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Discovering Thoughts, Inventing Future

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A Study on the Characteristics of Coal Fly Ash Collected from Southern U.S.A.

By Chukwu Onu & Ozioma Nwachukwu
Southern University

Abstract- The increasing dependency on coal for power generation to meet up with plummeting energy demands has led to the need for environmentally sustainable options for fly ash utilization. However, to accomplish this, information on the characteristics of the fly ash is required. The characteristics of coal fly ash obtained in southern U.S. was studied. The results of X-ray Fluorescence (XRF), Scanning Electron Microscope (SEM), and X-ray Diffraction (XRD) of twelve fly ash samples were obtained and analyzed.

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A Study on the Characteristics of Coal Fly Ash Collected from Southern U.S.A.

Chukwu Onu [α] & Ozioma Nwachukwu [σ]

Abstract- The increasing dependency on coal for power generation to meet up with plummeting energy demands has led to the need for environmentally sustainable options for fly ash utilization. However, to accomplish this, information on the characteristics of the fly ash is required. The characteristics of coal fly ash obtained in southern U.S. was studied. The results of X-ray Fluorescence (XRF), Scanning Electron Microscope (SEM), and X-ray Diffraction (XRD) of twelve fly ash samples were obtained and analyzed.

I. Introduction

Coal fly ash is obtained as a by-product of the combustion of coal for generation of electricity in thermal power plants. There are about 697 operating coal power plants in the U.S. according to the U.S. Energy Information Administration. According to a survey released by the American Coal Ash Association, it was estimated that about 53 million tons of coal fly ash is produced in the U.S. annually and is expected to increase by a little below 3% through 2033. About 53% of the ash is utilized leaving a substantial amount to be disposed of in landfills and lagoons [1].

The significant environmental and waste management challenge of coal fly ash (CFA) has received a great deal of attention over the past two decades. In response to this, coal fly ash is being examined for reuse and recovery applications to reach a more sustainable future. Currently, CFA is used in construction industry, zeolite synthesis, ceramic industry, catalysis, valuable metal recovery, and several agricultural and geotechnical applications [25]. However, with increased production of coal fly ash due to increase in demand for electricity arising from various economic factors including population growth, an increased rate of utilization in industry is required. Coal fly ash properties are strongly dependent on the geological origin, type of fuel and the combustion process of the coal [2,4]. Characterization of coal fly ash will enable industry stakeholders and researchers to fully embrace the potential of coal fly ash.

Multiple studies have been published that investigated the properties of coal fly ash and their potential application in the U.S. [5,15,16,17] and other parts of the world. The morphology, mineralogical and physico-chemical properties of coal fly ash obtained from various thermal power plants for utilization in zeolite synthesis in India, Pakistan, Japan and Indonesia have been investigated [3,7,8, 13, 14]. Medina et al (2010) reported the properties of Mexican fly ash. They concluded that fly ash was a potential raw material for cement industries, zeolite synthesis and as a support for heterogeneous catalysts due to its structural and thermal stability. Nathan et al (1999) characterized coal fly ash from Israel to study the potential toxic effect of coal ash leachates on soil and groundwater. In a study by Liu et al. [12], the petrologic, chemical, and trace elements in coal ashes in China was examined. It was concluded that coal fly ash is majorly composed of crystalline, glassy, and organic matter (incompletely combusted carbon). Van der Merwe et al (2014) studied the surface and physical properties of South African coal fly ash and its application in PVC composites. Two studies by Erol et al. [9] and Bayat [11] reported the characterization of various Turkish fly ashes. The studies concluded that fly ash have potential use in wastewater treatment, in glass production, as good binding agent, and as substitute for slags, pozzolana and gypsum in the amelioration of clinker.

Coal Fly Ash is classified worldwide into two main types based mostly on their application in cement industries, namely, class-C and class-F [1]. According to the American Society of Testing and Materials (ASTM), class-C fly ash is characterized by high calcium or lime content while class-F fly ash is characterized by low calcium or lime content [18]. While reviewing the existing literature, to the best of our knowledge, we have not found any literature characterizing and comparing class-C and class-F coal fly ash collected in the United States of America. As a result, this study focuses on the characterization of class-C and class-F coal fly ash using X-ray diffraction (XRD), Scanning Electron Microscope (SEM) and X-ray Fluorescence (XRF) to identify the structure, microstructure morphology, and chemical composition respectively.

II. Material and Methods

The twelve CFA samples used in this study were collected, dried and screened by Boral Resources. Characterization of the fly ash samples was carried out using non-destructive characterization techniques. A Rigaku Supermini200 XRF was used to identify the chemical composition of each CFA sample. For

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morphologic analysis, a Phenom Desktop SEM was used, operating at 15kV. The determination of the mineralogical composition was performed using a Rigaku MiniFlex600 X-ray Diffractometer, at 2kV, using CuKα radiation and a scattering angle variation from 5° to 90°. The MDI Jade standard was used to analyze the peaks obtained in diffraction patterns of the coal fly ash samples.

III. Results and Discussion

a) XRF Analysis

X-ray Fluorescence spectrometry has been used extensively in the determination of the chemical composition of fly ash [19, 20]. The results of this analysis are presented in Table 1. The major elemental composition of coal fly ash is similar to the composition of rocks in the Earth's upper crust. This can be attributed to the formation of ash from the inorganic components of coal such as quartz, feldspars, clays and metal oxides [24]. Metal elements such as Ca, Fe, K and Mg are present primarily from the organic matter (e.g. swamp plants) that formed the combusted coal [22].

Franus et al. (2015) reported that over 90% of coal fly ash is composed of oxides of Si, Al, Fe and Ca; minor elements such as Mg, K, Na, Ti and S make up about 8% and the remainder is made up of trace elements. This is observed in the data presented in table 1. From the table below, oxides of silicon, aluminum and calcium have the highest weight percentages, with other oxides present in minute quantities.

The ASTM D388 defines coal by ranks; high ranked coal such as anthracite or bituminous, and low ranked coal such as lignite or subbituminous [22]. Class-F fly ash, which is produced from the combustion of high ranked coal, is applicable in industries such as ceramic and metal recovery. Inversely, class-C fly ash is produced from low ranked coal and finds application in soil amelioration and construction industries [25].

Table 1: Chemical Composition of the Coal Fly Ash Samples

Chemical Composition, weight %										
Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	MgO	K_2O	Na_2O	SiO_2/Al_2O_3	$(SiO_2 + Al_2O_3 + Fe_2O_3)$
1	47.553	20.683	4.943	19.236	0.942	4.051	1.210	0.841	2.299	73.179
2	49.535	24.572	10.97	2.935	0.143	1.349	2.915	0.371	2.016	85.077
3	48.523	20.554	4.969	16.995	0.748	4.121	1.212	1.081	2.361	74.046
4	50.022	20.781	5.068	16.542	0.654	4.034	1.275	1.167	2.407	75.871
5	57.372	19.795	4.773	9.588	0.206	2.317	1.301	2.474	2.898	81.94
6	38.934	16.291	3.011	39.906	1.963	2.199	1.088	0.711	2.390	58.236
7	39.249	21.586	5.571	21.183	1.402	4.521	0.668	1.804	1.818	66.406
8	36.441	19.801	5.164	24.465	1.523	5.913	0.503	2.618	1.840	61.406
9	38.915	21.329	5.353	21.251	1.628	4.034	0.572	1.697	1.825	65.597
10	35.875	19.835	5.131	26.648	2.092	5.292	0.550	1.905	1.809	60.841
11	39.815	20.618	5.004	22.392	1.370	4.127	0.585	1.422	1.931	65.437
12	38.730	20.743	5.103	22.496	1.016	5.188	0.585	1.875	1.867	64.576
ASTM C618 limits	Class F				5 max.					70 min.
	Class C				5 max.					50 min.

From literature, identifying the class of coal fly ash will aid in determining suitable areas of application [20]. According to the ASTM guidelines for classification of coal fly ash, samples 1 – 5 can be classified as class-F coal fly ash, while samples 6 – 12 are class-C coal fly ash. Having more than half of the sample size classified as class-C fly ash is not surprising. This is due to the type of coal, Lignite, which is found predominantly in Texas and Louisiana states of America [22].

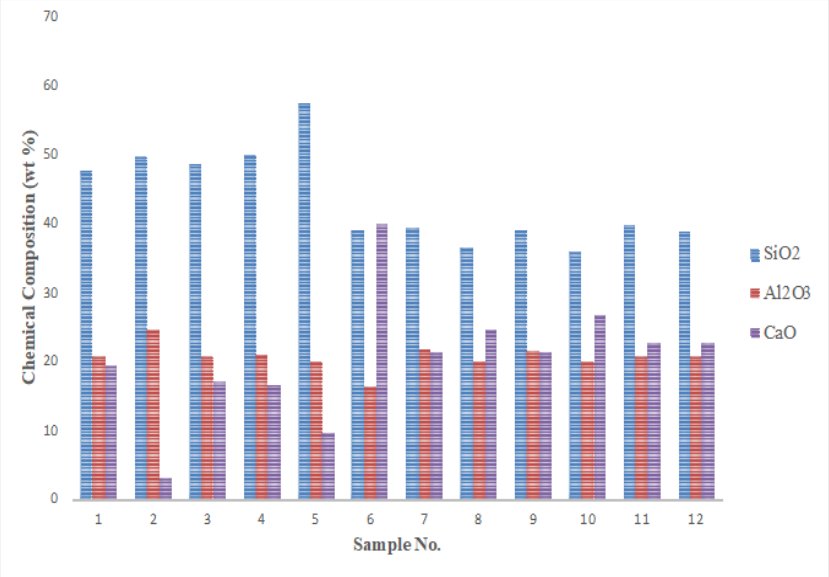


Figure 1: Plot showing weight % chemical composition of major oxides (SiO_2, Al_2O_3, and CaO) for each coal fly ash sample

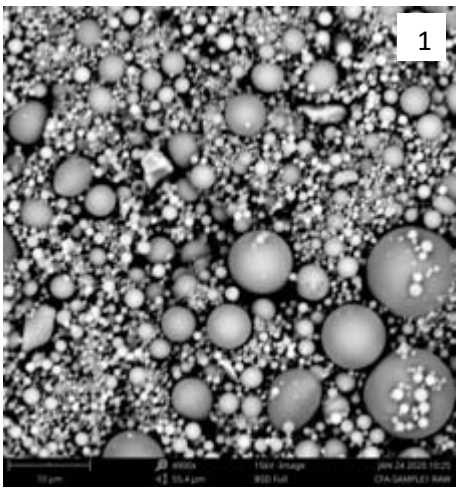
Although Class F fly ashes has been reported to contain < 15% CaO, and class C having CaO in the range of (10–35)% [24, 25], samples 1, 3, and 4do not align with this. A study by Fox (2017) stated that it is possible to have class-F fly ash with higher CaO content due to the average codabular variation (cv) value of the combusted coal. The cv value represents the deviation of the alkali (K_20 and Na_2O) weight percent from the codabular function and is dependent on the geochemistry of the coal. This phenomenon however does not hinder the classification of samples 1, 3, and 4 as class-F as they still comply with the requirements of $SiO_2 + Al_2O_3 + Fe_2O_3 > 70$ and the CaO values are generally lower than those samples classified as class-C [27].

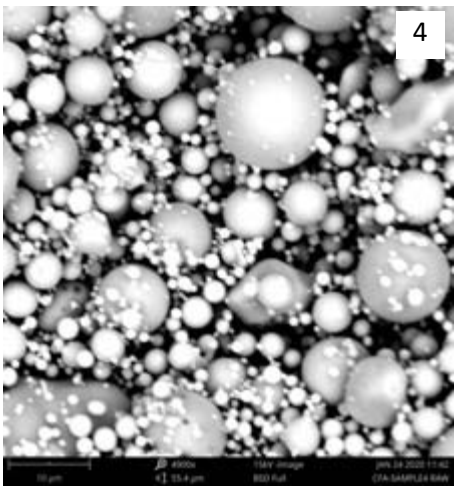
Inada et al. (2005) studied the importance of the SiO_2/Al_2O_3 composition in determining the yield and resulting zeolite type during the synthesis of zeolites. Generally, the optimal SiO_2/Al_2O_3 ratio for zeolite A is c.a. 2; between 2.2 - 5 for zeolite X; between 3.1 – 10 for zeolite Y have been reported [21, 26]. Thus, samples 1-6 can be synthesized to zeolite X, and samples 7 – 12 can be converted to zeolite A.

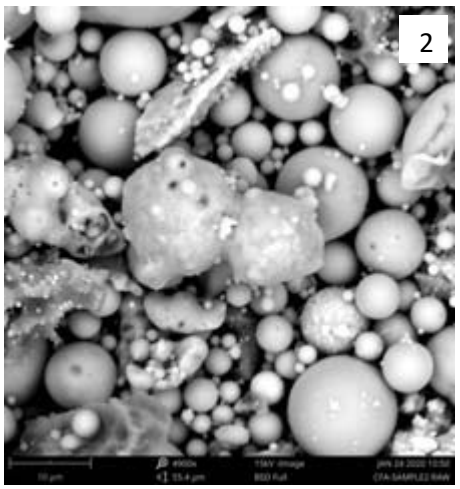
Figure 1 clearly shows the higher SiO_2 weight percent values of samples 1 – 5, which is consistent with Class-F fly ash due to its pozzolanic properties. Pozzolansare siliceous or aluminosilicate materials with little or no cementitious property on their own, but in the presence of moisture, will chemically react at room temperature with calcium hydroxide to form compounds with cementitious properties [28]. It can also be seen that samples 6 – 12 have higher CaO weight percentage consistent with the cementitious properties of class-C fly ash.

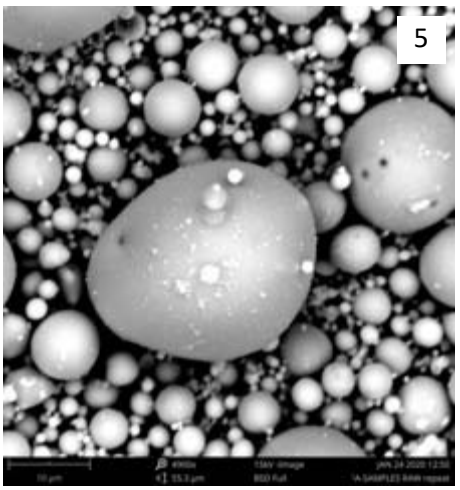
b) SEM Analysis

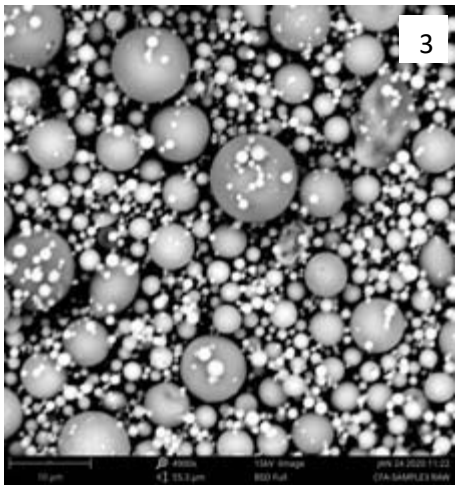
SEM images of different coal fly ash samples are presented in Figure 2. The cooling rate and the combustion temperature of the fuel determines the morphology of particles [21]. It can be seen from the morphology of all the samples, that the particles are mostly spherical in shape with varying sizes. From literature, this spherical morphology can be attributed to the high silicon content of the samples [19]. This agrees with the data presented in table 1 above. It can also be observed that there are some irregular shaped unburned carbon particles in samples 2,6,8,9,10, and 11. These irregular shaped particles are attributed to the improper combustion of the coal [20].

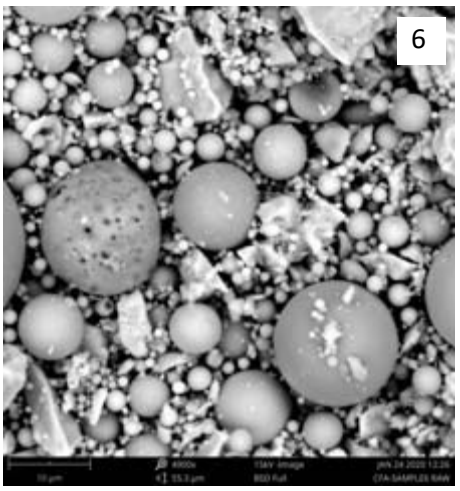












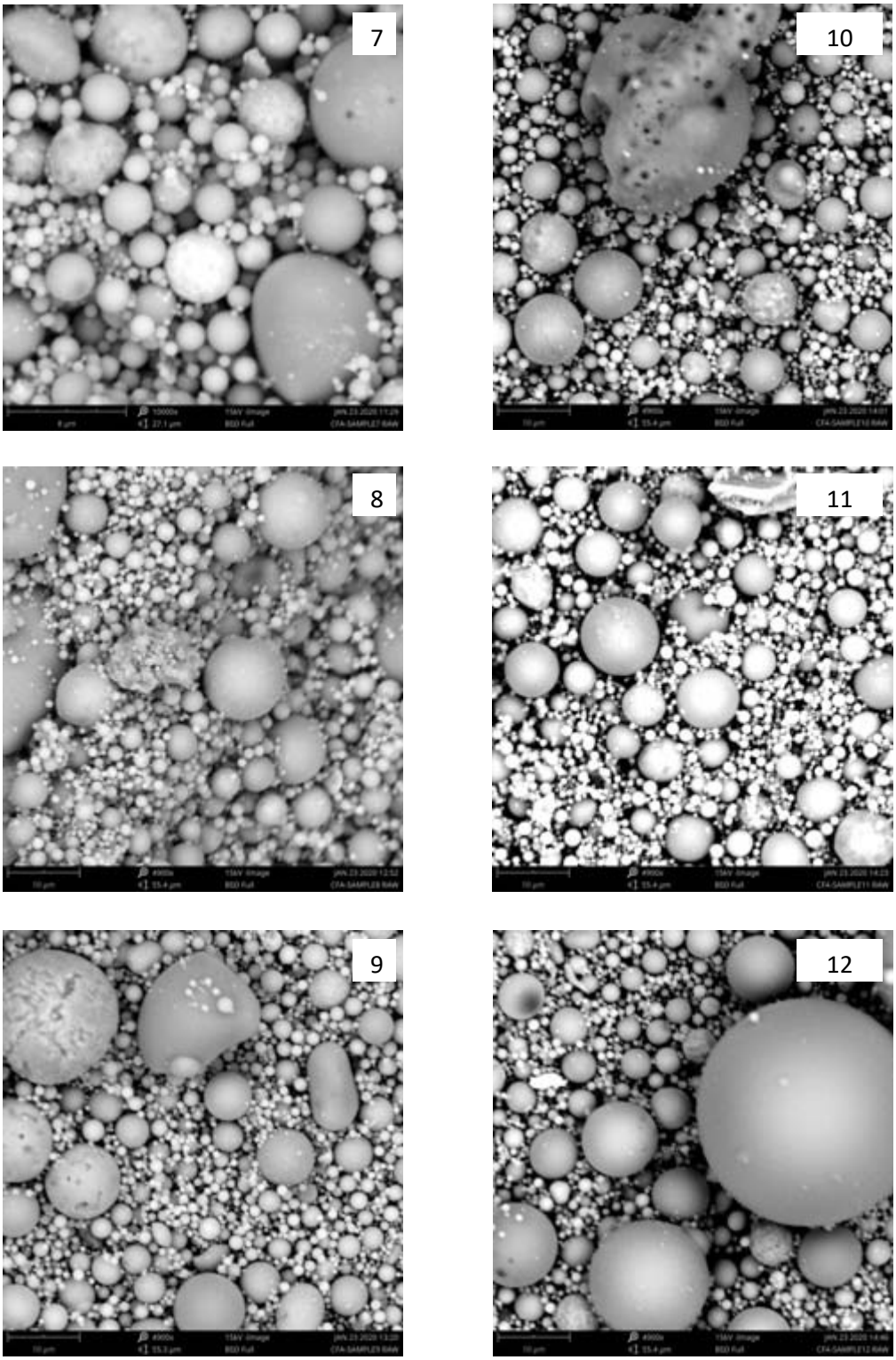
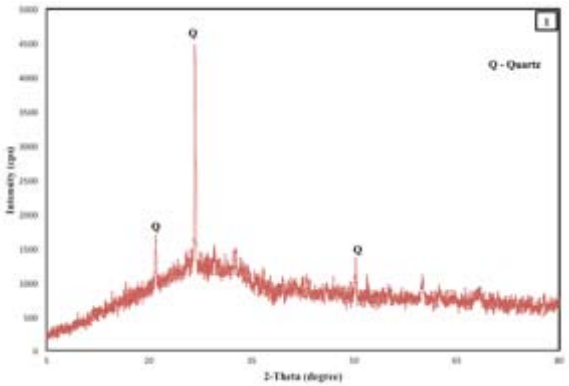


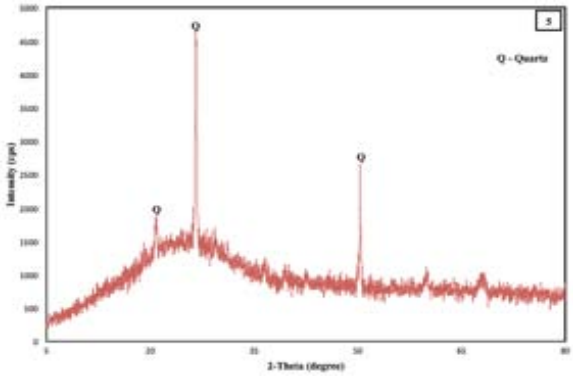
Figure 2: SEM Photographs of the different coal fly ash samples. (Class-F fly ashes: 1-5; Class-C fly ashes: 6-12)

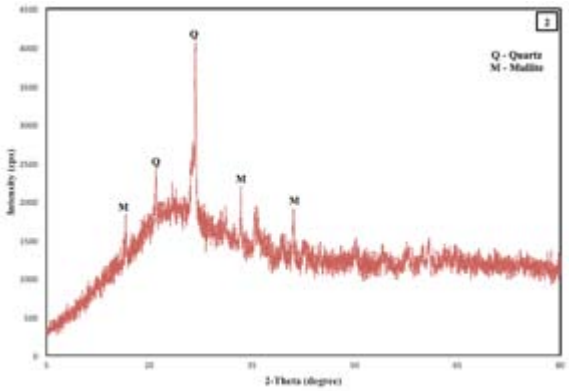
c) XRD Analysis

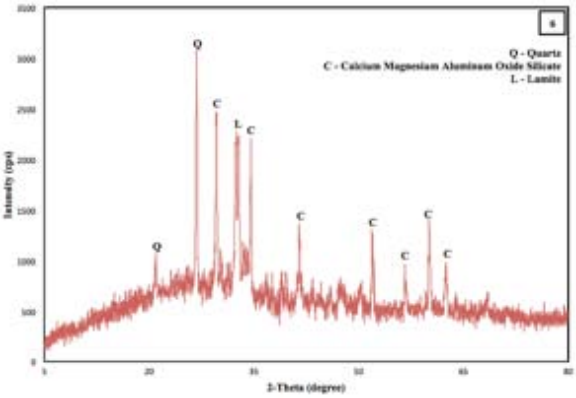
X-ray Diffraction is a powerful technique that detects the crystalline phases present in sufficient quantity in a sample [20]. Figure 2 presents the results of this analysis. Crystalline phases are represented by peaks, while amorphous phase is represented by the hump. The images presented show a large amount of amorphous content which is to be expected with fly ash (above 80%) [21].

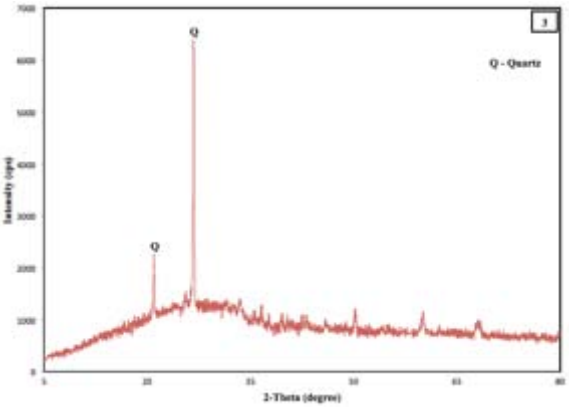
According to mineralogical analysis, the two main crystalline phases for the twelve samples are quartz (SiO_2) and mullite ($Al_6Si_2O_{13}$).

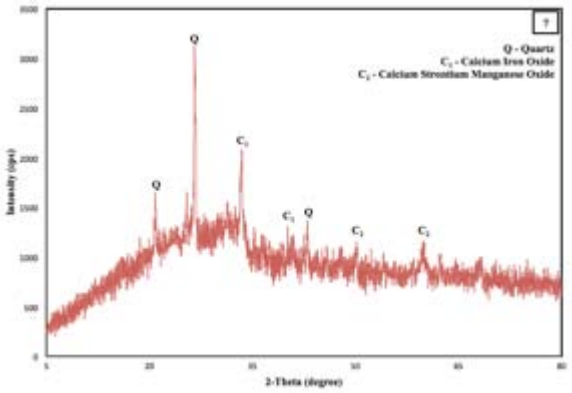


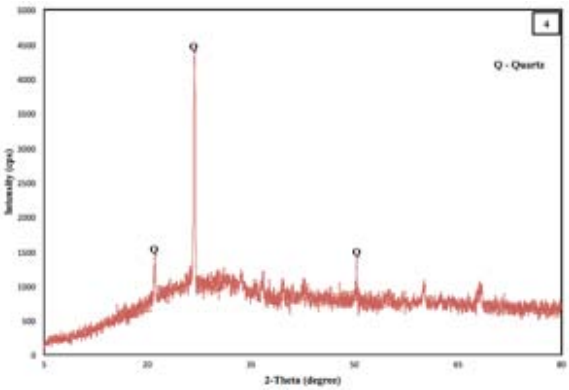


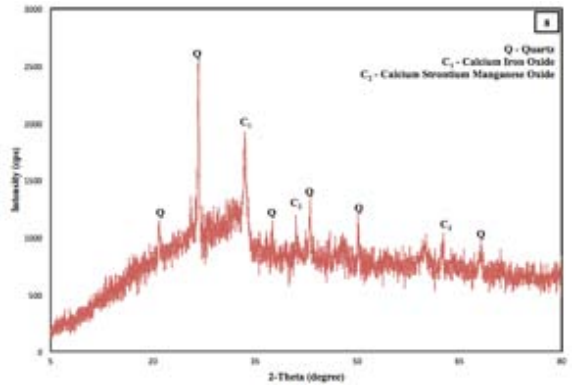












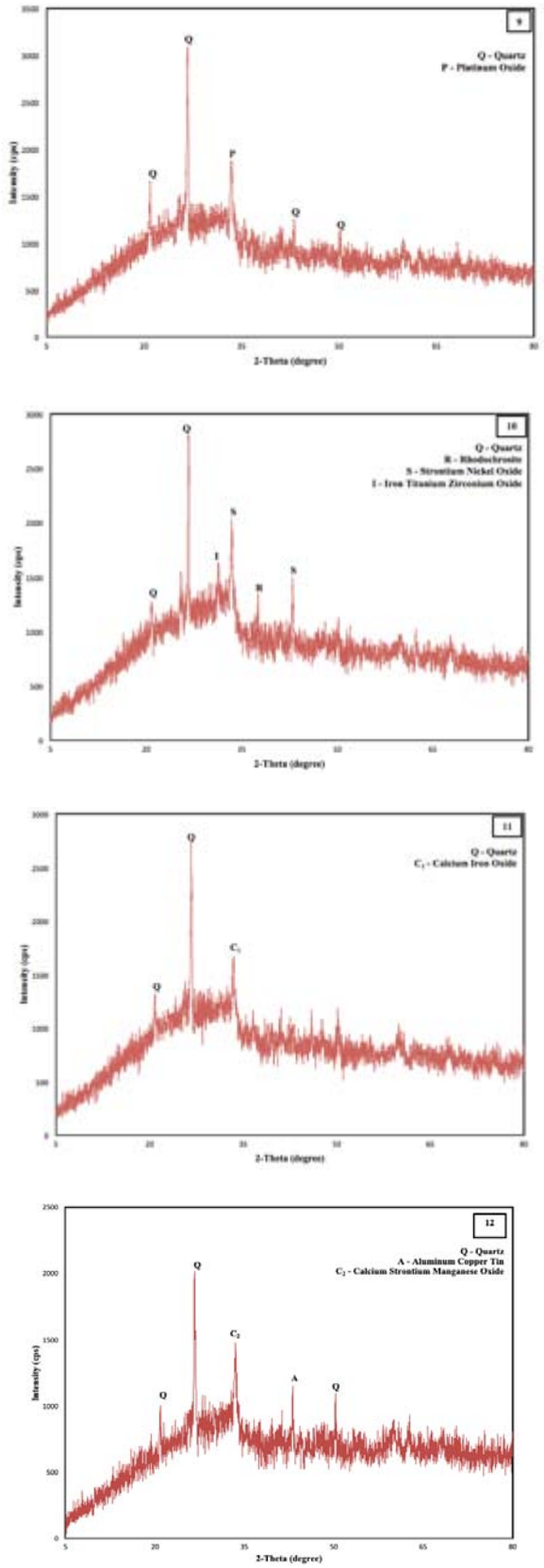


Figure 3: X-ray Diffraction Analysis of the Coal Fly Ash Samples

Other than these, Calcium Magnesium Aluminum Oxide Silicate ($Ca_{54}MgAl_2Si_{16}O_{90}$), Calcium Strontium Manganese Oxide ($(Ca_{0.5}Sr_{0.5})MnO_3$), Rhodochrosite ($MnCO_3$), Strontium Nickel Oxide ($SrNiO_3$), Iron Titanium Zirconium Oxide ($Fe_{0.88}Ti_{1.11}Zr_{0.94}O_5$), Calcium Iron Oxide ($CaFeO_3$), Aluminum Copper Tin ($Al_3Cu_{12}Sn$), Platinum Oxide (PtO), and Lamite (Ca_2SiO_4) are also identified in the fly ash samples.

IV. Conclusion

The results obtained from this chemical characterization study confirm the fact that the coal fly ash found in the southern part of the United Sates (mainly Texas and Louisiana) have high percentage oxides of Si, Al, Fe and Ca and therefore makes them good candidates for industrial application. With the problem of ash management and leachate contamination of groundwater, coal fly ash disposal on land or lagoons should be discouraged. This study has instead provided information to enable sustainable use of coal fly ash in various industries such as construction industry, zeolite synthesis, ceramic industry catalysis, wastewater treatment and valuable metal recovery.

Our next investigation is on the potential use of the coal fly ash in water treatment and to compare it to the traditional water treatment processes.

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A Structural Damage Identification Method based on Arrangement of Static Force Residual Vector

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Abstract- In order to effectively and conveniently identify the damage location and damage degree of structural members under static response, a structural damage identification method based on force residual vector is proposed. The force residual vector is defined by using the static displacement data and the stiffness matrix of the finite element model structure. The structural element corresponding to the non-zero element of the permutation force residual vector is intelligently determined as the damage element. The damage degree of the damaged unit calculated from the equilibrium equation which is established by the global stiffness matrix with only damage unit. As examples, the identification analysis of damage units of numerical models are carried out for a simply supported beam as a simple structure and a truss as a complex structure based on the proposed method.

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A Structural Damage Identification Method based on Arrangement of Static Force Residual Vector

Jibao Shen [α], Zhike Li [σ], Shuai Luo [ρ] & Wei Wang [ω]

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I. Introduction

With the time in the service period of structure, the damage of the structure often brings potential safety hazard. Structural damage identification technology plays an increasingly important role in structural health monitoring. Reliable and effective nondestructive identification can ensure structural safety and integrity [1-3].

In generally, the structural damage detection is mainly to identify the location and the damage level of structural. In the process of identification, the response of the external excitation is measured by dynamic test or static test. Therefore, the damage is usually directly identified by numerical operation. The result of structural damage is the reduction of the local stiffness of the structure. Therefore, the damage of the structure can be regarded as a change in stiffness, ignoring the change in quality, and can be detected by changes in dynamic or static characteristics[4-8].

Considering the nature of the measurement data, the measurement methods can be divided into two categories: dynamic methods and static methods. Due to the convenience of dynamic data measurement, a large number of damage identification methods have been developed on the basis of dynamic testing[9-12]. Many experts have done so much research work on damage identification using residual force vector method under dynamic response. Zimmerman et al.[13] firstly proposed the theoretical algorithm related to the residual force vector method. Kahl et al. [14] improved the theoretical algorithm proposed by the former and identified the damage location in the beam member. Li et al.[15] used the difference of the virtual residual force vector of the intact structure and the damaged structure to locate the damage location, combined with the response sensitivity method to identify the local damage degree, and better identified the location and damage degree of a single damage and multiple damages. Nobahariet al.[16] used the concept of residual force vector and proposed a method based on the damage index of truss units. This method can find the most likely damaged component location, and eliminate the undamaged units from all variables to reduce the amount of calculation, and then use the genetic algorithm to find a more specific damage unit in the concentrated position of the damaged component and calculate its damage degrees.

The purpose of dynamic analysis is to determine the parameters such as internal force, stress and displacement under dynamic load. In vibration modal analysis, the main calculation work is to solve the Eigen problem, which requires more calculation work than static analysis[17]. The general residual force vector method for damage identification is mainly based on the modal parameters of the dynamic test, which requires more complicated modal analysis, and the accuracy of the damage analysis results is not high. Based on the residual force vector method under dynamic response, this paper proposes a force residual vector method. This method uses the sparse property of the damage unit stiffness matrix and its corresponding residual vector distribution rule to realize the location of the damage unit and gives damage degree after the location by solving the self-balance equation of the damage unit. In this study, numerical examples of simply supported beams and trusses have been verified, and the damage location and damage degree of structure have been identified.

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II. Theory of Force Residual Vector Method

a) Basic Assumptions

In damage identification with the force residual vector method, it is necessary to make some basic assumptions about the structure:

1. When the structure is damaged, only the rigidity of the structure is reduced, and the influence of quality on the structure is ignored.
2. The damage of structural units is discontinuous in the finite element model. This assumption has been given in previous studies[18-19].

b) Theoretical Equations

A structural system produces node displacement *D* under the action of static force *F*. the static equilibrium equation in the global coordinate system can be expressed as the following formula.

$$\boldsymbol{KD} = \boldsymbol{F} \tag{1}$$

where *K* is the global stiffness matrix of the structural system, and *D* is the node displacement vector in the global coordinate system.

When the structure is damaged, its stiffness matrix will change. Assuming that $\boldsymbol{\alpha}_i$ is the damage degree of the stiffness matrix corresponding to the $\boldsymbol{i}$-th structural unit, the perturbation matrix △K of structural damage can be expressed as the following formula:

$$\Delta \boldsymbol{K} = \alpha \boldsymbol{K} \tag{2}$$

where $\boldsymbol{\alpha}$ is the damage degree vector.

Substituting the damage stiffness △K and the displacement d of the structure after damage into Eq. (1), we can get the following formula:

$$\left(\boldsymbol{K} - \Delta \boldsymbol{K}\right) d = \boldsymbol{F} \tag{3}$$

For Eq. (3), moving the term without △K to the right side of the equation, we can get the following equation.

$$\Delta \boldsymbol{K} d = \boldsymbol{K} d - \boldsymbol{F} \tag{4}$$

Define the vector on the right side of Eq. (4) as the force residual vector $\boldsymbol{P}$.

$$\boldsymbol{K} d - \boldsymbol{F} = \boldsymbol{P} = \begin{bmatrix} p_1 & p_2 & \cdots & p_n \end{bmatrix}^{\mathrm{T}} \tag{5}$$

The values of elements p_i corresponding to the damaged units in the *P* vector are much larger than those of the undamaged units. The values of elements p_i corresponding to the undamaged units approach 0. That can be used as a filtering condition in the analysis process. The elements in the vector *P* of Eq. (5) are arranged in descending order of their absolute values. The structure units with larger values in front are corresponding to the damaged units. It can be used to realize localization of damage unit precisely.

Eq. (5) is composed of n equilibrium equations at nodes, Suppose that there is an unit damage on a node, and that the elements p_i values, the unit stiffness matrix and the displacement vector are proportional for a given damage unit, the ratio is the damage degree. It can be realized identification of damage degree. Therefore, the damage coefficient can be obtained according to the following formula:

$$\alpha_i \boldsymbol{K}_i d = P_i \tag{6}$$

$\boldsymbol{K}_i$ is the global stiffness matrix containing only the unit stiffness matrix elements of the damage unit.

c) Solving Steps

The specific solving steps of this method are as follows:

1. Establish a stiffness matrix for the target structure and combine the static balance equation to obtain the force residual vector *P*.
2. List the elements of vector *P* according to their corresponding degrees of freedom of structure units, and arrange them in descending order of absolute value.
3. For the arranged absolute value sequence, divide the previous element by the next element. The position where the quotient obtained by the calculation tends to infinity is the last damaged unit, and the value of degree of freedom about the last damaged unit is expressed as the total amount of degree of freedom about the damaged units. According to the fact that a structure unit has four degrees of freedom, the number of damage units can be judged.
4. For the elements in the list arranged according to the structure unit number, the structure unit whose ratio of the vector value corresponding to the first displacement and the third displacement equals -1 is the damage unit, so that the damage unit is located. And verify the judgment result of step (3).
5. Take out the structure unit stiffness matrix of the located damage unit in the global coordinate system, establish the node balance equation one by one according to the number of the damage unit, and solve the damage degree of each unit according to equation (6) to determine the damage level of the structural member.

Fig.1 shows the flow chart of the specific solving steps of this method.

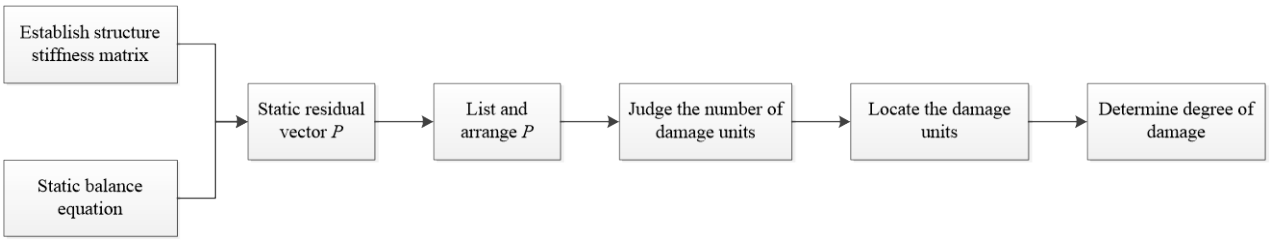


Fig. 1: Flow chart of calculation

III. Numerical Model Examples

In order to apply the force residual vector to practice, the following takes simply supported beams and truss structures as examples for numerical model calculations. At first we set the degrees of damage of some structural units, and calculate the displacements of the structural unit nodes by calculating the force residual vector. Then the node displacements are used to locate the damage units and to determine the degrees of damage. If the identified location and the identified degrees of damage are consistent with the set values, it can show that the force residual vector method can be used to identify the damage location and the damage degree of the structure through the values of node displacements.

a) Numerical Model Example of Simply Supported Beam

i. *Calculated Displacement Value of Simply Supported Beam*

Taking the simply supported beam model shown in Fig.2 as an example to explain the proposed method. The simply supported beam structure is divided into 12 units, and then the finite element analysis for it is carried out. The basic parameters of No.14I-beam are as follows: unit length L=0.1m, cross-sectional area A=2.15×10^{-3}m^2, elastic modulus E=200GPa, moment of inertia I=7.12×10-6 m4, density ρ=7.8×103kg/m3. The simply supported beam model structure is added a downward force F=10kN in the middle of the span, constrained the horizontal and vertical displacement at node 1, and constrained the vertical displacement at node 13.

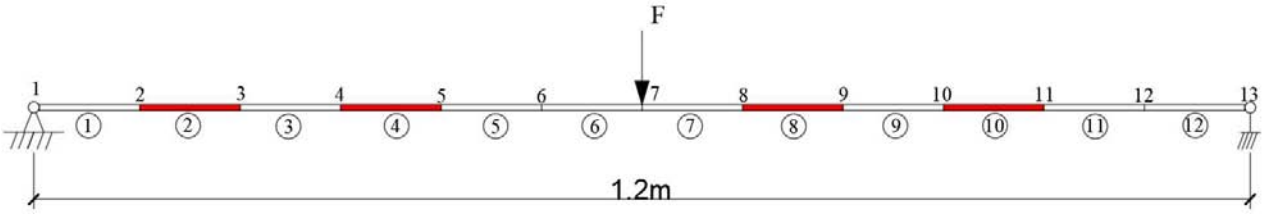


Fig. 2: Sketch of simply supported beam

Regardless of the axial displacement of the simply supported beam model, the stiffness matrix of the beam units related to the vertical and angular displacement is taken as[13-14]:

$$\boldsymbol{K}_e = \frac{EI}{L^3}\begin{bmatrix} 12 & 6L & -12 & 6L \\ 6L & 4L^2 & -6L & 2L^2 \\ -12 & -6L & 12 & -6L \\ 6L & 2L^2 & -6L & 4L^2 \end{bmatrix} \quad (7)$$

According to the degrees of damage $\boldsymbol{\alpha}_i$ (0＜αi＜1) introduced Eq.(2), the global stiffness matrix of the beam can be expressed as:

$$\boldsymbol{K} = \sum_{i=1}^{12}(1-\alpha_i)\boldsymbol{K}_i \quad (8)$$

where $\boldsymbol{K}_i$ represents the *i-th* unit stiffness matrix in the global coordinate system, and the subscript i represents the unit number.

Table 1 shows the node numbers and the numbers of the node degrees of freedom of simply supported beam units.

Table 1: Node number and number of node degrees of freedom of units

Node number		1	2	3	4	5	6	7	8	9	10	11	12	13
Number of node degrees of freedom	Vertical displacement	—	2	4	6	8	10	12	14	16	18	20	22	—
	Angular displacement	1	3	5	7	9	11	13	15	17	19	21	23	24

Take multiple damage case as an example: the loss of stiffness is 15% for unit 2, 60% for unit 4, 13% for unit 8, and 30% for unit 10, that is α_2=0.15、α_4=0.60、α_8=0.13 and α_{10}=0.30.

The node displacements are calculated according to Eq.(3), and arranged in Table 2 according to the order of degrees of freedom of the units. In the table, v_a and θ_a are the vertical and rotational displacements of the left node of an unit, and v_b and θ_b the vertical and rotational displacements of the right node of an unit.

Table 2: Node displacement of simply supported beam (mm)

Displacement	Unit					
	1	2	3	4	5	6
v_a	0.000	-0.787	-0.770	-0.708	-0.620	-0.313
θ_a	0.000	-0.078	-0.152	-0.219	-0.266	-0.290
v_b	-0.787	-0.770	-0.708	-0.620	-0.313	-0.155
θ_b	-0.078	-0.152	-0.219	-0.266	-0.290	-0.296
Displacement	Unit					
	7	8	9	10	11	12
v_a	-0.155	0.039	0.232	0.413	0.536	0.662
θ_a	-0.296	-0.282	-0.250	-0.202	-0.142	-0.073
v_b	0.039	0.232	0.413	0.536	0.662	0.714
θ_b	-0.282	-0.250	-0.202	-0.142	-0.073	0.732

Fig. 3 shows the deformation diagram of the simply supported beam. In the figure, the dotted lines present the original structure, and the solid lines present the deformed structure.

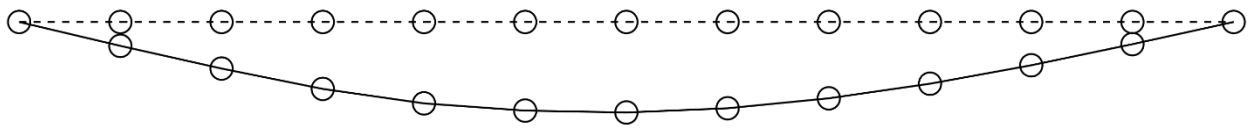


Fig. 3: Deformation diagram of simply supported beam

ii. *Damage Identification of Simply Supported Beam*

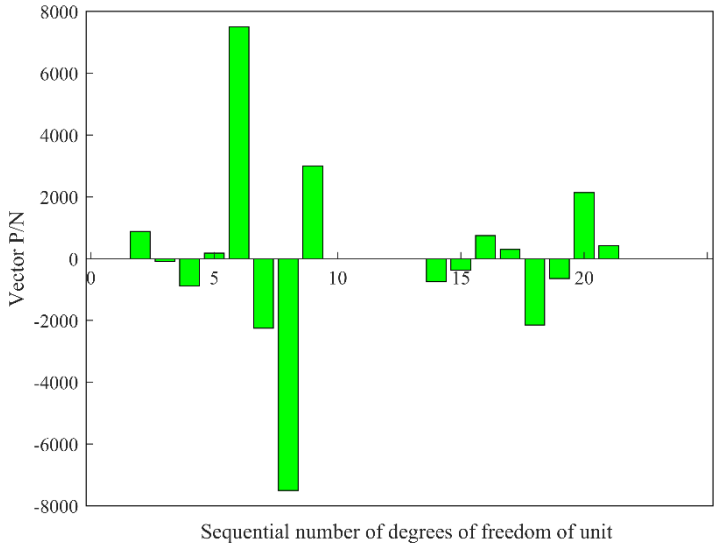
The calculated node displacements in Table 2 are used as the known values of structural damage identification.

The force residual vector P is determined according to Eq.(5) and shown in Table 3.

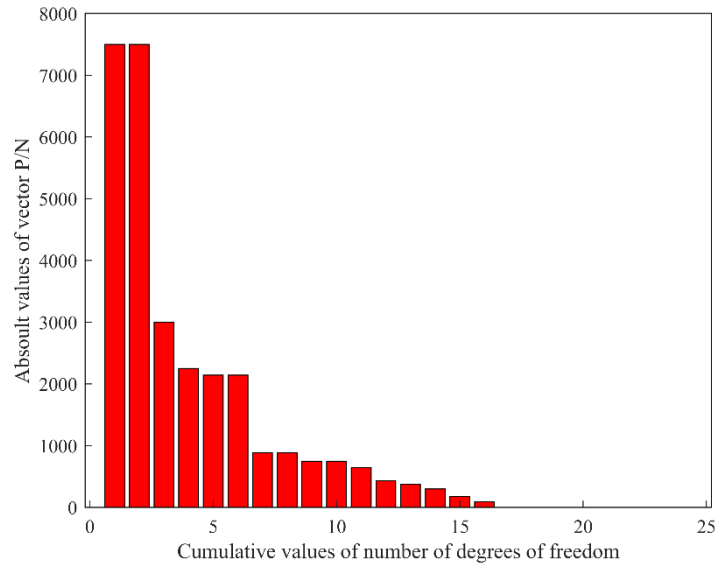
Table 3: Values of force residual vector P (N)

Displacement	Unit					
	1	2	3	4	5	6
v_a	0	882.535	-888.35	7500	-7500	0
θ_a	0	-88.24	176.47	-2250	3000	0
v_b	882.535	-888.35	7500	-7500	0	0
θ_b	-88.24	176.47	-2250	3000	0	0
Displacement	Unit					
	7	8	9	10	11	12
v_a	0	-747.13	747.13	-2142.90	2142.9	0
θ_a	0	-373.56	298.85	-642.86	428.57	0
v_b	-747.13	747.13	-2142.90	2142.9	0	0
θ_b	-373.56	298.85	-642.86	428.57	0	0

Fig. 4 shows the distribution and arrangement of force residual vector *P*.



(a) Distribution diagram of residual vector value



(b) Arrangement diagram of absolute value of residual vector

Fig. 4: Distribution and arrangement of residual vector values of simply supported beam

Fig. 4 (a) presents the distribution of force residual vector *P*. The abscissa represents from left to right, the sequential number of vertical and rotational degrees of freedom of unit nodes. The ordinate corresponds to the force residual vector of corresponding units. Fig.4 (b) shows the arrangement of the absolute values of P in descending order. The abscissa represents the cumulative values of the number of vertical and rotational degrees of freedom of unit left and right nodes.

For the arranged absolute value sequence in Fig.4 (b), divide the previous element by the next element, we obtain the positioning diagram shown in Fig.5. The maximum ratio which represents the total number of degrees of freedom of the damage units is located at 16. Since each unit corresponds to 4 degrees of freedom in the local coordinate system, it can be seen that four units in the simply supported beam have been damaged, which is consistent with the set number of damage units.

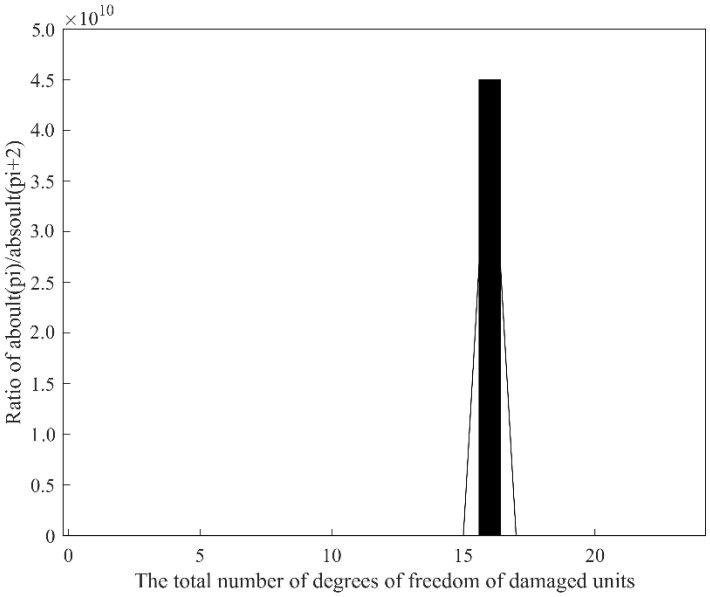


Fig. 5: Total number of freedom degrees of damage elements

In Table 3, the units 2, 4, 8 and 10 whose ratio of the residual vector values *P* corresponding to the first displacement and the third displacement of the units is -1 are damage units. Those located damage units are the same as the set damage units.

The identification values of damage degree obtained by solving damage degrees using Eq.(6), and the setting values of the corresponding units are listed in Table 4.

Table 4: Identification values and setting values of unit damage degrees of simply supported beam

Damage unit number	2	4	8	10
Setting value	0.15	0.60	0.13	0.3
Identification values	0.15	0.60	0.13	0.3

It can be seen from Table 4 that all the identification values of damage degrees are completely consistent with the corresponding setting values. It can be concluded that the force residual vector method can be used to locate the damage position and identify the damage degree of simply supported beam structure.

b) Example of Truss Numerical Model

i. *Calculated Value of Truss Displacement*

The specific numerical model size of the truss structure is shown in Fig. 6. The truss has 10 spans, 37 elements which are all bar units, the length of the bottom and upper horizontal bar units is 0.4m, 0.3m for the vertical bar units, and 0.5m for the diagonal bar units. The elastic modulus of the steel used is E=200GPa, the cross-sectional area of the L-shaped steel unit is A=2.276×10-4m2, the density ρ=7.8×103kg/m3, and the vertical concentrated *force* *F*=15kN is loaded at the bottom in the middle of the span.

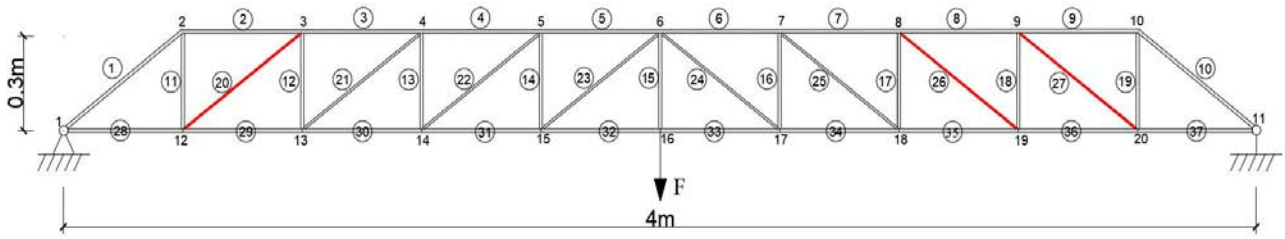


Fig. 6: Sketch of truss model

The unit stiffness matrix in the local coordinate system of the unit is expressed as

$$Ke=\frac{EA}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \tag{9}$$

where E is the elastic modulus of the unit, A is the cross-sectional area of the unit, and L is the length of the unit.

The transformation matrix of unit stiffness matrix in local coordinate system into that in global coordinate system can be expressed as

$$S=\begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 \\ 0 & 0 & \cos\theta & \sin\theta \end{bmatrix} \tag{10}$$

θ is expressed as the rotation angle of the unit between the local coordinate system and the global coordinate system.

The given unit stiffness matrix and transformation matrix under the local coordinate system of the unit, the unit stiffness matrix under the local coordinate system can be transformed into the unit stiffness matrix under the global coordinate system, and the unit stiffness matrix K_g^e(4×4 order matrix) under the global coordinate system can be obtained.

$$K_g^e=\frac{EA}{L}\begin{bmatrix} \cos^2\theta & \cos\theta\sin\theta & -\cos^2\theta & -\cos\theta\sin\theta \\ \cos\theta\sin\theta & \sin^2\theta & -\cos\theta\sin\theta & -\sin^2\theta \\ -\cos^2\theta & -\cos\theta\sin\theta & \cos^2\theta & \cos\theta\sin\theta \\ -\cos\theta\sin\theta & -\sin^2\theta & \cos\theta\sin\theta & \sin^2\theta \end{bmatrix} \tag{11}$$

In this example, the structure has 20 nodes with 40 degrees of freedom. The association table method[15-16] requires an extraction matrix $T_{4\times40}$. The matrix T extracts the degrees of freedom of different units in the global coordinate system. The T matrix changes with the degrees of freedom of unit and is expressed as

$$T=\begin{bmatrix} 0 & \cdots & 0 & 1 & 0 & 0 & 0 & 0 & \cdots & 0 \\ 0 & \cdots & 0 & 0 & 1 & 0 & 0 & 0 & \cdots & 0 \\ 0 & \cdots & 0 & 0 & 0 & 1 & 0 & 0 & \cdots & 0 \\ 0 & \cdots & 0 & 0 & 0 & 0 & 1 & 0 & \cdots & 0 \end{bmatrix}_{4\times40} \tag{12}$$

The unit stiffness matrix in the global coordinate system is

$$K_g^E=T^T K_g^e T \tag{13}$$

where K_g^E is 40 × 40 order matrix.

According to Eq. (2) the damage coefficient α_i $(0<\alpha_i<1)$ is introduced, and the global stiffness matrix of the truss can be expressed as

$$\boldsymbol{K}=\sum_{i=1}^{37}(1-\alpha_i)\boldsymbol{K}_i \tag{14}$$

where $\boldsymbol{K}_i$ represents the *i-th* unit stiffness matrix in the global coordinate system, and the subscript i represents the unit number.

In order to obtain the static response of the structure, the vertical concentrated force F = 15KN is loaded at the bottom in the middle of the span. The truss model is modeled by the correlation table method[15-16]. The steps of locating the position of the stiffness matrix by the correlation table method are as follows: assume that the node (i, j) of the unit N corresponds to the position of the node degrees of freedom of the global stiffness matrix as $N_i(2\times i\text{-}1,\ 2\times i)$, $N_j(2\times j\text{-}1,\ 2\times j)$. For example, for unit 12, the node numbers are 3 and 13, and the position of the node degrees of freedom corresponds to the global stiffness matrix are 5, 6, 25 and 26. Therefore, the corresponding positions of unit 12 in the global stiffness matrix are 5 rows, 6 rows, 25 rows, 26 rows, 5 columns, 6 columns, 25 columns and 26 columns.

In order to better simulate the actual damage situation, different damage coefficient values are set for different units of the truss. Assume that Units20, 26 and 27 are damaged by 15%, 60%, and 25%, that is, α_{20}=0.15, α_{26}=0.60 and α_{27}=0.25. Use Eq.(3) to solve the displacement values of each node after damage, as shown in Table 5. In the table, u and v represent horizontal and vertical displacements respectively.

Table 5: Displacement values of unit nodes (mm)

Displacement	Node									
	1	2	3	4	5	6	7	8	9	10
u	0.000	2.225	2.137	1.962	1.698	1.347	0.995	0.731	0.556	0.468
v	0.000	-3.196	-6.247	-8.790	-10.629	-11.531	-10.705	-8.941	-6.131	-3.120

Displacement	Node									
	11	12	13	14	15	16	17	18	19	20
u	2.636	0.088	0.264	0.527	0.879	1.318	1.757	2.109	2.373	2.548
v	0.000	-3.245	-6.297	-8.839	-10.678	-11.630	-10.754	-8.991	-6.181	-3.169

Fig. 7 shows the deformation diagram of the truss. In the figure, the dotted lines present the original structure, and the solid lines present the deformed structure.

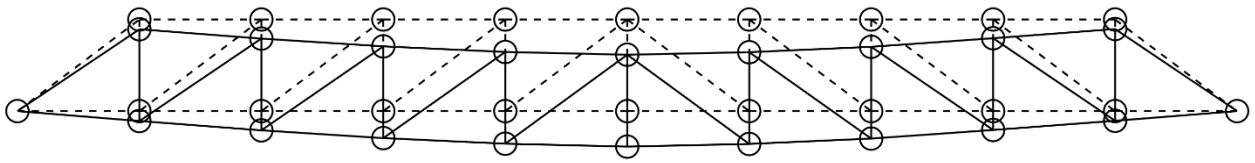


Fig. 7: Deformation diagram of truss

ii. *Truss Damage Identification*

Use Table 5 to calculate the node displacement value as the known value for structural damage identification.

According to Eq.(5), the force residual vector *P* is obtained, which is listed in Table 6. In the table, u_a and v_a are the horizontal and vertical vectors of the premier node of an unit respectively, and u_b and v_b the horizontal and vertical vectors of the second node of the unit.

Table 6: Values of force residual vector *P* (N)

Displacement	Unit							
	1	2	3	4	5	6	7	8
u_a	0	0	-1765	0	0	0	0	15000
v_a	0	0	-1324	0	0	0	0	-11250
u_b	0	-1765	0	0	0	0	15000	3333
v_b	0	-1324	0	0	0	0	-11250	-2500

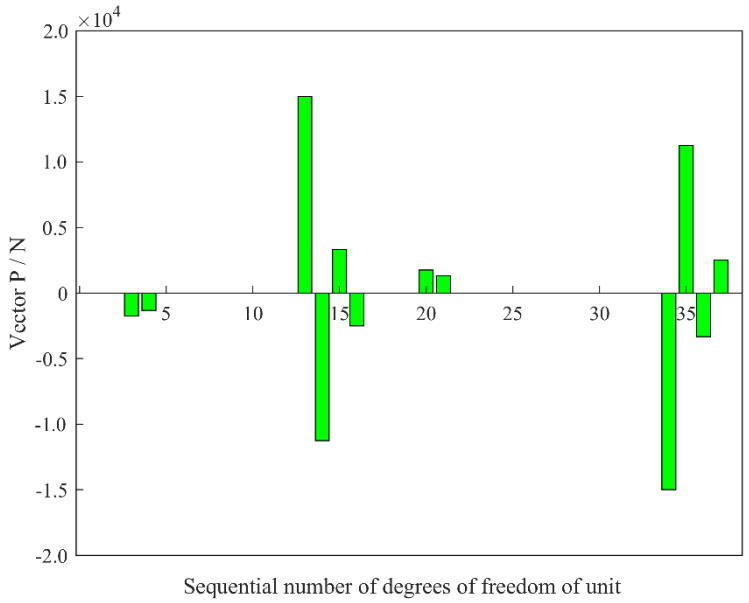
Displacement	Unit							
	9	10	11	12	13	14	15	16
u_a	3333	0	0	-1765	0	0	0	0
v_a	-2500	0	0	-1324	0	0	0	0
u_b	0	0	1765	0	0	0	0	0
v_b	0	0	1324	0	0	0	0	0

Displacement	Unit							
	17	18	19	20	21	22	23	24
u_a	15000	3333	0	-1765	0	0	0	0
v_a	-11250	-2500	0	-1324	0	0	0	0
u_b	0	-15000	-3333	1765	0	0	0	0
v_b	0	11250	2500	1324	0	0	0	0

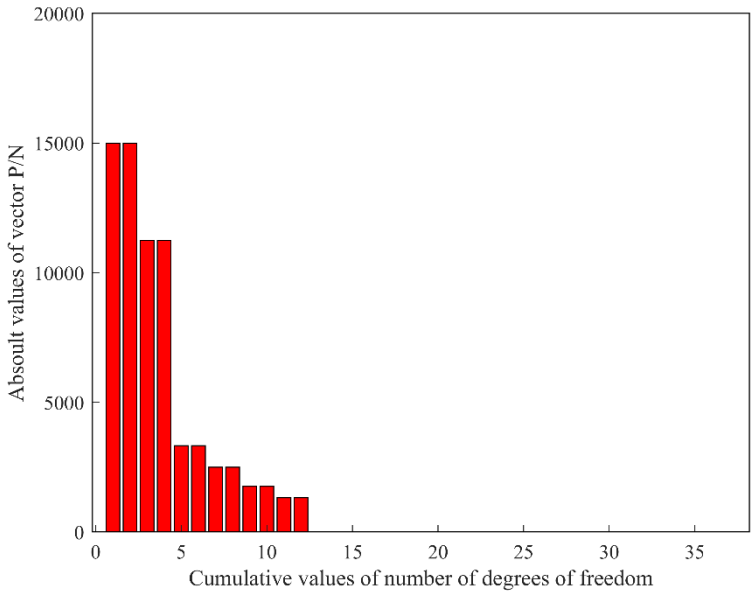
Displacement	Unit							
	25	26	27	28	29	30	31	32
u_a	0	15000	3333	0	1765	0	0	0
v_a	0	-11250	-2500	0	1324	0	0	0
u_b	0	-15000	-3333	1765	0	0	0	0
v_b	0	11250	2500	1324	0	0	0	0

Displacement	Unit				
	33	34	35	36	37
u_a	0	0	0	-15000	-3333
v_a	0	0	0	11250	2500
u_b	0	0	-15000	-3333	0
v_b	0	0	11250	2500	0

Fig. 8 represents a distribution and arrangement diagram of the force residual vector *P*.



(a) Distribution diagram of residual vector values



(b) Arrangement diagram of absolute value of residual vector

Fig. 8: Distribution and arrangement of residual vector values of truss

Fig. 8 (a) presents the distribution of force residual vector *P*. The abscissa represents the sequential number of the horizontal and vertical degrees of freedom of both nodes for each unit. The ordinate corresponds to the force residual vector of corresponding units. Fig. 8 (b) shows the arrangement of the absolute values of ***P*** in descending order. The abscissa represents the cumulative values of the number of the horizontal and vertical degrees of freedom of both nodes for each unit.

For the arranged absolute value sequence in Fig. 8 (b), divide the previous element by the next element, we obtain the positioning diagram shown in Fig. 9. The maximum ratio which represents the total number of degrees of freedom of the damage units is located at 12. Since each unit corresponds to 4 degrees of freedom in the local coordinate system, it can be seen that three units in the truss have been damaged, which is consistent with the set number of damage units.

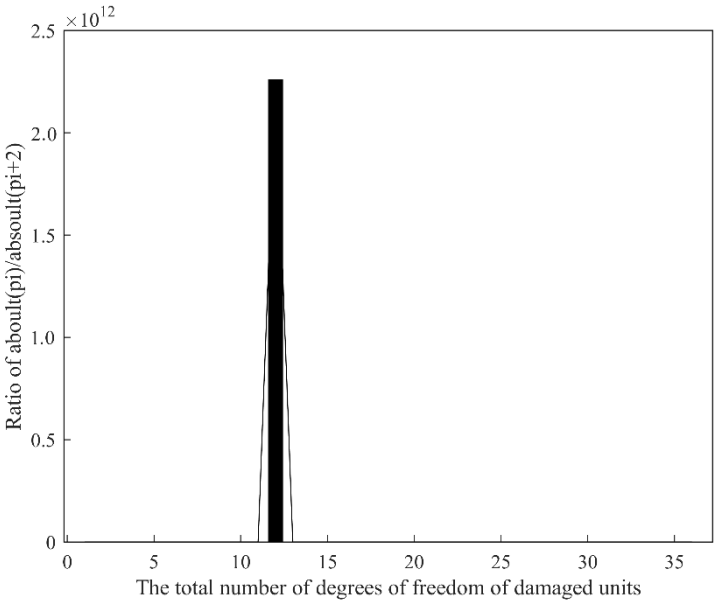


Fig. 9: Total number of freedom degrees of damage units

In Table 6, the truss units 20, 26 and 27 whose ratios of the residual stress vector value *P* corresponding to the first displacement and the third displacement of the element are -1 is the damaged units, and the damaged units located are the same as the set damaged units.

The identification values of damage degree obtained by solving damage degrees using Eq.(6), and the setting values of the corresponding units are listed in Table 7.

Table 7: Identification values and setting values of unit damage degrees of truss

Damage unit number	20	26	27
Setting value	0.15	0.60	0.25
Identification values	0.15	0.60	0.25

It can be seen from Table 7 that all the identification values of damage degrees are completely consistent with the corresponding setting values. It can be concluded that the force residual vector method can be used to locate the damage position and identify the damage degree of truss structure.

Eraky et al. [20] used the dynamic test method to obtain the eigenvalues and eigenvectors of the structure, and combined with the residual force vector method to identify the damage of the structure. In this paper, the static displacement parameters are obtained by the static test method. The static displacement parameters are easier to obtain than the dynamic parameters, and the accuracy of the results is more accurate. In addition, this paper uses the intelligent force residual vector algorithm to obtain more accurate results and faster damage identification.

IV. Conclusion

Based on the existing research results of residual force vector method, a new structural damage identification method based on force residual vector is proposed in this paper. Through the identification analysis of some units of the simply supported beam numerical model and the truss numerical model under different damage degrees at the same time, It is shown that this method uses the arrangement of force residual vector elements to intelligently obtain the location of damage recognition, the number of damage elements and the degree of damage.

It only needs the displacement information under static load and does not need complex modal analysis. In addition, because of the addition of substructure, the solution of the system will not be complicated, and the damage identification result is faster and the calculation speed has a great advantage.

Conflicts of Interest

The authors declares that there are no conflicts of interest.

Data Availability

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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The Impact of Social Media JN Privacy and their Role in Decision Making

By Dr. Christos P. Beretas

Abstract- Social media has been rumored in recent years, with social media not only referring to the popular but also the less popular, as well as targeted social media, including the collection. and analysis of information which information is then used for other purposes. Social media offers users plenty of features and smart features using artificial intelligence while making the most of the internet. Through the use of social media, it is possible to manage and view information from smart devices, also known as IoT. This implies on the one hand freedom of interfaces and freedom of operations and on the other hand implies an increased risk of privacy violations combined with the possibility of illegal access and control of smart devices. Various countries around the world have created cyber armies that use a variety of techniques - including social media - to monitor, suspend, and internally influence the functioning of states and directly influence decision-making, and generally intervene in the operation in another country, a typical example is the deepfake of politicians using social media to influence public opinion.

Keywords: social media, privacy, surveillance, violation, decision making, e-profile.

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Keywords: *social media, privacy, surveillance, violation, decision making, e-profile.*

I. Introduction

The use of the social media platforms becomes more intense over time with a plethora of new functions and applications. Many of the social media are used as a professional tool by various companies and organizations either for the promotion of products and services or for the extraction of data and the collection of open information. In the majority of social media, required by users to create a profile, enter and confirm either their personal email address or their mobile phone number, a practice that generates questions, with the most important question being whether it is possible behind a profile to identify the human factor and to record his/her associations, for example, way of life, habits, etc. Also, using social media, the user and profilemaker is not the only one who enters personal data in his / her profile, but also automatically enters meta-data related to various habits and information that is derived from the information entered by the social media user. On social media it is practically impossible to know the person on the other side, maybe there is someone with mental problems or another government official who purposefully wants to collect as much information as possible from the suspected victim. The reckless use of social media can become idiosyncratic for the following reasons, the addiction, in this case a person avoid the dangers that exist and is permanently located on a computer screen and uses the same tools. On the other hand, behind a social media profile can be hidden someone with psychological problems or a government employee after first creating a fake account trying to collect personal information which will later be used for various targeted purposes, such as creating riots in a country by presenting on social media high-ranking government officials to spread false news which will lead to a popular uprising. It is very important to understand that social media are systems that can be attacked at any

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time, this could be a further breach of personal data and leakage to third parties. One has to take seriously the possibilities of locating users, a feature that is available through social media, one might think that locating users limited to a city name is not dangerous, but no one knows internally in information systems and databases that reach the level of user tracking which may not be visible to users but to record with absolute accuracy the exact location of the user. The previous report on the dangers of locating is very important as it can greatly help information analysts locate important information about the user, information such as, frequency of visits to comparable locations, travel and return times, people who comment / mention /follow /connect / support, the hours of absence from home or work, habits, etc. The above are some important entities, which assist in the collection and analysis of information from open sources in order to more easily achieve the creation of **e-profiles of users**. Social media can be addictive, as can social outbursts of hatred and resentment if used as a means of **hybrid warfare** to exploit third countries' internal weaknesses in order to impose their own interests and beliefs. It's the easiest way to publish a fake video, a deepfake product that other users will unknowingly republish and quickly get a lot of publicity and switch from one social media to another by adding the appropriate hashtag **#hashtag**.

II. Analysis

Many people worry that social media is stealing or intending to steal their freedom. These people who think the above are not irrational and do not make completely wrong thoughts. Social media can be seen as responsible for policy and choice making, that is, it can influence decision-making and influence people greatly by making wrong decisions, taking into account perceptions that did not exist or have a different meaning from those presented in the social media networks. Deepfake's technique flourished growth to the proliferation of social media, enabling people to manipulate other people, governments to influence other governments to manipulate them. Public opinion is reluctant to believe, on the one hand there is common sense, and on the other a video that presents some facts that affect public opinion, because the image is more faithful than logic and thought, the people are manipulated and persuaded about what they see, simply by presuming that they saw with their own eyes and believed what they saw. For this reason, deepfake has made great progress and is widely used today to influence any entity whether it is an ordinary citizen or an adversary government, or the target country. Detecting deepfake is not an easy process, technology has made it relatively easy to perfect a fake video that looks like a real one, capable of affecting a large portion of the people. This technique is also used by the **hybrid war**, which without the use of real weapons, with the appropriate communication strategy, the necessary tools, and social media are capable of influencing and inciting even rebellious whole peoples against in their governments, is capable of inciting certain categories of citizens causing internal sabotage within target countries, infuriating and inciting citizens against their governments, without demanding any military intervention as would be the case in a real rather than a hybrid war.

The personal data that exists on social media that has been retrieved on them in any way, such as input by the users themselves, meta-data, personal data that has been retrieved on social media networking platforms by applications, are all information that is available from open sources. Depending on the origin and the goals, anyone can use this available information from open source for various reasons such as, targeted advertising, digital profile creation, blackmail, targeted interventions, etc. Note, that there is no clear legal framework that specifies the minimum exposure of users' personal data on social media, but even if it did exist, there are several methods of collecting personal data from social media that actually control personal data collected seems impossible.

Anonymity that can be applied to the internet in various ways, of course, does not mean anonymously creating a fake profile on the internet, anonymity is the inability to locate the real person behind a digital profile as it is impossible to locate because of the great restriction in its digital footprints. This feature allows skilled users to create fake profiles by completely hiding their information using deceptive IP addresses to browse the internet and social media anonymously, tracking, blackmailing, or collecting personal information from targeted third-party accounts. The reaction of social media at this point is limited, the reason is that even if the connections from anonymous proxy servers or the TOR network are restricted or banned, there are thousands of infected computers and information systems that can be used as anonymous proxy servers so that savvy users can cover their traces. The above is a technique used to gather information from open sources but also in hybrid warfare. In hybrid warfare, the above process is carried out in a more methodical and group way, hybrid warfare does not have the desired effect when it is not carried out by individuals, it has the desired results when it is carried out by groups.

Another crucial question about social media is privacy and ownership of information. The content that users upload to social media even when it is explicitly mentioned and the personal data in the terms of use, is not able to prove that this information - data where is actually stored, who else can access in them, if after deletion by their user they still remain in data warehouses invisible to the user, to whom these data belong, and by what legal framework and country they

are governed. The further processing of personal data and the storage of users' personal data in countries that are not known to users makes users skeptical about the use of social media. A social media platform that could be used for advertising or monetary purposes could sell this information to third parties, but in order not to be overlooked by users, it would sell limited information so that sensitive information could not be perceived by the users themselves. This also implies a violation of human rights, as part of their personal life and personal information are available for different purposes for which they were given. Therefore, the users themselves can receive these ads with different content so that it is not possible to detect the sale of their personal information. Another violation of privacy is the possibility of reading personal messages from third parties or even from Bot, many times in the boom of security the privacy is sacrificed, so in the name of security are established terms and conditions so that the violation of privacy is legal.

The privacy of social media should in no case be given either to personal data which was registered by the users themselves as mentioned above, or they were registered automated by various other methods such as automated applications which as mentioned above, also in various other ways such as Tracking cookies, and social media networks that operate as honeypot projects.

Let's analyze the first part which concerns tracking cookies. Tracking cookies are used by social media networks to identify the users which are browsing on social media networks where they can track them. These tracking targets as much as possible the display of targeted ads by recording the posts made by users on their profiles, the locations they are on, the searches they perform on social media, and finally tracking cookies may be used while remaining active for third party websites. from the operation of these websites the monitoring of the users can be expanded. On the other hand, there are Honeypot projects, these are fake social media networks (platforms) which have appeared and disappeared and have taken their place, new, created either by government agencies targeting citizens of certain countries to control the activities of users and to contribute In tracking specific users, such social media networks were also introduced by hackers as well as government agencies who wanted to create competitive social media networking platforms that enabled users to even receive a paid new sign-up bonus, cheaper payments in users 'ads in order for users to enter their credit or debit card number and then proceed to deduct amounts of money greater than the expansive cost, read users' personal messages ignoring the ownership and privacy of communications and in some cases the user could find a personal message posted on the internet without of course mentioning the origin of the message or the name of the user.

All of the above acknowledge how social media users need to be extremely careful not to be indifferent to their privacy and personal information. Do not subscribe to unknown and dubious social media networks (platforms), especially those social media networks where information, user registration is selective or even posts are filtered and there is no real freedom of speech.

III. Conclusion

According to what was mentioned in this article, conclude that social media on the one hand contributes to the further socialization of people, contributes to business development, user interaction, artificial intelligence is applied, there is increased potential for targeted advertising, businesses have the ability to be promoted globally by creating social media profiles most of the time for free, while there is the ability for businesses to interact with their customers by interacting with applications offered by social media platforms. On the other hand, social media accumulates and processes a significant amount of personal information, users' personal data is stored forever, users do not have access to their personal data, users do not know in which countries their personal data is stored, who owns this personal data if it has been stored to social media databases, they do not know if this personal data is used for publicity purposes or is shared with government agencies for analysis. In conclusion, users should create profiles on social media networks only in those that they deem absolutely necessary, with as little information as possible from users, upload and share as little content as they can, and do not use applications offered by social media which for their use presuppose the consent of users to access other private information.

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Methodology and Evaluation of Large Deformations in Romanesque Pillars

By Josep Lluis I Ginovart, Cinta Lluis-Teruel & Mónica López-Piquer
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Abstract- There is a set of Romanesque churches at Val d'Aran that were built between the eleventh and thirteenth centuries. One of the main features of these buildings is the presence of large deformations masonry as in the church of Santa Maria d'Arties (XII) in which arches and vaults have funicular shapes. The assessment is based on a three-dimensional model obtained with a terrestrial laser scanner (TLS). Geometrical evaluation of the least rigid elements, the pillars, allows to analyze the displacements. It is not only possible to deduce the regression plane of the central-nave pillars' displacements but also to define the deformation vectors over it. The methodology of this study focuses on the assessment of the deformations they have suffered. The point cloud is processed with the software Cyclone, the program 3DReshaper (2016) and, finally, with Google SketchUp (2019).

Keywords: romanesque, barrel vaults, masonry pillars, great deformations, val d'aran.

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Methodology and Evaluation of Large Deformations in Romanesque Pillars

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I. Introduction

The churches of Val d'Aran are located at the Spanish Pyrenees and were built between the twelfth and thirteenth centuries. Large deformations have been found on these Romanesque buildings masonry and are one of the main characteristics of them. In the church of Santa Maria de Arties (XII-XIII), the most deformed building, some antifunicular shapes have been found at their arches and vaults (Lluis i Ginovart, et alli, 2021: 210-221). This funicular shape is the inverse of the natural shape of an arch since it is convex in relation to its centerline. The case-study of this paper focuses on the church of Santa Maria d'Arties, which is the most assessed building of the group. Its great deformations were identified during the restoration works of the 70's (Saez, 1976). Afterwards, José Luis i Villanueva noted the existence of funicular shapes (Villanueva, 1974) and, in 2009, the structure was studied by means of finite elements method (FEM) by the team of Joan Polo i Berroy (Polo, 2009).

The deformation presents a typical pattern leaning vertical elements towards the outside because of vaults thrust and settlement, which is the cause of the apparition of funicular shapes. One of the apparition of funicular shapes. One of the reasons of these deformations in Santa Eularia d'Unha, Santa Maria d'Arties and Era Purificacio de Bossost is the displacement of the pillars since they are the least rigid elements of the structure (figure 1).

The study of the deformation of the walls and the pillars was done through the transversal sections where the deformations parallel to the plane was analyzed. For this, it was necessary to measure the vertical deformation of walls and columns, as a vault and wall must work jointly to transmit the weight. The investigation focuses on the geometrical parametrization and on the evaluation of these movements. Previous investigations set the assessment of the overall structure to understand the stability conditions, revealing that masonry was working to its limit, with the maximum status of deformation, and this plus the displacements had their origin in the rigidity of the structure.

The assessment was based on a three-dimensional model obtained with a terrestrial laser scanner (TLS). Direct measurement techniques for architectural heritage surveying requires many resources and the use of massive data capture by terrestrial laser scanner (TLS) has recently become prominent. On the other hand, topographic documentation of the heritage is a keytool for its preservation. Current techniques of massive data capture (MDC), such as digital photogrammetry and terrestrial laser scanner, have become widespread and numerous investigations have tested their reliability proving their effectiveness to survey the building's geometry with high precision. Point clouds make it possible to detect and track degradation processes and formal anomalies. Other applications go from heritage documentation to delve in the history of buildings constructions (Dhonju,"et alli", 2017). The specific issue of deformation assessment is essential for architectural heritage conservation. Many studies have developed simple procedures to address the issue from the 3D topographical information of the point clouds, e.g., the Cathedral of St. Johannis in Meldorf (Sternberg, 2012), the Cathedral of Tortosa (Lluis i Ginovart, "et alli", 2016; 42-50), the churches of Santa Maria in Portonovo (Quagliarini "et alli", 2016).

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Fig. 1: Deformation of the pillars: Santa Eularia d'Unha, Santa Maria d'Arties and Era Purificacio de Bossost

To analyze the deformations of the church of Santa Maria d'Arties (XII-XIII), we used the point cloud extract from the scanner Leica ScanStation P20, with a bandwidth of 808/658, class 1. The point cloud was processed with the software Cyclone and the program 3DReshaper version 2016, used to obtain the three-dimensional mesh with an average distance of points of 0.05 m as well as a measure of the triangle for detecting 0.1m holes. The model of the interior of the building has 80.582 points and 156.449 triangles, and the exterior has 314.650 points and 609.472 triangles (figure2a).

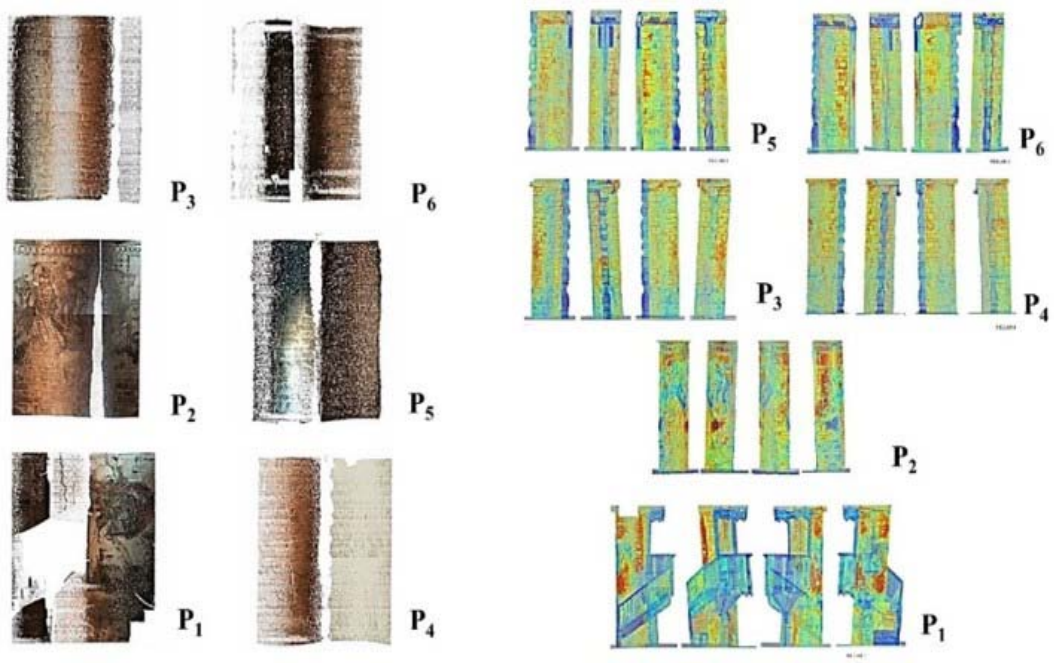

Fig. 2: Visualization of Santa María's pillars: a) Software Cyclone; b) Software Undet

The point cloud has been processed with the plugin Undet, of the software Google SketchUp version 2019. Nevertheless, in this occasion, the point cloud was not converted to a mesh because this plugin works with points, not with meshes. The models have a grid of points in coordinates (x, y, z) ranging from 0,06 to 0.09 m. (figure 2.b).

II. Methodology of the Geometrical Assessment of Pillars

The methodology of this study focuses on the assessment of the geometrical characteristics of the six pillars [P1…P6] of Santa Maria d'Arties with the objective of studying the displacements that they have suffered (figure 3). The pillars of the central nave have deformed in a specific way, namely, through the masonry joints (ns). These joints are perfectly visible on pillars P3, P4, P5 and P6, while they are more difficult to visualize on P1 and P2 since they are partially covered by mural paintings. The displacement of a particle in Cartesian coordinates (x, y, z) with its corresponding orthonormal base (ê1, ê2, ê3) starts from a reference configuration Ω0, where the position vector (X) of a particle G (corresponding to the center of gravity) in space is defined by the material coordinates; X = X1 ê1 + X2 ê2 + X3 ê3 = Xi êi; (x1, x2, x3). When moving to the current configurationΩt, occupying spatial point G', the position vector (x) in spatial coordinates at a snapshot of time (t) will be given by X' = X'1 ê1 + X'2 ê2 + X'3 ê3 = Xi êi; (x1, x2, x3). This change in position is represented by a displacement vector, uG = (uGx, uGy, uGz) (figure 4).

The displacements can be assessed according to the coordinates of the centroid of each row (xci, yci, zci), and the point of reference is taken from the row of the floor plan, which is believed that it is nondeformable. This establishes the coordinates as (xci, yci, 0). These points allow defining a regression plane Pri for each pillar. Thus, it is possible to define a vector of deformation contained on each plane [Pr1…Pr6]. Finally, this data allows to determine the general tendency of vaults' deformations (figure 5).

Fig. 3: Geometrical characteristics of the 6 pillars [P1…P6] of Santa Maria d'Arties

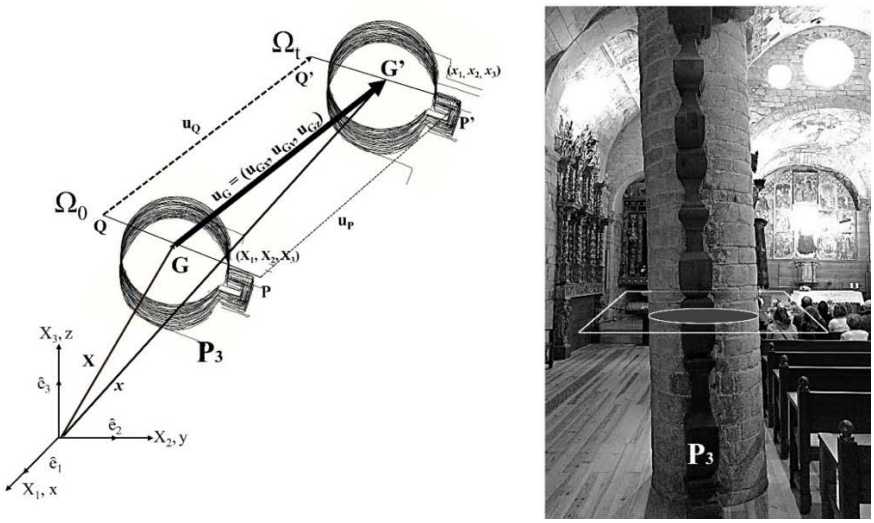

Fig. 4: Displacement of the center of gravity in the section of the pillar P3 of Santa Maria d'Arties

Fig. 5: Above is the example of single column image. Images must be of very high quality

The assessment of shapes can only be understood in three dimensions through an interval (a, b) which must impose the condition of equilibrium according to the elastic theory and the summation of the active thrusts (E_{ba}) of the vaults and the passive thrusts of the walls (Emp) and buttresses (E_{mc}) [1].

$$\sum_{b}^{a} F_{(x,y,z)}\left(E_{ba} + E_{mp} + E_{mc}\right) = 0$$

$$\sum_{b}^{a} M_{(x,y,z)}\left(E_{ba} + E_{mp} + E_{mc}\right) = 0. \quad [1]$$

The forces caused by the vaults are transmitted to the vertical structural elements. The vaults of the central nave are supported by the walls over former arches which, at the same time, are supported by the pillars of the central nave. Thus, the elements can deform over the three planes, the pillars dfp (dfpx, dfpy, dfpz), and the perimeter walls dfm (dfmx, dfmy, dfmz). On the other hand, the deformations of the pillars are a function of their monolithic nature. Therefore, the deformations are directly related to the stone cutting of the pillar and the thrust Ep (Epx, Epy, Epz). According to the internal distribution of forces, the masonry stone cutting, the mortar (Epz1) and the irregular geometry of the vault (Epz2), the structure tends towards a state of equilibrium (Epz1- Epz2) or to the opposite state (Epz1+Epz2).

A monolithic, infinitely rigid pillar tends to rotate on its base. The upper part moves over the axis (x) towards the exterior, since the main horizontal thrust (Ex), with the consequence that there is also movement in the axis (y) since their extreme upper part declines. Finally, there is also movement over axis (z), due to Ebz, which defines the deformations dfp (dfpx, dfpy, dfpz).

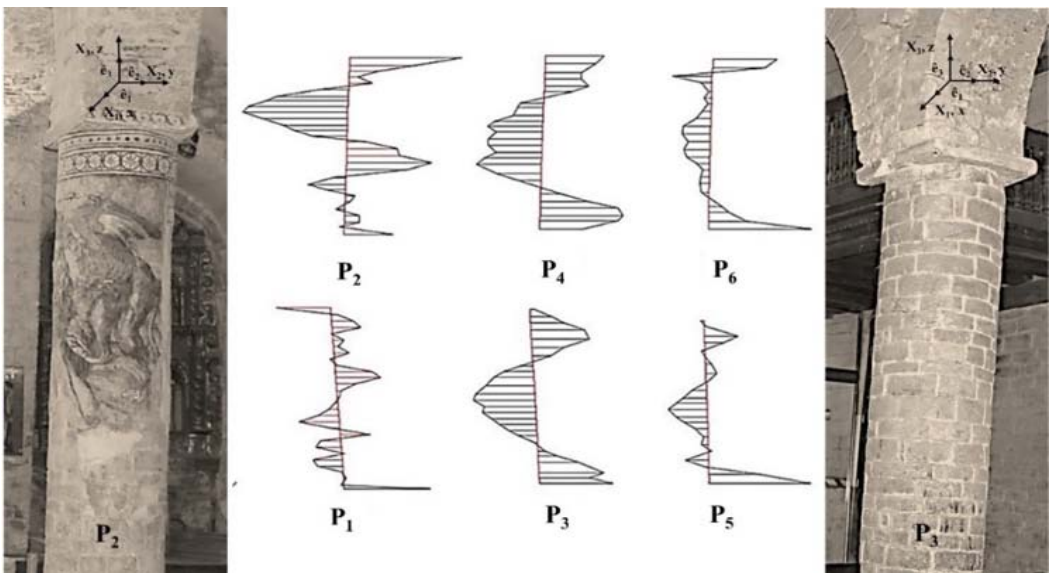

Fig. 6: Representation of displacements on the regression planes Pri over (y)

Pillars are not monolithic and are built with numerous joints, they tend to deform in the upper part so that there is no Δ dfpy. If we suppose that the extremes of the vaults have not suffered differential settlements and that the movement of these extremes is, thus, (Δz=0), then the deformations are dfp (dfpx, 0, dfpz) which is the hypothesis of the present case study. There can be a combination of rotations and translations, as a function of the stone cutting, so the general characterization of the displacements should be made through intervals I1; dfp (dfpx, dfpy, dfpz). Then, in I2, dfp (dfpx,0, dfpz) displacements (Δy>0) can occur because of the contact between mortar and stones or due to the friction between stones where there is no more mortar. The displacement of the pillar can be deduced through analysis of the displacement of the centroid of n sections (ns) of the pillar. Thus, coordinates (xci, yci, zci) are set for each section (ns). The centroid of reference (xc0, yc0, zc0) is set in the section of the floor plan since it would have not suffered any displacement (figure 6).

The reparation and containment of these deformations are the cause of the reinforcement of the perimeter walls by means of the construction of buttresses or strategical placement of bell towers, which are usually built in the opposite façade to the apse. The active thrusts (Eba) of the vaults over pillars and walls have been determined, but to understand the equilibrium of these constructions, it is essential to understand the passive thrusts of the buttressing elements, walls (Emp) and buttresses (Emc). Due to these thrusts, some vaults have deformed towards funicular shapes (figure 7).

Fig. 6: Passive thrusts of the buttressing elements, walls (Emp) and buttresses (Emc)

III. Data Treatment with the Software Cyclone

The use of the specific software Cyclone to process the data enables to visualize the obtained point-cloud and to process and join all the scanners done to convert the point-clouds to a mesh. This processing occurs through an automatic process with slight manual adjustments, so a complete-depurated point cloud and a triangular mesh are obtained.

The morphological features assessment of the pillars is made through the visible elements, such as the masonry joints. Non-visible elements are not considered. Thus, data is obtained according to the centroids of each visible row. Thus, pillars have following rows: (P1 =26), (P2=26), (P3= 27), (P4= 25), (P5= 23) and (P6= 23). Rows are numbered from bottom to top the identification of pillars' joints was made by means of a manual measurement system because the graphical capacity of the software Cyclone and the program 3DResheaper do not allow to specify pillar's joints because it constructs them three-dimensionally (Lluis I Ginovart, "et alli", 2017).

The greatest displacement is found in pillar P1, with a range of displacement on each row of [0.270, 0.001]. This displacement is followed by that in pillar P3, with a range of [0.190 – 0.001]. The range of displacements of the rest of the pillars is as follows: P2 [0.108 – 0.002], P4 [0.109 – 0.002], P5 [0.101 – 0.001], and, finally, the least deformed pillar, P6 [0.065 – 0.001].

Thus, pillars P1, P3 and P5 have greater deformations than the others. None of the regression planes Pri is perpendicular to the axis of the central vault. Each one is moderately sloped. The angle in P1 is 85.466º, so (ω φ) < 90º). It is also the most inclined pillar (0.270 m) and is the highest (4.170 m). The rest of the pillars have angles (ω φ) > 90º with a range [103.893º - 126.169º]; [P2; 103.893º], [P3; 108.,665º], [P4; 117.245º], [P5; 112.066º] and [P6; 126.169º] (figure 8).

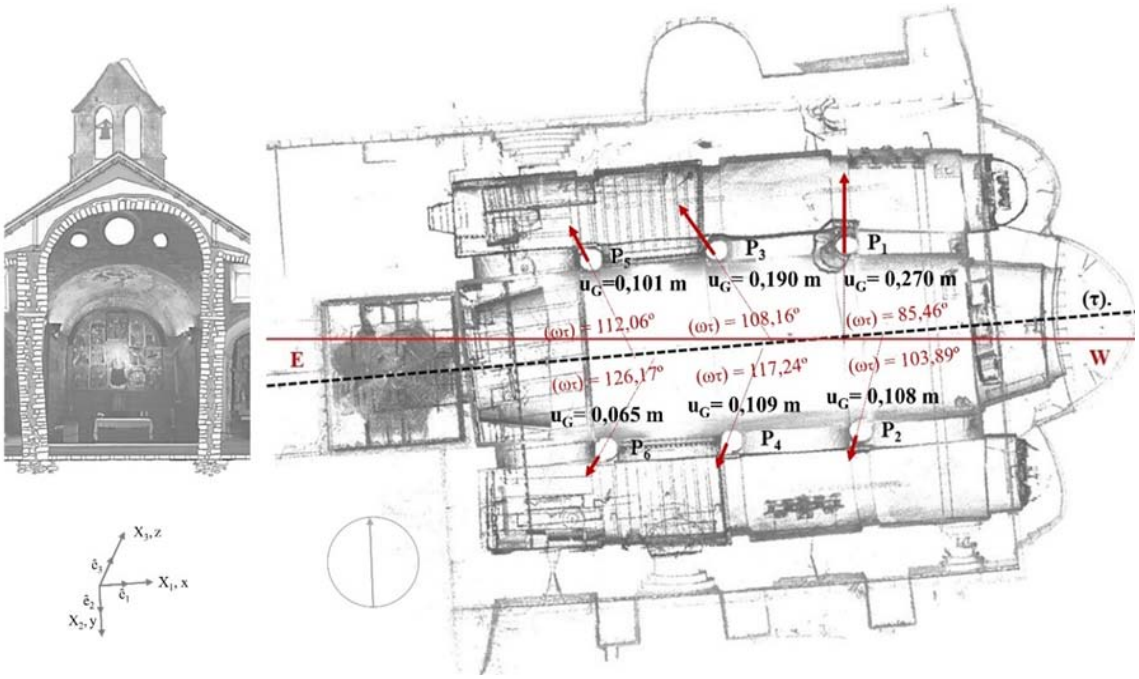

Fig. 8: Characterization of the regression planes Pri from Cyclone (2016)

IV. Data Treatment with the Plugin Undet for Google Sketchup

Using the plugin Undet for Google SketchUp 2019, the identification of pillar's joints was made directly with the image of the software. Undet is a plugin that combines individual scan stations into groups and point-clouds from a wide range of scanners. In this case, we have used the data extracted from the Massive Data Capture (MDC) of the Leica ScanStation P20 scanner. What we have experienced with this plugin is that the management of the point-clouds is more efficient and quicker than with the software Cyclone.

Undet for SketchUp 2019 has interactive coloring and density management so it let us to adjust transparency, change point-cloud and points size and, the most important thing for our research, we can see the point cloud colored by planes or heights. This function lets us see pillar's joints in detail so, from now on, we will be able to check the manual measurement previously done and to express that the joints measured with Undet range from 0.007 m to 0.015 m of width. We have also analyzed the regression planes Pri from the pillars, which, like the previous results obtained from the software Cyclone, are also non-perpendicular to the axis of the central vault.

We observed that there are little differences between the other results and these ones, being the deformation of P2 the biggest difference (2.599º less) and the one of P3 the smallest (0.003º less). The angle in P1 is 85.474º, so (ω φ) < 90º, and it is also the most inclined pillar (0.206 m). The rest of the pillars have angles (ω φ) > 90º, as we have previously seen, with a range [101.291º - 124.756º]: [P2: 103,893º], [P3: 108.657º], [P4: 119.417º], [P5: 124.756º] and [P6: 110.553º] (figure 9).

We have also seen that the deformations of P4 and P5 are bigger in the middle of pillars height than at the top of it. With Cyclone we did not find those deformations. The obtained results from both methods used are very similar to determine deformations in Romanesque masonry buildings, where the interest of the displacements is more qualitative than a quantitative order of magnitude. The graphic precision of the plugin Undet for Google SketchUp 2019 should be noticed, since it is higher and, therefore, allows the identification of the masonry joints of the pillars that each point composing the point-cloud extracts from the Terrestrial Laser Scanner (TLS). To work with this plugin, there is no need to have a computer with a lot of graphic capacity, and the point-cloud can be sectioned in few seconds. Regarding to its precision, in a section of 0.005 m, the error is about 0.006 m (0.030%), unlike the one obtained from the software Cyclone (2016), which was 0.03m.

Otherwise, the vectorization of the displacements of each row, deduced from the regression plane, makes it possible to parametrize the leaning of each pillar. In addition, two deformation modes were identified, so the displacements of the pillars are not uniform. Moreover, on pillars (P2, P3, P5), the displacements are variable and appear to be negative displacements on (y) in relation to the vertical, and the deformation of pillars (P1, P5, P6) is biggest in the middle of their height than in their extremes.

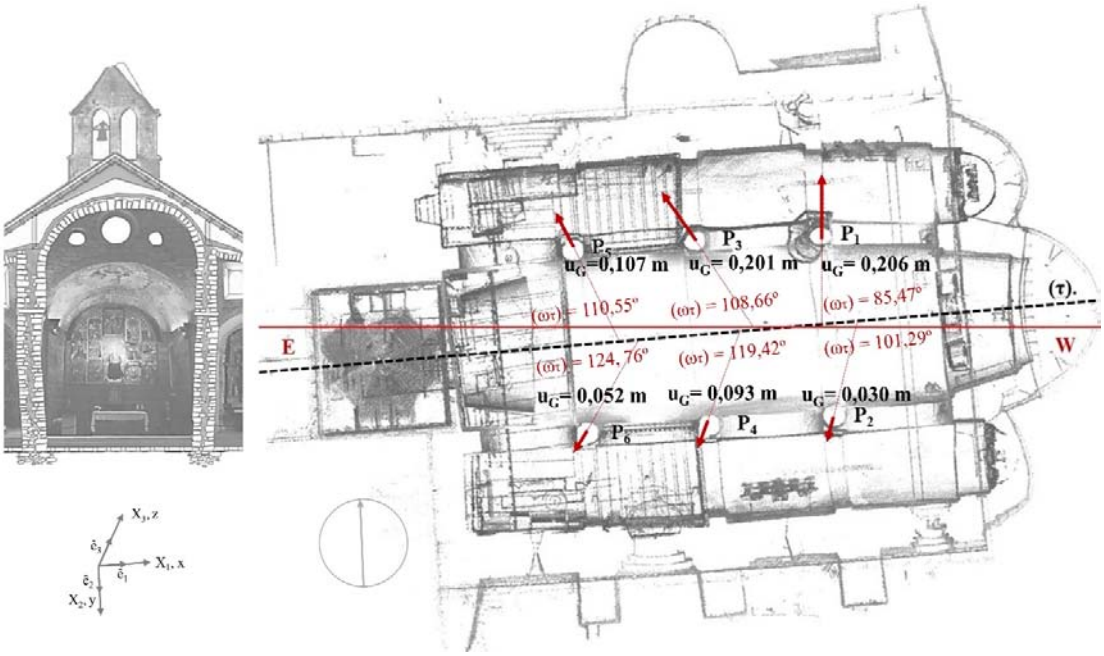

Fig. 9: Characterization of the regression planes Pri from the plugin Undet

V. Conclusions

The obtained regression planes Pri, which contain the deformations dfp (dfpx, dfpy, dfpz) for each pillar, tend to have the direction of the thrust over the pillar Pi. These displacements are the result of the active thrusts of vaults ⟦(E⟧ _ba) and the passive thrusts of the buttressing system, walls ⟦(E⟧ _mp) and buttresses (E⟧ _mc). This study revealed that the direction of the displacements of the six pillars Pi is not perpendicular to the central axis of the church φ1, since (ω φ) ≠ 90°. This result proves the hypothesis that the thrusts of the vaults are not perpendicular to the axis of the church, as was the case of Roman vaults, which Choisy (1873) [27] defined with regular geometry and stone cutting. The direction of displacements is caused by the irregular geometry of the vaults of Santa Maria d'Arties as well as the masonry stone cutting and the above-mentioned passive thrusts of the walls and buttresses. The last ones were placed to maintain equilibrium during the last millennium (figure 10).

The displacement of the five pillars (P2…P5), where (ω φ) > 90°, tends to the opposite façade of the apse. In addition, pillars P5 and P6, built during the twelfth century on that façade, are the least deformed pillars because of two subsequent transformations: the construction of the bell tower over the center of the façade (XIII-XIV) and the wood choir (XVIII). These elements have a stiffening function. Pillar P1 is the most deformed of Santa Maria d'Arties and has (ω φ) < 90° over the main axis. The displacement tends to the apse. This pillar, together with pillar P3, where (ω φ) > 90°, have achieved a great balancing through the passive thrust of the walls (Emp) and buttresses (Emc). For a specific weight of more than 24 kN/m3, the buttressing system weights 3144,96 kN. It is here where funicular shapes and inverted arches have appeared, therefore: ff''(x) > 0. Pillars deformations dfp (dfpx, dfpy, dfpz) tend to have the same direction of the thrust over pillars Pi, so regression planes Pri, which contain these deformations, are essential to define any intervention over these masonry buildings because they show the direction for possible preventive actions. The ranges of heights where great deformations occur have also been identified and are: P1; [1.50 – 2.00 m], P2; [3.00 – 3.50 m], P3; [2.00 – 3.00 m], P4; [1.50 – 2.50 m], P5; [2.00 – 3.00 m] and P6; [1.00 – 2.50 m]. There is a difference between the height of the base pillars too due to the inclination of the church floor, being P1 and P2 of the same height from their base center, and P3 of the same height of P4, but beginning 0.047 m upper than P1 and P2, and, finally, P5 is 0.0577 m upper than P1 and 0.019 lower than P6. These points are extremely important to determine the appropriate actions that need to be taken for intervention on these buildings to preserve the Romanesque architectural heritage.

Fig. 10: Vectorization of the displacements of each row from the regression plane

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Blue Covenant: Strategies for Managing Water Stress in Dwarka, New Delhi, India

By Angel Steffy Thomas

Abstract- Water is an indispensable resource available on earth for all living beings. A decline in the quality and quantity of water is now a global issue of concern. Due to the increasing demand controversy can be seen over command and sharing over water. Hence water stress is a complex issue which deserves urgent global attention and actions. Water stress refers to the ability, or lack thereof, to meet human and ecological demand for water. Therefore, this research aims to understand the reasons for water stress through different summits, policies and case studies. The main focus of this research is to frame strategies for waster stress management in Dwarka, Delhi, India. It is also known for being the largest sub-city in Asia with a potential for further development. Dwarka is already facing water stress and further development will only add to the tension on water supply and its availability in future. In-depth research is done on the existing water infrastructure and the potential to reduce water stress in Dwarka. Based on these studies strategies and proposals were formed to effectively reduce water stress in Dwarka. This study will help in planning for an area concerning the available resources. The outcome of this study is to practice different short and long term goals which can be followed to reduce the intensity of water stress and less dependency on the available resources.

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I. Introduction

India is in the grips of an unprecedented water stress with majority of its western areas under drought-like conditions. Taps are running dry in both rural and urban parts of the country. According to Composite water management index (CWMI) a report by NITI Ayog which claims that 21 Indian cities will run out of groundwater by 2020. Meanwhile, in the national capital Delhi, which recently saw mercury rise above 48*C. Apart from recent heatwave, depleting groundwater levels are among the reasons for the diminishing supply in these areas. Since Dwarka being Asia's largest sub-city and largest residential suburb which has a total of 1718 residential enclaves. Hence a detailed water stress management strategies is necessary for Dwarka, Delhi. The outcome of this study is to practice different short and long term goals which can be followed to reduce the intensity of water stress in Dwarka, Delhi.

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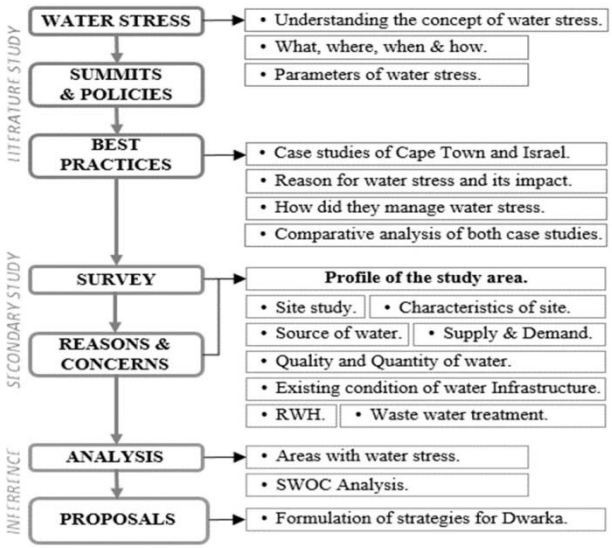


Fig. 1: Methodology

II. Water Scarcity and its Factors

a) Physical Factors

Geology which includes location of water storage, aquifers and ground water. **Climate** which includes change in rainfall, snowfall and rates of evaporation and **Water bodies** which includes change of water course, can dry up, pollution of water bodies.

b) Human Factors

Pollution of water supplies by discharge of untreated raw sewage from industries and households, agriculture runoffs, **Human littering. Overuse of Water.**

c) Economic Factors

Population which includes increase in population, demand and supply. **Urbanization** as it has an impact on the physical environment.

III. World Summits on Water Conservation and Policies

a) World Water Summits I

It was held in New on 21-23 August 2018. It focused on Nature for Water- Solution to the Water Challenges. It will synergies between water security and economic prosperity, finance and technology to deliver clean and safe water solutions for both industries and utilities.

b) World Water Summits II

It was held in Geneva on 7-8 February 2018. It focused on Leaving No One Behind. It provides a dynamic platform for bringing real projects and funders together in an engaging manner.

c) World Water Summits III

It was held in New Delhi on 24-26 August 2019. It focused on water management locally and globally. It will initiate an interaction between water security, economic prosperity, finance and technology to deliver water solutions for both industries and utilities.

d) Salient Features of National Water Policy (2012)

Emphasis on the need for a national water framework law. Water, after meeting the basic needs for safe drinking water and sanitation, food security, agriculture and high priority allocation for minimum eco system needs, be treated as economic good to promote its conservation and efficient use. Ecological needs of the river should be determined portion of river flows should be kept aside to meet ecological needs. Adaptation strategies in view of climate change for designing and management of water resources structures. Setting up of Water Regulatory Authority. Removal of large disparity in stipulations for water supply. Water resources projects and services should be managed with community participation.

IV. Case Studies: Cape Town and Israel

Cape Town is a port city on South Africa's southwest coast, on a peninsula beneath the Imposing Table Mountain. It is the legislative capital of South Africa. The city is known for its harbor. In 2015, the City of Cape Town won a prestigious international award recognizing their efforts at Water Conservation & Demand Management (WCWDM). It successfully reduced water use by more than 50% during drought from 2015 to 2018. 2019 was a recovery year after having successfully emerged from severe and unprecedented drought. Israel belongs to the Asian continent. Israel was once battling its worst drought but now is one of the water exporting countries due to technological advancements and water conservation measures. Despite being 60% desert and lacking perennial sources of water. Israel become world's leader in water conservation, reuse and recycling approximately 80% of its water.

Table I: Comparative analysis between two case studies: Cape Town and Israel

Parameter	Cape town	Israel	Remarks
Topography	Desert condition.	Rough mountain ranges and semi desert fringes	It helps to understand the spatial organization of activities & land use.
Population Growth	2011 = 19.90% rise, 2018 = 15.28% rise. The population is increasing.	2011 = 29.31% rise, 2018 = 18.44% rise. The population is increasing.	The impacts of the increasing number of people, their daily activities and the rising demands for resources eventually affects the environment.
Climate	Mediterranean Climate.	Mediterranean Climate.	Study of climate reveals change in climate. It helps in determining how climate is likely to change in the coming years.
Sources of Water	Less water resources. Relies more on reuse & recycle of water	Completely relies on dams.	Alternate source should be introduced instead of relying on the existing primary resources.
Water usage	Agriculture is the largest user of water resource.	Agriculture is the largest user of water resource.	Water is a central component in a sustainable and healthy built environment and planning for efficient water use is essential.
Water Quality	Varies from very low to high salinity water.	Achieved awards for excellent water quality.	Monitoring water quality helps determine the progress in cleaning of waterways. It helps to reveal the composition and health of water resources over months and years.
Reason for Stress	Domestic practices, Urbanization, Climate change, Industrial and Agricultural practices.	Urbanization, Climate change – anaemic rainfall, Increased water demand.	In the urban areas due to urbanization, climate change and human practices, it affects the availability of water.

V. Analysis from Case Study

Water scarcity was the major concern for both Cape Town and Israel and the major factor that induced water scarcity was climate change and their lack of availability of fresh water. Decrease in annual rainfall led to huge water stress. But both Cape Town and Israel successfully overcame the major concern with small and large scale measures. Every small action taken to conserve water can make a difference. These small changes in attitude towards water and efficient usage of water made Israel an example globally on how water can be conserved.

VI. Formulation of Strategies

The following strategies based on various parameters are derived from the study which can be used globally to conserve water and efficient water usage. The strategies are as follows:-

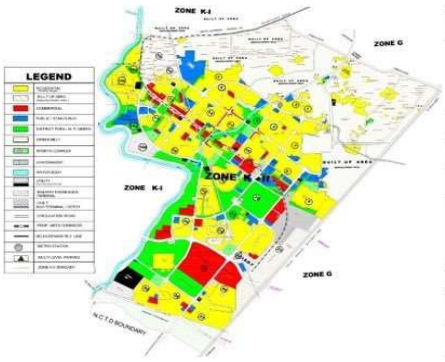
Sources of Water- Water needs to be managed as a community resource held by the state, under public trust doctrine. Periodic inspections of sources of water should be done and strict actions should be taken against the people responsible for the pollution. Regular monitoring of water resources. Traditional systems and source of water supply should be conserved as a build heritage for future generation.

Water Usage- Water should be returned to water cycle with minimum impact on the environment by proper wastewater treatment or directly reused. Community-based water management should be institutionalized and strengthened. Water using activities need to be regulated keeping in mind the local geoclimatic and hydrological situation. Recycle and reusing treated wastewater effluent for various applications, like watering of sports fields, irrigation, for certain industrial uses etc. Integrated Watershed development activities with groundwater perspectives need to be taken comprehensively. Planting of drought-resistant plants (Teff, Sorghum, Sunflower) and watering them at night. Optimizing cropping plants and crop rotation. Methods like aligning cropping pattern with existing natural resources, automated irrigation operation, drip, sprinkler, etc. should be encouraged and incentivized. Water from the industry can be recycled and reused for other applications, such as cooling towers, cleaning, and irrigation, or other uses.

Water supply- Urban water supply and sewage treatment should be integrated and executed simultaneously. Water supply bills should include sewerage charges. An effective management with skilled practitioners who work within and across institutions and among multiple stakeholders collaboratively should introduce measure for efficient water use.

VII. Dwarka

Dwarka is a sub-city and a diplomatic enclave which is located in the South West district of Delhi. Dwarka serves as the administrative headquarters of South West Delhi. It is the largest sub city in Asia which is organized into 29 sectors and mostly has Cooperative Group Housing Societies as residential options. Dwarka has a total area of 13,958.4 acres with a total population of 11,00,000. Dwarka is being developed as a smart city under Delhi Development Authority's 'smart sub city' project. It is the also the largest residential suburb in Asia, with a total of 1718 residential enclaves. Dwarka is relatively flat throughout. It experiences an extreme climate with extreme winters and summers throughout the year. The temperature can be seen increasing from 2015 onwards. The summers are becoming hotter. The winters are becoming less cold. Dwarka Sub city has an area of 5648 ha. Out of this, 1688 ha is designated as built-up. The balance 3960 ha is under planned/regulated development comprising sector 1 to 29. The major land use is residential, which is more that 50% of the total area of Dwarka sub city.



Land use	Area (ha)	%
Residential a) Built-up b) Planned area of sectors	2912.3 1688 (29.89%) 1224.3 (21.67%)	51.56
Recreational	1006.18	17.81
Transportation	777.33	13.76
Public & Semi Public	369.94	6.55
Commercial a)Commercial b)Service Centre	352.13 239.13 113.00	6.24
Utility	138.76	2.46
Govt. Use	91.36	1.62
TOTAL	5648.00	100.0

Source: Zonal Development Plan K-II (Dwarka)

Fig. 1: Map showing the Land use map of Dwarka

a) Sources of Water

Dwarka gets its water from Munak Canal in Haryana. The water received from Munak Canal is raw water. Present demand of Dwarka is 121.13 MLD. Water Treatment Plant provides only 20% of water to Dwarka rest is shared with Najafgarh and nearby villages. Delhi Development Authority supplies 15.91 MLD of water. Delhi Jal Board provides 36.36 MLD to Dwarka the rest 145.47 MLD is shared with Najafgarh and nearby villages. Water supplied by Delhi Development Authority + water supplied by Delhi Jal Board = Total water supplied to Dwarka sub-city. 36.36 + 15.91 = 52.27 MLD (Million Gallons per Day). Total water supplied to Dwarka sub-city is 52.27 MLD per day and 1,568.1 MLD per month. Non-revenue water (NRW) is water that has been produced and is lost before it reaches the customer. Losses can be real losses (through leaks, also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies). According to Delhi Jal Board, the NRW is taken as 15%. Total water supplied /100 x 15% NRW. 52.27 MLD / 100 x 15 = 7.84 MLD 78,40,000 litres/day). The water supplied from Delhi Jal Board to Dwarka has a shortage of 9.10 MLD which is 91,00,000 litres/day. After reducing the NRW the water received by Dwarka is 44.43 MLD of water which is 4,44,30,000 litres/day. The water received by Dwarka have already lost 16.94 MLD of water which is 1,69,40,000 litres/day. Total Demand = 121.13 MLD (12,11,30,000 litres/day), Total Supply = 44.43 MLD (4,44,30,000 litres/day) and Total Shortage = 76.70 MLD (7,67,00,000 litres/day).

b) Ground Water

Apart from receiving water from Munak Canal, Dwarka also depends mainly on groundwater. The water supplied to the 29 sectors is mixed with the groundwater after reaching the societies before supplying it to the individual households. Excess use of ground water has eventually lead to depleted groundwater. Only housing societies and DDA Flats have such rainwater harvesting systems. They have tanks which helps in naturally recharging the ground water. Ground water is saline at deeper depths. The Dwarka contain high concentration of fluoride beyond prescribed maximum permissible limit 1.5mg/l. The groundwater table near the Najafgarh drain has been contaminated with metals such as the cancer-inducing lead, and cadmium apart from other health hazards.

Table II: Comparison of groundwater extraction and its status in 2013 and 2017 and ground water recharge sources and quantity

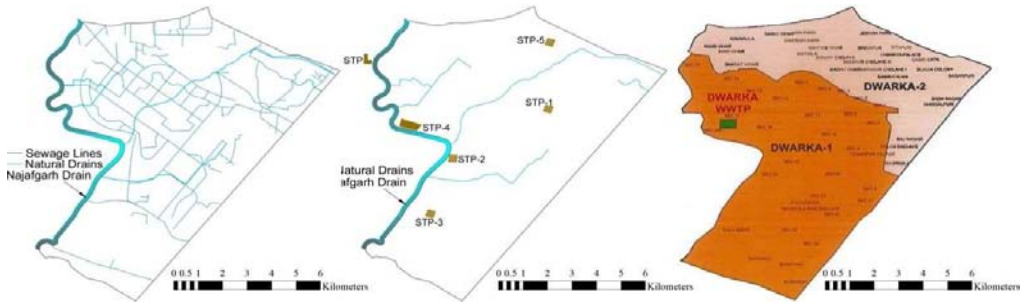
Place	Extraction % in 2013	Status in 2013	Extraction % in 2017	Status in 2017
Dwarka	95.15	Semi - Critical	230.57	Over - Exploited

DWARKA	Monsoon season recharge		Non - Monsoon season recharge		Annual recharge	Total natural discharge	Annual Extractable Ground Water Resources	Current Annual Ground Water Extraction	Net Ground Water Availability for future use
	Rainfall	Other sources	Rainfall	Other sources					
	1435.54	173.7	299.49	472.10	2380.29	238.03	2142.27	4482.64	0.0

Source: Central Ground Water Board, 2017

c) Waste Water and Sewerage

The sewerage network all over Dwarka is sufficient. The water from households and other building goes to small branches of drains which connects to the main sewer line goes to the Sewage Treatment Plant (STP). Residents are charged with 60% of water consumption as sewage charge. The water supplied by the DJB after use goes directly to sewage. The sewerage is estimated at the rate of 80% of the supply.

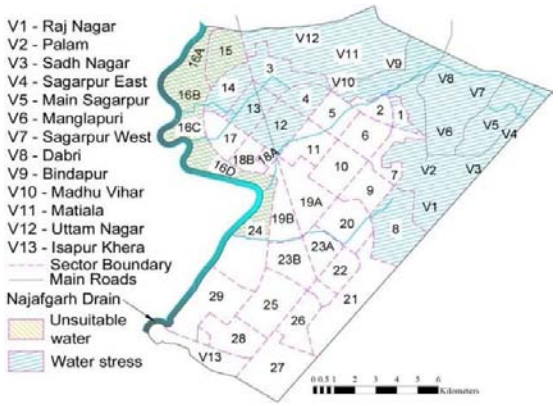


Source: Author, Sewage Master Plan, 2031

Fig. 2: Map showing Sewerage lines, Sewerage Treatment Plants and Drainages zones in Dwarka

VIII. Analysis

Majority of societies in Dwarka mix bore well water into the supply water before supplying it to the individual households. Excess use of ground water has led to depleted groundwater. Only housing societies and DDA Flats have the rainwater harvesting systems. The western side of Dwarka face major water stress due to the Najafgarh Drain flowing near it. The villages face acute water stress due to the shortage of water supply. The western and the northern side of Dwarka face major water stress which is in the villages and in sector 3, 4, 8, 12, 13, 16 and 24. The Najafgarh Drain carries large amount of raw sewage from neighbouring parts of Dwarka. Sewage disposal after treatment is disposed into the Najafgarh drain leading to more water pollution. People living near to Najafgarh drain dispose their household waste and solid waste into the drain making it more polluted. Water supplied by the Delhi Jal Board is also inadequate and does not fulfil the demands of Dwarka.



Source: Author

Fig. 3: Map showing the areas with face water stress

IX. SWOC Analysis

Strength of Dwarka is that well established water distribution network throughout Dwarka. 100% piped connection to all households. The government's scheme of 20,000 litres of water each month free of cost to every household. Weakness of Dwarka is that the availability of water towards Dwarka is not sufficient. Many infrastructures lacks rain water harvesting. Hard water leads to pipe clogging. Frequent repairs of water pipes. No proper sewage water disposal and solid waste management. Opportunities of Dwarka is that implementation of Rain water harvesting tanks in all residential areas. Implementation of waste water treatment at housing society at small level. Challenges of Dwarka is that the existing water bodies are completely polluted with treated and untreated waste. Due to excess boring the ground water in Dwarka is depleting.

X. Strategies and Proposal for Water Stress Management

a) Zone 1: Najafgarh Drain Area – LONG TERM GOALS

1. To restore and revitalize Najafgarh Drain - Najafgarh drain should be cleaned using phytoremediation method which is defined by UNEP (2012) as the use of living green plants for cleaning of contaminants in soils, surface waters, and groundwater.
2. Riverfront development at Najafgarh Drain - Parks on both sides with landscape, hawker zones, event zones and interaction zones. A new STP shall be installed to keep the drain clean. Best example is the Sabarmati river front development.

SHORT TERM GOALS

3. To ensure ban on disposal of Sewage into water reservoirs.
4. To ensure proper solid waste management - Proper solid waste management will decrease the disposal of household waste into the Najafgarh Drain.

b) Zone 2: Compact Settlement Area – SHORT TERM GOALS

5. Provision of safe and affordable water for all - Equal water supply to all places as some places get supply once a day whereas other places get supply twice- thrice.
6. Promote Rain water harvesting - According to Delhi Municipal building by- laws Rain Water Harvesting through storing of water runoff including rainwater in all new buildings and reconstructed buildings on plots of 100 sq. m. and above will be mandatory. Proper action should be taken to see that this is practiced everywhere and defaulters are to be levied with fine.
7. Store excess winter water underground - Saving excess water underground for higher demand times has been the practice for New Jersey. The excess winter water to be stored underwater. It helps natural aquifer replenishment and keeps water from evaporating.

c) Zone 3: Organised Settlemet Area – SHORT TERM GOALS

8. Reviving traditional systems and its conservation as build heritage for future generation - Revival of Lodi Era Baoli/ Stepwell in Dwarka sector - 12. It will be a build heritage for the future generation. After restoration it can be used as an alternate source of water and can help in reducing water stress to some extent.
9. Reviving traditional methods of water conservation Construction of Johads with a covered tank can collect rain water and avoid it from getting evaporated. It proved successful in Rajasthan.

LONG TERM GOALS

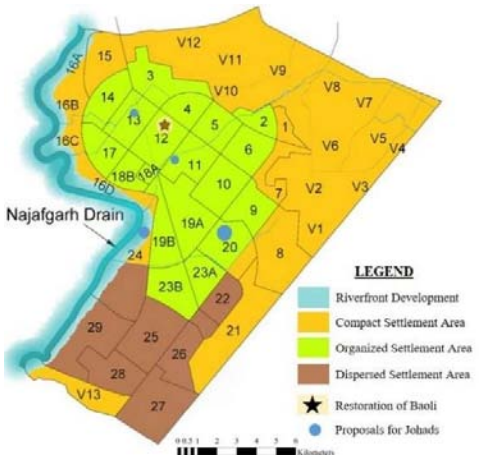
10. Re-route greywater to vegetation - All building having a minimum discharge of 10,000 l. and aboveper day shall incorporate waste water recycling system. Re-route greywater to trees and plants.

d) Zone 4: Disperesed Settlemet Area – SHORT TERM GOALS

11. Provision of Natural STP plants and parks - Greywater from households after getting treated gets collected in underground tank which can be used for watering the plants in parks. The entire plant is underground, with parks above. Best example is Rajokri pilot project.

e) General Strategies and Proposals – LONG TERM GOALS

Quality improvement in water supplies. Ensure all drainage structures to be free flowing. Install water efficient plumbing fixtures and water metering technology. Ensure proper sludge collection, treatment and disposal. Provide incentives for technology and measures that save water. Upgrade waste water treatment plants. Encourage active community participation. Change behavior among citizen to reduce the negative impact on water resources. Creating awareness about efficient water use among students. Improved water management practices that enhance beneficial and efficient use of water.



Source: Author

Fig. 4: Proposal map for all Zones

XI. Conclusion

Dwarka is a sub-city and a major residential hub. Dwarka-Papankala project which was launched in 1988 and is still under development. With further development the population is also increasing so is the demand for water. Increasing demand is leading to water stress due to poor quality and inadequate quantity of water supply and availability. Dwarka relies on surface water and groundwater but with continues decline in ground water level, which makes situation worse. The Najafgarh drain is one of the filthiest water reservoir in overall Delhi which contaminates the ground water. As stated in the above study that Dwarka has shortage of 76.70 MLD (7,67,00,000 litres/day). This clearly states that Dwarka lacks availability of freshwater throughout the year which directly affects the supply. The only best solution to cope with increasing water stress it efficient use of water and efficient water conservation. Hence Dwarka is in acute need of clean water for all and it's possible only with successful reuse and recycle of water and efficient water conservation.

Acknowledgment

Primarily I would like to thank God for helping me to complete this research. I would like to thank my external critics, for devoting their time and expertise to guide and refine my research. I would more over like to thank my family for all the assistance and support they have provided without which, I would not have been able to accomplish everything that I have done. My true mentor throughout this research has been my parents. I dedicate this research work to them.

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Comparative Analysis of Acoustic Properties between Construction Methods Insulated Concrete Formes and Conventional Masonry

By Felipe Daniel Bastos Lopes, Marco Antônio de Moura Fortes, Pedro Afonso de Araújo Costa, Tiago de Macedo Lima Moura Fé & Júlia Almeida Rosal Oliveira

Centro Universitário UNINOVAFAPI/AFYA

Abstract- Everything evolves according to the needs of culture and time. At all times, solutions are created by adding more and more to civil construction. In this context, the Insulated Concrete Forms (ICF) construction method appears as an option for regions with aggressive climate, however, as important as the thermal properties are, the acoustic properties are too since they provide comfort and quality of life for the resident. Thus, the present article aims to carry out a comparative analysis of the acoustic insulation properties between the ICF method and the conventional masonry method through data collection performed by a digital sound level meter while its analysis is performed with the aid of Excel.

Keywords: comparative analysis, acoustic properties, ICF, conventional masonry.

GJRE-E Classification: DDC Code: 693.1 LCC Code: TA670

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Keywords: comparative analysis, acoustic properties, ICF, conventional masonry.

I. Introduction

Everything evolves according to the needs of culture and time. However, it always has as a goal a better-quality product, that in general, and includes civil engineering.To reach this goal, a search for materials with favorable properties to construction began.

Among these wished properties, the most important are resistance, ductility, dilation and insulating properties, which has the function of bringing greater safety, reduction of maintenance expenses and better quality of life to the user of the structure.

Furthermore, the search for more efficient methods and growing attention to waste reduction, both to minimize costs and preserve the environment, requires engineering to be remodeled.

Since more than 60% of world's natural resources are wasted by the construction industry, which makes it unsustainable. Currently, the socioeconomic activities are able to promote significant impacts on the global system. (IPEA, 2010 apud BASTOS JUNIOR, 2018).

Driven by this search for more efficient and less environmentally aggressive construction systems, several constructive technologies were developed, among them the Insulated Concrete Forms (ICF), a method based on Expanded Polystyrene (EPS) forms.

Considering that the urbanization process contributes to an increase in noise pollution, a fundamental property to reduce the impacts of the noise is acoustic insulation. In this regard, the present article aims to analyze the acoustic properties of the ICF constructive method and compare them with the conventional masonry one.

II. Materials and Methods

Given the above, it is worth pointing out that this article uses an approach based on volume of collected data, therefore, a quantitative approach. Added to this factor, as the goal of the study is an underexplored topic and focused on a specific case, it is possible to characterize it as a case study of an exploratory nature.

In order to execute the experiment, two prototypes with a volume of 1m³ were produced in the city of Teresina-PI, one of conventional masonry and the other utilizing ARXX VEDA forms, both covered by thermoacoustic roof tiles. The choice of this line is justified by the fact that both the conventional masonry and the ARXX VEDA line has only a sealing function. Next, illustrated by Figure 1,2, photos of the prototypes in execution and finalized.

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Figure 1: Prototypes under construction

Figure 2: Finished prototypes

For data collection, the Octava-Plus All-In-One digital sound level meter was used, and for the emission of sound waves, the BOSE S1 Pro speaker (Figure 3) was used with a pink frequency noise.

Figure 3: Octava-Plus All-In-One digital sound level meter and BOSE S1 Pro speaker

Initially the distances between the prototypes and the sound source were defined, being determined 10 marks distanced 2 meters away from each other and the first mark, near the prototypes is also distant by 2 meters (Figure 4). Then, through the digital sonometer it was possible to capture the sound intensity emitted by the sound source. After that, for each one of the determined points the sound intensity was measured in each prototype and the external environment, in 5 seconds intervals for 2 minutes.

Figure 4: Marking the distances

After the data collection, the appropriate analysis of the measurements was made based on the Equivalent Level (Leq), as this value is used for execute the sound tests in accordance with the Brazilian regulatory norm, NR15.

In sequence, to verify if the construction methods difference has significative relevance in the acoustic isolation, was performed the variance analysis (ANOVA) test, which is a test used to compare 3 or more averages through analysis of sample variances, is based on a sample taken from each group and focuses on determining whether differences between sample averages suggest significant differences between groups or if these differences are caused by other factors (FAVERO, 2017).

Finally, the percentage reduction of the Leq values obtained for both construction methods in relation to the environment was also calculated, in order to obtain a better visualization of the difference in the results. These percentage reductions were expressed in graph and table format.

III. Results and Discussion

After executing the methodology, as ample group of Leq values was generated for the environment and the common masonry and ICF prototypes, which are contained in the following table (Table 1). For a better visualization, these values were also illustrated to in the Chart 1.

Table 1: Leq values

	ENVIRONMENT	MASONRY	ICF
2m	94.53	78.79	78.69
4m	91.33	75.78	76.67
6m	88.71	72.93	73.47
8m	85.02	70.86	72.56
10m	84.13	69.3	70.52
12m	80.37	67.56	69.78
14m	80.46	67.14	68.46
16m	77.96	66.36	67.67
18m	75.37	64.02	64.79
20m	73.9	63.5	63.86

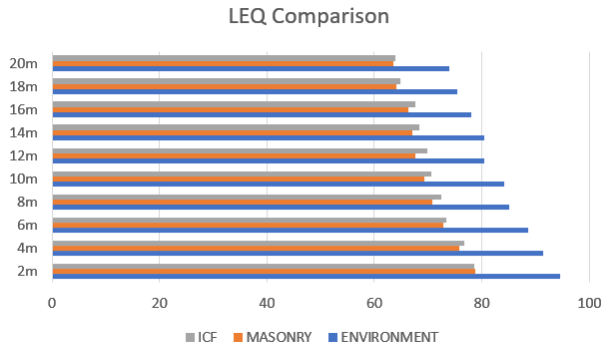

Chart 1: Leq Comparison

Based on the table and chart presented, it is possible to observe that the conventional masonry prototype presents better acoustic insulation than the ICF from 4m away, a result that persists until 20m, at the end of the experiment.

In order to verify the relevance of the differences between the acoustic properties of the constructive methods, the ANOVA test was performed. It is worth noting that in order to guarantee the relevance of the hypothesis, the value of F has to be higher than the Fcritical value, and this relevance is proven if the value of P is less than 0,05.

ABSTRACT				
Group	*Counting*	*Total*	*Average*	*Variance*
ENVIRONMENT	10	831.78	83.178	46.64126
MASONRY	10	696.24	69.624	24.94072
ICF	10	706.47	70.647	23.04182

ANOVA						
Variancy source	*SQ*	*gl*	*MQ*	*F*	*P-value*	*F critical*
Between groups	1139.278	2	569.639	18.06012	1.04987E-05	3.354131
In groups	851.6142	27	31.54127			
Total	1990.892	29				

Figure 5: ANOVA test

Based on the table above, it is possible to conclude that conventional masonry has better sound insulation compared to the ICF method, a difference that is relevant since F > Fcritical, and this relevance is proven since P < 0.05.

To complement the analysis, the percentage reductions of the Leq values of each of the construction methods in relation to the environment were also calculated and then the chart below was generated.

Table 2: Percentage reduction related to the environment

	MASONRY	ICF
2m	16,65%	16,76%
4m	17,03%	16,05%
6m	17,79%	17,18%
8m	16,65%	14,66%
10m	17,63%	16,18%
12m	15,94%	13,18%
14m	16,55%	14,91%
16m	14,88%	13,20%
18m	15,06%	14,04%
20m	14,07%	13,59%

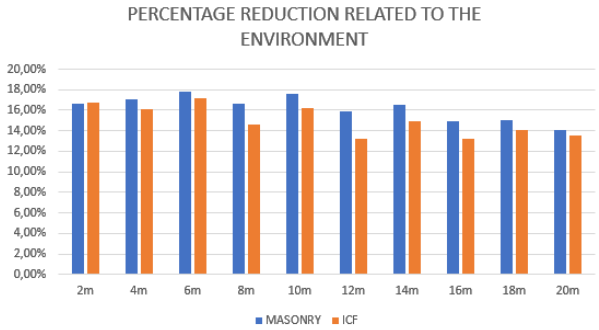

Chart 2: Percentage reduction in comparison to the environment

It is noted that the prototypes reduced the sound intensity coming from the environment between 13% and 18%, in addition, the conventional masonry prototype reduced an average of 16.23%, while the ICF reduced an average of 14.97%, that is, the performance of the masonry prototype was 8.16% higher than that of ICF.

IV. Conclusion

After the study carried out, it was possible to conclude that the conventional masonry construction method has better sound insulation than the Insulated Concrete Forms method, a difference that proved to be relevant thanks to the ANOVA test.

Possibly the construction methods have this difference due to the existing voids in the 6-hole ceramic brick, while the ICF walls are solid solids, as sound is a mechanical wave, the impact of the wave on a massive wall would make it vibrate, aiding in the propagation. the sound to the interior of the environment, while in the wall with voids of conventional masonry this vibration is not so intense, because the voids make it difficult for the sound to propagate.

It is also worth mentioning that the Insulated Concrete Forms constructive method presents a good acoustic performance in sound intensities up to 65 db (something equivalent to a conversation) according to its technical magazine.

It is suggested for future studies a mathematical analysis of the data obtained in order to generate a scatter plot using linear regression, and then find the function of sound intensity in relation to distance.

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Durability Evaluation of Normal and High Performance Concrete

By Arpan Sharma, Parikshit Thakur, Rajneesh Vashisht & Abhilash Shukla
Jaypee University of Information Technology

Abstract- Classification of concrete is often most feasible means for measuring the durability and has become progressively over the past 20 years. The present study is focused on the capability of concrete to improve its durability when the concrete is subjected to the highly aggressive environments. Existing concrete in cold or coastal regions are affected by chloride penetration under the freeze-thaw cycles. This collective deterioration process quickens the damage advancement of concrete and reduces the service life of the structures. In real life the structure may face numerous deterioration contrivances due to environmental factors surrounded by the concrete. A variety of laboratory test method were used for the determination of durability, which provide number of results, such as rapid chloride penetration value, electrical conductivity, water absorption rate in concrete. For evaluating the durability of concrete, to a single contrivance of deterioration, the techniques were economical and appropriate. For determining the durability of concrete the Ordinary Portland Cement was used.

Keywords: ordinary portland cement, high performance concrete, electrical conductivity, compressive strength.

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Keywords: ordinary portland cement, high performance concrete, electrical conductivity, compressive strength.

I. Introduction

Concrete was once thought to be an extremely long lasting that required no maintenance. The assumption is largely true, except when it is subjected to highly aggressive environments [1]. Concrete is a multipurpose and generally used in the construction material in the world. There are different limits for the design of concrete. One of the important parameters in the design of concrete is durability. To increase the service life of structure, not only strength is required but durability parameter is also important [1]. Durability of the concrete is defined as ability of the concrete to repel the weathering action, chemical attack, abrasion or any other process of deterioration. Durability is either through the concrete system like binder type, mixing, transportation, aggregates, admixtures, curing, and temperature at the time of curing, or through the assertiveness of the environment like abrasion, leaching, expansion, erosion, cavitation etc. [1]. Most commonly durability of concrete is affected by sulphate attack, chloride attack, carbonation, ASR reaction, freezing and thawing damage. Durability of concrete is fundamentally related to permeability [1].

In real environment concrete structures are exposed to numerous environmental factors acting in a shared and certainly synergistically physical and chemical manner to quicken the destruction procedure, so it is significant to study the chloride resistance of concrete to acquire satisfactory information on concrete durability [1]. The concentration of the hydroxyl ion inside the concrete is largely measured by the concentration of sodium and potassium. The mechanism of expansion of alkali silica reaction can be explained by absorption theory or osmotic pressure theory. In absorption theory, the reticence of pore water and bulge of the alkali silica gel causes expansion, whereas in osmatic pressure theory, there is an inward diffusion of OH^-, Na^+, K^+ and Ca^{2+} from the pores to aggregate surface. The ratio of the Ca^{2+} to the alkali present controls the expansive nature of the concrete [2]. The concrete can be protected against the alkali silica reaction by the use of stumpy alkali content (less than 0.6%), use of chemical admixtures, use of mineral admixtures such as silica fumes, or by applying coatings or water proofing agents. The use of high reactivity metakaolin has the prospective to improve the durability [2]. If the concrete remains frozen, then there will not much problem occurs, but if the cycles of the freezing and thawing repeat again and again, then there will be the existence of deterioration. The internal stress is produced in the concrete, due to the pore solution inside concrete freezes into ice through freezing-thawing process. When the stress is more than that of the strength of concrete, there will be the incidence of the micro-cracks, which will result in interconnecting the flow channels, owing to which there will be more chloride penetration, which result in decrease of durability [2].

Due to antagonistic marine acquaintance environment and wide use de-icing salts, corrosion in the reinforced concrete structure due to the chloride persuaded is most common cause of degradation [3]. In concrete, chlorides can chemically bound with

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cement C3A or C4AF phases [3]. The degree of diffusion of cl^- ions in concrete increases with increase in temperature [3]. The most unfavourable environment situation for the reinforced concrete is drying and wetting cycles [3]. In carbonation, there is a chemical reaction between portlandite (which is present in hydrated cement) and CO_2. Relative humidity, the concentration of CO_2, penetration pressure and the temperature of the environment where concrete is placed, are the factors on which the degree of carbonation rest on [4]. When using the normal PC, the degree of carbonation is lower [5]. The durability can be increased by using pozzalans material such as fly ash, as it reduces the calcium hydroxide of the cement matrix [6]. Sulphate solution and sulphuric acid solution are both harmful to durability part of concrete. The parameters to which the resistance of concrete to chemical attack depends are, the capability to neutralize the chemical solution, the passivation by the deposition of responded products and the pore structure characteristics [6]. The permeability of concrete is resolved by the pore structure. The corrosion rate can be accelerated, when there is crack present in the concrete because of the decay causing factors can pass past the crack [7]. The protection against the sulphate attack can be done by use of C_3A, as it will reduce the formation of CH. Low w/c ratio can also reduce the sulphate attack. Use of blended cement and high alumina cement can also reduce the sulphate attack in concrete. The presence of crack in the concrete, significantly influence the durability of reinforced concrete structure [7]. In ASR, there is a reaction between alkali (Na^+, K^+), reactive silica and moisture, which results in the formation of alkali-silica reaction gel which expands which results in concrete cracking. Various forms of reactive silica are opal, silica glass, chalcedony, tridymite crystallite and quartz. The use of larger size water glass as an auxiliary of coarse aggregate in concretes have been stated to facilitate the ASR [8]. In relations of the cement conformation, the main compound concerning the sulphate resistance of the cement is C_3A [9]. The sulphate resistance of the low C_3A Portland's cements is largely pretentious by the CH out from the silicates [9]. Carbonates addition have no substantial consequence on sulphate resistance, excluding C_3A dilution, when enormous filler substitutes are used in type 1 Portland cement [9]. The chloride penetration test is appropriate for the assessment of materials and material extents for design resolutions and research and development. For the aggregates in concrete that respond leisurely or produce enlargement late in the reaction, the accelerated mortar bar test is suitable. To assessment the chloride penetration into the cementitious combinations which are in saturated state is done by deceptive chloride diffusion coefficient. The concrete mix proportions, the occurrence of chemical admixtures and additional cementitious material, the kind and period of curing, the point of hydration, the entrained air content are roughly the issues on which the water absorption of the concrete rest on. The freezing-thawing can cause failures like paste failure, aggregate failure (D cracking, pop out) etc. To quicken the chloride ions through the concrete as the diffusion coefficients experiments were time overwhelming, the test set up of the migration test was useful [10]. Also for determine the diffusion coefficients values; the steady state migration test is effective way, as chloride binding just primes to an increase in time lag [10].

II. Experimental Program

a) Materials

All the chemicals and reagents used in the present study were of analytical grade. The cement used was Ordinary Portland Cement (OPC 43) conforming to IS: 8112 – 1989 (ACC Limited, India). A Super Plasticizer "High Range Water Reducing Agent" of Fosrec were procured which is used for the preparation of concrete and testing of concrete.

b) Methodology

The following flow chart represents the different stages:

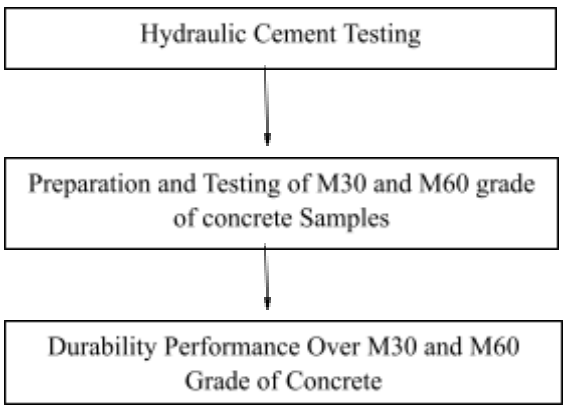

Figure 1: Flow Chart of Plan of this study

i. *Physical Properties of Cement*

Hydraulic Cement required to satisfy its physical properties up to its permissible limit. Hydraulic cement tests were performed to obtained the Physical characteristics of Cement used in the present study. To get the consistency and initial & final setting time of cement Vicat's apparatus used, the plunger penetration gave consistency and initial setting time for cement while the needle impression gave the final setting time of cement. The consistency helps us to find the water requirement for complete hydration of cement. Initial and Final setting time used to elaborate the setting times of cement when it starts to set till its hardening. Le-Chatelier apparatus used to obtained the soundness of the cement which is affected by the presence of free lime. The cement must be fine enough to pass the 90-micron sieve. The specific gravity of cement and all

cementitious materials were find out by using Le-Chatelier's bottle. The specific gravity of fine aggregate obtained by using fineness modulus of sand was also done to determine the zone of sand while density bucket used for measure the specific gravity of coarse aggregates. The specific gravity of fine and coarse aggregates along with the cement specific gravity helps us to design the concrete mix. The proportion of mix design for M30 and M60 grade of concrete is shown in Table 1 and Table 2.

Table 1: M30 grade of concrete mix design

Sr. No.	Material	Quantity (kg/m^3)
1.	Cement	413
2.	Water	186
3.	Coarse Aggregate	1186.688
4.	Fine Aggregate	674.804

Table 2: M60 grade of concrete mix design

Sr. No.	Material	Quantity (kg/m^3)
1.	Cement	500
2.	Water	165.8
3.	Coarse Aggregate	1072.3
4.	Fine Aggregate	660.21
5.	Micro Silica	35
6.	HRWR	0.0096

ii. *Sulfate Attack*

The 3 set of concrete cubes of 150 X 150 X 150 mm were casted by manual mixing in the laboratory for M30 and M60 grade of concrete. The cubes were in 2% Na_2SO_4 solution for curing at room temperature. Cubes were tested for compressive strength after 7, 14, & 28 days of curing in solution and tested in compression testing machine.

iii. *Chloride Attack*

The set of 3 concrete cubes of 150 X 150 X 150 mm and 100 X 50mm were casted by the manual mixing in the laboratory for M30 and M60 grade of concrete. The cubes were kept in 3% NaCl solution for curing at room temperature. The cubes were tested for the compressive strength after 7, 14, & 28 days of curing in chloride solution and testing in compression testing machine at respective days. And for the electrical conductivity, the test specimen of size 100 X 50mm for M30 and M60 grade of concrete; were also placed in 3% NaCl solution and reading were recorded with electric conductivity meter. For the Rapid Chloride Penetration Test, the test specimen was of size 100 X 50mm for M30 and M60 grade of concrete and negative cell was filled with 3.0% NaCl solution and positive side of the cell was filled with 0.3 N NaOH (Sodium Hydroxide) solution and power was set at 60V and Power was applied for 6 hours and recordings were recorded at an interval of 30 minutes from which total charge was calculated.

$$Q = 900\ (I0 + 2I30 + 2I60 + \ldots\ldots\ldots + 2I330 + I360)$$

where:
Q = charge passed (C).
I0 = current (A) immediately after voltage is given.
It = current (A) at t min after voltage is given.

iv. *Acid Attack Test*

The 3 set of concrete cubes of 150 X 150 X 150 mm were casted by manual mixing in the laboratory for M30 and M60 grade of concrete. The cubes were kept in respective solutions of 5% H_2SO_4, 5% HCL & in solution of 100% H_2O for curing, at room temperature. Cubes were tested for compressive strength after 28 days of curing, tested in compressive testing machine.

v. *Sorptivity Test*

It is the test method used to govern the rate of absorption of water by hydraulic cement concretes. It is measured as increase in mass of specimen resulting from the absorption of water, when alternate side is exposed to water. The test for determining the absorption rate follows ASTM C 1585 - 13. The test specimen was 100 mm diameter and with a length of 50 mm. The test specimen should be placed in a sealable container and store the container at 23°C. for at least 15 days. Then remove the specimen from the container after 15 days and record the initial mass of the specimen. Epoxy paint was used for sealing the specimen. And then record the mass of sealed specimen. Then, place the support on the pan and fill with water till it rises up to 1-3 mm, above the top of support device. Then place the test specimen on the supported material and immediately start the timing device. The mass of the specimen was recorded at interval of 60 secs, 5 min, 10 min, 20 min, 30 min, 60 min and every hour up to 6 hr. The absorption rate is calculated by the formula:

$$I = m/ (a \times d)$$

Where;
I = absorption
m = the change in mass of specimen in time t.
a = the specimen exposed area in mm^2
d = density of water in g/mm^3

vi. *Water Absorption Test*

A 100 X 50 mm cylinder were oven dried at 110°C for 24 hours. And weighed as W1; after 24 hours oven drying the samples were placed in warm water of about 80°C for 3.5 hours. The samples were then weigh after surface drying as W2. The calculation of water absorption was made by following equation;

Water absorption %age = (W2-W1)/W1 X 100%

Where;

W1 = Weight of oven dried core sample.

W2 = Weight of saturated core sample.

III. Results and Discussion

a) Sulfate Attack

The loss in compressive strength for M30 is 0.45% and for M60 is 1.113%. The comparative graphical representation between sulfate curing and tap water curing of M30 grade of concrete is shown in Figure 2 and similarly of M60 grade of concrete is shown in Figure 3.

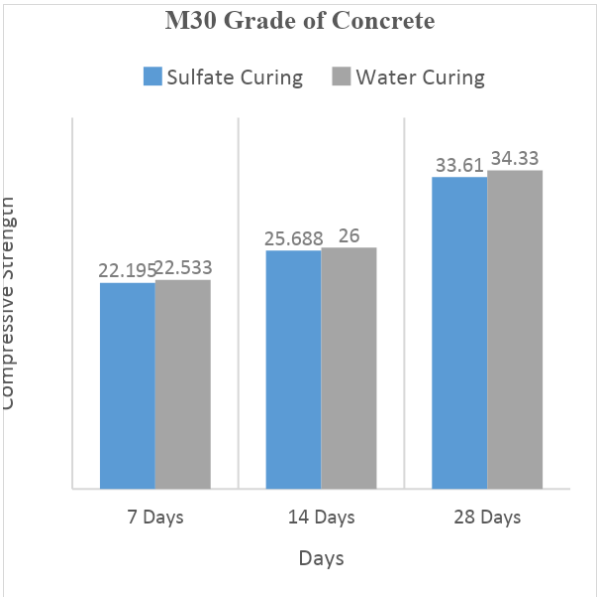

Figure 2: Comparison of Compressive Strength for M30

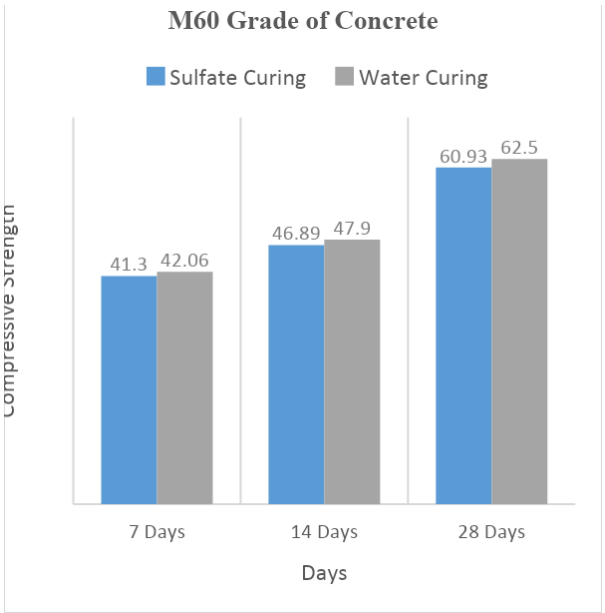

Figure 3: Comparison of Compressive Strength for M60

b) Chloride Attack

The change in compressive strength was compared to the standard samples were 0.567% for M30 and 1.078% for M60. The comparative graphical representation between chloride solution curing and tap water curing of M30 grade of concrete is shown in Figure 4, And similarly of M60 grade of concrete is shown in Figure 5.

Electric Conductivity: The electric conductivity of concrete samples of M30 and M60 shown in the Table.1. It was observed that the electric conductivity of M30 and M60 concrete core was 24.2 Mhos/cm and 21.0 Mhos/cm for 60 minutes respectively.

Table 3: Electric Conductivity for M30 and M60

	Electric Conductivity(Mhos/cm)			
Sample↓/ Time→	0 Min	15 Mins	10 Mins	60 Mins
Distilled Water	0.04	0.04	0.05	0.05
3%NaCl Solution	21.2	21.1	21.2	21.2
M30 in 3%NaCL	21.3	21.3	23.0	24.2
M60 in 3%NaCL	20.1	20.8	21.0	21.0

Rapid Chloride Penetration Test: It was observed that the M30 grade of concrete has moderate Chloride ion penetration as the electric charge passed through the concrete sample were in between 2000 to 4000 which is moderate penetration and for M60 grade of concrete the Chloride ion penetration recorded was low penetration as the charge pass through the sample was in between 1000 to 2000. The Rapid chloride penetration test results are shown in Table.2.

Table 4: Chloride ion penetration for M30 and M60

Specimen	Electrical Charge in coulomb	Chloride ion Penetration
M30	2250	Moderate
	2560	Moderate
	3200	Moderate
M60	1905	Low
	1890	Low
	1950	Low

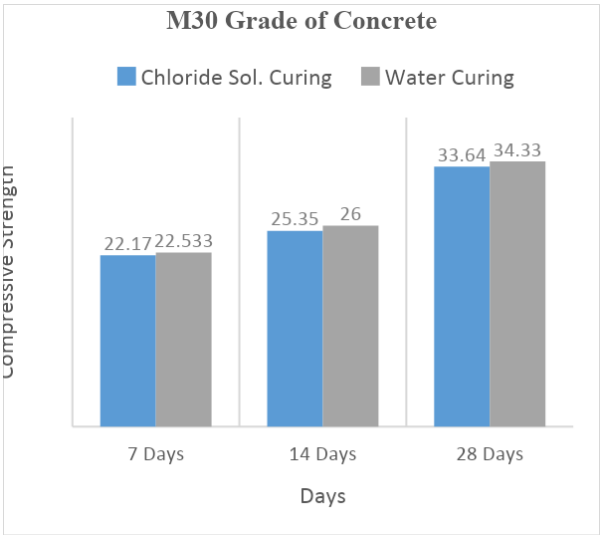

Figure 4: Comparison of Compressive Strength for M30

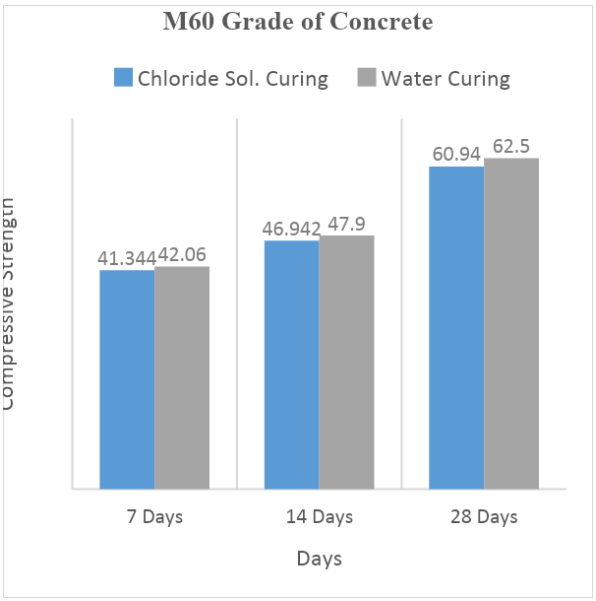

Figure 5: Comparison of Compressive Strength for M60

c) Acid Attack

The effect of acid attack measured by the reduction in compressive strength w.r.t., controlled samples is shown in the graph for M30 and M60 respectively. The comparative graphical representation between 5% HCl solution curing and tap water curing of M30 grade of concrete is shown in Figure 6, And M60 grade of concrete is shown in Figure 7. Similarly, the comparative graphical representation between 5% H_2SO_4 solution curing and tap water curing of M30 grade of concrete is shown in Figure 8, And M60 grade of concrete is shown in Figure 9.

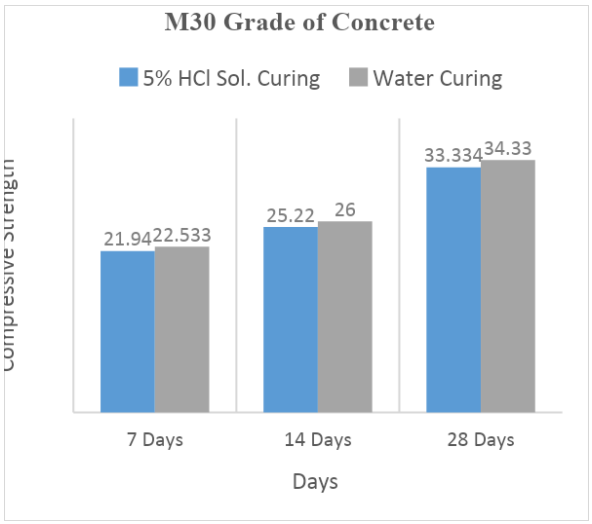

Figure 6: Comparison of Compressive Strength for M30

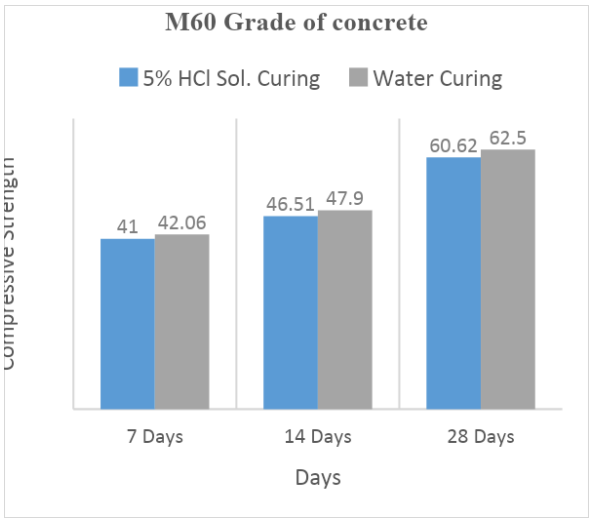

Figure 7: Comparison of Compressive Strength for M60

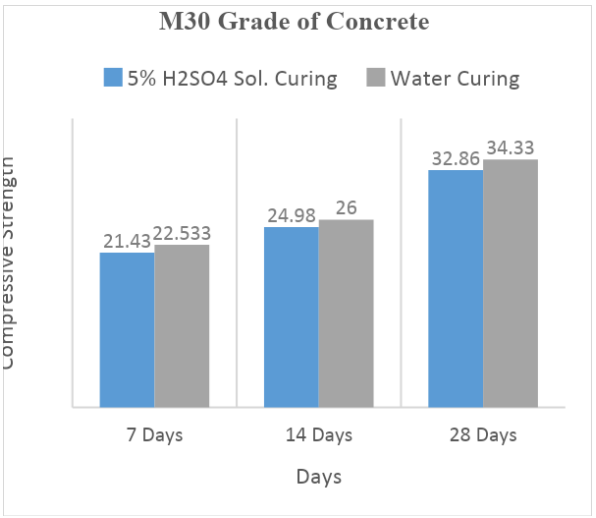

Figure 8: Comparison of Compressive Strength for M30

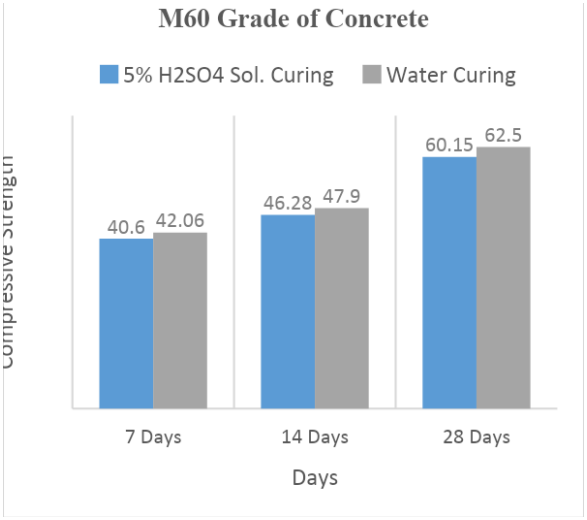

Figure 9: Comparison of Compressive Strength for M60

Therefore, it was observed that there was drop in the compressive strength when the samples were cured in the 5% HCl solution and 5% H_2SO_4 solution after 7, 14, and 28 days both for M30 and M60 Grade of concrete.

d) Sorptivity Test

The maximum absorption in M30 grade of concrete found 0.197352 mm after 8 days' immersion of 100X50 mm core in water. While the maximum absorption in M60 grade of concrete found 0.162974 mm after 8 days of immersion of M60 grade concrete sample. The data for different time duration is shown in the graphical representation as shown in figure.10 And figure.11 respectively for M30 and M60 Grade of concrete.

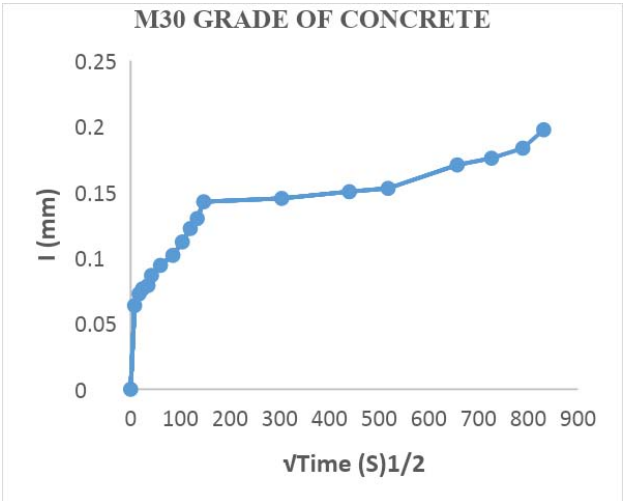

Figure 10: The absorption in M30 Grade of Concrete

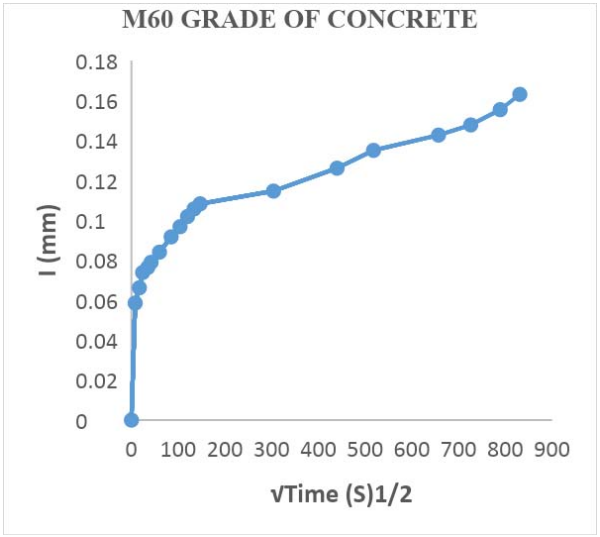

Figure 11: The absorption in M60 Grade of Concrete

e) Water Absorption Test

The test performed and the results are shown in Table.3. It was found that the average percentage water absorption for M30 grade of Concrete is 1.833% while for M60 grade is 1.3% of average percentage of water absorption recorded.

Table 5: Water absorption for M30 and M60

Specimen	Oven Dried Weight (W1) Kg	Saturated Weight (W2) Kg	Difference in Weight (W2-W1) Kg	Water Absorption %age
M30	0.727	0.907	.18	1.8
	0.735	0.925	.19	1.9
	0.736	0.916	.18	1.8
M60	0.614	0.744	.13	1.3
	0.630	0.770	.14	1.4
	0.652	0.772	.12	1.2

IV. Conclusions

The sulfate attack, the chloride attack, the acid attack, and the water absorption of M30 and M60 grade of concrete was investigated in this study. The following conclusions can be drawn on the basis of experimental results:

1. Concrete exposed to the sulfate solution shows the loss in compressive strength for M30 is 0.45% and for M60 is 1.113%.
2. Concrete exposed to chloride solution shows the loss in compressive strength for M30 is 0.567% and for M60 is 1.078%. The electric conductivity of M30 and M60 concrete core was 24.2 Mhos/cm and 21 Mhos/cm for 60 minutes respectively. the M30 grade of concrete has moderate Chloride ion penetration as the electric charge passed through the concrete sample were in between 2000 to 4000 which is moderate penetration and for M60 grade of

concrete the Chloride ion penetration recorded was low penetration as the charge pass through the sample was in between 1000 to 2000.

3. Concrete exposed to acid solution, it was observed that the strength reduction in 5% HCl solution for M30 Grade of concrete is 0.78% and for M60 grade of concrete is 1.44%. While the reduction in compressive strength for 5% H_2SO_4 immersed samples of M30 and M60 grade of concrete were found 1.197% and 1.81% respectively.
4. The maximum absorption in M30 grade of concrete found 0.197352 mm after 8 days' immersion core in water. While the maximum absorption in M60 grade of concrete found 0.162974 mm after 8 days of immersion concrete sample.
5. It was found that the average percentage water absorption for M30 grade of concrete was 1.833% while for M60 grade of concrete was 1.3% of average percentage of water absorption recorded.

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Diseño de Hormigón Permeable Para el Aprovechamiento de Agua Lluvia en Superficies de Uso Peatonal

By Ing. Juan Carlos Moya H., Ing. Jaime Gutiérrez P.,
Srta. María Belén Marroquín & Srta. Jéssica Trejo

Abstract- In recent years we have seen the need to develop new methods or construction techniques that reduce the impact on our environment, for this reason there is a constant search for organic products or at least sustainable alternatives. Among the developments of sustainable construction is permeable concrete, which allows the management of rainwater, the same that infiltrates through this concrete. Therefore, in the present investigation, we seek to focus on the design of a permeable transport system that provides water and that is not lost at the same time or to the water source. Drinking water, favoring the responsible management of the resource. Permeable concrete, being a non-structural concrete, has low resistance to compression, however, the study complies with the necessary conditions to be used in pedestrian traffic zones with resistances that vary between 14 MPa and 18 MPa, giving priority to the use of rainwater, thus reducing the water demand of this limited natural resource worldwide.

Keywords: *permeable concrete (Pc)/water demand/water rain (Wr)/cement water relationship (W/C).*

GJRE-E Classification: *DDC Code: 615.19 LCC Code: RS420*

Strictly as per the compliance and regulations of:

Diseño de Hormigón Permeable Para el Aprovechamiento de Agua Lluvia en Superficies de Uso Peatonal

Ing. Juan Carlos Moya H. [α], Ing. Jaime Gutiérrez P. [σ], Srta. María Belén Marroquín [ρ] & Srta. Jéssica Trejo [ω]

Resumen- En los últimos años se ha visto la necesidad de desarrollar nuevos métodos o técnicas de construcción que reduzcan el impacto ambiental que contamina nuestro ambiente, por tal motivo existe una búsqueda constante de utilizar materiales ecológicos o por lo menos alternativas sostenibles. Entre los desarrollos de la construcción sostenible se encuentra el hormigón permeable, que permite el manejo del agua lluvia, la misma que se infiltra a través de este hormigón. Por lo cual la presente investigación busca enfocarse en realizar el diseño de un hormigón permeable permitiendo que el agua lluvia pase gracias a la porosidad que este presenta y que a la vez esta agua sea recolectada y aprovechada para usos no domésticos donde no sea necesario que el agua sea potable, favoreciendo al manejo responsable del recurso. El hormigón permeable al ser un hormigón no estructural, posee baja resistencia a la compresión, sin embargo, el estudio realizado cumple con las condiciones necesarias para usarlos en zonas de tránsito peatonal con resistencias que varían entre 14 MPa y 18 MPa, dando como prioridad al aprovechamiento de aguas lluvias, reduciendo de cierta manera la demanda hídrica de este recurso natural limitado a nivel mundial. La idea es diseñar un sistema de recolección de Agua lluvia sostenible, que se aplicable de manera técnica y viable en lugares de tráfico ligero, convirtiéndose en una alternativa factible, para poder usarla rutinariamente.

Palabras Clave: hormigón permeable (Hp)/demanda hídrica/agua lluvia (All)/relación agua cemento (A/C).

Abstract- In recent years we have seen the need to develop new methods or construction techniques that reduce the impact on our environment, for this reason there is a constant search for organic products or at least sustainable alternatives. Among the developments of sustainable construction is permeable concrete, which allows the management of rainwater, the same that infiltrates through this concrete. Therefore, in the present investigation, we seek to focus on the design of a permeable transport system that provides water and that is not lost at the same time or to the water source. Drinking water, favoring the responsible management of the resource. Permeable concrete, being a non-structural concrete, has low resistance to compression, however, the study complies with the necessary conditions to be used in pedestrian traffic zones with resistances that vary between 14 MPa and 18 MPa, giving priority to the use of rainwater, thus reducing the water demand of this limited natural resource worldwide. The idea is to design a sustainable rainwater collection system, which is technically and feasibly applied in places of light traffic, becoming a feasible alternative, to be used routinely.

Keywords: permeable concrete (Pc)/water demand/ water rain (Wr)/cement water relationship (W/C).

I. Introducción

El estudio del hormigón permeable a manera de estudios de pregrado no es algo nuevo, sin embargo, algunos estudios lo catalogan como una alternativa de construcción frente al problema de inundaciones, el agotamiento de mantos y escasez de agua. (Cabello et al., 2015). Por ejemplo en Colombia, (Benites, 2014) en su investigación ha determinado las características del hormigón permeable, en México se ha construido estos hormigones para la recarga de los acuíferos. (Benites, 2014) menciona que en Perú las ciudades de la sierra tienen continuos problemas de inundaciones.

Hoy en día el desarrollo urbano aumenta cada vez más y esto hace que las zonas verdes vayan disminuyendo lo cual genera un problema según lo establece los SUDS (Sistemas Urbanos de Drenaje Sostenible de Colombia) ya que son aquellas las que permiten el paso de agua lluvia sin inconvenientes, a diferencia de las obras de drenaje vial como los sumideros, mismas que si no se toma en cuenta factores importantes como son la localización y el diseño, estos interfieren en su correcto funcionamiento. Entonces al disminuir la cobertura vegetal se están creando ciudades impermeables, que se vuelven vulnerables en grandes épocas de lluvia, teniendo como resultado el colapso de las alcantarillas e inundaciones indeseables y prácticamente agua lluvia desperdiciada sin ningún fin o uso aprovechable, tratándola al final como agua residual.

Según (Jumbo y Quiroz, 2019), mencionan que en el Ecuador actualmente existe la presencia de estaciones invernales muy concurrentes, en donde a causa de este fenómeno natural, se ha evidenciado, el deterioro del pavimento, casas destruidas, colapso del

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sistema de drenaje pluvial, deslaves e inundaciones, causando pérdidas físicas, estructurales y económicas. Por tal motivo se busca soluciones amigables con el ambiente, que ayuden a mitigar todos estos desastres naturales y según (Cadenas et al, 2017), es el hormigón permeable una de las soluciones frente a las inundaciones causadas por el agua lluvia.

Debido a la permeabilidad que presenta el hormigón, el agua lluvia infiltra por este, lo cual permite en cierta parte controlar problemas de formación de pozas o charcos, que se desarrollan en ciclo vías, plazas, parques, canchas deportivas, estacionamientos, entre otras zonas de tráfico ligero, sin embargo el presente trabajo de titulación busca desarrollar esta alternativa como un material sustentable para el medio ambiente y satisfagan las necesidades de la sociedad. (Arango, 2018).

De las investigaciones pasadas que ha realizado (Cruz et al., 2014), con respecto al hormigón permeable, manifiesta que éste se limita a almacenar el agua directamente en el suelo, como para controlar las inundaciones o recargar los acuíferos, cuya funcionalidad no es el objetivo de esta investigación, sino que a su vez se pueda aprovechar esta situación recolectando dicha agua para usos donde no se requiere agua potable para consumo.

Para mitigar el problema del agua lluvia desperdiciada, se plantea la inquietud del uso de áreas no estructurales de hormigón permeable como sistemas de recolección de agua lluvia, con el fin de cambiar el concepto de que la lluvia no tiene importancia en las zonas urbanas, para recolectar importantes volúmenes de agua, disminuyendo así el coeficiente de escorrentía superficial.

Construcciones sustentables es lo que se requiere en el país, sobre todo por su impulso hacia la investigación y análisis, mismos que permitirán profundizar el estudio y manejo correcto del agua. Para ello es necesario el diseño de un hormigón especial con características similares al hormigón convencional, pero que cumpla con dos parámetros importantes para que pueda ser una alternativa factible; el primer parámetro es el de resistencia para soportar cargas de tráfico ligero y el segundo es el de la permeabilidad, permitiendo filtrar cierta cantidad de agua lluvia y a su vez con opción para almacenarla, si se dimensiona un tanque recolector debajo de la estructura permeable.

II. Metodología

El hormigón permeable conocido también como hormigón poroso, se encuentra principalmente compuesto por agregado grueso, cemento, agua y cierta porción de agregado fino. Combinando estos materiales resulta una capa endurecida con varios espacios vacíos en su interior, por el cual se infiltra el agua que atraviesa su estructura. Los investigadores como (Hernández y Martínez, 2014) definen al hormigón permeable para su empleo en pavimentos, como una composición de materiales y técnicas que permitan a partir de su estructura, la circulación de las aguas pluviales, reduciendo la escorrentía y atrapando en si los sólidos en suspensión y filtros de contaminantes del agua.

Con relación a las ventajas y desventajas de los hormigones permeables, investigadores e instituciones como el American Concrete Institute (ACI) en su comité 522 (ACI, 2010), (Aoki, 2009), entre otros, establecen algunas de estas; teniendo entre las más relevantes las que se muestran a continuación:

a) Ventajas

- Control de Inundaciones
- Recarga de Acuíferos
- Es una técnica sustentable
- Reduce el colapso del sistema de drenaje pluvial
- Permite la reutilización del agua lluvia
- Ayuda de cierto modo con el ahorro de agua Potable, si se aprovecha su característica de permeabilidad y se dimensiona un tanque recolector de agua, bajo la estructura.
- Se reduce el tamaño de las alcantarillas
- Controlar la contaminación que arrastra la corriente en las aguas lluvias.
- Controla la escorrentía de aguas lluvias.
- Reduce el deslizamiento sobre la superficie de caminos y carreteras.

b) Desventajas

- La Resistencia frente a la compresión es baja.
- Tiene una trabajabilidad pobre.
- Por lo general son hormigones para tráfico ligero.
- No se recomienda en zonas de muy bajas temperaturas por las heladas que se suelen presentar, donde resultaría que los poros del hormigón se sean vean afectados o dicho de otras maneras obstruidas.
- Se vuelve poco operacional frente a torrenciales lluvias acompañadas con granizos.
- Alta vulnerabilidad a taponamientos causados por deslaves con grandes arrastres impurezas y sedimentos orgánicos.
- Sensibilidad al contenido de agua ya que es muy sensible a la cantidad que se utilice.
- Mayor frecuencia de mantenimiento y limpieza para evitar que los vacíos del hormigón se tapen y la permeabilidad del mismo se pierda.

c) Componentes

Básicamente los materiales a utilizar en un hormigón permeable son similares a los de un hormigón convencional (Agua, cemento, agregado grueso, agregado fino y aditivo si se requiere el caso), con la diferencia de que tanto el cemento como el

agregado fino se los añade en mínimas cantidades, las mismas que se encuentran regidos bajo la norma ACI 522R-10.

d) Proceso Experimental

Para lograr que el hormigón tenga características de permeabilidad, se basa en la normativa internacional del ACI 522-R10, misma que muestra ciertos parámetros iniciales muy importantes a tomar en cuenta para escoger los áridos a usar. Los materiales utilizados fueron:

- Agregado Grueso, granulometría No. 8 – Pifo, Holcim.
- Agregado Fino – Pifo, Holcim.
- Hormigón Holcim GU.

Ya con los materiales idóneos, se empezó la caracterización de cada uno de los materiales constituyentes del Hormigón, basándose siempre en las normas establecidas. Una vez determinadas las propiedades respectivas, se utilizó el método por volúmenes absolutos (b/b_o) detallado en la normativa ACI 522-R10.

Se desarrolló varias dosificaciones de prueba, tomando en cuenta un porcentaje de pasta de cemento del 25% y jugando con los distintos parámetros que pueden afectar o mejorar las propiedades en estado endurecido del mismo. A las 6 dosificaciones de prueba realizadas se varía los siguientes parámetros claves, para analizar la influencia en su comportamiento:

- *Relación agua – cemento (a/c):* Partiendo de las recomendaciones dadas por la normativa ACI 522-R10 para sus valores máximos y mínimos, se realizó probetas de experimentación para observar las propiedades en estado fresco que presenta y a partir de estos primeros ensayos se seleccionó los siguientes valores, mismos que poseen las mejores características buscadas para el estudio: 0.33, 0.35, 0.4 y 0.46.
- *Porcentaje de finos:* de acuerdo a la normativa se recomienda usar de 0%, 10% y 20%, pero solo se selecciona los valores que mejoren la adherencia entre las partículas que constituyen al hormigón, por lo que los valores usados para la experimentación son: 10% y 20%.

Tabla 1: Tabla de Dosificaciones prueba realizadas

N°	A/C	b/bo	% Vacíos Contenidos	%fino	Tamaño Agregado Grueso
1	0,35	0,85	20,00	20	3/8
2	0,40	0,85	20,00	20	3/8
3	0,35	0,93	10,00	20	#8
4	0,46	0,93	10,00	20	#8
5	0,33	0.85	10,00	10	#8
6	0,33	0,85	10,00	20	#8

e) Resistencia a Compresión Simple

A fin de verificar el comportamiento mecánico (resistencia a compresión y flexión) e hidráulico (permeabilidad), de cada una de las dosificaciones de prueba, se puede elegir la mejor dosificación, se toma muestras en probetas cilíndricas siguiendo las especificaciones del ASTM C-31–17/NTE INEN 1576, la cual menciona que se posee un número mínimo de especímenes a fabricar para las diferentes pruebas, considerando una cantidad mínima de 3 probetas, sin embargo la normativa ASTM C39-17/NTE INEN 1573 indica que la aceptación de variación del promedio de resultados es de un 9% para dos probetas, y una variación de 10.6% para tres probetas, dando a entender que al realizar una mayor cantidad de probetas, esta aceptación de variación aumenta siendo directamente proporcional, por lo que se decide incrementar dicho promedio de aceptación de resultados, por lo que se decide confeccionar 5 especímenes (D: 10cm y h: 20cm) por cada día de ensayo (7, 14 y 28 días).

(Meininger, 1988), proyecta en la Figura 2-9 la resistencia a la compresión del hormigón permeable según su contenido de vacíos, en donde se puede observar que, a mayor contenido de vacíos, menor es su resistencia y viceversa.

Figura 1: Gráfico de la resistencia a la compresión versus contenido de aire en especímenes de concreto permeable

f) Resistencia a Flexión

Ya con la dosificación final se procedió a realizar 5 vigas (L: 60cm, h: 15cm, b: 15cm) de hormigón a fin de determinar y comprobar su resistencia a la flexión, siguiendo la normativa ASTM C39-17/NTE INEN 1573.

Esto se lo analiza debido a que los pavimentos de hormigón trabajan principalmente a flexión se recomienda que su especificación de resistencia sea acorde con ello, por eso el diseño considera la resistencia del hormigón permeable trabajando a flexión, la cual es conocida también como Módulo de Ruptura (MR) normalmente especificada a los 28 días. Para determinar el módulo de rotura se debe analizar la posición de la falla y de acuerdo a eso se calcula con lo establecido en NTE INEN 2554 (2011).

$$R = \frac{PL}{bd^2} \ (dentro\ del\ tercio\ medio) \quad \text{Ec. (1)}$$

$$R = \frac{3Pa}{bd^2} \ (fuera\ del\ tercio\ medio) \quad \text{Ec. (2)}$$

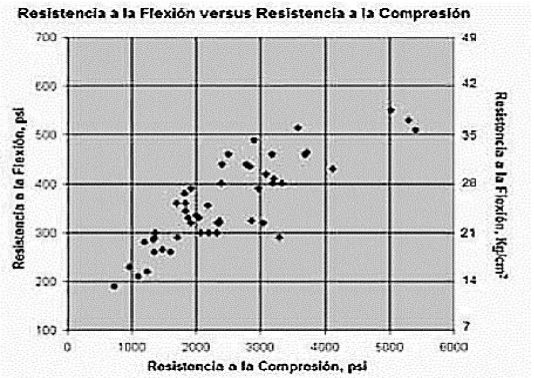

Figura 2: Gráfico de resistencia a la flexión versus resistencia a la compresión

g) Permeabilidad

La capacidad que tiene el hormigón permeable para permitir el paso del agua sin dificultad y sin alterar su estructura. Esta permeabilidad, también es conocida como la percolación. La normativa ACI 522R-10 presenta en la gráfica mostrada en la Figura 2-11 los valores propuestos por (Meininger, 1988), con el fin de poder definir si los resultados obtenidos son coherentes.

Figura 3: Gráfica de percolación versus contenido de vacíos en cilindros

Para el ensayo de permeabilidad se elaboró 3 especímenes por dosificación, debido a la dificultad con la que se ensayan las mismas, el equipo para ensayar y la variación de los diámetros de los cilindros. Estas muestras son ensayadas mediante el permeámetro a la edad de 28 días.

El permeámetro de carga variable, fue fabricado de forma artesanal con acrílico, tuberías PVC y sus respectivos accesorios, siguiendo las indicaciones del comité ACI 522-R10, adoptándolas de manera que se pueda medir la capacidad de filtración que poseen las probetas fabricadas.

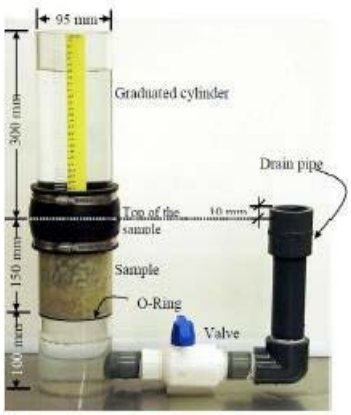

Figura 4: Permeámetro de carga variable

Usando la siguiente fórmula descrita para calcular la permeabilidad de la probeta en mm/s (k), utilizando los aspectos referentes al área del tubo en $mm^2(A_1)$, el área de la probeta en $mm^2(A_2)$, la longitud de la probeta (L), carga de agua en la marca 1 (h_1), carga de agua en la marca 2 (h_2), tomado el tiempo que tarda en bajar desde la primera marca, hasta la segunda (t).

$$k = \frac{A1 * L}{A2 * t} * \log\left(\frac{h2}{h1}\right) \quad \text{Ec. (3)}$$

h) Infiltración

Se lo define como cantidad de agua que pasa a través de la superficie permeable y por lo general este tipo de pruebas se realiza en campo, mientras que la permeabilidad es la velocidad del agua que a traviesa por el hormigón.

El coeficiente de infiltración (CI), el cual es calculado por la Ec.4.

$$CI = \frac{Qentrada}{Qssalida} \quad \text{Ec. (4)}$$

En el Laboratorio Hidráulica de la Universidad Central del Ecuador se procedió a efectuar el ensayo de simulación de precipitación mediante el equipo móvil simulador de lluvias elaborado por (Galarza y Manosalvas, 2018), de manera que se puede simular diversas intensidades de lluvias dentro del laboratorio, con la finalidad de analizar el caudal de agua que pasa por el hormigón permeable y a su vez determinar la cantidad de volumen de agua que se recolectó para diferentes tiempos e intensidades.

En el equipo móvil simulador de lluvia se le adoptó una losa de hormigón permeable de 117 cm largo, 98cm de ancho y 8cm de espesor. Para la fabricación de la losa se utilizó varias palas, un rastrillo y un rodillo, precautelando en todo el momento que no se pierda en exceso la cantidad de agua, por los agentes externos. Una vez fabricada la losa, se procedió a curarla por 28 días, a fin de que este obtenga la resistencia especificada.

Figura 5: Equipo Móvil Simulador de Lluvia (EMSL)

Para calibrar el equipo simulador de lluvias se utilizó diferentes intensidades de precipitación, se tomó aquellas registradas a nivel Nacional dependiendo de la duración de los mismos, en un período de retorno 10 años según la propuesta de (MINVU, 1996), donde se considera este periodo si aguas debajo de la misma no existe una red de drenaje bien desarrollada. Se obtienen las curvas IDF proporcionadas por el INAMHI para el periodo buscado.

Las experimentaciones realizadas entregan relaciones empíricas entre la precipitación, que es el dato de entrada, y la infiltración, que es el dato de salida. (Galarza y Manosalvas, 2018).

Se realizó varios ensayos para diferentes estados de humedad y diferentes intensidades registradas en el Ecuador (Tabla 2), con duración de 5 y 15 minutos, que es el tiempo donde se presenta la intensidad máxima.

Tabla 2: Intensidades máximas registradas por INAMHI-Ecuador

Duración min	Intensidad mm/h	Estación	Nombre
5	123.8	M0024	IÑAQUITO
5	197.4	M0037	MILAGRO - INGENIO
15	81.5	M0024	IÑAQUITO
15	139.8	M0051	BABAHOYO

i) Estructura de Recolección de Agua Lluvia

Lo ideal es que la lluvia se infiltre nuevamente al subsuelo, o esto pueda aprovecharse en espacios de uso peatonal, tales como parques, aceras, canchas, plazas, entre otros. Ayudando con la recarga de acuíferos, reduciendo el encharcamiento y las posibles inundaciones.

Se toma en cuenta que la estructura permeable debe cumplir la función de percolación del agua recolectada hasta un punto de almacenamiento, esta estructura será diseñada a manera de subdrén. (Figura 6).

Figura 6: Esquema de una Estructura Permeable

Los subdrenes de zanja pueden construirse de manera paralela entre ellas, aunque es complejo, presenta una gran efectividad, generando cambios importantes en la estructura de los suelos.

III. Resultados

En un hormigón permeable, se presentan 3 propiedades importantes; la resistencia a compresión simple, la resistencia a flexión y la permeabilidad, cuyos resultados deben ser analizados de manera adecuada, donde se cumpla con una resistencia apta para el uso planteado (peatonal), sin perder su característica propia de permeabilidad para el aprovechamiento el agua lluvia.

a) Resistencia a compresión simple

Los resultados de cada una de las dosificaciones indicadas en la Tabla 3, muestran la facilidad con la que puede cambiar la resistencia a compresión según el tamaño del árido grueso usado, el porcentaje de finos utilizados y la relación a/c que debe ser lo más baja posible para garantizar un buen desempeño del mismo.

El hormigón permeable al ser usado para superficies peatonales se lo considera como un hormigón no estructural y debe cumplir con una resistencia a compresión simple entre un rango de 14 y 18 Mpa, ya que se expone a cargas de tráfico ligero, cuyos valores referenciales están dispuestos por el MOP (2002) en su tabla 801-1.1.

Tabla 3: Resultados a compresión y permeabilidad

Dosificación	Edad	A/C	% Finos	Resistencia A Compresión	Permeabilidad	
	Días	-	-	MPa	mm/s	mm/min
1	28	0.35	20	13.2	3.68	220.77
2	28	0.4	20	11.23	3.47	208.26
3	28	0.35	20	11.73	0.55	32.74
4	28	0.46	20	11.3	1.11	66.67
5	28	0.33	10	14.21	1.43	85.57
6	28	0.33	20	17.47	1.09	65.55

Las primeras dosificaciones (D1 Y D2) corresponden a un solo tamaño nominal (Tamaño 3/8"), asumiendo que al ser una mezcla mal graduada se obtendrá una mayor permeabilidad, sin embargo, en la Tabla 3 se puede observar que la resistencia resultante de estas dosificaciones es menor a la requerida, por lo que se descartan los resultados, esto se debe a que el hormigón necesita una buena graduación para garantizar una adecuada adherencia entre sus componentes.

En cuanto a las dosificaciones D3 y D4, ya se usa una mezcla bien gradada (N° 8), donde se mejora notablemente en su adherencia y trabajabilidad, aumentando así el valor a la resistencia a compresión simple. En la dosificación 5 y 6 se usa la misma mezcla bien graduada y se observa que presentan mayor esfuerzo a compresión simple con resultados de 14.21 MPa y 17.47 MPa respectivamente; mismos que cumplen con el diseño establecido para este tipo de hormigones según su uso planteado (peatonal).

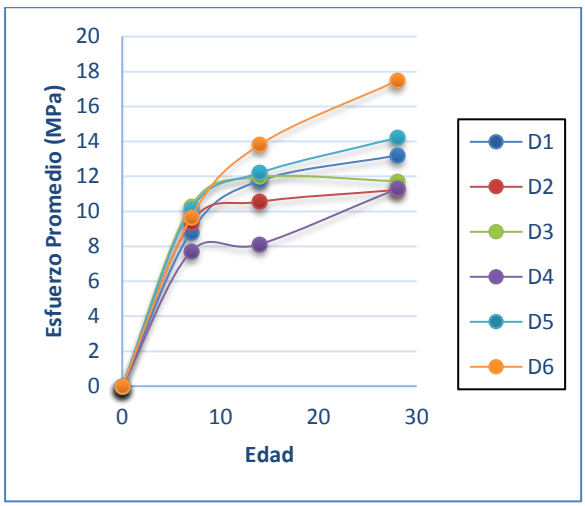

Figura 7: Esfuerzo vs Edad de las 6 mezclas realizadas

En la Figura 7 se puede observar que la evolución de la resistencia de la D6 vs la edad, tiene un aumento progresivo en cuanto a su esfuerzo a compresión, esto se da por una consistencia adecuada, donde a pesar de ser una mezcla seca con asentamiento casi nulo, no presentó ni segregación ni exudación, por lo cual a/c ideal para este tipo de hormigones y las condiciones del lugar resultó ser de 0.33, en donde a menor a/c mayor resistencia se obtuvo, siempre y cuando él % de finos utilizados sea mayor al 10%. También es importante recalcar que el método de compactación influye mucho en su resistencia final.

b) Resistencia a Flexión

La resistencia a la flexión de un hormigón es baja en comparación con su resistencia a la compresión, sin embargo se utiliza para determinar el Módulo de Rotura de diseño para el control de campo y aceptación de pavimentos. En este diseño se obtiene un módulo de rotura de 4.59 Mpa (Tabla 4) que corresponde a un 26.27% de la resistencia a compresión simple de la dosificación 6. Este valor se encuentra superior a los valores presentados en tracción en estudios anteriores, cuyos valores oscilan entre los 1 a 3.8 Mpa.

El resultado final nos proporciona una idea de la resistencia a flexión que tendrá este hormigón, ya que al ser superficies peatonales el hormigón tiende a estar expuesto a los esfuerzos de expansión y retracción, al aumentar o disminuir la temperatura.

Tabla 4: Resultados del ensayo a flexión para la mezcla definitiva

Edad	Base (B)	Altura (D)	Luz (L)	Carga	Módulo De Rotura	
días	cm	cm	cm	kg	kg/cm²	MPa
28	15.00	15.00	55.00	2490	40.58	3.98
	15.00	14.80	55.00	2830	47.37	4.65
	14.80	15.00	55.00	2790	46.08	4.52
PROMEDIO						**4.59**

c) Permeabilidad

Los resultados de la permeabilidad inciden mucho en la velocidad con la que atraviese el agua por la estructura de hormigón. Por la tanto se debe tener una permeabilidad adecuada, donde permita que el agua lluvia fluya por el hormigón pero a su vez que no pierda su característica de resistencia a la compresión.

En la Figura 8 claramente se puede observar que las dos primeras dosificaciones correspondientes a una mala graduación, poseen la mayor permeabilidad por la presencia de sus múltiples vacíos. Sin embargo, la dosificación D1 muestra que tiene mayor permeabilidad, lo cual se debe a que esta mezcla resultó tener una consistencia más seca que la D2, permitiendo al hormigón poseer una mayor cantidad de poros.

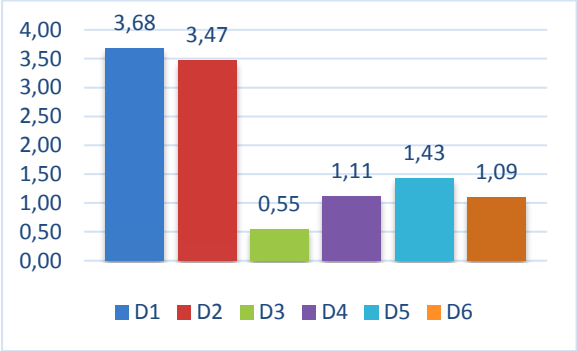

Figura 8: Permeabilidad obtenida (mm/s)

La dosificación D3 posee la menor de las permeabilidades ya que se usó el vibrador mecánico de probetas, donde al vibrar demasiado el cilindro resultó que pierda sus poros o vacíos característico de este tipo de hormigones, por lo que nos muestra que este hormigón debe seguir totalmente los lineamientos del ACI 522, donde menciona que se debe evitar el uso de vibradores, para conseguir que el hormigón tenga las características deseadas.

Las ultimas dosificaciones (D4, D5 y D6) poseen una permeabilidad media en comparación al resto de los resultados, sin embargo se debe tener claro que prevalece el criterio de que un hormigón expuesto al intemperie debe poseer la mayor resistencia que pueda alcanzar, siendo esta vulnerable a la presencia de diversas cargas presentadas diariamente, por tal motivo la dosificación ya establecida para diseño final de un hormigón permeable es la dosificación 6 (D6), por poseer la mayor resistencia y una permeabilidad que se encuentra dentro de un rango medio.

d) Infiltración

La capacidad de este hormigón por metro cuadrado dependiendo de cada una de las intensidades y el estado de humedad se encuentra en la siguiente tabla:

Tabla 5: Caudal captado por cada metro cuadrado, dependiendo de la intensidad de lluvia presentada y su estado de humedad

Duración (min)	Intensidad(mm/h)	Caudal (l/min)
ESTADO SECO		
5	123,800	1,200
5	197,400	2,000
15	81,500	0,867
15	139,800	1,467
ESTADO HÚMEDO		
5	123,800	1,400
5	197,400	2,400
15	81,500	0,933
15	139,800	1,600
ESTADO SATURADO		
5	123,800	1,800
5	197,400	2,500
15	81,500	1,200
16	139,800	1,800

Esto demuestra que el volumen recolectado de agua después de cada ensayo mejora conforme la superficie se encuentre con mayor humedad. Lo mismo se puede comprobar a través del coeficiente de infiltración, los resultados se los presenta en las tablas, 6, 7 y 8.

Tabla 6: Coeficiente de Infiltración para losa seca

Duración	Intensidad	Caudal de Entrada	Caudal de Salida	Coeficiente de Infiltración
min	mm/h	l/min	l/min	
5	123,800	2,404	1,376	0,572
5	197,400	3,732	2,293	0,614
15	81,500	1,569	0,994	0,633
15	139,800	2,644	1,682	0,636
			PROMEDIO	**0,614**

Tabla 7: Coeficiente de Infiltración para losa Húmeda

Duración	Intensidad	Caudal de Entrada	Caudal de Salida	Coeficiente de Infiltración
min	mm/h	l/min	l/min	
5	123,800	2,384	1,605	0,673
5	197,400	3,866	2,752	0,712
15	81,500	1,563	1,070	0,685
15	139,800	2,647	1,835	0,693
			PROMEDIO	**0,691**

Tabla 8: Coeficiente de Infiltración para losa saturada

Duración	Intensidad	Caudal de Entrada	Caudal de Salida	Coeficiente de Infiltración
Min	mm/h	m^3/s	m^3/s	
5	123,800	2,376	2,064	0,869
5	197,400	3,320	2,867	0,863
15	81,500	1,565	1,376	0,879
15	139,800	2,359	2,064	0,875
			PROMEDIO	**0,870**

Los resultados de Infiltración dados, no son comparables con los resultados de permeabilidad Tabla 3, ya que la permeabilidad es la velocidad del agua que, a traviesa por el hormigón, mientras que la infiltración se refiere a la cantidad de agua que pasa a través de la superficie permeable.

e) Estructura de Recolección de Agua Lluvia

La estructura de recolección de agua se encuentra planteada como un sistema compuesto por la losa permeable, el estrato permeable y las tuberías de conducción (tubería perforada). Para este tipo de hormigón el acero de refuerzo se descarta, ya que por el hecho de que ingresa el agua a la estructura, el acero con el pasar del tiempo tiende a correrse.

El hormigón de la losa se encuentra diseñado conforme a sus parámetros de permeabilidad y resistencia a la compresión más aplicable, para este caso se realizó una losa de 8cm y estrato granular de 15cm.

La tubería de conducción debe ser perforada, de tal manera que permita fácilmente, el ingreso del caudal a captar. Para ello se tomó como dato inicial el mayor caudal de salida por ser el más crítico, y se procedió a calcular su diámetro, su N° orificios y a su vez determinar el rango de aceptación de velocidad máxima y mínima, para evitar erosión y sedimentación respectivamente. Sus resultados se presentan en la Tabla 9:

Tabla 9: Diámetro de la Tubería de Conducción de Flujo

Estado de Huemdad	Duración min	Intensidad mm/h	Caudal de Salida l/min	Diámetro mm	Velocidad de Flujo	Rango de Aceptación 5 m/s - 0.3 m/s		No. Orificios
						MÁXIMO	MÍNIMO	
Saturado	5	123.8	2.867	21.929	m/s			
Comercial:				50	0.33	OK	OK	10

f) Análisis económico

A manera de tener una idea del ahorro del agua potable que se tendría si se usa el agua lluvia recolectada para usos donde no se requiere consumo directo humano, como es en la descarga de los inodoros, en el riego de jardines, en el lavado de pisos, para el control de polvo, entre otros, se realiza un análisis típico de consumo y pago mensual (Tabla 10) de una familia típica compuesta por 4 personas, equivalente al 20.4% de la población.

Tabla 10: Consumo típico para una familia de 4 personas

CONSUMO	ÍTEM	L/hab.d	SUMA	CONSUMO MENSUAL EN LITROS	CONSUMO MENSUAL M3	PAGO MENSUAL
DOMÉSTICO	Aseo personal	40	150.0	18000.0	18.000	7.74
	Descarga de sanitarios	35				
	Lavado de ropa	10				
	Cocina	10				
	Riego Jardines	40				
	Lavado de pisos	5				
	Control de Polvo	10				

La Tabla 11, en cambio es similar a la anterior, pero muestra el consumo y pago mensual si ya no se utilizaría el agua potable para usos donde no es necesaria la misma, por ello se observa el valor nulo en los ítems proporcionados en la siguiente tabla:

Tabla 11: Consumo proyectado para una familia de 4 personas (20.4% población)

CONSUMO	ÍTEM	L/hab.d	SUMA	CONSUMO MENSUAL EN LITROS	CONSUMO MENSUAL M3	PAGO MENSUAL
DOMÉSTICO	Aseo personal	40	60.0	7200.0	7.2	3.10
	Descarga de sanitarios	0				
	Lavado de ropa	10				
	Cocina	10				
	Riego Jardines	0				
	Lavado de pisos	0				
	Control de Polvo	0				

Con este análisis rápido del consumo mensual del agua potable, se puede tener un estimado del ahorro que se tendría en la tarifa mensual de la planilla del Agua potable (Tabla 11), si se utilizaría este tipo de hormigón en las superficies peatonales donde permita la recolección de agua lluvia.

Cabe recalcar que el valor presentado en la Tabla 12, correspondiente al pago mensual, solo corresponde al consumo, mas no a la implementación de toda la estructura en sí, ya que para ello se debe tener en cuenta, el tanque recolector y un cierto tipo de bombeo.

Tabla 12: Ahorro proyectado para una familia de 4 personas

TIPO DE CONSUMO PERSONAL	CONSUMO MENSUAL L/fam	PAGO MENSUAL L/fam	CONSUMO ANUAL L/fam	PAGO ANUAL L/fam
DOMÉSTICO COMÚN	18000.00	$ 7.74	216000	$ 92.88
DOMÉSTICO PROYECTADO	7200.00	$ 2.52	86400	$ 30.24
AHORRO	**10800.00**	**$ 5.22**	**129600**	**$ 62.64**

IV. Conclusiones

Las investigaciones en el campo del hormigón permeable son diversas, sin embargo, se ha encontrado pocos estudios como alternativa de recolección y aprovechamiento de agua lluvia, siendo esto novedoso en Ecuador, donde se puede optimizar el recurso agua si se diseña un tanque recolector bajo

la misma y a si utilizar el agua recolectada en usos no doméstico, ahorrando de cierta manera el agua potable, misma que genera una reducción económica de $5.22 en su tarifa de consumo mensual.

La relación agua – cemento, el porcentaje de finos y el contenido de cemento son parámetros que inciden en la resistencia final del hormigón, así como también una correcta manipulación al momento de elaborarlo, dado que la homogeneidad que debe presentar este tipo de hormigones debe ser suficiente para generar una correcta adherencia.

A través del modelo EMSL, se puede ensayar la intensidad más alta que posee el Ecuador de acuerdo a los registros del INAMHI, se observa que el hormigón permeable se comporta de manera satisfactoria, permitiendo ingresar un caudal de 2 litros/minuto por cada metro cuadrado de losa existente, contando esto solamente en estado seco. Mientras que en estado húmedo le corresponde un caudal de 2.4 litros/minuto y 2.84 litros/minuto para una losa saturada. Demostrando la capacidad que a mayor saturación de la losa, mayor caudal ingresa.

Al simular la lluvia en diferentes estados de humedad, se observa el comportamiento del hormigón permeable, es por eso que cuando la losa se encuentra en estado seco, se va verificando cómo cada una de las gotas de agua comienzan a humedecer la losa de hormigón, misma que permite su paso hasta un 61% del agua que ingresa; cuando esta se encuentra húmeda, permite hasta un 69% de paso de agua, y un 87% cuando se encuentra más humedecida, permitiendo así observar que el caudal que pasa por la losa aumenta a medida que esta se humedece, debido a que mientras más se humedecen las partículas pertenecientes al hormigón, la estructura comienza a funcionar como sumidero, ya que permite el paso libre de las partículas de agua.

En el equipo móvil simulador de lluvia se pudo apreciar que la precipitación no pudo saturar por completo a la losa, ya que debajo de esta no se encuentra una capa de suelo, de manera que el movimiento del agua va a ser continúo actuando a manera de sumidero, descartando la posibilidad de una medición de la escorrentía superficial.

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The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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