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An Anova-Based Numerical Analysis of WHA Partial Replacement Concrete

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Abstracts: In this work, a study exploiting concretes made with a bio-plant using natural waste is presented. The study examined the effects of partial cement substitution with bio-plants on the mechanical characteristics of conventional concretes and assessed the discrepancy between actual and expected elasticity modulus values. The usage of and effects on the modulus of elasticity of the partial replacement of concrete with WHA have been the subject of extensive research. Research was conducted in the area using various water-cement ratios coupled with water hyacinth ash and replacement percentages of cement. One-way analysis of variance (ANOVA) is used as a practical approach to verify normality. The supplied experimental data sets are used to train and evaluate the reliability predicting model. Thus, the study effort provides an overview of the numerical analysis performed using statistical techniques and the examination of the resulting data. The model's dependability is providedby the linear relationship between the Concrete mix% and with & without WHA. The 90C+10%WHA mixture performs better than conventional concrete.

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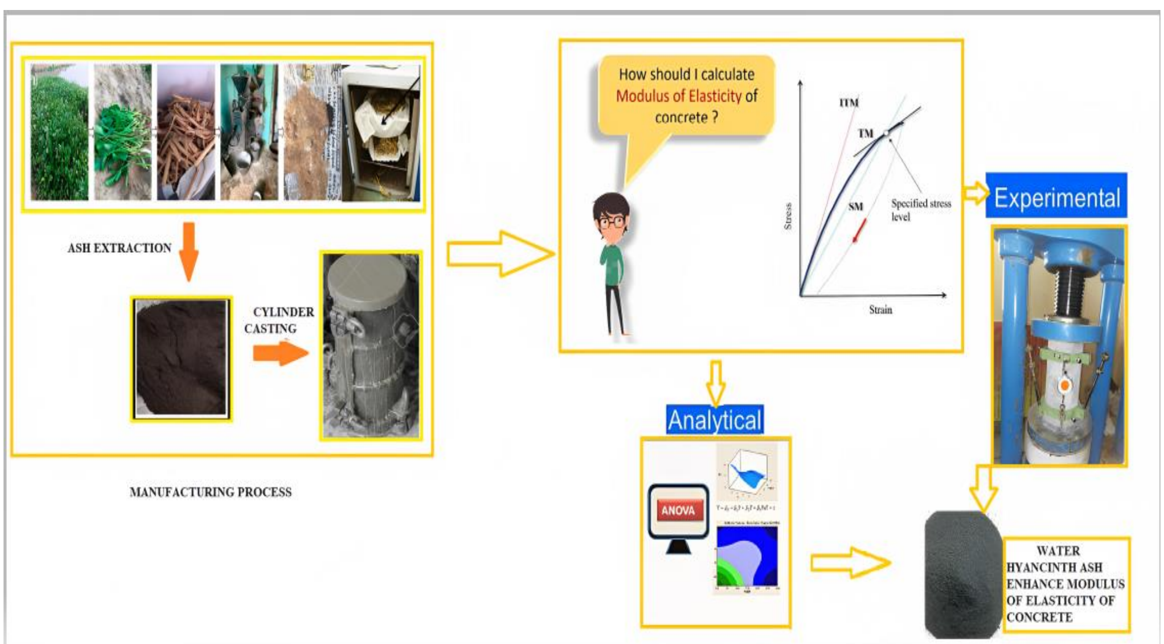
Keywords: Modulus of Elasticity, WHA, ANOVA, Regression Analysis, Stress-strain



1. INTRODUCTION

It has become imperative for the construction sector to support society by erecting new structures as a result of the population's exponential increase. Because it uses a lot of non- renewable resources and produces a lot of building and demolition debris, the construction industry is one of the key industries with a negative influence on the environment. Cement is regarded as the costliest component of concrete when compared to the other constituents. This is due to the energy-intensive method used to produce cement. One of the largest sources of carbon dioxide, the main contributor to global warming, is cement. Only byheating the cement to extremely high temperatures during the production process of cement can clinker be produced. As a result, a significant amount of carbon is released into the atmosphere. 40% of all investments are used for building upkeep worldwide. There is a lot of research being done to find a novel substance to replace cement that won't harm the environment[1,2,3]. Over the past few decades, substitute materials have included fly ash, rice husk, silica fume, egg shells, groundnut shells, etc[7]. As an alternative to calcium chloride segment in bond, bio-concrete quickening additive has been developed. However, research towards a bio-based cement impeding admixture for tropical environments is ongoing[6]. Since it is possible to predict how the structure will behave under load action in service and to ascertain the distribution of deformations and displacements, the elasticity modulus of concrete is a crucial factor in the design of concrete structures[8]. It is always required to validate the study and the standards' claims, like the authors of did with their restricted concrete columns, in order to match experimental results to values anticipated by standards. ANOVA – Analysis of Variance is an arithmetic software utilized to evaluate the difference among the groups. ANOVA method was first introduced by Ronald a statistician and biologist. ANOVA works on the rule of Variance concept and found the different variance in the Sample. ANOVA is used to evaluate two or more samples are an equal or significant difference. One way ANOVA method is utilized to evaluate the experimental data by statistical method. This method is used to analyze whether a significant difference between cement and water hyacinth ash from the compression strength. Adelaide Cerveira, Elisete Correia [9] describes Two-way ANOVA study to examine the compressive power of Alkali Fly Ash for the substitution of cement by industrial waste. In this analysis, as Alkali activated agents used as a partly replaced for cement fly ash and sodium hydroxide. The compression potency can be done under two factors i.e static proportion and temperature. Different types of mix ratios are 80:20, to 20:80. Over one week, samples are handled at 80 ° C. Dried specimens are tested by uniaxial compression strength. There are no variations in the 50% of curing humidity. The compressive strength often improves when the debris volume is raised. The compression strength is high at a combination of 25% & 75% and 75%, with 100%. So the two percentage mixes do not vary significantly.Vikrant S. Vairagadea [10] suggests that the result of one way Anova analysis shows some significant differences between the groups. The Tukey posthoc test shows a more considerable variation among controlled treatment and other treatments. There is no dissimilarity in T3, T4, and T5. The significant level of treatment is 0.0000 should below 0.05. The result shows the compressive strength and density of load-bearing masonry blocks is significantly dependent on the replacement of cement. The unacceptable suggestion is discarded and it shows water hyacinth ash might be employed as supplementary material for cement. Jayasuriya et al. (2018) states their numerical investigation came to the conclusion that compressive strength had the greatest impact on aggregate stiffness and mortar matrix stiffness. The empirical model for compressive strength and tensile strength developed in the current study is the first of its kind and may be used to optimise the proportions of a concrete mixture using any accepted method of optimisation or tool for any regression analysis.

2.Material and Mix

Standard Portland cement, coarse aggregate measuring 10 and 20 mm, fine aggregate made of river sand, water hyacinth ash, and water are the materials employed in this project.

2.1Cement

Using IS:8112-1989, this work has been approved by OPC grade 53. Cement is tested in accordance with Indian Standards IS 4031-1988.

2.2 Fine Sand

For the experimental investigation, sand from River was employed as an adequate aggregate. Sieve analysis and zone II are used to gauge the fine sand aggregate's quality. According to IS 2386-1963, the river sand had specific physical qualities.

2.3 Coarse Aggregate

For our experimental study job, 20 mm granite crushed stone is utilized. It is conveniently available from nearby quarries. We looked into crushed stone qualities.

2.4 Water Hyacinth Ash

The Coimbatore region's Stagnant Lake was utilized to gather water hyacinth plants. The plants are carefully cleansed to remove dirt and contaminants. The plants are then allowed to dry for two weeks outside. The samples are then divided into tiny pieces using a table knife and cleaned with a 15% sodium chloride solution. Using a milling machine, the sliced samples are crushed and processed into powder[11]. The materials are then sieved through a 150 mesh. The samples were burned in the open air to convert organic materials into inorganic ones, and the results are shown in Fig. 1.

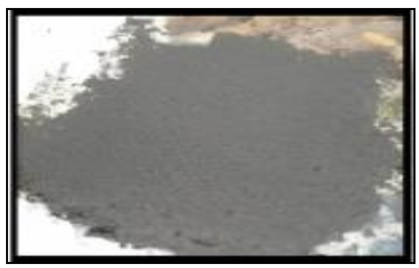
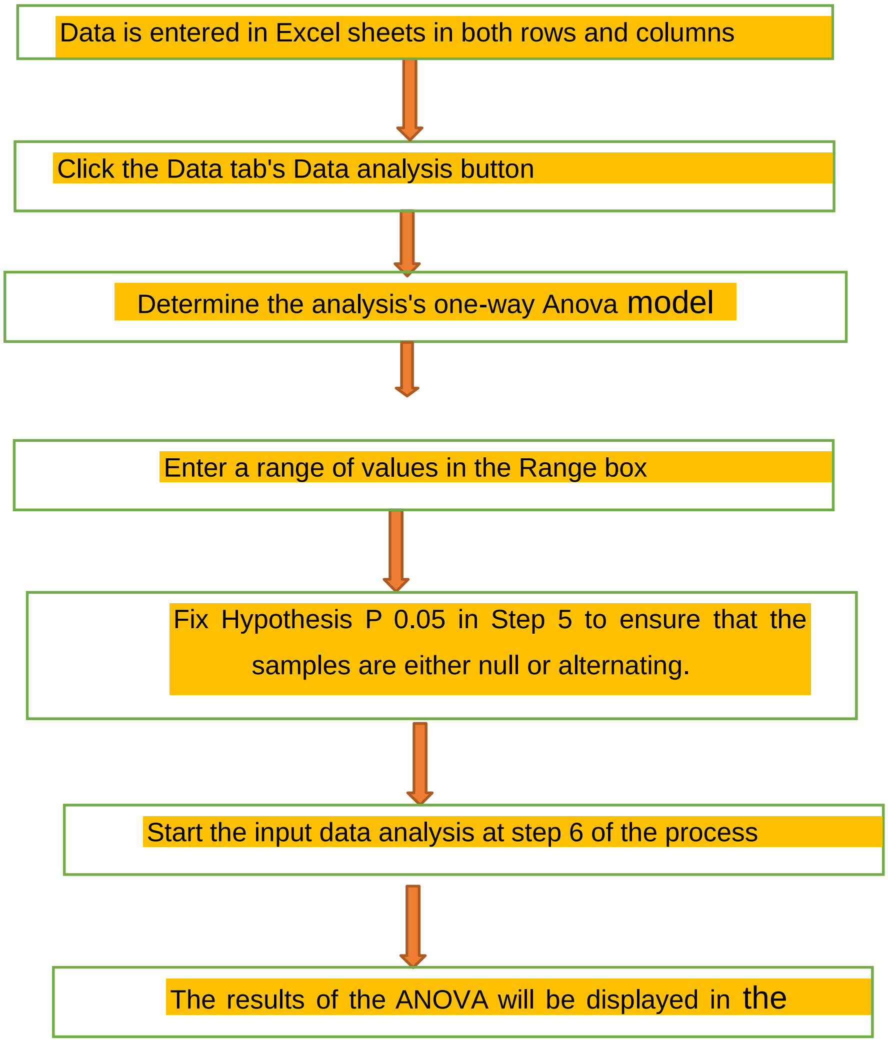


Figure 1. Schematic drawing of Water Hyacinth Ash

3.RESEARCH METHODOLOGY:

The current study's objective is to use a statistical approach to analyses the information provided for various concrete mixes with various water-cement ratios.

- Checking if the experimental data is consistent and follows the normal distribution is one of the study's goals.
- Using the provided practical data, a one-way ANOVA test will be used to determine the combined effect of partial cement replacement with and without.
- To choose the optimal option by deriving a mathematical equation from the supplied sampled data's reliability and strength.



To perform an ANOVA-based numerical analysis for the modulus of elasticity, you wouldtypically follow these steps:

Experimental Design: Define the groups or conditions for the analysis. In this case, youwould have at least two groups: a control group with conventional concrete (without WHA replacement) and one or more experimental groups with partial WHA replacement at different levels.

Sample Preparation: Prepare concrete specimens for each group according to the specified mix proportions. Ensure that the samples are properly cured and representative of the concrete mix used in practical applications.

Testing: Conduct the modulus of elasticity testing on the concrete specimens using appropriate testing methods. The modulus of elasticity measures the stiffness of the materialand is typically determined through compressive or tensile testing.

Data Collection: Collect the modulus of elasticity values for each specimen in every group. Ensure accurate and reliable data collection procedures are followed.

Statistical Analysis: Perform the ANOVA to analyse the data. The ANOVA will determine ifthere are statistically significant differences in the means of the modulus of elasticity betweenthe groups. It will also provide information on the significance of WHA replacement levels, such as whether different replacement percentages have a significant impact on the modulus of elasticity[5].

Post-hoc Analysis: If the ANOVA indicates significant differences, you can perform post-hoctests to determine which specific groups differ significantly from each other. Common post- hoc tests include Tukey's Honestly Significant Difference (HSD) test or Bonferroni correction.

Interpretation: Interpret the results of the ANOVA and post-hoc analysis. Identify the significance of WHA replacement levels on the modulus of elasticity. Consider any limitations or assumptions associated with the analysis.

By conducting an ANOVA-based numerical analysis on the modulus of elasticity, you can gain insights into the effects of WHA partial replacement on the mechanical properties of concrete[4]. This analysis can help in evaluating the feasibility and potential benefits of using WHA as a sustainable alternative in concrete production.

4. *EXPERIMENTAL ANALYSIS*

a. Modulus Of Elasticity:

It is a crucial mechanical feature that establishes the stiffness and strength of a product. A cylinder specimen of 15 x 30 cm is put on a compressometer to examine the elastic modulus of concrete experimentally. The setup for the test is shown in Figure 4.1. A strain gauge is available at the extensometer, and the load is delivered at stress levels ranging from 15% to 85%. After that, values are produced using regression analysis to analyse the readings. A cylindrical specimen may be used to measure elastic modulus with an extensometer, and the test is conducted under the CTM.

Fig2- Modulus Of Elasticity

Water hyacinth ash is used as a cement substitute in the making of the cylinder-shaped samples, both with and without it. The elasticity modules were established using the ANOVA software analytical tool, and the load was applied to the cylinder sample. The relationship between stress and strain for regular concrete and water hyacinth ash on concrete was depicted in the graph [12]. The values for conventional and replacement concrete are listed in Tables 1.

TABLE 1. Experimental Analysis Modulus Of Elasticityof Concrete With And Without WHA

Specimen	Load (kn)	Modulus of Elasticity N/mm2	Specimen	Load (kn)	ModulusOf Elasticity (N/mm2)
T1 (100 %+ 0%)	0	0	T2 (90 %+ 10%)	0	0
	50	42462.85		50	42462.85
	100	42462.85		100	42462.85
	150	31847.13		150	42462.85
	200	33970.28		200	42462.85

	250	35385.7		250	35385.7
	300	31847.13		300	33970.28
	350	29723.99		350	37154.99
	400	28308.56		400	35758.19
				450	27297.54

NUMERICAL ANALYSIS MODULUS OF ELASTICITYOF CONCRETE WITH AND WITHOUT WHA

Using statistical software, perform the ANOVA test on the collected data. The ANOVA output will provide you with the F-statistic and the associated p-value. Based on the p-value obtained from the ANOVA test, you can interpret the results as follows:

a) If the p-value is less than your chosen significance level (usually 0.05), you can reject the null hypothesis. This would indicate that the presence of "WHA" has a significant effect on the modulus of elasticity of concrete.

b) If the p-value is greater than or equal to your significance level, you fail to reject the null hypothesis. In this case, there is not enough evidence to suggest that the presence of "WHA" has a significant effect on the modulus of elasticity of concrete [22].

TABLE 2-Conventional Concrete - M30 (100 +0% WHA)

Summary Output: M 30 –Conventional Concrete								
Regression Statistics								
Multiple R	0.99							
R Square	0.99	Goodness Of Fit >= 0.80						
Adjusted R Square	0.98							
Standard Error	1.0							
Observations	9							
ANOVA								
	Df	SS	MS	F	P-Value			
Regression	1	474	474	466	0.000			
Residual	7	7.12	1.0					
Total	8	481				Confidence Level		
						0.95		0.99
	Coefficients	Standard Error	T Stat	P-Value	Lower 95%	Upper 95%	Lower 99%	Upper 99%

Intercept	1.3	0.6	2.3	0.06	- 0.06	2.66	-0.71	3.30
X	28203	1307	21.6	0.000	25113	31292	23631	32775
Y = 1.296 +28202.934*X								

Elastic Modulus = 28203 N/mm^2

TABLE 3-REPLACEMENT CONCRETE- M30 (90 +10% WHA)

SUMMARY OUTPUT –M30 (90 +10% WHA)								
Regression Statistics								
Multiple R	0.98							
R Square	0.95	Goodness of Fit >= 0.80						
Adjusted R Square	0.95							
Standard Error	2.00							
Observations	10							
ANOVA								
	DF	SS	MS	F	P-value			
Regression	1	629	629	156	0.000			
Residual	8	32.3	4.03					
Total	9	661					Confidence Level	
						0.95		0.99
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 99%	Upper 99%
Intercept	2.16	1.1	2.04	0.08	- 0.28	4.60	-1.40	5.71
X	28850	2311	12.5	0.000	23521	34179	21096	36604
y = 2.161 +28849.756*X								

Elastic Modulus = 28850 N/mm2

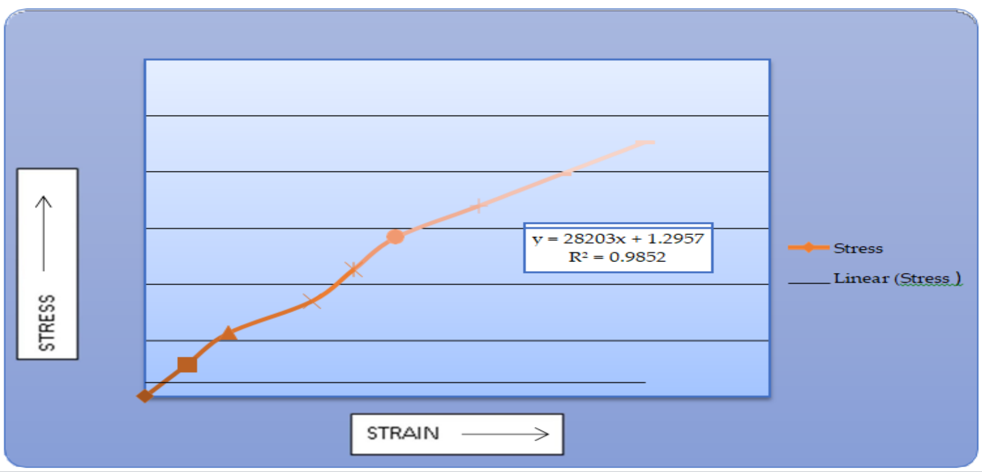
STRESS-STRAIN CURVE FOR THE MODULUS OF ELASTICITY

The stress-strain curve for the modulus of elasticity, also known as the Young's modulus, describes the relationship between stress (force per unit area) and strain (deformation) for a material. The modulus of elasticity quantifies a material's stiffness and is typically measured in units of pressure, such as Pascals (Pa) or Megapascals (MPa) [15]. When investigating the effect of water hyacinth ash on the modulus of elasticity, it's important to understand that water hyacinth ash is a byproduct of the water hyacinth plant, which can be processed to obtain an ash with potential applications in various fields, including construction materials.

Modulus of Elasticity without Water Hyacinth Ash:

In the absence of water hyacinth ash, the stress-strain curve for the modulus of elasticity follows a typical behavior for a given material. In the elastic region, the material undergoes deformation linearly with applied stress. This means that when the stress is removed, the material returns to its original shape without any permanent deformation [23]. The slope of the linear portion of the curve represents the modulus of elasticity, which remains constant for a specific material under specific conditions.

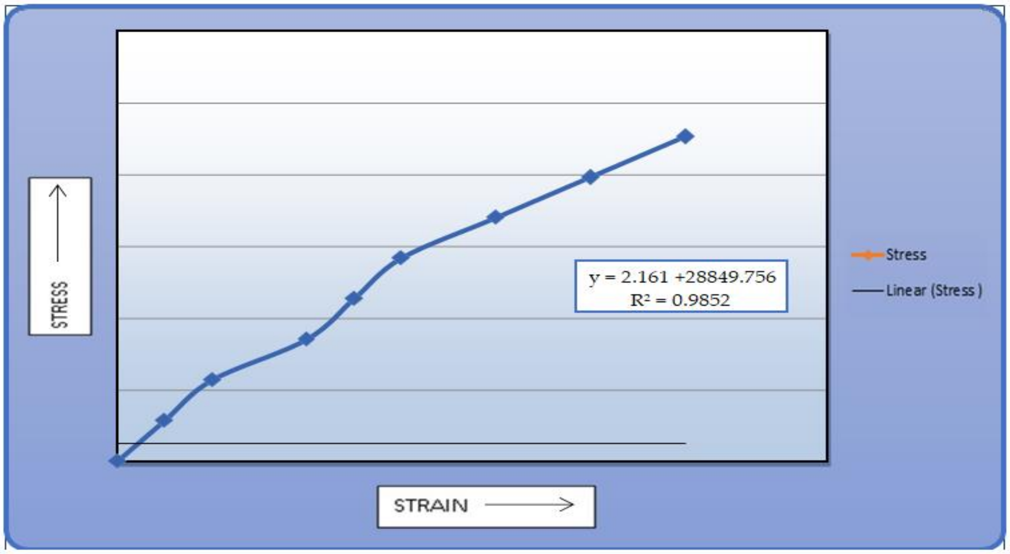
Figure 3. Graph Plotted For Numerical Analysis –Conventional Concrete



Modulus of Elasticity with Water Hyacinth Ash:

When water hyacinth ash is introduced into a material, its effect on the stress-strain curve and, consequently, the modulus of elasticity can vary depending on factors such as the amount of ash added, the type of material being modified, and the processing techniques used. If water hyacinth ash is used as a filler material, it can alter the mechanical properties of the composite material. Generally, the incorporation of ash may lead to a reduction in the modulus of elasticity compared to the original material. This is because the ash might not possess the same structural integrity and stiffness as the original material, and its inclusion can disrupt the material's overall network, resulting in a decrease in stiffness.

*FIG.4 .**Graph Plotted For Numerical Analysis –Replacement Concrete***



However, if properly treated and used in suitable proportions, water hyacinth ash can potentially contribute to improving the mechanical properties of certain materials, particularly if it enhances adhesion between the matrix and the filler, or if it introduces unique reinforcing properties.

It's important to note that the behavior of the stress-strain curve for the modulus of elasticity with water hyacinth ash will be specific to the composition and processing methods of the composite material. Extensive testing and characterization are necessary to understand the precise effects of water hyacinth ash on the modulus of elasticity in a particular application

RESULTS AND DISCUSSION:

- Regression analysis's findings reveal that cement's elastic modulus and cement that has had 10% of it replaced by water hyacinth exhibit less fluctuation. The elastic modulus of standard concrete M30, specimens T1 (100 + 0%), and T2 (90+10%), is 28203 N/MM2 and 28850 N/MM2, respectively. According to theory, M30 concrete has an elastic modulus of 27386 N/MM2. Finally, the theoretical value and analytical value are associated, and the influence of WHA on cement replacement demonstrates superior value than standard concrete.

- Elastic modulus for 10% of the cement substituted with water hyacinth ash performs better than traditional concrete.

- It grew more than regular concrete by 2.24%.

In summary, the stress-strain curve for the modulus of elasticity may change when incorporating water hyacinth ash into a material. The ash could potentially increase the modulus of elasticity due to its less rigid nature, but its specific impact would depend on how it is used and how well it bonds with the matrix material.

It is concluded that WHA is more rigid than conventional concrete.

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