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# General Engineering

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- Industrial Augmented Reality
- An Algorithm for Integration
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Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 7 VERSION 1.0

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# Intercalation of Metallic Potassium and Fullerene $C_{60}$ into Natural Graphite

By Zemanová Eva, Klouda Karel, Lach Karel & Weisheitelová Markéta
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*Abstract-* Graphite was intercalated with potassium to produce $C_8K$ intercalate which was subsequently exposed to suspension of fullerene $C^{60}$ in toluene. The resulting product stabilized potassium against effects of the atmosphere. The prepared product was exposed to tests of thermal stability and other analyses, such as FT-IR, SEM and Energy-dispersive X-ray Spectroscopy (EDAX) with the objective to describe arrangement of potassium in the carbon matrix.

The product with stabilized potassium in a carbon skeleton (graphite – fullerite) is partly able to resist the atmosphere, it is relatively thermally stable (up to 150°C) and the energy effects of its decomposition are low up to 600°C. The product may be used in numerous applications – catalysis, hydrogen storage and as an admixture component in aerosol fire suppression systems.

*Keywords: graphite, intercalate, potassium, fullerene.*

*GJRE-J Classification : FOR Code: 091599*

INTERCALATIONOFMETALLICPOTASSIUMANDFULLERENEC60INTONATURALGRAPHITE

*Strictly as per the compliance and regulations of:*

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Zemanová Eva [α], Klouda Karel [σ], Lach Karel [ρ] & Weisheitelová Markéta [ω]

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## I. Introduction

Graphite is an allotropic modification of carbon with sp2 bonds and made up of layers of mutually interconnected hexagonal rings. The layers are arranged in parallel planes 335 pm apart. Carbon atoms in the adjoining layers are not chemically bonded to each other and they are attached by weak Vander Waals forces that make it possible for various atoms or molecules in liquid or gaseous form to get in between the carbon layers. The resulting substances are called intercalation compounds of graphite and their characteristic parameter is the so-called "degree of intercalation", which indicates the number of carbon layers between two layers of an intercalated substance (Klouda, 1985).

Depending on a type of the intercalated substance the graphite plane may be either an acceptor or donor of electrons. Another option is the so-called – complex created by intercalation of substances of AXy type, where A is a metal or non-metal with a high valence status, X is an electronegative element and y is a stoichiometric coefficient.

Intercalates of graphite with alkali metals have been known since 1930s. They are called intercalates of the first degree with the formula $C_8M$ (M=K, Rb, Cs), i.e. they are characterized by a stacking sequence of layers of carbon and alkali metal.

Intercalates of graphite with alkali metals or in combination with other metals have been used in a number of applications as catalysts, e.g. for synthesis of ammonia, synthesis of carbohydrates by hydrogenation of carbon oxides, hydrogenation of olefins, they have sorption properties etc. Substituents can be chemically bonded to graphite under certain conditions by fluorination or oxidization (Klouda, 1985).

Fluorination of graphite with elemental fluorine at 400-600°C produces a covalent compound called fluorographite $CF_x$, x=0.25-1.12, depending on reaction conditions of the fluorination (Klouda, 1985). Oxidization of graphite with strong oxidizing agents produces graphene oxide (GO), which is a precursor for chemical preparation of graphene (Makharza et. al., 2013).

Graphene can be prepared by a chemical method which consists in reduction of oxidized carbon (functional groups) in GO with various reducing agents (hydrazine, metal hydride, hydrogen, hydrogen iodide) or reducing methods, such as reflux in a polar solvent, microwaves irradiation, electrochemical reduction (Dreyer et. al., 2010).

Another modification of carbon from the realm of nanoparticles are fullerenes: the best known representative is fullerene $C_{60}$ with spherical molecules consisting of 20 hexagonal and 12 pentagonal rings, crystallizing in a cubic system (fullerite). A fullerene molecule may be subject to nucleophilic and radical reactions (Troshin et. al., 2008).

In this work we have prepared graphite-potassium intercalate which was subsequently exposed to suspension of fullerene in toluene in order to intercalate fullerene between the graphite layers.

## II. Experimental Part

### *a) Materials Used*

Graphite PM – very fine crystalline powder graphite, mesh 0.025mm, Supplier: Koh-I-Noor Netolice, Czech Republic Fullerene $C_{60}$, 99.5% purity, SES Research, Houston USA Toluene, ethanol, metallic potassium – Supplier: Sigma - Aldrich

### *b) Measuring Instruments*

ATR analysis by means of FTIR spectrometry was performed using the spectrometer Brucker Aplha/FT-IR, ART crystal (identified as Platinum

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Diamond 1 Ref1), software OPUS 6,5, source j IR SiC Globar. The number of spectrum scans was 24, resolution 4 $cm^{-1}$, spectrum range 375-4000 $cm^{-1}$.

Thermal analyses TGA and DSC were performed on STA 1500, Instrument Specialists Incorporated-THASS, analytical scale SUMMIT, SI 234-4, at flow rate 20 ml/min., heating rate 10°C/min., ceramic crucible, diameter 5 mm and height 8 mm, degradation medium: air.

Morphology was determined with SEM Phenom FEI and SEM FEI Quanta 650 FEG (USA).

*c) Preparation of Intercalate C8K and its Subsequent Reaction with Fullerene*

Potassium (1.07 g) and graphite (2.4 g) were placed into a three-neck glass flask with inert $N_2$-atmosphere inside. The mixture was gradually heated for 30 minutes to reach the temperature ca. 90-100°C in an oil bath in which the flask was immersed. At that temperature the mixture was stirred for 2 hours and subsequently cooled to the laboratory temperature and solution (suspension) of fullerene (0.7 g $C_{60}$) in toluene (35-40 ml) was added, oversaturated at the laboratory temperature. The reaction mixture was stirred for 5 days. Then the mixture was decomposed by 30 ml of ethanol (no hydrogen was released). After 30 minutes the flask content was placed into a beaker with ethanol (40 ml) and the mixture was filtered by vacuum filtration.

The filtration and drying were performed without any protective atmosphere. Drying was performed for a relatively short period of time at 55°C for safety reasons because the thermal stability was not known and it was followed by FT-IR analysis, TGA and DSC analysis and electron microscope imaging, including Energy-dispersive X-ray Spectroscopy (EDAX).

*d) IR Spectrum of the Product*

The obtained IR spectrum is shown in Figure 1. The main absorbance peaks were found in the range 1562-500 $cm^{-1}$. The biggest peak 1562 $cm^{-1}$ has been attributed to the C-C vibration of the circular skeleton. Some frequencies corresponded to the published values (Giannozzi and Andreoni, 1996) for $K_6C_{60}$, e.g. 1476 $cm^{-1}$, 1359 $cm^{-1}$, 656 $cm^{-1}$, 416 $cm^{-1}$. In general, inorganic salts $K^+X^-$ demonstrate vibrations in the range 700-400 $cm^{-1}$. It is not possible to avoid or not to consider potential assignment of ν(O-O) of the superoxide ion $O_2$.- (Itoh et al., 2006) the formation of which can be expected in contact with atmospheric environment. The vibration at 3230 $cm^{-1}$, which corresponds to the –OH group, can be explained with adsorbed ethanol as a result of the short period of drying.

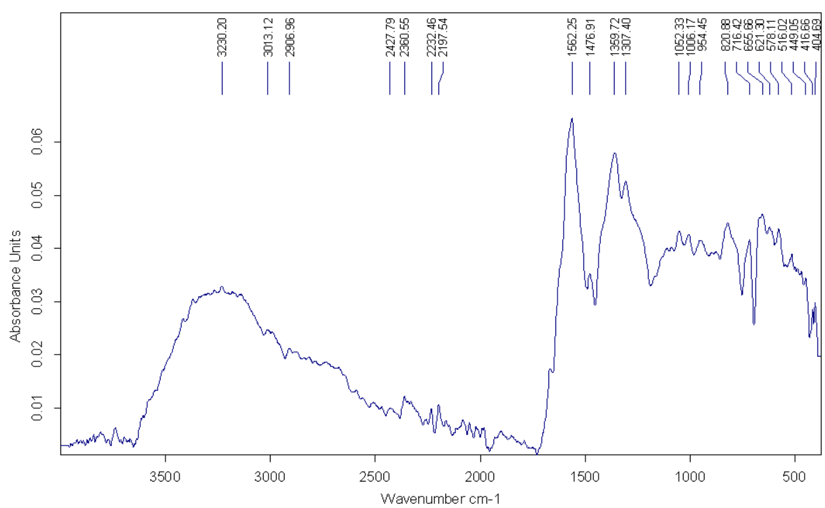


*Fig. 1 :* IR spectrum of the product of $C_8K$ reaction with fullerene

*e) Thermal Analysis of the Product*

Based on material balance of the individual components of the mutual reaction the summary formula of the product should be $C_{200}K_{27}C_{60}$, i.e. the content of carbon in form of graphite 57.55%, the content of carbon in form of fullerene 16.7% and 25.6% of potassium. The DSC curve (Figure 2) in the measured range featured two peaks corresponding to endothermic reactions with weight loss of 5-6% and we anticipate that this was mainly due to desorption of ethanol. After a further increase of temperature two partly overlapping peaks were identified which corresponded to exothermic thermal processes with heat release as shown in Table 2. The shape of the curve suggests that there is another exothermic process which would have occurred if we had further increased the temperature of the analysis. The weight loss of the samples (see TGA Tab. 1) was essentially linear and it depended on temperature; up to the temperature of 600°C the weight loss was 36%.

We can anticipate that while the sample was heated in the air and before fullerene was added potassium intercalated into graphite to form a

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pre-defined intercalate $C_8K$. We also anticipate that the added solution (suspension) of fullerene intercalated into graphite (the distance between the layers had expanded) which was probably associated with intercalation of potassium into the crystalline system of $C_{60}$-fullerite molecules to form $K_xC_{60}$, where x=1- 6. The content of potassium in the intercalate graphite is more than four times higher than that corresponding to the maximum stoichiometry of the $K_6C_{60}$ salt. We assume that the excessive potassium is further intercalated between the layers of graphitic carbon. We can only speculate about the position of K-fullerite salts in respect to graphite. The material is non-homogenous which has been also demonstrated by electron microscopy and by EDAX (see Figures 4 and 5 below).

EDAX also identified oxygen in a part of the sample while we can assume that a partial oxidation of potassium occurred during the product processing (filtration, drying). In case of thermal exposure we anticipate reaction of potassium with atmospheric oxygen to produce potassium superoxide $KO_2$ (the compound alone is thermally stable up to 550°C) but in presence of an oxidizable substance it may provide oxygen and oxidize carbon, both in the fullerene molecule ( we do not anticipate priority) and also partly in the graphite. A lower weight loss during the TG analysis can be also explained by partial contamination of the sample with potassium carbonate (reaction of $CO_2$ with $KO_2$), which may also operate as a fire retardant.

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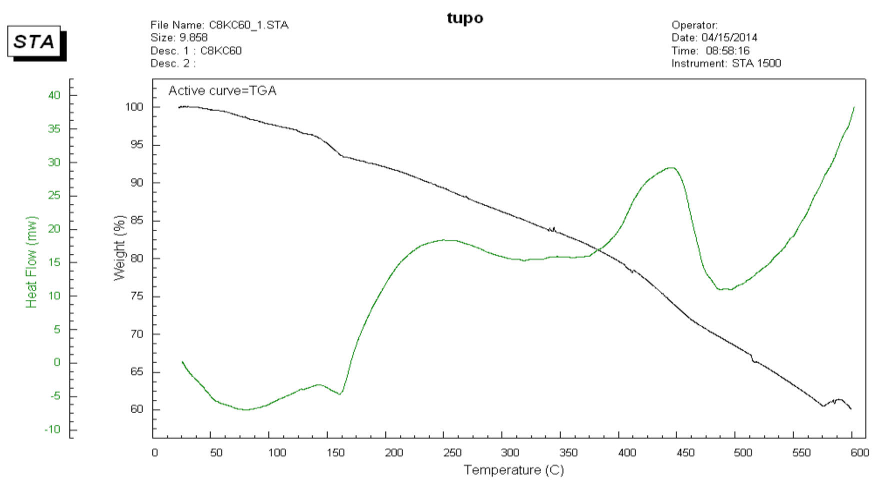



*Fig. 2 :* Thermal analysis of the product of $C_8K$ reaction with fullerene

*Table 1 :* Division of the TGA curve into temperature intervals

| Sample No. | Interval No. | Temperature range (°C) | Weight loss (%) |
|---|---|---|---|
| *)$C_{200}K_{27}C_{60}$ | 1 | 25,0–51,3 | 0,3 |
| | 2 | 51,3–126,8 | 3,0 |
| | 3 | 126,8–161,9 | 3,0 |
| | 4 | 161,9–374,1 | 11,9 |
| | 5 | 374,1–472,9 | 10,9 |
| | 6 | 472,9–576,4 | 10,3 |

**) Theoretical summary formula based on material balance of the individual components (degradation medium: air, air flow 20 ml/min, temperature regime 25-600°C, heating rate 10°/min, sample weight 8.6 mg)*

*Table 2 :* Parameters of the thermal processes (DSC)

| Sample No. | Thermal Process No. | Temperature Range (°C) | ΔH(kJ/kg)** | $H_{f1}$(mW) | ΣΔH(kJ/kg) |
|---|---|---|---|---|---|
| *)$C_{200}K_{27}C_{60}$ | 1 | 25,0–104,7 | 182,9 | 1,4 | |
| | 2 | 104,7–156,4 | 26,3 | 2,3 | -873,5 |
| | 3 | 156,4–302,5 | -572,1 | 23,1 | |
| | 4 | 370,7–482,3 | -510,6 | 13,2 | |

*** ΔH = thermal energy released /absorbed according to the DSC curves*
*(ΔH > 0…endothermic process, ΔH < 0…exothermic process)*
**) Theoretical summary formula based on material balance of the individual components*

*f) Morphology of the Product Prepared by Reaction of C8K Intercalate with Fullerene – Electron Microscope Images*

We investigated the prepared product with a scanning electron microscope with energy-dispersive micro-analyzer and we proved that the ratio of carbon and potassium was non-homogeneous. The lighter parts (see Fig. 3) are always enriched with potassium and, on the contrary, the darker parts are enriched with carbon. Parts with a higher content of potassium have different morphology (crystalline), while parts with dominating carbon have a layered structure. Changes of the mutual ratio of carbon and potassium in a selected crystal are visible in Figure 4.

The elemental analysis of the crystals identified also presence of oxygen and it confirmed non-homogeneity of the material (see the EDS spectrums on Figures 5 a) $C_{10}K_2O$, b) $C_{28}K_{1,6}O$, c) $C_{26}K_{1,33}O$).

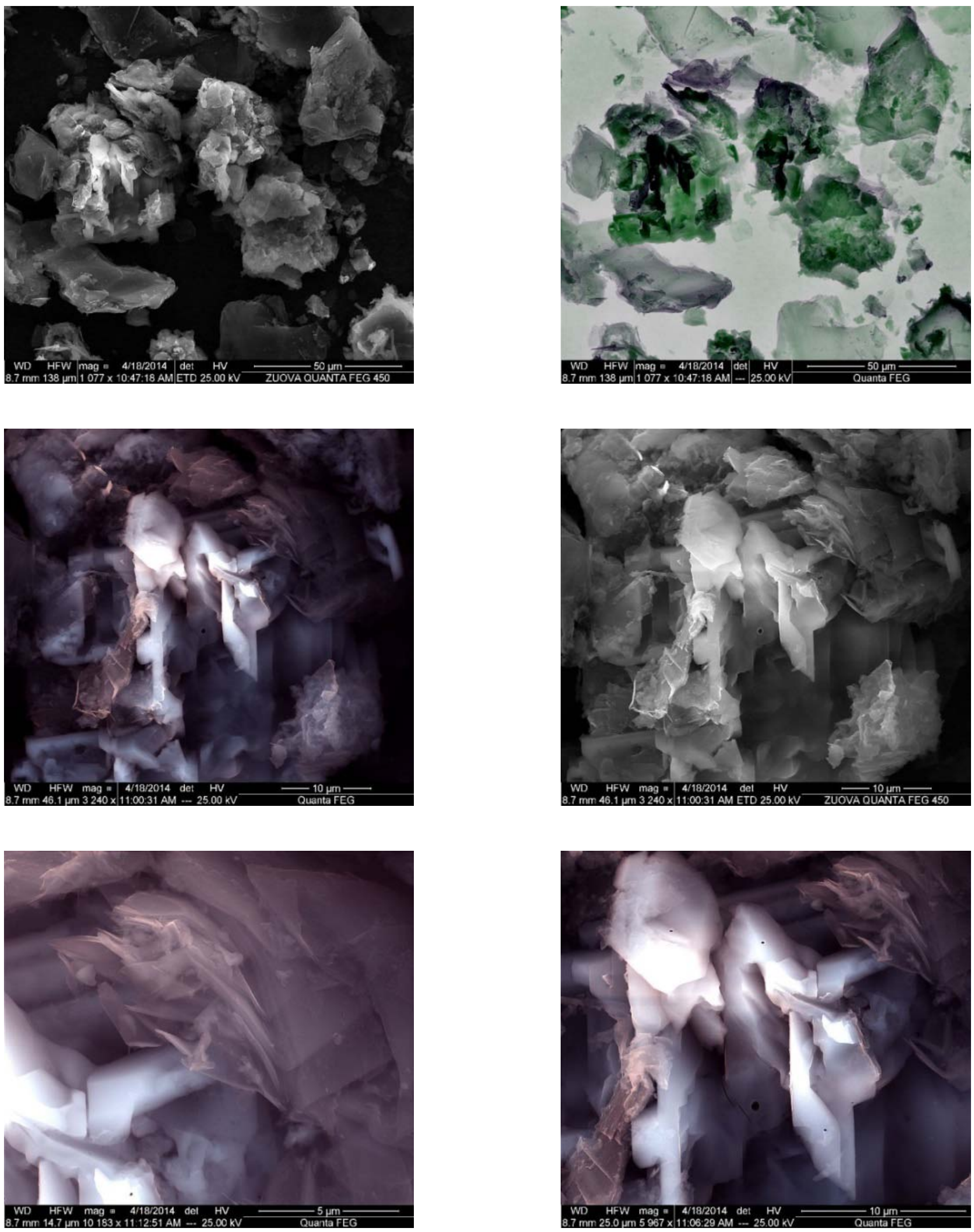
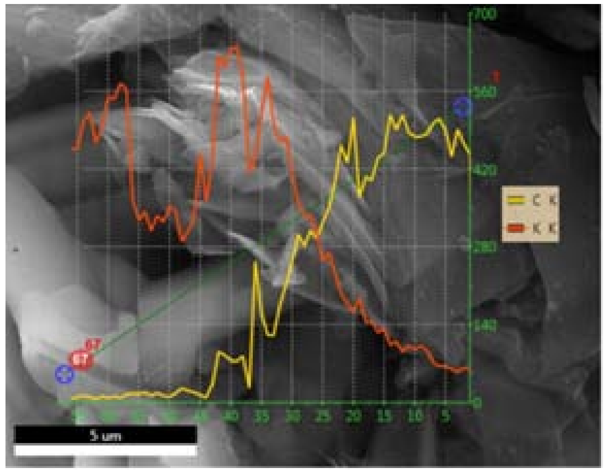


*Fig. 3 :* Electron microscope images of the product prepared by reaction of intercalate $C_8K$ with fullerene $C_{60}$, various images



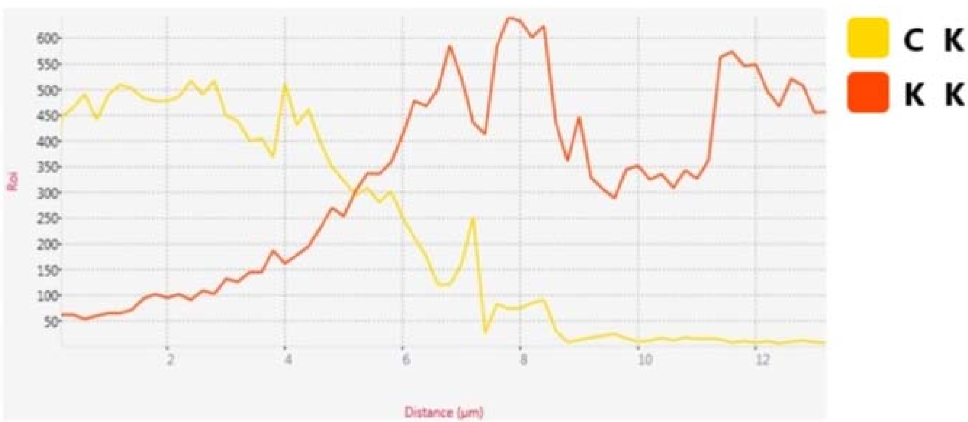
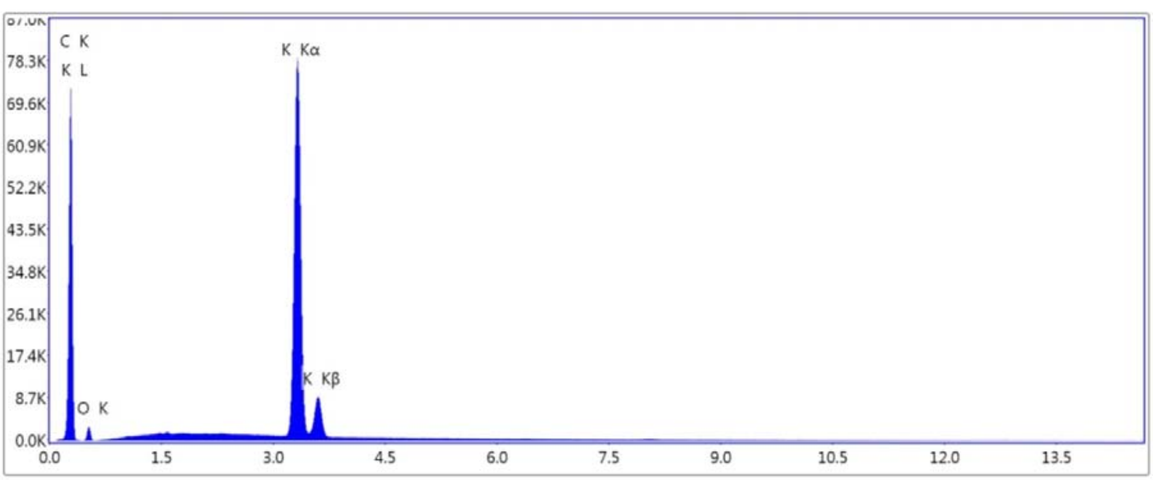




*Fig. 4 :* Distribution of carbon and potassium in a crystal

***Phase: K K/C K***



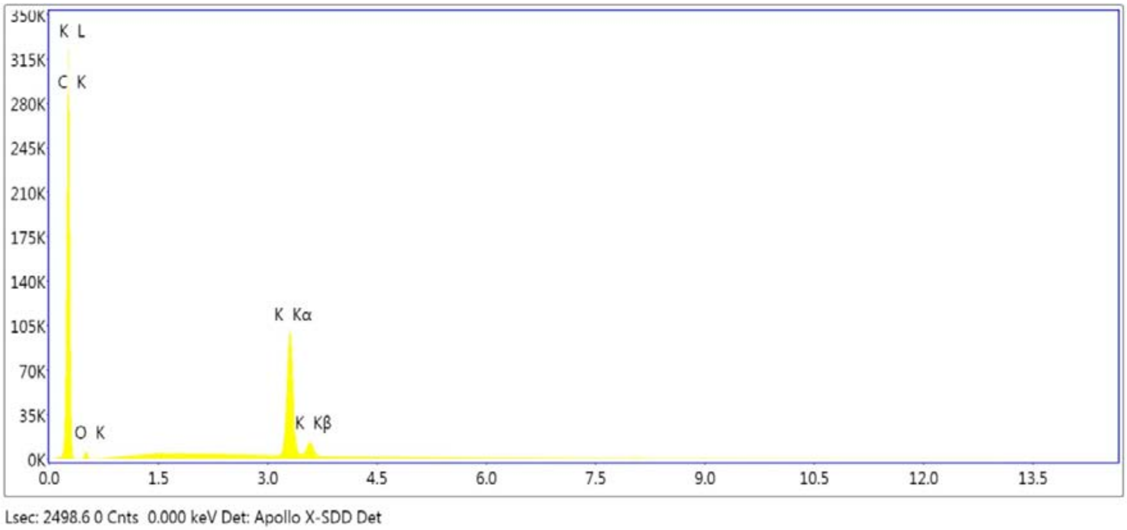

Lsec: 755.1 0 Cnts 0.000 keV Det: Apollo X-SDD Det

$C_{10}K_2O$

*eZAF Smart Quant Results*

| Element | Weight% | Atomic% | NetInt. | Error% |
|---|---|---|---|---|
| CK | 56.39 | 77.13 | 420.8 | 3.71 |
| OK | 7.49 | 7.69 | 16.4 | 11.42 |
| KK | 36.12 | 15.18 | 1061.6 | 1.39 |

***Phase: Sum Spectrum***

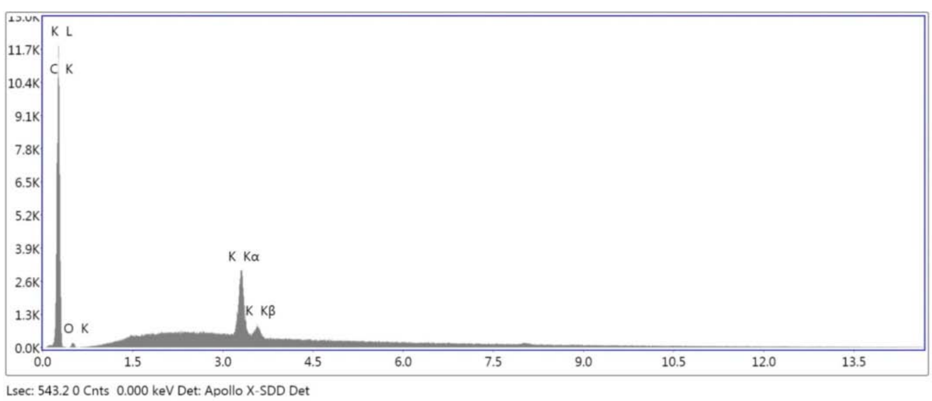



$C_{28}K_{1,6}O$

*eZAF Smart Quant Results*

| Element | Weight% | Atomic% | NetInt. | Error% |
|---|---|---|---|---|
| CK | 80.69 | 91.33 | 628.6 | 2.39 |
| OK | 3.9 | 3.31 | 8.1 | 11.18 |
| KK | 15.41 | 5.36 | 407.9 | 1.53 |

***Phase: Unallocated***




$C_{26}K_{1,33}O$

*eZAF Smart Quant Results*

| Element | Weight% | Atomic% | Net Int. | Error% |
|---|---|---|---|---|
| CK | 82.27 | 91.87 | 118.1 | 2.61 |
| OK | 4.13 | 3.46 | 1.6 | 15.49 |
| KK | 13.61 | 4.67 | 65.8 | 2.25 |

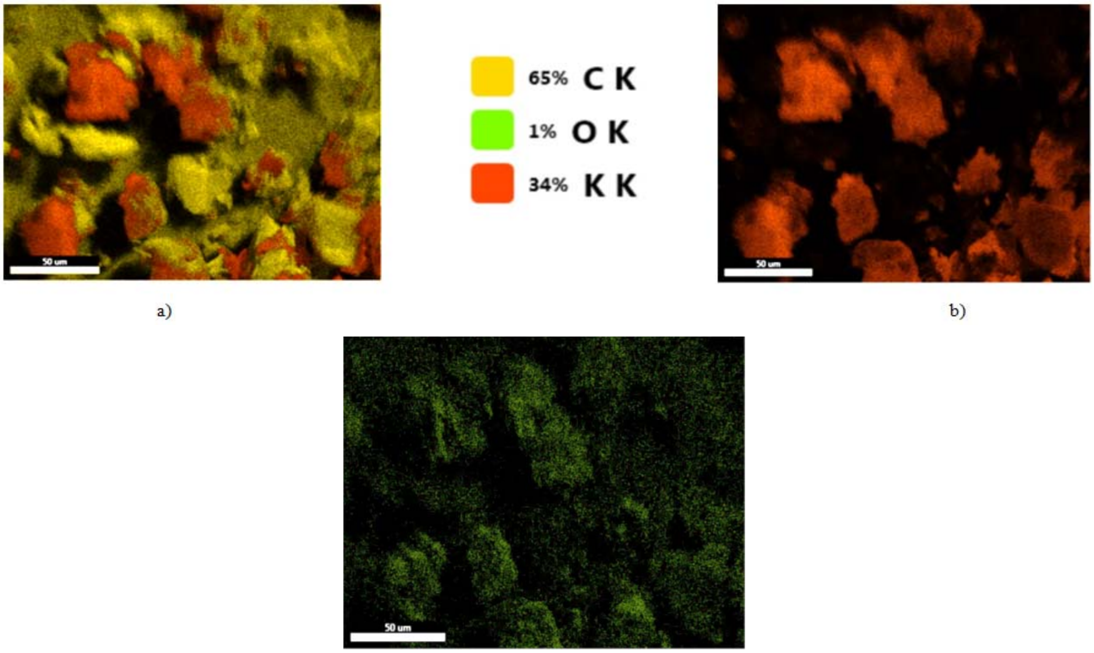



*Fig. 5 :* Elemental analysis in various parts of the product prepared by reaction of intercalate $C_8K$ with fullerene a) $C_{10}K_2O$, b) $C_{28}K_{1,6}O$, c) $C_{26}K_{1,33}O$

## III. Results and Discussion

*a) Reaction Product of Intercalate $C_8K$ and Fullerene $C_{60}$ (Fullerite)*

In this experiment we wanted to take advantage of our previous experience when we used intercalate $C_8K$ to replace potassium with various other metals (Cu, Co, Cd, Ni, Zn, Al, Ag, Fe, Sb) and thus we produced their intercalates in graphite (Klouda, 1985). We assumed that intercalation of potassium in between the graphite layers will expand the space and that the affinity of $C_{60}$ to the negative charge will facilitate the intercalation. Direct intercalation of $C_{60}$ into graphite requires heating of the mixture to a high temperature (600° C), deep vacuum and long reaction time (15 days). Before the intercalation process graphite must be expanded with sulfuric and nitric acids (Gupta et al., 2004; Miura et al., 2005).

Also intercalation of alkali metals into crystal lattice by means of $C_{60}$ fullerite molecules has been described.

There are three known methods that can be used (Hou et al., 2004; Holczer et al., 1991):

- in vapors of alkali metal in deep vacuum and at the temperature of 200 – 450° C for several days
- decomposition of alkali metal azide in presence of $C_{60}$ in vacuum at ca. 550° C
- at a relatively low temperature in a THF solvent, liquid ammonia, $CS_2$

Apart from mono-intercalation, it is also possible to prepare ternary intercalates by combination with other alkali metals (Hou et al., 2004) or even intercalates which, in addition to potassium, contain also an intercalated organic component (Janiak et al., 1996) e.g. the compound $K_3C_{60}$ $(THF)_{14}$ was prepared in a solution during preparation of potassium intercalate. Intercalation of potassium into the crystal lattice of fullerite produced intercalates KC60, $K_3C_{60}$, $K_4C_{60}$ and $K_6C_{60}$. We assume that in these compounds potassium operates as an electron donor and fullerene molecule as an electron acceptor, e.g. $K_3^{3+}C_{30}^{3-}$. Most works (Degiorgi, L., 1998) deal with testing of their superconductivity (Tc in $K_3C^{60}$ ~ 19K), physical properties, such as electric and optical conductivity, analysis of spectrums of electron spin resonance, 13C-NMR spectrums, distribution of electron density in a molecule etc. Compounds $K_xC_{60}$ (x=2,3,4,6) are extremely sensitive to the atmosphere, with the exception of $KC_{60}$, the so-called "rock salt" which decomposes at ca. 100°C into $K_3C_{60}$ and fullerene. $KC_{60}$ is expected to have a chain-like polymer structure (Koller et al., 1995).

Fullerene in the form of the so-called "nanowhiskers", prepared by the LLIP method (Liquid – Liquid Interfacial Precipitation Polymer), was intercalated to produce $K_{3,3}C_{60}$NWS with super a conductive properties (Takeya et al., 2012).

Apart from their atypical physical properties, potassium–fullerene intercalates may be also used to store hydrogen ($K_3C_{60}H_{29}$) (Loutfy and Wexler, 2001).

The method of mutual reaction which we have used to produce potassium fullerene intercalate was described by Fuhrer MS. (Fuhrer et al., 1994). The reaction was performed at 80°C and fullerene was applied in a solution of anhydrous benzene. According to the authors, the formula of the prepared product was $C_{32}K_4C_{60}$. The product prepared by us was a black powder. Its further processing, i.e. filtration and drying, was performed without protective atmosphere.

Drying was performed for a relatively short period of time at 55°C for safety reasons because the thermal stability was not known and it was followed by FT-IR analysis, TGA and DSC analysis and electron microscope imaging, including Energy-dispersive X-ray Spectroscopy (EDAX).

## IV. Conclusion

The works were performed to obtain experimental information for future routine preparation of the products for their further application. We have prepared and partly described a product with stabilized potassium in a carbon skeleton (graphite – fullerite). It is partly able to resist the atmosphere, it is relatively thermally stable (up to 150° C) and the energy effects of its decomposition are low up to 600°C. The product may be used in numerous applications – catalysis, hydrogen storage and as an admixture component in aerosol fire suppression systems.

It is essential to determine ecotoxicity of the prepared material, including verification of its potential antibacterial properties.

## V. Acknowledgement

The authors express their thanks to M. Urban of the chemical section of SÚJCHBO Kamenná for his help with preparation of the described products.

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# High-Efficiency Mission Planning and Distribution System of the Land Observation Satellites

By Qiu Hu
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*Abstract-* The mission planning of earth satellite observation generally refers to the optimized use of satellites' payloads. According to relevant experiences in project construction, this paper puts forth the concept of the integrated hub-style mission planning on the basis of consumers' satisfaction and data's timeliness. This concept takes the ground processing center as the integrated service point, and data demands of difference levels of users as the driving force. It fully considers the practical problems like station resources construction lag and data transmission link frequency interference conflicts, reasonably plan the satellite payloads data reception stations resources, monitor and control resources and data processing resources, so as to implement the remote sensing data from a data request, overall planning, telecontrol, data acquisition, data processing and the unified distribution in the whole process of mission planning model. This model effectively solves the problems like the difficulty to match single satellite programming model with user demands, and the low efficiency of resource use. Besides, the paper seeks to explore relevant elements, technology and techniques which are necessary in such mission planning.

The author thinks that from the vintage point of systems engineering, the commercialization of satellite observation products requires the full-cycle integrated mission planning that covers the period from the beginning of a user's order to the distribution of final data products, among which dispatching satellites' payloads is only one of important links. During the cycle, activities and constraints related to land support systems and other elements should also be taken into consideration.

*Keywords: mission planning, land observation satellite, hub-style, full-cycle, frequency interference, overall planning.*

*GJRE-J Classification : FOR Code: 090999*

HIGHEFFICIENCYMISSIONPLANNINGANDDISTRIBUTIONSYSTEMOFTHELANDOBSERVATIONSATELLITES

# High-Efficiency Mission Planning and Distribution System of the Land Observation Satellites

Qiu Hu

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*Keywords: mission planning, land observation satellite, hub-style, full-cycle, frequency interference, overall planning.*

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## I. Introduction

Because of its superiority in data acquisition, the observation satellite is playing a crucial role in all aspects of social development. With the maturity of satellite manufacture technology and constant development of aerospace equipment, China is applying Earth observation satellites in a more commercialized way. Thus, with the help of mission planning, how to maximize resources utility and users' satisfaction through overall management of producing of land observation products? At present, both at home and abroad satellite mission planning technology has received mass attention and has achieved admirable success in this field though, the concept of mission planning has been confined to the optimized operation of satellite payloads[1-3]. This paper from the aspect of systematic engineering, holds that the commercialization of satellite observation products requires the full-cycle integrated mission planning from users' requests to the final data distributed to users, of which the scheduling of satellite payloads is just one of important links. Besides, we should consider activities and constraints associated with the ground support systems and other factors including the deadline of distributing products to customers, the meteorology of observing regions, the constraints on the capability of satellite payloads, the limit of ground data transmission capability, the task allocation and the effective use of the distributed ground receiving systems, the flexibility of handling changes and unexpected events, and the frequency interference between different ground links. The whole management of data collection, processing, archiving and distribution make mission planning even more complicated, which needs to be explored further theoretically and practically, so that a number of elements should be considered, and a set of advanced techniques should be referred to.

## II. The Full-cycle Mission Planning

### a) *Fulfillment of full-cycle satellite application mission*

A fulfilled satellite application mission is a circulating from the submission of users' requests to the distribution of data products. As shown in the chart 1, the process is as follows.

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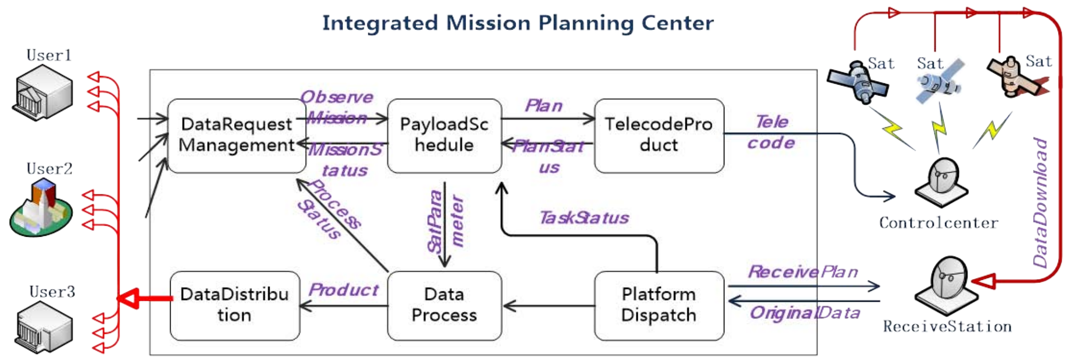


- Provide users with satellite observation planning through the Internet;
- Receive users' observation request through the Internet and the like;
- Preliminarily examine the feasibility of users' requests;
- Put users' requests into the payloads planning optimization module to avoid the conflict in resource use;
- Transform the planning results into remote commands towards satellite payloads;
- Check availability of other resources related to data acquisition, such as TDRSS satellites;
- The planning of ground support activities, including moderation made by the availability of resources and priority of different missions, to the scheduling of ground receiving activities, the data processing, and the scheduling of data distribution;
- Acquire, receive and process data;
- Send situations feedback to users;
- Archive and distribute data products;
- Users receive ordered products.

Among the steps above, (4) and (7), where resources use conflicts are most likely to happen thus mission planning is needed, are of the greatest importance. Traditional satellite mission planning always focuses on step (4). The result of planning corresponds to the sequence of satellites' observation activities, which is described in the nest section.

*b) The traditional concept of satellite mission planning*

Traditional satellite planning, usually interpreted as optimal use of satellite payloads, aims to schedule the space-borne sensor resources and specific time for each observation activity on the basis of the constraints on satellite payloads and requirements for observing missions, in order to maximize users' satisfaction. Relevant constraints should be considered by traditional planning include:

- The constraint of satellite system's capability
- Elements, including energy and power, the number and the type of sensors, capacity of data storage, and the time to change the angle of side-sway, would hinder the performance of observations.
- The constraint of the time window
- When satellites observe objects or transmit initial data down to the land reception station, all tasks should be finished within limited time window. Some objects could not be observed.
- The constraint of weather conditions
- For example, visible light shooting has strict restraints on cloud thickness.
- Special requirements for certain missions

Special constraints like periodical or paired observations are needed in some missions.

Traditional mission planning could only decide when to acquire initial data, while it could not determine whether the acquired data could be transferred to land stations without delay, or when the data could be processed and distributed to users successfully. As land observation satellites undergo the transition from experimental use to more practical and commercial use, users have more strict requirements on the quality of data products and the efficiency of collecting those products, for example, at some users' request, the time span, from high resolution imaging of the targets to the submission of data products should be less than a few hours. Typically the stricter the requirements are, the more profits are achieved by observing missions. Finally, application systems of land observation satellites shall provide consumers with continuous information service instead of occasional data products. However, traditional satellite mission planning cannot fulfill this kind of task. To solve the problem, this paper introduces the concept of full-cycle mission planning.

*c) The intension of full-cycle mission planning*

From the perspective of systematic engineering, full-cycle mission planning considers the whole process of satellite application task, including data acquisition, downlink, processing and distribution, as integral. By scheduling all activities in a integrated way, the planning endeavors to maximize users' satisfaction and satellites' use efficiency. Highlighting the quality of service, the full-cycle mission planning fully considers users' requirements on products, which contributes to commercialization of satellite data products and users' satisfaction.

Compared to traditional mission planning, some other elements should be added in the full-cycle mission planning:

- The change of distribution system
- While the ground support system is previously designed, the distribution system can be changed all the time. In that way, the service for consumers and the planning should be more flexible.
- The mechanism of ground support system
- The ground support system usually comprises a number of land stations with similar functions and processing centers. Its planning also requires coordination and distributed handling, and also involves specific constraints.
- The connection to the external data communication network
- Data distribution requires a communication network covering large areas, which is also a part of the full-cycle. Therefore, special requirements and constraints towards the connection between ground support system and communication network are involved.
- Automatic operation and operating cost saving

The trend of modern technology development is to save operating cost by promoting automation of operations, while weighing automation against technical risks. To achieve the goal of full-cycle mission planning, we can make full use of the progressive technology satellite payloads, for example, the solid-state storage devices with large capacity can increase the flexibility of data recording and downlinking, efficient power usage can prolong the service cycle of certain equipments, TDSSR satellites can improve amount of sent-back data, and technology of mass data downlinking at high speed improves the ability of missions accomplishment. At the same time, the scope of traditional mission planning shall be extended. Planning technology needed to be innovated, and only by combining hard technology and soft technology can maximize the profits. The following section will mainly describe the full-cycle mission planning from the perspective of soft technology.

## III. Elements to Realize Full-cycle Mission Planning

*a) User interface*

User interface is the direct channel of communication between users and satellite application systems. Fine user interface can enhance users' satisfaction of the service. Firstly, user interface should provide users with convenient consulting product database. When current database can meet users' requests, the interface then should permit them to download the data. When existing products fail to meet users' needs, the interface could supply standard formats and effective guidance for user's inputting new observation requests, so that the full-cycle mission planning can analyze the request and extracting mission-related information. Secondly, in view of different locations of the data users, the interface should apply distributed features, that is, the service meant for users' terminal should have a unified view that does not change with locations. What is more, to satisfy the need of near-real-time products, more customer service centers can be established in accordance with the layout of data storage, processing centers and ground stations. Data products are distributed by external communication network. Users can constantly submit orders or receive data products in a recycled way by the same network [4].

In addition, when the system is handling their requests, the interface should allow users to keep track of the progress. In particular, the cancellation of order and false information must be fed back to users in time. Thus, the interface should encompass monitoring mechanism of contingency in data distribution as well as the identification of the infeasible requests.

*b) The identification of missions and constraints*

Identifying all detailed requirement and related constraints is the premise of full-cycle mission planning. Users' observation orders may vary, so different satellite resources and different constraints are involve. For example, some users demands visible light imaging, indicating that the image should be taken by visible light imaging satellites under favorable sunlight conditions; some users may require all-weather observation, where SAR satellites are used. Some global scale missions require regular target observation and data downlink in every circle of satellites' flight to obtain continuous data products, where satellites with low resolution can manage. But in regional missions, it is satellites with high resolution that implement observation and downlink the data to ground station or TDRSS satellites. Requirements for the service are always changing, among which the near-real -time trait becomes the main constraint in the planning of data acquisition, processing and distribution.

*c) The planning of satellite payloads*

It is difficult to figure out a unified model and an efficient scheduling algorithm of multi-type satellites and their payloads based on constraints in satellite payloads planning. To give prominence of the advantages of full-cycle mission planning, it is necessary to schedule the various satellites in a unified and coordinated way. As for the different operating constraints of various satellites, such as visible light imaging satellites and SAR imaging satellites, they have to be described in a unified form in the integrated planning schedule model.

There are other aspects in scheduling algorithm need considering. If we simply follow the principle of First Come First Served, we may obtain a feasible solution, but it may not maximize the profits or users' satisfaction. The planning of satellite payloads is a combinatorial optimization problem with NP trait, which suggests that it is difficult to attend both the time constraint and the optimal solution of the algorithm. Therefore, the scheduling algorithm ought to strike a balance between solution performance and solution time to satisfy users' requirements in terms of the priority and time span of different observing missions.

*d) The planning of ground support systems*

According to its structure, mission planning of ground support system can be divided into two stages--data processing and control center stage and distributed ground stations stage. Stage two after preliminarily processing the data downlinked from satellites, sends the data to the former stage, and then the former processes data again and delivers final products to users. The planning cycle of stage one is rather longer (1~2 days), while the cycle of stage two depends on the circle of the satellite. The planning of two stages have to solve all conflicts in resource utilization related to data processing and distribution, as well as allow addition, revision and deletion of specific data products. A good number of departments and links are involved in the problem of ground support system planning, of which the scheduling of data processing is quite crucial. Because the same processing chains need to tackle offline missions, such as the additional processing of products and the disposition of overstocked missions, at the interval of finishing near-real-time data processing missions.

Furthermore, other elements should be considered in the scheduling of data processing, for instance, the test of capacity and feasibility of data processing chains, the allocation of the operating loads to different processors, and the automation of mission planning. The large number of products also contributes to the complexity of ground support planning, let alone the combination of processing and distribution of the products, which resulted from the different types of data processing activities (including near-real-time processing, offline processing, and overstocked mission handling), the site of data process(generally there are several data processing centers or stations.), the type of products(including regular products of global missions or occasional products of regional mission), the media for data distribution(such as solid-state recorders, wireless broadcast communication links, and multicast links), and the targets of data distribution(users or processing and control centers). The aspects of ground support systems mentioned above add to the difficulty of full cycle satellite land observation mission planning.

*e) Data distribution*

Data distribution is the last link of full-cycle mission plan. Users' satisfaction largely depends on whether they could receive ordered products within given time. Since the data processing center and the user who submits requests are not always at the same place, both near-real-time data products and regular mission products are delivered through particular distributed data communication networks. What is more, the mass amount of satellite observing data could easily lead to network congestion or interrupt, thus may delay users obtaining the products and decrease their satisfaction. Hence compression technique of massive information is significant to lessen the total amount without much information loss. After compression, data products are saved in remote servers and system will provide operating port to remote users.

In light of the limited bandwidth and transmission rate of current network system, proper transmission strategy and agreement should be reached to accelerate mass information transmission. Generally, data of smaller amount can be transmitted through broadcast communication links with relative low speeds. As for the massive data, multicast data links have more advantages. Also, if massive data is required to be transmitted within a rather short period, other high-speedy transmission channels can be utilized.

*f) Relevant technology and techniques*

A practical full-cycle mission planning software has to be flexible enough to facilitate the addition, moderation, and deletion of rules and constraints. Meanwhile, the software needs to maintain interaction with planners, while the final decision to solve the conflicts comes to planners. The expert system requires identification and authentication mechanism, so it is not applicable to planning and scheduling. Traditional operational researches methods like mathematic programming could not manage such a complicated problem either, whether in modeling or seeking the proper solution.

Given the development of planning and scheduling software outside of China, the algorithm of constraint-based scheduling is the most feasible. Constraint-based scheduling algorithm transforms scheduling problem into Constraint Satisfaction Problem (CSP) in artificial intelligence and applies relative Constraint Programming (CP) to modeling and scheduling. CSP problem can be defined by the triple combination of a variable set, a variable value set and a constraint set of variable values, and its solution should be a value combination of variables that meets all constraints. If required, the given target should be optimized. CP inaugurates a highly effective way to solve CSP--its programming language can describe a host of CSP models, and its constraints processing algorithms and predefined search algorithm library guarantee the efficiency of problem solving. For example, American GREAS satellite mission planning system employs CP tools, ILOG Solver and ILOG Scheduler, developed by French company OLOG, providing moulds of all missions, resources and constraints. Here, missions refer to the activities and operations to be conducted, resources are human, satellites, sensors and communication bands used in implementation, and constraints are those defining the time of mission implement, relationship between missions, and the capacity and availability of resources. Although GREAS system does not include the planning for ground support system, its solving approach is a splendid reference to full-cycle mission planning. Another point to be stressed--CP technique is different from mathematic programming in that the models do not necessarily correspond to the solving algorithms. In other words, the same model may have a variety of methods to figure out the solution, including accurate search like branch and bound algorithm, and also inaccurate heuristic search such as taboo search, and genetic algorithm. Accordingly we can make full use of CP approach to build flexible models in solving complex planning and scheduling problem. Meanwhile, we can design by ourselves or borrow other inaccurate search algorithms with outstanding time behavior to get satisfactory mission planning based on the exact description of problem traits.

*g) Prevention of frequency interference*

At present, most data transmission systems of remote sensing satellites use the X band (8025-8400MHz) for data downlink, they march in sun-synchronous polar orbit, their adopt the local time of descending node is 10:30, and the data is received by the same ground receiving station network. These similar parameters make frequency interference more likely to occur between different data link channel.

In the past years, one operator corresponds to one specific satellite, however, this mode could not solve the problem of frequency interference effectively. Nowadays, the "hub-style" satellite mission planning can formulate plans in advance, and then settle the problem with the optimal solution.

In accordance with the interference protection threshold of International Telecommunication Union (ITU), the calculation and analysis of interference margin of the link can make suggestions to the judgment and prevention of data link frequency interference.

## IV. Conclusion

That the application of observing satellites converts from experimental use to practical use requires the full-cycle mission planning of satellite systems and ground support systems as integral. Satellite is just one of the links in service to users and the feature of current missions embodies in the stricter requirement on the efficiency and quality of data products. New problem about management of the relevant activities around ground support system emerges as well. Since it is a long cycling chain from requests submission to products delivery, the monitoring and optimization of ground data processing and resource allocation become necessary. Only by viewing the cycle chain of production as a whole can we satisfy users' different requirements of desirable products. When practicing full-cycle mission planning, constraint-based scheduling is a favorable method, while more detailed techniques shall be further studied.

In the last a few decades, remote sensing satellites of China have witnessed significant changes, from single number to more than a dozen, from universal usage to specialized division. The full-cycle hub-style mission planning corresponds to national policy of civil remote sensing satellites, that is, unified planning and centralized handling. It is of great significance to timely deliver products of high quality to every professional user through remote sensing data planning and major processing points--first, this mode technically resolves the planning and optimization problem of numerous satellites; second, it helps to achieve the win-win situation where different users get what they want and the cost is reduced; third, it keeps supervising and monitoring various satellite data, and in turn propels the development of satellite processing and manufacturing techniques, and systematically stimulates the development and progress of aerospace remote sensing technology.

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# Developing Killer Apps for Industrial Augmented Reality

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*Abstract-* Human world are surrounded with the products manufactured by different industries. Each industry is unique in its own way and the requirements of the industry are different form one other. This difference in requirements leads to a new challenge that creates the need of specialization of technical solutions for every industry. Every industry concerns themselves with other in the fields of design, commissioning, manufacturing, quality control, training, monitoring and control, and service and maintenance. Augmented reality gives the industry a platform to develop virtual models according to their areas of interests and help them to visualize the designs with the stable view of the real world.

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DEVELOPINGKILLERAPPSFORINDUSTRIALAUGMENTEDREALITY

*Strictly as per the compliance and regulations of:*

# Developing Killer Apps for Industrial Augmented Reality

N. Yuvana [α], P. Lakshmi Uma [σ] & N.V.K. Ramesh [ρ]

*Abstract-* Human world are surrounded with the products manufactured by different industries. Each industry is unique in its own way and the requirements of the industry are different form one other. This difference in requirements leads to a new challenge that creates the need of specialization of technical solutions for every industry. Every industry concerns themselves with other in the fields of design, commissioning, manufacturing, quality control, training, monitoring and control, and service and maintenance. Augmented reality gives the industry a platform to develop virtual models according to their areas of interests and help them to visualize the designs with the stable view of the real world.

## I. Introduction

The idea of Augmented Reality was started in late 1960's by Ivan Sutherland's experiments, but did not acquire its fool gain as a technical felid sector till early 1990's [1]. For the first time Augmented Reality application for industries was developed in the year 1990 by David Mizell along with is colleagues at Boeing [2]. After this application development the Augmented Reality had undergone a series of development and came into usage by many industries.

German Federal ministry of education has sponsored the research organization for the development of IAR i.e. Industrial Augmented Reality to increase the development and production and services known by the German acronym ARVIKA [3]. Formation of R&G group in every institute for studying and developing the technology related to the industry is the primary goal of ARVIKA.

There are many research works conducted on IAR technology such that it meet the end to end requirement of the industries. Each industry is unique in its own way and the requirements of the industry are different form one other. This difference in requirements leads to a new challenge that creates the need of specialization of technical solutions for every industry. Every industry concerns themselves with other in the fields of monitoring and control, commissioning, manufacturing, design, quality control, training, and service and maintenance.

## II. Design

Augmented Reality developers proposed many alternate solutions for design and develop the virtual reality instruments which failed to prove the AR superiority. The design developed must be realistic with high quality and good rendering without any lag or misalignment that dramatically affects the idea of design. Using AR the cost of investment reduces which gives an added advantage of improvising the designs. AR application must be developed to compare the quality and efficiency to virtual reality or augmented virtually.

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## III. Commissioning

During the process of designing and development the designer and the building crew may be from different industries which results in ambiguity of the design and to avoid this by maintaining an original design. The AR is not used for financial advantages related to quality payment and delivery but also to have a flexibility of creation of a virtual design before setting the product for a life time use.

## IV. Manufacturing

The first AR application developed in 1990 at Boeing aimed at producing a prefabricated guidance boards. This AR application uses the optical device Head Mounted Display (HMD) and computer. But this idea later was not accepted by the final user. Even the ARVIKA projects have the equivalent solution which has failed in final stage.

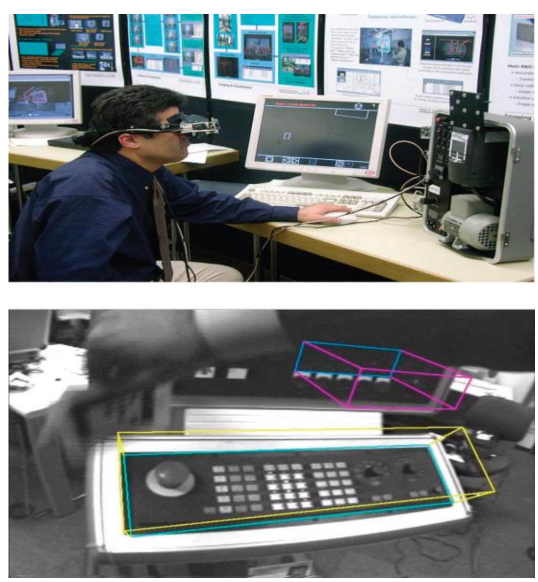

*Fig 1 :* HMD and system interfacing

The only manufacturing accepted by the final user is called as AR welding gun.

## V. Quality Control

Instead of technologies like laser or camera only IAR techniques for the quality control are suggested by ARVIKA [3]. Let us consider Benz R&D who built a system for detecting the dents on a crash tested car. But it was proved that instead of 3D recreation it is better to compare it on simulation.

## VI. Training

VR system without allowing virtual area to be accessed by the user is the main advantage offered by IAR training application. This application allows the training system to check different issues like safety are depending on the environment. At present the solutions exist only in prototypes which are not yet allowed into the market.

## VII. Monitoring and Control

Technologies such as CAD, VR, and advanced visualization are widely used for design and development procedures for different industries. New installations are often online based model which are fully virtual and visualized and evaluated. The online designs are developed and stored in the cloud.

The solution proposed for the problems are not measurable and they usually deal with identification but not the main problems of connecting database. The final solution is virtual designs and monitoring and controlling are integrated and used by mobile application which is a long term and a difficult goal. For designing 3D models for monitoring the data using mobiles we use Framatome ANP.

Siemens and Framatome aims to develop 3D models and Argument Reality Visualization, communication and speech based interaction which provides end to end solutions. The interaction between the system and the user is done through mouse or pen or speech based [4]. The real time automation and monitoring are observed in the mobile using Wireless communication. IAR as a technology started with the creation of CyliCon- Industrial Augmented Reality software solution. This software helps the user to create a virtual pipeline which reduces the need for complete. AR allows the users to reconstruct the designs virtually depending on their area of interest and imagine the models within the stable view. According to the industrial customers requirements some important industrial drawings are integrated in CyliCon was further developed and formed a new product called as co-registered orthographic and perspective image [5, 6]. Co-registered orthographic and perspective images allow the user to create new reconstruction algorithms, which reduces the need of calibration [7, 8].

Combining the solutions with Cylicon and co-registered orthographic and perspective images the user can develop a new solutions for mobile Augmented Reality visualization and data access which helps in locating the users in large industrial environment.

The latest development is done by joining Framatome and SCR allow the users captures the active display and relate the images to already existing preacquired 3D data. The Framatome uses the user to estimate the cameras and overlay the 3D data. The SCR at Siemens CT-PP4 Division considers industrial drawings for estimating the camera augmentation. In the two situations the interactive overlay which allows the user to directly access the image.

## VIII. Service and Maintenance

Service and maintenance deals with the connection of database where the application used in the industry access it. All the research works performed went in vain by just producing demonstrating prototype. These prototypes are often developed on kill the application that is at hand which has no scaling capacity for large number of parts.

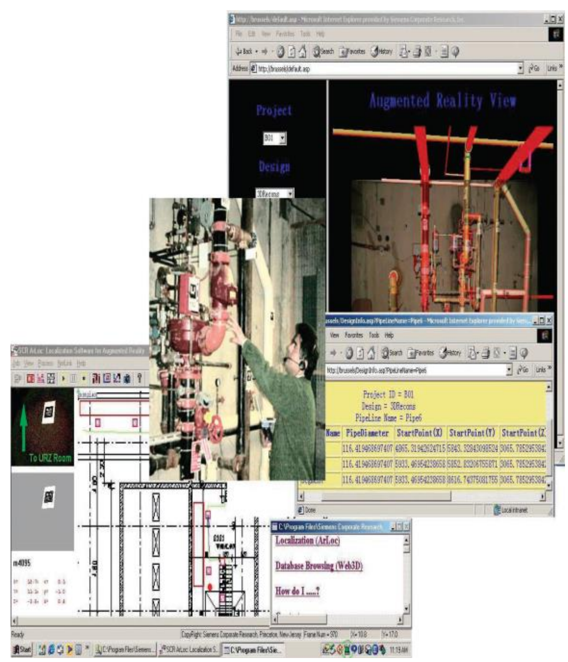


*Fig. 2 :* Mobile application of Augmented Reality

Industrial Augmented Reality solutions are not compactable with the existing services which became a major problem. Yet still the companies encourage the mobile handsets to interface with the present systems.

The present maintenance gave a flexibility of selection of spare parts and allowing the real time operations by using remote system which optimizes the work to maximum extent. IAR must develop which adds additional features to support user interface.

AR technology is used for maintaining and repairing the vehicles and other products by creating a virtual model of the design and developing the virtual design. This helps the R&D department in finding the necessary outputs for the problems faced by the institute.

## IX. Conclusions

Killer Augmented Reality application would provide a most accurate solution that traditional approach which wins the favour of many different users and creates large benefits in the aspect of finance. The R&D must make sure that any IAR solution must contain three different aspects in order to become a commercialized application. They are:

- Ease of access. The user must find the application easy and friendly for usage.
- The design outputs must be scalable. The owners and designers can easily reproduce and distribute.
- It should provide most accurate and equivalents so that the user feel it reliable.

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*Abstract-* In the present paper, elastic field parameters of a guided simply supported beam under three point bending has been investigated by a new approach called displacement potential formulation. Guided beams involve mixed mode of boundary conditions which the classical beam theory cannot handle. In displacement potential formulation, all the elastic field parameters has been expressed in terms of a single function **Ψ** which gives rise to a fourth order partial differential equation. The solution of this equation has been determined by trial and error process satisfying all the boundary conditions. This solution is then inserted to reduce the partial differential equation into an ordinary one. The obtained analytical solution of the beam has been presented as graphs. The stress concentration occurs mainly at the point of application of the load and the support at two corners. The analytical solution has further been verified by finite element analysis.

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## I. Introduction

A beam may be considered as one of the most commonly used structural elements in engineering applications. A beam is said to be a deep beam when the depth is comparable to its span. Design of deep beams based on classical Euler bending theory can be seriously erroneous, since the simple theory of flexure takes no account of the effect of normal pressures on the top and bottom edges of the beam caused by the loads and reactions (Chow, Conway and Winter, 1952). The effect of normal pressures on the stress distribution in deep beams is such that the distribution of bending stresses on vertical sections is not linear and the distribution of shear stresses is not parabolic. Consequently, a plane transverse section does not remain plane after bending, and the neutral axis does not lie at the mid-depth, which eventually causes the basis of classical theory to be violated.

In an attempt to make up the limitation, different theories as well as methods of solution have been reported in the literature (Conway, Chow and Morgan, 1951; Conway and Ithaca, 1953; Murty, 1984; Suzuki, 1986).

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However, each solution possesses certain limitations, and eventually none of the solutions are found to conform to all the physical characteristics of the problem for deep beam appropriately. Even, photoelastic studies (Uddin, 1966), finite element analysis (Hardy and Pipelzadeh, 1991) and finite difference solutions (Ahmed, Idris and Uddin, 1966; Ahmed, Khan and Uddin, 1998; Ahmed, Idris and Uddin, 1999; Ahmed, Hossain and Uddin 2005; Akanda, Ahmed and Uddin, 2002) have also been carried out for deep beams on two supports, mainly because all the physical conditions imposed on the beam could not be fully taken into account in the analytical methods of solution. Among the existing mathematical models of elasticity for the plane boundary-value problems, the stress function approach and the displacement formulation are noticeable. The stress function approach accepts boundary conditions in terms of loading only; boundary restraints cannot be satisfactorily imposed on it. On the other hand, the displacement formulation involves extreme difficulty especially when the boundary conditions are a mixture of restraints and stresses. As a consequence, serious attempts had hardly been made in the past for stress analysis using this formulation. As such, neither of the existing formulations is suitable for solving problems of mixed boundary conditions.

Further, the use of standard structures, like beams, columns, etc. with guides on part or full of their bounding surfaces is receiving increased importance in order to satisfy precise and strict design criteria in many of the engineering applications. Guided boundaries usually help in reducing the level of deformation in the structural elements, which eventually resist the change of the original shape of the bounding surfaces under loading. But structures with guided boundaries always remain away from the scope of analytical solutions, because the physical conditions of guided boundaries need to be mathematically modelled in terms of a mixed mode of boundary conditions.

Since the exact analytical solution of mixed-boundary-value elastic problems, is beyond the scope of existing mathematical models of elasticity, the use of a new mathematical formulation will be investigated to analyze the elastic behavior of a guided deep beam under three point bending loading and support arrangements. It would be worth mentioning that, as far as the reporting in the literature is concerned, the author has not come across any reliable study of the present problem. Therefore, the analytical solution for a guided deep beam under three point bending is yet to be developed.

## II. Boundary Conditions

The physical conditions at different boundaries of the beam are expressed mathematically as follows:

- $u_x = 0$ at the edge of $x = 0$
- $u_x = 0$ at the edge of $x = L$
- $\sigma_{xy}(0,y) = 0$ at the edge of $x = 0$
- $\sigma_{xy}(L,y) = 0$ at the edge of $x = L$
- $\sigma_{xy}(0,y) = 0$ at the edge of $y = 0$
- $\sigma_{xy}(0,y) = 0$ at the edge of $y = D$
- The lateral stress at the edge of $y = D$ is related to the applied load for the three point bending. Since the point load is actually acting over a certain area of the beam, for instance it can be considered for the length of x=0.45L to 0.55L. Again it is considered that the load intensity is $\sigma_o$. Therefore, the magnitude of point load, P= $0.1L\sigma_o$. Then for x=0.45L to 0.55L
- Similarly, the lateral stress at the edge of $y = 0$ is related to the reactions at the support. In this case $\sigma_{yy}(x,0) = \sigma_o/2$ for x=0 to 0.1L and 0.9L to L.

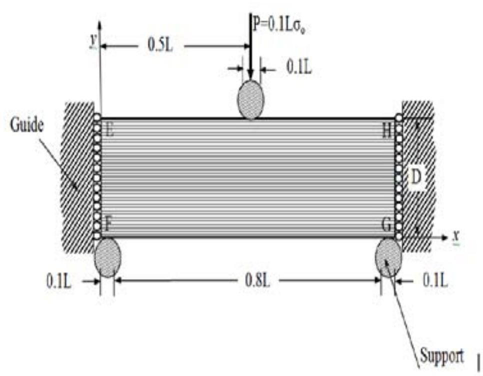


*Fig. 1 :* Geometry and loading (symmetric)of the guided simply supported beam under three point bending

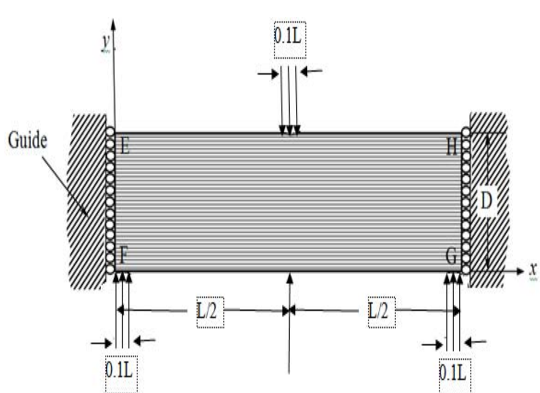


*Fig. 2 :* Analytical model of the guided beam

## III. Analytical Solution

The equation of equilibrium for isotropic material is as follows (Timoshenko and Goodier, 1970):

$$\frac{\partial^4\psi}{\partial x^4} + 2\frac{\partial^4\psi}{\partial x^2\partial y^2} + \frac{\partial^4\psi}{\partial y^4} = 0 \qquad (1)$$

The expressions of displacement and stress components in terms of function $\psi(x, y)$ are as follows (Nath, Ahmed and Afsar, 2006):

$$u_x(x,y) = \frac{\partial^2\psi}{\partial x\partial y} \qquad (2a)$$

$$u_y(x,y) = -\frac{1}{1+\mu}\left[2\frac{\partial^2\psi}{\partial x^2} + (1-\mu)\frac{\partial^2\psi}{\partial y^2}\right] \qquad (2b)$$

$$\sigma_{xx}(x,y) = -\frac{E}{(1+\mu)^2}\left[\frac{\partial^3\psi}{\partial x^2\partial y} - \mu\frac{\partial^2\psi}{\partial y^2}\right] \qquad (2c)$$

$$\sigma_{yy}(x,y) = -\frac{E}{(1+\mu)^2}\left[(2+\mu)\frac{\partial^3\psi}{\partial x^2\partial y} + \frac{\partial^3\psi}{\partial y^3}\right] \qquad (2d)$$

$$\sigma_{xy}(x,y) = -\frac{E}{(1+\mu)^2}\left[\frac{\partial^3\psi}{\partial x^3} - \mu\frac{\partial^3\psi}{\partial x\partial y^2}\right] \qquad (2e)$$

The potential function $\psi$(x, y) is first assumed in a way so that the physical conditions of the two opposing guided ends are automatically satisfied. At the same time solution has to satisfy the 4th order partial differential equation. After a long trial and error process, the solution of the governing equation (1) is thus approximated as follows:

$$\psi(x, y) = \sum_{m=1}^{\infty} Y_m(y)\cos\alpha x + K\,y^3 \qquad (3)$$

where, $Y_m = f(y)$, $\alpha = (m\pi/L)$, K is an arbitrary constant and m= 1, 2, 3, ……..$\infty$.

Derivatives of equation (3) with respect to $x$ and $y$ are substituted in Eq. (1) and following equation is obtained:

$$Y_m^{////} - 2\alpha^2 Y_m^{//} + \alpha^4 Y_m = 0 \qquad (4)$$

The solution of the above 4th order ordinary differential equation with constant coefficients [Eq. (4)] can normally be approximated as follows:

$$Y_m = A_m e^{r_1 y} + B_m y e^{r_2 y} + C_m e^{r_3 y} + D_m y e^{r_4 y} \qquad (5)$$

But the ordinary differential equation (4) has the complementary function of repeated roots. Thus $r_1 = r_2 = \alpha$, $r_3 = r_4 = -\alpha$ and the general solution of Eq. (4) can be written as:

$$Y_m = (A_m + B_m y)e^{\alpha y} + (C_m + D_m y)e^{-\alpha y} \qquad (6)$$

where $A_m$, $B_m$, $C_m$ and $D_m$ are arbitrary constants.

Now substituting the derivatives of $\psi$ and $Y_m$ in the expressions for displacement and stresses following expressions are found:

$$u_x(x,y)=\frac{\partial^2\psi}{\partial x\partial y}=-\sum_{m=1}^{\infty}\left[A_m\alpha e^{\alpha y}+B_m(\alpha y+1)e^{\alpha y}-C_m\alpha e^{-\alpha y}-D_m(\alpha y-1)e^{-\alpha y}\right]\alpha\sin\alpha x \tag{7a}$$

$$u_y(x,y)=-\frac{1}{(1+\mu)}\left[2\frac{\partial^2\psi}{\partial x^2}+(1-\mu)\frac{\partial^2\psi}{\partial y^2}\right]$$

$$=\frac{-1}{(1+\mu)}\left[\sum_{m=1}^{\infty}\left\{\begin{aligned}&-A_m(1+\mu)\alpha^2e^{\alpha y}+\\&B_m(-\alpha y-\mu\alpha y-2\mu+2)\alpha e^{\alpha y}\\&-C_m(1+\mu)\alpha^2e^{-\alpha y}+\\&D_m(-\alpha y-\mu\alpha y+2\mu-2)\alpha e^{-\alpha y}\end{aligned}\right\}\cos\alpha x+6K(1-\mu)y\right] \tag{7b}$$

$$\sigma_{xx}(x,y)=\frac{E}{(1+\mu)^2}\left[\frac{\partial^3\psi}{\partial x^2\partial y}-\mu\frac{\partial^3\psi}{\partial y^3}\right]$$

$$=\frac{-E}{(1+\mu)^2}\left[\sum_{m=1}^{\infty}\left\{\begin{aligned}&A_m\alpha(1+\mu)e^{\alpha y}+B_m(\alpha y+\mu\alpha y+3\mu+1)e^{\alpha y}\\&-C_m\alpha(1+\mu)e^{-\alpha y}+D_m(-\alpha y-\mu\alpha y+3\mu+1)e^{-\alpha y}\end{aligned}\right\}\alpha^2\cos\alpha x+6\mu K\right] \tag{7c}$$

$$\sigma_{yy}(x,y)=\frac{-E}{(1+\mu)^2}\left[(2+\mu)\frac{\partial^3\psi}{\partial x^2\partial y}+\frac{\partial^3\psi}{\partial y^3}\right]$$

$$=\frac{-E}{(1+\mu)^2}\left[\sum_{m=1}^{\infty}\left\{\begin{aligned}&A_m\alpha(-1-\mu)e^{\alpha y}+B_m(-\alpha y-\mu\alpha y-\mu+1)e^{\alpha y}+\\&C_m\alpha(1+\mu)e^{-\alpha y}+D_m(\alpha y+\mu\alpha y-\mu+1)e^{-\alpha y}\end{aligned}\right\}\alpha^2\cos\alpha x+6K\right] \tag{7d}$$

$$\sigma_{xy}(x,y)=\frac{-E}{(1+\mu)^2}\left[\frac{\partial^3\psi}{\partial x^3}-\mu\frac{\partial^3\psi}{\partial x\partial y^2}\right]$$

$$=\frac{-E}{(1+\mu)^2}\left[\sum_{m=1}^{\infty}\left\{\begin{aligned}&A_m(1+\mu)\alpha e^{\alpha y}+B_m(\alpha y+\mu\alpha y+2\mu)e^{\alpha y}\\&+C_m(1+\mu)\alpha e^{-\alpha y}+D_m(\alpha y+\mu\alpha y-2\mu)e^{-\alpha y}\end{aligned}\right\}\alpha^2\sin\alpha x\right] \tag{7e}$$

Now, the reactions on the bottom boundary (y = 0) are acting over the two supports. It is considered that the supports are located at x=0 to 0.1L and x=0.9L to L respectively. The total length for reaction is 20 percent of beam length. Now the compressive load exerted at the mid-span on the edge $y=D$ of the beam may be considered as acting over at least some length of the beam, for instance x= 0.45L to 0.55L. As a result the intensity of reaction is half of the load intensity. Therefore, the reactions over the beam at the supports can be taken as Fourier series in the following manner:

$$\sigma_{yy}(x,D)=\sigma_0=I_0+\sum_{m=1}^{\infty}I_m\cos\alpha x$$ For x= 0.45L to 0.55L

Here

$$I_0=\frac{1}{L}\left[\int_{9L/20}^{11L/20}\sigma_0\,dx\right]=\frac{\sigma_0}{10} \tag{8a}$$

$$I_m=\frac{2}{L}\left[\int_{9L/20}^{11L/20}\sigma_0\cos\alpha x\,dx\right]$$

$$=\frac{2\sigma_0}{\alpha L}\left\{\sin\left(\frac{11\alpha L}{20}\right)-\sin\left(\frac{9\alpha L}{20}\right)\right\}$$

$$=\frac{2\sigma_0}{m\pi}\left\{\sin\left(\frac{11m\pi}{20}\right)-\sin\left(\frac{9m\pi}{20}\right)\right\} \tag{8b}$$

The reaction load at the support on the edge $y=0$ can also be given by a Fourier series as follows:

$$\sigma_{yy}(x,0)=\sigma_0/2=E_0+\sum_{m=1}^{\infty}E_m\cos\alpha x$$ For x=0 to 0.1L and 0.9L to L

Here

$$E_0=\frac{1}{L}\left[\int_0^{L/10}\sigma_0/2dx+\int_{9L/10}^{L}\sigma_0/2dx\right]=\frac{\sigma_0}{10} \tag{9a}$$

$$E_m = \frac{2}{L}\left[\int_0^{L/10} \frac{\sigma_0}{2}\cos\alpha x dx + \int_{9L/10}^{L} \frac{\sigma_0}{2}\cos\alpha x dx\right]$$

$$= \frac{\sigma_0}{\alpha L}\left\{\sin\left(\frac{\alpha L}{10}\right) - 0 + \sin(\alpha L) - \sin\left(\frac{9\alpha L}{10}\right)\right\}$$

$$= \frac{\sigma_0}{m\pi}\left\{\sin\left(\frac{m\pi}{10}\right) + \sin(m\pi) - \sin\left(\frac{9m\pi}{10}\right)\right\} \quad (9b)$$

The loading considerations of equations (8a) and (9a) are to satisfy the boundary conditions at the bottom and top boundaries of the beam. Using boundary condition $\sigma_{xy}(x,0) = 0$ at the edge of $y = 0$, it is found that:

$$\frac{-E\alpha^2}{(1+\mu)^2}\left[(1+\mu)\alpha A_m + 2\mu B_m + (1+\mu)\alpha C_m - 2\mu D_m\right] = 0 \quad (10)$$

Using boundary condition $\sigma_{xy}(x,D) = 0$ at the edge of $y = D$

$$\frac{-E\alpha^2}{(1+\mu)^2}\left[\begin{array}{l} A_m(1+\mu)\alpha e^{\alpha D} + B_m(\alpha D + \mu\alpha D + 2\mu)e^{\alpha D} + \\ C_m(1+\mu)\alpha e^{-\alpha D} + D_m(\alpha D + \mu\alpha D - 2\mu)e^{-\alpha D} \end{array}\right] = 0 \quad (11)$$

Using boundary condition $\sigma_{yy}(x,0) = \sigma_0/2$ at the edge of $y = 0$

$$\frac{-E}{(1+\mu)^2}\left[\begin{array}{l} -(2+\mu)\sum_{m=1}^{\infty}\{(A_m\alpha + B_m) + (-C_m\alpha + D_m)\}\alpha^2\cos\alpha x \\ +\sum_{m=1}^{\infty}\left\{\begin{array}{l}(A_m\alpha^3 + 3B_m\alpha^2) + \\ (-C_m\alpha^3 + 3D_m\alpha^2)\end{array}\right\}\cos\alpha x + 6K \end{array}\right] = \sum_{m=1}^{\infty} E_m\cos\alpha x + E_o \quad (12)$$

Therefore,

$$\frac{E\alpha^2}{(1+\mu)^2}\left[A_m(1+\mu)\alpha + B_m(-1+\mu) - C_m(1+\mu)\alpha + D_m(-1+\mu)\right] = E_m \quad (13)$$

Using boundary condition $\sigma_{yy}(x,D) = \sigma_0$ at the edge of $y = D$

$$\frac{-E}{(1+\mu)^2}\left[\begin{array}{l} -(2+\mu)\sum_{m=1}^{\infty}\left\{\begin{array}{l}(A_m\alpha + B_m\alpha D + B_m)e^{\alpha D} + \\ (-C_m\alpha - D_m\alpha D + D_m)e^{-\alpha D}\end{array}\right\}\alpha^2\cos\alpha x \\ +\sum_{m=1}^{\infty}\left\{\begin{array}{l}(A_m\alpha^3 + B_m\alpha^3 D + 3B_m\alpha^2)e^{\alpha D} + \\ (-C_m\alpha^3 - D_m\alpha^3 D + 3D_m\alpha^2)e^{-\alpha D}\end{array}\right\}\cos\alpha x + 6K \end{array}\right] = \sum_{m=1}^{\infty} I_m\cos\alpha x + I_o \quad \text{or,}$$

$$\frac{E\alpha^2}{(1+\mu)^2}\left[\begin{array}{l} A_m(1+\mu)\alpha e^{\alpha D} + B_m(\mu\alpha D + \alpha D + \mu - 1)e^{\alpha D} - \\ C_m(1+\mu)\alpha e^{-\alpha D} - D_m(\mu\alpha D + \alpha D - \mu + 1)e^{-\alpha D} \end{array}\right] = I_m \quad (14)$$

and using Eq. (9a) and Eq. (12) the arbitrary constant K can be obtained as follows:

$$\frac{-E}{(1+\mu)^2}6K = E_0 = \frac{\sigma_0}{10}$$

$$\text{or, } K = \frac{-\sigma_0(1+\mu)^2}{60E} \quad (15)$$

The simultaneous equations (10), (11), (13) and (14) can be realized in a simplified matrix form for the solution of unknown terms like $A_m$, $B_m$, $C_m$ and $D_m$ as follows:

$$\begin{bmatrix} DD_1 & DD_2 & DD_3 & DD_4 \\ FF_1 & FF_2 & FF_3 & FF_4 \\ HH_1 & HH_2 & HH_3 & HH_4 \\ KK_1 & KK_2 & KK_3 & KK_4 \end{bmatrix}\begin{bmatrix} A_m \\ B_m \\ C_m \\ D_m \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ E_m \\ I_m \end{bmatrix} \quad (16)$$

where

$$DD_1 = Z_{11}(1+\mu)\alpha$$

$$DD_2 = 2\mu Z_{11}$$

$$DD_3 = Z_{11}(1+\mu)\alpha$$

$$DD_4 = -2\mu Z_{11}, \; FF_1 = Z_{11}(1+\mu)\alpha e^{\alpha D}$$

$$FF_2 = Z_{11}\{(1+\mu)\alpha D + 2\mu\}e^{\alpha D}$$

$$FF_3 = Z_{11}(1+\mu)\alpha e^{-\alpha D}$$

$$FF_4 = Z_{11}\{(1+\mu)\alpha D - 2\mu\}e^{-\alpha D}$$

$$HH_1 = -Z_{11}(1+\mu)\alpha$$

$$HH_2 = -Z_{11}(-1+\mu)$$

$$HH_3 = Z_{11}(1+\mu)\alpha$$

$$HH_4 = -Z_{11}(-1+\mu)$$

$$KK_1 = -Z_{11}(1+\mu)\alpha e^{\alpha D}$$

$$KK_2 = -Z_{11}\{(1+\mu)\alpha D+\mu-1\}e^{\alpha D}$$

$$KK_3 = Z_{11}(1+\mu)\alpha e^{-\alpha D}$$

$$KK_4 = Z_{11}\{(1+\mu)\alpha D-\mu+1\}e^{-\alpha D}$$

$$Z_{11} = \frac{-E\alpha^2}{(1+\mu)^2}$$

Therefore, stress and displacement components at various points of the beam can be obtained using equations of (7).

## IV. Result Analysis

The analytical solutions of displacement and stress components are obtained for various aspect ratios (L/D) of the beam. The material of the beam is mild steel whose modulus of elasticity is E=209 X 10^9 and poison's ratio μ=0.3. The result of a guided isotropic beam having aspect ratio two and the uniform loading parameter $\sigma_0$ = 40 N/mm is presented in sequence of axial displacement ($u_x$), lateral displacement ($u_y$), bending stress ($\sigma_{xx}$), normal stress ($\sigma_{yy}$) and shearing stress ($\sigma_{xy}$).

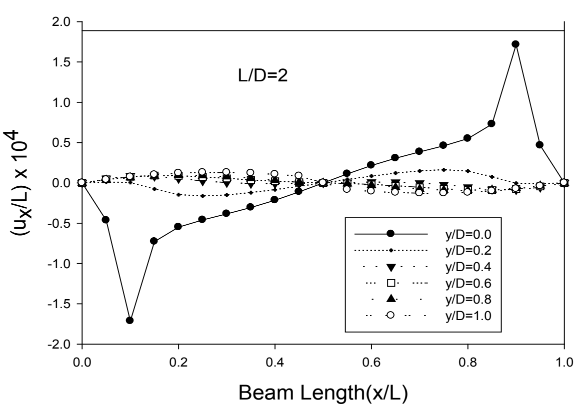


*Fig. 3(a) :* Axial Displacement along beam length

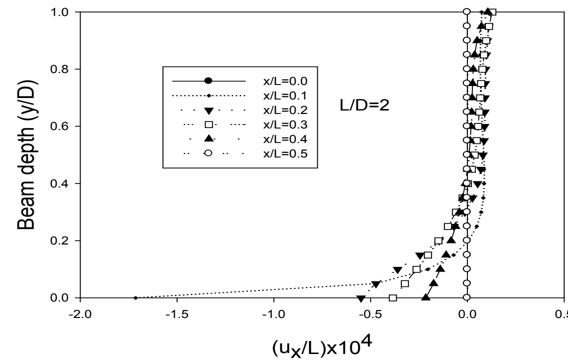


*Fig. 3(b) :* Axial Displacement along beam depth

Axial displacements ($u_x$) are found to be zero at the mid-section of span and at the lateral guided boundaries. Zero value of $u_x$ at the guided ends verifies the boundary condition of those edges of the beam. Axial displacements distribution is found skew-symmetric about the mid-span of the beam. The values of $u_x$ for sections 0<x/L< 0.5 are negative at the lower portion and positive at upper portion of the beam. The maximum magnitudes of $u_x$/L= ±0.000158 are observed on bottom fiber at the sections of x/L = 0.1 and x/L = 0.9 respectively.

Lateral displacements ($u_y$) are found to take positive value near the two guided lateral ends and negative in the region 0.25<x/L< 0.75 for L/D=2 The $u_y$ results are in confirmation to the physical condition of the beam. The beam is being pushed up at the corners and forced down at the mid-span region. The normalized values of positive and negative maximum lateral displacements are $u_y$/D= 0.000250 and $u_y$/D= - 0.000426 respectively for L/D=2. The maximum magnitude is observed on the topmost fiber at the mid-span.

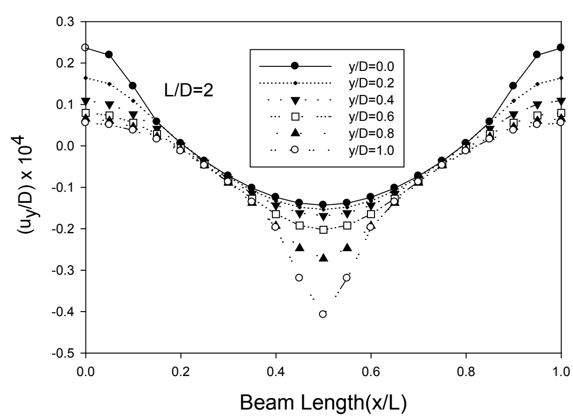


*Fig. 4(a) :* Lateral displacement along beam length

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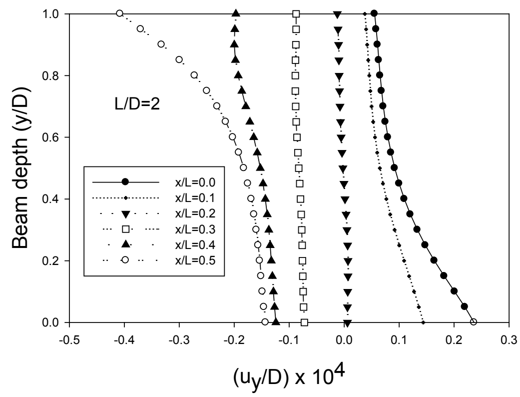


*Fig. 4(b) :* Lateral displacement along beam depth

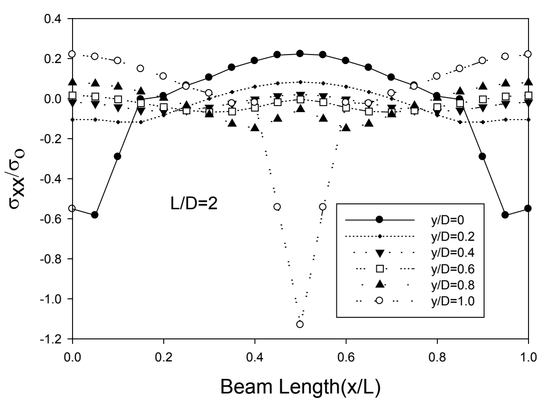


*Fig. 5(a) :* Bending stress along beam length

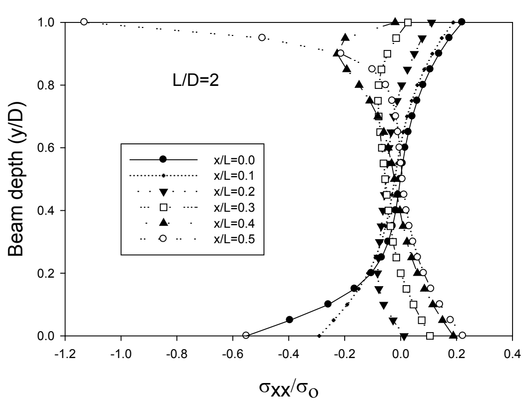


*Fig. 5 (b) :* Bending stress along beam depth

Bending stress distribution is observed non-linear over the whole span. The stress ($\sigma_{xx}$) maximizes at the mid-span at top fiber of the beam where the point type load is acting. The next locations of bending stress concentration are the two bottom corners and the bottom fiber at mid-span of the beam. The maximum magnitude of normalized bending stress on the top fiber at mid-span is a 1.19.

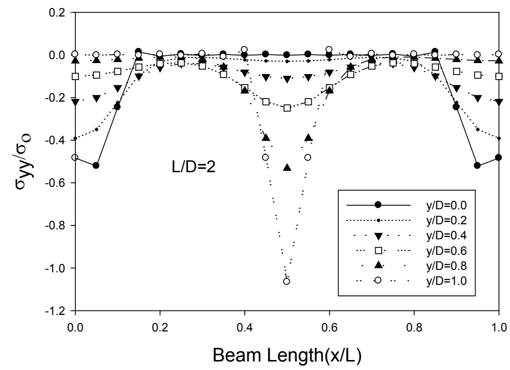


*Fig. 6(a) :* Lateral stress at beam length

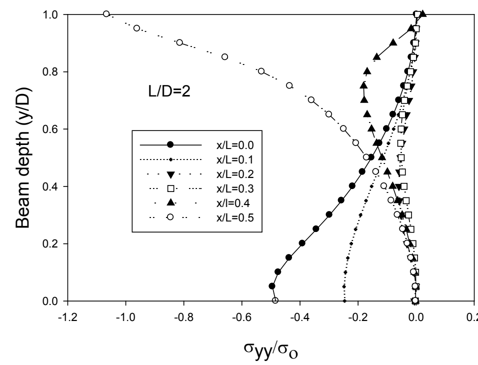


*Fig. 6(b) :* Lateral stress at beam depth

Lateral stress ($\sigma_{yy}$) concentrations are observed at the topmost fiber of mid-span section and bottom two corners. It is understandable that each reaction is half of the load along beam length and the normalized value of the lateral stress varies from zero to about unity at the topmost layer in the loaded region and it is almost half at the bottom layer of the support region along beam depth, which confirms the physical condition of the problem.

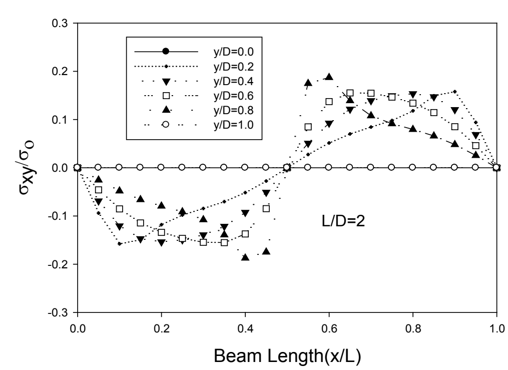


*Fig. 7(a) :* Shear stress along beam length

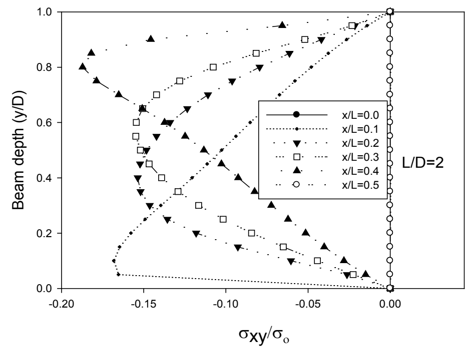


*Fig. 7(b) :* Shear stress along beam depth

All four edges and mid-span section of the guided simply supported beam are found free from shearing stress. The distribution of shearing stress ($\sigma_{xy}$) for point loading is anti-symmetric in two sides about the mid-span of the beam. The maximum concentration of shearing stress is observed near the bottom corners at the supports and is at the top edge where the termination of loading takes place. The normalized maximum magnitude of shear stress is ±0.2 for L/D= 2. Shear stress distribution at transverse section is nearly parabolic. Along beam depth maximum shear occurs at x/L=0.2 and normalized value of this shear stress is -0.18.Shear stress is zero at x/L=0.4.

As the aspect ratio increases, the magnitude of both axial and lateral displacement increases. The sharp changes in the curve become gradually smoother for higher aspect ratios.

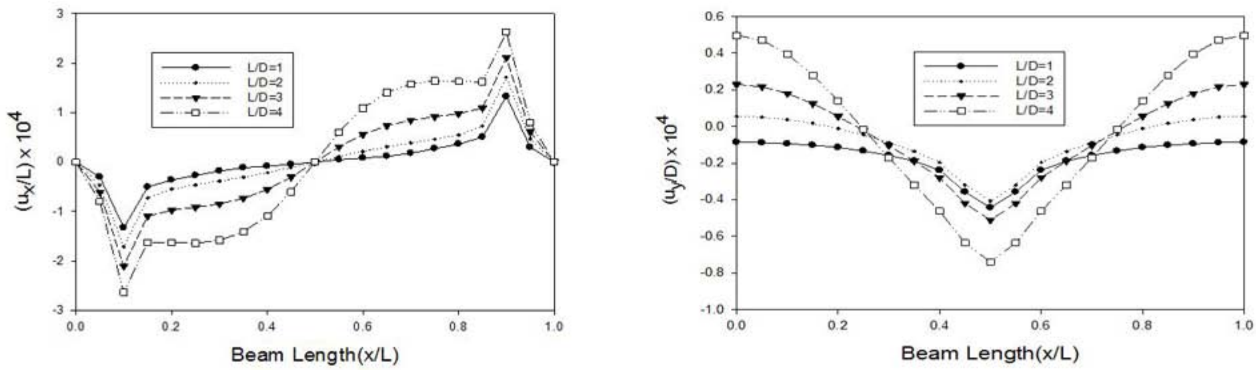


*Fig. 8 :* Comparison of axial and lateral displacement

## V. Verification

Finite element analysis has also been carried out to verify the stress component of the beam. It can be observed that the stresses found out by the analytical solution, is in complete harmony to that of the finite element analysis. Hence the validity of the displacement potential formulation is justified.

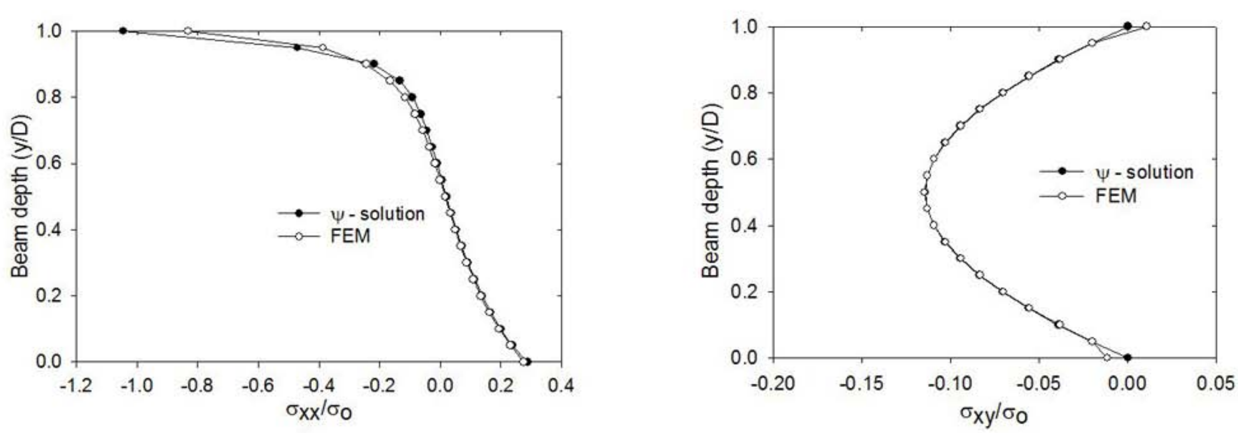


*Fig. 9 :* Verification of displacement potential formulation by finite element method

## VI. Conclusion

Analytical solution using displacement potential approach for the elastic fields of a guided simply supported beam of isotropic material under three point bending is explored satisfying all the physical conditions of the beam appropriately. The specialty of the guided ends is the mixed mode of boundary conditions.

Basically, the guided ends provide the freedom of lateral displacement but not the axial one. At this scenario the necessity of imposing boundary restraints is essential. But it is not practicable to use the classical Bernoulli-Euler beam theory for the solution of guided beam. Because, it cannot handle mixed mode of boundary conditions. Displacement potential formulation can handle mixed mode of boundary condition appropriately and we have found the solution of the beam.

It is observed from the solution of the beam that

a) Axial displacement is maximum at bottom fiber i.e. y/D=0.0.As the aspect ratio increases axial displacement also increases.
b) Lateral displacement is maximum at top fiber i.e. y/D=1.0. As the aspect ratio increases lateral displacement also increases. So if failure occurs it will occur at midsection of the beam i.e. where deflection is maximum.
c) Maximum stress concentration occurs at midsection of the beam .So in terms of stress, midsection is more vulnerable to failure for a simply supported beam.

These findings will have applications in aircraft, spacecraft and vehicle structures for predicting appropriate stress distribution in them, thus allowing designers to design with greater safety.

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# Investigation of some Technical Properties of Recycled Materials

By Rajesh Kumar Jain
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*Abstract-* The use of aggregates with different grades could have significant influence on workability and strength of concrete. A lower percentage of AIV indicates tougher and stronger aggregates. RA density is slightly lower than that of NA, probably because of the presence of impurities and old cement paste. Water absorption in RA ranges from 3-12% for coarse and fine fractions; this value is much higher than that of the natural aggregate for which the absorption is about 0.5- 1.0%. The substitution of PFA and RGD to partially replace cement improves and maintains, and at the very least did not adversely influence, the workability of RAC-SCC. Compressive strengths of RAC achieved higher strength with age reaching after 90 days. NAC and RAC concrete mixes with 30% PFA as a substitute for the cement exhibited substantial increase of strength at later, tensile and flexural strengths at 28 days of NAC-SCC-0.9SP (Mix 3) were relatively enhanced. The increased strengths were most likely due to the enhanced matrix of the concrete. The lower w/c ratio's influence clearly appeared in SCC without cement substitution; the compressive of strengths, particularly the tensile strength, was observed when 30% of the cement was replaced by PFA compared to all other mixes, the 90 day compressive strengths were less than the target mean strength. Bleeding due to use of RA is generally similar to that of natural aggregates. An internal friction angle (φ) of 48.8˚ and an apparent cohesion (c) of 41.1 kPa were corresponded to the Mohr Coulomb failure envelope of crushed brick sample sourced from site 1. Similarly, an internal friction angle (φ ) of 44.6˚ and a n apparent cohesion (c) of 65.5 kPa were corresponded to the crushed brick sample sourced from site 2.

*Keywords: RA, NA, PFA, SCC, unit weight, workability, slump, strengths.*

*GJRE-J Classification : FOR Code: 090599*

INVESTIGATIONOFSOMETECHNICALPROPERTIESOFRECYCLEDMATERIALS

*Strictly as per the compliance and regulations of:*

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*Keywords: RA, NA, PFA, SCC, unit weight, workability, slump, strengths.*

## I. Introduction

Infrastructure scenario of India showed that total investment has been double in 2011-12 vis-à-vis 2007-08,projected to cross 500,000Cr.In 2009-10, Govt. to spend Rs. 60000Cr only for up gradation of roads and private sector investment in roads to cross 35% by 2011-12 , while India has second largest road network (3.3 million km) in world and the Highway Network density is 0.66 km/sq.km of land .It accounts for 90% passenger traffic and 65% of total fright (~960 million tons/km-yr).The Eleventh Five Year Plan has a special focus on Rural Infrastructure Development[1].

The global production of cement is estimated at 2.7 billion tonnes in 2007 and should reach 3.4 billion tonnes and 3.5 billion tonnes by 2010 and 2012 respectively; demand is expected to grow by 4.7% annually[2,3]. Greater dependency on fossil fuel such as coal for electricity generation due to the current global economical crisis could result in more production of fly ash. The need to manage construction and demolition waste (CDW) has led to environment friendly actions that promote the reuse and recycling of this type of waste and other forms of waste valorization.

Recycled aggregates are those resulting from the processing of materials previously used in construction [4]. However, despite the enhanced quality of the recycled aggregates, the uptake of this alternative is still in fact too low[5,4]). The level of impurities is usually medium to high and can significantly affect the strength and performance when recycled in concrete. The limitation and provisions set in standards such as BS 8500-2: 2002 [6,7] split the available recycled material into four main categories.

The construction industry uses more materials by weight than any other industry[8]. A number of recycled materials are known to provide performance benefits, e.g. ground granulated blast furnace slag (GGBS) and pulverized fuel ash (PFA) as recycled cement replacement materials. The world production was $0.5 \times 10^{12}$ t in 1989[9], it reached $0.6 \times 10^{9}$ t in 2000[10]. In particular PFA improves workability, hinders segregation and alleviates bleeding, lowers heat of hydration and the risk of thermal cracks. Increases long-term strength, reduces permeability ,enhances the concrete stability to resist chemical attack and reduces harmful aggregate-silica reaction. Extends setting time and provides longer time for handling and casting of concrete. Due to these merits, PFA is increasingly considered in all sectors of the concrete industry. Red granite dust (RGD) is the fine powder produced from the rock faces when rocks are cut and crushed to produce coarse aggregate. A number of research papers on recycled self compacting concrete are there [11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29].

## II. Objectives

For more than one reason, the concrete community need to appreciate that projects should go in harmony with the concept of sustainable development. The use of recycled aggregates in construction, to the maximum possible limit. The use of PFA to produce natural aggregate concrete (NAC), particularly high strength concrete (HSC). To examine

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the potential of producing RAC concretes made with SP, PFA, and RGD in both conventional and self-compacting concrete (SCC).

## III. Material and Method

Kiyoshi (2007)[30] suggested a new production method for recycling aggregate for concrete. BS 8500-2: 2002[6] provides a basis for the use of RA in concrete. To obtain good quality materials from recycling sites, many researchers [31,32,33,34] suggested that contaminants should be removed before crushing. As per BS 8500-2:2002[6], limits were imposed on recycled aggregate composition. Recycled washed aggregate of 20 mm size that required no extra processing will be used as it was supplied from the recycling plant. This aggregate had been processed (crushed and screened) at Recycling Plant. The impurities were not removed from the RA so that their effects on the characteristics of the produced RAC are included; this is to simulate the case of real conditions when RA is used to make RAC in site.

RA was obtained by processing natural concrete produced in the laboratory by jaw crusher and used to replace the crushed black basalt stone in RAC mixes. RA replaced NA at levels of 25, 50, 75 and 100%. Natural concrete fine aggregate of medium grading was used throughout all the experimental work. PFA that complies with BS EN 450- Parts 1 and 2: 2005 [35,36] will be used as a mineral admixture. Crushed granite NA of 20 mm size which was proven to produce excellent NAC, and will be applied in this investigation. Granite is an extremely durable aggregate with high strength and superior quality. NAC will be used as control mixes. A general rule for the quality of water in concrete is that if it is fit for human consumption it can be used for concrete.

## IV. Material Testing

### *a) Testing of Aggregates*

To obtain representative samples, aggregates were riffled in compliance with BS 812: Part 102: 1989 “Method of Sampling”, the sample is split into two equal portions to decrease the size to a practical amount while ensuring the sample is representative. The selected aggregate samples were then tested for grading, impact, relative density, water absorption, and porosity. The estimation of impurities in the recycled aggregate will also be given. The description of each test, the apparatus used, and the procedure are according to standards. For instance BS 882 for particle size distribution sieve analyses, BS 812 Part 2[37] for particle density and water absorption, BS 812 Part 112[38] for aggregate impact value, etc.

### *b) Grading of coarse aggregates*

Sieve analysis was carried out on all coarse and fine concrete aggregates before their use in the experimental work. The sieve analysis is used to find the amount of different size aggregate in a particular sample; it is carried out by putting the sample through a series of sieves that get progressively smaller. For control purposes all samples of aggregates were air dried for equal periods of time before testing. Suitable stacks of sieves were used for each analysis in accordance with BS 812: Part 103: 1989[39] and BS 410: 1986[40].

### *c) Grading of fine aggregates*

Natural fine concrete aggregate was used throughout the investigation. The grading limits according to BS 882-1983[41] for fine aggregates.

### *d) Aggregate impact value*

The aggregate impact value (AIV) is used to establish the material's ability to resist impact and assess the extent of particle crushing thereafter. The impact value is calculated by recording the fractions passing and retained in a 2.36 mm sieve after the material has received 15 blows from a standard weight. This is expressed as a percentage of the total weight. This test is carried out to measure the resistance of a particular aggregate to sudden shock or impact. AIV in accordance with BS 812-112:1990 [38] were determined in a dry condition for all aggregates.

### *e) Unit weight of aggregates*

Aggregates were tested under saturated surface dry conditions (SSD) in accordance with BS 812: Part 2: 1995 [37] to measure the unit weight.

### *f) Testing cement, PFA, and RGD*

As cement, PFA, and RGD powder are very fine materials having low solubility in water at 20°C, wet sieve analysis is usually carried out for their gradation. Representative samples dried in an oven at 115 ± 5°C were used to undertake wet sieve analysis to BS 1377:1990[42]. The Vicat method has been based on shearing cement paste with a needle and on the idea that stiffening during the set induces a gradual increase in resistance to shearing. Although the Vicat test's application was generalised in the 19th century, the test remains today the most widely used test by cement manufacturers and is the subject of multiple standards (BS EN 196: Part 3: 2005; NF EN 196-3; ASTM C191-93; AASHTO T 131).[43,44,45,46,47]. Slump and Vebe time were measured every 30 minutes over a period of 90 minutes in accordance with BS EN 12350-1: 2000 and BS EN 12350-2: 2000.[48,49] Spreading diameter of the initial slumps was also measured.

### *g) Water cement ratio*

It is well known that the major factor controlling the strength of concrete is the water-cement ratio (w/c) or more precisely water to binder ratio (w/b). For a concrete to pass as a self-compacting concrete, it must satisfy certain requirements set out in BS EN 206-9[50]: Additional Rules for self-compacting concrete (SCC); testing methods and standards are covered in BS EN 12359[51].

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## V. Result and Discussion

Recycled aggregates are composed of the original aggregates and the adhered mortar. It is well known that physical properties of recycled aggregates are very much dependent on the type and quality of the adhered mortar. The crushing procedure of the RA and the size of recycled concrete masses have an influence on the amount of adhered mortar[52]. The adhered mortar is a porous material; its porosity depends upon the w/c ratio of the recycled concrete employed[53]. Cracks in the adhered mortar due to crushing can be considered as a source of weakness[54]. However, with a high strength matrix, cracks can be filled with new mortar to appreciably increase the matrix-aggregate bond.

*Table 1 :* Sieve analysis of NA and RA coarse aggregates

| Sieve size (mm) | Percentage by mass passing BS sieves for nominal sizes | | Limits for single-sized aggregate |
|---|---|---|---|
| | N A | R A | |
| 38.0 | 100 | 100 | 100 |
| 21.1 | 90.6 | 89.2 | 87-100 |
| 15.3 | 35 | 41.9 | - |
| 11.2 | 7.2 | 5.1 | 0-25 |
| 5.8 | 0 | 0 | 0-5 |
| 2.36 | 0 | 0 | - |

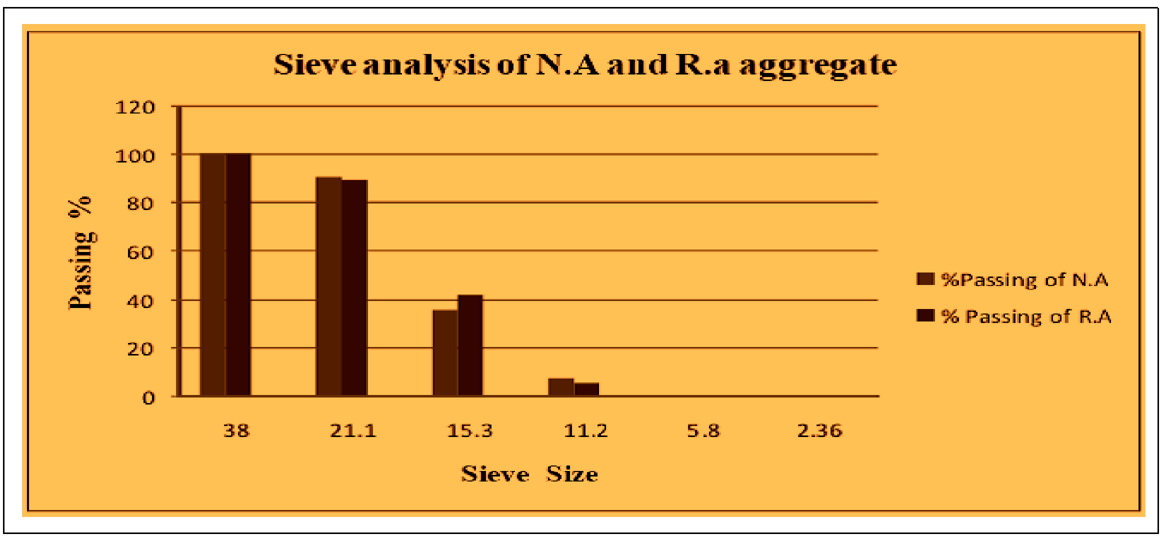


*Figure 1 :* Sieve analysis of N.A and R.A Aggregate

The data presented in Tables 1 & Figure 1, compared with grading limits for coarse aggregate from BS 882-1983[55] indicate that the tested NA and RA had sieve analysis gradings which placed them within the limits for 20 mm aggregates. The same aggregate with almost the same grading will be used; it is well known that the use of aggregates with different grades could have significant influence on workability and strength of concrete, even when the same type of aggregate is used. According to Mehta & Aïtcin (1990)[56] the small particles are less reactive than larger one, but when dispersed in the paste, they generate a large number of nucleation sites for the precipitation of the hydration products of the cementitious paste.

*Table 2 :* Sieve analysis of fine aggregate

| Sieve size | Mass Retained (g) | Mass passing (g) | Retained (%) | Cumulative passing (%) | % Passing (Overall limits from BS 882) |
|---|---|---|---|---|---|
| 10 mm | 0 | 571.11 | 0 | 100 | 100 |
| 5 mm | 12.84 | 546.30 | 4 | 97 | 89-100 |
| 2.36 mm | 90.83 | 460.01 | 18 | 83 | 60-100 |

| | | | | | |
|---|---|---|---|---|---|
| 1.18 mm | 83.44 | 363.42 | 15 | 68 | 30-100 |
| 600 µm | 66.77 | 289.05 | 14 | 55 | 15-100 |
| 300 µm | 95.94 | 196.11 | 19 | 39 | 5-70 |
| 150 µm | 88.04 | 106.70 | 18 | 22 | 0-15 |
| Loss (g) | 0.71 | | | | |
| Loss (%) | 0.12 | | | | |

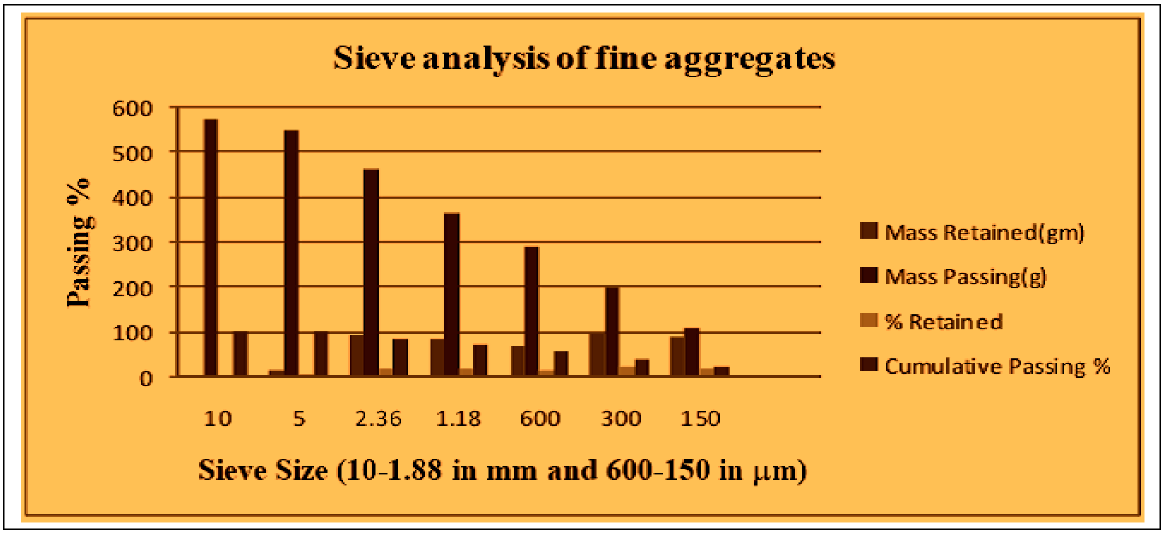


*Figure 2 :* Sieve analysis of fine aggregates

*Table 3 :* Impact value test for NA and RA

| Type of aggregate | NA | RA |
|---|---|---|
| Mass of steel cup | 2615 g | 2592.4 g |
| Mass of cup and aggregate | 3273.42 g | 3412.7 g |
| Mass of aggregate (Mass A) | 638.32 g | 611.1 g |
| Mass passing 2.36 mm (Mass B) | 28.13 g | 67.5g |
| Mass retained | 618.07 g | 549.14 g |
| AIV= (B/A) × 100 | 4.32% | 13.3% |

The AIV is determined as the percentage of the fraction of fines due to impact to the total aggregate; that is (B/A) × 100.

The average impact value of four specimens showed (Table-3) that the AIVs were 4.5 and 12% for NA and RA respectively. Based on the categories given in BS 812: Part 112: 1990[38], the aggregates fall within the suitability limits for concrete which can be used for heavy duty flooring and pavement wearing surfaces. However, good AIV is not the only parameter that guarantees good quality concrete. Table 3 shows that the RA is weaker than NA but this was expected, mainly due to the presence of mortar that adhered to RA particles which resulted in an increased amount of fines obtained under impact. A lower percentage of AIV indicates tougher and stronger aggregates. Results showed that concrete strengths were influenced by aggregate type. Although comparable, the cube strength of all RAC concerts were below similar NAC at all ages, this may be attributed to the superior quality of natural granite aggregate used to create NAC concrete mixes, and to the presence of deleterious materials in RA. For relatively rich RAC concrete mixes; *i.e.* having higher cement content, strength is evidently controlled by the RA, and RAC did not benefit much from the improved strength of the paste matrix; perhaps the strength of aggregate is limiting the ultimate strength.

*Table 4 :* Relative density of coarse NA

| Property | Relative density (RD) | | |
|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 |
| Weight in air (g) | 2024.2 | 2114.6 | 2064.5 |
| Weight in water(g) | 1275.5 | 1320.7 | 1292.2 |
| Volume (cm$^3$) | 748.7 | 793.9 | 772.3 |
| Average RD | 2.704 | 2.664 | 2.673 |

Density of water 1g/cm3

Average RD of NA = 2.91.

*Table 5 :* Relative density of coarse RA

| Property | Relative density (RD) | | |
|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 |
| Weight in air (g) | 2342.3 | 2293.7 | 2371.2 |
| Weight in water(g) | 1390.4 | 1401.2 | 1399.7 |
| Volume (cm3) | 898.6 | 869.7 | 896.8 |
| Average RD | 2.763 | 2.865 | 2.714 |

Average RD of RA = 2.73.

Results showed (Table 4 & 5) that the average unit weights (or densities) were 25.5 kN/m$^3$ (2600 kg/m$^3$) and 24.5 kN/m$^3$ (2500 kg/m$^3$) for NA and RA respectively. As these densities are > 2000 kg/m$^3$, NA and RA were classed as normal weight aggregates. The relative density of a material is the ratio of its unit weight to that of water and it has a major influence on the density of the finished concrete. Most rock types have relative densities within a limited range of approximately 2.55 - 2.75, and therefore all produce concretes with similar densities, normally in the range of 2250 - 2450 kg/m$^3$, depending on the mix proportions [57]. The relative density of fine aggregate and PFA were 2.6 and 2.25 respectively, therefore, the actual amounts of fine aggregate used were 525 kg/m$^3$ and for PFA 175 × 2.25/2.6=151 kg/m$^3$. Relative density is used to determine the equivalent weight of a material to a certain volume; for instance if a coarse aggregate of relative density 2.7 represents 60% by volume of concrete, the equivalent weight should be 2.7 × 60 × 9.81 = 1589 kg/m$^3$ (W = mg = ρvg), where g = 9.81 m/s$^2$ is the acceleration due to gravity. Turcotte (1993)[58] explores the fractal relationship, or its possibility, between particle size and specific gravity. The rounded average specific gravities of the tested aggregates were 2.7 for NA and 2.5 for RA .Results showed that RA density is slightly lower than that of NA, probably because of the presence of impurities and old cement paste. However, when a material is partially substituted for another in a mix, the replacement by weight could result in a greater volume of the material in the mix if the difference between their specific gravities is large; therefore if the density of RA is much lower than NA, mixes should be proportioned to take this difference into account. In this study no partial substitution will be examined and 100% RA will be used. Water absorption values were 6-7% by mass when RA was used at 20% by mass of NA, and 9% when used at 100% of NA (Levy 2004). Water absorptions of 5-10% can generally be found for recycled aggregates, however, relatively low absorption values were found for coarse recycled aggregates[59]. Water absorption in RA ranges from 3-12% for coarse and fine fractions; this value is much higher than that of the natural aggregate for which the absorption is about 0.5-1.0% [60].

*a) Recycled self-compacting concrete*

If self-compacting recycled aggregate concrete (RAC-SCC) is shown to achieve similar properties as its counterpart natural aggregate concrete (NAC-SCC) then it can be a viable alternative for the concrete industry.

*b) Recycled SCC Production*

A standard concrete mix, which will be considered as a reference mix, was designed to achieve 50 N/mm$^2$ at 28 days with a high slump of 60-180 mm and Vebe time of 0 - 3 s in accordance with the Building Research Establishment mix design method (BRE 1992)[61]. Mix proportions are shown in Table 6 and 7.

*Table 6 :* Mix proportions of standard mixes for SCC (control mixes)

| Material | Mass used (kg/m$^3$) | |
|---|---|---|
| | NA | RA |
| Cement | 535 | 535 |
| Water | 225 | 225 |
| Coarse aggregate | 1025 | 980 |
| Fine aggregate | 650 | 625 |
| Wet density | 2350 | 2330 |

*Table 7 :* Mix proportions of standard mixes for SCC with 30% PFA or RGD

| Mix | Code | Mass (kg/m3) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cement | PFA | RGD | Water | Coarse aggregate | Fine aggregate |
| 5 | RAC-SCC-30PFA | 430 | 185 | 0 | 190 | 960 | 620 |
| 6 | RAC-SCC-30RGD | 430 | 0 | 185 | 190 | 960 | 620 |

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*Table 8 :* Adjusted mix proportions of SCC concrete standard mixes

| Mix | Code | Mass (kg/m$^3$) | | | |
|---|---|---|---|---|---|
| | | Cement | Water | Coarse aggregate | Fine aggregate |
| 1 | NAC-SCC-CM (control mix) | 545 | 255 | 1020 | 615 |
| 2 | RAC-SCC-CM (control mix) | 545 | 255 | 978 | 625 |

*Table 9 :* Workability of successful mixes of RAC-SCC

| Mix | Code | w/c | w/b | Slump (mm) | Vebe (s) | Flow dia. (mm) | $T_{500}$ (s) | $T_{final}$ (s) | L-Box (PA) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | NAC-SCC-CM | 0.50 | 0.50 | 88 | 2 | - | - | - | - |
| 2 | RAC-SCC-CM | 0.50 | 0.50 | 73 | 4 | - | - | - | - |
| 3 | NAC-SCC-0.9SP | 0.40 | 0.40 | 277 | - | 700 | 2.23 | 15.6 | 0.90 |
| 4 | RAC-SCC-1.1SP | 0.40 | 0.40 | 260 | - | 683 | 2.37 | 13.1 | 0.83 |
| 5 | RAC-SCC-1.0SP -30PFA | 0.35 | 0.30 | 250 | - | 690 | 2.69 | 20.3 | 0.97 |
| 6 | RAC-SCC-1.1SP-30RGD | 0.35 | 0.30 | 267 | - | 715 | 1.54 | 10.7 | 0.97 |

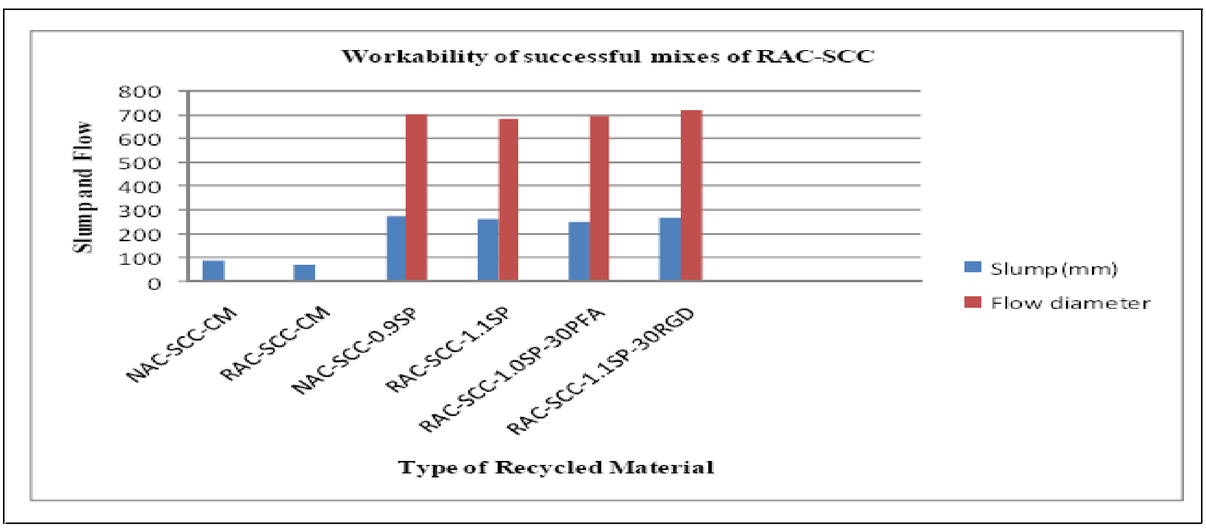


*Figure 3 :* Workability of successful mixes of RAC-SCC

Data in Table 8 showed that each mix is unique; each mix needed a certain amount of SP to satisfy SCC requirements. Concrete has to maintain its workability for a period of time to give operatives the chance to place it properly in the formwork. For successful mixes, the slump and slump flow were tested on the mix over the course of 90 minutes to see how the concrete would behave over time; loss of flow and slump were measured every 15 minutes. Data in Table 9 and Figure 3 show that slump was lost after one hour for mixes 3 to 6. This result indicates that the substitution of PFA and RGD to partially replace cement improves and maintains, and at the very least did not adversely influence, the workability of RAC-SCC. In particular, the RAC concrete mix without cement substitution (mix 4) has remarkably showed steady slump values within the period of 15 to 50 minutes; a larger drop was noticed within the first 15 minutes when compared with the similar mix with natural aggregate (mix 3), this however was expected due to the difference in absorption capacity. This feature was less pronounced in RAC-SCC mixes with PFA and RGD. A similar trend was observed for flow. The more water in a concrete mix the lower the quality at all ages. The w/b has very significant effects on both fresh and hardened properties of concrete. Strength and durability are considerably reduced when w/b ratio is increased; the less strong, the less durable the concrete. The effect of w/b ratio on the fresh properties of concrete restricts the choice of a low value on the strength, but SP can effectively remedy this situation. Aggregates form a considerable volume of concrete; typically 60-70% by volume. In addition to its serving as cheap filler, aggregate contributes to the strength of concrete, particularly when the strength of the paste matrix is low.

*Table 10 :* Slump and flow of SCC mixes at different times

| Mix | Code | Average slump (mm) and flow diameter (mm) after a time of (min.): | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 5 | 15 | 30 | 45 | 60 | 75 | 90 |
| 3 | NAC-SCC-0.9SP | 280 (710) | 267 (630) | 259 (600) | 235 (550) | 210 (470) | 85 (200) | 44 (200) |
| 4 | RAC-SCC-1.1SP | 277 (690) | 229 (580) | 212 (570) | 191 (550) | 183 (485) | 117 (210) | 48 (200) |
| 5 | RAC-SCC-1.0SP - 30PFA | 285 (780) | 280 (755) | 272 (710) | 260 (675) | 253 (640) | 227 (575) | 149 (430) |
| 6 | RAC-SCC-1.1SP-30RGD | 258 (680) | 250 (650) | 219 (605) | 193 (575) | 172 (505) | 97 (240) | 49 (200) |

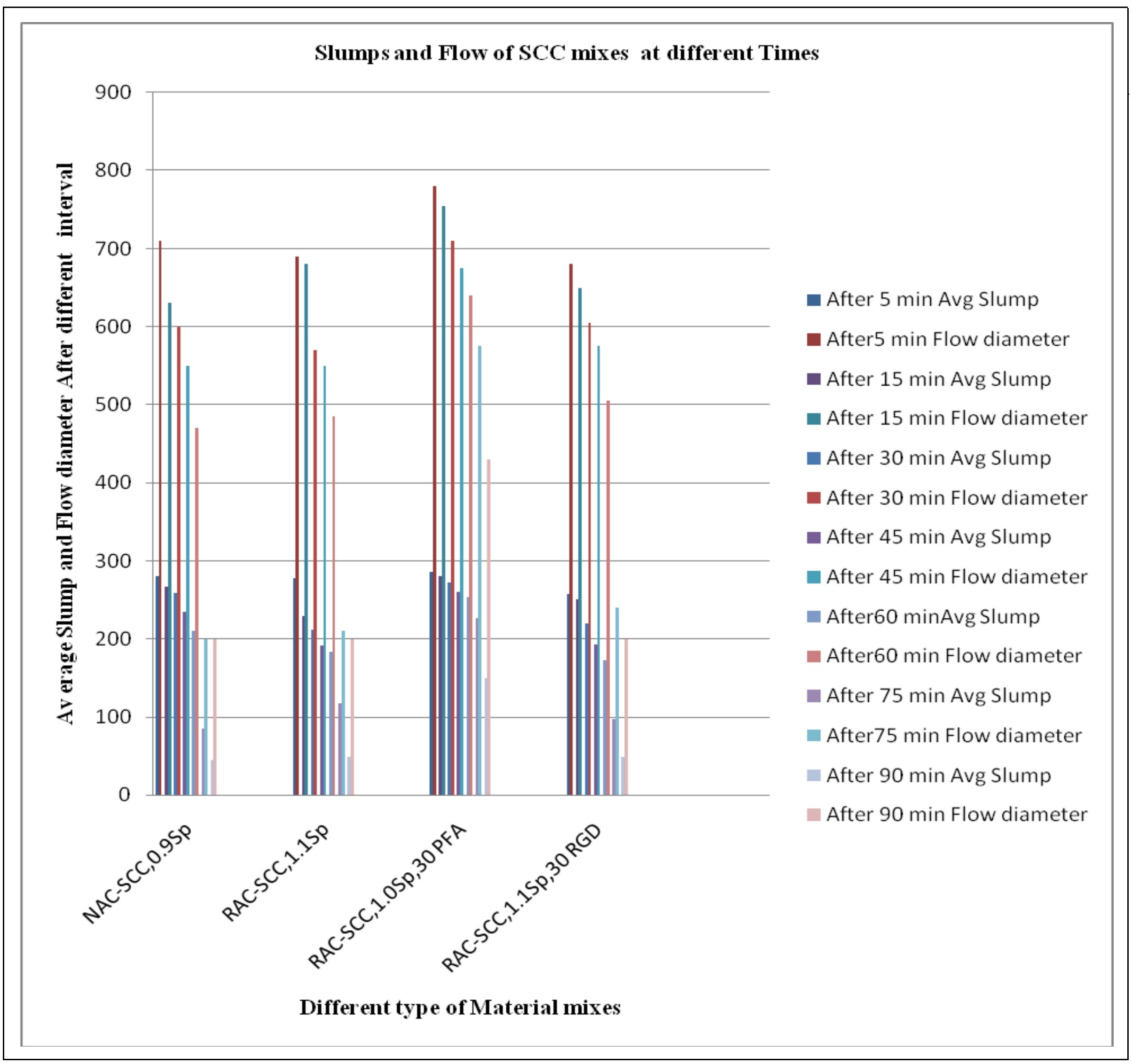


*Figure 4 :* Slumps and flow of SCC mixes at different time

Table 10 and Figure 4 show that the recycled aggregate mix with PFA was superior compared to other mixes when slump loss and flow are concerned; steady decrease of both values were observed. Even after 90 minutes, a slump of 145 mm and flow diameter of 430 mm were measured; this however can be attributed to the high initial slump which was basically comes from the higher design slump of the standard mix (60 -180 mm), the influence of SP, the spherical grain shape on fluidity, and the lower porosity of PFA grains. RAC exhibits similar behaviour to NAC, therefore concrete structures can be designed according to the prevailing theories used to design NAC members; however RAC is marginally deformable therefore attaining slightly more strain under similar stress (10 – 15 %).

*Table 11 :* Strengths of the SCC mixes

| Mix | Code | Compressive strength ($N/mm^2$) after: | | | Tensile strength ($N/mm^2$) after: | Flexural strength ($N/mm^2$) after: |
|---|---|---|---|---|---|---|
| | | 28 d | 56 d | 90 d | 28 d | 28 d |
| 1 | NAC-SCC-CM | 75.7 | 80.2 | 83.5 | 4.12 | 7.55 |
| 2 | RAC-SCC-CM | 58.9 | 61.3 | 63.0 | 3.71 | 6.63 |
| 3 | NAC-SCC-0.9SP | 92.9 | 91.8 | 93.4 | 5.11 | 12.1 |
| 4 | RAC-SCC-1.1SP | 60.7 | 61.5 | 62.2 | 4.16 | 9.16 |
| 5 | RAC-SCC-1.0SP -30PFA | 58.0 | 56.9 | 59.8 | 3.07 | 6.62 |
| 6 | RAC-SCC-1.1SP-30RGD | 48.2 | 55.2 | 56.8 | 2.91 | 5.91 |

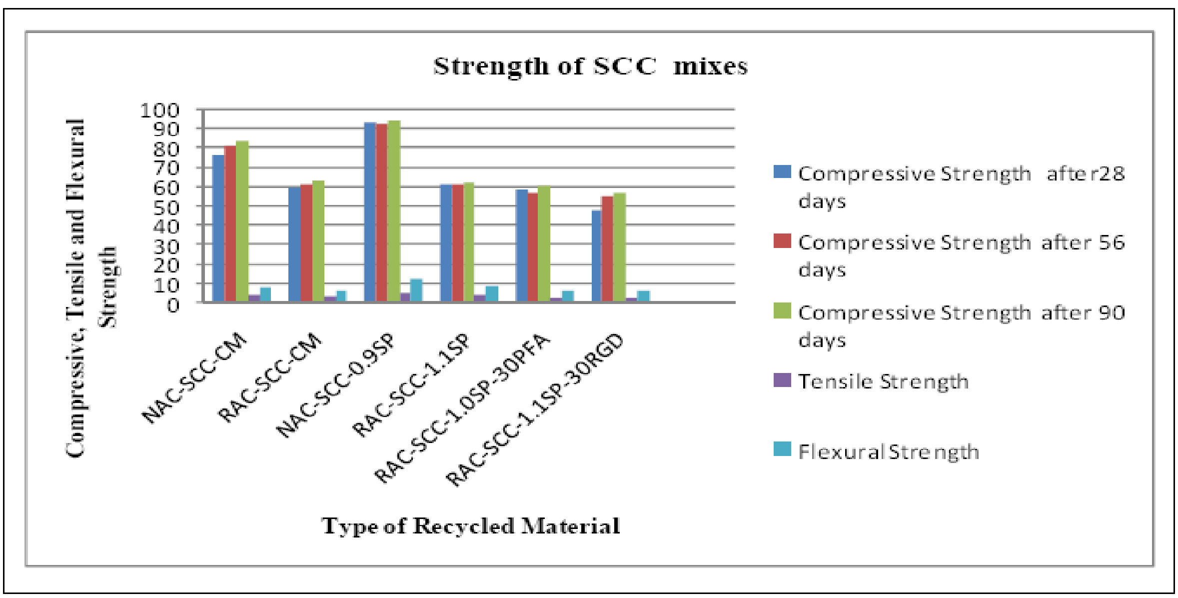


*Figure 5 :* Strength of SCC mixes

SCC is capable of filling all sections of complex shuttering perfectly, therefore will allow the engineer to design more complex connections, and facilitate the process of jointing pre-cast concrete units and SCC is ideal for deep concrete sections designed with dense reinforcement. Quality of RA and the level of replacement have an influence on mechanical and deformation characteristics of RAC. Result showed in Table 11 and Figure 5 the replacement level is increased, the strength and stiffness are decreased. Compressive strengths of RAC concrete reached 56 $N/mm^2$ after 28 days, and achieved higher strength with age reaching after 90 days. These were achieved for a mix designed to attain 40 $N/mm^2$ after 28 days curing, although the cement content was reduced by 25% thus contributing to its medium strength. Such strength levels, together with the well known benefits of PFA to the long-term performance of concrete, make this type of concrete more economical and satisfactory for many structural applications. The compressive strength of the super plasticized RAC with 30% PFA was much better than the RAC standard mix (improved by 33%) and similar to that of the NAC reference mix at 90 days. However, strength at 28 days was marginally below the target mean. RAC strengths at 28 days, 56 days and 90 days were achieved; these ranges practically cover the strength commonly required for several engineering applications. Results showed that NAC and RAC concrete mixes with 30% PFA as a substitute for the cement exhibited substantial increase of strength at later ages; 7 day compressive strengths improved by 80% and by about 90% for NAC and RAC concrete respectively (Table 11). A mild adverse influence of PFA on the tensile and flexural strength was observed. Strengths of concrete containing PFA increased over time, regardless of aggregate type. Therefore later age strengths of the resultant RAC are likely to increase. The achieved strengths of concrete with up to 50% replacement are good enough for many ordinary uses.

Results showed that the compressive strength of the SCC was increasing in a similar fashion to conventional concrete, regardless of aggregate type. The SP maintained workability, gave the required fluidity, contributed to form the slurry suspension needed to coat the aggregates and facilitate their relative movement. The SP also enabled the mix to be designed at low w/c ratio (Figure-6) therefore producing better strengths. It is well known that water has a great influence on the strength of concrete. The more water added, the weaker the concrete. The lower w/c ratio's influence clearly appeared in SCC without cement substitution; the compressive, tensile and flexural strengths at 28 days of NAC-SCC-0.9SP (Mix 3) were relatively enhanced. The increased strengths were most likely due to the enhanced matrix of the concrete (Figure-7).

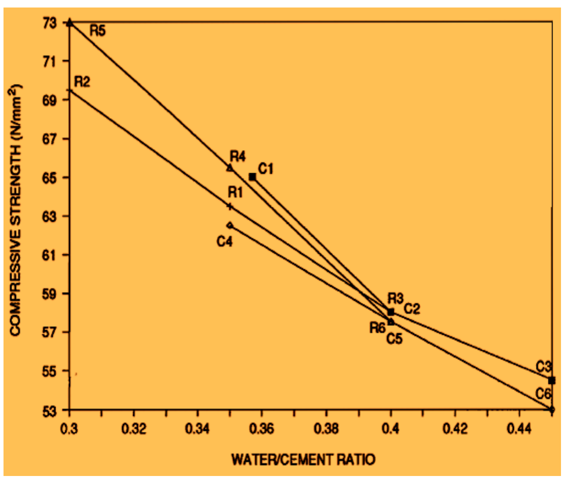


*Figure 6 :* Influence of water/Cement ratio on compressive strength

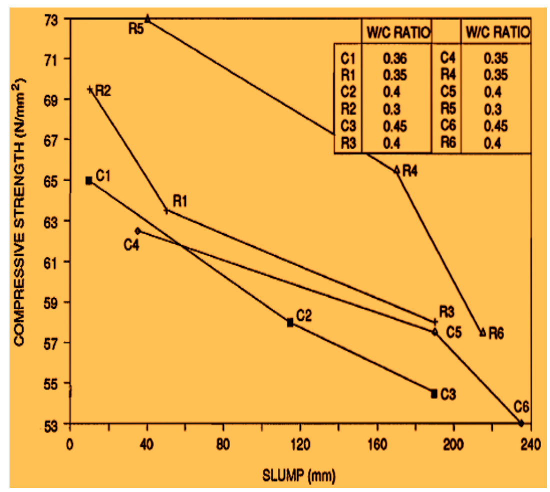


*Figure 7 :* Relationship between compressive strength and slump

A reduction of strengths, particularly the tensile strength, was observed when 30% of the cement was replaced by PFA and RGD compared to all other mixes, the 90 day compressive strengths were less than the target mean strength. The mix with PFA replacement was however better than its counterpart RGD mix. To make use of the observed benefit of PFA to the workability of SCC and perhaps to increase the strength, in addition to other well known advantages, PFA can be used as a supplement to cement instead of as a cement replacement. . A maximum strength reduction of 15% was observed when up to 50% of NA was replaced by RA. Bairagi & Kishore (1993)[33] reported that approximately 10% lower compressive strength, 0-20% reduction tensile and flexural strength, and 10-40% lower modulus of elasticity.

When PFA replaces fine aggregate in RAC concrete mixes, fine aggregate content is reduced and consequently, excess water available within the aggregate voids decreases. That may be developed by the relatively higher absorption capacity of RA and because the grain size of PFA is well below that of fine aggregate particles. Therefore, results showed that slump decreased as the level of PFA increased: the mix become less cohesive and drier.

It is believed that the impurities, particularly old cement paste stuck to RA have a significant influence on the strength of RAC. Several studies[52, 62, 53] concluded that adhered mortar from the original concrete plays an important role in determining performance with respect to permeability and strength. The absorption capacity is related to the size of RA; Hansen 1983[63] reported that the absorption capacity is about 3.7% for 4-8 mm RA, and about 8.7% for the 16-32 mm sizes, meanwhile it was only 0.8-3.7% for natural aggregates. Hansen & Narud 1992 shows that the volume percentage of mortar attached to natural gravel particles was between 25% and 35% for coarse recycled aggregates of 16-32 mm size, around 40% for 8-16 mm size and around 60% for 4-8 mm. A recent study (Etxeberria *et al.* 2007)[53] showed that crushed concrete comprises 49.1% of original aggregate plus the adhered mortar and 43% of original aggregate, 1.6% ceramic, 5.3% bitumen and 0.8% other materials. In this study, the total quantity of adhered mortar was estimated to be in the range 20-40% of the aggregate weight. This study also showed that the smaller the size of the aggregate the more adhered mortar. Therefore fine recycled aggregate would often contain more adhered mortar and have more absorption capacity. However, the utilisation of recycled fine aggregate for RAC concrete is usually avoided due to its higher absorption capacity and increased shrinkage[64]. The findings of the aforementioned studies are in agreement.

Bleeding (migration of mixing water to the top surface zone of the concrete section) due to use of RA is generally similar to that of natural aggregates. However, bleeding was observed to be reduced with recycled aggregates produced mainly from other materials rather than those originally produced from crushed concrete, such as the aggregates from cement, clay bricks, *etc*[65, 66] contends that the use of up to 30% RA to replace NA will not have significant adverse effects on RAC cube strength. For higher RA contents, minor alterations to the mix proportions may be needed to ensure that equivalent performance to NAC is achieved. Blending of natural and recycled aggregates did not result in significantly improved cube strength at high w/c ratio; the greatest improvement was less than 10%. Tensile strengths and elasticity modulus were found to follow the same trend as the compressive strength while the workability was little improved. In contrast, [67] reported that slump loss of concrete will be quite fast for RAC without pre-wetting of RA.

A study [68] reported that the results of concrete cast to contain 35% PFA cement replacement exhibited lower compressive strength, higher flexural strength and comparable modulus of elasticity of concrete at all ages as compared with the reference mixture containing no-fly ash.

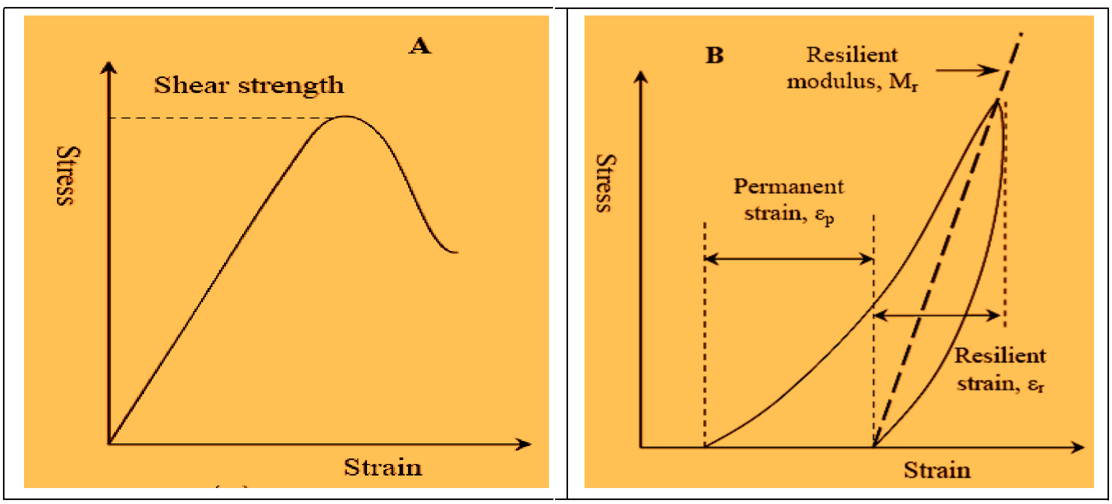


*Figure 8 :* (A) Monotonic loading to failure (B) strains in UGM during one load cycle

In general the monotonic failure triaxial tests are capable of providing the overall failure (strength) behavior of the granular materials and trends of the influence factors material type (Figure-8 a&b). However, there are limitations in order to precisely quantify the stress dependency of the strength behavior. One of the major limitations is the small magnitude of the maximum possible confining stress (80 kPa) that can be applied by the system compared to high levels of the failure stress ranging to 1800 kPa. The difference in magnitude between 20, 50 and 80 kPa confining stress is very small compared to the magnitude of the failure stresses.

## VI. Geotechnical Properties of Crushed Brick

### a) *Particle Size Distribution*

Coefficient of uniformity *Cu* is a basic shape parameter to define the grain size distribution and coefficient of curvature *Cc* is also used along with *Cu* [69]. Coefficient of uniformity *Cu* and coefficient of curvature *Cc* are defined by the following equations;

$$C_u = D_{60} / D_{10}$$

$$C_e = (D_{30})^2 / (D_{10}) x (D_{60})$$

Where $D_{60}$ = grain diameter (in mm) corresponding to 60% passing by weight

$D_{30}$ = grain diameter (in mm) corresponding to 30% passing by weight

$D_{10}$ = grain diameter (in mm) corresponding to 10% passing by weight

For site 1;

Before compaction

$D_{60}$ = 8 mm; $D_{30}$ = 1.8 mm; $D10$ = 0.18 mm

$C_u = 8/0.18 = 44.44$

$C_e = (1.8)^2/(0.18)(8) = 2.25$

After compaction

$D_{60}$=4.8mm; $D_{30}$=0.6mm; $D_{10}$=0.07mm

$C_u$=4.8/0.07=68.57

Ce= $(0.6)^2/(0.07)(4.8)$=1.07

For site 2

Before compaction

$D_{60}$=5.6 mm; $D_{30}$=0.6 mm; $D_{10}$=0.1mm

$C_u$=5.6/0.1=56

$C_e$= $(0.8)^2/(0.1)(5.6)$=1.42

After compaction

$D_{60}$=4.2 mm; $D_{30}$=0.56mm; $D_{10}$=0.07mm

$C_u$=4.2/0.07=60

Ce= $(0.56)^2/(0.07)(4.2)$=1.06

According AS 1726 Geotechnical site investigation ( AS 1726, 1993)[70], all the crushed brick samples were fall under category gravel as more than half of the coarse fraction was larger than 2.36 mm and lesser than 63mm. However, since the percentage of fines ( less than 75μm) is not less than 5% or greater than 12% and the samples satisfied with coefficient of uniformity and coefficient of curvature criteria, $Cu > 4$ and $1 < Cc < 3$ it could be either well graded gravel (GW) or silty gravel (GM) or clayey gravel (GC).

## VII. Particle Density

### *a) Coarse particle*

Particle density of crushed brick aggregates passing 19 mm and retaining on 4.75 mm are 2.67 t/m$^3$ and 2.65 t/m$^3$ for the samples from site 1 and site 2 respectively. Particle density of coarse crushed brick aggregates is lower than the crushed rock (class 3) aggregates.

### *b) Fine particle*

Particle density of crushed brick aggregates passing 4.75 mm are 2.63 t/m$^3$ and 2.60mm for the samples from site 1 and site 2. Particle density of fine crushed brick aggregates is lower than the crushed rock (class 3) aggregates.

### *c) Water Absorption*

#### i. *Coarse particle*

Water absorption of crushed brick aggregates passing 19 mm and retaining on 4.75 mm are 6.15 % and 6.20 % for the samples from site 1 and site 2 respectively. Water absorption of coarse crushed brick aggregates is higher than the crushed rock (class 3) aggregates.

### *d) Fine particle*

Water absorption of crushed brick aggregates passing 4.75 mm are 6.87 % and 7.16% for the samples from site 1 and site 2. Water absorption of coarse crushed brick aggregates is higher than the crushed rock (class 3) aggregates.

### *e) Modified Compaction*

Maximum density of crushed brick samples under modified compactive effort are 2.02 t/m$^3$ and 1.96 t/m$^3$ for the samples from site 1 and site 2 respectively. Optimum moisture content of crushed brick samples under modified compactive effort are 10.70 % and 11.5 % for the samples from site 1 and site 2 respectively.

### *f) Direct shear test*

Direct shear test was carried out to find out the shear strength parameters of crushed brick samples. The normal stresses of 30kPa, 60 kPa and 120 kPa were applied on the crushed brick specimens in three consecutive tests.

### *g) Consolidated drained triaxial test*

Consolidated drained triaxial tests were performed to find the apparent cohesion (c) and internal friction angle (ϕ) of the crushed brick samples. The effective confining pressures of 50 kPa, 100 kPa and 200 kPa were applied on the specimens in each test.

### *h) Shear strength*

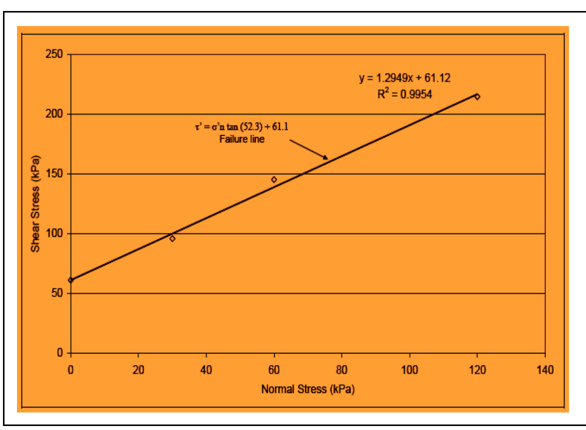


*Figure 9 :* Mohr- Coulomb envelope of crushed brick sample

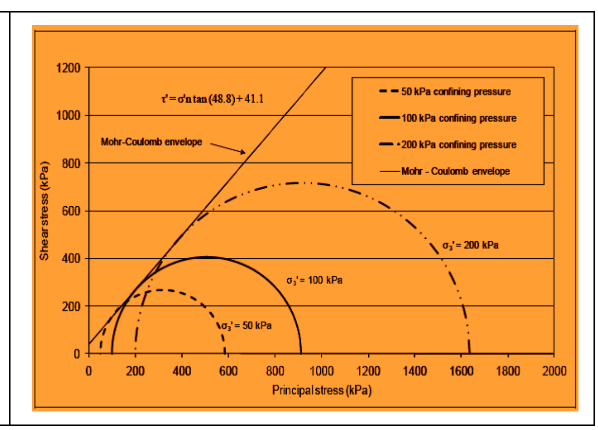


*Figure 10 :* Mohr‟s circles and Mohr- Coulomb failure envelope for crushed brick samples (site 1)

Figure 9 and 10 shows the Mohr's circles and Mohr-Coulomb failure envelope of crushed brick samples under drained triaxial compression from site 1 and site 2. The Mohr-Coulomb envelope corresponding to the peak deviator stress is linear for the tested stress ranges and shown in conventional Mohr-Coulomb stress space. An internal friction angle ($\phi$) of 48.8˚ and an apparent cohesion (c) of 41.1 kPa are corresponded to the Mohr Coulomb failure envelope of crushed brick sample sourced from site 1. Similarly, an internal friction angle ($\phi$ ) of 44.6˚ and an apparent cohesion (c) of 65.5 kPa are corresponded to the crushed brick sample sourced from site 2. Even though, crushed brick aggregates are considered as non cohesive frictional material, it deviates form purely frictional behaviour due to the effect of confining stress. At higher confining pressures, particle became flattened at contact points, sharp corners are crushed and interlocking also reduced.

## VIII. Conclusion

In terms of stress-strain relationship, RAC exhibits similar behaviour to NAC, therefore concrete structures can be designed according to the prevailing theories used to design NAC members. As the strength of RAC is not as high as that of NAC, the cement content needs to be increased by 20-30% for RAC mixtures to achieve similar compressive strength. To produce RAC concrete with similar workability to NAC concrete, water content needs to be increased by 5-8% depending on the aggregates absorption capacity; cement content must be also increased to keep w/c constant. RA is mixed in a saturated state e.g. not in surface dry condition the mechanical properties may be significantly influenced. SP and/or PFA can purposely be used instead. PFA generally slightly reduces the early age strength of concrete, but strengths continued to improve over time. While strength may be one of the most important concrete properties that control its performance. The use of recycled aggregates in concrete prove to be a valuable building materials in technical, environment and economical respect. As SCC can be easily pumped into high-rise concrete buildings; the increased volume of concrete will have a positive influence on the construction time and therefore the rate at which the whole structure is erected. In addition it requires fewer workers in comparison to traditional methods.

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# An Algorithm for Integration, Differentiation and Finding Root Numerically

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*Abstract-* Numerical analysis concerns the development of algorithms for solving various types of problems of mathematics; it is a vast-ranging field having deep interaction with computer science, mathematics, engineering, and the sciences. Numerical analysis mainly consists of Numerical Integration, Numerical Differentiation and finding Roots numerically. In this paper we develop an algorithm combination of Numerical Integration (Trapezoidal rule, Simpson's $\mathbf{1/3}$ rule, Simpson's $\mathbf{3/8}$ rule and Weddle's rule.), Numerical Differentiation (Euler, modified Euler and Runge- Kutta second and fourth order) and finding Roots (Bisection method and False position method) numerically.

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*Strictly as per the compliance and regulations of:*

# An Algorithm for Integration, Differentiation and Finding Root Numerically

N. Rahman [α], Aminul Islam [σ], Pulakesh Gain [ρ], B. K. Datta [ω] & R. C. Bhowmik [¥]

*Abstract-* Numerical analysis concerns the development of algorithms for solving various types of problems of mathematics; it is a vast-ranging field having deep interaction with computer science, mathematics, engineering, and the sciences. Numerical analysis mainly consists of Numerical Integration, Numerical Differentiation and finding Roots numerically. In this paper we develop an algorithm combination of Numerical Integration (Trapezoidal rule, Simpson's $1/3$ rule, Simpson's $3/8$ rule and Weddle's rule.), Numerical Differentiation (Euler, modified Euler and Runge-Kutta second and fourth order) and finding Roots (Bisection method and False position method) numerically.

## I. Introduction

Numerical analysis is the area of mathematics and computer science that creates, analyzes, and implements algorithms for solving numerically the problems of continuous mathematics. Such problems originate generally from real-world applications of algebra, geometry, and calculus, and they involve variables which vary continuously. The formal academic area of numerical analysis varies from highly theoretical mathematical studies to computer science issues involving the effects of computer hardware and software on the implementation of specific algorithms[5].

An algorithm is a procedure or formula for solving a problem. The word derives from the name of the mathematician, Mohammed ibn-Musa al-Khwarizmi.

Given a set of data of points $(x_0, y_0), (x_1, y_1), \dots\dots, (x_n, y_n)$ of a function $y = f(x)$, where $f(x)$ is not known explicitly, it is required to compute the value of the definite integral

$$I = \int_a^b y\, dx \qquad (1)$$

We derive a general formula for numerical integration using Newton's forward difference formula. Let the interval $[a, b]$ be divided into n equal subintervals such that

$$a = x_0 < x_1 \dots\dots\dots\dots\dots\dots\dots . < x_n = b$$

Clearly, $x_n = x_0 + n$. Hence the integral becomes $I = \int_{x_0}^{x_n} y\, dx$

Approximating $y$ by Newton's forward difference formula, we obtain. [4]

$$I = \int_{x_0}^{x_n} [y_0 + p\Delta y_0 + \left(\frac{p(p-1)}{2!}\right)\Delta^2 y_0 + \left(\frac{p(p-1)(p-2)}{3!}\right)\Delta^3 y_0 + \cdots]dx$$

Since $x = x_0 + ph,\ dx = h\, dp$ and hence the above integral becomes

$$I = h\int_o^n [y_0 + p\Delta y_0 + \left(\frac{p(p-1)}{2!}\right)\Delta^2 y_0 + \left(\frac{p(p-1)(p-2)}{3!}\right)\Delta^3 y_0 + \cdots]dp$$

$$\Rightarrow \int_{x_0}^{x_n} y\, dx = nh[y_0 + \left(\frac{n}{2}\right)\Delta y_0 + \left(\frac{n(2n-3)}{12}\right)\Delta^2 y_0 + \cdots]dp \qquad (2)$$

From this general formula, we can obtain different integration formula by putting $n = 1,2,3 \dots\dots$ etc.

Programming language C is very flexible and powerful. It originally designed in the early 1970s [3]. It allows us to maximum control with minimum command. It is recognized worldwide and used in a multitude of applications especially in Numerical Analysis. Along with other numerous benefits, we have used programming language C in this paper.

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Already B. K. Datta et all in [1] and [2] have given the algorithms of numerical differentiation and numerical integration. In this paper we have developed a combined algorithm of numerical differentiation, numerical integration and finding roots numerically.

The outline of this paper is as follows: Section 2 contains the brief description of the existing methods with methodology. In Section 3, we develop an algorithm, using the programming language C, which gives us the solution of a problem simultaneously regarding four popular existing numerical integration methods namely Trapezoidal rule, Simpson's $1/3$ rule, Simpson's $3/8$ rule and Weddle's rule or the solution of an ordinary differential equation simultaneously regarding four popular existing methods namely Euler, modified Euler, Runge-Kutta second and fourth order or

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the solution of a problem simultaneously regarding two existing numerical methods namely Bisection method and False position method. Moreover, the simulator identifies the method that gives the best solution comparing with possible exact solution of the problem in each case. Conclusions are given at the end at Section 4.

## II. Existing Methods

We give a brief description of the existing methods of Numerical Integration like Trapezoidal rule, Simpson's $1/3$ rule, Simpson's $3/8$ rule and Weddle's rule, methods of numerical differential equations like Euler, modified Euler, Runge-Kutta second and fourth order and numerical methods namely Bisection method and False position method in this section with their methodology[2].

*a) Trapezoidal Rule*

Putting $n = 1$ in (2) all differences higher than the first will become zero and we obtain

$$\int_{x_0}^{x_1} y\,dx = h\left[y_0 + \frac{1}{2}\Delta y_0\right] = h\left[y_0 + \frac{1}{2}(y_1 - y_0)\right] = \frac{h}{2}[y_0 + y_1]$$

For the next interval $[x_1, x_2]$ and others we have the similar expression as $\int_{x_1}^{x_2} y\,dx = \frac{h}{2}[y_1 + y_2]$ and so on. And for the last interval $[x_{n-1}, x_n]$, we have $\int_{x_{n-1}}^{x_n} y\,dx = \frac{h}{2}[y_{n-1} + y_n]$.

Combining all these expressions, we obtain the rule

$$\int_{x_0}^{x_n} y\,dx = \frac{h}{2}[y_0 + 2(y_1 + y_2 + \cdots y_{n-1}) + y_n]$$

This is known as Trapezoidal rule.

*b) Simson's 1/3 Rule*

Putting $n = 2$ in (2) all differences higher than the first will become zero and we obtain

$$\int_{x_0}^{x_2} y\,dx = 2h[y_0 + \Delta y_0 + \frac{1}{6}\Delta^2 y_0] = \frac{h}{3}[y_2 + 4y_1 + y_0]$$

Similarly, $\int_{x_2}^{x_4} y\,dx = \frac{h}{3}[y_2 + 4y_3 + y_4]$ and finally $\int_{x_{n-2}}^{x_n} y\,dx = \frac{h}{3}[y_{n-2} + 4y_{n-1} + y_n]$

Combining all these expressions, we obtain

$$\int_{x_0}^{x_n} y\,dx = \frac{h}{3}[y_0 + 4(y_1 + y_3 + \cdots + y_{n-1}) + 2(y_2 + y_4 + \cdots + \quad \ldots \quad + y_{n-2}) + y_n]$$

This is known as Simson's $1/3$ rule.

*c) Simson's 3/8 Rule*

Putting $n = 3$ in (2) all differences higher than the first will become zero and we obtain

$$\int_{x_0}^{x_3} y\,dx = 3h[y_0 + \frac{3}{2}\Delta y_0 + \frac{9}{12}\Delta^2 y_0 + \frac{3}{24}\Delta^3 y_0] = \frac{3}{8}h[y_0 + 3y_1 + 3y_2 + y_3]$$

Similarly, $\int_{x_3}^{x_6} y\,dx = \frac{3}{8}h[y_3 + 3y_4 + 3y_5 + y_6]$ and so on.

Summing up all these, we obtain

$$\int_{x_0}^{x_n} y\,dx = \frac{3}{8}h[y_0 + 3y_1 + 3y_2 + 2y_3 + \cdots + 2y_{n-3} + 3y_{n-2} + 3y_{n-1} + y_n]$$ [13]

This rule is known as Simson's $3/8$ rule.

*d) Weddle's Rule*

Putting $n = 6$ in (2) all differences higher than the first will become zero and we obtain

$$\int_{x_0}^{x_6} y\,dx = \frac{3}{10}h[y_0 + 5y_1 + y_2 + 6y_3 + y_4 + 5y_5 + y_6]$$

Similarly, we obtain the general form

$$\int_{x_0}^{x_n} y\,dx = \frac{3}{10}h[y_0 + 2(y_6 + y_{12} + \cdots\cdots + y_{n-6}) + 5(y_1 + y_7 + \cdots\cdots + y_{n-5})\ 5(y_5 + y_{11} + \cdots\cdots + y_{n-1}) + 6(y_3 + y_9 + \cdots\cdots + y_{n-3}) + y_2 + y_4 + \cdots\cdots + y_n]$$

This is known as Weddle's rule.

*e) Euler Method*

In mathematics and computational science, the Euler method is a first-order numerical procedure for solving ODEs with a given initial value. It is the most basic explicit method for numerical ODEs[1].

i. *Procedure*

We consider the differential equation

$$y' = f(x,y) \quad (3)$$

with the initial condition $y(x_0) = y_0$ (4)

Suppose that we wish to solve the equation (3) with (4) for the value of $y$ at $x = x_r = x_0 + rh\ (r = 1,2,\dots\dots\dots\dots)$

Integrating (3) with $y_0$ to $y_1$ and $x_0$ to $x_1$, we get $y_1 - y_0 = \int_{x_0}^{x_1} f(x,y)dx$

Or, $$y_1 = y_0 + \int_{x_0}^{x_1} f(x,y)dx \quad (5)$$

Assuming that $f(x,y) = f(x_0,y_0)$ in $x_0 \le x \le x_1$, this gives Euler's formula

$$y_1 \approx y_0 + h\,f(x_0,y_0)[\text{since} x_1 - x_0 = h] \quad (6)$$

Similarly for the range $x_1 \le x \le x_2$, we have $y_2 = y_1 + \int_{x_1}^{x_2} f(x,y)dx$

Substituting $f(x_1,y_1)$ for $f(x,y)$ where $x_1 \le x \le x_2$, we have

$$y_2 \approx y_1 + h\,f(x_1,y_1)\ [\text{since} x_2 - x_1 = h]$$

Proceeding in this way, we obtain the general formula

$$y_{n+1} = y_n + h\,f(x_n,y_n), \qquad n = 0,1,2,\dots\dots\dots\dots\dots$$

*f) Modified Euler's method*

i. *Procedure*

We consider the differential equation

$$y = f(x,y) \quad (7)$$

With the initial condition $y(x_0) = y_0$ (8)

Suppose that we wish to solve the equation (7) with (8) for the value of y at

$$x = x_r = x_0 + rh\ (r = 1,2,\dots\dots\dots\dots)$$

Integrating (7) with $y_0$ to $y_1$ and $x_0$ to $x_1$, we get $y_1 - y_0 = \int_{x_0}^{x_1} f(x,y)dx$

Or, $$y_1 = y_0 + \int_{x_0}^{x_1} f(x,y)dx \quad (9)$$

Now integrating (9) by means of trapezoidal rule to obtain

$$y_1 = y_0 + \left(\frac{h}{2}\right)[f(x_0,y_0) + f(x_1 y_1)] \quad (10)$$

We thus obtain the iterative formula

$$y_1^{(n+1)} = y_0 + \left(\frac{h}{2}\right)[f(x_0,y_0) + f(x_1,y_1^n)] \ ;n = 0,1,2,.. \quad (11)$$

Where $y_1^n$ is the nth approximation to $y_1$. The iterative formula (11) can be started by choosing $y_1^0$ from Euler's formula $y_1^0 = y_0 + h\,f(x_0,y_0)$

*g) Runge-Kutta method(Second order)*

i. *Procedure*

We consider the differential equation $y = f(x,y)$ (12)

With the initial condition $y(x_0) = y_0$ (13)

Suppose that we wish to solve the equation (12) with (13) for the value of $y$ at

$$x = x_r = x_0 + rh\ (r = 1,2,\dots\dots\dots\dots)$$

Integrating (12) with $y_0$ to $y_1$ and $x_0$ to $x_1$, we get $y_1 - y_0 = \int_{x_0}^{x_1} f(x,y)dx$

Or $$y_1 = y_0 + \int_{x_0}^{x_1} f(x,y)dx \quad (14)$$

Now integrating (14) by means of trapezoidal rule to obtain

$$y_1 = y_0 + (\frac{h}{2})[f(x_0,y_0) + f(x_1 y_1)] \quad (15)$$

Substitute $y_1 = y_0 + h\,f(x_0,y_0)$ on the right side of equation (15), we obtain

$$y_1 = y_0 + \left(\frac{h}{2}\right)[f_0 + f(x_0 + h, y_0 + h\,f_0) \quad (16)$$

Where $f(x_0,y_0) = f_0, x_1 - x_0 = h$

Now set $k_1 = h\,f_0$ and $k_2 = h\,f(x_0 + h, y_0 + k_1)$. And hence equation (16) becomes

$$y_1 = y_0 + \left(\frac{1}{2}\right)[k_1 + k_2].$$

This is the Runge-Kutta second order formula.

*h) Runge-Kutta method (Fourth order)*

i. *Procedure*

We mention the fourth order formulae defined by

$$y_1 = y_0 + W_1 k_1 + W_2 k_2 + W_3 k_3 + W_4 k_4 \quad (17)$$

Where

$k_1 = hf(x_0,y_0)$

$k_2 = hf(x_0 + \alpha_0 h, y_0 + \beta_0 k_1)$

$k_3 = hf(x_0 + \alpha_1 h, y_0 + \beta_1 k_1 + v_1 k_2)$

$k_4 = hf(x_0 + \alpha_2 h, y_0 + \beta_2 k_1 + v_2 k_2 + \delta_1 k_3)$ (18)

Where the parameters have to be determined by expanding both sides of (17) by Taylor's series and securing agreement of terms up to and including those containing $h^4$. The choice of the parameters is, again arbitrary and we have therefore several fourth order Runge-kutta formulae. If for example we set

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$\alpha_0 = \beta_0 = \alpha_1 = \frac{1}{2}, \alpha_2 = 1$

$\beta_1 = \frac{1}{2}(\sqrt{2} - 1), \beta_2 = 0$

$v_1 = 1 - \frac{1}{\sqrt{2}}, v_2 = -\frac{1}{\sqrt{2}}, \delta_1 = 1 + \frac{1}{\sqrt{2}}$

$W_1 = W_4 = \frac{1}{6}, W_2 = \frac{1}{3}\left(1 - \frac{1}{\sqrt{2}}\right), W_3 = \frac{1}{3}\left(1 + \frac{1}{\sqrt{2}}\right)$

We obtain the method of Gill, whereas the choice

$\alpha_0 = \alpha_1 = \frac{1}{2}, \beta_0 = v_1 = \frac{1}{2}$

$\beta_1 = \beta_2 = v_2 = 0, \alpha_2 = \delta_1 = 1$

$W_1 = W_4 = \frac{1}{6}, W_2 = W_3 = \frac{2}{6}$

Leads to the fourth order Runge-Kutta formulae, whereas

$k_1 = hf(x_0, y_0)$

$k_2 = hf\left(x_0 + \frac{1}{2}h, y_0 + \frac{1}{2}k_1\right)$

$k_3 = hf\left(x_0 + \frac{1}{2}h, y_0 + \frac{1}{2}k_2\right)$

$k_4 = hf(x_0 + h, y_0 + k_3)$

Then

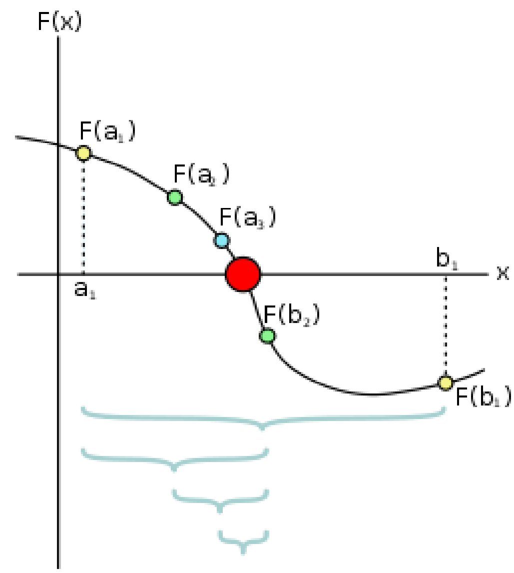
$$y_1 = y_0 + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

*i) Bisection method*

The bisection method in mathematics is a root-finding method which repeatedly bisects an interval and then selects a subinterval in which a root must lie for further processing. It is a very simple and robust method, but it is also relatively slow. Because of this, it is often used to obtain a rough approximation to a solution which is then used as a starting point for more rapidly converging methods. The method is also called the binary search method or the dichotomy method[4].

i. *Procedure*

The method is applicable when we wish to solve the equation $f(x) = 0$ for interval $[a,b]$ and $f(a)$ the real variable $x$, where $f$ is a continuous function defined on an and $f(b)$ have opposite signs. In this case $a$ and $b$ are said to bracket a root since, by the intermediate value theorem, the $f$ must have at least one root in the interval $(a,b)$. At each step the method divides the interval in two by computing the midpoint $c = (a+b)/2$ of the interval and the value of the function $f(c)$ at that point. Unless $c$ is itself a root (which is very unlikely, but possible) there are now two possibilities: either $f(a)$ and $f(c)$ have opposite signs and bracket a root, or $f(c)$ and $f(b)$ have opposite signs and bracket a root. The method selects the subinterval that is a bracket as a new interval to be used in the next step. In this way the interval that contains a zero of $f$ is reduced in width by 50% at each step. The process is continued until the interval is sufficiently small.




Explicitly, if $f(a)$ and $f(c)$ are opposite signs, then the method sets $c$ as the new value for $b$, and if $f(b)$ and $f(c)$ are opposite signs then the method sets $c$ as the new $a$. (If $f(c) = 0$ then $c$ may be taken as the solution and the process stops.) In both cases, the new $f(a)$ and $f(b)$ have opposite signs, so the method is applicable to this smaller interval.

*j) False Position Method*

In problems involving arithmetic or algebra, the false position method or regulafalsi is used to refer to basic trial and error methods of solving problems by substituting test values for the unknown quantities.

i. *Procedure*

The poor convergence of the bisection method as well as its poor adaptability to higher dimensions (i.e., systems of two or more non-linear equations) motivate the use of better techniques[6]. One such method is the Method of False Position. Here, we start with an initial interval $[x_1, x_2]$ and we assume that the function changes sign only once in this interval. Now we find an $x_3$ in this interval, which is given by the intersection of the $x$ axis and the straight line passing through $(x_1, f(x_1))$ and $(x_1, f(x_1))$. It is easy to verify that $x_3$ is given by

$$x_3 = x_1 - \frac{(x_2 - x_1)f(x_1)}{f(x_2) - f(x_1)}$$

Now, we choose the new interval from the two choices $[x_1, x_3]$ or $[x_3, x_2]$ depending on in which interval the function changes sign.

The false position method differs from the bisection method only in the choice it makes for subdividing the interval at each iteration. It converges faster to the root because it is an algorithm which uses appropriate weighting of the initial end points $x_1$ and $x_2$ using the information about the function, or the data of the problem. In other words, finding $x_3$ is a *static* procedure in the case of the bisection method since for a given $x_1$ and $x_2$, it gives *identical* $x_3$, no matter what the function we wish to solve. On the other hand, the false position method uses the information about the function to arrive at $x_3$.

## III. Algorithm

INPUT: Type your choice C.

If C==1

{

INPUT: function $f$, limits $x_0$ and $x_n$, number of division $n$, direct result $r$.

Step-1: Compute $h = \frac{x_n - x_0}{n}$

Step-2: Set $i = 0$

Step-3: While $i \leq n$, repeat Step- 4

Step-4: Set $y[i] = f(x_0 + ih)$

Step-5: Set $i = 1$

Step-6: While $i < n$, repeat Step-7

Step-7: Set $sum\_1 = sum\_1 + 2y[i]$

If $i\%2 = 0$

Set $sum\_2 = sum\_2 + 2y[i]$

Else

Set $sum\_2 = sum\_2 + 4y[i]$

If $i\%3 = 0$

Set $sum\_3 = sum\_3 + 2y[i]$

Else

Set $sum\_3 = sum\_3 + 3y[i]$

$t\_sum\_1 = (h/2) * (y[0] + y[n] + sum\_1)$

$t\_sum\_2 = (h/3) * (y[0] + y[n] + sum\_2)$

$t\_sum\_3 = (3h/8) * (y[0] + y[n] + sum\_3)$

If $i\%6 = 0$

Set $sum\_4 = sum\_4 + 2y[i]$

Else if $i\%3 = 0$

Set $sum\_4 = sum\_4 + 6y[i]$

Else

Set $sum\_4 = sum\_4 + y[i]$

Else If$(i\%6 == 1 || i\%6 == 5)$

$Sum\_4 = sum\_4 + 5y[i]$

Else

$Sum\_4 = sum\_4 + y[i];$

$t\_sum\_4 = \left(\frac{3h}{8}\right) * (y[0] + y[n] + sum\_4)$

Step-8: Set a= $|t\_sum\_1 - r|, b = |t\_sum\_2 - r|, c = |t\_sum\_3 - r|, d = |t\_smu\_4 - r|$

If$(a < b \ and \ a < c)$

If$(a < d)$

$t\_sum\_1$

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Else

$t\_sum\_4$

If$(b < a \ and \ b < c)$

If$(b < d)$

$t\_sum\_2$

Else

$t\_sum\_4$

If$(c < a \ and \ c < b)$

If$(c < d)$

$t\_sum\_3$

Else

$t\_sum\_4$

OUTPUT: $t\_sum\_1, t\_sum\_2, t\_sum\_3$ and t$_sum_4$ with message which sum is most accurate.

STOP.

}[2]

Else If C==2

{

INPUT: function $f(x, y)$, initial condition $(x_0, y_0)$, interval $h$, value of $x$, direct result $r$.

Step-1: Set n= $(x - x_0)/h$ ,$y_{00} = y_0, y_{0e} = y_0, y_{02} = y_0$

$$y_{04} = y_0, y_1 = y_{00} + hf(x_0, y_{00})$$

Step-2: Set $i = 1$

Step-3: While $i \leq n$, repeat Step-4 to step-7

Step-4: Set $j = 1$

Step-5: While $j \leq i$ repeat step-10

Step-6: Set $x_1 = x_0 + h, y_{10} = y_{00} + \frac{1}{2}hf(x_0, y_0) + f(x_1, y_1), y_1 = y_{10}$

Step-7: Set $y_{1e} = y_{0e} + hf(x_0, y_{0e}), k_{11} = hf(x_0, y_{04}), k_{22} = hf(x_0 + \frac{1}{2}h, y_{04} + \frac{1}{2}k_{11})$

$$k_{33} = hf\left(x_0 + \frac{1}{2}h, y_{04} + \frac{1}{2}k_{22}\right), k_{44} = hf(x_0 + h, y_{04} + k_{33})$$

$$r_4 = y_{04} + (k_{11} + 2k_{22} + 2k_{33} + k_{44})/6$$

$$k_1 = hf(x_0, y_{02}), k_2 = hf(x_0 + h, y_{02} + k_1)$$

$$y_1r_2 = y_{02} + \frac{1}{2}(k_1 + k_2), y_{0e} = y_{1e}, y_{00} = y_{10}$$

$$y_{04} = y_1r_4, y_{02} = y_1r_2, x_0 = x_n$$

Step-8: Set $a = |y_{1e} - r|, b = |y_{10} - r|, c = |y_1r_2 - r|, d = |y_1r_4 - r|$

If$(a < b \ and \ a < c)$

If$(a < d)$

$y_{1e}$

Else

$y_1r_4$

If$(b < a \ and \ b < c)$

If$(b < d)$

$y_{10}$

Else

$y_1r_4$

If$(c < a \ and \ c < b)$

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If($c < d$)

$y_1 r_2$

Else

$y_1 r_4$

Output: $y_{1e}, y_{10}, y_1 r_2$ and $y_1 r_4$ with message which method gives best solution.

}[1]

Else If C==3

{

INPUT: function $f$ end points $a, b;$ initial approximations $p_0, p_1;$ tolerance TOL, maximum number of iterations $N$ direct result $r$.

Step-1: Set $i = 2;$

$q_0 = f(p_0);$

$q_1 = f(p_1).$

Step-2: While $i \le N$ do Steps 3-7.

Step-3: Set $p = p_1 - q_1(p_1 - p_0)/(q_1 - q_0)$

Step-4: If $| p - p_1 | \le$ TOL then

OUTPUT $(p)$;

STOP.

Step-5: Set $i = i + 1;$

$q = f(p).$

Step-6: If $q * q_1 < 0$ then set

$p_0 = p_1;$

$q_0 = q_1.$

Step-7: Set $p_1 = p$;

$q_1 = q.$

Step-8: OUTPU (failure)

Step-9: Set $i = 1;$

$FA = f(a).$

Step-10: While $i \le N$ do steps 11-14

Step-11: Set $bi = a + (b - a)/2;$

$FB = f(bi).$

Step-12: If FB=0 or $\frac{b-a}{2}$ < TOL then

OUTPUT $(bi)$

STOP.

Step-13: $i = i + 1.$

Step-14: If $FA * FB > 0$ then set $a = bi$;

FA=FB

Else set $b = bi$

Step-15: OUTPUT(failure)

Step-16: Set $c = |p - r|, d = |bi - r|$

If (c<d) then

P

Else

bi

OUTPUT: A message which root is most accurate between Bisection and False position method.

STOP.

}

Else

STOP.

## IV. Conclusion

In this paper, we develop an algorithm incorporated with Numerical Integration (Trapezoidal rule, Simpson's $1/3$ rule, Simpson's $3/8$ rule and Weddle's rule.), Numerical Differentiation (Euler, modified Euler and Runge-Kutta second and fourth order) and finding Roots (Bisection method and False position method) numerically. We observed that the result obtained according to our procedure is completely identical with the hand calculation and save our time and labour. Moreover, Weddle's rule gives the best solution, the Runge-Kutta fourth order gives the best solution and the False position method gives the best solution in Numerical Integration, Numerical Differentiation and finding Roots numerically respectively.

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# Effect of Tool Tilt Angle on Aluminum 2014 Friction Stir Welds

By G. Gopala Krishna, P. Ram Reddy & M. Manzoor Hussain
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*Abstract-* Friction Stir Welding (FSW) is an emerging solid state welding process gaining more applicability in various industries due to better quality of the joint as it has no effect on the parent metal. This process utilises a non-consumable rotating tool to generate frictional hat between tool and abutting surface of work piece to accomplish the weld. Being a solid state joining process, friction stir welding process offers various advantages like low distortion, absence of melt related defects, high joint strength etc., as compared to other conventional fusion welding techniques.

An attempt has been made to study the influence of tool tilt angle on Aluminium 2014-T6 welds. A study on FSW of AA2014 Aluminium alloy at varying tool tilt angle ranging from 0 to 3 degrees at an interval of 0.5° and keeping other process parameters constant are presented in this paper. Present work also examines the force and torque during FSW with respect to defect development. This is due to owing to process parameters variation which results in variation in heat generation. The force on the pin in the metal flow direction (which is also called X-axis force) was correlated with defect formation, high X-axis force is recommended for defect free welds.

*Keywords: friction stir welding, aluminium AA2014-T6 alloy, tool tilt angle, microstructure, force and torque analysis.*

*GJRE-J Classification : FOR Code: 091399*

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## I. Introduction

Friction Stir Welding (FSW) is a solid state welding process (i.e., the metal is not melted during the process) developed and patented by The Welding Institute (TWI), UK in 1991 [1], emerged as a new welding technique to be used in high strength alloys that are difficult to join with conventional fusion welding techniques. The process was initially developed for Aluminium alloys but since then FSW was suitable for joining large number of other metals [2]. Conventional fusion welding of aluminium alloys often produce a weld which suffers from defects, such as porosity, distortion developed as a consequence of entrapped gas not being able to escape from the weld pool during solidification process. In contrast, with FSW the interaction of non consumable rotating tool traversing along the joint line creates a welding joint through plastic deformation and consequent heat dissipation resulting temperatures below the melting point of the materials being joined. Other interesting benefits of FSW compared to fusion welding processes are low distortion, excellent mechanical properties in the weld zone, execution without a shielding gas and suitability to weld all aluminium alloys [3].

FSW can be used to produce Lap, Butt, Corner, T, Spot, Fillet and Hem joints, as well as to weld hollow objects, such as tanks and tubes/pipes, stock with different thicknesses, tapered sections and parts with 3-dimensional contours [2 & 4]. The technique can produce joints utilizing equipment based on traditional machine tool technologies, and it has been used to weld a variety of similar and dissimilar alloys along with welding metal matrix composites and to repair existing joints. Replacement of fastened joints with FSW joints can lead to significant weight and cost savings, attractive propositions for many industries [5]. The basic principle of friction stir welding process is remarkable simple. A rotating tool with pin and shoulder is inserted in the material to be joined and traversed along the joint line. The heating is localized and generated by friction between the rotating tool and work piece, with additional adiabatic heating from metal deformation [6-7]. The pin and shoulder of the tool can be modified in number of ways to influence material flow and micro structural formation.

Mishra and Ma et.al reported that the recent development of scrolled tool shoulder tool shoulder allows FSW with no tool tilt [8]. Chen et.al. investigated that under the same welding parameters, channel-like defects were observed in the welds produced in tool tilt angle below 1.5° and above 4.5° [9]. They also stated that the tool tilt angle has an essential influence on the heat input and the position of the defects in the weld. Kato et.al. observed defects in the weld when the tool tilt angle is 0° and above 3° [10]. Z.Barlas et.al. experimentally studied and reported that defect free welds obtained with a tool tilt angle 2°. [11]. Moneer et.al reported that optimum results were achieved with a tool tilt angle of 2° and tool offset 1mm [12].

## II. Experimental Procedure

The material used for this research study is aluminium AA2014-T4 alloy of 5mm thick with 50 mm width and 80mm length. Holes of similar depth were drilled along the sides of the sample. Two holes were

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drilled, one on either sides (advancing and retreating side) of the weld line, where thermocouples were inserted to measure temperature. Holes of 2mm diameter were drilled till a depth of 3 mm away from the weld centre. These holes were 1 mm below the surface of weld as shown in Fig.1.

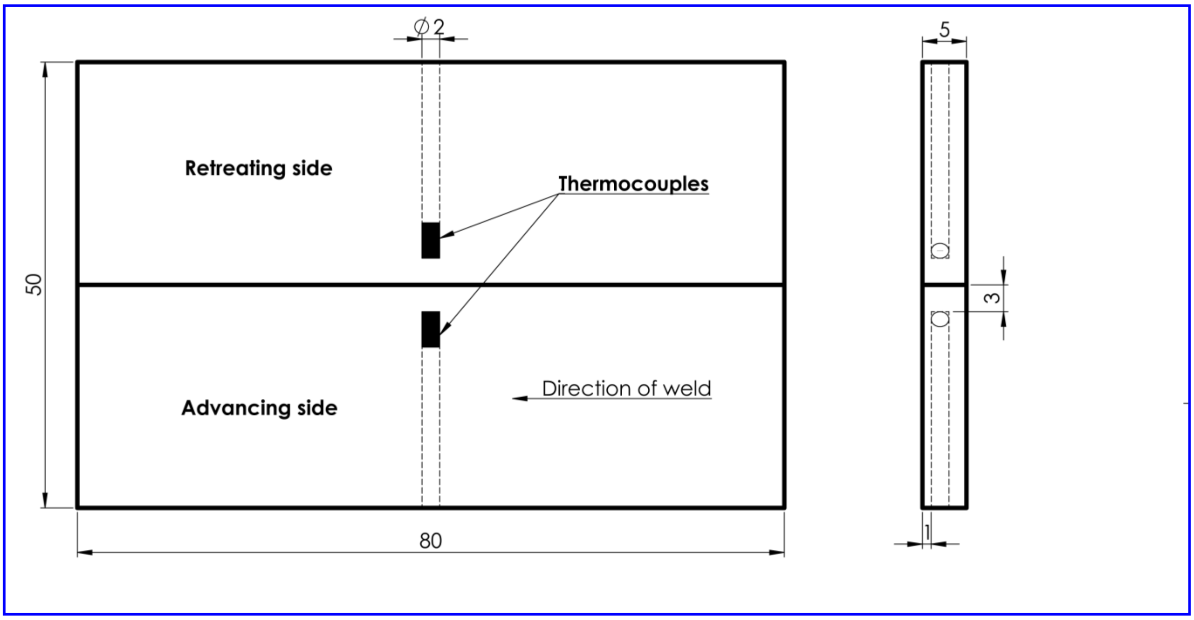


*Fig.1 :* Schematic diagram of plate used for FSW and temperature measurement (All dimensions are in mm)

A conical tool having right hand threads of pitch 1 mm with 6 mm diameter at the top and 3 mm diameter at the bottom is used for the experiments. The diameter of the shoulder of the tool is 15mm and pin length is 4.5mm. The tool material used in this study is hot worked die steel (AISI – H13) and is hardened to 50-55 HRC. The length of the pin is 0.5 mm, shorter than the base material thickness.

Die steel (AISI-H13) is known for its excellent hot hardness. It gains its elevated temperature strength from precipitation of chromium, vanadium and molybdenum carbides upon hardening and tempering. The dissolution temperature of chromium, vanadium and molybdenum carbides is above 550°C which makes the material suitable for FSW tool material.

The equipment is a three-axis vertically configured Friction Stir Welding / Friction Stir Surfacing machine which accommodates a maximum plate size of 500 X 300 mm and has a maximum thrust of 50 kN on Z-axis. To maintain tool tilt angle during linear welding, the head can be tilted manually. The machine is controlled through a high-end CRIO (Compact Real Time) module PLC (Programmable Logical Controller) from National Instruments with Lab view software. The equipment can acquire and record the X-axis load / displacement, Y-axis load / displacement, Z-axis load / displacement and Spindle speed / Torque.

The temperature reached by each point at the end of the drilled holes were monitored and stored in Midi Logger GL900, equipment from GRAPHTEC. It is capable of obtaining multifunction inputs from its 8 channels. Long-term data can be captured directly to built-in flash memory or to an external USB memory stick at sampling intervals of from 1micro seconds to 1 minute. For high-speed sampling at intervals faster than 1micro second, up to one million data points can be captured to internal RAM (Random Axis Memory). The acquired or displayed data can be transferred directly to PC (Personal Computer).

Temperature is measured by K-type thermocouples connected to the equipment. K-type (chromel {90 percent nickel and 10 percent chromium} – alumel {95% nickel, 2% manganese, 2% aluminium and 1% silicon}) is the most common general purpose thermocouple with a sensitivity of approximately 41 $\mu$V/°C, chromel positive relative to alumel. It is inexpensive, and a wide variety of probes are available in its −200°C to +1350°C / -328°F to +2462°F range.

FSW of AA 2014 plates were carried out at spindle speed 800 rpm, weld traverse speed 100 mm/min, tool downward feed 50 mm/min, plunge depth 4.8 mm and the force, torque data were acquired from the FSW equipment, for different tilt angle of tool: 0º, 0.5º, 1º, 1.5º, 2º, 2.5º and 3º. The temperatures attained by the different points were obtained from the temperature indicator "Midi Logger".

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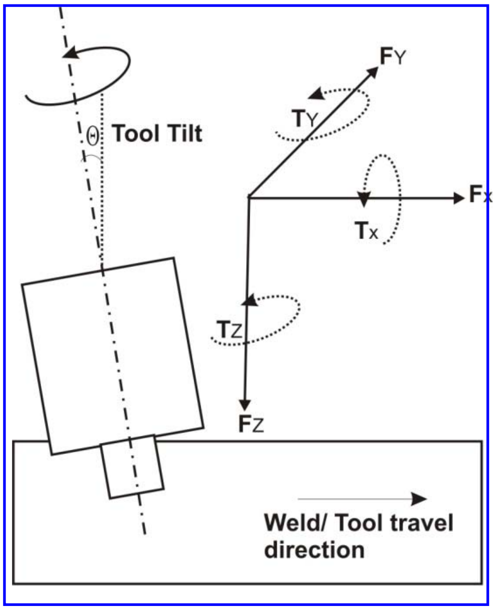



*Fig. 2 :* Tool Travel and applied Force Directions(x, y, z) on Friction Stir Welds

From the obtained data, average forces and torques were calculated from the stabilized values. Also the highest temperature attained during each tilt angle was plotted against tilt angle.

The plates were then cut, to view the microstructures obtained at different regions along the width of the plate – WNZ (Weld Nugget Zone), HAZ (Heat Affected Zone) and TMAZ (Thermo Mechanically Affected Zone). Hot mounting was done to the cut samples, where Bakelite powder was used to mount the sample. Hot mounting was done on all the samples at 150°C and 290 bar pressure, with 2 minutes heat time and 4 minutes cool time. The samples were then polished using emery papers and diamond polisher. Finally kerosene cloth used to obtain final finish to be viewed under microscope. Keller's reagent (190ml distilled water, 5ml $HNO_3$, 3ml HCL and 2ml HF) used to etch the sample. The sample was then viewed under microscope and micrographs were captured at different location.

## III. Results and Discussion

### *a) Macro and Microstructure*

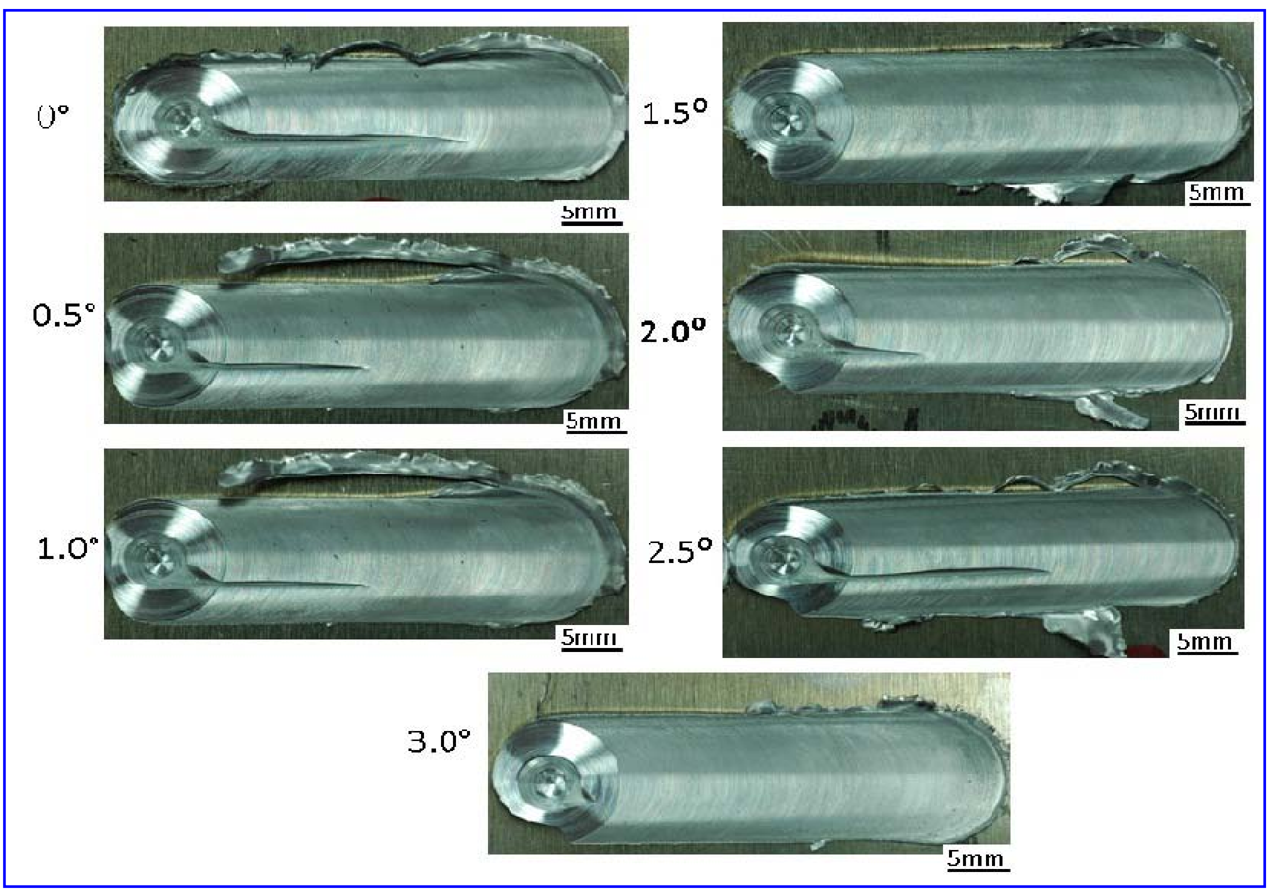



*Fig. 3 :* Top surface of weld at different Tool Tilt angle

Top surface of the weld shows surface defects on all welds made at different tool tilt angle except 1.5$^0$ and 3$^0$ tool tilt angle (Fig.3).

Microstructure of weld shows internal cavity formation in all joints except the joint made at tool tilt angle of 3$^o$ (Fig.4). The defect size reduces gradually from the lower tool tilt angle to higher tool tilt angle and vanishes at 3$^o$ tool tilt angle (Fig.5).

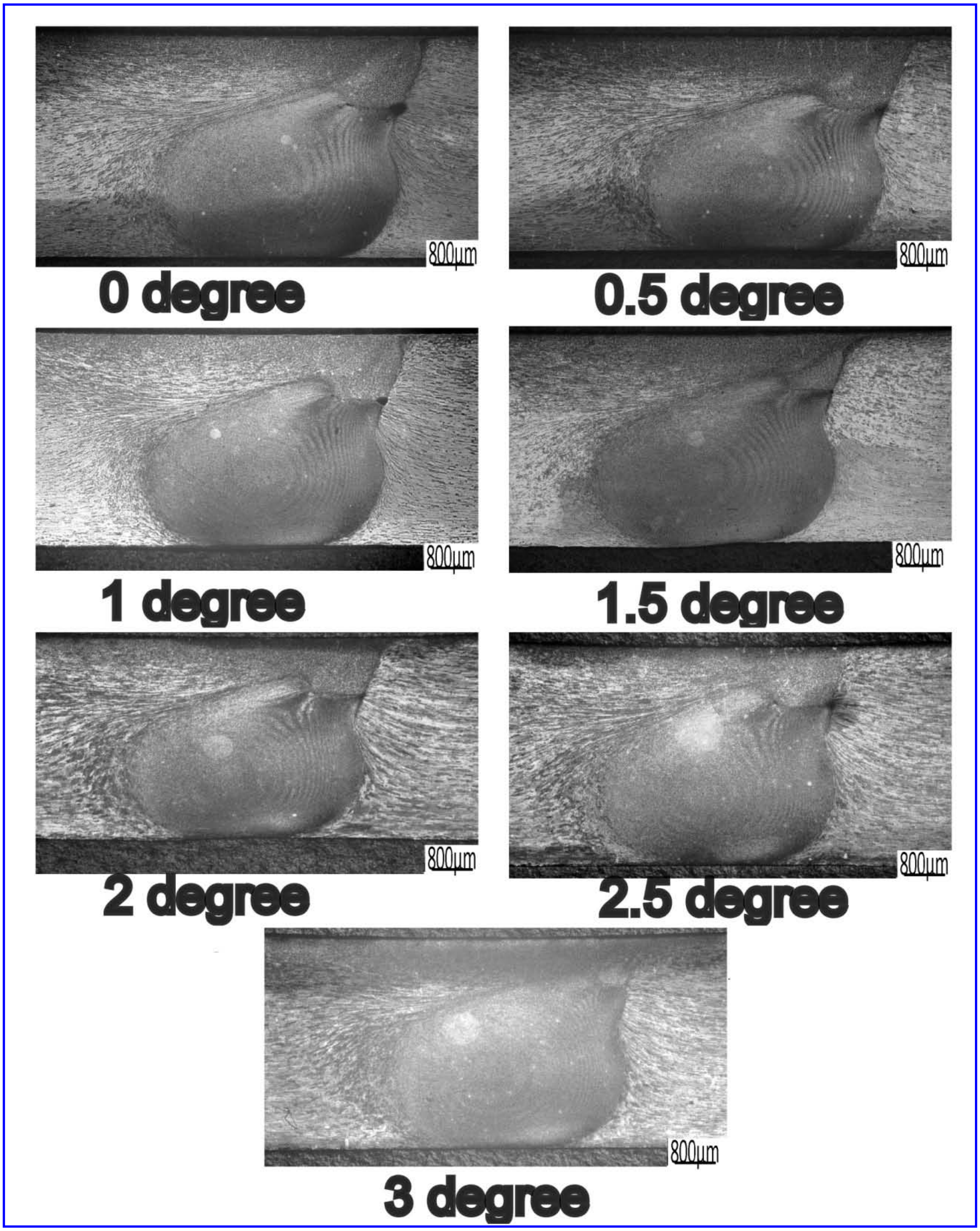



*Fig. 4 :* Microstructure of the friction stir welds elements at different tool tilt angle

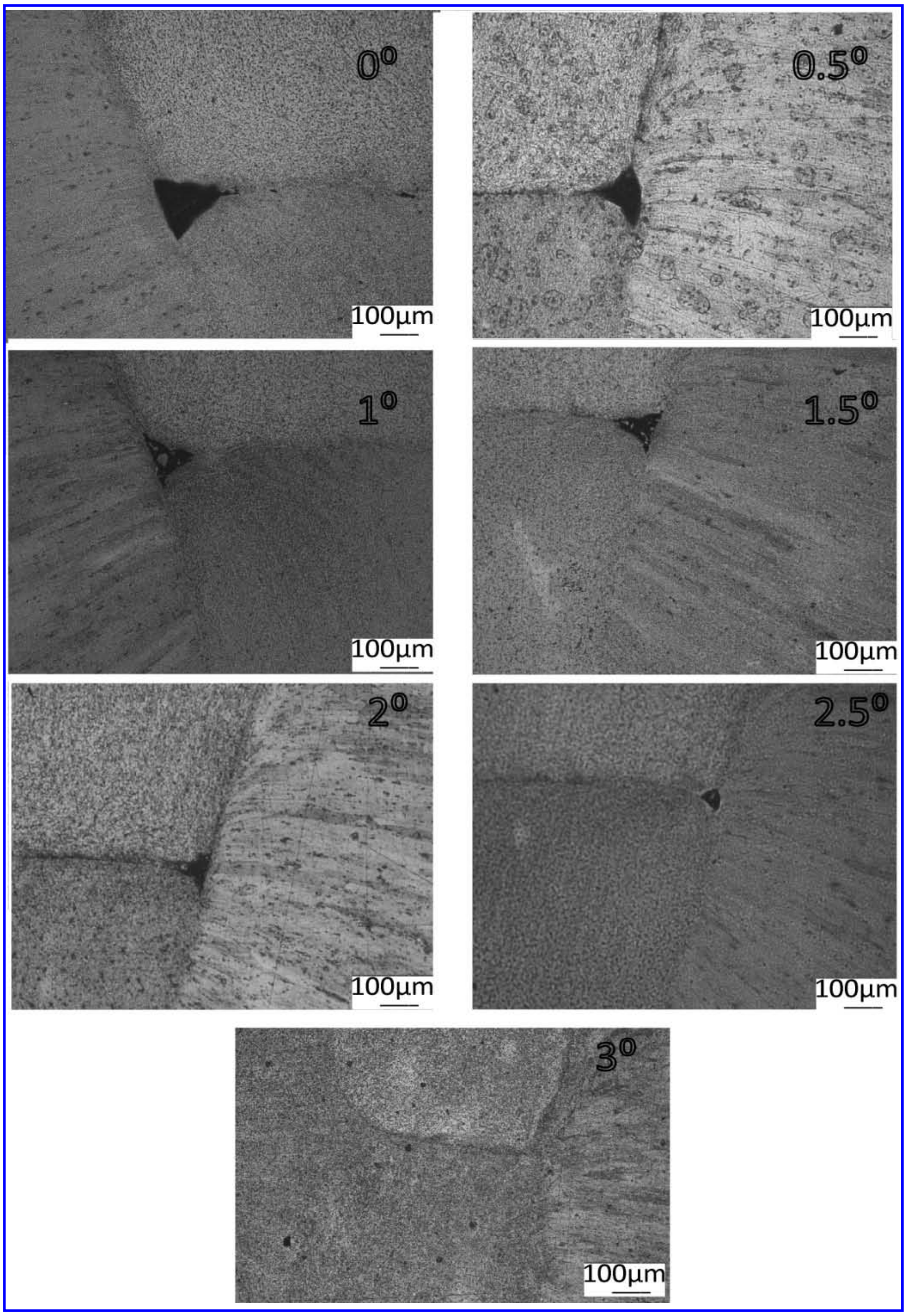



*Fig. 5 :* Defects at different tool tilt angle

Types of defects observed in surface (Fig.3.) and inside the weld (Fig.5.) can be considered as those which arise due to the lack of filling. Increase in tool tilt results in sharp increase in Z-torque, (Fig.7), X-load (Fig.9) and Z-load (Fig.11) with slight increase in temperature (Fig.12). High torque, load and temperature indicate that the material is heated up to a wider extent and stirred adequately to fill the cavities left unfilled at low tool tilt angle. Increase of tool tilt angle also results in increase of forging action on the trailing edge of the weld thereby filling the cavities which otherwise remains at lower tool tilt angle.

i. *Different zones revealed during optical microscopy are:*

A- Heat Affected Zone (HAZ) at retreating side

B- Thermo-Mechanically Affected zone (TMAZ) at retreating side

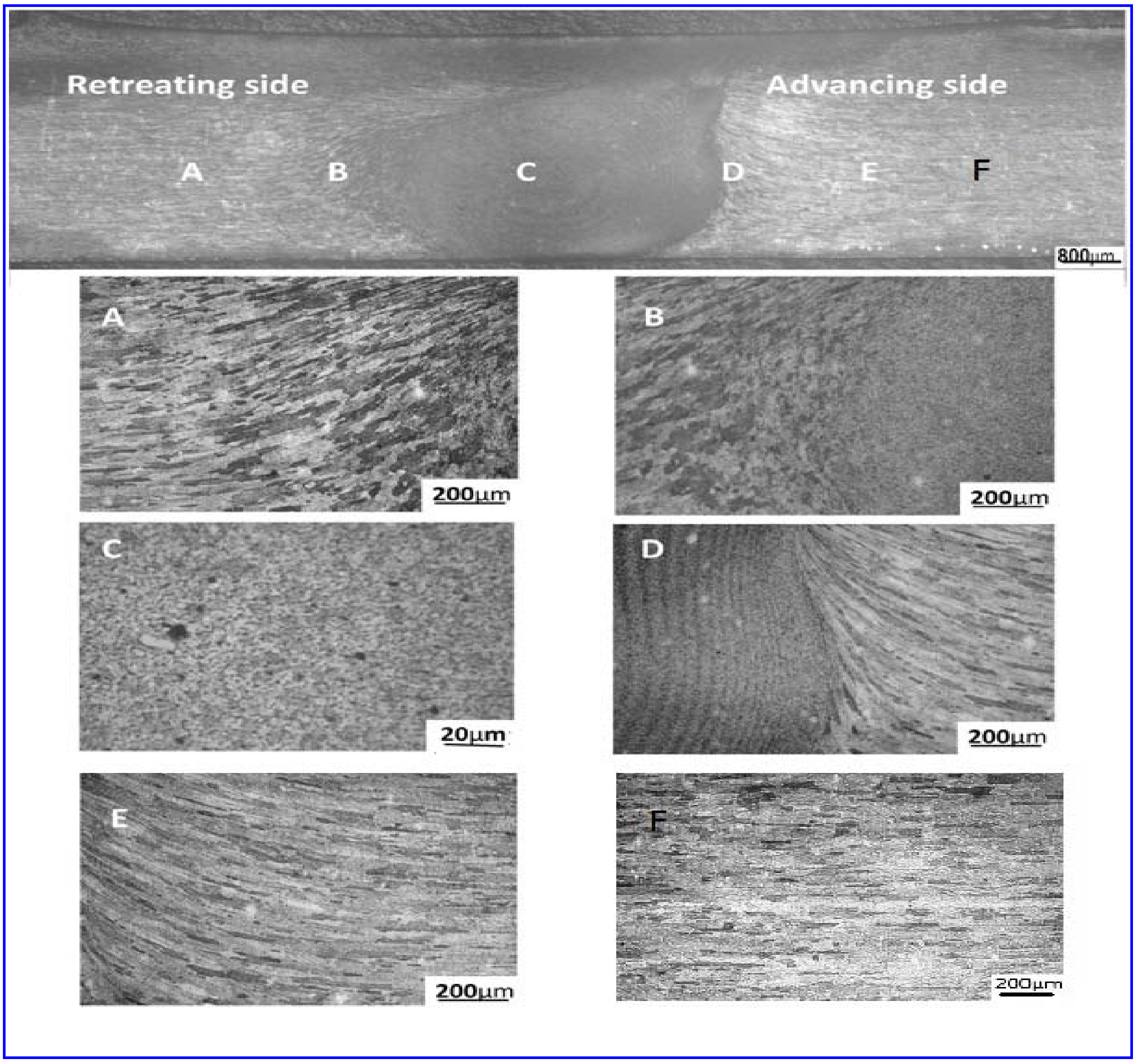
C- Stir Zone

D- Thermo-Mechanically Affected zone (TMAZ) at advancing zone

E- Heat Affected Zone (HAZ) advancing zone

F- Parent metal

Typical microstructures at different locations of a weld at tool tilt angle of 3° are shown in Fig.6. The Weld Nugget Zone (WNZ) has experienced high-temperature and extensive plastic deformation, and is characterized by a dynamically re-crystallized, fine equi-axed grain structure (Fig.6C). The Thermo-Mechanically Affected Zone (TMAZ) is created by plastic shear stress around the plastic flow of material and the grains are elongated along the direction of maximum shear stress. The elongated grains are seen around the WNZ (Fig.6 B & D). The Heat-Affected Zone (HAZ) is affected only by the thermal cycle without the role of mechanical stir, so the microstructure characteristic of the HAZ is coarse grains (Fig.6 A & E). It can also be observed that in the advancing side, a clear boundary is visible in between TMAZ and WNZ, which is not observed in the retreating side (Fig.6 B & D).




A- HAZ at retreating side
B- TMAZ at retreating side
C- Stir Zone
D- TMAZ at advancing zone
E- HAZ advancing zone
F- Parent metal

*Fig. 6 :* Microstructures at different zones of a friction stir welded joint with 3° tool tilt angle

### *b) Force and Torque analysis*

i. *Z-torque*

Z torque increases with increase in tool tilt angle. Increase in tool tilt angle results in more heat generation and hence more material is plasticized which has to be stirred resulting in increase of z torque (Fig.7).

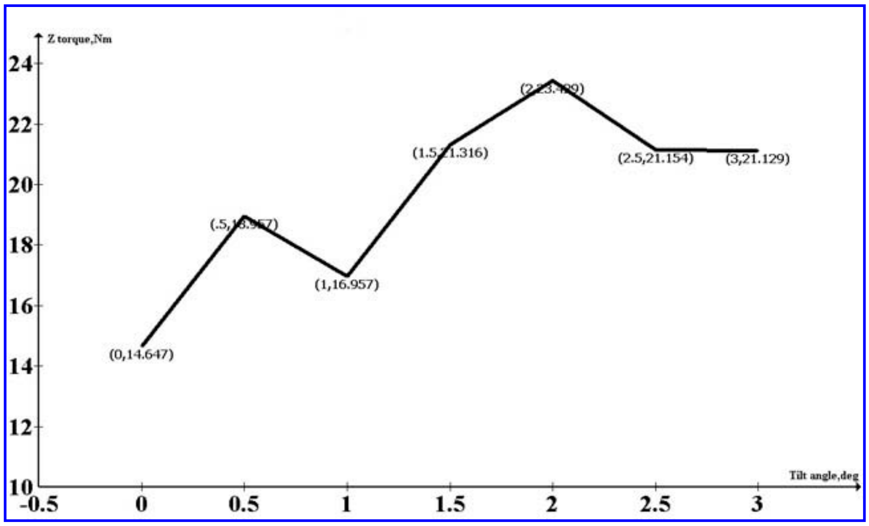



*Fig.7 :* Variation of Z torque Vs tilt angle

ii. *X-Load*

X-load is minimum during the initial plunging and dwelling period (Fig.8). Once the lateral movement of the tool starts an increase in X-load is observed as the tool has to move against the solid material ahead.

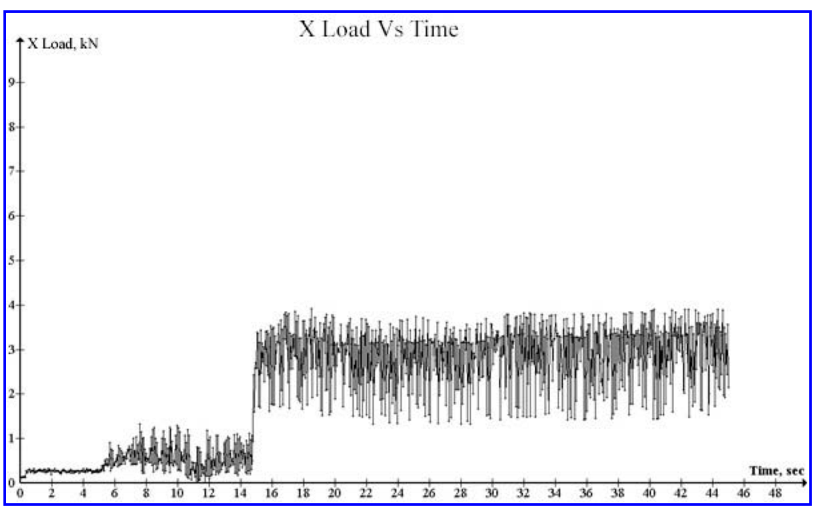



*Fig. 8 :* Variation of X load Vs time

X load increases gradually with increase in tool tilt angle (Fig.8) due to the following factors:

- With increasing tool tilt X component of Z-load increases continuously which adds to X-load.
- The pin of the tool is exposed more to the solid material.
- Due to the rise in temperature more material is plasticized, hence tool has to carry more material along with it during welding.

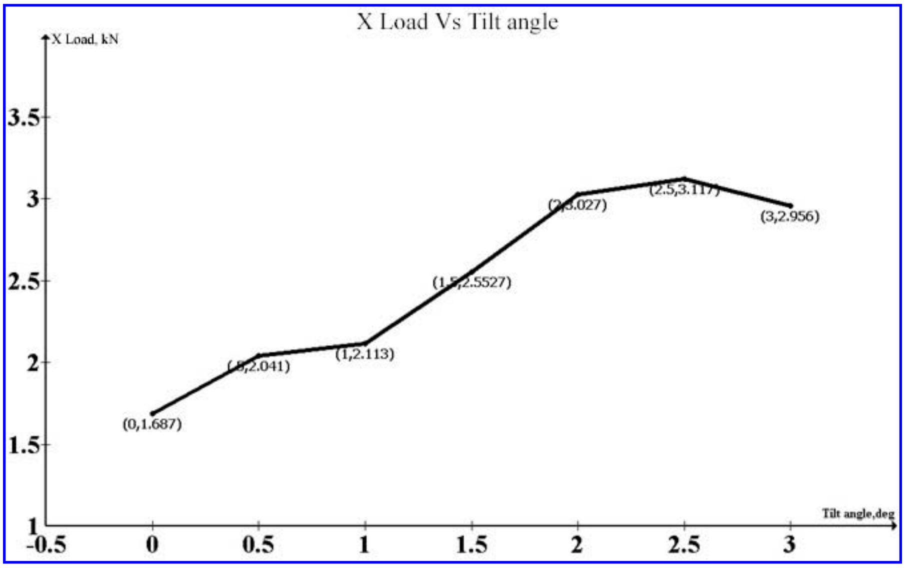



*Fig. 9:* Variation of X load Vs tilt angle

iii. *Z-Load*

Z-load continuously increases as the plunging starts. Two peaks are observed, first corresponding to full penetration of the pin while the second corresponds to rubbing of the shoulder (Fig.10). Once the shoulder touches the material and starts dwelling, the material gets soften and Z-load drops till the steady state is reached when Z-load becomes uniform.

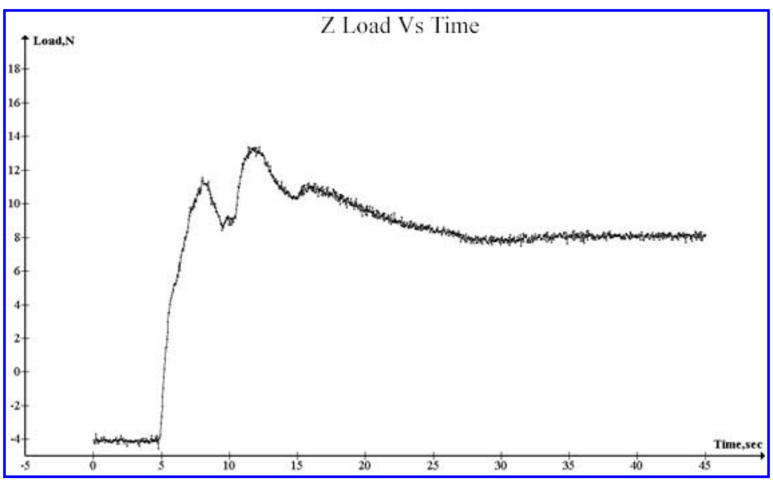



*Fig.10 :* Variation of Z Load Vs Time

Increase in Z-load with increase in tool tilt angle is observed (Fig.11). This increase in Z-load can be attributed to effective increase in plunge depth (plunging of shoulder) at the trailing edge of weld. Increase in plunge depth due to the shoulder results in increased forging action on the weld and there by filling the cavity generated at the surface or inside the welds at lower tool tilt angle.

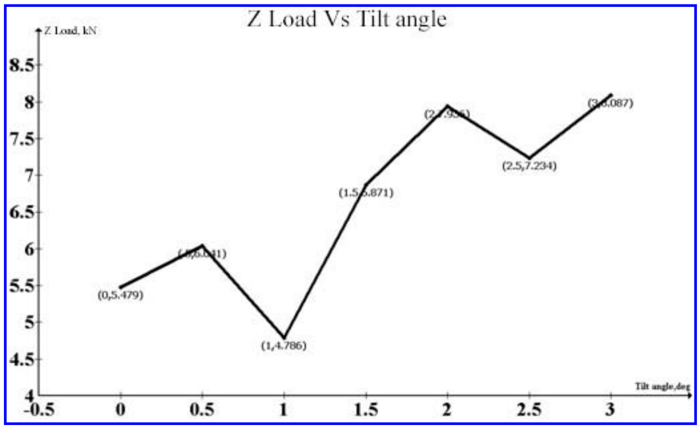



*Fig.11 :* Variation of Z load Vs tilt angle

iv. *Temperature Analysis*

In general, it can be observed that temperature attained is higher in advancing side, than the retreating side (Fig.12). This is because material flow and plastic deformation around tool is from advancing side to retreating side additional to friction heat under the shoulder that gives higher temperature. So, the slipping rate on the retreating side is lower than the slipping rate on the advancing side. This is the reason that the heat fluxes on the advancing sides are higher, which leads to the fact that the temperatures are higher in this region. Due to the difference in temperature profile in advancing and retreating side, difference in microstructure (Fig.4) is also observed between advancing and retreating side.

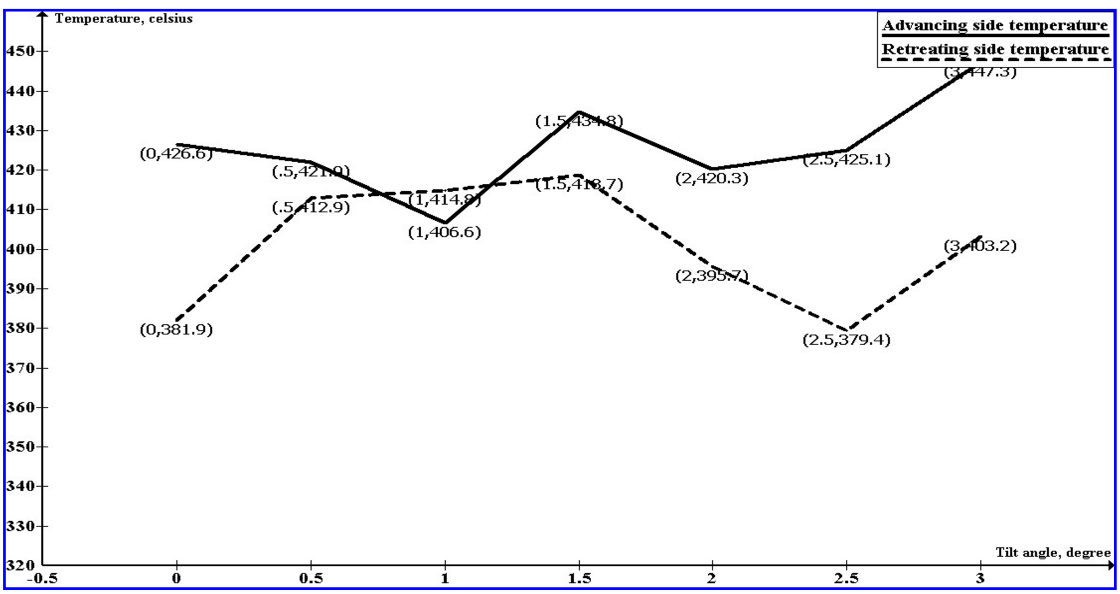



*Fig.12 :* Variation of peak temperature (at advancing and retreating side) with tool tilt angle

## IV. Conclusions

a) Defects are formed on the surface and inside the weld due to lack of filling at lower tilt angles.

b) The weld nugget zone (WNZ) experiences high-temperature and extensive plastic deformation, and is characterized by a dynamically recrystallized, fine equiaxed grain structure. The thermo-mechanically affected zone (TMAZ) is created by plastic shear stress around the plastic flow of material and the grains are elongated along the direction of maximum shear stress. In the advancing side, a clear boundary is visible in between TMAZ and WNZ, which is not observed in the retreating side.

c) X load increases gradually with increase in tool tilt angle because,

   i. With increasing tool tilt X component of Z-load increases continuously which adds to X-load.

   ii. The pin of the tool is exposed more to the solid material.

   iii. Due to the rise in temperature more material is plasticized, so tool has to carry more material along with it.

d) Increase in Z-load with increase in tool tilt angle is observed. This increase in Z-load can be attributed to effective increase in plunge depth (plunging of shoulder) at the trailing edge of weld. Increase in plunge depth due to the shoulder results in increased forging action on the weld and thereby filling the cavity generated at the surface or inside the weld.

e) Z torque increases with increase in tool tilt angle as increase in tool tilt results in more heat generation and hence more material is plastized which has to be stirred resulting in increase of z torque.

f) Temperature distribution during FSW is not uniform throughout the plate being welded. There is a difference in temperature attained by regions in advancing side and retreating side. In general, it can be observed that temperature attained is higher in advancing side, than the retreating side.

g) High tool tilt angle of around $3^{o}$ is recommended for welding AA 2014 aluminium alloy for the given value of feed 100 mm/min and speed 1000 rpm to get defect free welds.

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# Increasing Productivity through Facility Layout Improvement using Systematic Layout Planning Pattern Theory

By Md. Riyad Hossain, Md. Kamruzzaman Rasel & Subrata Talapatra
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*Abstract-* In this paper ongoing production process layout of jute industry are studied and a new layout will be developed based on the systematic layout planning pattern theory to reduce production cost and increase productivity. The number of equipment and travelling area of material in yarn production have been analyzed. The detailed study of the plant layout such as operation process chart, activity relationship chart and relationship between equipment and area has been investigated. The new plant layout has been designed and compared with existing plant layout. The new plant layout shows that the distance and overall cost of material flow from stores to dispatch area are significantly decreased.

*Keywords: operation process chart, facility layout, SLP, activity relationship chart.*

*GJRE-J Classification : FOR Code: 290502*

INCREASINGPRODUCTIVITYTHROUGHFACILITYLAYOUTIMPROVEMENTUSINGSYSTEMATICLAYOUTPLANNINGPATTERNTHEORY

*Strictly as per the compliance and regulations of:*

# Increasing Productivity through Facility Layout Improvement using Systematic Layout Planning Pattern Theory

Md. Riyad Hossain [α], Md. Kamruzzaman Rasel [σ] & Subrata Talapatra [ρ]

*Abstract-* In this paper ongoing production process layout of jute industry are studied and a new layout will be developed based on the systematic layout planning pattern theory to reduce production cost and increase productivity. The number of equipment and travelling area of material in yarn production have been analyzed. The detailed study of the plant layout such as operation process chart, activity relationship chart and relationship between equipment and area has been investigated. The new plant layout has been designed and compared with existing plant layout. The new plant layout shows that the distance and overall cost of material flow from stores to dispatch area are significantly decreased.

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## I. Introduction

Facility layout concerns with the optimum arrangement of departments with known dimensions in such a way that minimizes materials handling and ensure effective utilization of men, equipment and space. In the competitive world, demand is continuously increasing where resources are always limited. In industry sectors, it is important to manufacture the products which have good quality and meet customers demand. This action could be conducted under the existing resources like employees, machines and other facilities. For this reason, industrial factories need to increase their potentials in production and effectiveness to compete against their competitors. That is why; the production process needs to be set in a proper organized way that minimizes production cost with higher effectiveness. Therefore, the way of solving the problem of production is very important.

There are many techniques like quality control (QC), Pareto analysis, total quality management (TQM), control chart and plant layout are used to solve the problems concerning productivity. However, plant layout improvement could be one of the tools to response to industrial productivity improvement by the reduction of cost of manufacturing with a proper workflow in production route. For ensuring proper workflow departments are arranged in such a way that optimizes their relative placement. Sometimes, optimal placement means placing inter dependent traffic departments adjacent to one another. Knowing the nature of flow between departments and process of material flow is important.

Systematic layout planning pattern (SLP) theory is used to analyze the step-by-step of layout facility from raw material storage to finish product dispatched. This method helps to develop a new plant layout with improved process flow and effective utilization of space. On the Basis of production, designing a new layout may follow different ways such as product, process, mixed, fixed position and group layout. Since yarn is produced in mass production system with a limited variety on a steady demand, product layout is the matter of concern.

This paper is organized as follows. Section 2 gives an overview of relevant literature. In section 3 provides the methodology of SLP procedure. Analysis of original plant layout is shown in section 4. In section 5 original plant layout is analyzed by SLP theory. Proposed layout is shown in section 6. Comparison between proposed and existing layout is shown in section 7. Finally in section 8 shows the resells, conclusion & further work that can be done in this field.

## II. Literature Review

Many researches have been done in facility planning area. Effective facility planning can reduce significantly the operational costs of a company by 10-30%. Proper analysis of facility layout design could result in the improvement of the performance of production line. This can be realized by optimizing the capacity of a bottleneck; minimizing material handling costs; reducing idle time; maximizing the utilization of labor, equipment and space.

Facility planning is an overall approach concerned with the design, layout and incorporation of people, machines and activities of a system. Huang emphasizes that facility layout design defines how to organize, locate, and distribute the equipment and support activities in a manufacturing facility to accomplish minimization of overall production time, maximization of operational efficiency, growth of revenue and maximization of factory output in conformance with production and strategic goals.

Wiyaratn and A. Watanapa study plant layout of iron manufacturing based on the systematic layout planning pattern theory (SLP) for increased productivity.

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The detailed study of the plant layout such as operation process chart, flow of material and activity relationship chart has been investigated. The new plant layout has been designed and compared with the present plant layout. The SLP method showed that new plant layout significantly decrease the distance of material flow from billet cutting process until keeping in ware house.

R. Jayachitra and P. S. S. Prasad, study the suitability of a virtual cellular layout (VCL) along with an existing functional layout (FL) of an industry and a classical cellular layout (CL), if considered for implementation. A Genetic algorithm (GA) based intra-cell formation procedure is used in the cellular layout design. To identify the suitability of a particular layout in a given environment, a typical manufacturing system is modeled using the WITNESS 2006 simulation software. Design of experiments (DOE) is used to plan the simulation experiments.

Bozarth C. and P. M.Vilarinho (2006) discuss the impact of space utilization and production planning on the spacer requirement. It highlights the fact that layout is affected by all other activities. Chung S-H., W. L.Pearn and A. H. I. Lee (2006) provides some production performance measures on product mixes in semiconductor fabrication, which also clarifies the complexities involved in this environment. Pinto and Shayan (2007) applied several formal layout procedures to a real production environment demonstrating the advantages of formal methods over the ad hoc practices of the company. Although traditionally layout problems were mainly focusing on process layout scenarios, mathematical modeling of product based layout shave also been developed considerably.

## III. Methodology

The data were collected and the number of tools & equipment for manufacturing were counted in terms of directional flow of raw materials and product. The operation process chart, flow of material and activity relationship chart have been used in analysis. The problem of the plant was determined and analyzed through SLP method to plan the relationship between the equipment's and the area. The framework of SLP is shown. Based on the data such as product, quantity, route, support, time and relationships between material flow from –to chart and activity relation chart are displayed. From the material flow and relationship activity in production, the relation between each operation unit can be observed. Muther's Systematic Layout planning include following steps-

a) Flow of materials.
b) Activity relationships.
c) Relationship diagram.
d) Space requirements & Space available.
e) Space relationship diagram.
f) Modifying considerations.
g) Practical limitations.
h) Develop layout alternatives.
i) Evaluation.

Above steps are used to analyze the existing layout and developed a new layout.

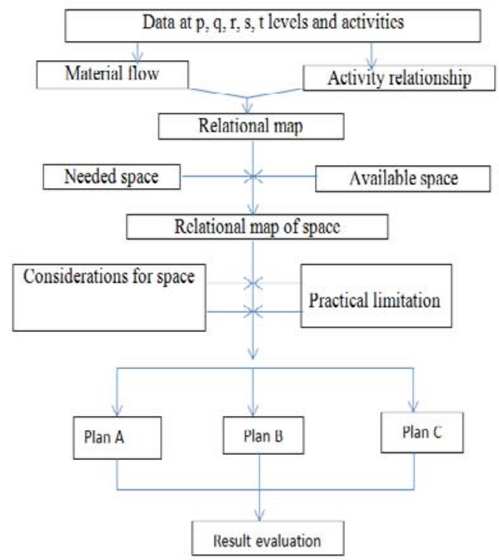



*Fig. No. 1 :* Systematic Layout planning

Operation flow process chart

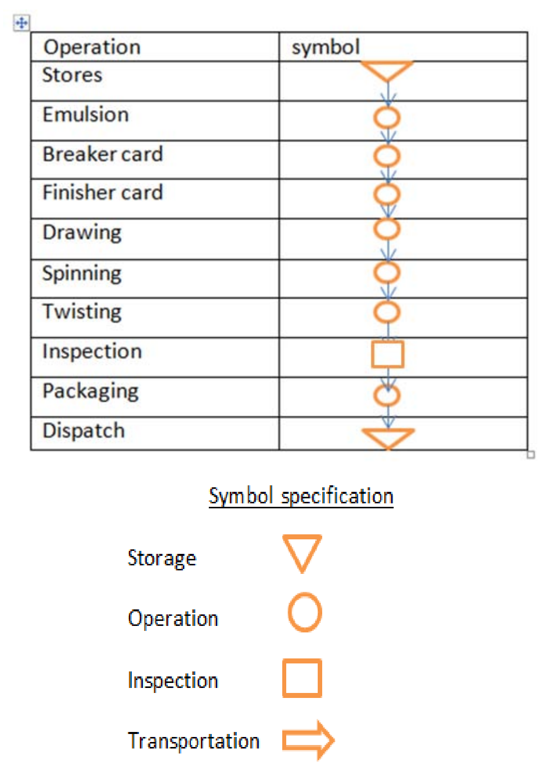



*Fig. No. 2 :* Operation flow process chart

## IV. Analysis of Original Plant Layout

This case is based on the yarn production of jute industry. The original layout of company shown in

Fig.No.3 and the details of each section were described as follows:

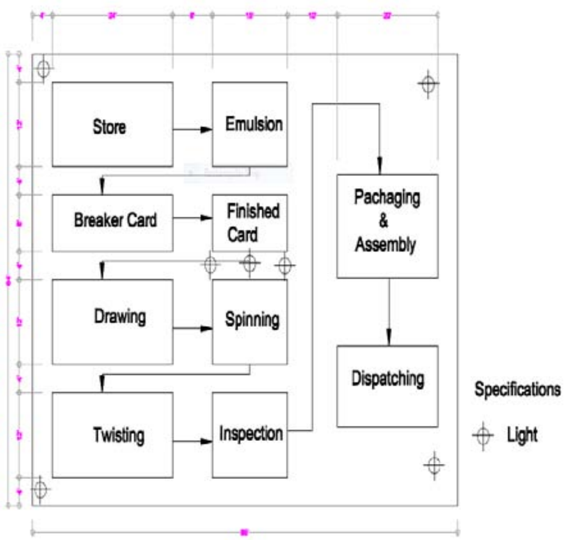



*Fig. No. 3 :* Existing layout

In this study, the yarn production of standard sizes is mostly analyzed. The operation process flow is shown in Fig. 2. The size of the equipment was relational to the area as shown in Table 1. According to the original plant layout, total working area, distance travelled of materials and unit flow cost and total cost could be discussed as follows:

*Table No.1 :* Relationship between equipment size and area

| Department | Number of equipment | Equipment area ( $ft^2$) | Total working area ( $ft^2$) |
|---|---|---|---|
| Stores | - | - | 180 |
| Emulsion | 1 | 140 | 180 |
| Breaker card | 2 | 160 | 192 |
| Finisher card | 1 | 240 | 288 |
| Drawing | 4 | 240 | 288 |
| Spinning | 2 | 160 | 180 |
| Twisting | 1 | 160 | 180 |
| Inspection | 4 | 100 | 120 |
| Packaging | 2 | 260 | 300 |
| Dispatch | - | - | 240 |

a) *The Flow of Materials*

Raw materials carrying are barely maintained in a sequential path that increases the waste of time, resulting in high cost as shown in Table No.2 that clearly show a relationship between distance with cost.

b) *Utility of the Area*

Total working area is more than equipment area because some spaces are required for the temporal storage of work in process inventory as well as free movement of worker.

c) *The Amount and Sequence for Manufacturing*

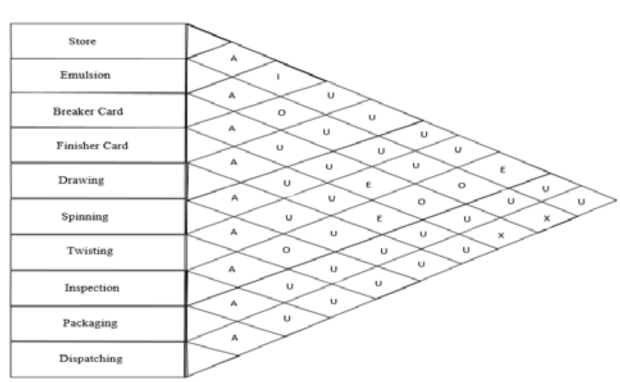
In a cycle of yarn production, there produced 100KG of final product. Total cost incurred with production is raw material cost, machining cost, transportation cost and wages. By applying the process of SLP costs related with transportation can be reduced. Statistics shows that per meter transportation cost is 6.75BDT. Our goal is to rearrange the department in such a way that will reduce both travelled distance and transportation cost.

*Table No. 2 :* Distance and cost incurred with present layout

| From | To | Distance (ft.) | Unit cost (BDT) |
|---|---|---|---|
| Stores | Emulsion | 23.5 | 158.625 |
| Emulsion | Breaker card | 37.5 | 253.125 |
| Breaker card | Finisher card | 23.5 | 158.625 |
| Finisher card | Drawing | 37.5 | 253.125 |
| Drawing | Spinning | 23.5 | 158.625 |
| Spinning | Twisting | 39.5 | 266.625 |
| Twisting | Inspection | 23.5 | 158.625 |
| Inspection | Packaging | 45.0 | 303.75 |
| Packaging | Dispatch | 17.5 | 118.125 |
| | Total | | 1829.25 |

## V. Analysis Plant Layout based on SLP

According to the study of the manufacturing process, it was found that the travelled distance should be reduced for moving raw materials and also the useless area should be reduced. It is done by applying SLP method on the existing plant lay out. The result is continuous work flow with a sequential departmental arrangement. Activity relationship chart is used to find the most dependent department based on sequential activity. The activity relationship chart is defined as follows. The reason behind most absolute essential department is continuous flow of material. Beside that sometimes they share common personnel, similar type of supervision, same space or equal opportunity of convenience.



Closeness Rating

| Rating | Definition |
|---|---|
| A | Absolutely essential |
| E | Especially important |
| I | important |
| O | Ordinary closeness |
| U | Unimportant |
| X | Undesirable |

| Code | Reason |
|---|---|
| 1 | Flow of material |
| 2 | Type of supervision |
| 3 | Common personnel |
| 4 | Share same space |
| 5 | Convenience |

*Fig. No. 4 :* Activity relationship chart

## VI. Analysis of Proposed Layout

The proposed layout is based on the activity relationship chart and the theme of reducing travelled distance. Altering the positions between several departments will ensure smooth flow of materials as well as it will reduce total travelled distance throughout the production unit. The proposed layout are shown in Fig.No.5 with some ergonomic advantages over existing layout while Table No.3 shows the relationship between cost and distance of proposed layout.

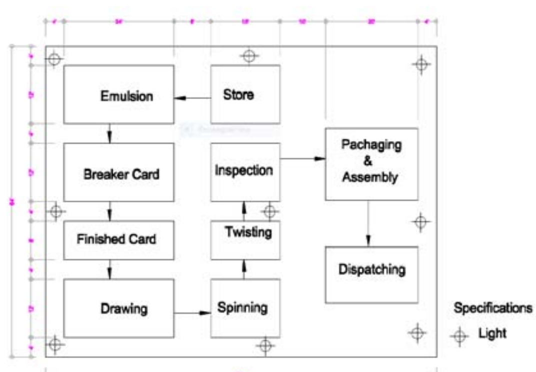



*Fig. No. 5 :* Proposed Layout

*Table No. 3 :* Distance and cost associated with present layout:

| From | To | Distance (ft.) | Unit cost (BDT) |
|---|---|---|---|
| Stores | Emulsion | 23.5 | 158.65 |
| Emulsion | Breaker card | 14.0 | 94.5 |
| Breaker card | Finisher card | 14.0 | 94.5 |
| Finisher card | Drawing | 16.0 | 108.0 |
| Drawing | Spinning | 23.5 | 158.65 |
| Spinning | Twisting | 16.0 | 108.0 |
| Twisting | Inspection | 14.0 | 94.5 |
| Inspection | Packaging | 27.5 | 185.625 |
| Packaging | Dispatch | 17.5 | 118.625 |
| | Total | | 1120.5 |

## VII. Result

After analyzing the existing layout it is shown that for a production of 100kg yarn total material handling costs are 1829.25BDT while it is reduced to 1120.5BDT for the modified layout. Implementation of newly developed layout can save 38.75% of total handling costs. It is due to the reduction of the distance between workflow and smooth flow of material throughout the cycle. Therefore rearranging the layout improves material flow, reduced travelled distance and cost resulting in an increase in production.

Conclusions & future study

In this paper per unit cost and distance are considered to improve existing layout but there are many other parameters to analyze the layout that may be worker number, area required, equipment required. Due to Lack of opportunity and practical limitations above two parameters are used in our calculation.

The problem of existing layout is large comparative distance between several departments that's forced to travel long distance and impedes the smooth material flow and leads to higher cost.

In our proposed layout the position of various departments are altered with various others based on activity relationship chart.

The machines (Breaker card, Finisher card, Drawing, twisting) used in yarn production are highly weighted. The alternation of those machines are highly costly and time consuming. So, This proposed model will mostly be preferable while setting up a new plant.

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# Common Fixed Point Theorems for Self-Maps on Metric Spaces with Weak Distance

By V. Siva Rama Prasad & T. Phaneendra
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*Abstract-* **Fixed point theorems on complete metric spaces with a weak distance proved by Ume and Yi [4] have been improved under weaker conditions. The results of this paper also generalize those of Brian Fisher [1], Dien [3] and Liu et al. [6].**

*Keywords:* *self-map, w-distance on a metric space, (g; f)-orbit at a point, Common fixed point.*

*GJRE-J Classification :* *FOR Code: 47H10, 54H25*

*Strictly as per the compliance and regulations of:*

# Common Fixed Point Theorems for Self-Maps on Metric Spaces with Weak Distance

V. Siva Rama Prasad [α] & T. Phaneendra [σ]

***Abstract-*** **Fixed point theorems on complete metric spaces with a weak distance proved by Ume and Yi [4] have been improved under weaker conditions. The results of this paper also generalize those of Brian Fisher [1], Dien [3] and Liu et al. [6].**

*Keywords: self-map,* w*-distance on a metric space,* (g; f)*-orbit at a point, Common fixed point.*

## I. Introduction

Let $(X;\ d)$ be a metric space. If $f$ is a self-map on $X$, and $x_0 \in X$, we denote by $fx$ the $f$-image of $x_0$.

As a weaker form of the metric $d$, Kada et al. [5] introduced the notion of weak distance (or simply $w$-distance) on $X$ as follows:

*Definition 1.1.* Let $(X;\ d)$ be a metric space and $p : X \times X \to [0, \infty)$ satisfy the following conditions:

$(w_1)$ $p(x, y) \leq p(x, z) + p(z, y)$ for all $x, y, z \in X$

$(w_2)$ For any $x \in X$, $p(x, \cdot) : X \to \mathbb{R}_+$ is lower semi continuous in the second variable, that is $p(x, y_n) \leq \liminf p(x, y_n)$ whenever $y_n \to y$ as $n \to \infty$ for some $x \in X$, and

$(w_3)$ Given $\epsilon > 0$, there is a $\delta > 0$ such that $p(z, x) \leq \delta$ and $p(z, y) \leq \delta$ imply that $d(x, y) < \epsilon$.

Then $p$ is known as a $w$-distance on $X$.

Obviously, every metric $d$ on $X$ satisfies the conditions $(w_1)$-$(w_3)$, that is $d$ is a $w$ -distance on $X$.

*Example 1.1.* Let $X = \left\{\frac{1}{m} : m = 1, 2, 3, \ldots\right\} \bigcup \{0\}$ with metric $d(x,\ y) = x + y$ if $x \neq y$ and $d(x,\ y) = 0$ if $x = y$ for all $x, y \in X$. Note that $(X, d)$ is a complete metric space. Define $p(x,y) = y$. Then $p$ a $w$ -distance on $X$.

For other examples one can refer to [5].

Recently Ume and Sucheol [4] have proved two common fixed point theorems, given below, for self-maps on a complete metric space with a $w$ -distance on $X$, which generalize and improve the results of Fisher [1], Dien [3] and Liu et al. [6].

*Theorem 1.1* ([4], Theorem 3.1). Let $X$ be a complete metric space $(X,\ d)$ with $w$-distance $p$ on it. Suppose that $f$, $g$: $X \to X$ and $\phi : X \to [0,\infty)$ satisfy the conditions:

(a)
$$g(X) \subset f(X) \tag{1.1}$$

(b) there exists $at \in X$ such that
$$p(t, gx) \leq rp(t, fx) + \phi(fx) - \phi(gx) \quad for\ all \quad x, y \in X, \quad 0 \leq r < 1 \tag{1.2}$$

(c) for every sequence $\langle x_n \rangle_{n=1}^{\infty}$ in $X$ with
$$\lim_{n\to\infty} p(t, fx_n) = 0 = \lim_{n\to\infty} p(t, gx_n), \tag{1.3}$$
we have
$$\lim_{n\to\infty} \max\{p(t, fx_n), p(t, gx_n), p(fgx_n, gfx_n)\} = 0,$$
and

(d) for each $u \in X$ with $u \neq fu$ or $u \neq gu$
$$\{p(u,fx) + p(u,gx) + p(fgx,gfx) : x \in X\} > 0. \tag{1.4}$$

Then $f$ and $g$ will have a unique common fixed point.

*Theorem 1.2* ([4], Theorem 3.6). Let $X$ be a complete metric space $(X,\ d)$ with $w$-distance $p$ and the mappings $f$,$g$: $X \to X$ satisfy the conditions $(a)$ and $(d)$. Suppose that $\phi, \psi : X \to [0,\infty)$ are such that

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(e) for every sequence $\langle x_n \rangle_{n=1}^{\infty}$ in $X$ with $\lim_{n\to\infty} fx_n = \lim_{n\to\infty} gx_n = t$,

we have $\lim_{n\to\infty} \max\{p(t, fx_n), p(t, gx_n), p(fgx_n, gfx_n)\} = 0$,

and

(f)

$$p(gx, gy) \le a_1 p(fx, fy) + a_2 p(fx, gx) + a_3 p(fy, gy)$$

$$+ a_4 p(fx, gy) + a_5 \sqrt{p(gx, fy)d(fy, gx)} + [\phi(fx) - \phi(gx)] + [\psi(fy) - \psi(gy)] \quad (1.5)$$

for all $x,\ y \in X$ where $a_i \in [0,1),\ i = 1,2,3,4,5$ are such that

$$a_1 + a_4 + a_5 < 1 \text{ and } a_1 + a_2 + a_3 + 2a_4 < 1 \quad (1.6)$$

Then $f$ and $g$ will have a unique common fixed point.

The purpose of this paper is to establish two fixed point theorems, which generalize those of Brian Fisher [1], Dien [3] and Liu et al. [6].

## II. Preliminaries

First we state the following lemma, proved in [5]:

*Lemma 2.1.* Let $X$ be a metric space with $w$-distance $p$ on it. Then

(g) $p(x,y) = 0$ and $p(x,z) = 0$ imply that $y = z$.

Also $\langle x_n \rangle_{n=1}^{\infty} \subset X$ is *a* Cauchy sequence in $X$, provided

(h) $p(x_n, x_m) \le \alpha_n$ for all $m > n \ge 1$

(i) $p(x, x_n) \le \alpha_n$ for all $n \ge 1$ for each $x \in X$.

We now introduce an orbit notion that is followed in the rest of the paper.

*Definition 2.1.* Let $f$ and $g$ be self-maps on $X$. Given $x_0 \in X$, if there exit points $x_1, x_2, x_3, \ldots$ in $X$ such that

$$y_n = gx_{n-1} = fx_n \text{ for } n \ge 1, \quad (2.1)$$

the sequence $\langle y_n \rangle_{n=1}^{\infty}$ is called a $g$-*orbit* relative to $f$ at $x_0$ or simply a $(g,\ f)$-orbit at $x_0$. We call $\langle x_n \rangle_{n=1}^{\infty}$ a *base sequence* associated with the $g$-*orbit* (2.1). Note that when $f$ is the identity map $i$ on $X$, (2.1) and the base sequence coincide with the $g$-*orbit* $gx_0, gx_1, \ldots$ at $x_0$. This notion was adopted in [8]. The notion of $(g,\ f)$-orbit is not unique. For instance, Nesic [7] defined a $(g,\ f)$-orbit at $x_0$ by the iterations:

$$x_{2n-1} = gx_{2n-2},\ x_{2n} = fx_{2n-1} \text{ for } n \ge 1 \quad (2.2)$$

which was employed by Fisher [1] though no name was mentioned.

*Remark 2.1.* If the self-maps $f$ and $g$ on $X$ satisfy the inclusion (1.1), then by a routine induction, it can be easily shown that $(g,\ f)$-orbit at each $x_0$ exists with the choice (2.1). Given $x_0 \in X$, there can be more than one base sequence $\langle x_n \rangle_{n=1}^{\infty}$ as the following examples reveal:

*Example 2.1.* Let $X = \mathbb{R}$ with usual metric $d(x, y) = |x - y|$ for all $x,\ y \in X$. Define $f,\ g : X \to X$ by $f(x) = x_2$ and $g(x) = \frac{x^2}{4}$ for $x \in X$. Then (1.1) is obvious and hence by Remark 2.1, orbits can be specified at each $x_0$. Given $x_0 \in X$, choose $x_n = \pm\frac{x_0}{2^n}$ for $n \ge 1$. Since each $x_n$ has two choices, several base sequences $\langle x_n \rangle_{n=1}^{\infty}$ can be specified to get the respective $(g, f)$-orbit.

We now prove

*Lemma 2.2.* Suppose that $(X,\ d)$ is a metric space with $w$-distance $p$ on $X$. Let $f,\ g : X \to X$ and $\phi : X \to [0, \infty)$ satisfy the inclusion (1.1) and the condition (b) of Theorem 1:1. If $X$ is complete metric space and $x_0 \in X$, then

$$\lim_{n\to\infty} fx_n = \lim_{n\to\infty} gx_n = z \text{ for some } z \in X. \quad (2.3)$$

*Proof.* Given $x_0 \in X$, Suppose that $\langle x_n \rangle_{n=1}^{\infty}$ is a base sequence at $x_0$ and $f,\ g$ are such that (2.1) holds good. Now, by condition $(b)$ with $x = x_{n-1}$, we have

$$p(t, fx_n) = p(t, gx_{n-1}) \le r.p(t, fx_{n-1}) + \phi(fx_{n-1}) - \phi(gx_{n-1})$$

so that for any $k \ge 2$

$$\sum_{n=1}^{k} p(t, fx_n) \le r.\sum_{n=1}^{k} p(t, fx_{n-1}) + \sum_{n=1}^{k} [\phi(fx_{n-1}) - \phi(fx_n)]$$

which gives

$$\sum_{n=2}^{k} p(t, fx_n) \leq \frac{r}{1-r} p(t, fx_1) + \frac{1}{1-r}[\phi(fx_0) - \phi(fx_k)]$$

$$< \frac{r}{1-r} p(t, fx_0) + \frac{1}{1-r}\phi(fx_0)$$

Showing that $\sum_{n=2}^{\infty} p(t, fx_n)$ converges so that $n$ th term tends to 0 as $n \to \infty$, that is $\lim_{n\to\infty} p(t, fx_n) = 0.$

Now, by $(i)$ of Lemma 2.1, it follows that $\langle fx_n \rangle_{n=1}^{\infty}$ is a Cauchy sequence in the $(g, f)$-orbit $X$. Since $X$ is complete, there is a $z \in X$ such that $fx_n \to z$ as $n \to \infty$.

Similar argument shows $\langle gx_n \rangle_{n=1}^{\infty}$ converges to $z'$ in $X$. Proceeding the limit as $n \to \infty$ in (2.1) and using these limits, it follows that $z = z'$, proving the lemma.

*Remark 2.2.* The converse of Lemma 2.2 is not true. Infact, the example given below shows that we can find a metric space $(X, d)$ with a $w$-distance $p$ on it satisfying condition (a) and (b) of Theorem 1.1 such that for any $x_0 \in X$ and for any base sequence $\langle x_n \rangle_{n=1}^{\infty}$ at $x_0$, both $\langle fx_n \rangle_{n=1}^{\infty}$ and $\langle gx_n \rangle_{n=1}^{\infty}$ converge to the same point in $X$; but $X$ is not complete.

*Example 2.2.* Let $X = [0, 1)$ with $d(x,y) = |x-y|$ for all $x, y \in X$. Clearly $(X, d)$ is an incomplete metric space. Define $f, g : X \to X$ by $fx = \frac{2x+1}{4}$ and $gx = \frac{1}{2}$ for $x \in X$. Then $g(X) = \left\{\frac{1}{2}\right\}$ and $f(X) = \left[\frac{1}{4}, \frac{3}{4}\right)$ so that $g(X) \subset f(X)$. Let

$$p(x,y) = \frac{1}{4}\max\left\{ |2x-1|, |2x-4y+1|, 2|x-y| \right\} \text{ for } x, y \in X,$$

which will be a $w$-distance on $X$. Also for any $t \in X$; $p(t, gx) = \frac{1}{4}|2t-1|$ and

$$p(t, fx) = \frac{1}{8}\max\left\{ |2(2t-1)|, |4(t-x)|, |(4t-2x-1)| \right\}$$

from which it follows $p(t, gx) \leq \frac{1}{2} p(t, fx) + \phi(fx) - \phi(gx)$ for any $x \in X$ where $\phi(x) = 1$ for all $x \in X$.

Note that for any $x_0 \in X$ there is only one base sequence $\langle x_n \rangle_{n=1}^{\infty}$ given by $x_n = \frac{1}{2}$ for all $n \geq 1$ so that both $\langle fx_n \rangle_{n=1}^{\infty}$ and $\langle gx_n \rangle_{n=1}^{\infty}$ are constant sequences with each term equal to $\frac{1}{2}$; and hence they converge to $\frac{1}{2} \in X$.

*Lemma 2.3.* Suppose $(X, d)$ is a metric space with $w$-distance $p$ on it. Let $f, g : X \to X$ and $\phi, \psi : X \to [0,\infty)$ be such that $(a)$ of Theorem 1.1 and (f) of Theorem 1.2 hold. If $(X, d)$ is a complete metric space, then for any $x_0 \in X$ and for any base sequence $\langle x_n \rangle_{n=1}^{\infty}$ at $x_0$, both the sequences $\langle fx_n \rangle_{n=1}^{\infty}$ and $\langle gx_n \rangle_{n=1}^{\infty}$ converge to the same point in $X$.

*Proof.* Suppose that $\langle x_n \rangle_{n=1}^{\infty}$ is a base sequence at some $x_0 \in X$ with the choice (2.1). Write

$$\gamma_n = p(fx_n, fx_{n+1}) = p(gx_{n-1}, gx_n \text{ for } n \geq 1$$

Then by $(f)$ of Theorem 1.2, we have

$$\begin{aligned}\gamma_n &= p(gx_{n-1}, gx_n) \\ &\leq a_1 p(fx_{n-1}, fx_n) + a_2 p(fx_{n-1}, gx_{n-1}) + a_3 p(fx_n, gx_n) \\ &\quad + a_4 p(fx_{n-1}, gx_n) + a_5 \sqrt{p(gx_{n-1}, fx_n) d(fx_n, gx_{n-1})} \\ &\quad + [\phi(fx_{n-1}) - \phi(gx_{n-1})] + [\ \ (fx_n) - \ \ (gx_n)] \\ &\leq a_1\gamma_{n-1} + a_2\gamma_{n-1} + a_3\gamma_n + a_4(\gamma_{n-1} + \gamma_n) \\ &\quad + [\phi(fx_{n-1}) - \phi(fx_n)] + [\ \ (fx_n) - \ \ (fx_{n+1})] \\ &= (a_1 + a_2 + a_4)\gamma_{n-1} + (a_3 + a_4)\gamma_n \\ &\quad + [\phi(fx_{n-1}) - \phi(fx_n)] + [\ \ (fx_n) - \ \ (fx_{n+1})]\end{aligned}$$

from which we get

$$\gamma_n \quad \leq \alpha\gamma_{n-1} + \beta\{[\phi(fx_{n-1}) - \phi(fx_n)] + [\ \ (fx_n) - \ \ (fx_{n+1})]\},\ n \geq 2,$$

where $\alpha = \dfrac{a_1 + a_2 + a_4}{1 - a_3 - a_4}$ and $\beta = \dfrac{1}{1 - a_3 - a_4}$

Therefore for any integer $k \geq 2$,

$$\sum_{n=2}^{k} \gamma_n \leq \alpha \sum_{n=2}^{k} \gamma_{n-1} + \beta\Big[\phi(fx_1) - \phi(fx_k)] + [\ \ (fx_2) - \ \ (fx_3)\Big]$$

which gives

$$\sum_{n=2}^{k} \gamma_n \leq \frac{\gamma_1\alpha}{1-\alpha} + \frac{\beta\big[\phi(fx_1) + \ \ (fx_2)\big]}{1-\alpha}$$

showing that $\sum_{n=2}^{\infty} \gamma_n$ converges and hence $_n \to 0$ as $n \to \infty$. Also from the above lines, for $m > n \geq 2$, we see that $p(fx_n, fx_m) \leq \alpha_n$ where $\alpha_n = \gamma_n + \gamma_{n+1} + \cdots + \gamma_{m-1}$. Since $\alpha \to 0$ as $n \to \infty$' it follows from $(h)$ of Lemma 2.1 that $\langle fx_n \rangle_{n=1}^{\infty}$ is a Cauchy sequence in $X$ and hence converges to some $z \in X$. Similarly we can prove that $\langle gx_n \rangle_{n=1}^{\infty}$ converges to some $z'$ in $X$. But $gx_{n-1} = fx_n$ for all $n \geq 1$ it follows that $z = z'$, completing the proof of lemma.

*Remark 2.3.* The converse of Lemma 2.3 is not true. In fact, it is not difficult to exhibit a metric space $(x,\ d)$ with $w$-distance p on it for which $(a)$ of Theorem 1.1 and $(f)$ of Theorem 1.2 in which for any $x_0 \in X$ and for any base sequence $\langle x_n \rangle_{n=1}^{\infty}$ at $x_0$ both sequences $\langle fx_n \rangle_{n=1}^{\infty}$ and $\langle gx_n \rangle_{n=1}^{\infty}$ converge to the same point, yet (x; d) is not complete.

## III. Main Results

*Theorem 3.1.* let $(x,\ d)$ be a metric space with $w$-distance $p$ on it. Suppose that $f,\ g : X \to X$ and $\phi : X \to [0, \infty)$ satisfy the inclusion (1.1) and the condition (1.4) of Theorem 1:1. Also suppose that

$(j)$ there is a base sequence $\langle x_n \rangle_{n=1}^{\infty}$ at some point $x_0 \in X$ such that $\langle fx_n \rangle_{n=1}^{\infty}$ and $\langle gx_n \rangle_{n=1}^{\infty}$ converge the same point $z \in X$

(k) $p(z, gx) \leq rp(z, fx) + \phi(fx) - \phi(gx)$ for all $x \in X$, where $0 \leq r < 1$ and

(l) for every sequence $\langle u_n \rangle_{n=1}^{\infty} \subset X$ with $\lim_{n\to\infty} p(z, fu_n) = \lim_{n\to\infty} p(z, gu_n) = 0$, we have

$$\lim_{n\to\infty} \max\{p(z, fu_n), p(z, gu_n), p(fgu_n, gfu_n)\} = 0. \tag{3.1}$$

Then $z$ is $a$ unique common fixed point of $f$ and $g$.

*Proof.* Writing $x = x_n$ in $(k)$ we get

$$p(z, fx_{n+1}) = p(z, gx_n) \leq rp(z, fx_n) + \phi(fx_n) - \phi(gx_n).$$

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Then as in Lemma 2.2, we can prove that $\sum_{n=1}^{\infty} p(z, fx_n)$ converges hence

$$\lim_{n\to\infty} p(z, fx_n) = \lim_{n\to\infty} p(z, gx_n) = 0.$$

Using this in (3.1), it follows that $\lim_{n\to\infty} p(fgx_n, gfx_n) = 0.$.

Now if z is not a common fixed point of $f$ and $g$, then either $fz \neq z$ or $gz \neq z$; and therefore, by the condition (1.4) of Theorem 1:1

$$0 < \inf\{p(z, fx) + p(z, gx) + p(fgx, gfx) : x \in X\}$$
$$\leq \inf\{p(z, fx_n) + p(z, gx_n) + p(fgx_n, gfx_n) : n \geq 1\}$$
$$= 0,$$

a contradiction. Hence $fz \neq z$ and $gz \neq z$.

The uniqueness of the common fixed point $z$ follows as in the proof of Theorem 3.1 of [4].

*Remark 3.1.* In view of Remark 2.3, Theorem 3.1 generalizes Theorem 1.2. Also since $d$ is a $w$-distance, the results proved by Dien [3] and Liuet.al [6] will be particular cases of Theorem 3.1.

*Theorem 3.2.* Let $(X, d)$ be a metric space with $w$-distance $p$ on it. Suppose that $f, g : X \to X$ and $\phi : X \to [0,\infty)$ satisfy the inclusion (1.1) and the condition (1.4) of Theorem 1:1 and the condition (*f*) of Theorem 1.2. If (*j*) and *l*) hold good, then $z$ is the unique common fixed point of $f$ and $g$.

*Proof.* The proof is similar to the first main result and is omitted here.

*Remark 3.2.* In view of Remark 2.6, Theorem 3.2 generilzes Theorem 1.2. Also since $d$ is a $w$-distance on $X$, the fixed point theorem of Fisher [1] is a partcular case of Theorem 3.2 with $p = d$.

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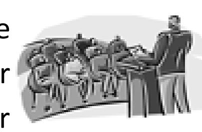

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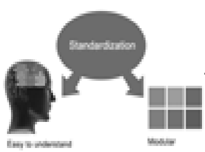

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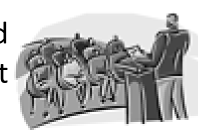

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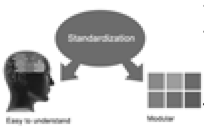


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*Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.*

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

**Structure**

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

*Abstract, used in Original Papers and Reviews:*

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

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

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

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

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

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

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

*Acknowledgements: Please make these as concise as possible.*

References

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

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

*Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.*

*Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.*

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

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

*Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.*

**6. AFTER ACCEPTANCE**

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

**6.1 Proof Corrections**

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

**6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)**

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

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**6.4 Author Material Archive Policy**

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

**6.5 Offprint and Extra Copies**

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You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.

Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

## TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

**1. Choosing the topic:** In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

**2. Evaluators are human:** First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

**3. Think Like Evaluators:** If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

**4. Make blueprints of paper:** The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

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

**6. Use of computer is recommended:** As you are doing research in the field of Computer Science, then this point is quite obvious.

**7. Use right software:** Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## Informal Guidelines of Research Paper Writing

**Key points to remember:**

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

**Final Points:**

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

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

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

**General style:**

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

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

In every sections of your document

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

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

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

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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

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

**Title Page:**

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

**Abstract:**

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

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

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

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

Approach:

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

**Introduction:**

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

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

Approach:

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

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

**Procedures (Methods and Materials):**

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

Materials:

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

Methods:

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

Approach:

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

What to keep away from

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

**Results:**

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

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

Content

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

What to stay away from

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

Approach

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

Figures and tables

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

**Discussion:**

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

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

Approach:

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

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

**Segment Draft and Final Research Paper:** You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

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

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

## Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

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

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

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