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UNCONFINED COMPRESSIVE STRENGTH TEST OF A FLY ASH STABILIZED SANDY SOIL

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Abstract: This study deals with the stabilization of sandy soils through the application of fly ash. Soil stabilization simply means the permanent physical and chemical alteration of soils to enhance their physical and engineering properties.
The main aim of this study is to determine the percentage of fly ash that would be added to a sandy soil to obtain the optimum stability of the soil. In order to achieve these, the following tests were carried out: Sieve analysis, Compaction test, unconfined compressive strength test.
Sieve analysis is carried out purposely to determine the percentage of different grain sizes contained within a sandy soil. On the other hand, Compaction test was carried out in order to determine the maximum dry density and optimum moisture content of the sandy soil and lastly, unconfined compressive strength test was carried out to determine the compressive strength of the sandy soil sample with the addition of fly ash in percentages as a stabilizing agent.
After carrying out the above tests, observations were noted and considered and it was discovered that 40% fly ash has the highest impact in the increment of the compressive strength of the sandy soil and will be most suitable for the stabilization of sandy soil. So therefore, we recommend the addition of 40% fly ash to the sandy soil to be used on site for maximum stability

Key words: Unconfined Compressive Strength and Fly-Ash

Introduction

Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties and stabilization can also be the application of a chemical or mechanical treatment of a mass of soil to maintain its stability or improve its engineering properties (Coka, 2001). Stabilization increases the shear strength of soil thus, improving the load-bearing capacity of a sub-grade to support pavements and foundations. Stabilization can be used to treat a wide range of sub-grade materials from clay to granular materials. Stabilization can be achieved with a variety of chemical additives including lime, fly ash, and Portland cement, as well as by-products such as Lime-Kiln Dust (LKD) and Cement-Kiln Dust (CKD). It can also be achieved by injecting cementing materials or chemical solutions into the ground and also by applying electric currents to the ground. Proper design and testing is an important component of any stabilization project, this allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used to achieve the desired engineering properties (Gantenbein, 2002).

Benefits of the stabilization process can include: Higher resistance (R) values of the soil, reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation – material hauling/handling – and base importation, aids compaction, provides “all-weather” access onto and within projects sites(White, 2002a&2002b).

On the other hand, one very important property of a soil is its compressive strength, which is the soil’s ability to withstand axial forces. The compressive strength of a soil is very important in nearly all geotechnical engineering designs because it is used in obtaining an estimate of the soil strength. The main aim of this study is to determine the percentage of fly ash that would be added to a sandy soil to obtain the optimum stability of the soil.

Sandy Soil

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz (Hunter, 1998).

Fly Ash

Fly ash, also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal (Zia and Fox 2000).

Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the furnace is in this case jointly known as ***coal ash***. Depending upon the source and makeup of the coal being burned, the component of fly ash vary considerably, but all fly ash includes substantial amount of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredient in many coal-bearing rock strata(Naibantoglu and Gucbilmez 2002).

Toxic constituent depend upon the specific coal bed makeup, but may include one or more of the following elements or substances in quantities from trace amounts to several percent: arsenic, beryllium, boron, cadmium, chromium, hexavalent chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium and vanadium, along with dioxins and PAH compounds.

In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used to supplement Portland cement in concrete production. Some have expressed health concerns about this.

In some cases, such as the burning of the solid waste to create electricity, the fly ash may contain higher levels of contaminants than the bottom ash and mixing the fly and bottom ash together brings the proportional levels of contaminants within the range to qualify as non-hazardous waste in a given state, whereas, unmixed, the fly ash would be within the range to qualify as hazardous waste (Rupnow 2002).

Chemical composition

Fly Ash is also a pozzolanic material, consisting of non – crystalline silicate and aluminates particles and rounded magnetic iron oxide (Fe_3O_4) grains, materials which when mixed with other chemicals like cement or lime containing calcium and in the presence of water can enhance cementation. Fly Ash possesses a wide quality range and this may be problematic.

Soil stabilization with fly ash

Soil stabilization is a technique aimed at increasing or maintaining the stability of soil mass and chemical alteration of soils to enhance their engineering properties. Stabilities can be used to treat a wide range of sub-grade materials from expansive clays to granular materials. This allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used in order to achieve the desire engineering properties (Senol et al. 2002). Benefits of the stabilization process can include higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation material hauling or handling. Stabilization of expansive soils with admixture controls the potential of soil for a change in volume, and improves the strength of soils. In the field of geotechnical engineering, it has long been known that swelling of expansive soils caused by moisture change result in significant distresses and hence in severe damage to overlying structures. Expansive soils are known as shrink swell or swelling soils. Different clays have different susceptibility to swelling. Such soils expand when they are wetted and shrink when dried. This movement exerts pressure to crack sidewalks, basement floors, pipelines and foundations (Kaniraj and Havanagi 1999).

The density of soil with coal ashes is an important parameter since it controls the strength, compressibility and permeability. The compacted unit weight of the material depends on the amount and method of energy application, grain size distribution, plasticity characteristics and moisture content at compaction. The variation of dry density with moisture content for fly ashes is less compared to that for a well-graded soil, both having the same grain size (Mahrt 2000). The tendency for fly ash to be less sensitive to variation in moisture content than for soil is due to higher air void content of fly ash. The higher void content could tend to limit the buildup of pores pressure during compaction, thus allowing the fly ash to be compacted over a larger range of water content.

Materials and Methods

Materials

These were the basic materials used for this study (i) sandy soil (ii) class C fly ash (iii) water

Laboratory tests employed

Sieve Analysis

Sieve analysis, also known as gradation test, is a practice used in civil engineering to assess the particles size distribution of a granular material. The dependence of the behaviour of a soil mass on the size of particles had led investigators to classify soils according to their particles size.

Compaction Test

The purpose of carryout this test is to determine the maximum dry density and optimum moisture content of each sample so as to enable us calculate the constant mass of sand and constant volume of water needed for compaction. The test is classified into viz-a-viz;

i. Dynamic compaction test.
ii. Static compaction test

Unconfined compressive strength (UCS) Test

The primary purpose of this test was to determine the unconfined compressive strength of a sandy soil sample with the addition of fly ash in percentage as a stabilizing agent. According to the ASTM standard, the unconfined compressive strength (q_u) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. In addition, in this test method, the unconfined compressive strength is taken as the maximum load attained per unit area, or the load per unit area at 15% axial strain, whichever occurs first during the performance of test.

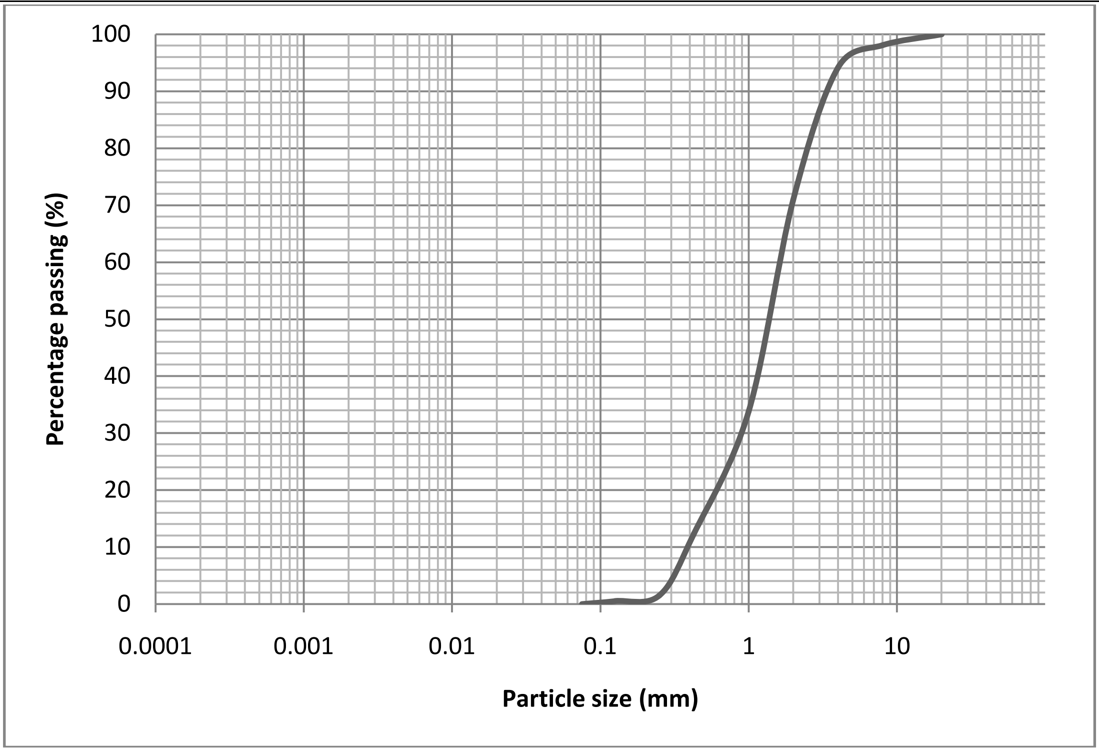
Results

Particle Size determination results

The particle size analysis was carried out majorly to classify the sample used for this study. The result shown clearly that the sample contains no clayey and silty content. Sample comprises of fine, medium and coarse sand and also fine and medium gravel.(Table 1and Figure 1)

Table 1 the sieve analysis of the sandy soil sample

Sieve Sizes (mm)	**Weight of Empty sieve (g)**	**Weight of sieve + sample (g)**	**Mass Retained (g)**	**Percentage Retained (%)**	**Cumm. Percentage Retained (%)**	**Percentage Passing (%)**
20.000	471.0	471.0				100
8.000	462.0	462.0				100
4.000	437.0	441.0	4	1.96	1.96	98.04
2.000	411.0	419.0	8	3.92	5.88	94.12
1.000	386.0	415.0	29	14.22	20.10	79.90
0.425	442.0	536.0	94	46.08	66.18	33.82
0.250	314.0	358.0	44	21.57	87.75	12.25
0.125	296.0	318.0	22	10.78	98.53	1.47
0.075	381.0	383.0	2	0.98	99.51	0.49
< 0.075			1	0.49	100	0.00



Fugure1 Graph of Sieve analysis of the sandy soil sample

Dynamic Compaction results

Figures 2-7 show the results for 0%, 10%, 20%, 30%, 40%, 50% addition of fly ash to the sandy soil sample under dynamic compaction. The dynamic compaction test was use to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) by adding water to the sample (i.e. sand mixed with fly ash) at percentage intervals. From Figures 2-7 OMC and MDD for each percentage of fly ash was determined.

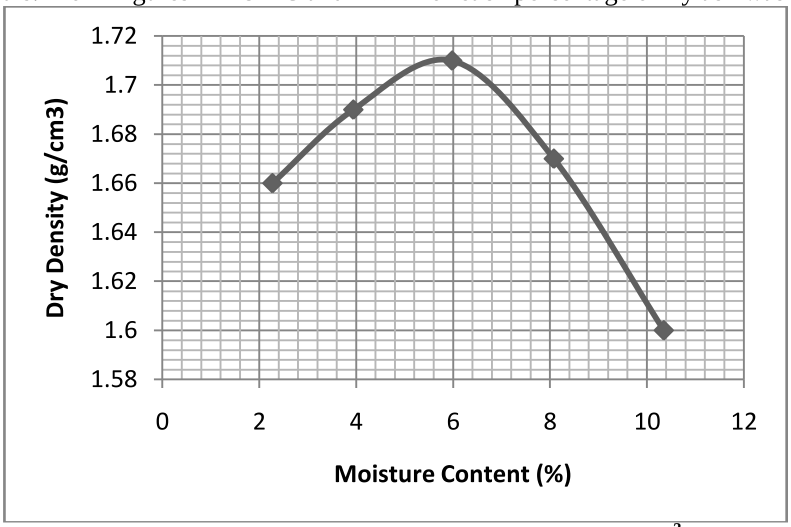


Figure 2 Graph of DD against MC for 0% fly ash ***MDD= 1.71g/cm^3 OMC= 5.98%***

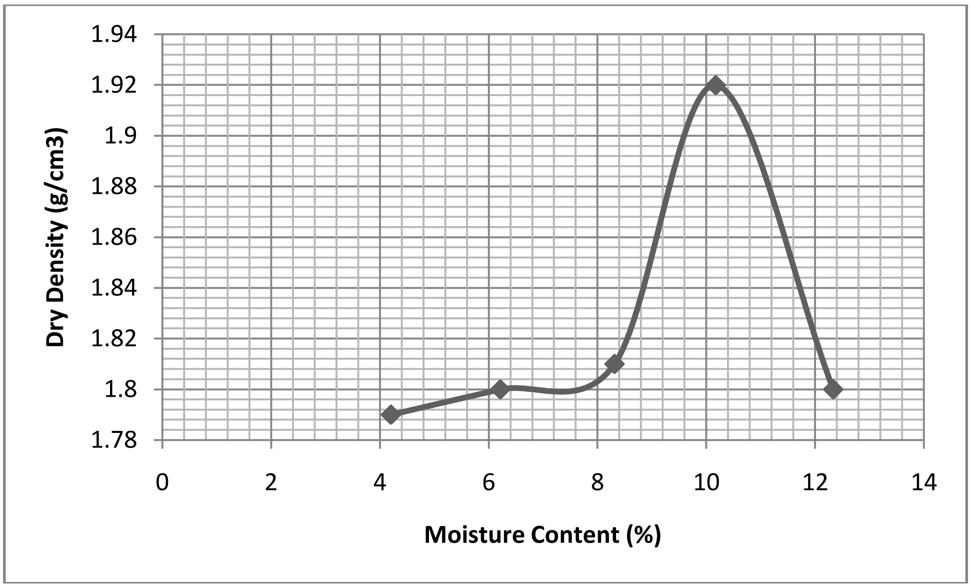


Figure 3 Graph of DD against MC for 10% fly ash
MDD= 1.92g/cm^3
OMC= 10.17%

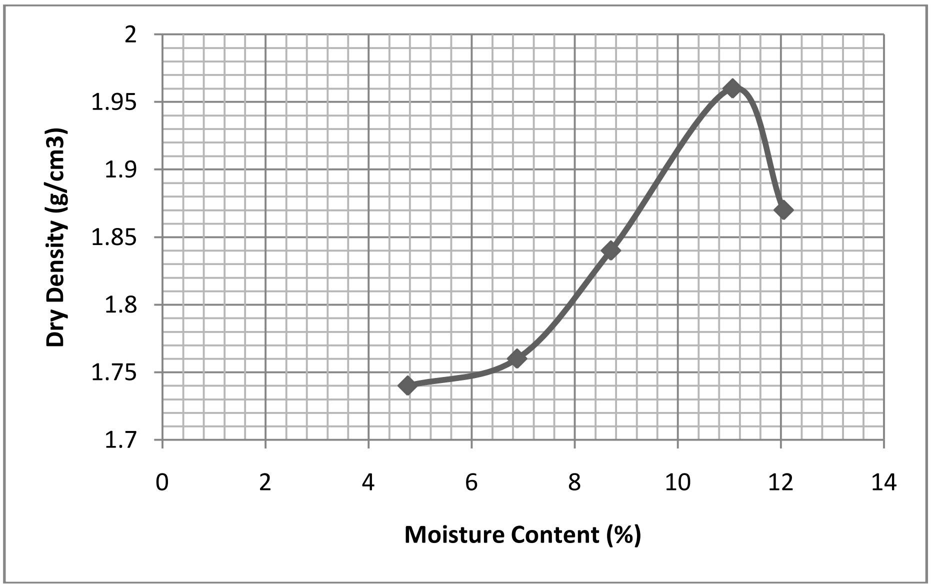


Figure 4 Graph of DD against MC for 20% fly ash
MDD= 1.96g/cm^3
OMC= 11.06%

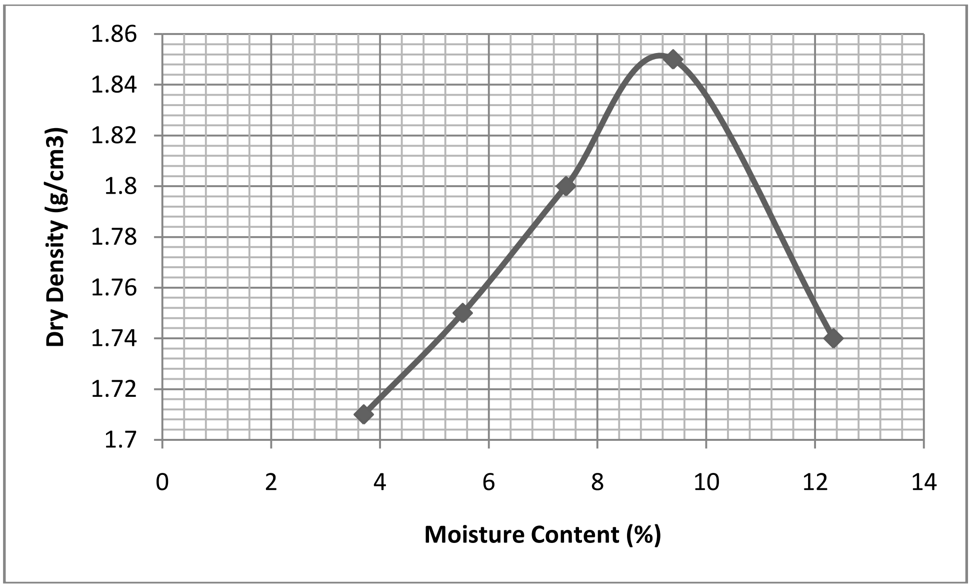


Figure 5 Graph of DD against MC for 30% fly ash
MDD= 1.85g/cm^3
OMC= 9.39%

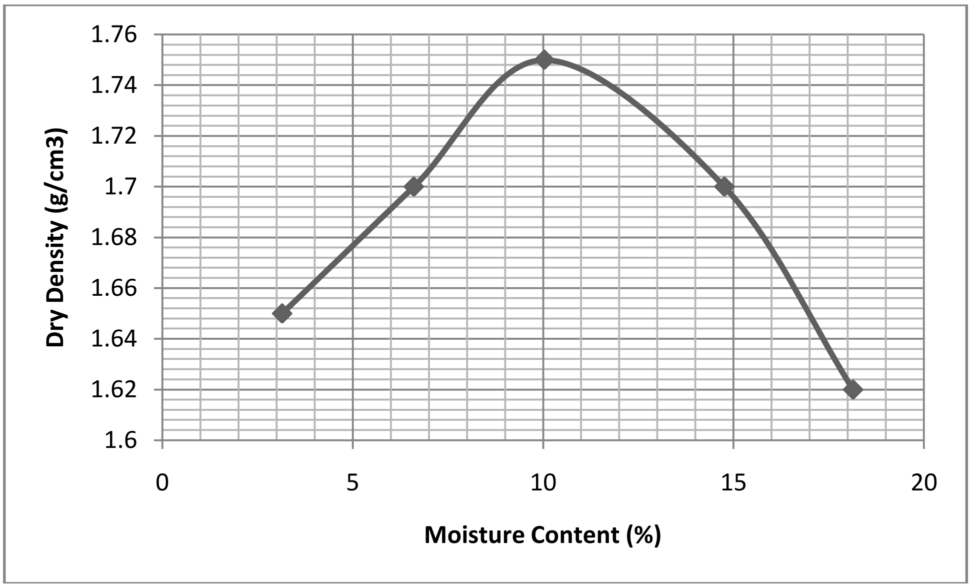


Figure 6 Graph of DD against MC for 40% fly ash
MDD= 1.75g/cm^3
OMC= 10.03%

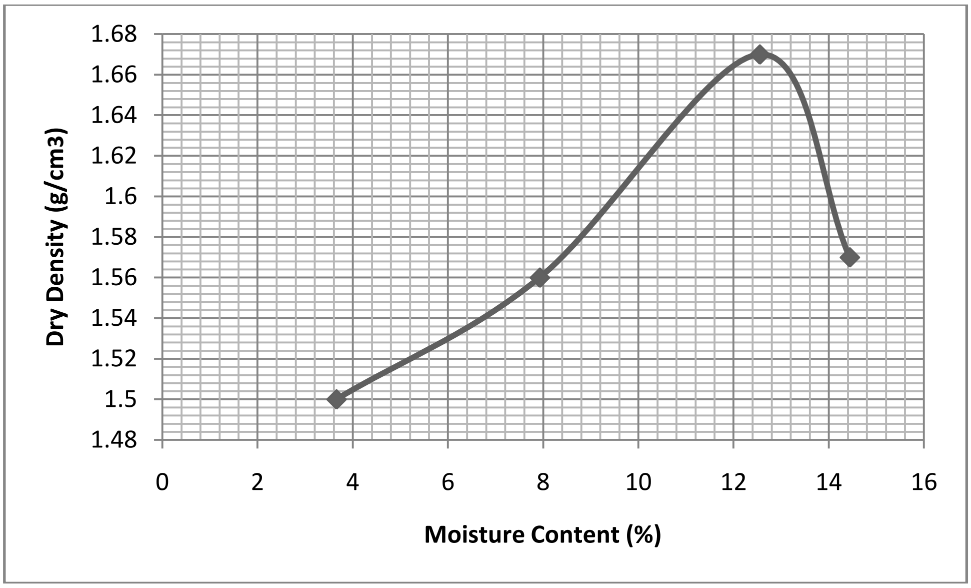


Figure 7 Graph of DD against MC for 50% fly ash

MDD= 1.67g/cm^3

OMC=12.55

Static Compaction results

i. ***For 0% addition of fly ash, the result obtained is:***
Mass of Bulk soil for recompaction (M_b) = 1676.0g
Volume of water for the bulk soil (W_v) = 69ml

ii. ***For 10% addition of fly ash, the result obtained is:***
Mass of Bulk soil for recompaction (M_b) = 1892g
Volume of water for the bulk soil (W_v) = 156ml

iii. ***For 20% addition of fly ash, the result obtained is:***
Mass of Bulk soil for recompaction (M_b) = 1970g
Volume of water for the bulk soil (W_v) = 180ml

iv. ***For 30% addition of fly ash, the result obtained is:***
Mass of Bulk soil for recompaction (M_b) = 1825g
Volume of water for the bulk soil (W_v) = 136ml

v. ***For 40% addition of fly ash, the result obtained is:***
Mass of Bulk soil for recompaction (M_b) = 1725g
Volume of water for the bulk soil (W_v) = 140ml

vi. ***For 50% addition of fly ash, the result obtained is:***
Mass of Bulk soil for recompaction (M_b) = 1646g
Volume of water for the bulk soil (W_v) = 175ml

The result from each dynamic compaction test (i.e. OMC and MDD) is used to calculate the constant mass of soil that is to be used in recompaction with a constant volume of water (i.e. static compaction). For instance, with 10% addition of fly ash, 10% will be removed from the mass of bulk sand and replaced with fly ash and then recompact. This however is the same for 20%, 30%, 40% and 50%.

Unconfined Compressive Strength results

From the static compaction results, recompaction of each percentage addition of fly ash to the sandy sample was done. While the recompacted sample was placed in UCS machine and firmly gripped, the dial-strain gauge was rotated at 5mm interval while corresponding reading was notably taken from the load gauge. The readings were taken until the sample began to fail. At the point of failure, readings were stopped being taken. Results were eventually obtained and graphs of axial load were plotted against axial strain, after which the compressive strength of each recompacted sample (i.e. 10%, 20% etc.) was determined. Figures 8-12 show for each percentage.

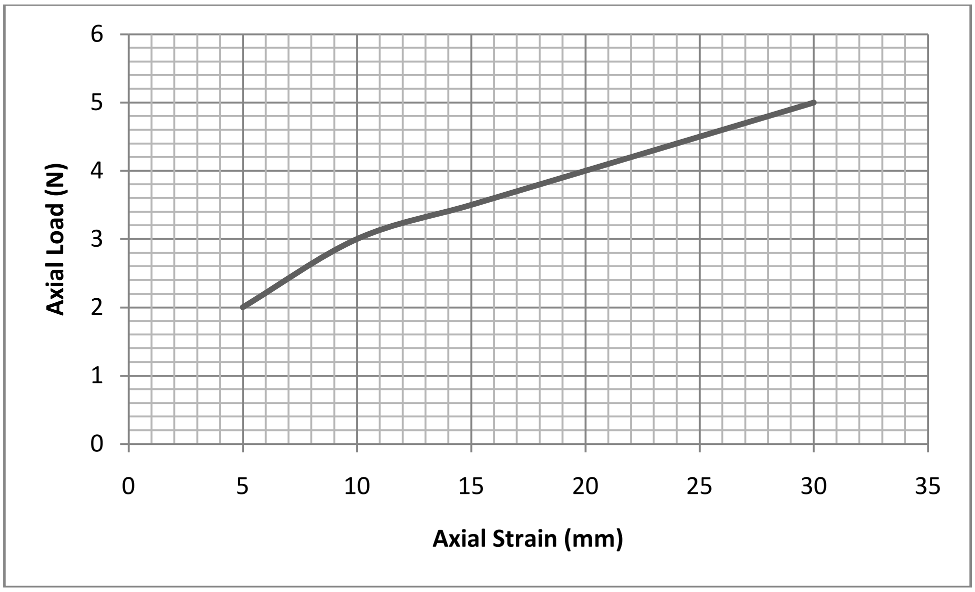


Figure 8 Graph of Axial Load against Axial Strain for 10% fly ash

Compressive Strength (q_u) = 8.80kN/m²

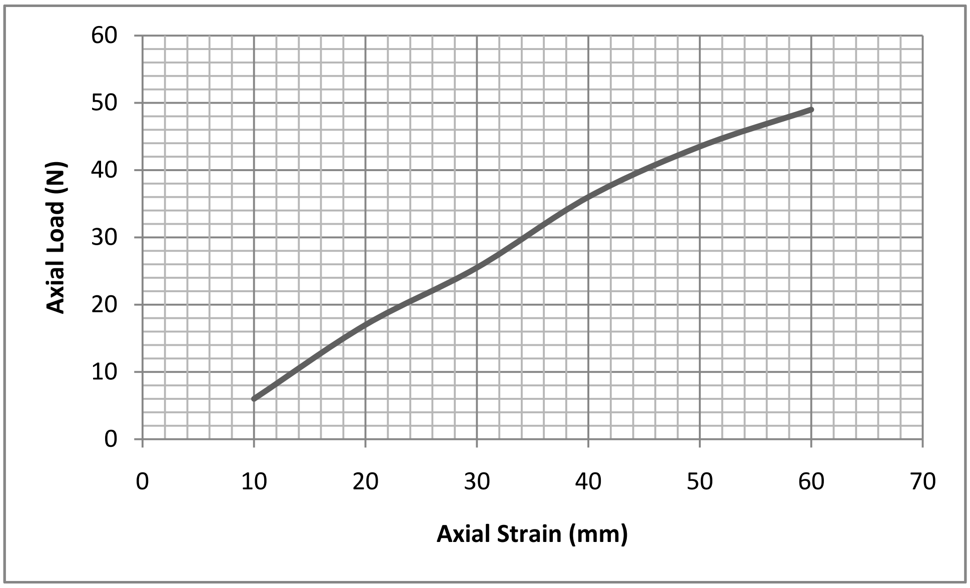


Figure 9 Graph of Axial Load against Axial Strain for 20% fly ash

Compressive Strength (q_u) = 86.1kN/m²

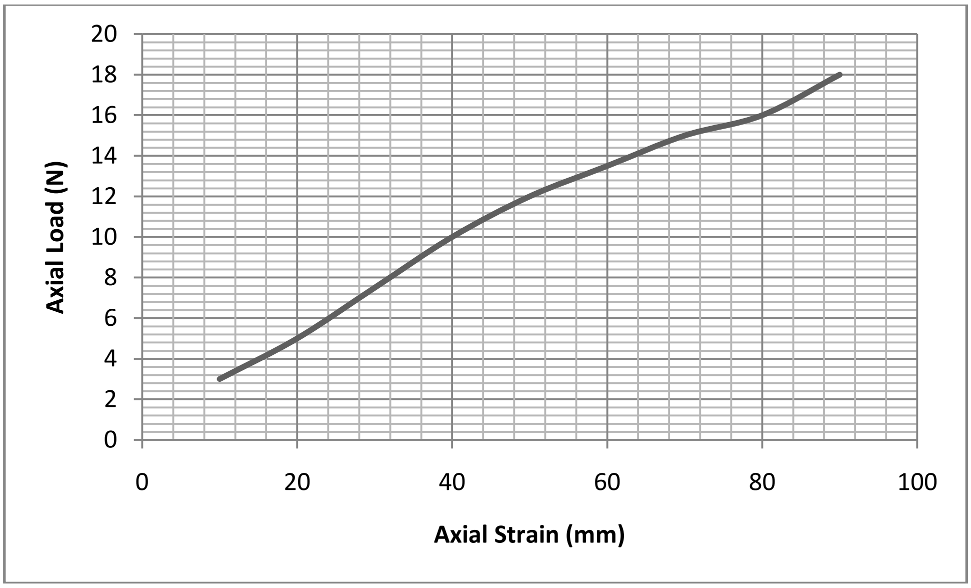


Figure 10 Graph of Axial Load against Axial Strain for 30% fly ash

Compressive Strength (q_u) = 31.51kN/m^2

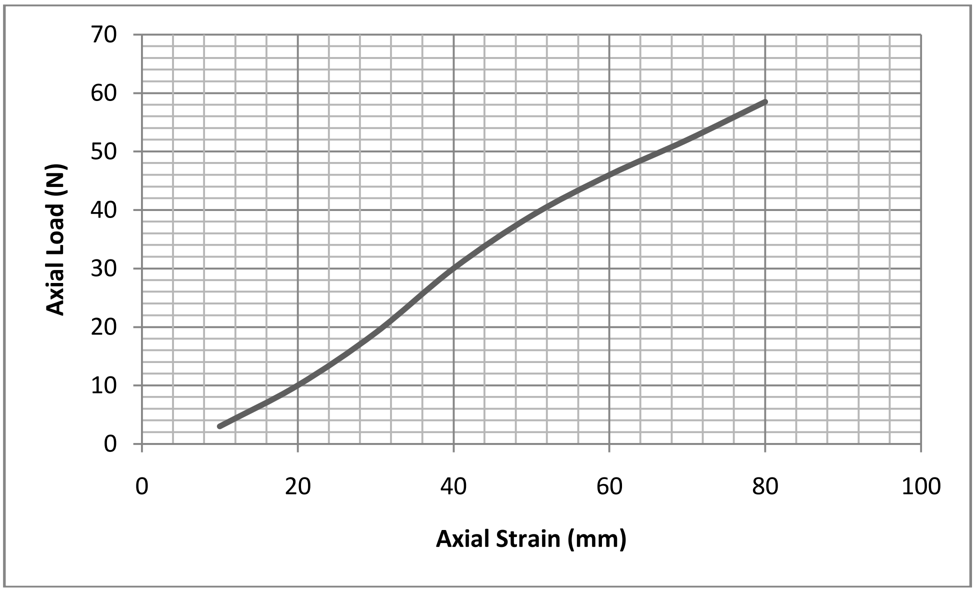


Figure 11 Graph of Axial Load against Axial Strain for 40% fly ash

Compressive Strength (q_u) = 102.51kN/m^2

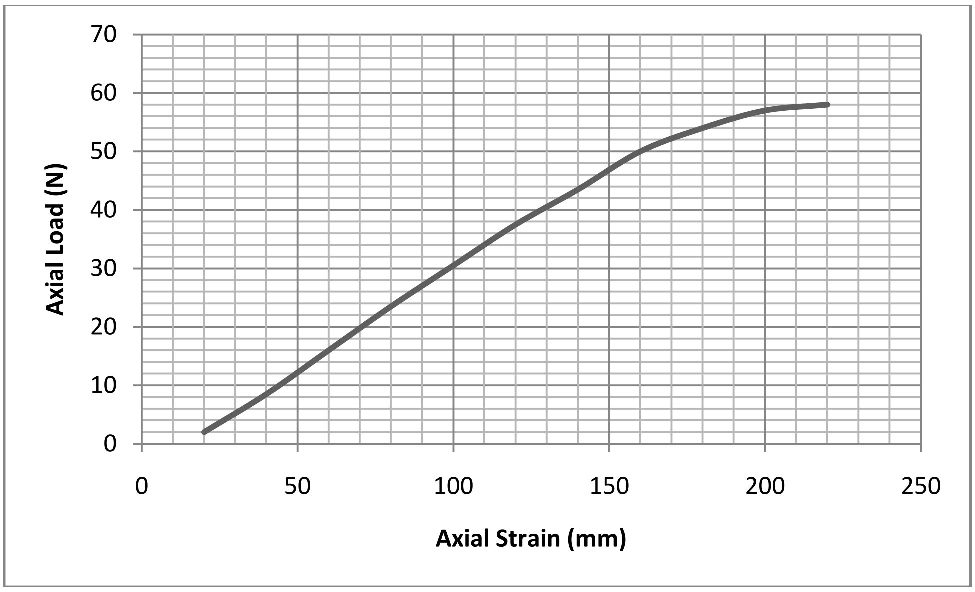


Figure 12 Graph of Axial Load against Axial Strain for 50% fly ash

Compressive Strength (q_u) = 100.35kN/m^2

The summary of compressive strength results from UCS for 0% fly ash is 0 kN/m^2 as shown in Figure 13 of which the effect of fly ash is clearly seen as it increases to 8.80 kN/m^2 with 10% addition to the sand. It increased further with 20% addition of fly ash to 86.1kN/m^2. For 30% addition of fly ash, the compressive strength reduced to 31.51kN/m^2. For 40% addition of fly ash, the compressive strength greatly increased to 102.51kN/m^2. For 50% addition of fly ash, the compressive strength slightly reduced to 100.35kN/m^2.

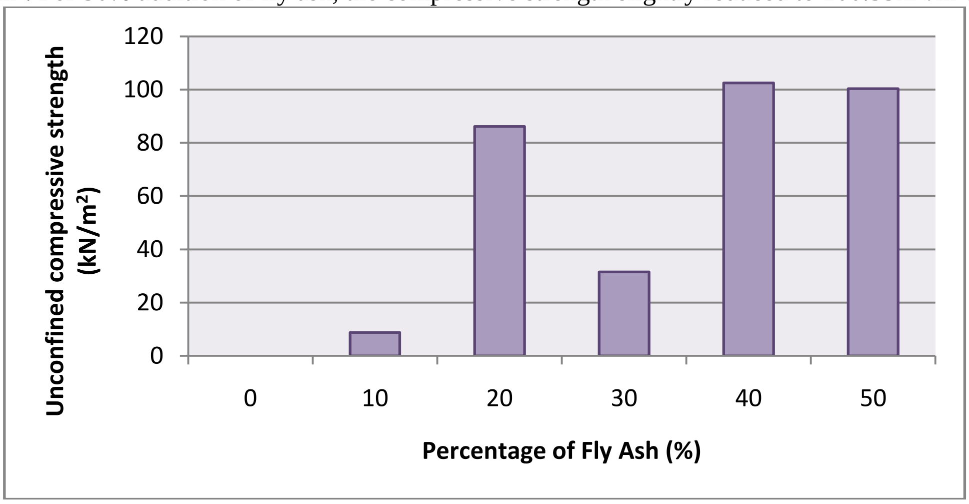


Figure 13 Bar chart reflecting the percentage of fly ash with corresponding compressive strength

Conclusion

In conclusion it was established that 40% of fly ash would perfectly stabilize sandy soil due to its highest compressive strength (i.e. 102.51kN/m^2).

REFERENCES

[1]. **Çokça, E. (2001).** "Use of Class C fly ashes for the stabilization of an expansive soil." *Journal of Geotechnical and Geoenvironmental Engineering*, 127(7), 568-273.

[2]. **Gantenbein, B. (2002).** "Pilot program: Fly ash stabilization used as alternative to subgrade stabilization in Waukesha County." *Western Builder, March 7, 2002*, Reed Construction Data Circulation, Norcross, GA.

[3]. **Hunter, D. (1998).** "Lime-induced heave in sulfate bearing clay soils." *Journal of Geotechnical Engineering*, 114(2), 150-167.

[4]. **Kaniraj S R, Havanagi V.G (1999)** Geo technical characteristics of fly- ash soil mixtures. Geo technical Engineering journal,30 (2):129-147.

[5]. **Mahrt, D.B. (2000).** "Reclaimed class c Iowa fly ash as a select fill material: hydraulic conductivity and field testing of strength parameters." MSci thesis, Iowa State University, Ames, IA.

[6]. **Nalbantoglu, Z. and Gucbilmez, E. (2002).** "Utilization of an industrial waste in calcareous expansive clay stabilization." *Geotechnical Testing Journal*, 25(1), 78-84.

[7]. **Rupnow, T.D., (2002).** "Subgrade stabilization using recycled asphalt pavement and fly ash mixtures." *Transportation Scholars Conference Compendium of Student Papers*, Midwest Transportation Consortium, Iowa State University, Ames, IA..

[8]. **□enol, A., Bin-Shahafique, Md.S., Ed□l, T.B., and Benson, C.H. (2002).** "Use of class c fly ash for stabilization of soft subgrade." *Procedures, Fifth International Congress on Advances in Civil Engineering*, Istanbul, Turkey.

[9]. **White, D. J. (2002a).** "Reclaimed hydrated fly ash as select fill under pcc pavement Wapello County demonstration project – Field Performance." *ISU-ERI-Ames Report 01176*, Engineering Research Institute, Iowa State University, Ames, IA.

[10]. **White, D.J. (2002b).** "Sutherland generating station and Ottumwa-Midland landfill access roads – Field performance." *ISU-ERI-Ames Report 01060*, Engineering Research Institute, Iowa State University, Ames, IA.

[11]. **Zia, N. and Fox, P. J. (2000).** "Engineering properties of loess-fly ash mixtures for road bases." *Transportation Research Record 1717*, Transportation Research Board, 49-56.

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Computer Simulation of EPR Orthorhombic Jahn-Teller Spectra of Cu^{2+}in $Cd_2(NH_4)_2(SO_4)_3$ Single Crystals at Low Magnetic Field Direction (M=-3/2) at Different Temperatures

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Abstract: In this paper, we have carried out computer simulation of Cu^{2+}:$Cd_2(NH_4)_2(SO_4)_3$ in the low magnetic field corresponding to x-direction and M=-3/2 at different temperatures. The normalized intensity decreases with temperature showing a phase transition temperature of about 195 K. The least squares method yields the intensity-temperature relation $I_N = -0.0466T + 10.482$ with correlation coefficient of R^2=0.9789. The activation energy varies withtemperature in a similar pattern as intensity but has lower values than those obtained from intensity and linewidths studies in all directions. The resonance field and linewidths depend on temperature in the form of sum of polynomials and exponential terms confirming earlier findings (Yerimaand De, 2014; De, 1986).
Keywords: Computer simulation, temperature, intensity, activation energy

Introduction

The Langbeinite family of complexes with general chemical formula $(X^{+})_2(Y^{2+})_2(SO_4)_3$ was discovered by Jona and Pepinsky (1956) where X^{+} is ammonia or monovalent metal and Y^{2+} is a divalent metal. Babu et al (1984) stated that a host of authors have carried out a number of investigations on the microscopic properties of the langbeinite family of crystals. The complex cadmium ammonium sulphate, $Cd_2(NH_4)_2(SO_4)_3$ abbreviated as CAS is isomorphous to potassium magnesium sulphate, $K_2Mg_2(SO_4)_3$ abbreviated as PMS and both are members of the langbeinite family of crystals. The explicit x-ray data on the atomic positions in CAS does not seem to be available in the literature but that of PMS have been reported by Zemann and Zemann (Babu*et al*, 1984). In addition, they stated that some authors have shown that the langbeinite family of complexes in cubic space group $P_{2/3}$ with a=10.35 $\dot{A}$ have four molecules per unit cell. The structure consists of a group of $(SO_4)^{2-}$ tetrahedral and Cd^{2+} metal ions. There are two each crystallographically non-equivalent Cd^{2+} and $(NH_4)^{+}$sites. Each Cd^{2+} is surrounded by six oxygen atoms which form a slightly distorted octahedron. Yerima (2005, 2007) stated that EPR studies of Misra and Korezak in 1986 using Mn^{2+} as a probe revealed a phase transition at 94.5 K whose mechanism was attributed to the freezing out of the rotation of the $(SO_4)^{2-}$ ion. In addition, he stated that EPR studies of Mouli and Sastry in 1962 using Cu^{2+} probe at room temperature and 77 K yielded eight poorly resolved hyperfine lines in a general direction and a set of four unresolved hyperfine lines in any crystallographic plane. Their computed values of the g-factor showed that $g_{//}>g_{\perp}$ and that the A_{max} is falling along g_{min}. They concluded that Cu^{2+} ions in this system may be in a compressed octahedral position or entered into the system interstitially rather than substitutionally. The shortcomings of the study of Mouli and Sastry include its limitation to 77 K and its failure to focus on JT effect that could be associated with Cu^{2+} in this crystal as earlier hinted by Babu et al in 1984. Raman spectroscopy performed by Rabkin*et al* (1981) provided substantial information on the structural phase transition in this crystal. They observed that CAS exhibits a structural phase transition on lowering the temperature from space group $p_{2/3}$ to p_{21} at about 95 K, the lower the temperature phase being ferroelectric. Babu et al (1984) in their summary stated that Bhat*et al* (1973) EPR spectra of Mn^{2+} in the two phase groups of CAS observed at room temperature and at liquid nitrogen were slightly different, particularly in the magnitudes of their zero-field splitting, as a result of small orthorhombic component in the low temperature phase. The differences in the spectra indicated a phase transition from high temperature phase $p_{2/3}$ to a low temperature phase p_{21}. In another outlook, Yerima (2005) stated that Ng and Calvo in 1975 observed in their EPR studies using Mn^{2+} in the temperature range 300-77 K observed definite change in the spectral pattern from that of room temperature to that of liquid nitrogen temperature due to a phase transition from $p_{2/3}$ to a space group of lower symmetry at low temperature. They did not analyze the spectra nor determine the phase transition temperature due to the complexity of the spectra at liquid nitrogen temperature.

The study of phase transition in CAS using VO^{2-} as a probe in the temperature range of 573-77 K showed a complex spectrum, in which Babu et al (1984) were unable to identify the phase transition temperature and they suggested that the lower temperature phase stabilizes at temperatures higher than 95 K. This was due to a local stabilization of the low symmetry phase by vandyl ions. They also found that the data of their experiment contained Cu^{2+} ion as contaminant and thus concluded that the complication in their results could have been due to a possible JT effect associated with Cu^{2+} ion in this crystal. Unfortunately, they did not carry out further investigation to establish or rule out the possibility of JT effect due to Cu^{2+} ion in this system.

De (2010) said in order to ascertain JT effect of Cu^{2+} in CAS Oguama carried out detailed EPR study of Cu^{2+} doped in CAS at various temperatures in the range of 300-15 K with angular variations usually at steps of 5^o and 0.5^o near JT extreme points in three mutually perpendicular planes of CAS single crystals. The Cu^{2+}:CAS spectra consists of finely resolved hyperfine lines in the low magnetic field region at all temperatures except 15 K while those in the high magnetic field region are poorly resolved at high temperatures. The insufficient resolved splitting patterns of the spectra constitute a major problem in the extraction of the relevant spectroscopic parameters (resonance frequency, coupling constants, linewidths) from the spectra as starting points in the computer simulation of the spectra. Therefore, a straightforward analysis is not possible in general (neither for the human expert nor for a conceivable computer expert system (kirste, 1992)). It is against this background, several methods (spectrum contraction or elimination hyperfine splitting constants, extraction of hyperfine splitting constants, correlation method, maximum method, significance plots and ''roll-up'' transformation) have been employed in the analysis of high resolution EPR spectra (Kirste, 1992; Wu, 2006). These methods may be more or less useful in providing estimates for the hyperfine coupling constants. On the other hand, the set of relevant spectroscopic parameters extracted from the spectra can be verified by spectrum simulation and comparison with the experimental spectrum which is the method adapted in this paper. We have adapted the spectrum fitting because it is considered an indispensable component in any scheme automated spectrum analysis. In this work, we have considered the computer simulation of Cu^{2+}:$Cd_2(NH_4)_2(SO_4)_3$ spectra for M=-3/2 in the low field or x-direction.

Theory and method of computer simulation of EPR spectrum

In our earlier work (Yerima*et al.*,2014),we have reported that the first derivative line shape function of EPR spectra of Cu^{2+} manifesting static JT effect with orthorhombic g and A tensors in CAS is given by

$$F^{'}(H) = -\{2\alpha f_1\}\left[\frac{H-\frac{h\upsilon}{\beta g_z}+A_zM_I}{\left(\left(H-\frac{h\upsilon}{\beta g_z}+A_zM_I\right)^2+R_1\right)^2}\right] - \{2\alpha f_2\}\left[\frac{H-\frac{h\upsilon}{\beta g_x}+A_xM_I}{\left(\left(H-\frac{h\upsilon}{\beta g_x}+A_xM_I\right)^2+R_2\right)^2}\right] - \{2\alpha f_3\}\left[\frac{H-\frac{h\upsilon}{\beta g_y}+A_yM_I}{\left(\left(H-\frac{h\upsilon}{\beta g_y}+A_yM_I\right)^2+R_3\right)^2}\right]$$

1

where $f_1 = g_z^2\left(g_x^4 - g_y^2\right)\frac{\pi}{2} + \pi g_y^4,\ f_2 = g_x^2\left(g_z^4 - g_y^2\right)\frac{\pi}{2} + \pi g_y^4,\ f_3 = g_y^2(g_x^4 - g_z^2)\frac{\pi}{2} + \pi g_y^4$, α is the fractional relative abundance of copper isotopes $\alpha(Cu^{63}) = 0.69$ and $\alpha(Cu^{65}) = 0.31$; g_x, g_y, g_z are g-factors along the x-, y-, and z-axes respectively; H is the applied magnetic field; A_x, A_y, A_z are the hyperfine constants in the x-, y-, and z-axes respectively; R_1, R_2, R_3 are the linewidth parameters in the x-, y-, and z-axes respectively; M_I=-3/2, -1/2, 1/2, 3/2 and β is the Bohr magneton. The terms in the curly brackets represent the magnification factor of the line shape while the terms in square brackets determine the shape of the EPR line.

Since computer simulation of the line shape function represented by equation (1) is cumbersome and time consuming because many variables are involved, we search for a simpler line shape function involving less number of variables. One of such functions is the integrated Lorentzian line shape function involving only three variables of theform (Blakemore, 1985)

$$P = \frac{\Gamma^2 P_{max}}{\Gamma^2+(H-H_r)^2} \qquad 2$$

where P power, Γ is the half linewidth, H is the magnetic field and H_r is the resonance magnetic field. Equation (2) is simpler to simulate since it has only three variables (H, H_r, Γ) as compared to sixvariables (H, α, R_i, A, M, g) in equation (1). In theory, the plot of P versus H gives the expected resonance curve as shown in Fig.1b. In practice, when the resonance curve is broad, it becomes difficult to locate the resonance magnetic field precisely. As a result, the EPR spectrometer machine is designed in such a way that it records the derivative spectrum instead (Fig.1a) from which the resonance field can be located precisely.

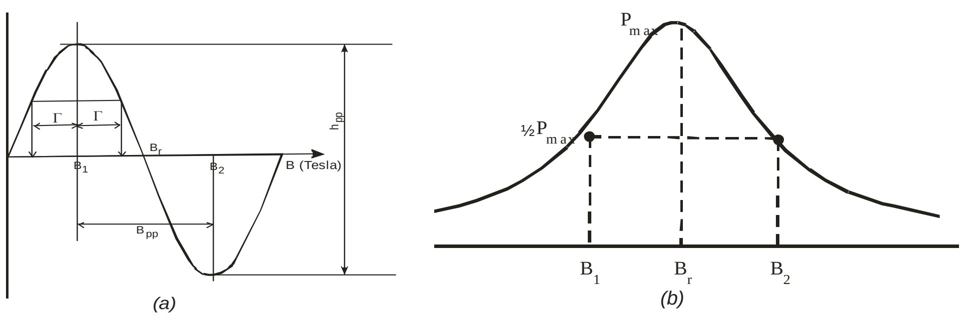


Fig.1 (a) first derivative and (b) integrated EPR spectrum

Now from Fig.1b, it can easily be shown that

$$2\Gamma = \Delta B_{\frac{1}{2}} \quad (3)$$

Taking the first derivative of equation (2) with respect to H, we have

$$\frac{dP}{dH} = \frac{-2\Gamma^2 P_{max}\,(H-H_r)}{\left[\Gamma^2+(H-H_r)^2\right]^2} \quad (4)$$

The ratio $\frac{dP}{dH}$ represents the normalized intensity designated by I_N. In practice, the normalized intensity is defined as the ratio of the peak-to-peak height of the spectrum of the sample to that of the standard spectrum. It is also defined as the ratio of power to maximum power which is equal to 1 at maximum absorbance power by the sample in the cavity. At this point resonance occurs and the resonance condition is $h\nu = g\beta H$ where h is the Planck's constant, ν is the frequency of the microwave signal, g is the spectroscopic splitting constant, β is the Bohr magneton and H is the varying magnetic field.

The plot of I_N versus H is the EPR spectrum (Fig.1a) that the EPR machine displays. Also, from Fig. 1a we can easily deduce the resonance magnetic field H_r as the field corresponding to zero lineshape, that is, $H = H_r$.

Similarly, taking the second derivative of equation (4) with respect to H, gives

$$\frac{d^2P}{dH} = \frac{\Gamma^2+(H-H_r)^2-4(H-H_r)^2}{\left[\Gamma^2+(H-H_r)^2\right]^3} \quad (5)$$

Again we can easily show that at resonance, $\frac{d^2P}{dH^2}=0$, which gives

$$2\Gamma = \sqrt{3}\Delta H_{pp} \quad (6)$$

Therefore, combining equations (3) and (6), we have

$$\Delta H_{\frac{1}{2}} = \sqrt{3}\Delta H_{pp} \quad (7)$$

The ratio $\frac{\Delta H_{\frac{1}{2}}}{\Delta H_{pp}} = \sqrt{3} = 1.7321$ from equation (7) gives the condition that the line is Lorentzian.

In our previous works (Yerima 2014; Yerima and De 2014), we have studied the linewidth, intensity, relaxation times and computer simulation of the spectra of Cu^{2+} in CAS at various temperatures using equation (1) involving six variables which made the simulation tedious and time consuming (Yerima *et al.*, 2014). In all these studies, we have reported that the orthorhombicity of the spectra is attributed to the non-equivalency of the three JT potential wells of Cu^{2+} in this system. Therefore, it is expected that the potential would vary with temperature. However, in our earlier study of linewidth and intensity as functions of temperature it was only possible for us to determine the average potential. It is against this background that we investigated the variation of energy with temperature by simulating the spectra in the lower magnetic field or x-direction for M=-3/2 using equation (4) which is simpler involving only two variables instead of that of Yerimaand De (2014) involving six variables.In the computer simulation process, first, the resonance magnetic field H_r, estimated value of peak-to-peak linewidth ΔH_{pp} from the observed spectrum (Fig. 1a) and the calculated value of Γ from equation (6) were used as starting points. Second, these values of H_r, Γ and ΔH_{pp} were substituted in equation (4) and the resulting line shape was compared or matched with observed EPR line. Third, the value of H_r was kept constant since it can be measured accurately from the spectrum while thevalues of Γ and ΔH_{pp} were varied by small amounts in the ranges ±0.005-0.01 and ±5-10 G respectively around the initial values until the line that best fits the observed EPR line was obtained. Fourth, the effective values of H_r, Γ and ΔH_{pp} corresponding to the simulated EPR lines of Cu^{2+} in CAS at a particular temperature was recorded. Fifth, the effective values of H, Γ and ΔH_{pp} were substituted into equation (2) to obtain the type of integrated spectrum (Fig. 1b) from which $\Delta H_{\frac{1}{2}}$ was measured. Sixth, other EPR parameters of interest were either measured from the type of spectra in Fig. 1 and others calculated from relevant equations. Finally, these procedures were repeated for Cu^{2+}:CAS spectra at different temperatures.

Results and discussion

Table 1 Intensity and potential energy of CAS at various temperatures

T (K)	I_N	ΔH_{pp}(Tesla)	Γ (Tesla)	H_r (Tesla)	E(cm^{-1})
80	7.14	0.00121	0.00104	0.2634	59.7
110	5.83	0.00329	0.00285	0.2522	58.9
120	5.41	0.00241	0.00209	0.2684	57.6
130	5.20	0.00263	0.00228	0.2660	56.0
140	4.45	0.00219	0.00190	0.2680	51.4
180	1.89	0.00351	0.00304	0.2618	23.9
190	1.79	0.00482	0.00418	0.2737	23.8
200	0.91	0.00307	0.00266	0.2765	12.2
210	0.85	0.00406	0.00351	0.2794	11.9

220	0.60	0.00329	0.00285	0.2779	8.7
230	0.50	0.00351	0.00304	0.2787	7.5
240	0.30	0.00318	0.00275	0.2772	4.7

The peak to peak height of the spectra of Cu^{2+}:CAS and that of the standard were measured at various temperatures. The ratio of the peak to peak height of Cu^{2+}:CAS spectrum to that of the standard gives the normalized intensity $I_N$of this system.

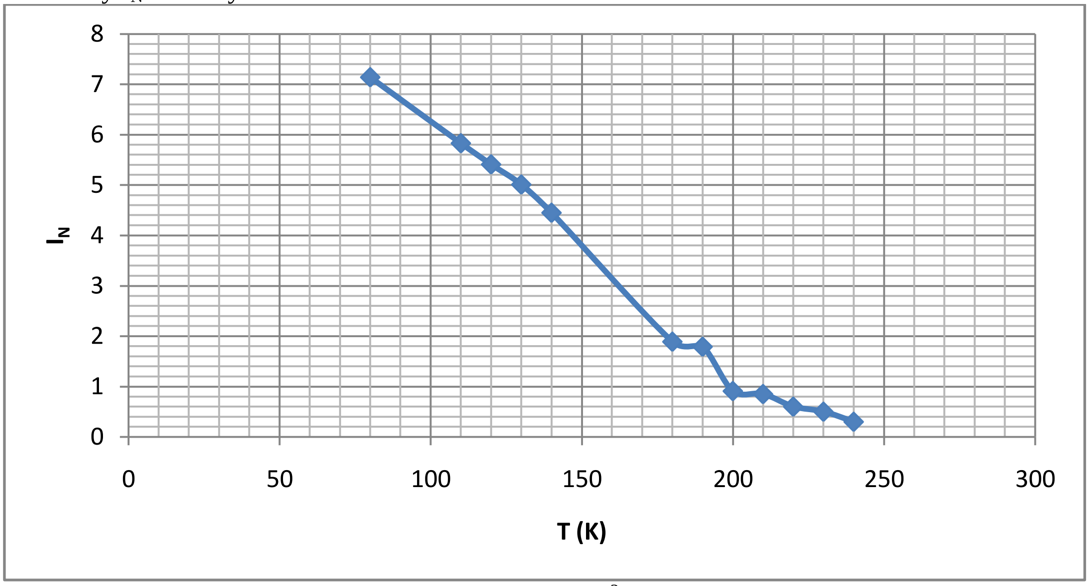
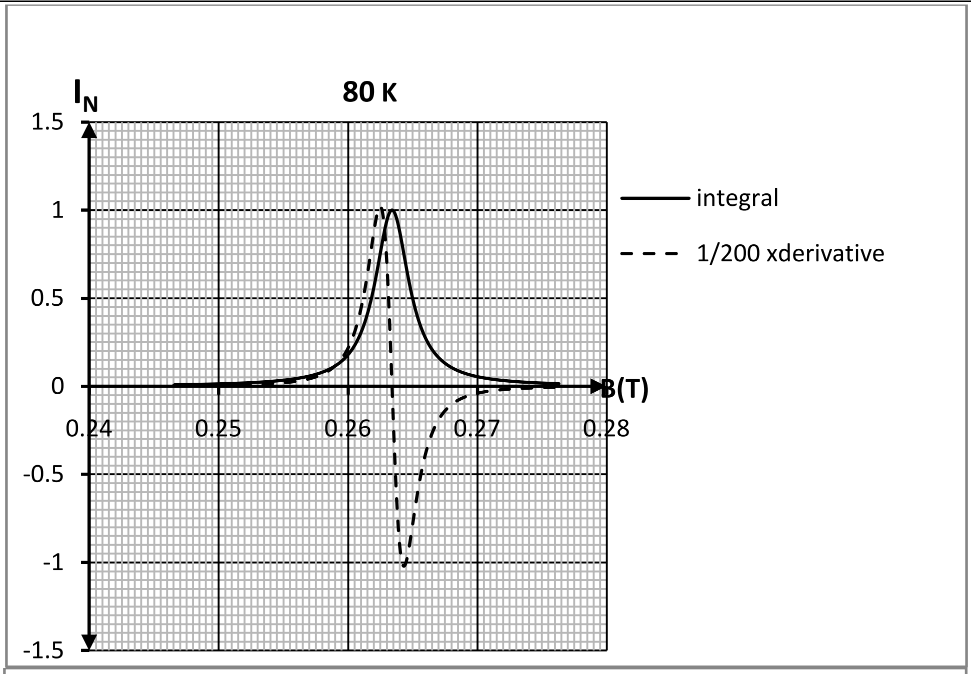
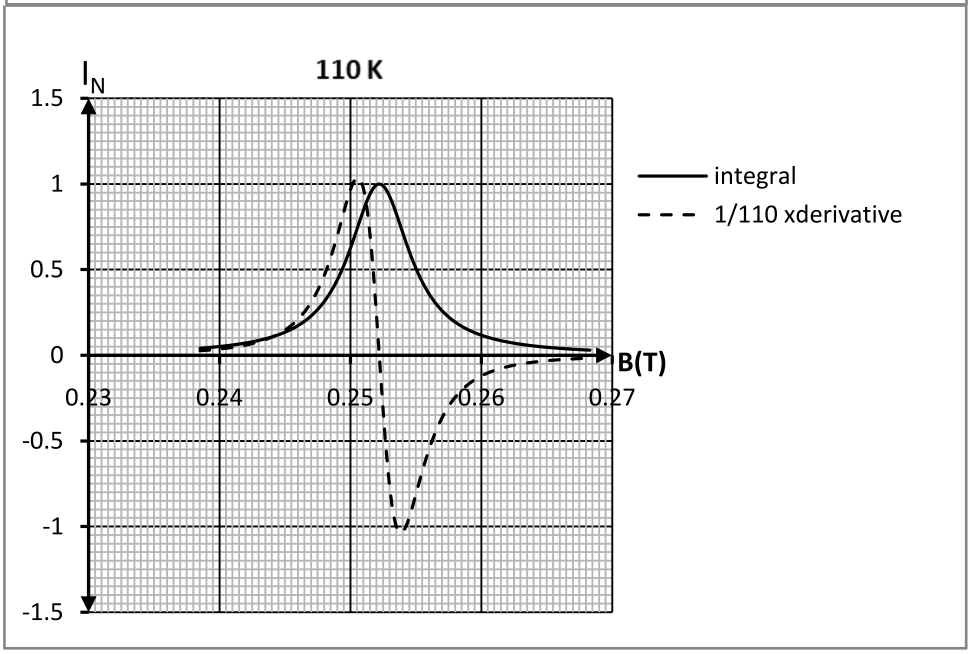


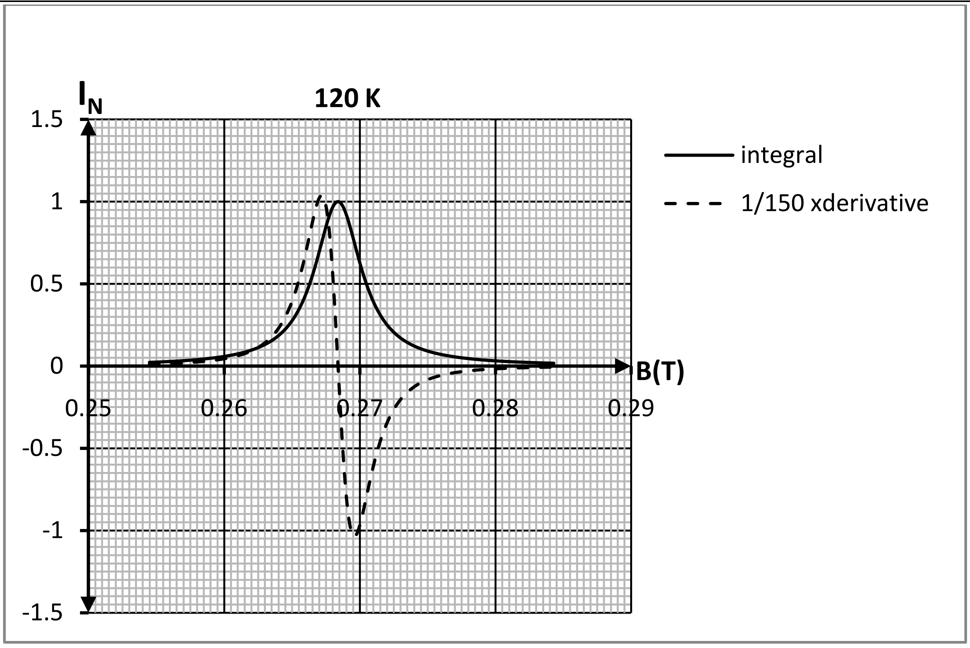
Fig. 2 Variation of normalized intensity of Cu^{2+}:CAS with temperature

In Fig. 2, the normalized intensity of Cu^{2+}:CAS spectra in the lower magnetic field (M=-3/2) decreases with temperature. The intensityshows abrupt change between 190 K and 200 K which may be attributed to phase transition temperature at about 195 K. The decrease in the intensity of this system depends on the way the population of the lower energy level changes on heating i.e. the population of the lower energy state or intensity is higher than that of the excited state.This is in agreement with earlier findings that the three Jahn-Teller (JT) potential wells are non-equivalent i.e. the separation of the potential wells in this direction varies with temperature. To calculate the potential energy of the wells in this direction, we employed to first approximation the least squares method and we obtained the intensity-temperature relation$I_N = -0.0466T + 10.842$ with correlation coefficient R^2=0.9789. The coefficient -0.0466 K^{-1} of T in this relation represents the rate of the decrease of the intensity with temperature and the intercept represents the intensity I_o=10.842as the temperature tends to absolute zero. The activation or potential energy $E = -kTln\left(1 - \frac{I_N}{I_o}\right)$ is calculated for each measured I_N at temperature T where k is the Boltzmann constant and recorded in Table 1. The variation of E with temperature is similar to that of intensity with temperature. However, the values of E obtained in this work in the x-direction or low magnetic field lie in the range 4.7-59.7 cm^{-1}as opposed to average range 393.5-417.2 cm^{-1} obtained for intensity and linewidth studies of this system in all directions (Yerima and De, 2014).

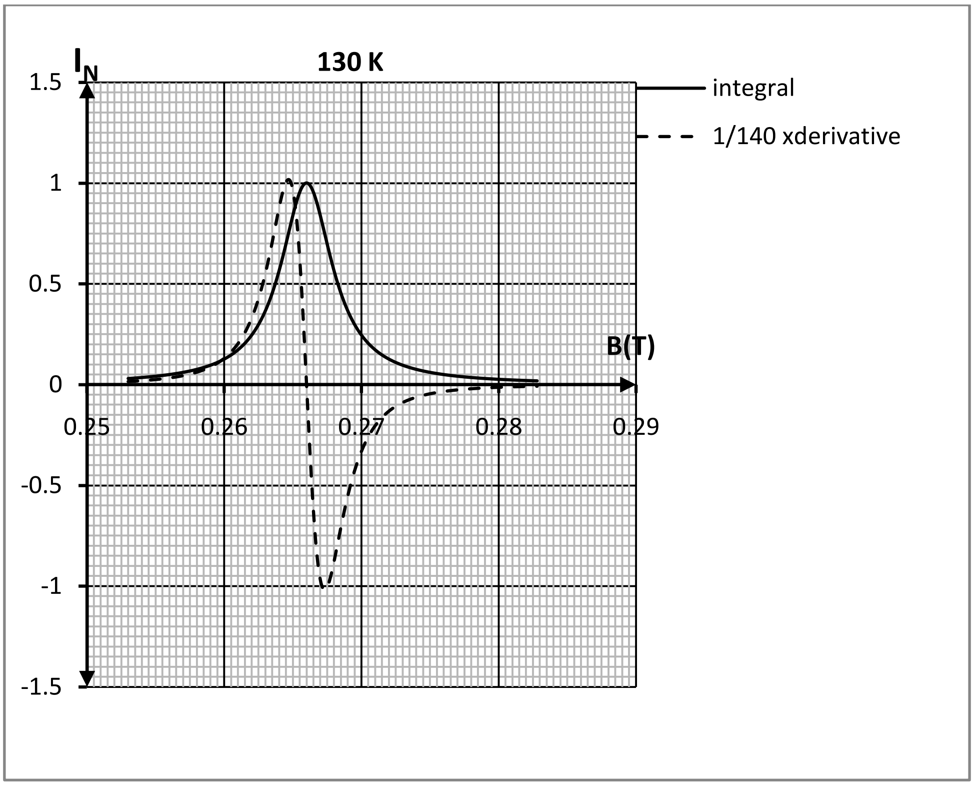
On the other hand, the resonance field H_r, linewidthsΓandΔH_{pp}were obtained from the simulated spectra (Fig. 3) and recorded in Table 1. These quantities fluctuate with temperature in the form of polynomial (Table 1). This agrees with earlier findings that bothrelaxation time and linewidthdepend on temperaturein the form of sum of polynomials and exponential terms (Yerima, 2014; De, 1986).


I_N
80 K
1.5
1
0.5
0
-0.5
-1
-1.5
0.24
0.25
0.26
0.27
0.28
B(T)
integral
1/200 xderivative

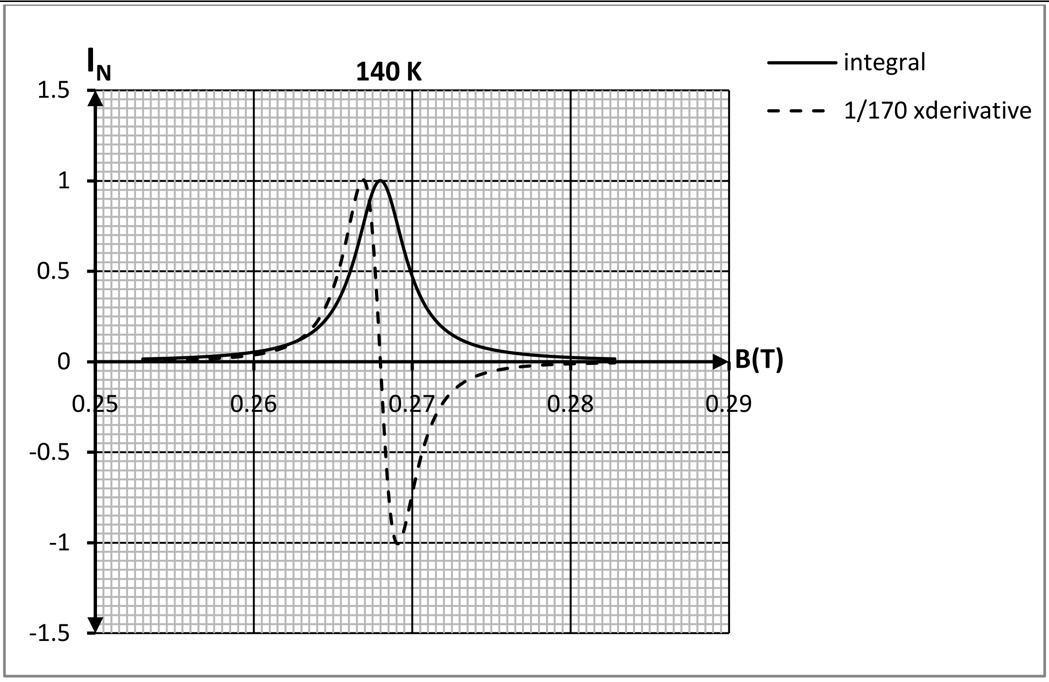

I_N
110 K
1.5
1
0.5
0
-0.5
-1
-1.5
0.23
0.24
0.25
0.26
0.27
B(T)
integral
1/110 xderivative



I_N
120 K
1.5
1
0.5
0
-0.5
-1
-1.5
0.25
0.26
0.27
0.28
0.29
B(T)
integral
1/150 xderivative



I_N
130 K
1.5
1
0.5
0
-0.5
-1
-1.5
0.25
0.26
0.27
0.28
0.29
B(T)
integral
1/140 xderivative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140 K
integral
1/170 xderivative
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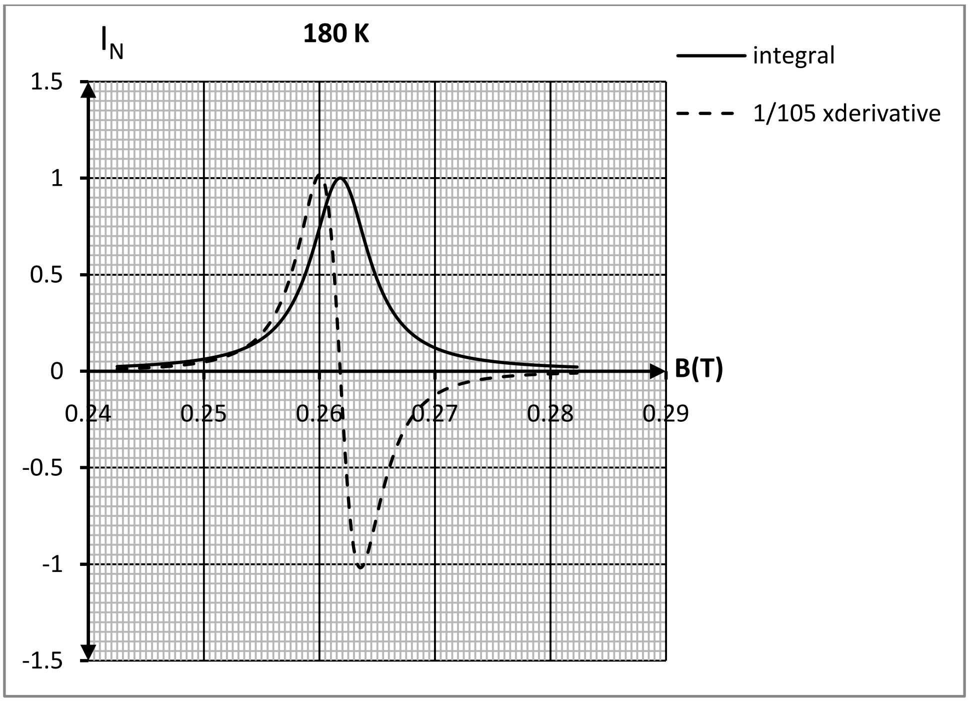
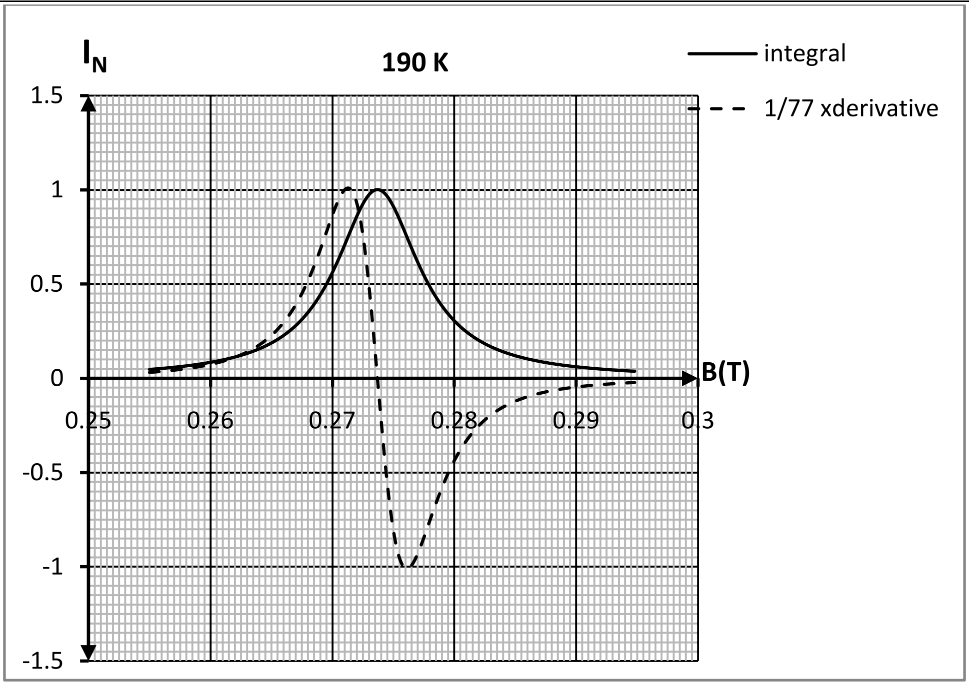
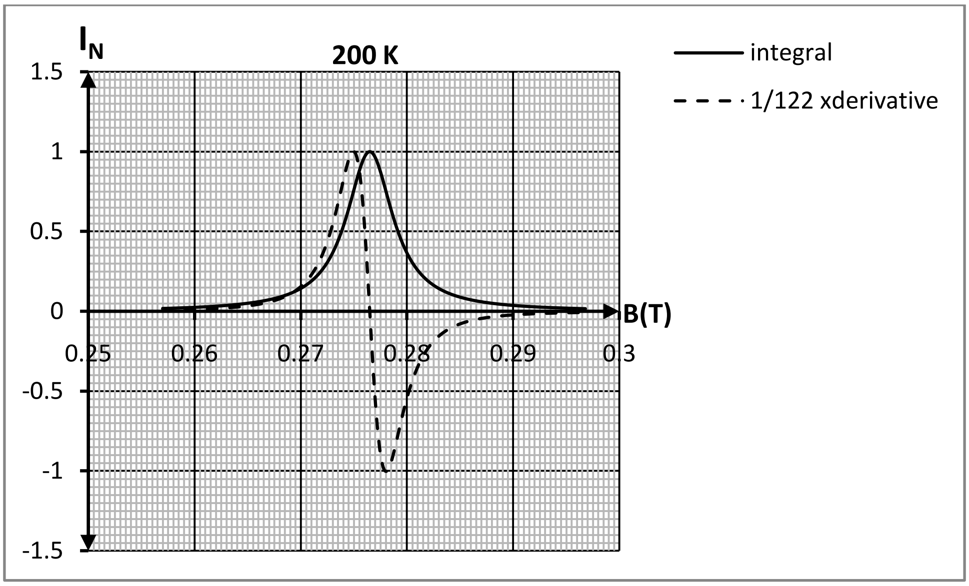
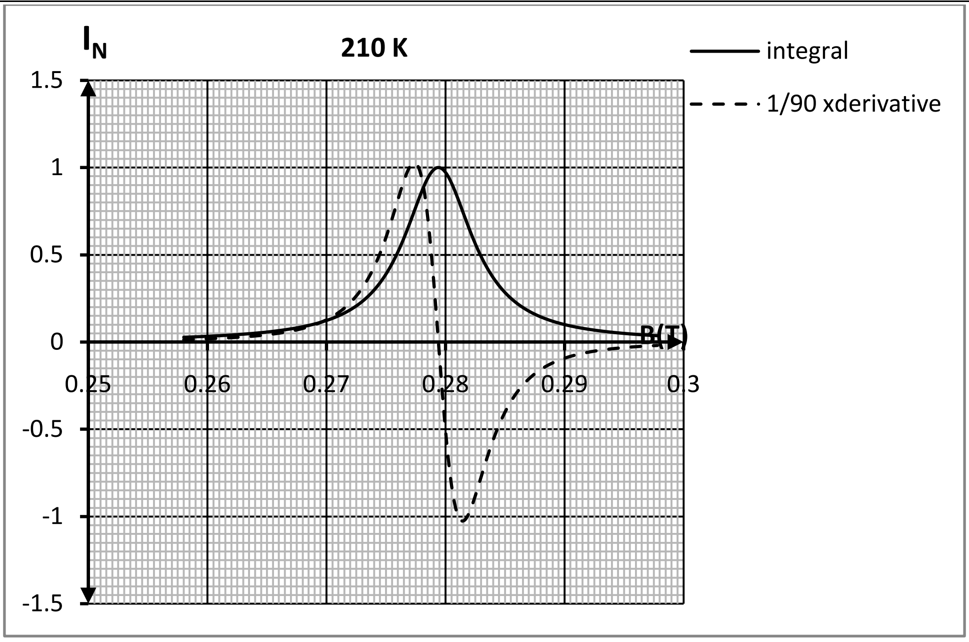
1
0.5
0
-0.5
-1
-1.5
0.25
0.26
0.27
0.28
0.29
B(T)


I_N
180 K
integral
1/105 xderivative
1.5
1
0.5
0
-0.5
-1
-1.5
0.24
0.25
0.26
0.27
0.28
0.29
B(T)


I_N
190 K
integral
1/77 xderivative
1.5
1
0.5
0
-0.5
-1
-1.5
B(T)
0.25
0.26
0.27
0.28
0.29
0.3


I_N
200 K
integral
1/122 xderivative
1.5
1
0.5
0
-0.5
-1
-1.5
B(T)
0.25
0.26
0.27
0.28
0.29
0.3



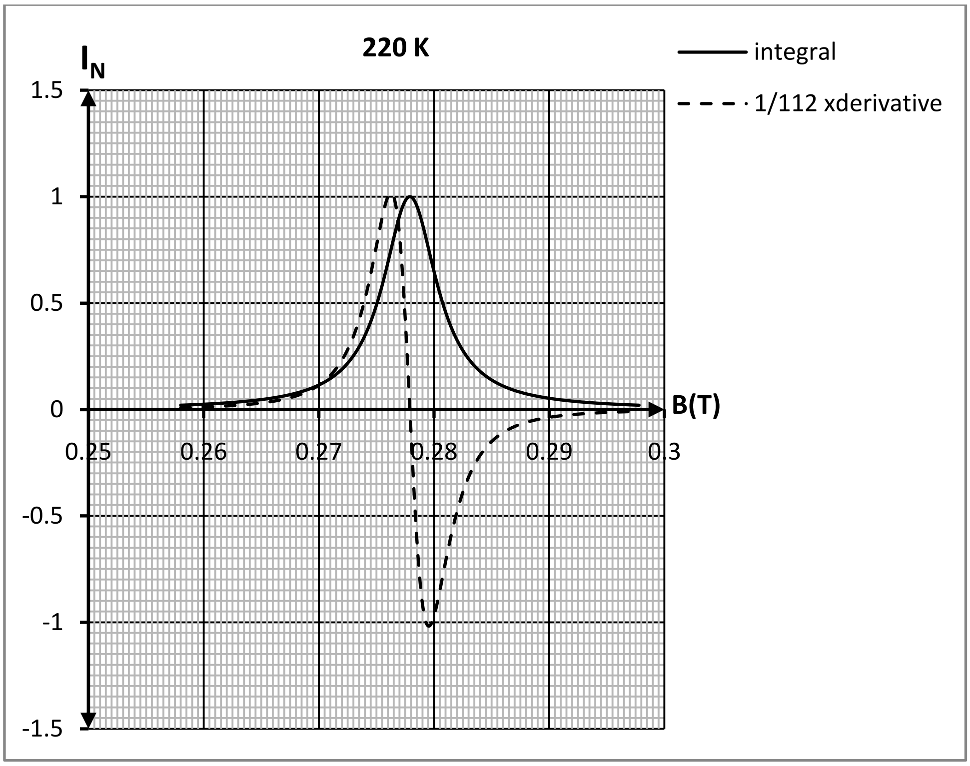


Fig. 3 Temperature dependence of the normalized intensity and lowmagnetic field in the M=-3/2 or x-direction

Conclusion

In this paper, we have carried out computer simulation of the Cu^{2+}:CAS spectra in the low magnetic field in the x-direction for M=-3/2 at different temperatures. The normalized intensity obtained from the simulated spectra decreases with temperature showing a phase transition temperature of about 195 K. The calculated activation energy varies with temperature in the same way as the normalized intensity. In another vein, we observed that the peak to peak linewidth and resonance field vary in the form of polynomials as opposed to exponential behaviour in our earlier studies of the linewidth and intensity of this system in all directions.

References

[1]. Babu D. S, SastryG. S, Sastry M. D and Dalvi A. G. I (1984) Structural phase transition in Langbeinites an EPR study, J. Phys. C. Solid state Phys. 17, 4245

[2]. Blakemore, J. S (1985) Solid State Physics, Update Second Ed., Cambridge Uni. Press, 506.

[3]. De D. K (1986) Powder EPR study of the Jahn-Teller effect and phase transition in Cu^{2+}: $ZnTiF_6.6H_2O$. Phys Rev B 34, 4655.

[4]. De D K (2010) First observation of orthorhombic Jahn-Teller EPR spectra in Cu II doped $(NH_4)_2Cd_2(SO_4)_3.6H_2O$ single crystals, Paper I, African Physical review$:0011, 87

[5]. Jona F and Pepinsky R (1956) In low energy electron diffraction (LEED) spectra. Al. IBMJ. Res. Center, York Town

[6]. Kirste B (1992) Methods of automated analysis and simulation of EPR spectra. Anal. Chim. Acta. 191-200, 265

[7]. Oguama F A (1997) EPR studies on the effect of magnetic Jahn-Teller and Jahn-Teller impurities on solid state phase transitions. Doc. Dessert. Wake Forest Uni. USA.

[8]. Rabkin L. M, Torgashov V. I and Brezina B (1981) Ferroelectrics 36, 476

[9]. Wu H (2006) EPR spectra simulation of anisotropic ½ spin. Hanqing@csd.uwIII.edu.

[10]. Yerima J. B (2005) EPR studies in the effect of paramagnetic impurities in phase transition and Jahn-Teller effect in crystalline solids: A review. Tech and Dev Journal,9

[11]. Yerima J. B (2007) EPR studies of the effect of paramagnetic impurity concentrations in phase transition and Jahn-Teller effect in crystalline solids. Doc. Dissert. FUTY, Nigeria

[12]. Yerima J B (2015) Temperature Dependence of EPR Linewidth, spin concentration, spin relaxation times and exchange in $Cd_2(NH_4)_2(SO_4)_3$ single crystals. VunoklangMultidisciplinary Journal of Science and Technology Education, Vol 1, 2

[13]. Yerima J B and De D K (2014) Temperature Dependence of EPR Linewidth and Intensity in

[14]. $Cd_2(NH_4)_2(SO_4)_3$ single crystals, VonuklangMultidisplinary Journal of Science and Technology, Vol 1, No.1

[15]. J B Yerima,A B Dikko and D K De (2014) Theory and simulation of EPR orthorhombic Jahn-Teller

[16]. spectra of Cu^{2+} in $Cd_2(NH_4)_2(SO_4)_3$ single crystals at different temperatures. The International Journal of Engineering and Science (The IJES), Vol 3, 7, 79-85. www.theijes.com

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VALUATION OF NIGERGAS COMPANY, EMENE, ENUGU, NIGERIA USING THE ENVIRONMENTAL FACTOR (E-FACTOR) MODEL

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ABSTRACT: *Industries in Nigeria are heavy sources of Environmental pollution. However, before now there was no realistic valuation model for valuation of the environmental damage caused by these industries. Advocates of environmental protection in Nigeria then tasked the Estate Surveyors and Valuers to develop valuation models that would consider the extent of damages caused by industries to the environment while interpreting the value of such industries and other facilities generating waste in Nigeria. The E-factor model was then developed. This paper tries to value NIGERGAS Company Enugu, using the E-factor model. The company was valued using the Conventional Cost Approach to Valuation and thereafter the E-factor model. The results indicated a loss of value of about ₦16,266,020 representing 14.54%. This loss of value is attributable to the inability of NIGERGAS Company to meet up with world best practices in terms of environmental protection standards. The paper then recommends that the E-factor model be accepted by the Nigerian Institution of Estate Surveyors and Valuers (NIESV) as a veritable valuation tool for valuation of industries and other facilities generating wastes in Nigeria.*

Keywords: *Environmental Factor, Industries, Model, NIGERGAS Company, Pollution, Valuation, Waste.*

1.0 Background of the Study

Deane, Gray and Steel (1986) pointed out that valuation is a professionally derived estimate of value, which is based on supportable conclusions arrived at through a thorough and logical analysis of facts and data at a particular time. The Estate Surveyor and Valuer is the professional that is bestowed with the responsibility of interpreting the values of different categories of properties both fixed and movable in Nigeria. Exercising this valuation duty has not been easy since the valuer in practice in Nigeria still depends on models developed many years ago by scholars in Europe. Gross lack of data has also made it extremely difficult for them to use the highly academic models that are currently emerging.

Again, Baum and Mackmin (1989) opined that the Estate Surveyors and Valuers concept of value is from a strictly economic perspective based on the premise that legal interest in landed properties are usually exchanged with money and are therefore regarded as scarce resources. In this sense, valuers see open market value as price struck between a willing and well informed buyer and seller under conditions approximating to that of a perfect competition. When viewed from another prospective, the Estate Surveyors and Valuers see value as the Replacement Cost (New) of the improvements on the property. This concept of value has been widely criticized.

With the worlds' recent focus on environment (OECD, 1989) brings to limelight the concept of Total Economic Value (TEV) which is very important in the valuation natural and man-made environment. TEV provides various perspectives on different kinds of benefit that accrue from environmental preservation and improvement. Ogunba (1999) opined that TEV covers the use value, the option value and the non-use value. According to Bishop (1982) the use value has a striking relationship with the existing use value, exchange value and alternative use value as practised by Estate Surveyors and Valuers. He however pointed out that the non-use value has been seriously neglected by majority of Estate Surveyors and Valuers in practice during their valuation exercise. This according to Aina (1992) has resulted in gross over-valuation of environmentally unsound properties. Proponents of TEV in Nigeria, have therefore called on Estate Surveyors and Valuers in Nigeria (both academicians and practitioners) to develop more generally accepted Environmental valuation models that can handle serious cases of environmental damage and by implication take care of the non-use value. In tandem with this called, the Environmental Factor (E-factor) adjusted cost approach to valuation was developed by Aniagolu (2009). This work therefore tries to apply the model to the valuation of NIGERGAS Company Limited, Emene, Enugu, Nigeria.

2.0 Statement of the Problem

Aniagolu (2009) developed the E-factor model. This is an extension of the Cost Approach to valuation which is derived from the Cost Theory of value. E-factor simply measure the rate of compliance of industries or other facilities generating waste / pollution in Nigeria to Environmental Standards as contained in the National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Waste) Regulation of 1991. The model is designed in such a way that valuers are expected to inspect pollution abatement facilities in industries and other facilities generating waste in addition to their usual inspection of Land & Buildings, Equipment and Hand tools, Plant & Machinery, Motor Vehicle, Furniture and Fittings, etc.

Aniagolu, Iloeje and Emoh (2015) had earlier demonstrated the use of the model in terms of data collection, data collating and data analysis. Also Aniagolu, Iloeje and Okwu-Delunzu (2015) had also applied the model to the valuation of Anambra Motor Manufacturing Company (ANAMMCO), Emene, Enugu, Nigeria: a company with international repute and affiliation. This paper therefore tries to apply the model also to NIGERGAS Company Nigeria Limited: a local company that is indigenous to Nigeria.

3.0 Aim and Objectives of the Study

This study aims at applying the E-factor model to the valuation of NIGERGAS Company Limited, Emene, Enugu, Nigeria. To achieve this aim, this study will first of all describe NIGERGAS Ltd to the reader so that a visual impression of the company could be attempted by the reader. Secondly, an attempt will be made to value NIGERGAS Ltd using the Cost Approach to Valuation as adopted by valuers in Nigeria. Thirdly, NIGERGAS Ltd would be valued with the E-factor model. Finally the result from the two valuation processes would be compared and inferences drawn.

4.0 Research Methodology

The E-factor model makes extensive use of the experimentation and survey research methods. According to Odoziobodo and Amam (2007), Experimentation research is the manipulation of experimental variables to ascertain that one is related to or has any effect on the other. Also Anyadike (2009) described survey research as one that tends to cover a large population of people by taking and studying samples from the population.

5.0 NIGERGAS Company Limited, Emene, Enugu, Nigeria

5.1 Ownership:

NIGERGAS Limited started in May 1962 as a partnership business between the former Eastern Nigerian Government and Siad Machine Impianti Italy who supplied the plant and managed the company until the Nigerian/Biafra Civil War broke out in 1967. After the Biafran war, as states were being created and assets were shared, Enugu State Government retained ownership of the company. Hence the company is 100% owned by Enugu State Government (NIGERGAS, 1980).

5.2 Range of Products:

The Company's products are welding and processing Oxygen, Medical Oxygen, Nitrogen, Acetylene and waste-lime which can be used in paint production, production of fillers and production of chalk (NIGERGAS, 1980). The products of the company and their installed capacity are presented in table 1.

Table 1: Product Range of NIGERGAS and Their Installed Capacity.

S/N	Product	Installed Capacity	Purity
1.	Welding/Process Oxygen	620M3/HR	97 – 98%
2.	Medical Oxygen	620M3/HR	99.9%
3.	Nitrogen	620M3/HR	-
4.	Acetylene	32M3/HR	-

Source: Aniagolu (2009)

Products of NIGERGAS, until recently were used nationwide and are marketed through their distributors' and agents.

5.3 Raw Material Requirements

For the production of Acetylene, NIGERGAS imported Calcium Carbide (CaO_2) from Europe. The calcium carbide came in drums of 100kg. Each production process requires 10 drums. Hence, the major raw material for production of acetylene was imported.

For the production of Oxygen and Nitrogen gases, no raw material was required since production is from atmospheric air which is required to be free from pollutants. As at 2009 when field work for this study was carried out, only the acetylene plant was working.

5.4 Production Processes

NIGERGAS operates two production processes with two separate production plants. The first production plant produces Oxygen and Nitrogen alternately (i.e the plant can only produce one of the gases at a time) while the second production plant produces acetylene. Details of the two production lines are as follows:

5.4.1 Oxygen Plant:

The oxygen plant is a 1973 model oxygen plant with the capacity of filling 100 (one hundred) cylinders at a time. The plant as originally installed is fully automated and operates with cryogenic technology (technology of very low temperature). To manufacture Oxygen or Nitrogen, atmospheric air is sucked-in from the intake point by an aspirator which is fitted with filters to remove impurities. The air so sucked-in then moves through pipes to the compressor. As the name implies, the compressor compresses the air giving it additional pressure and very high velocity. The high velocity air then moves from the compressor to the Freon coolers in a 4 (four) stage compression and cooling process. The Freon cooler reduces the temperature of the air to a very low negative point. From there, the air moves to the preliminary heat exchange where the air is further cooled. The air then moves to the molecular adsorber units where other impurities (carbodioxide, hydrocarbons, moisture, etc) are removed. From the adsorbers, the air moves to the Expansion Turbine where the air is liquefied. In the Expansion Turbine the liquefied air is between $- 192^{oC}$ and $- 194^{oC}$. The liquefied air is then sent to the fractionating column. This comprises the lower column and upper column. Between the two columns are two sub-coolers which further reduce the temperature of the liquefied air. At this very low temperature, the liquefied air is then separated into its components: Oxygen and Nitrogen (NIGERGAS, 1980).

The gas desired at each point in time is collected and sent to the condenser/evaporator from where it is transferred to the ramp for filling of the cylinders. The undesired gas is evaporated through a valve back into the atmosphere. As at the time of this work this plant is not working.

5.4.2 Acetylene Plant:

The acetylene plant is fully automated too. Acetylene is produced by a wet process. The plant is installed to produce pure acetylene gas with the use of calcium carbide (CaO_2) as a major source of raw material. It has a filling capacity of 120 (one hundred and twenty) cylinders at a time.

For acetylene production, the movable hopper is lowered and loaded with 1000kg of calcium carbide. The hopper is then lifted by an air operated crane of about 1500kg capacity into the immovable hopper. The immovable hopper accepts the CaO_2 with the help of a media screw conveyor and introduces the CaO_2 into the generator which is half filled with water. The water then reacts with the CaO_2 to produce lime, heat and low purity Acetylene gas (LPAG). A paddle stir is installed in the generator to ensure maximum output. A cooling system is installed to circulate water into the generator to keep it cool. Since the generator is expected to operate at normal temperature. The waste carbide (lime) is purged from the generator periodically through a valve, while other gaseous impurities escape into hydraulic safety blow-out machine. The water inside the generator prevents the LPAG from escaping. Nitrogen is passed manually to separate or prevent oxygen from having contact with the acetylene to avoid explosion/accident. The LPAG then travels through a pipe to the gasometer or gas reservoir (which is filled with water to serve as a scalant) while carbide waste lime and water escape for processing at the recycling plant.

From the gasometer, the LPAG travels through pipes to two low pressure driers for purification. The low pressure drier removes moisture and lime particles. From there the LPAG passes through pipes to the purifier (mass filters) to eliminate the last lime particles and moisture before going through pipes again to the 3 (three) stages compressor. The compressor releases High Purity Acetylene Gas (HPAG) which again passes through pipes to 6 (six) high pressure driers for final purification before moving to the ramp via pipes for bottling in cylinders. As at the date of this work (2009) this plant is in a very good state of repairs and is functioning very efficiently.

Carbide waste (lime and water) is pumped through pipes from acetylene plant to the waste recycling plant. This plant comprises three mixers arranged in stages. The mixers mix the waste by-product very well before they are pumped into a sieving machine. From this machine, the waste by-product moves to the nomadic dryer before they are moved to the oven for baking. The backed products are then returned to the crusher from where they are bagged. The entire processes work manually. As at the date of our field work in 2009, this recycling plant broke down. An improvised waste recycling system was dug in the area. This consist of 4 (four) underground septic sedimentation tanks. The waste carbide passes through the four tanks and as they are doing so, the carbide settles under while the waste water collects at the last tank. The carbide sediments are collected manually and bagged while the water is piped back to the acetylene plant for further production.

5.5 Sources of Pollution from the Production Processes

The major sources of pollution from the production processes of NIGERGAS Limited would include but not limited to solid/sanitary wastes from various offices: waste carbide (lime and water) from production of acetylene gas, emissions from plants, vehicles and power generating sets, noise pollution from vehicles plant and power generation sets, waste water from acetylene processing plants.

5.6 Existing Pollution Abatement and Safety Measures in NIGERGAS

Our survey reveals the following waste management strategies in NIGERGAS

a. Waste Water

Waste water is generated from acetylene plant in the form of a mixture of lime and water. The installed waste treatment plant was not functional at the time of this study rather an improvised waste treatment process comprising four sedimentation / septic tanks which was dug in the premises. This by all standards is grossly inadequate.

b. Solid Waste:

The solid waste management system in NIGERGAS is very poor probably because of the low level of activities in the factory. Waste bins are located only inside administrative offices. The production area and the entire premises do not have waste bins. Open incineration system is used for disposal of the wastes.

c. Gaseous Emissions:

The acetylene plant generates a lot of CO_2. Result from the E-factor model attest to this. Unfortunately, the company has no gas masks or any other remedy to this problem. Factory workers were so surprised when they saw the readings from our gasometers.

d. Noise Pollution:

Noise pollution level is minimal. This may be attributed to the fact that the level of activities within the factory is quite low. Besides, power generating sets were not on as at the date of this work.

e. Industrial Health and Safety:

In the area of industrial Health and Safety, NIGERGAS has a lot to improve on. There is no clinic for workers, the first-aid boxes in the factory are not functional and firefighting materials are mostly sand buckets and fire extinguishers. The workers were not wearing safety devices and enforcement of such safety precautions are almost non-existent.

6.0 Valuation of NIGERGAS Using the Conventional Method

6.1 Method of Valuation Adopted:

The cost approach to valuation was adopted for the valuation of assets of NIGERGAS Company Limited, Emene, Enugu, Nigeria. The method can also be called the contractors method, the contractors taste, the replacement cost approach, the re-instatement cost method or the depreciated replacement cost (DRC) approach. According to Aniagolu (2009) the DRC approach is most preferred because it best describes what the valuer is doing.

6.2 Rationale for Using the Method.

The method is best used when the market approach is impracticable due to dearth of comparables and the investment method is inapplicable probably because there is no rent passing (Kalu, 2002). Hence, NIGERGAS has no comparable sales evidence in Enugu and there is no rent passing on the properties. Again, according to Aniagolu (2009) the method (i.e DRC method) is best used for special purpose industries, service properties such as schools, hospitals, churches, etc. (where comparable sale evidence is not available) and any other type of property where there is no rent passing and there is no comparable sales evidence.

6.3 Valuation of NIGERGAS Company, Emene, Enugu, Nigeria Using the Conventional Method

Messrs Frank Maluze and Associates carried out the valuation of NIGERGAS in 2001. In the concluding part of their report Frank Maluze Associates (2001) declares that "consequent upon the foregoing and having regards to the location and condition of the property as well as the present economic circumstances in the country, it is our well considered opinion that the capital value of NIGERGAS Company Limited, Emene, Enugu for Balance Sheet purposes as at 12th September, 2001 or within a reasonable period of that date is ₦111,841,000 (One Hundred and Eleven Million, Eight Hundred and Forty-One Thousand Naira only)". It must be stated that as at 2001 the exchange rate of dollar to naira is about One Dollar to One Hundred and Twenty Naira (1:120). The summary of the valuation is as follows:

1.	Land	₦10,608,000
2.	Building & Improvement	₦44,106,000
3.	Motor Vehicles	₦10,020,000
4.	Plant, Machinery & Equipment	₦39,595,000
5.	Furniture and Fittings	₦ 7,517,000
	Total	**₦111,846,000**

7.0 Valuation of NIGERGAS Using the E-Factor Model

The procedure for determining the E-factor was clearly demonstrated by Aniagolu, Iloeje and Emoh (2015). According to them, the data required for the E-factor model include data on air, effluent and soil quality. Also data on noise level including industrial Health and Safety were also required. The valuer in practice needs to determine the E-factor alongside his physical and socio-economic analysis of the properties.

7.1 Determination of Rate of Compliance of NIGERGAS to Air Quality Standards.

Air quality at NIGERGAS was monitored in-situ at four different locations namely central workshop, Ramp, Acetylene Plant and Waste Treatment Area. These locations where chosen because of their strategic nature. Gascom gasometers fitted with special gas detectors/sensors and calibrated in parts per million were used to collect data on air quality. The average of the results from the four locations was then compared with World Health Organization (WHO) / Federal Ministry of Environment (FMENV) Standards. The result is presented in table 2.

Table 2: Comparison Between WHO/FMENV Standards and NIGERGAS Air Quality.

Parameters	Methodology	FMENV/ WHO Standard	Result from Industrial Sample	Deviation	Rate of Compliance	Rate of Non Compliance	Remarks
Dust Particles	Gasometer	NS	-	-	16.67%	3.33%	NC
Carbon II Oxide (CO)	"	1-5	14	9			ASL
Sulphur IV Oxide (SO2)	"	0.5	0.1	-			WSL
Carbon IV Oxide (CO_2)	"	1-5	NC	NC			NC
Nitrogen IV Oxide (NO_2)	"	0.085	0.0	-			WSL
Ammonia (NH_3)	"	0.2	0.14	-			WSL
Hydrocarbons	"	6.0	2.0	-			WSL
Chlorine	"	1.0	0.14	-			WSL
Hydrogen Cyanide	"	NS	0.0	NC			NC

Source: Aniagolu (2009)

Legend: NC = Not Compared , NS = Not Stated, WSL = Within Stipulated Limit, ASL = Above Stipulated Limit

Table 2 clearly shows that the rate of compliance of NIGERGAS to air quality standard is 16.67 percent while the rate of non-compliance is 3.33%. Hence, of the 20 marks which the model assigned to air quality NIGERGAS scored 16.67 marks and lost 3.33 marks.

7.2 Determination of the Rate of Compliance of NIGERGAS Effluent to Water Quality Standards.

Water sample was collected from NIGERGAS effluent discharge point and sent to the laboratory for analysis. The result was then compared with WHO/FMENV Standards. The result is presented in table 3.

Table 3: Result of Comparison Between NIGERGAS Effluent Quality and WHO/FMENV Standards.

Parameters	Methodology	FMENV/ WHO Standard	Result from Industrial Sample	Deviation	Rate of Compliance	Rate of Non Compliance	remarks
(a) Physical Analysis							
Odour	-	NC	NC	-			
Colour (Haven Unit)	Lovibond	25	10	-			NC
Ph (31^{0C})	Meter	6.5 – 9	10	1			WSL
Conductivity (chm/km)	Meter	1000	130,000	129,000			ASL
(b) Chemical Analysis							
Acidity Ng/Ica/Co_3	Microbiological	400	100	-			WSL
Alkalinity Mg/LCa/Co_3	Microbiological	30 – 500	2,650	2150			ASL
Total Solid Mg/L	A.P.H.A	2000	1520	-			WSL
Dissolved Solids Mg/L	A.P.H.A	500	1380	880			ASL
Suspended Solids Mg/L	A.P.H.A	30	NC	-			NC
Calcium Mg/L	E.D.T.A	75	76.152	1.152			ASL
Magnesium Mg/L	E.D.T.A	30	389.12	359.12			ASL
Total Hardness Mg/L	E.D.T.A	50 – 200	1790	1590	9.45%	10.55%	ASL
Sodium Mg/L	Flame Photometer	NS	NC	NC			NC
Potassium Mg/L	"	NS	NC	-			NC
Copper Mg/L	"	NS	NC	-			NC
Zinc Mg/L Ca/Co_3	ASS	200	32,493.5	32,293.5			ASL
Iron Mg/L	Spectrophotometer	0.3	2.167	1.867			ASL
Manganese Mg/L		0.1-0.5	0	-			WSL
Lead PPM		0.01	5.25	5.24			ASL
Chloride Mg/L	"	250	35.46	-			WSL
Sulphate Mg/L	"	250	NC	NC			NC
Nitrate Mg/L	"	50	0.10	-			WSL
COD Mg/L	A.P.H.A	80	49.77	-			WSL
BOD Mg/L	A.P.H.A	30	54.80	24.8			ASL
Dissolved Oxygen Mg/L		NS	NC	NC			NC
(c) Microbiological Analysis							
E-Coli 100ml	Microbiological	-ve	-ve	-			WSL
Coliform 100ml	Microbiological	100	NC	NC			NC
Total Plate	Plate count	100	NC	NC			NC

Count							

Source: Aniagolu (2009).

Legend: NC = Not Compared , NS = Not Stated, WSL = Within Stipulated Limit, ASL = Above Stipulated Limit

The result shows that out of the 20 marks which the model assigned to water quality NIGERGAS scored 9.45 marks and lost 10.55 marks. This result shows immediately that the recycling plant in the factory is not working.

7.3 Determination of the Rate of Compliance of NIGERGAS to Soil Quality Standards.

Soil quality analysis is subdivided into solid waste management system and soil element analysis. The model assigned 10 marks each to the two. To assess the solid waste management system, the model considered the waste collection method, percentage of waste that is non-biodegradable, availability of recycling equipment and solid waste disposal method. The result of the assessment carried out in NIGERGAS is presented in table 4.

Table 4: Result from Inspection of Solid Waste Management System in NIGERGAS

S/No	Parameters	Maximum Points Obtainable	Points Obtained	Deviation	Rate of Compliance	Rate of Non Compliance	Remarks
1	Collection methods	2.5	1.0	1.5	4.5%	5.5%	FAIR
2.	% Non Biodegradable	2.5	1.5	1.0			-
3.	Availability of Recycling Equipment	2.5	1.0	1.5			FAIR
4.	Disposal Method	2.5	1.0	1.5			FAIR

Source: Aniagolu (2009).

From table 4, it could be seen that the rate of compliance of NIGERGAS to acceptable solid waste management practices is 45% while the rate of non-compliance is 55%. Hence out of the 10 marks allocated by the model NIGERGAS scored 4.5 marks and lost 5.5 marks.

Also, for the soil element Analysis, soil sample from NIGERGAS dumpsite was collected and sent to the laboratory for analysis. The result from the analysis was then compared with WHO/FMENV Standards as presented in table 5.

Table 5: Result of the Comparison Between NIGERGAS Soil Sample and WHO/FMENV Standard.

Parameters	Methodology	FMENV/ WHO Standard	Result from Industrial Sample	Deviation	Rate of Compliance	Rate of Non Compliance	Remarks
(b) Element Analysis	Composite Soil Analysis				10%	0%	
Calcium (Ca)		NS	NC				NC
Magnesium (Mg)		2 – 10	4.80	-			WSL
Sodium (Na)		NS	NC	-			NC
Iron (Fe)		0.5-1.0	0	-			WSL
Aluminium (Al)		10-100	60.0	-			WSL
Lead (Pb)		1 – 20	3.40	-			WSL
Zinc (Zn)		0.10-300	0.03	-			WSL
Copper (Cu)		20	0	-			WSL
Manganese (Mn)		0.20-300	0.3	-			WSL
Silica (Si)		NS	NC	-			NC
Titanium (Ti)		NS	NC	-			NC
Cadmium (Cd)		0.03-0.3	0	-			WSL
Loss on Ignation (Lol)		NS		NC			NC

Source: Aniagolu (2009)

Legend: NC = Not Compared , NS = Not Stated, WSL = Within Stipulated Limit

Table 5 shows that all the parameters measure and compared are within stipulated limits. Thus, NIGERGAS scored full 10 marks in the area of soil element analysis.

7.4 Determination of the Rate of Compliance of NIGERGAS to Noise Level Analysis

Noise Level Analysis was also done in-situ using Radio shack sound level meter which is calibrated in decibel (dBA). The meter ranges from between 50 dBA – 120 dBA. Noise level in the administrative block, workshop area, generator area, distribution area, security post and waste treatment area were measure and compared with WHO/FMENV Standard. The result is presented in table 6.

Table 6:Result of Noise Level Analysis Carried out in NIGERGAS

S/N	Parameters	Methodology	FMENV / WHO Standard (dBA)	Result from Industrial Sample	Deviation	Rate of Compliance	Rate of Non Compliance	Remark
1.	Administrative block		90	72	-	20%	0%	WSL
2.	Workshop Area	Radio Shack	90	80	-			WSL
3.	Generator Area	Sound Level	90	80	-			WSL
4.	Distribution Area	Meter	90	85	-			WSL
5.	Security Post		90	85	-			WSL
6.	Waste Treatment Plant		90	85	-			WSL

Source: Aniagolu (2009)

Legend: WSL = Within Stipulated Limit

Again, table 6 shows that noise level in all the section of the factory are within stipulated limits. Hence, NIGERGAS is fully compliant to acceptable noise level. This means that NIGERGAS scored full 20 marks that the model assigned to Noise pollution.

7.5 Determination of the Rate of Compliance of NIGERGAS to Industrial Health and Safety Standards

The model assigned 20 marks to Industrial Health and Safety. The parameter for determination of the rate of compliance is shown in table 7. Facilities in NIGERGAS were then inspected and scored accordingly. The result is presented in table 7.

Table 7: Industrial Health and Safety Analysis in NIGERGAS, Enugu

Parameters	Methodology	Maximum Point Obtainable	Points Obtainable	Deviation	Rate of Compliance	Rate of Non Compliance	Remark
Availability of Clinics and First Aid Boxes	Inspection / Observation	2.0	0.4	1.6	5.6%	14.4%	P00R
Availability of Fire Fighting Prevention Equipment / System	Inspection / Observation	2.0	0.4	1.6			POOR
Availability and use of Industrial Safety Devices	Inspection / Observation	2.0	0.8				
Availability of Facility for Solid Waste Management	Inspection / Observation	2.0	1.2	1.2			FAIR
Establishment of Pollution Monitoring Unit	Inspection / Observation	2.0	0.4	0.8			GOOD
Availability of list of Chemicals use in the Industry	Inspection / Observation	2.0	0.8	1.6			POOR
Availability of Pollution Responses Machinery & Equipment	Inspection / Observation	2.0	0.4	1.2			FAIR
Availability of FEPA Discharge Permit	Inspection / Observation	2.0	0.4	1.6			POOR
Availability of Pollution Prevention Equipment	Inspection / Observation	2.0	0.4	1.6			POOR
Evidence of Environmental Audit Report	Inspection / Observation	2.0	0.4	1.6			POOR

Source: Aniagolu (2009)

Table 7 clearly shows that out of the 20 marks assigned by the model, NIGERGAS scored 5.6 marks and lost 14.4 marks. This result shows that a lot desires to be done in NIGERGAS in term of Industrial Health and Safety.

7.6 Summary of the Parameters for E-Factor Model.

Summary of the results from air quality analysis, effluent discharge quality, soil element analysis and solid waste management system as well as noise pollution level are presented in table 8.

Table 8: Summary of the Results from E-Factor Analysis for NIGERGAS

S/No	Parameters	NIGERGAS	
		Compliance Rate %	Non-Compliance Rate %
1.	Air Quality	16.67	3.33
2.	Effluent Discharge	9.45	10.55
3.	Solid Waste Management	4.50	5.50
4.	Soil Quality	10.00	0.00
5.	Noise	20.00	0.00
6.	Industrial Health and Safety	5.60	14.40
	Total	66.22	33.78

Source: Aniagolu (2009)

This shows a rate of compliance of 66.22% and a rate of non-compliance of 33.78%.

7.7 Valuation of NIGERGAS Using the E-Factor Model.

The E-factor model as propounded by Aniagolu (2009) and demonstrated by Aniagolu, Iloeje and Emoh (2015) is as follows:

$CV = V_L + V_{BI} + V_{FF} + [(V_{PME} + V_{MV})$. E-factor]

Where:

CV = Capital Value of Industry
V_L = Value of Land
V_{BI} = Depreciated Replacement Cost of Buildings and Improvements
V_{FF} = Depreciated Replacement Cost of Furniture and Fittings
V_{PME} = Depreciated Replacement Cost of Plant, Machinery and Equipment
V_{MV} = Depreciated Replacement Cost of Motor Vehicles
E-Factor = Rate of Compliance of the Industry to Environmental Standards

Therefore, valuation of NIGERGAS using the E-factor model is as follows:

CV = ₦54,714,000 + ₦7,517,000 + [(₦39,595,000 + ₦10,020,000) x 0.662]
= ₦54,714,000 + ₦7,517,000 + [₦49,615,000 x 0.662]
= ₦54,714,000 + ₦7,517,000 + ₦32,845,130
= ₦95,579,980

This shows a reduction in value of about ₦16,266,020 (Sixteen Million, Two Hundred and Sixty Six Thousand and Twenty Naira) and 14.54% loss of value.

8.0 Discussion of Findings:

NIGERGAS Company Emene, Enugu, Nigeria was valued using the Conventional Cost Approach to Valuation. Messrs Frank Maluze and Associates interpreted the value of the company in 2001 to be ₦111,846,000 (One Hundred and Eleven Million, Eight Hundred and Forty-Six Thousand Naira). Since industries in Nigeria are heavy polluter of the environment proponents of environmental protection called for models that would consider environmental factor in valuation of industries. Aniagolu (2009) then developed the Environmental Factor Adjusted Cost Approach to Valuation or the E-factor model. The model considers the level of air, noise and soil pollutions generated by the industry, as well as the quality of effluent discharge and compliance to industrial health and safety standards. The model was then used to re-value NIGERGAS Company, Emene, Enugu, Nigeria.

The air quality analysis shows that NIGERGAS scored 16.67 marks out of the 20 marks assigned to air quality by the E-factor model. Also the quality of effluent discharge from NIGERGAS was also investigated. It was also discovered that out of the 20 marks assigned to effluent discharge quality, NIGERGAS scored 9.45 marks losing as much as 10.55 marks. Further, the soil quality of NIGERGAS was again investigated. The model assigned 10 marks each to soil element analysis and solid waste management system. NIGERGAS obtained 10 marks and 4.5 marks respectively. Furthermore, the noise level in the factory was compared with international standards. It was discovered that NIGERGAS score 20 full marks that the model assigned to noise pollution. Finally under industrial Health and Safety, NIGERGAS performed very poorly scoring 5.6 marks out of the 20 marks which the model assigned to Industrial Health and Safety.

At the end of our analysis NIGERGAS score a total rate of compliance of 66.22% loosing 33.78%. When the factory was then re-valued with the E-factor model the value of the factory came down to ₦95,579,980 (Ninety-Five Million, Five Hundred and Seventy-Nine Thousand, Nine Hundred and Eighty Naira only). This represents a loss of value of 14.54%.

9.0 Recommendations

NIGERGAS Company, Emene, Enugu, Nigeria was valued with E-factor model. The result shows a 14.54% loss in value due to the inability of NIGERGAS to meet up with international best practices in terms of environmental protection. It is therefore recommended that the E-factor model should be adopted by the Nigerian Institution of Estate Surveyors and Valuers (NIESV) for the valuation of industries and other facilities generating waste in Nigeria. Also the model should be integrated into the academic curriculum of Tertiary Institutions offering Estate Surveying and Valuation in Nigeria. Again the valuer in practice in Nigeria should adopt this model since it is not too academic. Finally, further research should be extended to integration of environmental considerations into other valuation models.

10.0 Conclusion

The valuation of NIGERGAS using the E-factor model reveals that the company does not comply with international best practices. The E-factor detected about 33.78% rate of non-compliance to WHO/FMENV Standards. This resulted in about 14.54% loss in value when the valuation figure from the conventional valuation is compared with the valuation figure obtained from the use of the E-factor model. Valuers as environmental protection advocates should therefore make extensive use of the model.

REFERENCES

[1]. Deane, T.M., Gray, R.N. and Steel, H.W. (1986); Real Estate Valuation. Progress, Publishing House, Enugu, Nigiera.
[2]. Baum, A.E. and Mackmin, D. (1989); The Income Approach to Property Valuation. 3rd Edition. Routledge, London.
[3]. OECD (1989); Environmental Policy Benefits: Monetary Valuation. Organisation for Economic Co-operation and Development, Paris, France.
[4]. Ogunba, A. O. (1999); Environmental Resource Valuation: New Challenges for Estate Surveyors and Valuers in 21st Century. A Paper Presented During 1999 NIESV National Conference in Calabar.
[5]. Bishop, R.C. (1982); Option Value: An Exposition and Extension, Land Economics. Vol.58, No.1, Pp1-15.
[6]. Aina, E.O.A. (1992): Environmental Considerations in the Valuation of Properties, Monuments and Artifacts and Expectations of FEPA from Estate Surveyors and Valuers. The Estate Surveyors and Valuer, July, 1992.
[7]. Aniagolu, C.O. (2009); A Model for Integrating Environmental Considerations into the Valuation of ANAMMCO and NIGERGAS in Emene Industrial Layout, Enugu Nigeria. An Unpublished Doctorial Research Thesis, ESUT, Enugu.
[8]. Aniagolu, C.O, Iloeje, A. F and Emoh, F. I.(2015); A Model for Integrating Environmental Considerations into the Valuation of Industries in Enugu Urban Area, Nigeria. International Journal of Engineering Research and Application Vol.5, Issue 6 (Part-3) June, 2015.
[9]. Odoziobodo, S.I. and Amam, W.I. (2007); Research Methodology for Social and Management Sciences. Ingenious Creation Services Ltd, Enugu, Nigeria.
[10]. Anyadike, R.N.C. (2009); Statistical Methods for Social and Environmental Sciences. Spectrum Books Limited, Ibadan, Nigeria.
[11]. NIGERGAS (1980); Key Facts about NIGERGAS Company Limited. Industrial and Medical Gas Producers" Information Leaflet, Enugu, Nigeria.
[12]. Kalu, I.U. (2002); Valuation: An Economic Contribution to Environmental Degradation Remediation. The Estate Surveyor and Valuer, Vol.25, No.1, pp26-31.
[13]. Frank Maluze & Associate (2001); Report on Valuation of Assets of NIGERGAS Limited, Emene, Enugu Nigeria. December 2001.

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Deformation and Tribological studies of A356 Slag Reinforced Composites

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ABSTRACT: BF Slag is a major unwanted material during production of iron in the blast furance process. It comprises of oxides of iron, Al_2O_3 and silica along with some other minor constituents. Based on economics as well as environmental related issues, lot of efforts has been directed worldwide towards BF slag management issues i.e. of utilization, storage and disposal. In this paper an attempt has been made to reinforce the BF slag in aluminium silicon alloy A356, to prepare light weight composites. The hardness and compressive strength of the composites were determined as a function of the BF slag content. The best results were achieved with the aluminum composites with 5 wt. % slag.
Keywords: Blast furnace slag (BF slag), aluminium silicon alloy

1. INTRODUCTION

Metal Matrix composites (MMCs) are becoming beckoning materials for advanced aerospace and automobile and naval structures because of their properties can be tailored through the addition of selected reinforcements [1, 2]. In particular particle reinforced MMCs have found special interest because of their high specific strength and specific stiffness at room or elevated temperature. Normally micron sized ceramic particles are used as reinforcement to improve the properties of the MMCs. Ceramic particles have low coefficient of thermal expansion (CTE) than metallic alloys, and therefore incorporation of the these ceramic particles may exist interfacial mismatch between matrix and reinforcement. This phenomenon may be higher for high ceramic particle concentration. Among various dispersoids used, BF slag is one of the most inexpensive reinforcement available in large quantities as solid waste by-product during melting of pig iron.

2.0 MATERIALS AND METHODS

2.1 Matrix Material

In the present work, A356 alloy (Al-Si alloy), supplied by M/s Synergies Dooray automotives limited, Visakhapatnam, and is used as matrix material.

Table 1: Chemical composition of A356 alloy, wt. %

Si	Mg	Cu	Ti	Zn	Fe	Al
6.5	0.4	0.05	0.06	0.03	0.09	Balance

2.2: Fabrication of Composites

In the present investigation, aluminium based metal matrix composites containing 5, 10 and 15wt% BF slag particulates of 125 µm were successfully synthesized by vortex method. The matrix materials used in this study was A356 alloy (Al-Si alloy) whose chemical composition was shown in table 1.

The fabrication of these composites was carried out by stir casting technique. The cylindrical fingers (20 mm Φ and 150 mm length) of A356 alloy were taken into a graphite crucible and melted in an electric furnace. After maintaining the temperature at 790 °C, a vortex was created using mechanical stirrer. The preheated slag particulates were added slowly in the vortex.. The molten metal was stirred at 600 rpm under nitrogen gas cover. The stirring was continued for about 5 minutes after addition of particles for uniform distribution in the melt, after casting, cast ingots of both alloy and composites were homogenized at 200 ^{0}C for 24hrs to get relieve the internal stresses and minimize the chemical inhomogenities which may be present in the cast condition.

2.3: Characterization of Composites

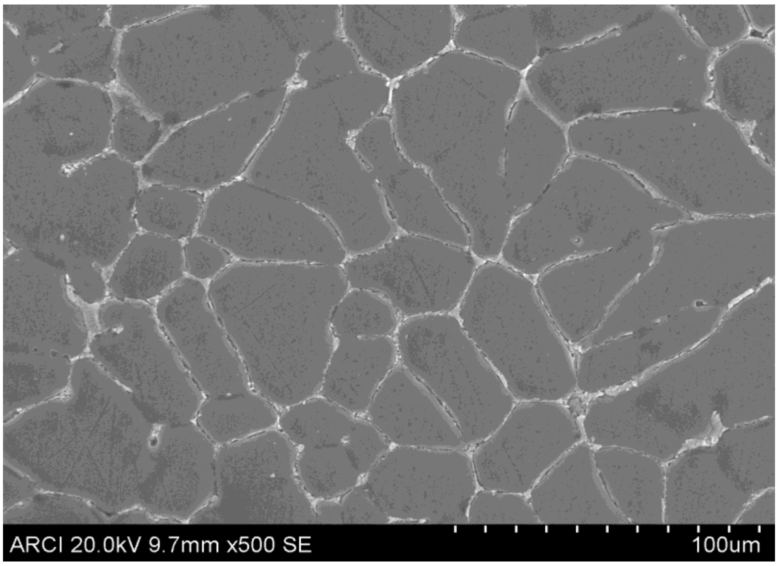
2.3.1: Metallography and Hardness tests

Scanning electron microscopy with Energy dispersive X-ray spectroscopy (EDS) was used in order to evaluate the morphological changes and the elemental analysis of the alloy and the composites. The hardness of the alloy and composite was evaluated by using Vickers hardness tester. An average of 12 readings was taken for each hardness value.

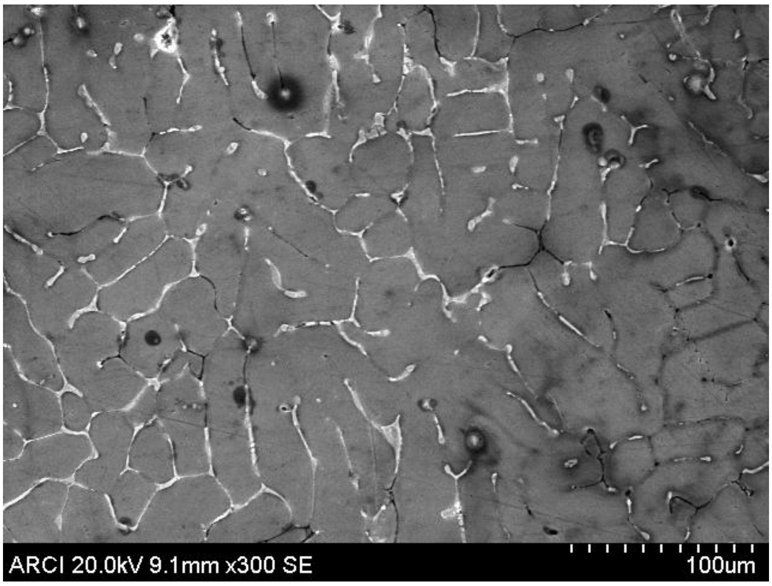
3 RESULTS AND DISCUSSION

a. Microstructures and EDS of alloy and composites

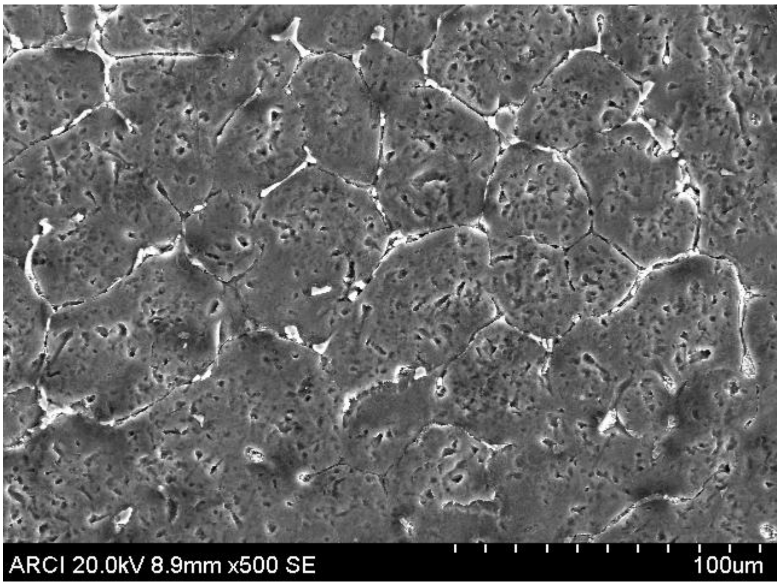
Figure 1 (a-d) shows the SEM and optical micrographs of alloy and composites, it is evident from the microstructures that interdendritic regions (IDRs) were formed, and also the distribution of slag particulates was uniform throughout. Similarly, the reinforcement phase shows only the constituents, such that no contamination has occurred. Since, perfect shielding of nitrogen gas is maintained, traces of oxygen is not seen either with the matrix or the reinforcements



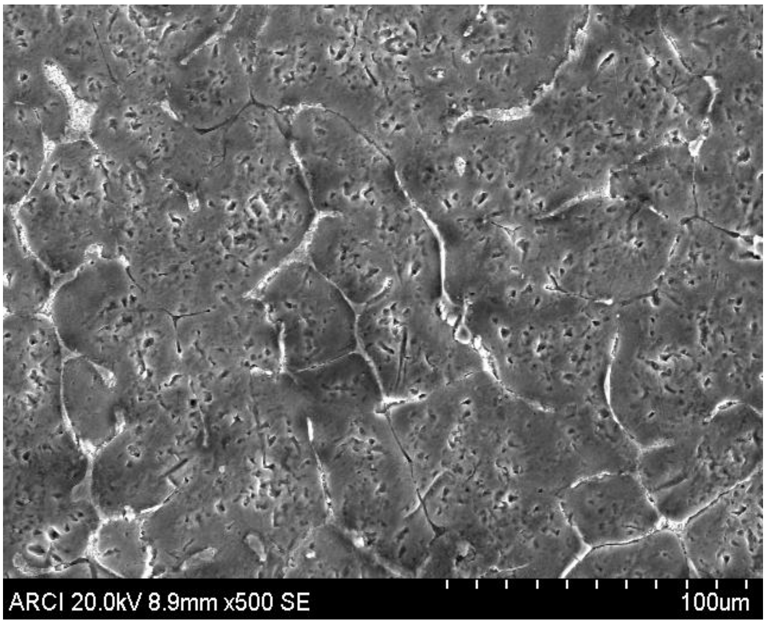
(a)



(b)



(c)



(d)

Figure 1: (a) A356 base at 100X **(**b) A356 –5% COMPOSITE at 100X (c) A356 10% COMPOSITE at 100X (d) A356 –15% COMPOSITE at 100X

4. CONCLUSIONS

[1]. A356/BF slag composites were produced by stir casting route successfully.
[2]. There was a uniform distribution of particles in the matrix phase.
[3]. From the SEM figures, it clearly shows that there were no voids and discontinuities in the composites; there was a good interfacial bonding between the FA/SiC particles and matrix phase.
[4]. From the EDX analysis of composites shows that no oxygen peaks were observed in the matrix area, confirming that the fabricated composite did not contain any additional contamination from the atmosphere. This might be due to a shield of nitrogen gas was maintained during the mechanical stirring while reinforcement addition.
[5]. The hardness of the composites increased with increasing the amount of FA/SiC than the base alloy.

ACKNOWLEDGMENTS

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REFERENCES

[1]. R.K. Everett, and R.J.Arsenault, Metal Matrix Composites; Mechanisms and Properties, 1991 (Academic Press, San Diego).

[2]. M.J. Kocjak, Kahtri S.C, J.E. Allison. Fundamentals of Metal Matrix Composites (Eds S. Suresh, A. Mortensen and A. Needleman), 1993 (Butterworth-Heinemann, Boston).

[3]. Hassan S. F, Gupta, M, Development of high strength magnesium copper based hybrid composites with enhanced tensile properties, *Materials Science and Technology*, 19 (2003) 253-259.

[4]. Ma, NG, Deng, CJ, Yu, P, Kwok, WY, Aravind, M, Ng, DHL, Chan, SLI, Formation of Mg-Mg_2Cu nanostructured eutectic in Mg-based metal matrix composite, Journal of Materials Research, 188. (2003)1934-1942

[5]. Wu G.H., Dou Z. Y., Jiang L. T., Cao J. H., 2006, Damping properties of aluminium matrix – fly ash composites, *Materials Letters*, **60**: 2945-2948.

[6]. Davis Joseph R. ASM specialty hand book, aluminum and aluminum alloys. ASM International; 1993

[7]. Mondolfo L. F., "Design Aluminium alloys: Structure and properties", Butterworth and Co (Publishers) Ltd. London, (1976) 253.

[8]. Babu Rao J. Syed Kamaluddin, Appa Rao J., Sarcar M. M. M., Bhargava N.R.M.R., "Deformation behavior of Al–4Cu–2Mg alloy during cold upset forging", Journal of Alloys and Compounds, Vol. 471, 2009, pp. 128-136.

[9]. Babu Rao J, Venkata Rao D, Narasimha Murthy I., and Bhargava NRMR, "Mechanical properties and corrosion behaviour of fly ash particles reinforced AA 2024 composites", International Journal of Composite Materials (ISSN: 0021-9983)" – Vol.46(12), 2011, pp.1393-1404.

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Three Dimensional Analysis Of Fits And Effect Of Layer Orientation In Laminated Composites Under Press Fits For Static And Dynamic Stability

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Abstract: Fits plays important role in structural integrity, load carrying capacity and vibrations. Proper fit increases the life of the joint. In the present work, an analysis has been carried out to find effect of fit on radial stress and contact pressure for Aluminum and composite materials. A three dimensional modeling approach is consider studying contact nature, loading carrying capacity and induced stresses. Also stress distribution is calculated for different layer orientation of composite materials. Finally modal analysis is carried out to find the dynamic stability of the structure. A system with higher natural frequency is considered as more stable compared to lower frequency system. The analysis results shows higher natural for interference fits compared to the clearance and push fits. Similarly composite structure modal analysis results indicate, dynamic stability is a function of layer orientation. This conclusion is very important in usage of composites for dynamic structure. A through analysis is required for improving the dynamic stability of the composites.
Key Words: *Structural integrity, Dynamic stability, fatigue damage. Modal analysis, induced stress*

Introduction

A composite is structural materials which consist of combining two are more constituent. The constituent are combined at a microscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fires, partials or flakes. The matrix phase materials are generally continues. Example of composite system include concert Reinforced with steel, epoxy reinforced with graphite fibers, etc.

Steps Used for the analysis of problem in FEM are:

- **Pre-processing**
  It is the act of preparation of data such as nodal locations, element connectivity co-ordinates imposing boundary condition application of load and providing material.
  Information to element and etc. one can decide in this stage regarding the no. of nodes, elements, types with their order and the pattern of FH mesh.
- **Processing**
  This stage of involves stiffness generation, strain energy calculation and solution of equations resulting in the evolution of nodal variables, induced elemental forces, strains and stresses.
- **Post –processing**
  The geometric deformation and distribution of forces, stresses and strain in the structure. Here the aspect of plotting a displaced plotting nodal data in the form of contour plots, such as isotherms and isobars, and conversion of element oriented data into best fitting nodal values is discussed.
  Preprocessing and post processing are integral parts of finite element analysis. The general purpose mesh generation scheme can model a variety of complex regions. The node numbering gives spars matrices and in many cases should give minimum band width proper block representation. Mesh plotting shows the element layout.

2. Problem Definition and Scope of Present Work:

2.1 Definitions:

Analysis of push fit, interference fit and clearance fit pin joints by using laminated composites and modal analysis of the three different fits is the main objective of the problem.

2.2 Requirements:

In mechanical engineering, there are multiple methods for fastening objects together. A pin joint is a solid cylinder-shaped device, similar to a bolt, which is used to connect objects at the joint area. This type of joint connection allows each object to rotate at the point of joint connection.

Most mechanical devices that require bending or opening typically use a pin joint. These joints can be welded solid or allow movement between the two connected objects. A door hinge is a simple example of a free-moving pin joint. The hinge has a pin that allows the door to connect and open freely in the door jam. In this design, the pin is the only device holding the door hinge to the door jam.

A steel-framed truss bridge is an example of a solid-welded pin joint. These bridges have steel beams of multiple angles that are connected together with solid pins. These pins allow the connection of severe angles within the bridge support systems. The solid pins are typically bolted together at the joint area and welded tight. This adds strength and prevents the joints from collapsing under stress.

- Finite element modeling of laminated composite plate using Ansys.
- Comparative strength study of aluminum and composite members.
- Effect of layer orientation on the structural strength.
- And effect of dynamic strength of composites and aluminum can be predicted by using modal analysis.

2.3 Geometrical Models of Plate with Different Fit Joints:

(a) Push fit (b) Interference fit: (c) Clearance fit

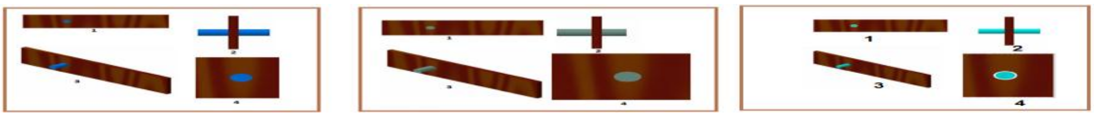

Fig 2.3: Geometrical models

The figure 2.3(a): shows geometrical modeling of problem. A push fit (**same** diameter of plate hole and pin used), An interference fit (diameter of plate hole is **less than** the pin used, A clearance fit (diameter of plate hole is **greater than** the pin used) in pin joint. The configuration is shown above.

2.4 Methodology:

- Modeling for the dimensions using ANSYS software using mixed approach.
- 2 Dimensional Meshing and extruding to form three dimensional mesh of the components of assembly.
- Analysis of the problem for aluminum properties.
  Analysis of the same problem with composite (glass epoxy resin) properties.
- Contact definition between shaft and the plate.
- Nonlinear analysis of the problem by defining yield point to find failure load.
- Comparison of strength between aluminum and composite members.
- Analysis for push and interference fits.
- Failure predictions for composite materials
- Dynamic strength of aluminium & composite member and comparison.
- Results presentation.

2.5 Meshed Plot:

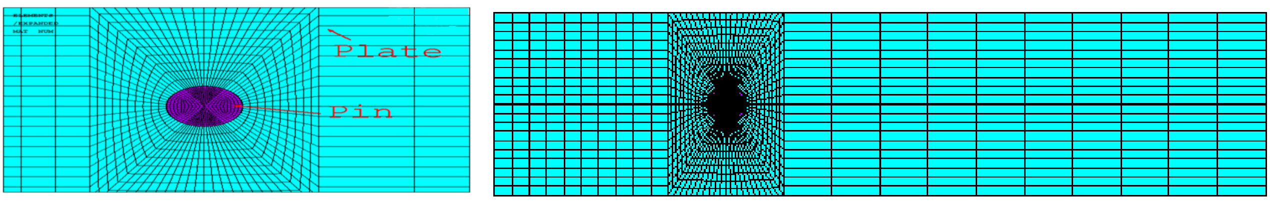

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Fig 2.5: Meshed Model of the problem.

The above figure shows pin surface extraction from the geometry using hyper-mesh. The pin joint are solid meshed and pined plate mesh to apply the composite properties.

2.6 Boundary Conditions Plot

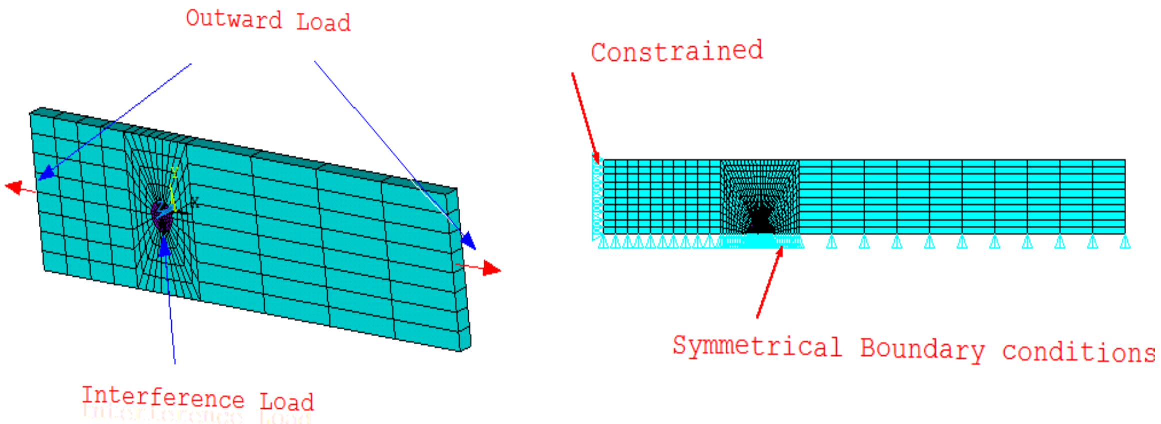

Fig 2.6: Geometrical models boundary conditions

Figure 2.6 (a): shows the boundary condition for outward and interference load in plate with pin joints and symmetrical boundary condition for outward and interference load in half plate with pin joints.

3.Results and Discussions

The composites usage of different pin joints is demonstrated and results are presented. The analysis process is divided as follows.

- Analysis based on aluminum material up to the failure load.
- Composite analysis for the same load and the maximum strength.
- Analysis up to failure of the structure.
- Modal analysis is carried out, and the results are presented for aluminium member and composite member.

3.1 Assumptions:

- ✓ The material is considered are isotropic material.
- ✓ Laminated composite member have different degrees of layer orientation.
- ✓ All FEM approximations are applied for the problem.
- ✓ Mid surface extracted for analysis.

3.2 Different Pin Joints with Zero Loads:

3.2.1 Clearance Fit:

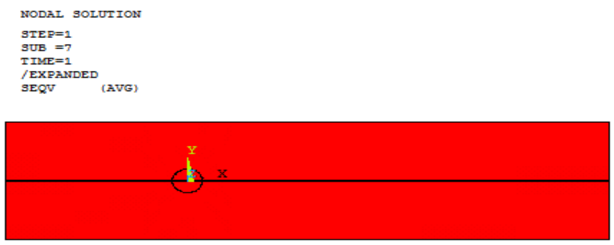

Fig 3.2.1: Clearance fit

The above figure shows Clearance fit with no external load. The maximum structural deformation is around zero which indicates no stress in the member.

3.2.2 Push Fit:

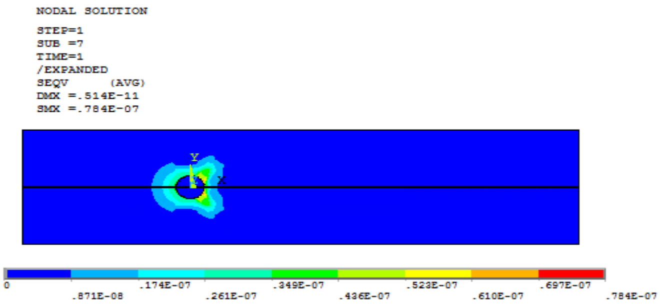

Fig 3.2.2: Push fit

The above figure shows push fit with no external load. The maximum structural deformation is around 0.514E-11mm and the stress developed is 0.78E-07 Mpa

3.2.3 Interference Fit (Interference Value=0.01):

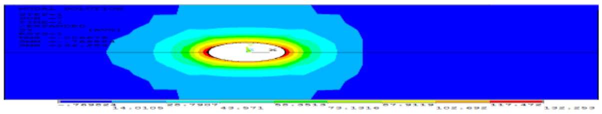

Fig 3.2.3: Interference fit

The above figure shows interference fit with no external load. The maximum structural deformation is around 0.006676mm and the stress developed is 132.253 Mpa.

3.2.4 Stress in pin (0.01 Interference):

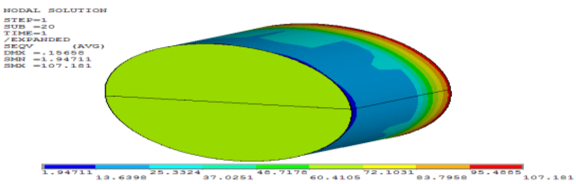

Fig 3.2.4: Stresses in pin - interference pin joint

The above figure shows stresses in pin for interference pin joint. The maximum structural deformation on pin is around 0.15658mm and the stress developed is 107.181Mpa

3.2.5 Stress in plate (0.01 Interference):

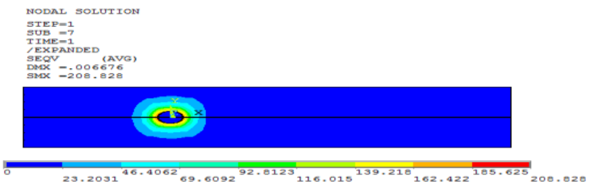

Figure 3.2.5: Stresses in plate - Interference pin joint.

The above figure shows stresses in plate for Interference pin joint. The maximum structural deformation in plate is around 0.006676 mm and the stress developed is 208.828 Mpa.

3.2.6 Contact pressure

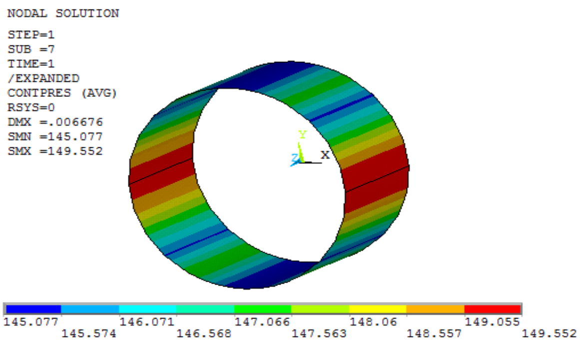

Figure 3.2.6: Circumferential contact pressure - interference fit

The above figure shows circumferential contact pressure between pin and plate. The maximum structural deformation is 0.155806mm and the contact pressure is 149.5 N/mm^2.

3.2 Tabular Representation – zero Load

Type of Fit	Contact Pressure(Mpa)	Radial Stress(Mpa)
Clearance Fit	**0**	**0**
Push Fit	**0**	**0**
Interference Fit(0.01)	**149.5**	**149.5**

Table 3.2: Tabular representation of contact pressure & radial stress for different fits at Zero Load

The results shows contact pressure development of 149.5N/mm2 at the interface. Almost equal contact pressure across the interface can be observed in the figure. The contact pressure shows joint strength. Higher contact pressure indicated higher joint strength. Few times, the joints are press-trussed to almost 80% of yield strength to increase the load carrying capacity.

3.3 Interference And External Load

Type of Fit	Radial Stress		Hoop Stress	
	180^0	90^0	180^0	90^0
Clearance Fit	25	-1	-52	198.4
Push Fit	24	-20	4.707	29
Interference Fit	0	-95	17	10

Table 3.4: Tabular representation of contact pressure & radial stress for different fits at External Loads

4. Conclusion

- For the first time, an analysis has been carried out for fits in three dimensional domain which is difficult compared to the two dimensional analysis due to convergence problems.
- Initially a two dimensional mesh is carried out and later converted to three dimensional meshing using solid185 element which is suitable for both isotropic and composite materials.
- Radial and hoop stress plots are represented across the interface between pin and the plate. In the analysis, pin is assumed as rigid. The analysis results give insight of stress distribution, contact pressure by which separation regions can be identified. Uneven contacts automatically reduce the load carrying capacity.
- The plots indicates initial higher radial stress due to interference helps in higher load carrying capacity as it induces compressive stresses in the structure. The external loads have to exceed these stresses to

put the members in tension. Tension stress is not desirable in the structure, it indicates separation and also the source for fatigue cracks.

- Also composite analysis with different orientation of the layer orientation gives insight of contact and radial stress distribution in the joints. The results indicate non-uniform contacts between the members with composites. So special care should be considered for composite usage in pin joints.
- Nonlinear distribution of contact pressure and radial stresses along with unpredicted hoop stress distribution complicates composite design in the joint regions. So special focus should be taken during composite design to provide higher compressive stresses which will increase the load carrying capacity of the joint. For certain orientation, the stress is becoming tensile which indicates separation of the joint.
- Modal Analysis is also carried out to find the dynamic stability of the structures. The results show higher natural frequencies with increased interference.
- Compared to clearance and push fits, interference fit shows higher nature frequencies indicating higher stiffness in the structure for the same mass distribution.
- Composite modal analysis results also shows depends of dynamic stability on the layer orientation. The results shows complete variation of modal results with change in layer orientation. So a proper study is important before using the composites for dynamic problems.

REFERENCES

[1]. Shigley, Joseph E., Mechanical Engineering Design, McGraw-Hill, 1977, 3 rd edition
[2]. Norton, Robert L., Machine Design – An Integrated Approach, Prentice-Hall: New Jersey, 1998, 2 nd printing
[3]. Levinson, Irving J., Machine Design, Reston Publishing: Virginia, 1978, 1 st printing
[4]. Spotts, M. F., Design of Machine Elements, Prentice-Hall: New Jersey, 1978, 5 th edition
[5]. Adams, Vince, and Askenazi, Abraham, Building Better Products with Finite Element Analysis, On Word Press: New Mexico, 1999, 1 st printing
[6]. Sopwith, D. G., "The Distribution of Load in Screw-Thread," Institution of Mechanical Engineers, Proceedings, Vol. 159, No. 45, pp. 373-383, 1948
[7]. Advances in Structural Testing, Analysis & Design, Vol. I, II & III, T.S. Ramamurthy and others, Eds., Pubs: Tata McGraw-Hill Publishing Company Limited, 1990.
[8]. Finite element determination of contact stresses in engineering problems', (B.Dattaguru, T.S.Ramamurthy & A.K.Rao), J Ae S I Vol 37(4), pp 347-355, 1985.
[9]. Analysis of interfence fit pins in composite plates', (T.S.Rama murthy), Proc. 3rd Tech. Conf on Composite matls, American Soc. for Composites & Univ. of Washington, Seattle, pp 623-632, 1988
[10]. Analysis of interference fit pins in composite plates: Nonlinear behaviour under bypass loading', (T.S.Ramamurthy), Paper 89-1231,Proc. 30th SDM Conf. (AIAA), Vol 2, pp 653-651, Mobile, AL, 1989.
[11]. Recent studies on the behaviour of interference fit pins in composite plates', (T.S.Ramamurthy), Composite Structs an Int J, Vol 13 (2), pp 81-99, 1989.
[12]. Analysis of pin joints under bypass loads', (T.S.Ramamurthy), AIAA J, Vol.28 No.10, pp 1800-1805, 1990.
[13]. Design and analysis of bolted joints in compositees', T.S. Ramamurthy and B. Dattaguru, Proc. of Indo-US Workshop on composites for Aerospace applications, Vol. II, pp69-74, 1990.
[14]. Concepts and Application of Finite Element Analysis Rober D. Cook, David S – Joh Wiely & Sons Pte. Ltd. Fourth Edition 2003.
[15]. Finite Element Procedures – Klaus-Jurgen Bathe, Prentice Hall of India Pvt. Ltd.- Sixth Edition 2002
[16]. Finite Elements in Engineering – Tirupathi R. Chandrupatla, Ashok D. Belegundu, Prentice-Hall of India Pvt. Ltd, 2003
[17]. Introduction to the Finite Element Method, Desai/Abel – CBS publishers 2002 Finite Element Analysis – C.S. Krishnamoorthy, Second Edn, TMH - 2002

DESIGN AND ANALYSIS OF DISCONE ANTENNA

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ABSTRACT:A discone antenna is a version of a biconical antenna in which one of the cones is replaced by a disc. It is usually mounted vertically, with the disc at the top and the cone beneath. A discone antenna is a version of a biconical antenna in which one of the cones is replaced by a disc. It is usually mounted vertically, with the disc at the top and the cone beneath. Omnidirectional, vertically polarized and exhibiting unity gain, it is exceptionally wideband, offering a frequency range ratio of up to 10:1.The radiation pattern in the vertical plane is quite narrow, making its sensitivity highest in the plane parallel to the Earth. The discone's wideband coverage makes it attractive in commercial, military, amateur radio and radio scanner applications. The radiation fields of the discone antenna with an oblique cone can be derived from the fields of an equivalent Huygens source on the aperture. For a symmetrical discone antenna, the numerical and experimental radiation patterns are presented. For an asymmetrical discone antenna with an oblique cone, the radiation patterns are also presented. The curves of the front-to-back ratio on the patterns of the horizontal plane are shown for various oblique cone shapes.

Keywords: Discone Antenna, Omnidirectional, Sensitivity.

I.INTRODUCTION:

An antenna (or aerial) is an electrical device which converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an electric current oscillating at radio frequency (i.e. high frequency AC) to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a receiver to be amplified. Typically an antenna consists of an arrangement of metallic conductors (elements), electrically connected (often through a transmission line) to the receiver or transmitter. An oscillating current of electrons forced through the antenna by a transmitter will create an oscillating magnetic field around the antenna elements, while the charge of the electrons also creates an oscillating electric field along the elements. These time- varying fields radiate away from the antenna into space as a moving transverse electromagnetic field wave conversely, during reception, the oscillating electric and magnetic fields of an incoming radio wave exert force on the electrons in the antenna elements, causing them to move back and forth, creating oscillating currents in the antenna. Antennas may also include reflective or directive elements or surfaces not connected to the transmitter or receiver, such as parasitic elements, parabolic reflectors or horns, which serve to direct the radio waves into a beam or other desired radiation pattern. Antennas can be designed to transmit or receive radio waves in all directions equally.

Antennas are required by any radio receiver or transmitter to couple its electrical connection to the electromagnetic field. Radio waves are electromagnetic waves which carry signals through the air (or through space) at the speed of light with almost no transmission loss. Radio transmitters and receivers are used to convey signals (information) in systems including broadcast (audio) radio, television, mobile telephones, wi-fi (WLAN) data networks, trunk lines and point-to-point communications links (telephone, data networks), satellite links, many remote devices such as garage door openers, and wireless remote sensors, among many others. Radio waves are also used directly for measurements in technologies including RADAR, GPS, and radio astronomy. In each and every case, the transmitters and receivers involved require antennas, although these are sometimes hidden (such as the antenna inside an AM radio or inside a laptop computer equipped with wi-fi).

According to their applications and technology available, antennas generally fall in one of two categories:

1) Omnidirectional or only weakly directional antennas which receive or radiate more or less in all directions. These are employed when the relative position of the other station is unknown or arbitrary. They are also used at lower frequencies where a directional antenna would be too large, or simply to cut costs in applications where a directional antenna isn't required.

2) Directional or beam antennas which are intended to preferentially radiate or receive in a particular direction or directional pattern.

II.DISCONE ANTENNA

A discone antenna is a version of a biconical antenna in which one of the cones is replaced by a disc. It is usually mounted vertically, with the disc at the top and the cone beneath. Omni directional, vertically polarized and exhibiting unity gain, it is exceptionally wideband, offering a frequency range ratio of up to ~10:1. The radiation pattern in the vertical plane is quite narrow, making its sensitivity highest in the plane parallel to coverage makes it attractive in commercial, military, amateur radio and radio scanner applications.

When employed as a transmitting antenna, it is often less efficient than an antenna designed for a more limited frequency range. SWR (standing wave ratio) is typically ~2:1 over the range of the design frequency to the second harmonic and ~3.1 thereafter. A discone antenna typically has at least three major components: the the cone, and the insulator. The disc should have an overall diameter of 0.7 times a quarter wavelength of the antenna's minimum frequency. The antenna's feed point is at the center of the disc. It is usually fed with 50 Ω coaxial cable, with the center conductor connected to the disc, and the outer conductor to the cone. The length of the cone should be a quarter wavelength of the antenna's minimum operating frequency. The cone angle is generally from 25 to 40 degrees. The disc and cone must be separated by an insulator. In order to extend low-frequency response, a vertical whip may be placed affixed vertically to the disc. But this may reduce efficiency at higher frequencies. In this configuration, at lower frequencies the discone may more closely resemble a ground plane antenna or a coaxial dipole.

Description:

The discone antenna has a useful frequency range of at least 10 to 1. When employed as a transmitting antenna, it is often less efficient than an antenna designed for a more limited frequency range. A discone antenna consists of three main parts: the disc, the cone, and the insulator.

1. **The Disc**: The disc should have an overall diameter of 0.7 times a quarter wavelength of the antenna's lowest frequency. The antenna's feed point is at the center of the disc. It is usually fed with coaxial cable, with the center conductor connected to the disc, and the outer conductor to the cone.
2. **The cone**: The length of the cone should be a quarter wavelength of the antenna's lowest operating frequency. The cone angle is generally from 25 to 40 degrees.
3. **The insulator**: The disc and cone must be separated by an insulator, the dimensions of which determine some of the antenna's properties, especially on near its high frequency limit.

III.CONSTRUCTION AND ANALYSIS

A discone may be made from solid metal sheet (often copper), which is practical for small indoor UHF antennas, such as for Wi-Fi. At lower frequencies a sufficient number of metal wires or rods in a spoke configuration is often used to approximate a solid surface. This simplifies construction and reduces wind loading. The spokes may be made of stiff wire, brazing rods or even coat hanger wire. The optimal number of rods comprising the disc and cone is often quoted as being from 8 to 16.

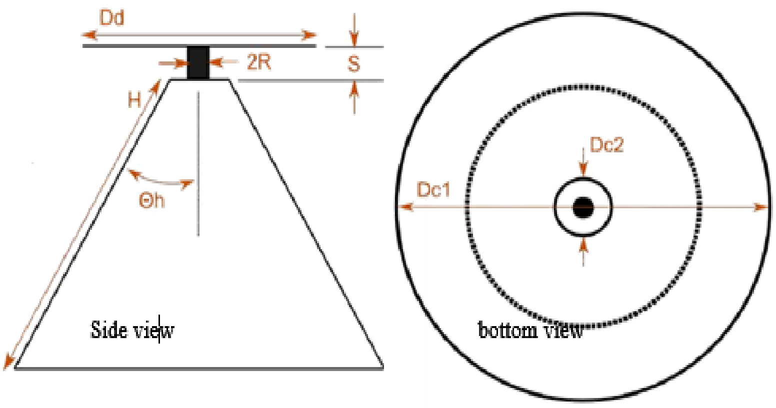


Figure 1: Discone Antenna side and bottom views

Parameters of Discone Antenna:

Name	Description
F_0	Center frequency
D_d	Disc diameter
R	Feed pin radius
S	Gap between cone and disc
Dc2	Diameter of the narrow side of the cone
H	Length of the cone side
Dc1	Diameter of the broad side of the cone
X	Diameter of the antenna
Y	Diameter of the antenna
Z	Height of the antenna
□h	Cone flare angle

IMPLEMENTATION

Design objective

Name	**Description**	**Value**
f0	Centre frequency	15.13GHZ

Physical parameters

Name	**Value**
D_d	9.851 mm
R	35.24 µm

S	52.86 µm
Dc2	176.2 µm
Dc1	14.07mm

Derived quantities

Name	**Value**
X	14.07 mm
Y	14.07 mm
Z	12.29 mm
□h	29.59^{o}

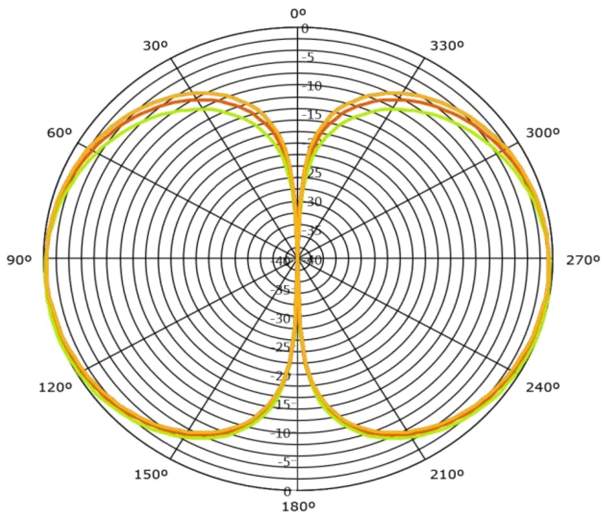
IV.RESULT

Radiation pattern in accordance with the arbitrary variations of H,R,S as followed.

Name	**Description**
H1	14.07 mm
H2	16.15 mm
H3	18.14 mm
R1	30.6 µm
R2	34.96 µm
R3	38.76 µm
S1	77.80 µm
S2	44.82 µm

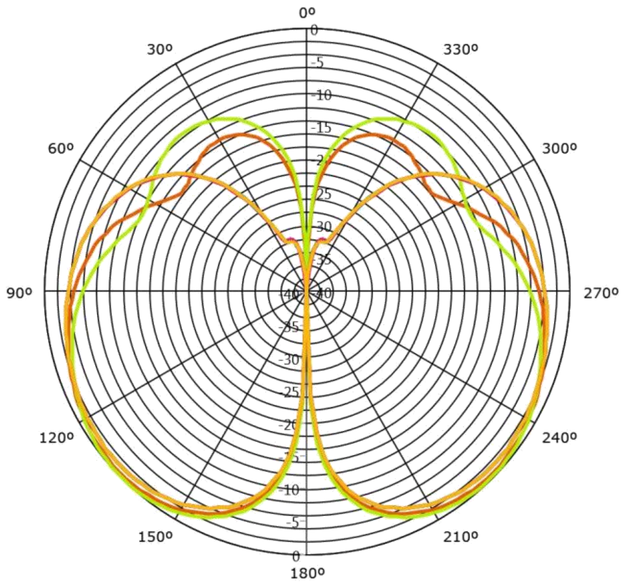
Radiation pattern of minimum frequency

Gain (Total-normalized)



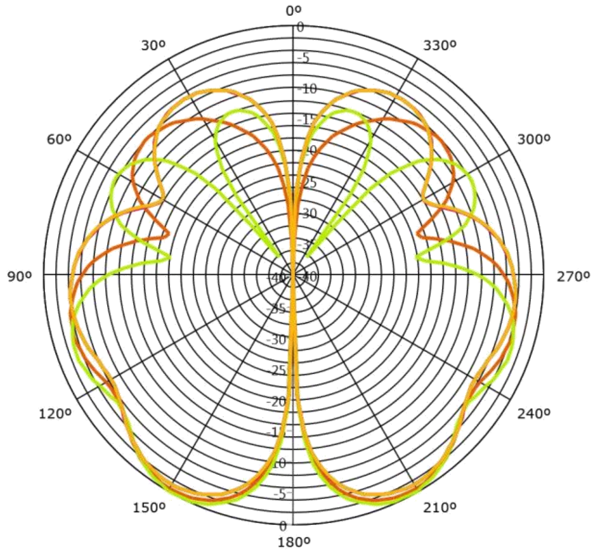
	H1	**H2**	**H3**	**R1**	**R2**	**R3**	**S1**	**S2**
Peak gain @ angle (freq) [□ = 0 °]	1.708 dBi @ θ = 98 ° (7.563 GHz)	1.897 dBi @ θ=102 ° (7.563 GHz)	2.170 dBi @ θ=-106° (7.563 GHz)	1.708 dBi @ θ=98° (7.563 GHz)	1.708 dBi @ θ = 98 ° (7.563 GHz)	1.708 dBi @ θ = 98 ° (7.563 GHz)	1.709 dBi @ θ=-98 ° (7.563 GHz)	1.707 dBi @ θ = 96 ° (7.563 GHz)
Main 3dB beamwidth (freq) [□ = 0 °]	91.93 °	86.75 °	80.38 °	91.94°	91.94 °	91.94 °	91.89 °	91.94 °

Radiation pattern at center frequency:



	H1	**H2**	**H3**	**R1**	**R2**	**R3**	**S1**	**S2**
Peak gain @ angle (freq) [φ = 0 °]	3.114 dBi @ θ=-132° (15.13 GHz	3.861 dBi @ θ=134° (15.13 GHz)	4.254 dBi @ θ=136° (15.13 GHz)	3.115 dBi @ θ=132° (15.13 GHz)	3.115 dBi @ θ=-132° (15.13 GHz)	3.115 dBi @ θ=132° (15.13 GHz)	3.122 dBi @ θ=-132° (15.13 GHz)	3.112 dBi @ θ=132° (15.13 GHz)
Main 3dB beamwidth (freq) [φ = 0 °]	71.48 °	59.54 °	52.97 °	71.48 °	71.48 °	71.48 °	71.35 °	71.53 °

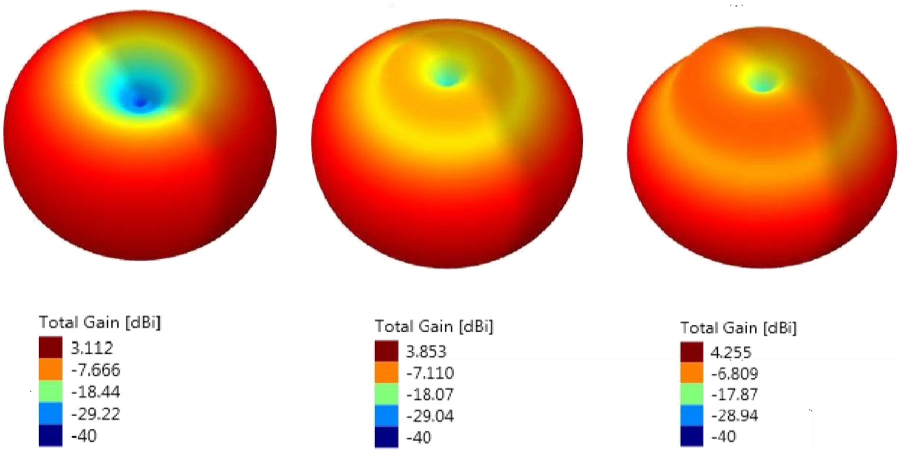
Radiation pattern at maximum frequency



	H1	H2	H3	R1	R2	R3	S1	S2
Peak gain @ angle (freq) [φ = 0 °]	4.503 dBi @ θ=150° (22.69 GHz)	5.238 dBi @ θ=-152° (22.69 GHz)	5.714 dBi @ θ=152 ° (22.69 GHz)	4.504 dBi @ θ=150 ° (22.69 GHz)	4.504 dBi @ θ=-150° (22.69 GHz)	4.505 dBi @ θ=150° (22.69 GHz)	4.508 dBi @ θ=150 ° (22.69 GHz)	4.501 dBi @ θ=150° (22.69 GHz)
Main 3dB beamwidth (freq) [φ = 0 °]	33.30 °	31.33 °	29.58 °	33.30 °	33.30 °	33.30 °	33.30 °	33.30 °

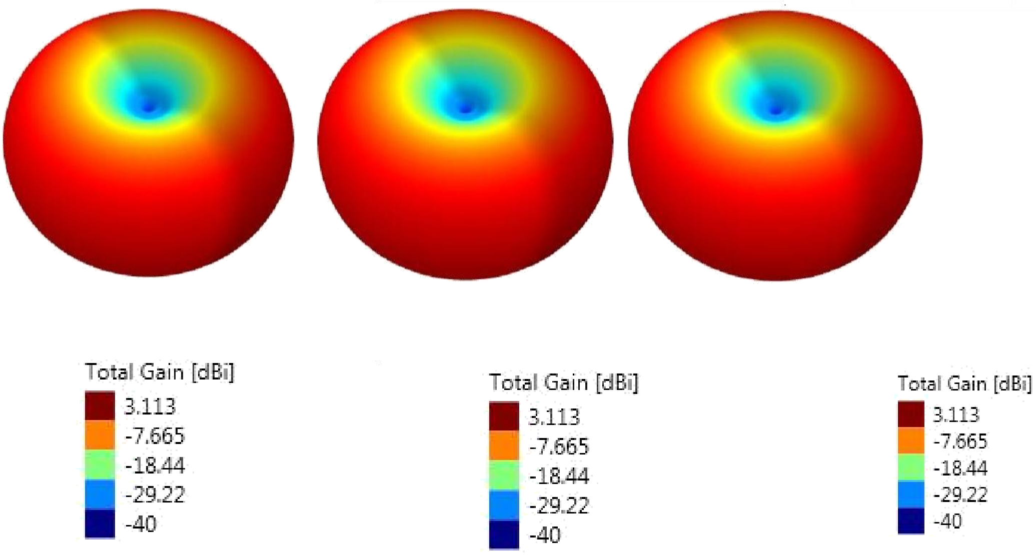
Radiation by varying length of the cone:

When h=14.07mm,16.15mm,18.14mm



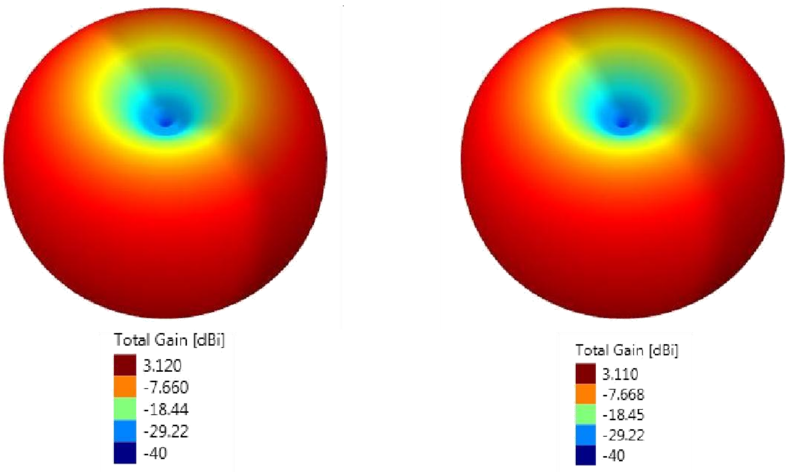
Radiation by varying feed pin radius:

When R=30.16µm,34.96µm,38.76µm



Radiation by Varying gap between Cone and feed pin radius:

When S=77.80µm,44.82µm



IV.CONCLUSION

The radiation pattern of the disccone antenna varies in accordance with the length of the cone side of the disccone antenna. The length of the cone side and its radiation pattern (gain) are inversely related. The gain pattern of the disccone antenna doesn’t depend on the feed pin radius. There is a slight variation observed with the change in gap between cone and disc. Gain of the antenna varies in proportion with gap between cone and disc. The discone's wideband coverage makes it attractive in commercial, military, amateur radio applications. The discone's inherently wideband nature permits it to broadcast undesirable spurious emissions from faulty or improperly filtered transmitters.

REFERENCES

[1]. Analysis of Variation of Various Parameters on Design of Discone Antenna by

[2]. Optimization of a Broadband Discone Antenna Design and Platform Installed Radiation Patterns Using a GPU-Accelerated Savant/WIPL-D Hybrid Approach Tod Courtney1 , Matthew C. Miller1 , John E. Stone2 , Robert A. Kipp1

[3]. Antenna Magus, an design tool

[4]. Antenna Theory - Analysis and Design by Constantine A. Balanis.

[5]. A Spherically capped discone antenna for ultra wideband operation by Debalina Goshi, Tapank Sarkari, Ericl Mokole.

[6]. White Paper Discone Antenna design by Bill Pretty.

[7]. Novel Ultra Wide Discone antenna by Jinu Kim and Seong Ook Park.

[8]. Broadband radial discone antenna: Design, application and measurements by N. I. Yannopoulou, P. E. Zimourtopoulos, E. T. Sarris.

[9]. Design of UHF miniature discone antenna by Wei Yan

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Modest Formalization of Software Design Patterns

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ABSTRACT: Formalization is the document form of formalism, where the practical compositional elements are represented by the symbols and variables. The Software Requirement Specification is documented in such a way that it breaks the deliverables into smaller components. Design patterns are among the most powerful methods for building large software systems. Patterns provide well-known solutions to recurring problems that developers face. Predicate logic is used for describing the formal specification of the design patterns. In this paper we urge to explain that formal specification of design patterns is very essential before they are implemented in any platform, further the formal specification of the design pattern is derived into a formula with respect to the application of the domain. In this paper we state some of the illustration to understand the concept of the formal specification and formula and we call this Modest Formalization of Software Design Patterns.
KEYWORDS – modesty, formalization, design patterns, software architecture, calculus.

I. INTRODUCTION

In art theory, formalism is the concept that a work‘s artistic value is entirely determined by its form–the way it is made, its purely visual aspects, and its medium. Formalism emphasizes compositional elements such as color, line, shape and texture rather than realism, context, and content. The philosopher Nick Zangwill of Glasgow University has defined formalism in art as referring to those properties "*that are determined solely by sensory or physical properties—so long as the physical properties in question are not relations to other things and other times*." The philosopher and architect Branko Mitrovic has defined formalism in art and architecture as "*the doctrine that states that the aesthetic qualities of works of visual art derive from the visual and spatial properties*." A formal analysis is an academic method in art history and criticism for analyzing works of art: "In order to perceive style, and understand it, art historians use '*formal analysis*'. This means they describe things very carefully. These descriptions, which may include subjective vocabulary, are always accompanied by illustrations, so that there can be no doubt about what exists objectively".

Formalization is the document form of formalism, where the practical compositional elements are represented by the symbols and variables. However, the theoretical impact on formalization has often been obscured in empirical investigations; the concept of building the basic idea of a system remains unchanged. Formalization (as efficiency) is likely to contribute to effectiveness early even in an organization's history. Formalization is defined high level at the implementation and so each component has to be clearly defined in its role of specialization.

II. SOFTWARE ENGINEERING PERSPECTIVES

Software Requirement Specification assures the project management stakeholders and client that the development team has really understood the business requirements documentation properly. The Software Requirement Specification is documented in such a way that it breaks the deliverables into smaller components. The information is organized in such a way that the developers will not only understand the boundaries within which they need to work, but also what functionality needs to be developed and in what order. These two points are particularly important in the process of software development. If a development team does not understand that there are certain constraints on their work, as for example the code must be tightly written so that it will compile and run quickly, then problems will creep later on when the code might deliver the functionality required. Understanding what order the functionality will be developed in means that the developers have the "big picture" view of the development. This gives them an opportunity to plan ahead which saves both project time and cost. As for some of the important characteristics to be followed in SRS of a Software Development activity, accuracy, clarity, completeness, consistency, prioritization of requirements, verifiability, modifiability, traceability, etc., the formalization improves the specification's readability and understandability.

Software Development process can be divided into smaller, interacting sub processes. Generally software development can be seen as a series of transformations, where the output of one transformation becomes the input of the subsequent transformation.

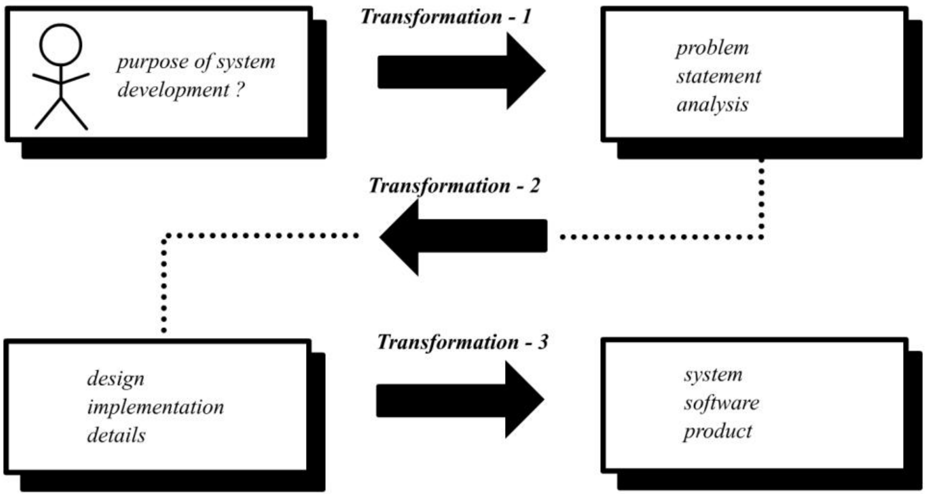

Fig II. (1a): Transformations in Software Development Process.

III. SOFTWARE DESIGN PATTERNS

Design patterns are among the most powerful methods for building large software systems. Patterns provide In 1987, Ward Cunningham and Kent Beck were working with Smalltalk and designing user interfaces. They decided to use some of Alexander's ideas to develop a small five pattern language for guiding novice Smalltalk programmers. They wrote up the results and presented them at OOPSLA'87 in Orlando in the paper "Using Pattern Languages for Object-Oriented Programs". Soon afterward, Jim Coplien (more affectionately referred to as "Cope") began compiling a catalog of C++ idioms (which are one kind of pattern) and later published them as a book in 1991, Advanced C++ Programming Styles and Idioms. From 1990 to 1992, various members of the Gang of Four had met one another and had done some work compiling a catalog of patterns. Discussions of patterns abounded at OOPSLA'91 at a workshop given by Bruce Andersen (which was repeated in 1992). Many pattern notables participated in these workshops, including Jim Coplien, Doug Lea, Desmond D'Souza, Norm Kerth, Wolfgang Pree, and others. In August 1993, Kent Beck and Grady Booch sponsored a mountain retreat in Colorado, the first meeting of what is now known as the Hillside Group. Another patterns workshop was held at OOPSLA'93 and then in April of 1994, the Hillside Group met again (this time with Richard Gabriel added to the fold) to plan the first PLoP conference. Thereafter the GoF book is published and the history of Design Patterns is classified. Current pattern representations are textual. They include the Gang-of-Four (GoF) form, the Coplien form, and the Alexandrian form. The GoF form (Gamma et al., 1994) includes sections for intent, motivation, structure, participants, and collaborations. The emphasis of this format is on the structure of the solution. However, the discussion of the forces is spread out over multiple sections, which makes it challenging for a developer to get an overview of when to apply a particular pattern and the consequences of using it.

IV. FORMALIZATION OF PATTERNS

Design patterns are among the most powerful methods for building large software systems. Patterns provide well-known solutions to recurring problems that developers face. There are several benefits of using patterns if they are applied correctly. Although design patterns are only over a few decades old, the science of patterns is becoming established, allowing for consistent communication. By using well-known patterns reusable components can be built in frameworks. Providing frameworks for reusability and separation of concerns is the key to software development today.

First-order logic (aka. first-order predicate calculus) is a formal system used in mathematics, philosophy, linguistics, and computer science. It is also known as first-order predicate calculus, the lower predicate calculus, quantification theory, and predicate logic. First-order logic uses quantified variables over (non-logical) objects. This distinguishes it from propositional logic which does not use quantifiers. The adjective "first-order" distinguishes first-order logic from higher-order logic in which there are predicates having predicates or functions as arguments, or in which one or both of predicate quantifiers or function quantifiers are permitted.[3] In first-order theories, predicates are often associated with sets. In interpreted higher-order theories, predicates may be interpreted as sets of sets.

Programming languages has many intense characteristics that fit well into the formal syntax and semantics in order to be executed on a computer. In general for the early phases of a software project, however, the intended behaviour of a program has to be specified in an abstract way, using some kind of specification language. Formal specification languages can be used successfully for non-trivial pieces of software, like Z and LARCH. These formal specification languages force the specifier to express him- or herself in terms of mathematical logic.

In 1974, Jean-Raymond Abrial published "Data Semantics" [1] and further used notation that would later be taught in the University of Grenoble until the end of the 1980s. While at EDF (Électricité de France), Abrial wrote internal notes on Z. The Z notation is used in the 1980 book Méthodes de programmation [2].

V. FORMAL SPECIFICATION OF DESIGN PATTERNS

In specifying structural aspects of Design patterns, we investigated a formal specification method using general first-order logic to represent each Design pattern structure as a logic theory (Dong et al., 2000). To illustrate the problem, let us consider the Composite pattern and the Iterator pattern from (Gamma et al., 1995) as examples. The structural aspect of the Composite and Iterator patterns is depicted in Figure 1. The Component class is an abstract class which defines the interfaces of the pattern. The Composite and the Leaf classes are concrete classes defining the attributes and operations of the concrete components. The Composite class can contain a group of children, whereas the Leaf class cannot. The Composite pattern is often used to represent part-whole hierarchies of objects. The goal of this pattern is to treat composition of objects and individual objects in the composite structure uniformly. In the Iterator pattern, the Iterator class is an abstract class which provides the interfaces of the operations, such as First, Next, IsDone, CurrentItem, to access the elements of an aggregate object sequentially without exposing its underlying representation. The ConcreteIterator class inherits the operation interfaces from the Iterator class and defines concrete operations which access the corresponding concrete aggregate. The Aggregate class defines a common interface for all aggregates that the Iterator accesses. The ConcreteAggregate class defines an operation to create the corresponding concrete Iterator.

The representations of the Composite pattern and the Iterator pattern contain predicates for describing classes, state variables, methods, and their relations. More precisely, the following sorts denote the first-class objects in a pattern: class and object. We also make use of sorts bool and int. The signature for the Composite pattern is:

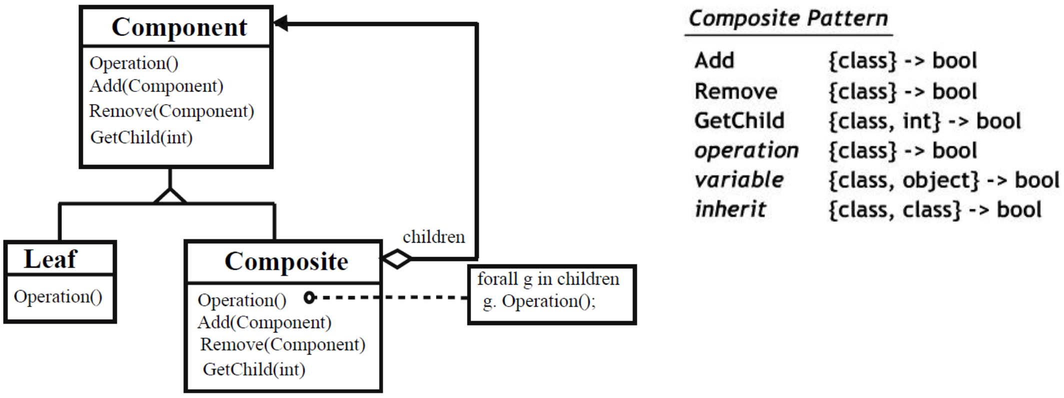

Fig IV. (1a): Composite Design Pattern and its Signature.

The signature of the Iterator pattern is:

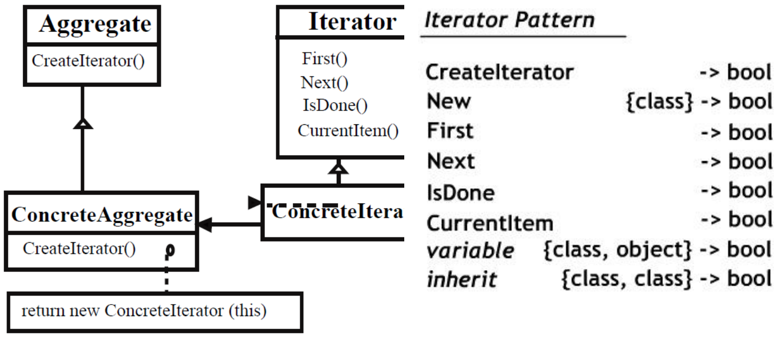

Fig IV. (1b): Iterator Design Pattern and its Signature.

The above Fig IV.(1a) and IV.(1b) contains (partial) theories associated with the two patterns. Θ_C denotes the theory of the Composite pattern and Θ_I denotes the theory of the Iterator pattern. The theory Θ_C is divided into three class groups and one relation group. The first group defines the abstract class Component and four method interfaces. The second group corresponds to the Leaf class. The third group contains theories about the Composite class, which include the definition of a state variable and the operations applied to it. The last group defines two inheritance relations. The first class in each inheritance relation is the parent class and the second class is the child class. The theory Θ_I is divided into five groups. The first four groups contain theories about four classes in the pattern. The last group contains two inheritance relations.

Θ_C	Θ_I
AbstractClass(Component) Operation(Component) Add(Component) Remove(Component) GetChild(Component, int)	AbstractClass(Aggregate) CreateIterator Class(ConcreteAggregate) CreateIterator→New(ConcreteIterator)
Class(Leaf) Operation(Leaf)	AbstractClass(Iterator) First Next IsDone CurrentItem
Class(Composite) Variable(Component, Children) Operation(Composite)→[∀g[Children(g)→Operation(g)]] ∀v [Add(v)→Children(v)] ∀v [Children(v)→Remove(v)] ∃v [Children(v) ∧ GetChild(v, int)]	Class(ConcreteIterator) Variable(Aggregate, aggregates)
Inherit(Component, Leaf) Inherit(Component, Composite)	Inherit(Aggregate, ConcreteAggregate) Inherit(Iterator, ConcreteIterator)

Table V (1): Theories associated with the two patterns Composite and Iterator.

VI. MODEL

Design patterns are represented in many programming languages that support Object Oriented paradigm. Design patterns are represented in terms of object-oriented design primitives in a predicate like formats. Each design primitive consists of two parts: *name* and *argument*. The *name* part contains the name of a feature or a relationship in object-oriented design, such as class or inheritance. The *argument* part contains general information about a feature or a relation such as the information on the participants of an inheritance relationship. Some of the examples are given below table. A higher level of abstraction is provided by introducing pattern primitive operators. Pattern primitive operators are represented in terms of design primitive operators and they allow general object-oriented schemas such as delegation, aggregation, and polymorphism to be defined. Pattern primitive operators can capture the subpatterns, which occur frequently in the declarative representation of Design patterns. They can also be used to change, transform, or make the declarative representation evolve. This operator can assist with the evolution of the pattern schema and also with the application of this pattern.

Class(C): **C** is a class.
Inherit(A, B): B is a subclass of **A.**
Attribute(C, A, V, T): V is the name of an attribute in class **C** with type **T**. **T** is optional. **A** describes the access right of this attribute, that is, public, private, or protected.
Method(C, A, F, R, P_1, T_1, P_2, T_2, ...): F is a method of a class **C**. **A** describes the access right of this method, that is, it can be public, private, or protected. **R** describes the return type. The method's parameters and their types are **P_1**, **T_1**, **P_2**, **T_2**, ..., respectively, and this part is optional. The return type **R** is also optional if the method has no parameters.
Member(E_1, S_1, E_2, S_2, ...): E_1 is an element of set S_1. E_2 is an element of set S_2, and so on. When universal quantification forall and member are used together, it enumerates set S_1, S_2, ..., S_n simultaneously, that is, the first elements of all sets are enumerated first, then the second elements.

Table V I(1): Model Formalisms for Object Oriented Concepts.

VII. PREDICATE LOGIC

In mathematical logic, predicate logic is the generic term for symbolic formal systems like first-order logic, second-order logic, many-sorted logic, or infinitary logic (*An infinitary logic is a logic that allows infinitely long statements and/or infinitely long proofs*). This formal system is distinguished from other systems in that its formulae contain variables which can be quantified. The two common quantifiers are the existential ∃ ("there exists") and universal ∀ ("for all") quantifiers. The modest approach of this formalization is a gradual development of the formula for the application of design patterns in the software development.

The design patterns of a design pattern school are set up in a catalog which is a searchable data structure for finding suitable design pattern application for the software development problem in the domain. The organization of the catalog contains formal specifications of the design patterns. In general, the formal specification of object oriented concepts is induced into an application driven representation of classes and objects as domain specific formulae. In this context of designing the modest formalization for design patterns, we embark on the approach for designing the formal specification for the design patterns and later their implementation indications are directed to develop the formula, further to directly use them in the software development. Certain assertions are made before the generation of formula for the formal specifications derived from the modest thought.

Assertions:

A Pattern Family reflects a philosophical school of thought about pattern evolution
Object is implementation or instantiation of the class (which repeats its encapsulated members)

Class is a particular functionally specified group of members (methods and functions)

We use the following predicate calculus for design the formula of the problem in the domain.

Description	Formalization
The Pattern Catalog belongs to a Pattern Family	(A*x*) **pattern**(*x*) ➔ *belongs*(*x*, **patternfamily**)
The Patterns used to solve the software development problem are in a Pattern Catalog	(A*y*) **problem**(*y*) ➔ *has*(*y*, **pattern**)
	(A **pattern**) (E **problem**) ***patternfamily*** (**pattern**) ➔ ***solves***(**pattern, problem**)
Every software developer-designer understands pattern	(A **pattern**) designer (**pattern**) ➔ *understands* (**pattern**)
	(A **x**) (E **y**) (***designer*** (**x**)^ ***problem*** (**y**)) ➔ ***understands*** (**x, y**) **x : pattern; y : problem (specifications)**
Each pattern is described by relative group of objects and classes	(A*y*) **pattern**(x,*y*) ➔ *has*({x,*y*}, **pattern**) **x : classes; y : objects**

VIII. CONCLUSION

Formalization is a very essential activity to be done for every software development problem, in order to understand the quantified application of the resources. Formalization with respect to a platform or a development tool limits the functional applications and derivations of the formal representation. Thus in this paper we urge to develop a formal specification for the generic design and the formula for the constituent design of the software. May categories of Predicate Logic exists where we can take the formal specification into a higher resolution.

REFERENCES

[1] Toufik Taibi, "*Design Pattern Formalization Techniques*", United Arab Emirates University, UAE, (C) 2007, IGI Publishing Hamburg, New York.
[2] Henderson-Sellers, Brian. "*Object-Oriented Metrics Measures of Complexity*", Upper Saddle River, NJ: (C) 1996, Prentice Hall.
[3] Clark Archer, Michael Stinson, "*Object-Oriented Software Measures*", Technical Report submitted to Software Engineering Institute, Carnegie Melon University, CMU/SEI-95-TR-002, April 1995.
[4] Ian Somerville, "*Software Engineering*", 8th Edition, Chapter 27, Formal Specification, Prentice Hall Inc. (C) 2009.

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AREA OF REGULAR n-POLYGON

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Abstract: In this theorem we will give a relation between perimeter and area of polygon in terms of perimeter and area of circle formed incentered in polygon and also give a formulae for area of regular polygon.
Keywords: A_c = area of circle
$A_{pol.}$ = area of polygon
P_c = perimeter of circle
$P_{pol.}$ = perimeter of polygon

1. Introduction

There is a problem to calculate the area of regular n-polygon.usually if any one wants to calculate the area of regular n-polygon then the polygon must be cracked in triangles or several polygons of known ares and sum the areas of each tringles.it is also difficult to find the area of each tringle as the sides of triangles may not be easily find also whole process is very large.

But using this principal we can easily calculate the accurate area of the polygon in very short step.this helps us to calculate the accurate area of regular polygon as well as also save our time in calculation of area.

2. Statement

If a circle is incentered in a regular polygon.then;
$\boldsymbol{P_{pol.} / A_{pol.} = P_c / A_c}$

3. Proof

Let polygon have 'n' sides of length 'a' and circle of radius 'r'.
Join all vertices to the centre of circle. for example-fig.1.(a regular hexagon)

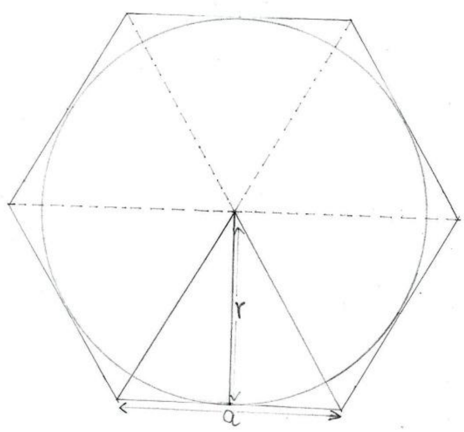

Fig.1. a regular hexagon

When conjugative vertices of polygon are jointed to centre of circle then each triangle formed will be congruent and of equal areas.

Hence,

$P_{pol.}$ = n×a
……………….(1)
$A_{pol.}$ = n×area of one triangle
$A_{pol.}$ = n×a×r×1/2
……………….(2)

{ as 'r' be the perpendicular height of triangle, because each side is perpendicular to radius (as tangent) }

Deviding (1) by (2)
$P_{pol.}/A_{pol.} = n\times a/n\times a\times r/2 = 2/r$
$P_{pol.}/A_{pol.} = 2/r$
…………………………….(3)
$P_c = 2\times\pi\times r$
$A_c = \pi\times r^2$
$P_c/A_c = 2\times\pi\times r/\pi\times r^2 = 2/r$
$P_c/A_c = 2/r$
……………………………..(4)
From (3) and (4),
$P_{pol.}/A_{pol.} = P_c/A_{c.}$ Whence proved.

4. Conclusion

The relation is
$P_{pol.}/A_{pol.} = P_c/A_{c.}$
or the area of polygon
$A_{POL.} = A_C \times P_{POL.} / P_C$

5. Advantages

(i) It helps us to calculate the accurate area of the regular polygon.
(ii) It shorts the steps of calculation and prevent to missing in calculation by shorting the calculation.
(iii) It save our time in calculation of area of polygon.
(iv) It also supports the rule that "a regular polygon of infinite side become a circle".

6. Limitations

(i) It does not tell us about irregular polygon.
(ii) For given polygon, the radius of circle must be known.

7. Applications

(i) To calculate the area of any plot in the form of regular polygon.
(ii) To draw the incentered circle inside a regular polygon and vice-versa.

8. Acknowledgements

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I must be thankful to our parents for their supports and guidance.

(HARIKESH PANDEY)

JNV MIRZAPUR (U.P.)

References

Books:
[1] NCERT mathematics for clas 10th

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To find raise to five of any number

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ABSTRACT: This method uses these exceptions to lead the analyst to interesting regions of the five squaredduring navigation. We present the statistical foundation underlying our approach. We then discuss the computational issue of finding exceptions in data and making the process efficient on large multidimensional data bases. We present performance results and experience with real-life datasets to illustrate the effectiveness of the proposed paradigm.

1. Introduction

A data five squared consists of two kinds of attributes: measures and dimensions. The set of dimensions consists of attributes like product names and store names that together form a key. The measures are typically numeric attributes like sales volumes and profit. Dimensions usually have associated with them hierarchies that specify aggregation levels. For instance, store name - city - state is a hierarchy on the store dimension and UPC code - type - category is a hierarchy on the product dimension.

Discovery-drivenExploration.
We propose a new“discovery-driven”method of data exploration where an analyst's search for anomalies is guided by precomputed indicators of exceptions at various levels of detail in the raise to five digit. This increases the chances of user noticing abnormal patterns in the data at any level of aggregation. This paradigm could be especially valuable when the number of dimensions and hierarchies is large, making it overwhelming for the user to navigate through the multitudes of views of a data five squared.
We present a formal notion of exceptions. Intuitively, we consider a value in a cell of a data five squared to be an exception if it is significantly different from the value anticipated based on a statistical model. This model computes the anticipated value of a cell in context of its position in the data five squared and combines trends along different dimensions that the cell belongs to. Thus, for instance, a large increase in sales in December might appear exceptional when looking at the time dimension but when looking at the other dimensions like product this increase will not appear exceptional if other products also had similar increase. The model allows exceptions to be found at all levels of aggregation.

Our techniques use the same kind of data scan operations as required for raise to five aggregate computation and thus enables overlap of exception finding with routine aggregate precomputation. These techniques recognize that the data may be too large to tin main memory and intermediate results may have to be written to disk requiring careful optimization. We describe some experience of using this methodology on a real data set and give performance results.

2. Method to solve five squared:

First of all we will see how to find the cube of a number with the easy method which is already derived, by the help of it we have discovered to find a five squared of a number.

Finding the cube of a number:

Example: Find the cube of 12

Step 1: cube the left most digit, i.e. 1, in this case, and write it down on the extreme left.

Step 2: write three more numbers to its right such that the ratio of successive pairs of numbers is same as the ratio of the digits in the original no. We get the following 1 2 4 8 (1:2 = 2:4 = 4:8)

Step 3: Double the second no. and the third no. of the above four numbers and write the result under the respective numbers.

Step 4: Add the two rows – one column at a time – such that each column contributes only one digit to the total. Let's see it practically,

1 ---------- carry forward

12 4 8

4 8

$12^3 =$ 1 7 2 8

Now we will see the method to find five squared it is as easy as to find the cube of a number. Let's see,

$(ab)^5=$ a^5b^0 a^4b^1 a^3b^2 a^2b^3 a^1b^4 a^0b^5

$4a^4b^1$ $4a^3b^2$ $4a^2b^3$ $4a^1b^4$

$5a^3b^2 5a^2b^3$

Step 1: Take raise to five of the left most digit. In this case write it down on the extreme left.

Step 2: Writefour more numbers to its right such that the ratio of successive pairs of numbers is same as the ratio of the digits in the original number. We get the following ($a^5b^0 : a^4b^1 = a^4b^1 : a^3b^2$)

Step 3: Four times the second, third, fourth no. and the fifth no. of the above six numbers and write the result under the respective numbers.

Step 4: Five times the second and third no. of the above new four numbers and write the result under the respective numbers.

Step 5: Add the three rows – one column at a time – such that each column contributes only one digit to the total.

3. Illustrative examples:

$(12)^5$

$(a/b)^5=$ a^5b^0 a^4b^1 a^3b^2 a^2b^3 a^1b^4 a^0b^5

$4a^4b^1$ $4a^3b^2$ $4a^2b^3$ $4a^1b^4$

$5a^3b^2 5a^2b^3$

a=1 & b=2

$(1/2)^5= \quad 1^5 2^0 \quad 1^4 2^1 \quad 1^3 2^2 \quad 1^2 2^3 \quad 1^1 2^4 \quad 1^0 2^5$

$4(1^4 2^1) \quad 4(1^3 2^2) \quad 4(1^2 2^3) \quad 4(1^1 2^4)$

$5(1^3 2^2) 5(1^2 2^3)$

3

1 2 4 8 16 32

8 16 32 64

20 40

2

---

8 3

1 2 4 8 16 32

8 16 32 64

20 40

---

3 2

---

8 8 3

1 2 4 8 16 32

8 16 32 64

20 40

---

8 3 2

---

1 4 8 8 3

1 2 4 8 16 32

8 16 32 64

20 40

---

4 8 8 3 2

---

1 4 8 8 3

1 2 4 8 16 32

8 16 32 64

20 40

---

2 4 8 8 3 2

Step 1: Take raise to five of the left most digit. In this case write it down on the extreme left.

Step 2: Write four more numbers to its right such that the ratio of successive pairs of numbers is same as the ratio of the digits in the original number. We get the following ($a^5b^0 : a^4b^1 = a^4b^1 : a^3b^2$)

Step 3: Four times the second, third, fourth no. and the fifth no. of the above six numbers and write the result under the respective numbers.

Step 4: Five times the second and third no. of the above new four numbers and write the result under the respective numbers.

Step 5: Add the three rows – one column at a time – such that each column contributes only two digit to the total.

Note: As the digits of the b is increased, one should increase each column's contribution.(As per given example below)

$(117)^5 = (1/17)^5 = 1^5 17^0 1^4 17^1 1^3 17^2 1^2 17^3\ 1^1 17^4 1^0 17^5$

$4(1^4 17^1)\ 4(1^3 17^2)\ 4(1^2 17^3)\ 4(1^1 17^4)$

$5(1^3 17^2)\ 5(1^2 17^3)$

---

1 17 289 4913 83521 1419857

68 1156 16772 334084

1445 20965

431814198

1 17 289 4913 83521 1419857

68 1156 16772 334084

1445 20965

---

03 57

469431814198

1 17 289 4913 83521 1419857

68 1156 16772 334084

1445 20965

---

68 03 57

---

33 469 4318 14198

1 17 289 4913 83521 1419857

68 1156 16772 334084

1445 20965

5968 03 57

1 33 4694318 14198

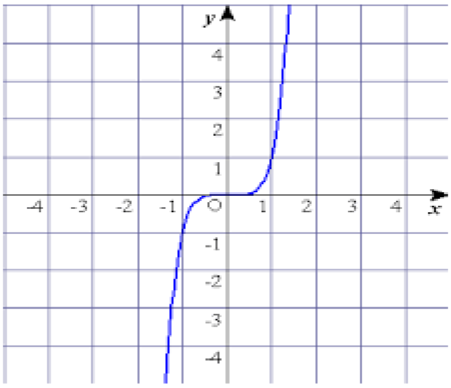
1 17 289 4193 83521 1419857

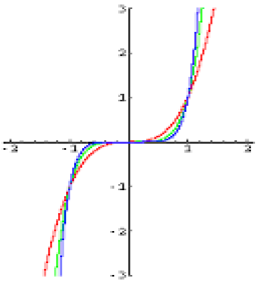
68 1156 16772 334084

1445 20965

218 59 68 03 57

4. Charts and Real life Examples:





5. Conclusion:

Future work

Special treatment of time dimension: Time is an ordered dimension and it is possible to apply special time series analysis techniques to further refine the notion of exceptions. We are working on ways to enhance our model equation to integrate these order specific terms.

User customization: In some situations users may want to influence the automated process with their own domain-dependent notion of exceptions, for instance, providing different weights to variations along different dimensions. The challenge in providing support for user customization is finding an appropriate expression language that can integrate with our statistical notion. Also, users might want to find exceptions only in certain regions of the raise to five and not in others. This customization is relatively easy to incorporate.

6. References:

[1]. "Abstract algebra, Theory and applications" by Thomas W. Jandson, Stephen F. Austin State University, 2009.
[2]. A First course in Abstract Algebra, by J. B. Fealeigh, pearson Education,2013
[3]. Notes on Galob Theory by Marrk Reeder, Boston college, 2012

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Analysis and Design of a Low Voltage Si LDMOS Transistor

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ABSTRACT : This paper presents a compact model of lateral double diffused MOS (LDMOS) transistor having small size and got good result with different characteristics. This model is designed with ATLAS SILVACO and get better simulations of breakdown voltage, on resistance etc. comparing with reference LDMOS. We have designed this device with channel 0.3 µm length and gate 0.75 µm length.
KEYWORDS - ATLAS, Breakdown Voltage, Capacitance, LDMOS, On Resistance.

I. INTRODUCTION

Lateral double diffused MOS (LDMOS) transistors are mostly used in high voltage and RF applications. These applications include high breakdown voltage, low on resistance and compatibility with standard CMOS and BiCMOS manufacturing process. Comparing with other semiconductor devices, an accurate and physical compact model is critical for LDMOS based circuit design because size of this device is so large. That's the reason LDMOS device are seldom used compared with other semiconductor devices. Today, the size of LDMOS device is needed to smaller and smaller for safe operations [2].Presence of the lightly doped drift region in LDMOS device has different characteristics effect on breakdown voltage w.r.t conventional MOSFET. Impact ionization in LDMOS, which depends on the bias conditions, primarily occurs either in the intrinsic MOSFET or in the drift region. The purpose of this paper is to provide a new resize device with better simulated characteristic results [1]-[4].

II. DEVICE STRUCTURE AND SIMULATIONS

The schematic cross section of the reference and proposed LDMOS device is illustrated in Fig.1 and fig. 2. The LDMOS parameters used in our simulation are shown in Table 1. All the device parameters of the new structure are equivalent to those of the reference LDMOS [5].

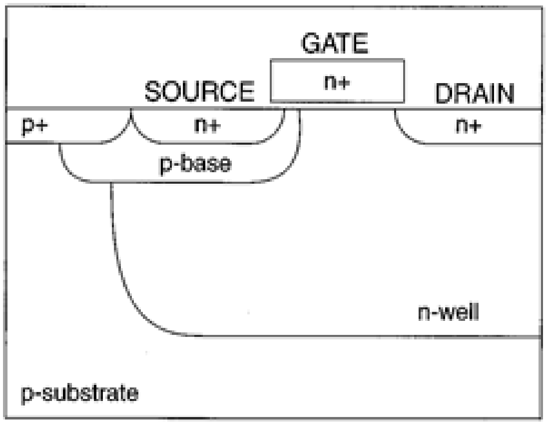


Fig.1: LDMOS Cross Section [5]

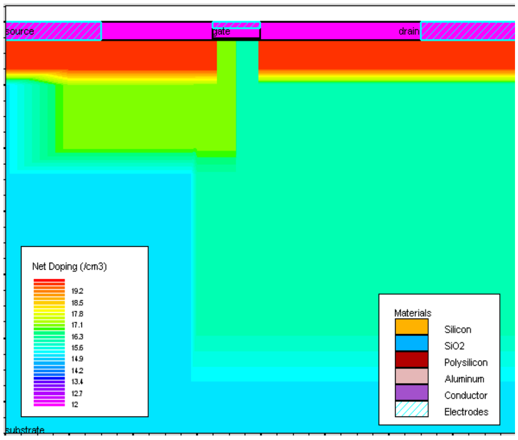


Fig.2: Simulator based LDMOS model

TABLE 1: SIMULATION PARAMETERS

Parameters	**Value**
Gate length	0.75 µm
Channel length	0.3 µm
Oxide thickness	35 nm
Thickness of n well	5 µm
Thickness of p body	1 µm
Doping	
Substrate (p type)	10^{15} cm $^{-3}$
Source & drain diffusion	5e ^{19} cm $^{-3}$
P body doping	10^{17} cm $^{-3}$
N well doping	10^{16} cm $^{-3}$

Two dimensional numerical simulations of the proposed structure are done with ATLAS simulator. In addition to, Poisson and drift/diffusion equations, SRH (Shockley-Read- Hall) and Auger models are considered for generation/recombination and also IMPACT SELB for impact ionization. These simulations methods allow taking into account carrier velocity saturation, carrier–carrier scattering in the high doping concentration, dependence of mobility on temperature and vertical electric influence. Breakdown mechanism is investigated by both two dimensional process simulations with SILVACO [6]-[9]. It is worth noting that the two dimensional (2D) simulator is calibrated to experimental data.

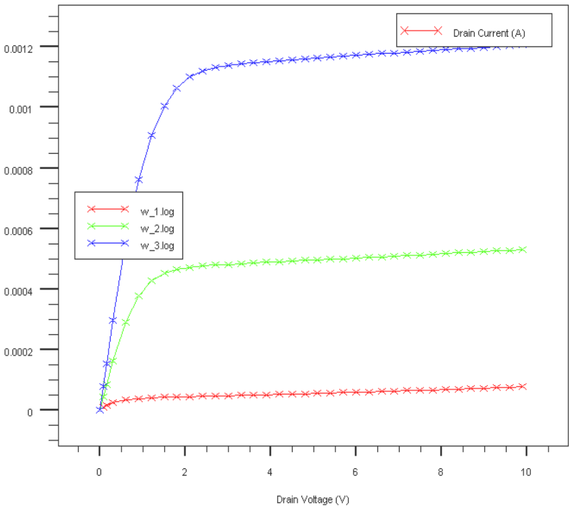
III. RESULTS & DISCUSSION

A. Drain Characteristics

The drain characteristics for the LDMOS structure with an LDD dose of 1×10^{16} cm^{-3} are shown in fig.3 for gate bias voltages ranging from 1 to 10V. It can be seen that the output resistance decrease at high drain voltages due to the onset of impact ionization which is shown in fig.6 and fig.8. The non-linear increase in drain current is due to the channel length modulation.

B. Transfer Characteristics

Transfer characteristics shows the relation of the drain current (I_D) with the variation of the gate voltage (V_{GS}) keeping the drain voltage (V_{DS}) fixed. The drain-current flows only if the gate voltage exceeds the threshold voltage V_T. However, for LDMOS after the threshold voltage the current of LDMOS is lower than that of conventional MOS. This is due to the fact that it has higher on-resistance. Ron is higher due to the addition of the drift region. At V_{DS}=0.1 Volt and 0.2 Volt, the drain current is plotted against gate voltage (V_{GS}) are shown in fig.4.



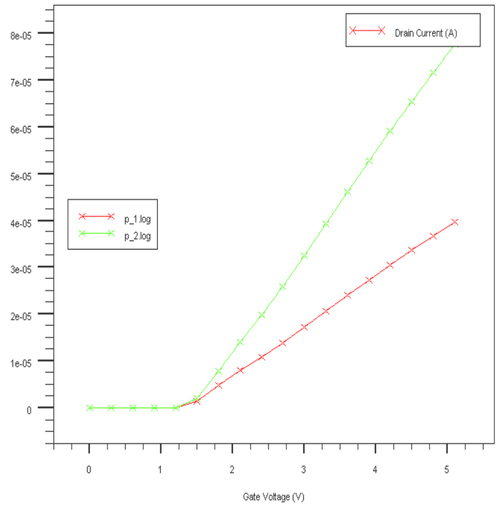


Fig.3. IV characteristics with different gate voltage. Fig.4: I_D vs. V_{GS} plot having threshold Voltage (V_T) = 1.3V.

C. Breakdown Voltage

In MOSFET when VDS exceeds a certain value, the drain current abruptly increases. As V_{DS} increases, the peak electric field at drain end of the channel also increases. When

the peak electric field approaches the middle of 10^5 V/cm range, the impact ionization takes place at the drain junction leading to sharp increase in I_D. The high-energy electrons, which have gained energy from electric field, have sufficient kinetic energy to generate secondary electrons and holes by impact ionization. The generated electrons are collected at the drain and then added to I_D, while the holes flow to the substrate contact resulting in substrate current. In LDMOS the drift region supports the applied voltage and protects the channel region from high voltage. At the applied potential, the depletion stretches along the lateral length or surface over a much longer distance. Therefore, the electric field is far below the critical field (Ec) and hence more voltage can be applied before breakdown occurs. It can also be seen from impact ionization rate in fig.6. That it is shifted from the drain.

In present work, the breakdown occurs at 13.75 V when gate voltage is at 0 V. By increasing gate voltage breakdown voltage decreases. Fig.5. shows the breakdown curves with varying gate voltage in range 0 to 10 V.

D. Impact Ionization

Impact ionization is the process in a material by which one energetic charge carrier can lose energy by the creation of other charge carriers. For example, in semiconductors, an electron (or hole) with enough kinetic energy can knock abound electron out of its bound state (in the valence band) and promote it to a state in the conduction band, creating an electron-hole-pair. If this occurs in a region of high electrical field then it can result in avalanche breakdown. In a device the original charge carrier is created by the absorption of a photon [10]-[12]. In some sense, the impact ionization is the reverse process to Auger recombination. For n-channel MOSFET, the impact ionization takes place at the junction of substrate and drain region. As voltage is applied at the drain region, the avalanche breakdown occurs for a very low voltage. However, for LDMOS, the impact ionization occurs at the junction of drift region and substrate, which is away from the drain region (as shown in Fig.5). For this reason, this device shows a higher breakdown-voltage.

The electric field is high at drift region, thus avoiding a premature avalanche before reaching the required breakdown voltage. The potential linearly increase with increase gate voltage shown in fig 7. The high electric

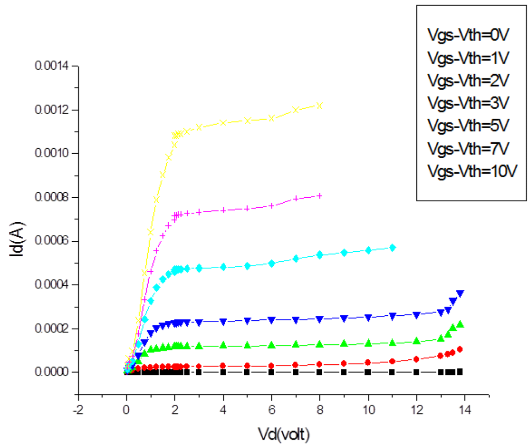


Fig.5: BV vs. V_D at the different gate voltage

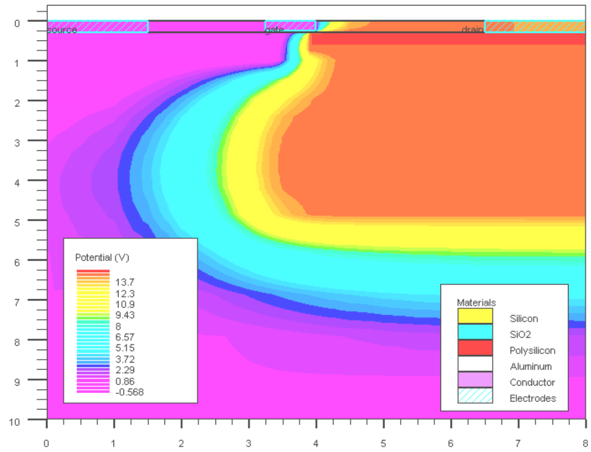
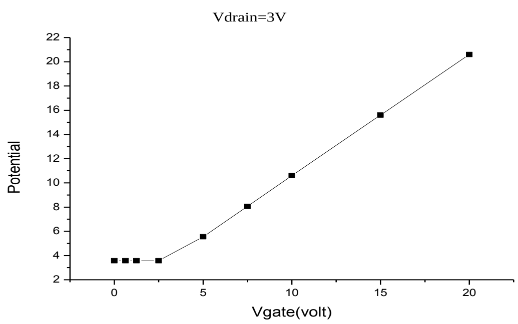


Fig.6: Impact ionization at breakdown.



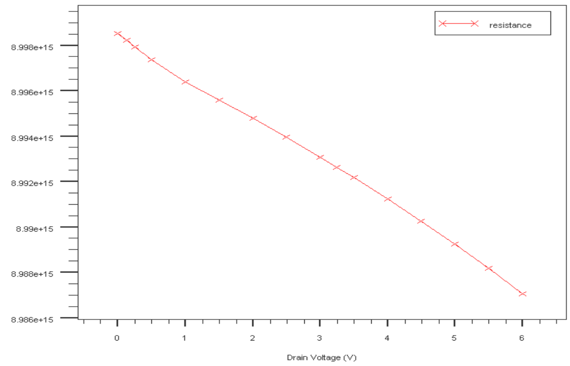


Fig.7: Plot between potential vs. gate voltage. Fig. 8: R_{ON} resistance vs. drain voltage, with increase drain voltage, on resistance decreases.

field peak is located at the drift/drain edge where the high impact ionization rate at this point is responsible for the avalanche mechanism. The high electric field region is found at the body/drift junction, being responsible of the wide P-body depletion and the high increment of the electron current density at the channel region.

E. On Resistance

In LDMOS, drift region represents a dynamically varying resistance for current flow and also introduces additional charges. When drain voltage increases from 0 to 6 volts, drain current increases, resistance decreases.

A. Capacitance and Trans conductance

Other peculiar features are observed in capacitance, showing strong sharp peaks, which significantly change depending on the structure as well as Doping levels. The Trans conductance increases sharply with low gate voltage until 1.6 vaults and then rapidly decreases due to the compression phenomenon and lightly doped drain region.

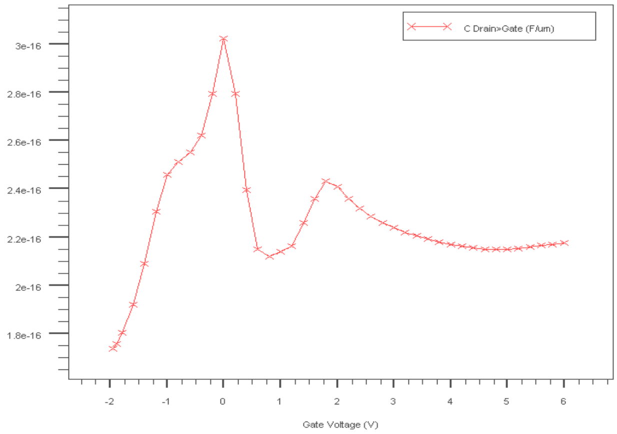


Fig.9: Capacitance vs. gate voltage

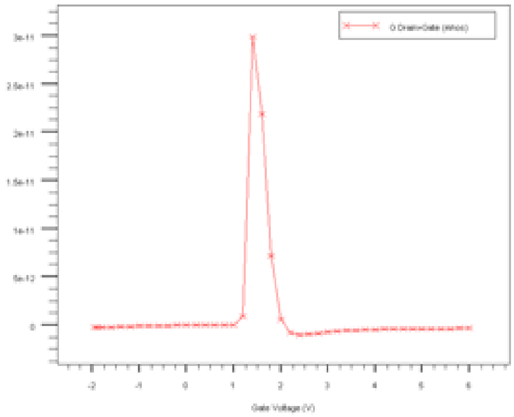


Fig.10: Trans-conductance vs gate voltage.

IV. CONCLUSION

The results of two dimensional numerical simulations have been provided to describe its characteristics. The proposed device gives better result than reference device. The breakdown voltage of this device is higher compared with reference device. The R_{ON} resistance is lower compared with reference device. The feedback capacitance is reduced so breakdown voltage is improved.

REFERENCES

[1] Wei Yao, Student Member, IEEE , Gennady Gildenblat, Fellow, IEEE, Colin , McAndrew, Fellow, IEEE, and Alexandra Cassagnes, "Compact Model of Impact Ionization in LDMOS Transistors," IEEE Electron Devices., vol. 59, No. 7,July 2012.

[2] Hua Ting-Ting 1, Guo Yu-Feng 1, Yu Ying 1, Gene Sheu2, Jian Tong 1 and Yao Jia-Fei ," Analytical models of lateral power devices with arbitrary vertical doping profiles in the drift region"Chin.Phys.B Vol.22,No.5,2013.

[3] Yogesh Singh Chauhan, Francois Krummenacher, Costin Anghel, Renuad Gillon†, Benoit Bakeroot‡, Michel Declercq and Adrian Mihai Ionescu,"Analysis and Modeling of Lateral Non-Uniform Doping in High-Voltage MOSFETs," AMIS,Belgium,IEEE, 2006.

[4] Nie Weidong 1, 2, Yi Fayou2, and Yu Zongguang 1, ".Kirk effect and suppuration for 20 V planar active gap LDMOS,"Journal of Semiconductors, Vol.34,No.5, May 2013

[5] Lars Vestling, Member,IEEE,Johan Ankarerona,and Jorgen Olsson,Member,IEEE ,"Analysis and Design of a Low Voltage High Frequency LDMOS Transistor," IEEE Electron Devices., vol. 49, No.6,June 2002.

[6] Ali A. Orouji* Mahsa Mehrad, "Breakdown Voltage Improvement of LDMOS by Charge Balancing:An Inserted P Layer in Trench Oxide," Electrical Engineering Department,Semnan University,Semnan,Iran,Superlattices and Microstructures vol.51,pg.412-420,2012.

[7] Device Simulator ATLAS,Silvaco,International,2007

[8] Atlas User's Manual, Silvaco International,Santa Clara,CA,2007.

[9] John L. B. Walker, Handbook of RF and Microwave Power Amplifiers, Cambridge, 20 February 2013

[10] Matthew Hazel ,Marc Cyr ,"Semiconductor TCAD Fabrication Develepment for BCD Technology," Worcester Institute ,2006

[11] N.G.H. Van Melick,"RF Power LDMOS Transistors," Eindhoven University of Technology, December 1996.

[12] M Jagadesh Kumar and Avikal Bansal," Improving the breakdown voltage, ON-resistance and gate-charge of InGaAs LDMOS power transistors," *Semicond. Sci. Technol.vol.* 27,No.10,October 2012.

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Seismic Evaluation of G+2 Institutional Building in Bhopal

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ABSTRACT- A Seismic design is aimed at controlling the structural damage based on precise estimations of proper response parameters. Seismic design explicitly evaluates how a building is likely to perform; given the potential hazard it is likely to experience, considering uncertainties inherent in the quantification of potential hazard and uncertainties in assessment of the actual building response. It is an interactive process that begins with the selection of performance objectives, followed by the development of a preliminary design, an assessment as to whether or not the design meets the performance objectives, and finally redesign and reassessment, if required, until the desired performance level is achieved.
In this present study one R.C. buildings, of G + 2 storey institutional building (designed according to IS 456:2000) are analysed. Analysis and redesigning by changing the main reinforcement of various frame elements and again analyzing. The structural analysis has been carried out using STAAD.Pro V8i, a product of Structural Analysis and Design Program. A total of 1 cases for a particular G + 2 storey institutional building located in Zone-II have been analyzed. The results of analysis are compared in terms of reinforcement in the column and beam. The best possible combination of reinforcement that is economical, effective and whose damage is limited to Grade 2 (slight structural damage, moderate non structural damage) in order to enable Immediate Occupancy is determined and is termed as Seismic Design.

INTRODUCTION

Amongst the natural hazards, earthquakes have the potential for causing the greatest damages. Since earthquake forces are random in nature & unpredictable, the engineering tools needs to be sharpened for analyzing structures under the action of these forces. Performance based design is gaining a new dimension in the seismic design philosophy wherein the near field ground motion (usually acceleration) is to be considered. Earthquake loads are to be carefully modelled so as to assess the real behaviour of structure with a clear understanding that damage is expected but it should be regulated. In this context pushover analysis which is an interactive procedure shall be looked upon as an alternative for the orthodox analysis procedures. This study focuses on pushover analysis of multi-storey RC framed buildings subjecting them to monotonically increasing lateral forces with an invariant height wise distribution until the preset performance level (target displacement) is reached. Te promise of performance-based seismic engineering (PBSE) is to produce structures with predictable seismic performance. To turn this promise into a reality, a comprehensive and well-coordinated effort by professionals from several disciplines is required.

Performance based engineering is not new. Automobiles, airplanes, and turbines have been designed and manufactured using this approach for many decades. Generally in such applications one or more full-scale prototypes of the structure are built and subjected to extensive testing. The design and manufacturing process is then revised to incorporate the lessons learned from the experimental evaluations. Once the cycle of design, prototype manufacturing, testing and redesign is successfully completed, the product is manufactured in a massive scale. In the automotive industry, for example, millions of automobiles which are virtually identical in their mechanical characteristics are produced following each performance-based design exercise.

The primary objective of this work is to compare the design of building with and without seismic forces by variation in reinforcement by using STAAD.Pro of RC framed building designed. The effect of earthquake force on G+2 storey institutional building of Bhopal, with the help of STAAD.Pro, for various different sets of reinforcement at different levels has been investigated.

Some of the prominent literature on the topic are as follows:

S.Mahesh and Dr.B.Panduranga Rao (2014) considered the behaviour of G+7 multi story building of regular and irregular configuration under earthquake. A residential of G+7 multi story building is studied for earthquake and wind load using STAAD.Pro V8i .Assuming that material properties and static and dynamic analysis are performed. These analysis are carried out by considering different seismic zones and for each zone the behaviour is assessed by taking three different types of soils namely Hard , Medium and Soft .

Kevadkar, Kodag et.al. (2013) observed that the structure heavy susceptible to lateral forces may be concerned to severe damage. In this they found that along with gravity load (dead load, live load) the frames are able to withstand to lateral load (loads due to earthquake, wind, blast, fire hazards etc.) which can develop high stresses. For that purpose they used shear wall and steel bracing system to resist such type of loading like earthquake, wind, blast etc. In this study according to author R.C.C. building is modeled and analyzed in STAAD.Pro and results are compared in terms of Lateral Displacement, Storey Shear and Storey Drifts, Base shear and Demand Capacity (Performance point).

P.B. Kulkarni et. al. (2013) Masonry infill walls are mainly used to increase initial stiffness and strength of reinforced concrete (RC) frame buildings. It is mainly considered as a non-structural element. In this paper, symmetrical frame of college building (G+5) located in seismic zone-III is considered by modeling of initial frame. With reference to FEMA-273, & ATC-40 which contain the provisions of calculation of stiffness of infilled frames by modeling the infill panels are modeled as a equivalent diagonal strut method. This linear static analysis is to be carried out on the models such as bare frame, strut frame, strut frame with centre &corner opening, which is performed by using computer software STAAD.Pro from which different parameters are computed. In which it shows that infill panels increase the stiffness of the structure. While the increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame.

Salehuddun (2011) focused on nonlinear geometric analysis to be compared with linear analysis. In this study, a six storey 2-D steel frame structure with 24 m height has been selected to be idealized as tall building model. The model was analyzed by using SAP2000 structural analysis software with the consideration of geometric nonlinear effect. This study showed that a steel frame with the consideration of wind load produce greater sway value as compared to the steel frame without wind load

Gajjar and DhavalP.Advani(2011) focused on the design of multi-storeyed steel buildings to have good lateral load resisting system along with gravity load system because it also governs the design. This paper is presented to show the effect of different types of bracing systems in multi storied steel buildings. For this purpose the 20 stories steel buildings models is used with same configuration and different bracings systems such as knee brace, X brace and V brace is used. A commercial package STAAD.Pro is used for the analysis and design and different parameters are compared. The property of the section is used as per IS 800:2007 which incorporates Limit State Design philosophy.

Kevadkar, Kodag et.al. (2013) observed that the structure heavy susceptible to lateral forces may be concerned to severe damage. In this they found that along with gravity load (dead load, live load) the frames are able to withstand to lateral load (loads due to earthquake, wind, blast, fire hazards etc) which can develop high stresses. For that purpose they used shear wall and steel bracing system to resist such type of loading like earthquake, wind, blast etc. In this study according to author R.C.C. building is modeled and analyzed in STAAD.Pro and results are compared in terms of Lateral Displacement, Storey Shear and Storey Drifts, Base shear and Demand Capacity (Performance point).

Qiang Xue, Chia-Wei Wu et al (2007) summarized the development of the seismic design draft code for buildings in Taiwan using performance-based seismic design methodology and case studied. They presented the design of a reinforced concrete building by using the draft code. Seismic design code provisions are examined according to the theoretical basis of PBSD to identify which methodologies of PBSD need to be incorporated into the current seismic design code. The performance-based seismic design code introduces a transparent platform in which the owners and designers can exchange their views on the expected seismic performance of the buildings under different levels of earthquakes.

METHODOLOGY

METHODOLOGY AND SELECTION OF PROBLEMS

In this present study one R.C. buildings, of G + 2 storey institutional building (designed according to IS 456: 2000) are analysed. Analysis and redesigning by changing the main reinforcement of various frame elements and again analyzing. The structural analysis has been carried out using STAAD.Pro V8i, a product of Structural Analysis and Design Program. Following steps are implemented in this study:-

Step-1 Selection of building geometry

Step-2 Selection of seismic zones

TABLE 1: SEISMIC ZONES FOR DIFFERENT CASES AND MODELS

Case	Model	Earthquake zones as per IS 1893 (part-1) : 2002
Case-1	RCC Structure	II

Step-3 Considering of load combination (13 load combinations)

TABLE 2: LOAD CASE DETAILS

Load case no.	Load case details
1.	E.Q. IN X DIR.
2.	E.Q. IN Z DIR.
3.	DEAD LOAD
4.	LIVE LOAD
5.	1.5 (DL + LL)
6.	1.5 (DL + EQX)
7.	1.5 (DL - EQX)
8.	1.5 (DL + EQZ)
9.	1.5 (DL - EQZ)
10.	1.2 (DL + LL + EQX)
11.	1.2 (DL + LL - EQX)
12.	1.2 (DL + LL + EQZ)
13.	1.2 (DL + LL - EQZ)

Step-4 Modelling of building frames using STAAD.Pro software.
Step-5 Results evaluation in terms of maximum bending moment, maximum shear force, axial force, maximum joint displacement and maximum section displacement

MATERIAL AND GEOMERICAL PROPERTIES

Following properties of material have been considered in the modelling -
Density of RCC: 25 kN/m^3
Density of Masonry: 20 kN/m^3 (Assumed)
Young's modulus of concrete: $5000\sqrt{fck}$
Poisson's ratio: 0.17
The foundation depth is considered at 1.5 m below ground level and the floor height is 4 m.

LOADING CONDITIONS

Following loadings are considered for analysis -
(a) **Dead Loads**: as per IS: 875 (part-1) 1987
Self wt. of slab
Slab = 0.15 x 25 = 3.75 kN/m^2 (slab thick. 150 mm assumed)
Floor Finish load = 1 kN/m^2
Total slab load = 4.75 kN/m^2
Masonry Wall Load = 0.25 m x 2.55 m x 20 kN/m^3 = 12.75 kN/m
Parapet wall load = 0.25 m x 1 m x 20 kN/m^3= 5 kN/m
(b) Live Loads: as per IS: 875 (part-2) 1987
Live Load on typical floors = 3 kN/m^2
Live Load in earthquake = 0.75 kN/m^2
(c) Earth Quake Loads: All Structures are analyzed for 4 earthquake zones
The earth quake calculation are as per IS: 1893 (2002) [21]
a. Earth Quake Zone-II,III,IV,V (Table - 2)

b. Importance Factor: 1 (Table - 6)
c. Response Reduction Factor: 5 (Table - 7)
d. Damping: 5% (Table - 3)
e. Soil Type: Medium Soil (Assumed)
f. Period in X direction (PX): $\frac{0.09*h}{\sqrt{dx}}$ seconds — Clause 7.6.2 [21]
g. Period in Z direction (PZ): $\frac{0.09*h}{\sqrt{dz}}$ seconds — Clause 7.6.2 [21]

Where h = height of the building
dx= length of building in x direction
dz= length of building in z direction

LOADING DIAGRAM

Typical diagram for different types of loading conditions are shown below

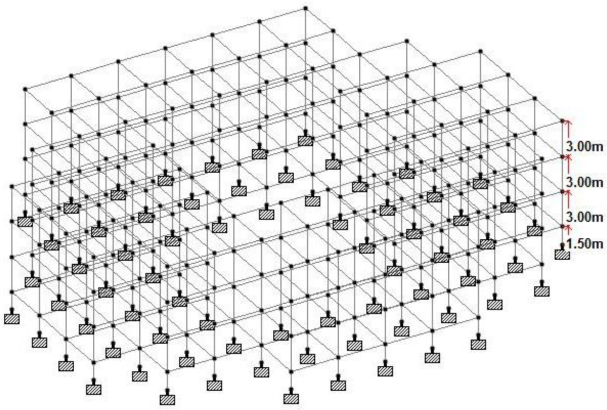

Figure 1 : Isometric view of institutional building

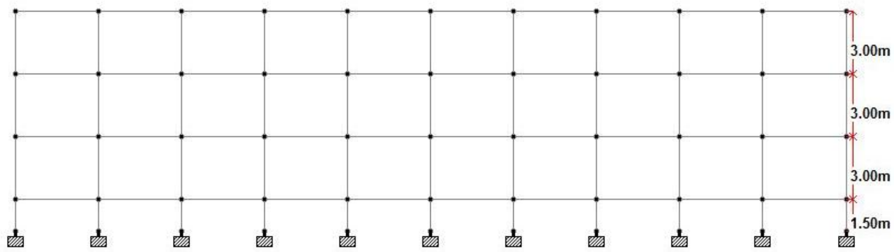

Figure 2 : Front view of institutional building

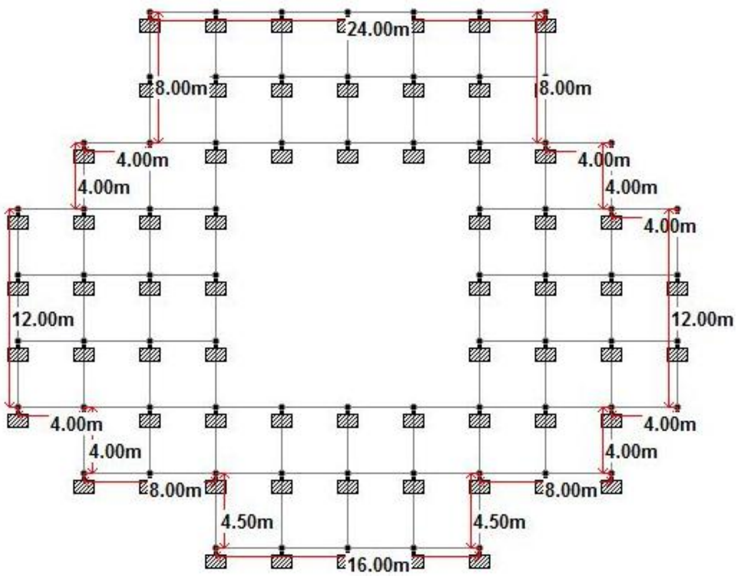

Figure 3 : Plan of institutional building

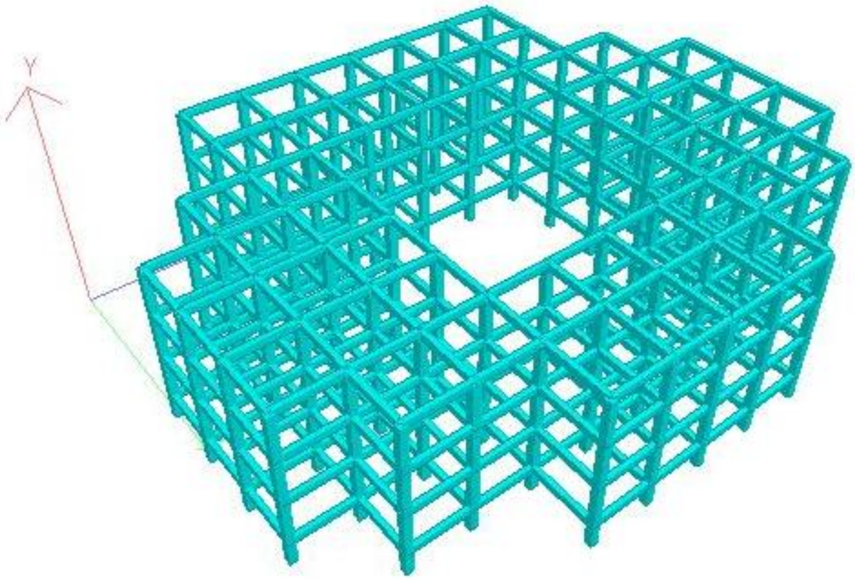

Figure 4 : 3D rendering view of institutional building

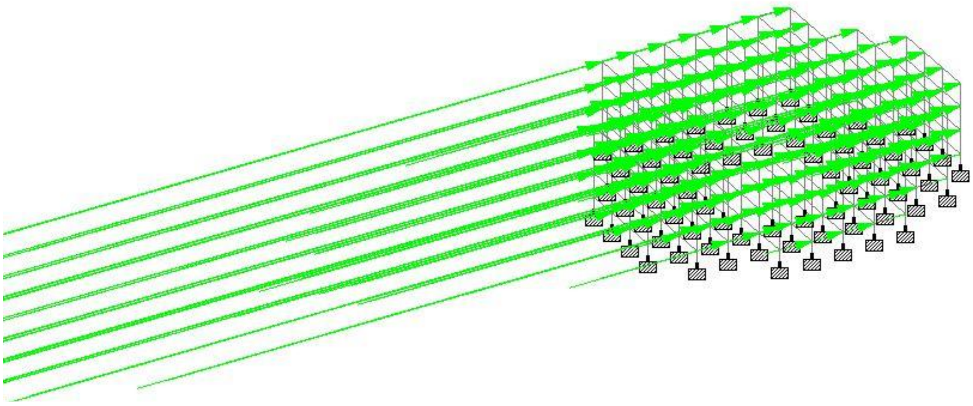

Figure 5 : Seismic loading in X direction of institutional building

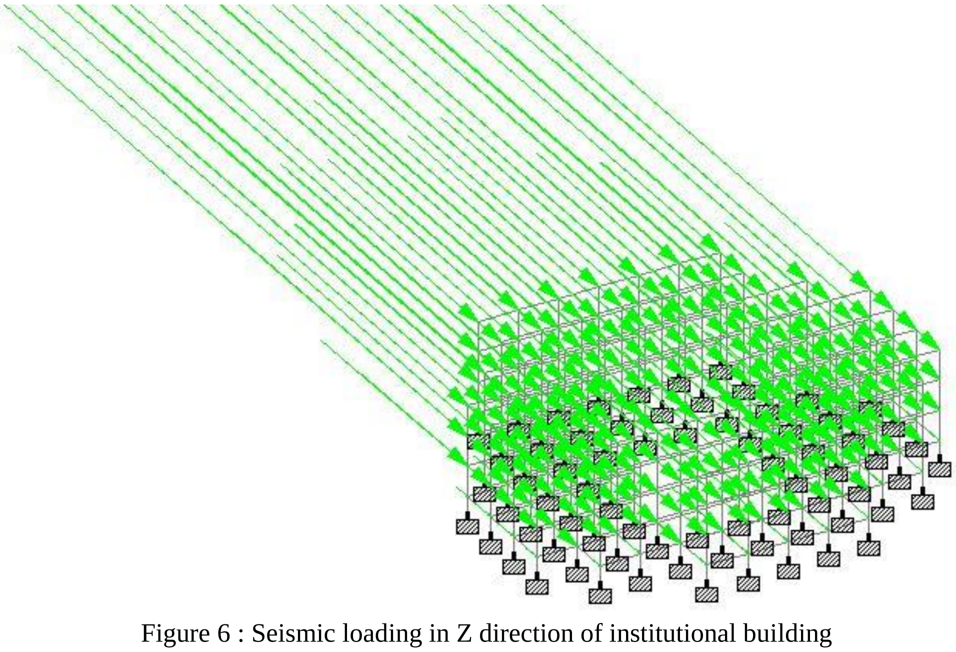

Figure 6 : Seismic loading in Z direction of institutional building

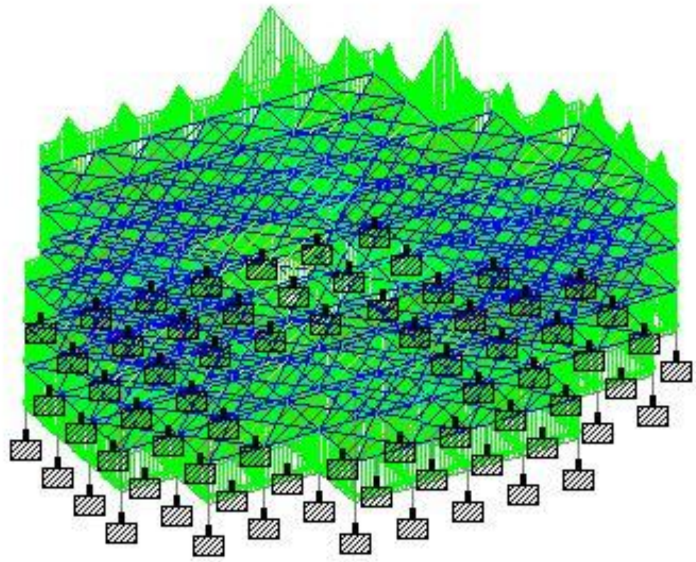

Figure 7 : Dead load of institutional building

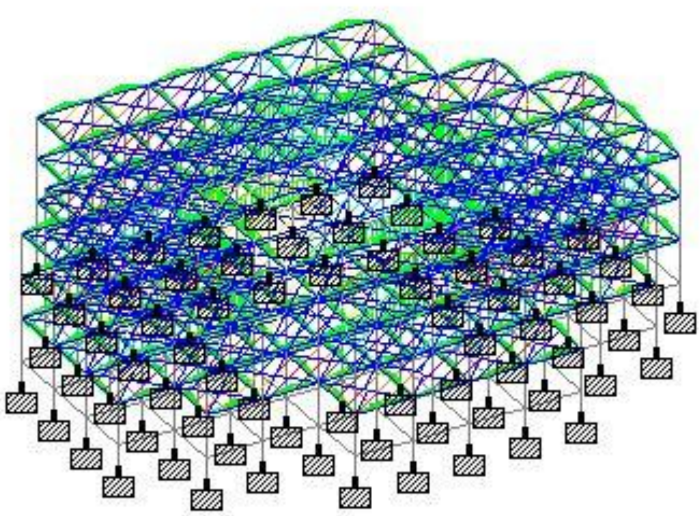

Figure 8 : Live load of institutional building

RESULT AND DISUSSION

The various results like maximum bending moment, maximum shear force, maximum axial force, maximum joint displacement and maximum section displacement are evaluated and effective and critical floor is determine among the structure considering seismic loading. Following tables and graphs are presented to find optimum system to resist seismic forces under following heads:-

A. Maximum Bending Moment

TABLE 3: MAX. BENDING MOMENT (Mz) kNm FLOOR WISE

MAX. BENDING MOMENT (Mz) kNm FLOOR WISE	
FLOOR	BENDING MOMENT kNm
GF	86.946
FIRST	164.067
SECOND	147.948
TOP	99.015

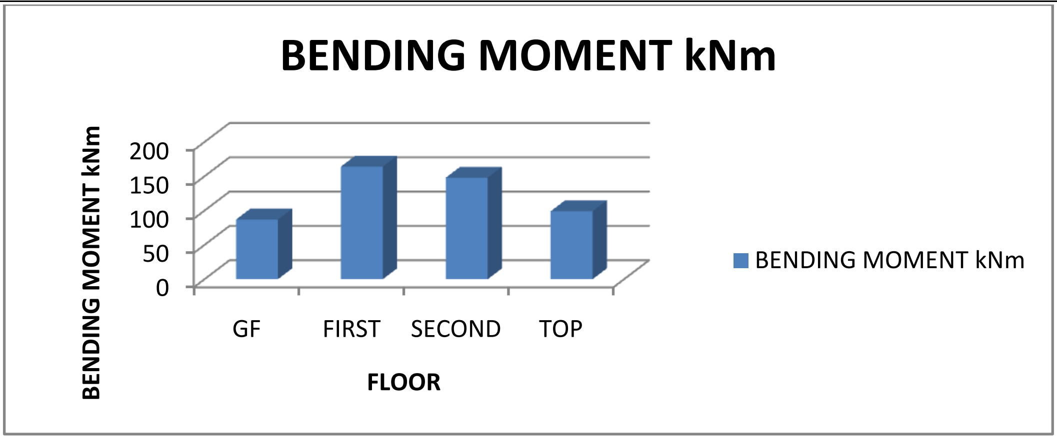

FIGURE 9: MAX. BENDING MOMENT (Mz) kNm FLOOR WISE

B. Shear Force

TABLE 4 : MAXIMUM SHEAR FORCE kN FLOOR WISE

MAXIMUM SHEAR FORCE kN FLOOR WISE	
FLOOR	SHEAR FORCE kN
GF	75.667
FIRST	189.15
SECOND	180.975
TOP	138.357

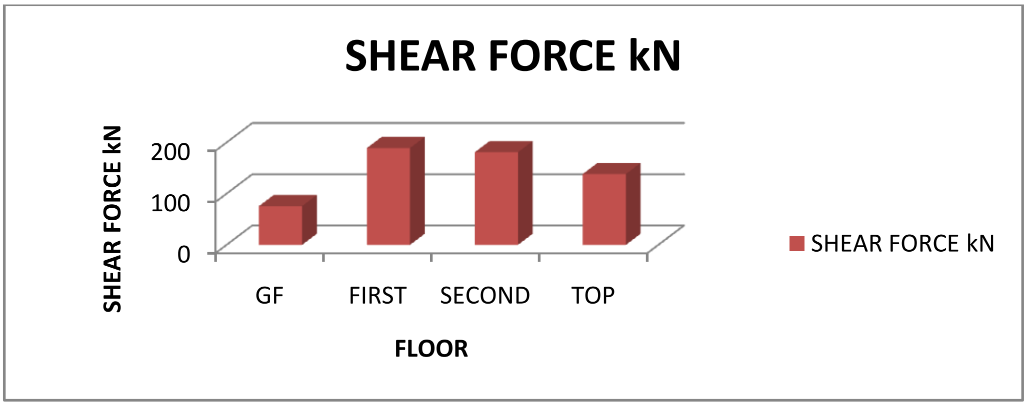

FIGURE 10: MAXIMUM SHEAR FORCE kN FLOOR WISE

C. Axial Force

TABLE 5: MAXIMUM AXIAL FORCE KN

MAXIMUM AXIAL FORCE KN	
FLOOR	AXIAL FORCE KN
BASE	1384.535
GF	1234.356
FIRST	783.897
SECOND	336.103

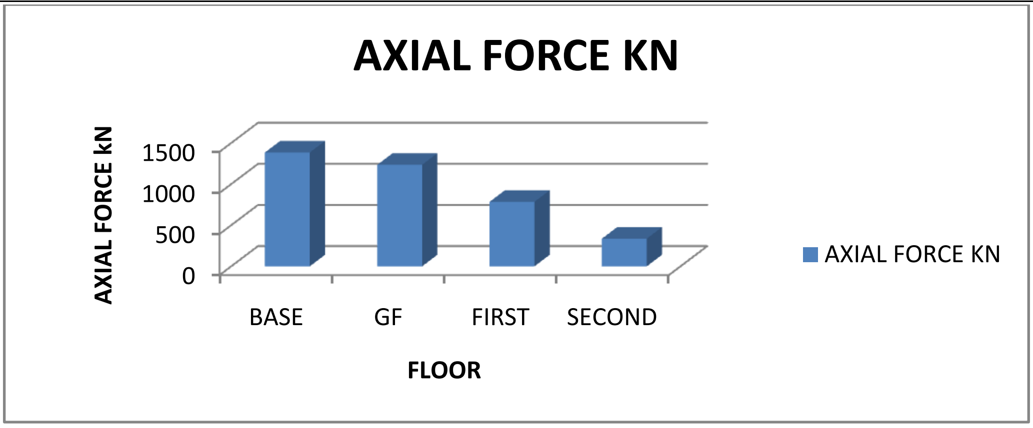

FIGURE 11 :MAXIMUM AXIAL FORCE KN

D. Maximum Joint Displacement

TABLE 6: MAX. JOINT DISPLACEMENT MM FLOOR WISE IN X DIRECTION

MAX. JOINT DISPLACEMENT MM FLOOR WISE	
FLOOR	DISPLACEMENT IN X DIRECTION
GF	0.701
FIRST	4.576
SECOND	8.484
TOP	11.029

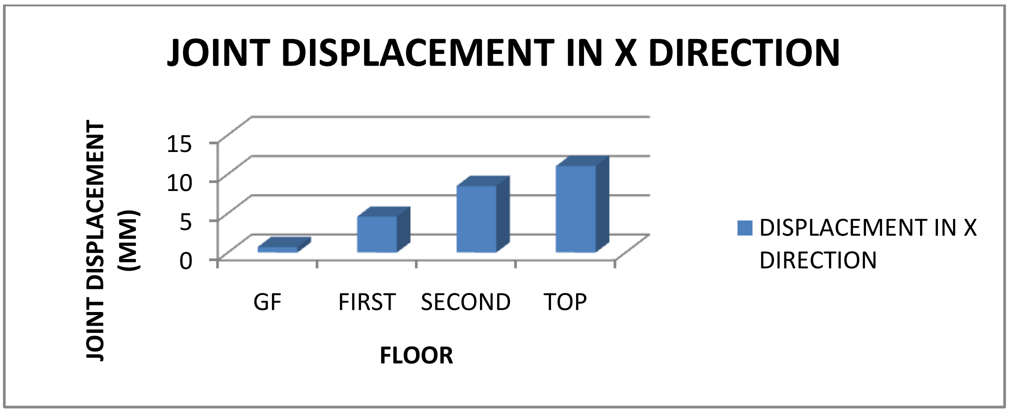

FIGURE 12: MAX. JOINT DISPLACEMENT MM FLOOR WISE IN X DIRECTION

TABLE 7: MAX. JOINT DISPLACEMENT MM FLOOR WISE IN Z DIRECTION

MAX. JOINT DISPLACEMENT MM FLOOR WISE	
FLOOR	DISPLACEMENT IN Z DIRECTION
GF	0.783
FIRST	5.126
SECOND	9.622
TOP	12.706

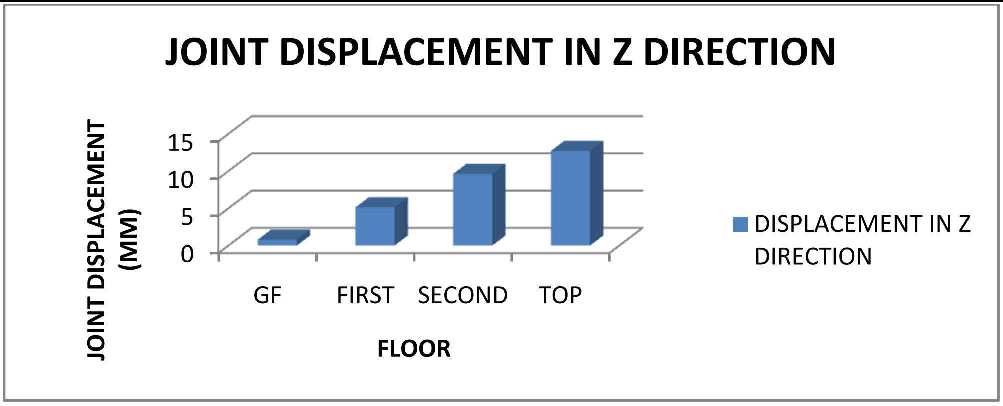

FIGURE 13: MAX. JOINT DISPLACEMENT MM FLOOR WISE IN Z DIRECTION

E. Maximum Section Displacement

TABLE 8: MAX. SECTION DISPLACEMENT MM FLOOR WISE IN X DIRECTION

MAX. SECTION DISPLACEMENT MM FLOOR WISE	
FLOOR	DISPLACEMENT IN X DIRECTION
GF	0.533
FIRST	1.175
SECOND	1.164
TOP	0.97

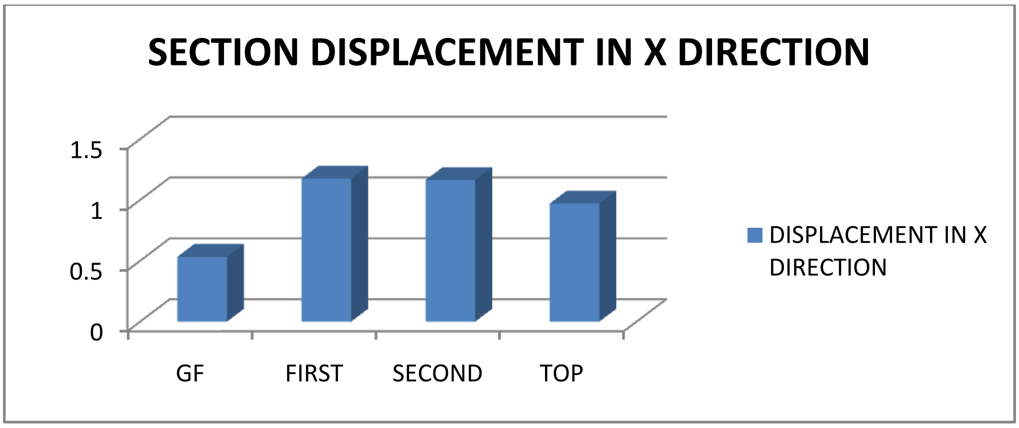

FIGURE 14: MAX. SECTION DISPLACEMENT MM FLOOR WISE IN X DIRECTION

TABLE 9: MAX. SECTION DISPLACEMENT MM FLOOR WISE IN Z DIRECTION

MAX. SECTION DISPLACEMENT MM FLOOR WISE	
FLOOR	DISPLACEMENT IN Z DIRECTION
GF	0.764
FIRST	1.455
SECOND	1.336
TOP	0.969

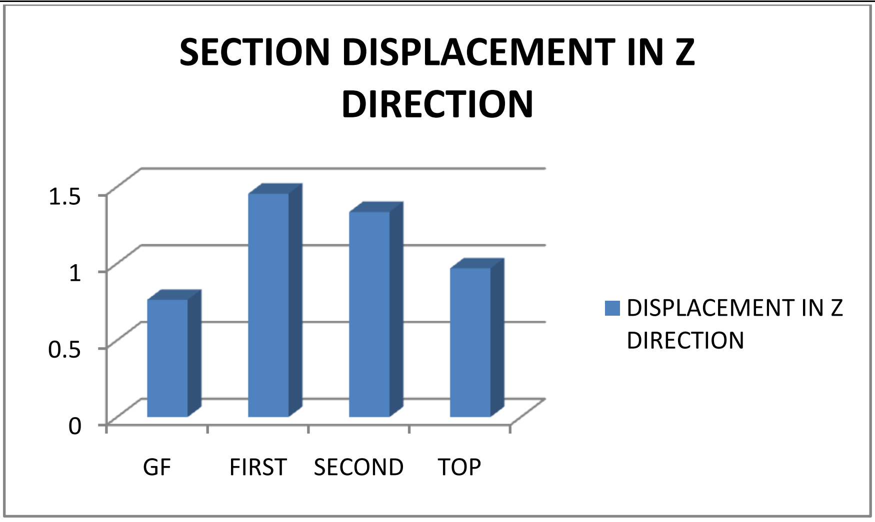

TABLE 15: MAX. SECTION DISPLACEMENT MM FLOOR WISE IN Z DIRECTION

CONCLUSIONS

In this study, performance of institutional building frames are studied considering various combination and seismic parameters. Results of this parametric study are as follows

1. In beam forces, maximum bending moment and maximum shear force are calculated and it is observe that second floor is critical and ground floor is efficient because of direct contact with soil and foundation.
2. In column force, maximum axial force is calculated and it is observed that maximum load is in base columns because it resist complete load of institutional building and as seen in top floor axial force is reduced up to 4 times of base
3. In joint displacement, maximum displacement is seen in top floor in both direction (X and Z direction)
4. In section displacement, maximum displacement is seen in first floor section in both direction (X and Z direction)

REFERENCES

[1]. **S.Mahesh and Dr.B.Panduranga Rao** Comparison of analysis and design of regular and irregular configuration of multi Story building in various seismic zones and various types of soils using STAAD- Volume 11, Issue 6 Ver. I (Nov- Dec. 2014), PP 45-52

[2]. Kevadkar M.D., Kodag P.B., 'Lateral load (loads due to earthquake, wind, blast, fire hazards etc) (earthquake loads, wind loads, blast, fire hazards etc) Analysis of R.C.C. Building', International Journal of Modern Engineering Research (IJMER), Vol.3, Issue.3, May-June. 2013, pp-1428-1434.

[3]. Salehuddin Shamshinar, Stability of a six storey steel frame structure, International Journal of Civil & Environmental Engineering, Vol.13 No.06, 2011.

[4]. User Manual STAAD.Pro.

[5]. Chopra, A. K., Dynamics of Structures(1995): Theory and Applications to Earthquake Engineering, Prentice-Hall. Inc., Englewood Cliffs, New Jersey.

[6]. IS 1893 : 2002, Indian Standard criteria for earthquake resistant design of frames, Part 1 General provisions and buildings, Draft of Fifth Revision, Bureau of Indian Standards, New Delhi, 2002.

[7]. IS 800:2007, ‘General construction in steel – Code of practice Bureau of Indian standards, New Delhi.

[8]. IS: 875(Part-1)- 1987 ‘Code of Practice for Design Loads (Other than Earthquake) buildings and frames’, Part-1 Dead load, Unit weight of building materials and stored materials, Bureau of Indian Standards, New Delhi.

[9]. IS: 875(Part-2) - 1987 ‘Code of Practice for Design Loads (Other than Earthquake) buildings and frames’, Part-2 Imposed loads, Bureau of Indian Standards, New Delhi.

[10]. IS: 875(Part-3) - 1987 ‘Code of Practice for Design Loads (Other than Earthquake) for buildings and structures’, Part-3Wind loads, Bureau of Indian Standards, New Delhi.

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Study of the Forestry and Artisanal Diamond production linked to the conflict in the Central African Republic (CAR)

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ABSTRACT: The Central African Republic (CAR), a country with rich in timber and diamond deposits and a tumultuous political history. Central African Republic once had the third largest area of rainforest cover in Africa. Today, while tropical forest covers 36 percent of the country, most of this has been degraded by logging. Very little of Central African Republic forest cover can be considered primary forest.

Diamond mining and forestry form the bulk of the economy of the Central African Republic. Burdened with poor infrastructure and high transportation costs, a largely unskilled work force, and poor economic policies, the Central African Republic is not a particularly attractive source for timber among African producers. Nevertheless, most of the country's forests have been logged for valuable tree species including sapelli, ayous and sipo. Most wood from the Central African Republic is exported to Europe. Deforestation and poor agricultural practices are resulting in desertification in the northern parts of the country.

Diamonds as Timber are supposed to be symbols of love, commitment, and joyful new beginnings. But for many people in diamond-rich countries, these sparkling stones are more a curse than a blessing. Too often, the world’s diamond mines produce not only diamonds – but also civil wars, violence, worker exploitation, environmental degradation, and unspeakable human suffering.

When discussing the link between conflict and insecurity on the one hand and natural resources on the other, terms like ‘conflict diamonds’ or ‘blood diamonds’ easily come to mind. Particularly, the alliance between the CAR regime and Congolese rebel leader Jean-Pierre Bemba at the turn of the century. Bemba’s troops thwarted a coup attempt against Patassé in 2001 and he allegedly had links with two Central African diamond buying offices. Bemba financed his war in the DRC by controlling the sale of one to three million dollars worth of diamonds a month. Diamonds that were mined in the Congolese territory held by Bemba were allegedly often sold or laundered through the CAR. This linked; experienced in the conflict in the CAR is the goal for our study.
KEYWORDS: Forestry, Artisanal Diamond, Conflict, CAR.

I. INTRODACTION

The Central African Republic is a landlocked country in Central Africa. It is bordered by Chad to the north, Sudan to the northeast, South Sudan to the east, the Democratic Republic of the Congo and the Republic of the Congo to the south and Cameroon to the west. The CAR covers a land area of about 622,984 square kilometers (240,535 sq mi).

The CAR disposed two main areas production of the diamonds, at Eastern by Mouka-Ouadda Sandstone and the most important in the Western by Carnot Sandstone. The forests are located at south of the CAR in the regions bordering to the Democratic Republic of Congo (Fig. 1-1, 2-1). The CAR is known for its wealth in mineral resources, over the past decade till today the CAR confronts the different crises that linked to its natural resources; this is the focus of this study.

Diamonds have been linked to conflicts in several countries in recent decades, including those in Sierra Leone (Smillie et al., 2000), Angola (Le Billon, 2001), the Democratic Republic of the Congo (DRC) (Samset, 2002), Ivory Coast (UNSC, 2005), and Liberia (UNSC, 1992). Most recently, the international community has voiced concern that the diamonds in the Central African Republic (CAR) may be the latest example of a conflict resource. As calling blood diamond or diamond of conflict most of the diamonds occurred from Africa continent or a country rich in diamond producing and in conflict. According to the CAR those resources mineral did not escape in the conflict.

Gold and diamonds in Central Africa easily conjure up images of conflict, rebel funding, human rights violations, and smuggling. As a country landlocked within an unstable region, neighboring the Democratic Republic of Congo (DRC), and recently the scene of another coup attempt, the Central African Republic (CAR) might be considered an appropriate candidate for analysis within the conflict-mineral perspective. Yet this framework would ignore the country’s mining sector’s very specific characteristics. The sector offers an essential livelihood to many households, represents the country’s second most important export product, and is organized in a particular way. Nonetheless, a wide range of issues regarding the country's mining sector persist, (Ken Matthysen and Iain Clarkson 2013 .CAR Gold & Diamond Mining).

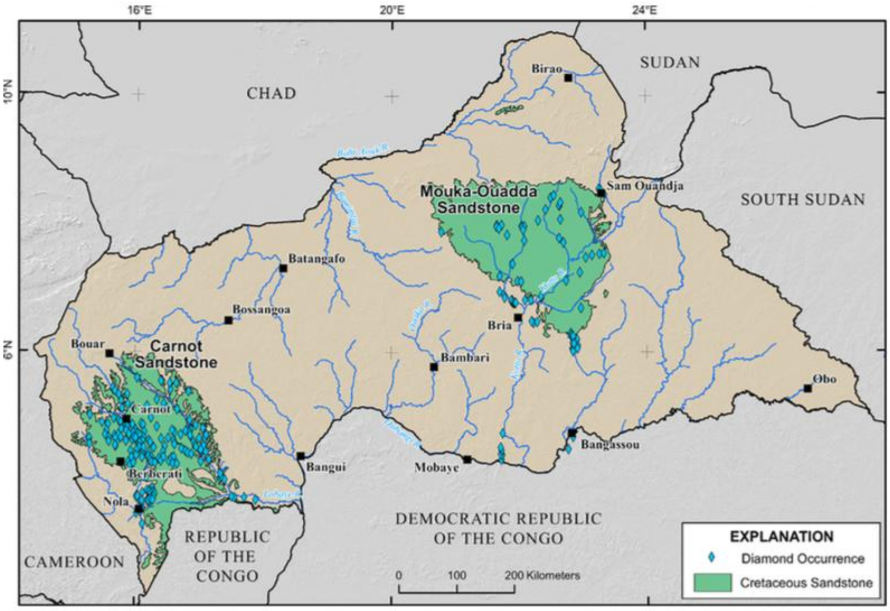


Fig. 1-1: CAR's map and diamond deposits area (Carnot and Mouka-Ouadda Sandstone formation).

II. LOCALISATION OF STUDY AREAS CONCERNING

2-1 Location of forests

Located In the south-west, in the regions of Sangha and Lobaye, forests cover an area of 3.7 million hectares. Most logging concessions are located in this area, especially along the borders with Cameroon and Congo. This area is also where most of the diamond mining takes place; in the east, in the Bangassou area, forests cover an estimated 1.2 million hectares. This region is very isolated, and little is known about its forests. They are not being exploited commercially because of transport difficulties. (Forests Monitor. Reports 2006)

Located entirely within the tropical zone of Central Africa, the Central African Republic has an area of 622,984 sq km (240,535 sq mi), extending 1,437 km (893 mi) E–W and 772 km (480 mi) N–S. Comparatively, the area occupied by Central African Republic is slightly smaller than the state of Texas. Compared to the other countries in the Congo region, CAR has a relatively small area of forest around five million hectares corresponding to 8% of the country's territory.

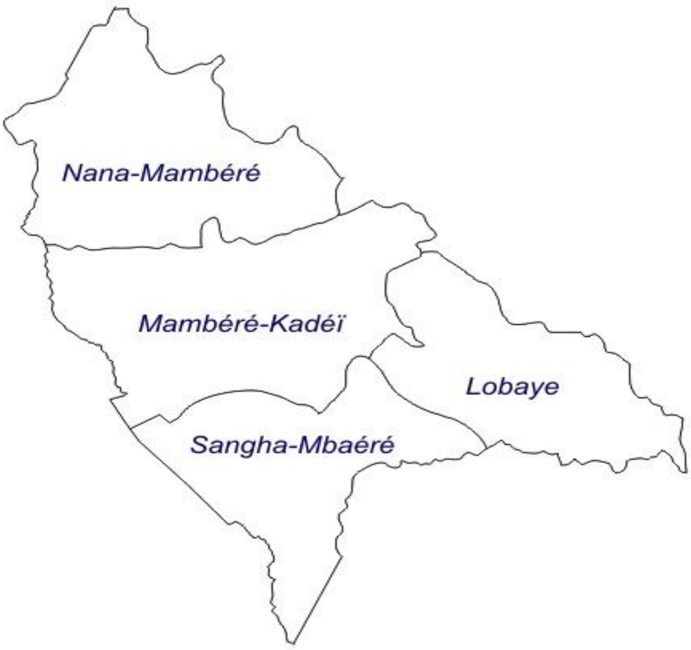


Fig 2-1: CAR's S-W areas cover by forest

2.2 Carnot sandstone

Previous study By Peter G and others (Report 2010). The Carnot Sandstone is of Mesozoic age and of fluviatile origin, which, in the most recent depositional environments, may have also included lacustrine and palustrine deposits. As a result, the formation is composed of several successional layers of conglomerates, sandstones and mudstones, and siltstones. It lies in the southwestern part of the CAR and covers an area of more than 40,000 km². The thickness of the unit is highly variable but has been reported to be as thick as 300 to 400 m in places (Censier, 1990). Heavy mineral and quartz exoscopic analysis (Censier, 1990) demonstrate that the detrital material of the Carnot came from a southerly origin, has similar mineralogical composition throughout the whole in filled basin, and was composed of reworked detrital formations. The Nola and Bolé River series was originally thought to be the source of the reworked material. Subsequent analysis supports the assigning of the glacial Devonian–Carboniferous Mambéré Formation and the Precambrian schist and quartzite rocks as the source of the detrital materials that have been reworked and cemented into the Carnot Sandstone. The underlying Precambrian granitic-gneissic complex of rocks formed the landscape for Carnot deposition (Censier and Lang, 1999). The paleogeography and paleotopography show that this landscape was a general peneplain with monadnocks. The monadnocks' subsequent erosion causes the mineralogical heterogeneities in the current landscape and also results in the irregularities in the basal surface of the Carnot Sandstone. The surface of the original sedimentary basin was much larger than has been interpreted on the basis of current limits of the Carnot Sandstone. The western margin may have extended beyond the CAR and Cameroon border (Censier, 1990).

Deposition of the reworked material occurred from the Albian to the Maastrichtian in north-northwest-flowing riverine braided channels flowing into the Doba Trough (Chad) and into the Touboro Basin (Cameroon) (Censier and Lang, 1999). Subsequent uplift and faulting during the Cenozoic reversed the direction of low and erosion of the Carnot from north-northwest to south-southeast and emplaced the current fluvial drainage system.

Followed previous study of (Claude Censier, Jacques Lang 1999). The discovery of the first diamond-bearing alluvial deposits in 1931 marked the onset of mining and geological surveying in the west and southwest CAR. Subsequently, reconnaissance studies of the Carnot Formation were carried out (Asselberghs, 1934) and various scale maps were made (Babet, 1948; Gerard and Gerard, 1953a, b; Wolff, 1962). The realisation that the Carnot Formation was the host rock of the diamonds led to its detailed geological study (Borgniez, 1935; Babet, 1935; Delany and Delorme, 1956; Berthoumieux and Delany, 1957). This work, which was mostly undertaken for mining companies, was interrupted when exploitation stopped after the country became independent (1960).

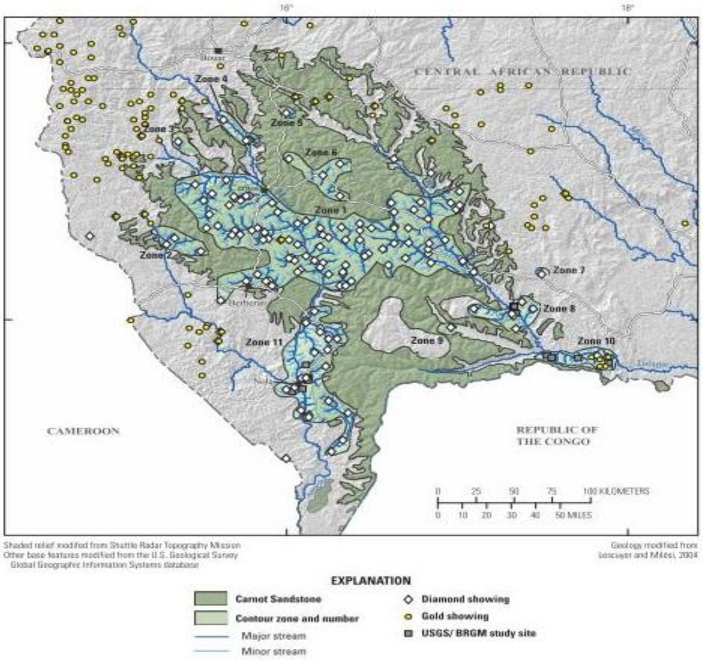


Fig. 2-2: Location diamond deposit and Carnot Sandstone formation

2.3 Mouka-Ouadda Sandstone

The Mouka-Ouadda Sandstone is Cretaceous fluviatile sandstone that lies in the eastern Central African Republic. It is thought to be the secondary host rock of the alluvial diamond deposits in the region. The Mouka-Ouadda Sandstone covers an area of approximately 40,000 km², forming a plateau that is generally less than 500 m thick. It is composed of layers of sandstone and conglomerate. Similar to that of the Carnot Sandstone, the Mouka-Ouadda is thought to have been derived from detrital material from the Fluvial-glacial Kombélé

Formation and from the Precambrian schist and quartzite complex and was also deposited on a peneplained Precambrian granitic- gneissic basement. Paleocurrent measurements indicate that the major source of sediment lies to the south-southwest, and the direction of deposition was to the north-northeast. As structural evolution of the landscape progressed, the orogenic uplift to the north reversed the riverine low, thus developing the current drainage system (Malingbar and others, 2006).

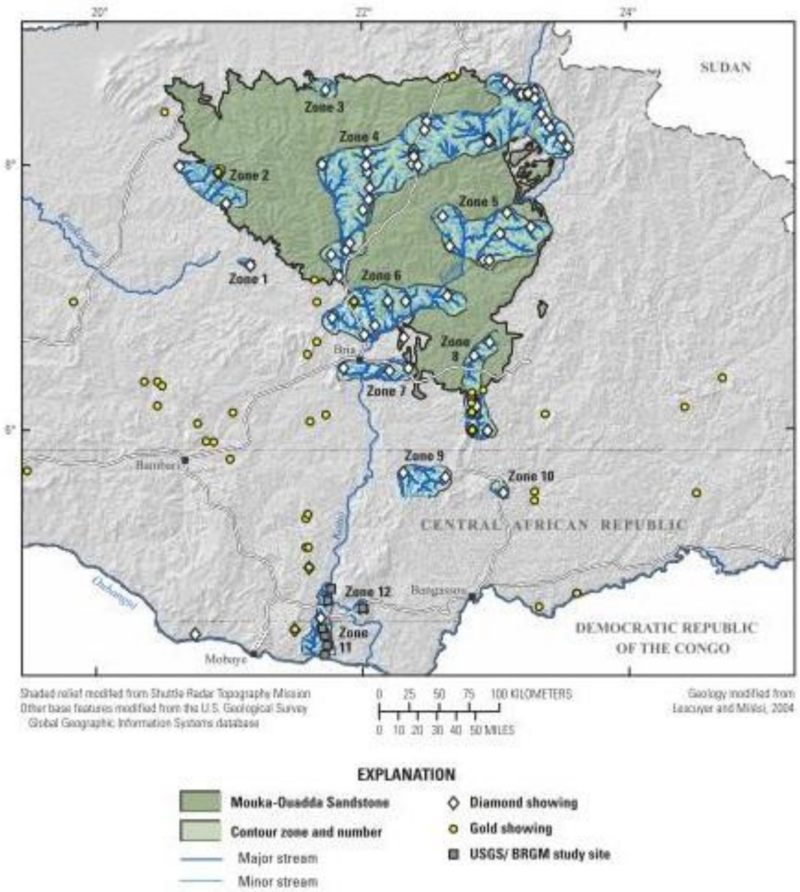
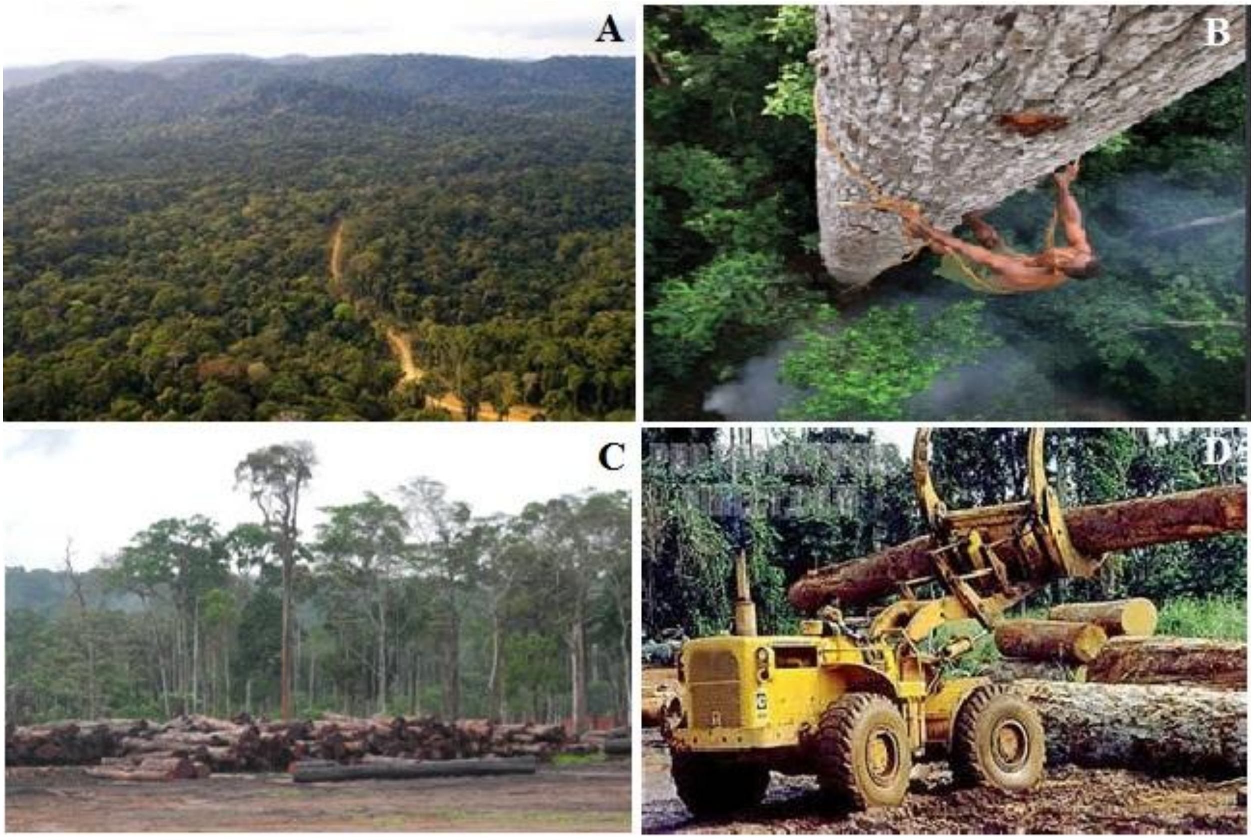


Fig. 2-3: Location diamond deposit and Mouka-Ouadda Sandstone formation

III. PHYSICAL GEOGRAPHIC

3.1 CAR forestry

An estimated 15 percent of CAR's territory is covered by forests, part of the Congo Basin rainforest, vital to the regional and global climate as the second largest tropical forest in the world after the Amazon. Located in the South-West and South-East of the country, these forests are a vital source of livelihood for an estimated 15,800 forest-dependent peoples including thousands of indigenous people. The forests are exploited by both artisanal and industrial loggers.



Appendix 3-1: CAR’s Lobaye areas forests

3.1.1 Artisanal and industrial forestry and transportation

The artisanal sector is mostly informal, generating 33,000 cubic meters of sawnwood for the local market, but a further 6,000 cubic meters, most of it illegal, is exported to Chad. The sector answers to the needs of local populations, 90 percent of whom use wood for their energy needs. Before the 2013 crisis, it employed an estimated 2,000 people.

The industrial sector, on the other hand, commercially exports roundwood (logs) and sawnwood, mainly to China and the European Union. In 2013, six logging companies operated in CAR in 11 concessions: IFB, SEFCA, SCAD, SCAF, SCD and VICWOOD group (its subsidiaries Vica, Thanry Centrafrique and Sofokad hold logging titles). Active in the country’s South-West, these companies are owned by foreign investors, and due to the country’s very low levels of economic development, hold an outsized influence in the country. Before the war, they were responsible for slightly more than forty percent of export revenues, 10 percent of its GDP, and generated revenues of around EUR 3.5 million a year, which apparently accounted for 34 percent of government revenues. Before the crisis, the sector employed approximately 4,000 people, and apparently supported 6,000 indirect jobs, a figure now in constant decline (currently 2,717 direct jobs) according to the Minister of Forests. The war is believed to have reduced the sector’s turnover by half.

There are 22.9 million hectares (56.5 million acres) of forest (37% of the total land area), but only 3.4 million hectares (8.4 million acres) of dense forest, all in the south in the regions bordering the Democratic Republic of Congo. The CAR's exploitable forests cover 27 million hectares (68 million acres), or 43% of the total land area. Transportation bottlenecks on rivers and lack of rail connections are serious hindrances to commercial exploitation. Most timber is shipped down the Ubangi and Zaire rivers and then on the Congo railway to the Atlantic. More than a dozen types of trees are felled, but 95% of the total is composed of obeche, sapele, ebony, and sipo.

A dozen sawmills produced 703,000 cu m (25 million cu ft) of sawn logs and veneer logs in 2000. The government is encouraging production of plywood and veneer. Roundwood removals were estimated at 3 million cu m (106 million cu ft) in 2000. Competition from lower-cost Asian and Latin American loggers has hurt the local industry, which is encumbered with high transportation and labor costs. In 2000, the country exported $39.6 million of roundwood and $16.3 million of sawn wood.

Appendix 3-2: CAR's timber transporting

3.1.2 Illegal practices and permits in the logging sector

The complete absence of government controls has obviously increased the likelihood of logging companies engaging in illegal and hence harmful practices in the country's rainforest. A number of illegalities have been recorded in recent years. In 2012, an audit conducted in the framework of a WWF project showed that SEFCA and IFB were not following laws regulating labour conditions, harvesting practices, environmental protection, etc. In the case of SEFCA, there were 16 cases of major non-conformity identified; it indicated major illegalities, including in its logging operations.

First on the list: the applications submitted by the companies were deficient in various ways. The documents submitted by some of the companies did not provide information on company ownership and the origins of their shareholders. Many essential documents were also absent, inter alia: tax payment certificates, bank guarantees, proof of at least five years of experience in the logging sector, corporate affiliations.

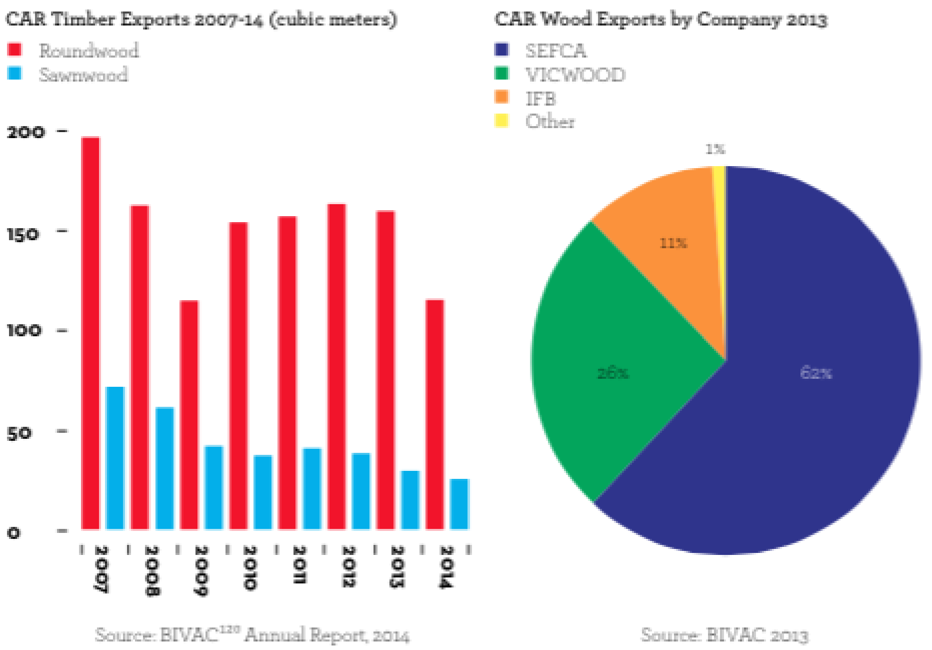


Fig 3-1: CAR Timber Exports 2007 (cubic meters) (Blood timber July 2015)

3.2 CAR's Diamond

CAR's diamond deposits are generally of high quality, with approximately 40% of stones being of gem quality (Bardet, 1974). The diamonds located within the Carnot and Mouka-Ouadda Sandstone formations represent CAR's two significant diamond deposit zones. One distinguishing factor between these two deposits is the fact that in the east, 85–90% of the stones are of high to medium quality (Bardet, 1974; WGDE, 2012). These stones are also often larger than those found in western CAR, with stones of 10 carats or greater frequently recovered. While the average price per carat in CAR is $169.79 (in 2012), the value of stones in eastern CAR ranges from $200 to more than $300 per carat (WGDE, 2012). Some discrepancy exists concerning the quantity of diamonds located within each zone. Production figures suggest that 65–75% of diamond production comes from western CAR, with eastern CAR contributing 25–35% (Bardet, 1974; Censier, 1996). However, Chirico et al. (2010) calculate that the two plateaus are similarly endowed with diamonds. This result suggests that the higher western zone production figures noted by Bardet (1974) and Censier (1996) may be a function of population density and mining intensity, as the west is significantly more populated and is known to have more artisanal miners and active mine sites than the east. The lower production figures for eastern CAR may also reflect the presence of unofficial channels through which diamonds mined in the east exit the country (Matthysen and Clarkson, 2013). Institutional capacity is particularly low in eastern CAR, Rendering it difficult for the country to guard against illicit smuggling and trading.

3.2.1Illegal practices on CAR diamond

Diamonds from eastern CAR have been smuggled through South Darfur and Chad, and armed bandits and rebels set up roadblocks and steal from miners and traders (ICG, 2010). According to the low Institutional capacity in eastern CAR, While it is clear that the diamonds producing in eastern have a link in recently conflict in the CAR, according to the illegal diamonds transaction through South Darfur and Chad, and the high percentage of people from Chad and Sudan joining the group armed in the eastern diamonds areas production of CAR and formed Seleka rebel that is estimated as 15% for CAR local population and 85% for the countries neighboring (Chad and Sudan) closed to eastern of CAR and set up the Seleka rebel mainly activity in the CAR since beginning of 2012 (see Fig. 7-1)

3.2.2 Companies holding exploration and exploitation permits

At the moment, all other companies that hold exploration or exploitation concessions in the CAR have suspended their activities. Most of them cite the global economic crisis as their main reason for not being present in the country. South of AXMIN's concessions, Tala Mining and Dimbi Diamants hold their exploration permits near the Congolese border. Tala Mining has been present in the country since March 2010. That year it contributed more than US$500,000 to the CAR's treasury. The company suspended its activities only a few months ago.

Dimbi Diamants had been in the country for a longer time. As a subsidiary of Pangea Diamondields, it was exploring the Dimbi project near Kembé, and the 2009 EITI report announced that industrial exploitation of diamonds was foreseen for the near future. In 2010, however, Pangea Diamondields went into liquidation and its concessions were taken over by IGE Resources AB. The latter deems Pangea's old CAR projects, Dimbi as well as Etoile, no longer relevant.

In the east of the country lies AREVA's 25-year uranium exploration and exploitation permit, near Bakouma. The company acquired the concessions in August 2007 when it bought the South African junior miner UraMin. In recent years, it was the most important source of tax revenues within the CAR's mining sector. In 2010, for example, it was responsible for 39% of the State's fiscal revenues from the sector. Since the beginning of this year, however, AREVA has suspended its activities in the country.

Most of the country's concessions are, however, located in the western part of the country. In 2011, Société Perrière acquired a three-year exploration permit for gold and diamonds near Boda. Likewise Kamach Mines also holds gold and diamonds exploration permit near Boda, however, like most others, it has also suspended its activities.

IV. HUMAN GEOGRAPHIC

4.1 Population

Central African Republic ended 2014 with a population of 4,709,203 people, which represents an increase as of 92,786 people compared to 2013. Central African Republic ranks No. 120 among196 countries which published this information in countryeconomy.com. The female population is greater, with 2,344,699 women, representing 50.79% of the total, compared to 2,271,718 or 49.21% men. Central African Republic is a country with a very low population density, with 8 people per square km and it was in position 13th in our ranking of density population in 2014.

According to the 2010 revision of the World Population Prospects the total population was 4 401 000 in 2010, compared to only 1 327 000 in 1950. The proportion of children below the age of 15 in 2010 was 40.4%, 55.6% was between 15 and 65 years of age, while 4% was 65 years or older.

There are more than 80 ethnic groups in the Central African Republic (CAR), each with its own language. About 50% are Baya-Mandjia, 40% Banda (largely located in the northern and central parts of the country), and 7% are M'Baka (southwestern corner of the CAR).

Period	Total population (x 1000)	Population aged 0–14 (%)	Population aged 15–64 (%)	Population aged 65+ (%)
1950	1 327	36.2	58.7	5.1
1955	1 399	37.0	58.3	4.7
1960	1 504	38.2	57.5	4.3
1965	1 649	39.6	56.2	4.2
1970	1 829	40.6	55.3	4.1
1975	2 017	41.7	54.2	4.1
1980	2 274	42.2	53.6	4.1
1985	2 627	42.4	53.6	4.0
1990	2 935	43.2	52.8	4.0
1995	3 328	42.5	53.5	4.0
2000	3 702	42.0	54.0	3.9
2005	4 018	41.6	54.5	4.0
2010	4 401	40.4	55.6	4.0

Table 4-1: Population statistic from 1950 to 2010

4.1.1 Cultural geographic context

The location and spread of ethnic groups in CAR was analyzed using the GREG dataset. This dataset this dataset identifies thirteen major ethnic groups in CAR and shows that the majority of the populations (80%) are Banda. When mapped in relation to the country's diamond deposits, it becomes clear that almost all of western and southeastern CAR's diamond deposits fall within Banda Territory (Fig. 4-1). In eastern CAR, the situation is more complex. Though the majority of deposits are found within the territory of the Banda, diamonds are also found within the territories of the Bagirmi and the Sudan Arabs, groups that make up 3.7% and 1.3% of the total population, respectively. Both groups have experienced incidences of conflict involving rebel groups.

Northeastern CAR has a long history of marginalization. The groups that inhabit this region are mostly Muslim, as opposed to the Christian national majority, and speak Arabic, rather than the national language, Sango. Many inhabitants of the northeast believe that their region has been purposely underdeveloped because of these cultural differences (Bauters, 2012).

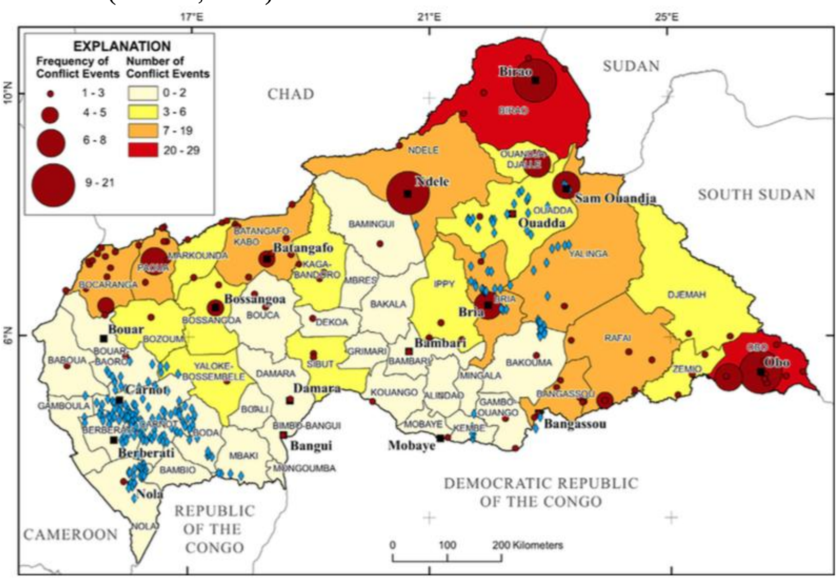


Fig. 4-1: The results of the population density analysis per sub-prefecture.

4.2 Economics activities

The economy of the Central African Republic is expected to grow slightly faster in 2015 after a 2014 marked by a positive return to growth, following the massive slump in 2013. The country remains, however, marked by insufficient growth to ensure job creation – a situation which, however, already existed before the 2013 crisis and led to ubiquitous poverty (62% of the population) and alarming social indicators.

Subsistence agriculture, diamond mining, and forestry form the bulk of the economy of the Central African Republic. Burdened with poor infrastructure and high transportation costs, a largely unskilled work force, and poor economic policies, the Central African Republic is not a particularly attractive source for timber among African producers. Nevertheless, most of the country's forests have been logged for valuable tree species including sapelli, ayous and sipo. Most wood from the Central African Republic is exported to Europe.

Logging roads have opened up much of the Central African Republic to subsistence agriculture and poachers. Bushmeat hunting some of the most severe in Africa has taken a heavy toll on the country's once abundant and diverse wildlife. The black rhino is no longer present in the country due to poaching. Fuelwood collection has also put pressure on the Central African Republic's forests.

Deforestation and poor agricultural practices are resulting in desertification in the northern parts of the country.

The Central African Republic had one of the lowest total deforestation rates among tropical countries between 1990 and 2005 when just 1.9 percent of its forests were lost. However, the country's forest degradation rate was considerably higher due to logging.

Today about 16.6 percent of the Central African Republic is under some form of protection, though institutional support for protected areas has historically been weak, and hunters and loggers have continued to operate in national parks. The Central African Republic is home to about 3,600 species of plants, 663 birds, 131 mammals, 187 reptiles, and 29 amphibians.

V. PREVIOUS CAR GEOLOGY STUDY

5.1 Geology of CAR

Previous study By Peter G. and others (Report 2010). The underlying geology of the CAR consists mainly of basement rocks of Archean and Proterozoic age, which can be divided into two main geologic groups: a granitic-gneissic complex and a schist-quartzitic complex. The granitic-gneissic complex is probably of Neoarchean age and is composed of gneissic, granite, and amphibolitic rocks. Also included in this group of basement rocks is a series of sedimentary volcanic sequences that are typically referred to as “greenstones.” Overlying the Archean basement rocks is the schist-quartzitic complex, which is thought to be of Neoproterozoic age and is composed of quartzitic and schistose rocks that are only weakly metamorphosed and generally folded. Both of these complexes are intruded throughout the country by basic rocks of Neoproterozoic age (Schlüter, 2006).

Overlying these older rocks is a sequence of Paleozoic rocks. The two major Paleozoic formations are the Mambéré Formation located in the western CAR and the Kombélé Formation located in the eastern CAR (Fig. 5-1). Both Paleozoic formations are of glacial origin. The Mambéré Formation is a tillite composed of both basal and low tills as well as reworked glacial deposits derived from sandstone, conglomeratic sandstone, and siltstone that occur in continuous beds, lenses, and isolated blocks (Censier and Lang, 1992). Similarly, the Kombélé Formation is a conglomeratic sandstone tillite composed of glacial-outwash plain sediments (Censier and others, 1992). Both the Mambéré and the Kombélé Formations generally range in thickness from 30 to 50 meters (m) and are covered by Cretaceous sandstone units lying unconformably above them. The exact areal extent of the Paleozoic rocks is not known because the more recent Mesozoic geology conceals a great deal of them. The Paleozoic units crop out in selected locations at the margins and in selected river valleys where the Mesozoic units have been completely eroded (Censier, 1996).

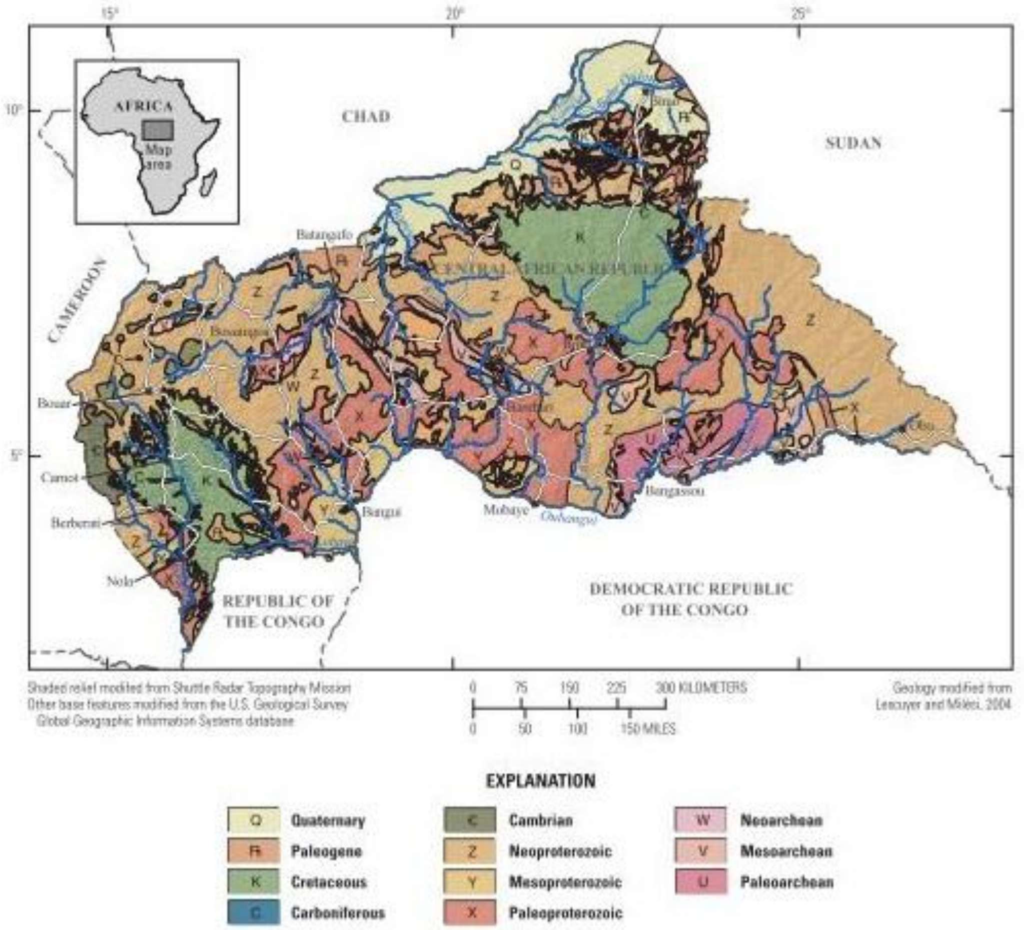


Fig 5-1: Geology of the Central African Republic

The Mesozoic, probably Cretaceous, fluvial sequences of conglomeritic sandstones concealing the Paleozoic glacial tillites form two distinct plateaus, one in the east and one in the west. The western plateau is made up of the Carnot Sandstone, and the eastern plateau is composed of the Mouka-Ouadda Sandstone. At one time, these two sandstone units extended much farther south and somewhat farther north than they do today. Later erosion of these two formations developed the current plateau landforms, which characterize the eastern and western CAR landscape (Censier and Tourenq, 1986; Censier, 1996). These two sandstone units are widely reported to be the secondary hosts of the diamonds in the CAR.

A series of Cenozoic rocks occurs in two distinct zones within the CAR. The first is a series Paleo-Tchadienne continental terminal sandstones extending north of Batangafo to the northern border of the CAR, forming smaller distinct plateaus. The second is the Bambio Sandstone, which is generally located between Nola and Boda just north of the Bangui River in the southwestern part of the country. The Bambio Sandstone lies atop the Carnot Sandstone but only covers an area of approximately 1,700 square kilometers (km²).

Recent Pleistocene deposits have filled in the northern basin and are generally divided into either Neo-Tchadienne alluvium or recent alluvial deposits. Quaternary alluvial deposits are also found in the many riverine floodplains throughout the country. Chemical weathering, which is typical in the humid tropical environment, has created lateritic duricrusts and ferricretes during the Quaternary. The weathering crusts may be as thick as 40 m in places and extend over large portions of the topography throughout the CAR (Petit, 1985; Beauvais, 1989; Beauvais and Roquin, 1996). (Chad) and into the Touboro Basin (Cameroon) (Censier and Lang, 1999). Subsequent uplift and faulting during the Cenozoic reversed the direction of low and erosion of the Carnot from north-northwest to south-southeast and emplaced the current fluvial drainage system.

VI. GEOLOGICAL CONTEXT

Diamonds occur in the Eastern part of the CAR in an area covered by Mouka-Ouadda Sandstones. These sandstones are considered to be the reservoir rocks comparable in age (Cretaceous?) and formation history to the Carnot Sandstones that form the most important diamond deposits of the CAR in the Western part of the country.

Fig.6-1: Diamond production areas in Eastern CAR. Hashed area represents occurrence of Mouka-Ouadda Sandstone Formation. Diamond deposits in zones 2-3-4-5-6 ("Bria") -7 and 8 share morphological characteristics. Diamonds increase in size and quality from North to South. Diamonds from deposits 9-10-11

("Dimbi") and 12 show stronger resemblance to diamonds from Northern DRC. Asteriks represent individual diamond deposits. Yellow circles indicate artisanal gold diggings (Map source: RCA (2009); DNG-BRGM-USGS).

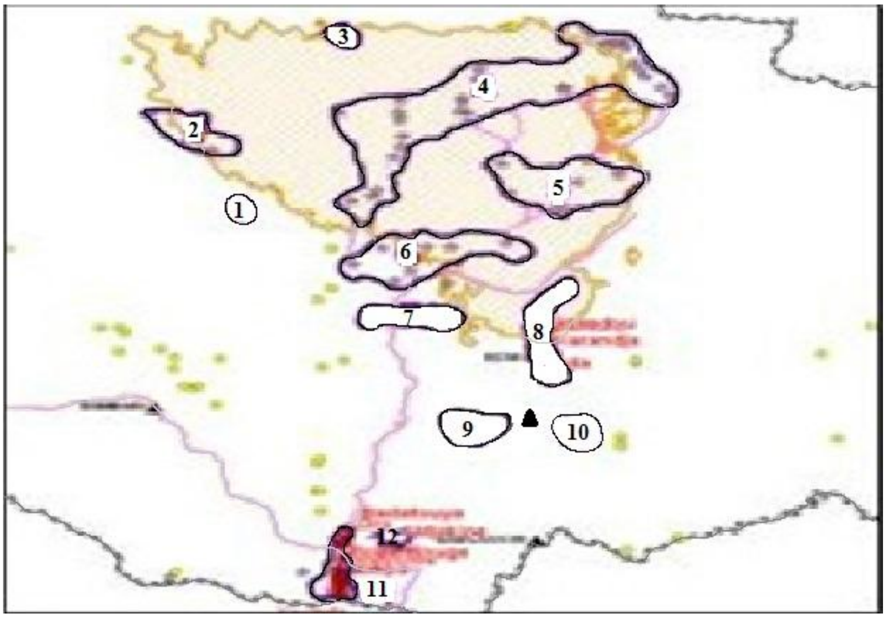


Fig 6-1: Diamond production areas in Eastern CAR.

	Description
Size	Avg. weight/stone: 0.7ct; 2ct common; >3-4ct less common; >10ct frequent; exceptionally ~100ct.
Crystal Morphology	Saweables (Octahedrons rare): 70-75% Makeables: 25-30% (incl. up to ~30% broken crystals). Mostly rounded, slightly flattened crystals with shiny surface. Many with (alluvial) Transportation damage.
Quality	~85-90%: High & Medium: Mostly greenish-yellowish, Greenish coatings common. Mostly commercial. Rarely colourless. Mostly cleanish. ~10-15%: Low: dark and heavily included crystals.
Value	Sam Ouandja: ~ 200$/ct; Bria: 200-250$/ct; Nzako: >300$/ct
Production Capacity	Sam Ouandja: ~ 10,000ct; Bria: 40,000-50,000ct; Nzako: ~ 5,000 - 7,500 ct

Table 6-1: Description of Diamond producing in Eastern area of CAR

According to study (Katherine C. Malpeli, Peter G. Chirico). CAR's eastern, southeastern, and western diamond deposits are similarly lootable according to the current definition of lootability. They are alluvial in nature, spread over vast areas, mined exclusively artisanally, and have a high value-to-weight ratio. These similarities are a result of their shared geologic history. While no primary source of diamonds has been discovered in CAR, the Carnot and Mouka-Ouadda Sandstone formations, located in western and eastern CAR, respectively, are thought to be secondary source rocks for the diamonds (see Fig.2-2 and 2-3). The deposits in southeastern CAR are also thought to be related to the sandstone formations, which have since eroded from this area. Only remnants of the former plateau remain in the southeast (Censier, 1996; Chirico et al., 2010)

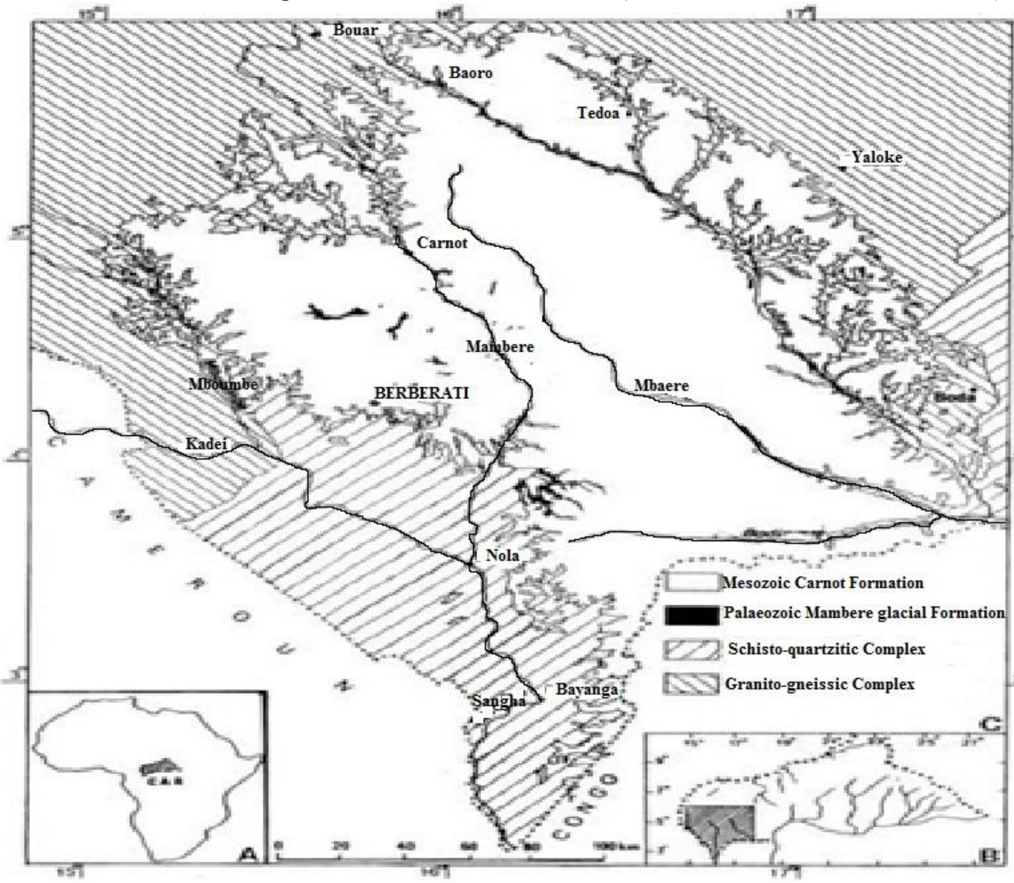


Fig. 6-2: Geological setting of the Carnot formation (Claude Censier, Jaques Lang 1999)

Watershed	Number of Cells	Cell Area (m^2)	Total Surface Area (m^2)	Average Gravel Thickness (m)	Total Alluvial Volume(m^2)	Volume of Deposit (ct/ m^2) (2% of Total Alluvial Volume)	Concentration Grade (ct/ m^2)	Concentration Reserves (ct/m^2) (2%)
Nola 1								
AF	50451	8402.77	211,964,074.64	0,8	169,571,259.71	3,391,425.19	0,60	2,034,855.12
AT		8402.77	211,964,074.64	0,2	42,392,814.93	847,856.30	0,20	169,571.26
Nola 2								
AF	13011	8402.77	54,664,220.24	0,8	43,731,376.19	874,627.52	0,60	524,776.51
AT		8402.77	54,664,220.24	0,2	10,932,844.05	218,656.88	0,20	43,731.38
Boda 1								
AF	99778	8402.77	419,205,792.53	0,8	335,364,634.02	6,707,292.68	0,60	4,024,375.61
AT		8402.77	419,205,792.53	0,2	83,841,158.51	1,676,823.17	0,20	335,364.63
Sub-Total								7,132,674.51
Estimated Historical Production								2,000,000
Total Resources Remaining 5,132,674.51								

Table 6-2: Western of the CAR's watershed details

Zone	Total Estimated Resources Volume Grade Approach (carat)	Total Estimated Resources Content per Kilometer Approach (carat)		Mean Total Estimated Resources (carat)
Country-level assessment				
Western Zone (Carnot)	29,227,742.00	36,990,718.65		33,109,230.33
Eastern Zone (Mouka-Ouadda)	27,235,608.30	26,916,727.00		27,076,167.65
	56,463,350.30	**63,907,445.65**	**Total Resources**	**60,185,397.98**
			Historical Production From 1991-2006	**21,000,000.00**
			Total Resources	39,185,397.98
PRADD Study Area Assessment				
Nola Watershed				**2,772,934.27**
Boda Watershed				**4,359,740.24**
			Sub-Total	**7,132,674.51**
Estimated Past Production				**2,000,000.00**
			Total Resources	**5,132,674.51**

Table 6-3: CAR western and eastern zone inferred and speculated Resources

Year	Volume (carats)	US$/carats	Value, US$
2004	348,205.16	148.50	51,709,404.00
2005	382,756.00	158.25	60,572,404.80
2006	419,528.35	140.79	59,066,866.49
2007	467,710.53	127.98	59,857,870.53
2008	377,209.12	126.59	47,752,281.70
2009	311,779.42	151.03	47,086,829.60
2010	301,557.62	162.13	48,892,376.57

Table 6-4: Production and value statistic of CAR

6.2 CAR diamond history and producing

Diamonds were discovered in the CAR in 1914 and again in 1929 when the widespread presence of alluvial diamond deposits was recognized (Dempster and Tutusaus, 1995). Commercial mining and production began in 1931 in the Bossangoa and Nola regions (western region) and rapidly expanded from 1935 to 1945. The alluvial exploitation of the eastern region expanded from 1943 to the present. Several mining companies exclusively exploited the diamond resources in the CAR from 1931 until 1960, and diamond production remained relatively low, averaging about 75,000 to 100,000 carats per year. In 1960, the Central African Republic gained independence and shortly thereafter, in April 1961, authorized the Bureau d'Achat to act as an organization of diamond export companies. In addition, the government of the CAR began licensing artisanal miners who, in turn, hired diggers to exploit the alluvial deposits. From 1961 through the early 1970s, production of diamonds increased rapidly from approximately 100,000 carats a year to approximately 450,000 carats a year. The increase was largely due to the authorization and introduction of artisanal miners working throughout the sector. Annual production of diamonds varies from year to year in relation to the seasonal environmental conditions, stability and security within the country, and the number of diggers employed in the sector.

As of 2006, there were 7 *Bureaux d'Achat and 18 Centre d'Achat* acting as buyers and diamond exporters. There are estimated to be approximately 300 *collecteurs* who purchase the diamonds locally from artisans close to the alluvial mining sites and resell them to the *Bureau d'Achat* for sale and export. There are 1,988 artisanal miners and 6,515 *ouvrier miniers* for a total of 8,503 artisanal miners. *Ouvrier miniers* are licensed artisans who work on smaller scales and pay less of a licensing fee than the other artisanal miners. Each artisanal miner hires a team of diggers, which may range in size from 6 to 15 persons. There are also a few small-scale mining companies that operate in the CAR either through hiring diggers to exploit the deposits or by acting as buyers, *collecteurs,* and exporters.

It is estimated that between 50,000 and 100,000 diggers are exploiting alluvial diamond deposits in the CAR. Dietrich (2003) has reported the total number of licensed artisanal diggers as being approximately 50,000, while Censier (1996) reported an estimated 70,000. According to a 2003 unpublished report by Koyatro (Direction Générale des Mines), it is estimated that the total number of diggers is around 70,000 and that teams are typically constituted of approximately 10 to 15 diggers. Each team is hired and organized by a licensed artisan. Licensed artisans may sell diamonds either to a *collecteur* or directly to one of the registered diamond buying offices composing the Bureau *d'Achat. The collecteurs* may buy diamonds from many artisans and generally act as middlemen between the artisan and the *bureau* (Fig. 6-3).

In 1982, the *Bureau d'Evaluation et de Contrôle de Diamant et d'Or* (BECDOR) was established to officially value all diamond and gold exports. BECDOR assesses the value of all official diamond exports from the CAR and collects official statistics on diamond and gold production within the CAR. BECDOR also evaluates the receipts of sale from artisans and export companies operating in the CAR for all diamonds that they have purchased from artisans and mining societies. Each diamond sale is recorded through a series of receipts listed with the buyer's and seller's names and license numbers, in addition to carat, value, and place of origin of the diamonds.

Artisans and the teams of diggers that they employ utilize little if any mining technology beyond the occasional pumps. Most continue to use hand tools, sieves, jigs, and local timber and wood resources to perform the mining activities. There-fore, there are few barriers to entry for diamond diggers, as little or no training is required and basic tools are used. Often diggers move seasonally from site to site as new deposits are mined or as variations in the farming seasons occur.

While there are teams of 6 to 15 diggers typically employed by the artisans, there are often a number of ancillary workers at mine sites. These ancillary workers are usually family members of the diggers and include their wives and children. Women and children perform tasks such as transporting, washing, and sorting the gravel ore. Consequently, at a site where an artisan has a team of 10 diggers, there may be as many as 50 individuals working throughout all phases of the extraction and production process.

In addition, at some larger mine sites, women were observed cooking and selling food to the mine workers, operating independently of any specific digger family group. Markets may also be located close to the mine sites on certain days, developing a small-scale informal economy that may consist of all types of food and material sales and services. (Peter G. Chirico, and others 2010).

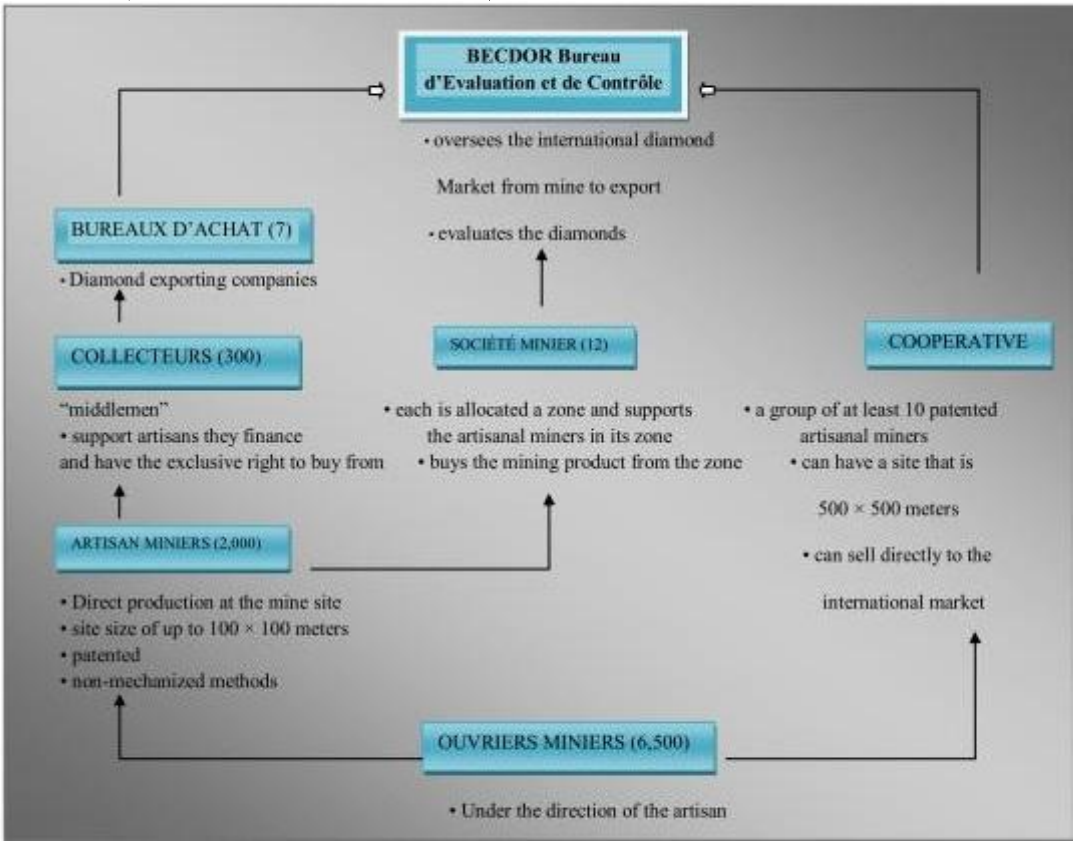


Fig. 6-3: Official diamond transactions, Central African Republic.

Diamonds and gold were discovered for the first time in the Central African Republic in the early twentieth century, when the country was still under French colonial rule. The colonial administration exerted strong control over access to the natural resources and granted concessions to private companies to exploit rubber, coffee, cotton and mineral resources. Diamonds soon became the CAR's second export product, after cotton.

International mining companies experienced their heyday in the CAR in the 1950s, with diamond production figures amounting to 147,104 carats in 1954. As these figures declined and exploration results lagged towards the end of the 1950s and early 1960s, mining companies confined their operations to the commercialization of minerals extracted from their concessions by artisanal miners.

During the colonial period, exploration exercises were carried out for gold and diamonds. After independence, however, international mining companies retreated from the country and investments in exploration disappeared. Diamond production, on the other hand, increased considerably after the end of colonial rule in 1960. The new Central African government liberalized the diamond sector, opening the mines to all citizens, which resulted in a rush to mining zones. Annual diamond exports consequently rose from 70,000 carats in 1960 to almost 537,000 in 1965.

After CAR's independence, successive rulers treated the country's mining sector as an important cash cow to sustain their patron-client network. Rulers would demand a share of production and impose high taxes on mineral exports. The most striking example is president/emperor Jean-Bédel Bokassa, who came to power in 1966. After an initial period of high production figures, diamond exports soon fell back because of Bokassa's greed, the exhaustion of the most easily exploitable deposits, and a lack of investment in new exploration. By the end of Bokassa's rule in 1979, production fluctuated at around 290,000 carats per year.

During the next decade, however, export statistics were revived once again with the introduction of a certiication system developed by the World Bank, the creation of the *Bureau d'évaluation et de contrôle de diamant et d'o*r (BECDOR), the lowering of export taxes, and the tapping of deposits that are less easily exploitable. (Source by Ken Matthysen and Iain Clarkson 2013)

In 1994, the Central African Republic's mining industry remained dominated by the production and export of alluvial diamonds of gem quality and the production and export of gold. Indeed, diamonds were the most important commodity produced in the landlocked country, which remained 1 of the top 10 diamond-producing countries of the world. The mining sector of the Central African Republic has historically contributed about 4% of the Nation's gross domestic product (GDP), which was $2.5 billion in 1993. Increased production and export of diamonds were due partly to the Government's recent administrative and regulatory reforms with regard to the diamond sector (Source by Thomas P. Dolley, 1995)

In 2010, Central African Republic was ranked 14th among the world's leading producers of rough diamond, by volume, and 12th among the world's leading producers of rough diamond, by value. Comparing CAR's and Togo exporting and importing to the United States: Central Africa Republic's exports to the United States were valued at about $5.6 million in 2010 compared with about $3.4 million in 2009; rough diamond accounted for $3.3 million of these exports. Imports from the United States were valued at about $10.3 million in 2010 compared with about $31.4 million in 2009. This total included nearly $2.7 for drilling and oilfield equipment and $12,000 for excavating machinery. Production of gold and diamond, which was mostly artisanal, came from the regions of Berberati, Haute-Kotto, and Haute-Sangha. Data on diamond production are in table 6-6. (Source by Yadira Soto-Viruet 2010).

	2010	2011	2012 (January-June)
Diamonds (carats)	301,557.62	322,575.30	210,684.78
Source BECDOR (Bureau d'évaluation et de contrôle de diamante et d'or)			

Table 6-5: CAR, official diamond exports 2010-2012

6.2.1 Artisanal and industrial diamond producing

Diamond production supported an artisanal labor force of about 40,000, primarily in the riverbeds surrounding Carnot and Berberati, where the stones are more abundant, but of lower quality. Additionally, diamonds were mined at Bria. Diamond mining cooperatives also were present in the country. Officially, 9,052 miners were registered in 1992. The balances of the artisanal miners are subject to paying a license fee to the Government. The highest recorded diamond production, which started in 1925, was in 1968 at 636,000 carats. In 1994, Canada's United Reef Ltd., through their local subsidiary, Howe Centrafrique Ltd., was the sole foreign company actively mining diamonds.

Commodity 3/		1990	1991	1992	1993	1994 e/
Diamond						
Gem	carats	303,000	206,000	302,000	370,000	400,000
Industrial	do.	78,000	82,000	102,000	125,000	131,000
Total	do.	381,000	379,000	404,000	495,000	531,000

Table 6-6: CAR, production of diamond commodities

Togo's exports to the United States were valued at about $9 million in 2010 compared with about $6 million in 2009. Imports from the United States were valued at about $170 million in 2010 compared with about $125 million in 2009. These included nearly $32 million of petroleum products, $3 million of excavating machinery, and $127,000 of drilling and oilfield equipment.

Countries	Commodities		2006	2007	2008	2009	2010
CAR	Diamond[5]	carats	419,528[4]	467,711[4]	377,209[4]	311,779[4]	301,557[4]
TOGO	Diamond	carats	28,176[4]	17,362[4]	8,787[4]	125[4]	96[4]

Table 6-7: CAR &Togo, comparing estimated production of diamond commodities

Countries	Greenstones	Industrial diamonds	Total
Angola	12,500	1,300	13,800
CAR	250	60	310
DRC	5,500	22,200	27,700

Source: Olson D. W. 2010 minerals Yearbook: Diamond, Industrial, USGS, June 2012

Table 6-8: Central African 2012 diamond production, thousand carats.

Diamonds are almost exclusively extracted by artisanal means in the CAR. According to accumulated diamond export figures since 1931, more than 84% of extraction is produced artisanally. Since independence, industrial exploitation has almost completely disappeared.

In order to legally join the artisanal mining sector, there are a few possibilities. With a miner's card (carte d'exploitant artisan minier), miners are permitted to operate in designated artisanal mining zones, which are demarcated by the government' mining administration. So far, however, not a single artisanal mining zone has been designated. In case a miner wants to obtain a title outside of a designated artisanal mining zone, he should also apply for a prospecting- or artisanal mining exploitation license.

The CAR's diamond mining sector involves mainly small alluvial deposits - in rivers and riparian areas - which are especially it for artisanal mining. The southwest of the country is the area most densely populated by artisanal miners. It involves the prefectures of Nana-Mambéré, Mambéré-Kadéï Sangha-Mbaéré and Lobaye. The deposits are spread along the Mambéré, Lobaye, Sangha and Kadeï rivers. Important mining zones include Berbérati, Carnot, Nola, Boda, Salo, Bouar and Bozoum.

A number of other key mining sites can be found in the centre-east prefectures Ouaka and Haute-Kotto, along the Kotto River. Mining areas are centred around Bria, Ippy, Dimbi, Bambari, Bangassou, Ndélé and Sam-Ouandja.

The southwestern zone produces more diamonds than the east - an estimated 80% of total production - but they are smaller in size. Historically, the upper-Sangha region has accounted for about 60% of the CAR's diamond production. The east's lower official production might be partly explained by the fact that bigger diamonds are a more alluring candidate for smuggling and the government's relatively limited control over its eastern territory.

In the above-mentioned mining areas, ASM offers an important livelihood strategy for local communities. It is an attractive employment opportunity in impoverished, rural areas as it requires very little capital, knowledge and technology. Furthermore, it is labour intensive and consequently an important provider of employment opportunities, providing cash income that helps to pay for healthcare, education for children, and construction of infrastructure.90 The artisanal mining sector employs an estimated 80,000 to 100,000 miners; 600,000 people - 13% of the country's population sector for their income.

In order to make a living, many people in rural areas combine mining with other economic activities such as subsistence agriculture and fishing. During the rainy season in particular, from May/June to October/November, there's a fall back in mineral production, and miners have to rely more on alternative sources of income.

In the 1980s and 1990s, however, many households started to rely more exclusively on artisanal diamond mining for their daily income. Consequently, it increased their dependency on the mining sector and made them more vulnerable to shocks. Such shocks occurred several times during the first decade of the century: political instability because of a failed coup in 2001, the overturn of Patassé, the closing down of several mineral buying offices in 2008 and the fall of diamond prices on the world market.

Because of the crisis within the diamond sector, it appears that increasing numbers of people are willing to leave artisanal mining behind, as revenues from diamond mining are often no longer sufficient to provide basic necessities. Many people have therefore decided to return (partly) to agriculture in order to make more money and to secure their own food supply (Ken Matthysen and Iain Clarkson. 2013).

Mining buying offices in CAR	2010	2011	First half of 2012
	Diamonds	**Diamonds**	**Diamonds**
BADICA	83,161.18	93,449.41	74,061.70
SODIAM	145,240.01	131,222.96	75,184.61
ADR	72,298.35	65,423.25	26,222.97
INALA	517.65	392.98	0,00
SINO SANGO		20,595.30	27,097.93
ADAMAS-SWISS			
SUD AZUR		10,776.23	7,386.59
IAS		3.01	536.61
ANANT EXIM			
COMIGEM		446.94	0.00
UNCMCA (cooperatives' union)	340.43	1,265.22	194.37

Table 6-9: Diamond (carats) exports per buying office, 2010-2012 (Source: BECDOR)

Appendix 6-1: B. 53-carats rough diamond being evaluated at BECDOR in Bangui prior to export, July 2008

6.3 CAR forest and deforestation

Many parts of Africa have been deforested by the expansion of agricultural land. This loss of trees has many detrimental effects. Soil erosion increases because trees no longer block wind and their roots no longer hold soil together. Soil fertility decreases because the input of nutrients in the form of organic matter like leaves from trees vanishes. Renewable sources of fuel and building materials are lost when trees are removed to convert land to agricultural landscapes.

Deforestation and poor agricultural practices are resulting in desertification in the northern parts of the country.
The Central African Republic had one of the lowest total deforestation rates among tropical countries between 1990 and 2005 when just 1.9 percent of its forests were lost. However, the country's forest degradation rate was considerably higher due to logging.

Today about 16.6 percent of the Central African Republic is under some form of protection, though institutional support for protected areas has historically been weak, and hunters and loggers have continued to operate in national parks. The Central African Republic is home to about 3,600 species of plants, 663 birds, 131 mammals, 187 reptiles, and 29 amphibians.

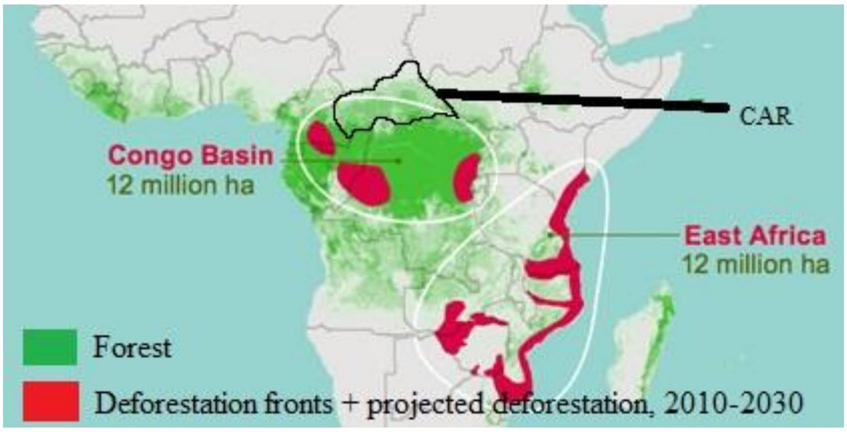


Fig. 6-4: Map of deforestation fronts

Central African Republic
Deforestation Rates, 2000-2005
Annual change in forest cover: -29,600 ha
Change in defor. rate since '90s: n/a
Total forest loss since 1990: -448,000 ha
Total forest loss since 1990:-1.9%

Table 6-10: Central African Republic Forest Figures

VII. CONFLICT LINKED TO TIMBER AND DIAMOND IN CAR

7.1 Complicity of logging companies in funding CAR’s conflict

The relationship between natural resources and conflict is still poorly understood by the international community, though the link is now routinely recognized in UN resolutions. According to Interpol and the United Nations Environment Programme as many as 40% of intrastate conflicts over the past sixty years have been linked to natural resources. Conflicts involving natural resources last longer and have a greater chance of reigniting after resolution than other types of conflicts. Lessons relating to the natural resource dimension of conflict are still to be properly consolidated for the design of resource-sensitive conflict prevention, transition and post-war reconstruction strategies. This is particularly pertinent to CAR, a country extremely rich in natural resources (bearing diamonds, gold, timber, oil and uranium), which remains one of the poorest countries on earth, having suffered violent unrest and numerous coups d’état since independence in 1960. Its natural resource wealth has been at the centre of competing claims for power, but the relationship between natural resources and the country’s repeated conflicts has been barely examined until recently. Timber is one of CAR’s most prized industries, harvested in part of the world’s second largest rainforest. As this report shows, it has not been spared the attentions of armed groups.

Understanding of the phenomenon of “conflict timber” has evolved as cases have garnered international attention 1% over the past twenty years. The timber trade has financed conflict while fuelling corruption and illegality in many countries, notably Cambodia, Ivory Coast, Myanmar and Liberia.

Global Witness – an organization that has worked on breaking the links between timber, conflict and corruption for over twenty years – has found that during the Seleka's rule, Chinese, French and Lebanese companies continued to log CAR's rainforest at scale and for significant profit. Despite thousands of innocent civilians being tortured and murdered by the Seleka, international timber traders, in particular those in Europe and China, continued to sell and trade Sapelli, Sipo, Iroko and other Central African wood species. Logging companies were able to continue operating and exporting thanks to lucrative financial arrangements concluded with Seleka leaders, by which they paid an estimated EUR 3.4 million in total, for example for "protection" services, allowing the Seleka to maintain armed rebels on the ground and procure weapons.

Since then, despite the rout of the Seleka in 2014, these companies have continued to contribute to the country's instability, by making an estimated EUR 127,864 in payments to "anti-balaka" militias, the Seleka's successors in CAR's forested areas. Though the sums are lower than in the Seleka period, they still help the anti-balaka maintain their presence in the forested South-West.

These logging companies have financed groups who have committed the worst kind of human rights abuses. They should be held responsible as accessories to the crimes of their protectors. (Global Witness. Blood Timber, July 2015)

Appendix 7-1: CAR logs image taken in Cameroon, China and France, 2014

7.2 CAR's diamond linked to the conflict

CAR is one of the world's least developed countries, ranking 180 out of 187 countries in the 2012 United Nations Development Programme's Human Development Index (Malik, 2013).The recent government takeover in CAR follows a turbulent history of political instability, defined by a series of coups and attempted coups and the formation of multiple armed rebel groups. Prior to the formation of the Seleka rebel group in 2012, three principle groups were operating in CAR: the Popular Army for the Restoration of the Republic and Democracy (APRD), the Union of the Democratic Forces for Unity (UFDR), and the Convention of Patriots for Justice and Peace (CPJP) (Bauters, 2012; Spittaels and Hilgert, 2009). In September 2012, the UFDR CPJP, and a third group, the Wa Kodro Salute Patriotic Convention (CPSK), aligned to form the Seleka rebel group (ICG, 2013).

Members of the Ugandan-based Lord's Resistance Army (LRA) have also been operating in CAR since 2008, primarily in the southeast (Bauters, 2012).

Complicating this unstable political situation is the fact that CAR is home to extensive alluvial diamond deposits. The Deposits are principally located in the southwest (hereafter referred to as the western zone deposits) and northeast (hereafter referred to as the eastern zone deposits), and in a smaller zone in the southeast (Fig. 1-2). CAR is the world's 12th leading producer of rough diamonds in terms of value and diamonds represent 40% of the country's total export revenues, with production fluctuating between 300,000 and 450,000 carats since the late 1960s (KPCS, 2013b). While CAR is a relatively minor producer in terms of volume, the quality of the diamonds is exceptionally high.

Diamond production in CAR has been nearly exclusively artisanal in nature since independence in 1960, with miners extracting stones using only rudimentary tools and techniques. Artisanal mining is frequently perceived as an attractive livelihood option by impoverished populations due to its low entry barriers and potential for high earnings. However, it is also associated with a high degree of uncertainty, as miners lack efficient exploration techniques and often operate largely by guesswork (Jønsson and Fold, 2011). It is estimated that there are approximately 60,000–90,000 miners operating in CAR (Bermudez-Lugo, 2011; Chirico et al., 2010). It is important to note, however, that estimating the number of artisanal miners in a particular region or country is a challenging task, due to factors such as the transient nature of miners, poor record-keeping by mine managers, and the informality of the sector (Heemskerk, 2001). It is made even more difficult in countries such as CAR, where political instability and open conflict are widespread.

Conflicts are typically diffuse, persistent, and sub-national in nature, and are usually the result of an unequal distribution of resources, issues of resource control, and the failures of institutions to adequately manage them (Homer-Dixon, 1994; Turner, 2004). Collier and Hoeffler (1998, 2004) were among the earliest researchers to suggest a significant link between resource abundance and the risk of civil war onset. Alluvial diamonds are the secondary resource most commonly represented by the conflict resources argument, and are also the focus of this study. A study by Lujala et al. (2005) was the first to concentrate on the specific role of diamonds in conflicts. The authors found that the effect of diamonds on the incidence of civil war depends on two principle actors: the level of existing ethnic fractionalization and the geologic nature of the deposits. Secondary diamond deposits were found to be positively related to the occurrence of civil war, in particular in countries with ethnic fractionalization.

Previous case studies have established that some resources appear to have stronger links to conflict than others and that resource abundant countries have had different experiences with respect to conflict (Auty, 2004; Le Billon, 2008; Lujala et al., 2005; Samset, 2002; Silberfein, 2004).

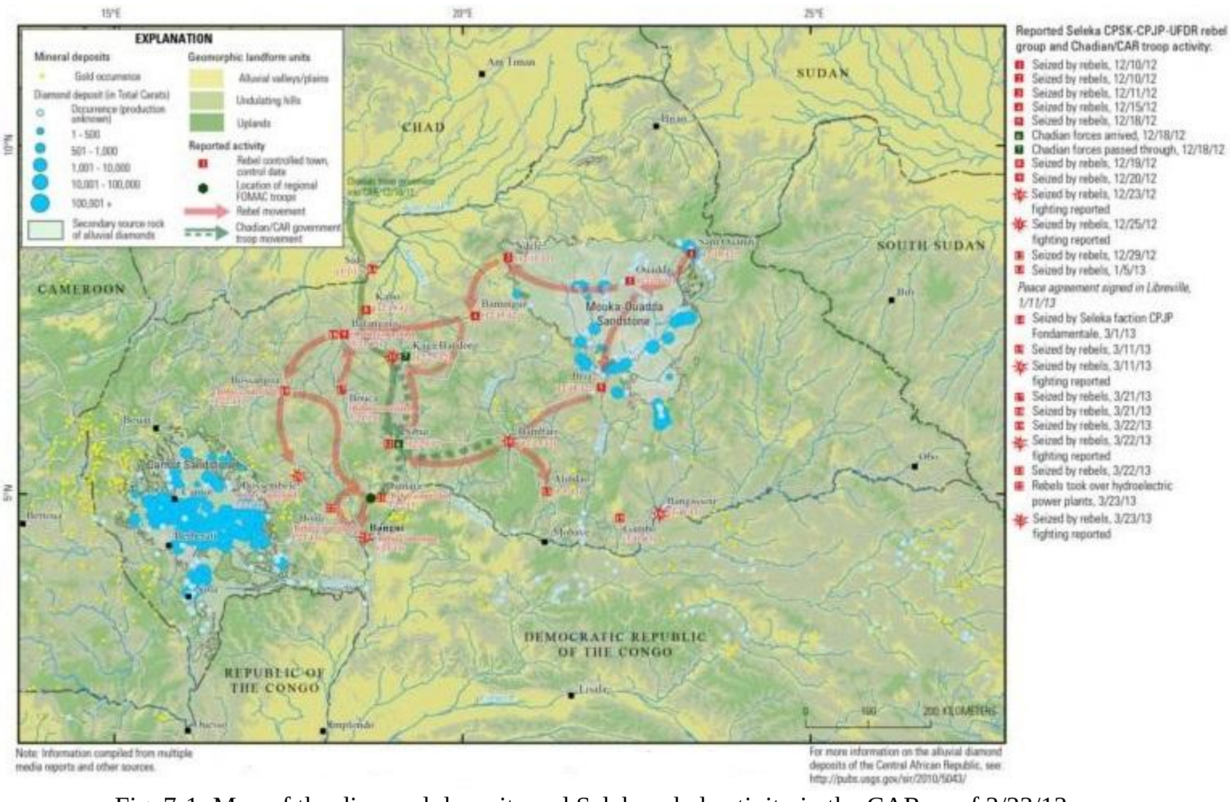


Fig. 7-1: Map of the diamond deposits and Seleka rebel activity in the CAR as of 3/23/13

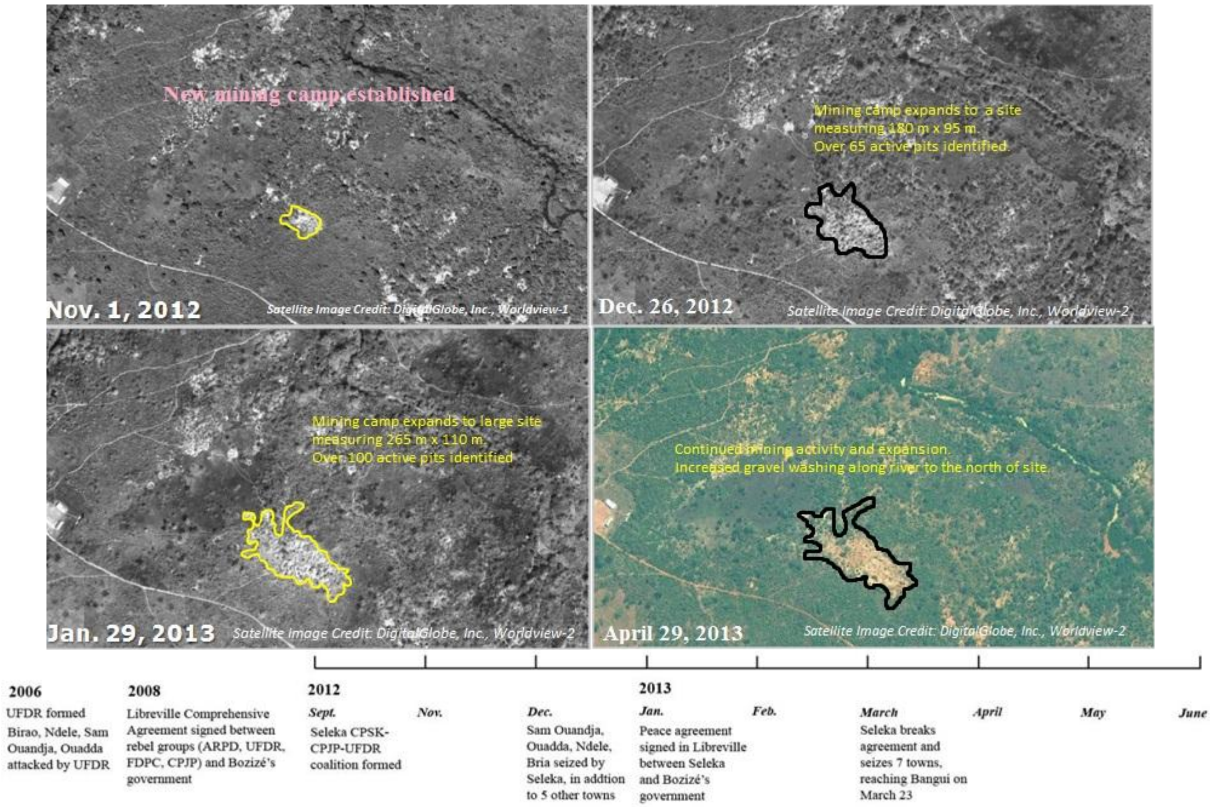


Fig. 7-2: CAR Monitoring: Sam Ouandja terrace mining and washing site

VIII. INTERNATIONAL SOLUTION ON FOREST AND DIAMOND PRODUCING IN CAR

8.1 Logging industry

Finally, the EU assigns the logging industry and its trade a role which should not be theirs. At the time the VPA was signed, the European Commission said that it aimed "to prevent illegal wood imports to EU from Central African Republic and to boost the country's timber sector". Today, the Commission justifies its decision to resume FLEGT-VPA implementation with CAR, by saying that it is "a means to understand the current state of the forest sector and how this sector can contribute to stabilizing the country towards a strong peace-building process". But is it really appropriate to "stabilize" CAR by supporting the logging sector, when it is implicated in the financing of armed groups? Equally, is it wise, considering their track record and antecedents, to invite logging companies as "stakeholders" to meetings to reform CAR's forestry sector, as the EU did in 2014 in Bangui or in March 2015 in Brussels? Is treating logging companies, which funded armed groups, as actors and partners in policy-making processes not a way of perpetuating impunity?

Today, it is no longer possible to showcase the industrial logging sector as an important or indispensable lever in CAR's economic and social development, as the EU continues to do. The latter appears to believe that it is not possible to ignore the sector, because of its role in CAR's economy: it officially employs 2,175 people (down from 4,000 previously), and has fiscal revenues in the order of EUR 3.7 million per year. However, the Kimberley process suspended CAR, despite the diamonds sector employing 400,000 people and bringing in EUR 6.2 million in tax revenues.

In fact, the EU has not properly evaluated the real impacts or contribution of the timber industry. For a correct appraisal, you would need to take account of the costs of corruption in the sector, the resulting weakening of CAR's state and the rule of law, the environmental impacts of its activities, its impact on land and customary rights, access to land and forest resources of local and indigenous communities and obviously also the industry's willingness to support armed groups and illegitimate power-holders.

CAR is confronted with huge peace-building and reconstruction challenges. Breaking the links between the exploitation of natural resources, conflict and corruption, which damages the long-term viability of peace, development and stability, is the biggest of these challenges. The cycle of coup and counter- coup, misappropriation of natural resources and destruction of environments and endangered species, must stop. CAR deserves international support to reach these objectives, including debt reduction and significant budgetary support. (Global Witness. Blood Timber, July 2015)

8.2 Kimberley process in CAR

8.2.1 Creation of Kimberley process and its goal

During the late 1990s the issue of "conflict diamonds," or "blood diamonds," became increasingly recognized by the global community, largely due to civil unrest and wars in Sierra Leone and in Angola.

In May of 2000, a meeting was convened in Kimberley, South Africa, and attended by representatives of the diamond industry and leaders of African governments to develop a certification process intended to assure that rough, exported diamonds were free of conflictual concerns. This meeting was supported later in 2000 by the United Nations in a resolution adopted by the General Assembly. By 2002, the Kimberly Process Certification Scheme (KPCS) was ratified and signed by diamond-producing and diamond-importing countries. Over 70 countries were included as members of the KPCS at the end of 2007.

The KPCS is an international activity whose goal is to prevent trade in conflict diamonds while helping to protect legitimate trade through monitoring of the production, exportation, and importation of rough diamonds throughout the world. To accomplish this task, the KPCS requires that each country set up an internal system of controls to prevent conflict diamonds from entering any imported or exported shipments of rough diamonds. Every diamond or diamond shipment must be accompanied by a Kimberley Process (KP) certificate and be contained in tamper-proof packaging. The certificate includes an export origin section, an import verification section, and a security slip. The KP also requires that no diamonds be imported from or exported to a nonmember of the KPCS. Additionally, a recommendation of the KPCS is that all artisanal miners and buyers within a country should be licensed by the host government (Olsson, 2006).

Countries that are members of the scheme are required to report their official amount of diamond imports and exports, as well as the value of the diamonds each year to the KP.

8.2.2 Chair process

The Chair oversees the implementation of the Kimberley Process Certification Scheme, the operations of the working groups and committees, and general administration. The Chair rotates annually. The Vice Chair is selected at the annual 'plenary' meeting and becomes Chair automatically the following year.

Years	Kimberley Process Chairs	Vice Chairs
2015	Angola	
2014	China	Angola
2013	South Africa	People's Republic of China
2012	The United States of America	South Africa
2011	Democratic Republic of Congo	The United States of America
2010	Israel	Democratic Republic of Congo
2009	Namibia	Israel
2008	India	Namibia
2007	The European Union	India
2006	Botswana	The European Union
2005	The Russian Federation	Botswana
2004	Canada	The Russian Federation
2003	South Africa	Canada

Table 8-1: Kimberley Process Chair 2003-2015

8.2.2.1 Kimberley Process Administration Decision on CAR

The Plenary further noted ongoing WGDE efforts to support the implementation of the Central African Republic (CAR) KP roadmap and to implement the Administrative Decision on CAR (July 2014). The Plenary welcomed the export of a rough diamond shipment from CAR to South Africa to update the CAR footprinting analysis and work on a fingerprinting analysis. The Plenary looks forward to the results of this research analysis expected in March 2015.

8.2.2.2 Temporary Suspension on CAR

Behind the CAR conflict link to diamonds, according to the Twelfth Kimberley Process (KP) Plenary Meeting convened from November 11-14, 2014 in Guangzhou, The People's Republic of China some decisions had been taken. To know:

In light of the AD on the Central African Republic (CAR) [Temporary Suspension] as approved through written procedure on 23 May 2013 and the AD on ensuring that diamonds from CAR are not introduced into the legitimate trade as approved through written procedure on 11 July 2014, the Plenary took note of the progress made by CAR on implementation of its Work Plan and roadmap for addressing issues of non-compliance with KPCS minimum standards and strengthening the internal control system. Also the

Participants and Observers to the Kimberley Process Certification Scheme (KPCS), meeting in regular Inter-sessional format in Shanghai on 9-12 June 2014, devoted special attention to illicit trafficking of diamonds from the Central African Republic (CAR).

The Plenary encouraged CAR's KP authorities to continue implementing its Work Plan and share any relevant information and data directly with the appropriate KP working bodies. The Plenary also encouraged CAR to continue working closely together with the African Union (AU), relevant United Nations bodies - notably the Panel of Experts established pursuant to UNSC Resolution 2127 (2013), the international community and neighboring countries on KP compliance issues with a regional dimension. The Plenary invited the WGM to proceed with the planning of a Review Mission, in line with the AD on the Central African Republic (CAR) [Temporary Suspension] as approved through written procedure on 23 May 2013.

The Plenary requested Participants to consider providing technical assistance to CAR and its neighboring countries, with a view to enhancing their capacity and strengthening their internal controls over diamond production and trade (Kimberley Process Plenary Meeting 2014).

Other report noted that: Having regard to the enhanced Vigilance Notice on the CAR as issued by the KP Chair on 18 April 2013, the Plenary notes that pockets of rebel groups are operating in the Eastern part of the country including in a number of diamond-producing areas around Sam Ouadja, Bria and Bamingui and decides that the information reviewed could constitute non-compliance with the minimum requirements of the certification scheme, in particularly Section IV of the KPCS document, according to which each Participant should “establish a system of informal controls designed to eliminate the presence of conflict diamonds from shipments rough diamonds imported into and exported from its territory”. Due consideration is given to the fact additional verification measures are currently not feasible give to security situation on the ground.

Appendix 8-1: An official KP Certificate accompanying a diamond shipment from CAR

IX. CONCLUSION AND SUGGESTION

The goal of this study was to focus on forestry and diamond linked to the conflict in the CAR. The mining sector is constituted an important source for an estimated 600.000 person. Mining sector is the third economic activity after Agriculture and Forestry. According to its third places after Agriculture and Forestry, mining sector is taken the first place linked to the conflict accompany to the forestry in the CAR. Always its link to the conflict is joined to the technical problem such as inequality sharing on the resources producing, ethnic, nongovernment of state, insecurity increasing and so on.

In general the risk forestry link to the conflict is lower than mining sector in the CAR. Following to the last conflict began in 2012 in the CAR; we suggested that to avoid the same situation in the future. The government must be working hard to make down the risk of the conflict linked to the mining sector and forestry, and to have more attracting of local and international partner legal to invest in mining sector or forestry. The CAR government must set up a high level of the security in the country, at the country bordered and also judiciary security, all these factor can guarantee mining sector and forestry to partner investment. The absence of the state in rural CAR has resulted in political instability across the country.

Agriculture is the primary economic activity in the CAR; more than 70% of citizens are engaged in subsistence farming and agriculture represents 54% of the country’s Gross Domestic Product (GDP). With its vast forests, logging is the country’s second key economic activity. The export value of the forestry sector narrowly outruns that of the diamond sector, earning the country respectively $52.3 million and $49.3 million in

2009, or 42.2% and 39.8% of the country's total export value. The mining sector in total accounted for 7% of GDP in 2007, and fiscal revenues from the sector came to 9% and 11% of the State's total fiscal revenues in 2009 and 2010 respectively.

Export values demonstrate that diamonds are by far the country's principle mineral. In 2011, the CAR officially exported 323,575.30 carats, worth CFA 29.7 billion, or $61.4 million. Official gold exports were only 72.8 kg, which equated to an export value of CFA 1.25 billion.

However, the CAR's diamond production volume is still far below that of the Central African region's other top producers, the Democratic Republic of the Congo (DRC) and Angola. The DRC and Angola produced 27.7 and 13.8 million carats respectively in 2010, which clearly overshadows the CAR's 310 thousand carats (table 6-7). The regions' other diamond producers are Cameroon, the Republic of Congo and Gabon, however the precise production outputs for these countries are unknown

In terms of quantity, the CAR is therefore a relatively minor diamond producer compared to Angola and the DRC. The quality of diamonds is however quite a different matter (table 6-7). While the DRC mainly produces industrial diamonds, 80% of the CAR's diamonds are gem quality. In order to have an idea of the difference in quality, Barthélémy compared the average prices per carat in 2008. The average price per carat was $30 in the DRC, $150 in Angola, and $180 in the CAR. The quality of the CAR's diamonds ranks fifth in the world.

The situation today is much more nuanced. Despite some links between the country's minerals and insecurity, and the fact that some conflict actors occasionally gain profit from CAR's natural resources, these resources should not be regarded as a conflict motivator.

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REFERENCES

[1]. Smillie, I., Gberie, L., Hazleton, R., 2000. The heart of the matter: Sierra Leone, diamonds and human security. Partnership Africa Canada, Ottawa.

[2]. Le Billon, P. (2001a). Angola's political economy of war: the role of oil and diamonds 1975–2000. African Affairs, 100, 55–80.

[3]. Samset, I., 2002. Conflict of interests or interests in conflict? Diamonds and war in the DRC. Rev. Afr. Polit. Econ. 29 (93–94), 463–480, http://dx.doi.org/10.1080/ 03056240208704633

[4]. United Nations Security Council (UNSC), 2005. Resolution 1643 (2005): Adopted by the Security Council at its 5327th meeting, on 15 December 2005. United Nations Security Council Press Release, New York. December 15, 4 p. Available at http://www.sipri.org/databases/embargoes/eu_arms_embargoes/cote/un- security-council-resolution-1643-2005 (accessed 31.07.13).

[5]. United Nations Security Council (UNSC), 1992. Resolution 788 (1992): Adopted by the Security Council at its 3138th meeting, on 19 November 1992. United Nations Security Council, New York. November 19, 3 p. Available at http:// www.un.org/en/ga/search/view_doc.asp?symbol=S/RES/788 (1992).

[6]. Ken Matthysen and Iain Clarkson, 2013, Gold and diamonds in the Central African Republic; The country's mining sector, and related social, economic and environmental issues, International Peace Information Service, Antwerp.

[7]. Reports Database. Annual Reports; Congo Brazzaville Annual Reports (Phase 2) by Forests Monitor, REM and CAGDF 2010-present Français. Congo Brazzaville Annual...

[8]. Chirico, P.G., Barthelemy, F., Ngbokoto, F.A., 2010. Alluvial diamond resource potential and production capacity assessment of the Central African Republic: In: U.S. Geological Survey Scientific Investigation Report 2010-5043.

[9]. Censier, C., 1990. Characteristics of Mesozoic fluvio-lacustrine formations of the western Central African Republic (Carnot Sandstones) by means of mineralogical and exoscopic analyses of detrital material. J. Afr. Earth Sci. 10 (1–2), 385+/–398.

[10]. Censier and Lang, 1999.Palaeogeography (specifically palaeotopography and palaeobathymetry) ... Sedimentary processes in the Carnot Formation.

[11]. Asselberghs, E., 1934. Sur l'extension du système du Karoo dans la région de Carnot (A.E.F.) et dans la région de l'Ubanghi. Bull. Soc. Géol. Belg. 44, 338–342.

[12]. Babet, V., 1948. Exploration géologique et minière de la Haut Sangha et de la région de Bouar-Baboua. Bull. Serv. Min A.E.F. 4, 110 pp.
[13]. Borgniez, G., 1935. Esquisse géologique de l'Oubangui-Chari occidental et des régions voisines. Chron. Min. Col., Paris 44,354–372
[14]. Babet, V., 1935. Sur les grés horizontaux de la Haute Sangha (Afrique Equatoriale Française). Bull. Soc. Geol. Fr., 5eme ser., 5, 455–463.
[15]. Delany, F., Delorme, J., 1956. Etude préliminaire de la série argilo-gréseuse de la région diamantifère de l'Ouest-Oubangui. C.R. 20me Congr. Int. Geol., Mexico, Commission Gondwana, pp. 65–72.
[16]. Berthoumieux, G., Delany, F., 1957. Mission Diamant dans l'Ouest-Oubangui. Bull. Dir. Min. Géol. A.E.F., Brazzaville, 8, 77–85.
[17]. Malingbar, A., Lang, J., Buoncristiani, J.-F., and Censier, C., 2006, The Mouka-Ouadda Formation, A Cretaceous fluviatile environment in the Eastern part of the Central African Republic: Africa Geoscience Review, v. 13, no. 3–4, p. 301–322
[18]. Global Witness Report July 2015. Blood Timber. HOW EUROPE HELPED FUND WAR IN THE CENTRAL AFRICAN REPUBLIC.
[19]. Bardet, M.G., 1974. Géologie du diamant. Gisements de diamants d'Afrique. Mem. BRGM 83 (2), 223 pp.
[20]. WGDE, 2012. ''Footprint'' or characteristics of the diamond production from the Eastern region around Bria in the Central African Republic. Working Group of Diamond Experts. Available at http://www.kimberleyprocess.com/en/2012- wgde-footprint-car-final (accessed 29.07.13).
[21]. Censier, C., 1996. Alluvial diamond deposits in the Central African Republic. Afr. Geosci. Rev. 3 (2), 217+/–230.
[22]. ICG, 2010. Dangerous Little Stones: Diamonds in the Central African Republic. Africa Report Number 167. International Crisis Group, Brussels.
[23]. Bauters, J., 2012. A Taxonomy of Non-state Armed Actors in the Central African Republic. International Peace Information Service, Antwerp.
[24]. Schlüter Thomas, 2006, Geological atlas of Africa, with notes on stratigraphy, tectonics, economic geology, geohazards and geosites of each country: Berlin, Springer, 272 p.
[25]. Censier, C., Lang, J., 1992. La formation glaciaire de la Mambéré (République centrafricaine): reconstitution paléogéographique et implications a l'échelle du Paléozoïque africain. Géol. Rundsch. 81 (3), 769+/–789.
[26]. Censier, C., Tourenq, J., 1986. Mise en évidence d'une extension occidentale des Grès de Carnot (République Centrafricaine) par analyses sedimentologiques compare´es des gisements alluvionnaires diamantifères. Géodynamique 1 (1), 21–32.
[27]. Petit, M., 1985, A provisional world map of duricrust, *in* Douglas, I., and Spencer, T., eds., Environmental change and tropical geomorphology: London, George Allen & Unwin, p. 269–279.
[28]. Beauvais, A., 1989, Étude pétrographique et géochimique de profils d'altération latéritique cuirassés dans le Sud-est de la République Centrafricaine: Géodynamique v. 4, no. 2, p. 71–91.
[29]. Beauvais, A., and Roquin, C., 1996, Petrological differentiation patterns and geomorphic distribution of ferricretes in Central Africa: Geoderma, v. 73, no. 1–2, p. 63–82.
[30]. Censier, Claude, and Lang, Jaques, 1999, Sedimentary processes in the Carnot Formation (Central African Republic) related to the paleogeographic framework of Central Africa: Sedimentary Geology, v. 127, no. 1–2, p. 47–64.
[31]. Map source: RCA et Processus de Kimberley -Estimation du potentiel diamantifère alluvionnaire et de la capacité de production (2009); DNG-BRGM-USGS.
[32]. Katherine C. Malpeli · Peter G. Chirico 2014. A sub-national scale geospatial analysis of diamond deposit lootability: The case of the Central African Republic.
[33]. Censier, C., 1996. Alluvial diamond deposits in the Central African Republic. Afr. Geosci. Rev. 3 (2), 217–230.
[34]. Dempster, A., and Tutusaus, J.P., 1995, Project d'élaboration d'un plan minier national de la République Centrafrique Rapport Final – Tome 2, Annexe 9 – Brochure promotionnelle sur le secteur minier centrafricain, Secrétaire d'Etat aux Finances, au Plan et á la Coopération Internationale B.P. 696, Bangui: Ireland, Crowe Schaffalitzky Associates.
[35]. Dietrich, Christian, 2003, Diamonds in the Central African Republic, Trading, valuing and laundering, in Smillie, Ian, The Diamonds and Human Security Project: Partnership Africa Canada, Occasional Paper #8, 8 p.
[36]. Ken Matthysen and Iain Clarkson, 2013, Gold and diamonds in the Central African Republic; The country's mining sector, and related social, economic and environmental issues, International Peace Information Service, Antwerp.
[37]. Thomas P. Dolley, 1995. The mineral industry of Central African Republic

[38]. Yadira Soto-Viruet 2010. The mineral Industries of CAR, Ivory Cost, and Togo
[39]. Malik, K., 2013. Human development report 2013: the rise of the South. In: Human Progress in a Diverse World. United Nations Development Programme, New York. Available at http://hdr.undp.org/en/content/human-development-re-port-2013 (accessed 29.07.13).
[40]. Spittaels, S., Hilgert, F., 2009. Mapping conflict motives: Central African Republic. International Peace Information Service, Antwerp.
[41]. ICG, 2013. Central African Republic: Priorities of the Transition. Africa Report Number 03. International Crisis Group, Brussels.
[42]. Jønsson, J.B., Fold, N., 2011. Mining 'from below': taking Africa's artisanal miners seriously. Geogr. Compass 5 (7), 479–493, http://dx.doi.org/10.1111/j.1749-8198.2011.00435.x.
[43]. Bermudez-Lugo, O., 2011. The mineral industries of Central African Republic and Togo In: U.S. Geological Survey Minerals Yearbook—2011. .
[44]. Heemskerk, M., 2001. Collecting data in artisanal and small-scale mining communities: measuring progress towards more sustainable livelihoods. Nat. Resour. Forum 29, 82–87.
[45]. Homer-Dixon, T.F., 1994. Environmental scarcities and violent conflict: Evidence from cases. Int. Secur. 19 (1), 5–40, http://dx.doi.org/10.2307/2539147.
[46]. Turner, M.D., 2004. Political ecology and the moral dimensions of ''resource conflicts'': the case of farmer-herder conflicts in the Sahel. Polit. Geogr. 23 (7), 863–889, http://dx.doi.org/10.1016/j.polgeo.2004.05.009.
[47]. Collier, P., Hoeffler, A., 1998. On the economic causes of civil war. Oxf. Econ. Pap. 50(4), 563–573.
[48]. Collier, P., Hoeffler, A., 2004. Greed and grievance in civil war. Oxf. Econ. Pap. 56 (4), 563–595, http://dx.doi.org/10.1093/oep/gpf064.
[49]. Lujala, P., Gleditsch, N.P., Gilmore, E., 2005. A diamond curse? Civil war and a lootable resource. J. Confl. Resol. 49 (4), 538–562, http://dx.doi.org/10.1177/0022002705277548.
[50]. Auty, R., 2004. Natural resources and civil strife: a two-stage process. Geopolitics 9(1), 29–49, http://dx.doi.org/10.1080/14650040412331307822.
[51]. Le Billon, P., 2008. Diamond wars? Conflict diamonds and geographies of resource wars. Ann. Assoc. Am. Geogr. 98 (2), 345–372, http://dx.doi.org/10.1080/00045600801922422.
[52]. Silberfein, M., 2004. The geopolitics of conflict and diamonds in Sierra Leone. Geopolitics 9 (1), 213–241, http://dx.doi.org/10.1080/14650040412331307892.
[53]. Olsson, Ola, 2006, Diamonds are a rebel's best friend: The World Economy, Blackwell Publishing, v. 29. no. 8, p. 1133–1150.
[54]. Guangzhou 14 November 2014. Final Communiqué from the Kimberley Process Plenary Meeting

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Primary study of weathering and different formations of rocks outcrops in the Zigui region, western Hubei province (China).

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ABSTRACT: This paper describes the formation of the Zigui region; the geological processes play an important activity in the area. The stratigraphic developed well in the area and the characteristic components passed the jointing positions are not different from each other in certain geological ages, suggesting that the characteristic components in the areas are probably primary at the same time during geological processes.
The composition of rocks varies according to its minerals, which are the building blocks of rocks. The types of minerals that make a rock depend largely on the source of the rock - igneous rocks have more magma-related minerals like olivine and biotite; sedimentary rocks have more sediment-related minerals like quartz; metamorphic rocks have all these minerals, but they may look different due to re-crystallization.
Considering the location, landscape, and present system of slopes, could have been covered by deposition of sediment from running water, wind, or lakes? The sediment transported in from some other area, but simply covered in their weathered debris. Weathering is a rapid process capable of producing a regolith in only a few hundred years in a temperate climate. The products of weathering are spheroidal boulders, decomposed rock fragments, and soil.
KEYWORDS: Zigui, Weathering, outcrops

I. INTRODUCTION

Zigui County is a county of western Hubei Province. It is under the administration of Yichang City and encompasses the easternmost portion of the Yangtze River Gorges, including the Xiling Gorge. The county seat of Zigui is now the town of Maoping (Maoping Zhen) situated a few kilometers west of the Three Gorges Dam on the high southern shore of the river. The original Zigui town was upstream to the west and was abandoned and submerged under the rising waters of the reservoir in the early years of the 21st century. As it is common in China, Maoping is typically labeled as "Zigui County" (Fig. 2-1).

Most of Zigui is hilly or mountainous with basic farming and tea production. There are many small coal mines in the mountains, with the coal trucked to the river then loaded onto barges for shipping downstream. Zigui is also called Stone Town or Gourd Town, because in ancient times their walls were of huge stone stabs and the city itself looked like a gourd. The walled city features with traditional Chinese style architecture.

Fragrant Stream is a small stream just below Zigui and above the entrance to Xiling Gorge. The county located at the foot of Woniu Mountains and the north side of the Yangtze River. It is a world cultural celebrity Qu Yuan's hometown, the birthplace of dragon boat racing.

II. LOCALISATION OF THE AREAS AND REGIONAL GEOLOGICAL SETTING

2.1 The study area

The study area is located at the Zigui segment of The Yangtze Three Gorges (Fig. 2-2), which is known as one of the most landslide-prone areas in the Three Gorges Reservoir region, lying between the latitudes 30.837° N and 31.06° N and the longitudes 110.566° E and 110.875° E, and covering an area of 405.54 km^2. There are five towns: Xietan, Shazhenxi, Guizhou, Guojianba and Quyuan. The area is separated from N to S by The Yangtze River with a declining topography from SW to NE.

The Yangtze Three Gorges area was formed by a severe incision of massive lower Paleozoic and Mesozoic (Jialinjiang Group of Triassic system) limestone mountains, along narrow fault zones, in response to the Quaternary uplift. Steep slope angles develop on outcrops of easily weathering or ‘‘soft’’ materials, which are extended, and landslides are common in these areas (Bai et al., 2010).

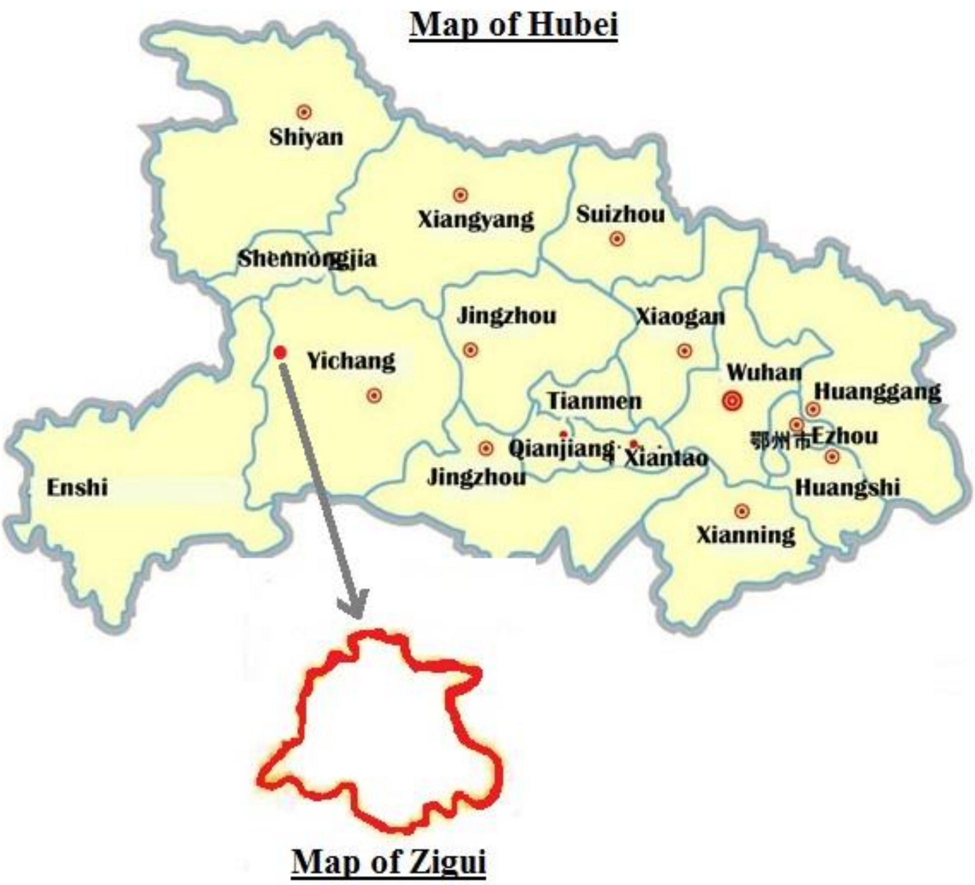


Fig. 2-1: Location of study area

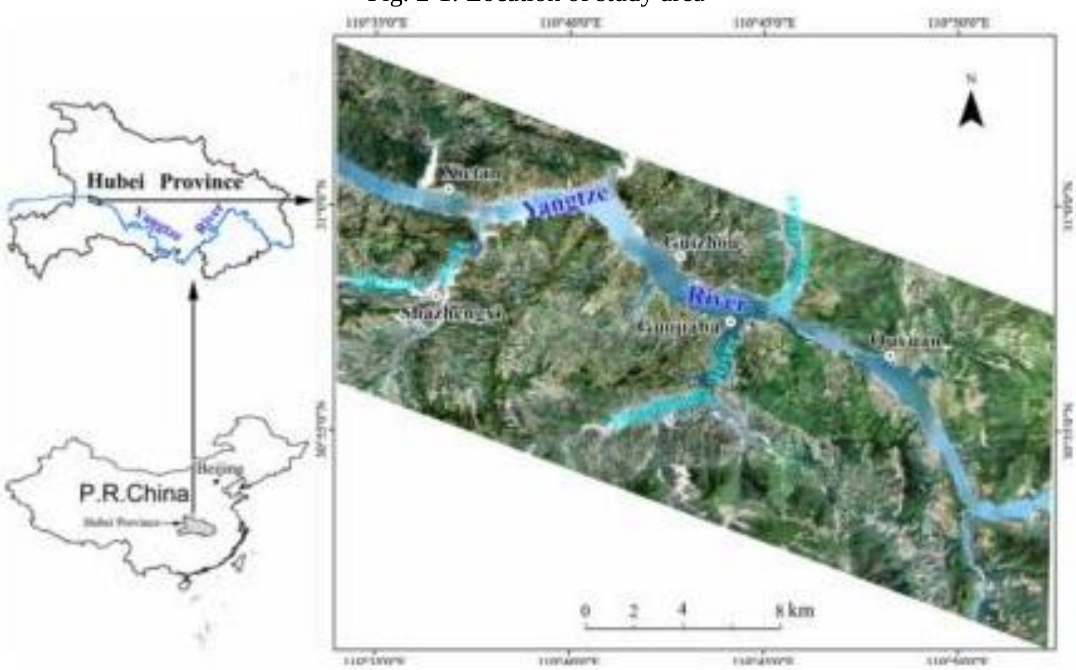
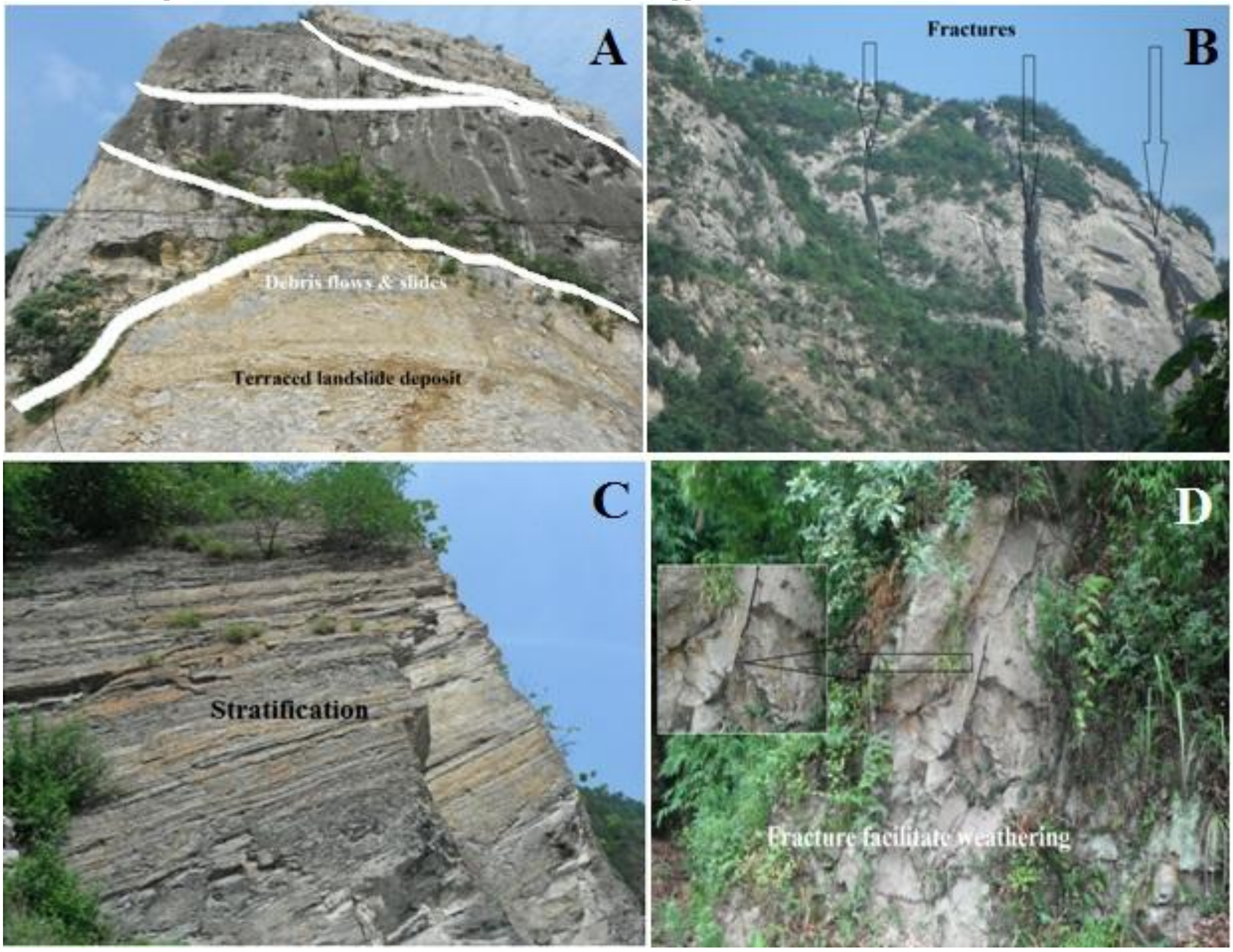


Fig. 2-2: The study area and its location

2.2 Strata

A layer of material, naturally or artificially formed, often one of a number of parallel layers one upon another. In this area, mainly hosted mineral deposit, comprised dolomite with mud, limestone, shale and slate. Some mineral spots can also be observed in Cambrian strata (Appendix 2-1 C).



Appendix 2-1: Stratification and fracture facility weathering

2.3 Structures

The Xingshan-Zigui section (110.38"E, 3 1 .15"N) is a continuous section located along the Xiangxi River valley in Xingshan and Zigui counties in Hubei Province, near the northern bank of the Yangtze Gorges, geologically situated at the northern margin of Yangtze Block. The valley cuts through the eastern part of a great Paleozoic and Mesozoic geosynclinorium that folded at the Cretaceous (Fig. 2-3). the oldest rock exposed to this region is the Banxi Formation, with an about 800 Ma

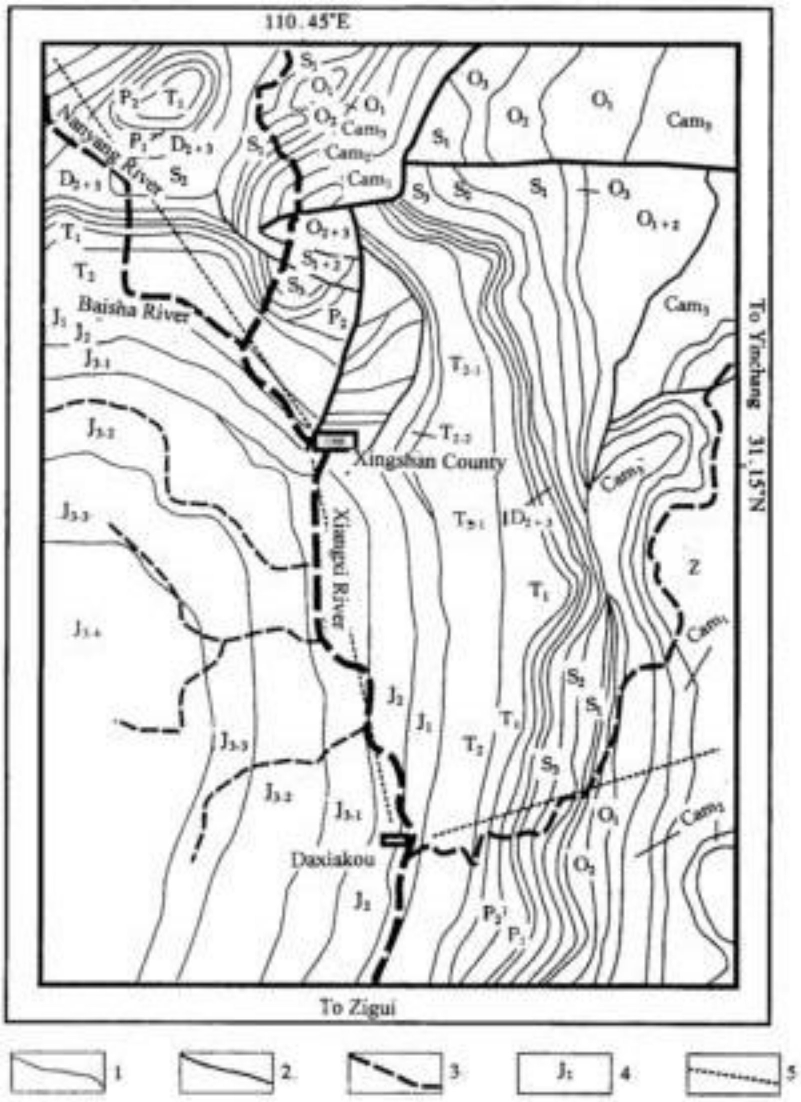


Fig. 2-3: Schematic map of sampling, XS-X~Ngshan City. 1, Geological boundary; 2, fault; 3, river; 4, geological time; 5, sampling section.

metamorphic age, which was the basement of the Late Proterozoic to the Jurassic sedimentary basin. The Paleozoic and Mesozoic sedimentary rocks were almost continually formed in this grand basin. We said "almost continually where because of the sedimentary hiatus of the Early to Middle Devonian and Carboniferous in this basin, the most widely recognized regional parallel unconformities in the stratigraphic sequence of the Yangtze Block. Omitting that, all the Paleozoic and Mesozoic sediments were continually deposited there. From the Cambrian to Early Triassic the sediments were deposited in an epicontinental to the shelf shallow sea. The Cambrian is argillaceous-carbon- ate facies (dark gray mudstone, marl and limestone). The Ordovician to Devonian are carbonate and argillaceous-clastic deposits (limestone, marl, mudstone and siltstone, all with dark colors). The Permian and Lower and Middle Triassic are carbonate facies (dark gray limestone). From the Upper Triassic the epicontinental marine basin had changed into a great inland drainage basin in which the Upper Triassic gray sandstone, Jurassic varicolored sandstone and red beds were formed. There is not any sort of volcanic rocks discovered there. Fossil control for the sedimentary sequence is excellent. The ages of the sediments have been well determined based on biostratigraphic methods by the Chinese geologists since geology mapping in the 1960s. 825 oriented paleomagnetic samples distributed at 84 sites, covering the time during Cambrian to Jurassic were collected by using a carriageable drill (WU Hanning et al., 1998).

The Yangtze Three Gorges area of China has attracted attention around the world because of the Three Gorges Dam and its potentially strong impact on the environment. Historically the Three Gorges area was always been characterized by a high landslide disaster. More than 2,500 known localities with unstable slope angle exist in this area (Bai et al. 2010).

2.4 Formations of the study area

Our identifications in the Zigui region focused on the three types of rocks, there are the basic foundation of Geology as a science: Igneous rocks, sedimentary rocks and metamorphic rocks.

2.4.1 Igneous rock

Igneous rock is formed through the cooling and solidification of magma or lava. Igneous rock may form with or without crystallization, either below the surface as intrusive (plutonic) rocks or on the surface as extrusive (volcanic) rocks.

Mineral composition: Feldspars, quartz or feldspathoids, olivines, pyroxenes, amphiboles, and micas are all important minerals in the formation of almost all igneous rocks, and they are basic to the classification of these rocks. All other minerals present are regarded as nonessential in almost all igneous rocks and are called *accessory minerals*. Types of igneous rocks with other essential minerals are very rare, and these rare rocks include those with essential carbonates (Appendix 3-6).

2.4.2 Sedimentary rock

Sedimentary rocks are formed from sediments. Sediments are small pieces of material which do not dissolve in water. They slowly fall down to the bottom of a lake or the sea, and gather together over the years forming a large mass of material.

Imagine stirring very fine sand into a glass of water. Slowly the sand particles settle on the bottom of the glass.

They are called "sediments" from the Latin sedimentum meaning "a settling". Materials which do dissolve (salts) stay in the water. This is what has made the sea salty over many millions of years.

2.4.3 Metamorphic rock

Metamorphic rocks are rocks that have undergone a change from their due to changes in temperature, pressure or chemical alteration. The classification of metamorphic rocks based on the minerals that are present and the temperature and pressure at which these minerals form determination of this information is not easily accomplished.

The mineralogical and structural adjustment of solid rocks to physical and chemical conditions that have been imposed at depth below the near surface zones of weathering and digenesis and which differ from conditions under which the rocks in question originated.

III. REGIONAL GEOLOGICAL SETTING OF MINERAL RESOURCES

3.1 Weathering

Weathering is the breakdown and alteration of rocks at Earth's surface through physical and chemical reactions with the atmosphere and the hydrosphere. We noted different types and nature of weathering:

- Physical weathering is the mechanical fragmentation of rocks from stress acting on them. Ice wedging may be the most important type.
- Chemical weathering involves chemical reactions with minerals that progressively decompose the solid rock. The major types of chemical weathering are dissolution, acid hydrolysis, and oxidation.
- Joints and fractures facilitate weathering because they permit water and gases in the atmosphere to attack a rock body at considerable depth. They also greatly increase the surface area on which chemical reactions can occur.
- The major products of weathering are spheroidal rock forms, a blanket of regolith, and dissolved ions. Soil is the upper part of the regolith—a mixture of clay minerals, weathered rock particles, and organic matter.
- Climate and rock type greatly influence the type and rate of weathering.

Physical weathering is the breakdown of rock into small fragments by physical processes without a change in chemical composition. No chemical elements are added to, or subtracted from, the rock. The most important types of physical weathering are ice wedging and sheeting, or unloading.

Other Types of Physical Weathering: Animals and plants play a variety of relatively minor roles in physical weathering. Burrowing animals, such as rodents, mechanically mix the soil and loose rock particles, a process that facilitates further breakdown by chemical means. Pressure from growing roots widens cracks and contributes to the rock breakdown. Lichens can live on the surface of bare rock and extract nutrients from its minerals by ion exchange; the presence of lichens, therefore, results in both physical and chemical alteration of the minerals. These processes may seem trivial, but the work of innumerable plants and animals over a long period of time adds significantly to the disintegration of the rock.

Chemical weathering is the breakdown of minerals by chemical reactions with the atmosphere or hydrosphere. The three main types of chemical reactions are (1) dissolution, (2) hydrolysis, and (3) oxidation. During chemical weathering, rocks are decomposed, the internal structure of the minerals is destroyed, and new minerals are created. Thus, there is a significant change in the chemical composition and physical appearance of the rock.

Dissolution is a process whereby a mineral passes completely into solution, like salt dissolving in water. Some minerals dissolve directly in water and the ions are leached, or flushed away. Halite (salt) is perhaps the best-known example. The most common dissolution reactions involve slightly acidic water. Carbonic acid H_2CO_3 is common in natural environments and forms when water combines with carbon dioxides. This reaction takes place in the atmosphere and in the root zones of plants where carbon dioxide is released into the soil.

Hydrolysis is a chemical reaction wherein water and another substance both decompose into ions; the OH^- ion groups with one of the fragments and the H^+ ion with another fragment.

Oxidation is the chemical combination of oxygen, in the atmosphere or dissolved in water, with one mineral to form a completely different mineral in which at least one of the elements has a higher oxidation state (higher ionic charge). Of the elements that have variable charges, iron is the most important in weathering reactions on Earth.

The weathering of rocks is influenced by a number of variables, such as the mineral composition, the texture of the rock, and the climate in which weathering occurs. Differential weathering is a result of differences in the rates of weathering. Weathering is influenced by so many factors that it is difficult to make a meaningful generalization concerning the weathering of specific rock types. Limestone, for example, may weather and erode into a soil-covered valley in a humid climate, whereas the same formation forms a cliff in an arid climate. Similarly, a well-cemented quartz sandstone may be extremely resistant to weathering, whereas a sandstone with a high clay content is likely to be soft and weak and weather rapidly.

Products of weathering: The major products of weathering are (1) rock bodies modified into spherical shapes; (2) a blanket of loose, decayed rock debris, known as regolith, of which soil is an important part; and (3) ions in solution.

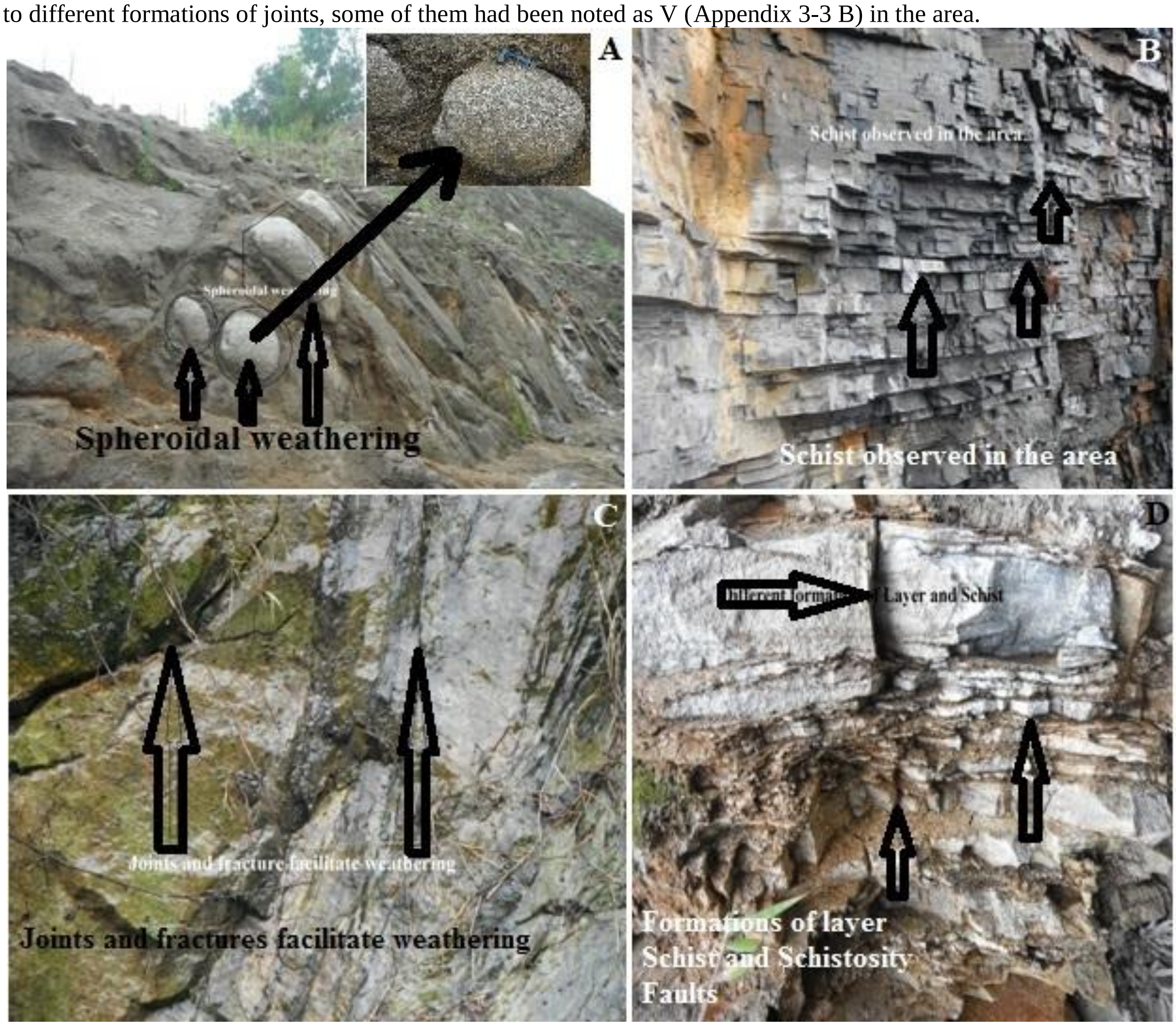
Appendix 3-1: Sandstone bedding and slope instability

3.1.1 Spheroidal weathering

In the weathering process, there is a universal tendency for rounded (or spherical) surfaces to form on a decaying rock body regardless of the original shapes of the rock fragments. The sphere is the geometric form that has the least amount of surface area per unit of volume. A rounded shape is produced because weathering attacks an exposed rock from all sides at once, and decomposition is most rapid along the corners and edges of the rock (Fig. 3-1(A, B, C). Appendix 3-2 A). As the decomposed material falls off, the corners become rounded, and the block eventually is reduced to an ellipsoid or a sphere. Once the block attains this shape, it simply becomes smaller with further weathering. This process is known as spheroidal weathering.

Examples of spheroidal weathering can be seen in almost any exposure of rock (Appendix 3-2 A (3-4)). It can also be seen in the rounded blocks of ancient buildings and monuments. The original blocks had sharp corners and were fitted together with precision. The edges are now completely decomposed, and each block has assumed an ellipsoidal or spherical shape. In nature, spheroidal weathering is produced both at the surface and at some depth.

In the study area we had observed the formation of Schist and Schistosity (Appendix 3-2 A, D). According to different formations of joints, some of them had been noted as V (Appendix 3-3 B) in the area.



Appendix 3-2: Spheroidal weathering. Schist and schistosity in the areas

Granite starts out in the subsurface already fractured by "joints". The pattern of fracturing splits granite into blocks that are cube-like in shape. This happens when the joint fractures come into contact with water that seeps into the cracks. This all takes place meters beneath the surface, where chemical decay weathers the minerals into granite sand. Corners of the cube have three joints that intersect, so the corners decay the most. Decay on the corners gives the boulder a "spheroidal" shape. Erosion of the decayed granite (Grus) exposes these boulders at the surface. Spheroidally-weathered boulders are "born rounded" by subsurface mineral decay (subsurface weathering).

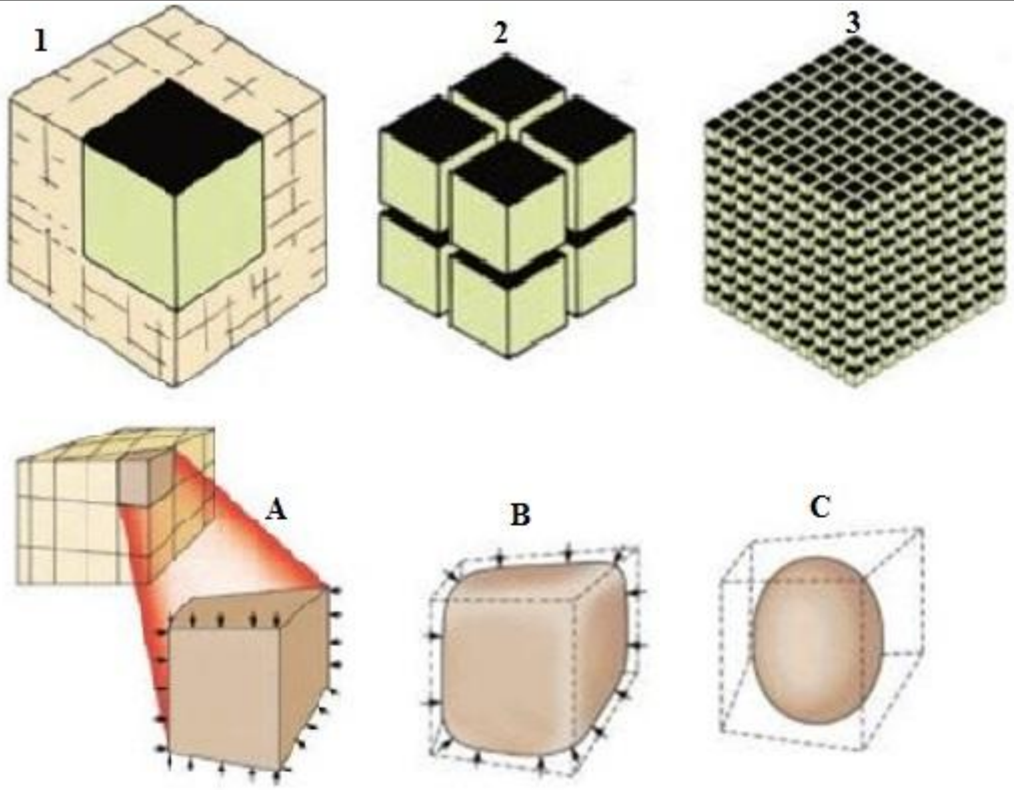


Fig. 3-1: A set of joints systems cut a rock body into angular blocks

3.2 Structure

The regional geology of the Three Gorges consists of apre-Sinian crystalline basement, composed of magmatic and metamorphic rocks, and a Sinian–Jurassic sedimentary cover, comprising interbedded carbonate, sandstone and shale formations (Wu et al. 2001).

The lithological formations of Wushan–Zigui can be classified according to their competence into (1) massive limestones and dolomites, (2) sandstone–shale–marl interbeddings, and (3) mudstone, slope deposits, and Quaternary sand and gravel. Limestones tend to form steep slopes and ridges, and, where traversed by tectonic faults and lineaments, can be heavily jointed and sheared. Sandstones, shales, and marls form complex interbeddings where lithologies of contrasting physical properties, such as shear strength and permeability, are frequently juxtaposed. Mudstones are usually weathered, and often comprise loose bedrock fragments within a matrix of finer material, such as sand and clay. Quaternary deposits tend to accumulate on gentle or moderately steep slopes, or along river banks where they form easily eroded terraces (I.G. Fourniadis & J.G. Liu 2007).

The main structure of the Three Gorges area contains developing faults , including the Hubei tectonic belt in the northwest, the Hubei fold belt to the southwest and the central Hubei block. The earthquakes in this area are mainly distributed in the Hubei tectonic belt and the central Hubei block. The Hubei tectonic belt trends NWW, which corresponds to the E-W -trending that crosses the core of the Huangling anticline and reveals its deep structure (Wang Jian et al., 2012).

April 1, 2014. A magnitude-4.7 earthquake hit Zigui County in central China’s Hubei Province last Sunday, around 23 kilometers from the Three Gorges Dam site location, several days after a magnitude -4.3 tremor was felt early Thursday morning about 30 kilometers from the dam.

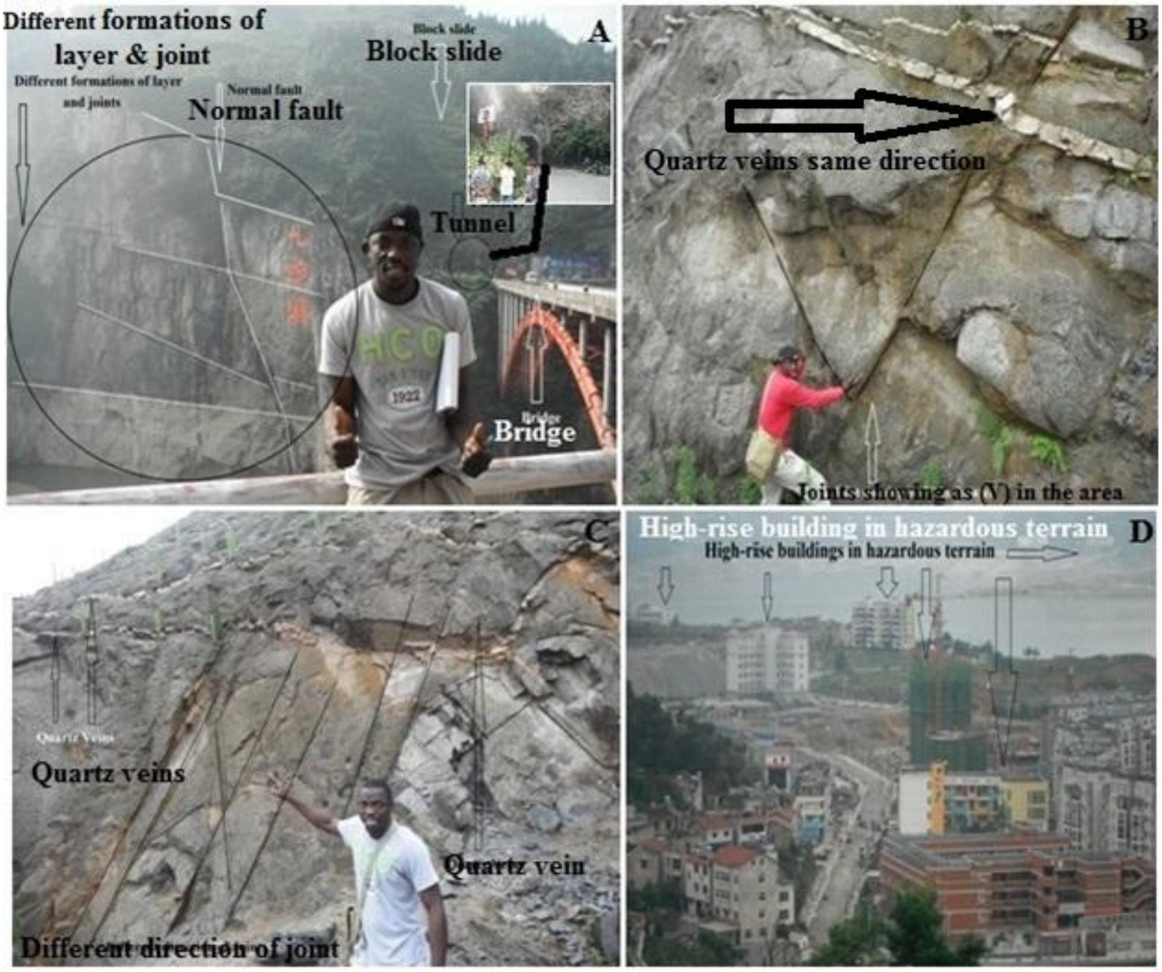
May 28, 2014. Another earthquake has struck the Three Gorges Dam reservoir region in central China’s Zigui County. No casualties have been reported so far and the dam is operating normally. The 3.4 magnitude tremor which hit early Monday morning, some 23 km from the dam, follows two earthquakes of magnitude above 4.0 and hundreds of aftershocks which shook the same region in late March of this year.

The upper Neoproterozoic section of Sandouping Town (Jiulongwan-Toudingshi), Zigui County, Hubei Province shows the most intact and completes sequence of the Nantuo and Doushantuo Formation (TANG Feng 2005).

3.2.1 Fault

In geology, a fracture in the rocks of the Earth's crust, where compressional or tensional forces develops, causes the rocks on the opposite sides of the fracture to be displaced relative to each other. Faults range in length from a few inches to hundreds of miles, and displacement may also range from less than an inch to hundreds of miles along the fracture surface (the fault plane). Most, if not all, earthquakes are caused by rapid movement along faults. Faults are common throughout the world.

However the region of Zigui developed joints are in the same direction through quartz veins because they occur at the same time and under the same geological processes (Appendix 3-3 B. Appendix 3-4).



Appendix 3-3: Fault and quartz veins showing in the area

We noted that in the area, the jointing is commonly the major type of structural weakness in granite and related rocks and causes the rock to break up into large blocks. Spheroidal weathering then rounds the edges of the fragments (Appendix 3-4). Granular disintegration in granite is common, producing crumbly spheroidal boulders. The disintegrated material consists of feldspars weathered to clay and quartz grains. The dissolution of calcite cement in a sandstone also causes granular breakdown. See also (Appendix 3-4 A).

Exfoliation is a special type of spheroidal weathering in which the rock breaks apart by separation along a series of concentric shells or layers that look like cabbage leaves. The layers, essentially parallel to each other and to the surface, develop by both chemical and physical means. Exfoliation may involve sheeting in rocks such as granite; if they are brought to the surface after deep burial, they have a tendency to expand upward and outward as the overlying rock is removed.

Appendix 3-4: Fault and quartz veins showing in the area

3.2.2 Fold

Fold is used in geology when one or a stack of originally flat and planar surfaces, such as sedimentary strata, are bent or curved as a result of permanent deformation. Many folds are directly related to faults, associate with their propagation, displacement and the accommodation of strains between neighboring faults.

The elevation of the ore body occurrence is strongly controlled by structures, and the thickness and grade of the ore body increases in the fracture zone. The mineralization is confined to the structural area with the metasediments and crushed quartz veins and calcitization (N. BASSANGANAM 2015).

The region of Zigui, structural orientations of folds is roughly developed; the mainly structural orientations are joints. We noted that the Soil structure in the area is also the most important aspect. The uppermost layer of the regolith is the soil. It is composed chiefly of small particles of rock, new minerals formed by weathering, plus varying amounts of decomposed organic matter. Soil is so widely distributed and so economically important that it has acquired a variety of definitions (Appendix 3-1). The transition from the upper surface of the soil down to fresh bedrock is a soil profile, which shows a rather systematic sequence of layers, or horizons, distinguished by composition, color, and texture.

Several special kinds of soils are worth noting here. The major soil orders are shown in (Appendix 3-1). Some soils are noteworthy because they are ore deposits. For example, aluminum does not migrate far during weathering, and, in fact, it may be concentrated as a residual deposit as other elements are removed.

Topography affects soil development because it influences the amount and rate of erosion and the nature of drainage. Flat, poorly drained lowlands develop a bog-type soil, rich in decomposed vegetation and saturated with water, whereas steep slopes permit rapid removal of regolith and inhibit the accumulation of weathered materials. Well-drained uplands are conducive to thick, well-developed soils (Appendix 3-1). Time is important in soil development in that it takes time for physical and chemical processes to break down the bedrock. In (Appendix 3-1) the young lava flow has a very thin, patchy soil, whereas the older flow has had time for a thick soil layer to develop.

3.3 Alteration of Wall Rock

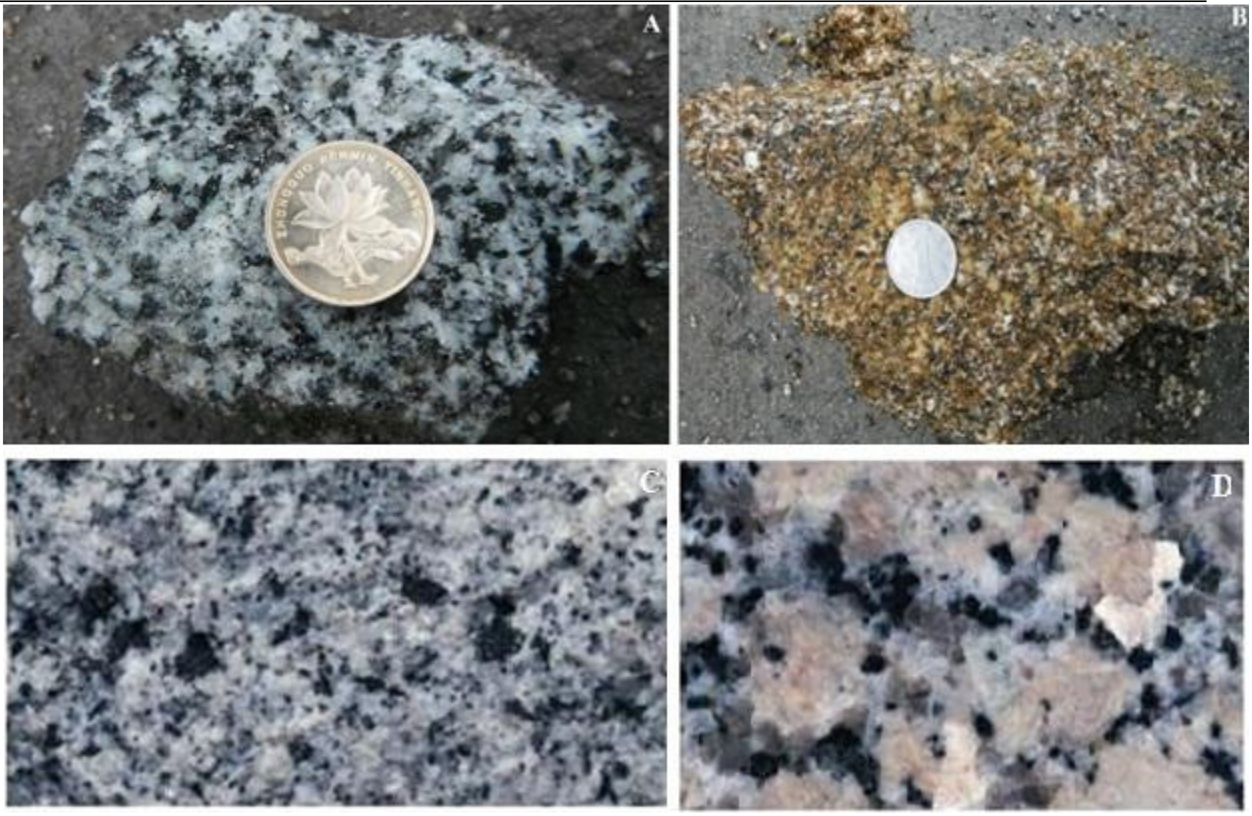
In the area, the degree of weathering decreases from top to bottom. The top layer is heavily weathered while the bottom is nearly un-weathered. From bottom there is the base rock, then half-weathered rock, residual, soil. When a rock is exposed to weathering (physical or chemical) for a long time, it disintegrates into smaller particles which when deposed in the same place are called residual

Appendix 3-5: Changing rock body during wreathing process

3.4 Minerals

Ore minerals occur in open faults, stock works, and breccias and replace adjacent strata resulting in the formation of disseminated ore (Appendix 3-4). In brittle, impermeable, and unreactive rocks, the bulk of the ore is along faults and fractures. In less competent, permeable, and reactive lithologies, ore extends outward from faults to form large tabular bodies.

The increment of fine grade size aggregates is of great significance to absorb Au particles and to form the economic ore bodies.



Appendix 3-6: White and red granite

Granite is a coarse-grained igneous rock composed predominantly of feldspar and quartz (Appendix 3-6 C). K-feldspar is the most abundant mineral, and usually it is easily recognized by its pink color. Plagioclase is present in moderate amounts, usually distinguished by its white color and its porcelain-like appearance. Mica is conspicuous as black or bronze-colored flakes, usually distributed evenly throughout the rock. A very important property of granite is its relatively low density, 3about 2.7 g/cm, in contrast to basalt and related rocks, which have a density of 33.2 g/cm .This fact, is important in considering the nature of continents and the contrast between continental crust and oceanic crust. Granite and related rocks make up the great bulk of the continental crust.

Diorite is similar to granite in texture (Appendix 3-6 D), but it differs in composition. Plagioclase feldspar is the dominant mineral, and quartz and K-feldspar are minor constituents. Amphibole is an important constituent, and some pyroxene may be present. In composition, diorite is intermediate between granite and gabbro. Its extrusive equivalent is andesite.

IV. CONCLUSION

We noticed that in Zigui region, the rocks were igneous rocks mainly composed of three mineral namely: quartz, black mica and feldspar. The rocks were affected by weathering at the same time as such quartz veins, the joint lines are in the same direction; chemical weathering is the most significant form natural influence. Also the multiple stratigraphic occurrences in the area developed under geological processes.

There is high potential impact from landslides in the Wushan–Zigui region of the Three Gorges. Although a large proportion of slope failures seem to occur in the area, and noted that areas are dominated by the mountains that pose little threat to human activities, enough works to combat slope instability have occurred in recent years to justify the need to identify and map landslide distribution and hazard.

Recent studies have shown the feasibility of remote sensing, and of imagery from the ASTER sensor in particular, for the regional assessment of landslide impact (Fourniadis et al. 2007a, b); such regional assessment can form the first step towards identifying those areas in greater need of detailed geotechnical studies with the aim of mitigating the hazard and minimizing the negative impact.

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REFERENCES

[1]. Bai SB, Wang J, Guo NL, Zhou PG, Hou SS, Xu SN (2010) GIS- based logistic regression for landslide susceptibility mapping of the Zhongxian segment in the Three Gorges area, China. Geomorphology 115:23–31

[2]. WU Hanning ZHU Rixiang, Vincent Courtillot, BAI Lixin, XING Jianxiao, ZHAO Yongxin and YANG Gelian 1998 Paleomagnetic results of Paleozoic and Mesozoic rocks from Xingshan-Zigui section in Hubei Province, South China

[3]. Bai SB, Wang J, Guo NL, Zhou PG, Hou SS, Xu SN (2010) GIS- based logistic regression for landslide susceptibility mapping of the Zhongxian segment in the Three Gorges area, China. Geomorphology 115:23–31

[4]. WU, S.R., SHI, L., WANG, R.J. ET AL. 2001. Zonation of the landslide hazards in the forereservoir region of the Three Gorges Project on the Yangtze River. Engineering Geology, 59, 51–58.

[5]. I.G. Fourniadis & J.G. Liu 2007 Landslides in the Wushan–Zigui region of the Three Gorges, China.

[6]. Wang Jian, Shen Chongyang , Li Hui, Sun Shaoan and Xing Lelin 2012 Gravity inversion of deep-crust and mantle interfaces in the Three Gorges area

[7]. TANG Feng, YIN Chongyu, Bengtson Stefan, LIU Yongqing, WANG Ziqiang, LIU Pengju & GAO Linzhi 2005. A new discovery of macroscopic fossils from the Ediacaran Doushantuo Formation in the Yangtze Gorges area

[8]. BASSANGANAM Narcisse, Associate Prof. Minfang Wang, Yang MeiZhen, Prince E. YEDIDYA DANGUENE. 2015 Study on genesis of the primary orebody in Shewushan gold deposit. *(AJER)* e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-4, Issue-7, pp-00

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An Ergonomics Study of UniKL MSI Perodua Eco-Challenge Race Car Cockpit

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ABSTRACT : This research will concern itself primarily with the ergonomics of motor vehicle specifically in race car especially for cockpit UniKL MSI Perodua Eco-Challenge Race Car. Motor racing is very popular sport around the world. There are several types of motorsport that has long existed, including the Formula 1 which is the sport's most prestigious motor racing category. UniKL MSI Perodua Eco-Challenge Race Car is an adaptation of the concept of single-seat racing cars similarly as Formula 1. The cockpit is one of the most important things in racing, including the race car in the UniKL MSI Perodua Eco-Challenge Race Car. In the cockpit, there are several components required by the driver such as steering, gear lever, accelerator pedal and brake pedal, and seat. These are basic components that should be in a cockpit. UniKL MSI Perodua Eco-Challenge Race Car has been completely built. However, this race car needs to go through some test and should be completely finalized before the competition. One of the major problems is about the driver cockpit. In order to obtain the best cockpit design, RULA analysis has been used to utilize the suitable cockpit design for UniKL MSI Perodua Eco-Challenge Race Car. The resulting of cockpit design is solved by using CATIA V5R16. From the analysis, it was found that design E is the best cockpit design in term of RULA analysis final score achieved when compared to the other designs.

KEYWORDS - Ergonomics, Ergonomic Software, Cockpit, Anthropometry

1. INTRODUCTION

Ergonomics is the application of scientific principles, methods, and data drawn from a variety of disciplines to the development of the engineering systems in which people play a significant role. Among the basic disciplines are psychology, cognitive science, physiology, biomechanics, applied physical anthropometry, and industrial systems engineering. The engineering systems to be developed range from the use of a simple tool by a consumer to a multiperson, sociotechnical systems.

There is a hierarchy of goals in ergonomics. The fundamental task is to generate “tolerable” working conditions that do not pose known dangers to human life or health. When this basic requirement is assured, the next goal is to generate “acceptable” conditions upon which the people involved can voluntarily agree, according to current scientific knowledge and under given sociological, technological, and organizational circumstances. The final goal is to generate “optimal” conditions which are so well adapted to human characteristics, capabilities, and desires, that physical, mental, and social well-being is achieved. The multitude of different consumer goods which we encounter in our daily lives, safe and comprehensible operation is also included under “ergonomics”.

In our present civilized world, ergonomics appear in many different forms such as general ergonomics, micro-ergonomics, and multitude of different consumer goods. The most important field of application is general ergonomics in technical systems such as mechanical engineering and road vehicle, aircraft, and marine vessel engineering. In principle, ergonomics is the study of people and their work. Objective of the ergonomics is to optimally match labor and the work environment to human being. This project will concern itself primarily with the ergonomics of motor vehicle specifically in race car especially for cockpit UniKL MSI Perodua Eco-Challenge Race Car.

Motor racing is very popular sport around the world. There are several types of motorsport that has long existed, including the Formula 1 which is the sport's most prestigious motor racing category. UniKL MSI Perodua Eco-Challenge Race Car is an adaptation of the concept of single-seat racing cars such as Formula 1.

The cockpit is one of the most important things in racing, including the race car in the UniKL MSI Perodua Eco-Challenge Race Car. Referring to cockpit definition, it can be such a lot of definition. Mostly, cockpit is well known as the compartment in a small aircraft in which the pilot, crew, and sometimes the passengers sit. However, in motorsport cockpit defined as the driver's compartment in a racing car. In the cockpit, there are several components required by the driver of which are the steering, gear lever, accelerator pedal and brake pedal, and seat. These are basic components that should be in a cockpit.

UniKL MSI Perodua Eco-Challenge Race Car has been completely built. However, this race car needs to go through some test and should be completely finalized before the competition. One of the major problems is about the driver cockpit.

2. LITERATURE REVIEW

2.1 Ergonomics

Ergonomics is the application of scientific principles, methods, and data drawn from a variety of disciplines to the development of the engineering systems in which people play a significant role. Among the basic disciplines are psychology, cognitive science, physiology, biomechanics, applied physical anthropometry, and industrial systems engineering. The engineering systems to be developed range from the use of a simple tool by a consumer to a multiperson, sociotechnical systems [1].

2.2 Hierarchy Goal of Ergonomics

There is a hierarchy of goals in ergonomics. The fundamental task is to generate “tolerable” working conditions that do not pose known dangers to human life or health. When this basic requirement is assured, the next goal is to generate “acceptable” conditions upon which the people involved can voluntarily agree, according to current scientific knowledge and under given sociological, technological, and organizational circumstances. The final goal is to generate “optimal” conditions which are so well adapted to human characteristics, capabilities, and desires, that physical, mental, and social well-being is achieved [3].

2.3 Anthropometric

Anthropometry literally meaning "measurement of humans", in physical anthropology, refers to the measurement of the human individual for the purposes of understanding human physical variation. Today, anthropometry plays an important role in industrial design, clothing design, ergonomics and architecture where statistical data about the distribution of body dimensions in the population are used to optimize products. Changes in life styles, nutrition and ethnic composition of populations lead to changes in the distribution of body dimensions, and require regular updating of anthropometric data collections [2].

2.4 Ergonomics Model

In ergonomics and human-factor engineering, the term model is often defined as a model is a mathematical or physical system that obeys specific rules and conditions and whose behavior is used to understand a real (physical, biological, human-technical, etc.) system to which it is analogous in certain respects to the real system.

2.5 Testable Hypothesis

A lack of rigor ergonomics studies has been reported by Heacock et al. (1997), who compiled a checklist that is useful both for planning experiment and for assessing past studies. Investigations of, and experiment with, human being and their performance must be carefully planned, executed, evaluated, and reported in order to test a theory or, more often, a hypothesis. The usual approach is to state a hypothesis and then determine whether it is true or false based on the experimental result.

Testing is commonly done in term of the null hypothesis. There is no difference between the outcomes of the test. Whether the null hypothesis is rejected or not is determined by statistical evaluation of the experimental data. Weimer (1995) discussed, in a down-to-earth manner, how to develop and carry out a research project. This is also a topic of many more theoretical treatises on methodological and statistical aspects in human-factors research. Through guide to the design of experiments and the analysis, the result have been compiled by Williges (1995) and Han et al. (1997), with the latter dealing with complex studies with multiple variables. A major aspect of their discussion is how to control individual differences among the subjects who participate in experiments [4].

2.6 Cockpit

Mostly, cockpit is well known as the compartment in a small aircraft in which the pilot, crew, and sometimes the passengers sit. However, in motorsport cockpit defined as the driver's compartment in a racing car [10].

2.7 Race Car

The control and instrumentation of race cars has changed dramatically since motor sport began early in the 20th century. A very simple vehicle design in the early years meant that the main control input came from the driver, and this hasn’t changed here at the start of the 21st century. However the driver’s job is made easier by the greater inclusion of control and instrumentation systems. The use of control and instrumentation systems on modern racing cars is mainly dependent on the cash budget of a competing team. This section of the background investigation will analyze the cockpit design solutions utilized in three vehicles used in different motor-sport categories with differing annual budgets. The vehicles chosen are an Intercontinental Super kart, a Formula SAE, and a Formula One car. These vehicles were chosen as they represent the entire scope of motor sport categories while also including a sequential gear shift or similar and require similar characteristics of acceleration, braking and cornering performance, albeit at an elevated level, and the design solutions used could be directly applied to the UniKL MSI Perodua Eco-Challenge Race Car [9].

3. METHODOLOGY

3.1 Rula Analysis.

RULA (Rapid Upper Limb Assessment) is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported. This tool requires no special equipment in providing a quick assessment of the postures of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body. A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator. It is of particular assistance in fulfilling the assessment requirements of both the European Community Directive (90/270/EEC) on the minimum safety and health requirements for work with display screen equipment and the UK Guidelines on the prevention of work-related upper limb disorders [6][7].

RULA was developed to investigate the exposure of individual workers to risk factors associated with work related upper limb disorders. Part of the development took place in the garment-making industry, where assessment was made of operators who performed tasks including cutting while standing at a cutting block, machining using one of a variety of sewing machines, clipping, inspection operations, and packing. RULA was also developed through the evaluation of the postures adopted, forces required and muscle actions [7].

RULA was developed without the need for special equipment. This provided the opportunity for a number of investigators to be trained in doing the assessments without additional equipment expenditure. As the investigator only requires a clipboard and pen, RULA assessments can be done in confined workplaces without disruption to the workforce. Those who are trained to use it do not need previous skills in observation techniques although this would be an advantage [8].

3.2 Ergonomics Analysis in CATIA V5R16.

CATIA V5R16 was included with Ergonomics Design and Analysis (EDA) module. By implementing and using the ergonomics facilities, a CATProduct in CATIA is generated. The ergonomics design processes are defined by four sub modules which are:

i. Human Builder
ii. Human Measurements Editor
iii. Human Posture Analysis
iv. Human Activity Analysis.

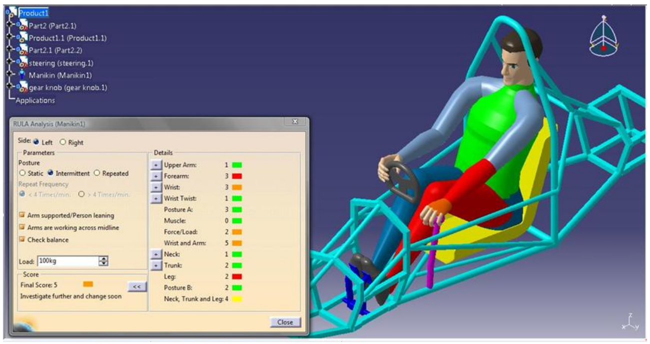


Figure 1: Example of RULA analysis in Catia using manikin.

3.3 The development of RULA

It can be divided into three stages and the example of RULA analysis interface in Catia using manikin as shown in Figure 1 above:

STAGE 1: The development of the method for recording working postures
STAGE 2: Development of the system for grouping the body part posture scores
STAGE 3: Development of the grand score and action list

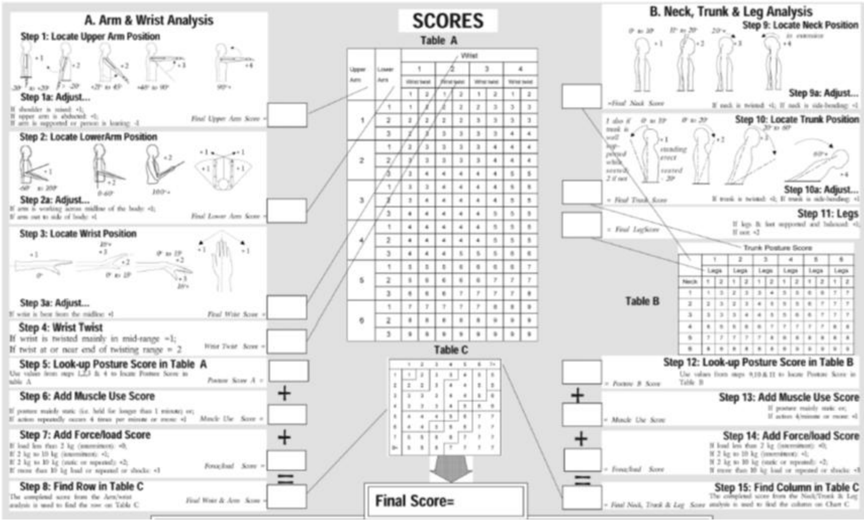


Figure 2: RULA worksheet (personal.health.usf.edu/tbernard/Hollow Hills/RULA)

3.4 Method of Design

3.4.1. Design Sketching

Sketching has proved to be the fastest way to define problem, explore ideas and develop. Sketch generally the meaning of a rough or unfinished drawing, and the activity to sketch for general outline of something. Benefit of sketching is that the mere acts of formulating a mental image in a concrete way possible for designer to reflect over the concept at once. Sketching is valuable activities such as brainstorming and concept evaluation [5].

3.4.2. Detail of Design

Detailed design is the process of developing a fully defined design from a clear set of requirement while creating deliverables and documentation appropriation. In this project, CATIA (Computer Aided Three-Dimensional Interactive Application) is use for the proper drawing.

3.4.3. Analysis of the Design

Design analysis had used for every type of design development and research effort imaginable. Design analysis can elucidate a wide range of development problems. In this research, RULA analysis was used for the analysis. These RULA analysis descriptions have been mention at the beginning of this research. The worksheet that was used to determine the RULA analysis is shown in Figure 2.

4. RESULT AND DISCUSSION

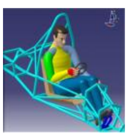
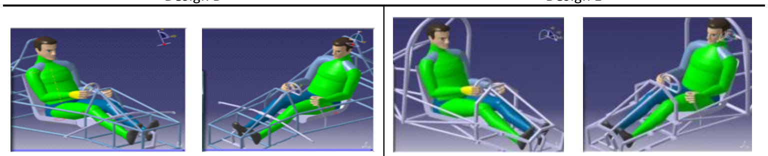
		Concept Rating (0-7 as RULA analysis score)					
		Design A		Design B		Design C	
No.	Criteria						
		Right	Left	Right	Left	Right	Left
1	Upper Arm	2	3	2	2	3	3
2	Forearm	2	2	2	2	2	2
3	Wrist	2	3	4	4	1	1
4	Wrist Twist	1	1	1	1	1	1
5	Posture A	3	4	4	4	3	3
6	Muscle	0	0	0	0	0	0
7	Wrist and Arm	3	4	4	4	3	3
8	Neck	2	2	1	1	1	1
9	Trunk	2	2	3	3	2	2
10	Leg	1	1	1	1	1	1
11	Posture B	2	2	2	2	1	1
12	Neck, Trunk and Leg	2	2	2	2	1	1
13	Final Score	3	3	3	3	3	3

Figure 3: Proposed design comparison in term of RULA analysis score

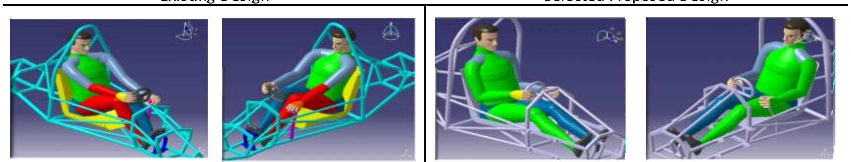
Based on the RULA analysis of the proposed design which is design A, B and C as shown in Figure 3 above, the acceptable score did not reach as per required. As a result, all of these designs can be accomplish as unacceptable. At this point, this current chassis was not suitable to use as UniKL MSI Perodua Eco-Challenge Race Car because it will not be able to fulfil the ergonomics required for the driver.



No.	Criteria	Concept Rating (0-7 as RULA analysis score)			
		Design D		Design E	
		Right	Left	Right	Left
1	Upper Arm	2	1	1	1
2	Forearm	1	1	1	1
3	Wrist	2	1	2	1
4	Wrist Twist	1	1	1	1
5	Posture A	3	1	2	1
6	Muscle	0	0	0	0
7	Wrist and Arm	3	1	2	1
8	Neck	1	1	1	1
9	Trunk	1	1	1	1
10	Leg	1	1	1	1
11	Posture B	1	1	1	1
12	Neck, Trunk and Leg	1	1	1	1
13	Final Score	3	1	2	1

Figure 4: New proposed design using new chassis comparison in term of RULA analysis score

From the Figure 4 above shows that the comparison upon all three new proposed design using new chassis of the cockpit arrangement; design D and design E. According to the RULA analysis results, it can be conclude that the design E was selected proposed design based on the final score for each left and right side which 1 and 2, and it also stated 'acceptable' in the analysis which had been done.



No.	Criteria	Concept Rating (0-7 as RULA analysis score)			
		Existing Design		Selected Proposed Design	
		Right	Left	Right	Left
1	Upper Arm	1	1	1	1
2	Forearm	3	3	1	1
3	Wrist	2	3	2	1
4	Wrist Twist	1	1	1	1
5	Posture A	3	3	2	1
6	Muscle	0	0	0	0
7	Wrist and Arm	5	5	2	1
8	Neck	1	1	1	1
9	Trunk	2	2	1	1
10	Leg	2	2	1	1
11	Posture B	2	2	1	1
12	Neck, Trunk and Leg	4	4	1	1
13	Final Score	5	5	2	1

Figure 5: Comparison between existing and selected proposed design

Presently, proposed design has been not selected yet. Hence, the selected and existing proposed design today is being compared in order to meet the final design which is suit with UniKL MSI Perodua Eco-Challenge Race Car. To begin with, both designs will be compared by using the score obtained from RULA analysis. Formerly, it needs to be compared based on requirement of basic component which will include in the cockpit that has been shown in Figure 5 above. At this moment, the selected proposed design had considerable improvement in ergonomics compared to the existing design. The greatest perceived improvement is using the new design of cockpit.

5. CONCLUSION

Based on the analysis that has been done, it can be determined that this research has a high prospect if continued. After going through the process of scientific research, nowadays known that the ergonomic been emphasized since the beginning of the automotive industry. Thus, progress in this area is growing regardless of the private car or racing engine. Consequently, this research refer to the ergonomic study on the UniKL MSI Perodua Eco-Challenge Race Car, an emphasis on ergonomics aspects involving cars is discovered. Among them are Formula 1, Formula SAE and Super kart which of the three categories were used as reference.

By referring to the objectives and scope, this research is now on the right track. The definition of ergonomics, cockpit layout of race cars, and also the way to conduct ergonomics analysis using the RULA analysis have been achieved in order to fulfill the resolutions.

New cockpit arrangements layouts have been design based from the original chassis design with a basic component in the cockpit. There are five new designs proposed; which are design A, B, C, D and E. RULA analysis has been well performed on all the new cockpit arrangement layout design. The results of each comparison for the new designs show that design E is the best among the other two proposed design. Whereas, the existing design need to be revised back in order to compare it again with the selected proposed design equally to final design which is the best suit with the UniKL MSI Perodua Eco-Challenge Race Car.

REFERENCES

[1]. David, G., Woods, V., Buckle, P., and Stubbs, D., (2003), *"Further development of the Quick Exposure Check (QEC)"*. In: Ergonomics in the Digital Age. Proceedings of the XVth Triennial Congress of the *International Ergonomics Association*, August 24-29, 2003, Seoul, Korea.

[2]. Goonetilleke, R. S., Ho, Edmond C. F., and So, R. H. Y. (1997). Foot Anthropometry in Hong Kong. Proceedings of the *ASEAN 97 Conference, Kuala Lumpur, Malaysia*, 1997. pp. 81-88.

[3]. Kilbom A. (1994) Repetitive work of the upper extremity: Part I - Guidelines for the practitioner. *International Journal of Industrial Ergonomics 14*: 51-57.

[4]. Kilbom A. (1994) Repetitive work of the upper extremity: Part II - The scientific basis (knowledge base) for the guide. *International Journal of Industrial Ergonomics 14:* 59-86.

[5]. Kroemer, K.H.E., Kroemer, H.B., Kroemer-Elbert, K.E. (2001). "Ergonomics: How To Design For Ease And Efficiency" 2nd Ed. New Jersey : Prentice Hall.

[6]. McAtamney, L. & Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders, Applied Ergonomics, 24, 91-99.

[7]. McAtamney, L. & Corlett, E.N. (1993). "RULA: a survey method for the investigation of work-related upper limb disorders". Applied Ergonomics. 24. pp 91-99.

[8]. McAtamney, L. & Corlett, E.N. (2004) Rapid Upper Limb Assessment (RULA) In Stanton, N. et al. (eds.) "Handbook of Human Factors and Ergonomics Methods". Boca Raton, FL, pp. 7:1 - 7:11.

[9]. Race Car Design Tips and Information – Safety/Ergonomics, viewed 5 June 2004, http://www.gmecca.com/byorc/dtipssafetyergo.html