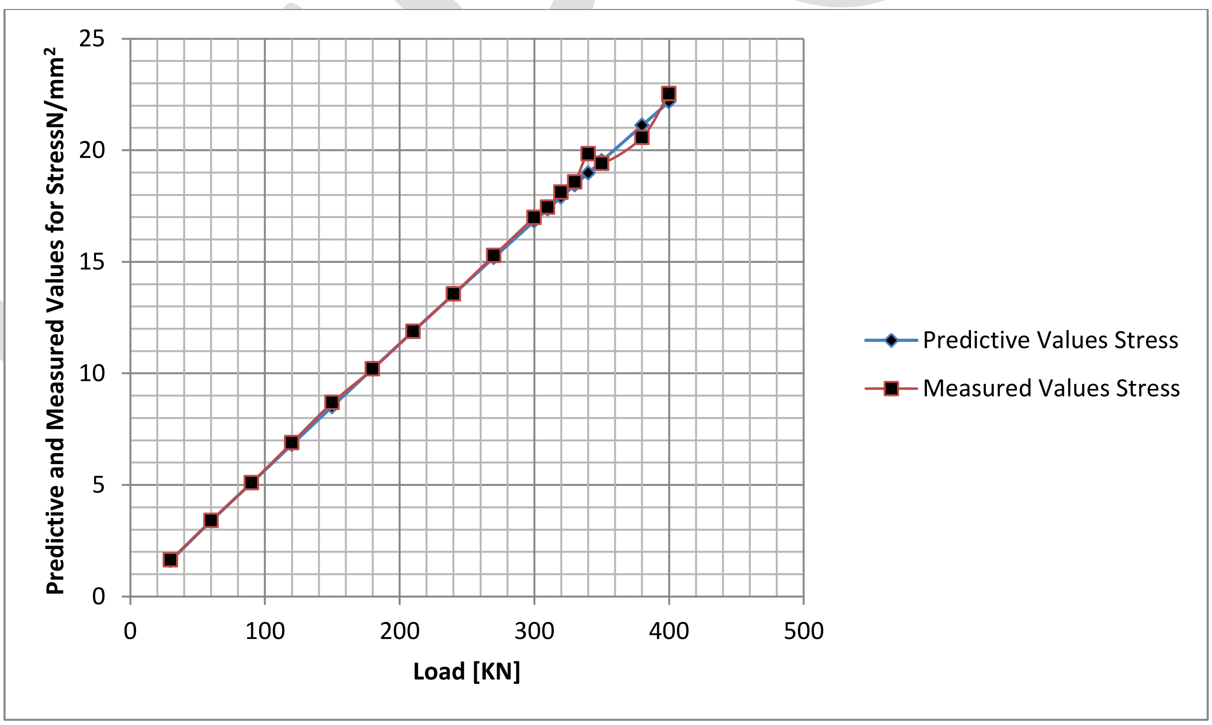

Figure 2: Predictive and Measured Values of Stress Relationship at Different Load

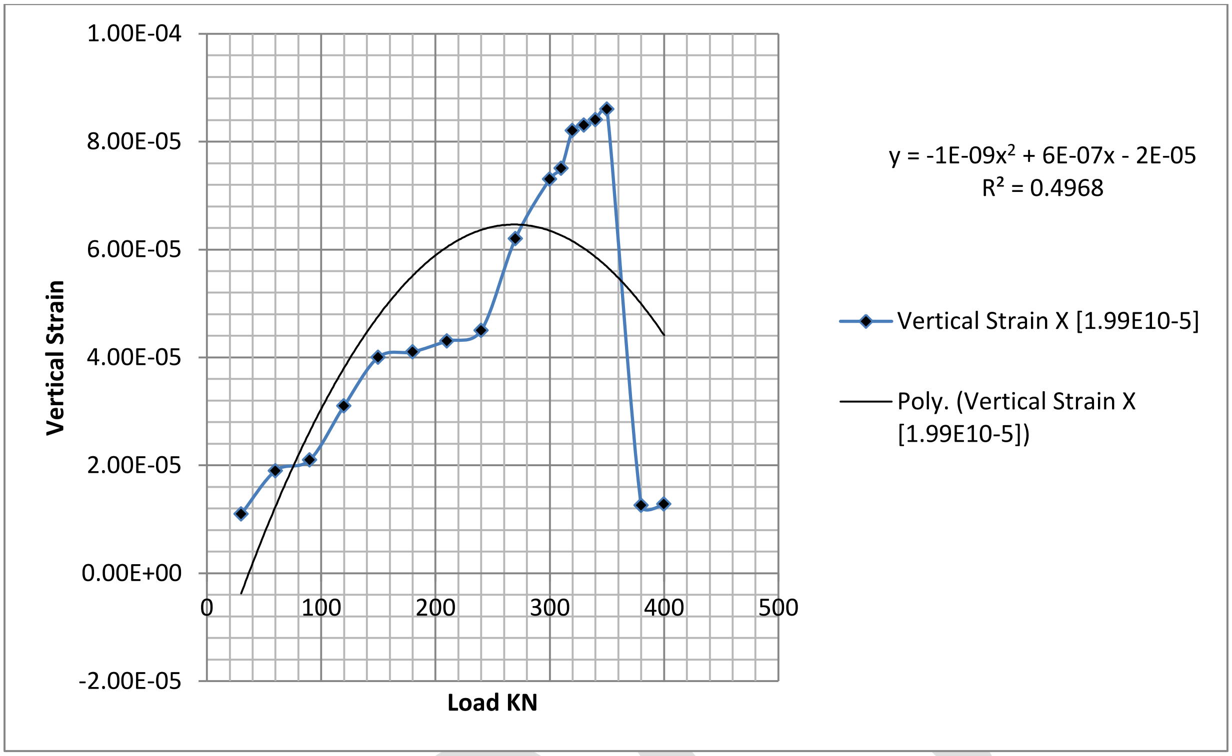

Figure 3: Figure 1: Strain relationships at Different Load

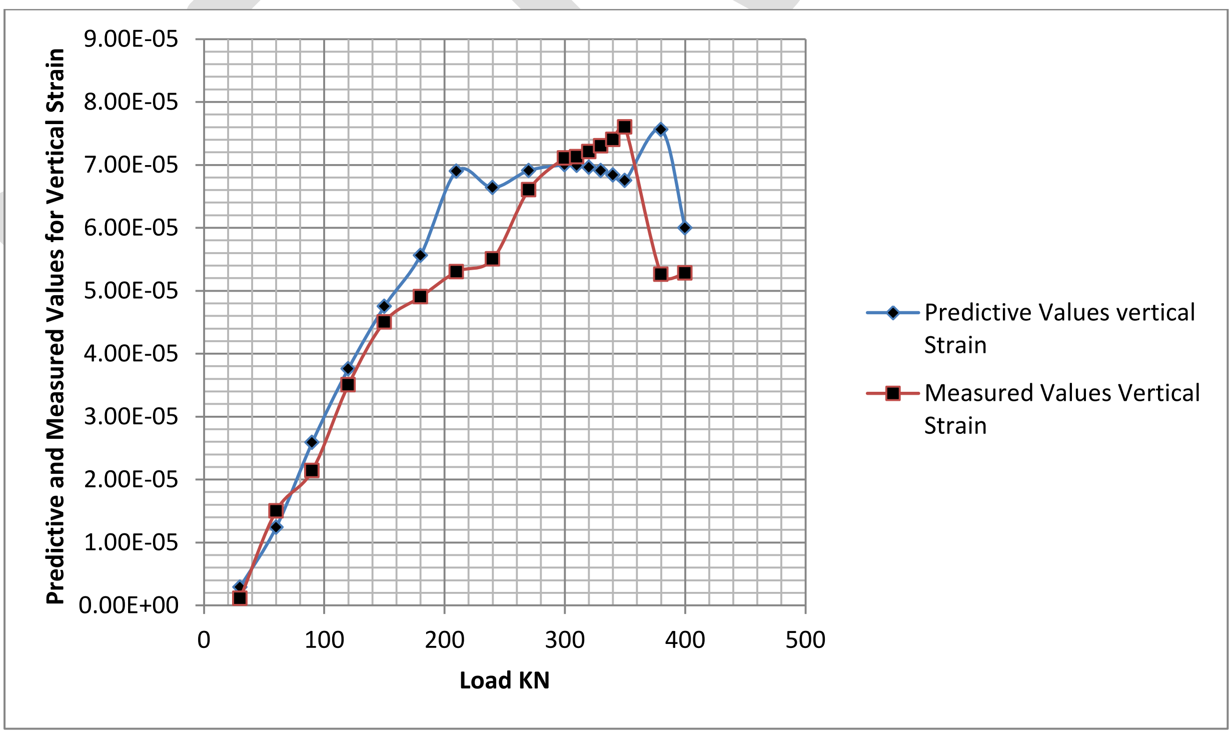

Figure 4: Predictive and Measured Values of Strain Relationship at Different Load

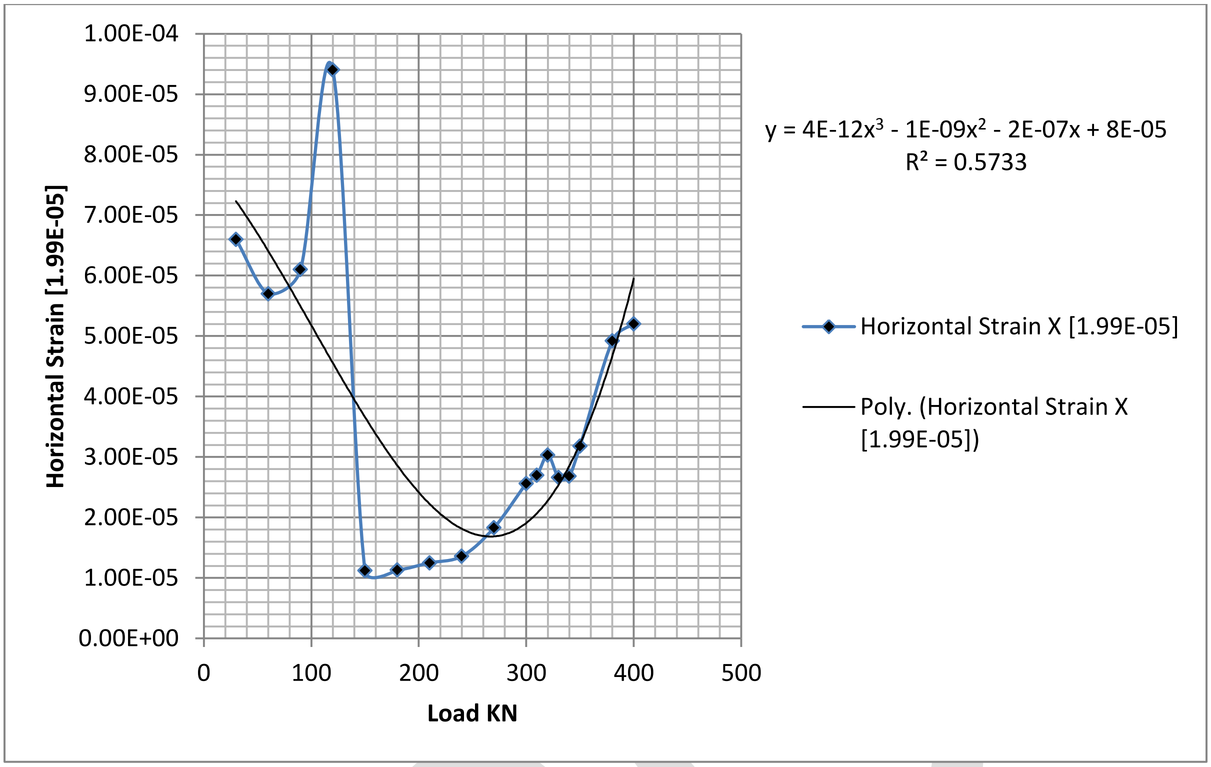

Figure 5: Strain relationships at Different Load

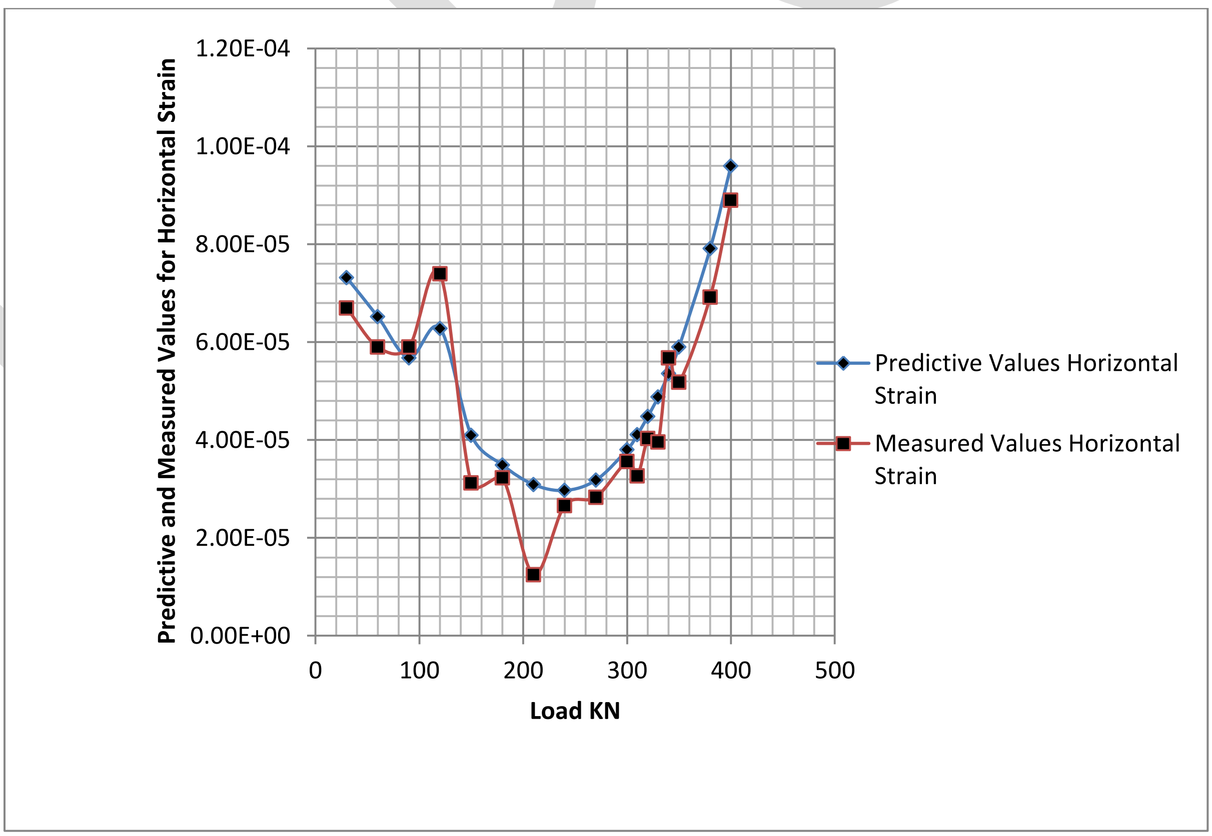

Figure 6: Predictive and Measured Values of Strain Relationship at Different Load

The figure express the relationship of stress and strain in compressive strength of concrete using locally occurring 3/8 gravel to developed high concrete strength. Figure one express the behaviour of stress in linear condition to the point it attain it optimum recorded at 400KN..in figure two, resolving the expressed model equation theoretical measured values developing linear exponential loading to the optimum level recorded at 400KN while figure three experiences linear increase and suddenly develop vacillation where the strain decreased at 400KN, Figure four express it predictive and measured values in the same vein exponential conditions were observed thus sudden declined in strain were recorded at 400KN. Figure five developed fluctuation in it developed strain at different loading point between 200KN, sudden increase in strain were experienced to the optimum level at 400KN, similar condition were observed in figure six where the predictive and measured express best fits in the same trend fluctuating to the optimum level at 400KN.

Conclusion

The stress - strain relationship for locally occurring 3/8 gravel for high concrete strength were developed to express the stress – strain relationship, the expression were subjected at different loading point to the optimum at 400KN. The expression of the stress and strain at different loading condition were monitored through experimental application, the results were calibrated, these resulted generated mathematical model equations resolved to generated theoretical values from the calibrations. The theoretical values were compared with other measured values for validation, both parameters express faviourable fits, the effect on the stress and strain are base on the on the size of the locally occurring 3/8 gravel, the mix design thus variations of water cement ratios, the deposited porosity of the concrete and the compaction relation to the permeability's, others includes mix design variation through water cement ratios and type of curing and age.

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