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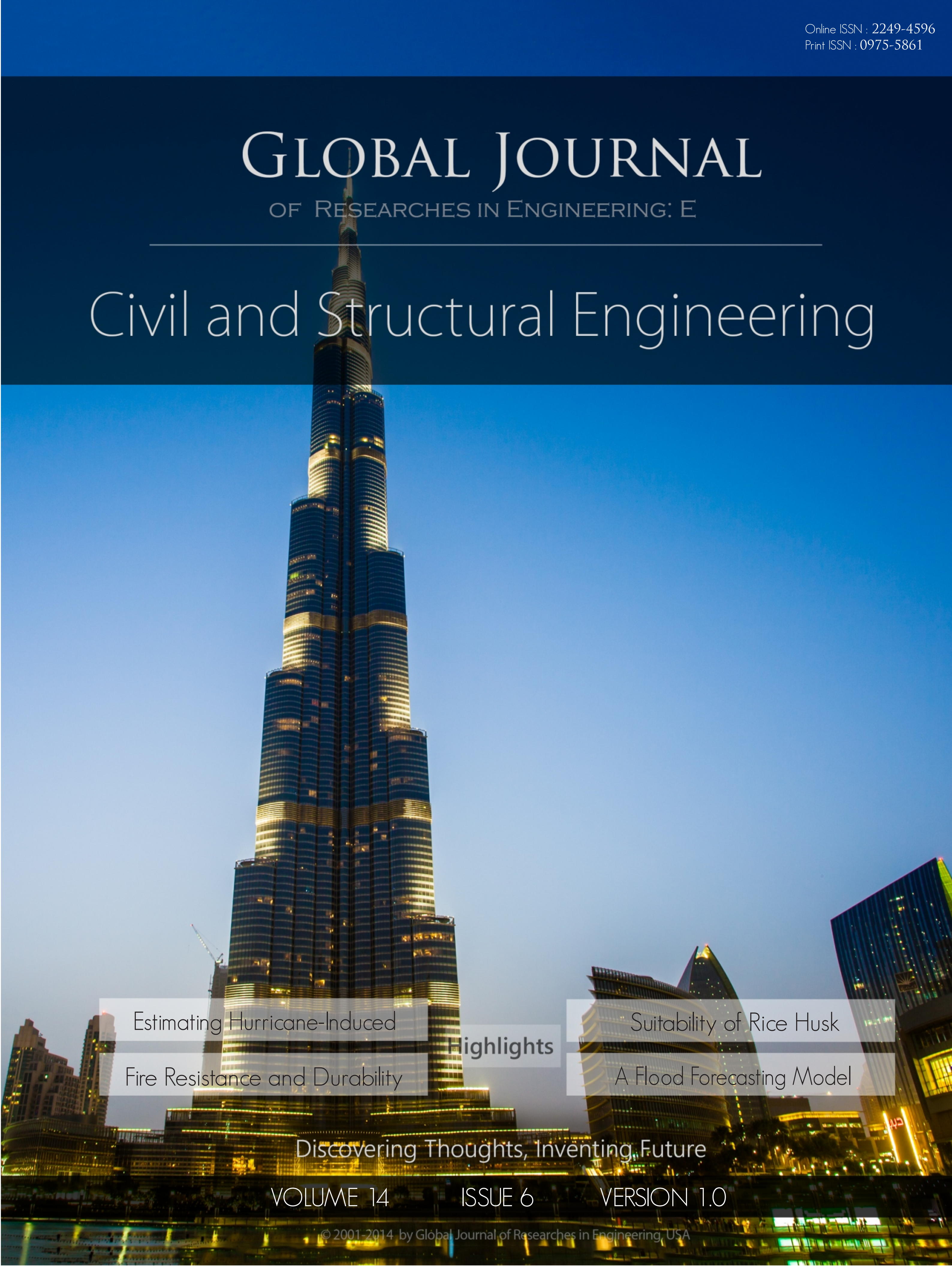

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- Estimating Hurricane-Induced
- Fire Resistance and Durability
- Suitability of Rice Husk
- A Flood Forecasting Model

Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 6 VERSION 1.0

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Behavior of I-Section GFRP Beam Including Retrofitting for Damage Effects

By Mamadou Konate & Zia Razzaq
Old Dominion University, United States

Abstract- This paper presents the outcome of a study of an I-section Glass Fiber Reinforced Polymer (GFRP) beam including retrofitting for damage effects. A total of three beam tests were conducted in the following sequence: GFRP beam with no retrofitting and a single mid-span web brace; the partially damaged (cracked) beam with GFRP plates used for retrofitting; and the retrofitted beam re-tested with the lateral brace at the top flange level. Both cracking and lateral-torsional buckling behavior is studied and experimental load-deflection relationships recorded. Using the mechanical properties of GFRP based on the experimental data, theoretical predictions are made for the buckling load values. The results show that retrofitted damaged beam provided about half of the original strength of the undamaged beam. The study also shows that the mid-span brace played a significant role in beam behavior and strength.

Keywords: I-section GFRP, retrofitting, lateral bracing.

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Mamadou Konate α & Zia Razzaq σ

Abstract- This paper presents the outcome of a study of an I-section Glass Fiber Reinforced Polymer (GFRP) beam including retrofitting for damage effects. A total of three beam tests were conducted in the following sequence: GFRP beam with no retrofitting and a single mid-span web brace; the partially damaged (cracked) beam with GFRP plates used for retrofitting; and the retrofitted beam re-tested with the lateral brace at the top flange level. Both cracking and lateral-torsional buckling behavior is studied and experimental load-deflection relationships recorded. Using the mechanical properties of GFRP based on the experimental data, theoretical predictions are made for the buckling load values. The results show that retrofitted damaged beam provided about half of the original strength of the undamaged beam. The study also shows that the mid-span brace played a significant role in beam behavior and strength.

Keywords: I-section GFRP, retrofitting, lateral bracing.

I. Introduction

Glass fiber reinforced polymer (GFRP) composites are increasingly been used for civil and mechanical structures. Under real-life use, situations can arise where a damaged GFRP structure needs to be retrofitted to restore all or a significant portion of its original strength. The damage could be a result of accidental overloading, misuse, or environmental conditions. A number of papers have previously been published about reinforced concrete structures retrofitted with GFRP composites [1, 4, 5, 11, 14]. This paper presents the outcome of a study of retrofitting a GFRP beam with GFRP plates.

a) Problem Statement

This investigation details an experimental and theoretical study of bending and lateral-torsional buckling of an I-section GFRP beam first loaded to its maximum load capacity, and then retrofitted with GFRP and re-tested. The beam has shear-type boundary conditions and mid-span lateral bracing. In each case, the beam is subjected to a gradually increasing mid-span load P until it reaches its maximum load-carrying capacity. The small moment resistance of the shear type steel end connections is considered to be negligible. The main objectives of this paper are to both experimentally and analytically investigate the cracking loads for a GFRP beam with and without GFRP retrofitting including lateral torsional buckling effects. Figure 1 shows the schematic of the GFRP beam of length L studied herein.

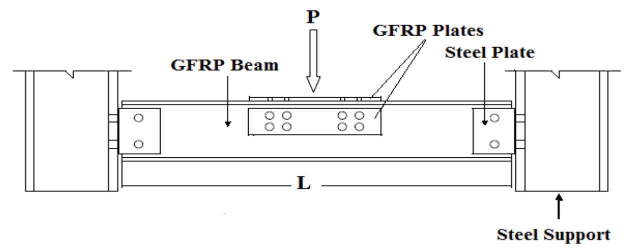

Fig. 1 : Schematic of GFRP beam

A three-fold problem has been studied in the present paper. First, the behavior of a GFRP beam with no retrofitting and a single mid-span web brace is studied. Next, the partially damaged beam with mid-span web brace is retrofitted with GFRP plates and its behavior observed. Lastly, the GFRP beam is re-tested, however with the mid-span brace provided at the top flange level. A comparison of the experimental peak loads is also made to those obtained with approximate analysis. Figure 2 shows the cross section with two alternative mid-span brace locations. Often one or more lateral braces are provided in order to increase the load-carrying capacity of a GFRP beam. The ultimate load is also influenced by whether a lateral brace is provided on the web or top flange. A comparison of the experimental peak loads is also made to those obtained with approximate analysis.

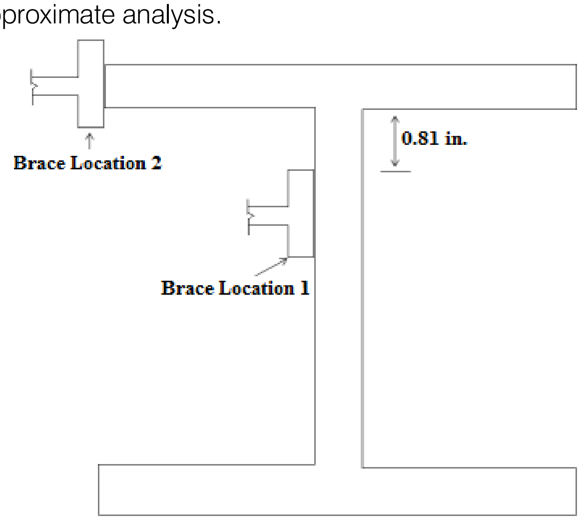

Fig. 2 : Cross section with alternative mid-span brace locations

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II. Experimental Investigation

Three experiments are conducted using a GFRP beam with a clear length of 93 inches. The damaged GFRP is retrofitted with GFRP in the last two experiments. The load-deflection curves and the peak loads are recorded. Figure 3 shows the experimental test setup. In this figure, a dial gage (DG4) is also shown which is used to record the mid-span vertical deflection. A total of seven dial gages were mounted to record both vertical and lateral deflections. A hydraulic jack of 50-kip capacity with load cell and a loading device are also shown in Figure 3.

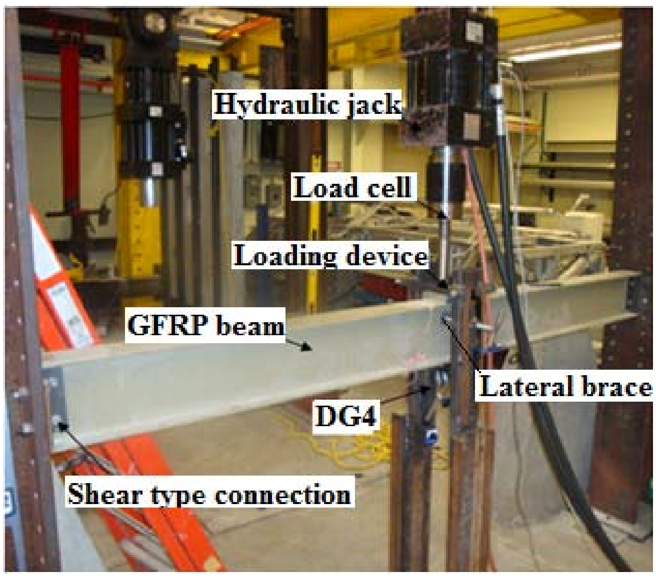


Fig. 3 : Experimental test setup

The hydraulic jack is controlled by the system console. This arrangement gradually transmits load from the hydraulic jack to the GFRP beam. The test procedure involved applying the load, P, in small increments and recording the resulting deflections. The loading process is continued until the member's load-carrying capacity is reached.

a) Beam with Mid-span Lateral Brace on Web

The mid-span web brace is provided on both sides of the web at 0.81 in below the bottom surface of the top flange. When approaching failure, the GFRP beam first buckled and then cracked. Figure 4 shows the view showing the top flange cracks and length of the GFRP beam. The buckling mode observed in the horizontal plane was S-shaped. The beam developed lateral-torsional buckling at a load of 8,426 lbs, and subsequently cracked at a load of 8,542 lbs. The beam exhibited elastic behavior up to the attainment of buckling load. Figure 5 shows the beam load-deflection curves of the GFRP beam for the lateral deflection (DG2) and the vertical deflection (DG3) both at the beam quarter length from the left support, and for the mid-span deflection (DG4).

Fig. 4 : Top flange GFRP beam cracking in Experiment 1

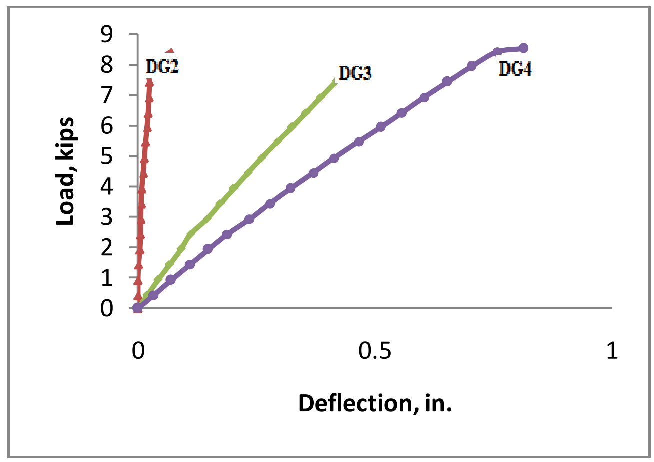
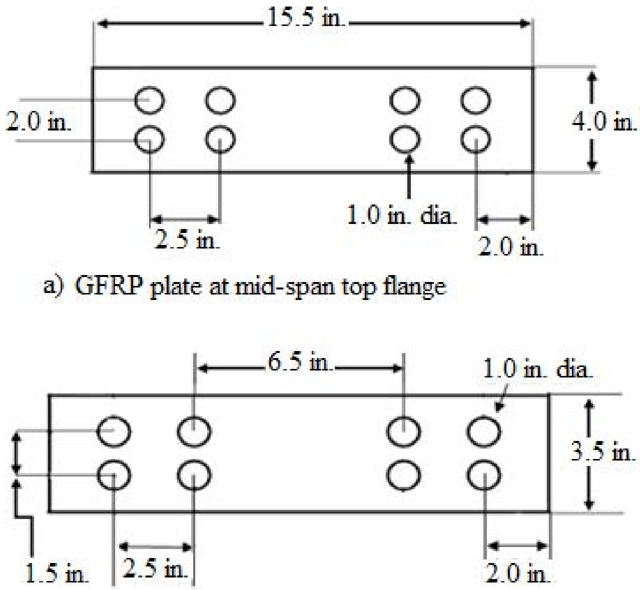


Fig. 5 : Load-deflection relations for Experiment 1

b) Damaged and Retrofitted GFRP Beam with Mid-span Brace on Web

The GFRP damaged beam from Experiment 1 is first retrofitted with CFRP plates on both sides of the web and top flange and then re-tested. Figure 6 shows the GFRP plates used to retrofit the mid-span top flange and two sides of the web, respectively. The plates were 0.5-inch thick and mounted to the beams using 0.875-inch diameter steel bolts.



a) GFRP plate at mid-span top flange

b) GFRP plate at both sides of mid-span web

Fig. 6 : GFRP retrofitting plates used at mid-span

Figure 7 shows a part of the retrofitted beam for Experiment 2. For Experiment 2, the arrangement for the dial gages, mid-span web brace Location 1 indicated in Figure 2, the applied load location, and the beam end connection remain the same as for Experiment 1. The resulting load-deflection curves for Experiment 2 are shown in Figure 8 showing a buckling load of 3,910 lbs.

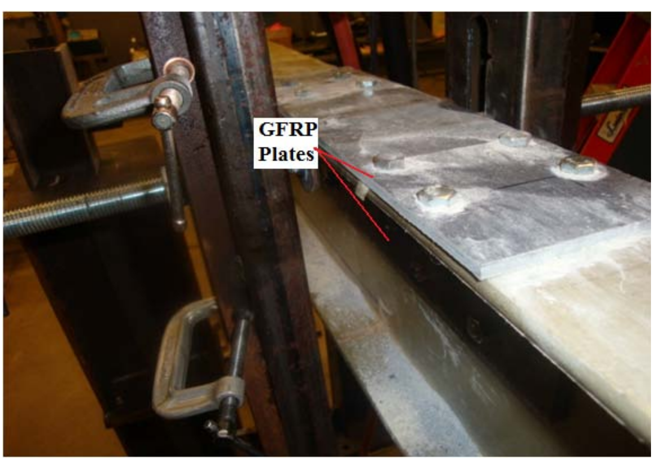


Fig. 7 : Retrofitted damaged beam

c) Residual Strength of Retrofitted Damaged Beam with Mid-span Brace on Top Flange

The damaged GFRP beam with GFRP retrofitting tested in Experiment 2 is tested again in Experiment 3 in which the mid-span braces are located at the top flange indicated as Location 2 in Figure 2. In this experiment, the beam buckled at a load of 4,372 lbs. The load in Experiment 3 is approximately 12 percent greater than that found in Experiment 2 indicating a greater effectiveness of the brace at the top flange as compared with the one on the web. Figure 9 shows the load-deflection relations obtained for Experiment 3.

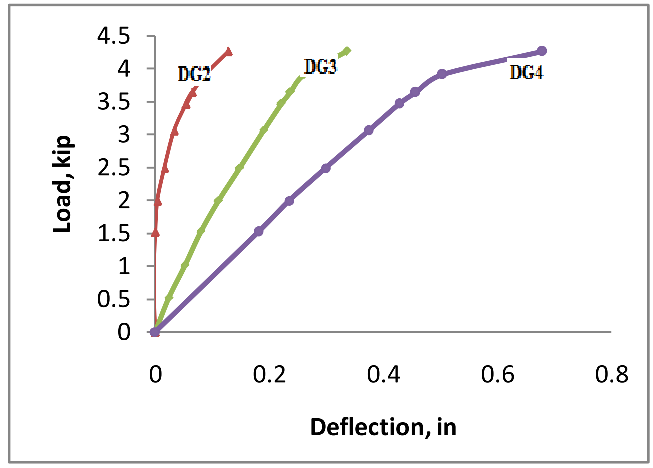


Fig. 8 : Load versus deflection relations for Experiment 2

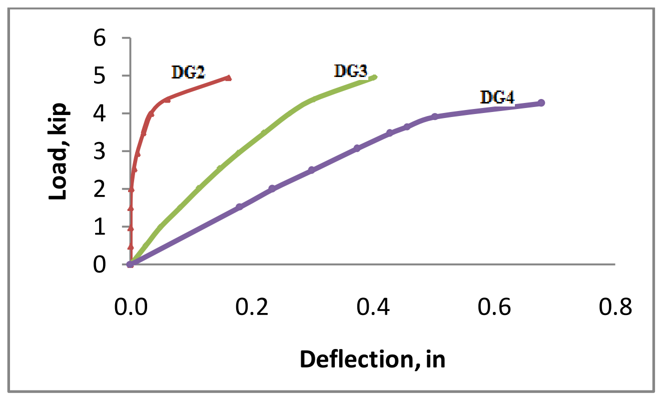


Fig. 9 : Load versus deflection relations for Experiment 3

III. Analysis and Comparison of Results

The following deflection equation from Reference 13 is used to calculate the longitudinal modulus of elasticity, E_{11}:

$$\Delta = \frac{PL^3}{48E_{11}I} \tag{1}$$

In this equation, P and Δ are obtained from the load-deflection curves for each experiment in the linear range. These values are also used to calculate the relative stiffness values, K. The value of the shear modulus is estimated using the following ratio [8]:

$$\frac{G_{12}}{E_{11}} = \frac{1}{8} \tag{2}$$

Table 1 presents the elastic limit load and deflection for each experiment, the relative stiffness values, the calculated modulus of elasticity, and the estimated shear modulus, respectively. The results shown in this table reveal that GFRP beam with mid-span lateral brace on web appeared to be much stiffer with K = 11,354 lbs/in. compared to both retrofitted damaged GFRP beam with mid-span web brace (K = 7,915 lbs/in.) and re-tested retrofitted damaged GFRP beam with flange brace (K = 8,922 lbs/in.). The K values also indicate that the retrofitted damaged GFRP beam with mid-span top web brace has a smaller stiffness than that of re-tested retrofitted damaged GFRP beam with mid-span flange brace.

Table 1 : Loads, Deflections, Stiffness, E11, and G_{12}

Experiment	P lbs	Δ in.	$K = \frac{P}{\Delta}$ lb/in	$E_{11}x10^6$ psi	$G_{12}x10^6$ psi
1	7948	0.7	11354	2.33	0.29
2	3641	0.46	7915	1.88	0.23
3	4372	0.49	8922	1.94	0.24

If $E_{11} = E_x$, the modified E_y can be calculated based on an averaged ratio $\lambda = \frac{E_y}{E_x}$ which is found to be 0.6 using the GFRP material properties given in Reference 8. The beam lateral-torsional buckling moment, M_{cr}, is calculated using the following equation [8]:

$$M_{cr} = C_b \frac{\pi}{kL_b} \sqrt{(\frac{\pi E_y}{kL_b})^2 C_w I_y + E_y I_y G_{12} J} \qquad (3)$$

In this expression, C_w = warping constant (in^6); J = torsional constant (in^4); C_b = moment gradient multiplier; L_b = unbraced length (in); k = effective length coefficient; and I_y = moment of inertia about the minor axis. Table 2 presents the predicted lower, upper bound, and interpolated approximated buckling loads designated as P_L, P_U, P_{IB}, and P_{IU} respectively, for the three cases both with and without mid-span web brace. The lower bounds loads were found by neglecting the GFRP retrofitting plates in the cross-section properties calculations. The upper bound loads were calculated as if the retrofitting plates existed for the entire length of the beam. Also, for the theoretical buckling load calculations corresponding to Experiments 2 and 3, it was assumed that the beam is un-cracked. Presented in Table 2 are also the interpolated approximate theoretical buckling loads P_{IB} and P_{IU} calculated by using the upper and lower bound estimates for the buckling loads. The interpolation is done by using a weighted average involving the retrofitted and non-retrofitted portions of the beam length, namely, 15.5 in., and 77.5 in., respectively. For example, P_{IB} for the beam in Experiment 2 is calculated as follows:

$$P_{IB} = [15.5(4995) + 77.5(2670)]/93.0 = 3058 \text{ lbs}$$

Table 2 : Theoretical Lower and Upper Bound and Interpolated Buckling Loads

	Buckling Load (lbs) with brace			Buckling Load (lbs) without brace		
Exp	P_L lbs	P_U lbs	P_{IB} lbs	P_L lbs	P_U lbs	P_{IU} lbs
1	8148	12702	8907	1040	1545	1124
2	2670	4995	3058	409	608	442
3	3330	5191	3640	425	631	459

The beam in Experiment 1 was not retrofitted, however, the upper bound and interpolated buckling loads are still included in Table 2 to determine the theoretical effect of retrofitting. The results in Table 2 also clearly show that adding a brace at the beam mid-span results in a dramatic increase in the buckling load capacity.

Table 3 summarizes a comparison between theoretical estimates (P_t) for the buckling loads and those determined experimentally (P_e). Since no retrofitting was used for Experiment 1, the P_L value from Table 2 is taken as its P_t value in Table 3. The P_{IB} values corresponding to Experiments 2 and 3 from Table 2 are taken as their respective P_t values in Table 3. Both theoretical and experimental investigation revealed a reasonable agreement between the theoretically estimated and experimental buckling load values for Experiment 1. However, for Experiments 2 and 3, there was a difference of about 20 percent between the predicted loads and the experimental ones. This may be attributable to the complex nature of the retrofitted beam behavior with pre-existing cracking that Experiment 1 created. All of the predicted load values, however, are found to be on the conservative side.

Table 3 : Predicted and Experimental Loads

Experiment	P_t lbs	P_e lbs	P_t/P_e lbs
1	8148	8426	0.97
2	3058	3910	0.78
3	3640	4372	0.83

IV. Conclusions

A number of conclusions are drawn based on the results presented in this paper. The damaged or cracked GFRP beam retrofitted with GFRP plates carried nearly 46 percent of the load capacity of the originally undamaged GFRP beam without retrofitting but with the same mid-span web brace location. The re-tested and retrofitted GFRP beam with a mid-span brace at the top flange carried nearly 52 percent of the load carried by the originally undamaged GFRP beam. The mid-span lateral bracing played a significant role in the beam behavior and strength. Placing a lateral mid-span brace at the compression flange location results in a higher buckling capacity compared to that obtained using web bracing. Lastly, the results show that the use of lateral bracing dramatically increases the buckling capacity of the beam in comparison with that without the bracing.

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Fire Resistance and Durability of Concrete Buildings Strengthened with FRP Sheets "Review Analysis"

By Ghanim Kashwani & Abeer Sajwani

Abstract- Sustainability is the way or the method to improve the human life by using the natural resources. There are three basic aspects of the sustainability which are; Social aspect, Economical aspect, and Environmental aspect. As result of that, civil engineers now days try to find new materials and methods to reach and apply the sustainability concept. For example, in the materials aspect, there are many ingredients such as Fibers, polymers, lightweight aggregates, fly ash, and slice fume were added in the concrete mix to have better durability. Concrete is one of the most commonly used materials in building construction projects. Many scientists and professionals continue to find new ways to improve the strength of concrete material and reduce its weight/volume ratio to the preserve natural materials and reduce energy. One of the most important factors in concrete structures is the stability of the structure against external forces such as earthquakes, wind loads, fires and etc. The Fiber Reinforced Polymers (FRP) sheets are externally bonded to the concrete surfaces to enhance the performance of the concrete structures. Several studies were conducted to investigate the compressive strength of the concrete that wrapped with FRP composite when they are exposed to harsh environment factors such as elevated temperature, freeze-thaw cycles, high humidity and etc. However, there are many studies which cover and study the effects of the extreme conditions at concretes wrapped with FRP which could help the engineers in the future to avoid fatal results such as structures failures. The main goal of this paper is to collect information about durability and fire resistance of concretes wrapped with FRP polymers and that will be done by reviewing different journals which cover these points. The experimental programs of the journals will be explained and supported by the figures.

Keywords: construction material, fire resistance, impact of fire on structures, structural performance.

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FIRERESISTANCEANDDURABILITYOFCONCRETEBUILDINGSSTRENGTHENEDWITHFRPSHEETSREVIEWANALYSIS

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Ghanim Kashwani [α] & Abeer Sajwani [σ]

Abstract- Sustainability is the way or the method to improve the human life by using the natural resources. There are three basic aspects of the sustainability which are; Social aspect, Economical aspect, and Environmental aspect. As result of that, civil engineers now days try to find new materials and methods to reach and apply the sustainability concept. For example, in the materials aspect, there are many ingredients such as Fibers, polymers, lightweight aggregates, fly ash, and slice fume were added in the concrete mix to have better durability. Concrete is one of the most commonly used materials in building construction projects. Many scientists and professionals continue to find new ways to improve the strength of concrete material and reduce its weight/volume ratio to the preserve natural materials and reduce energy. One of the most important factors in concrete structures is the stability of the structure against external forces such as earthquakes, wind loads, fires and etc. The Fiber Reinforced Polymers (FRP) sheets are externally bonded to the concrete surfaces to enhance the performance of the concrete structures. Several studies were conducted to investigate the compressive strength of the concrete that wrapped with FRP composite when they are exposed to harsh environment factors such as elevated temperature, freeze-thaw cycles, high humidity and etc. However, there are many studies which cover and study the effects of the extreme conditions at concretes wrapped with FRP which could help the engineers in the future to avoid fatal results such as structures failures. The main goal of this paper is to collect information about durability and fire resistance of concretes wrapped with FRP polymers and that will be done by reviewing different journals which cover these points. The experimental programs of the journals will be explained and supported by the figures.

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I. Introduction

Fiber reinforced polymer are materials that present the future in the civil engineering and construction industry. The FRP composites materials industry still does not provide enough codes and standards for civil engineers so that many tests and experiments should be done to have more knowledge about composite materials. These materials could provide to the structural building many important aspects such as freedom of design, high strength-to-weight ratio, excellent durability, minimum maintenance and excellent fire resistance. FRP composite materials have very high good strength comparing with other construction materials such as mild steel. Fig (1) explains the stress-strain behavior curves for some composite materials; GFRP and CFRP with mild steel and shows the brittle behavior of FRP composites and the ductile behavior of mild steel.

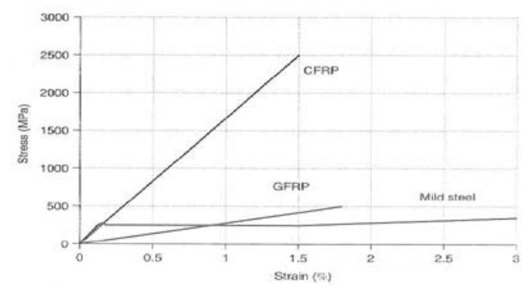

Figure 1 : Typical FRP and Mild Steel Stress-Strain Curves

For External FPR reinforcement system, it is useful for beams and other unusual shapes. However, the shape of the cross section and the spacing of FRP straps can directly impact the effectiveness of the External FPR reinforcement and it also has many applications such as maintain the beams and slabs that contain cracks and increase the surface life for the columns, beams, and slabs. Externally strengthening techniques of shear deficient are: Fibers applications, strengthening with externally applied clamps, jacketing, and external bonding of steel plates with epoxy. For strengthening shear deficient, many different tests have been applied and proven that composite materials are an excellent way to be used as external reinforcing [2].

There are two kinds of FRP sheets:

Pre-cured laminates: This considers a rigid plate and is applied on flat surfaces. They are usually applied to the beams to increase the flexural capacity or reducing deflection where normally attached to the bottom.

Thin/flexible sheets: The main function of them is to wrap them around beams, columns and slabs. This type of sheet increases the shear and flexural capacities for different structural members with different cross sections.

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The most common FRP composite used are CFRP and GFRP so that they will be studied and analyzed in depth in this paper

II. CFRP –GFRP Sheets

For (CFRP), carbon fibers structures consist of a mixture between amorphous carbon and graphitic carbon. This shape of graphitic carbon comes from the high tensile modulus, in which the particles of carbon are set in an engineering hexagonal form of parallel layers as shown in the Fig (2). The bond between the carbon particles is strong, but it is weak in the layers because of the van der Waals-type forces [3].

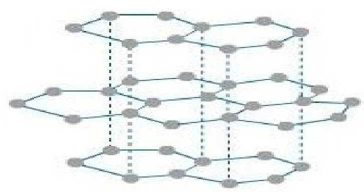

Figure 2 : Arrangement of Carbon atoms in a graphite crystal [4]

Glass Fiber Reinforced Polymer (GFRP) chemical compositions are [5], [6], [7]:

- SiO_2: 54.3%,
- Al_2O_3 & Fe_2O_3: 15.2%
- CaO:17.3%,
- Na_2O/K_2O 0.6%
- B_2O_3: 8% to 10%

According to these elements, the function of GFRP sheets could be affected against the environmental factors such as alkalinity, moisture, and temperature. For example, alkalinity can cause hydrolysis for the glass fiber by hydroxide ions.

a) Glass Transition Temperature

Glass transition temperature is the temperature in non-crystalline solids where the material start changing its behavior and it becomes rubbery instead of being glassy. When the material is rubbery that means it's a flexible material and elastic while glassy means brittle material [8]. The reason of the changing from glassy to rubbery is the temperature of the material and the temperature needed to rearrange the molecules in the material. In case where the material has a high temperature which is above the transition temperature the molecules will have the ability to move while the molecules will be frozen if the temperature is below the transition temperature.

III. Case Studies

a) Tensile properties of carbon fibers and carbon fiber–polymer composites in fire

Carbon fiber tensile properties and strength are directly affected by the increase of temperature. When exposing the carbon fibers to fire with the application of tensile stress, you will see that the fiber modulus decreases with the increase amount of fire. Decreasing the fiber modulus will soften the carbon fibers at the surface, which will lead to a decrease in the overall tensile strength of the fibers. The authors said that the fiber modulus is not affected when carbon fiber subjected to fire in nitrogen atmosphere, and that because of the absence of oxygen. In regular atmosphere oxidation will occur. Reduction in tensile strength when the fibers are exposed to fire will occur regardless the presence oxygen or not. The tensile strength of carbon fibers will be reduced by 50% when exposing the fibers to a temperature in the range of 400-700 degree Celsius, also regardless the presence of oxygen. Finally the carbon fiber laminates at the surface of structures, aircrafts, and ships thermally decompose and become thinner due to oxidization when a temperature exceeds 400 Celsius. The surface and subsurface fibers will decrease in strength regardless the presence of oxygen [9].

b) The effect of different passive fire protection systems on the fire reaction properties of GFRP pultruded profiles for civil construction

Glass fiber reinforced polymers (GFRP) are light, stiff, strong, low thermal conductive material, durable under aggressive environment, and needs lower maintenance, but concerning their fire behavior, GFRP when heated with fire of a range temperature between 100-200 degrees Celsius it soften and creep, causing considerable loss in strength and stiffness. According to the authors, when subjected to higher temperatures between 300-500 degrees Celsius their organic matrix decomposes and produces heat, smoke, and toxic volatiles. Using good flame retardants, self reaction of GFRP under fire exposal can be avoided, but unfortunately the structural requirements for elements performance under (60-90 min) of fire can't be achieved. Most of flame retardants cause an instant decrease in the mechanical properties of FRP materials. There are some commercially available GFRP materials that can avoid the instant flexural strength loss when exposed to fire, but in longer periods of fire exposal protected and unprotected GFRP flexural loss will be the same. Temperatures measured during the test shows that all protective material used shows a reduction in overall temperatures of the GFRP laminates. All GFRP reaction to fire reduces after using the insulation and protective materials [10].

IV. Concluding Remarks

Elevated Temperature level and durability are very critical properties for any constriction material that is used in civil engineering. Since FRP is used now very often in the construction world, it is important to understand the mechanical behavior of these materials to apply them by efficient way. This paper gives the basic understand of the fire resistance and durability of FRP materials and how the strength can be affected due them. Also this paper explains the chemistry change of FRP materials and the chemical reaction that are happened under high temperature.

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Estimating Hurricane-Induced Drift Velocity: A Case Study during Ivan

By Prof. S. A. Hsu
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Abstract- During a tropical cyclone such as a hurricane, meteorological and oceanographic (met-ocean) conditions are severe. Estimates of these met-ocean parameters including winds, waves, current and storm surges are needed before and after the storm. Using Hurricane Ivan in 2004 as a case study, it is found that near surface wind measurements cannot be used to estimate waves and currents. An alternative method is proposed to estimate the wind drift velocity, i.e., Usea = 21 Hs^2/Tp^3, where Hs is the significant wave height and Tp the dominant wave period, both parameters are available routinely online from the National Data Buoy Center. Application of this Usea formula during Ivan shows that it is consistent with the near surface current measurements, particular the peak velocity.

Keywords: wind drift velocity, friction velocity, significant wave height, dominant wave period, hurricane inez, hurricane kate, hurricane ivan, north sea storms.

GJRE-E Classification : FOR Code: 290899

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I. Introduction

About a decade ago in September 2004 Hurricane Ivan (see Figures 1 thru 3 and Table1) devastated numerous infrastructures including coastal bridges and offshore oil rigs and damaged or displaced miles of oil and gas pipelines in the northeastern Gulf of Mexico (see, e.g., Panchang and Li, 2006). Measurements of meteorological and oceanographic (met-ocean) conditions near Ivan's track were as follows:

According to Stewart (2004, p.15), wind and gust measurements at 400ft (122m) elevation on an oil rig named Ram Powell VK-956 located near the Ivan's track at 29.05N 88.10W indicated that at 2256Z on 15 September wind speed = 102 knots and wind gust = 135knots. According to the National Data Buoy Center (NDBC), this oil platform (code name as 42364) is very near Buoy 42040 (Fig.2) (see www.ndbc.noaa.gov), which recorded significant wave height (Hs) = 15.96m and dominant wave period (Tp) = 16.67 second as provided in Table 1. According to Teague et al. (2007), the maximum current speed reaching 2.14 m/s (see Fig.3) at a direction of almost due west was observed on the shelf in 60m of water at station M1 (see Fig.2) near the surface (6m). Similar speeds, ranging between 1.73 and 1.96m/s, were found near the surface at the other moorings on the shelf.

Normally, hourly wind speed is employed to estimate waves and currents. However, because the max wind speed measured at Buoy 42040 was only 28.2m/s (see Table 1), this wind speed was too low to generate 2m/s current and 16m significant wave height. Therefore, the use of wind speed to estimate waves and currents near the continental shelf could result gross error. The cause may be due to the effects of land mass near the hurricane's landfall and of low anemometer height (at 5m above the sea surface as compared to 16m significant wave height, the effect of wave shadow) on Buoy 42040. Because of these effects, we propose to employ hourly measurements of Hs and Tp instead of using the hourly wind speed. This is the purpose of this investigation.

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Figure 1 : Hurricane Ivan over the northern Gulf of Mexico on September 15, 2004, (http://catalog.data.gov/dataset/hurricane-ivan-poster-september-15-2004)

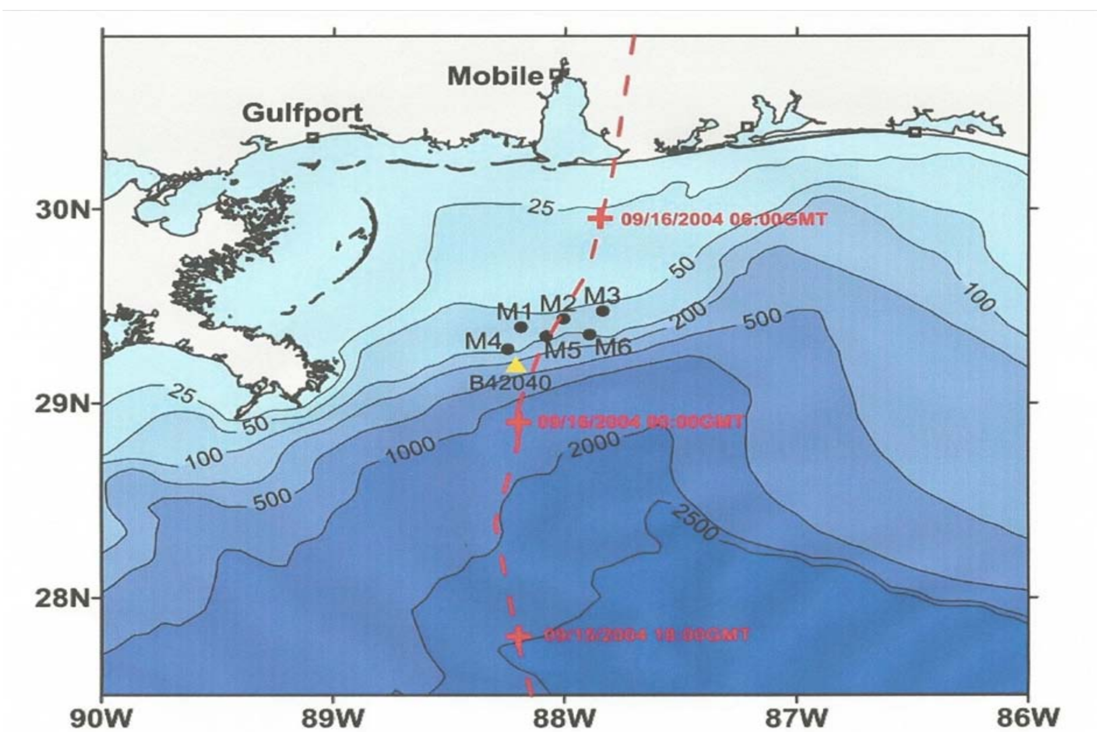

Figure 2 : Ivan Track and measurement stations (see Wijesekera et al., at http://www.motherjones.com/files/Source_177__High_Sea-Floor_Stress_Induced_by_Extreme_Hurricane_Waves_1.pdf)

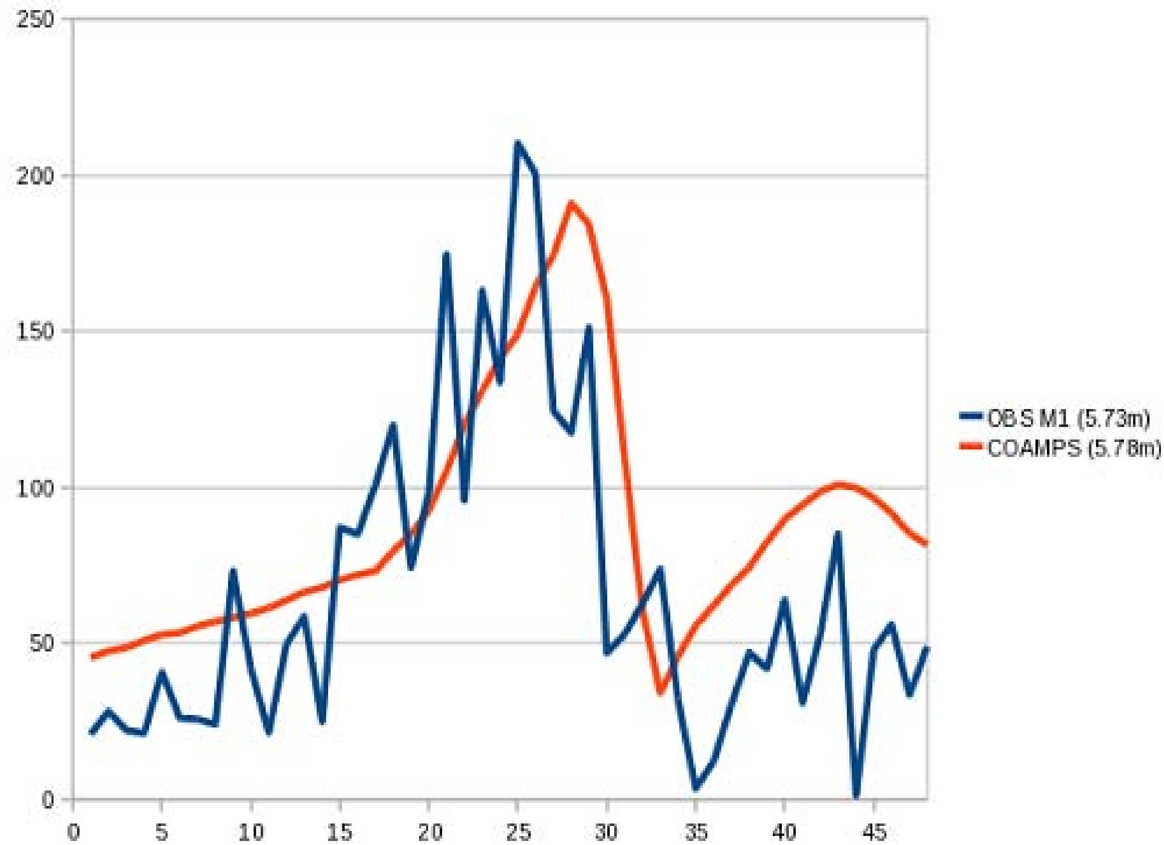

Figure 3 : Acoustic Doppler Current Profiler (ADCP) measurements of the near surface current speed (cm/s) at approximately 6 m water depth (blue) and Model simulation (red) at NRL Station M1 (see Fig.2) (see Chen et al., at www.onr.navy.mil/reports/FY10/npchen.pdf) over a 48-hour period from September 16, 2004

Table 1 : Measurements of wind speed (WSPD), wind gust (GST), Barometric pressure (BARO), significant wave height (Hs), and dominant wave period (Tp) at NDBC Buoy 42040 during Hurricane Ivan in September 2004. Both friction velocity (U*) and wind drift velocity (Usea) are computed from Hs and Tp according to Equations 5 and 6, respectively

Day	Hour	WSPD	GST	BARO	Hs, m	Tp, sec	U*, m/s	Usea, m/s
15	0	12.9	15.3	1008.5	3.45	11.11	0.33	0.18
15	1	13.4	15.7	1008.4	4.23	11.11	0.50	0.27
15	2	13.6	16.1	1008.4	4.59	11.11	0.58	0.32
15	3	13.7	17.1	1008.2	4.98	12.5	0.48	0.27
15	4	14	17.4	1008.1	5.09	14.29	0.34	0.19
15	5	13.4	16.2	1007.5	5.83	14.29	0.44	0.24
15	6	14.5	18.3	1006.6	5.96	14.29	0.46	0.26
15	7	15.1	19.8	1005.7	6.23	14.29	0.51	0.28
15	8	15.8	19.6	1004.4	6.93	14.29	0.63	0.35
15	9	16.5	20	1003.5	7.2	14.29	0.68	0.37
15	10	17.4	22.1	1002.5	7.47	14.29	0.73	0.40
15	11	17.6	21.9	1002.2	7.03	14.29	0.64	0.36

15	12	19.3	24.2	1001.1	7.91	14.29	0.81	0.45
15	13	18	23.3	1001.3	8.2	16.67	0.55	0.30
15	14	19.5	24	1000.3	8.52	14.29	0.95	0.52
15	15	22.2	28.9	997.7	9.94	14.29	1.29	0.71
15	16	22.2	27.6	996	10.63	16.67	0.93	0.51
15	17	23.6	29	993.5	11.74	16.67	1.13	0.62
15	18	25.6	31.6	989.2	10.96	16.67	0.99	0.54
15	19	25.6	31.9	985.1	12.76	16.67	1.34	0.74
15	20	27.8	34.2	979.9	15.25	16.67	1.91	1.05
15	21	27.9	37.8	974.8	13.69	14.29	2.44	1.35
15	22	26.8	34.2	969	14.85	14.29	2.87	1.59
15	23	28.2	34.9	963.1	14	12.5	3.81	2.11
16	0	26.5	32.6	958.2	15.96	16.67	2.09	1.15
16	1	25.4	32.9	956.3	14.15	14.29	2.61	1.44
16	2	25.4	32.6	955.3	8.72	11.11	2.11	1.16
16	3	21.6	29.5	962	8.43	10	2.70	1.49
16	4	26.8	34.2	967.6	7.27	14.29	0.69	0.38
16	5	24.5	30.7	976	7.45	10	2.11	1.17
16	6	24.2	29.9	983.6	7.63	10	2.21	1.22
16	7	21.1	27	989.4	7.89	10	2.37	1.31
16	8	18.9	23.5	992.7	7.22	10	1.98	1.09
16	9	16.8	22.7	995.5	6.17	9.09	1.93	1.06
16	10	16.2	22.7	997.8	5.63	10	1.20	0.67
16	11	14.7	18.2	999.6	6.14	10	1.43	0.79
16	12	14	17	1001.6	5.66	11.11	0.89	0.49
16	13	12.5	16.3	1002.8	4.91	11.11	0.67	0.37
16	14	12.2	15.7	1003.9	4.8	9.09	1.17	0.64
16	15	11.6	15	1005	4.58	10	0.80	0.44
16	16	10.6	13.8	1005.8	4.29	10	0.70	0.39
16	17	10.9	13.4	1006.2	4.46	9.09	1.01	0.56
16	18	9.6	11.6	1006.7	4	9.09	0.81	0.45
16	19	8.9	10.4	1006.9	3.54	9.09	0.63	0.35
16	20	8.9	10.8	1006.4	3.09	7.69	0.80	0.44
16	21	7.2	8.8	1006.6	2.97	8.33	0.58	0.32
16	22	7.7	9.9	1007	2.84	8.33	0.53	0.29
16	23	7.4	9.2	1007.6	2.64	8.33	0.46	0.25

II. Methods

According to Wu (1975),

$$Usea = 0.55\, U^* \qquad (1)$$

Where Usea is the surface drift velocity, in m/s, and U* is the friction velocity, in m/s.

Analysis of the direct measurements of U* and U10m by sonic anemometry over the North Sea during storms from the data provided in Geernaert et al. (1987) is shown in Fig.4. Our result indicate that

$$U^* = 0.0195\, U10m^{1.285} \qquad (2)$$

Since the coefficient of determination (R^2) is 94 percent, meaning that 94% of the variation in U* can be explained by the U10m in this power law formula, therefore, we are confident to use Eq. (2) for our applications.

In order to extend Eq. (2) into hurricane conditions, Fig. 5 is presented. Because the vorticity method is based on atmospheric physics (Anthes, 1982), it is used here. Since the slope between this method and Eq. (2) is near one and that the R^2 value reaches to 94%, we are confident that Eq. (2) can be extended into hurricane conditions.

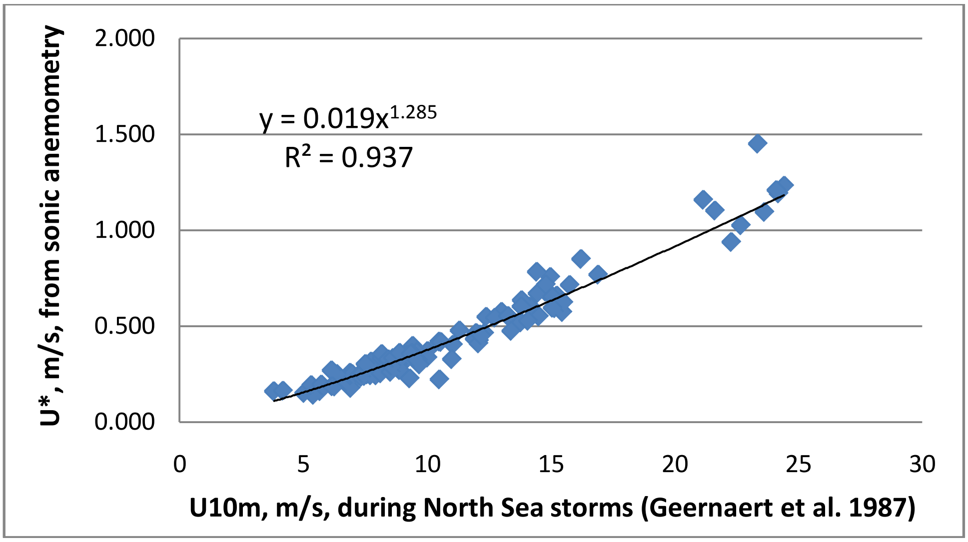

Figure 4 : Relation between direct measurements of U* and U10m using sonic anemometry based on data provided in Geernaert et al. (1987)

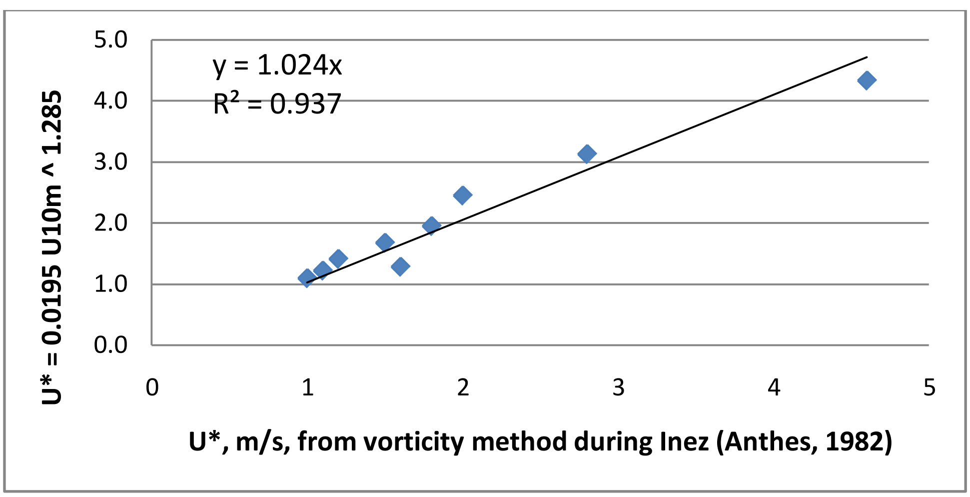

Figure 5 : An extension of Equation (2) into hurricane conditions during Inez based on the dataset provided in Anthes (1982, p.71)

Now, according to Csanady (2001, p.68),

$$g\,Hs/U^{*}{}^{\wedge}2 = A\,(g\,Tp\,/U^{*})\ {}^{\wedge}\ (3/2) \qquad (3)$$

Where g (= 9.8 m/s^2) is the gravitational acceleration, Hs is the significant wave height, Tp is the dominant wave period, and A is the coefficient to be determined in the field during storms. Note that both Hs and Tp are measured by NDBC routinely.

With the data provided in Table 2, we can now compute U* from U10mbased on Eq. (2) (except one data point during the hour when the eye of Kate passed over Buoy 42003). Our results are shown in Fig.6. The coefficient "A" is determined to be 0.052 with R^2 = 0.93 so that Eq. (3) becomes

$$g\,Hs/U^{*}{}^{\wedge}2 = 0.052\,(g\,Tp/U^{*})\ {}^{\wedge}(3/2) \qquad (4)$$

Or,

$$U^{*} = 38\,Hs\ {}^{\wedge}2/\,Tp\ {}^{\wedge}3 \qquad (5)$$

Now, substituting Equations (5) into (1), we have

$$Usea = 21\,Hs{}^{\wedge}2/Tp{}^{\wedge}3 \qquad (6)$$

Eq. (6) is our proposed formula to estimate surface currents using wave parameters during a tropical cyclone.

Table 2 : Measurements of wind and wave parameters at Buoy 42003 during Kate in November 1985 where U10m is the wind speed at 10m, Hs is the significant wave height, Tp is the dominant wave period, and U10m > 7.5m/s to ensure that mechanical turbulence dominants the thermal effects (see Hsu, 2003)

Day	Hour	Wind direction	U10m,m/s	Gust	Hs,, m	Tp, sec.
18	11	98	9.5	10.4	1.1	6.3
18	12	94	8.3	9.4	1.1	6.3
18	13	91	8.7	9.9	1.2	6.7
18	14	89	9	9.9	1.3	6.7
18	15	85	9.6	10.4	1.3	6.7
18	16	89	8.9	9.9	1.5	6.3
18	17	84	9.2	10.4	1.5	6.3
18	18	86	9.5	10.4	1.5	6.3
18	19	83	8.9	10.4	1.6	6.3
18	20	78	8.7	9.4	1.6	6.7
18	21	70	9.6	10.4	1.6	7.1
18	22	69	9.7	10.4	1.6	7.1
18	23	72	9.8	10.4	1.7	7.1
19	0	71	10.2	11.5	1.7	6.7
19	1	68	8.8	9.9	1.6	6.7
19	2	61	9.2	9.9	1.5	6.7
19	3	55	9.4	10.4	1.5	6.7
19	4	46	9.8	11	1.5	6.7
19	5	51	9.2	10.4	1.5	6.3
19	6	59	9.2	11	1.4	6.7
19	7	78	11.7	13.1	1.5	6.3
19	8	70	10.7	12.5	1.6	5.6
19	9	66	11	13.1	1.8	5.9
19	10	55	10.4	11.5	1.6	6.7
19	11	58	11.4	12.5	1.9	6.3
19	12	49	9.9	11.5	1.9	6.7
19	13	46	9.4	10.4	2	7.1
19	14	46	10.3	11	2.1	7.7
19	15	46	11	13.6	2.2	7.1
19	16	43	10.8	12.5	2	7.1
19	17	36	11.2	13.1	2	7.7
19	18	37	12	13.6	2	7.7
19	19	40	12.5	14.1	2	7.7
19	20	45	13.2	15.7	2	7.7
19	21	43	13.6	15.2	2	7.1
19	22	48	13.3	15.7	2.4	7.1
19	23	45	13.6	15.2	2.3	7.1
20	0	40	12	14.1	2.4	7.7
20	1	38	10.8	12.5	2.3	7.7
20	2	46	12	14.1	2.4	7.7

20	3	51	13.4	15.7	2.6	7.7
20	4	51	14.3	16.2	2.6	7.7
20	5	59	16.9	19.9	2.7	7.7
20	6	52	16.2	18.8	3.1	7.7
20	7	50	16.6	21.9	3.7	8.3
20	8	61	20	24	4.6	11.1
20	9	70	21.6	26.7	5.5	11.1
20	10	55	24.1	29.3	5.4	11.1
20	11	34	23.3	27.2	6.2	14.3
20	12	40	23.1	27.2	7.4	14.3
20	13	38	23.6	28.7	7.5	12.5
20	14	42	26	31.9	7.2	12.5
20	15	40	29.3	37.1	8.6	14.3
20	16	41	35.9	43.4	9.4	12.5
20	17	64	47.3	58.5	10.7	12.5
20	Eye at 18	129	16.6	19.9	9.9	12.5
20	19	195	36.5	47.6	7.1	11.1
20	20	208	35.5	47.6	6.6	9.1
20	21	208	29.9	37.6	6	10
20	22	208	23	27.7	5.6	8.3
20	23	214	22.2	26.7	5.3	9.1
21	0	216	20.9	26.7	4.8	9.1
21	1	221	20.8	24.6	4.5	10
21	2	216	21.5	26.1	4.4	9.1
21	3	230	20.4	24.6	4.3	10
21	4	241	22.2	26.7	3.8	7.7
21	5	241	22.7	27.2	5.1	9.1
21	6	223	19.2	22.5	5.2	9.1
21	7	219	16.7	19.9	4.5	9.1
21	8	226	16.1	18.8	4.5	10
21	9	234	15.2	18.3	4.3	10
21	10	234	14.6	16.7	4.3	10
21	11	240	15	19.3	3.9	9.1
21	12	246	14	17.2	3.7	9.1
21	13	253	13.4	15.7	3.9	9.1
21	14	255	13.9	16.7	4.6	10
21	15	259	13.8	15.7	3.8	9.1
21	16	255	12.3	14.1	4.1	10
21	17	262	13.4	15.2	3.9	9.1
21	18	262	12.2	14.6	4.1	10
21	19	265	11.2	14.6	3.7	10
21	20	259	10.2	12	3.6	10
21	21	266	10.4	12.5	3.4	9.1
21	22	271	10.6	12	3.4	8.3
21	23	269	9.4	12.5	3.3	10

22	0	257	8.8	10.4	2.8	10
22	1	278	8.7	9.9	2.6	10
22	2	275	8.6	9.9	2.5	10
22	3	267	7.6	8.9	2.5	9.1

(Data source: www.ndbc.noaa.gov)

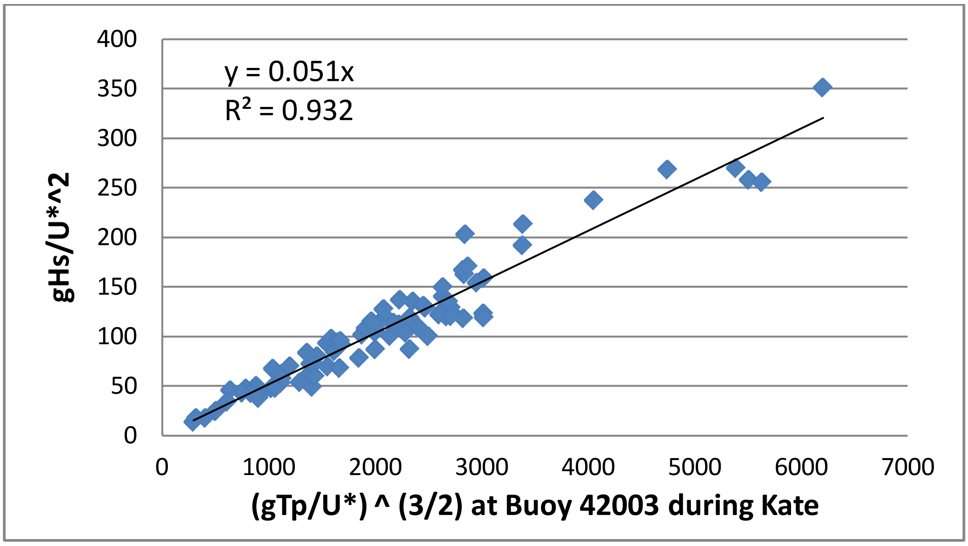

Figure 6 : A validation of Equation (3) based on data provided in Table 2 except during the passage of eye at 18UTC on November 20. Note that the coefficient "A" needed in Equation (3) is determined to be 0.052

III. Results

Based on aforementioned methodology we can now compute hourly U* and Usea values according to Equations (5) and (6), respectively. Our results are listed in the last 2 columns in Table 1. In order to compare with Fig.3, the time series of Ivan induced drift velocity is also presented in Fig.7. It can be seen that the comparison is reasonable, particularly the max Usea, which was 2.11m/s. This value is in excellent agreement with that of 2.14m/s as measured by Teague et al. (2007), which is also shown in Fig.3.

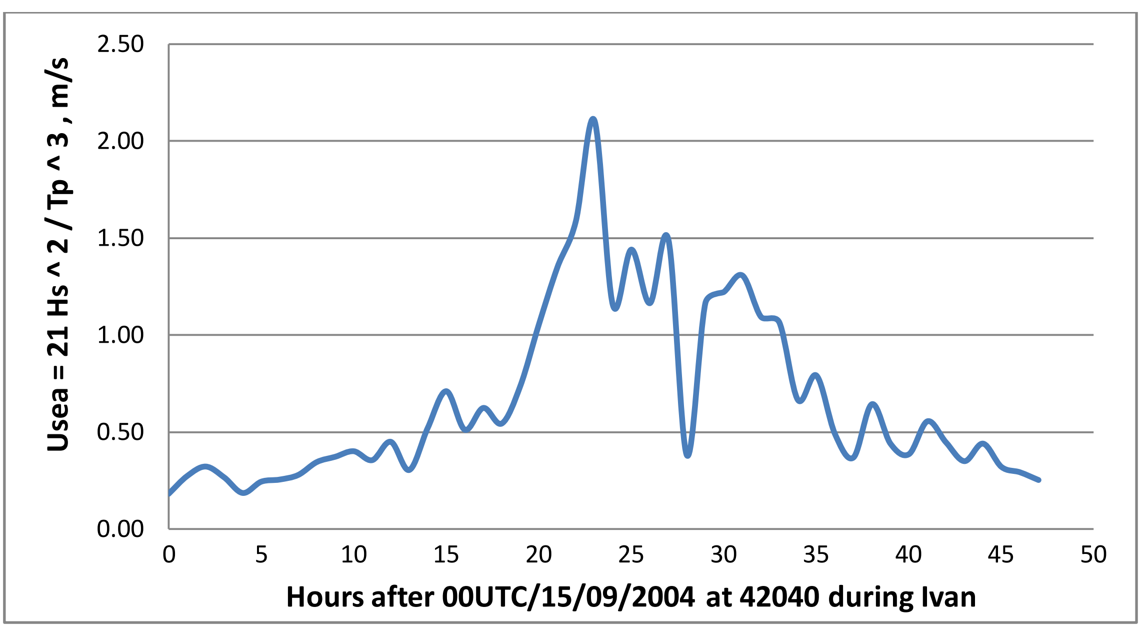

Figure 7 : Time series of the wind-drift velocity as estimated by Equation (6) based on wave measurements provided in Table 1 for Hurricane Ivan in 2004

IV. Conclusions

On the basis of aforementioned analysis, several conclusions can be drawn:

- Using Hurricane Ivan in 2004 as a case study, it is demonstrated that near surface wind measurements cannot be used to estimate waves and currents.
- A power-law relationship (Eq.2) between the direct measurements of friction velocity (U*) and the wind speed at 10m over the North Sea is found with a coefficient of determination as high as 94%.
- Eq.2 is further supported by the atmospheric vorticity method during Hurricane Inez.
- Applications ofEq.2to the open sea during Katefound that U* = 38 Hs^2/Tp^3, and Usea = 21 Hs^2/Tp^3, where Hs is the significant wave height, Tp is the dominant wave period, and Usea is the wind drift velocity. And,
- Using Eq.5 during Ivan shows that this formula is consistent to the near surface current measurements, particular the peak velocity.

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A Sediment Phytoattenuation Evaluation by Four Sessions of Vetiver Planting and Harvesting

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Abstract- Phytoattenuation is a novel green remediation approach which can be employed in both a sediment and a soil decomination. Pot experiments have been conducted to evaluation two pollution levels of a sediments consisted of high pollution from swine industries and low contamination from campus wetland. EDTA demonstrated satisfactory metal uptake and mobility enhancement has been achieved. Pb is less mobile which induced low vetiver translocation while Zn is the most mobile which possesses high bioavailability. Four sessions of planting and harvesting gradually decreasing Cu and Zn levels the constrictions decreasing to achieve local a sediment criteria which can be used for agricultural a soil conditioning. The results of this study is prominent with gradually mitigating a sediment contamination is less detriment to a sediment properties relative to commonly used a soil washing.

Keywords: phytoattenuation, Cu, Zn, vetiver, heavy metal.

GJRE-E Classification : FOR Code: 820699

ASEDIMENTPHYTOATTENUATIONEVALUATIONBYFOURSESSIONSOFVETIVERPLANTINGANDHARVESTING

Strictly as per the compliance and regulations of :

A Sediment Phytoattenuation Evaluation by Four Sessions of Vetiver Planting and Harvesting

T. Y. Yeh [α] & C. L. Lin [σ]

Abstract- Phytoattenuation is a novel green remediation approach which can be employed in both a sediment and a soil decomination. Pot experiments have been conducted to evaluation two pollution levels of a sediments consisted of high pollution from swine industries and low contamination from campus wetland. EDTA demonstrated satisfactory metal uptake and mobility enhancement has been achieved. Pb is less mobile which induced low vetiver translocation while Zn is the most mobile which possesses high bioavailability. Four sessions of planting and harvesting gradually decreasing Cu and Zn levels the constrictions decreasing to achieve local a sediment criteria which can be used for agricultural a soil conditioning. The results of this study is prominent with gradually mitigating a sediment contamination is less detriment to a sediment properties relative to commonly used a soil washing.

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I. Introduction

In Taiwan the brand new a sediment reused and management Act has been in progress. The lingering a sediment illeagle dumping expected to be solved after the enacted of a sediment mangagement regulatory standard. The main contaminant management was risk based control while in situ capping phytoremediation and exsitu a sediment pressured Chelator pretreated following by phytoextraction has been proposed. Phytoattentuation is a novel concept to denominated a sediment metal contents without abrasively destroys a sediment properties rendering for agricultural a soil fertilizing.

Vetiver is known for its effectiveness in a sediment erosion control due to its unique morphological and physiological characteristics. Vetiver is also a high biomass plant with remarkable photosynthetic efficiency which renders it tolerant against various harsh environmental conditions. Vetiver with deep-rooted and higher water-use can effectively stabilize soluble metals in a sediments (Chen et al., 2004). These properties enable vetiver to be an ideal candidate for phytoextraction.

EDTA, a synthetic chelator, is poorly biodegraded in the a soils though its effectiveness at completing metals. Excess amounts of EDTA may leach to groundwater and cause in subsurface water contamination. However, due to its high chelation ability, potential leaching to groundwater should be into serious concern.

A novel green remediation approach intends to convey in this paper by employing plant to gradually reduce a soil metal contamination through several rounds of planting and harvesting. Unlike phytoextraction, phytoattenuation aims to reduce a soil metal pollution in a gradually and less aggressive approach such as chelator assisted remediation (Meers et al., 2010). The initial pollution level generally is lower than most a soil contamination sites. Therefore, plant is easier to propagate to increase biomass inducing reliable metal uptake. The conceptual model is shown in Fig. 1.

Attenuation is borrowing from the concept “natural attenuation” which has been commonly proposed as a remediation approach for organic pollutants such as DNAPL (dense non-aqueous liquid) solvent TCE (tri-chloro ethylene) and PCE (tetra-chloro ethylene) or LNAPL (light non-aqueous liquid) petroleum product BTEX (benzene, toluene, ethyl benzene, and xylene. Natural attenuation mainly used natural pollution mitigation mechanism including microbial degradation, adsorption, volatilization, etc. This approach is targeted to pollutant which is not degraded in a reasonable time using conventional remediation techniques, technical imperfectability, or the cost beyond the affordable monetary amounts, economical imperfectability.

Cu and Zn are used as the fodder additives for preventing swine diarrhea and skin abrasion (Yeh and Wu, 2009). Cu has been reported the toxicity to phytoplankton and been employed as algaecide for serious eutrophication mitigation. The careless management of Cu and Zn wastewater from swine industries could damage the water and a soil environment. Previous studies regarding (Bioconcentration factor) BCF and (Translocation factor) TF are summarized in Table. EDTA, DTPA, EDDS, citric acid, and

The objectives of this study were to research the phytoattenuation to gradually mitigate the a sediment Cu and Zn pollution via employing EDTA chelator enhancement. Possible a sediment metal fraction and vetiver uptake evaluation also be conducted. The recent reference is listed in Table 2.

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II. Materials and Methods

a) Plant, biostimulators, and a sediment preparation

Vetiver and sunflower were collected from the University of Kaohsiung campus wetlands (22°73'N, 120°28'E) precultured for 5 days and carefully washed with distilled water. Plant samples were dried at 103°C in an oven until completely dried.

b) Total metal content, a sediment retained fractionation and plant metal uptake analysis

Plant after last session of operation was harvested, careful washed, and air dried for metal analysis. Plant samples were dried at 103°C in an oven until completely dried. Dried plant samples were divided into root and shoot for metal accumulation assessment. These pretreated plants were digested in a solution containing 11:1 HNO_3: HCl solution via a microwave digestion apparatus (Mars 230/60, CEM Corporation) and diluted to 100 mL with deionized water. 0.2 g of dried a sediment adding *aqua regia* rending for microwave digestion and 2.5 g of dried for sequential extraction experiments. Metals analyses were conducted via an atomic absorption spectrophotometry (AAS, Perkin Elmer).

c) Harvested Plant tissue and final a sediment metal content analysis

Plant was harvested, careful washed, and air dried for metal analysis. Plant samples were dried at 103°C in an oven until completely dried. Dried plant samples were divided into root and shoot for metal accumulation assessment. These pretreated plants were digested in a solution containing 11:1 HNO_3: HCl solution via a microwave digestion apparatus and diluted to 100 mL with deionized water. 0.2 g of dried a sediment was added *aqua regia* rending for microwave digestion. Metals analyses were conducted via an atomic absorption spectrophotometry (AAS, Perkin Elmer).

d) Data and Statistical Analysis

Data were evaluated relative to the control to understand their statistical variation. Metal concentration of plants was recorded as mg of metal per kilogram of dry biomass. A triplicate of water and a sediment samples from each treatment were recorded and used for statistical analyses. Plant metal concentration was recorded as mg of metal per kilogram of dry biomass. Bioaccumulation coefficient (BCF; Croots/Ca soil or water) calculated as the metal concentration in plant divided by the heavy metal concentration in the solution or a soil for hydroponic and pot experiments, respectively. TF (shoots/Croots) was depicted as the ratio of concentration of metal in shoot to its concentration in root. It was calculated by dividing the metal concentration in shoot by the metal concentration in root. Schematic diagram of pot experiment and BCF and TF are shown in Fig. 1. Statistical significance was assessed using mean comparison test. Differences between treatment concentration means of parameters were determined by Student's t test. A level of $p < 0.05$ considered statistically significant was used in all comparisons. Means are reported ± standard deviation. One-way ANOVA wee employed to inference the difference among treatments. All statistical analyses were performed with Microsoft Office EXCEL 2007.

III. Results and Discussion

a) Pot Experiment Results

The conceptual setup of the pot experiment is shown in Fig. 1

i. *The background and metal fraction results*

The background propert8es of a sediment was pH, organic matter were 6.58 ± 0.44, 3.43 ± 0.13 %, respectively. The background Cu, Zn, and Pb a sediment concentrations were 3.26 ± 4.72, 121.55 ± 6.34, and 76.55 ±12.68 mg/kg, respectively. Total metal leaves were 898.35 ±15.70, 5933.96 ±5 91.09, and 3109.26 ± 60.37 mg/kg，respectively which was around 1.5 to 3 folds (Cu：400 mg/kg, Zn：2000 mg/kg, Pb：2000 mg/kg). The a sediment particle size of sand, silt, and clay were 5.7%, 82.2%, and 12.1% which is common for most farmland a soil properties.

ii. *Sequential Fraction Results*

Sequential extraction was performed to illumine the adsorption fraction; namely exchangeable, ionic adsorp organic bound, Fe-Mn bound, and sulfide bound portions were in the descending order.

a. Cu uptake enhancement results

For Cu, sequential extraction results are depicted in Fig, Exchangeable fraction was 44 folds while adsroped fraction increased 1.98 folds relative to control while the organic bound and carbonated bound fraction were decreasing. The results indicated whicht EDTA significant enhanced Cu mobility which transfersed from stable to loosely bound fractions from 1.49 to 23.47% which might facilitate future plant uptake.

iii. *Zn Fractionation Results*

Zn fraction results are depicted in Fig. Initial exchangeable, adsorped bound, organic bound, carbonate bound, and sulfide bound fraction of Zn concentration 519.25 ±29.80 mg/kg, 1.08 ± 1.27 mg/kg, 1.08 ± 1.27 mg/kg, 1091.41 ±1 3.78 mg/, 2587.85 ± 84.80mg/kg, 294.84 ± 24.17 mg/kg, respectively. After addition EDTA the fractions were exchange able, adsorped bound, organic bound, carbonate bound and sulfide bound fraction of Zn concentrate on771.07 ± 37.20 mg/kg mg/kg, 21.38 ± 3.33 mg/kg, 1.08 ± 1.27 mg/kg, 1651.88 ± 19.49 mg/kg, 2968.19 ± 9.09 mg/kg, 208.16 ± 41.97 mg/kg respectively. Stable adsorp factions increased 19.80 as EDTA addition which depicted whicht EDTA enhanced metal transfer to loosely bound from 11.57% to 14.1% which will further increase vetiver uptake.

iv. *Pb Fractionation Results*

The results shown in Fig 2. Exchangeable, adsorbed, organic bound, carbonated bound and sulfide bound were 676.88 ± 32.21 mg/kg, 31.69 ± 1.70 mg/kg, 692.08 ±22.97 mg/kg, 207.41 ± 58.67 mg/kg, and 207.41 ± 58.67 mg/kg, respectively. Zn+ EDTA wars moving 33.43% from stable to loosely bound fraction. EDTA mobility enhancement was increasing in upgrading sequence Pb> Cu > Zn due to Pb in a sediment generally was demonstrated more stable bound.

b) *Growth observation metal accumulation in different parts of vetiver*

The vetiver growth observation is shown in Fig. The results form left to right were Cu, Cu+EDTA, Zn, Zn+EDTA, Pb, Pb+EDTA, respectively. The observation time period was 15 days. Vetiver yields leaf yellowing and abrasion. Zn performed the worst propagation among all experiments while Pb and Pb+ EDTA without significant adverse impact.

Zn demonstrated the worst growth which is rapid to wilt. Cu+EDTA was 1.26 + 0.80 which was 21 folds relative to Zn only. For BCF Zn performed the best for with or without EDTA were 2.84 and 1.41 folds, respectively. The vetiver root: stem: leaf weight was 2:1.5:1 Cu and Pb with addition were 3.62 and 3.55 folds relative to control. EDTA demonstrated prominent Cu and Zn vetiver uptake and translocation. No EDTA toxic effects had been observed.

- *2nd stage a sediment and a soil analysis*

c) *The growth and toxicity symptoms of vetiver in pot experiments*

The increased heights of vetiver for three chelators of pot experiment are shown in Table 5. The growth of vetiver was observed for 24 days to study the toxic effect of chelators. The initial average length and weight of vetiver was approximately 30cm and 18 g, respectively. For Cu, the increased height of vetiver for control, EDDS, citric acid, and EDTA were 14.4, 1.2, 9.0 and 0.7 cm, respectively. For Zn, the increased height of vetiver for control, EDDS, citric acid, and EDTA were 0.3, 0.2, 0.5 and 0.2 cm, respectively. For Pb, the increased height of vetiver for control, EDDS, citric acid, and EDTA were 1.3, 2.0, 2.3 and 0.8 cm, respectively. The results of Zn did not present significant growth in chelator amended a sediments.

Cu+EDDS and Cu+EDTA both presented yellowing and chlorosis of leaves at the 12th day. The control and citric acid presented less toxic symptom. For Zn, the control, Zn+EDDS, Zn+citric acid, Zn+EDTA all showed the yellowing at the 8th day of treatment. All Zn treated vetiver were presented serious chlorosis and wilt symptom at the 14th day. For Pb, all treatments presented yellowing at 10th day and the toxic effect was the in the order of EDTA> citric acid> EDDS. According to the aforementioned results, the toxic effect of EDTA was more significant than whicht of other two chelators.

d) *The impact of chelator on the uptake and translocation of metals in pot tests*

The results of the uptake and translocation of metals are shown in Table 6 For Cu, total metal accumulation concentrations of EDDS, citric acid, and EDTA were 14, 4, and 12 folds ($p = 0.002$, 0.02, and 3.5×10^{-6}) increase compared to the control, respectively. The translocation to aerial parts were significant for EDDS, citric acid, and EDTA showing in shoot Cu concentrations raised 151, 6 and 84 folds ($p = 0.004$, 4.76×10^{-5}, and 0.002) compared to control, respectively. The results demonstrated whicht EDDS and EDTA statistically significant increased total metal concentration and metal in aerial parts of vetiver. In particular, the shoot concentration of Cu+EDDS was 936±274 mg/kg which was around the hyperaccumulator level (1,000 mg/kg). For Zn, the whole plant accumulation concentrations of EDDS, citric acid, and EDTA were 1.2, 1.1, and 1.1 folds compared to control, respectively. The statistical analysis compared with the control did not present significant difference ($p = 0.52$, 0.88, and 0.77) for three chelators. However, the aerial parts Zn concentration all achieved hyperaccumulator levels for three chelator treatment (10,000 mg/kg). For Pb, the whole plant accumulation concentrations of EDDS, citric acid, and EDTA were 1.1, 1.3, and 1.6 folds ($p = 0.55$, 0.128, and 0.045) increase relative to control plants, respectively. EDTA presented significant difference ($p<0.05$) with respect to the control. The other two chelators did not show clear uptake enhancement. EDTA also improved Pb uptake in aerial parts to reach the hyperaccumulator levels (1,000 mg/kg). The prominent uptake of Pb by EDTA can be explained by the stability constant ($\log Ks = 17.88$) with Pb while the constants for biodegradable chelators EDDS and citric acid with were $\log Ks = 18.4$ and $\log Ks = 6.5$, respectively. The critical results of our current research were the achievement of vetiver as a hyperaccumulator.

Another similar research showed whicht prominent metal uptake and translocation of Pb with EDTA. They explained by its effect on enhancing the solubility of Pb and absorption of the Pb-EDTA complex by the plant *Brassica napus* (Zaier et al., 2010). In Lin's study, a sediment was applied with EDTA by using sunflower. Pb concentration in the shoot of plants was found directly proportional to the amount of EDTA added to a sediment. The a sediment concentration of soluble Pb was correlated with the Pb concentration in plants grown on the a sediment (Lin et al., 2009). Another investigation also demonstrated whicht EDTA bound Pb was less toxic to free Pb ions and might induce less stress on plants. Pb complexes with phytochelatins were the possible Pb tolerance mechanisms. The results showed whicht vetiver accumulated 19,800 and 3350 mg/kg in root and shot tissues, respectively (Andra et al., 2009). A discrepancy study demonstrated whicht EDDS caused in 2.54, 2.74, and 4.3 fold increase in Cd, Zn, and Pb shoot metal concentration, respectively as compared to control plants. In their study also reported whicht EDTA induced 1.77, 1.11, and 1.87 fold increase in Cd, Zn, and Pb shoot metal concentration, respectively, as compared to control plants. Their results demonstrated whicht EDDS was more effective than EDTA in stimulation the translocation of metals from roots to shoots (Santos et al., 2006).

Research has reported whicht he treatment with 5 mmole/kg EDDS, a sediment resulted in accumulation of 157, 129, and 122 mg/kg of Cu, Zn, and Pb in whole plant, respectively. The concentration in *Brassica carinata* shoots with 2 to 4 fold increase compared to control. Comparing to NTA, the results showed whicht EDDS in a sediment degraded rapidly, reducing the risks associated with the leaching of metals to the groundwater (Quartacci et al., 2007). Other research studied the EDDS enhancement phytoextration of Cu, Zn, and Pb by maize. The results indicated whicht a sediment treated with EDDS significantly increased the concentration of metal in maize shoots (increments of 66%, 169%, and 23% for Cu, Zn, and Pb with respect to the control (Salati et al., 2010). Wang et al. (2009) suggested whicht phytoremediation of high Pb a sediment, EDDS would be better at concentration of 5 mmole in a single dosage. Citric acid showed less obvious effect might be related to its easy biodegraded in the a sediment in their study. Rescarach demonstrated whicht he accumulation of metals in the plant fractions was in descending sequence Cr>Zn>Cu>Pb. The presence of either compost or *B. licheniformis* BLMB1 strain enhanced metal by B. *napus* accumulation, Cr in particular, in the experimental conditions used (Brunetti, et al, 2011).

Our results for EDTA addition revealed the concentration of Cu, Zn, and Pb of 521, 11233, and 1125 mg/kg in shoot, respectively. The discrepancy compared to other studies might be due to the variation of plant species, initial total metal concentration, and metal bound fraction in a sediment. In particular, the metal concentration in a sediment was higher than most of research reported in our study.

e) BCF, TF, and PEF factors in pot-cultural experiments

BCF, TF and PEF in pot experiments of different treatment conditions are depicted in Fig. 5. BCF values in the pot experiment can be referenced to evaluate vetiver accumulation and adsorption at its root rhizosphere. For Cu, the values EDDS, citric acid, and EDTA were 1.97, 0.88, and 2.22 equivalent to 9, 4, 10 times of control, respectively. Based on t test analysis, the variation between control and three chelators presented significant difference ($p = 0.00084$, 0.022, and 8×10^{-7}). Three chelators all showed the significant enhancement of root Cu uptake. For Zn, the BCF values of control, EDDS, citric acid, EDTA were 2.24, 1.95, 1.67, and 1.50, respectively. Three chelators did not presented statistical difference compared to control ($p = 0.48$, 0.22, and 0.09). For Pb, the BCF values of control, EDDS, citric acid, EDTA were 0.51, 0.63, 0.67, and 0.58, respectively. Similar to Cu results, Pb with three chelators treatment also did not presented statistical difference compared with control ($p = 0.296$, 0.1, and 0.29). Three tested chelator only has significant effect on Cu. The variation might be due to the metal complex property with chelators and total metal concentration in a sediment.

TF ratio can be used to evaluate the translocation effects in vetiver. High TF can be explained as prominent transfer from root to aerial parts of plant. For Cu, TF of the control, EDDS, citric acid, EDTA were 0.03, 0.51, 0.04, and 0.2. EDDS, citric acid, and EDTA treatments were equivalent to 17, 1.3, 8 folds ($p = 0.0003$, 0.18, and 0.0022) TF increase relative to the control treatment, respectively. For Zn, TF values of the control, EDDS, citric acid, and EDTA were 0.64, 0.74, 0.82, and 0.86 which indicated the TF of EDDS, citric acid, EDTS equivalent to 1.2, 1.3, 1.3 times of control ($p = 0.027$, 0.034, and 0.05), respectively. EDDS, citric acid, and EDTA all revealed statistical difference relative to control ($p<0.05$). For Pb, the TF values of the control, EDDS, citric acid, and EDTA were 0.02, 0.06, 0.05, and 0.24. These TF values of EDDS, citric acid, and EDTA were equivalent to 3, 2.5, 12 folds ($p = 0.08$, 0.1, and 5×10^{-5}) increase to the control, respectively. Only EDTA revealed statistical difference when compared with the control. PEF was calculated by the concentrations and weights of a sediment and shoot. The p values of EDDS, citric acid, and EDAT compared to the control were Cu: 0.004, 4×10^{-5}, and 0.001, for Zn: 0.17, o.19, and 0.39, and for Pb: 0.025, 0.04, and 0.0007, respectively. Our results compared with preious are depicted in Table which demonstrated whicht our results were conformed with those researches.

In our study, the critical finding is whicht vetiver has been demonstrated as a hyperaccumultor for treatment of EDDS with Cu; EDDS, citric acid, and EDTA with Zn; and EDTA with Pb. The other important message is using PEF value to predict the required duration for a sediment remediation. The remediation time required for phytoextraction reference to PEF can be predicted by the following formula. Phytoextation time (yr) = (metal concentration (mg/kg) in a sediment needed to decrease × a sediment mass (kg))/(metal concentration in plant shoot (mg/kg) × plant shoot biomass × the frequency of harvested (number of harvest/yr)). This information is paramount crucial for a project engineer to design an in-situ phytoremediation. In this study, EDTA has been showed to be an effective chelator though its toxic effect and possible leaching to subsurface to induce groundwater contamination. EDDS has the comparable effect with EDTA, but it might be more pricy than EDTA. The alternative might chose biodegradable EDDS if groundwater leaching was a major concern. Future study should be focused on the synergistic effect of muti-metal contamination which is more realistic for the real word application.

IV. Conclusion

EDTA significantly increased a sediment mobility and further enhance vetiver plant uptake, Pb performed the best among four metals while and underground and aboveground were increased 6.9 and 2.86 folds with addition chelator EDTA. High concentration from Ho-Jin river due to contaminated by improperly treated of swine wastewater the Cu, Zn, and Pb reveal rate I 6 monthswere29.51% 、56.59% 及 49.05%, respectively. Low concentrayuon from University campus wetland Cu, Zn, and Pb reveal rate of two consecutive months were first month 29.51 %, 6.59 %, and 49.05%, respectively, and second 9.97 %, 41.69%, and 45.12%, respectively. Four sessions EDTA enhancement a sediment experiments demonstrated satisfactory results. A sediment phytoattenuation can be referenced to future operation to employ this green remediation approach.

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Table Captions

- Table 1 Plant uptake and transportation in recent study.

Figure Captions

- Fig. 1 Schematic diagram of pot experiment
- Fig. 2 Chemical bond distribution results of (a) Cu, (b) Zn and (c) Pb of a sediment in sequential extraction experiment

Table 1 : BCF and TF summery list from previous studies

Reference	Plant	Chelator	Metal content	BCF	TF
Nascimento et al. (2004)	*Brassica juncea*	EDTA 10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 9.3 mg/kg Pb 645.3 mg/kg Zn 454.8 mg/kg Cu 296.8 mg/kg Ni 204.2 mg/kg Aerial part： Cd 127.3 mg/kg Pb 1013.4 mg/kg Zn 1239.9 mg/kg Cu 476.9 mg/kg Ni 252.7 mg/kg	Pb:53.30 Zn:5.33 Cu :17.05 Ni:12.53	Cd:13.68 Pb:1.57 Zn:2.73 Cu:1.61 Ni:1.24
		DTPA 10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 32.4 mg/kg Pb 453.8 mg/kg Zn 355.2 mg/kg Cu 264.5 mg/kg Ni 183.3 mg/kg Aerial part： Cd 147.1 mg/kg Pb 280.4 mg/kg Zn 765.3 mg/kg Cu 283.7 mg/kg Ni 168.3 mg/kg	Pb:37.50 Zn:4.16 Cu:15.20 Ni:11.25	Cd:4.15 Pb:0.62 Zn:2.15 Cu:1.07 Ni:0.92
		Oxlic10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 103.9 mg/kg Pb 484.9 mg/kg Zn828.8 mg/kg Cu 256.4 mg/kg Ni 191.4 mg/kg Aerial part： Cd 87.9 mg/kg Pb 43.7 mg/kg Zn 783.1 mg/kg Cu Cu 125.8 mg/kg Ni 226.1 mg/kg	Pb:40.07 Zn:9.72 Cu:14.74 Ni:11.74	Cd:0.85 Pb:0.09 Zn:0.94 Cu:0.49 Ni:1.18

		Citric acid 10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 105.3 mg/kg Pb 512.1 mg/kg Zn 799.3 mg/kg Cu 246.6 mg/kg Ni 211.5 mg/kg Aerial part： Cd 138.0 mg/kg Pb 112.5 mg/kg Zn 649.1 mg/kg Cu 329.2 mg/kg Ni 276.4 mg/kg	Pb:42.32 Zn:9.37 Cu:14.17 Ni:12.98	Cd:1.31 Pb:0.22 Zn:0.81 Cu:1.34 Ni 1.31
		Vanillic acid 10mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 96.2 mg/kg Pb 442.9 mg/kg Zn 701.8 mg/kg Cu156.9 mg/kg Ni 158.9 mg/kg Aerial part： Cd 141.1 mg/kg Pb 41.5 mg/kg Zn 699.3 mg/kg Cu 43.0 mg/kg Ni 98.3 mg/kg	Pb:36.60 Zn:8.23 Cu:9.01 Ni :9.75	Cd:1.47 Pb:0.09 Zn:1.00 Cu:0.27 Ni:0.62
		Gallic acid 10mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg A soil： Cd 275.2 mg/kg Pb 572.4 mg/kg Zn 829.3 mg/kg Cu 324.5 mg/kg Ni 373.9 mg/kg Aerial part： Cd 125.2 mg/kg Pb 25.0 mg/kg Zn 748.4 mg/kg Cu 58.5 mg/kg Ni 183.8 mg/kg	Pb:47.31 Zn:9.72 Cu:18.65 Ni:22.94	Cd:0.45 Pb:0.05 Zn:0.90 Cu:0.18 Ni:0.49
Sudova et al. (2007)	*Glomus intraradices*	EDDS 2.5 mmol/kg	Root part： Pb 462 mg/kg Aerial part： Pb 145 mg/kg		Pb 0.31
		EDDS 5.0 mmol/kg	Root part： Pb 558 mg/kg Aerial part： Pb 351mg/kg		Pb 0.63
Lim et al. (2004)	*Brassica juncea*	EDTA 2 mmol/kg	Root part： Pb 350 mg/kg Aerial part：		Pb 1.11

			Pb 390mg/kg		
		EDTA 5 mmol/kg	Root part： Pb 420 mg/kg Aerial part： Pb 690mg/kg		Pb 1.64
Chen and Cutright (2001)	Sunflower *Helianthus annuus*	EDTA 0.5 g/kg	Root part： Cd 900 mg/kg Ni 590 mg/kg Aerial part： Cd 910 mg/kg Ni 700 mg/kg		Cd 1.01 Ni 1.19
		EDTA 1.0 g/kg	Cd shoot:115 mg/kg Root : 68 mg/kg Ni shoot :150 mg/kg Root:50 mg/kg		Cd 1.69
Madrid et al. (2003)	*Hordeum vulgare*	EDTA 0.5 g/kg	Root part： Cu 15.0 mg/kg Zn 15.3 mg/kg Fe 1077.5 mg/kg Mn 53.1 mg/kg Aerial part： Cu 11.7 mg/kg Zn 25.0 mg/kg Fe 210 mg/kg Mn 86.3 mg/kg		Cu 0.78 Fe 0.19 Mn 1.63 Pb 1.63
Turgut et al. (2004)	Sunflower *(Helianthus annuus)*	Citric acid 1 g/kg	Root part： Cd0.09 mg/g Ni 0.01mg/g Cr 0.06 mg/g Aerial part： Cd 0.02 mg/g Ni 0.01 mg/g Cr 0.09 mg/g		Cr 1.50 Ni 1.00 Cd 0.22
		Citric acid 3 g/kg	Root part： Cd 0.05 mg/g Ni 0.01 mg/g Cr 0.09 mg/g Aerial part： Cd 0.0025 mg/g Ni 0.03 mg/g Cr 0.07 mg/g		Cr 0.78 Ni 3.00 Cd 0.05
		EDTA 0.1 g/kg	Root part： Cd 0.09 mg/g Ni 0.01 mg/g Cr 0.06 mg/g Aerial part： Cd 0.125 mg/g Ni 0.01 mg/g Cr 0.07 mg/g		Cr 1.17 Ni 1.00 Cd 1.39
		EDTA 0.3 g/kg	Root part： Cd 0.22 mg/g Cd 0.01 mg/g Cr 0.11 mg/g Aerial part： Cd 0.015 mg/g Ni 0.17 mg/g		Cr 1.55 Ni 3.50 Cd 0.09

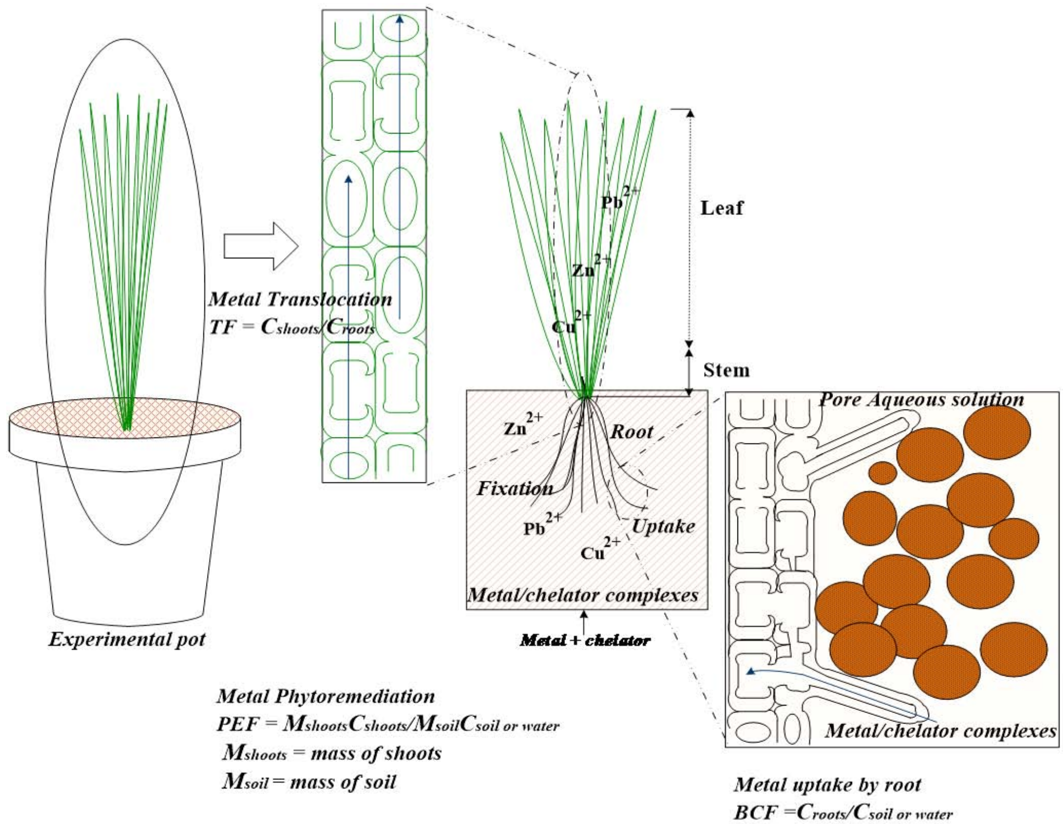

Figure 1 : Schematic diagram of pot experiment

1st day

4th day

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15th day

Fig. 2 : Vetiver groth observation via EDTA application

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Numerical Analysis of Piles in Layered Soils: A Parametric Study

By C. Ravi Kumar Reddy & T. D. Gunneswara Rao

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Abstract- In this paper, numerical analysis of a pile-soil interaction problem is presented considering the parameters influencing the axial load-deformation behavior of the pile embedded in a layered soil medium. The analysis is demonstrated with parametric solutions of a pile with underlain model soil strata under the axial force. An attempt is made to ascertain the extent of influence of elastic properties of the pile, geometry of the pile, end conditions of the pile and the elastic properties of the underlain soil strata on the response of the piles under axial loads lying in a model soil layers in terms of the settlement of the pile and the internal deformation of the pile. The study revealed that the increase in modulus of elasticity of pile improves the settlement resistance of the pile, increase in the ratio of cross sectional dimensions causes decrease in the top deformations of the pile, the settlement of the pile reduced to a great extent when the cross section of the pile adopted is non circular instead of circular and increase in the elastic modulii of top and bottom layers of soil has decreased the settlement of the pile to a great extent, but elastic modulus of soil layers other than top and bottom has got negligible influence on the settlement of the pile.

Keywords: pile; settlement; parametric study; layered soil; pile-soil interaction; load-deformation; internal deformation.

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C. Ravi Kumar Reddy [α] & T. D. Gunneswara Rao [σ]

Abstract- In this paper, numerical analysis of a pile-soil interaction problem is presented considering the parameters influencing the axial load-deformation behavior of the pile embedded in a layered soil medium. The analysis is demonstrated with parametric solutions of a pile with underlain model soil strata under the axial force. An attempt is made to ascertain the extent of influence of elastic properties of the pile, geometry of the pile, end conditions of the pile and the elastic properties of the underlain soil strata on the response of the piles under axial loads lying in a model soil layers in terms of the settlement of the pile and the internal deformation of the pile. The study revealed that the increase in modulus of elasticity of pile improves the settlement resistance of the pile, increase in the ratio of cross sectional dimensions causes decrease in the top deformations of the pile, the settlement of the pile reduced to a great extent when the cross section of the pile adopted is non circular instead of circular and increase in the elastic modulii of top and bottom layers of soil has decreased the settlement of the pile to a great extent, but elastic modulus of soil layers other than top and bottom has got negligible influence on the settlement of the pile.

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I. Introduction

The design of pile foundations to resist axial loads completes when one can perform evaluation of ultimate bearing load, settlement prediction under the design load and structural design. Numerous studies have been carried out on the behavior of axially loaded piles (Basu et al.[2], Guo[4], Guo and Randolph[5], Lee and Small[7], Motta[10], Mylonakis[11], Rajapakse[15], Randolph and Worth[17]) and laterally loaded piles (Lee et al.[8], Poulos[13], Randolph[16]). Extensive research has concerned the evaluation of ultimate bearing capacity but little attention has been given for settlement of pile as well as the compression of the pile under the axial loads. Usually the methods of analyzing the behavior of piles are the load transfer method (Coyle and Reese[3], Hazarika and Ramasamy[6], Matlock and Reese[9]) and elastic continuum method (Poulos[12], Banerjee and Davis[1], Poulos and Davis[14]). The subgrade reaction theory idealizes the pile as an elastic beam supported by a series of discrete linear springs representing the soil. Simplicity of the subgrade reaction theory lies in its straight forward computations and the disadvantage is the approximation in subgrade reaction modulus leads to inaccurate solutions. The most powerful continuum approach is the finite element approach. Theoretically elastic solution is more realistic because it considers the soil as a continuum rather than a series of unconnected springs as in the subgrade reaction analysis.

In this paper, extensive parametric studies are performed and presented in graphical form to facilitate the understanding of settlement prediction, which will be useful in the design and analysis of piles under the axial loads in layered soil. The main purpose of this study is to investigate the more practical case of the behavior of piles under the axial loads in layered soils using the continuum based numerical analysis.

II. Pile with Extended Soil Layers

Pile with underlain soil layers in model soil strata is presented in fig.1. The pile having three different cross sections viz., rectangular with dimensions a x b (example 1), square (example 2) and circular (example 3) of length L and axial load P is considered for the analysis.

The governing differential equation for the pile settlement given by Basu et al.[2]:

$$\frac{d^2u}{dz^2} - \frac{k_i}{1+2t_i}u_i = 0 \qquad (1)$$

Where u_i is the displacement function u(z) in the i^{th} layer, k_i is the term which accounts for the shear resistance developed between soil columns due to differential movement of the soil columns, t_i is the term which accounts for spring effect of the soil (compression of the soil columns due to vertical movement of the pile) The general solution of the differential equation (Eq. 1) is

$$u_i(z) = C_1 \sinh \beta_i z + C_2 \cosh \beta_i z \qquad (2)$$

The evaluation of the integration constants (C1 and C2 in Eq. 2) for each layer is a difficult process if the layers in soil strata are more in number. In the present study the pile and soil layers are modeled with 20-noded three dimensional solid elements in the ANSYS (A powerful finite element analysis program) to carry out finite element analysis. No slip condition is assumed at the interface of pile and soil. The horizontal extent of the soil domain from the pile axis is taken as 15 times the

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pile width and the vertical extent of the soil domain below the pile base is taken as the pile length.

a) Model Soil Strata

The top layer having a thickness of H_1 consists of yellow sand and its elastic modulus and Poisson's ratio are Es_1 and ν_1 respectively. The next two layers below the yellow sand are consisting of grey sand with their elastic modulii Es_2, Es_3 and Poisson's ratios ν_1, ν_2. The bearing layer (Bottom layer) consists of brownish sand with elastic modulus Es_4 and Poisson's ratio ν_4.

i. *Example 1*

A rectangular pile (Fig. 2) of cross sectional dimensions 2m x 1m having a length of 40m and underlain soil strata with top layer consisting of yellow sand (SPT (10) - $Es_1 = 25$MPa, $\nu_1 = 0.35$) extending to a depth of 4m. The next layer is a grey sand (SPT (20) - $Es_2 = 45$MPa, $\nu_2 = 0.3$) extending to a depth of 12m. The next layer is a grey sand (SPT (25) - $Es_3 = 55$MPa, $\nu_3 = 0.25$) extending to a depth of 18m. The bearing layer consists of brownish sand (SPT (45) - $Es_4 = 75$MPa, $\nu_4 = 0.2$) extending to a depth of 46m. The axial load on the pile is taken as 9700kN.

ii. *Example 2*

A square pile (Fig. 3) of cross sectional area 2300cm^2 having a length of 15m and underlain soil strata with top layer consisting of black clay (SPT (10) - Es1 = 12MPa, $\nu 1 = 0.3$) extending to a depth of 3m. The next layer is a yellow sand (SPT (10) - Es2 = 25MPa $\nu 2 = 0.25$) extending to a depth of 4m. The next layer is a grey sand (SPT (15) - Es3 = 35MPa, $\nu 3 = 0.2$) extending to a depth of 6m. The bearing layer consists of brownish sand (SPT (50) - Es4 = 80MPa, $\nu 4 = 0.2$) extending to a depth of 17m. The axial load on the pile is taken as 3300kN.

iii. *Example 3*

A circular pile (Fig. 4) having diameter of 1.5m, length of 40m and underlain soil strata with top layer consisting of yellow sand (SPT (10) - Es1 = 25MPa, $\nu 4 = 0.2$) extending to a depth of 4m. The next layer is a grey sand (SPT (20) - Es2 = 45MPa, $\nu 2 = 0.3$) extending to a depth of 12m. The next layer is a grey sand (SPT (25) - Es3 = 55MPa, $\nu 3 = 0.25$) extending to a depth of 18m. The bearing layer consists of brownish sand (SPT (45) - Es4 = 75MPa, $\nu 4 = 0.2$) extending to a depth of 46m. The axial load on the pile is taken as 9700kN.

The analysis is carried out using the above examples to evaluate the effect of grade of concrete of the pile, effect of ratio of cross sectional dimensions (a/b), elastic modulus of each underlain soil layers and the shape of the cross section (circular, non-circular) on the top deformation of the pile as well as the internal deformation of the pile with the two end conditions of the pile namely floating pile condition and the fix-base condition.

III. Results and Discussions

a) Effect of Elastic Modulus of Pile (Floating Base Condition)

Fig.5 shows the variation of settlement of the rectangular pile (example 1) with pile depth, for different grades of pile material (concrete). Fig.6 gives the variation of settlement of the square pile (example 2) with pile depth, for different grades of pile material (concrete). Fig.7 represents the variation of settlement of the circular pile (example 3) with pile depth, for different grades of pile material (concrete).

From Fig.5, 6 and 7 it is observed that, as the grade of concrete of pile increases the axial deformations in the pile decreases and this decrease in the deformation is very less when compared with the extent of increase in the grade of concrete. For example the decrease in the settlement at the top of the pile is about 14% as the grade of concrete is increased from M20 to M100.

As the pile is taken as the floating pile, the internal deformation in the pile is calculated as the difference between top and bottom deformations in the pile and it is evident from the fig.5, 6 and 7 that the internal deformation in the pile is decreased to a higher extent than the decrease in the top deformation of the pile when the grade of concrete is increased. For example the decrease in the internal deformation of the pile is about 55% if the grade of concrete is increased from M20 to M100 (5 times).

Hence, Increase in modulus of elasticity of pile has decreased the top deformation of the pile to a little extent however increase in the modulus of elasticity of pile decreased the internal compression of the pile.

b) Effect of Elastic Modulus of Pile (Fixed Base Condition)

Fig.8 shows the variation of settlement of the rectangular pile (example 1) with pile depth, for different grades of pile material (concrete). Fig.9 shows the variation of settlement of the square pile (example 2) with pile depth, for different grades of pile material (concrete). Fig.10 shows the variation of settlement of the circular pile (example 3) with pile depth, for different grades of pile material (concrete).

Fig.8, 9 and 10, it is evident that the top deformation of the pile decreases with increase in the grade of concrete of the pile. As the base of the pile is fixed (in case of a pile resting on a very hard stratum), the top deformation of the pile itself is the internal deformation of the pile. For example the decrease in the settlement of the pile is about 55% if the grade of concrete is increased from M20 to M100.

Increase in the grade of concrete of the pile decreases the settlement of the pile. Hence increase in modulus of elasticity of pile improves the settlement resistance of the pile.

c) *Effect of Ratio of Cross Sectional Dimensions of the Pile*

Fig.11 shows the variation of settlement of the pile (example 1) with pile depth, for different ratios of the cross sectional dimensions of the pile, keeping the cross sectional area of the pile constant for floating base condition.

Fig.12 shows the variation of settlement of the pile (example 1) with pile depth, for different ratios of the cross sectional dimensions of the pile, keeping the cross sectional area of the pile constant for fixed base condition.

For a floating pile condition (Fig.11) it is observed that as the ratio of cross sectional dimensions increases the deformation of top of the pile decreases, but the change in the internal deformation of the pile is almost negligible because all other parameters (viz., area of cross section axial force, underlain soil profile, boundary conditions etc.) being kept same. For example if the ratio of cross sectional dimensions is increased from 1.0 to 4.0 without changing the area of cross section of the pile the decrease in the settlement of the top of the pile is about 14% and the internal deformation is almost constant.

This can be viewed as, increase in the ratio of cross sectional dimensions increases the perimeter of the pile, which increases the area of contact of the surrounding soil with the pile which in-turn improve the resistance from the soil on the settlement of the pile. Hence we see the decrease in the deformations of the pile. In other words the pile – soil friction improves the resistance to the pile settlement.

For a fix-base pile condition (Fig.12) it is observed that the increase in the ratio of the cross sectional dimensions of the pile does not have a significant influence on the top deformation of the pile as well as the internal deformation of the pile. Because all other parameters (viz., area of cross section axial force, underlain soil profile, boundary conditions etc.) being the same fix-base pile has got less influence on the deformations of the pile with respect to its contact with the surrounding soil and the settlement of the pile is almost constant and it is about 7mm for all the cases shown (fig.12).

Hence change in the ratio of cross sectional dimensions has got no influence on the settlement of the pile for a fixed base pile condition, all other factors being the same.

d) *Effect of Elastic Modulus of the Soil in Top and Bottom Layers*

Fig.13 shows the variation of settlement of the rectangular pile (example 1) with pile depth, for different values of elastic modulii of the soil in the top layer for floating base condition, keeping the elastic modulii of all other layers constant. Fig.14 shows the variation of settlement of the rectangular pile (example 1) with pile depth, for different values of elastic modulii of the soil in the bearing layer for floating base condition, keeping the elastic modulii of all other layers constant.

Pile behavior in layered soil strata for floating pile condition from fig.13 and 14 can be assessed as the change in the elastic modulus of the soil in the top layer and bearing (bottom) layer has got great influence on the deformation of the pile.

For example, it is observed for the elastic modulus values from 2.5MPa to 70Mpa (normal range of elastic modulus of cohesive soils and sands for the earlier case the top deformation of the pile has decreased about 27% and also the internal deformation of the pile has decreased about 30% where as in the later case the top deformation of the pile has decreased about 85% and the internal deformation of the pile is increased about 65%.

Hence there is a possibility to reduce the settlement of the pile by engineering the top layer; generally the sandy soils with SPT values 50-80 can be the choice to arrive at the lower pile settlement values.

The above discussion infers that the bearing layer greatly influence the settlement of the pile, for lower values of elastic modulus of the bearing layer fig.14 show that the pile has got almost the rigid body motion which says that though the pile is embedded in the strong soil layers (in terms of elastic modulus) above the bearing layer the settlement of the pile can be very high.

As it is practically impossible to have proper care on bearing area, however it is to be noted that the bearing layer should have larger value of elastic modulus than any other layer in the soil strata.

e) *Effect of Elastic Modulus of the Intermediate Soil Layers*

Fig.15 shows the variation of settlement of the rectangular pile (example 1) with pile depth, for different values of elastic modulii of the soil in the layer just below the top layer for floating base condition, keeping the elastic modulii of all other layers constant.

Fig.16 shows the variation of settlement of the rectangular pile (example 1) with pile depth, for different values of elastic modulii of the soil in the layer just above the bearing layer for floating base condition, keeping the elastic modulii of all other layers constant.

From fig.15 and 16 it is observed that the increase in the elastic modulus of the intermediate soil layers has got almost negligible effect on the deformations of the pile. It can also be noted that the change in the internal deformation of the pile is also negligible. Hence the change in the elastic modulii of the underlain soil layers other than top layer and bearin layer has got no influence on the settlement of the pile.

f) *Effect of Shape of the Cross Section of the Pile*

To study the effect of shape of cross section of the pile, soil domain and the geometry of the pile used in example1 is considered with floating base condition. It is solved for three different cross sections namely, rectangular, square and circular keeping area of the cross section of pile and all other parameters same as that of the parameters used in example1. Results are furnished in the form of a plot shown in Fig.17.

The plot (Fig.17) clearly indicates that the axial deformation of the pile having circular cross section is very high when compared to the piles having square and rectangular cross sections. For example the reduction in the axial deformation of the pile is about 25% when the pile cross section is changed from circular to non-circular. Also the internal deformation of the pile is reduced about 25% as the cross section of the pile changes from circular to non-circular.

IV. Conclusions

With the help of numerical simulation using ANSYS, pile – soil interaction problem for axial loads has been solved and the parametric study revealed that,

- Increase in modulus of elasticity of pile has decreased the top deformation of the pile to a little extent however increase in the modulus of elasticity of pile decreased the internal compression of the pile. Increase in the grade of concrete of the pile decreases the settlement of the pile. Hence increase in modulus of elasticity of pile improves the settlement resistance of the pile.
- Increase in the ratio of cross sectional dimensions has decreased the top deformations of the pile. Hence the settlement of the pile decreases with increase in the ratio of cross sectional dimensions of the rectangular pile with floating base condition, whereas change in the ratio of cross sectional dimensions has got no influence on the settlement of the pile for a fix-base pile condition all other factors being the same.
- Increase in the elastic modulii of top and bottom layers has decreased the axial deformations of the pile to a great extent, hence there is a possibility to reduce the settlement of the pile by proper care given to the top layer, generally the sandy soils with SPT values 50-80 can be the choice to arrive at the lower pile settlement values, As it is nearly impossible and not feasible to have proper care on bearing area, it is to be noted that the bearing layer should have larger value of elastic modulus than any other layer in the soil strata.
- Change in the elastic modulii of the underlain soil layers other than top layer and bearing layer has got negligible influence on the settlement of the pile.
- When compared to the circular cross section, the non-circular cross sections of piles reduce the settlement of the pile to a great extent though the reduction in the internal deformation is taking place to a lesser extent than the settlement of the pile.

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Figures

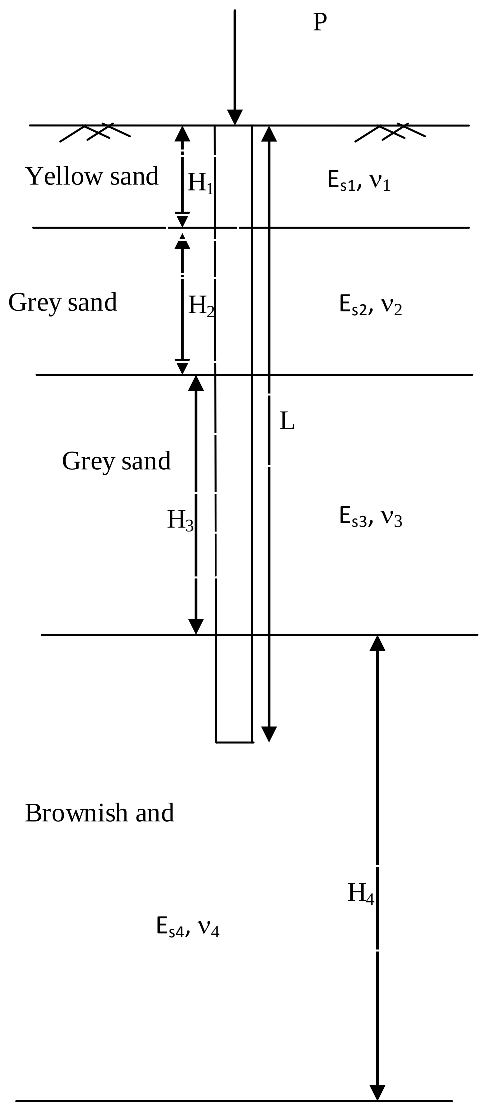

Fig.1 : Pile embedded in a model soil strata with axial load

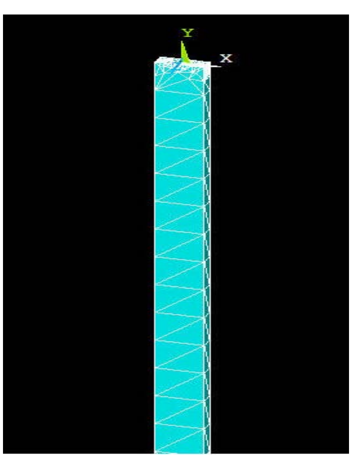

Fig. 2 : Rectangular pile

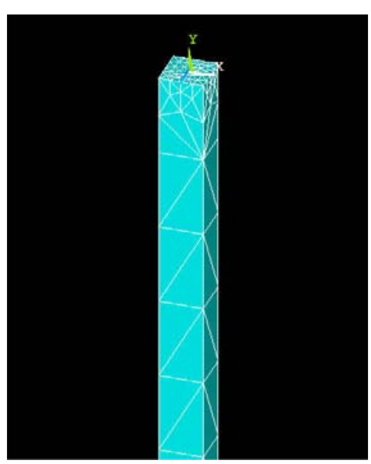

Fig. 3 : Square pile

Fig. 4 : Circular pile

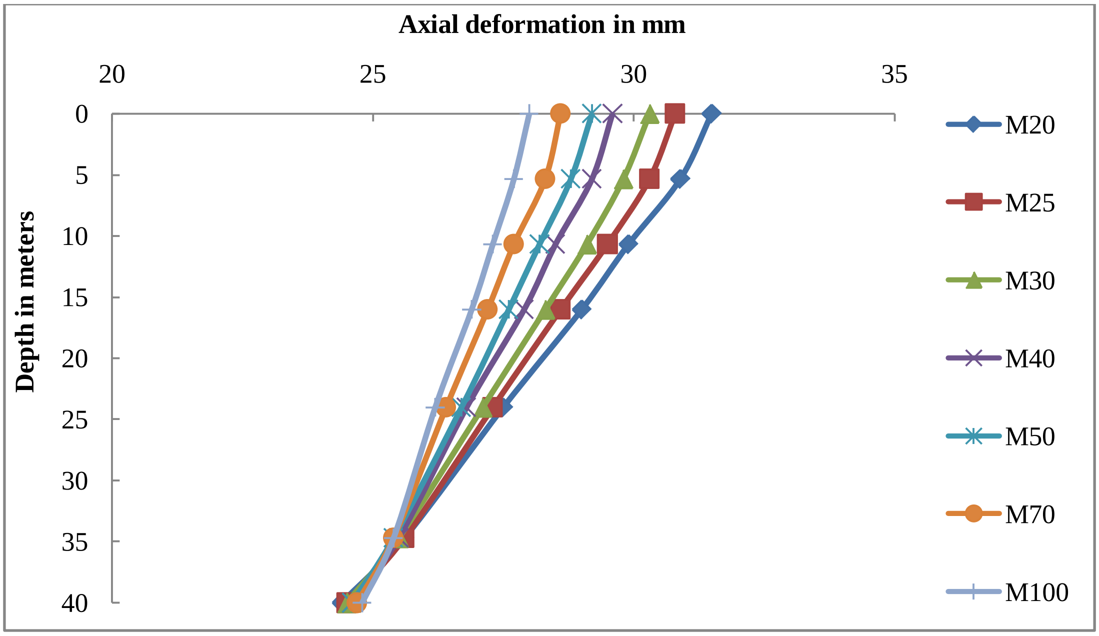

Fig. 5 : Vertical deformations of axially loaded rectangular pile in layered soil for various grades of concrete of pile for floating base condition

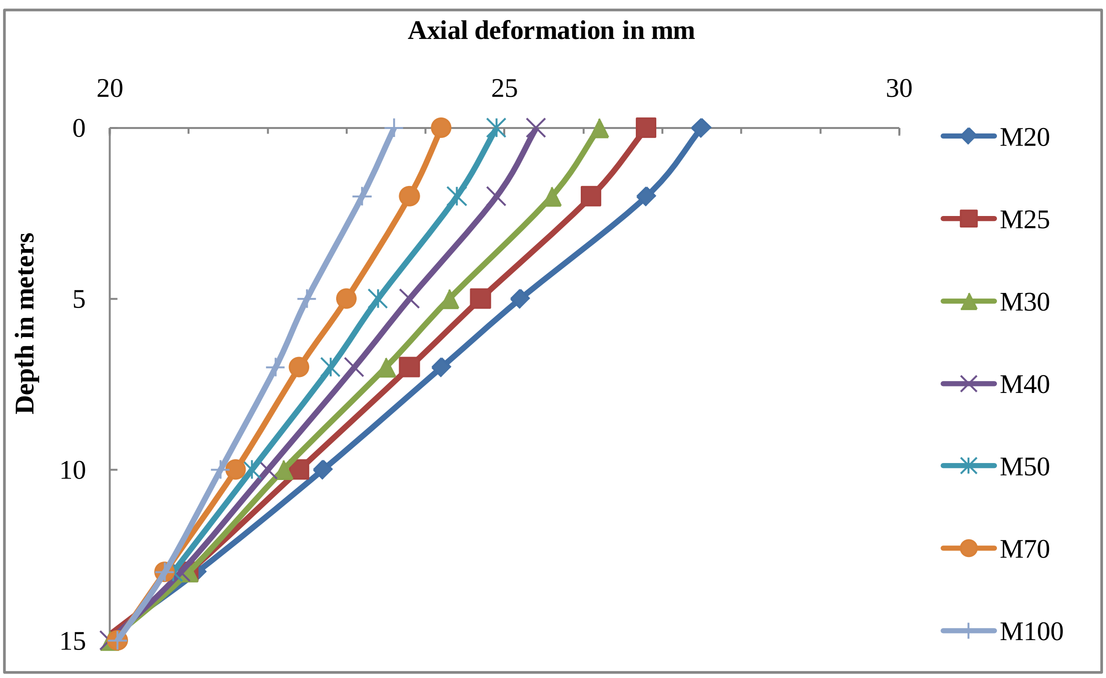

Fig. 6 : Vertical deformations of axially loaded square pile in layered soil for various grades of concrete of pile for floating base condition

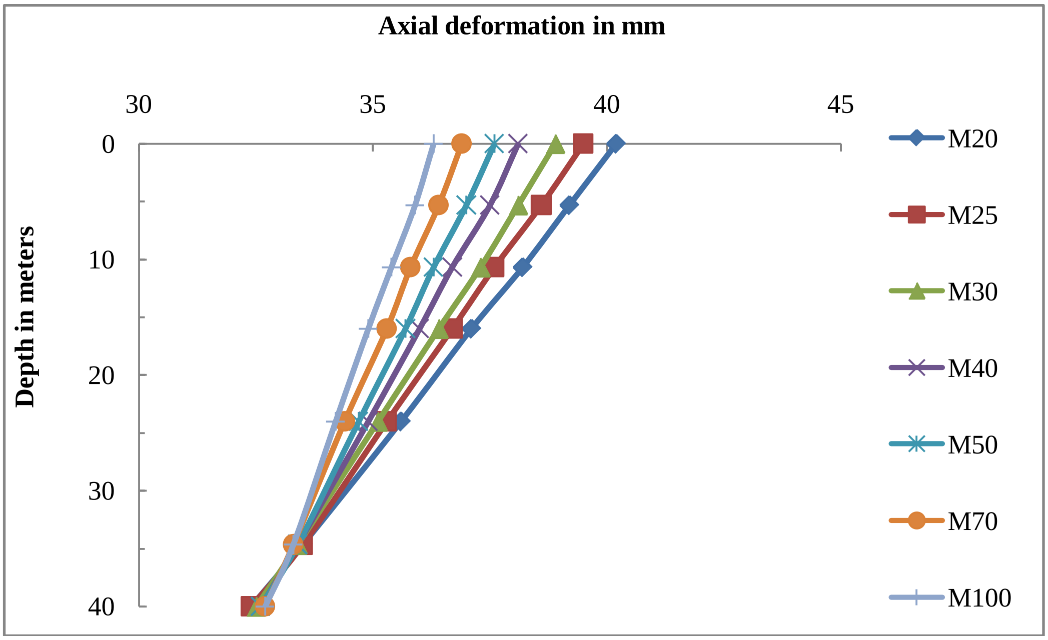

Fig. 7 : Vertical deformations of axially loaded circular pile in layered soil for various grades of concrete of pile for floating base condition

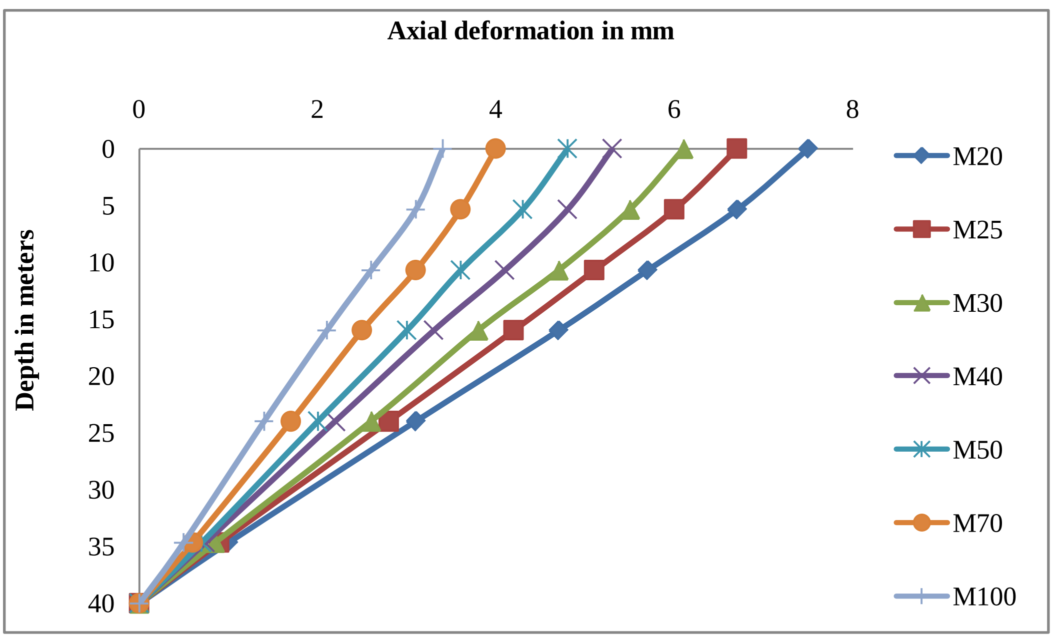

Fig. 8 : Vertical deformations of axially loaded rectangular pile in layered soil for various grades of concrete of pile for fixed base condition

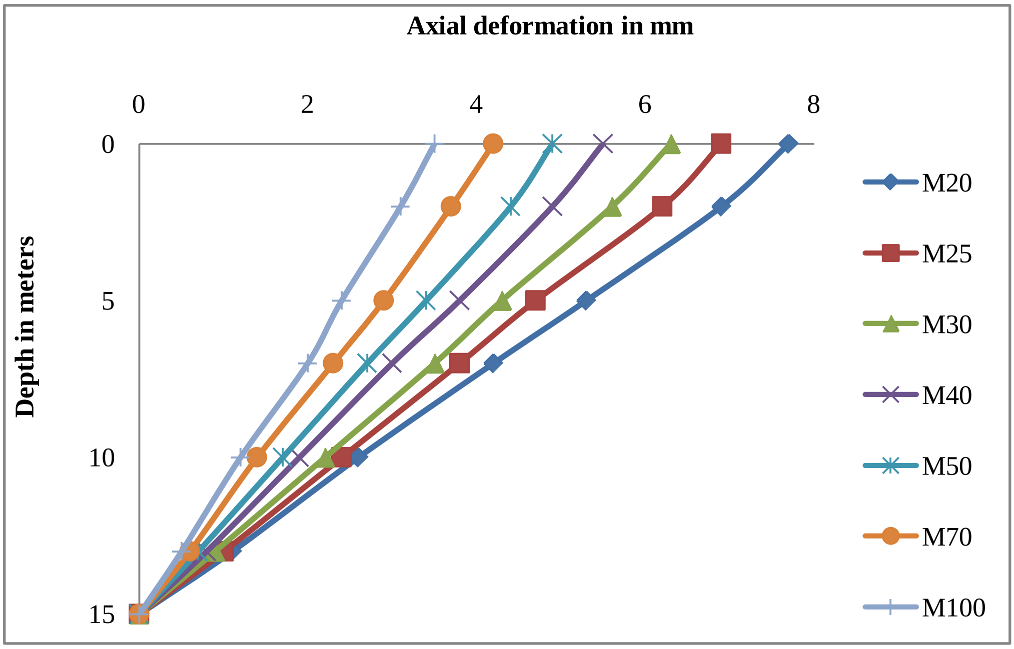

Fig. 9 : Vertical deformations of axially loaded square pile in layered soil for various grades of concrete of pile for fixed base condition

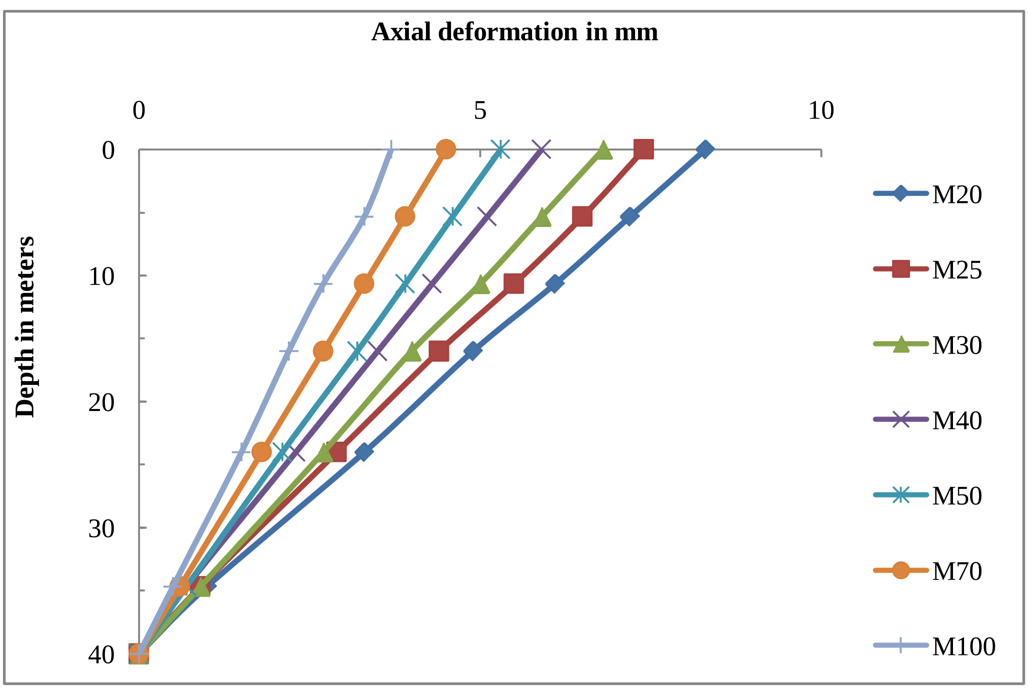

Fig. 10 : Vertical deformations of axially loaded circular pile in layered soil for various grades of concrete of pile for fixed base condition

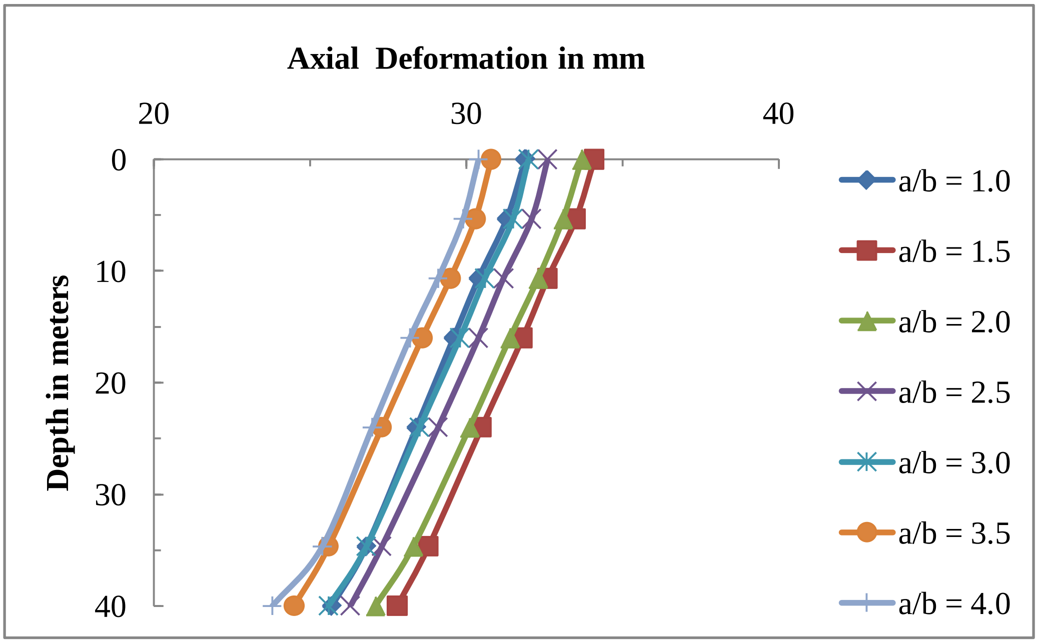

Fig. 11 : Vertical deformations of axially loaded pile in layered soil for various ratios of cross sectional dimensions of pile for floating base condition

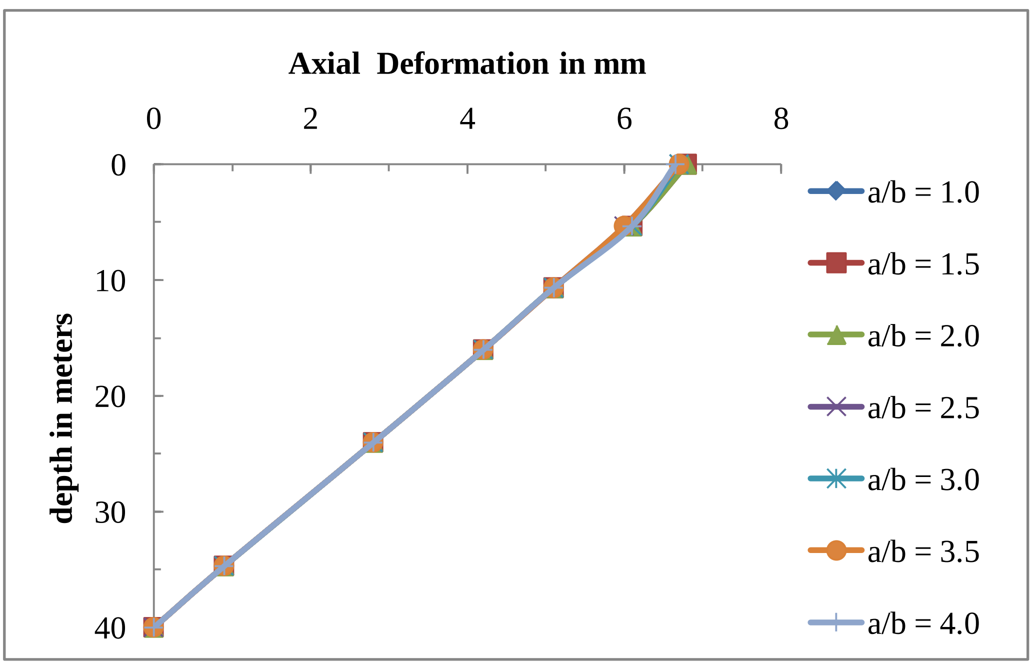

Fig. 12 : Vertical deformations of axially loaded pile in layered soil for various ratios of cross sectional dimensions of pile for fixed base condition

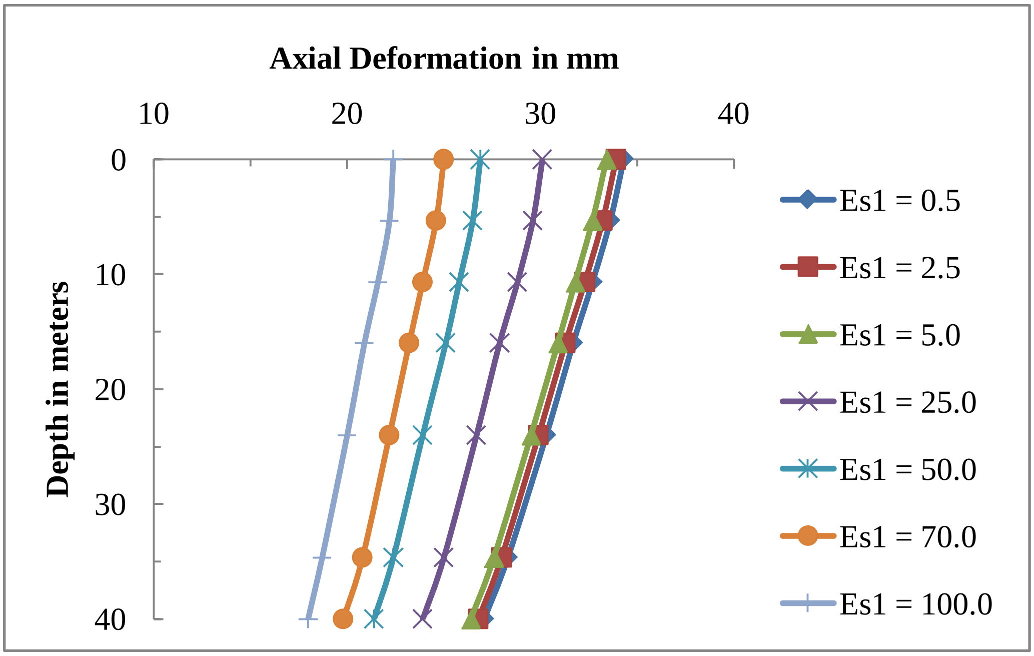

Fig. 13 : Vertical deformations of axially loaded rectangular pile in layered soil for various values of elastic modulii of soil in the top layer for floating base condition

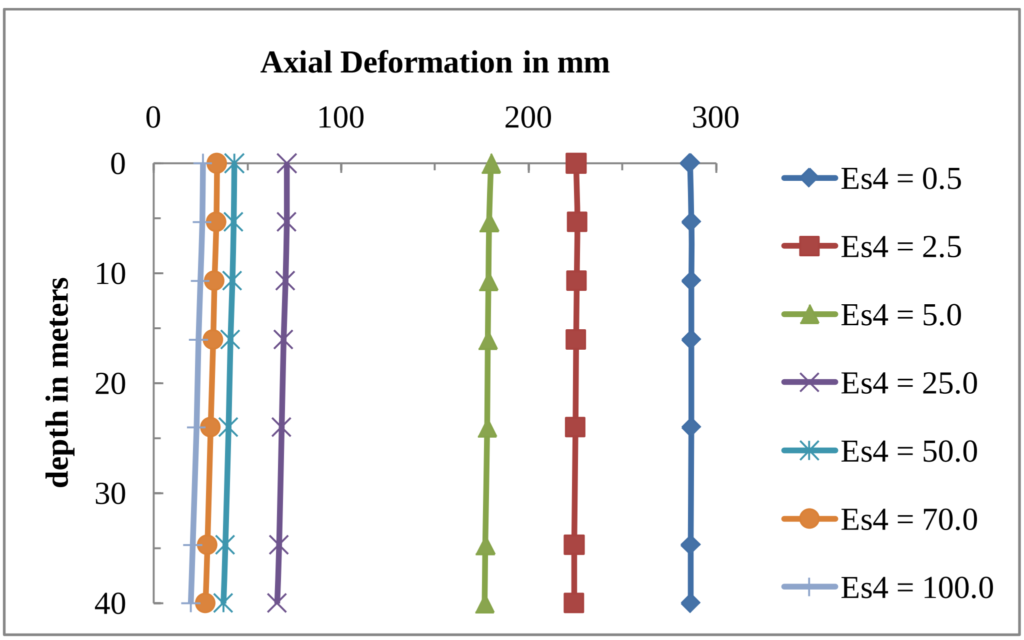

Fig. 14 : Vertical deformations of axially loaded rectangular pile in layered soil for various values of elastic modulii of soil in the bearing layer for floating base condition

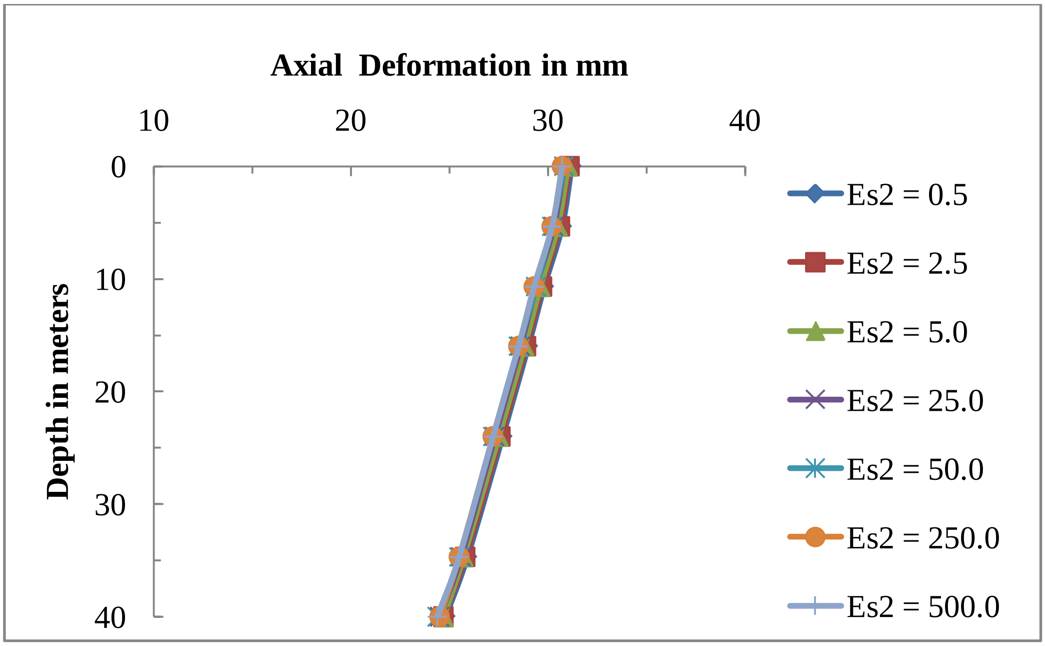

Fig. 15 : Vertical deformations of axially loaded rectangular pile in layered soil for various values of elastic modulii of soil in the intermediate layer for floating base condition

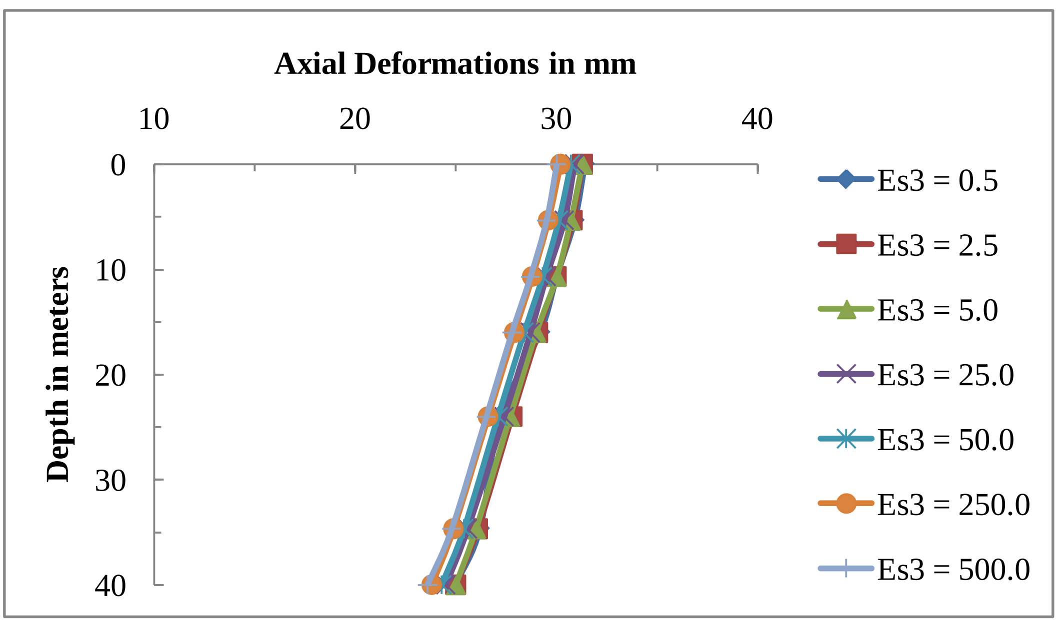

Fig. 16 : Vertical deformations of axially loaded rectangular pile in layered soil for various values of elastic modulii of soil in the intermediate layer for floating base condition

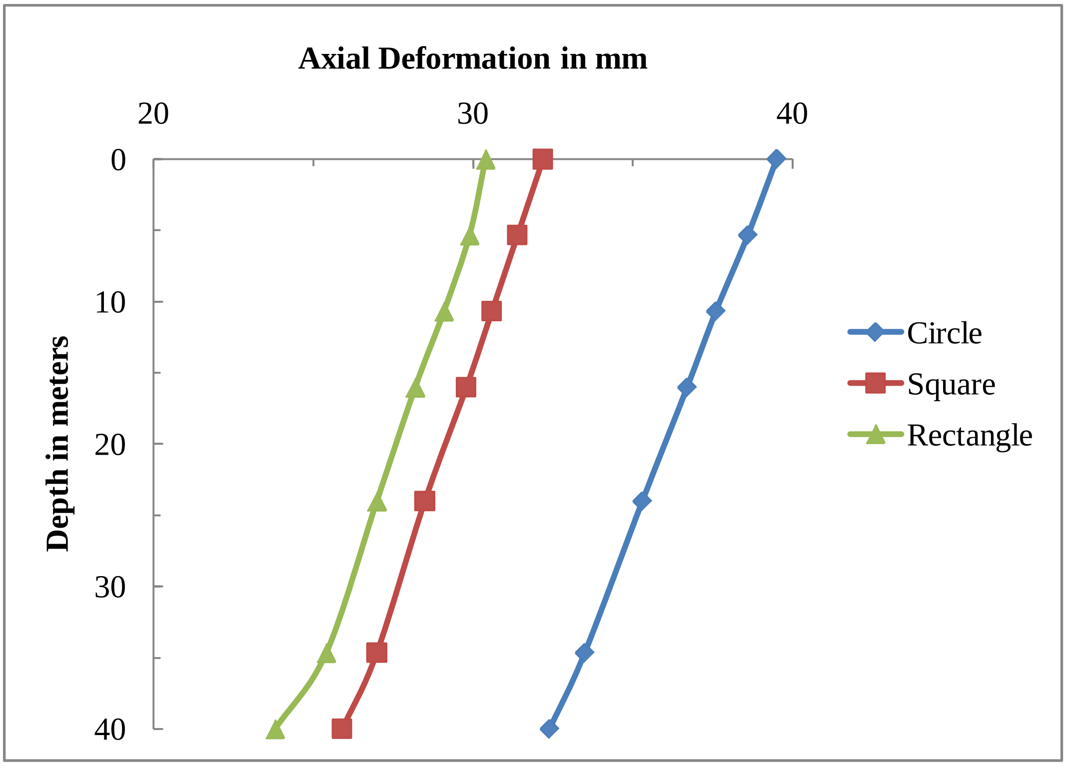

Fig. 17 : Vertical deformations of axially loaded circular, square and rectangular cross sectional shaped piles for floating base condition

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A Flood Forecasting Model for the River Padma

By Md. Nuruzzaman, Md. Abdur Rakib Hasan & Sharid Shahnewaz
Rajshahi University of Engineering & Technology, Bangladesh

Abstract- Flood constitute one of the critical problems faced by Bangladesh. Due to the unique graphical situation of Bangladesh in the delta of three great rivers, namely the Brahmaputra, the Padma and the Meghna, which drains a vast catchment, flood in this country is usually complex. The problem is gigantic and becomes more complicated with the passage of time. The flood in 1998 sever flood is the highest record. Analysis of water level data of two stations shows that the forecasting model is a linear equation of the type Y= a+bX. Data of the nine hydrologic years have been analyzed in this paper. In most cases values of co-efficient “a” varies from 0.3112 to 1.558 and “b” from 1.047 to 11.91. The general equation for the flood forecasting for the GoalundoTransi station has been established as Y = 1.283X - 8.351 in this paper. The value of travel time of flood wave from base station to forecasting station according to historical method andMutreja’s method is 2 days for both.

Keywords: flood, forecasting model, statistical method, travel time.

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AFLOODFORECASTINGMODELFORTHERIVERPADMA

Strictly as per the compliance and regulations of :

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Abstract- Flood constitute one of the critical problems faced by Bangladesh. Due to the unique graphical situation of Bangladesh in the delta of three great rivers, namely the Brahmaputra, the Padma and the Meghna, which drains a vast catchment, flood in this country is usually complex. The problem is gigantic and becomes more complicated with the passage of time. The flood in 1998 sever flood is the highest record. Analysis of water level data of two stations shows that the forecasting model is a linear equation of the type Y= a+bX. Data of the nine hydrologic years have been analyzed in this paper. In most cases values of co-efficient "a" varies from 0.3112 to 1.558 and "b" from 1.047 to 11.91. The general equation for the flood forecasting for the GoalundoTransi station has been established as Y = 1.283X - 8.351 in this paper. The value of travel time of flood wave from base station to forecasting station according to historical method andMutreja's method is 2days for both.

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I. Introduction

Flood affected many of the engineering structures such as bridge, embankment, barrage, levees, reservoirs, etc. while designing the proper safeguards must be made for the safe passage of the maximum expected flood. The structure must be sound not only for its own safety but also for the life and property which might be in danger by its failure. The valley then becomes ''flooded". A flood is commonly considered to be an unusually high stage of a river. It is often the stage at which the stream channel becomes filled and starts overflowing its banks. In Webster's new international dictionary, a ''flood" is "a great flow of water especially, a body of water, rising, swelling and overflowing and not usually thus covered a deluge, a freshet, an inundation". A flood problem in Bangladesh is gigantic and becomes more complicated with the passage of time. Every year a large area of this country is more or less affected by the flood. For the unique geographical situation of Bangladesh flood cannot be protected. But damages caused by the flood are lowered by the proper and timely forecasting about flood. Most of the flood studies are made for the flood controlling. Here flood forecasting system is very poor. So attempts have been taken to develop appropriate flood forecasting model. Flood is a serious problem in our country. Every year a large number of hydraulic structures, crops and properties are damaged by the flood.

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The necessity of the study is given below:

1. To ensure the safety of the hydraulic structure (like-Barrage, levees etc.).
2. To take measure for the safety of the crops and properties of the adjacent land.
3. Improvement of the existing channel section for the computed discharge.

Within the Padma basin in Bangladesh the important tributaries are the Punarbhaba and Mahananda from the left which drain Panchagar, Dinajpur and Chapainawabgong districts. They enter southeast zone of Bangladesh covering greater districts of Kustia, Jessore, Faridpur, Khulna and Barishal served by the important distributaries of the Padmaviz the Mathavanga and the Arialkhan are the most important. The lower gigantic delta in Bangladesh has a large area subjected to the tides from the Bay of Bengal. Catchment area of this basin is 53706 km2.

The general objectives of this study are given below:

1. Determine the travel time of flood wave from base station to forecasting station.
2. To determine the correlation between the N-th hour stage of base station and (N+T)-th hour stage of forecasting station.
3. To develop a flood forecasting model for the river Padma.

II. Background

Rahman, M.M., Goel, N.K. and Arya, D.S. (2012) developed flood forecasting system by using MIKE11 river-modeling software modules rainfall-runoff (RR) [or Nedbor-Afstromnings model (NAM)], hydrodynamic (HD), and flood forecasting (FF) for the Jamuneswari river catchment of the northwestern part of Bangladesh. A Chowdhury, M. R. , and Ward, N. (2004) worked on Hydro-meteorological variabilty in the greater Ganges-Brahmaputra-Meghna basins. Rahman, M. M. ,Arya, D. S. , Goel, N. K. , and Dhamy, A. P. (2011a) have carried out their research for design flow and stage computation in the Teesta river.The statistical model uses the multiple correlation technique. Basically, only gauge of base stations and forecasting stations are utilized in different forms in developing these models.

III. Methodology

Statistical method has been used in this paper to develop the forecasting model.

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a) Outline of Statistical Method

Daily water level of base station X has been used to develop a multiple correlation model for predicting water level Y, at the forecasting station. The model is Y = a + bX.

Where, Y is a dependent variable and is the water level at the forecasting station at time, t(MSL), X is a independent variable and is the water level at the base station at time (t-T) with T as the travel time between this station and the forecasting station, a, b are multiple correlations co-efficient.

It should be noted that the advanced time for the forecast at the forecasting station is the least of the travel times. The procedures involved in the development of the model are:

- Identifying flood forecasting stations;
- Identifying potential base stations;
- Preparation of data base;
- Estimation of travel time; and
- Development of flood forecasting model

b) Estimation of Travel Time To estimate the travel time the approaches used in this paper are:

- Historical Method
- Mutreja's method

i. *Historical Method*

In this method the travel time is considered as the time difference between the peak water level of the base station and forecasting station.

ii. *Mutreja's Method*

This method consists in collecting the water level data of flood at base station for the Nth hour and at the forecasting station for the (N+T)-th hour in a tabular form. By taking different values of T different data tables are prepared such that each data table corresponding to one of assumed T. To compute the cross correlation of the water level data of these two stations at different legs the cross correlation of the data on each table is computed. The value of T corresponding to the data table the maximum correlation is travel time of the reach.

c) Necessary Data

In this study the following three types of data have been collected:

- Daily water level data
- Daily discharge data
- Danger level data

All these data used in this study were collected from the surface water hydrology– II of Bangladesh Water Development Board (BWDB).

i. *Discharge Level Data*

The BWDB in this the primary source of discharge data. The mean daily discharge data during a water year is published by hydrology directorate of the BWDB. Data sheet for daily discharge also contains the annual maximum and minimum discharge. Daily discharge data of Hardinge Bridge and GoalundoTransi station of the river Padma are collected for the purpose of this study.

ii. *Water Level Data*

The BWDB is also the primary source of water level data. The water level of the river is measured 5 times a day, at 6.00, 9.00, 12.00, 15.00 and 18.00 hour on stuff gauges. The mean of the 5 measurements is published as mean daily water level by the hydrology directorate of BWDB of Dhaka. Data sheets containing the mean daily water level at Hardinge Bridge and Goalundo Transi station of the river Padma during a water year (July to October) are given in Appendix-A. The data sheet also contains the annual maximum water level data of the monsoon period has been used for this study.

iii. *Danger Level*

Danger level data for two stations Hardinge Bridge and GoalundoTransi has been collected from the BWDB, Dhaka. The danger level of Padma at the selected river at the selected stations is given below:

Table 1 : The Danger Level of Padma River

River	Stations	Danger level (m)
Padma	Hardinge Bridge(Base Station)	14.25
	GoalundoTransi(Forecasting Station)	8.65

IV. Results and Discussion

a) Travel Time From Base to Forecasting Station

The travel time from the base station to the forecasting station is given in the following table calculated by two separate methods.

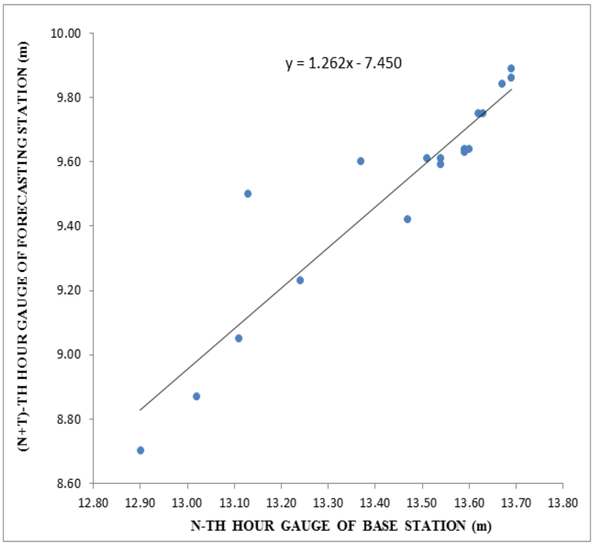
Table 2 : Travel Time from Base to Forecasting Station

Hydrologic year	Travel time (day)	
	Historical method	Mutreja's methods
2004	1	2
2005	1	2
2006	2	2
2007	1	2
2008	2	2
2009	1	2
2010	2	2
2011	1	2
2012	1	2

The accepted travel time by both the methods is 2 days.

b) Correlations Between Nth hour stage of Base Station and (N+T)th hour Stage of Forecasting Station

The following graphs show the correlation of N-th hour stage of base station with (N+T)-th hour stage of forecasting station. Putting the value of daily water level data at X axis (base station) and daily water level data at Y axis (forecasting station) after the travel time T and finally get a linear equation.



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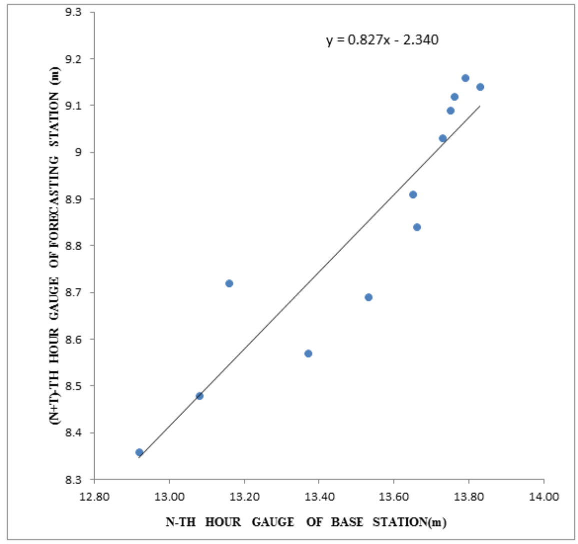

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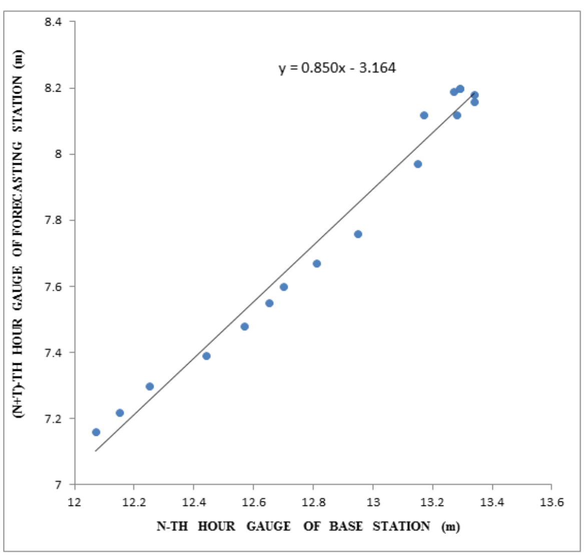
Figure : Correlation of Nth hour stage of base station with (N+T)th hour stage of forecasting station for 2004 and 2005



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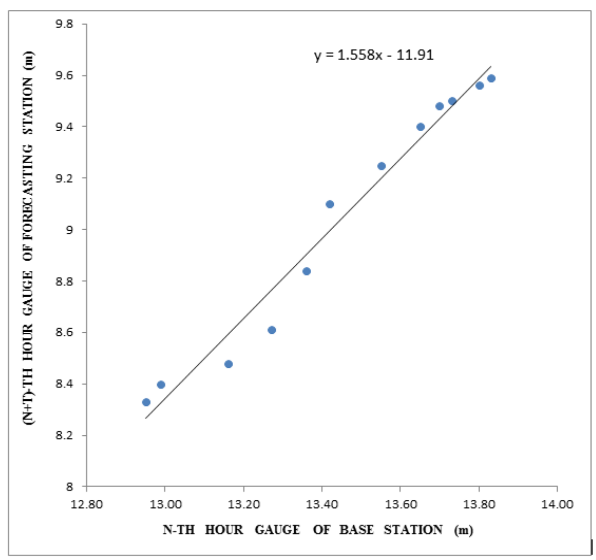

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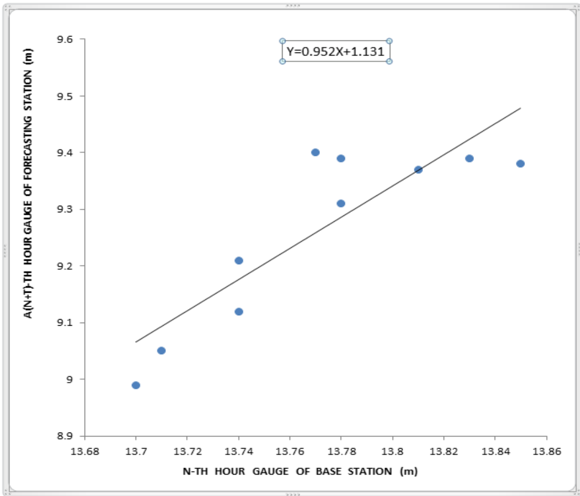

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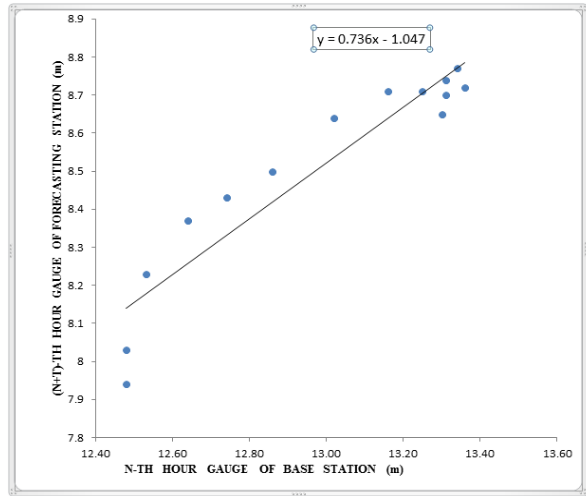

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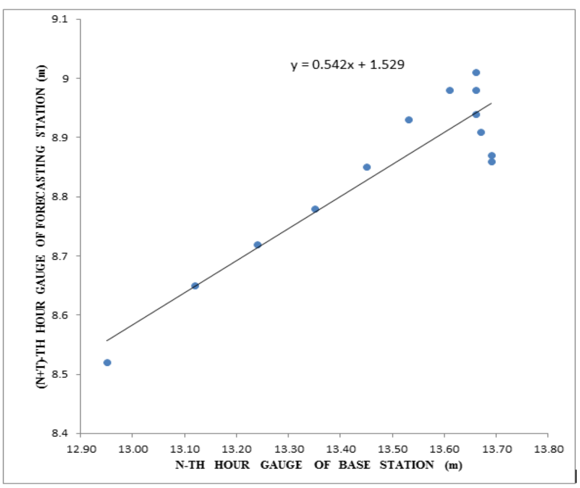
Figure : Correlation of Nth hour stage of base station with (N+T)th hour stage of forecasting station for 2006, 2007, 2008 and 2009



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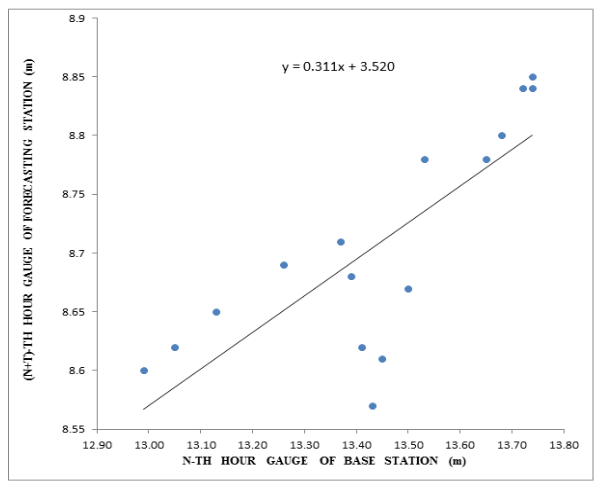

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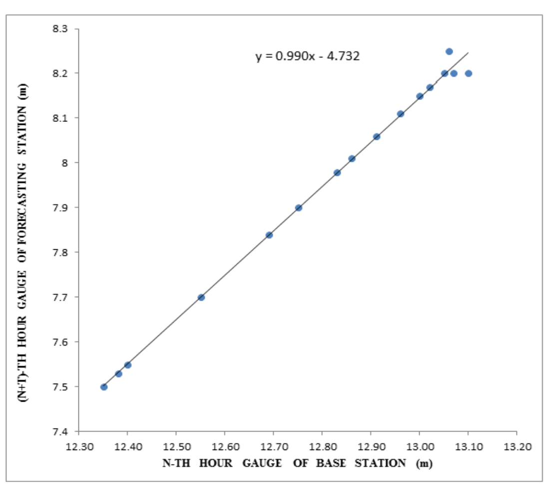

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Figure : Correlation of Nth hour stage of base station with (N+T)th hour stage of forecasting station for 2010, 2011 and 2012

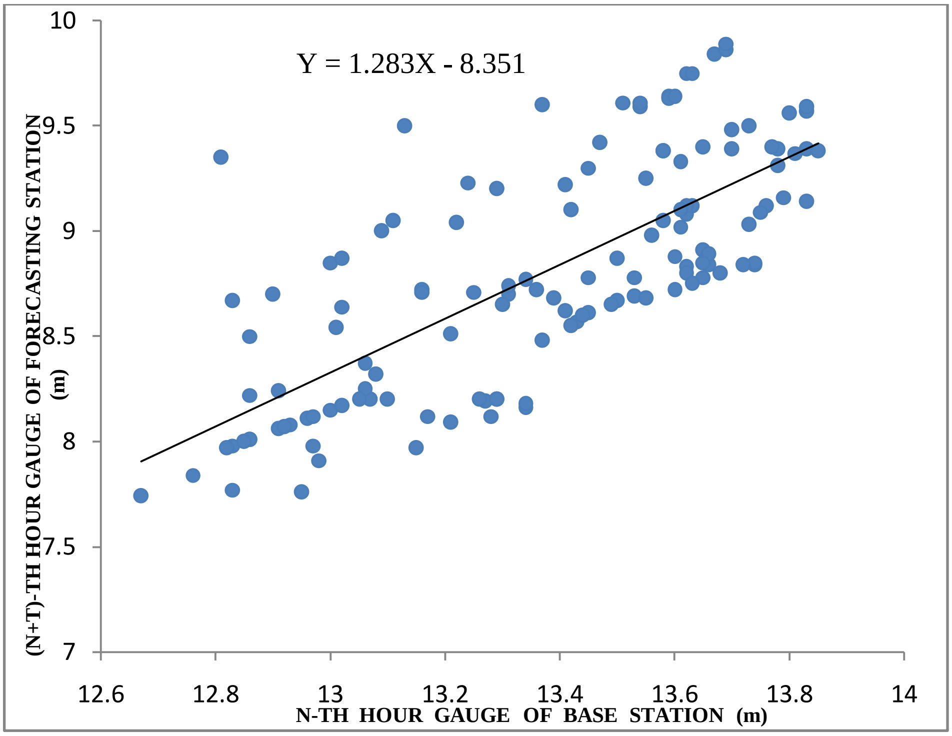

Figure 10 : Combined co-relation of N-th hour stage of base station with (N+T)th hour stage of forecasting station

V. Development of Flood Forecasting Model

From the correlation of different years daily water level data different flood forecasting model Y = a+bX are established. If X is replaced by the highest water level data of the corresponding year then the value of Y can be calculated. If the value of Y exceeds 8.65 m (which is the danger level of forecasting station) then flood will occur. If the value of Y does not exceed 8.65 m then flood will not occur. The following table shows the flood condition for different years.

X=Water level at base station

Y=Water level at forecasting station

Table 3 : Development of Flood Forecasting Model

Hydrological year	Flood Period (day)	Forecasting model Y= a+bX	Nature of the curve	Remarks
2004	23	Y = 1.262X-7.450	Linear Variation	Flood Occurred
2005	22	Y = 0.827X-2.340	Linear Variation	Flood Occurred
2006	19	Y = 0.850X-3.164	Linear Variation	No Flood
2007	20	Y = 1.558X-11.91	Linear Variation	Flood Occurred
2008	16	Y = 0.952X+1.131	Linear Variation	Flood Occurred
2009	19	Y = 0.736X-1.047	Linear Variation	No Flood
2010	28	Y = 0.452X+1.529	Linear Variation	Flood Occurred
2011	22	Y = 0.311X+3.52	Linear Variation	No Flood
2012	24	Y = 0.99X-4.732	Linear Variation	Flood Occurred

The general equation for the flood forecasting for the Goalundo Transi station is Y = 1.283X - 8.351.

VI. Conclusions

The following conclusions can be drawn from the above analysis:

- The accepted value of travel time from Hardinge Bridge to Goalundo Transi is 2 days.
- Combined co-relation of N-th hour stage of base station with (N+T)th hour stage of forecasting station has been established as a linear equation.
- The general equation for the flood forecasting for the GoalundoTransi station is Y = 1.283X - 8.351.

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Suitability of Rice Husk as Bio Sorbent for Removal of Dyes from Aqueous Solution on the basis of Chemical Oxygen Demand Analysis

By Binod Kumar, Upendra Kumar & K. M. Pandey
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Abstract- Researchers are investigating the various biomaterials as an effective alternative to the activated carbon for removal of dyes from aqueous solution. Some of the biosorbent have shown extremely high capacity for removal of dyes. But being a biomaterial, consists of organic molecules, they also contribute organic matter to the solution during adsorption process and thus contribute to the COD of the treated solution. There is a very strong and strict restriction on the value of COD of the industrial waste water before discharging into environment. So the biomaterial which is capable of removing the dyes below the prescribed limit, if increases the COD then it is not suitable for use in the adsorption process for removal of dyes from industrial effluent. In this paper the suitability of raw rice husk, sodium carbonate treated rice husk and potassium hydrogen phosphate treated rice husk has been examined and found that raw rice husk is not suitable biosorbent where as treated rice husk are the promising biosorbent.

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I. Introduction

Chemical oxygen is an important parameter to determine the quality of water. It is the amount of oxygen consumed to oxidize the organic substances present in the waste water into carbon dioxide. Almost all the organic substances get oxides into carbon dioxide by strong oxidizing agent. It differs from BOD in the sense that BOD stands for biochemical oxygen demand which is defined as the amount of dissolved oxygen consumed by the microorganism present in the waste water responsible for aerobic decomposition of the degradable organic substances present in the waste water. The BOD test involves taking an initial dissolved oxygen (DO) reading and a second reading after five days of incubation at 20oC whereas COD is a much faster, more accurate test and can be completed within 2-3 hours. The value of COD of waste water is always greater than the BOD of the same waste water. Higher the value of COD means more dissolved water will be consumed in oxidizing the pollutant in the water leaving less amount available for the aquatic life and thus lower the quality of water. Ministry of Environment and Forests, Government of India has laid the standard of COD as 250 mg/L for Common Effluent Treatment Plants.

At present millions of dyes are being used in leather, textile, pulp & paper, paints, medicines ete. As a rough estimate it has been reported that 12% of total dye lost during manufacturing storage and transportation to the end user. About 20 to 25% of dyes used in industries find its way into the effluent and finally enter into the environment. [3] Dyes are stable, incompatible with strong oxidizing agents, acids, light-sensitive and combustible. [7] They are very toxic, extremely small amount produces intense colour and hence repulsive to our aesthetical sense, interfere with photosynthesis by obstructing the sunlight and so harmful to aquatic eco system. [9] Moreover it has a tendency to accumulate in the cell of living organism and thus enter into our food chain. Since dyes are organic molecule and so their presence in waste water enhances its COD. Due to such evil consequences various governmental and environmental agencies have put extremely stringent regulation regarding the quality of effluent which has to be discharged into the natural water bodies. Their strict enforcement has drawn the attention of the researcher to find out the suitable and cost effective method for removal of dyes from aqueous solution. The dyes are very complex organic molecule, resistance to aerobic digestion and are stable to light, heat and oxidizing agents and hence their treatment are difficult.[8] Several methods like chemical precipitation, ion exchange, reverses osmosis; coagulations & Flocculation, solvent extraction, Oxidation and distillation etc., have been reported in the abundant available literature during the last three decades. But all these methods have limitation. Among them the adsorption is found to be the best available method as involves simple low cost technique and non generation of toxic products. [4] Activated carbon is the best known adsorbent. But due to its high cost and difficult to regenerate it has limited applicability. Researchers are now looking for alternative material which can be used as an effective alternative of activated carbon. Many biological and agricultural waste/by product like barley

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straw, waste tea leaves, sago waste, peanut hulls, hazel nut shell, saw dust, neem bark, chitin beads, thermally treated rice husk ash, waste banana, orange peels, cocoa shells, tree fern, coffee residue, palm kernel fibre, olive stone waste, grape stalk, bagasse, fly ash, etc., have promised to be a good alternative on the basis of their removal capacity. [6] But their impact over the COD of the waste water i.e., the overall quality of waste water has not been examined after the adsorption.

In the present study the suitability of Raw Rice husk, sodium carbonate treated rice husk and potassium hydrogen phosphate treated rice husk as a biosorbent for the removal of MG and CV have been examined on the basis of their removal capacity as well as by observing the change in the COD value of dyes solution before and after the removal of dyes by adsorption process.

II. Materials and Methods

a) Adsorption Experiment

i. Preparation of adsorbent

The rice husk, collected from a rice mill in silchar, was passed through different sieve sizes. The fraction of the particle between 425 and 600micron (geometric mean size: 505 micron) was selected. This was washed thoroughly with distilled water several times for removing dirt and impurities. It was then first air dried and after that dried at temperature 60^{0}C. The dried rice husk was designated as Raw Rice Husk (RRH). it was then suspended in 0.1M potassium hydrogen phosphate (K_2HPO_4) solution and in 0.1M sodium carbonate solution in separate beaker. Both were kept in the incubator whose temperature and rotational speed were maintained at 40^{0}C and 100 rpm respectively, for about 2 hours. Then incubator was switched off. It was left at normal temperature for next 24 h. After that solution was filtered and the filtered rice husk was washed thoroughly with distilled water until the rice husk gave no color and the pH of the washed water was close to neutral. They were then dried at 60^0 C for 6 h. After drying, the adsorbents were stored in sealed glass containers and designated as potassium hydrogen phosphate treated rice husk (KHPRH) and sodium carbonate treated rice husk. They were now used in all the experiments.

ii. Stock Solution

One gram each of commercial grade crystal violet and malachite green obtained from local chemist, were dissolved in one liter of distilled water to prepare the stock solution of 1000 mg/L. Experimental dye solution of different concentrations was prepared by adding the appropriate volume of distilled water in the stock solution.

iii. Batch Adsorption Experiments

Three samples of 150 ml of both dyes solution of 50 mg/L concentration were taken in 250 mL glass-stoppered, Erlenmeyer flasks. Now 1.5gm of RRH, NCRH and KHPRH to keep the dose 10 gm/L were added to the sample and marked the flask as RRH, NCRH and KHPRH. All these six flask were kept in incubator whose temperature and rotational speed were maintained at 30^0 C and 200 rpm respectively, for about 90minutes. Samples from the flasks were collected after 90 minutes and the residual dye concentration in the solution was measured by using double beam UV/VIS spectrophotometer (Model 3501/0706). The percentage removal of dye by the adsorbent was using Equation 1:

$$\%\ \text{Removal} = \frac{C_0 - C_t}{C_0} * 100 \qquad (1)$$

Where C_0 & C_t are initial concentration and concentration at any instant t of dye in mg/L. All the experiments were performed twice and the average values of results were taken.

b) Test for chemical oxygen demand measurement

The principle involves in the COD test is that all organic compounds can be oxidized to carbon dioxide, ammonia and water. The oxidation reaction can be expressed as

$$C_nH_aO_bN_c + \left(n + \frac{a}{4} - \frac{b}{2} - \frac{3}{4}c\right) O_2 \rightarrow nCO_2 + \left(\frac{a}{2} - \frac{3}{2}c\right) H_2O + cNH_3$$

This expression includes the oxygen demand caused by the oxidation of ammonia into nitrate through the process of nitrification represented by the following equation

$$NH_3 + 2O_2 \rightarrow NO_3^- + H_3O^+$$

Dichromate does not oxidize ammonia into nitrate, so this nitrification can be safely ignored in the standard chemical oxygen demand test. [10]

For the test COD block digestion system (model Pelican Kelplus -08L CAC) were used for the test. The test was started with switching on the digestion system and set the temperature 150^{0}C in the temperature controller. Now mercuric sulphate was added to each digestion tubes and took 50ml of sample in it. After that standard $K_2Cr_2O_7$ (potassium dichromate of strength 0.125N) was added in it. At this stage the digestion tube was kept in plastic tray with water to cool the tube during addition of sulphuric acid. Now 50 ml of Sulphuric acid as reagent was added slowly and carefully. Then the solution was mixed thoroughly. After mixing the digestion tubes were placed properly in the COD digester. The air condensers were kept on the digestion tubes and reflux the mixture for 90 minutes by setting the time in timer. At the end of the digestion the air condensers were separated from the digestion tube. The tube were now removed and kept over tube support rack and left them to cool at room temperature. Finally the tube was taken one by one for titration for determination of COD. The titration was done against 0.1 M Ferrous Ammonium sulphate solution by adding 1-2 drops of Ferroin indicator. [1]

The amount of COD was calculated from equation 2

$$\text{COD (in}\frac{\text{mg}}{\text{L}}) = \frac{(\text{blank} - \text{sample})*0.1*8000}{\text{volume of sample}} \quad (2)$$

III. Results and Discussions

Table 1 : % removal of dyes by raw rice husk, sodium carbonate treated rice husk and potassium hydrogen phosphate treated rice husk

DYES ↓	Percentage removal by		
	RRH	NCRH	KHPRH
Crystal violet	40.63	90.6	89.6
Malachite green	51.38	98.4	97.3

Table 2 : COD of the various solutions

COD (mg/L) →	Before adsorption the COD of solution		COD of CV solution after adsorption onto			COD of MG solution after adsorption onto		
	CV sol	MG sol	RRH	NCRH	KHPRH	RRH	NCRH	KHPRH
	127.84	116.52	133.76	66.88	81.65	121.11	43.27	50.66

Table 1 shows that raw rice husk; sodium carbonate treated rice husk and potassium hydrogen phosphate treated rice husk are able to remove the crystal violet from aqueous solution up to 40.63%, 90.6 % and 89.6% respectively through the process of adsorption. Similarly they can remove malachite green up to 51.38%, 98.4% and 97.3 % respectively.

It can be seen from table 2 that the COD of the CV solution after adsorption onto raw rice husk increased from 127.84 before adsorption to 133.76 after adsorption of CV onto RRH. Similarly the COD of the MG solution after adsorption onto raw rice husk increased from 116.52 before adsorption to 121.11 after adsorption of MG onto RRH. The increase in the COD after adsorption onto RRH may be due to the fact that the RRH which was made of various organic molecules likes cellulose (25 to 35%), hemicelluloses (18 to 21%), lignin (26 to 31%), soluble (crude protein) (2 to 5%) [5] though remove the dyes from aqueous solution but it also contributes the organic matter to the solution. During the process of adsorption onto RRH the addition of organic molecule is much more compare to the removal of dyes then there is an increase in the COD. In case of the treated rice husk the value of COD decreased after adsorption but the decreased was not proportional to the % removal of the dyes. The same reason may be preferred here also. In this case the contribution of organic matter by the rice husk was less compare to the raw rice husk as during treatment most of the weakly attached organic matter got washed away. So the COD analysis suggests that raw rice husk is not appropriate biomaterial for adsorption of CV and MG in waste water whereas sodium carbonate treated rice husk and potassium hydrogen phosphate treated rice husk can be used as adsorbent for CV and MG dyes although they all show removal capabilities of dyes from the waste water.

IV. Conclusion

The adsorption experiments suggest that raw rice husk, sodium carbonate treated rice husk and potassium hydrogen phosphate treated rice husk may be used as biosorbent for removal of CV and MG from aqueous solution. But COD analysis suggests that RRH cannot be a suitable biosorbent as it increases the COD of the treated waste water through the process of adsorption of dyes onto RRH. However sodium carbonate treated rice husk and potassium hydrogen phosphate treated rice husk may be used as biosorbent for removal of CV and MG from aqueous solution. As they not only remove the dyes from waste water but also reduce the COD of the treated waste water. This result suggests that COD analysis has to be made in deciding the suitability of the biosorbent.

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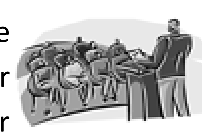

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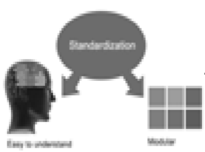

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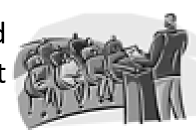

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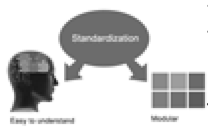

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One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

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Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

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Acknowledgements: Please make these as concise as possible.

References

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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.

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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.

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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.

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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.

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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.
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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.

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· 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

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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.

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- Fundamental goal
- To the point depiction of the research
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- Significant conclusions or questions that track from the research(es)

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- 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:

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- 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.

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- Shape the theory/purpose specifically - do not take a broad view.
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- 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.

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- Report the method (not particulars of each process that engaged the same methodology)
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- 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.

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- 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

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- Leave out information that is immaterial to a third party.

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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.
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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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