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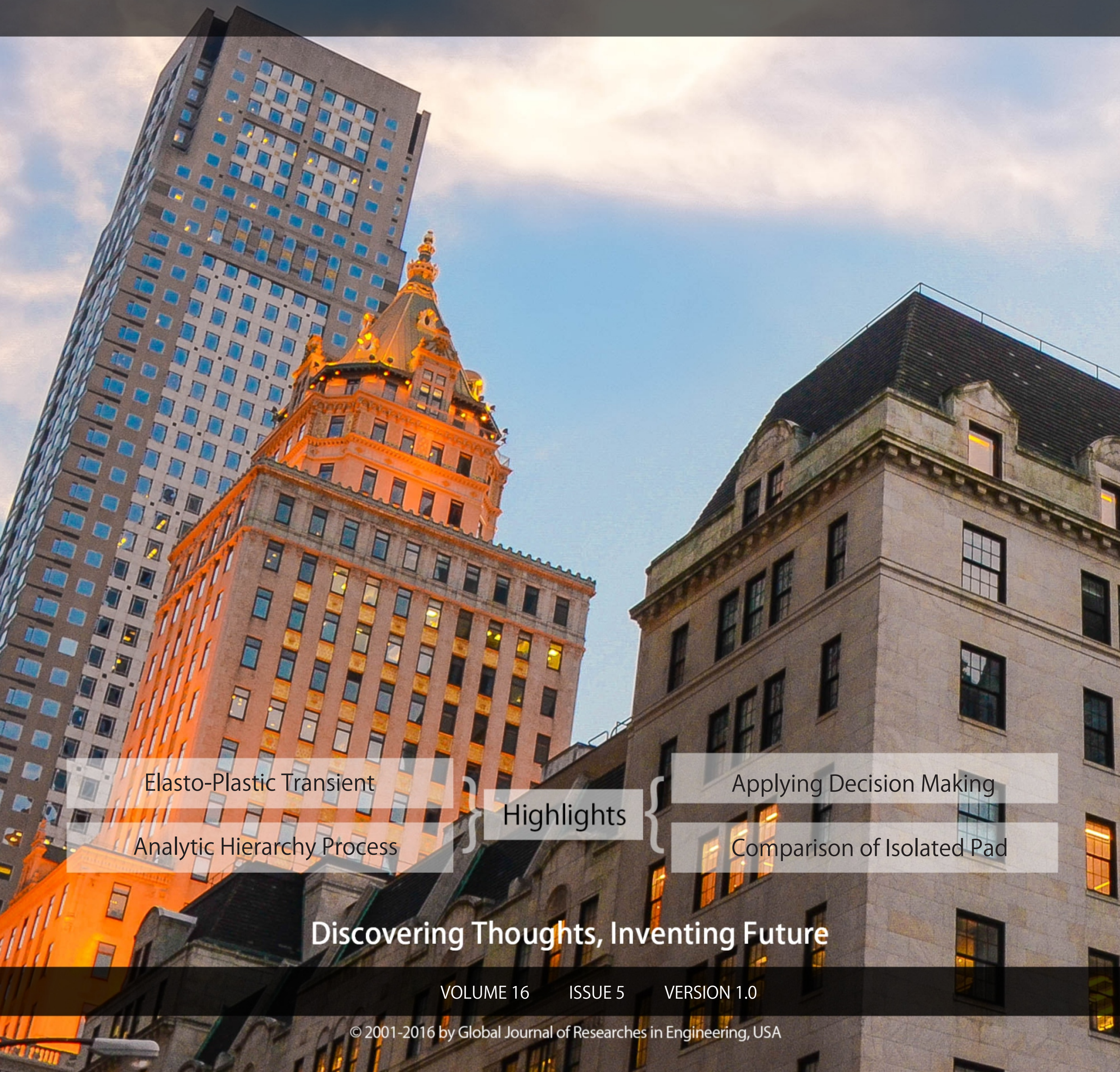

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Analytic Hierarchy Process

Highlights

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Discovering Thoughts, Inventing Future

VOLUME 16 ISSUE 5 VERSION 1.0

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Lateral-Torsional Buckling of FRPI-Section Beams

By Mojtaba B. Sirjani & Zia Razzaq
Old Dominion University

Abstract- This paper presents the outcome of an experimental and theoretical investigation into the load-carrying capacity of Fiber Reinforced Polymer (FRP) I-section beams subjected to four-point loading. The overall lateral-torsional buckling, web and flange local buckling as well as material rupture load estimates are also made using the American Society of Civil Engineers' Load and Resistance Factor Design (ASCE-LRFD) Pre-Standard for FRP Structures. Lateral-torsional buckling failure mode is found to govern for each of the beams studied. The study also revealed that the height of applied loads relative to the shear center has a very significant influence on lateral-torsional buckling load of a beam thus making ASCE-LRFD buckling load estimates over-conservative in a vareity of cases.

Keywords: lateral-torional buckling, I-section FRP, ASCE-LFRD pre-standard for FRP structures.

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LATERALTORSIONALBUCKLINGOFFRPISECTIONBEAMS

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Lateral-Torsional Buckling of FRPI-Section Beams

Mojtaba B. Sirjani α & Zia Razzaq σ

Abstract- This paper presents the outcome of an experimental and theoretical investigation into the load-carrying capacity of Fiber Reinforced Polymer (FRP) I-section beams subjected to four-point loading. The overall lateral-torsional buckling, web and flange local buckling as well as material rupture load estimates are also made using the American Society of Civil Engineers' Load and Resistance Factor Design (ASCE-LRFD) Pre-Standard for FRP Structures. Lateral-torsional buckling failure mode is found to govern for each of the beams studied. The study also revealed that the height of applied loads relative to the shear center has a very significant influence on lateral-torsional buckling load of a beam thus making ASCE-LRFD buckling load estimates over-conservative in a vareity of cases.

Keywords: lateral-torional buckling, I-section FRP, ASCE-LFRD pre-standard for FRP structures.

I. Introduction

A Fiber-Reinforced Polymer (FRP) beam subjected to inplane bending moments about its cross-sectional strong axis can develop lateral-torsional buckling. Such a beam will initially deflect normal to the strong axis until the critical value of the bending moment is reached after which lateral and torsional deflections develop. Mamadou and Razzaq [1] investigated the failure modes for I-section Glass Fiber Reinforced Polymer (GFRP) beams with single mid-span web brace in which theoretical predictions were made based on ASCE-LFRD Pre-Standard for Pultruded Fiber Reinforced Polymer (FRP) Structures [2]. It was found that for small and medium I-sections, lateral-torsional buckling failure mode governed while the larger I-sections reached their peak capacity associated with material rupture. Sirjani, Bondi and Razzaq [3] presented the outcome of an experimental and theoretical study on FRP beams with an I-shaped cross section subjected to four-point loading with and without applied torsion. The focus of that study was to identify the significance of lateral bending and warpingstrains due to practical imperfections.

The present paper addresses the influence of vertical location of applied loads with respect to the shear center when estimating the beam lateral-torional buckling strength. Three different applied load locations are considered, namely, when the loads act above, below and at the shear center. In addition, load-carrying capacity predictions are made for various failure modes using the ASCE-LRFD Pre-Standard, and the buckling load estimates compared to those observed experimentally as well as obtained using the buckling formula presented by Razzaq, Prabhakaran, and Sirjani [4].

II. Experimental Study

Figure 1 shows a FRP beam of length L with an I-shaped cross section, and subjected to a pair of gradually increasing applied loads each of magnitude P. Figure 2 shows the experimental test setup. The beam ends were simply supported both flexurally and torsionally. The test procedure,

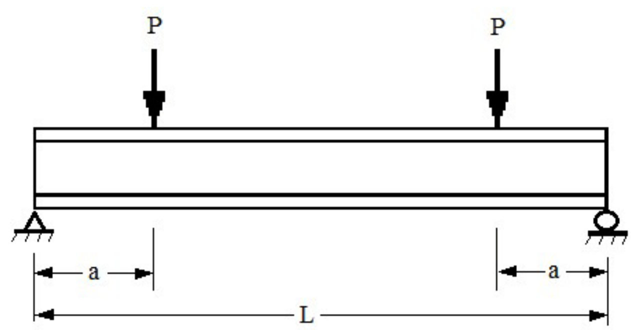

Fig. 1: Schematic of I-Section FRP beam

involved applying the load pair(P, P) in small increments and recording the resulting load-deflection relationship until the peak lateral-torsional buckling load was reached.

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Fig. 2: Exprimental test setup

The experimental and theoretical maximum loads P_e and P_t, respectively, are presented in Table 1 in addition to their ratios for a 4x2x0.25 in. I- shaped FRP cross section withlength L equal to 60, 72, 84, 96 and 108 inches, respectively. The value of (L – 2a), that is, the distance between the two applied loads P and P shown in Figure 1 was kept constant at 24 inches. The Young's (E_{11}) and shear (G_{12}) modulus values of the FRP beam material were 2,550 ksi and 420 ksi, respectively.

Figure 3, shows the applied loading mechanism in which a pair of steel tie rods are used to apply upward vertical load (P/2 per tie rod) placed symmetrically about the shear center, S. the resultant load P is transmitted to a steel bar which pushes a steel shaft against an aluminum loading plate mounted on to the FRP beam. The resultant force P acts at a distance y_o^*below the x-axis but passes through S. The value of y_o^* defines the vertical location of the applied loads. It should be noted that the downward load pair (P, P) shown in Figure 1 was applied in the upward direction by means of two separate sets of the loading mechanism schematically depicted in Figure 3.

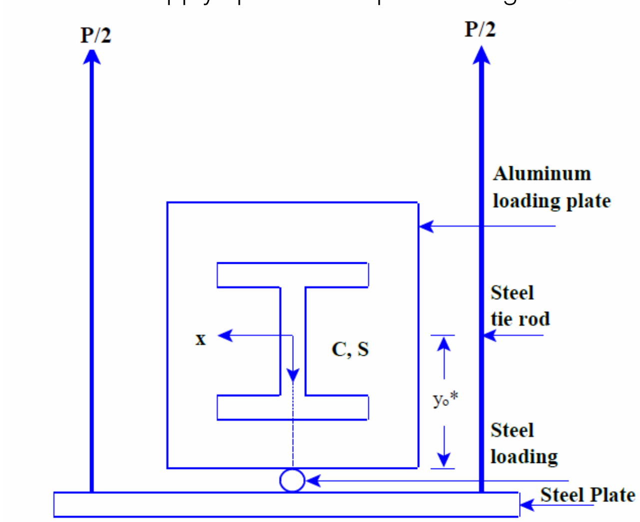

Figure 3: Loading Mechnism

Table 1: Experimental and Theortical Maximum loads

L (in.)	P_e(Lb.) (Experimental)	P_t(Lb.) (Theoretical)	P_t / P_e
60	292	340	1.164
72	190	214	1.126
84	125	150	1.200
96	111	112	1.009
108	77	88	1.143

III. Theoretical Study and Results

For the beam shown in Figure 1, the lateral-torsional buckling load P_{cr} can be found using the following formula presented by Razzaq, Prabhakaran, and Sirjani[4]:

$$P_{cr} = \frac{0.5\left[-f_2 + \sqrt{f_2^2 + 4 f_1 f_3}\right]}{f_1} \qquad (1)$$

in which:

$$f_1 = \frac{1}{16}\left[f(a) - \frac{\pi^2 a^2}{L^2} - \frac{2\pi a}{l} g(a)\right]^2 \qquad (2)$$

$$f_2 = \frac{\pi^4 E_{11} I_y}{4L^3} y_0^* \sin^2\left(\frac{\pi a}{L}\right) \qquad (3)$$

$$f_3 = \frac{\pi^6 E_{11} I_y}{16L^4}\left[\frac{\pi^2 E_{11} I_w}{L^2} + G_{12} K_T\right] \qquad (4)$$

$$f(a) = \frac{\pi a}{L}\sin\left(\frac{2\pi a}{L}\right) - \sin^2\left(\frac{\pi a}{L}\right) \qquad (5)$$

$$g(a) = \frac{1}{2}\left[\pi\left(1 - \frac{2a}{L}\right) - \sin\pi\left(1 - \frac{2a}{L}\right)\right] \qquad (6)$$

In the above expressions, the distances a and L are defined in Figure 1; I_y is the minor-axis moment of inertia; K_T is the St. Venant torsional constant; and I_w is the warping moment of inertia of the cross section.

Table 2 presents the ASCE-LRFD theortical maximum load values with aresistancefactor of ø =0.80for flange or web local buckling, and ø =0.65 for rupture load. Also, this table presents the moment modification factorC_b for unsupported spans with both ends braced corresponding to various L values of the beam shown in Figure 1 with (L – 2a) kept constant at 24 inches.

Table 2: ASCE-LRFD Therotical Maximum loads

Based on ASCE-LRFD					
L (in.)	C_b	P_{LT} (Lb.)	$øP_{fcr}$ (Lb.)	$øP_{wcr}$ (lb.)	$øP_{rupture}$ (lb.)
60	1.087	468	43749	13626	2057
72	1.136	288	43749	13626	1543
84	1.168	195	43749	13626	1244
96	1.190	141	43749	13626	1028
108	1.207	107	43749	13626	881

Table 3 pesents the critical load results for different distance y_o* of applied load about the shear center. The last three columns in Table 3 present the load ratios r_1, r_2, and r_3 defined as P_{LT} divided by P_{cr} correspoinding to y_o* = -2.00 in., 0.0 in., and +2.0 in., respectively.

Table 3: Critical Load for various applied load through shear center

L (in.)	P_{cr}(Lb.)with y_o* equal to			P_{LT} (Lb.)	r_1	r_2	r_3
	-2.0(in.)	0.0(in.)	+2.0(in.)				
60	451	689	1053	468	1.038	0.679	0.444
72	278	408	600	288	1.036	0.706	0.480
84	190	268	378	195	1.026	0.728	0.516
96	139	189	257	141	1.014	0.746	0.549
108	107	140	185	107	1.000	0.764	0.578

IV. Conclusions

Expeimental results are in good agreement with the lateral-torsional buckling load formula presented [4]. Theoretical predications for various beam failure modes are also made using ASCE-LRFD Pre-Standard for FRP Structures. It is found that in all of the cases presented, the I-section beam failure mode was governed by lateral-torsional buckling. The study also clearly reveals that the height of the applied loads relative to the shear center has a very significant influence on the lateral-torsional buckling load of the beam thus making ASCE-LRFD buckling load estimates over-conservative in a number of cases.

Appendix

This appendix summarizes the ASCE-LRFD Pre-Standard expressions used in arriving at those particular numerical results which were based on the ASCE-LRFD Pre-Standard [2]. The critical stress for the compression flange local buckling is given by:

$$f_{fcr} = \frac{4}{(\frac{b_f}{t_f})^2}\left(\frac{7}{12}\sqrt{\frac{E_{L,f}E_{T,f}}{1+4.1\xi}} + G_{LT}\right) \qquad (1)$$

in which:

G_{LT} = characteristic in-plane shear modulus, ksi

v_{LT} = characteristic longitudinal Poison's ratio

b_f = Full width of the flange, in.

h = Full height of the member, in.

t_f = Thickness of the flange, in.

k_r = Rotational spring constant, kip/rad

$E_{L,f}$ = Characteristic longitudinal modulus of the flange, ksi

$E_{L,w}$ = Characteristic longitudinal modulus of the web, ksi

$E_{T,f}$ = Characteristic transverse modulus of the flange, ksi

$E_{T,w}$ = Characteristic transverse modulus of the web, ksi

$$f_{wcr} = \frac{11.1\pi^2}{12(\frac{h}{t_w})^2}\left(1.25\sqrt{E_{L,w}E_{T,w}} + E_{T,w}v_{LT} + 2G_{LT}\right)$$

in which, f_{wcr} is the critical stress for the web local buckling.

There are four nominal moments that are calculated based on the formulae [2] as summarized here. The nominal bending moment M_{LB} due to lateral-torsional buckling is given by:

$$M_{LB} = C_b\sqrt{\frac{\pi^2 E_{L,f} I_y D_J}{L_b^2} + \frac{\pi^4 E_{L,f}^2 I_y C_w}{L_b^4}} \qquad (3)$$

A resistance factor $\phi = 0.7$ is used for M_{LB}. The other terms are defined as follows:

C_b = Moment modification factor for unsupported spans with both ends braced

D_J = Torsional rigidity of an open section $= G_{LT}\sum\frac{1}{3}b_i t_i^3$, $kip - in.^2$

C_ω = Warping constant $= \frac{t_f h^2 b_f^3}{24}$, $in.^6$

$$M_{fLT} = f_{fcr}\frac{E_{L,f}I_f + E_{L,w}I_w}{yE_{L,f}} \qquad (4\text{-a})$$

$$M_{wLT} = f_{wcr}\frac{E_{L,f}I_f + E_{L,w}I_w}{yE_{L,w}} \qquad (4\text{-b})$$

In which, M_{fLT} and M_{wLT} are the nominal flexural strengths due to local instability in the flanges and webs, respectively; the resistance factor $\phi = 0.80$ is used. The other terms are defined as follows:

I_f = Moment of Inertia of the flange(s) about the axis of bending, in^4

I_w = Moment of Inertia of the web(s) about the axis of bending, in^4

y = Distance from the neutral axis to the extreme fiber of the member, in.

$$M_{cr} = \min\left(\frac{F_{L,f}\,(E_{L,f}I_f + E_{L,w}I_w)}{y_f E_{L,f}}, \frac{F_{L,w}\,(E_{L,f}I_f + E_{L,w}I_w)}{y_w E_{L,w}}\right) \qquad (5)$$

In which, M_{cr} is the nominal flexural strength due to material rupture and the resistance factor $\phi = 0.65$ is used. The other terms are defined as follows:

$F_{L,f}$ = characteristic longitudinal strength of the flange (in tension or compression),ksi

$F_{L,w}$ = characteristic longitudinal strength of the web (in tension or compression),ksi

I_f = Moment of Inertia of the flange(s) about the axis of bending, in^4

I_w = Moment of Inertia of the web(s) about the axis of bending, in^4

y_f = Distance from the neutral axis to the extreme fiber of the flange, in.

y_w = Distance from the neutral axis to the extreme fiber of the web, in.

t_w = Thickness of the web, in.

ξ = Coefficient of restraint

Lastly, applying the formula of maximum moment for a simply supported beam with a point load as shown in Figure 1, the respective loads are obtained

$$P_{LT} = \frac{M_{LT}}{a} \qquad (6)$$

$$P_{fLT} = \frac{Mf_{LT}}{a} \qquad (7)$$

$$P_{wLT} = \frac{Mw_{LT}}{a} \qquad (8)$$

$$P_{cr} = \frac{M_{cr}}{a} \qquad (9)$$

If $P_{LB} = P_{fLT} = P_{wLT} = P_{cr} = P_c$ is the load-carrying capacity of the member, a LFRD approach is proposed as follows:

$$P_c = \phi P_n \qquad (10)$$

in which ϕ = 0.7, 0.8, and 0.65 depending whether the failure is due to lateral torsional buckling, local instability in the flanges and webs, and rupture of the materials.

The C_b values in Table 2 were computed using the following expression:

$$C_b = 12.5M_{max}/(2.5M_{max} + 3M_A + 4M_B + 3M_C) \qquad (11)$$

in which Mmax is the maximum bending moment, and M_A, M_B, and M_C are the values of quarter-point moments along the beam length.

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Elasto-Plastic Transient Dynamic Response of Tubular Section Steel Cantilever Beam under Impact Loading

By AliAl Aloosi & Zia Razzaq
Old Dominion University

Abstract- This paper presents the outcome of an experimental and theoretical investigation into the load-carrying capacity of Fiber Reinforced Polymer (FRP) I-section beams subjected to four-point loading. The overall lateral-torsional buckling, web and flange local buckling as well as material rupture load estimates are also made using the American Society of Civil Engineers' Load and Resistance Factor Design (ASCE-LRFD) Pre-Standard for FRP Structures. Lateral-torsional buckling failure mode is found to govern for each of the beams studied. The study also revealed that the height of applied loads relative to the shear center has a very significant influence on lateral-torsional buckling load of a beam thus making ASCE-LRFD buckling load estimates over-conservative in a vareity of cases.

Keywords: impact, dynamic, elasto-plastic, flexural dynamic equilibrium.

GJRE-E Classification: FOR Code: 090506

ELASTOPLASTICTRANSIENTDYNAMICRESPONSEOFTUBULARSECTIONSTEELCANTILEVERBEAMUNDERIMPACTLOADING

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Elasto-Plastic Transient Dynamic Response of Tubular Section Steel Cantilever Beam under Impact Loading

AliAl Aloosi [α] & Zia Razzaq [σ]

Abstract- This paper presents the outcome of a theoretical and experimental study of the dynamic elasto-plastic behavior of a steel cantilever beam. An apparatus is constructed and used for conducting a series of experiments by applying a vertical impact load on the cantilever. A mathematical prediction model based on a partial differential equation of flexural dynamic equilibrium is formulated including new nonlinear terms to account for the elasto-plastic behavior of a steel cantilever beam. The experimental results are found to be in good agreement with the predicted behavior.

Keywords: impact, dynamic, elasto-plastic, flexural dynamic equilibrium.

I. Introduction

Razzaq et al. [1] conducted a theoretical and experimental study of slender tubular columns with partial rotational end restraints in the presence of initial imperfections. New explicit formulas and finite-difference formulation were derived for predicting the elastic buckling load and predicting the natural frequency. Jones [2] studied the behavior of fully clamped beams when struck at the mid-span by a rigid mass and compared it with the corresponding exact theoretical predictions of dynamic rigid-plastic analyses. Wen et al. [3] proposed a quasi-static procedure based on the principle of virtual work for estimating the dynamic plastic response and failure of clamped metal beams subjected to a low velocity impact at any point on the span by a heavy mass. The paper by Zeinoddini et al [4] described experimental studies in which axially pre-loaded tubes were examined under lateral dynamic impact loads. The tubes were impacted by a dropped object with a velocity of about 7 meter/sec at their mid-span.

The current paper presents the outcome of an experimental and theoretical study of a partially end-restrained cantilever beam under impact loading. New terms are added to the governing dynamic equilibrium equation for the problem to account for elasto-plastic effects when transient dynamic response of the cantilever needs to be predicted.

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Numerical results are obtained using an iterative finite-difference procedure. The iterative solution process also involves a materially nonlinear tangent stiffness method to deal with cross-sectional plastification as a funcation of time.

II. Experimental Study

Figure 1 shows schematic of a cantilever beam QB subjected to a forcing function F(t) generated by a freely falling impact load. For the beam, the origin of the longitudinal ordinate z is at Q. At end B, the cantilever beam is attached to a rotationally flexible elastic support simulated as a rotational spring having a rotational spring constant valule of k_B=6x10^6 kip-in/rad. The cantilever beam QBhas a length L of 33 in. and a 2x2x0.125 in. hollow square cross section. The test set-up is shown in Figure 2.

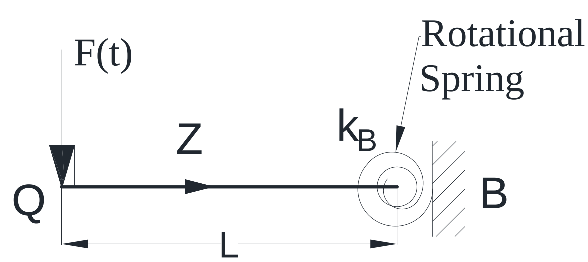

Figure 1: Analysis model of the cantilever

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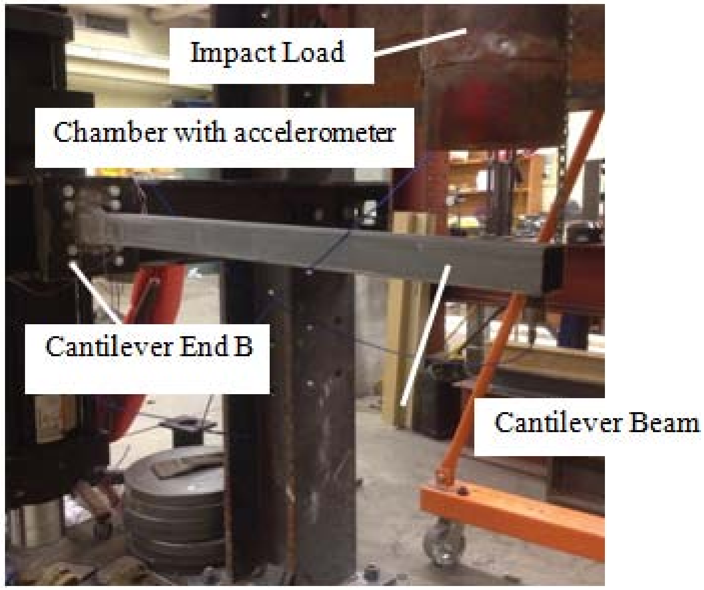

Figure 2: Test setup

The impact tests were performed using three different impactors numbered 1, 2, and 3 weighing 60 lb., 140 lb., and 400 lb., respectively. Each impactor had an accelerometer inside a steel chamber attached at the impactor bottom end to record acceleration-time relationship which was curve-fitted using a quadratic function of time t. The relationships marked C1-1, C1-2, and C1-3 shown in Figure 3 correspond to Impactors 1, 2, and 3 each dropped onto the cantilever beam with a gap of one inch between the cantilever beam's top surface and the bottom face of the steel chamber. In the same figure, the relationship marked C1-4 is for Impactor 3 dropped with a gap of two inches. The forcing function F(t) is generated by multiplying the ordinate of Figure 3 by mg, where m is the impactor mass and g is 32.2 ft./sec^2.The forcing functions for Impactors 1, 2, and 3 when dropped from 1 inch height are as follow:

$$F_1(t) = (-6338.8\, t^2 + 418.56\, t - 3.0877)\, mg \quad \text{for} \quad 0.008 \le t \le 0.057 \qquad (1)$$

$$F_2(t) = (-2506.8\, t^2 + 241.92\, t - 2.8519)\, mg \quad \text{for} \quad 0.008 \le t \le 0.083 \qquad (2)$$

$$F_3(t) = (-628.55\, t^2 + 91.886\, t - 1.4533)\, mg \quad \text{for} \quad 0.008 \le t \le 0.129 \qquad (3)$$

The forcing function for Impactor 3 when dropped from 2 inches height is as follows:

$$F_4(t) = (-804.63\, t^2 + 111.12\, t - 1.4058)\, mg \quad \text{for} \quad 0.008 \le t \le 0.125 \qquad (4)$$

The lower limit represents the time when the impactor hits the cantilever beam tip while the upper limit represents the time when the impactor is deatached from the beam.

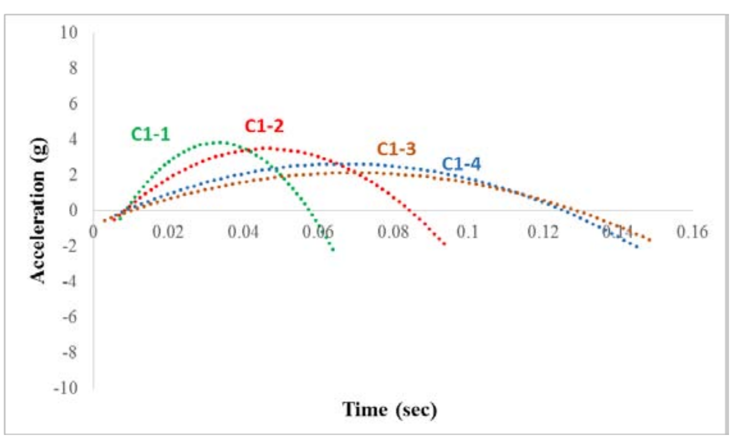

Figure 3: Curve-fitted acceleration-time relations

Three strain gauges were installed on the cantilever beam to measure strain-time histories. The strain gauges, designated as SG1, SG2, and SG3, were installed on the cantilever beam at three locations at a distance of one inch from end B as shown in Figure 4.

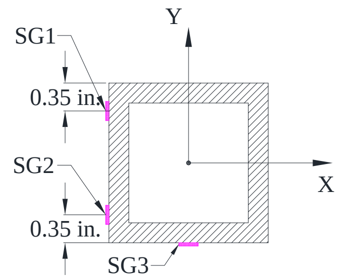

Figure 4: Location of strain gauges at section B

III. Theoretical Study

The elastic dynamic flexural equilibrium equation for a beam without damping is given in the literature [5] as follows:

$$EI\frac{\partial^4 v}{\partial z^4} + m\frac{\partial^2 v}{\partial t^2} = F(t) \qquad (5)$$

in which $EI$is the elastic flexural rigidity, $v$is the beam deflection, *m*is the beam mass per unit length, *z*is the horizontal distance along the member, *t*is the time, and F(t)is aforcing function. In the inelastic range, *EI* changes with the applied load. Therefore, the inelastic partial differential equation of motion can be expressed as:

$$\frac{\partial^2}{\partial z^2}\left(B_e\frac{\partial^2 v}{\partial z^2}\right) + m\frac{\partial^2 v}{\partial t^2} = F(t) \qquad (6)$$

where B_e is the elasto-plastic flexural rigidity.In this equation, damping is not included since it is negligible due to the predominant influence of impact loading on the beam response for the duration of the impact. For a given time t, $B_e$is a function of z, thus Equation 6 becomes:

$$B_e\frac{\partial^4 v}{\partial z^4} + 2\frac{\partial^3}{\partial z^3}\left(\frac{\partial B_e}{\partial z}\right) + \frac{\partial^2 v}{\partial z^2}\left(\frac{\partial^2 B_e}{\partial z^2}\right) + m\frac{\partial^2 v}{\partial t^2} = F(t) \qquad (7)$$

To obtain the numerical results presented in this paper, the first and second partial derivatives of$B_e$appearing in Equation 7 were iteratively generated with Lagrangian polynomials along the z axis.

a) Boundary Conditions

At Q in Figure 1, the bending moment is zero, thus:

$$m_Q = \frac{\partial^2 v}{\partial z^2}(0,t) = 0 \qquad (8a)$$

The shear force at Q can be expresses as:

$$V_Q = \frac{\partial^3 v}{\partial z^3}(0,t) = -F(t) \qquad (8b)$$

At end B, the cantilever beam has no vertical movement:

$$v_{(L,t)} = v_B = 0 \qquad (8c)$$

The elastic moment-rotation relationship of the rotational spring at B is expressed as:

$$m_B = k_B\theta_B \qquad (8d)$$

Where k_B is the stiffness of the rotational spring at end B, and $\theta_B$is the rotation of the cantileverbeam at the same location. Since$\theta_B$is the first derivative of the deflection at end B, thus:

$$\theta_B = -v'(L) \qquad (8e)$$

The minus sign in this equation is consistent with downward deflections taken as positive in the derivation of Equation 7. The boundary conditions presented above are used in the elasto-plastic dynamic analysis of the cantilever beam.

b) Initial Conditions

The initial conditions for the problem are:

$$v(z,0) = 0 \qquad (9a)$$

$$\frac{\partial v}{\partial t}(z,0) = 0 \qquad (9b)$$

The initial condition given by Equation 9a states that at time t equal zero, the deflection is zero. Equation 9b states that the initial velocity is zero.

c) Finite-Difference Solution

Central finite-difference expressions [6] were used to solve Equation 7 with boundary and intial conditions presented in Sections 3.1 and 3.2. A total of N panels were used for the cantilever beam over the interval (0, L) involving nodes i = 1, 2, 3, …. (N+1). The finite-difference scheme also results in 'phantom points' outside of the interval (0,L) and are accounted-for in the solution algorithm. Using second order finite-difference expressions, Equation 7 can be written as:

$$\frac{B_e}{h^4}\left(v_{i-2,j} - 4v_{i-1,j} + 6v_{i,j} - 4v_{i+1,j} + v_{i+2,j}\right)$$
$$+\frac{2}{h^3}\left(-v_{i-2,j} + 2v_{i-1,j} - 2v_{i+1,j} + v_{i+2,j}\right)\left(\frac{\partial B_e}{\partial z}\right)$$
$$+\frac{1}{h^2}\left(v_{i-1,j} - 2v_{i,j} + v_{i+1,j}\right)\left(\frac{\partial^2 B_e}{\partial z^2}\right) + \frac{m}{(\Delta t)^2}\left(v_{i,j-1} - 2v_{i,j} + v_{i,j+1}\right) = F(t) \quad (10)$$

in which, h is the panel length along the z-axis of the sub-assemblage, and Δt is the time interval. The subscript i refers to the ith nodal point over the domain $0 < x < L$, and the subscript j refers to the number of time increments such that the time at j is given by the following equation:

$t_j = j(\Delta t)$, for each $j = 0, 1, 2, 3, \ldots$

Similarly, the boundary conditions 8a, 8b, 8c, and 8d can be expressed in finite-difference form as follows:

$$\left(\frac{1}{h^2}\right)\left(v_{0,j} - 2v_{1,j} + v_{2,j}\right) = 0 \quad (11a)$$

$$\left(\frac{1}{2h^3}\right)\left(-v_{-1,j} + 2v_{0,j} - 2v_{2,j} + v_{3,j}\right) = -F(t) \quad (11b)$$

$$v_{N+1,j} = 0 \quad (11c)$$

$$\left(\frac{B_e}{h} + \left(\frac{K_B}{2}\right)\right)\left(v_{N+2,j}\right) - \left(\frac{2B_e}{h}\right)\left(v_{N+1,j}\right) - \left(\frac{-B_e}{h} +\right.$$

KB2vN,j=0 (11d)

Applying Equation 10 at i=1, 2, 3…, N, and invoking conditions 11a, 11b, 11c, and 11d leads to the following matrix equation:

$$\{v_{i,j+1}\} = C_1[\aleph]\{v_{i,j}\} + C_2\{v_{i,j-1}\} - C_1\{F(t)\} \quad (12)$$

in which

$$C_1 = -\frac{1}{(b_3)} \quad (13a)$$

$$C_2 = b_3 C_1 \quad (13b)$$

$$b_3 = \frac{m}{(\Delta t)^2} \quad (13c)$$

The $[\aleph]$ coefficient matrix is symmetric and of the order NxN.

A finite-difference iterative algorithm was developed for the nonlinear dynamic analysis of the cantilever beam. The deflections along the cantilever beam were found for the first time increment using the elastic formula. To avoid having a negative time interval due to the use of central finite-difference, a start-up equation [1] was used to initialize the process. Initial nodal deflections were found using Equation 10.An iterative tangent stiffness procedure was utilized to compute the curvatures due to the applied moments which satisfied cross-sectional equilibrium. Next, the elasto-plastic cross-sectional properties were calculated using the computed curvatures, and Revised deflections were found using the updated cross-sectional properties. The revised deflections were compared with the intial deflections for the same time increment. If the difference was found to be larger than a specified tolerance value, another iteration was performed for that time increment. If the difference was found to be smaller than a tolerance value, the procedure was continued to the next time increment with the corresponding new value of the forcing forcing function. This solution procedure was used to generate the theoretical strain-time curves shown in Figures 5 through 12.

d) Cantilever Behavior under Impact Loading

Table 1 compares the maximum experimental and theoretical moments at section B of the cantileverbeam for Tests C1-1, C1-2, C1-3, and C1-4. For Test C1-1, Impactor 1 was dropped from one inch above end Q of the cantilever beam. Figures 5 and 6 show theoretical and experimental strain-time curves for SG1 and SG2, respectively. Both figures show the same trending, and the peak values agreed well. The ratios between the tested to the predicted strain results ranged from 0.99 to 1.17.

Table 1: Comparison between theoretical and experimental maximum moments at B for the cantilever beam impact tests

Test	Theoretical Max. Moment at B (kip-in.)	Experimental Max. Moment at B (kip-in.)
C1-1	9.4	10.8
C1-2	17.8	20.3
C1-3	37.7	38.1
C1-4	39.8	39.5

Table 2 shows the experimental and the theoretical strains, and their comparison. For this test, the experimental maximum moment at section B was 10.8 kip-in. and the theoretical value was 9.4 kip-in. The difference between the theoretical and the experimental results was 15%. The experimental and the theoretical moment values were in good agreement and they were in the elastic range.

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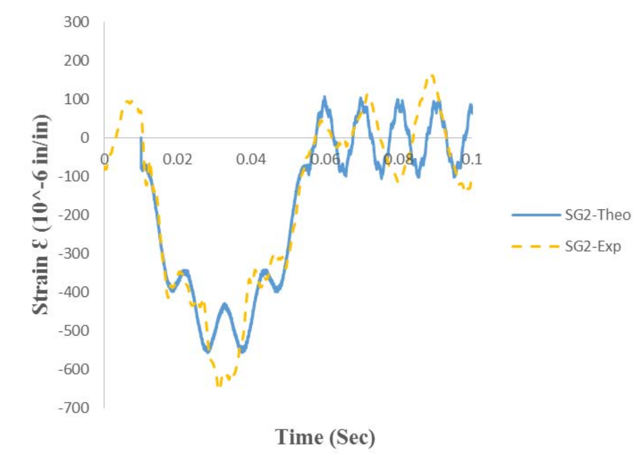

Figure 5: Comparison of theoretical and experimental strain-time relations of SG1for test C1-1

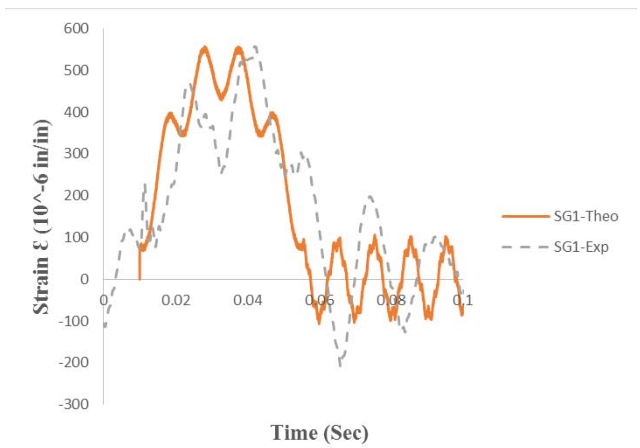

Figure 6: Comparison of theoretical and experimental strain-time relations of SG2 for test C1-1

Table 2: Experimental and theoretical strains for test C1-1

Strain gauge	Experimental strain (in./in.)	Theoretical Strain (in./in.)	Experimental / Theoretical
SG1	0.000557	0.000557	0.999477
SG2	-0.00065	-0.00056	1.17443

For Test C1-2, Impactor 2 was dropped from one inch above end Q of the cantilever beam. Figures 7 and 8 show the theoretical and the experimental strain-time curves for SG1 and SG2, respectively. Table 3 shows the experimental and the theoretical strains and, their comparison. The ratios between the tested to the predicted strain results ranged from 0.93 to 1.01. For this test, the experimental maximum moment at section B was 20.3 kip-in and the theoretical value was 17.8 kip-in. The difference between the theoretical and the experimental results was 14%. A good agreement was reached between the tested and the predicted results. Results from this test were in the elastic range.

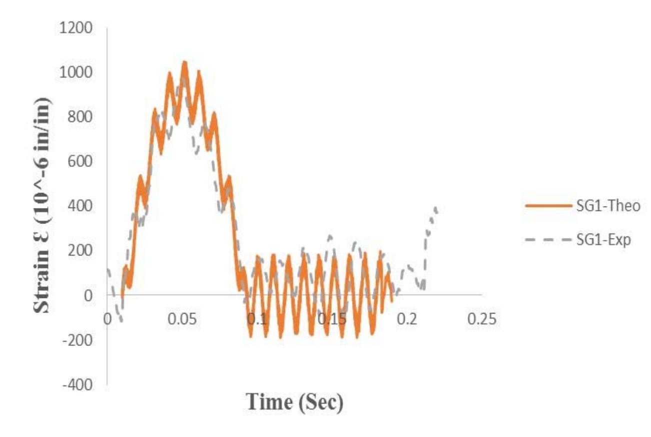

Figure 7: Comparison of theoretical and experimental strain-time relations of SG1for test C1-2

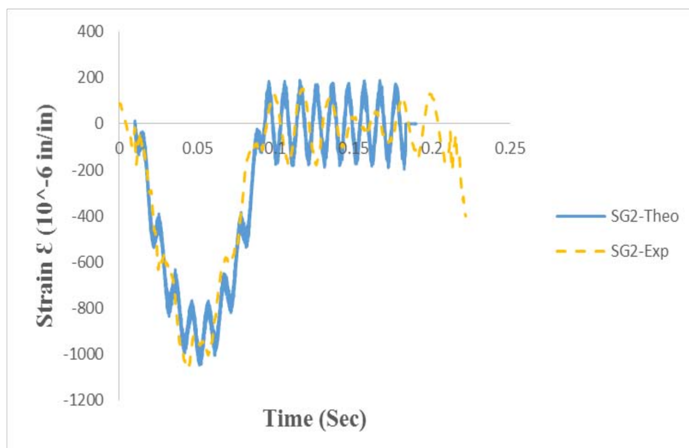

Figure 8: Comparison of theoretical and experimental strain-time relations of SG2 for test C1-2

Table 3: Experimental and theoretical strains for test C1-2

Strain gauge	Experimental strain(in./in.)	Theoretical strain(in./in.)	Experimental / Theoretical
SG1	0.000971	0.001046	0.927865
SG2	-0.00106	-0.00105	1.011955

For Test C1-3, Impactor 3 was dropped from one inch above end Q of the cantilever. Figures 9 and 10 show the theoretical and the experimental strain-time curves for SG1 and SG2, respectively. Table 4 shows the experimental and the theoretical strains and, their comparison. The ratios between the tested to the predicted strain results ranged from 0.89 to 0.86, which are considered to be reasonable results. There was an overall good agreement in the shape of all the load-strain curves. For this test, the experimental maximum moment at section B was 38.1 kip-in and the theoretical value was 37.7 kip-in. The difference between the theoretical and the experimental results was 2%. Both the experimental and the theoretical curves were very similar and their peak values were very close. This test caused partial plastification on the cantilever beam.

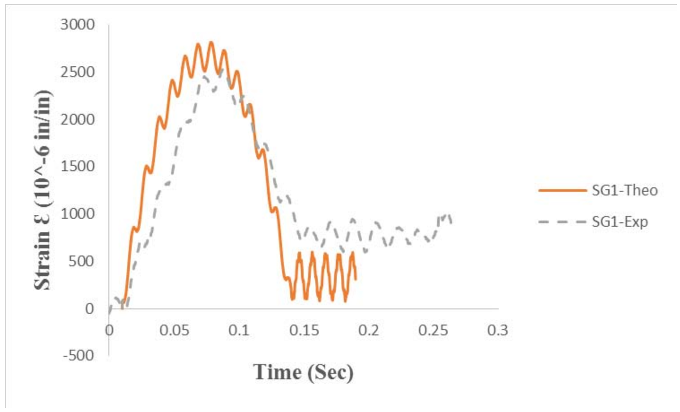

Figure 9: Comparison of theoretical and experimental strain-time relations of SG1for test C1-3

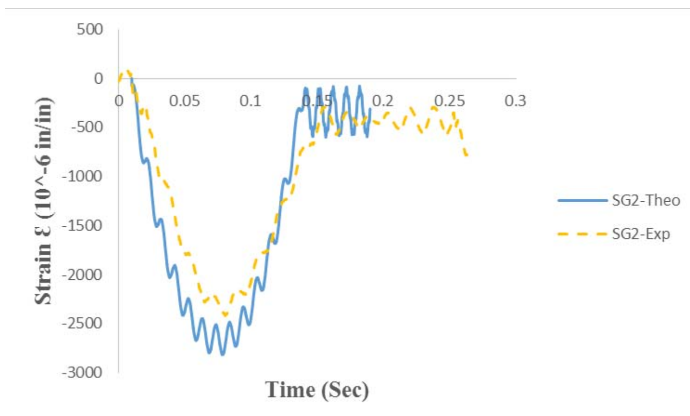

Figure 10: Comparison of theoretical and experimental strain-time relations of SG2 for test C1-3

Table 4: Experimental and theoretical strains for test C1-3

Strain gauge	Experimental strain (in./in.)	Theoretical strain (in./in.)	Experimental / Theoretical
SG1	0.002531	0.002817	0.898389
SG2	-0.00242	-0.00282	0.859344

For Test C1-4, Impactor 3 was dropped from two inches above end Q of the cantilever. Figures 11 and 12 show the theoretical and the experimental strain-time curves for SG1 and SG2, respectively. Table 5 shows the experimental and theoretical strains, and their comparison. The ratios between the tested to the predicted strain results ranged from 1.01 to 1.06. For this test, the experimental maximum moment at section B was 39.5 kip-in and the theoretical value was 39.2 kip-in. Both the theoretical and the experimental results showed the formation of a plastic hinge at section B. It can be seen that there was good agreement between the predicted and the experimental values for the strains and the moments.

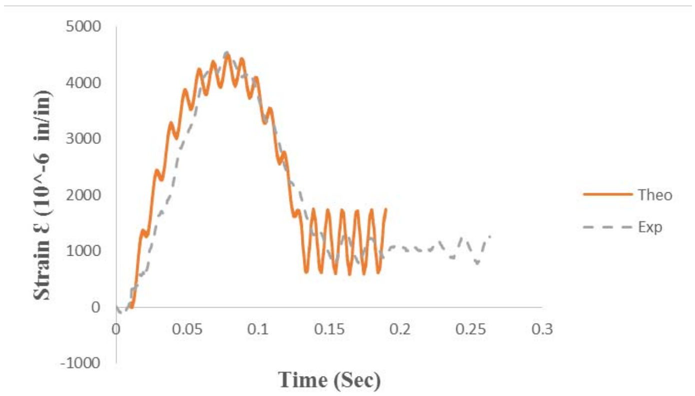

Figure 11: Comparison of theoretical and experimental strain-time relations of SG1for test C1-4

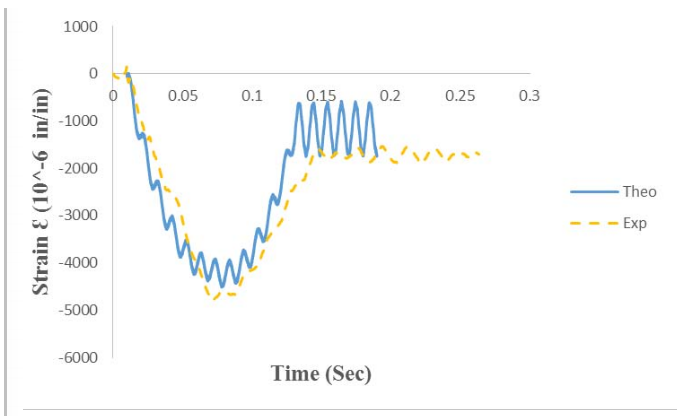

Figure 12: Comparison of theoretical and experimental strain-time relations of SG2 for test C1-4

Table 5: Experimental and theoretical strains for test C1-4

Strain gauge	Experimental strain (in./in.)	Theoretical strain (in./in.)	Experimental / Theoretical
SG1	0.004545	0.004512	1.007121
SG2	-0.004783	-0.004512	1.05997

IV. Conclusion

A theoretical and experimental study of the dynamic elasto-plastic behavior of a steel cantileverbeam is presented. A mathematical model based on a partial differential equation of inelastic dynamic equilibrium is successfully developed including new terms to account for elasto-plastic behavior of a steel cantilever beam. The iterative finite-difference solution algorithm predicted experimental elasto-plastic behavior of the cantilever beam for various impact forcing functions. It was also found that the weight of the impactor is directly related to the total duration of impact. By comparing the curve-fitted acceleration response generated by different impactors, it was found that the maximum curve-fitted acceleration value is inversely related to the mass of the impactor.

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Development of the Water Infrastructure in the Estuarine Part of Niger Delta to Ameliorate the Prevailing Transportation Problems

By B.O. Adegbenle & A.A. Olatunji
Federal Polytechnic Ede

Abstract- The problems facing the river transportation in estuarine region of Niger Delta were studied. The study revealed the problems, the effect of river transportation on the social-economic life of the communities, and the state of the terminals and jetties in those communities. The study also made some useful observation and recommendations were made. It is hoped that this study will assist in understanding, planning, operations and management of river transportation in estuarine region of Niger Delta. For researchers, the study will provide a useful insight into this aspect of transport systems which is relatively neglected in the past research efforts.

Keywords: water transportation, niger delta estuarine.

GJRE-E Classification: FOR Code: 090509

Development of the Water Infrastructure in the Estuarine Part of Niger Delta to Ameliorate the Prevailing Transportation Problems

B.O. Adegbenle [α] & A.A. Olatunji [σ]

Abstract- The problems facing the river transportation in estuarine region of Niger Delta were studied. The study revealed the problems, the effect of river transportation on the social-economic life of the communities, and the state of the terminals and jetties in those communities. The study also made some useful observation and recommendations were made. It is hoped that this study will assist in understanding, planning, operations and management of river transportation in estuarine region of Niger Delta. For researchers, the study will provide a useful insight into this aspect of transport systems which is relatively neglected in the past research efforts. The role of river transportation in the estuarine region of Niger Delta is felt to be very important, especially in those more remote places, which are unreachable, by land transportation. The potential of rivers transport, especially in serving access for people in remote area of Niger Delta is enormous. Nigeria has the second longest length of waterways in Africa. It has 8,600 kilometres of inland waterways and an extensive coastland of about 852 kilometres. Although river is a very important mode of transport, yet such is the case that this form of transport is not adequately harnessed for the socio-economic development of the people of estuarine Niger Delta. Another problem faced by rural water transport is safety caused by inadequate security measures, infrastructure decay and. Regulation and institutional concerns were important issues in three study areas. Recommendations were made to integrate river transport within intermodal transport systems and provide security for the system.

Keywords: water transportation, niger delta estuarine.

I. Introduction

Transport is the cornerstone of civilization (Oni& Okanlawon, 2004). As the society and economic organizations become complex, the relevance of transport grows. Transportation is a requirement for every nation, regardless of its industrial capacity, population size, or technological development. Moving goods and people from one place to another is critical to fostering economic growth. A country's transportation system is comparable to the blood circulatory system in humans (NDES, 1997). An efficient transportation system facilities the movement of goods and people cheaply and quickly which is vital in producing in a vibrant economy. The more efficient the transport system is, the lower the cost of transport, and invariably the lower the cost of goods and services (NDDC, 2006).

The most common and effective transportation mode in the rural Niger Delta areas is by water in canoes, ferries and small boats (NDRDMP, 2000). River transport is a very significant means of transport in Niger Delta region of Nigeria, which are now usually used in movement over short distances and for fishing activities across several nautical miles (Daramola, 2003).

In recent times, emphasis has been placed on urban road transport; with less regard to rural transportation development, especially river transport - for example, modern jetties hardly exist - which is essential for the movement of the majority of the rural population (Fig. 1). As a result, there is immense difficulty of movement of people and goods in the estuarine part of the Niger Delta. Apart from a few State-owned transport companies, transport services are provided by private operators.

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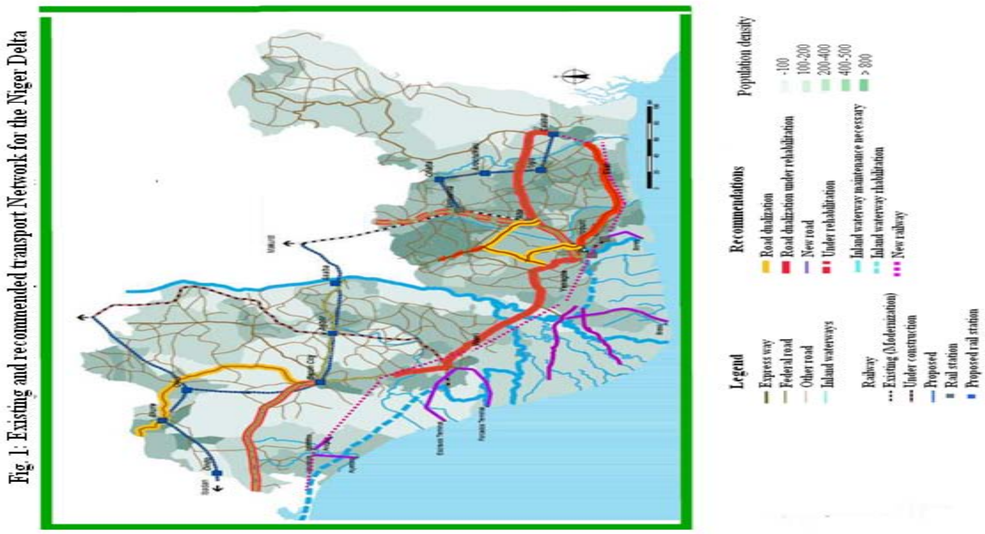

Figure 1

The Niger Delta region is situated in the southern part of Nigeria and bordered to the south by the Atlantic Ocean and to the East by Cameroon, occupies a surface area of about 112,110 square kilometers (UNDP, 2006). It represents about 12% of Nigeria's total surface area and it is estimated that by the beginning of 2006 its population will be over 28 million inhabitants. The region comprises nine of Nigeria's constituent states (Table 1) (CASS, 2002).

Table 1: The Nine States s of Niger Delta region

State	Land Area (square kilometres)	Population	Capital City
Abia	4,877	3,230,000	Umuahia
Akwa ibom	6,806	3,343,000	Uyo
Bayelsa	11,007	1,710,000	Yenagoa
Cross River	21,930	2,736,000	Calabar
Delta	17,163	3,594,000	Asaba
Edo	19,698	3,018,000	Benin
Imo	5,165	3,342,000	Owerri
Ondo	15,086	3,025,000	Akure
Rivers	10,378	4,858,000	Port Harcourt
Total	112,110	28,856,00	

Source: GTZ population projection (2004) based on National Population Commission Data

Since 1960 several attempts have been made by the Nigerian government to pay special developmental attention to the river transportation in the estuarine Niger Delta region because of its uniqueness; by establishing development agencies to plan, organize and implement necessary phases of the service delivery process (CASS, 2002). This region of the Niger Delta suffers a major lack of basic physical infrastructure, badly maintained road and water networks, along with unemployment the region is virtually cut off from the entire country be virtue of living in water surrounded environment (Abam, 2001).

II. Materials and Methods

A desktop research approach has been adopted for this study with extensive literature and archived programme information extracted and used as a basis for inference.

The Niger Delta Region is divided into nine States; this report is limited to only three communities in each of the three States (Delta, Edo and Bayelsa State) of N/Delta as representative of the whole region.

a) *Design*

The research questionnaires were administered to mostly people between the ages of 18 and 60 years and those who have lived in the area or community for over 15 years. Most of the respondents are also well educated with at least the West African School certificate.

The questionnaire technique was used to supplement other sources of information and data. The method was useful in tapping respondents' knowledge on river transportation through their experience on when travelling. More so, it is the most convenient means of appreciating or gauging respondents' perception of the pertinent socio-economic variables as they relate to the study.

b) Settings

The study data were collected across the three states (i.e. Delta State, Bayelsa State and Edo State) that make up the Niger Delta region. Some identified communities namely: Ekeremor zion, Ijasan and Azama towns of Delta State; Aghoro, Toru-Ndoro and Odeama towns of Bayelsa State and; Ovia, Erenegbe and Gegele communities in Edo State. In each of these communities as shown in Fig. 2, where river was major means of transportation were approached for data collection. In all, a total of three communities were selected, thereby making up a total of nine communities across the three selected states of the Niger Delta Region. A total of 100 different people participated in the study per State.

c) Procedure

The study is an attempt to assess the problem of water transport in the estuarine of Niger Delta region in Nigeria. The core Niger Delta states are Bayelsa State, Delta State and Rivers State. In the year 2000, former President Olusegun Obasanjo's regime expanded the definition of Niger Delta region by incorporating some other states, including Abia State, Edo State, Imo State.

In all, three river line communities where river is the major means of transportation was selected in each state, thereby making up a total of nine communities for the three states in the Niger Delta region. A total of 300 copies of the questionnaire were produced and distributed across the selected communities in the three states, with 100 copies of the questionnaire meant for each state. These copies were distributed as follows: 33 copies for each community, across the three communities. In order to encourage the study participants to respond to the questionnaire items freely, they were asked not to include their names. Essentially, the participants were asked to respond to the questionnaire items as sincerely as possibly, and they were assured that their responses would be treated with utmost confidentiality.

In all, out of the 300 copies of the questionnaire, only 250 copies could be retrieved with the assistance of some residents in the community. While the remaining 50 copies could not be retrieved. Out of the 250 copies, only 225 were deemed fit and usable for data entry and analysis. The remaining 25 copies could not be used because some of the participants failed to indicate their gender or age or some other personal characteristics, while some other participants filled the questionnaire poorly in general.

d) Statistical analysis

The study utilized both the charts and descriptive statistics. The descriptive statistics were meant to obtain some summary information on some data such as percentages (%) and frequency. Specifically, the statistical package (SPSS) version 16.0 was utilized for data entry and data analysis.

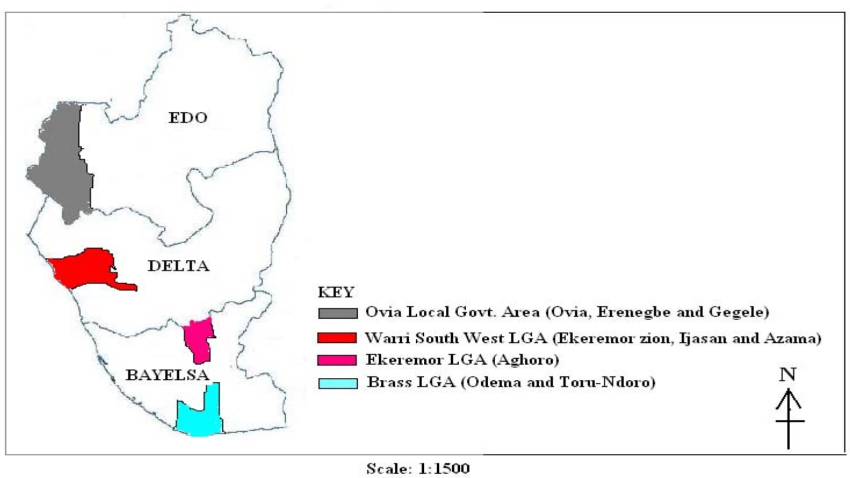

Fig. 2: Map showing the studied communities

Source: modified from UNDP, 2006

III. Results

The results are presented in charts and descriptive statistical form for easy understanding of the existing situations of the area.

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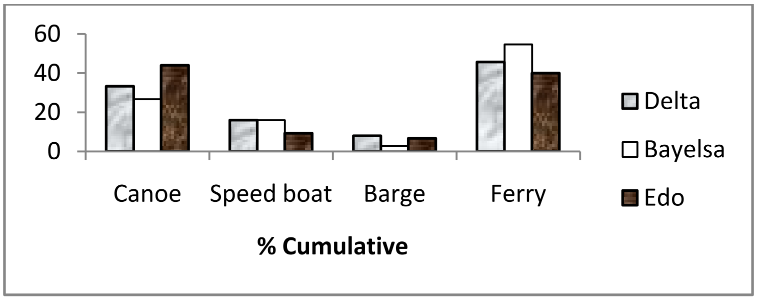

Fig. 3.1: Cumulative percentage of the respondent's major means of transportation

Fig. 3.2: Cumulative percentage of the efficiency of river transportation

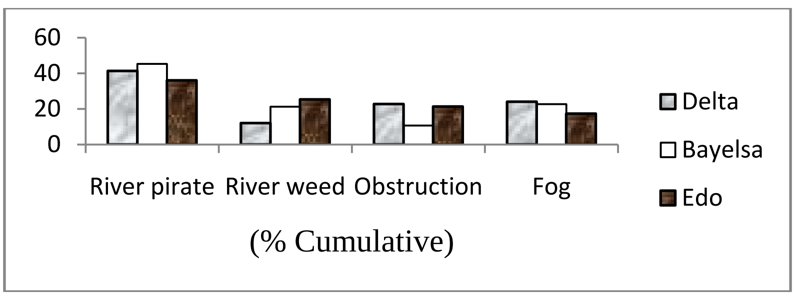

Fig. 3.3: Cumulative percentage of major problem of river transport

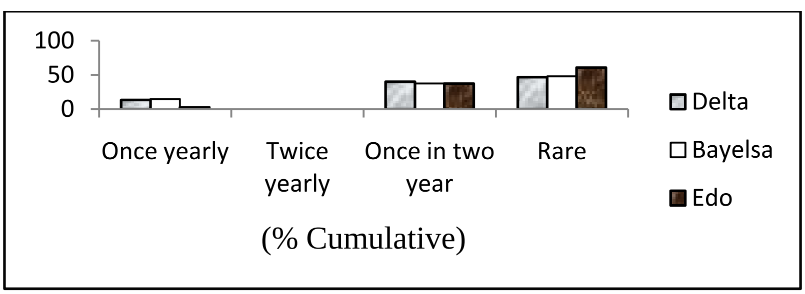

Fig. 3.4: Cumulative percentage of the number of times the river is dredge

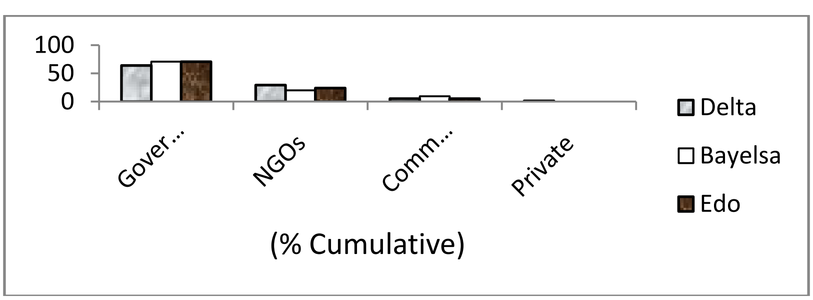

Fig. 3.5: Cumulative percentage of the organ responsible for river dredging

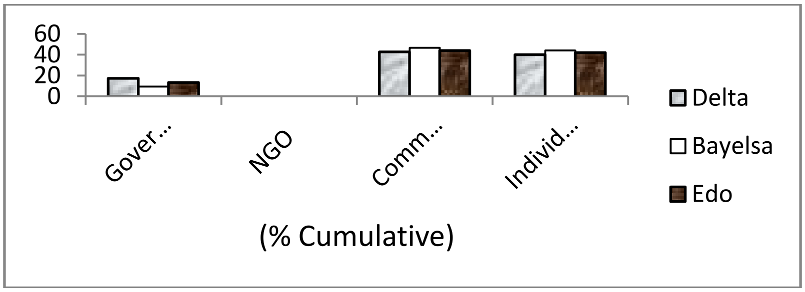

Fig. 3.6: Cumulative percentage of the organs responsible for operation of the Jetties

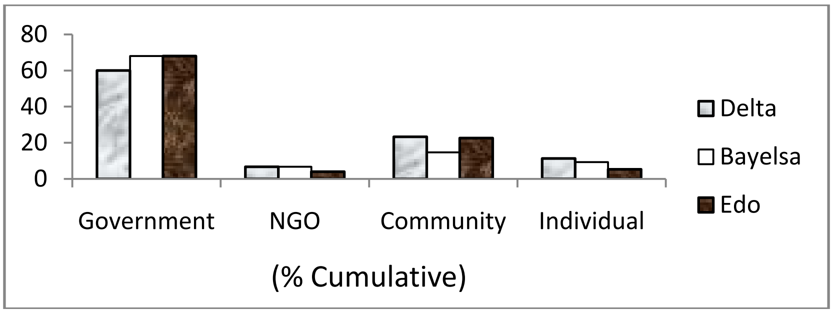

Fig.3.7: Cumulative percentage of organs responsible for the development and maintenance of Jetties

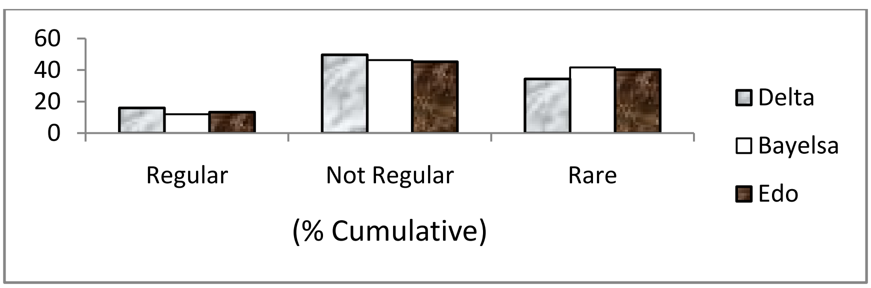

Fig. 3.8: Cumulative percentage of occurrence of accident in river transportation

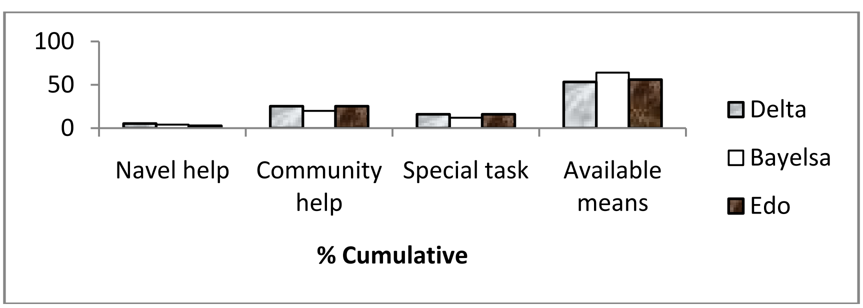

Fig. 3.9: Cumulative percentage of management of accident cases

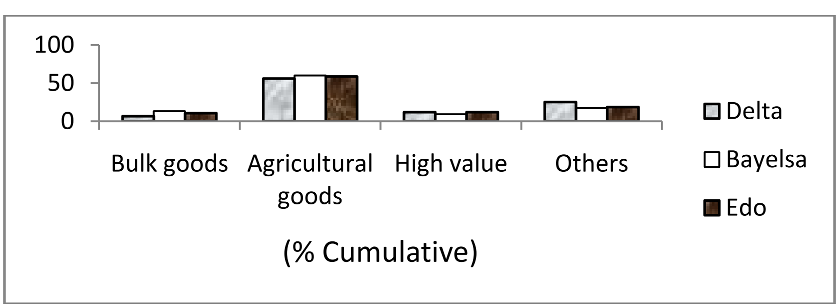

Fig. 3.10: Cumulative percentage of major goods transported

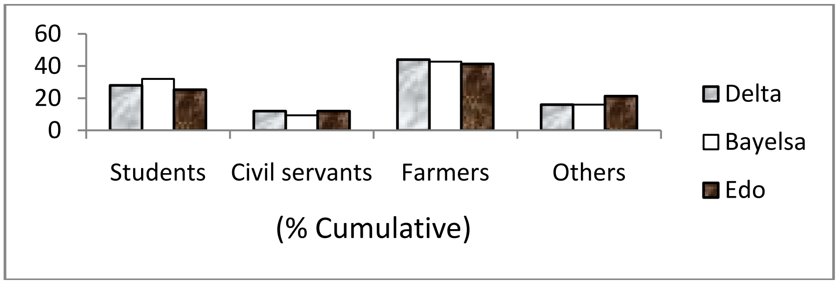

Fig. 3.11: Cumulative percentage of major users of river transport

Fig. 3.12: Cumulative percentage of development through river transportation

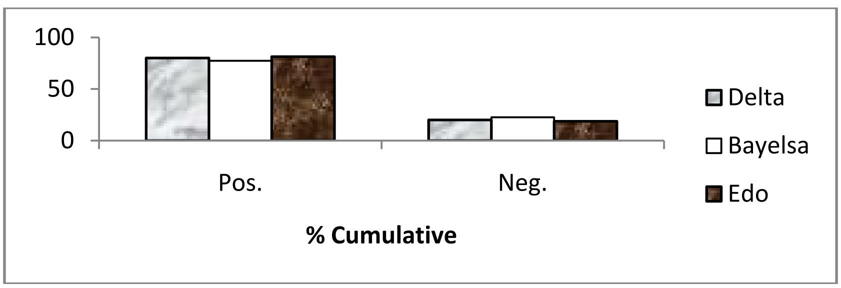

Fig. 3.13: Cumulative percentage on effect of river transportation on intercommunity relationship

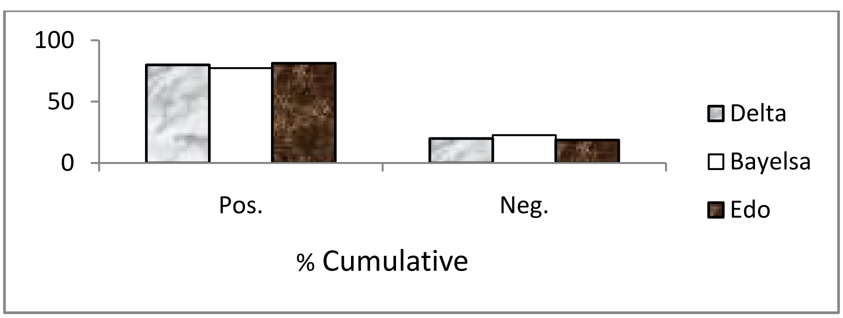

Fig. 3.14: Cumulative percentage of the effect of river transport on the economy of the area

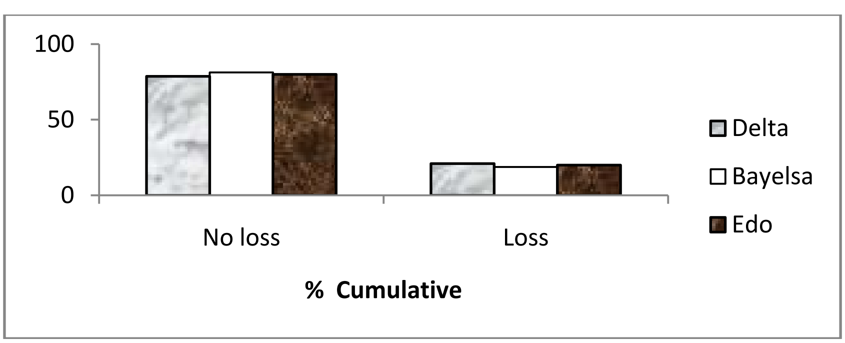

Fig. 3.15: Cumulative percentage of the loss by the community through river transport

IV. Discussion

In the communities studied within the estuarine part of the Niger Delta. It could be deduced that the River-based passengers' movement is mainly by Ferry in Delta and Bayelsa State as shown in Fig. 3.1, where the cumulative percentage was 42.7 and 54.7% respectively. While in Edo State (cumulative percentage: 44%) the use of Canoe was favoured compare to other means of river transportation.

The organisation of river transportation in the Niger Delta was high with cumulative percentage of 65.7, 64 and 67.3% for Delta, Bayelsa and Edo State respectively are shown in Fig. 3.2. This level of organisation could be attributed to the seemly private ownership of the passengers vessel and there desire to maximize profit.

The major problem militating river transportation in the estuarine region of the Niger Delta as shown in Fig. 3.3. Majorly, River pirate has a cumulative percentage of 46.7, 48 and 60.7% for Delta, Bayelsa and Edo State respectively. This however revealed that the percentage of River pirate was highest in Edo communities followed by Bayelsa communities. This was followed by Fog as indicated in the Fig.3.3.

The frequency of clearing and dredging of the river channels was shown in Fig. 3.4. The result indicated a cumulative percentage between 46.7 to 60.7% few and far between in clearing and dredging of the river. As a result of failure to dredge or clear the river, it is reported that the least average depth for River Niger between Warri and Jebba is one metre whereas the least average depth for commercial navigational operation should not be less than 1.5 metres (Ogah and Odita, 2009).

In Fig.3.5, it was inferred that the government was solely responsible for the dredging and clearing of the rivers in the Niger Delta region.

The organ responsible for the operation of the Jetties is presented in Fig. 3.6. The result revealed that the communities have the responsibility of Jetty operation with cumulative percentage of 42.7, 46.7 and 44% Delta, Bayelsa and Edo respectively.

Fig.3.7 shows the government is responsible for the development and maintenance of Jetties. (NDDC, 2005).

Fig. 3.8 show the occurrence of accident in river transportation. The result indicated that river transport does not have high incident of water mishap.

Fig. 3.9 shows how incident of water accident is managed. The result indicated that the river transportation in the Niger Delta region does not have any special arrangement to rescue accident victims rather the system depend on any available means to rescue survivals. Water transport safety is felt to still be lacking, because some of the passengers rely only on their ability to swim and thus rely on themselves (GRSL, 1995).

Fig. 3.10 show the major goods transported by the communities using river transport. The result indicated a cumulative percentage of 56-60% for Agricultural products. This was followed by others. Type of goods which are transported by water is bulk material such as rice, wheat, oil and woods which produced from the forest along the river (Jansen *et al*., 1985).

Fig. 3.11 Show the major users of river transportation. Most of the passengers use water transportation majorly for farming and moderately for school. Most of the residents are farmer, therefore the need for agriculture equipment such as fertilizer, seeds and tools (PT, 1995).

Fig 3.12 shows communities' development through river transportation. This indicated a cumulative percentage of 34.7, 36 and 40% in Commercial activities for Delta, Bayelsa and Edo State respectively. This was also followed by employment across the three State and their communities.

Fig. 3.13 shows the effect of river transportation on intercommunity relationship. The result indicated a cumulative percentage of 80, 77.3 and 81.3% in favour of better intercommunity relationship through river transportation.

Fig. 3.14 shows the effect of river transport on the economy of the communities. The result indicated a positive effect on the economy of the communities. Indication of an improvement on the communities through river transportation and there were no loss by the community as a result of river transport as there were increase in commercial activities and employment for the people in the localities.

Fig.3.15 shows the loss incurred by the community through river transport. From the response of participate, there were no lost by the communities as a result of river transportation.

V. Conclusion and Recommendation

Some of these problems are inability of the authorities to upgrade and maintain the available Terminals and Jetties in these river line communities, lack of adequate security for the passengers on board the boats travelling in the Niger delta communities, lack of modern river transportation vessel for the navigable river channels in the Niger Delta communities and the inability of the authorities to clear/dredge the river channels.

Generally speaking, years of government's insensitivity and unresponsiveness to the plight of the people of the Niger Delta has led to a deterioration of the water infrastructures whereby the cost of living in these areas was highly unbearable. From all indication the water channels in the area are navigable and there is urgent need for the government to pay attention to the

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development of the water infrastructure in the estuarine part of Niger Delta to ameliorate the prevailing transportation problems as indicated in this study.

In other to alleviate the identified problems in the river transportation in the estuarine region of Niger Delta the following solutions are recommended:

1. The government should encourage private investment in the river transportation system by giving soft loans to the people as a means of empowerment and Job creation.
2. Modern boats for river transportation should be introduced to these estuarine communities for rapid movement of cargo and passengers to their destinations.
3. The dredging and clearing of river channels should be done at least once in a year; this is to allow easy movement and travel using the river ways without obstruction and accident due to collision.
4. The communities should be encouraged to invest in river transportation by forming cooperative in order to rinse fund and purchase a modern vessel that is capable to river transport.
5. The upgrading and maintenance of the Jetties should be made priority by the government, so as to encourage the participation of private organization in river transportation.
6. The local and State Government should take up the responsibility of providing safety of passengers by arranging on alert rescue term in case of emergency. This should also involve the use of modern communication gadgets to give signal and information to the authorities in case the need arises.
7. Night navigation facilities should be provided to the estuarine Niger Delta navigable rivers, so that passengers travelling in the night may find it comfortable and safe; and thus improve the average turnaround time of the boats.

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Software named AHPM (Analytic Hierarchy Process Model) was developed using MATLAB for flexible pavement. The first step in the AHP procedure is to decompose the decision problem into a hierarchy that consists of the most important elements of the decision problem.

Keywords: analytic hierarchy process (AHP); decision making; flexible pavement; mulicrieria; pavement maintenance strategy.

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Dr. Asma Th. Ibraheem [α] & Noor S. Atia [σ]

Abstract- This paper aimed to develop methods and tools for supporting maintenance management system for transportation. This is done by using Multicriteria Decision Making Process techniques. Also analytic hierarchy process (AHP) were applied to evaluate the techniques that are used for maintaining the road pavements.

Software named AHPM (Analytic Hierarchy Process Model) was developed using MATLAB for flexible pavement. The first step in the AHP procedure is to decompose the decision problem into a hierarchy that consists of the most important elements of the decision problem. In developing a hierarchy identified the objective, factors and alternatives. The hierarchy model of a decision problem is the objective of the decision at the top level and then descends downwards lower level of decision factors until the level of attributes is reached. Each level is linked to the next higher level.

In this study the researchers conducted many personal interviews with senior engineers who have an experience in road maintenance projects. About 6 senior engineers were selected to conduct the interviews. Every engineer of those experts gave pairwise comparison matrices as weights of AHP process.

For the purpose of ascertaining the efficiency of the developed software (AHPM), it has been applied to a case study included the main street in Bagdad university, it has a length of (2.38) km and width of (7m). The result of this application was that road requires an asphalt thin hot mix overlay.

Keywords: analytic hierarchy process (AHP); decision making; flexible pavement; mulicrieria; pavement maintenance strategy.

I. Introduction

A major problem that faces highway and transportation agencies is that the funds they receive are usually insufficient to adequately repair and rehabilitate every roadway section that deteriorates. The problem is further complicated in that roads may be in poor condition but is still unable; making it easy to defer repair projects until conditions becomes unacceptable. Roadway deterioration usually is not the result of poor design and construction practices but is caused by the inevitable wear and tear that occurs over years. The gradual deterioration of a pavement occurs due to many factors including variations in climate, drainage, soil conditions, and truck traffic. Just as a piece of cloth eventually tears asunder if a small hole is not immediately repaired, so will a roadway unravel if its surface is allowed to deteriorate. Lack of funds often limits timely repair and rehabilitation of transportation facilities, causing a greater problem with more serious pavement defects and higher costs (Garber and Hole 2009).

In order to carry out the maintenance in as cost-effective manner as possible, a logical coherent procedure must be adopted in order to select the most effective form that the maintenance should take, together with the optimum time at which this work should be undertaken. Minor maintenance may be sufficient to maintain the required standard of service for the motorist (Rogers 2003).

The AHP is a general theory of measurement. It is used to derive relative priorities on absolute scales (invariant under the identity transformation) from both discrete and continuous paired comparisons in multilevel hierarchic structures. These comparisons may be taken from actual measurements or from a fundamental scale that reflects the relative strength of preferences and feelings. The AHP has a special concern with departure from consistency and the measurement of this departure, and with dependence within and between the groups of elements of its structure. It has found its widest applications in multicriteria decision making (Saaty and Elexander 1989) in planning and resource allocation (Saaty 2005), and in conflict resolution. In its general form, the AHP is a nonlinear framework for carrying out both deductive and inductive thinking without use of the syllogism. This is made possible by taking several factors into consideration simultaneously, allowing for dependence and for feedback, and making numerical tradeoffs to arrive at a synthesis or conclusion (Saaty and Vargas 2006).

The foundation of the Analytic Hierarchy Process (AHP) is a set of axioms that carefully delimits the scope of the problem environment (Saaty 1996). It is based on the well-defined mathematical structure of consistent matrices and their associated right-eigenvector's ability to generate true or approximate

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weights. The AHP methodology compares criteria, or alternatives with respect to a criterion, in a natural, pairwise mode. To do so, the AHP uses a fundamental scale of absolute numbers that has been proven in practice and validated by physical and decision problem experiments. The fundamental scale has been shown to be a scale that captures individual preferences with respect to quantitative and qualitative attributes just as well or better than other scales (Saaty 1980). It converts individual preferences into ratio scale weights that can be combined into a linear additive weight w (a) for each alternative.

The resultant w (a) can be used to compare and rank the alternatives and, hence, assist the decision maker in making a choice. Given that the three basic steps are reasonable descriptors of how an individual comes naturally to resolving a multicriteria decision problem, then the AHP can be considered to be both a descriptive and prescriptive model of decision making. The AHP is perhaps, the most widely used decision making approach in the world today. Its validity is based on the many hundreds (now thousands) of actual applications in which the AHP results were accepted and used by the cognizant decision makers (DMs) (Vahidnia et.al. 2008).

a) *Decision Making of Multiple Criteria Sealing*

The analytic hierarchy process (AHP) is a basic approach to decision making. This multiple criteria scaling method was founded by Saaty (1977). It is designed to cope with both the rational and the intuitive to select the best from a number of alternatives evaluated with respect to several criteria. In this process, the decision maker carries out simple pairwise comparison judgments. These are used to develop overall priorities for ranking the alternatives. The AHP both allows for inconsistency in the judgments and provides a means to improve consistency. The procedure starts with development of alternative options, specification of values and criteria, then, it follows the evaluation and recommendation of an option (Farkas 2010).

b) *Philosophy of AHP*

The AHP is a general theory of measurement. It is used to derive the most advanced scales of measurement (called ratio scales) from both discrete and continuous paired comparisons in multilevel hierarchic structures. These comparisons may be taken from actual physical measurements or from subjective estimates that reflect the relative strength of preferences of the experts (Farkas 2010).

The AHP is a method that can be used to establish measures in both the physical and human domains. The AHP has special concern with departure from consistency and the measurement of this departure, and dependence within and between the groups of elements of its structure. This is made possible by taking several factors into consideration simultaneously, allowing for dependence and for feedback, and making numerical tradeoffs to arrive at a synthesis or conclusion (Saaty 1996).

In using the AHP to model a problem, one needs a hierarchic structure to represent that problem, as well as pairwise comparisons to establish relations within the structure. In the discrete case, comparisons lead to dominance matrices and in the continuous case to kernels of Fredholm operators, from which ratio scales are derived in the form of principal eigenvectors, or eigen functions, as the case may be. These matrices, or kernels, are positive and reciprocal. In a real world application of the AHP the required number of such matrices is equal to the number of the weighting factors. In addition, regarding that the number of the group members is 5–15, there is a need for aggregation what is called the process of synthesizing group judgments. By synthesizing the particular priorities with the average weighting factors of the attributes the ultimate output is yielded in the form of a weighted priority ranking indicating the overall preference scores for each of the alternatives under study (Saaty and Vargas 2006).

The AHP procedure involves six essential steps (Vahidnia et.al. 2008):

1. Define the unstructured problem.
2. Developing the AHP hierarchy.
3. Pairwise comparison.
4. Estimating the relative weights.
5. Checking the consistency.
6. Obtaining the overall rating.

1. Define the unstructured problem

In this step the unstructured problem and their characters should be recognized and the objectives and outcomes stated clearly.

2. Developing the AHP hierarchy

The first step in the AHP procedure is to decompose the decision problem into a hierarchy that consists of the most important elements of the decision problem. In this step the complex problem is decomposed into a hierarchical structure with decision elements (objective, attributes i.e. criterion map layer and alternatives). Figure 1 represents this structure.

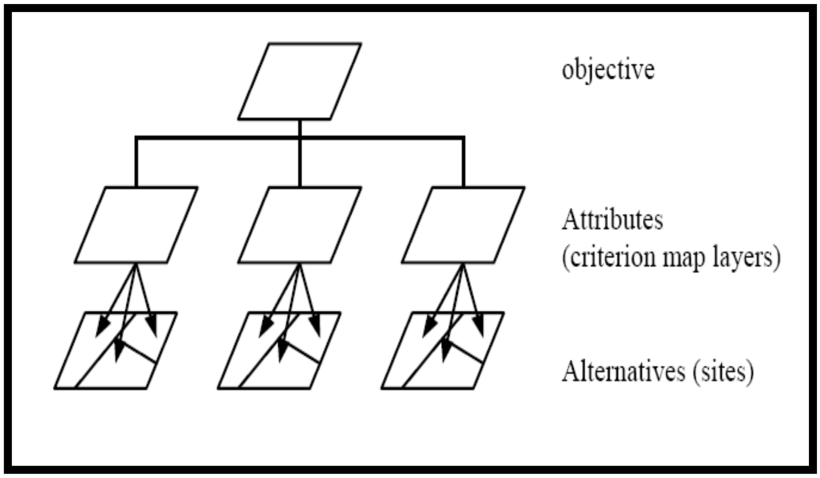

Figure 1: Hierarchical structure of decision problem (Vahidnia et.al. 2008)

3. Pairwise Comparison

For each element of the hierarchy structure all the associated elements in low hierarchy are compared in pairwise comparison matrices as follows:

$$A = \begin{bmatrix} 1 & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & 1 \end{bmatrix} \quad (1)$$

where

A = comparison pairwise matrix,

w_1 = weight of element 1,

w_2 = weight of element 2,

w_n = weight of element n.

In order to determine the relative preferences for two elements of the hierarchy in matrix A, an underlying semantically scale is employs with values from 1 to 9 to rate.

4. Estimating the relative weights

Some methods like eigenvalue method are used to calculate the relative weights of elements in each pairwise comparison matrix. The relative weights (W) of matrix A is obtained from following equation:

$$(A - \lambda_{max} I) \times W = 0 \quad (2)$$

where λ_{max} = the biggest eigenvalue of matrix A,

I= unit matrix.

From the standpoint of engineering applications, eigenvalue problems are among the most important problems in connection with matrices.

Let $A = [a_{jk}]$ be a given n×n matrix and consider the vector equation:

$$Ax = \lambda x \quad (3)$$

Here, x is an unknown vector and λ an unknown scalar. Clearly, the zero vector x=0 is a solution of equation (3) for any value of λ. This is of no practical interest. *A* value of λ for which (4.3) has a solution x≠0 is called an eigenvalue or characteristic value (or latent root) of matrix *A*. The corresponding solutions x≠0 of equation (3) are called eigenvectors or characteristic vectors of *A* corresponding to that eigenvalue λ. The set of Eigenvalues is called the spectrum of *A*. The largest of the absolute values of the eigenvalues of *A* is called the spectral radius of *A*.

5. Checking the consistency

In this step the consistency property of matrices is checked to ensure that the judgments of decision makers are consistent. For this end some pre-parameter is needed. Consistency Index (*CI*) is calculated as (Vahidnia et.al. 2008):

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (4)$$

The consistency index of a randomly generated reciprocal matrix shall be called to the random index (*RI*), with reciprocals forced. An average *RI* for the matrices of order 1–15 was generated by using a sample size of 100.

Table (1) shows random indexes of the matrices of order 1–15 (Coyle 2004). The last ratio that has to be calculated is *CR* (Consistency Ratio). Generally, if *CR* is less than 0.1, the judgments are consistent, so the derived weights can be used. The formulation of *CR* is:

$$CR = \frac{CI}{RI} \quad (5)$$

Table 1: Average random consistency (*RI*) (Coyle 2004)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Figure (2) developed from table 2 to determine the random index (*RI*) for all sizes of matrices (*n*) and create the following equation from that graph by using least square polynomial method:

$$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 \qquad [R^2 = 0.9766] \qquad (6)$$

where

$a_0 = 0.6304$, $a_1 = 0.5222$, $a_2 = 0.0430$, $a_3 = 0.0012$

6. Obtaining the overall rating

In last step the relative weights of decision elements are aggregated to obtain an overall rating for the alternatives as follows (Vahidnia et.al. 2008):

$$W_i^S = \sum_{j-1}^{j-m} w_{ij}^s \; w_j^a \qquad i = 1,\dots,n \qquad (7)$$

where

W_i^S = total weight of site i,

w_{ij}^S = weight of alternative (site) i associated to attribute (map layer) j,

w_j^a = weight of attribute j,

m = number of attribute,

n= number of site.

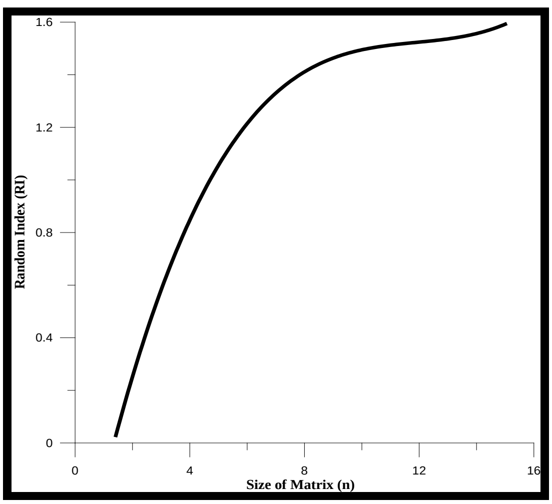

Figure 2: Average random consistency (*RI*).

c) Modeling the Decision Making with AHP for Treatment Selection of pavement

The first step in the AHP procedure is to decompose the decision problem into a hierarchy that consists of the most important elements of the decision problem. In developing a hierarchy identified the objective, factors and alternatives. The hierarchy model of a decision problem is the objective of the decision at the top level and then descends downwards lower level of decision factors until the level of attributes is reached. Each level is linked to the next higher level.

Decision making with AHP for treatment selection of pavement is modeled as a program by using MATLAB 2008a. Figure (3) illustrates the flowchart of the developed program for modeling AHP as the basic form of a hierarchical model of making decision, where the objective to identify suitability for choosing the type of maintenance activity. This can be achieved in the following nine steps:

1. Ranking the highway road (classes of road): express highway, urban streets and suburban streets.
2. Defining the type of pavement, flexible pavement or rigid pavement.
3. Defining the severity of distresses, low, moderate and high then input the degree of severity of distresses as weights of important of intensity (AHP process), and solve the compared matrix by eigenvector.
4. Selecting the major types of distresses, preventive distress, corrective and emergency distress, then input the degree of hurt of major distress as weights of important of intensity (AHP process), and calculated the compared matrix by eigenvector.
5. Multiplying the eigenvectors calculated from step 4 by eigenvector calculated from step3.
6. Selecting the type of minor distress: for flexible pavement; cracking, raveling rutting, distortion potholes and excess asphalt. For rigid; joint distress, faulting, pattern cracking, surface distress and slab cracking. Input the degree of hurt of minor distress as weights of important of intensity (AHP process), then calculate the compared matrix.
7. Multiplying the eigenvectors result from step 6 by eigenvector result from step 5.
8. Selecting the proper type of treatments for each distress. Input the weights of important of intensity (AHP process) for the treatments then calculate the compared matrix.
9. Multiplying the eigenvectors result from step 8 by eigenvector result from step 7, then select the treatment that its number equal to λ_{max}.

d) Development of the Comparison Matrix

In this stage the researchers conducted many personal interviews with senior engineers who have an experience in road maintenance projects. About 6 senior engineers were selected to conduct the interviews. Every engineer of those experts gave pairwise comparison matrices as weights of AHP process.

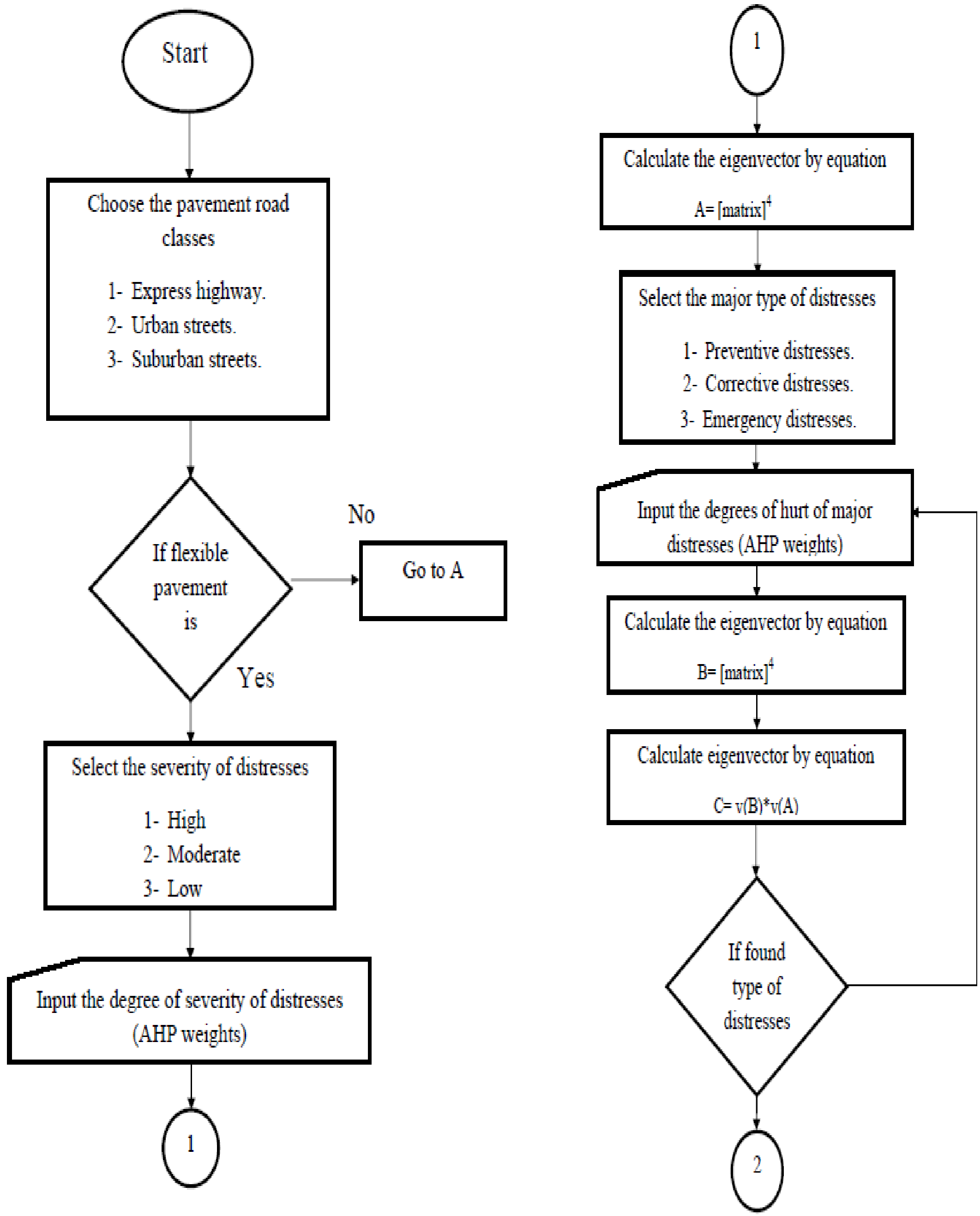

Figure 3: Flowchart of AHPM Software for Flexible Pavement

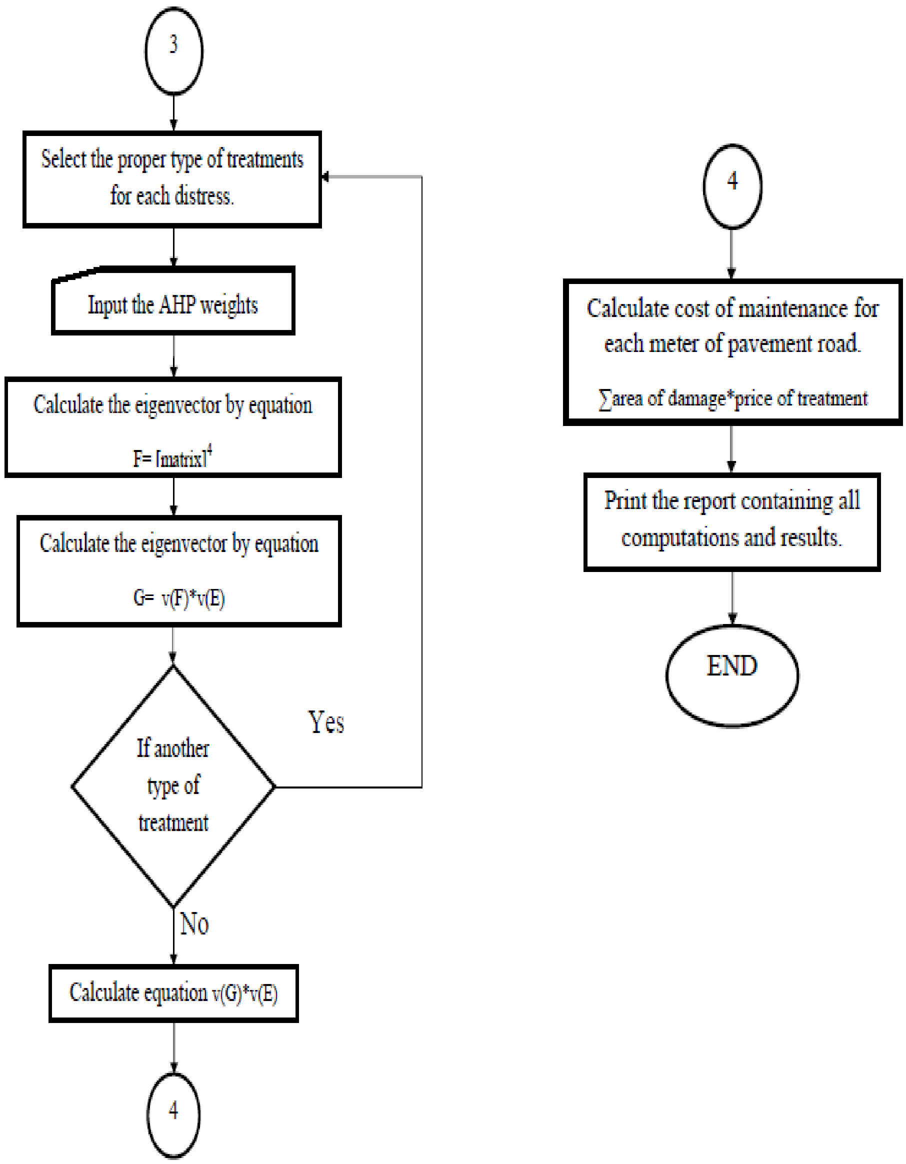

Figure 3: (continued)

II. Case Study

The case study is a local road of University of Baghdad, which is begin from gate of University of Baghdad returned as a ring to the gate with length 2.38 Km and width 7 m with 2-lane and one way, as it is clear in figure (4). Table 2 shows the distresses types of this case study (University of Baghdad street).

Table 2: Distresses types of second case study.

	Distress type	Severity level	Extent level
1	Edge cracks	Moderate	High
2	Block cracks	High	Very high
3	Transverse cracks	Very high	High
4	Longitudinal cracks Alligator	Moderate	Low
5	cracks	High	Moderate
6	Potholes	High	Moderate
7	Raveling	High	Moderate

Figure 4: Top view for University of Baghdad main street

a) *Development of the pairwise comparison matrix*

There are 12 pairwise comparison matrices in all: One for the criteria with respect to the goal, which is shown here in Table 4, two for the subcriteria, the first of which for the subcriteria under high distresses: preventive, corrective and emergency, that is given in Table 5 and one for the subcriteria under moderate distresses that is given in Table 6.

Then, there are nine comparison Saaty matrices for the four alternatives with respect to all the 'covering criteria', the lowest level criteria or subcriteria connected to the alternatives. The 9 covering criteria are: corrective distresses, emergency distresses, and edge cracking treatment, block cracking treatment, transverse cracking treatment, longitudinal cracking treatment, and alligator cracking treatment, potholes distress treatment, and raveling distress treatment.

The comparisons matrices of this case are calculates as then shown in the four tables below (from table 3 to table 6).

Table 3: Pairwise comparison matrix of the main criteria with respect to the Goal

	Low	Moderate	High	4th root of product of values	Eigenvector (Priorities)
Low	1	1/3	1/5	48.2522	0.1007
Moderate	3	1	1/4	108.0709	0.2256
High	5	4	1	322.6167	0.6736
Total				478.9398	≈1.000

$\lambda_{max} = 3.086$, CI= 0.043, RI= 0.58, CR= 0.074<0.1 o.k

Table 4: Pairwise comparison matrix for the subcriteria with respect to moderate distresses

	Preventive	Corrective	Emergency	4th root of product of values	Eigenvector (Priorities)
Preventive	1	1/3	1/7	45.3283	0.0810
Corrective	3	1	1/5	105.4457	0.1885
Emergency	7	5	1	408.7524	0.7305
Total				559.5264	1.00

$\lambda_{max} = 2.064$, CI= -0.468, RI= 0.58 , CR= -0.81<0.1 o.k

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Table 5: Pairwise comparison matrix for the subcriteria with respect to high distresses.

	Preventive	Corrective	Emergency	4th root of product of values	Eigenvector (Priorities)
Preventive	1	1/3	1/8	48.0384	0.0705
Corrective	3	1	1/7	104.4175	0.1532
Emergency	8	7	1	520.1131	0.7705
Total				681.569	≈1.00

$\lambda_{max} = 3.104$, CI= 0.052, RI= 0.58, CR= 0.09<0.1 o.k

Table 6: Results of multiplying of eigenvectors

	Moderate (0.2256)	High (0.6736)	Eigenvector (Priorities)
Preventive	0.0810	0.0705	0.0658
Corrective	0.1885	0.1532	0.1457
Emergency	0.7305	0.7705	0.6838

For subcriteria (distresses of pavement), a comparison matrix shown in table 7 with respect to corrective maintenance, the eigenvector of relative importance for E, B, T, L, A, P and R is (0.1065, 0.08, 0.1489, 0.2142, 0.3182, 0.0818, 0.0504), where E, B, T, L, A, P and R is abbreviation for edge cracks, block cracks, transverse cracks, longitudinal cracks, alligator cracks, potholes distress and raveling distress respectively.

Table 7: Pairwise comparison matrix for the subcriteria with respect to corrective maintenance

	E	B	T	L	A	P	R	4th root of product of values	Eigenvector (Priorities)
E	1	2	1/2	1/3	1/4	2	3	$3.45*10^3$	0.1065
B	½	1	1/3	1/4	1/6	2	3	$2.5906*10^3$	0.0800
T	2	3	1	1/2	1/3	2	3	$4.8231*10^3$	0.1489
L	3	4	2	1	1/2	2	3	$6.9354*10^3$	0.2142
A	4	6	3	2	1	2	3	$10.3033*10^3$	0.3182
P	½	1/2	1/2	1/2	1/2	1	2	$2.6474*10^3$	0.0818
R	1/3	1/3	1/3	1/3	1/3	1/2	1	$1.6337*10^3$	0.0504
Total								$32.3835*10^3$	

$\lambda_{max} = 7.567$, CI= 0.095, RI= 1.32 , CR= 0.072 <0.1 o.k

Table 8 shows the comparison matrix for distresses with respect to emergency maintenance. The eigenvector of relative importance for A, P and R is (0.5396, 0.297, 0.1634) respectively.

Table 8: Pairwise comparison matrix for the subcriteria with respect to emergency maintenance

	A	P	R	4th root of product of values	Eigenvector (Priorities)
A	1	2	3	167.25	0.5396
P	½	1	2	92.0417	0.2970
R	1/3	1/2	1	50.6528	0.1634
Total				309.9445	

$\lambda_{max} = 3.009$, CI= 0.005, RI= 0.58 , CR= 0.008 <0.1 o.k

Table 9 shows the results of multiplying eigenvectors from tables 7 and 8 by the eigenvector from table 6

Table 9: Results of multiplying eigenvectors

	Corrective (0.1457)	Emergency (0.6838)	Eigenvector (Priorities)
E	0.1065	0	0.0155
B	0.0800	0	0.0117
T	0.1489	0	0.0217
L	0.2142	0	0.0312
A	0.3182	0.5396	0.4153
P	0.0818	0.297	0.2150
R	0.0504	0.1634	0.1191

Finally the final overall priorities of treatments of distresses calculated by multiplying the eigenvectors of treatments of distresses by the eigenvector of types of distresses that shown in table 10. From table 10 the eigenvector of the relative importance or value of D, C, F, SC, SL, CH, MS, M, CP, HP, TC, TH, PA, O and RE is (0.0286, 0.0162, 0.0292, 0.0494, 0.0523, 0.0753, 0, 0.0194, 0, 0, 0.1609, 0.2063, 0.0771, 0.0603 and 0.0541) respectively. Thus, TH is the most valuable and MS, CP and HP are less significant.

Table 10: Final Results

	E (0.0476)	B (0.2252)	T (0.2962)	L (0.1473)	A (0.1249)	P (0.0848)	R (0.074)	Overall Priorities
D	0.0564	0.0627	0.0573	0.0801	0.0201	0.0392	0.0546	0.0286
C	0.1310	0.0878	0.0682	0.3725	0	0	0	0.0162
F	0	0.0993	0.0963	0	0.0447	0	0.0619	0.0292
SC	0	0.0712	0.0810	0.2530	0.0617	0	0.1114	0.0494
SL	0	0.1538	0.1373	0	0.0921	0	0.0780	0.0523
CH	0	0.1179	0.1633	0.1799	0.1129	0	0.1503	0.0753
MS	0	0	0	0	0	0	0	0
M	0	0	0.1203	0	0	0.0780	0	0.0194
CP	0	0	0	0	0	0	0	0
HP	0	0	0	0	0	0	0	0
TC	0.2388	0.1738	0	0	0.2077	0.2154	0.1895	0.1609
TH	0.5737	0.2336	0	0	0.2980	0.1354	0.3512	0.2063
PA	0	0	0.2763	0.1145	0.1627	0	0	0.0771
O	0	0	0	0	0	0.2805	0	0.0603
RE	0	0	0	0	0	0.2515	0	0.0541

Table 11 shows results of priorities of judgments for six experts and average of their judgments. Where 1, 2, 3, 4, 5 and 6 represent expression of six experts and 7 the average of their judgments. The eigenvector of the relative importance or value of distresses treatments is varying in values according the judgments of experts. For expert number 1, TC is the most valuable and MS, CP and HP are less significant. For expert number 2, F is the most valuable and MS, CP and HP are less significant. For expert number 3, SC is the most valuable and MS, CP and HP are less significant. For experts numbers 4 and 5, F is the most valuable and MS, CP and HP are less significant. For expert number 6, TC is the most valuable and MS, CP and HP are less significant. From the average of judgments of experts, TH is the most valuable and MS, CP and HP are less significant.

Table 11: Final results of priorities experienced judgments.

Experienced / Overall priorities	1	2	3	4	5	6	7 Average
D	0.0361	0.0280	0.0404	0.0296	0.0529	0.0456	0.0286
C	0.0080	0.0118	0.0186	0.0231	0.0337	0.0067	0.0162
F	0.0484	0.1304	0.1368	0.1822	0.1567	0.0449	0.0292
SC	0.0552	0.1138	0.1422	0.1383	0.1538	0.0353	0.0494

Global Journal of Researches in Engineering (E) Volume XVI Issue V Version I Year 2016

SL	0.0576	0.0764	0.0780	0.0689	0.1162	0.0378	0.0523
CH	0.0588	0.0621	0.0720	0.0615	0.1047	0.0481	0.0753
MS	0	0	0	0	0	0	0
M	0.0389	0.0248	0.0181	0.0186	0.0070	0.0374	0.0194
CP	0	0	0	0	0	0	0
HP	0	0	0	0	0	0	0
TC	0.1353	0.1152	0.0994	0.0901	0.1065	0.1526	0.1609
TH	0.1236	0.0949	0.0747	0.0665	0.0590	0.1262	0.2063
PA	0.0219	0.0187	0.0328	0.0363	0.0224	0.0546	0.0771
O	0.1309	0.0803	0.0606	0.0603	0.0215	0.1268	0.0603
RE	0.1174	0.0720	0.0544	0.0541	0.0193	0.1137	0.0541

III. Conclusions

The conclusions drawn from this work can be summarized as follows:

1. The analytic hierarchy process (AHP) is an excellent method, which has been applied in this study for estimating the relative weighs of different factors that considered in spatial analysis process to the case of selecting a proper treatment for pavement. It provides a convenient approach for solving complex MCDM problems in engineering. The main advantage of the AHP is its ability to rank choices in the order of their effectiveness in meeting conflicting objectives.
2. The developed program AHPM (Analytic Hierarchy Process Model) is written by using MATLAB2008a. It can determine the best treatment for damages of pavements. The AHPM contains nine steps for choosing the type of maintenance activity of asphalt and rigid pavement. Those steps include the inputs of elements (criteria, sub-criteria and alternatives) of asphalt pavement and rigid pavement as weighs of important of intensity.
3. In this study, comparisons matrices were developed as weighs of AHP process according to judgments of experts who have an experience in road maintenance projects.
4. The (AHPM) software was applied to a case study, which was a main road of University of Baghdad. The result was yielding an asphalt thin hot mix overlay as the required maintenance activity.

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Comparison of Isolated Pad Footing & Beam-Slab Isolated Footing based on Varying the Footing Size and Grade of Steel

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Abstract- This paper presents a comparison of isolated pad footing with the Beam-Slab Isolated footing. In this paper beams have been introduced in the isolated pad footing to accommodate the tension in the footing. This in return reduces the overall depth of the footing. The design has been carried out to satisfy the Flexural and shear values for the foundation as per IS 456:2000. The diameter of the bar is decided such as to ensure that the area of steel provided is closest to the steel required as per the Limit State Design. Graphs are prepared to analyze the steel and concrete required for varying sizes of the footing (starting from 1m upto 6 m with a 0.5m increment) and comparing the values for 415 and Fe 500 steel values

Keywords: *isolated footing, excel spread sheet, size of footing, soil bearing capacity.*

GJRE-E Classification: FOR Code: 090502

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I. Introduction

Footings are the substructure of the building which is in direct contact with the soil. It is responsible for safely transferring the loads from the superstructure to the soil. It develops stability and hence prevents overturning of the building. Due to loads and soil pressure, footings are generally designed for bending moment (BM) and shear force (SF). In this paper the design has been completed in reference to IS 456:2000.

Isolated footings are designed when high soil bearing capacity is available at a shallow depth or the columns are far apart carrying very less load. In isolated pad footings (IPF), the lower portion of the footing is in tension. Beams are added to reduce the tension and hence reduce the overall depth of the slap. This reduction in the depth of slab helps in reduction of the concrete required.

Cost is a major factor in the construction industry. With the growing cost of raw materials attempts are made to reduce the raw materials used in a footing. Optimization of the design of footing is one technique employed in the industry for reducing the cost. [1] In this paper an attempt is made to reduce the quantity of material required in the foundation by the method of introduction of beams in an IPF.

Beam slab isolated footing (BSIF) is designed to analyze the materials required to enable safe transfer of loads from the superstructure to the substructure. Quantitative study has been carried out to analyze the steel and concrete requirement for Fe415 and Fe500 grade steel. An attempt has been made to analyze the values by varying the size of the footings for two grades of steel.

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II. Methodology

While designing the rigid foundation, approach has been followed. According to this approach it is assumed that the foundation is rigid enough to bridge the non-uniformities of the upward pressure acting from the soil. Hence it is assumed that the pressure acts uniformly throughout the soil. In this type of footing the differential settlements are relatively low but the BM and SF acting on the foundation is high. [3]

All the calculations for this paper are done by preparation of Excel sheets. The Excel sheets were prepared in accordance to the limit state method mentioned in IS code 456:2000.

The upward pressure is assumed to be equal to the Soil bearing Capacity (SBC) for carrying out the analysis in this paper.

Throughout the paper certain parameters like M20 grade of concrete, column dimension as 300*300mm and SBC as 600kN/mm^2 have been kept constant. Calculations are carried out by varying the size of footing and grade of steel.

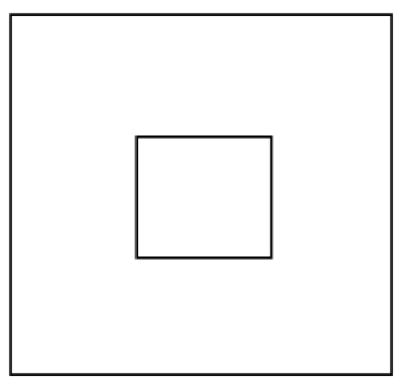

Figure 1: Isolated Pad Footing

a) Isolated Pad Footing

1. Depth Calculation

Depth is found out by performing the BM check, one-way shear check and two-way shear check. It is found that among the varying parameters, the depth of the footing is directly proportional to the size of the footing. Clear cover is taken as 50mm throughout the paper to avoid corrosion as per IS code 456:2000.

The BM for the critical section is located at the intersecting point of the column and the footing.

The minimum percentage of steel i.e. 0.12% for HYSD bars as per IS 456:2000 has been taken for calculation of depth for one-way shear. This process is carried out iteratively to ensure that design shear strength of concrete isgreater than or equal to nominal shear stress. For one way shear the critical section is located at a distance d (effective depth) from the face of the column as per IS code 456:2000.

The critical section for two-way shear is taken at distance .05 times the effective depth of the footing from the periphery of the column. The nominal value of two-way shear is equated to the Design value hence we attain the depth require. Two-way shear check is performed to ensure that the footing does not fail due to the punching action of the column.

Further the highest of the three values is taken as the effective depth for the footing. It is observed that for footings of size 1m to 1.5m, the depth obtained by one-way shear is taken as the effective depth of the footing while for footings of size greater than 1.5m the depth obtained from two-way shear check is governing for both the grades of steel.

2. Area of Steel Calculation

All the diameter values for steel are greater than or equal to 10mm and for stirrups they have been set to 8mm diameter or more. These values are taken to prevent corrosion of the bars. As the diameter of the bars decreases larger periphery of the bar is exposed to the atmosphere hence greater is the corrosion. Corrosion reduces the durability of the structure. The diameter of the bars is assumed by ensuring the minimum amount of steel required within the permissible limits.

The area of steel is carried out as per IS 456. This value is compared with the percentage of steel obtained after iteration from one-way shear. For all the sizes of footing the calculated are of steel is greater than minimum value. Hence the calculated value is taken as the area of steel for both the grades of steel.

The spacing is assumed to be the lesser of the value obtained by calculation, 3 times the effective depth value and 300.

For the calculation of development length (L_d) difference in the projected length of the footing is made with the value calculated by using the formula in IS 456:2000

3. Total Material required

Steel required is calculated by finding the number of bars and then multiplying it with the length and the weight per m of the bar.

Volume of concrete is obtained by finding the gross volume of concrete for the entire footing.

b) Beam Slab Isolated Square Footing

1. Depth calculation for Slab

The depth of the slab is calculated by taking half of the upward pressure while calculation of BM. This is done to ensure that the deflection occurring at the corners is equal for both length and breadth.

The deflection for cantilever slab is calculated by

$$\frac{WL_x^{\ 4}}{8EI} = \frac{WL_y^{\ 4}}{8EI} \qquad (1.1)$$

W is the uniformly distributed load acting on the cantilever slab (N/m)

L_x and L_y is the length of the cantilever slab in the x and y direction respectively (m)

E is the Young’s Modulus for the given beam

I is the modulus of Elasticity for the given beam

Here L_x is equal to L_y. Hence, the upward pressure is divided by 2.

The depth check is performed for BM and one-way shear alone. The continuous beam prevents the additional punching action from the column.

It has been observed that the depth of the slab is governed by the one-way shear check for both the grades of steel. Depth calculation for one-way shear for BSIF is carried out in the same way as IPF.

2. Depth calculation for Beam

The depth for beam is calculated by carrying out BM check. The entire load from the slab is transferred to the beam while calculating the BM for the beam. The load is assumed to be distributed uniformly over the beam. Load from one slab is assumed to be distributed evenly on two beams.

3. Area of Steel Calculation

The area calculation for slab and the beam is carried out in the same manner as the IPF. In BSIF main reinforcement for the slab is provided in one direction. For the other direction, only minimum reinforcement is provided. This is done as a part of the tension is taken care by the insertion of beams in the BSIF.

Shear check has been performed for the beam and 8mm diameter 2 legged stirrups have been provided.

The diameter of the bar, spacing and the development Length (L_d) value for the slab is calculated in the same way as mentioned for the IPF.

4. Total Material required

The total amount of material required for the slab is calculated in the same way as the IPF.

For beam the volume of concrete is added for the extra depth of the beam. For main reinforcement, the steel required is calculated by adding the weight required in stirrups to the length times the no of bars in the beam.

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III. Results and Discussion

a) Steel Quantity

In graph 1, as the size of footing increases the percentage reduction in the steel requirement for BSIF increases in comparison to the IPF for both Fe415 and Fe 500. The values for the steel requirement have been given in the table above.

This phenomenon is attributed to the provision of main reinforcement in both the direction for the IPF. While designing slab for the BSIF, main reinforcement is provided only in one direction with distribution bars in the other direction. This is done as the tension in the foundation is kept in check by the beam reinforcement.

It is observed that the percentage reduction in steel for BSIF in comparison to IPF is more for Fe 415 than for Fe 500. The graph is in congruence with the IS 456, which states that the area of steel calculated is inversely proportional to the strength of steel.

From table 1, it can be noted that the steel required for smaller size of BSIF is more than that required for IPF. This trend seems to reverse for footings of larger dimension.

Table 1: Steel Requirement

Side (m)	Fe 415			Fe 500		
	IPF	BSIF	% Reduction	IPF	BSIF	% Reduction
1	12.2	16	-31.1	12.4	15.8	-27.4
1.5	34.5	49.6	-43.8	30	43.3	-44.3
2	91.1	113.4	-24.5	72.6	97.6	-34.4
2.5	174.7	212.9	-21.9	145	183.3	-26.4
3	314.7	354.1	-12.5	257.5	306.5	-19
3.5	504.4	552.2	-9.5	415	472.2	-13.8
4	751	801.1	-6.7	630	689.3	-9.4
4.5	1085.1	1128.4	-4	888.9	977.7	-10
5	1522.6	1518.7	0.3	1226.8	1309.6	-6.7
5.5	2079.6	1984.4	4.6	1704.6	1727.8	-1.4
6	2677.2	2550.6	4.7	2182.5	2205.6	-1.1

All Values are in kg

b) Concrete Quantity

In graph 2, it is observed that with the increase in the size of the footing, the difference in the percentage reduction of the required concrete in BSIF increases in comparison to IPF. The values for the concrete requirement and the percentage reduction have been given in the table above. From the table it can be observed that the volume of concrete required for BSIF is less than that required for IPF. The decrease in the depth of the slab for BSISF in comparison to IPF is the reason for the observed trend. For BSIF the load is transferred to the beams from the slabs hence reducing the depth of the footing.

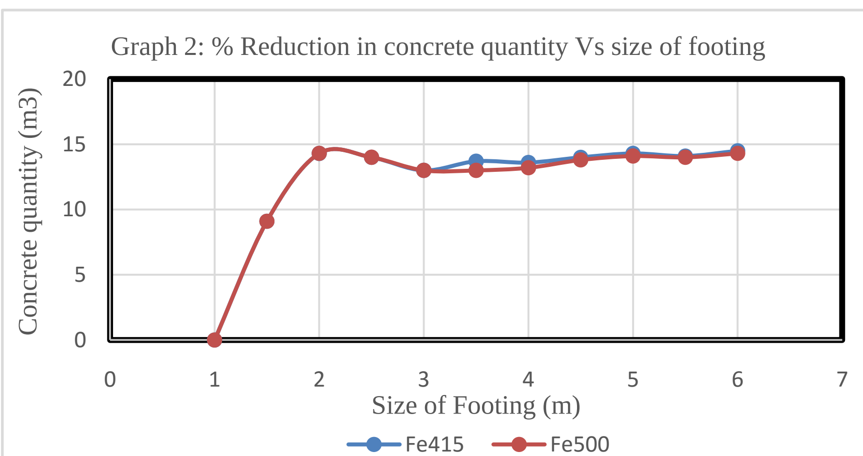
A sudden increase in the percentage reduction of concrete in BSIF in comparison to IPF for footing of length 1m to 1.5m length is observed. This sudden increase is due to the provision of minimum depth for the footing (150mm). The depth calculated is less than. 15mm hence in both the cases the concrete required is same for 1m footing.

The depth value for BM varies with the strength of steel. This accredits to the fact that the depth calculated by BM is inversely proportional to x_{umax}/d value, which is inversely proportional to the strength of steel as per the IS 456, where d is the effective depth of the footing and x_{umax} is the maximum depth of the numeral axis. When the depth attained by the BM governs the calculation, there is a deviation between the graph for the two steel values.

Table 2: Concrete Requirement

Side (m)	Fe 415			Fe 500		
	IPF	BSIF	% Reduction	IPF	BSIF	% Reduction
1	0.3	0.3	0	0.3	0.3	0
1.5	1.1	1	9.1	1.1	1	9.1
2	2.8	2.4	14.3	2.8	2.4	14.3
2.5	5.7	4.9	14	5.7	4.9	14
3	10	8.7	13	10	8.7	13
3.5	16.1	13.9	13.7	16.1	14	13
4	24.3	21	13.6	24.3	21.1	13.2
4.5	34.9	30	14	34.9	30.1	13.8
5	48.3	41.4	14.3	48.3	41.5	14.1
5.5	64.4	55.3	14.1	64.4	55.4	14
6	84.1	71.9	14.5	84.1	72.1	14.3

All Values are in m



c) *Weight by Volume Ratio*

In graph 3, it is observed that with the increase in the size of the footing the percentage reduction in the weight by volume ratio for the BSIF in comparison follows a similar trend like the percentage reduction for the steel. This is ascribed to the fact that the percentage reduction in the steel is minimal in comparison to the percentage reduction in the concrete.

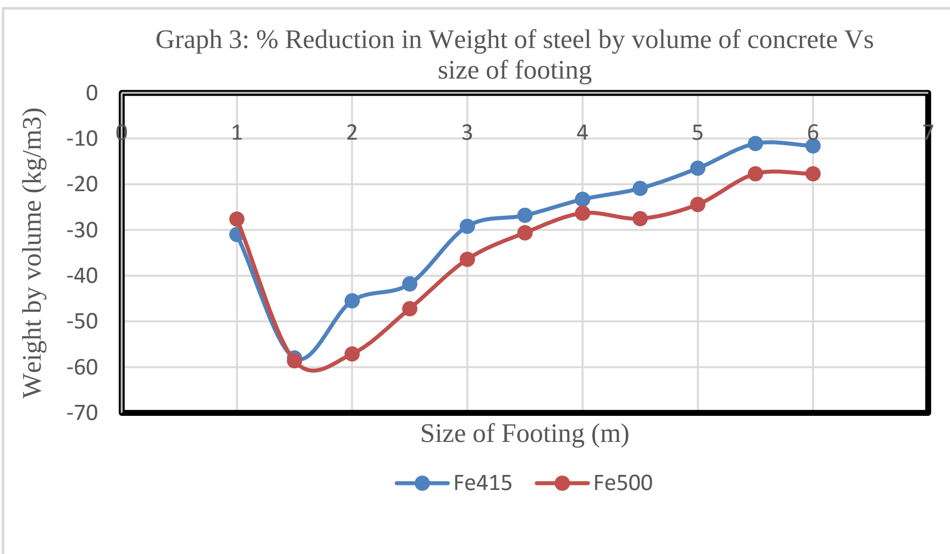
The table indicates that more weight by volume for IPF is less than that for BFIS, which indicates that less steel in kg is required per m^3 of concrete.

For Fe415 the percentage reduction in the weight by volume ratio is more than that observed in Fe500. This is because the percentage reduction in steel is much greater in Fe 415 in comparison to Fe500 whereas the difference in percentage reduction in concrete for the two steel values is negligible.

The percentage reduction of weight by volume decreases sharply from footing of size 1m to 1.5m and then increases. The abrupt fall in the percentage reduction is due to the sudden decrease in the concrete quantity for BSIF for footing of size 1.5m from footing of size 1m.

Table 3: Weight By Volume

Side (m)	Fe 415			Fe 500		
	IPF	BSIF	% Reduction	IPF	BSIF	% Reduction
1	40.7	53.3	-31	41.3	52.7	-27.6
1.5	31.4	49.6	-58	27.3	43.3	-58.6
2	32.5	47.3	-45.5	25.9	40.7	-57.1
2.5	30.6	43.4	-41.8	25.4	37.4	-47.2
3	31.5	40.7	-29.2	25.8	35.2	-36.4
3.5	31.3	39.7	-26.8	25.8	33.7	-30.6
4	30.9	38.1	-23.3	25.9	32.7	-26.3
4.5	31.1	37.6	-20.9	25.5	32.5	-27.5
5	31.5	36.7	-16.5	25.4	31.6	-24.4
5.5	32.3	35.9	-11.1	26.5	31.2	-17.7
6	31.8	35.5	-11.6	26	30.6	-17.7



All values are in Kg/m^3

IV. Conclusion

From the analysis performed on different graphs the following inferences can be drawn

1. For BSIF in comparison to IPF, as the size of footing increases from 1m to 6m the percentage reduction in steel increases from -31.1% to 4.7% for F1415 and -17.4% to -1.1% for Fe500.
2. For BSIF in comparison to IPF, as the size of footing increase from 1m to 6m the percentage reduction in concrete increases from 0% to 14.5% for Fe415 and 0% to 14.3% for Fe500.
3. For BSIF in comparison to IPF, as the size of footing increases from 1m to 6m the percentage reduction in weight by volume increases from -31% to -11.6% for F1415 and -27.6% to -17.7% for Fe500
4. It is safe to conclude that BSIF can be designed for footings of larger size with lower steel strength to reduce the material required. This conclusion is made taking size of the columns as 300mm, M15 grade of concrete and SBC of 600MPa.

Further research should be carried out on cost incurred for the skill labor and various other parameters like soil medium, column dimension while designing.

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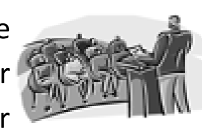

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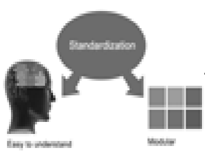

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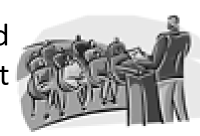

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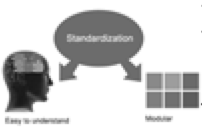

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

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Note :

"

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- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

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2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

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Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

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References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Informal Guidelines of Research Paper Writing

Key points to remember:

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

Final Points:

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

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

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

General style:

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

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

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

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

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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

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

Title Page:

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

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

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

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

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

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

Methods:

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

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

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

Results:

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

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

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

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

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

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

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- Do not give permission to anyone else to "PROOFREAD" your manuscript.

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

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

Index

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