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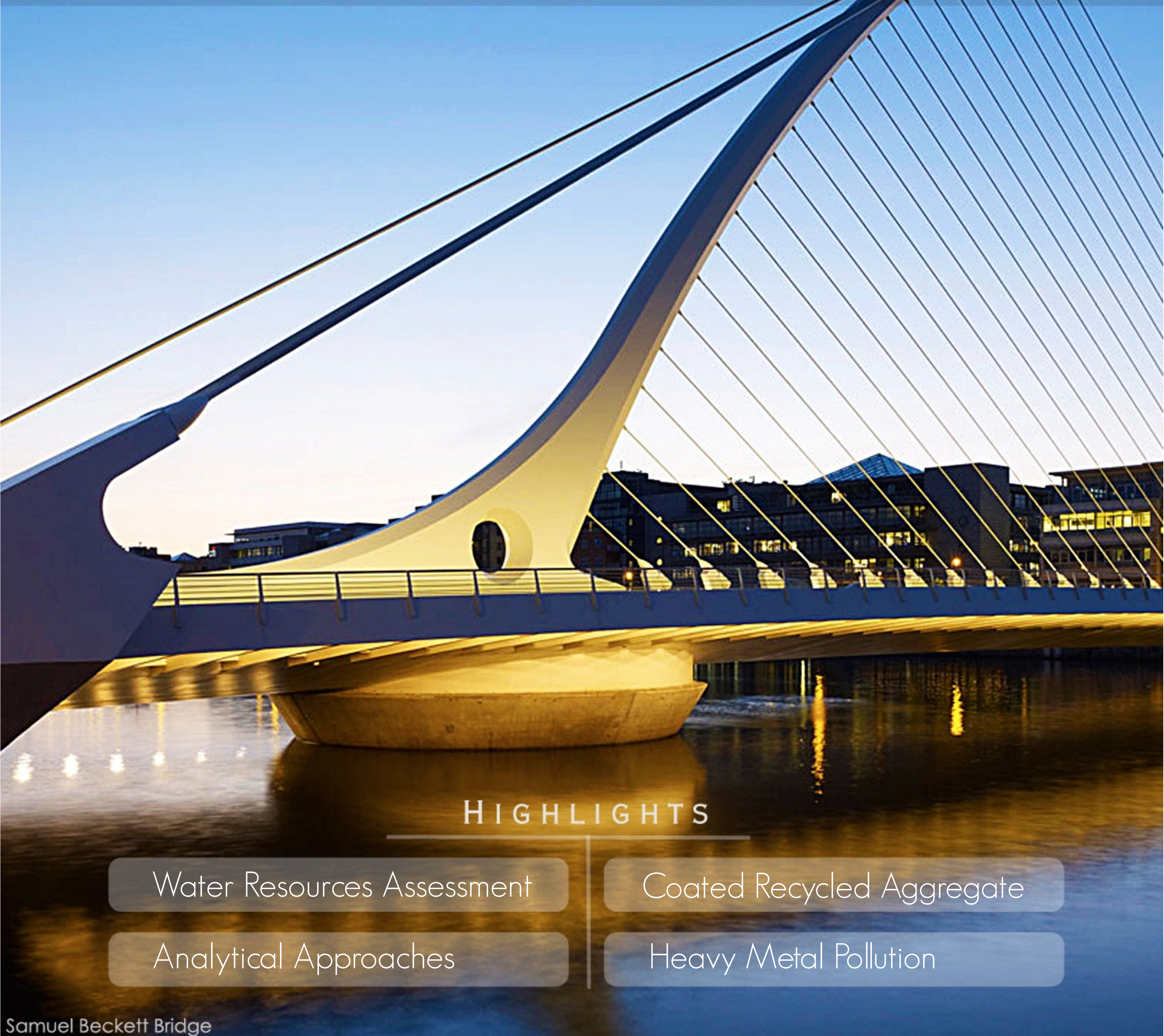

Samuel Beckett Bridge

Highlights

- Water Resources Assessment
- Coated Recycled Aggregate
- Analytical Approaches
- Heavy Metal Pollution

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Assessment of The Heavy Metal Pollution in The Sediment Samples of Major Canals in Dhaka City by Multivariate Statistical Analysis

By Provat K. Saha & Md. Delwar Hossain
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Abstract - In this study, the levels of selected metals (Cd, Cr, Cu, Mn, Fe and Pb) concentrations were measured by Flame Emission Atomic Absorption Spectrophotometer (FL-AAS) in sediment (sludge) samples collected from 10 different Canals in and around the Dhaka City Corporation (DCC) area of Bangladesh. The analysis result shows that Cr, Cu and Pb were present as major pollutants in the some canals in the DCC area with high concentration levels, while Cd, Mn and Fe emerged as minor pollutants. Principal Component Analysis (PCA) and Cluster analysis were used to assess the metal contamination in the canals. Positive correlations were found between Mn–Fe ($r = 0.860$), Pb–Cu ($r = 0.786$), Pb–Cd ($r = 0.398$) and Cu-Cd ($r = 0.227$) pairs. The present metal concentration in the canal sediments data shows that Cr, Pb and Pb levels are higher than recommended sediment quality guideline by USEPA but pollutants concentrations in the sludge are below the prescribed hazard limit provided by USEPA for land application of sludge.

Keywords : Canals, sludge, heavy metal, Principal component analysis, Cluster analysis.

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Assessment of The Heavy Metal Pollution in The Sediment Samples of Major Canals in Dhaka City by Multivariate Statistical Analysis

Provat K. Saha [α] & Md. Delwar Hossain [σ]

Abstract - In this study, the levels of selected metals (Cd, Cr, Cu, Mn, Fe and Pb) concentrations were measured by Flame Emission Atomic Absorption Spectrophotometer (FL-AAS) in sediment (sludge) samples collected from 10 different Canals in and around the Dhaka City Corporation (DCC) area of Bangladesh. The analysis result shows that Cr, Cu and Pb were present as major pollutants in the some canals in the DCC area with high concentration levels, while Cd, Mn and Fe emerged as minor pollutants. Principal Component Analysis (PCA) and Cluster analysis were used to assess the metal contamination in the canals. Positive correlations were found between Mn–Fe ($r = 0.860$), Pb–Cu ($r = 0.786$), Pb–Cd ($r = 0.398$) and Cu-Cd ($r = 0.227$) pairs. The present metal concentration in the canal sediments data shows that Cr, Pb and Pb levels are higher than recommended sediment quality guideline by USEPA but pollutants concentrations in the sludge are below the prescribed hazard limit provided by USEPA for land application of sludge.

Keywords : Canals, sludge, heavy metal, Principal component analysis, Cluster analysis

I. Introduction

In the current decades the heavy metal accumulation in the soils is a growing concern due to its potential health risks as well as its detrimental effects on soil ecosystems (McLaughlin et al., 1999; Qishlaqi & Moore, 2007). Heavy metals have characteristics including that they are non-biodegradable (Facchinelli et al. 2001) and they can be necessary or beneficial to plants at certain levels, but can be toxic when exceeding specific thresholds (Qishlaqi & Moore, 2007; Bilos et al., 2001) Sources of these elements in soils mainly include natural occurrence derived from parent materials and anthropogenic activities. Anthropogenic inputs are associated with industrialization and agricultural activates, deposition, such as atmospheric deposition, waste disposal, waste incineration, emissions from traffic, fertilizer application and long-term application of wastewater in agricultural land (Qishlaqi & Moore, 2007; Bilos et al., 2001; McLaughlin et al., 2001; Koch et al., 2001).

For the present day's environmental researchers, knowledge of the heavy metal accumulation in soil, the potential source of heavy metals and their possible interactions with soil are one of the prime focuses. Different statistical analysis tools can provide such knowledge and can be very helpful for the interpretation of environmental data (Tuncer et al., 1993; Sena et al., 2002; Einax et. al 1999). In recent times, the statistical methods (univariate or multivariate) have been applied widely to investigate heavy metal concentration, accumulation and distribution in soils. (Vega et al. 1998; Wunderlin et al., 2001; Grande et al., 2003; Simeonov et al., 2003; Pekey et al., 2004; Singh et al., 2004; Astel et al., 2006; Kowalkowski et al., 2006; Shrestha & Kazama, 2007 Salman et al., 1999).

Once, Dhaka City, the capital of Bangladesh had excellent natural drainage system even 40 years ago. The city was interlaced with numerous natural channels/canals and wetlands. It is estimated that there were up to 45 natural drainage canals that span the city. In the course of rapid expansion of the city, most of the natural drainage canals as well as wetlands has been intervened and destroyed. Now only few canals exist but these have become contaminated wetland because of disposal of solid waste, toxic industrial waste which are the potential sources of heavy metal pollution (Subramanian, 2004; Karn & Harada, 2001). Now even after a medium size rainfall, the streets of the city get flooded for hours at a time because water has no way to drain out easily. Although some drainage structures have been built over the last two decades, they are woefully inadequate. In addition, due to haphazard design and construction of these drainage structures and lack of proper maintenance, over the years these have lost their carrying capacity due to severe clogging. The effects of water logging causes serious suffering of the city dwellers as well as damage the roads and thereby increasing the road maintenance cost. On the other hand, water supply and sanitation infrastructures have been being become ineffective due to unwanted water logging in the city. There is thus an immediate need for rehabilitation and development of the natural

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drainage network and find ways to properly operate and maintain the already constructed drainage structures, such as box culverts and drain lines. For the restoration of these canals in Dhaka city, it is very important to explore the current pollution status of the sludge deposited at the bottom of canals over the year. The present study stems from the above concerns, with the primary focus on the current status of distribution of some selected toxic metals in the sludge sample collected from 10 major canals in the Dhaka city Corporation (DCC) area by multivariate statistical analysis.

II. Major Canals in Dcc Area and Their Present Conditions

The major canals (Khals) are located in the various part of the city and their other particulars are shown in the Table 1.

Table 1 : Major canals in the DCC area

Serial No.	Canal's Name	Location	Length (Km)
1	Kalyanpur main khal	Western part of the city	3
2	Kalyanpur branch khal - Ka	Western part of the city	1.5
3	Kalyanpur branch khal - Kha	Western part of the city	2.4
4	Kalyanpur branch khal - Gha	Western part of the city	1.56
5	Kalyanpur branch Khal - Umo	Western part of the city	1.78
6	Kalyanpur branch Khal - Cha	Western part of the city	0.98
7	Baunia Khal	North western part	8.8
8	Digun Khal	North eastern part	4.5
9	Mohakhali Khal	Central city	2.3
10	Hazaribagh Khal	South-western part.	0.7
11	Shegunbagicha khal	Central-eastern part	1.0
12	Manda khal	Central-eastern part	1.0
13	Shangbadik Colony	North western part	1.0
14	Section 2 to Digun Canal through Section 6 and Rupnagar	North western part	3.5
15	Mirpur Housing Canal	North western part	1.0
16	Kashaibari - Boalia to Balu river	North eastern part	3.0
17	Gerani khal	Central-eastern part	5.0

Source : Study of storm water drainage system by JICA in 1990

From our field survey, it was found that illegal encroachment and nearby pollution activities are the major concerns to maintain the natural conditions in most of the canals in Dhaka city. A variety of small industries are building up near the bank of the canals. Various Residential plots are now under construction on the different parts of the canals. The water of the canals water gets polluted and become blackish with lots of waste including construction debris, vegetations, chemical waste, polythene sheets and as a result there is partial drainage blocking. Some photographs, which were taken during our field survey, are presented in Fig. 1

(a) *Northern part of Kayallanpur Main khal (canal) beside ACME*

(b) Kayallanpur '*Ka' khal(canal) near Bosupara*

(c) *End point of Shegunbagicha khal (canal)before the Kadamtala bridge*

(d) *Mirpur Housing khal (canal)*

(e) *Hazaribagh khal (canal) beside the Leather Technology College*

(f) Mohakhali *khal (canal) near Mohakhali rail crossing*

Fig. 1 : Photographs of some canals in and around the Dhaka city depicting the current pollution scenario

III. Materials and Methods

For the present study, sediment (sludge) samples were collected from 10 canals (name of the canal mentioned in Table 2) on the months of March and April, 2011 and samples were analyzed for the metals, Cd, Cr, Cu, Mn, Fe and Pb. Above mentioned metals concentration in the collected sludge samples were determined by total extraction with Aqua-Regia. The extracted aqueous solution was analyzed for Cd, Cr, Cu, Mn, Fe and Pb by using Flame Emission Atomic Absorption Spectrophotometer (FL-AAS, Model:

Shimadzu, Japan, AA6800). Standard QA/QC protocol was followed throughout, including replicate analysis (1 in every 5 samples), checking of method blanks (1 in every 10 analysis) and standards (1 in every 10 analysis). The estimated metal levels were compared with the permissible safe levels for the sediment sample proposed by USEPA. Multivariate statistical techniques (Lin et al. 2002; Facchinelli et al. 2001; Nolte 1988; Tahri et al. 2005; Yeung 1999; Lin et al. 2004; Sandhu et al. 1976) were adopted to assess the metal contamination in the sludge. For this purpose, the well founded techniques of Pearson correlation analysis, Principal Component Analysis (PCA), and Cluster Analysis (CA) were jointly used, the first affording a direct measure of interdependence of the set of variables under investigation while the latter two provides the visual grouping of the data to help understand the interrelated metal clusters produced (Hopke 1992). SPSS software (Version 16.0) was used to perform the multivariate statistical analyses.

IV. Results and Discussion

The Sludge samples analysis results for different heavy metals are presented in *Table 2*. The comparison between the metals concentration present in the sludge samples of DCC canals with permissible metal concentration limit proposed by USEPA for the sediment sample shows that some canals in DCC area are facing heavy metal pollution.

Table 2 : Present Status of the heavy metals concentration in sludge samples collected from 10 different canals of Dhaka city area

Sl. No.	Canal's name and (sampling location)	Heavy metals concentration (mg/kg)					
		Cd	Cr	Cu	Mn	Pb	Fe
1.	Hazaribagh Khal (Sikder Medical)	0.25	61.8	3.8	0.72	1.9	0.11
2.	Kalyanpur 'Kha' khal (Navana CNG pump)	BDL	70.6	6.6	1.60	11.1	0.22
3.	Kalyanpur main khal (Darussalam)	0.06	48.6	2.8	0.63	0.1	0.09
4.	Section-2 Digun khal (Rupnagar)	0.13	45.2	2.6	0.67	0.2	0.08
5.	Baunia khal (Section-13)	0.18	**116.8**	5.4	0.51	0.1	0.08
6.	Kalyanpur Shakha 'Gha" (Shewrapara)	BDL	**191.2**	6.2	0.79	2.7	0.06
7.	Mohakhali Khal (Near Bus Stand)	0.38	72.4	**116.4**	0.62	51.1	0.15
8.	Mirpur Housing Khal (Mirpur-10)	0.15	48.8	**187.4**	0.23	**69.1**	0.07
9.	Segunbagicha Khal (Kamalapur Stadium)	0.02	**78.6**	**165.8**	1.51	24.9	0.22
10.	Jirani Khal (Kadamtola)	0.19	**75.4**	**303.8**	0.66	37.3	0.06
	EPA guideline for sediments (mg/kg)						
	Not Polluted	….	<25	<25	<300	<40	….
	Moderately Polluted	….	25-75	25-50	300-500	40-60	….
	Heavily Polluted	**>6**	**>75**	**>50**	**>500**	**>60**	….
	EPA limit for land application of sludge (mg/kg)						
		85	….	4300	….	840	….

Note: *BDL- Below Detection Limit*

According to USEPA guideline, the sludge samples of Mohakhali Khal, Mirpur Housing Khal, Segunbagicha Khal, Jirani Khal are heavily polluted with Cu. Baunia Khal, Kalyanpur Shakha 'Gha" (Shewrapara), Segunbagicha Khal, Jirani Khal are heavily polluted with Cr. Pollution level of Pb in Mirpur Housing Khal is also exceed the USEPA heavily polluted criteria. Pollution level of Hazaribagh Khal, Kalyanpur "Kha" Khal , Kalyanpur main Khal ,Digun Khal are comparatively low for all tested heavy metals except Cr. By reviewing the pollutant limits of USEPA against the result from sludge samples analysis, it can be easily stated the pollutants concentration in the sludge of the selected canals are below the prescribed hazard limit for land application but some canals exceed the EPA guideline for heavily polluted sediments for some metal.

Before forming a judgment on the observed distribution of metal levels and interrelationship among them, the metal data was first examined on the basis of linear correlation between metal pairs in terms of significant positive correlation coefficient. Strong positive correlations were observed for Mn – Fe (r = 0.860), Pb – Cu (r = 0.786), Pb – Cd (r = 0.398) and Cu - Cd (r = 0.227) pairs (Correlation matrix is shown in *Table 3*), indicating the existence of a common source/origin of these metals in the sludge sample.

Table 3 : Correlation matrix between different heavy metal pairs

	Cd	Cr	Cu	Mn	Fe	Pb
Cd	1.000					
Cr	-0.292	1.000				
Cu	**0.227**	-0.200	1.000			
Mn	-0.547	0.064	-0.109	1.000		
Fe	-0.207	-0.206	-0.048	**0.860**	1.000	
Pb	**0.398**	-0.282	**0.768**	-0.273	0.031	1.000

Further confirmation of this hypothesis of 'different heavy metals may have common origin' was secured through multivariate methods of statistical analysis (Hair et al. 1988). In this study, two multivariate techniques were applied: Principal Component Analysis (PCA) and Cluster Analysis (CA). The PCA has emerged as a useful tool for better understanding the relationships among the variables (e.g., metal concentrations in this study) and for revealing groups (or clusters) that are mutually correlated within a data body (Qishlaqi & Moore, 2007). This procedure reduces overall dimensionality of the linearly correlated data by using a smaller number of new independent variables, called principal components (PC), each of which is a linear combination of originally correlated variables. On the other hand, Cluster Analysis (CA) exclusively classifies a set of observations into two or more unknown groups based on combination of internal variables. Therefore, the purpose of CA is to discover a system of organized observations where a number of groups/variables share properties in common, and it is cognitively easier to predict mutual properties based on an overall group membership (Everitt 1993; Jolliffe 1986). This helps define source profiles of variables, such as metal concentrations, and their interpretation in terms of possible sources (Jobson 1991).

Principal Component Analysis (PCA) using Varimax normalized rotation was conducted for common source identification. The variables are correlated with two principal components in which 70.3% of the total variance in the data was found. The rotated Principal Component Loadings are given in *Table 4*. Principle component plot in a rotated space is shown in Fig. 2. The first component with 40.92% of variance comprises Pb, Cu (bold figures in Table 4) with high loadings. This association strongly suggests that these variables have a strong interrelationship. The second component (PC2) contributes Mn and Fe at 29.40 % variance, which also infers the strong correlation between this metal pair. The corresponding cluster analysis Dendrogram is shown in Fig. 3. From the cluster analysis result it can be said that there is a strong correlation between Fe-Mn metal pair, which is a good agreement with PC2, but cluster analysis results did not show a good agreement between Cu-Pb pair. This result suggests that the strong relationship between Cu-Pb pair does not confirm.

Table 4 : Rotated Principal Matrix

(Rotation Method: Varimax with Kaiser Normalization)

	Component	
	PC1	PC2
Cd	0.511	-0.525
Cr	-0.585	-0.113
Cu	**0.812**	-0.066
Mn	-0.140	**0.968**
Fe	0.184	**0.927**
Pb	**0.890**	-0.140

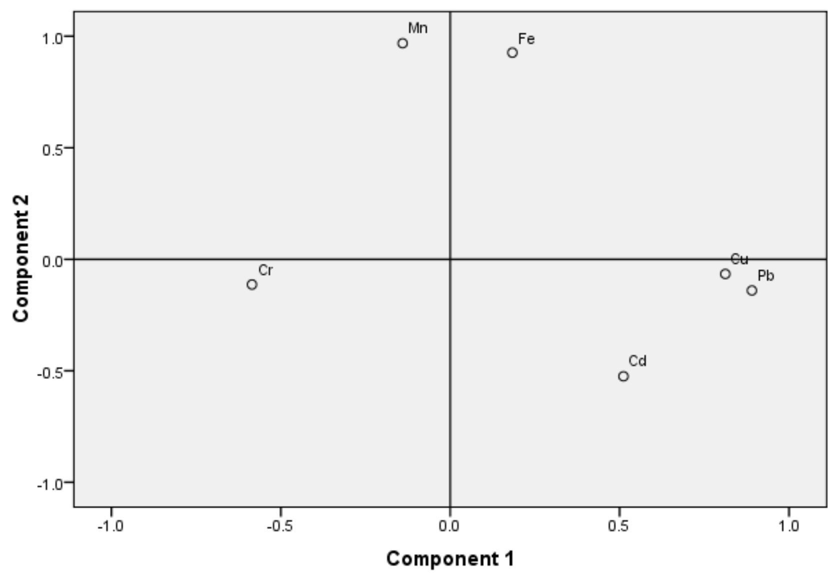

Fig. 2 : Principal component plot in a rotated space

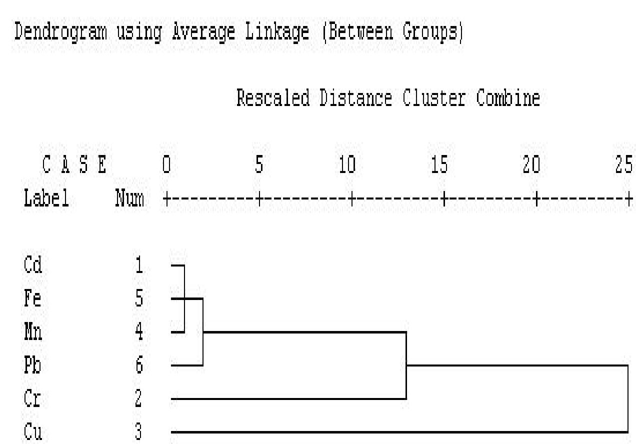

Fig. 3 : Dendrogram of Cluster Analysis

V. Conclusions

The present study showed that Cr, Cu and Pb were present as major pollutants in the some canals in the DCC area with high concentration levels, while Cd, Mn and Fe emerged as minor pollutants. Strong positive linear correlations were found between Mn, Cu and Pb from linear regression analysis. Principal component analysis summarizes (reduces) the data set into two major components representing the different interrelationship among the elements. Strong interrelation between Cu - Pb pair and Mn - Fe pair was found from principle component analysis. Corresponding cluster analysis result confirms the relationship between Mn - Fe metal pair but, does not confirm the strong interrelationship between the Cu – Pb metal pair. Comparison with USEPA guideline for sediment showed that Cr, Pb and Cu levels are in far excess of the recommended safe limits for some canals but pollutants concentration in the sludge are below the prescribed hazard limit for land application of sludge.

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Durability-Based Optimization of Reinforced Concrete Reservoirs Using Artificial Bee Colony Algorithm

By Saeed KIA & Mohammad Reza Ghasemi

University of Sistan and Baluchestan, IRAN

Abstract - Optimization techniques play an important role in structural design, the very purpose of which is to find the best ways so that a designer or a decision maker can derive a maximum benefit from the available resources. This paper describes a new reinforced concrete reservoirs optimization with artificial bee colony algorithm base on durable structure for three major filed as theoretical, practical, and using prismatic stiffeners in shell elements of structure according to the modeling and design philosophy. In this research, firstly, the elements of RCR shells are typed according to the performed analysis; then the range of membrane thickness and the minimum and maximum cross section of consumed bar are determined on the maximum stress. In next phase, based on RCR analysis and using the algorithm of PARIS connector, the related information are combined with the code for ABC algorithm to determine the optimum thickness of cross sections for RCR membrane elements and the optimum cross section of consumed bars.

Keywords : Artificial Bee Colony, Durability, Optimization, Reinforced Concrete Reservoirs.

GJRE-E Classification : FOR Code: 090503

DURABILITY-BASED OPTIMIZATION OF REINFORCEDCONCRETE RESERVOIRS USING ARTIFICIAL BEE COLONYALGORITHM

Strictly as per the compliance and regulations of:

Durability-Based Optimization of Reinforced Concrete Reservoirs Using Artificial Bee Colony Algorithm

Saeed KIA[α] & Mohammad Reza Ghasemi[σ]

Abstract - Optimization techniques play an important role in structural design, the very purpose of which is to find the best ways so that a designer or a decision maker can derive a maximum benefit from the available resources. This paper describes a new reinforced concrete reservoirs optimization with artificial bee colony algorithm base on durable structure for three major filed as theoretical, practical, and using prismatic stiffeners in shell elements of structure according to the modeling and design philosophy. In this research, firstly, the elements of RCR shells are typed according to the performed analysis; then the range of membrane thickness and the minimum and maximum cross section of consumed bar are determined on the maximum stress. In next phase, based on RCR analysis and using the algorithm of PARIS connector, the related information are combined with the code for ABC algorithm to determine the optimum thickness of cross sections for RCR membrane elements and the optimum cross section of consumed bars. Based on very complex mathematical linear models for correct embedding and angles related to a chain of peripheral strengthening membranes, which optimize the structure vibrational, a mutual relation is selected between the modeling software and code for ABC algorithm. Finally, the comparative weight of RCR optimized by peripheral strengthening membrane is analyzed by traditional type. This analysis shows 19% decrease for steel bar weight, 20% decrease for mass concrete weight and minimum 13% saving for construction costs according to price analysis for a RCR at 20,000 m^3.

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I. Introduction

The main requirements for an efficient RCR design is that the response of the structure should be acceptable as per various specifications, i.e., it should at least be a feasible design. There can be large number of feasible designs, but it is desirable to choose the best from these several designs. The best design could be in terms of minimum cost, minimum weight, maximum durability or maximum performance or a combination of these. Many of the methods give rise to local minimum/maximum. Most of the methods, in general give rise to local minimum. This, however, depends on the mathematical nature of the objective function and the constraints. In nature everything which made is optimize for its global and local condition and in this research base on using natural algorithm such as ABC in traditional RCR it will develop its durability and performance during service loads. Nowadays, the use of reinforced concrete structures (RCR) In order to save water or other aqueous liquids has greatly expanded. In this regard, an appropriate design and exact implementation is of particular importance to build structures with high quality and economic efficiency defined in Lloyd and Doyle (1978). Any structure that is designed to hold liquids should possess stability, resistance and sufficient strength against deformation and cracking. The designing and simulation should be in a manner that liquid cannot penetrate or infiltrate the concrete structures which discuss by Mohaghegh (2011). In the typical structures, main aspect of design is structural stability and resistance against loads. But in designing of the liquid holding tanks, the structure should be resistant to penetration and leakage In addition to structural stability and structural strength. Thus, concrete cover for bars should be considered in these structures. So, designing the liquid holding structures is more sensitive than conventional structures such as seismic analysis and penetration in the study of Chen and Kianoush (2009).

In the past, designing the concrete structures has been done based on elastic theory that control of maximum tension under loads is foundation of this theory. The blue liquid holding structures designing has been done to the authorized amounts based on elastic relations and with limited material stresses, despite the low tension the fracture has not left much of the structure. For this reason, in designing structures, thick sections of concrete with a large amount of steel are used. In that time, analyzing of possibility of thermal cracking and cracking due to concrete drop was not performed based on acceptable bases. Also only a nominal amount of steel was mentioned in the regulations. In recent years, limit state which was on more rational basis was introduced to determine the safety factors. In this method, in designing structure, loads coefficients have been used with the ultimate

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strength of materials. In order to calculate the flexural crack width and compare it with maximum allowable amount, developed analytical methods are used. In addition to that, methods of calculating the effects of thermal strains and strain caused by the loss of drying concrete have been considered. By the mentioned advances the limit state method has been used to design the blue liquid holding structures. Through designing method of limit states gives conceivability of identification and evaluation of possible failure modes of structures to the designers as premature rupture of structures can be avoided which during times these problem change and research by Ziari and Kianoush (2009) as investigation of flexural cracking and leakage in RCR.

In this study, regarding structure of the concrete reservoirs uniformity and amount of discharge of input water which is from 1000 to 30,000 m^3, at first a reservoir has been selected with an input discharge amount of 20,000 m^3 according to maximum design conditions in the country. According to the conducted analysis and based on discussed assumptions, a range of thickness of the shell elements and used bars has been determined according to maximum tension in the structure. Then by PARIS (Parameter Identification System) algorithm which developed benchmark modeling by Sanayei et all (2007) means connecting computational software with finite element method. Written code of Matlab software for optimizing particle significance of modeling error provided by Sanayei et all (2001) has been selected to achieve optimal levels in a bilateral relationship. At the end, for using the confirmatory sheath surrounding, each optimized parameters are evaluated again regarding to the relevant provisions in analysis process that their orientation be clear.

II. Discrete Reinforced Concrete Reservoirs Optimization

Reinforced concrete reservoirs as many problems in engineering have multiple solutions and selecting the appropriate one can be a major task. In discrete RCR shape optimization, the major task is to select an optimal cross-section of the elements and shells from a permissible list of standard sections that minimize the weight of the structure while satisfying the design constraints. The constraint form of the optimization problem can be expressed as:

$$\text{Minimize} \quad W(A) = \sum_{j=1}^{m} \sum_{i=1}^{n} A_{i_j} L_{i_j} \rho_{i_j} \qquad (1)$$

Subjected to the stress, displacement and buckling constraints. In equation (1), because of heterogeneous of structure, i will represent number of materials such as steel and concrete and j will represent number of shells and elements which A_{i_j}, L_{i_j}, and ρ_{i_j} are the cross-sectional area, length and unit weight of i - th RCR member, respectively; *W (A)* is the weight of RCR which is minimized; *n* is the total number of members. In RCR discrete optimization problems, the $\vec{X}$ represents the ready element section vector selected from permissible profile list. The list *Z* includes all available discrete values arranged in ascending sequences and can be expressed as follows:

$$Z = \{X_1, X_2, ..., X_j, ..., X_p\}, \qquad 1 \le j \le p \qquad (2)$$

Where the letter *p* is the number of available sections subjected to the following normalized constraints:

$$s_{m,z}(\vec{A}) = \frac{\sigma_{m,z}}{\sigma_{m,allowed}} - 1 \le 0, \qquad m = 1, 2, ..., n \qquad (3)$$

$$b_{m,z}(\vec{A}) = \frac{\lambda_{m,z}}{\lambda_{m,allowed}} - 1 \le 0, \qquad m = 1, 2, ..., n \qquad (4)$$

$$d_{k,z}(\vec{A}) = \frac{u_{k,z}}{u_{k,allowed}} - 1 \le 0, \qquad k = 1, 2, ..., n_n \qquad (5)$$

where $s_{m,z}$, $b_{m,z}$ and $d_{k,z}$ are respectively, the stress, element buckling and nodal displacement constraint functions; $\sigma_{m,z}$ and $\lambda_{m,z}$ are the stress and the slenderness ratio of m - th member due to the loading condition *z*; $\sigma_{m,allowed}$ and $\lambda_{m,allowed}$ are the allowable axial stress and allowable slenderness ration for m -th member, respectively; $u_{k,allowed}$ and $u_{k,z}$ are allowable displacement and nodal displacement of k -th degrees of freedom due to the loading condition z, respectively; n_n is the number of restricted displacements. All the normalized constraint functions are activated when the violated constraints have values larger than zero.

III. Artificial Bee Colony Algorithm (ABC)

Artificial Bee Colony (ABC) algorithm is a new meta-heuristic population based swarm intelligence algorithm developed by Karaboga (2007). The ABC algorithm consists in a set of possible solutions *xi* (the population) represented by the positions of food sources where the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. The ABC algorithm is to assign artificial bees to investigate the search space searching the feasible solutions. These artificial bees collaborate and exchange information so that bees concentrate on more promising solutions in terms of certain evaluation criteria. The ABC algorithm basically uses three types of bees in the colony: (i) employed bees, (ii) onlooker bees and (iii) scout bees. While employed bees are chosen from half of the colony at the beginning, the other half is assigned as onlookers who employed bees' searches a new food source neighboring to its current food source by using equation (6), and then computes the amount of nectar of the new food source.

$$v_{ij} = x_{ij} + \theta_{ij}(x_{ij} - x_{kj}) \qquad (6)$$

Where v_i is a candidate solution, x_i is the current solution, x_k is a neighbor solution and θ is a random number between [-1, 1] that controls the production of neighbor food sources around x_{ij}. An onlooker bee analyzes the nectar information and selects a food source in terms of a probability related to the nectar amount of the sources, computed by equation (7). These empirical probabilities enable a roulette wheel selection which produces better solution candidates to have a greater chance of being selected.

$$p_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_n} \qquad (7)$$

In equation (7) fit_i is the fitness value of solution i; which is proportional to the nectar amount of the food source at position i; and *SN* is the number of food sources, which is equal to the number of employed bees. The scout bee generates a new random solution by equation (8). Assume that x_i is the abandoned source and $j \in \{1, 2, ..., D\}$ where D is the dimensionality of the solution vector, the scout discovers a new food source which will be replaced with x_i where j is determined randomly, to be different from i:

$$x_i^j = x_{\min}^j + rand(0,1)(x_{\max}^j - x_{\min}^j) \qquad (8)$$

There are three control parameters in the ABC algorithm: (i) the number of food sources which is equal to the number of employed and also onlooker bees *(SN)*, (ii) the limit parameter, and (iii) the maximum cycle number. Algorithm and flow chart which use in this optimization show in Fig. 2 which relates structural analysis with ABC algorithm by PARIS link. ABC algorithm uses populations like hereditary algorithm, which seeks the problem space to best point. Therefore, for each particle, velocity scale and its direction with the other one will be different. At the time of relocation, the obtained velocity multiplies inertia, then pluses to the present space of the particle.

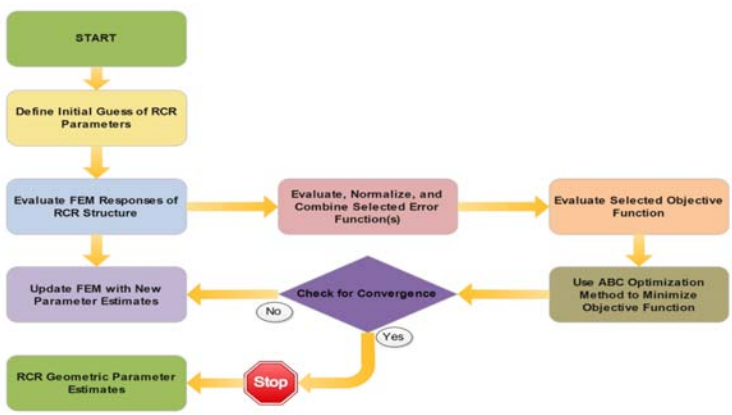


Fig. 1 : ABC and PARIS algorithms flow chart

Base on flowchart which shows in Fig. 1 these two algorithm cause link between modeling and optimization field. PARIS algorithm is a Parameter Identification System which uses static or modal measurements for stiffness and mass parameter estimation at the elements of RCR structure. This algorithm is capable of handling two and three dimensional parameter estimation of RCR which written in the Matlab programming language. PARIS files are compiled in Matlab compiling language p-code for ease of transport on various platforms without any Matlab libraries and data files are kept in Matlab so can create other data files or modify these which related by ABC algorithm.

IV. Reinforces Concrete Reservoirs Design

a) Basic Details

In water supply construction, to coordinate production and water use and to regulate the pressure in water supply network water reservoirs are used. Dewatering construction and water refinement are designed based on the maximum discharge utilization daily to weekly. Considering the economic aspects of the design and exploitation construction should be in manner that could provide the required water in an identical process during the day defined by Chen and Kianoush (2009). Based on Chau and Lee (1991) it is clear that water consumption in the city could not be function of this identical process. Water consumption at different hours depending on conditions may vary up to several times daily. To reduce or eliminate the impact of these fluctuations and create coordination between consumption and production, reservoirs coordinator or modulator construction from the perspective of economic and operational is justified. Since research from Thevendran and Thambiratnam (1987) which work on optimal shapes of cylindrical concrete water tanks, these concrete reservoirs are built anywhere in the water supply construction and be hold safe from hourly water consumption drastic changes. If the conditions require, appropriate location for this repository is in water distribution or behind it. In this position, transmission lines and dewatering construction and refinement are safe from consumption time changes and costs of the design utilization are appropriate from an economic perspective.

In this study, a concrete storage tank with a 20,000 m^3 water network required has been selected regarding structural elements assimilation in the buried rectangular reinforced concrete reservoirs s. In this stage, the thickness of the walls, foundation and roof have been selected to achieve the bonds marginal ambit regarding repositories designing various records to select the optimization space in the appropriate space. In the next stage with finite element method and by computational analysis help, amplitude of sidewalls of the tank shell has been selected regarding lateral and intermediate positions supposing the effect of waterpower loading of inside the tank on the double reciprocal In the case of full water. Among the proposed elements, the range of elements that have the maximum tension have been chosen at first to calculate the optimum thickness of the shell wall and amount of optimal used bar, then in the next stage these investigated parameters are evaluated based on the confirmatory cover.

b) *Assumptions of modeling*

In the present study, some assumptions have been chosen based on accomplished modeling regarding the types of structural reinforced concrete reservoirs. The reservoir structure is half-buried which 20,000 m^3 of water tank is directed. The maximum water balance in the reservoir is equal to +4.70 m toward bed balance. Dimensions of the reservoir structure balances in the bed are equal to 86.40 m wide, 52.40 m length, and in height +5.35 m equal to 87.80 m wide, and 53.80 m length. In order to increase confidence and reduce tension levels at the foot of the walls, a heel 40 cm wide is intended in the bed. Reinforced concrete reservoirs structure is included the surrounding concrete walls by height 5.10 m which 40 cm embankment has been done on its roof. This structure has been considered half buried in the ground and there is no possibility of movement of vehicles on the roof of the tank regarding to protection of the cargo.

Concrete materials used in the tank are considered with regard to required resistance and also desired structural performance with a minimum 28 days compressive strength of its cubic sample equal to 350 kg/cm^2 and minimum used cement equal to 400 kg/cm^2. In preparation using concrete, the maximum water cement ratio is presumed 0.45 and commixture design will be available to administrative operation in the construction of structures regarding existing conditions. Type of using bar in the different parts of the concrete structure (foundations, walls, ceiling and columns) is deemed of ribbed AIII and with at least flowing 4000 to 4200 kg/cm^2 regarding required persistence and a good charisma creation between steel and concrete materials and simultaneous performance.

Soil on the site has been considered type II. Soil bearing capacity and specific weight of the soil in the site is supposed equal to 0.60 kg/cm^2 and 2.20 (ton/cm^3) respectively. Groundwater level in the construction site is considered below the bed balance and thereupon static and dynamic load side water resulting from earthquake around the structural walls is not defined.

Location of the operation is selected in a city with a high ratio of earthquake risk which the values of earthquake power and dynamic loads of water and soil on the structure can be calculated. In calculating the coefficient of earthquake, structural site, and arena or a high risk earthquake and maximum acceleration of earthquake equal to and regarding that the structure is related to water supply installation, the structure is considered with importance coefficient 1.4 and very important. Also behavior coefficient equal 3 is considered in order to the lateral seismic loads application on the reinforced concrete reservoirs structure and dynamic pressures on the grounds plasticity and depreciation feature of low energy of these structures. Under the terms of regulations in order to application of the terms of the elements cracking and effects of resistance reduction and cross section of each of them, effective coefficient of cracking in the space of inertial member has been considered 0.70 around axes y and z for the columns. Also effects of reduced stiffness due to fraction are assumed 0.70 in the walls with reduction coefficient, 0.25 in the ceiling with reduction coefficient and rigidity of rigid endusers in the arena at connections is assumed equal to 0.50 estimated.

c) *Elements of RCR structure*

Thick shell elements for surrounding walls, foundation and roof is defined based on previous experiences in modeling regarding the dimensions of each element and its loading conditions, so that by reducing tension in the walls and movement towards the reservoir roof thickness values are gradually declined. Also in the foundation that these walls are connecting to it, greater thickness defined in order to provide appropriate charisma and freightage at the foot of the walls, which these amounts reduced by moving towards the reservoir center regarding tension levels decrement. In defining these elements, local axes direction pursuant to the original design assumptions and structural loading circumstance is defined.

Sections dimensions of the columns frame have been studied based on values of applied loads subjected to the size of craters, structure height and loading conditions and also previous experiences and regarding the loading conditions, ease of framing and bar bending and the thickness of the roof have been intended in the models initially. In defining these elements, local axes direction is defined according to designing the original assumptions and cracking column sections, in the models are considered based on the regulations and reduction effect of rigidity at the junctions is defined too. The primary dimensions of the columns is considered through previous experiences for modeling and regarding to the mouthpiece length, height of the structure and values of applied loads equal; to 40 cm in 40 cm. In addition, the number of the bars supposed equal to eight in each column primarily. Level of the crossbar consumption has been determined equal to 0.004 to 0.04 cm^2 plus 5 cm covering base on durability of concrete structure in using services.

d) Analysis load combinations

Regarding to the matter that structure has half-buried saved in the soil and static and dynamic water pressure, although have been applied to define different types of loads and regulations criteria of structures. To lateral forces of earthquake on reservoir structure, the seismic coefficient amount is used C equal to 0.35 and after the initial analysis and calculated intermittence time; assumption authenticity of reflection coefficient is selected equal to 2.5 estimated. Modal analysis performing and right defining of the reservoir alternation time in the model and earthquake structural tank loading by using seismic coefficient signification requires to define an effective mass for the structure during an earthquake, so regarding to the concepts of earthquake analysis, this mass defined as sum of dead load with 0.2 of live load in the model.

In brief, loads on the structure during the calculations are total of the dead load, equal to 0.72 ton/m^2 and 0.150 ton/m^2 snow load according to relevant criteria. Weight of shell elements and frames available in the models are recorded in the self-increasingly dead load by applying coefficients 1 in the loads definition. Regarding to being half-buried the structure in the soil effects of lateral soil, pressure must apply on the walls elements in contact with the concrete walls of the tank shell, so coefficient of lateral earth pressure is calculated equal to 2.57 ton/m^2 in one width meter.

Changes in soil Pressure, during an earthquake for lateral soil pressure application in the dynamic mode can be found through the relation between Whitman and Sid based on the design criteria and calculation of ground water. In addition, the resulting dynamic pressure to the shell elements of the buried in soil sidewalls can be applied. So this variable varies at height of 3m start as 1.57 (ton/m^2) to the reservoir bed level. Lateral pressure and vertical fluids are calculated by the theory of fluid mechanics in accordance with relation which is lateral pressure or vertical fluid is specific gravity of liquid, and y is desired balance depth. Regarding this structure using and existence of 4.7 m water in the reservoir, side effects of water pressure must be entered to the elements of shell surrounding concrete walls, and then vertical pressure resulting from weight of water on the reservoir bed arrives widely. Specific weight of water is considered equal to 1 ton/m^2 and amount will be equal to 4.70 ton/m^2 estimated.

In repository loading, structure wall is hard, so according to Hasner theory, fluid dynamic model is same with two degrees of freedom with viscosity about water, which are into a reservoir with a hard wall. A freedom degree is related to a mass which contains the weight of a liquid part that vibrates along the reservoir and is called hard mass (w_1), and a freedom level contains the weight of a liquid part that vibrates along alternative time independently much larger than the alternative time of the hard part and the structure calling wavy mass (w_2). Regarding changes in water pressure during an earthquake, for applying this lateral pressure in the dynamic mode, existing relations in the criteria and the design scales and calculation of groundwater can be used, and apply resulting dynamic pressure to the elements of the side walls shell. This measure in raster for two q_1 measures is equal to 1.55 ton/m^2 on ceiling and 3.97 ton/m^2 in the bed, in addition in raster for two q_2 measures is equal to 1.71 ton/m^2 in ceiling and 4.13 ton/m^2 in the bed. In order to applying the forces resulting from change in temperature on the shell elements, temperature changing is applied equal to 20°C on these members regarding to this structure in the earth and bulwark on the roof. According to modeling and analysis of RCR with software 20 load combination for this structure selected based on codes and durability design of structure. Load combinations reached from dead load (DL), soil load (KHAK), soil dynamic load in x and y direction (EKHAKX/Y), snow load (SNOW), water load (WAT), dynamic water load in x and y direction (EWX/Y), earthquake loads in x and y direction (EQx/y), and temperature load (T) which related each other and make 20 load combinations (Table1).

Table 1 : Load combinations for RCR structural analysis

Number	Combo. Name	Load Combinations
01	Comb1	1.4 DL+ 1.7 WAT + 1.7 SNOW
02	Comb2	1.4 DL+ 1.7 KHAK + 1.7 SNOW
03	Comb3	0.75 (Comb1 + 1.87 EWX + 1.87 EQx)
04	Comb4	0.75 (Comb1 + 1.87 EWY + 1.87 EQy)
05	Comb5	0.75 (Comb2 + 1.87 EKHAKX+ 1.87 EQx)
06	Comb6	0.75 (Comb2 + 1.87 EKHAKY - 1.87 EQy)

07	Crackstc1	1DL+1WAT+1SNOW
08	Crackstc2	1DL+1KHAK+1SNOW
09	Crackdyn1	0.75 (Crackstc1 + EWX + EQx)
10	Crackdyn2	0.75 (Crackstc1 + EWY + EQy)
11	Crackdyn3	0.75 (Crackstc2 + EKHAKX + EQx)
12	Crackdyn4	0.75 (Crackstc2 + EKHAKY - EQy)
13	TEMP1,2	0.75 (Comb1 + 1.4 T)
14	TEMP3,4	0.75 (Comb2 + 1.4 T)
15	FOUND1	1.0 DL+ 1.0 WAT + 1.0 SNOW
16	FOUND2	1.0 DL+ 1.0 KHAK + 1.0 SNOW
17	FOUND3	0.75 (FOUND1 + 1.0 EWX + 1.0 EQx)
18	FOUND4	0.75 (FOUND1 + 1.0 EWY + 1.0 EQy)
19	FOUND5	0.75 (FOUND2 + 1.0 EKHAKX + 1.0 EQx)
20	FOUND6	0.75 (FOUND2 + 1.0 EKHAKY - 1.0 EQy)

e) Modeling and analysis software in use

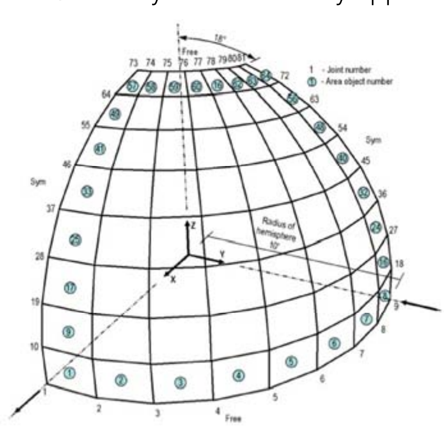
Rao and Hinton (1993) work on analysis and optimization base on shell structures and because of using the shell elements and the need for networking and analyzing different parts of this structure to the reservoir modeling, finite element software SAP2000 with the linear analysis of the shell elements connected to the frame elements has been used. The reservoir structure is divided into six parts regarding to expansion fissures which three models has been made and checked in the abovementioned program to design the different parts of this structure. For these wall members, thickness of the shell element regarding to the length and height of the wall and its loading conditions, at the junction to the foundation moving upward is reduced up to 80 cm and is supposed at least 35 cm at the junction to the ceiling. The thickness of shear walls is supposed at least 35 cm, the foundation thickness is presumed up to 80 cm regarding to previous experiences, and anchor, transferred cutting from the walls that by moving toward the center of the tank, this amount reduces gradually, and is supposed at least 40 cm after seven meters. In addition, the thicknesses of the ceiling and excess load soil is intended at least 25 cm regarding the experiences and the anchor and transferred cutting from the walls. After geometry and loading finalization, all above models are linear static analyzed, the shell elements, and the frame elements are designed manually and by program respectively according to outcome results.

V. Verification Of Analysis Software

In order to the analysis software verification, hemispherical shell structure is analyzed for the effects of four 0.90 ton-force edge point loads alternating in sign at 90° intervals around the equator of the hemisphere. The deflections at the locations where the point loads are applied, in the direction of the point loads, are compared with published independent results. The geometry, properties and loading are as suggested in MacNeal and Harder (1985). The 0.012m thick hemispherical shell has a 3.04 m radius. A hole is introduced at the top of the hemisphere, as shown in the figure on the following page, to avoid triangular elements at the top of the hemisphere.

With the joint local axes as described in the previous paragraph, the symmetry conditions are applied as follows. Joints 1, 10, 19, 28, 37, 46, 55, 64, and 73 are restrained in the U2 and R3 degrees of freedom. Joints 9, 18, 27, 36, 45, 54, 63, 72 and 81 are also restrained in the U2 and R3 degrees of freedom. In addition, a single vertical restraint is applied at the center of the bottom edge, at joint 5, to maintain stability of the structure.

Fig. 2 : Geometry of shell to verify application



MacNeal and Harder (1985) indicates that the theoretical lower bound for the displacement at the point load locations in the direction of the point load is 28.16 mm for the condition where the hole at the center of the shell structure is not present. The reference further suggests a value of 28.16 mm for comparison of results with the model where the center hole is present. The 28.16 mm value is used in the comparison.

Table 2 : Output parameter calculations

Shell Type	Output Parameter	SAP2000	Independent	Percent Difference
Thin plate	U_x (jt 1) mm	28.62	28.65	0%
	U_y (jt 9) mm	-28.62	-28.65	0%
Thick plate	U_x (jt 1) mm	28.25	28.65	-1%
	U_y (jt 9) mm	-28.25	-28.65	-1%

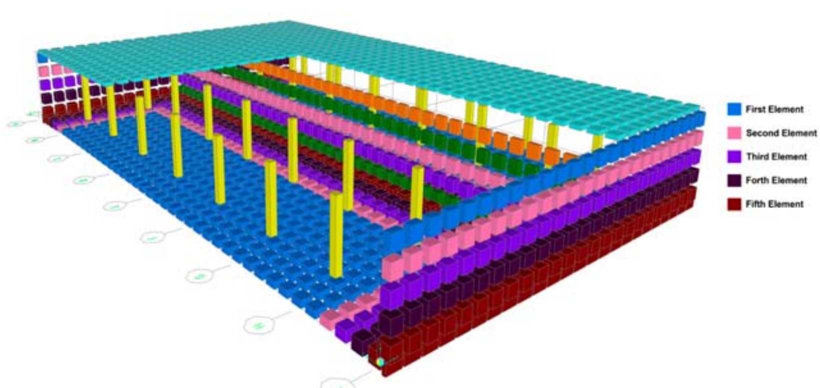
a) Analysis results of RCR modeling

After performing of the analysis, results of the linear static analysis of all model states to manual design the concrete structure are applied based on the forces and anchor values resulted from the models analysis. To design the reservoir concrete structure formed by the shell elements, the structure analysis results for all types of loads on it are studied in determined load compounds bending anchor responses and tensile forces on the wall shell, the foundation, and ceiling. The required bars for the members are calculated with additional amounts at points of the tension concentration by the tension anchor amounts and designing of thickness of structural members to resist against incoming shear force besides optimize the required bars amount to resist against the anchor and extension. Amount of the foundation vertical shift under compounds of the foundation loading is controlled to control the underfoundation tensions to create extension in the soil besides under-foundation tensions increment than the allowable tension soil. Thus, upheaval is not created in the foundation according to the resulted outcomes from the modeling analysis and the under-foundation soil is not pulled.

VI. Applied Abc Algorithm To Rcr Model

Optimization in structure means access to structural elements with minimum weight and best performance against static and dynamic loads with the lowest vulnerability and maximum safety. At first in reinforced concrete reservoirs, a range for the thickness of the structural elements based on previous experiences and regarding dimensions of the tank and its height of 5.1 m is selected in the model. The elements of the reinforced concrete reservoirs shell with diminutions of 100 cm have been networking and considered according to the done analysis in range of the tank shell thickness from 35 to 80 cm, foundation from 35 to 80 cm and the ceiling from 25 to 35 cm variable. A tank as shown in Fig.3 has the four peripheral directions which wall corner in the positive directions of x, y and z is selected for calculating, regarding maximum tension ratio into each of the selected elements, and each of the five selected element are widespread as peripheral tapes along with the tank environmental shell based on categorized by type tank shell walls.

Fig. 3 : Modeling and locating of optimize elements in RCR



At first, a range of elements details was created between the modeling software and artificial bee colony optimization algorithm code based on PARIS (Parameter Identification System) relation regarding ambit of the problem space to minimize the amount of the structure weight and control stability under static and dynamic loads to minimize the selected range thickness according to each repetition and optimizing the used bar measure Per length unit to calculate type of the used bar. After achieving the optimized elements, two peripheral sheaths are used in the shell element numbers 2 and 4 (Fig.3). Effect of this issue on the structure behavior will be evaluated at the modeling and optimizing phase. Accordingly, this reciprocal relation between analysis and algorithm code has been done in three sections of the structure weight reduction, achievement to the minimum thickness of the tank wall side under done loading and the amount of used bar optimizing Per length unit.

a) The objective function of rcr base on abc algorithm

KIA and Ghasemi (2012) research on finding objective optimization function to minimizing the RCR structure weight and developing equation during time. In equation (9) $f(W)_{d_i}^t$ is function of minimizing the RCR weight based on changing the thickness of the i^{th} element in t-time base on durability of structure, F_y is characteristic strength of steel, f'_c is characteristic compressive strength of concrete, M_{u_i} is the ultimate flexural resistance of the anchor of the i^{th} element, ϕ and λ are partial safety factors, γ is specific gravity of materials, b_w is spirit width, d is the thickness of the i^{th} element, V_{u_i} is The ultimate shear strength of the i^{th} element, h_i is the total thickness of the i^{th} element, α and β are design coefficients, l is the tank length and is the tank width. A range of the bending anchor amount and the final cutting power is obtained regarding minimizing the parameters involved in the tank optimization according to performed analysis. In each of the elements, the respective function has been minimized regard to the design criteria to the optimum thickness amount of the tank shell and the used bar are calculated based on the design criteria.

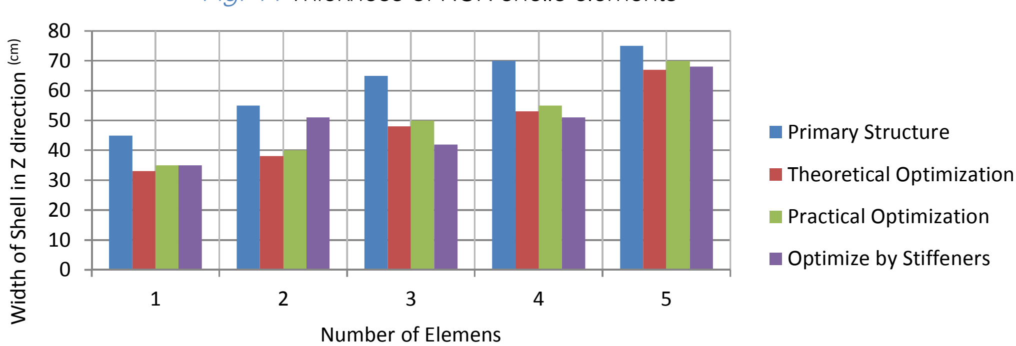
$$f(W)_{d_i}^t=\sum_{i=1}^{n}\left(\frac{\left(1-\sqrt{1-\dfrac{2\dfrac{F_y}{.85f'_c}\dfrac{M_{u_i}}{\phi b_w d_i^2}}{F_y}}\right)}{\dfrac{F_y}{.85f'_c}}\alpha b d_i\gamma_1(l+b)\right)+\sum_{i=1}^{n}\left(\frac{\beta\gamma_2 h_i V_{u_i}(l+b)}{.17\lambda d_i\sqrt{f'_c}}tg\left(\frac{h}{n(b+l)}\right)\right) \tag{9}$$

Regarding to the different variables existence in accordance with (9) relation and considered suppositions to solve the problem, M_{u_i}, V_{u_i}, d_i of the i^{th} element according to Fig. 3 are considered as the scope and constraints of the problem to minimize the structures weight. Regarding to the problem solving by artificial bee colony algorithm, a part of used parameters in MATLAB software are considered as colony size 10^3, limit range and parameter range estimated base RCR model analysis database, number of cycle set to 5×10^3, number of runs set to 50. The optimization code was run on a personal computer with a Intel core i7, 3.1 GHz processor with 6 GB DDR3 RAM under the Microsoft Windows 7 professional operating system.

b) Optimal shell elements comparison

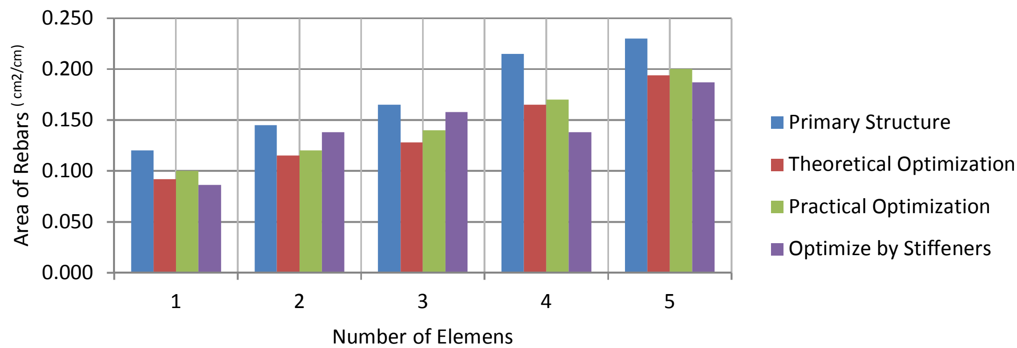
After solving the function based on the debated terms, the optimal thickness of reinforced concrete reservoirs shell cab ne considered by particle swarm algorithm methods according to Fig.4 and based on comparison of thickness of the concrete shell wall side to for situations as follow in tables.

Fig. 4 : Thickness of RCR shells elements



Common-mode design, the optimized mode-design based on theory numbers, the optimized mode-design based on executive numbers, and the optimized mode-design by peripheral confirmatory sheath. In Fig.5 amount of the used bar is studied. This section is to achieve the best confine, which contains four phases as follow which common mode design with the maximum used bar, optimization of the using bar amount based on the theory results, optimization of the using bar based on numbers with executive possibility, and optimization of this characteristic by the using confirmatory sheath. In the structure calculation by executive method, accuracy is based on the theory solution but respective numbers are chosen according to executing possibility and minimizing materials tails.

Fig. 5 : Area of steel rebars in RCR shells elements



c) Optimal weight and total construction cost of RCR

Proceeds of particle swarm algorithm to optimize a 20,000 m^3 of reinforced concrete reservoirs about optimal weight of structures, reduction present of structural weight, reduction percent of using bar, and minimum economic saving on small foundations of list price items of department of planning and strategic supervision regulations of technical affairs based on three parameters comparing as reinforced concrete reservoirs with a conventional design, optimization of the reinforced concrete reservoirs shell in two executive and theoretical states, and also optimization of the tank shell by peripheral confirmatory sheath, all shown in (Table 4).

Table 4 : Volume of mass concrete, weight of steel rebar, and total construction cost

No.		RCR Types	Mass Concrete m^3	Mass Concrete %	Steel Rebar Longitudinal (Ton)	Steel Rebar Total (Ton)	Steel Rebar %	Total Cost Billion IRR	Total Cost %
1		Traditional	877.92	0%	147.71	280.64	0%	18.00	0%
2	Optimize	Theoretical	676.85	-23%	117.72	223.67	-20%	15.42	-14%
3	Optimize	Practical	708.00	-19%	123.47	234.59	-16%	15.90	-12%
4	Optimize	Prismatic Stiffeners	699.50	-20%	119.06	226.22	-19%	15.66	-13%

VII. Conclusion

Reinforced concrete reservoirs are used to store liquid for release on demand and it is necessary to consider all the aspects of a durability of structure with catchment area, including the amount and distribution of liquid, evaporation, soil or rock conditions, and elevation. In this paper, an efficient optimization algorithm, namely the artificial bee colony algorithm (ABC) is proposed for the solution of discrete RCR structural problems. Based on the findings in the 20,000 m3 RCR by three shell types: (i) theoretical, (ii) practical, and (iii) prismatic stiffeners, the research described in this paper has resulted in the following findings:

- Reduction mass concrete consumption
- Reduction steel rebars consumption
- Reduction total construction cost

These findings show that the optimization algorithm such as ABC can be successfully applied to redesign concrete structures with discrete design variables. The authors of this study believe that using optimization algorithm in structural analysis and design will be develop for next years and will pursue using in the next articles these natural algorithms in new structure field such as dams and bridges.

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Effects of Congestion and Travel Time Variability along Abuja - Keffi Corridor in Nigeria

By Ibitoye A. Biliyamin & Mrs Bello A. Abosede
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Abstract - Uncontrolled motorization is one of the major causes of traffic congestion along the outer ring corridor of Abuja due to the absence of adequate mitigation measures. The purpose of this paper is to identify the traffic influencing events causing congestion, determine the travel time variability along Abuja – Keffi corridor and to make suggestions for effective traffic-related measures in reducing congestion along this route. The process of traffic impact mitigation was examined in this study and it was found that a measure related to bus stops provision is most effective in reducing congestion along this corridor. It is recommended that the Federal Capital Territory Administration (FCTA) should develop more explicit policy tools for mitigating the traffic impact along this outer ring corridors of Abuja.

Keywords : Traffic Influencing Events, Non-recurring Congestion, Travel Time Reliability. Traffic Mitigation Measures, Traffic Count.

GJRE-E Classification : FOR Code: 091503

EFFECTS OF CONGESTION AND TRAVEL TIME VARIABILITY ALONG ABUJA -KEFFI CORRIDOR IN NIGERIA

Strictly as per the compliance and regulations of:

Effects of Congestion and Travel Time Variability along Abuja - Keffi Corridor in Nigeria

Ibitoye A. Biliyamin[α] & Mrs Bello A. Abosede[σ]

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Keywords : Traffic Influencing Events, Non-recurring Congestion, Travel Time Reliability. Traffic Mitigation Measures, Traffic Count

I. Introduction

An effective transport system is indispensable to the economic progress of any nation. This is because of the fact that without adequate facilities for moving goods and people from place to place, economic and social activities could be paralyzed. Nigeria's increasing population over the years coupled with diminishing resources has worsened its transport system especially in the sub-urban and urban centers especially in the Federal Capital cities like Abuja and Lagos. (Ibi, 2004)

The demand for transport outstrip the supply, while the poor interchange system, high cost of transport and lack of passenger information system are some of the problems facing the average commuters (Ibi, 2004). It was found out in this study that good transport with major bus stops would make significant contribution to travel time and patterns and can provide movement of large number of people while occupying a relatively small portion of road space. A good transport with well-located bus-stops helps to eliminate congestion which is the major problem along the study route and also reduce the number of road accidents and overall safety and efficiency of the road network. Congestion has, in fact become one of the dominant factors that determine how a city grows and its effect has caused significant increase in undesired long delays, adverse pollutions, increased operating costs and adverse sociological effects along the study road corridor.

Traffic congestion is one of the most significant problems faced in modern cities like Abuja. Statistics indicate that road transport is the dominant mode of transportation in Africa (Kerekezi, 2002), about 95% in Nigeria; resulting in road traffic congestion. The effects of congestion cause increase in undesired long delays, adverse pollutions, potential increase in accidents, increased operating costs and adverse sociological effects (Philpott, 1997).

Congestion causes increase in travel time which may eventually become increasingly variable and unpredictable as congestion increases. Congestion levels are never the same from day-to-day on the same highway because the varieties of traffic-influencing events that influence congestion are never the same. Commuters could be late for work or after-work appointments, business travelers could be late for meetings, and truckers could incur extra charges by not delivering their goods on time (http://wwwcf.fhwa.dot.gov cited on 14th December 2009).

II. Description Of Study Area

Abuja is a city in the central part of Nigeria and the Federal Capital of Nigeria. Abuja is about 1250m (about 4100 ft) above sea level, occupying 713km^2 of land area. The city average monthly temperature is in the range 21^0- 25^0 C (69^0 - 77^0 F).

The city center of Abuja is crowded with a mix business wholesale and retail outlets which attracts customers from all parts of the country. Also, the three outer ring corridors of Abuja generate high traffic levels due to high rate of daily drift from sub-urban area into Abuja especially along Abuja – Keffi corridor. This concentration of activities as well as the high traffic levels explains the recurring traffic congestion at peak periods and the need for traffic management operations to maintain acceptable levels of traffic performance.

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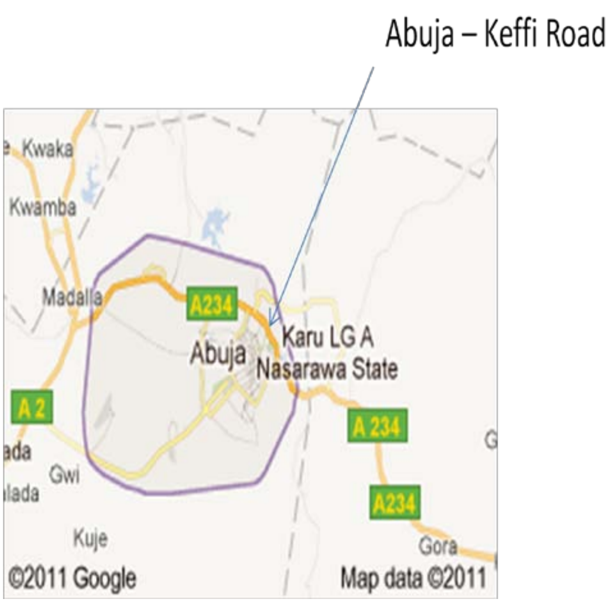

Fig 1 : Map of Abuja showing the study road

Statistics has shown that the city population is growing in relation to vehicle ownership and is likely to continue to grow in future. The growth pattern of the population and vehicle registration of Abuja between the years of 2000 and 2010 is shown in Fig. 2.. The implication of all these is an unexpected growth in the traffic levels which may lead to overloading of some major sub-urban corridor such as Abuja – Keffi road. It can be established that there is a corresponding increase in the number of vehicles being registered to the rise in the population.

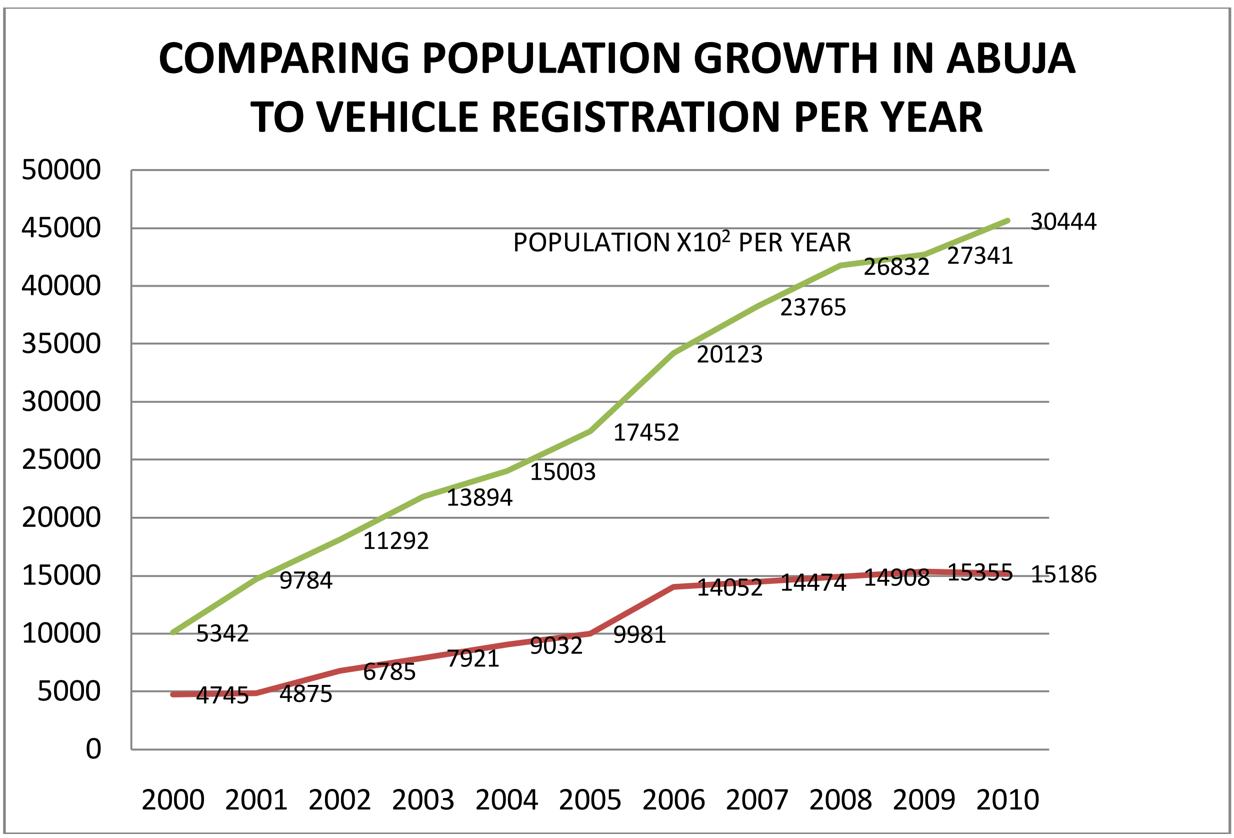

Fig 2 : Growth Pattern of Abuja population and Vehicle Registration

Fig.2 shows the statistics relating population to vehicle registration in the city. It can be established that there is a corresponding increase in the number of vehicles being registered to the rise in the population.

III. Travel Time Variability

Travel time variability can be defined in terms of how travel times vary over time (e.g., hour-to-hour, day-to-day). The traffic-influencing "events" such as traffic incidents, weather, and work zones; contribute to total congestion which produces unreliable travel times. This event-driven variability in travel conditions is referred to as non-recurring congestion since it happens differently every day.

a) Methodology

Two hours video coverage each was recorded for both peak and non-peak periods (weekday and weekend) at the three critical congested locations along the road. The traffic volume at the each location; Sani Abacha, Karu and Nyanyan Flyovers were recorded for all existing modes of transport. The travel time of vehicles during peak and non-peak period at each location was analyzed using random selection method while playing back the video at 15 minutes interval. The events that impede traffic flow and cause travel to be unreliable often occur in combination. An analysis of how the combination of these events affect the travel time reliability was carried out along Abuja – Keffi road for the weekday and weekend during peak and non-peak period respectively. The possible trips and travel time are plotted to illustrate the travel time variation. Few roadside interviews were also conducted to test the view of travelers on daily trip. It was revealed that it becomes hard for travelers to predict how long time to commute to work. It appears even more difficult for travelers to plan their work trip as most offices resume work by 8.00am and the road section is always filled up beyond capacity between the hours of 7am and 9am. This uncertainty in travel time could introduce extra travel time and cost into the daily trip in order to account for time variability thereby resulting in travel time reliability. Four scenarios; namely (i) widening of the road (ii) construction of by-pass (iii) replacing of car usage with improved public transport and (iv) provision of bus stops at critical locations were examined in determining the most appropriate mitigation measure for this corridor..

b) Results and Discussions

Tables 1 to 6 present the summary of the classified traffic count at each counting location.

Table 1 : Peak Hour Traffic Counts

Sani Abacha Flyover

Time (min)	Car	Bus	Truck/Van	Motorcycle
0 – 15	1,243	206	97	6
15 – 30	1,579	178	68	5
30 – 45	1,467	301	72	11
45 – 60	1,622	98	101	5
Peak Hr. Traffic	5,911	783	338	27

Karu flyover

Time(min)	Car	Bus	Truck/Van	Motorcycle
0 – 15	983	183	78	23
15 – 30	1,039	214	94	19
30 – 45	501	312	111	37
45 – 60	1,426	381	176	15
Peak Hour Traffic	3,949	1,090	459	94

Nyanya Flyover

Time(min)	Car	Bus	Truck/Van	Motorcycle
0 – 15	783	225	49	17
15 – 30	895	81	58	54
30 – 45	987	102	34	16
45 – 60	920	89	102	12
Peak Hour Flow	3,585	497	243	99

The traffic volume distribution in Tables 1 indicates that the flow of car traffic reduces as one moves away from Abuja central district while the motorcycle traffic increases At Karu flyover which serve as collecting and distributing arterial between Abuja district and suburbs presents more buses and truck traffic compared to other locations. It is not surprising having number of cars entering Abuja district to be high as a result of distributed traffic from other sub-urban districts being linked by Karu flyover.

The number of motorcycles entering Abuja central district is very low due to a ban on use of commercial motorcycles within the district. However, congestion resulting from this high number of cars interacting with some other events on the road can be complex and varies greatly from day-to-day. The problem is that with the exception of the physical bottlenecks, the sources of congestion occur with maddening irregularity.

The variation in travel time as collected in the study area from Karu Junction to Nyanyan junction is shown in Figures 3 - 6.

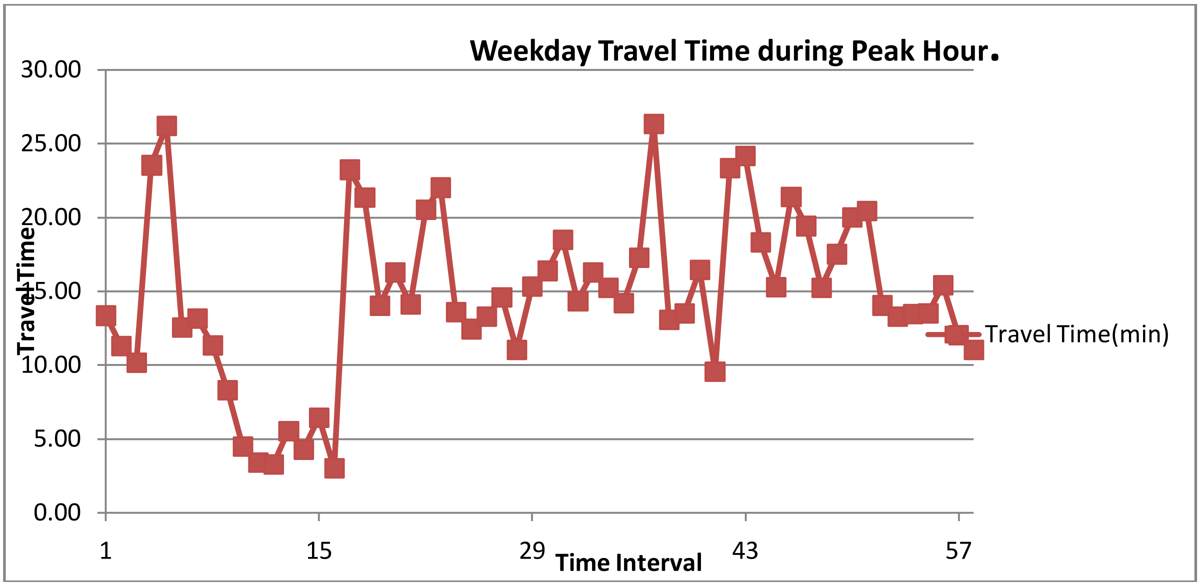

Figure 3 : Travel Time Variability at Weekday Peak Hour (7.00am – 8.00am) at Karu

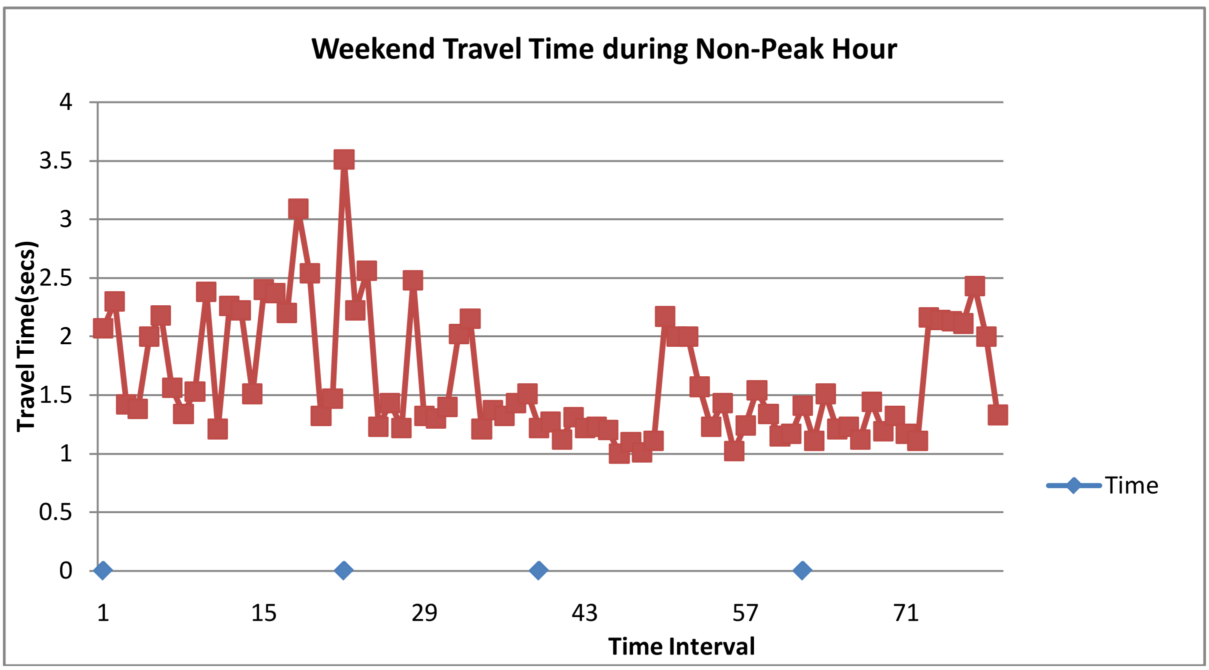

Figure 4 : Travel Time Variability at Weekend Non-Peak Hour (7.00am – 8.00am) at Karu

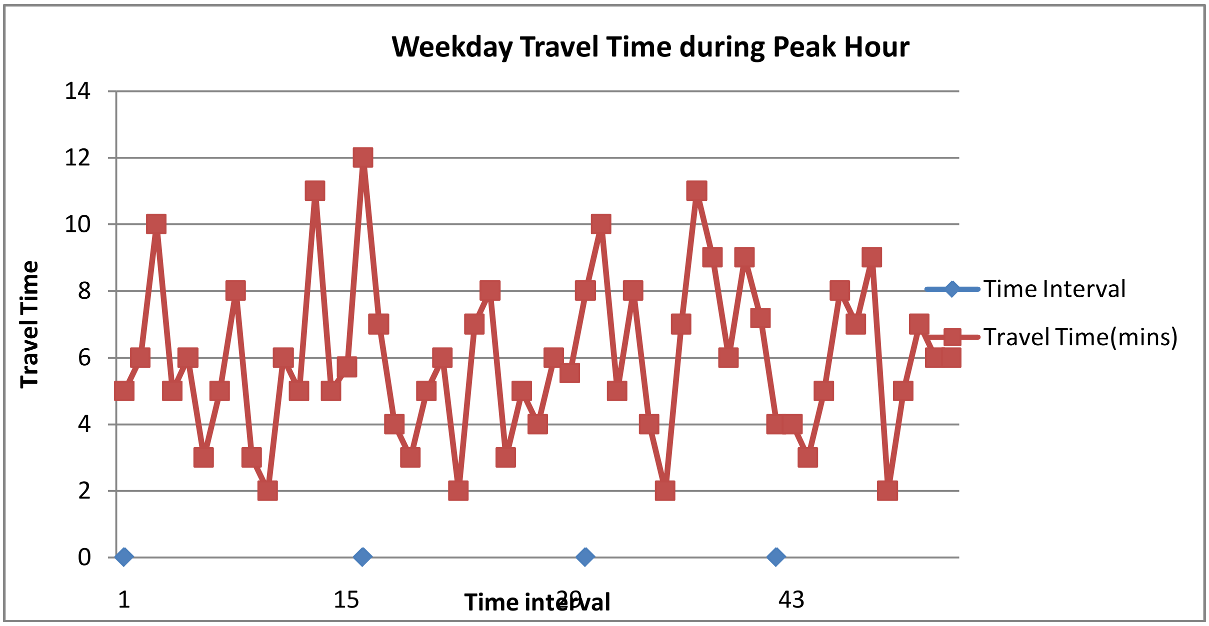

Figure 5 : Travel Time Variability at Weekday Peak Hour (7.00am – 8.00am) at Nyanyan

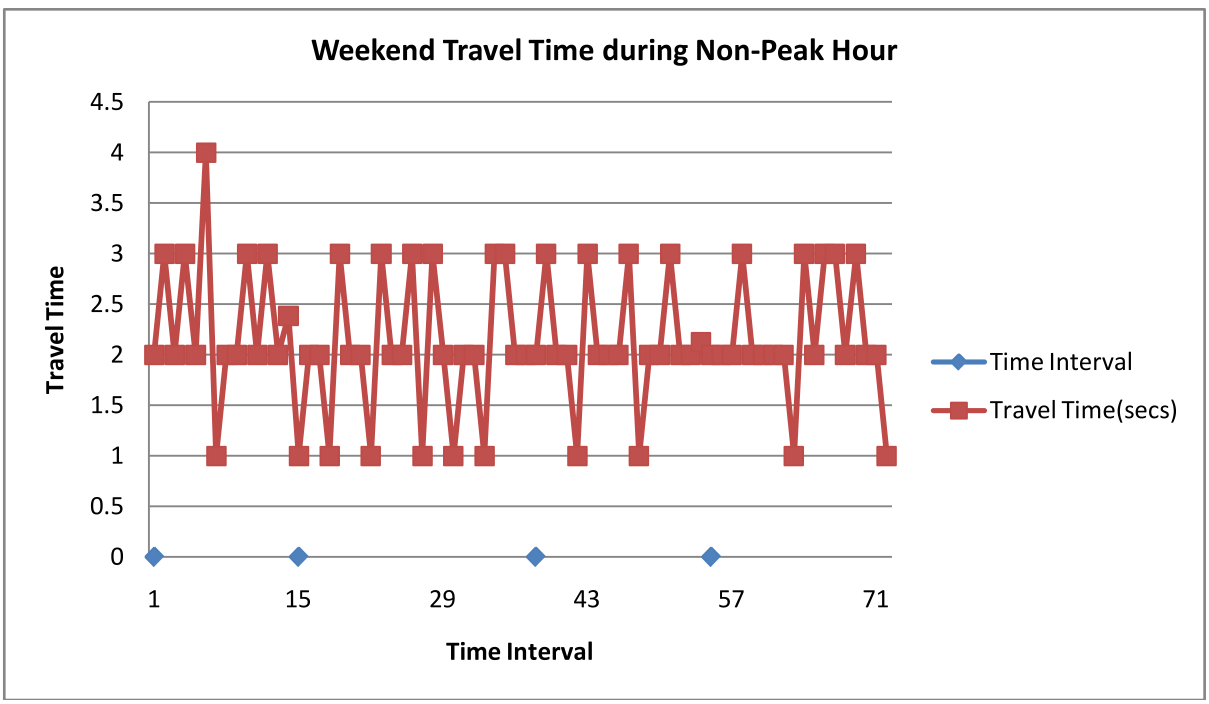

Figure 6 : Travel Time Variability at Weekend Non-Peak Hour (7.00am – 8.00am) at Nyanyan

Fig 7 : Traffic Situation at Karu Junction showing Effect of Merging Traffic

Fig 8 : Traffic Situation at Nyanyan showing Effect of Breakdown Vehicles

As shown in Figures 3 through 6 above, the minimum travel time during peak hour (7.00am – 8.00am) is about 27 minutes while at non-peak on weekend a commuter can travel the same stretch of road for about 3.5 minutes. This implies that a commuter's travel time is 87 percent more during the weekday compared to weekend. Thus, the travel time becomes unreliable during the weekday as unusual circumstances can dramatically change the performance of the road, thereby affecting both travel speed and throughput volume. The road then becomes susceptible to traffic delay and may result in jam density. Figures 7 and 8 above show the traffic situations during peak period at Karu junction and Nyanyan respectively. This traffic incidence occurring in erratic patterns in form of unpredictable blocking of lanes contributes significantly to making travel unreliable for commuters

Variability is determined by how travel times vary over time, and developing of trip frequency distributions reflects how much variability exists. This implies that every traveler needs a buffer or extra time to ensure a high rate of on-time arrival and thereby helps in the development of variety of variability measures. This paper therefore recommends introduction of bus stops as the immediate mitigating measures for reducing congestion along the study road because the shoulder of the road corridor is wide enough to accommodate bus stops and bays without interfering with the traffic flow. Bus-Stops if located along this road will prevent indiscriminate parking or waiting of buses during the peak hour while picking or dropping passengers. It will also reduce the risk of commuters being knocked down while alerting or boarding transport system. Since the cost implication is low and it can be implement immediately.

IV. Conclusion

The study has been able to identify congestion and its causes, estimate the travel time and determine the variability of average travel time. It observed that increasing traffic leads to increasing severity, spatial extension and duration of congestion. The two immediate consequences of congestion; travel times that increase on average and that travel times become increasingly variable and unpredictable are becoming a major concern for transportation agencies. However, at present, there is no well-established practice of accounting for changes in average travel time and changes in the variability of travel times. The interaction between travel demand, traffic flow, congestion, travel time variability, and individual scheduling choices should be understood by the commuters as well as government agencies that are responsible for planning road networks in Nigeria. Therefore, like many developed countries, Nigeria should try to improve the performance of the existing transport systems in order to enhance mobility and safety, reduce demand for car use, and improve traffic fluidity.

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Coated Recycled Aggregate Concrete Exposed To Elevated Temperature

By Arundeb Gupta Somnath Ghosh & Saroj Mandal
Jadavpur University, India

Abstract - An experimental investigation has been conducted to study the mechanical as well as micro structural properties of Recycled aggregate concrete (RAC) with uncoated and Geopolymer / Cement coated recycled aggregate exposed to elevated temperature. Fly ash (as replacement of cement) was added while making concrete. Cubes test specimens were prepared and cured under water for 28 days. Test specimens were exposed to different levels of temperature (400oC, 600oC, 800oC) for a period of 6 hours in the muffle furnace. The reduction in compressive strength was observed are in the ranges from 23.4% to as high as 50.3% when exposed to different elevated temperature. MIP (Mercury intrusion porosimetry) test was conducted to estimate the pore diameter and also to appreciate the change of total pore volume due to change of exposure temperature. SEM (Scanning electron microscopy) study was also done to appreciate the micro-structural change in recycled aggregate concrete.

Keywords : Coated Recycled aggregate, Natural aggregate, Concrete, Fly ash, Elevated temperature, Geopolymer, Mercury intrusion porosimetry, Compressive strength.

GJRE-E Classification : FOR Code: 090503

COATED RECYCLED AGGREGATE CONCRETE EXPOSED TO ELEVATED TEMPERATURE

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Keywords : Coated Recycled aggregate, Natural aggregate, Concrete, Fly ash, Elevated temperature, Geopolymer, Mercury intrusion porosimetry, Compressive strength.

I. Introduction

Use of recycling of concrete waste have already been started all over the world but the use is restricted. Recycled aggregates have some basic problems like excessive absorption phenomena, poor surface texture, formation of weak interfacial zone etc compared with natural aggregates. Different research works are in progress to improve recycled aggregate properties, so that high performance concrete could be developed out of concrete waste (as coarse aggregate) [9]. Pre soaking of recycled aggregate in some acidic medium (HCl, H_2So_4 / H_3Po_4) is suggested to improve the quality [1].But addition of acidic solution may create durability problem in concrete. Ultrasonic cleaning method is reported to remove loose particle from recycled aggregate, for betterment of recycled aggregate[2].

Two stage mixing approach (TSMA) is suggested to improve the strength of concrete with replacement of recycled aggregate from 0% to 100% [3].

Surface coating over recycled aggregate helps to improve the performance of recycled aggregate as coarse aggregate of concrete. Similar findings are reported using coating of pozzolanic powder on recycled aggregate concrete [7,8].

This paper deals with the study of mechanical as well as microstructural properties of Recycled aggregate concrete (RAC) with uncoated and Geo-polymer / Cement coated recycled aggregate exposed to elevated temperature. Fly ash (as replacement of cement) was added while making concrete. MIP (Mercury intrusion porosimetry) test was conducted to estimate the pore diameter and also to appreciate the change of total pore volume due to change of exposure temperature. Change in microstructure due to temperature was studied using SEM.

II. Experimental Details

Materials

Cement : Ordinary Portland cement of Grade 53 Conforming to IS 12269-1987 [10].

Fine aggregate : Locally available natural sand of Zone III as per IS 383-1970 [11].

Coarse aggregate : a) Coated recycled aggregate -10mm down recycled aggregates without dust were coated with Cement and geopolymer. Geo polymer is prepared by activating flyash with NAOH solution (4-5% concentration) and Sodium silicate. The aggregates are coated and then kept in the oven for 24 hours at 85^{0}C.

Recycled aggregates are coated with flyash based Portland Pozzolana cement slurry and dried in normal temperature for 7 days.

b) Uncoated recycled aggregate and natural stone aggregate- 10mm down recycled aggregates without dust.

Fly ash : The fly ash was directly obtained from Bandel thermal power plant near Kolkata. The chemical composition of fly ash is shown in Table–1 below. Specification of fly ash as prescribed by IS 3812 - Part-I [12] are also compared.

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Table 1 : Chemical composition of Fly ash

Chemical properties	Properties of Fly ash weight(%)	Specified requirement weight (%) IS –3812 Part-I
SiO_2	60.0	35.0 minimum
Al_2O_3	20.0	
CaO	8.0	
MgO	1.0	5.0 maximum
TiO_2	0.5	
Loss of ignition	8.0	12.0 maximum
Na_2O/K_2O	1.0	

Concrete Mix : There is no standard mix design procedure for recycled aggregate concrete. Hence, trial mixes as per ACI [13] for natural aggregate concrete (NAC) was adopted. Eight different mixes were prepared as shown in Table 2. In some mixes of RAC (both uncoated and coated) and NAC certain percent of cement was replaced by fly ash like in RAC-10F mix, 10% cement was replaced by fly ash .Similarly in coated recycled aggregate mix, 10% cement was replaced by fly ash.

Table 2 : Mix Proportion

Mix No.	Mix designation	Cement	Fly ash	Sand	Coated Coarse aggregates	Water binder ratio
1	NAC	1.00	-	1.6	3.3	0.4
2	NAC-10F	0.9	0.1	1.6	3.3	0.4
3	RAC	1.00	-	1.6	3.3	0.4
4	RAC-10F	0.90	0.10	1.6	3.3	0.4
5	Geo polymer coated RAC	1.00	-	1.6	3.3	0.4
6	Geo polymer coated RAC -10F	0.90	0.10	1.6	3.3	0.4
7	Cement coated RAC	1.00	-	1.6	3.3	0.4
8	Cement coated RAC -10F	0.90	0.10	1.6	3.3	0.4

Specimen casting, curing and testing : Cube of 70mm x 70mm x 70mm has been casted with: i) Geo-polymer coated recycled aggregate, ii) Cement coated recycled aggregate iii) Uncoated recycled aggregate iv) Natural aggregate.

Cube has been prepared both with flyash replacement and without flyash. The specimens were then cured under water for 28 days. Specimen were heated in a furnace at 400°C, 600°C and 800°C temperature for 6 hours. Compressive strength were determined by testing cubes to destruction. Mercury intrusion porosimetry, SEM study were also conducted. Six cubes were cast from each mix which are exposed to elevated temperature and tested.

III. Results And Discussion

a) Behavior of coated recycled aggregate concrete before and after heating

i. *Porosity*

The surface texture of recycled aggregate concrete become rough and cracked when exposed to higher temperature level and the strength decreases with increase in temperature level. Fig. 1[4] shows that total intruded mercury volume is 0.052cc/gm in RAC-10F sample at normal temperature and major pore diameter lies between .04 μm to 1μm but the same sample (RAC-10F) after heating to 800°C, the total intruded mercury volume increases to 0.0867cc/gm. These values provide total porosity of RAC-10F at normal temperature and RAC-10F specimen after heating to 800°C, which are 7.57%, 13.49%. respectively i.e. an increment of total porosity is around 78%, which lead to reduction in strength and modulus of elasticity at higher temperature level[4]. Similar observations are made in case of concrete out of geopolymer coated aggregates exposed to 800°C temperature level. Here, total intruded mercury volume before heating is 0.0428 cc/gm and after heating it becomes 0.0666 cc/gm. These values provide total porosity of concrete out of geopolymer coated aggregates before and after heating is 6.66% and 10.36% respectively, i.e. an increment of 55% porosity due to temperature. (ref. to Fig 2) . Total porosity in concrete out of geopolymer coated aggregates is 43% less than concrete out of uncoated recycled aggregates (ref. to Fig.3). This explains the advantage of using geopolymer coated aggregate over recycled aggregate.

ii. *Strength behavior*

After heating to different temperature it is seen that the reduction of cube strength for all types of concrete (ref. to fig.4) at 600°C ranges from 23.4% to 41.7% which after heating at 800°C rises to 31% to 50.3%. At all temperature level percent reduction of strength is smaller in NAC compare to the other mix. This is due to the stronger interfacial bonding between matrix and aggregate. In three different mix of RAC, the performance of coated aggregate concretes are better than normal recycled aggregate concrete. Performance of concrete out of geopolymer coated aggregates is found to some extent better than that of concrete out of cement coated aggregates. At 600°C and 800°C reduction in strength is 36.5% and 47.4% respectively for concrete out of geopolymer coated aggregates, and 40.9% and 48.2% respectively for concrete out of cement coated aggregates. Again, the performance is further improved in presence of fly ash. The drawbacks of recycled aggregate concrete i.e. porous and loose interfacial zone could be improved by using coating recycled aggregates having better surface texture. It is observed that 10% fly ash addition improves substantially the cube compressive strength (at all ages) of both natural aggregate concrete and recycled aggregate concrete. Flyash addition modifies the microstructure of the interfacial zone which leads to a better performance of the concrete.

Similar results are also reported in other different literature [5,6].

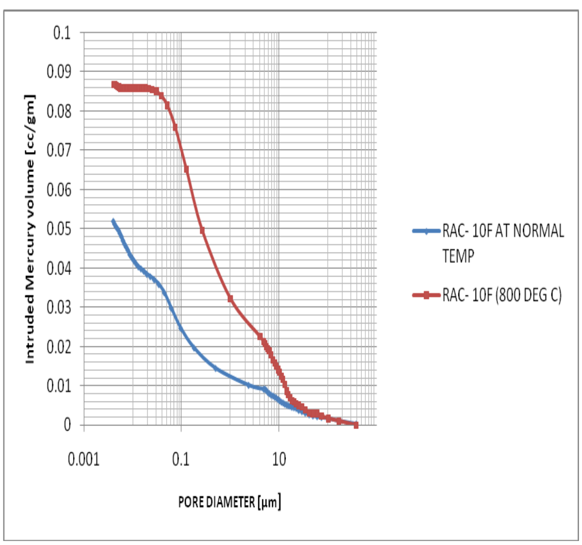

Fig 1 : Comparison of intruded mercury volume vs pore diameter curve for recycled aggregate concrete with 10% fly ash at normal temperature and after heating to 800°C temperature[4]

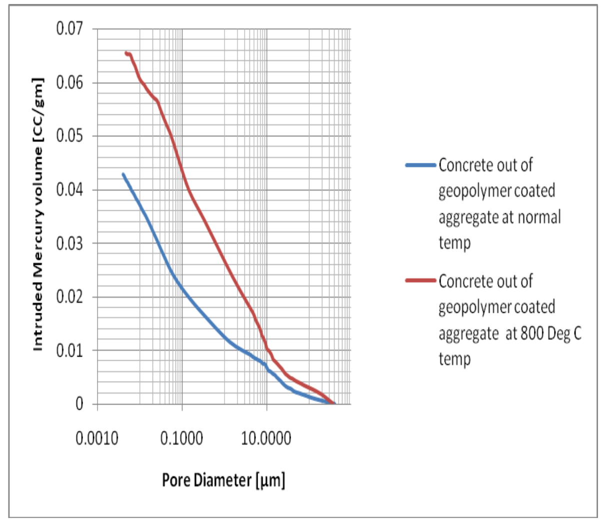

Fig 2 : Comparison of intruded mercury volume vs pore diameter curve for concrete out of geopolymer coated aggregate at normal temperature and after heating to 800°C temperature

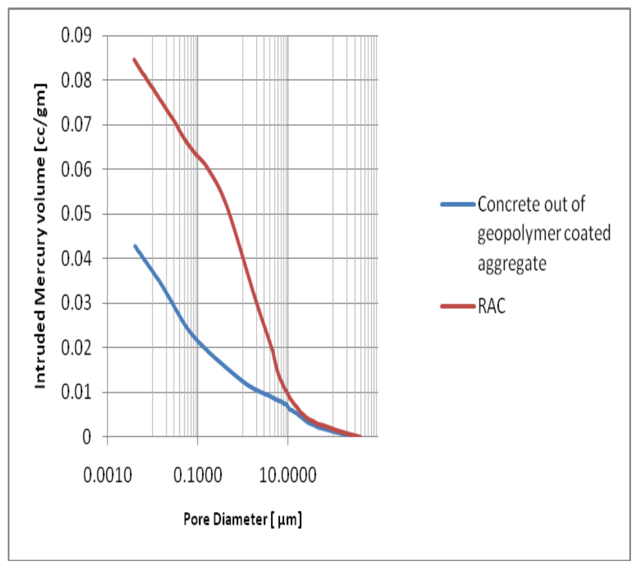

Fig 3 : Comparison of intruded mercury volume vs pore diameter curve for RAC and concrete out of geopolymer coated aggregate

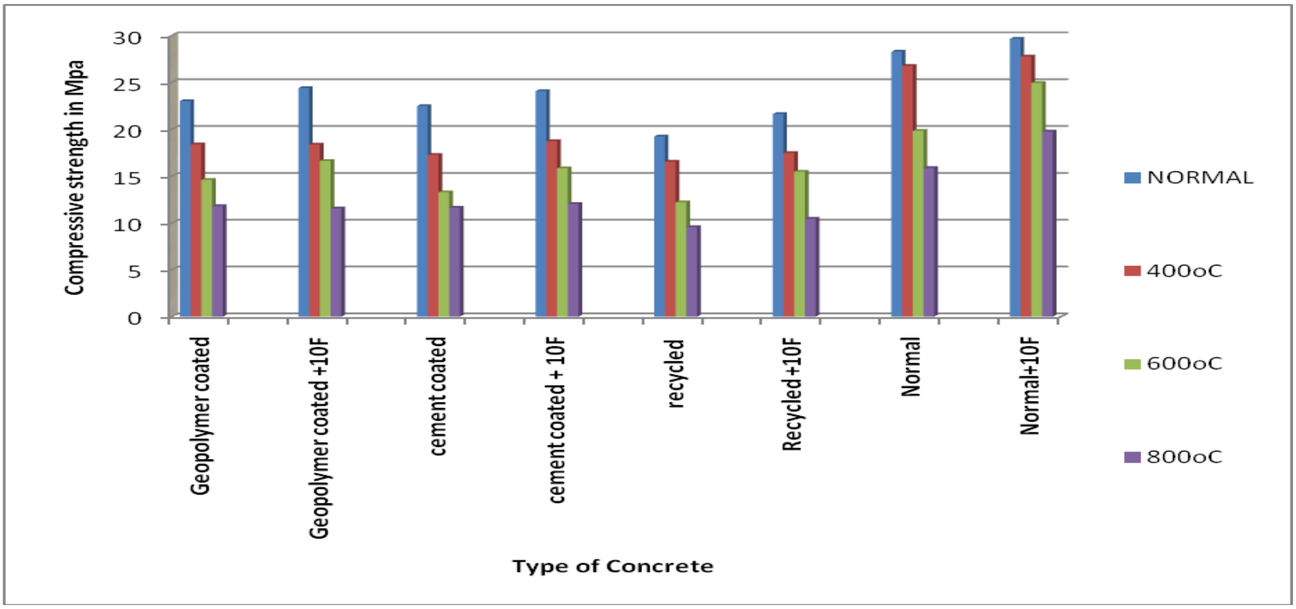

Fig 4 : Cube compressive strength of natural aggregate concrete and concrete out of coated recycled aggregate concrete (with and without flyash)

iii. *Scanning electron microscopy (SEM)*

Fig 5, 6, 7 & 8 shows the condition of microstructure of RAC-10F and Geo polymer coated RAC -10F sample before and after exposure to 800°C by Scanning electron microscopy (SEM). It is already reported in the other literature that RAC-10F sample is much denser than RAC sample after exposed to 800°C[4]. Comparing RAC-10F sample with geopolymer coated RAC-10F sample after exposed to elevated temperature of 800°C, it is observed that microstructures of geopolymer coated RAC with flyash are definitely better than RAC sample with flyash. Compressive test result and mercury intrusion porosimetry result also indicates similar findings.

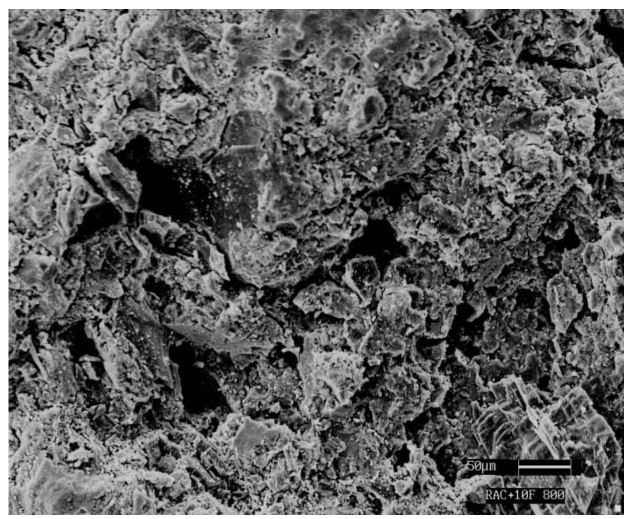

Fig 6 : Microstructure of RAC-10F sample after exposing to 800°C temperature

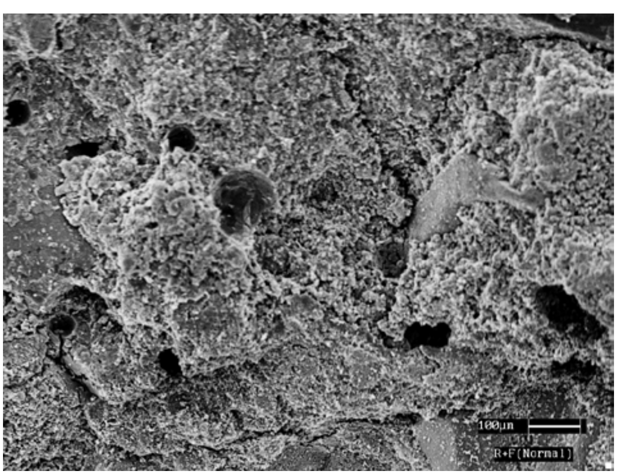

Fig 5 : Microstructure of RAC -10F sample before exposing to 800°C temperature

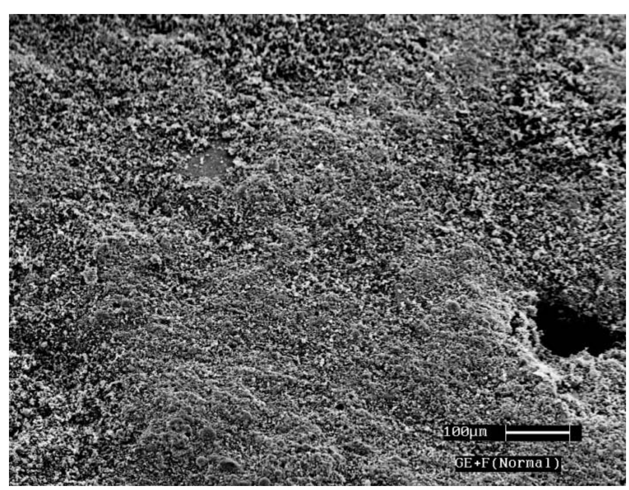

Fig 7 : Microstructure of Geo polymer coated RAC -10F sample before exposing to 800°C temperature

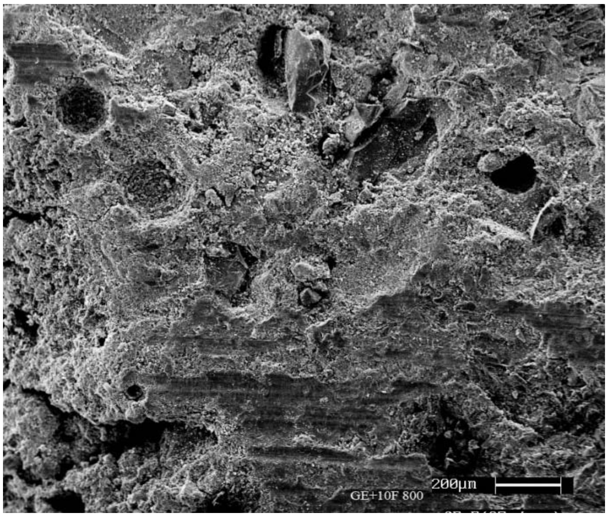

Fig 8 : Microstructure of Geo polymer coated RAC -10F sample after exposing to 800°C temperature

IV. Conclusion

Based on test results the following conclusions can be drawn:

1. In general NAC sample performs better than RAC sample with coated or uncoated recycled aggregate, including samples exposed to elevated temperature.
2. Geopolymer coated recycled aggregate concrete showed higher compressive strength (when exposed to different elevated temperature) compared to uncoated recycled aggregate concrete and also cement coated recycled aggregate concrete.
3. Partial replacement of cement by fly ash (10%) in case of coated recycled aggregate concrete showed higher strength compare to coated recycled aggregate concrete without fly ash.
4. Porosity of geopolymer coated recycled aggregate concrete (without flyash) after exposing to elevated temperature is 23% less than that of uncoated recycled aggregate concrete (with flyash) exposed to same temperature level.
5. Compressive strength of RAC with Geo polymer coated aggregate and cement coated aggregate at different level of temperature are comparable
6. Microstructure of geopolymer coated recycled aggregate concrete with fly ash is denser than uncoated recycled aggregate concrete with fly ash at unheated and heated condition.

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Water Resources Assessment of the Manya Krobo District

By F. K.Y. Amevenku, B. K. K ortatsi & G. K . Anornu
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Abstract - The study on water resources assessment carried out in the Upper Manya Krobo district of the Eastern region, Ghana with the sole objective of identifying feasible options for water supply augmentation to communities in the district. The methodology consisted of inventory of boreholes and hand dug wells, rivers, streams, pipe schemes. Surveys conducted on the hydrogeology, geomorphology and buildings (roof) to determine the prospect of constructing underground dams and rain harvesting schemes. Interviews as well as sampling of groundwater and laboratory measurements determined the quality status of groundwater. Also carried out was limited pumping test. The results showed that groundwater potential is generally low. Borehole yield varies from 0.48 m^3h^{-1} to 12.00 m^3h^{-1} with mean of 3.4 m^3h^{-1} and standard deviation of 2.97 respectively.

Keywords : *Ghana, Groundwater, Rain harvesting, underground dams, Upper Manya District.*

GJRE-E Classification : *FOR Code: 090509*

WATER RESOURCES ASSESSMENT OF THE MANYA KROBO DISTRICT

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F. K.Y. Amevenku[α] B. K. K ortatsi[α] & G. K . Anornu[σ]

Abstract - The study on water resources assessment carried out in the Upper Manya Krobo district of the Eastern region, Ghana with the sole objective of identifying feasible options for water supply augmentation to communities in the district. The methodology consisted of inventory of boreholes and hand dug wells, rivers, streams, pipe schemes. Surveys conducted on the hydrogeology, geomorphology and buildings (roof) to determine the prospect of constructing underground dams and rain harvesting schemes. Interviews as well as sampling of groundwater and laboratory measurements determined the quality status of groundwater. Also carried out was limited pumping test. The results showed that groundwater potential is generally low. Borehole yield varies from 0.48 m^3h^{-1} to 12.00 m^3h^{-1} with mean of 3.4 m^3h^{-1} and standard deviation of 2.97 respectively. Generally, the southern half of the district seems to have relatively higher yields than the northern half. Except for the high iron concentration, which is mostly outside the WHO (2006) guideline values, other chemical constituents were generally low and within the WHO (2004), guideline limits. The potential for rain harvesting is high, however, in a few communities; sheds would need to be provided for the dual purposes of school, community centre, etc on one hand and rain harvesting system on the other. The geology and geomorphology of the district are suitable for underground dam construction, however, more detailed hydrogeological investigations are required prior to construction.

Keywords : Ghana, Groundwater, Rain harvesting, underground dams, Upper Manya District.

I. Introduction

Upper Manya Krobo district is one of the districts that benefited from the District Based Water and Sanitation Component (DBWSC) of the Water and Sanitation Sector Programme Support (WSSPS) Phase II in the Eastern Region. It has been implemented with Community Water and Sanitation Agency, Eastern Region Office, as the facilitators. During the implementation of the programme in the districts, some challenges were observed to be militating against the success of the programme. These included low success rate, low yield and poor water quality. These challenges prevented the achievements of the expected targets of water delivery and coverage in the district, which according to the Millennium Development Goals, should reach at least 75 % by 2015. Currently, about 52 % of communities have access to potable water supply in the whole of the Eastern Region. After much cogitation and deliberation, it was realized that most of the water supply projects in the Eastern Region were put in place without due reference to the source of supply and the amount of replenishment to the underlying groundwater reservoirs leading to low yields, water shortages and deterioration water quality. As a first step to address the challenges mentioned above, this research had the objective of water resource inventory and source identification for water supply to communities in the Upper Manya Krobo district.

II. The Study Area

The Upper Manya Krobo district is located to the East of Ghana between latitude 6.17°N and 6.55°N and longitude 0.10°W and 0.33°W. Figure 1 presents the location map of the study area. The geomorphology consists of undulating topography with alternating series of ridges and valleys. The ridges attained elevations between 350 m and 600 m, mostly separated by long narrow strike valleys in which small streams flow for most parts of the year. The district falls under the Equatorial Climatic Zone. The climatic conditions of the area are, characterized by high temperatures, ranging from 26° C in August to about 32° C in March. The area has two rainfall regimes, with the first rainy season starting from May and ends in July with heaviest rainfall occurring in June. The second rainy season starts from September and ends in October or early November. The annual rainfall varies between 1200 mm and 1450 mm with a mean value of 1250 mm (Benneh and Dickson, 2004; WARM, 1998). Relative humidity is generally high throughout the year.

a) Size and distribution of population

The population of the district according to the 2000 population and housing census was 18,741. Out of this, 9,400 were females and 9,341 were males. With a growth rate of 2.5%, the estimated population of the district stood as 25,205 as at the end of the year 2012.

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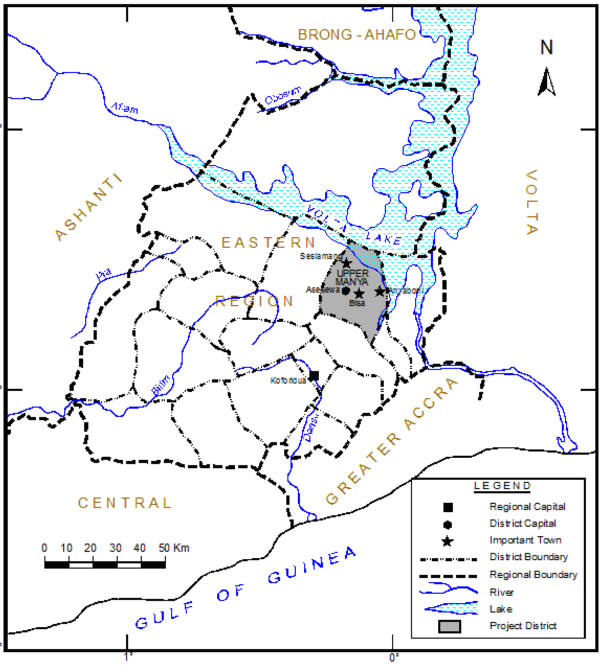

Fig. 1 : Location map of the Upper Manya District

b) Land use and socioeconomic issues

The major economic activity in the district is rain fed agriculture using the slash and burn method. Also, petty trading and small-scale industry for dehydrating cassava dough and extracting palm kernel oil form part of the economic activities in the district. Food crops like maize, cassava, plantain and vegetables are cultivated throughout the district. Livestock farming is undertaken at the household level. In communities along the Volta Lake, extensive fishing in the lake is their major occupation. As the effect of these activities on water resources intensified with increases in human and livestock populations, settlements, farming (using the "slash and burn" method and under shorter rotation periods), the use of agrochemicals, fishing and charcoal production more land is being used in the district.

c) Geological Setting

The Voltaian Formation mainly underlies the Upper Manya Krobo district as a sedimentary basin that has more or less concentric distribution of sediments because of its overall gently synclinal form (Wright *et al.* 1985). The sediments of the Voltaian system range in age from Upper Proterozoic to Paleozoic and include facies interpreted as products of two ancient glaciations, one in the infra-cambrian and the other in the Upper Ordovician (Wright *et al.*, 1985). The rocks are commonly flat-bedded with a mean dip of about 5° except at the eastern flank approximating a tectonic contact with the Buem Formation (Mason, 1963). The Voltaian System has three main divisions, which are the Lower, Middle and Upper Voltaian units (Junner and Hirst, 1946; Grant, 1967; Annan Yorke and Cudjoe, 1971; Affaton *et al.*, 1980). Nonetheless, the predominate rock that has underlain the Upper Manya Krobo district is Upper Voltaian unit. The sediments, probably typify mosassic deposit that accompanied the uplift in the Pan African event (Grant, 1967). The sediments consist primarily of sandstones and conglomerates that contain pebbles of granite and other igneous rocks and quartzite fragments. The sandstones weather mainly to sandy clay and fine sand in the numerous valleys. The Obosum and Oti Beds form only 2% of the total rock cover of the Upper Manya district and occur as discontinuous unit along the bank of the Volta Lake (Fig. 2).

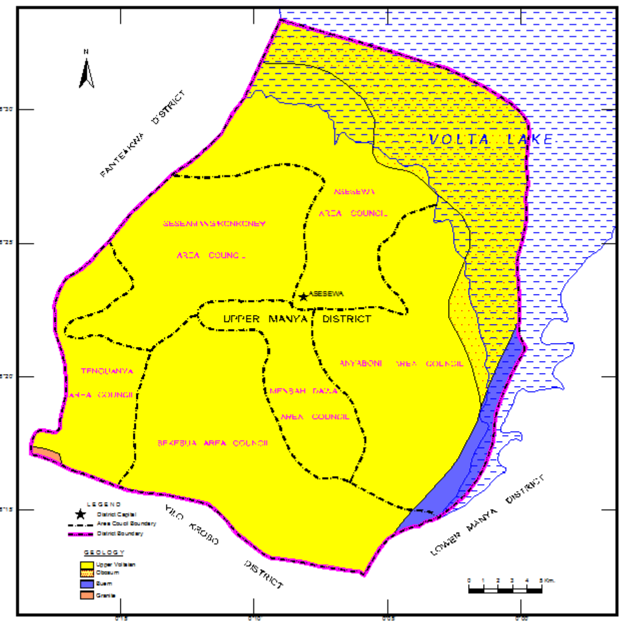

Fig. 2 : Geological map of the Upper Manya Krobo District

III. Materials And Methodology

The methodology considered was principally made of desk study, interviews, field measurement, laboratory analyses, map preparation and reporting.

The desk study involved re-evaluation of relevant literature notably hydrogeological and hydrological reports; geological and topographic maps, drilling logs and borehole records. Borehole records and hydrogeological information were collected from Water Research Institute (WRI), Community Water and Sanitation Agency (CWSA), the Adventist Development and Relief Agency (ADRA). Hydro meteorological and hydrological data were collected from Ghana Meteorological Services Agency (GMSA) and Hydrological Services Department (HSD) of the Ministry of Water Resources, Works and Housing respectively.

Hydrometeorological data (rainfall and temperature) were obtained for two (2) meteorological stations (Anyaboni and Asesewa) in the study area. The Upper Manya Krobo District Assembly provided data on the water resources and environmental plan for the district. All the information gathered were collated, analysed and presented as the background of the study area. Additionally, field data sheets were designed based on information gathered from the desk study to obtain further primary data.

Field Reconnaissance survey was carried out in the entire district between September 8th and 25th, 2008 and 248 boreholes, 24 hand-dug wells and 41ephemeral streams were inventoried. Survey of roofs was also carried out in 42 communities in the district, which had low groundwater and surface water potentials to determine the suitability of the roofs for rain harvesting and the volume of rain water that each roof could harvest annually. Interviews were also conducted on a sample of the communities with regards to the adequacy of water supply, water quality problems, sanitation facilities etc. The field work also involved careful ground observations to delineate areas, which by their geological history and geomorphology could be suitable for underground dam construction. Based on the results of the desk study and field reconnaissance survey, 13 boreholes were sampled for water quality of which 2 of them were pump tested to ascertain their yields and analysis carried out using Jacob Cooper methodology.

The boreholes sampled were randomly selected and distributed in such a way that they represented the whole district. Sampling protocols described by Claasen (1982) and Barcelona *et al*. (1985) for chemical water quality determination were strictly adhered to during the sample collection. Samples collected into 4:1 acid-washed polypropylene containers after three-pore volumes purge. Each sample meant for trace metal determination immediately filtered on site through 0.45 μm pore size on acetate cellulose filters. The filtrate transferred into 100 cm^3 polyethylene bottles and immediately acidified to pH < 2 by the addition of Merck™ ultra pure nitric acid. Samples for anions analyses collected into 250 cm^3 polyethylene bottles without preservation. All samples were stored in an ice-chest at a temperature of < 4°C and transported to the Potable Water Quality Laboratory of the Water Research Institute in Accra for analyses, which was carried out within three days.

Temperature, pH and electrical conductivity were measured *'in situ'* using WTW-Multiline P4 Universal Meter. Chemical analyses of the samples were carried out using appropriate certified and acceptable international standard methods (APHA, 1998; Global Environmental Monitoring System/Water Operational Guide, 1988). An ionic balance was computed for each chemical sample and used as a basis for checking analytical results. In accordance with international standards, results with ionic balance error greater that 5% were rejected (Freeze & Cherry, 1997; Appelo & Postma, 1999).

IV. Results And Discussions

a) Groundwater Resources Evaluation

Data on 248 boreholes, 24 hand-dug wells in the district were collected and analysed, and results revealed complex hydrogeological conditions. Much of the primary porosity of the bedrocks in the Upper Voltaian formation has been destroyed due to consolidation and cementation (Kesse, 1985). The formation, therefore, have very little intergranular pore-space and are thus characterized by insignificant primary porosity and permeability. The rocks however, are fractured and weathered as they occur close to the surface. Cavities along joints, bedding and cleavage planes frequently act as channels for groundwater transmission and storage. Where these fissures are prevalent, incessant, interconnected and/or filled with permeable material, percolation and circulation of significant quantity of water do occur.

The pumping test analysis indicated that the trend lines of most of the field data cut below the zero on the residual drawdown axes (Fig. 3) suggesting that the aquifers are generally discrete and limited in extent. Depth to water varied throughout the district but was generally shallow, ranging from 0.5 m to 18.3 m with mean and median values of 6.4 m and 4.2 m respectively. The depth of boreholes varied from 22 m to 84 m with mean and median values of 35 m and 25 m respectively. Data on potentiometric heads indicate that the potentiometric surface resembles that of the land surface elevation. Groundwater generally occurs under semi-confined conditions, but confined conditions also exist at a few places. Static water levels (SWL) ranged from 1.0 m to 20 m below the land surface. Transmissivities values were between 0.3 and 70.0 m^2d^{-1}. This range is consistent with transmissivity values obtained in similar geological formation in the Afram Plains (Buckley, 1986; Minor *et al*., 1995). Estimated well yields range from 0.25 to 12.00 $m^3 h^{-1}$ with mean 3.2 $m^3 h^{-1}$ and standard deviation 3.5 respectively. The median yield is 1.6. $m^3 h^{-1}$. The histogram in Fig. 4 shows that the yields of the boreholes were discontinuous and not normally distributed. In such situations, non-parametric statistics needs to be applied (UNESCO/WHO/UNEP, 1996; Caritat, 1998). Therefore, the use of the median is more robust than the mean in describing the central tendency of the yield distribution (Caritat, 1998). The low median value, suggests that generally the yields of majority of boreholes in the Upper Manya Krobo district are low. Nonetheless, boreholes are apparently higher yielding and more numerous in the areas underlain by the Upper Voltaian than those of the Obosum and Oti beds areas. Spatially, relatively higher yields were obtained in the southern half of the district than in the northern half.

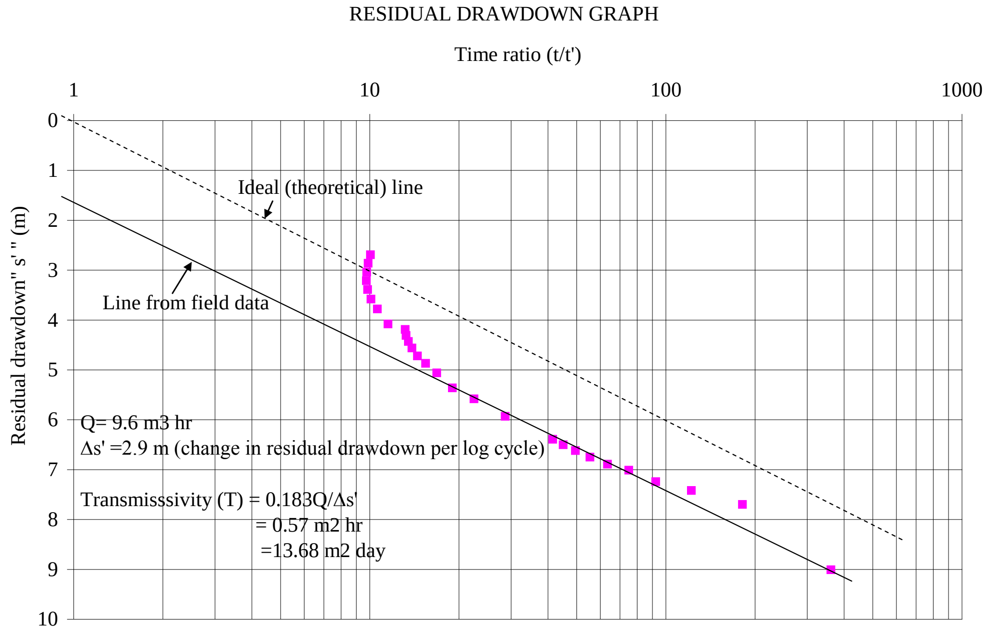

Fig. 3 : Pumping test analysis using Cooper-Jacob time-drawdown and residual drawdown methods.

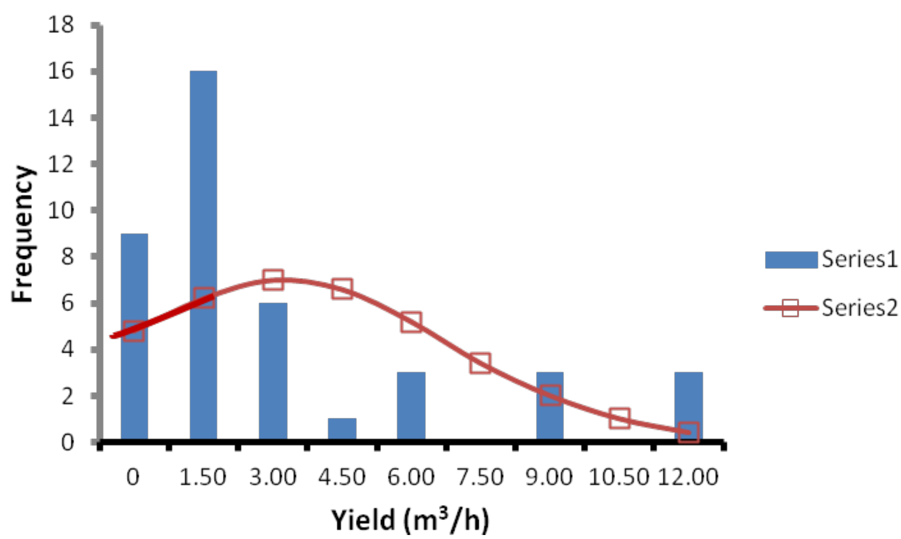

Fig. 4 : Frequency distribution of yield within the Upper Manya Krobo District

b) Hydrochemistry of groundwater in Upper Manya district

The results and the summary statistics of the physico-chemical parameters and chemical constituents in groundwater in the Upper Manya District (Tables 1 & 2 respectively) are mostly non-parametric (UNESCO/WHO/UNEP, 1996; Caritat, 1998). It is, therefore, more useful to use the median (non-parametric statistics) instead of the mean.

Groundwater temperature in the district ranged from 26.4°C to 30.0°C with a median of 27.6°C (Tables 1 & 2). The groundwater was slightly acidic with pH in the range 5.5-7.0 pH units with median 6.3 pH units (Tables 1 & 2) as compared to natural water pH range of 4.5-9.0 pH units (Langmuir, 1995). EC levels varied from 76 μS cm^{-1} to 1198 μS cm^{-1}, with median 240 μS cm^{-1}. Groundwater in the district was relatively turbid with turbidity values ranging from 0.2 to 68 NTU and a mean value of 13 NTU. The alkalinity of the groundwater values varied largely ranging from 6.0 mg/l^{1} to 432 mg/l^{1}, with a mean value of 114.6 mg/l^{1}.

Table 1 : Results of the physico-chemical parameters and constituents in groundwater in the Upper Manya District.

Community	Sampled ID	Temp	pH	Cond	TDS	Turb.	Tot.alk	Hard	Ca	Cl	NO_3	PO_4	SO_4	Na	K	F	HCO_3	Mg	Mn	Fe	Zn
Akatawiah	UM1	27.6	6.6	440	242	-	160	164	30.5	31	1.37	0.94	27.1	19	8.5	<0.005	195	21.3	0.64	4.68	0.010
Agome Bisa	UM2	27.8	5.7	127	69.9	0.3	18.0	44.0	16.0	18	5.27	1.10	38.0	13	9.4	<0.005	22.0	1.0	0.017	0.011	0.019
Kabu	UM3	27.5	5.8	136	74.8	6.8	18.0	25.0	8.8	21	7.78	1.72	18.8	16	5.3	<0.005	22.0	0.7	0.072	0.358	0.021
New Anyaboni Quarters	UM4	27.3	5.9	678	373	68	150	240	68.2	45	1.68	1.48	42.1	14	5.8	<0.005	183	16.9	0.617	5.23	0.005
Kwabia Asaasehene	UM5	28.5	7.0	1198	659	0.2	432	560	120	114	1.03	1.56	35.6	35	5.9	<0.005	527	63.2	0.279	0.047	<0.005
Seseame Sisi	UM6	28.0	5.6	164	90.2	12	22.0	30.0	8.8	28	2.79	1.57	20.7	16	11	<0.005	26.8	1.9	0.212	0.285	0.042
Akateng Manya	UM7	30.0	5.5	76	41.8	2.3	6.0	48.0	16.4	17	1.83	3.38	17.4	1.8	0.8	<0.005	7.3	1.7	0.043	0.113	0.019
Akrusu Saisi	UM8	28.6	6.9	930	512	3.5	252	332	97.0	87	0.741	1.60	37.3	50.5	6.9	<0.005	307	21.7	0.579	0.298	<0.005
Abrese Akwenor	UM9	27.2	6.9	438	241	6.2	182	116	29.7	21	1.03	1.72	19.0	57	13	<0.005	222	10.1	0.408	0.870	<0.005
Brepon Kpeti	UM10	27.3	5.5	135	74.3	0.5	6.0	16.0	4.0	21	8.89	0.800	35.3	22.2	7.8	<0.005	7.3	1.5	0.108	0.113	0.005
Dawatrim	UM11	27.5	6.6	406	223	4.7	128	146	33.7	27	1.06	0.780	47.3	29	4.4	<0.005	156	15.0	0.578	1.09	<0.005
Takorase	UM12	26.4	6.3	226	124	44	40.0	68.0	11.2	11	1.00	1.57	54.5	17	4.9	<0.005	48.8	9.7	0.376	3.45	<0.005
Agbletsom	UM13	27.6	6.5	240	132	7.1	76.0	72.0	20.8	9.9	1.00	1.85	26.4	19	3.2	<0.005	92.7	4.9	0.332	0.543	0.005

Table 2 : Statistical summary of chemical parameters and constituents of groundwater in the Upper Manya Krobo district compared with the limits recommended for drinking water.

Parameter	Upper Manya Range	Mean	Median	WHO (2006) Guideline	GCWL Guideline
Temperature	26.4 – 30.0	27.8	27.6		
*p*H-unit	5.5 - 7.0	6.2	6.3	6.5-8.5	6.5 - 8.5
Conductivity	76 – 1198	400	240		
TDS	41.8 – 659	220	132	1000	1000
Turbidity	0.2 - 68.0	13.0	5.45	5.0	0-15.0
Total alkalinity	6.0 – 432	114.6	76		
Tot. Hardness	16 – 560	143	72		
TSS	1.0 - 41.0	15.7	10.2		
Cl^-	9.9 – 114	34.6	21	250	600
SO_4^{2-}	17.4 – 54.5	32.2	35.3	250	400
HCO_3^-	7.3 – 527.0	139.8	92.7		
NO_2-N	0.041 - 0.145	0 .073	0.070	0.3	
NO_3-N	0.74 - 8.89	2.73	1.37	10	10
PO_4^{2-}	0.78 - 3.38	1.54	1.57		
Na^+	1.8 – 57	24	19	200	
K^+	0.8 - 12.5	6.63	5.9	30	
Ca^{2+}	4.0 – 120	35.8	20.8	200	
Mg^{2+}	0.7 - 63.2	13.1	9.7	150	
Fe^{2+} (Total)	0.011 - 5.23	1.314	0.358	0.3	0.3
Mn^{2+}	0.017 - 0.64	0.328	0.332	0.5 (P)	
Zn	0.005-0.042	0.016	0.005		
F^-	Below detection	Below detection	Below detection	1.5	1.5

c) *Hydrochemical facies*

The chemical trend of groundwater in the Upper Manya Krobo district was derived using the Piper trilinear diagrams (Piper, 1944). Four main water types (labelled A-D) characterized the district. In the first type (**A**), alkaline earth and weak acids, dominate the chemical properties of the groundwater, that is the groundwater consists mainly of low salinity calcium bicarbonate ($Ca(HCO_3)_2$). This water type designated (A) occurs principally at Agbetsom, Akatawiah, Akusu Saisa, Dawatrim, Kwabia Asaasehene and New Anyaboni Quarters. The second type (B and D) consists of mixed water type where no particular ion pair exceeds 50 %. This water type is found mainly at Takorase and Abrese Akwenor. Alkali and strong acids dominate the chemical properties of the third water type (C) that is, this water type has Na as the main cation and Cl or SO_4 as the principal anion and mainly found at Seseame Sisi, Agome Bisa, Brepon Kpeti and Kabu. In the fourth water type (E), non-carbonate hardness (permanent hardness) exceeds 50%. In other words, Mg^{2+} and Ca^{2+} are the main cations and SO_4^{2-} is the key anions, dominating the chemical properties of the water. This water type occurs principally at Akenteng Manya area.

d) *Quality of groundwater in the Upper Manya Krobo district*

Groundwater has good quality for domestic use if it is soft, low in total dissolved solids (TDS) and free from poisonous chemical constituents as well as bacteria (Karanth, 1994; Kortatsi *et al.*, 2008). The quality of groundwater in the Upper Manya district evaluated in terms of physico-chemical and bacteriological parameters would ascertain whether the water is soft, low in TDS, free from deleterious chemical constituents and bacteria.

Water is considered soft if the total hardness is between 0 -75 mg l^{-1} of $CaCO_3$; moderately hard if the total hardness is between 75-150 mg l^{-1} of $CaCO_3$, hard if the total hardness is between 150-300 mg l^{-1} of $CaCO_3$ and very hard if the total hardness is greater than 300 mg l^{-1} of $CaCO_3$. Total hardness values of the groundwater ranged from 16 mg l^{-1} to 560 mg l^{-1} of $CaCO_3$ with a median value of 143 mg l^{-1} of $CaCO_3$ suggesting that about half the boreholes are soft to moderately hard.

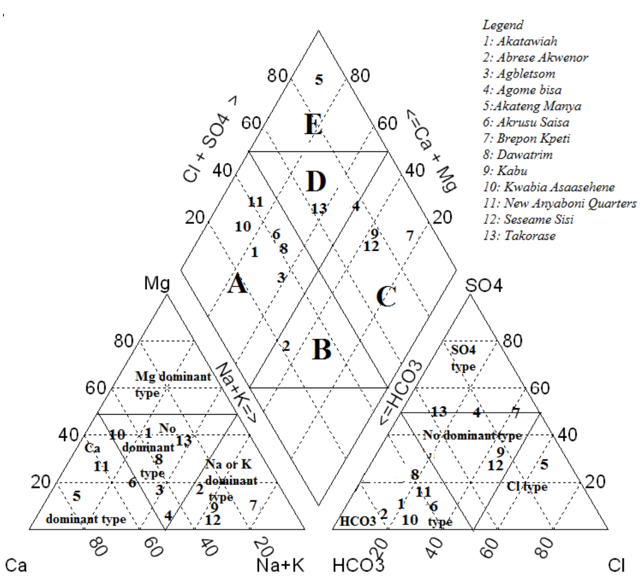

Fig. 5 : Piper (Trilinear) diagram of groundwater from Upper Manya Krobo District.

The TDS of the groundwater is in the range 41-659 mg l^{-1} with a median 132 mg l^{-1} while the WHO (2004) recommended upper limit for drinking water is 1000 mg l^{-1}. This implies that the water quality is good with respect to TDS. Similarly, all the major ions (calcium, magnesium, sodium, bicarbonate, sulphate, and chloride) are within the WHO (2004) limits for drinking water. Nitrate (NO_3-N) levels are generally low with values in the range 0.74- 8.89 mg l^{-1} and median 1.37 mg l^{-1} and, therefore, within the WHO guideline value of 10 mg l^{-1} (Table 2). Iron concentration in the groundwater in the district is relatively high. It is in the range 0.01- 5.23 mg l^{-1} with a median 0.36 mg l^{-1}. The WHO (2004) guideline value is 0.3 mg l^{-1}, suggesting that the majority of the well in the Manya Krobo district have iron problem. On the contrary, manganese (Mn^{2+}) concentration in the groundwater is generally low. Its range was 0.02 - 0.64 mg l^{-1}, with a median value of 0.33 mg l^{-1} as against the WHO (2004) provisional upper limit of 0.5 mg l^{-1} signifying that a larger proportion of the boreholes are potable with regards to Mn^{2+}.

The presence of high Fe^{2+} and Mn^{2+} concentrations in water do not particularly pose physiological problems. However, they have the ability of producing aesthetic or sensory effect due to discoloring of water, i.e. high Fe^{2+} concentrations results in reddish brown coloration, while high Mn^{2+} concentrations results in black coloration. These sensory effects can lead to the total rejection of the boreholes. It also results in staining of laundry and sanitary wares (WHO, 2004). Very distinct reddish brown coloration in water pertained in some abandoned boreholes in some communities during sampling period. The reddish colouration might probably have led to the abandonment of the boreholes. Other trace metals measured only have background concentrations. Bacteriological survey of boreholes in the Upper Manya district suggests that the boreholes are generally free from *E. coli* and total coli form but some hand-dug wells contain bacteria due to unhygienic conditions around the hand-dug wells (CSIR-WRI, 2009).

e) *Rainwater Harvesting*

Generally, rainwater harvesting requires simple arrangement to collect, store, treat and to distribute the captured rainwater. Rainwater offers additional advantages in water quality for domestic use. It is naturally soft (unlike well water), contains almost no dissolved minerals or salts, is free of chemical treatment, and is a relatively reliable source of water for households. Rainwater collected and used on site can supplement or replace other sources of household water. Rainwater can be drunk if properly stored and suitably treated.

f) *Availability of rain for collection (harvesting)*

The annual rainfall in the area is in the ranges 120-160 cm with a mean of about 130cm and median 125 cm (Dickson and Benneh, 2004). Fig.s 6. & 7. present the mean annual rainfall distributions for the respective stations. The data covered a period 1939-1996. The rainfall pattern is bimodal, with the major peak in June and minor peak in October. In August, there is a minor dry spell.

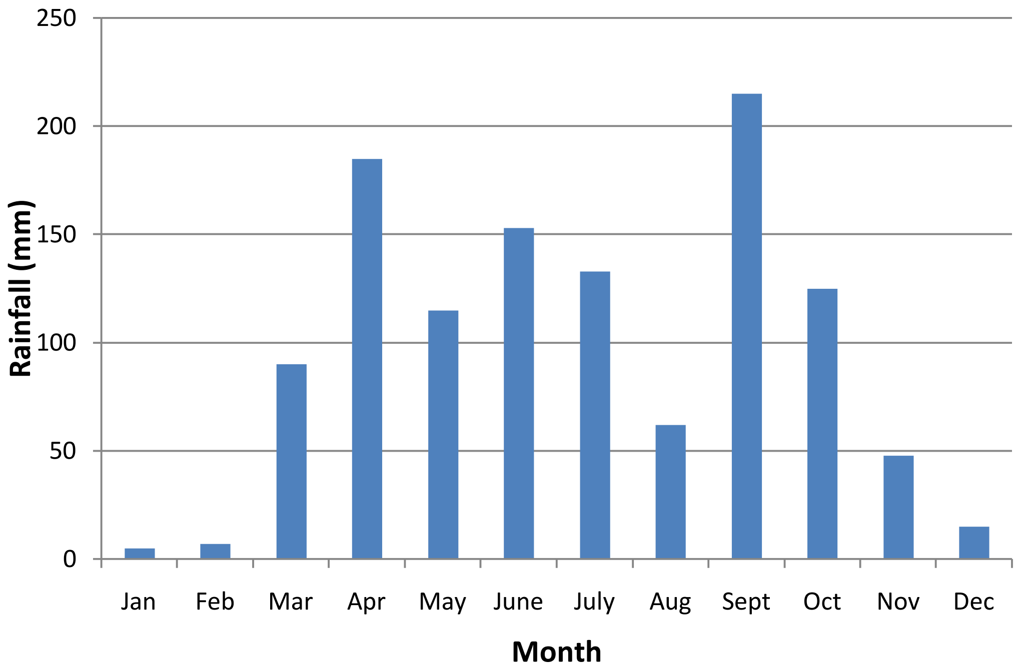

Fig. 6 : Mean monthly rainfall distribution pattern at Anyaboni.

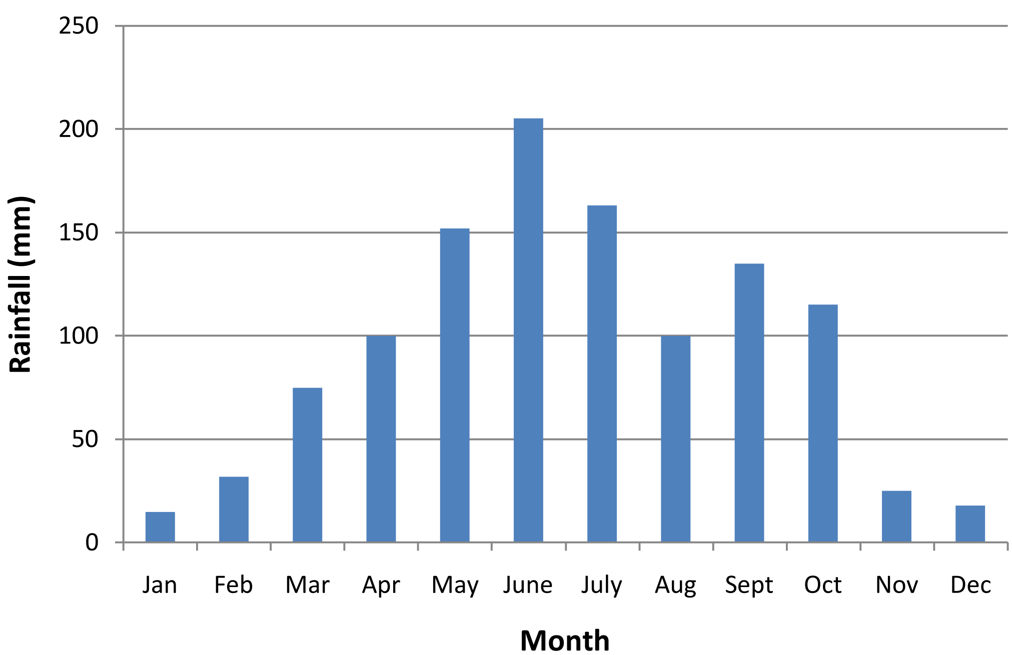

Fig. 7 : Mean monthly rainfall distribution pattern at Asesewa.

Assumption for computation of the volume of rainwater expected to harvest.

The following assumptions were made for the computation of the volume of water that can be harvested by buildings (roofs) currently available and the projected population that the rain harvested system can serve.

- Mean annual rainfall of 1.2 m;
- Rainfall available for harvesting is only 70 per cent of the mean annual precipitation since there are partial losses due to interception, evaporation etc.
- Daily per capita consumption of 25 litres;
- Duration of usage of 366 days;
- Average household size of 5 persons.

Using the criteria above the volume of rainwater likely to be harvested annually from metallic roofs, the average number of persons to be served by the expected harvested volume of water and the estimated average current population coverage of settlement within the various area councils have been computed and presented in Table 3.

Table 3 : Rain Water Potential of Selected Communities

Area Council	Average number of persons expected to be served by estimated harvested volume of water.	Average estimate of current population of the settlement
Anyaboni Bisa	464.26	379.75
Mensah Dawa	332.00	142.55
Sekesua	384.25	286.30
Konkoney Sisiamang	452.45	208.25
Ternguanya	655.20	357.70
Asesewa	204.11	284.20

The results indicate that the estimated annual harvested rainwater from approximately 43 major settlements within the Upper Manya district varies from 807.77 to 10,143.00 m^3. The results also suggest that 76.8 % or thirty three (33) of the settlements could harvest water to suffice the inhabitants with water for their daily needs annually. The remaining twelve (12) communities or 23.2 % had few metallic roofed buildings. In these poor communities, funds used for the search for groundwater and the drilling of unproductive boreholes can be channelled into the provision of sheds or pavilions, which can be utilised dually as community centres, schools etc. on one hand and rain harvesting system on the other hand. With such basic infrastructure provision, enough volume of water can be obtained to provide for the needs of these settlements. Another solution would be to utilise raw water from the Volta Lake for their requirements.

Problems that may militate against rain harvesting in the Upper Manya Krobo district.

Most buildings in Upper Manya Krobo district were unsuitable for rainwater harvesting. Structural modification of buildings particularly attaching a gutter system will be necessary to make them suitable for rainwater harvesting. The cost of such modification will be beyond the financial means of most families living in the district. Additionally, some villagers living in houses roofed with straws would probably not have the means and resources to adopt such rainwater harvesting technique.

The next problem is how to store rainwater for dry season. Currently, in the communities visited, storing rainwater in vessels for later use will be practically impossible, for it will require a large number of containers. Various techniques of water storage are available but the most feasible option is to build large underground concrete tanks. Again, investment cost for storage system can be prohibitive for most households in the district. Pollution may also be a major problem in spite of the fact that rainwater in rural areas as the Upper Manya district remote from atmospheric and industrial pollution is practically clean except for some dissolved gases it may pick up while it precipitates through the atmosphere. Rainwater often contains dissolvable atmospheric gases proportionate to their abundance. It also contains sediments, dust, bird droppings, aerosols, particulates, and anthropogenic gases that may result from biomass and fossil fuel burning. These are often the main sources of rainwater pollution. Since rainwater is not pure water, some precautions have to be observed before the water is consumed. Sediments removal and further water purification could be carried out by using slow sand filtration system with activated charcoal. Slow sand filter is low energy consuming process that has great adaptability in components and application; also, its maintenance requirement is minimal.

g) Underground dams

Underground dams (sand storage dam) construction is another option considered for the Upper Manya district. Underground dams can be constructed anywhere water resources are scarce and hydrogeological and geomorphological conditions are favourable (Onder and Yilmaz, 2005).

h) Criteria for underground dam site selection

The underground dam cannot be constructed just anywhere. The following appropriate conditions are necessary (dos Santos and Frangipani, 1978):

- An aquifer with high effective porosity, sufficient thickness and great areal extent;
- An impermeable bedrock layer under the aquifer;
- Sufficient groundwater inflow to the underground area;
- An underground valley where an underground barrier can be built.

i) Feasibility of Underground Dam construction in the Upper Manya District

The availability of numerous ephemeral springs and streams as well as the favourable geomorphology and geology satisfy the criteria for sand storage dam construction in the Upper Manya Krobo district. Therefore, in addition to rain harvesting system recommended for the Upper Manya district, construction of sand storage dam is also a feasible option for the district. However, there is the need to conduct more detailed hydrogeological and bacteriological investigations to determine the conditions that exist underground, the type of microbes that may be available in the stored water, nutrient levels and the types of microbes that exist underground to purify the water.

V. Conclusions

The option for water supply augmentation include the provision of additional boreholes, rain harvesting and sand storage (underground) dam construction. In spite of the fact that, groundwater potential is generally low in the Upper Manya district, intensive groundwater exploration in some localities particularly in the southern half of the district where boreholes are relatively higher yielding than the north should result in adequate yield for existing water supply augmentation. Generally, the quality of groundwater encountered is physiologically safe for drinking purposes. The only perennial yielding spring (Ternguanya), could be protected for supply of water to nearby settlements.

The potential exists for harvesting clean rain water in substantial quantities to supplement water supply from current sources. However, existing metallic roofs need modification for rain harvesting. In communities with thatch buildings, rain harvesting schemes can be effective when installed on institutional and church buildings in the rural communities. Individual household schemes with ferro-cement tanks may also be considered for rural communities with no other option for water supply. This is because the size of storage system required for using harvested rainfall to meet the full demand of an average rural community may be too prohibitive and not cost-effective.

Detailed designs, especially of receptacles and storage facilities are required to plan for an effective programme to pursue this option; while educational programmes to reawaken the populace on the importance and benefits of harvesting rain water at the local level; is required.

The geology and geomorphology of this district are apparently suitable for under ground dam construction. However, more detailed hydrogeological investigations are required prior to construction.

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Analysis of Pile Capacity of In-Situ Piles In Homogeneous Sandy Soil Using Empirical and Analytical Approaches

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Keywords : Bearing capacity of piles, bored and cast in hole(BCIH), static analysis, in situ analysis, non cohesive soils.

GJRE-E Classification : FOR Code: 090501

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Strictly as per the compliance and regulations of:

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Abstract - The use of static analysis and in situ methods were adopted to evaluate the capacity of piles innon cohesive soils of a typical sedimentary formation. The piles were for a proposed five span five span bridge along road dualisation project traversing Northwestern and Northeastern Nigeria. The results shows that the bearing capacity of piles were higher by the static method than those evaluated by in situ techniques. Specifically, the capacity of piles ranges from 2829 – 12,147 kN and 2454 – 6009 kN for static analysis and in situ method respectively. The latter method has proved to be more reliable and shows more inherent agreement than the static method.

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I. Introduction

The determination of the load bearing capacity of piles entails a variety of procedures which can be either analytical or empirical. The former entails an evaluation of soil-pile interaction with several underlying assumptions while the latter is based on the use of results of in-situ tests and procedures. Dewi and Tjie-Liong as well as Basack (2008), Shoda et al (2007) and Moayed and Rabe (2008) have all given various approaches to analysis of bearing capacity based on the evaluation of soil properties viz their interaction with the piles.

Evaluation of bearing capacity of piles using data obtained from in-situ tests and procedures have been highlighted by Shariatnadari et al (2008). Sahedja (2011) used in-situ field test results, specifically penetration tests to estimate pile capacity.

This work attempts to compare the differences between bearing capacity of piles in homogenous, non-cohesuve soils evaluated by in-situ and analytic technique.

II. General Description Of The Study Area

The data used for this work were from deep soils investigations (DSI) conducted at a proposed 4-apan bridge along a dualisation road project traversing North west to North east Nigeria. The area lies within the region covered by extensive sedimentary formation. Specifically, it is made up of the keri-keri formation. This comprises of grits, sands and clays. The particular materials observed at the project location were primarily sands and silts up to the maximum depth explored (25 - 35m).

The road lies along latitude 10 – 11^{0}E and around longitude 11^{0}N

III. Materials And Methods

a) Field works

Field works was facilitated by drilling of five (5 Nos) boreholes between 25 – 35m depths along the proposed bridge axis. This was done with the use of hydraulic rotary drilling rig with the provision for conducting standard penetration tests (SPT). Sample, predominantly disturbed, were collected at 1.5m interval for index and strength property tests.

All field works were in accordance with ASTM D 2488, D420, D1586,-08a and BS 1377.

b) Laboratory Tests

Index and strength properties test were conducted on recovered samples from all the drilled holes. The specific tests include particle size distribution (PSD), atterberge limits, direct shear and consolidation. Laboratory test were conducted according to ASTM D 2488, and BS 1377.

c) Method of Pile Capacity Analysis

For the purpose of this work, two distinct methods have been adopted to analysed the bearing capacity of piles. These are static analysis method which entails the use of soil parameter deduced from laboratory test and insitu test result methods respectively there are five approaches to determine nature of bearing capacity of piles as reported by shariat madari et al (2008) viz:

1. Use of pile loading test data;
2. Dynamic analysis method based on wave equation analysis;
3. Pile during analysis (PDA);
4. Static analysis by the use of soil parameters
5. Use of insitu test results

Specifically the static analysis method used for this work is based on the analysis of the skin friction

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resistance of bored and cast in hole plate (BCIH) or replacement pile which is esto method from the relationship as given by Tomlison (2001) and Bowles (1997).

$$Q_s = K_s tan\emptyset \ldots\ldots\ldots 1$$

Where

$Q_s -$ skin frictional resistance in kN/m^2
$K_s -$ coefficient of lateral resistance
$\emptyset -$ angle of frictional resistance
$\gamma -$ unit weight of soil in kN/m^3

The total frictional resistance in kN is deduced by multiplying the result of equation 1 by the total shaft area.
The end resistance is given by

$$Q_b = CN_q \ldots\ldots\ldots 2$$

Where $Q_b -$ base resistance at pile tip
$C -$ undrained shear strength

The total end bearing is also deduced by multiplying equation 2 by the cross sectional area of the pile base.

A typical analysis of pile capacity using this method is given in Table 1 while the summary for all the tested points are given in Table 2.

The use of insitu test entails the application of the following relationship to evaluate pile capacity as given by Meyerhof (1956, 1976).

$$Q_b = P_b(40N)\, L_b/D \ldots\ldots\ldots 3$$

$$Q_s = 2N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

$$Q_u = Q_b + Q_s \ldots\ldots\ldots\ldots\ldots 5$$

Where $N -$
average SPT N_{30} values over the pile critical length
$D -$ Pile width or diameter

$L_b -$ Pile penetration depth into bearing stratum
$A_b -$ Area of thepile cross section

IV. Discussions

Varition of pile capacity with pile diameter, are shown in figs. 1-2, for static analysis method. These were deduced for various pile depth for 600 – 1300m pile diameters. These shows that pile capacity increases with increasing pile diameter for the different pile length. Obviously there was an observed increase in pile capacity with increase in pile length (viz25,30 and 35m).

These increase were observed for both pile capacity deduced by static analysis and for insitu methods. The variation in pile capacity for insitu analysis is also shown in Fig 3-7.

Comparative Analysis of in-situ and Static Analysis method shows that values from static analysis were considerably higher than the values deduced by in-situ techniques. These are depicted in Tables 2 and 3 and figs 8- 10.The values of pile capacity by static analysis ranges between 2829 – 12,147kN while for in-situ analysis the values are between 2454-6009kN.

The values of pile capacity by both static and insitu methods are closer at lower diameter and the difference increases with increase in pile diameter as depicted in figures 8 - 10. The difference also increases with increasing depth of boring as shown in the plots for various depths of boring.

V. Conclusion

The analysis of the capacity of pile for a proposed five span concrete bridge along a road dualization project in North east Nigeria. The piles were for the abutment and the piers of the proposed bridge. The capacity of piles were analysed by static analysis by using derived geotechnical parameters as well as insitu test results .The following conclusion were drawn there from:

1. The capacity of piles deducted by static analysis were higher than the values deduced by insitu test results;
2. The capacity of piles increase with pile length and diameter of piles
3. The capacity of piles range from 2829-12,147KN and 2454 – 6009KN for static analysis and in-situ test results method respectively.

The higher values of the piles capacity computed from static analysis are due to the values of laboratory parameters used. These are subject to errors and assumption as compared to the parameters applied in the in- situ technique.

The latter values (in-situ procedures) agrees with the results deduced by Shariatmadari et al for which it was demonstrated the pile capacity deduced by SPT N-value show more accuracy and less scatter than other methods.

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Boring No.	Pile Diameter (mm)	Total Pile Capacity (kN)		
		Pile Length (m)		
		35	30	25
BH1	600	5564.66	4163.14	2974.24
	900	8205.99	6103.71	4324.85
	1300	11,727.77	8691.13	6121.68
BH2	600	5510.54	4123.38	2949.62
	900	8124.81	6044.06	4283.43
	1300	11,610.50	8604.98	6061.85
BH3	600	5758.60	4305.63	3076.18
	900	8496.90	6317.44	4473.28
	1300	12147.97	8999.86	6336.07
BH4	600	5725.29	4281.15	3059.19
	900	8446.93	6280.73	4447.78
	1300	12075.79	8946.83	6299.24
BH5	600	5270.70	3950.10	2829.29
	900	7771.04	5784.15	4102.94
	1300	11095.51	8229.56	5801.14

Table 1: Total pile capacity for varying pile diameters (Static analysis)

Boring No.	Pile Diameter (mm)	Total Pile Capacity (kN)		
		Pile Length (m)		
		35	30	25
BH1	600	2850	2912	2912
	900	4148	4237	4237
	1300	5716	6009	6009
BH2	600	2454	2558	2642
	900	2571	3723	3844
	1300	5046	5280	5451
BH3	600	2683	2787	2829
	900	3904	4056	4116
	1300	5537	5752	5838
BH4	600	2621	2704	2746
	900	3814	3935	3995
	1300	5292	5580	5666
BH5	600	2704	2746	2787
	900	3935	3995	4036
	1300	5460	5666	5752

Table 2 : Total pile capacity for varying pile diameters (In situ analysis)

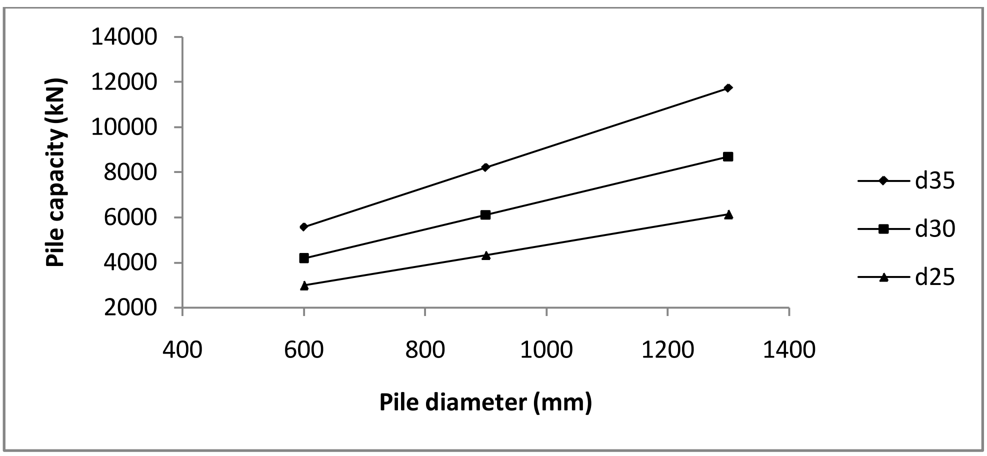

Fig. 1: Variation of Pile Capacity with Pile diameter for different pile depths – Static Analysis (BH1 –Abutment)

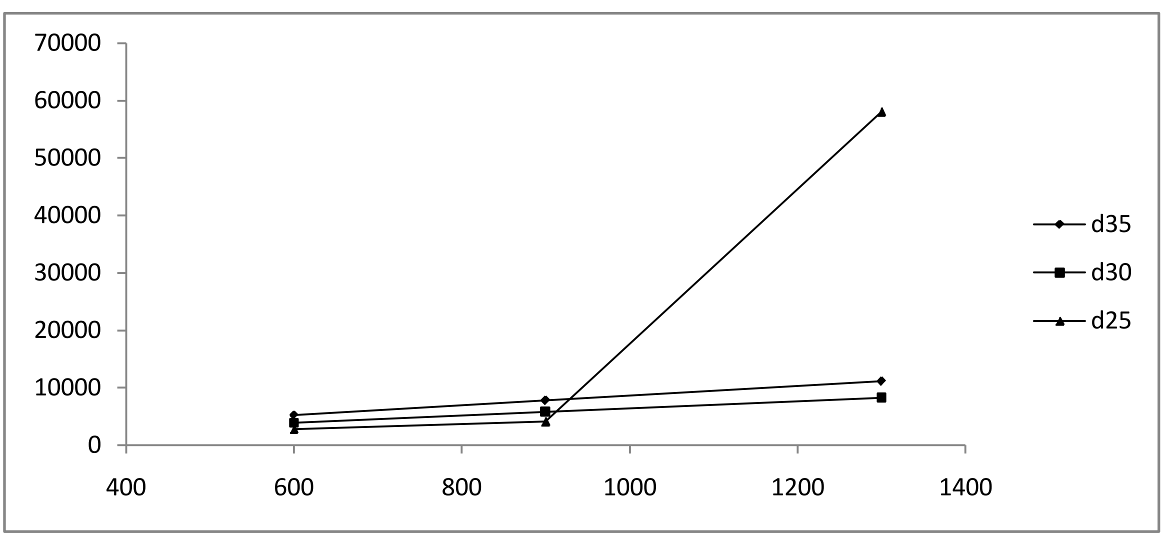

Fig. 2 : Variation of Pile Capacity with Pile diameter for different pile depths– Static Analysis (BH5 –Abutment)

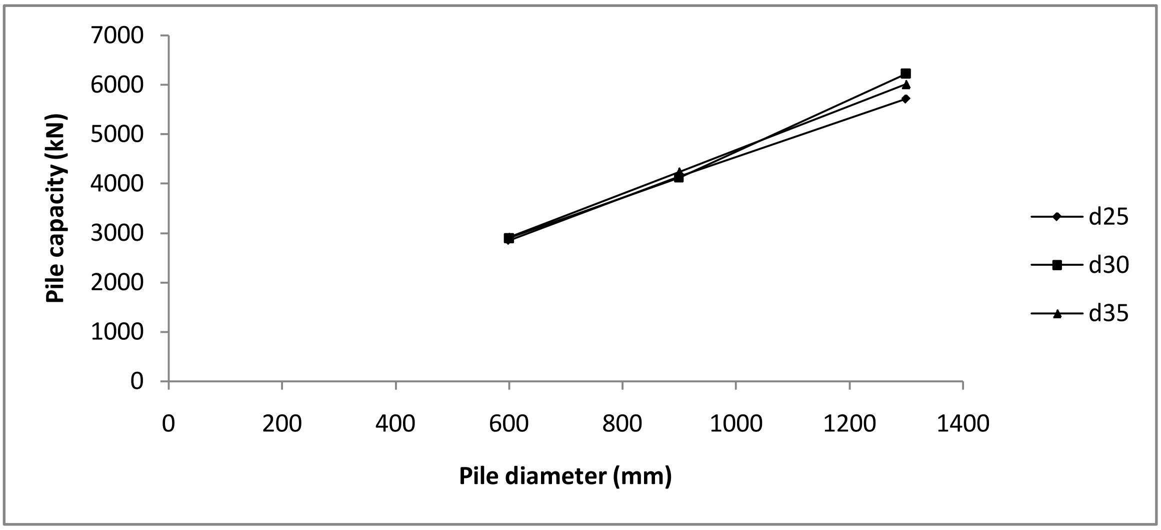

Fig. 3 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH1–Abutment)

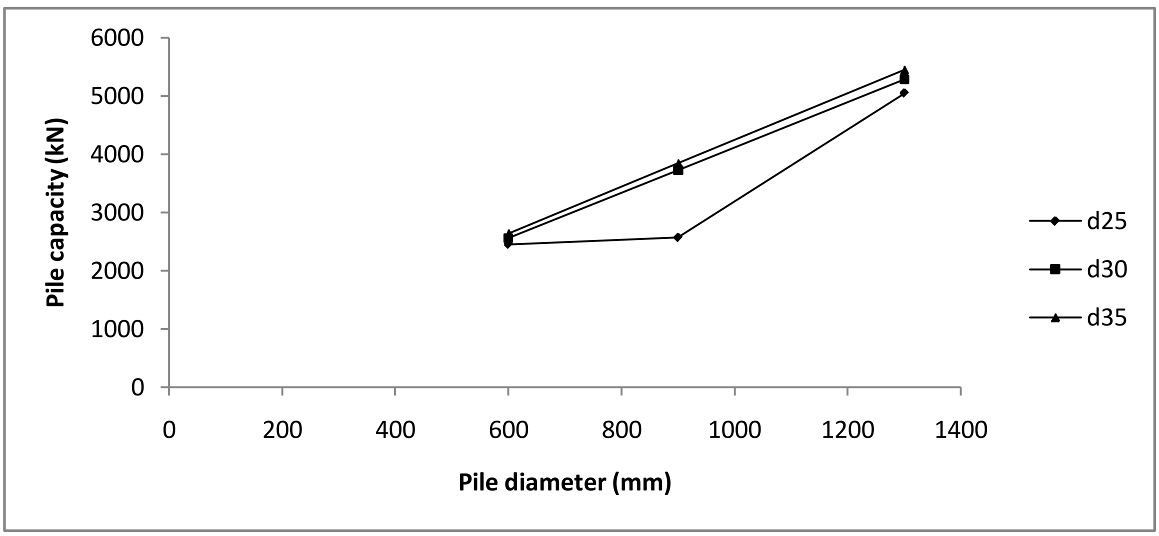

Fig. 4 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH2–Pier)

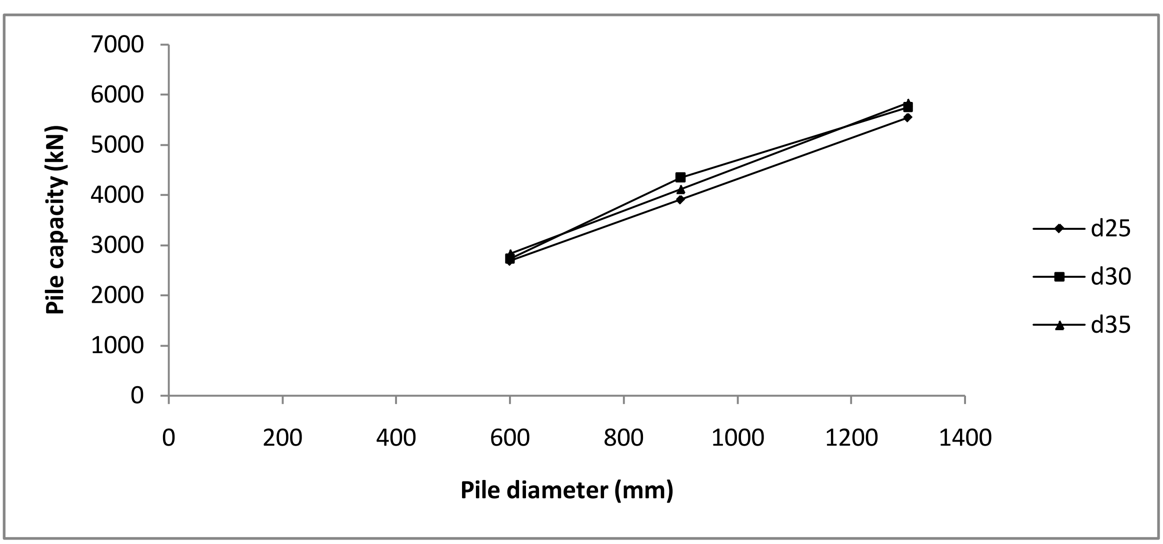

Fig. 5 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH3–Pier)

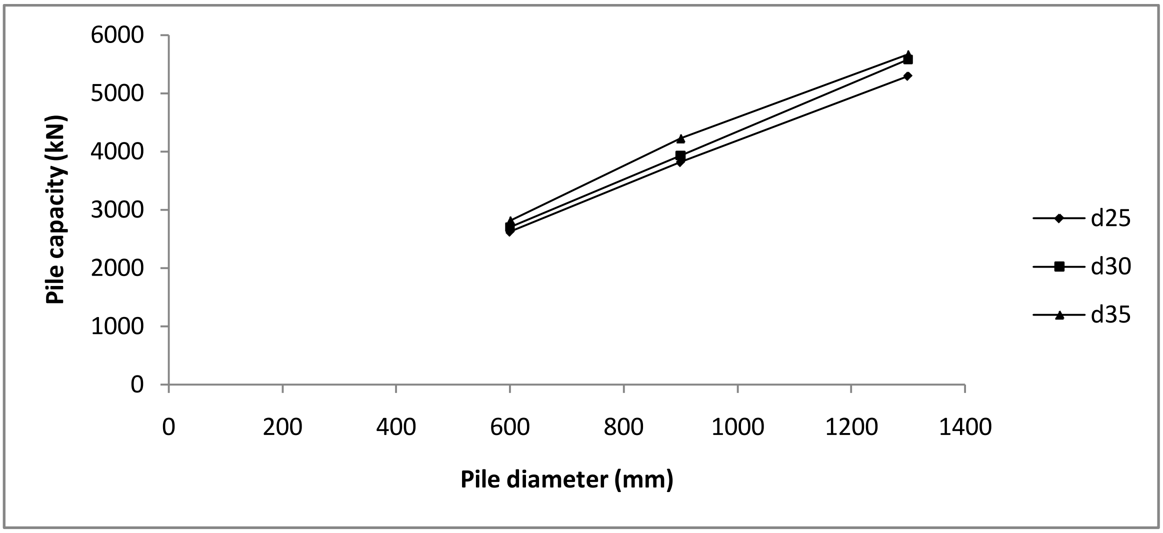

Fig. 6 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH4–Pier)

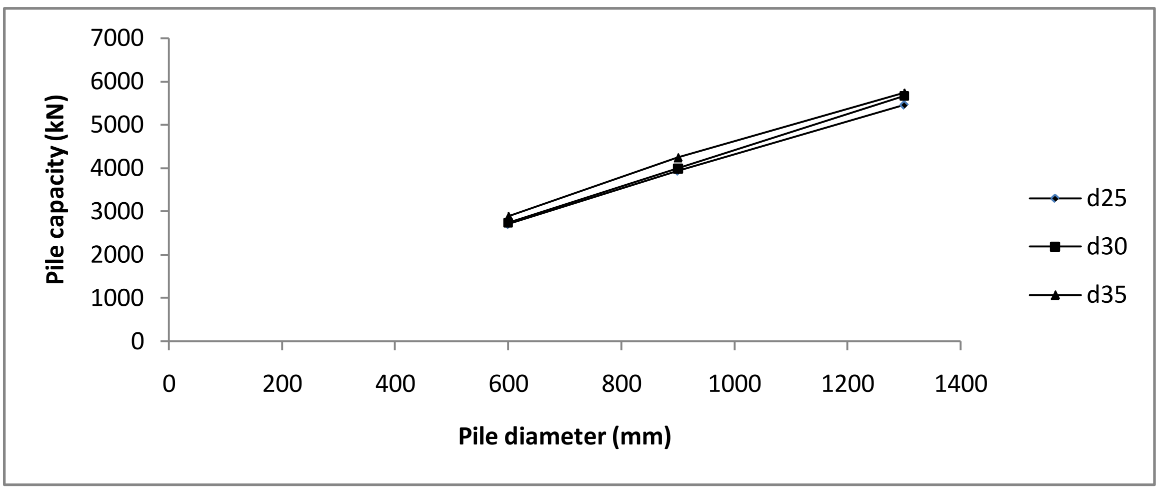

Fig. 7 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH5–Abutment)

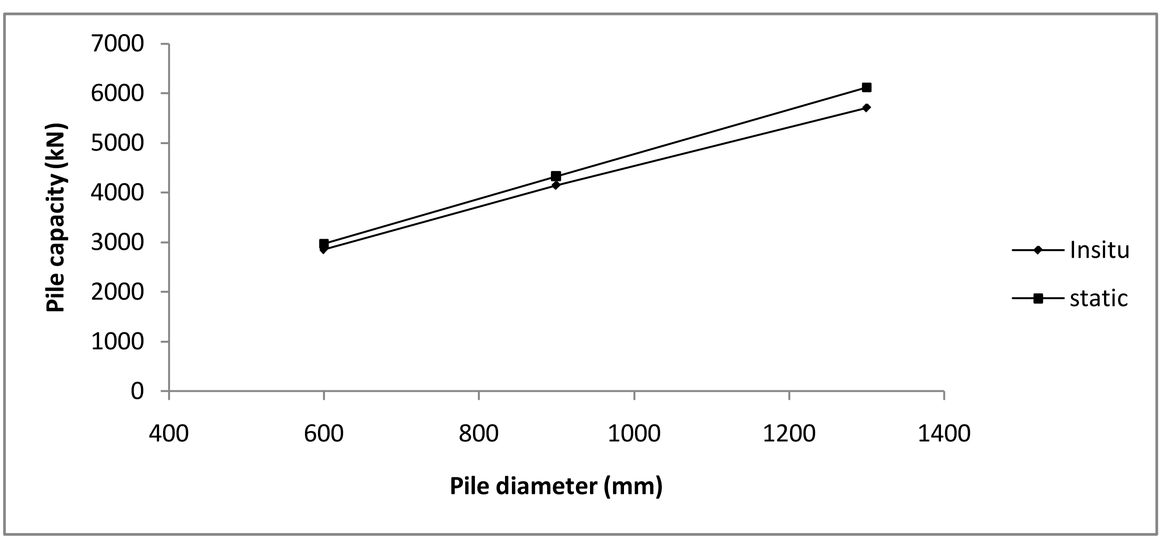

Fig. 8 : Plot of pile capacity by static analysis and In situ analysis for 25m depth

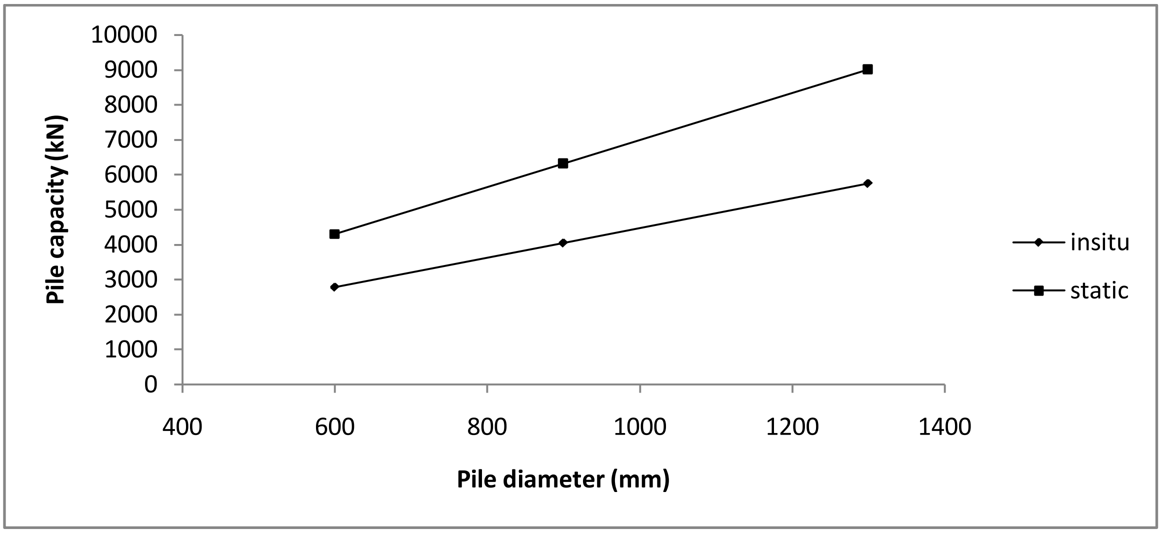

Fig. 9 : Plot of pile capacity by static analysis and In situ analysis for 30m depth

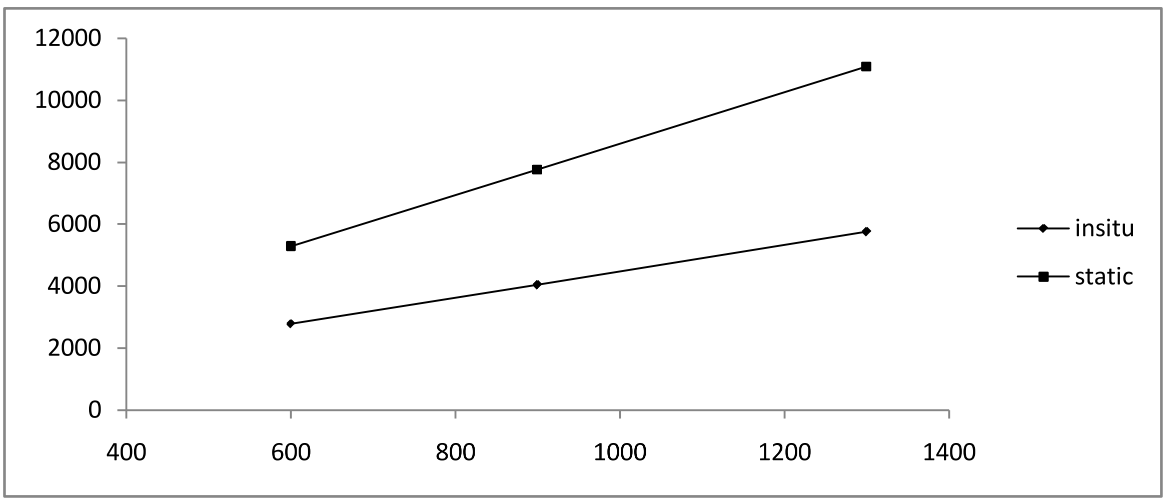

Fig. 10 : Plot of pile capacity by static analysis and In situ Analysis for 35m depth

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8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

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

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

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. 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 to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

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

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After 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 to 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 in 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 criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of 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 the 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 evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

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

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing 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 approach 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. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than 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 maintain the initial two items to no more than one ruling each.

- Reason of the study - 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 quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness 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 to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled 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 with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose 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 sound written Procedures segment allows a capable scientist to replacement 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 for the least amount of information that would permit another capable scientist to spare 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 object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text 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:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not 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 - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in 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 a 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. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise 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 in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to 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 part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a 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 implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly 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 with prospect, and let it drop at that.

- Make a decision if each premise is supported, 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 the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One 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 available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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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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