CONVERGENCE OF THE SEQUENCE OF ISHIKAWA ITERATION PROCESS WITH ERRORS FOR FIXED POINTS

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ABSTRACT

In this paper, we study the convergence of the sequence of Ishikawa iteration process with errors for fixed points on generalized non expansive mapping in Banach spaces. Our results generalize and improve the results of Deng [1] and Tan and XU [5].

Keywords And Pharses: Ishikawa Iteration Process With Errors, Generalized Nonexpansive Mapping, Opial's Condition and Uniformly Convex Banach Spaces

I. INTRODUCTION

Let D be a non empty subset of Banach space X and $T : D \to D$ be a generalized nonexpansive defined as follows:

$$\|Tx - Ty\| \le a\|x - y\| + b\{\|x - Tx\| + \|y - Ty\|\} + c\{\|x - Ty\| + \|y - Tx\|\} \quad \forall\, x, y \in D \tag{1.1}$$

Where $a, b, c \ge 0$ with $a + 2b + 2c \le 1$.

For $a, b, c \ge 0$ with $a = 1, T$ is called none xpansive, i.e., $\|Tx - x - Ty\| \le \|x - y\| \;\forall\, x, y \in D$. In 1976 Ishikawa [2] provide the following theorem with out any assumption on convexity on domain of none xpansive mapping in banach space. Theorem 1.1 [2] Let D be a nonempty subset of normed space X and $T : D \to X$ s be a none xpansive mapping. Give a sequence $\{x_n\}$ in D and a sequence $\{t_n\}$ in $[0,1]$ Satisfying,

(i) $0 \le t_n \le t < 1$ *and* $\sum_{n \ge 0} t_n = \infty$

(ii) $x_{n-1} = (1 - t_n)x_n + t_n T x_n \;\forall\, n = 1,2,3,\ldots$

If $\{x_n\}$ is bounded, them $\|x_n - Tx_n\| \to 0$ as $n \to \infty$ Deng [1] generalized Theorm 1.1 to Ishikawa iteration process and established weak and Strong convergence results for nonexpansive mappings in Banch spaces. On

the other hand, Tan and $XU[5]$ extended theorem 2 of reich [8]for Ishikawa iteration process in uniformly convex Banach space in [5], Zeng [9] gave refinement of iteration parameters appeared iteration process in Tan and Xu's results.

In [10], XU introduced Ishikawa iteration process with errors as follows.

Let D be anonempty subset of Banach space X and $T : D \to D$ be a non liner mapping.

For any given $x^0 \in D$, then $\{x_n\}$ is called Ishikawa iteration process with errors if it defined iteratively by

(1.2) $$x_1 \in D_1,\ x_{n+1} = a_n x_n + b_n T y_n + y_n u_n,$$
$$yn = a'_n x_n + b'_n t y_n + y'_n v,\ {}_n \geq 0$$

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Where $\{u_n\}$and$\{v_n\}$ are two bounded sequences in D and$\{a_n\},\{b_n\},\{y_n\},\{a'_n\},\{b'_n\},\{y'_n\}$ are six Sequences in [0,1] Such that

(1.3) $$a_n + b_n + y_n = a'_n + b'_n + y'_n = 1\ n \geq 0$$

On Other hand Goebel, Kirk and Shimi [15] provide the following existence theorem,

Theorem 1.2. Let X be auniformly convex Banach space, D nonempty bounded, closed and convex subset of X and $T : D \to D$ a continuous mapping such that

$$\|Tx - Ty\| \leq a\|x - y\| + b\{\|x - Tx\| + \|y - Ty\|\} + c\{\|x - Ty\| + \|y - Tx\|\} \quad \text{for all} \quad x, y \in D,$$

Where $a, b, c, \geq 0$ with Then T has a fixed point in D.

It this note, we consider and study the problem of approximating fixed points of generalized nonexpansive mapping by revised Ishikawa iteration Process with errors. Our result generalize and improve the results of Deng [1] and Tan and Xu [5].

II. PRELIMINARIES

We give the following definitions and lemmas which we shall need in the sequel.

Definition : A Banach space X is called uniformly convex if for each $\epsilon > 0$ there is $\delta > 0$ a such that if $x, y \in X$ with $\|x\| \leq 1, \|y\| \leq 1$ and $\|x - y\| \geq \epsilon$ it follows that $\frac{1}{2}\|x + y\| \leq 1 - \delta(\epsilon)$

Definition : Recall that a banach space X satisfies the Opial's condition [7] if for each sequence x_n is X weakly convergent to a Point x and for all $y \neq x$

$$\limsup\|x_n - x\| < \limsup\|x_n - y\|$$

Definition: [7] Let D be a nonempty subset of normed space X. A mapping $T : D \to D$ is called dmiclosed with respect to $y \in X$ if for each sequence x_n in D and each $x \in Xx \in X, s\, x_n \to x$ and $TX_n \to y$ imply that $x \in D$ and $Tx = y$.

Lemma 2.1 [4] Let $\{a_n\}$, $\{b_n\}$ are sequences of nonnegative real numbers satisfying the inequality $a_{n+1} \le (1+d_n)a_n + b_n$ for all $n \ge 1$. If $\sum_{n=1}^{\infty} b_n < \infty$ then lim a_n exists.

Lemma 2.2 [1] Suppose $\{a_n\}$ and $\{b_n\}$ are two sequences in a normed space E. if there is a sequence $\{t_n\}$ of real number satisfying.

(i) $0 \le t_n < t < 1 \, and \sum_{n \ge 1} t_n = \infty$

(ii) $a_{n+1} = (1 - t_n)a_n + t_n b_n, \; for \; all \; n \ge 1$

(iii) $\lim_{n \to \infty} \|a_n\| = a.$

(iv) $\limsup_n \|b_n\| \le$ and $\left\{\sum_{i=1}^{n} t_i b_i\right\}$ is bounded, then $a = 0.$

Lemma 2.3 [3] Let X be a uniformly convex Banach space, D be a nonempty closed convex bounded subset of X and let T be a continuous generalized nonexpansive mapping. If suiz is weakly convergent sequence in D with weal limit u_0 and $(I - T)u_i$ converges strongly to an element w in X, then $(I - T)u_0 = w.$

III. MAIN RESULTS

Theorem 3.1 Let be a nonempty subset of normed space X and $T : D \to D$ be a generalized nonexpansive mapping defined as (1.1). Given a sequence $\{X_n\}$ in D, two bounded sequences $\{u_n\}$ and $\{v_n\}$ in D and six real sequences $\{a_n\}$ in D, two bounded sequences $\{u_n\}$ and $\{v_n\}$ in D and six real sequences $\{a_n\}, \{b_n\}, \{Y_n\}, \{a_n'\}, \{b_n'\}$ and $\{Y_n'\}$ in [0, 1] satisfying the following conditions:

(i) $a_n + b_n + Y_n = a_n' + b_n' = 1, \forall \; n \ge 0.$

(ii) $0 \ge b_n < b < 1, \; for \; n \ge 0, \sum_{n=0}^{\infty} Y_n < \infty . and \lim n b_n' = 0.$

(iii) $\sum_{n=0}^{\infty} Yn < \infty \; and \; \sum_{n=0}^{\infty} Y_n < 8.$ and

(iv) $x_{n+1} = a_n x_n + b_n T y_n + Y_n U_n$

$Y_n = a_n' x_n + b_n' T x_n + y_n' U_n \; \forall \; b \ge 0.$

If $\{x_n\}$ ius bounded, then $\lim_n \|x_n - Tx_n\| = 0$

Proof Note that

$$\|x_{n+1} - Tx_{n+1}\| = \|a_n x_n = b_n Ty_n + y_n u_n - Tx_{n+1}\|$$

$$= a_n(x_n - Tx_n) + b_n(Ty_n - Tx_n) + y_n(u_n - Tx_n) + Tx_n - Tx_{n+1}$$

3.1 $$\|(x_{n+1} - Tx_{n+1}) £ (1 - b_n)\|x_n - TX_n\| + b_n\|(Ty_n - Tx_n)\| + Y_n\|(u_n - Tx_n) + Tx_n - Tx_{n+1}$$

Since T is generalized non expansive mapping, then

$$\|Tx_n - Ty_n\| £ a\|x_n - y_n\| + b\{\|(x_n - Tx_n)\| + \|y_n - Ty_n\|$$

$$+ c\{\|x_n - Ty_n + \|y_n - Tx_n\|\} £ a\|x_n - y_n\|$$

$$+ b\{\|x_n - Tx_n\| + \|y_n - x_n\| + \|x_n - Tx_n\| + \|Tx_n - Ty_n\|\}$$

$$+ c\{\|x_n - Tx_n\| + \|Tx_n - Ty_n\| + \|y_n - x_n\| + \|x_n - Tx_n\|\}$$

$$(1 - b - c)\|Tx_n - Ty_n\| £ (a + b + c)\|x_n - y_n\| + (2b + 2c)\|(x_n - Tx_n\|$$

3.2 $$\|Tx_n - Ty_n\| £ \|x_n - y_n\| + \frac{2b + 2c}{1 - b - c}\|(x_n - Tx_n\|$$

From (3.1) and (3.2), we obtain

$$\|x_{n+1} - Tx_{n+1}\| £ (1 - b_n)\|x_n - Tx_n\| + b_n\left\{\|x_n - y_n\| + \frac{2b + 2c}{1 - b - c}\|x_n - Tx_n\|\right\}$$

$$+ y_n\|u_n - Tx_n\| + \|x_n - x_{n+1}\| + \frac{2b + 2c}{1 - b - c}\|x_n - Tx_n\|$$

$$£ \left\{1 - b_n + (b_n + 1)\frac{2b + 2c}{1 - b - c}\right\}\|z_n - Tx_n\| + b_n\|x_n - y_n\|$$

$$+ y_n d + \|x_n - (a_n x_n + b_n Ty_n + y_n u_n)\|$$

$$p \left\{1 - b_n(b_n + 1)\frac{2b + 2c}{1 - b - c}\right\}\|x_n - Tx_n\| + b_n\|x_n - y_n\|$$

$$+ b_n\|x_n - Tx_n\| + b_n\|Tx_n - Ty_n\| + 2y_n d$$

$$£ \left\{1 + (2b_n + 1)\frac{2b + 2c}{1 - b - c}\|x_n - Tx_n\| + 2b_n\|x_n - y_n\| + 2y_n d\right\}$$

$$£ \left\{1 + (2b_n + 1)\frac{2b + 2c}{1 - b - c}\right\}\|x_n - Tx_n\| + 2b_n b_n\|x_n - Tx_n\| + 2y_n d + 2b_n y_n' d$$

$$\pounds \left\{1+(2)\frac{2b+2c}{1-b-c}\right\}\|x_n - Tx_n\| + 2d\left(b_n b_n^{'} + y_n + y_n^{'}\right)$$

Setting $b_n = x_n - Tx_n, k_n = d\left(b_n b_n^{'} + y_n + y_n^{'}\right)$ then

$$\|b_n + 1\| \pounds \left\{1+(2b_n+1)\frac{2b+2c}{1-b-c}\right\}\|b_n\| + k_n \quad {}_n \geq 0$$

Since fro m (iii), $\sum_{n=0}^{\infty} k_n < \infty$. It follows from Lemma 2.1 that $\lim_n \|b_n\|$ exists.

Suppose $\lim_n \|x_n\| = x_n$

Setting $$2b_n + 1 = (1-2b_n)p_n + b_n)Ty_n - Tx_n + y_n(u_n - Tx_n) + (Tx_n - Tx_{n+1})$$

$$b_n + 1 = (1-2b_n)p_n + b_n B_n$$

Where,

3.3 $$bn = (Tx_n - Ty_n) + b_n^{-1}(Tx_{n+1} - Tx_n) + b_n^{-1} y_n (u_n - Tx_n)$$

$$\|b_n\| \pounds \|Tx_n - Ty_n\| + b_n^{-1}(Tx_{n+1} - Tx_n) + b_n^{-1} y_n (u_n - Tx_n)$$

$$\pounds \|x_n - y_n\| \frac{2b+2c}{1-b-c}\|x_n - Tx_n\| + b_n^{-1}\|x_{n+1} - x_n\|$$

$$+ \frac{2b+2c}{1-b-c}\|x_n - Tx_n\| + b_n^{-1} y_n d$$

$$\pounds \|x_n - y_n\| + \left(1 + b_n^{-1}\right)\frac{2b+2c}{1-b-c}\|x_n - Tx_n\| + b_n^{-1} b_n \|Ty_n - x_n\| + 2b_n^{-1} y_n d$$

$$\geq \left\{1 + \left(b_n^{-1}\right)\frac{2b+2c}{1-b-c}\right\}\|x_n - Tx_n\| + 2\|y_n - x_n\| + 2b_n^{-1} y_n d$$

$$\pounds \left\{1 + 2b_n^{'} + \left(2 + 2b_n^{-1}\right)\frac{2b+2c}{1-b-c}\right\}\|x_n - Tx_n\| + 2d\left(b_n^{-1} y_n + y_n\right)$$

Using (ii) and (iii) and taking lim superior both sides, we have $\limsup_n \|P\|$

Since from (3.3), we have

$$\left\|\sum_{n=0}^{m} B_n b_n\right\| = \left\|\sum_{n=0}^{m} \{(Tx_{n+1} - Tx_n) + y_n(u_n - Tx_n) + b_n(Tx_n - Ty_n)\}\right\|$$

$$\pounds \left\|\sum_{n=0}^{m} (Tx_{n+1} - Tx_n)\right\| + \left\|\sum_{n=0}^{m} y_n(u_n - Tx_n)\right\| + \sum_{n=0}^{m} b_n(Tx_n - Ty_n)$$

$$\pounds \|x_{m+1} - x_0\| + \frac{2b+2c}{1-b-c}\|x_0 - Tx_0\| + d\sum_{n=0}^{m} y_n + \sum_{n=0}^{m} b_n b_n^{'}\|(x_n - Tx_n)\|$$

$$+\sum_{n=0}^{m} b_n \frac{2b+2c}{1-b-c}\|x_n - Tx_n\| + d\sum_{n=0}^{m} b_n y_n^{'}$$

$$\pounds \|x_{m+1} - x0\| + \frac{2b+2c}{1-b-c}\|x0\| + \sum_{n=0}^{m}\left(b_n b_n^{'} + y_n + y_n\right) + \sum_{n=0}^{m} b_n \frac{2b+2c}{1-b-c}\|x_n\|$$

By (ii) and (iii) $0 \pounds b_n < 1$ and $\sum_{n=0}^{m}\left(b_n b_n^{'} + y_n + y^{i}\right) < ¥$ it follows that $\left(\sum_{n=0}^{m} b_n b_n^{'}\right)$ is bounded. Hence from Lemma 2.2

$$\lim_{n}\|x_n - Tx_n\| = 0.$$

Completing the proof: Remark 1. if we put a=1 and b=c=0, then Theorem 3.1 due to Deng [1] becomes a corollary of the above theorem.

Theorem 3.2 Let D be a nomepty subset of normed space X and $T : D ® D$ be a generalized non expansive mapping defined as (1:1). Give a sequence $\{X_n\}$ in D and two real sequences $\{a_n\}$ and $\{b_n\}$ satisfying:

(i) $0 \pounds a_n \pounds 1''\ n ³ 0 \, and \sum_{n³0} a_n = ¥_0 \pounds a_n$

(ii) $0 \pounds b_n \pounds 1''\ n ³ 0 \, and \sum_{n=0} a_n = ¥_0 \pounds a_n$

(iii) $x_{n+1} = (1 - a_n)x_n + a_n T y_n{}'$

$$y_n = (1 - b_n)x_n + b_n T y_n, n = 0,1,2,...$$

If $\{X_n\}$ is bounded, then $\{x_n - Tx_n\}$ converges strongly to zero.

Remark:

(i) Theorem 3.2 generlizes Lemma 2 of Ishikawa [2]

(ii) We observe that

Theorem 3.3: Let x be a Banach space satisfying Opials condition, D weakly compact subset of X and let T and $\{X_n\}$ be as in Theorem 3.1 Then $\{X_n\}$ converges weakly to a fixed point of T.

Remark

Proof: First we show that $w_w(x_n) \grave{I} F(T)$. Let $x_{nk} ® x$ weakly. By Theorem 3.1 we have and since is demanded at zero. Hence. By Opial's condition possesses only one weak limit point, i.e., Converages weakly to a fixed point of T.

Remark: Theorem 3.3 generlaize and improve. Theorem 2 of Deng [1]. Under remarks 2 (ii).

Theorem 3.5 Let D be a closed convex bounded subset of a uniformly convex Banach space X which satisfies Opial's condition, $T : D \to D$ be a generalized nonexpansive mapping with a fixed point such that $F(T) \neq \emptyset$. Given a sequence $\{x_n\}$ as in Theorem 3.1 Then $\{x_n\}$ converges weakly to fixed point of T.

Proof. Let $w_w(x_n) \subseteq F(T)$. Let $x_{nk} \to x$ weakly by Lemma 2.3 and Theorem 3.1 $w_w(x_n) w_w(x_n)$ is contained in $F(T)$ by Opial's condition (x_n) Possesses only one weak limit point, i.e., (x_n) converges weakly to a fixed point of T.

Remark Theorem 3.4 generlaize the results of Tan and Xu [5, Theorem 3.1]

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A STUDY ON MERIT OF IMPLEMENTATION OF IFRS IN INDIAN FINANCIAL ENVIRONMENT

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ABSTRACT

The feasibility of International Financial Reporting Standards (IFRS) in India needs serious attention when we are all set to upgrade the accounting standards to International Financial Reporting Standards (IFRS) from 2011 as per the recommendation of International Accounting Standards Board (IASB). It was hoped that it shall ease the process of economic globalization. Hence it is imperative to think of its feasibility and assessment of compatibility of domestic accounting standards with international standards (IFRS). IFRS is a manifested single standardized format of financial reporting and single consistent accounting framework. It serves the purpose of reducing diversity/ bringing uniformity in accounting practices and seems indispensible in order to protect the interest of stakeholders of the business society. But considering the capital and functional variations of Indian firms in complex business environment would it be a viable option? Is uniformity of accounting practices feasible for financial environment of India considering the dynamic yet erratic attributes of her? Does not it endanger trustworthiness of accounting declaration by bringing conflict between domestic accounting standards and International standards?

This paper uses an exploratory approach to answer these questions and therefore conclude that India needs an integrated-team-approach with clear roles and responsibilities combined with the support of technical experts.

Key Words: Accounting Standards, Uniformity Stakeholders, Financial Environment, Feasibility.

I INTRODUCTION

The process of globalisation has shrunken the geographical boundaries of commerce between countries giving a swift way to the cross-border economic activities blessed by technological innovations. Investors from different countries trade in shares and securities worldwide in the most advantageous markets and rely upon financial statements for decisions making. Thus they face different reporting frameworks in different countries subject to varied treatments and disclosure patterns corresponding to the same economic event, which creates confusion while interpreting the financial statements and lead to inconsistent treatment and presentation of economic transactions by business entities, which can weaken the outlook and perspective of investors vis-à-vis economic entities, resulting in capital market inefficiencies across the world.

To remove this inefficiency IFRS has been introduced by IASB by providing a standardized format of financial reporting and single consistent accounting framework to reduce diversity and bring uniformity in accounting practices to protect interest of investors. It means conversion of domestic accounting standards with IFRS to ease

business transactions with the world economy and the process of this intention has already begun by a big crowd of economies. According to a survey by Deloitte, Touche Tohmatsu India Private Limited (2008) about 109 countries presently require or permit use of IFRS in preparation of financial statements in their countries and by 2011 this number is expected to reach 150 whereas European Union, Australia, New Zealand and Russia have already adopted IFRS for listed companies, China adopted IFRS in 2008 and India like Canada would adopt the same from 2011.

India is about to take off with IFRS in its first phase fuelled by globalization. As we know that a number of listed Indian companies on major stock exchanges of the world testify that India has marked a significant place in the process of global economic growth. Over the last few decades India has emerged as a country of ever-expanding opportunities for Indian companies as well as multinational companies with cross border financial transactions, mergers, and acquisitions, which resulted into expansion of capital markets. This leads to free flow of foreign direct investments from different parts of the world, which seeks a common and uniformly accepted Financial Reporting System supported by strong governance practices and a firm regulatory framework, and thereby strengthening the economic development of Indian and the world economy both.

With regard to India, the Ministry of Corporate Affairs has committed conversion of the Indian Accounting Standards with the IFRS effective from 1st April 2011 and process is picking up momentum because a non-IFRS compliant country is perceived as an additional risk factor. That is why Ministry Corporate Affairs has extended its unstinted support and guidance to the various regulatory and legal bodies that are spearheading a smooth transition process. For Indian corporate ICAI has proposed the first reporting date as 31-03-2012 and transition date 01-04-2010. Therefore, the first set of financials would be for the period between 01-04-2011 to 31-03-2012 with IFRS comparables which was meant for the period 01-04-2010 to 31-03-2011. It is mandatory for entities to include at least one comparative period in IFRS compliant financial statements.
Success or failure of IFRS in India depends on whether it can stand the test of time. But issues related to IFRS in past and experiences compel to set a discussion about it.

Diverse accounting practices and treatment to the economic transaction has been criticized and uniformity has long been the holy grail of rule-making in accounting. People advocate that accountants treating similar transactions in a similar manner and different ones in different manner intuitively have made more useful financial statements. But the problem is that, that two events or transactions are rarely and exactly identical as the nature of transactions are limitlessly varied and difficult to be classified and aggregate into a manageably small number of categories. There has always been conflict between theoretical and practical aspects of accounting. Such as theoretically two criteria may appear to be the same, but yield quite different results, hence selection of one directly violates the other.

Moreover uniformity of accounting system would be comfortably applicable in a system of similar organizations, which have common associations, federal and state regulatory bodies. Receiving global command and applying consecutively at a time worldwide does not sound practical because the principal objective behind all such

development of elaborate, categorical classifications of accounts are designed to facilitate comparisons, or the construction of macro statistics, but aim in micro accounting practices are limited to the peculiar and specific information desired and sought by a micro business entity, which is difficult to be adjusted and incorporated to a macro setup of the world.

We have example of Infosys and issues faced by it upon transition. Infosys had adopted IFRS for the fiscal year ending March 31, 2009 with a transition date of April 1, 2007. All interim filings (i.e. quarters ending June 30, 2008, September 30, 2008 and December 31, 2008) with the States Securities Exchange Commission (SEC) had also been in compliance with IFRS. In December 2007, the United SEC proposed to allow foreign private issuers (companies like Infosys, Siemens, Wipro, etc.) to submit their financial statements in a accordance with IFRS as issued by IASB without reconciliation to generally accepted accounting principles as used in the United States. They were instructed to adopt IFRS regardless of whether its previous financial statements were prepared in accordance with US GAAP in accordance with the requirements of their home country regulations.

Experience of Infosys and like companies suggest us that India need to judge potential advantages and disadvantages of implementation of IFRS once again before she takes off. An interrogation of this purpose has been made in this paper by raising some vital issues related to characteristics based constraints of Indian business units and more specifically Indian business environment.

II RESEARCH METHODOLOGY

This paper presents an interrogative perspective on International Financial Reporting Standards (IFRS) in Indian environment, which is based on secondary data gathered by ICAI and other international institutions. A comparative table carrying major difference between Indian GAAP and IFRS has also been used for the sake of reference here. The paper tries to explore the merits of implementation of IFRS in Indian firms considering the daily accounting practices of all sorts of business entities here and their educational awareness in a given time period to standardize their accounting behavior. This assessment is basically based on the nature of accounting standard and study of Indian business environment, such as nature of IFRS, macro level Indian Business Environment, nature of corporate governance and educational platform of IFRS in India etc.

International Financial Reporting Standards (IFRS), as formulated by the International Accounting Standards Board has emerged to deal with increasing complexity of business operations and globalisation of capital markets makes mandatory a single set of high quality reporting standards and IFRS has emerged as a new force in aligning the global firms on a single line. In order to exchange financial information in a meaningful and trustworthy manner the adoption of IFRS is justified to accelerate the process of globalisation of finance. Implementation of IFRS in India is based on two separate sets of Accounting Standards u/s Section 211(3C) of the Companies Act, 1956, Wherein first set comprising of the IASs converged with the IFRSs applicable to specified class of companies and second set comprising of existing IASs applicable to other companies, including small and medium companies. ICAI is leading

this paradigm shift in the economic environment in India during last few years and it has increased attention being devoted to accounting standards as a means towards ensuring potent and transparent financial reporting by any corporate.

III ANALYSIS OF BUSINESS ENVIRONMENT

But there is another aspect too of this Indian business environment, which should not be ignored and before appreciating the merits of IFRS and making mandatory for every economic unit we should ponder upon the facts, which have been considered as assessment elements for the suitability of convergence of IFRS in Indian Accounting Standard as follow:

3.1 Major conceptual differences and Coordination between IFRS and Indian GAAP- There lie a significant difference between disclosures and accounting treatment of Indian GAAP and IFRS, which has been used as a base to study and the same has been substantiated in the further proceeding of the topic:

Major Conceptual Differences between IFRS and Indian GAAP**:**

Subject	**IFRS**	**Indian GAAP**
Components of Financial Statements	Comprises of _Statement of Financial Position, _*Statement of Comprehensive Income Statement of Cash flow _Notes to Accounts _Statement of Changes in Equity (Note * - Also includes items of other comprehensive income such as revaluation gains, foreign exchange fluctuations, etc)	Comprises of _ Balance sheet _ Profit and Loss A/c _ Cash flow statement and _Notes to Accounts
Format of SOFP	No particular format prescribed. However IAS prescribes disclosure on the basis of current and non-current assets and liabilities.	According to the format prescribed in Schedule VI to the Companies Act 1956, Banking Regulation Act for Banks etc.
Format of Income Statement	IAS 1 prescribes the format of income statement.	According to the format prescribed in Schedule VI to the Companies Act 1956, Banking Regulation Act for Banks etc.

Statement of Cash Flows	Mandatory for all entities	Exempted for Level 3 entities as prescribed by ICAI.
Presentation of extraordinary items	IFRS prohibits the presentation of extraordinary items in the statement of comprehensive income or in the notes.	Indian GAAP requires extraordinary items to be presented in the profit and loss statement of the entity distinct from the ordinary income and expenses for the period. As a result, extraordinary items are considered to determine the profit / loss for the period.
Dividends proposed after the end of the reporting period	Dividends declared after the end of the reporting period but before the financial statements are authorised for issue are not recorded as liability in the financial statements.	Dividends declared after the end of the reporting period but before the financial statements are approved are recorded as liability in the financial statements.
Depreciation rates	Allocated on a systematic basis to each accounting period during the useful life of the asset.	Depreciation is based on the higher estimate of useful life of the asset, or the rates prescribed by Schedule VI of The Companies Act 1956.
Change in the depreciation Method	Treated as a change in the accounting estimate and hence is accounted for prospectively.	Treated as a change in the accounting policy and is accounted for retrospectively (i.e. for all the relevant previous years). Any excess/ deficit in the case of this kind of recalculation must be adjusted in the period in which the change is effected.
Entire class to be revalued	If an item of property, plant and equipment is revalued, the entire class of assets to which that asset belongs should be revalued.	An entire class of assets can be revalued, or selection of assets for revaluation can be made on a systematic basis.

Component accounting	Mandates component accounting.	Recommends component accounting.
Functional and foreign Currency	Functional currency is the currency of the primary economic environment in which the entity operates. Functional and presentation currencies may be different. The standard contains detailed guidance on this.	No concept of functional currency.
Goodwill	Goodwill is not amortised under IAS 38 but is subject to annual impairment test under IAS 36.	AS 14 provides that goodwill arising on amalgamation in the nature of purchase is amortised over a period of 5 years.
Measurement of intangible Assets	Can be measured at cost or revalued amount.	Are measured at cost only.
Actuarial gain or loss	IAS 19 gives three choices for the treatment of actuarial gains or losses arising on measurement of employee benefits.	Actuarial gains and losses should be recognised immediately in the statement of profit and loss as an income or expense.
Contingent assetdisclosure	Contingent assets are disclosed in the financial statements only if the inflow of economic benefit is probable. (Para 37)	Contingent assets are disclosed as part of the director's report (approving authority)and are not disclosed in the financial statement.
Entities operating in hyper inflationary economies	IAS 29 – Financial Reporting in Hyper Inflationary Economies prescribes reporting requirement for entities operating in hyperinflationary economies.	There is no equivalent standard.

Understanding and measurement of economic transactions made by the firms of different nature becomes quite confusing and troublesome in such environment. But problem does not end at this point only as there are conceptual differences too even in early and latest version of IFRS.

For example a research and development (R&D) outlay of two companies, who spends money to get a patent goes like this:

Indian company	spends $5 million on R&D	develop a patent whose market value is estimated by the firm to be $50 million
An MNC	spends $5 million on R&D	develop a patent whose market value is estimated by the firm to be $50 million

If we consider two possible standards: Q1 that allows firms to capitalize that part of the R&D cost that does not exceed the firm's estimate of the value of the R&D; and standard Q2 that requires the firm to treat all R&D outlays as expense when incurred. Under standardQ1, Indian company could capitalize an amount between 0 and $5 million depending on what it claims to be the value of future benefits of R&D project and MNC also do the same, although it will likely capitalize the entire cost of $5 million. Here we can see that user of the statements; two companies could look the same when their underlying states are entirely different. Under standard Q1, both firms must expense the $5 million outlay against the current period income, and their balance sheets and income statement for the year should be identical while in reality the underlying economic situations of these two firms are quite different. Here the comparison has been made considering the outlay they both spent i.e. the same amount of money on R&D during the year, which was shown in their balance sheet as a charge against current income and thus they have no resulting assets on their balance sheets.

If we consider standard Q2 (the current method) then comparison would become difficult as the economic situation of Indian company in its financial statements has been depicted quite accurately and it misleads the user about the valuable resource of a patent of MNC has and this is not revealed on its balance sheet. So, even in this simplest of accounting examples, it is not clear which of these two possible standards is of higher quality and which one results in financial statements that are more comparable attribute so highly valued in the Accounting Consensus and yet hard to define. Pursuit of uniformity diminishes the effectiveness of financial reporting in stewardship and governance, and loses its significance in informing security markets.

3.2Consideration of the nature of IFRS- IFRS guidance sounds simple and compatible but reality does not support it as its thousands of pages are difficult to be assimilated during the stipulated time frame by the firms of companies. A recently compiled international standards in March 2008 the official interpretations and guidance carries 2,752 pages long publication. The businessmen and their practices are unable to match perfectly with our Indian Accounting Standard completely and principles are contradictory, in such environment expectation from IFRS and Indian companies theoretically may be implemented but it is difficult to bring in practical being in corporate.

There is a wide gap between the levels of details in the pronouncements of IFRS and AS exhibits, which demands our business units to employ a professional who is interested to read these many pages. Moreover it is wondering about the distinction between principles and rules as visualized by the accounting standard writers. Moreover lack of mass understanding of accounting standards make it futile and unfruitful and creates apprehension about the implementation of IFRS in such kind of environment.

For example market valuation and historical cost valuation concepts are found to be different theoretically when measure at the practical ground. Contrary to it fairness is an *ex post* judgment about a particular instance of valuation in the eyes of accountants and users, which is alternatively could be thought of as their *ex ante* judgment about the outcomes expected from a given method of valuation that is difficult to define.

The length, specificity, generality, readability, and reliability of two different accounting standards are difficult to be harmonized for two different foreign environments and their expertise. The nature of written standards depends not only on intent but even more so on the local climatic requirement and process of writing them. That is why key feature in the process of standard writing done by ASB and IASB does not convince.

We all are aware about the auditing of "SATYAM" by PricewaterhouseCoopers (PwC), a global professional services firm headquartered in London, United Kingdom. It is the world's second-largest professional services firm (after Deloitte) and one of the "Big Four" accountancy firms. We know the consequence of it and it is unreasonable to expect that the IFRS, after having tumbled through this process over a few financial scandals and cycles of the world economy during the next couple of decades, will look any different than the AS looks now, the rhetoric about rules versus principles notwithstanding. It would be helpful to know the substance of the distinction between rules and principles in the context of what the ASB and the IASB have done in the past and plan to do in the future.

Too many alternative accounting treatments in the accounting standards are almost impossible to be followed. It is rightly said that too many cooks spoil the broth. When a multinational company (MNC) has to report under the standards of both the countries it might lead to some extremely odd results. A case of Daimler Benz bears testimony of lack of harmony among governments, standards setting. Daimler Benz was the first German to secure stock market listing in the United States, reported a net profit of DM 158 m for the six months to June 1998 based on German GAAP. The U.S GAAP reconciliation statement revealed that the company had incurred a loss of DM. 949m. Similarly, British Telecom Inc. reported a net profit of £1767 for the year ended 31-3-1994 under the UK GAAP but under the US GAAP reconciliation- the net profit reduced to £1476. Thus on the name of harmonization it is possible that our objective would be defeated.

3.3Macro level acceptability of IFRS in Indian Business Environment- A single set of high-quality written standards of financial reporting system is suggested for all companies whose shares are publicly traded once in the world and it is advocated and supposed to improve financial reporting by making financial reports more comparable, and thus help investors and other users of financial statements to make better decisions. There is little doubt that investors prefer high quality standards over low. However, to impart an operational meaning to this preference, one should consider the following characteristics of a high quality accounting standard pertaining:

i. Legal structure

ii. Maturity of accounting profession
iii. Government participation in accounting
iv. Acceptance by tax authorities
v. Assess the impact on areas such as results, equity, banking covenants and make necessary system amendments;
vi. Manage the expectations of shareholders, board audit committee, regulator, markets & other stakeholders;

A comparison of our Indian accounting Board and the IASB side-by-side standards to obtain some reasonable agreement across it would be quite troublesome to do justice with the quality or methods of measuring the quality of a standard which have been defined and specified by them. In India we have significant amount of literature printed but much of that high quality standards does not appear in organizations dedicated to telling the world how to measure things and we have no measure of quality of a standard available.

Uniformity of accounting standard is appreciated in order to facilitate comparability of financial statements. A myth like gradation of quality of accounting standards based on principles instead of rules are supposed to help generate financial reports that are more useful by reason of being more comparable across all sorts of micro, small, medium and big industries in Indian environment under private sector, public sector and joint sector, which is always not true. This herculean task further extends to review the accounting standards from the point of view of acceptance or changed conditions at regular intervals, and subsequent revision from time to time, analysis of interpretations of dynamic environment and desired guidance on Accounting Standards. This high-sounding goal deserves a moment of reflection. Sometimes a general, concise and varied principle across individuals and situations and calls for judgment in its application give rise to greater ease and comfort to the business entity than more detailed rules.

3.4 Nature of corporate governance- As we know that we have different sorts of industries considering their ownerships and varied size of capital and it should not be ignored. In order to converge/ implement IFRS better we should create a single deliberative corporate body consisting of chosen experts with a proper governance structure, due process, and legally assured funding, functioning under the oversight of regulatory authorities such as the Securities and Exchange Board of India, Insurance Regulating and Development Board or International Organization of Securities Commissions etc. Because our firms differ on the following bases:

i. Sources of corporate finance
ii. Degree of conformity of financial accounts
iii. Degree of exposure to international market
iv. Managing market expectations and investor relationships
v. Managing day to day business issues – MIS, tax planning, performance indicators, mergers and acquisitions, etc.

In such scenario would not it be difficult for our regulators to assess the consequences of their proposed actions accurately? The complex interactions among different interests units and their stereotype actions of numerous agents make it difficult for a regulatory body to assess, *ex ante*, the final consequences of implementing a proposal and its

ultimate desirability. For instance recently we have had an experience of the debacle issue of hybrid product between our two apex regulatory bodies in capital market among the investors, which took considerable time to convince the customer and also affected the velocity of circulation of liquidity. Therefore the task of conversion of accounting standard which affects millions of individuals, all with potential to modify their own way of treatment to an economic action in response to the standard seems very complex.

Regulatory bodies want no competition within their jurisdictions as they deny themselves the benefits of discovery and innovation when multiple business entities compete with each other but harmonization of accounting standard may mar their efficiency and interest as the standard setting agencies are assured of tax revenues to pay their expenses. If world manifest the sole responsibility on a single regulatory body then it would discourage research and experimentation and innovative solutions to various financial reporting problems. Because it is impossible for any monopoly regulatory body to collect feedback at world level and then circulate the subsequent changes globally. Moreover it would also forbid learning process from trial-and-error and from alternative practices.

Thus it would cause loss of opportunities for evolutionary change and would bring stagnancy, which cannot be compatible with the increasing flow of global capital in the term of volume and direction both. Perhaps accounting too, could handle the problem through a combination of written standards, social norms, and professional judgment, exercising self-restraint through sparing use of the power of enforcement. Past experience does not convince the virtues of heavy-handed intervention by rule-making monopolies and active enforcement by the power of state, which has always failed to improve financial reporting.

If we talk about the evaluation of asset then conversion of Indian GAAP with IFRS Financial reports would experience changes in treatment of depreciation. Hence, the value of assets as well the profitability of the organization may swing, which, in turn, may impact the net worth. Small scale industries, which are already facing a tough market time, they would further face difficulties as large scale firms would innovate and make the difficult trade-offs necessary to limit the complexity of their standards to earn their own way in the form of benefits (royalties) gathered from organizations if they choose to claim that their financial reports conform to their respective standards.

3.5Educational platform of IFRS in India- In India many people are yet not aware of IFRS, their complexities and impact. A change in the reporting format will require awareness of these new norms and systems, training and education. The fact is that even prevailing accounting rules have not been perceived uniformly in our country and people pursue convenient accounting practices. There is a need of study of several existing lacunae of our prevailing accounting practices like earning per share, information about future cash flows, consolidation, mergers, acquisitions etc. and so are the accounting rules, which are difficult to be followed due to lack of establishment of scientific test like historical cost, feedback concept etc.

Before IFRS is converged with AS and practiced in the Indian environment the educational system should prepare itself to integrate IFRS into its curricula so that Indian graduates would grasp it and can make best possible usage of audit financial reports based on IFRS. Identification of key convergence of current Indian GAAP should be considered to add the requisites in accounting curricula and incorporated in our education system. For the sake of

assimilation and conversion point of view vital facts should be brought to the attention in a generlised form, such as changes to reporting, system changes, valuations, IFRS differences and GAAP policies with IFRS, external IFRS packages communication plan for stakeholders and other users of financial statements, revisions to performance incentives and covenant agreements and independent valuations under IFRS2 or IFRS3 etc.

Although the attempts to write uniform standards of financial reporting are primarily driven by their direct and immediate impact on capital markets, they also have major educational consequences, which have different level of magnitude and that they deserve more attention from academics and those charged with the responsibility to develop standards. Like we have limited pool of skilled resources and moreover conversion process demands huge cost on enhancement of IT systems.

Apart from it, expansion of the ambit of written authoritative standards needs fundamental changes in textbooks, course content, classroom discourse, and examinations procedure along with the professional examination for CPA certification. In the absence of an authoritative standard for a class of transactions, textbooks, class discussion, and examinations tend to explore various possible ways in which a transaction could be accounted for, consequences of alternative accounting treatments for various parties and the economy as a whole.

In education, uniformity discourages thoughtful classroom discourse, attracts less talent to accounting programs and, ultimately, to the accounting profession. Uniform standards induce a follow-the-rule-book attitude among accountants at the expense of developing their professional judgment. Since judgment and personal responsibility are the hallmarks of a learned profession, pursuit of uniform written standards weakens the accountants' claim to belong in this class, as well as the claim of accounting degree programs to belong in universities alongside professions such as architecture, dentistry, engineering, law, medicine, and nursing.

To conclude, finding a balance between uniform standards and norms, and defining the extent of their respective roles in financial reporting, are not easy tasks. Standard-setters find it difficult to know which standards are superior, and what should be the criteria for ranking the alternative standards. Societies that depend on norms and tradition also can get stuck in inefficient solutions and it may take reform movements, even armed uprising, to release them. By their nature, evolved social norms and culture are specific to the society they serve. Variations in evolved systems, such as in the beaks of the finches inhabiting various valleys of the Galapagos Islands, or in wedding ceremonies in various parts of the world, cannot be explained entirely in terms of identifiable factors. Random chance and history also play a role.

Attempts to harmonize financial reporting across the world assume that all cross-country variation in financial reporting practices is random or at least that the advantages of dispensing with such variations exceed a reduction in fit between the local economic environments and the financial reports. The practices proposed for universal use are those prevalent in the English-speaking countries, and their authoritative versions written down in English often have no exact equivalents in Chinese, Japanese, or even Italian and German.

Can authoritative uniform standards ignore the social and cultural environments to bring a semblance of order to the chaos to financial reporting? Although the development of an uniform set of accounting standards has its own justification, but considering the demographic elements like, education and awareness level of different economies of the world, the application of IFRS to all public firms across most countries of the world through regulatory fiat

does not seem viable. Would implementation encourage discovery and evolution toward better methods of financial reporting or make it difficult to conduct comparative studies of the consequences of using alternative methods of accounting, discourage substitution of analysis and thinking by rote learning in accounting classes, demotivate talented youth from collegiate programs in accounting, and probably endanger the place of accounting discipline in university curricula. The presumed benefits in the form of increased comparability of financial reports internationally or stateside are unlikely to be realized, and the wisdom of undertaking these burdens remains questionable. To formulate Accounting Standards with a view to assisting the Council of ICAI is evolving and establishing in India. To carry out such other functions relating to Accounting Standards being granted a monopoly status for public companies, intermediate accounting classes have moved toward focusing on line-and-verse application of those standards, and not on critical examination of the merits of alternative accounting treatments for various classes of transactions. In many schools, two terms are no longer sufficient to cover this expanding volume of material generating calls for more teaching resources.

3.6 Regulatory endorsement and acceptance- The applicability of IFRS for convergence of Indian entities would be in several phases as the issues involved in one-shot adoption, which are complex. For example, there are issues to be addressed, which may impact tax revenue collection in the Indian scenario. Also to be sorted is the applicability of IFRS to Small and Medium Scale Enterprises, pending deliberations by various authorities. The Income Tax Act does not recognize the accounting standards for most of the items while computing income under the head "Profits & Gains of Business or Profession". Section 145(2) of the I.T. Act has empowered the Central Government to prescribe accounting standards. For examples application of prudence substance over form, adherence to principles of going concern etc. are important issues of accounting practices.

The accounting framework in India has peculiar nature and it is deeply affected by laws and regulations unlike other countries. So a management would have to undergo the rigorous task to redesign key processes to accommodate IFRS HR, Sales, Procurement, Legal, IT, and individual business unit owners, who usually skip such structuring. Critical third-party contracts, debt covenants, and key leadership metrics would also change with the change in accounting policies. Though ICAI has submitted a suggested list of companies that come under different parameters for adoption of IFRS standards but it would be difficult to access their financial reporting and bring them into the net. These entities include companies listed with BSE / NSE Sensex, insurance companies, mutual funds, entities with a capital base of over 50 million dollars outside India, companies that are publicly accountable with an aggregate borrowing of over Rs. 1,000 crores and such others.

Amendments in law would be required for the conversion process of accounting system in India as IFRS will have a bearing on the legal provisions as are presently set out in the Indian Income Tax Act, Companies Act, etc. and Changes may be required to various regulatory requirements under The Companies Act, 1956, Income Tax Act, 1961, SEBI, RBI, etc. so that IFRS financial statements are accepted generally.

Our financial environment is dealt by a group of regulating authorities and their robust legal net itself need compliance with each other. We have Reserve Bank of India ('RBI') for banks, the Insurance Regulatory and Development Authority (IRDA) to monitor insurance companies and the Securities and Exchange Board of India

(SEBI) for all listed companies and they require compliance with the Accounting Standards issued by ICAI which has to be devised in accordance with the IFRS system. Besides Foreign Exchange Dealers Association (FEDAI) provides guidelines of accounting for foreign exchange transactions and it needs to work in the same suit. ICAI has identified the legal and regulatory requirements arising out of convergence with IFRS and recommended changes in the respective Acts, guidelines and other regulatory provisions related to RBI, SEBI, National Advisory Committee on Accounting Standards (NACAS) and IRDA and have submitted its recommendations to the respective authorities and in the extract form, which are as followed:

i. Changes required in SEBI guidelines
ii. Changes required in Company's Act 1956
iii. Changes required in IRDA rules and regulations
iv. Changes required in RBI Banking Regulation Act.
v. Standards to be notified by NACAS

Above investigation of the various areas of assessment of Indian business environment it can be said that Accounting is closely interlinked with the social practices and laid laws of the land, which while ignoring these fundamental differences usually become cumbersome and difficult to handle. We would need to keep continuous track of changes at IASB, broadening the pool of trained resources, both in the industry and the audit firms, active participation in the standard setting process by commenting on the Exposure Drafts and Staff Drafts. Besides this our corporate would need to spend significant time and efforts in order to educate their investors, lenders, analysts, Board of Directors, regarding the impact of IFRS on the financial position and performance. Success or failure cannot be predicted but of course complacency by corporate and management has always taken its toll and we should be at high alert otherwise the advantages of international coordination would override the cost of abandoning the fit between accounting practices and local conditions. These vital issues guide us to the tailored solution in respect to meet specific needs and objectives of corporate.

IFRS conversion of Indian accounting standard requires careful planning, programme, management and resources with in-depth knowledge of IFRS and methodology of application of IFRS according to the specific needs of an organization particularly in view of the tight reporting deadline otherwise it may affect our internal control, accounting policy, tax provisioning, shared services, financial reporting processes, IT systems, treasury, legal, internal audit & several other functions of an enterprise. That is why it needs a serious concern and its viability in the context of Indian business environment needs to be proved.

Moreover first time IFRS is not the only issue, there are $IFRS_2$ and $IFRS_3$ and so on. Warren Buffet rightly pointed out that the third level of "fair" risks becoming mark-to-myth. In response to political pressures of mid-October 2008, the IASB (2008) proposed to allow special dispensation for application of fair values to various financial instruments. In what sense can this proposal be called an ultimate principle? Because it is the beginning and it would be impossible to the general principles in a morass of complex rules under pressure from money and power.

IVCONCLUSION

Thus there is a need of integrated team approach of a well thought-out project structure with clear roles and responsibilities combined with the support of technical experts; detailed milestones showing the status of the project and highlighting problems; with the identification and alternative solution of problems quickly and efficiently in order to ensure effective communication among business units to safeguard the interest of stakeholders. Otherwise understanding and implementation of IFRS is not easy task and there is a risk that if Indian firms are late to catch the train they may fall in a perplexed situation.

Annexure 1 – List of IFRS

IFRS 1 First-time Adoption of International Financial Reporting Standards

IFRS 2 Share-based Payment

IFRS 3 Business Combinations

IFRS 4 Insurance Contracts

IFRS 5 Non-current Assets Held for Sale and Discontinued Operations

IFRS 6 Exploration for and Evaluation of Mineral Resources

IFRS 7 Financial Instruments: Disclosures

IFRS 8 Operating Segments

Annexure 2 – List of IAS

IAS 1 Presentation of Financial Statements

IAS 2 Inventories

IAS 7 Statement of Cash Flows

IAS 8 Accounting Policies, Changes in Accounting Estimates and Errors

IAS 10 Events after the Reporting Period

IAS 11 Construction Contracts

IAS 12 Income Taxes

IAS 16 Property, Plant and Equipment

IAS 17 Leases

IAS 18 Revenue

IAS 19 Employee Benefits

IAS 20 Accounting for Government Grants and Disclosure of Government Assistance

IAS 21 The Effects of Changes in Foreign Exchange Rates

IAS 23 Borrowing Costs IAS 24 Related Party Disclosures

IAS 26 Accounting and Reporting by Retirement Benefit Plans

IAS 27 Consolidated and Separate Financial Statements

IAS 28 Investments in Associates

IAS 29 Financial Reporting in Hyperinflationary Economies

IAS 31 Interests in Joint Ventures

IAS 32 Financial Instruments: Presentation

IAS 33 Earnings per Share

IAS 34 Interim Financial Reporting

IAS 36 Impairment of Assets

IAS 37 Provisions, Contingent Liabilities and Contingent Assets

IAS 38 Intangible Assets

IAS 39 Financial Instruments: Recognition and Measurement

IAS 40 Investment Property

IAS 41 Agriculture

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STUDY ON WORKABILITY AND DURABILITY CHARACTERISTICS OF SELF-COMPACTING GEOPOLYMER CONCRETE COMPOSITES

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ABSTRACT

Increase in production of cement causes the huge amount of carbon-dioxide emission, which results in global warming. In order to overcome this problem many researchers put their effects to achieve the optimum strength and durability of concrete by replacing the cement with fly ash and when it combines with the alkali activator solution it becomes geopolymer concrete. These concretes have the ability to fail due to lack of compaction. Self-compacting concrete is the innovative way of concreting; it can be compressed into every corner of formwork by means of its own weight. In order to trounce poor compaction and global warming; the new way of concreting is introduced as self-compacting geopolymer concrete. This concrete has two limitations such as delay in setting time and heat curing to gain strength. The present research intended to set right these limitations by replacing the fly ash by OPC up to 20% on a mass basis. Also an attempt to make to use of manufactured sand instead of using river sand due to scarcity of river sand and natural resource depletion. The durability of self-compacting geopolymer concrete composites is based on the tests conducted such as acid attack, sulphate attack, and Sorptivity.

Keywords : Acid Resistance, Geopolymer Concrete Composites, Self-Compaction, Sorptivity, Sulphate Attack.

I INTRODUCTION

Concrete is one of the most widely used construction material in the world and ordinary Portland cement is the main building material in concrete. During manufacturing of cement, there will be a release of large amount of carbon-dioxide gas into atmosphere, which results in global warming. The most effective way of reducing the CO_2 emission of cement industry is to substitute a proportion of cement with the other materials. These materials called supplementary cementitious material. Usually used supplementary cement materials are Fly ash, Slag, Silica fume and metakaolin [1].

Geopolymer concrete is an alkali activated concrete. In the past few decades it has emerged as one of the possible alternative to OPC binders due to their high early strength and resistance to acid and sulphate attack. Though geopolymers are manufactured from various source material, fly ash based geopolmer concrete [2] has more attractive than the other. Geopolymer binders might be a alternative acid resistant concrete since it relies the aluminum silicate rather than calcium silicate hydrate bonds for structural rigidity [3]. Geopolymersis is a

type of inorganic polymeric composite that are produced and hardened even at ambient temperature under highly alkaline conditions. Polymerization takes place when reactive alumino silicates are rapidly dissolved and free SiO_4 and AlO_4 tetrahedral units are released in the solution. Fly ash based geopolymer concrete have better durability than Ordinary Portland Cement concrete due to that fly ash has very less CaO. Geopolymer concrete has a good resistance to acid and sulphate attack.

Concrete has considered as a brittle material because of its low tensile strain capacity. For long time concrete was considered as a very durable and required little maintenance. As a matter of fact that earlier concrete was prepared only by considering the compressive strength. It is now recognized that strength of concrete alone is not sufficient, durability of concrete is also equally important. Concrete is said to be durable when it have resistance to cavitations, good abrasion and impact.

SCC is a type of concrete, which can be compressed into every corner of the formwork purely by means of its own weight. SCC has been developed to ensure adequate compaction and facilitate placement of concrete and structures with congested reinforcement and in restricted areas. It is generally accepted that SCC was developed first in Japan in the late 1980s in response to the lack of skilled labour and the need for improved workability. According to Ouchi [4] the need for SCC was first identified by Okamura in 1986 and the first prototype was developed in 1988. SCC offers many benefits and advantages over traditional concrete.

Self-compacting geopolymer concrete composite (SCGC) is relatively a new concept and can be regarded as the most revolutionary development in the field of concrete technology. SCGC is an innovative and improved type of concrete that does not require vibration for placing it and can be produced by complete elimination of ordinary Portland cement. On the other hand, SCGC that is produced by a polymeric reaction of alkaline liquid with a byproduct material like low-calcium fly ash with total replacement of cement by fly ash have several limitation such as necessity of heat curing and delay in setting time [5]. In order to overcome these limitations effects have been taken in the present investigation to develop Self-compacting geopolymer concrete composites (SCGCC) with Fly Ash, Ordinary Portland cement, alkaline liquids.

II EXPERIMENTAL PROGRAMME

2.1 Materials for Concrete Mixture

2.1.1 Fly Ash

In this research study, Low – calcium (ASTM Class F) Fly Ash conforming to IS 3812-2003[6] was used as a source material for the synthesis of Self-compacting geopolymer concrete. The fly ash was obtained from Thoothukudi Thermal Power Plant. The Physical properties of Fly Ash are given in the Table 1.The chemical composition of fly ash was tested at Department of Industries & Commerce, Regional Testing Laboratory, Madurai as shown in Table 2.

Table 1 Physical properties of Fly Ash

S.No	Physical Properties of Fly Ash	Test Results
1	Specific Gravity	2.36
2	Fineness	4%

Table 2 Chemical Composition of Fly Ash

S.No	Oxide	Percentage By Mass (%)
1	Silicon di (SiO_2) plus Aluminum Oxide(Al_2O_3)plus Iron Oxide)Fe_2O_3)	95.95
2	Silica (SiO_2)	59.71
3	Magnesium Oxide (MgO)	1.06
4	Total Sulphur As Sulphur trioxide (SO_3)	Nil
5	Available Alkalis As Sodium Oxide(Na_2O)	0.63
6	Loss on Ignition	0.71
7	Moisture	0.32
8	Calcium Oxide(CaO)	0.50

2.1.2 Aggregate

Fine aggregate used is manufactured sand [7]. Fine aggregate sieved using 4.75mm sieve to remove all the pebbles. Coarse aggregate of size used is 12.5mm. The physical properties of fine and coarse aggregate are given in Table 3 and Table 4 accordance with [8], [9].

Table 3 Physical Properties of Manufactured Sand (M-Sand)

S.No	Physical Properties	Test Results
1	Fineness modulus	2.72
2	Specific Gravity	2.71
3	Bulk Density(kg/m^3)- Loose State	1709.41
4	Zone Conformation	Zone-II

Table 4 Physical Properties of Coarse Aggregate

S.No	Tests For Coarse Aggregate	Results
1	Specific Gravity	2.78
2	Bulk density	1592.295 kg/m^3
3	Compaction Factor	0.921
4	Flakiness Index	12.162%
5	Elongation Index	28.72%

2.1.3 Alkaline Solution

In this study, a combination of sodium hydroxide and sodium silicate was chosen as an alkaline solution. Sodium based alkaline solutions were chosen because they are cheaper than potassium based solutions. Sodium hydroxide and sodium silicate are available commercially in flakes or pellets form. For the present study sodium hydroxide pellets with 98% purity were used for the preparation of alkaline solution with the concentration of 12M. The chemical composition of sodium silicate is Na_2O=14.7%, SiO_2=29.4% and water=55.9% by mass. Both the liquids were mixed together and alkaline solutions were prepared.

2.1.4 Super plasticizers

The chemical admixture based on Polycarboxylic ether, which is commercially known as Master Glenium SKY 8233 was used in producing SCC as a super plasticizer admixture.

2.1.5 Water

Specified amount of extra water was also used in the mix. The ordinary potable water available in the concrete laboratory was used for this purpose.

2.1.6 Cement

The SCGC mix has two limitations such as delay in setting time and necessity of heat curing to gain strength. In order to overcome these two limitations Ordinary Portland cement replace the fly ash up to 20% increasing in the order of 5% and the mix design was altered accordingly which results in self-compacting geopolymer concrete composites. Ordinary Portland cement conforming to IS 8112-1989[10], with the specific gravity of 3.15 was used.

2.2 Mix Proportion

In this study, Fly Ash based geopolymer and cement was used as a binder to produce concrete. The manufacture of SCGCC was carried out by using traditional trial and error concrete technology methods [11]. Table 5 shows the symbol of grade of concrete. The details of these mixtures are given in Table 6 & 7. The alkaline solution to Fly Ash ratio was kept constant at 0.5 where as the ratio of sodium silicate to sodium hydroxide solution was kept as 2.5.

Table 5 Designation of Grade of Concrete

S.NO	Grade of Concrete	Designation
1	M20	M1
2	M30	M2
3	0% of Cement	SCGCC
3	5% of Cement	SCGCC1
4	10% of Cement	SCGCC2
5	15% of Cement	SCGCC3

6	20% of Cement	SCGCC4

Table 6 Details of Mix Proportions for M1

Mix Id	Fly Ash (kg/m^3)	OPC (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	NaOH Solution (kg/m^3)	Na_2Sio_3 Solution (kg/m^3)	Extra Water (kg/m^3)	Super Plasticizer (kg/m^3)
SCGC	480	-	644.84	927.95	68.57	171.43	48	24
SCGCC1	456	24	644.84	927.95	68.57	171.43	57.6	24
SCGCC2	432	48	644.84	927.95	68.57	171.43	57.6	24
SCGCC3	408	72	644.84	927.95	68.57	171.43	67.2	24
SCGCC4	384	96	644.84	927.95	68.57	171.43	67.2	24

Table 7 Details of Mix Proportions for M2

Mix Id	Fly Ash (kg/m^3)	OPC (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	NaOH Solution (kg/m^3)	Na_2Sio_3 Solution (kg/m^3)	Extra Water (kg/m^3)	Super Plasticizer (kg/m^3)
SCGC	555	-	681	903	94	234	55.5	27.75
SCGCC1	527.25	27.75	681	903	94	234	66.6	27.75
SCGCC2	499.5	55.5	681	903	94	234	66.6	27.75
SCGCC3	472.5	82.5	681	903	94	234	77.7	27.75
SCGCC4	444	111	681	903	94	234	77.7	27.75

2.3 Mixing Procedure

Mixing was carried out in two stages. Initially, Fly ash, OPC, Fine Aggregate, Coarse Aggregate were mixed in a pan mixture for about 2-3 minutes. At the end of this mixing, the liquid component of the geopolymer concrete mixture comprising alkaline solution, super plasticizer and the extra water, was added to the dry mix and the wet mixing continued for another 3-4 minutes. The freshly prepared concrete mix was the assessed for the essential tests required for characterizing the self-compacting concrete. Tests such as V-funnel, J-Ring, L-Box, and V-funnel at T5 minutes were performed for this purpose.

2.4 Casting and Curing of Test Specimens

After assessing the necessary workability properties as guided by EFNARC [8], the fresh concrete was placed in steel moulds of 150mm side cubes and allowed to fill all the spaces of the moulds by its own weight. Three cubes were prepared for each test variable. After casting the specimens, without any delay, the SCGC specimens were kept in the oven at a specified period of time. At the end of the curing period, the moulds were taken out from the oven and left undisturbed for about 15 minutes. The SCGCC specimens were removed from the mould immediately after 24 hours since they set in a similar fashion that as conventional concrete. The plain SCC specimens were cured at water curing.

III DISCUSSION ON TEST RESULTS

3.1 Fresh Properties of SCGC & SCGCC

The properties of SCC differ significantly from that of conventional fresh concrete. There are three distinct fresh properties of SCC, which are basic requirements to its performance both in fresh and hardened state. According to EFNARC [5] a concrete mix can only classified as SCC if the requirements for all the workability properties are fulfilled. The three essential fresh properties required by SCC are Filling Ability, Passing Ability and Segregation resistance. To accomplish the workability properties, tests such as V-funnel, J-Ring, L-Box, V-funnel at T5 minutes were carried out. All the tests were performed by following the European Guidelines for SCC. The test results of fresh properties of SCGC and SCGCC are presented in Table 8& 9 and fig.1to 4.

Table 8 Workability Test Results for M1

Workability Tests	Proportion Of Cement					
	PLAIN SCC	SCGC	SCGCC1	SCGCC2	SCGCC3	SCGCC4
V Funnel (Sec)	6	7	8.5	9	12	14
J Ring (Mm)	5.5	6	7	8.3	9	11
L Box (H_2/H_1)	0.8	0.84	0.87	0.93	0.98	1.1
V Funnel At T5 Minutes (Sec)	7	9	11	12.5	14.5	16

Table 9 Workability Test Results for M2

Workability Tests	Proportion Of Cement					
	PLAIN SCC	SCGC	SCGCC1	SCGCC2	SCGCC3	SCGCC4
V Funnel (Sec)	6	7	8.5	9	11	13
J Ring (Mm)	5	6.3	7	9	10	10.8
L Box (H_2/H_1)	0.7	0.81	0.91	0.95	0.98	1.03
V Funnel T5 Minutes (Sec)	7.5	10.5	11	12	14.5	15.5

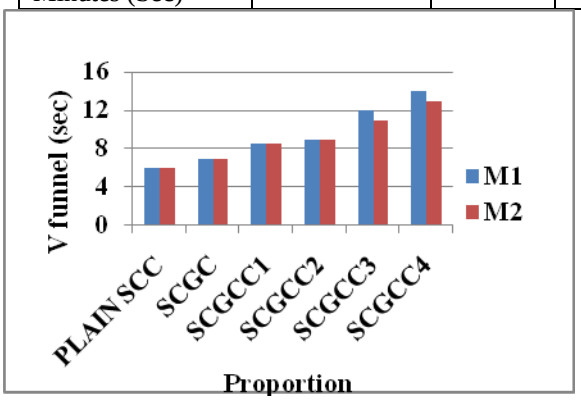

Fig 1.V funnel Test

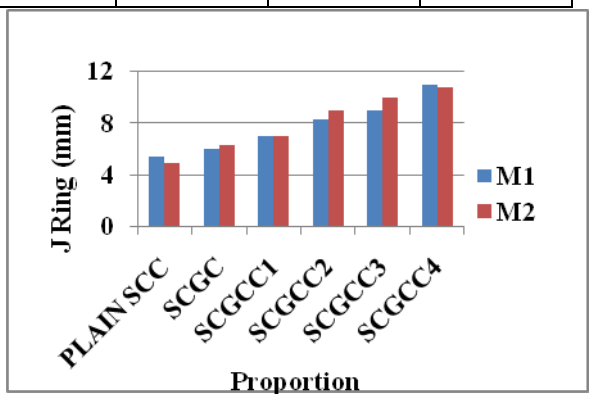

Fig 2. J Ring Test

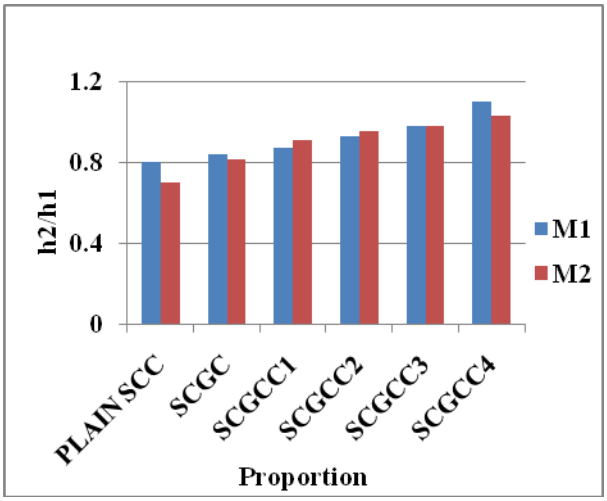

Fig 3. L Box Test

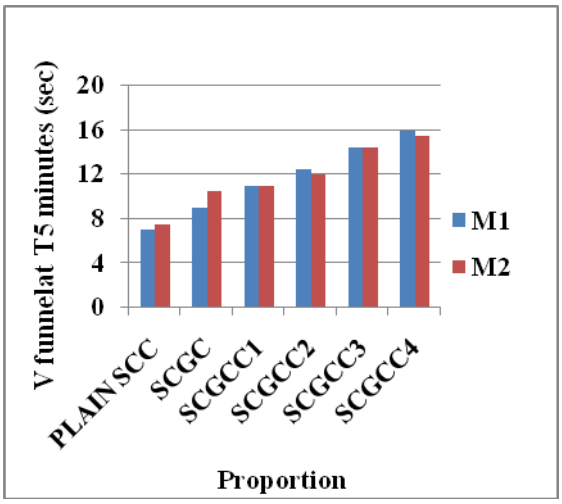

Fig 4. V funnel at T5 minutes Test

3.2 Durability Study

3.2.1 Acid Attack

In fact concrete is not fully resistant to acids. All acids will have impact on concrete. The rate of speed of action may differ but they finally disintegrate the concrete. Almost all the aggregates are susceptible to acid attack if they contain more calcareous content. The content like Ca and C-S-H are more susceptible to chemical attack. The intensity of disintegration of concrete caused by Hydrochloric (HCl) acid is more than the Sulphuric acid with an equal amount of concentration [3]. Because HCl has more calcareous content than sulphuric acid. The present experimental study has conducted on concrete of cube specimen of size 150x150x150 mm. The specimens are immersed in 5% HCl solution. The deterioration of specimen can be estimated by finding out the reduction in weight of the specimen and also the reduction in compressive strength of the specimen when they are immersed in chemical solution is identified. The results of acid attack are shown in Table 10.

Table 10 Effect of Acid Attack on SCC, SCGC & SCGCC

Concrete Grade	Concrete Type	Weight of Specimen Before Acid Immersion (Kg)	Weight of Specimen After Acid Immersion (Kg)	Compressive strength of Specimen Before Acid Immersion (N/mm^2)	Compressive strength of Specimen After Acid Immersion (N/mm^2)	Reduction in Compressive strength (N/mm^2)
M1	Plain SCC	8.130	8.063	27.07	25.81`	1.80
	SCGC	8.128	8.086	29.33	28.27	1.06
	SCGCC1	8.135	8.068	30.78	29.86	0.92
	SCGCC2	8.137	8.049	32.41	31.27	1.14
	SCGCC3	8.140	8.035	31.59	29.73	1.86
	SCGCC4	8.142	8.026	28.32	26.23	2.09
M2	Plain SCC	8.120	8.057	39	37.05	1.95
	SCGC	8.127	8.061	41.8	40.41	1.39

	SCGCC1	8.132	8.058	43.63	41.85	1.78
	SCGCC2	8.135	8.046	46.07	43.94	2.13
	SCGCC3	8.132	8.033	44.78	41.92	2.86
	SCGCC4	8.130	8.021	40.37	37.08	3.29

The acid resistance results show that the weight reduction and reduction in compressive strength for SCC, SCGC & SCGCC specimens. In that the reduction of weight &strength of SCGCC1 specimen have the better requirement than the other specimens for both grade of concrete.

3.2.2 Sulphate Attack

The sulphate attack testing procedure was conducted by immersing the cube specimen of size 150x150x150 mm in the 5% $MgSO_4$ solution over a period of time of 28 days. The deterioration of specimen can be estimated by finding out the reduction in weight of the specimen and also the reduction in compressive strength of the specimen when they are immersed in chemical solution is identified. The results of acid attack are shown in Table 11.

Table 11 Effect of Sulphate Attack on SCC, SCGC & SCGCC

Concrete Grade	Concrete Type	Weight of Specimen Before Acid Immersion (Kg)	Weight of Specimen After Acid Immersion (Kg)	Compressive strength of Specimen Before Acid Immersion (N/mm^2)	Compressive strength of Specimen After Acid Immersion (N/mm^2)	Reduction in Compressive strength (N/mm^2)
M1	Plain SCC	8.130	8.076	27.07	25.4	1.67
	SCGC	8.119	8.073	29.33	28.29	1.04
	SCGCC1	8.127	8.057	30.78	29.93	0.85
	SCGCC2	8.131	8.034	32.41	31.31	1.10
	SCGCC3	8.137	8.031	31.59	29.83	1.76
	SCGCC4	8.141	8.029	28.32	26.43	1.89
M2	Plain SCC	8.120	8.057	41.8	40.05	1.75
	SCGC	8.127	8.061	43.63	42.39	1.24
	SCGCC1	8.132	8.058	46.07	44.49	1.58
	SCGCC2	8.135	8.046	44.78	42.8	1.98
	SCGCC3	8.132	8.033	40.37	37.89	2.48
	SCGCC4	8.130	8.021	41.8	38.74	3.06

The sulphate attack results show that the weight reduction and reduction in compressive strength for SCC, SCGC & SCGCC specimens. In that the reduction of weight &strength of SCGCC1 specimen have the better requirement than the other specimens for both grade.

3.2.3 Sorptivity Test

Sorptivity test measures the rate of penetration of water into the pores of concrete by capillary suction. The cylindrical specimen of size 60 mm height and 100mm dia were cured in the respective curing type. After curing the SCC and SCGC &SCGCC specimens were kept in a oven for 110°C [12]. Then the side surface of the specimen was sealed with coating to allow the penetration of water into the concrete only from the bottom surface. The specimens are immersed in the container containing water and the specimens were supported on rods that was submerged about 10mm. The quantity of water absorbed in the period of 30 minutes was weighed using weighing balance. Surface water of the specimen was wiped with the disuse and each weighing operation was completed within 30 seconds. The cumulative volume of water that has penetrated per unit surface area of exposure plotted against the square root of the time elapsed. The results of sorptivity are shown in Table 12

The sorptivity was computed by,

$$S = I/\sqrt{t}$$

Where,

S = Sorptivity (mm/min$^{0.5}$),

I = ΔW/Ad,

ΔW = Change in Weight = $W_2 - W_1$,

W_1 = Oven dry weight (grams),

W_2 = Weight of specimen after 30 minutes penetration of water (grams),

A = Surface Area through which water penetrated (mm^2),

d = Density of water,

t= time elapsed (min)

Table 12 Effect of Sorptivity on SCC, SCGC & SCGCC

Concrete Grade	Concrete Type	Dry weight of specimen (W_1) (gram)	Wet weight of specimen(W_2) (gram)	Sorptivity Value in 10^{-5} (mm/min$^{0.5}$)
M1	Plain SCC	1306.5	1307.85	0.08717
	SCGC	1230.7	1231.5	0.05166
	SCGCC1	1247.6	1249.25	0.10654
	SCGCC2	1248.5	1250.21	0.11042
	SCGCC3	1248.7	1250.87	0.13792
	SCGCC4	1249.3	1251.24	0.16780

M2	Plain SCC	1286.8	1287.98	0.07619
	SCGC	1251.5	1252.67	0.07555
	SCGCC1	1256.53	1258.03	0.09685
	SCGCC2	1267.47	1269.19	0.11106
	SCGCC3	1270	1271.85	0.11946
	SCGCC4	1273.35	1275.37	0.13043

IV **CONCLUSION**

Based on the experimental investigation the following observations are made regarding the durability study as replacement of fly ash by cement up to 20% for M1and M2 grade concrete.

1. The workability properties for M1 & M2 mixes are satisfies the EFNARC guidelines; give the best replacement percentage of fly ash by cement was SCGCC2 and for SCGCC4 specimen slightly beyond the requirements of EFNARC guidelines.
2. The test results of acid attack & sulphate attack of the concrete shows at SCGCC1 specimen have lower disintegration than the other type of concrete because SCGCC2, SCGCC3 & SCGCC4 have the higher Ca and C-S-H content than SCGCC1.
3. The sorptivity of the concrete also shows lower water penetration for SCGCC1 specimen than the others.

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TIME TO RECRUITMENT IN A TWO GRADE MANPOWER SYSTEM WITH TWO SOURCES OF DEPLETION AND CORRELATED INTER-POLICY DECISION TIMES

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ABSTRACT

In this paper, the problem of time to recruitment is studied for a two grade manpower system in which attrition, takes place due to policy and transfer decisions which form respectively two independent sources of depletion. A Stochastic model is constructed and using a univariate policy of recruitment, the variance of time to recruitment is obtained when inter-policy decision times form a sequence of exchangeable and correlated exponential random variables.

Keywords- Two grade manpower system, two independent sources of depletion, univariate policy of recruitment and variance of the time to recruitment.

2000MSC Subject classification: Primary: 990B70, Secondary: 91B40, 91D35.

I INTRODUCTION

The study on manpower planning has a rich empirical background beginning with Bartholomew [1]. Many researchers like Young and Almond [2], Bartholomew and Morries [3], Young and Vassiliou [4], Grinold [5] and so on have contributed to this purview in different directions. Numerous stochastic models for the estimation of time to recruitment in a single and multi graded organization with only one source of depletion using shock model approach have been constructed and studied by Elangovan[6], Savithri[7], Esther Clara[8], Muthaiyan[9], Parthasarathy[10], Sendhamizh Selvi[11], Vidhya[12], to name a few. Elangovan et.al [13] have initiated the study on recruitment problem for a single grade manpower system with two sources of depletion and obtained the variance of time to recruitment using univariate CUM policy of recruitment when the loss of man power in the organization due to the two sources of depletion, inter-policy decision times, inter-transfer decision times and threshold for the loss of man power in the organization are independent and identically distributed exponential random variables. Usha et.al[14] have studied the work in[13] when inter-policy decision times are constantly correlated exchangeable and exponential distribution. In [15] and [16] Dhivya and Srinivasan have extended the work in [13] for a two grade manpower system according as the inter-policy decisions and inter-transfer decisions form the same or different ordinary renewal process respectively. In [17], Dhivya and Srinivasan have studied their work in [15] & [16] using univariate **max** policy of recruitment. In

[18], Dhivya and Srinivasan have studied their work in [15] when the policy decisions are classified into two types according to the intensity of attrition. The objective of the present paper is to study the problem of time to recruitment in [15] when inter-policy decision times are exchangeable and constantly correlated exponential random variables thereby extending the work in [14] for the manpower system with two grades.

II MODEL DESCRIPTION

Consider an organization taking decisions at random epoch (0,∞) and at every decision making epoch a random number of persons quit the organization. There is an associated loss of manpower if a person quits. It is assumed that the loss of manpower is linear and cumulative. For i=1,2,3…, let X_{Ai} and X_{Bi} be the continuous random variables representing the amount of depletion of manpower(loss of man hours) in grades A and B respectively caused due to the ith policy decision. It is assumed that X_{Ai} and X_{Bi} areindependent for each i and each form a sequence of independent and identically distributed random variables with distributions $G_A(.)$ and $G_B(.)$ and probability density functions $g_A(.)$ and $g_B(.)$ respectively. Let $\bar{X}_{Am}$ and $\bar{X}_{Bm}$ be the total depletion of manpower in the first m policy decisions in grades A and B respectively. Let $\bar{X}_m$ be the cumulative depletion of manpower in the organization due to thefirst m policy decisions. For j=1,2,3…,let Y_{Aj} and Y_{Bj} be the continuous random variables representing the amount of depletion of manpower in grades A and B respectively caused due to the jth transfer decision. It is assumed that Y_{Aj} and Y_{Bj} are independent for each j and each form a sequence of independent and identically distributed random variables with probability density functions $h_A(.)$ and $h_B(.)$ respectively.Let $\bar{Y}_{An}$ and $\bar{Y}_{Bn}$ be the total depletion of manpower in the first n transfer decisions in grades A and B respectively. Let $\bar{Y}_n$ be the cumulative depletion of manpower in the organization due to the first n transfer decisions. For each i and j X_{Ai}, X_{Bi}, Y_{Aj} and Y_{Bj} are statistically independent.Let $\bar{g}_A(.)$, $\bar{g}_B(.)$, $\bar{h}_A(.)$ and $\bar{h}_B(.)$ be the Laplace transforms of $g_A(.)$, $g_B(.)$, $h_A(.)$ and $h_B(.)$ respectively. Let Z_A and Z_B beindependent exponentially distributed threshold levels for the depletion of manpower ingrades A and B with mean $\frac{1}{\theta_A}$ and $\frac{1}{\theta_B}$ $(\theta_A, \theta_B > 0)$ respectively and let Z be the threshold level for the depletion of manpower in the organization. Let $k_A(.)$, $k_B(.)$ and $k(.)$ be the probability density function of Z_A, Z_B and Z respectively. Let the inter-policy decision times be constantly correlated exchangeable and exponential random variables with distribution $F(.)$, probability density function $f(.)$ and parameter α, Let $F_m(.)$ be the distribution of the waiting time upto m policy decision times. Let the inter-transfer decision times be independent and identically distributed exponential random variables with distribution $W(.)$, probability density function $w(.)$ and mean $\frac{1}{\mu_2}$ $(\mu_2 > 0)$. It is assumed that the two sources of depletion are independent. Let $W_n(.)$ be the n-fold convolution of $W(.)$ with itself. The univariate CUM policy of recruitment employed in this paper is stated as follows:

Recruitment is done whenever the cumulative loss of man hours in the organization exceeds the threshold for the loss of man hours in this organization

Let T be the random variable denoting the time to recruitment with distribution L(.),probability density function l(.), Laplace transform $\bar{l}(s)$, mean E(T) and variance V(T). Let $N_P(T)$ and $N_{Trans}(T)$ be the number of policy

decisions and transfer decisions taken until the time to recruitment T respectively. Let $\bar{X}_{N_P(T)}$ and $\bar{Y}_{N_{Trans}(T)}$ be the respective total loss of manpower in $N_P(T)$ and $N_{Trans}(T)$ decisions until the time to recruitment T.

III MAIN RESULTS

$$P(T > t) = \sum_{m=0}^{\infty}\sum_{n=0}^{\infty}\left\{\begin{array}{c}\text{Probability that there are exactly } m \text{ policy decisions and } n \text{ transfer} \\ \text{decisons in } [0,t) \\ \text{and the total loss of manhours due to } m \text{ policy decisions and } n \text{ transfer} \\ \text{decisions does not exceed the threshold } Z\end{array}\right\}$$

From renewal theory [19],

$$P(T > t) = \sum_{m=0}^{\infty}[F_m(t) - F_{m+1}(t)]\sum_{n=0}^{\infty}[W_m(t) - W_{m+1}(t)]P(\bar{X}_m + \bar{Y}_n \le Z) \qquad (1)$$

where $F_0(t) = W_0(t) = 1$. Invoking to the law of total probability, we get

$$P(\bar{X}_m + \bar{Y}_n \le Z) = \int_0^{\infty} P(\bar{X}_m + \bar{Y}_n < z)\ k(z)\ dz \qquad (2)$$

We now obtain some performance measures related to time to recruitment for different forms of Z.

Case (i) $Z = \min(Z_A, Z_B)$.

In this case

$$k(z) = (\theta_A + \theta_B)e^{-(\theta_A+\theta_B)z} \qquad (3)$$

From (1),(2)and (3)

$$P(T > t) = \sum_{m=0}^{\infty}[F_m(t) - F_{m+1}(t)]\,[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^m\ X\sum_{n=0}^{\infty}[W_n(t) - W_{n+1}(t)]\ \left[\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]^n$$

On simplification, it can be shown that

$$P(T > t) = \{1 - [1 - \bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]\sum_{m=1}^{\infty}F_m(t)\,[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1}\}X$$
$$\left\{1 - \left[1 - \bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]\sum_{n=1}^{\infty}W_n(t)\left[\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]^{n-1}\right\} \qquad (4)$$

Since $w_n(t) = \frac{\mu_2{}^n e^{-\mu_2 t}t^{n-1}}{(n-1)!}$ by hypothesis, we find that

$$\left[1 - \bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]\sum_{n=1}^{\infty}W_n(t)\left[\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]^{n-1} = 1 - e^{-\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]t} \qquad (5)$$

Therefore from (4) and (5) we get

$$L(t) = 1 - e^{-\mu_2[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)]t}$$
$$-[1 - \bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]\sum_{m=1}^{\infty}F_m(t)e^{-\mu_2[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)]t}[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1}$$

Since $l(t) = \frac{d}{dt}L(t)$ and $E(T^r) = (-1)^r\left[\frac{d^r}{ds^r}(\bar{l}(s))\right]_{s=0}$, the first two moments of time to recruitment are given below.

$$E(T) = \frac{1}{\mu_2\left[1 - \bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]}$$
$$-\frac{1 - \bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)}{\mu_2\left[1 - \bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]}\sum_{m=1}^{\infty}\bar{f}_m\left[\mu_2\left(1 - \bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)\right][\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1} \qquad (6)$$

$$E(T^2)=\frac{2}{\left[\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]\right]^2}$$
$$-\frac{2[1-\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]}{\left[\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]\right]^2}\sum_{m=1}^{\infty}\bar{f}_m\left[\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)\right][\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1}$$
$$+\frac{2[1-\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]}{\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]}\sum_{m=1}^{\infty}\bar{f}'_m\left[\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)\right][\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1} \quad (7)$$

When $K_i, i=1,2,\dots,m$ are exchangeable and constantly correlated exponential random variables with correlation R, Gurland [20] has obtained the expression for the cumulative distribution function of the partial sum $S_m=K_1+K_2+\cdots+K_m$ as

$$P(S_m\le x)=(1-R)\sum_{i=0}^{\infty}\frac{(mR)^i}{(1-R+mR)^{i+1}}\frac{\psi\left(m+i,{}^{x}/_{b}\right)}{(m+i-1)!} \quad (8)$$

where $\psi(n,x)=\int_0^x e^{-u}u^{n-1}du$ and $b=\alpha(1-R)$, α being the parameter of the exponential distribution.

Therefore in this paper

$$\bar{f}_m(s)=\frac{1}{(1+bs)^m\left(1+\frac{mRbs}{(1-R)(1+bs)}\right)} \quad (9)$$

Using (9) in (6) and (7), and on simplification we get

$$E(T)=\frac{1}{\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]}$$
$$-\frac{1-\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)}{\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)\right]^{1-m}}{1-R+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)(1-R+mR)}[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1} \quad (10)$$

and

$$E(T^2)=\frac{2}{\left[\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]\right]^2}-\frac{2[1-\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]}{\left[\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]\right]^2}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)\right]^{1-m}}{1-R+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)(1-R+mR)}[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1}$$
$$+\frac{2[1-\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^2(1-R)}{\mu_2[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)]}\sum_{m=1}^{\infty}\left(1+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)\right)^{-m}\left\{\frac{b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)(1-m(1-R+mR))-m}{\left[1-R+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)(1-R+mR)\right]^2}\right\}[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1}$$
(11)

(10) gives the mean time to recruitment and (10) together with (11) give the variance of time to recruitment for this case.

Case (ii) $Z=\max(Z_A,Z_B)$.

For this case, $k(z)=\theta_A e^{-\theta_A z}+\theta_B e^{-\theta_B z}-(\theta_A+\theta_B)e^{-(\theta_A+\theta_B)z}$ (12)

From (1),(2)and (12) and on simplification

$$P(T>t)=\{1-[1-\bar{g}_A(\theta_A)\bar{g}_B(\theta_A)]\textstyle\sum_{m=1}^{\infty}F_m(t)[\bar{g}_A(\theta_A)\bar{g}_B(\theta_A)]^{m-1}\}\left\{1-\left[1-\bar{h}_A(\theta_A)\bar{h}_B(\theta_A)\right]\textstyle\sum_{m=1}^{\infty}W_m(t)\left[\bar{h}_A(\theta_A)\bar{h}_B(\theta_A)\right]^{m-1}\right\}+$$
$$\{1-[1-\bar{g}_A(\theta_B)\bar{g}_B(\theta_B)]\textstyle\sum_{m=1}^{\infty}F_m(t)[\bar{g}_A(\theta_B)\bar{g}_B(\theta_B)]^{m-1}\}\left\{1-\left[1-\bar{h}_A(\theta_B)\bar{h}_B(\theta_B)\right]\textstyle\sum_{m=1}^{\infty}W_m(t)\left[\bar{h}_A(\theta_B)\bar{h}_B(\theta_B)\right]^{m-1}\right\}-$$
$$\{1-[1-\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]\textstyle\sum_{m=1}^{\infty}F_m(t)[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1}\}$$
$$\left\{1-\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]\textstyle\sum_{m=1}^{\infty}W_m(t)\left[\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]^{m-1}\right\}$$

Proceeding as in case (i) we get

$$E(T)=\frac{1}{\mu_2\left[1-\bar{h}_A(\theta_A)\bar{h}_B(\theta_A)\right]}-\frac{1-\bar{g}_A(\theta_A)\bar{g}_B(\theta_A)}{\mu_2\left[1-\bar{h}_A(\theta_A)\bar{h}_B(\theta_A)\right]}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_2\left(1-\bar{h}_A(\theta_A)\bar{h}_B(\theta_A)\right)\right]^{1-m}}{1-R+b\mu_2\left(1-\bar{h}_A(\theta_A)\bar{h}_B(\theta_A)\right)(1-R+mR)}[\bar{g}_A(\theta_A)\bar{g}_B(\theta_A)]^{m-1}+\frac{1}{\mu_2\left[1-\bar{h}_A(\theta_B)\bar{h}_B(\theta_B)\right]}$$
$$-\frac{1-\bar{g}_A(\theta_B)\bar{g}_B(\theta_B)}{\mu_2\left[1-\bar{h}_A(\theta_B)\bar{h}_B(\theta_B)\right]}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_2\left(1-\bar{h}_A(\theta_B)\bar{h}_B(\theta_B)\right)\right]^{1-m}}{1-R+b\mu_2\left(1-\bar{h}_A(\theta_B)\bar{h}_B(\theta_B)\right)(1-R+mR)}[\bar{g}_A(\theta_B)\bar{g}_B(\theta_B)]^{m-1}-\frac{1}{\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]}$$
$$+\frac{1-\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)}{\mu_2\left[1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right]}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)\right]^{1-m}}{1-R+b\mu_2\left(1-\bar{h}_A(\theta_A+\theta_B)\bar{h}_B(\theta_A+\theta_B)\right)(1-R+mR)}[\bar{g}_A(\theta_A+\theta_B)\bar{g}_B(\theta_A+\theta_B)]^{m-1} \quad (13)$$

and

$$
\begin{aligned}
E(T^2) = {} & \frac{2}{\left[\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]\right]^2} - \frac{2\left[1-\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]}{\left[\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]\right]^2}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)\right]^{1-m}}{1-R+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)(1-R+mR)}\left[\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]^{m-1} \\
& + \frac{2\left[1-\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]\theta^2(1-R)}{\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]}\sum_{m=1}^{\infty}\left(1+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)\right)^{-m}\left\{\frac{b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)(1-m(1-R+mR))-m}{\left[1-R+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)(1-R+mR)\right]^2}\right\}\left[\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]^{m-1} + \frac{2}{\left[\mu_1\left[1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]\right]^2} \\
& - \frac{2\left[1-\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]}{\left[\mu_1\left[1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]\right]^2}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_1\left(1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right)\right]^{1-m}}{1-R+b\mu_1\left(1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right)(1-R+mR)}\left[\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]^{m-1} \\
& + \frac{2\left[1-\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]\theta^2(1-R)}{\mu_1\left[1-\bar{h}_1(\theta_{A_2})\bar{h}_2(\theta_{A_2})\right]}\sum_{m=1}^{\infty}\left(1+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)\right)^{-m}\left\{\frac{b\mu_1\left(1-\bar{h}_1(\theta_{A_2})\bar{h}_2(\theta_{A_2})\right)(1-m(1-R+mR))-m}{\left[1-R+b\mu_1\left(1-\bar{h}_1(\theta_{A_2})\bar{h}_2(\theta_{A_2})\right)(1-R+mR)\right]^2}\right\}\left[\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]^{m-1} - \frac{2}{\left[\mu_1\left[1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right]\right]^2} \\
& + \frac{2\left[1-\bar{g}_1(\theta_A+\theta_B)\bar{g}_2(\theta_A+\theta_B)\right]}{\left[\mu_1\left[1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right]\right]^2}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_1\left(1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right)\right]^{1-m}}{1-R+b\mu_1\left(1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right)(1-R+mR)}\left[\bar{g}_1(\theta_A+\theta_B)\bar{g}_2(\theta_A+\theta_B)\right]^{m-1} \\
& - \frac{2\left[1-\bar{g}_1(\theta_A+\theta_B)\bar{g}_2(\theta_A+\theta_B)\right]\theta^2(1-R)}{\mu_1\left[1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right]}\sum_{m=1}^{\infty}\left(1+b\mu_1\left(1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right)\right)^{-m}\left\{\frac{b\mu_1\left(1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right)(1-m(1-R+mR))-m}{\left[1-R+b\mu_1\left(1-\bar{h}_1(\theta_A+\theta_B)\bar{h}_2(\theta_A+\theta_B)\right)(1-R+mR)\right]^2}\right\}\left[\bar{g}_1(\theta_A+\theta_B)\bar{g}_2(\theta_A+\theta_B)\right]^{m-1}
\end{aligned}
\tag{14}
$$

(13) gives the mean time to recruitment and (13) together with (14) give the variance of time to recruitment for case(ii).

Case (iii) Let $Z = Z_A + Z_B$

In this case $k(z) = \frac{\theta_A\theta_B}{\theta_A-\theta_B}\left[e^{-\theta_B z} - e^{-\theta_A z}\right]$ (15)

From (1),(2)and (15)

$$
\begin{aligned}
P(T > t) = {} & \frac{\theta_A}{\theta_A-\theta_B}\left\{1-\left[1-\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]\sum_{m=1}^{\infty}F_m(t)\left[\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]^{m-1}\right\}\left\{1-\left[1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]\sum_{m=1}^{\infty}W_m(t)\left[\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]^{m-1}\right\} - \\
& \frac{\theta_B}{\theta_A-\theta_B}\left\{1-\left[1-\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]\sum_{m=1}^{\infty}F_m(t)\left[\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]^{m-1}\right\}\left\{1-\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]\sum_{m=1}^{\infty}W_m(t)\left[\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]^{m-1}\right\}
\end{aligned}
$$

Proceeding as in case (i) we get

$$
\begin{aligned}
E(T) = \frac{1}{\theta_A-\theta_B}\Bigg\{ & \frac{\theta_A}{\mu_1\left[1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]} - \frac{\theta_A\left[1-\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]}{\mu_1\left[1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_1\left(1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right)\right]^{1-m}}{1-R+b\mu_1\left(1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right)(1-R+mR)}\left[\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]^{m-1} - \frac{\theta_B}{\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]} \\
& + \frac{\theta_B\left[1-\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]}{\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)\right]^{1-m}}{1-R+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)(1-R+mR)}\left[\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]^{m-1}\Bigg\}
\end{aligned}
\tag{16}
$$

and

$$
\begin{aligned}
E(T^2) = \frac{1}{\theta_A-\theta_B}\Bigg\{ & \frac{-2\theta_B}{\left[\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]\right]^2} + \frac{2\theta_B\left[1-\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]}{\left[\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]\right]^2}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)\right]^{1-m}}{1-R+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)(1-R+mR)}\left[\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]^{m-1} \\
& - \frac{2\theta_B\left[1-\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]\theta^2(1-R)}{\mu_1\left[1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right]}\sum_{m=1}^{\infty}\left(1+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)\right)^{-m}\left\{\frac{b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)(1-m(1-R+mR))-m}{\left[1-R+b\mu_1\left(1-\bar{h}_1(\theta_A)\bar{h}_2(\theta_A)\right)(1-R+mR)\right]^2}\right\}\left[\bar{g}_1(\theta_A)\bar{g}_2(\theta_A)\right]^{m-1} + \frac{2\theta_A}{\left[\mu_1\left[1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]\right]^2} \\
& - \frac{2\theta_A\left[1-\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]}{\left[\mu_1\left[1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right]\right]^2}\sum_{m=1}^{\infty}\frac{(1-R)\left[1+b\mu_1\left(1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right)\right]^{1-m}}{1-R+b\mu_1\left(1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right)(1-R+mR)}\left[\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]^{m-1} \\
& + \frac{2\theta_A\left[1-\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]\theta^2(1-R)}{\mu_1\left[1-\bar{h}_1(\theta_{B_2})\bar{h}_2(\theta_{B_2})\right]}\sum_{m=1}^{\infty}\left(1+b\mu_1\left(1-\bar{h}_1(\theta_B)\bar{h}_2(\theta_B)\right)\right)^{-m}\left\{\frac{b\mu_1\left(1-\bar{h}_1(\theta_{B_2})\bar{h}_2(\theta_{B_2})\right)(1-m(1-R+mR))-m}{\left[1-R+b\mu_1\left(1-\bar{h}_1(\theta_{B_2})\bar{h}_2(\theta_{B_2})\right)(1-R+mR)\right]^2}\right\}\left[\bar{g}_1(\theta_B)\bar{g}_2(\theta_B)\right]^{m-1}\Bigg\}
\end{aligned}
\tag{17}
$$

(16) gives the mean time to recruitment and (16) together with (17) give the variance of time to recruitment for case(iii).

3.1 Special Case

Suppose X_{Ai}, X_{Bi}, Y_{Aj} and Y_{Bj} follow exponential distribution with parameters $\alpha_{1A}, \alpha_{1B}, \alpha_{2A}$ and α_{2B} respectively.

In this case $\bar{g}_A(\theta) = \frac{\alpha_{1A}}{\alpha_{1A}+\theta}, \bar{g}_B(\theta) = \frac{\alpha_{1B}}{\alpha_{1B}+\theta}, \bar{h}_A(\theta) = \frac{\alpha_{2A}}{\alpha_{2A}+\theta}, \bar{h}_B(\theta) = \frac{\alpha_{2B}}{\alpha_{2B}+\theta}$ (18)

Using (18) in (10), (11), (13), (14), (16) and (17), we get explicit form of mean and variance of time to recruitment for all the three cases.

Note:

Some performance measures related to time to recruitment are presented below.

1. The average number of policy decisions taken until the time to recruitment T is

$$E\left(N_P(T)\right) = \int_0^\infty E\left(N_P(t)\right) i(t)dt$$

2. The average number of transfer decisions taken until the time to recruitment T is

$$E\left(N_{Trans}(T)\right) = \int_0^\infty E\left(N_{Trans}(t)\right) i(t)dt = \mu_2 E(T)$$

3. The cumulative loss of manpower due to $N_P(T)$ policy decisions is

$$\bar{X}_{N_P(T)} = E(X_i)E\left(N_P(T)\right) = E\left(N_P(t)\right)[E(X_{Ai}) + E(X_{Bi})]$$

4. The cumulative loss of manpower due to $N_{Trans}(T)$ transfer decisions is

$$\bar{X}_{N_{Trans}(T)} = E(X_i)E\left(N_{Trans}(T)\right) = \mu_2 E(T)\,[E\left(Y_{Aj}\right) + E(Y_{Bj})]$$

IV CONCLUSION

The manpower planning model developed in this paper is new in the context of correlated inter-policy decision time. This model can be used to plan for the adequate provision of manpower for the organization at graduate, professional and management levels in the context of attrition. There is a scope for studying the applicability of the designed model using simulation. Further, by collecting relevant data, one can test the goodness of fit for the distributions assumed in this paper. The findings given in this paper enable one to estimate manpower gap in future, thereby facilitating the assessment of manpower profile in predicting future manpower development not only on industry but also in a wider domain.

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SOUND – A NEW FORM OF RENEWABLE ENERGY

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ABSTRACT

The lifetime of modern embedded systems and mobile devices depends on battery. It requires periodic recharging or replacement of these batteries for extending the working of such devices. Each time in order to charge these batteries an alternating current is necessary. Here we present sound as a new form of renewable energy for charging of these batteries to some extent. Sound energy can be converted to electric energy using piezoelectric material which exhibit piezoelectric effect. In our system we employ the direct piezoelectric effect.

Keywords – Alternating Current, Direct Piezoelectric Effect, Embedded System, Piezoelectric Material

I. INTRODUCTION

Due to the immense need of energy for various applications, researchers are mainly focusing on developing new and improved measures to meet this energy demand. Also with the invention of small and micro devices which need continuous supply of energy for its working, new measures to provide energy for satisfying their need is also an ongoing research topic. As a result energy harvesting from sound is a recent research trend. Sound to some extent can be used as a new energy. Charging of small embedded devices can be done to a certain extent using sound energy.

Renewable energy is generally defined as energy that comes from resources which are naturally replenished. Renewable energy sources exist over wide geographical areas in country to other energy resources. Rapid deployment of energy efficiency and renewable energy is resulting in significant energy security.

Sound energy when used as renewable energy makes large sound which is a nuisance for normal man a boon for him. Large amount of sound is produced around as daily. If this sound can be used for harvesting energy then at least one by fourth or 10% of the normal energy need can be met.

Renewable energy usually arises from natural sources thatare constantly and sustainably replenished. The technology featured here will make the society healthier and secure. The prosperity of the human and their innovations will find a fast growing phase. Sound energy which is the upcoming trend in the energy world is a form of energy associated with vibrations or disturbance of matter. A sound is a mechanical wave and consists in oscillatory elastic compression and in oscillatory displacement in a fluid. Sound power or acoustic power is the measure of sound energy per time unit.

Since sound is the movement of energy through substances in longitudinal wave it is a form of mechanical energy. So in order to harvest sound energy some kind of piezoelectric materials need to be used. Piezoelectric material is another major concept behind sound energy harvesting.

II. PIEZOELECTRICITY

Piezoelectricity is the electric charge that accumulates in certain solid materials in response to applied mechanical stress. The word piezoelectricity means electricity from pressure. The piezoelectric effect is a reversible process. In that materials exhibit the direct piezoelectric effect and also exhibit the reverse piezoelectric effect. Piezoelectricity is found in useful applications such as production and detection of sound.

The piezoelectric effect describes the relation between a mechanical stress and an electrical voltage in solids. The piezoelectric effect occurs only in non-conductive materials. The piezoelectric effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. The unique characteristic of the piezoelectric effect is that it is reversible.

When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezoelectric material. The piezoelectric effect occurs only in non-conductive materials. The piezoelectric effect describes the relation between a mechanical stress and electrical voltage. It can be described as the link between electrostatics and mechanics.

A piezoelectric transducer is a device that transforms one type of energy to another by taking advantage of the piezoelectric properties of certain crystals or other materials. When a piezoelectric material is subjected to stress or force, it generates an electrical potential or voltage proportional to the magnitude of the force. These make the transducer ideal as a converter of mechanical energy or force into electric potential.

The high sensitivity of piezoelectric transducers makes them useful in microphones where they convert sound pressure into electric voltage. They are also used in non-destructive testing, in the generation of high voltages, and in many other applications requiring the precise sensing of motion or force. The voltage generated by piezoelectric transducers can be quite high, often in thousands of volts, but is brief, occurring only when the material is initially deformed.

Piezoelectricity means “Electricity from pressure”. The so called “direct effect” means that piezoelectric materials develop charge if deformed by mechanical stress. The inverse effect in piezoelectricity is production of deformation due to the application of an electrical field.

When a crystal is mechanically strained, or when the crystal is deformed by the application of an external stress, electric charges appear on certain of the crystal surfaces; and when the direction of the strain reverses, the polarity of electric charge is reversed. This is called the Direct Piezoelectric Effect, and the crystals that exhibit it are classified as piezoelectric crystal.

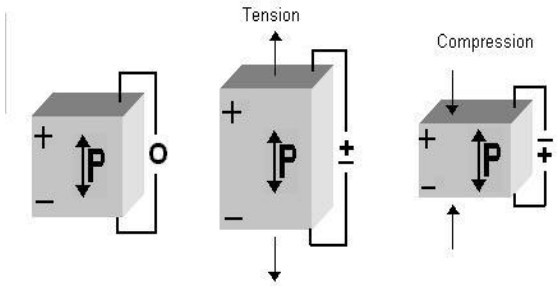

Fig. 1- Direct Piezoelectric Effect

When a piezoelectric crystal is placed in an electric field, or when charges are applied by external means to its faces, the crystal exhibits strain, i.e. the dimension of the crystal change. When the direction of the applied electric field is reversed, the direction of the resulting strain is reversed. This is called as converse piezoelectric effect.

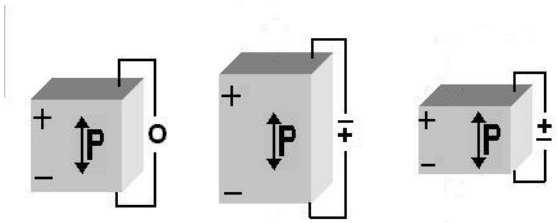

Fig. 2- Converse Piezoelectric Effect

The piezoelectric effect describes the relation between a mechanical stress and an electrical voltage in solids. The piezoelectric effect occurs only in non-conductive materials. Piezoelectric materials can be divided in 2 main groups: crystals and ceramics. The most well-known piezoelectric material is quartz (SiO2).

III. PROPOSED WORK

Use of Renewable energy in charging battery is not a new concept. Recent advances in energy conversion have shown a great hope in this measure. Many researchers proposed solar, wind and heat due to their availability. Here, we propose a new source of energy namely sound or air pressure which can be easily used to charge batteries in embedded system

The proposed work is to present an effective method for producing useful electric power to charge the conventional battery from available sound energy around us from noises. Piezoelectric material is one of the most effective sound sensors. The way it works is that the mechanical energy of sound or air pressure is applied directly to a crystal with strong piezoelectric characteristics. The piezoelectric crystal will generate a small amount of voltage in response to the application of mechanical energy. If more number of piezoelectric materials is serially connected they can produce more amount of energy. So the amount of energy produced can be used for charging small devices. In order for the effective charging of small devices continuous supply of noise is needed. In our proposed system we are implementing a system so as to charge a cellphone when sound reaches the system from any means.

VI. CONCLUSION

Energy harvesting or scavenging, which harvests or scavenges energy from a variety of ambient energy sources and converts into electrical energy to recharge the batteries and power electronic devices, has emerged as a promising technology. A new form of renewable energy i.e. sound is proposed as the new solution for the energy needs that arise in the developing world of technology.

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EXTRACTION AND ANALYSIS OF TRANSABDOMINAL FETAL HEART RATE BY NIR PHOTOPLETHYSMOGRAPHY

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ABSTRACT

Fetal heart rate variability is known to be of great meaning in assessing the fetal health status. It remains standard for the intrapartum assessment of fetal well being and to diagnose the cardiac disorders. Measurements of heart rate on the maternal abdomen provide a valuable alternative for standard fetal monitoring. In this paper, the heart rate is initially measured using an Optical Fetal Heart Rate Detector (OFHR). Then signal conditioning and conversion is applied to the recorded heart rate. Digital synchronous detection and preprocessing techniques are applied to segregate the fetal heart rate from the mixed signal (mother + fetal) by adaptive noise cancelling techniques, whereas PPG from the mother's index finger is the reference input. Removal of the maternal heart rate from the mixed signal provides the fetal heart rate. Finally the resulted fetal heart rate is correlated with the Ultrasonic Doppler fetal heart rate detector values to analyze the performance of the proposed technique. The results act as the beneficiary tool to detect the fetal disorders.

Index Terms –Adaptive Filter, Fetal Heart Rate, Optical , PPG.

I.INTRODUCTION

Heart rate is the major core vital sign to detect the health of an individual. Heart rate is defined as the number of heart beats per minute measured in bpm. The average heart rate of the resting adult is 72bpm. The normal heart rate of an adult ranges from 60 to 100bpm. The normal fetal heart rate ranges from 110 to 160 bpm. Cardiac disorders are the most life threatening disorders amongst the birth defects. Their diagnosis is necessary at the fetal stage as it might provide an opportunity to plan and manage the baby as and when the baby is born. The most dangerous cardiac disorder in fetus is the Congenital Heart Disease (CHD). CHD is the defect in the heart vessels which is present at the time of birth. It obstructs the blood flow in the heart or the vessels near it which causes the blood to flow in the abnormal pattern. The only way of detecting these defects is by monitoring the FHR. There are various kinds of methods to detect FHR. One such traditional method to detect the FHR is by auscultation of the heart sounds by using the stethoscope at the maternal abdomen. This method has

the great drawback of not providing the sufficient information for the doctors to diagnose the heart rate based on the heart sounds since they are very feeble to hear. Generally the methods of detecting the fetal heart rate is classified as invasive and non invasive methods of detection.

Direct fetal electrocardiography (FECG) is one of one of the invasive methods of detection. It is the name of the test to diagnose the cardiac functions of the fetus ate early stage. It is recorded only after the rupture of the membranes by attaching the scalp electrode. This test gives the better reading, but this type of invasive recording may lead to the perforation of the fetus and in turn results in infection and possibilities of scalp injuries to the fetus. These methods may cause some major injuries which leads to some sort of blood loss for the fetus.

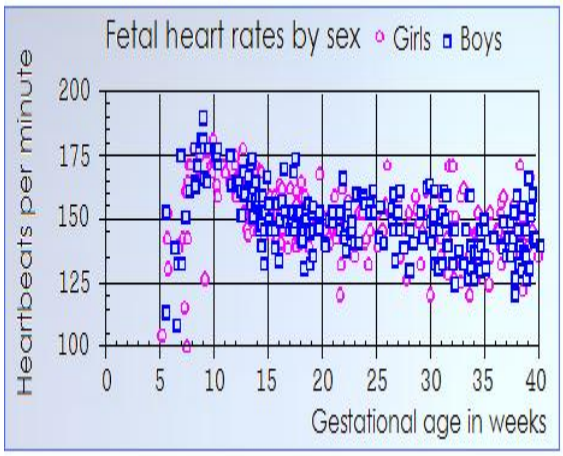

Fig 1.FHR Chart

The hazards which are caused by those invasive methods are eliminated in the noninvasive methods of detecting the FHR. One of the noninvasive methods is noninvasive transabdominal FECG. But these FECG signals have a low SNR due to filtering and attenuation effects of multiple layers of maternal tissue, and interference from noise and maternal ECG. Nowadays, Doppler ultrasound technology is used to examine the heart or blood vessels. It measures the blood flow within the heart without any invasive procedures such as cardiac catheterization. But FHR detection using Doppler ultrasound is always not reliable. This method has some drawbacks. It increases the occurrence of the intrauterine growth restriction. It also causes the thermal and mechanical effects in tissues with the increased O/P power.In this paper, a system for detecting the fetal heart rate based on the transabdominal noninvasive procedures is proposed.The existing systems for fetal heart rate detection are doppler ultrasound and auscultation of heart sounds by the stethoscope.

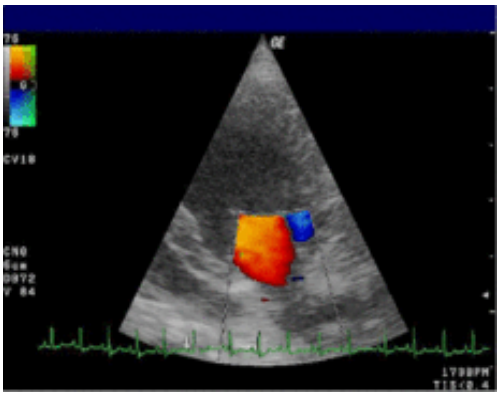

Fig 2. Doppler Ultrasound

But there are some drawbacks lies in these two approaches. The drawback lies in the doppler ultrasound technique is that it provides some hazardous effects to the fetus like intrauterine growth restriction. The auscultation of fetal heart sounds by the stethoscope doesnot provide better accuracy in FHR detection.The proposed system to detect the fetal heart rate is based on the Transabdominal non invasive procedures. It consists of an optical based module to sense the heart rate. Both the source and the detector is based on the optical techniques. This system is less hazardous and more accurate in detecting FHR.Transabdominal procedures are based on the continuous wave Near infrared techniques and pulse oximetry. FECG usage is limited to research studies since it requires multiple leads and advanced digital signal processing techniques. This paper made the measurements on the maternal abdomen using NIR. The migration of photns through the fetal head are done using the phantom tissue in in-utero manner. The errors in saturation is minimized by using the wavelengths in the range of 675-700 and 850-900nm.

In this transabdominal approach of spectroscopy, the optical radiation which is emitted from the mother's abdomen must travel through the maternal tissues and amniotic fluid before rezching the fetal layers and further it has to travel back to the detector loc I(MF) ; mother abdomen.

II.SYSTEM DESIGN AND DEVELOPMENT

2.1. System Description

Optical techniques such as Photoplethysmography (PPG) is used for FHR detection. FHR detection based on the Doppler ultrasound provides some hazardous effects. This can be eliminated by the proposed system of FHR detection. Moreover auscultation of sounds by the stethoscope does not provide better accuracy of FHR detection. The proposed system is based on the Digital synchronous detection technique too. This is utilized to enhance the SNR and to provide better accuracy. Adaptive noise cancelling (ANC) using the recursive least square (RLS) algorithm is able to extract the fetal photoplethysmography (PPG) peaks even at the SNR of -34dB. Virtual instrumentation is used as an user interface to display the results of FHR tracings and its value. The PPG of the mother is obtained

from her index finger. It is considered as the reference input to extract the FHR from the MHR that is detected at the mother's abdomen.

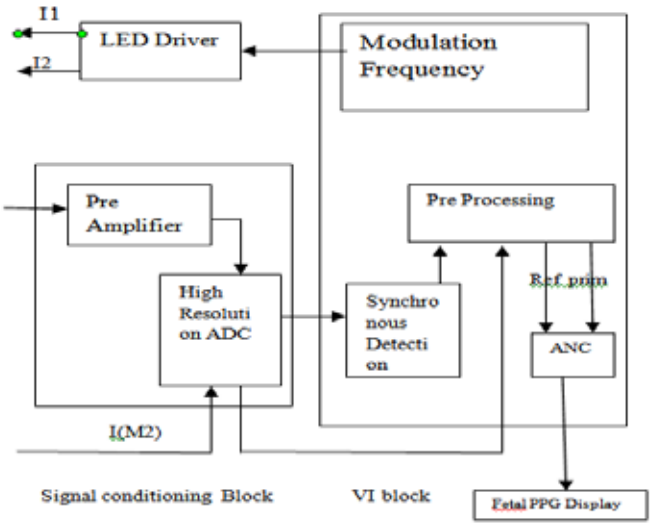

Fig 3. Hardware Setup Block diagram

IR transmitter and receiver diode is used as the source and the receiver to detect the fetal heart rate. Source to detector separation plays a vital role as it affects the detection of the signal. The value at which the source is separated from the detector is based on the three layered tissue model. The three layered tissue are maternal , fetal and amniotic fluids which are present as the barrier for FHR to reach the detector and the source light to reach the fetus. The optical power from the fetal layer increases with the source to detector separation. At a source to detector separation of 2cm , only 3% of the received optical power comes from the fetal tissue layer. At 6cm , the value of the received signal power which reaches at the detector increases to 97%. But at the 6cm of separation, the intensity of the collected light becomes too low for the detector compared to the noise. So a compromise of 4cm of separation is selected as it provides 70% of the received optical power at the detector which comes from the fetal layer.

Signal at the separation of 6cm is too weak and the signal at the separation of 2cm will result in the leakage of light directly into the detector. So to improve the signal quality and to reduce the amount of leakage of light into the detector a separation range of 4cm is selected. This overcomes the above 2 drawbacks.IR transmitter and IR receiver LED will act as the source and the detector. The source IR LED will emit the light at the abdomen layer and the detector LED will receive the signal. They are separated at the distance of 4cm for the better acquired signal to be reached at the detector. These results show that the expected optical power at the input of the detector is in the range of 10^{-6} to 10^{-10}W/cm^2.

2.3. Mechanical Setup Of the Hardware

The OFHR instrumentation is shown in Fig 3. The primary signal is derived from the fetal probe which is attached to the maternal abdomen to hold IR – LED (both the source and the receiver LED). The

probe is attached to the abdomen using a transducer belt. As already said , the source and the detector LED are placed at the distance of 4cm. The reference signal is obtained from the mother's index finger by the method of pulse oximetry. The reference signal is very much necessary since it extracts only mother's heart rate. The reference probe is attached to the index finger since FHR is very feeble at the finger. The main idea is to extract the FHR from MHR. This is done by taking the difference between the reference and the primary signal which are derived separately at the abdomen and the index finger. This difference process is done with the help of the virtual instrumentation software like labview.The selected IR LED will only emit the maximum optical power of about 55mW. The total OFHR system operates at the optical power which is less than the limit of 87mW that is specified by the International Commission on Non-Ionizing Radiation Protection(ICNIRP). The choice of the modulation frequency for detecting the signal is based on the power spectrum of the ambient noise. The ambient noise must be low and it must be far away from the odd and even harmonics of the power line frequency. So the detection band must be shifted to such a region frequency of 725Hz is selected as it falls between the odd and the even harmonics of the power line frequency and the PSD is close to the baseline. Modulation frequency is generated using a software subroutine through a counter port to the LED driver.

The diffused reflected light from the maternal abdomen is detected by the detector LED is denoted as I(M1F) , where M1 and F denote the contribution to the signal from the mother's abdomen and the fetus respectively. A low noise transimpedance amplifier is utilized to convert the detected current to a voltage level. The reference probe is attached to the mother's index finger consists of an IR-LED to act as the source and the receiver with an integrated pre amplifier (LM358). The signal from this reference probe is noted as I(M2) , where M2 refers to the the maternal contribution. There is no fetal heartbeat involved in this signal since it is measured at the index finger of the mother. Synchronous detection is not required in this channel as the finger PPG has high SNR. The digitization of the two signals are simultaneously done with an ADC at a rate of 5.5KHz. The demodulation , digital filtering and signal estimation are all performed in the digital domain.

2.4 Digital Synchronous Detection And Noise Cancellation

The algorithm is implemented using the virtual instrumentation software Lab VIEW. This is chosen since it is the most user friendly software and a graphical programming environment which facilitates the implementation of the hardware via software. So the entire process of digital synchronous detection, preprocessing and ANC is done using Lab VIEW.The digital synchronous detection is done in software. The digitized signal from the primary probe I(M1F) is filtered by a 30Hz bandwidth band pass filter. Such bandwidth is selected since it passes PPG spectrum. This band pass filter is centered at the centre frequency of 725Hz. This is in turn multiplied by the in-phase reference frequency. This in-phase reference signal is obtained by the following method. The band pass filtered signal is fed into a reference signal generation algorithm (Hann - weighted spectrum) that will automatically calculate the

phase of the band pass filtered signal , since the effective spectrum of the PPG signal covers frequencies up to 15Hz only , the output of the multiplier is then low pass filtered at 15Hz to recover the signal of interest.

The pre processing part for the primary signal is shown in fig 3.2.3. It consists of down sampling to 55Hz. This is to reduce the number of computations and the processing time. The minimum computation is needed if the power consumption is a major concern in the practical implementation of the hardware. Inorder to reduce the effect of the maternal signal and to remove the respiration artifact , a high pass filter is used prior to the adaptive filter. The frequency of the maternal signal is different for each individual , the cut off frequency of this high pass filter is the fundamental frequency of the reference signal acquired from the maternal index finger. This frequency is relatively stable during the duration of the recording. The demodulated , preprocessed signal is denoted as $I_{primary.}$ I(M2) is downsampled at the frequency of 55Hz and filtered with a bandpass filter, so that the respiration artifact occurs at 0.1-0.55Hz and the high frequency noises are rejected. The preprocessed signal is denoted as $I_{reference}$.$I_{primary}$ and $I_{reference}$ are fed into an RLS adaptive filter algorithm inorder to estimate the fetal signal $I_{est.}$(F). Finally the FHR is found by estimating the prominent peak of the PSD. This is done by using Yule – Walker autoregressive method.

2.5. Measurement of Primary and Reference signal

The heart beat can be measured at any spot of the body where the pulse can be felt at the fingers. The number of pulses can be counted within any interval and can easily determine the heart beat in bpm. Here IR and microcontroller based system is proposed for detecting the heart rate at the finger and the abdomen to measure both the reference signal and the primary signal which are measured at the index finger and abdomen of mother respectively. This System uses the optical sensors to measure the alteration in the blood volume at finger tip with each heart beat.Haemoglobin molecules of the blood absorb the infrared light. Each time the heart pumps , the volume of the oxygen rich blood increases in the finger. As a result , the amount of Oxyhaemoglobin molecules also increases in the blood. Absorption of the infrared light is also high and the reflection of the infrared light is low. Then each heart beat slightly alters the amount of the reflected light which can be detected by the IR Receiver. More infrared light is received , less the voltage of the input from the sensor part is produced.

The IR receiver picks an AC signal with some unwanted DC components which comes from non pulsative tissues. Direct crosstalk is avoided if the IR receiver and the IR Transmitter are placed closely. Resistor is connected to IR Receiver to reduce the current drawn by the detection system. If the intensity of the IR light is too high, the reflected infrared light from the tissue will be sufficient enough to saturate the receiver diode all the time and no signal will exist. Thus the intensity of the reflected light must be low to avoid such situation. To avoid this, the value of resistance is connected in series with the IR Transmitter to limit the current and the intensity of the transmitted infrared light.

The signal conditioning circuit consists of LM358 which act as a filter and a comparator. The filtering is achieved by the low pass filtering unit. The filtering is necessary to block the high frequency noises present in the signal. The two stage amplifier and the filter will provide the sufficient gain to boost the weak signal coming from the photo sensor unit and convert it to a pulse. It also act as a comparator which counts the number of pulses arriving within the certain amount of time. An LED connected at the output blinks at each time the heart beat is detected. The output from the signal conditioner goes to the TOCKI input of the pic microcontroller.Small movementin the organs causes the high frequency noise. So pulse rate filtering is essential. The desired signal can be extracted from the noisy signal using a low pass filter.

The cut off frequency of the filter is set as 2.34Hz.The signal must be amplified for counting the pulse rate by PIC. A two stage signal filter and amplifier circuit using LM 358 is designed for this purpose. This opamp is operated at the voltage range of 5V.The display unit comprises of a 3digit common anode seven segment module that is driven using multiplexing technique. Segment a-g are driven through pins of port B of the PIC microcontroller. Units , tens and hundreds digits are multiplexed through A port pins. During the certain interval of time, the number of pulses arriving at the TOCKI input pin is counted. Resolution of the measurement is 4. PIC runs at 4.0MHZ using an external crystal.

III.RESULTS AND DISCUSSIONS

The output is displayed in the Lab VIEW front panel. The use of this device is so simple. The finger is placed between the IR transmitter LED and IR receiver LED to display the reference signal. The primary signal is measured in the same manner by placing both the source and the detector in the abdomen. The LED gets blinked till the pulses are arrived at the detector. The output will be displayed when there is obstacle in the path of the pulses.The results are displayed as shown in the following figure.

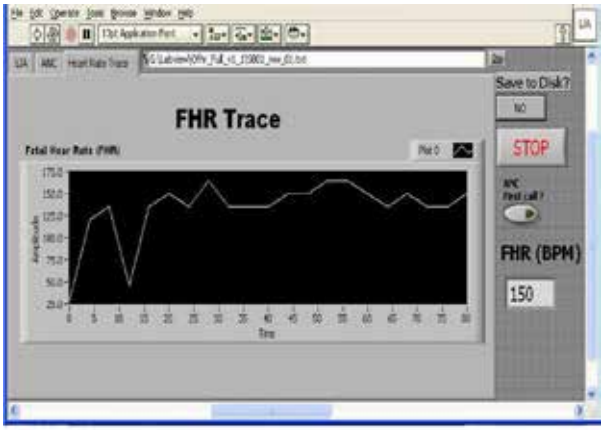

Fig 4.FHR Trace

IV.CONCLUSION

A low cost OFHR detection system is proposed using very low power IR source and detectors. FHR is determined using digital synchronous detection and adaptive filtering techniques. Results are obtained with the acceptable accuracy. For better results, the probe can be placed near to the fetal tissues. A compact, wearable system composed more number of LED source and detectors can be used to improve the accuracy of the detected FHR. It may also be implemented using an embedded processor like MY- RIO processor to enhance the better results.

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A REVIEW ON DUAL NARROWBAND IN DIELECTRIC RESONATOR ANTENNA

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ABSTRACT

Several narrowband antennas are presented for wireless application. This paper presents the review on dual band dielectric resonator antenna. Various designs of dual mode DRAs are derived in this paper. In this paper, a review on past work done discussed on dual narrow band in dielectric resonator antenna.

Keywords: Dielectric resonator antenna (DRA), Dual narrowband

I. INTRODUCTION

Before the introduction of the Dielectric Resonator Antenna, it was used for filter applications in microwave circuits. DRA have been proposed as an alternative to the conventional conductor antennas. In high frequency application, as the frequency increases, ohmic losses in conventional antenna increases. DRA has so many advantages features such as compact size, low loss, high efficiency, light weight, ease of excitation, feeding mechanism and versatility in the shape. DRA radiate throughout their entire volume and therefore the amount of energy radiated is larger than the energy stored in their near fields. The basic DRA structure is consist of a DR element of a specific shape. DRA excited by a single feed such as a micro strip line, coplanar waveguide, aperture or coaxial cable. For the simple geometry, permittivity of the DRA decreased to achieve wider bandwidth. The most common method of feeding mechanism is the aperture –coupled arrangement. There are three basic shapes available for common design, including rectangular, cylindrical, and spherical.

Figure 1 Various shape of DRA

There are various shapes of DRAs like rectangular, circular, triangular, spherical-cap, cylindrical-ring, hemispherical, etc. Figure 1 shows a photo of various shapes of DRAs. It was found that DRAs operating at their fundamental modes radiate like a magnetic dipole, independent of their shapes

II. MULTIBAND OPERATION

With the development of wireless communication systems, the compact and dual or multi-frequency are highly desirable. Recently, many investigations have been reported on DRAs with dual-frequency operation using various approaches. Dual mode excitation is hardly designed because the different modes in DRA are sensitive. And stacking two DRAs increases the size and the weight of DRA.

III. SINGLE AND DUAL BAND OPERATION

Two rectangular DRA were used to achieve dual band operation. The value of dielectric constant was 32. Micro strip line was used for feeding mechanism. For impedance matching, DR had to be offset in Y direction from the center of the slot. The values of resonant frequencies were 5.12 GHz and 6.15GHz [1].

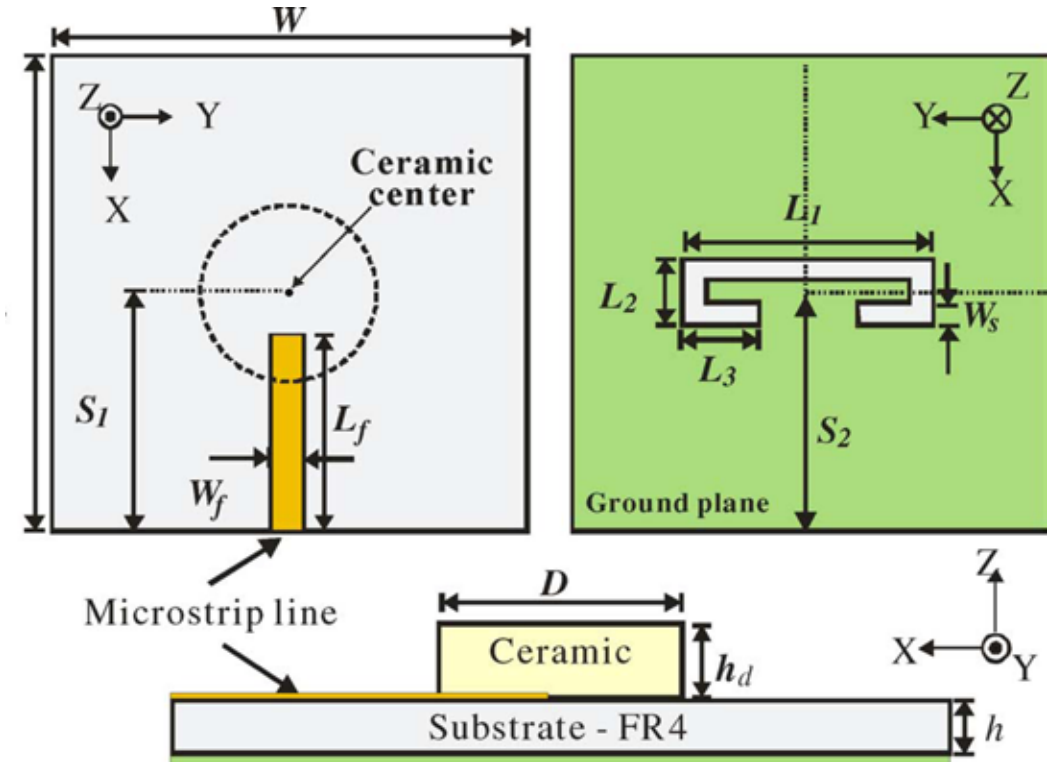

Figure 2 Top view and side view of the dual-frequency DRA [2].

In [2], represent the use of circular disk shape of DRA as shown in Figure 2. The value of Dielectric constant was 25. Micro strip line was used for feeding mechanism. The values of resonant frequencies were 2450 and 5640 MHz. A parasitic c-slot etched in the ground plane. The c- slot consists of three parts of a rectangular slot of length L_1, L_2 and L_3 and width 0.5 mm. the value of resonant frequencies were 3.456 and 4.797 GHz. It is observed that the

resonant frequency of C-slot remain unchanged but the frequency of the DR decreased. It is also observed that the resonant frequency of C-slot remains unchanged and the frequency of DR decreased at ε_d was increased.

In [3], represent the use of circular disk shape of DRA as shown in Figure 3. The value of Dielectric constant was 27. The CPW inductive slot was used as the DR feeding mechanism. Resonant frequencies of DRA were 3456 and 4797 MHz. The centre point of DR was placed above the centre of the ground plane with offset distance S. S was used to adjust the coupling level between the two resonators. The positive S corresponds to moving up, and negative S corresponds to moving down. It is observed that the resonant frequency of the slot radiator increased as S increased from -5 to 5 mm. But the resonant frequency of the DR remains unchanged. For different ε_r, it is observed that the dual-bands decreased as ε_d was increased. The lower band was due to the CPW inductive slot while higher band was due to the DRA.

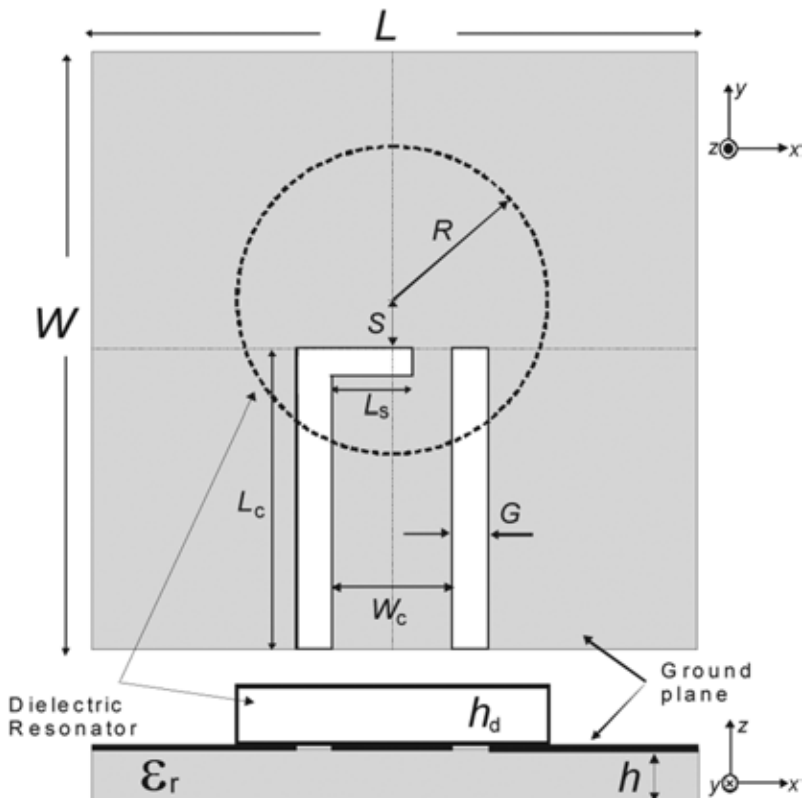

Figure 3 Top view and side view of the dual-frequency compact hybrid resonator Antenna [3].

In [4], represent the use of bridge shape DRA. The value of dielectric constant ε_r was 40. The coaxial probe was used for feeding mechanism. B-DRA was excited in its lowest order mode. It is observed that for low values of dielectric permittivity, the radiation patterns of the DRA were like monopole. Resonant frequency of DRA decreased as the permittivity increased. Dielectric constant for b-shaped DRA was 40, dielectric constant for RDRA was 10. 50 Ω micro strip line was used with width 2.4 and length 3.6 mm. It is observed that this design operate on

dual frequency. Resonant frequencies were 3.5 and 5.5 GHz. These frequencies correspond to the frequency of the excitation of the b-DRA and RDRA. It is observed that variation of the width of RDRA has a significant effect on the resonance frequency of the second mode. The frequency of first resonant mode is slightly changed. For feeding aperture, micro strip line was used with width 24 mm and length 10 mm.

In [5], represent the use of rectangular shape of DRA. The value of dielectric constant was 90. Rectangular shorting strip and T-shaped shorting strip were used for feeding mechanism. The feeding mechanism adopts another T-shaped metal strip attached to the bottom force of the DRA and connected to the inner conductor of the coaxial prob. It is observed that the resonant frequency was mainly depended on the height H along the Z-axis and remain relative stable regardless of changed in length along the Y-axis. Because horizontal electric fields are distributed homogeneously along Y-axis no variation exists. The value of resonant frequency was 3.5 GHz. Now mode shows good radiation efficiency and broad side pattern as fundamental mode does.

In [6], represent the use of rectangular shape of DRA. The value of dielectric constant was 10. Experiment frequency was 1.74 GHz. Band width was 1.716- 1.767 MHz. Proposed mode was $TE^{X}_{\delta 01}$. 50 Ω micro strip line was used for feeding mechanism. Proposed RDRA with metal coating located at the centre of a square substrate of Ɛrs = 2.65. Reference antenna 1 had the same size DR as proposed one, but without metal coating. Reference antenna 2 worked at the same frequency as antenna 1, but in the new radiating mode. Comparing the proposed DRA to antenna 1, it is observed that both have different frequency. Due to two metal plates on the DR, the proposed antenna works at 1.71 GHz, much lower frequency. It is observed that changed in values of a,b resonant frequency of the mode remain almost constant. It is observed that change the value of b still has little effect on the frequency and increase of both a and b causes decrease of the frequency. To validate the theoretical analysis, the proposed DRA and reference antenna 1 were designed and measured. Feeding mechanisms of two antennas are different.

IV. DIFFERENT COUPLING METHODS

Different methods are used for exciting the antenna, which are coaxial probe, aperture coupling with micro strip line, aperture coupling with coaxial feed line, direct micro strip line, coplanar feed, slot line , micro strip line, T-shape metal strip and waveguide probe.

V. CONCLUSION

This paper presents the review on past done work in the field of dual band Dielectric Resonator Antenna. A brief description of the research works done in the field of dual band operation, different coupling method are presented here. A dual band antenna can replace two single band antennas of suitable operating bands.

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INFLUENCE OF SAND MOLDING PROCESS PARAMETERS ON PRODUCT QUALITY OF AL-SI ALLOY CASTING - AN ANOVA APPROACH

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ABSTRACT

Sand mold casting is an age old metal casting process. Even today, though there are many advanced techniques present to produce metal castings, sand molding remains one of the most widely used casting process because of its ability to produce low cost and wide variety of castings. Sand casting process involves many parameters which affect the quality of the produced castings. In this study, an attempt has been made to optimize the sand molding parameters, and to study the influence of these parameters on quality of Al-Si alloy castings. Taguchi's experimental design approach is adopted to achieve optimum level of parameters, and Analysis of Variance (ANOVA) technique is used to identify the significant factors and their percentage contribution for improved mechanical properties. Experimental results show that amount of clay and amount of moisture are the parameters making significant influence on mechanical properties of these castings. Based on optimum level of parameters, verification test is performed and the results are found to be in confidence level. Experimental results confirmed the validity of selected approach in enhancing and optimizing the sand mold casting process for aluminium alloys.

Keywords: Al-Si alloy, Analysis of Variance, Product quality, Sand casting, Taguchi design

I. INTRODUCTION

Aluminum is the third most abundant element in the earth's crust. After iron and steel, the most popular metal used is aluminium. It is widely used in transportation, defense, construction, aerospace, maritime, domestic, and general engineering purpose. This is because of its unusual combinations of properties such as light weight (high strength to weight ratio), resistance to corrosion, good cast-ability, good machinability, chemical resistance, excellent conductor of heat and electricity, etc. Pure aluminium is soft having comparatively poor casting features and little strength, that's why aluminium castings are prepared from aluminium alloys. The main alloying elements are silicon, copper, magnesium, zinc, etc. Fluidity of aluminium increases with silicon addition. Al-Si alloys have good casting and corrosion resistance properties. In transportation industry, more use of these alloys decreases weight of vehicle, improve its performance and reduces fuel consumption.

Sand mold casting is an important process for casting aluminium alloys. It is used to create castings of any shape and size. The process involves, melting a metal, pouring it into a previously prepared mold cavity formed out of natural or synthetic sand, allowing liquid metal to solidify, and breaking sand mold to get the castings. For every single casting new mold is to be prepared, quality of mold determines the quality of produced

castings. For this reason aluminium foundries have to focus more on optimizing on sand molding process to improve the quality of products and reduce cost.

According to Taguchi, the key element for achieving high quality and low cost product is parameter design. Through parameter design optimal levels of process parameters are selected and these parameters should be controlled to improve the quality of both casting process and the product [1]. A number of automotive suppliers have achieved quality and cost improvement through Taguchi's robust design. These applications include improvement in metal casting, injection molding of plastic parts, etc. [2]. Taguchi has introduced several statistical tools and concepts of quality improvement that depend heavily on the statistical theory of experimental design [3]. To overcome the problems of defects, flaws and imperfections in castings, and improve the quality of products produced, optimization of process parameters for sand mold casting should be carried out [4].

In this study, the experiments are designed by selecting four parameters (sand grain size, amount of clay, amount of moisture and number of ramming) all at three levels. The required number of experiments under full factorial method was $3^4 = 81$. Using Taguchi's L9 orthogonal array, the number of experiments are reduced to nine. All these nine experiments are performed to produce test castings which are then examined for improved mechanical properties – tensile strength and hardness.

The signal to noise (S/N) ratio for each parametric setting is computed. The optimal level of process parameters promotes highest S/N ratio [5]. Analysis of variance (ANOVA) on the collected data from the Taguchi design of experiments is used to select new parameter values to optimize the performance characteristic. The data from the arrays is analyzed by performing a visual analysis. ANOVA and Fisher's exact test (F-Test) is applied to find significant factors and test the level of significance. The percentage contribution of significant factors is also obtained.

II. LITERATURE REVIEW

Mekonnen Liben Nekere and Ajit Pal Singh [1] has examined optimal settings of two groups of aluminum blank sand casting processes. Single aluminum blank sand casting and double aluminum blanks sand casting for process robustness comparison. The results have shown that single aluminum blank sand casting process is more robust than double aluminum blank sand casting process. The experimental results confirmed the validity of used Taguchi robust design method for enhancing sand casting process and optimizing the sand casting parameters in aluminum blank casting process.

Lakshmanan Singaram [6] has studied the analysis of green sand process parameters strength, moisture content, permeability, mold hardness using Taguchi method and ANN Analysis. Outcome is optimized green sand process parameters which lead to improved process performance, reduced process variability and thus minimum casting defects.

Rasik A Upadhye and Dr. Ishwar P Keswani [7] has studied the sand casting process parameters of the castings manufactured in iron foundry by maximizing the signal to noise ratios and minimizing the noise factors using Taguchi method. The process parameters considered are moisture, sand particle size, green compression strength, mold hardness, permeability, pouring temperature, pouring time and pressure test. The results indicated that the selected process parameters significantly affect the casting defects in the foundry.

P. Senthil and *K. S. Amirthagadeswaran* [8] has investigated the influence of process parameters on mechanical properties of the castings prepared through squeeze casting process using Taguchi method. Experimental results showed that squeeze pressure, die preheating temperature and compression holding time were the parameters making the significant improvement in mechanical properties.

Jhon O. OJI et. al. [9] has investigated the effect of mold temperature and pouring temperatures on ultimate tensile strength of aluminum alloy sand castings. The result shows that mold temperature is the significant factors which influence the casting quality.

L. Ceschini et. al. [10] has investigated the relationships between ultimate tensile strength and micro structural parameters for the sand cast A357 aluminum alloy. Starting from the micro structural parameters and taking in to account the material hardness, a relationship able to predict the ultimate tensile strength of the alloy was found.

III. EXPERIMENTAL APPROACH

To find the optimum conditions of the control factors, Taguchi's robust experimental design methodology is used to design the experiments. This methodology is used by applying eight experimental steps that can be grouped into three major categories as follows [1, 2]:

- **Planning the experiment**
  1. Identify the main function of casting process.
  2. Identify the quality characteristic to be observed and objective function to be optimized.
  3. Identify control factors and their alternate levels.
  4. Identify noise factors and testing conditions of the process.
  5. Design matrix experiment and define data analysis procedure.
- **Performing the experiment**
  6. Conduct the matrix experiment.
- **Analyzing and verifying the experimental results**
  7. Analyze the data, determine the optimum levels, and predict the performance under these levels.
  8. Conduct the verification test (also called confirmation experiment) and plan future actions.

Experimental data can also analyzed using Analysis of Variance (ANOVA) where the relative percentage contribution of all factors is determined by comparing with the relative variance. In ANOVA calculations, the degree of freedom for all factors is obtained first, the values of variance for all factors are then calculated and finally F-ratio and percentage contributions for the factors are calculated. The intention is to determine the significant control factors and their level of significance to optimize the process.

3.1 Sand Mold Casting Process and its Main Function

Initially, two solid square cross section wooden patterns are prepared with dimensions 3cm x 3cm x 16cm to make mold cavities in which molten metal is poured to produce castings which are used to prepare test specimens. Molding sand is prepared using silica sand as base sand, bentonite powder as clay or binder, and water as moisture. Nine molds are prepared by varying grain fineness of silica sand, amount of clay, amount of moisture and number of ramming, as per the experimental design. Molds are then dried in air to remove the

moisture completely. Aluminium alloy LM25 (AlSi7Mg) is melted for pouring into the molds. Melting is done in lift out crucible type coke fired pit furnace.

After melting degassing is done using Hexa-chloro-ethane (C_2Cl_6) tablets which are added to the molten metal which liberates stable chlorine gas to flush out the dissolved hydrogen gas by creating partial pressure in molten metal. To protect the molten charge from getting oxidized, coveral-36 is used as a flux powder to cover the molten metal from atmospheric gases. Thermocouples with digital temperature indicator are used to measure the temperature of molten metal. All nine molds are poured to produce test castings. After solidification the molds are broken to obtain the castings. Finally machining operations are performed on CNC machine to prepare standard test specimen as per ASTM A370 standard, 12.5 mm round tension test specimen with 50 mm gauge length, for measuring tensile strength. Universal Testing Machine is used for measuring tensile strength and Dynamic Hardness Tester is used for measurement of Brinell Hardness.

3.2 Quality Characteristics and Objective Functions

To determine the effect each parameter has on the response, the signal-to-noise ratio, or the SN ratio, needs to be calculated for each experiment conducted. Taguchi defines it as three categories of quality characteristics which are: Lower-the-better, Larger-the-better and Nominal-the-best. As in this study, tensile strength and hardness are selected as response; both are larger-the-better type of quality characteristics. The objective function is to be maximized by using the S/N ratio:

$$S/N = -10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_i^2}\right) \quad \text{---------- (1)}$$

Where ‘n’ is trial number, ‘y’ is response and ‘i' is experiment number. After calculating the S/N ratio for each experiment, the average SN value is calculated for each factor and level.

3.3 Control Factors and Their Levels

In general, sand casting process involves many parameters such as type of sand, size of sand grain, clay type and amount, percentage of moisture, green compressive strength, shear strength, permeability, number of ramming, shatter index, mold type, mold hardness, pouring temperature, pouring time, pouring height, metal composition, metal fluidity, running and gating, risering and feeding, casting design, alloy type, and many more [4,7]. As this study aims to optimize sand molding process, four key sand molding parameters – sand grain size, amount of clay, amount of moisture and number of ramming are selected at three different levels as given in the *Table 1*, keeping other parameters constant.

Table 1: Control Factors with Levels

Control factor designation	Control factors	Levels		
		1	2	3
X_1	Sand grain size	40	55	70
X_2	Amount of clay (%)	6	9	12
X_3	Amount of moisture (%)	7	10	13
X_4	Number of ramming	2	3	4

3.4 Noise Factors and Testing Conditions

Number of noise factors affecting the casting process was identified from literature for sand mold casting process. Some of these factors are variation in humidity, pouring temperature, metal flow rate, ambient temperature and so forth. For this experiment the important noise factors considered were: pouring temperature, metal flow rate and humidity. To capture the effects of noise factors during the casting process, different sand mold castings were prepared and examined.

3.5 Matrix Experiment Design and Data Analysis Plan

The experiments are conducted by keeping four parameters at three levels; the number of experiments required was $3^4 = 81$ under full factorial method. Using Taguchi's orthogonal array table, for four parameters at three levels, L9 orthogonal array is selected. With this number of experiments is reduced to nine. These nine experiments are conducted in order to optimize the process parameters to achieve castings with less defects and improved mechanical properties.

The standard table of combinations for experiment for L9 orthogonal array is as given below.

Table 2: Standard L9 orthogonal array table

Experiment Run Order	Control Factors			
	X_1	X_2	X_3	X_4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

3.6 Conducting Matrix Experiment

As per the nine rows of L9 standard orthogonal array table, nine experiments are conducted. To prevent the translation error, the table is translated incorporating level table to create experimental design sheet as shown in the *Table 3*. The responses of each experiment are tabulated in adjacent columns.

Table 3: Experimental Design Table and Responses

Experiment Run Order	Control factors (or) Process parameters				Responses	
	Sand Grain Size X_1	Amount of Clay (%) X_2	Amount of Moisture (%) X_3	Number of Ramming X_4	Tensile Strength (MPa) Y_{TS}	Hardness (BHN) Y_H
1	40	6	7	2	104.5	41
2	40	9	10	3	106.8	41
3	40	12	13	4	125.7	51

4	55	6	10	4	102.9	40
5	55	9	13	2	119.2	46
6	55	12	7	3	117.7	44
7	70	6	13	3	111.1	42
8	70	9	7	4	108.9	42
9	70	12	10	2	114.8	42

3.7 Analyzing Data, Determining Optimum Levels And Predicting Performance Under These Levels

For analysis of results obtained from the experiment, the SN ratios are to be calculated [2]. Test samples are prepared for each experiment, tensile strength and hardness tests are performed on each sample. The results obtained for tensile strength and hardness are listed under responses in *Table 3*. Based on these responses S/N ratio calculations and ANOVA calculations are carried out.

3.7.1 S/N Ratio Calculations [4, 11]

S/N ratio for tensile strength and hardness are calculated using 'larger-the-better' quality characteristics for each experiment run order by using expression (1) of Para 3.2, the calculated values are tabulated in the *Table 4* as shown below. The *Table 5* gives the calculated average S/N values for each factor and each level for both tensile strength and hardness.

Table 4: S/N ratio calculations

Experiment Run Order	S/N Ratio	
	Tensile strength	Hardness
1	40.38	32.25
2	40.57	32.25
3	41.98	34.15
4	40.24	32.04
5	41.52	33.25
6	41.41	32.86
7	40.91	32.46
8	40.74	32.46
9	41.19	32.86

Table 5: S/N ratio response table

	Tensile Strength				Hardness			
LEVEL	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4
1	40.97	40.51	40.99	41.03	32.88	32.25	32.52	32.78
2	41.05	40.94	40.64	40.96	32.71	32.65	32.38	32.52
3	40.94	41.52	41.47	40.98	32.59	33.29	33.28	32.88
Max-Min	0.11	1.01	0.83	0.07	0.29	1.04	0.90	0.36

Rank	3	1	2	4	4	1	2	3
Optimum level	$X_{1,2}$	$X_{2,3}$	$X_{3,3}$	$X_{4,1}$	$X_{1,1}$	$X_{2,3}$	$X_{3,3}$	$X_{4,3}$

3.7.2 ANOVA Calculations

In order to find out the level of significance of control factors and their percentage contribution towards tensile strength and hardness in sand mold casting process, Analysis of Variance approach is followed and ANOVA calculations are made.

3.7.3 ANOVA Calculations for Tensile strength

ANOVA calculations are made using the experimental results data from *Table 3*. Sample calculation is presented below.

Number of experiments, N = 9

Total Degrees of Freedom (DOF) = N-1 = 9-1 = 8

Sum of the response, T = 1011.6

Correction Factor, C.F. = T^2/N = 113703.84

Total of response for factor X_1 at level 1, $X_{1,1}$ = 337

Similarly total response for all four factors at all three levels are calculated for both tensile strength and hardness and are tabulated in *Table 6*.

Table 6: Level totals table

Control factor designation	Control factors	Level Total for Tensile Strength			Level Total for Hardness		
		1	2	3	1	2	3
X_1	Sand grain size	337	339.8	334.8	133	130	128
X_2	Amount of clay	318.5	334.9	358.2	123	129	139
X_3	Amount of moisture	331.1	324.5	356	127	125	139
X_4	Number of ramming	338.5	335.6	337.5	131	127	133

$$S_T \text{ (Total Sum of square)} = \sum_{i=1}^{n} y_i^2 - CF \quad S_T = \sum_{i=1}^{n} y_i^2 - \frac{T^2}{N}$$

Where 'i' is experiment run order number.

Total sum of square, S_T = 454.94

Number or repetitions of factor X_1 at level 1, $n_{X_{1,1}} = 3$

Sum of squares of X_1, $S_{X1} = \frac{X_{1,1}^2}{n_{X_{1,1}}} + \frac{X_{1,2}^2}{n_{X_{1,2}}} + \frac{X_{1,3}^2}{n_{X_{1,3}}} - CF = 4.18$

Similarly S_{X2}, S_{X3} and S_{X4} are calculated.

In this case, since there are no empty columns or repetitions, experimental and reputational error cannot be calculated. Pooling the smallest variance factors X_1 and X_4 would provide some information of error so that we could proceed with the construction of ANOVA Table.

Sum of square of pooled error, $S_e = S_{X1} + S_{X4} = 5.62$

DOF of pooled error = DOF of X_1 + DOF of X_4 = 2 + 2 = 4

DOF of X_3 = 2

Variance of X_3, $V_{X3} = \frac{S_{X3}}{DOF\ of\ X3} = 132.66$

Similarly V_{X2}, V_{X1} and V_{X4} are calculated.

Variance of error, $V_e = \frac{S_e}{DOF\ of\ error} = 1.40$

Pure variation of X_2, $S'_{X2} = S_{X2} - (DOF\ of\ X2 * V_e) = 262.52$

Similarly S'_{X3} is calculated.

Pure variation of pooled error, $S'_e = S_e + [(DOF\ of\ Total - DOF\ of\ error) * V_e] = 11.22$

Percentage contribution of factor X_2, $P_{X2}{}^{\%} = \left(\frac{S'_{X2}}{S_T}\right) * 100 = 57.70\%$

Percentage contribution of pooled error, $P_e{}^{\%} = \left(\frac{S'_e}{S_T}\right) * 100 = 2.46$

Similarly ANOVA for hardness is calculated.

Table 13: ANOVA table for tensile strength

Source	Pool	S	DOF	Variance	F-ratio	S'	P%
X_1	yes	4.18	2	2.09	-	-	-
X_2		265.32	2	132.66	94.75	262.52	57.70
X_3		183.98	2	91.99	65.70	181.18	39.82
X_4	yes	1.44	2	0.72	-	-	-
Pooled error		5.62	4	1.40	1.00	11.22	2.46
Total		454.92				454.92	100.00

From the ANOVA table for tensile strength, F-ratio for amount of clay and amount of moisture is greater than F critical value, which is 18 at 0.01 level of significance, this makes them the significant factors.

Table 14: ANOVA table for hardness

Source	Pool	S	DOF	Variance	F-ratio	S'	P%
X_1	yes	4.23	2	2.11	-	-	-
X_2		43.56	2	21.78	8.34	38.34	41.56
X_3		38.23	2	19.11	7.32	33.01	35.79
X_4	yes	6.23	2	3.11	-	-	-
Pooled error		10.46	4	2.61	1.00	20.9	22.66
Total		92.25				92.25	100.00

From the ANOVA table for hardness, F-ratio for amount of clay and amount of moisture is greater than F critical value, which is 6.94 at 0.05 level of significance, this also makes them the significant factors.

3.8 Verification Test

Based on optimum level of process parameters, verification test is performed; the results obtained are:
Tensile strength: 130 MPa, and Hardness: 53 BHN.

IV. RESULTS AND DISCUSSIONS

From the above experimentation, it is observed that amount of clay and amount of moisture are the significant factors which are affecting tensile strength and hardness of aluminum alloy sand mold castings.

Increase in the amount of clay decreases permeability, which increases porosity in castings hence reducing mechanical properties. If amount of clay is decreased, mold hardness, shatter index and green compressive strength will also decrease which decreases the quality of the sand mold. Therefore optimum amount of clay for making a sand mold is to be selected.

Increase in the amount of moisture will also decrease permeability which affects the quality of produced castings. If more amount of moisture present in sand mold, it creates more amount gases during pouring which in turn results in casting defects like blowholes, open holes, porosities, etc. Hence optimum amount of moisture is to be used while making a sand mold.

From S/N ratio response table, *Table 5*, it is found that the optimum level of significant parameters is 12% amount of clay and 13% amount of moisture.

Verification test conducted based on optimum level of process parameters shows that the values of tensile strength and hardness are 130 M Pa and 53 BHN respectively. These values were found to be in confidence level.

From ANOVA tables, it is observed that amount of clay (X_2) and amount of moisture (X_3) are the factors contributing 57.70% and 39.82% for tensile strength, 41.56% and 35.79% for hardness respectively; these are represented in the chart below.

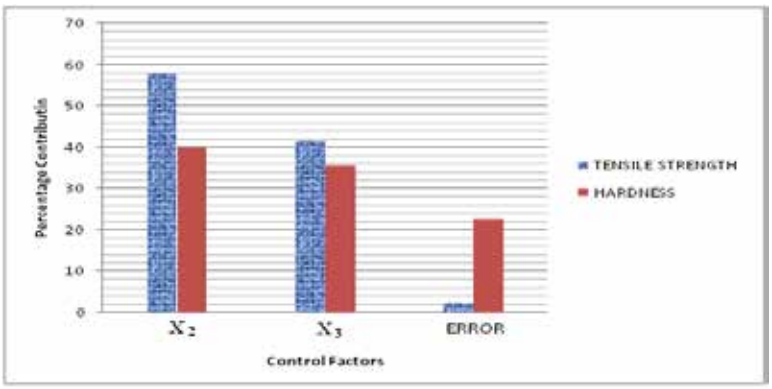

Figure 1: Bar chart of percentage contribution

V. CONCLUSIONS

On the basis of experiments conducted and analysis carried out in this study, many conclusions can be drawn; few of them are mentioned as follows:

- Study shows that this approach can be effectively applied in foundry shops for deciding optimum setting of process parameters to improve the quality of the castings produced.

- Results indicated that the selected process parameters are significantly affecting the selected mechanical properties.
- It is observed that amount of clay and amount of moisture are the significant control factors from among the selected factors.
- Amount of clay is the major contributing factor for the improvement of tensile strength and hardness of LM25 alloy casting.
- It is also observed that amount of clay and amount of moisture are the factors contributing 57.70% and 39.82% for tensile strength, 41.56% and 35.79% for hardness respectively.
- Verification test conducted based on optimum level of process parameters shows the increase in values of both tensile strength and hardness. Work is in progress to adopt ANOVA approach to study the influence of other parameters such as melting and gating design and include other mechanical properties to optimize the process for improving the quality of Al-alloy castings.

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EXPERIMENTAL STUDY ON FIBER REINFORCED SELF-COMPACTING GEOPOLYMER MORTAR

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ASTRACT

Geopolymer technology is one of the radical technologies. The main problem of global warming is CO_2 emission, during the cement production. This problem can be minimized by replacing the cement with fly ash. When the cement is used as a binder for the construction, it requires more an amount of water for mixing, curing and the period of curing is also very long. Ferrocement construction is a type of thin reinforced concrete laminate commonly constructed with hydraulic cement mortar. In thin densely reinforced elements, it is difficult to apply proper compaction. In ferrocement and densely reinforced thin elements,the failures usually occurs on compression by crushing mortar at ultimate stage and leads to reduce the tensile and flexural strength of the element. To overcome the above problems, fiber is used in self-compacting geopolymer mortar to increase the tensile and flexural strength of the mortar. This study was carried out to evaluate the mix proportions,self-compacting and strength properties of geopolymer mortar for various mix proportions with different fiber. Mortar cubes of size 70.6x70.6x70.6 mm were casted and cured at 70°C for 24 hours in the oven. The workability of fresh mortar was determined using slump flow, V-funnel, U-Box, J-Ring, and V-funnel at T5 minutes as per EFNARC guidelines. The results show better performance in tensile strength and also flexural strength when fiber is introduced.

Keywords: Fiber, Flyash, Self-Compacting Geopolymer Mortar, Sodium Hydroxide, Sodium Silicate.

I. INTRODUCTION

For the production of concrete-the most widely used construction material in the world, Ordinary Portland Cement (OPC) is the main ingredient used which is among the most energy intensive construction material and whose production is for an increase of 3% annually [1]. The production of OPC releases large amount of carbon dioxide (CO_2) to the atmosphere that significantly contributes to greenhouse gas emissions. One ton of CO_2 is released into the atmosphere for every ton of OPC produced [2]. Therefore, there is a need to find an alternative type of binder to produce more environmentally friendly mortar. A promising alternative is the replacement of cement with by product material such as fly ash.

Self-compacting geopolymer mortar is relatively a new concept and can be regarded as the most revolutionary development in the field of mortar technology [3]. Self-compacting geopolymer mortar is an innovative type of mortar that does not require vibration for placing it and can be produced by complete elimination of ordinary

Portland cement. This paper presents the preliminary results of ongoing research study of mechanical behavior of low-calcium flyash were assessed [4]. The test result substantiates the viability to develop self-compacting geopolymer mortar.

Fiber influences the mechanical properties of concrete in all modes of failure, especially those that induce fatigue and tensile stresses [5]. The strengthening mechanism of Fibers involves transfer of stress from the matrix to the fiber by interfacial shear or by interlock between the fiber and matrix [6] . With the increase in the applied load, stress is shared by the fiber and the matrix [7]. With the increase in the applied load, stress is shared by the fiber and the matrix in tension until the matrix cracks then the total stress is progressively transferred to the fibers, till the fibers are pulled out, or break, or break in tension [8]. fiber efficiency and the fiber content are the important variables controlling the performance of fiber reinforced mortar [9]. fiber efficiency is controlled by the resistance to pull out, which depends on the bond at the fiber matrix interface. Pull out resistance increases with fiber length [10]. Since pull out resistance is proportional to the interfacial area, the smaller the diameter, the larger is the interfacial area available for the bond. For a given fiber length, smaller the area, more effective is the bond [11]. The composite effect of these two variables is expressed by the 'aspect ratio' (length/diameter). Fiber efficiency increases with increase in 'aspect ratio'. The contribution of fiber to the composite depends upon the fiber material and type, Length (l), diameter (d), aspect ratio (l/d), and volume concentration of fibers in the matrix.

II. MATERIALS PROPERTIES AND MIX PROPORTIONS

2.1 Materials Properties

2.1.1 Flyash

In this study Low-Calcium Flyash (ASTM Class F), obtained from Thermal Power Plant at Thoothukudi was used as a source material for the synthesis of Self-Compacting Mortar. The specific gravity of flyash is 2.36 and fineness of flyash is 4%. The chemical composition and properties of Flyash as determined as shown in Table1.

S.No	Characteristics	Percentage
1	Silicon dioxide (Sio_2) plus Aluminum oxide (Al_2O_3) plus iron oxide (Fe_2O_3)	95.95
2	Silica (as Sio_2)	59.71
3	Magnesium oxide (as MgO)	106.0
4	Total Sulphur as Sulphur tri-oxide (So_3)	Nil
5	Loss on ignition	0.71
6	Moisture	0.32
7	Calcium oxide as CaO	0.50
8	Available by alkaline solution oxide (Na_2O)	0.63

Table 1 Chemical Composition of Flyash

2.1.2 Fine Aggregate

Natural River Sand conformation to Zone II of IS383:1997 was used and its properties are found as follows in Table 2.

S.No	Properties	Result
1	Specific Gravity	2.71
2	Fineness Modulus	2.72
3	Bulk Density, Kg/m^3	1709.47
4	Zone Conformation	II

Table 2 Properties of Fine Aggregate

2.1.3 Alkaline Solution

In geopolymerization alkaline solution also plays an important, alkaline solution used in geopolymerization is a combination of sodium hydroxide and sodium silicate. In the present study, a combination of sodium hydroxide and sodium silicate was used as the alkaline solution.

Sodium hydroxide in the form of pellets with 99% purity and Sodium silicate solution (Grade 53A with Sio_2= 29.43%, Na2O= 14.26% and Water = 56.31%) obtained from Deepa Enterprises Madurai was used as the alkaline activator solution. In order to make sodium hydroxide solution the potable water was used for dissolve Sodium hydroxide pellets. Both the liquid solutions were then mixed together and alkaline solution was prepared.

2.1.4 Superplasticizer

To attain higher workability and flowabilty of the fresh mortar, a commercially available Superplasticizer (Conplast SP430 and Glenium SKY 8233 from BASF) supplied by Sivakasi& Coimbatore and specified amount of extra water was also used. The ordinary drinking water available in mortar in concrete laboratory was used for this purpose

2.1.5 Fiber

Name of Fiber	Effective Length in mm	Diameter in µm	Specific Gravity in Kg/cm^3	Aspect Ratio	Company Name
Polypropylene Fiber	12	18	0.91	0.67	Polyfibers Private, Coimbatore
Recron 3s Fiber	12	10	0.91	1.2	Reliance, Tirunelveli.
E-Glass Fiber	11	18	0.91	0.61	GVR Enterprises, Madurai
Steel Fiber	12.5	450	0.91	27.77	Bajaj, Chennai

Table 3 Properties of different fiber

Fig 1: Steel Fiber

Fig 2: E-Glass Fiber

Fig 3: Polypropylene Fiber

Fig 4: Recron 3s Fiber

2.2 Mix Proportions

S.No	Mix ID	Mix Proportion
1	GM	Geopolymer Mortar
2	GM +SF	Geopolymer Mortar with Steel Fiber
3	GM + PPF	Geopolymer Mortar with Polypropylene Fiber
4	GM + RF	Geopolymer Mortar with Recron 3s Fiber
5	GM + GF	Geopolymer Mortar with Glass Fiber
6	SC-GM	Self-Compacting Geopolymer Mortar
7	SC-GM + SF	Self-Compacting Geopolymer Mortar with Steel Fiber
8	SC-GM + PPF	Self-Compacting Geopolymer Mortar with Polypropylene Fiber
9	SC-GM + RF	Self-Compacting Geopolymer Mortar with Recron 3s Fiber
10	SC-GM + GF	Self-Compacting Geopolymer Mortar with Glass Fiber

Table 4 Mix Proportion Detailed

S.No	Mix ID	Flyash / Alkaline Solution	Flyash	SP % of FA	Molarity of NaOH	Na_2Sio_3 / NaOH	Fiber % by Volume Fraction
1	GM	0.45	1	1	10M	1:1	1
2	GM +SF						
3	GM + PPF						
4	GM + RF						
5	GM + GF						
6	SC-GM						
7	SC-GM + SF						
8	SC-GM + PPF						
9	SC-GM + RF						
10	SC-GM + GF						

Table 5 Mix Proportions of Different Mortar

NaOH - Sodium Hydroxide Na_2Sio_3 - Sodium Silicate SP - Superplaticizer

III. MIXING, CASTING AND CURING OF MORTAR

3.1 Geopolymer Mortar

The manufacture of Geopolymer mortar was carried out using the usual concrete technology methods. The Geopolymer mortar Mix design using natural river sand, flyash, sodium hydroxide, and sodium silicate. The flyash and the fiber were first mixed together in the mixer then the fine aggregate were mixed together in the laboratory mortar mixer for about 3Minutes. the liquid component of the mixture, i.e. alkaline liquid prepared 1 day before casting was then added to the dry material and mixing continued for further about 4 minutes to manufacture the fresh mortar. The alkaline solution of flyash ratio was kept at constant as 0.45 whereas the ratio of sodium silicate to sodium hydroxide solution was kept 1:1 and Fly-ash to Sand ratio was 1:1 for mix proportion. Finally the chemical admixture was ConplastSP230 was added in to the mixture the proportion of 1% volume in cementitious mortar the fresh mortar could be handled up to 120 minutes without any sign setting and without any degradation in the compressive strength.

The cubes were cast for mortar. The mortar cube size is 70mm*70mm*70mm. The mortar was placed in the moulds and compacted by manual strokes and together on a vibrating table. All specimens were cured undisturbed for 24 hours at 70 degree Celsius temperature. After that the specimens were removed from the moulds and left open to air up to the testing. The flyash based Geopolymer mortar did not harden immediately at room temperature.

3.2 Self Compacting Geopolymer Mortar

In this study, flyash based Geopolymer was used as the binder instead of ordinary Portland cement based paste to produce mortar. The manufacture of self-compacting Geopolymer mortar was carried out by using the traditional trial and error mortar technology method [12]. A total mixture was made to assess the workability characteristics and the study the influences of various parameters on the compressive strength. The alkaline solution to flyash ratio was kept at constant as 0.45 whereas the ratio of sodium silicate to sodium hydroxide solution was kept 1:1, and Fly-ash to Sand ratio was 1:1 for mix proportion. Finally the chemical admixture was Glenium SKY8233 was added in to the mixture the proportion of 1% volume in cementitious mortar. Then such as V-funnel, L-Box and J-Ring were performed for this purpose all specimens were undisturbed for 24 hours at ambient condition. After that the specimen were removed.

The cubes were cast for mortar. The mortar cube size is 70mm*70mm*70mm. The mortar was placed in the moulds and compacted by manual strokes and together on a vibrating table. All specimens were cured undisturbed for 24 hours at 70 degree Celsius temperature [13]. After that the specimens were removed from the moulds and left open to air up to the testing. The flyash based Geopolymer mortar did not harden immediately at room temperature.

Fig: 1 Casting of Mortar Specimens

Fig: 2 Specimens under heat curing in oven

IV. TESTING OF SPECIMENS

4.1 Fresh Properties

The functional requirement on a fresh self-compacting mortar is different from those on a vibrated fresh mortar. According to EFNARC [14], a mortar mixture can only be classified as self-compacting mortar, if the requirement for its three key characteristics via: filling ability, passing ability and segregation are fulfilled. In the study the workability related fresh properties of various self-compacting geopolymer mortar were measured using v-funnel, l-box and j-ring test methods. The entire test was performed by following the European guidelines of self-compacting mortar [14].Workability test result for Self-compacting Geopolymer with Fiber Mortar in Table 6.

Mortar Type	V-funnel in Sec (0-10)	V-Funnel At T 5minutes in Sec (0 -10, +3)	J-Ring in mm (6-12)	L-box (H_2/H_1) (0.8 – 1)
SC-GM	6	9	6	0.8
SC-GM + SF	8	10	7.3	0.91
SC-GM + PPF	7	10	6.5	0.85
SC-GM + GF	9	11	7.9	0.88
SC-GM + RF	11	13	9.2	0.98

Table 6 Workability Test Result of Self-compacting Geopolymer Mortar with Fiber

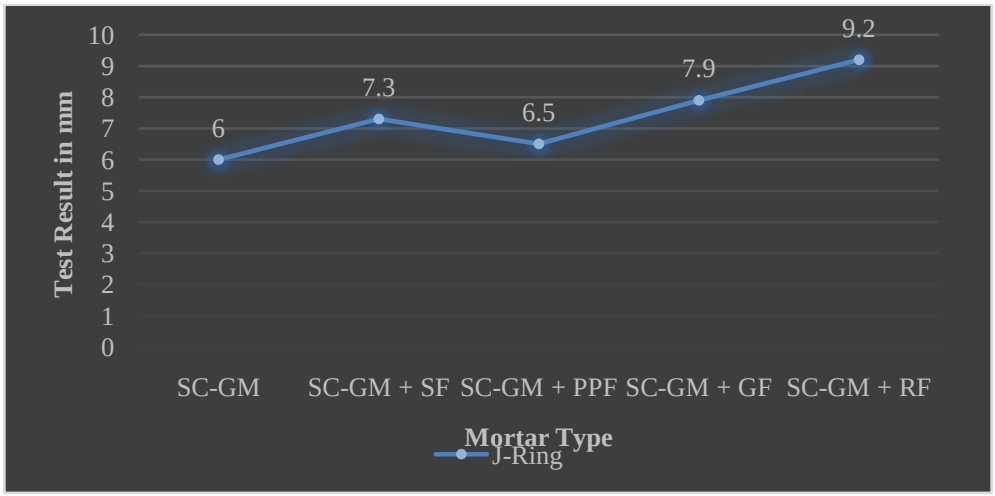

Fig 1: J-Ring Test Results

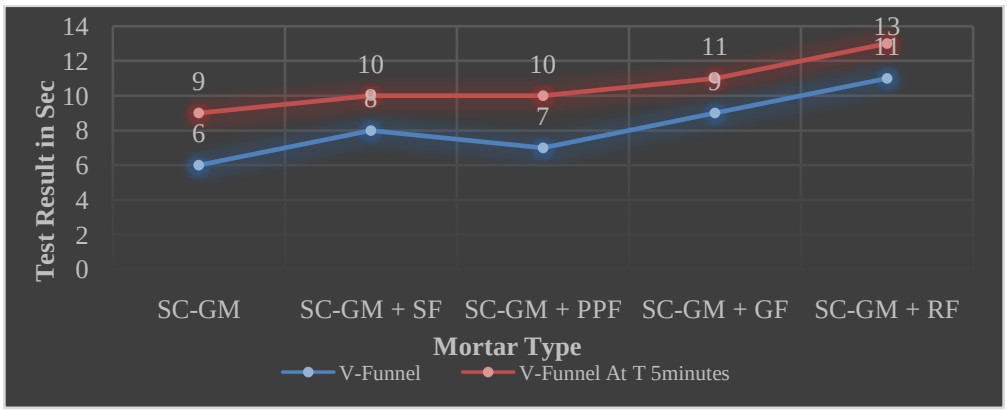

Fig 2: V-Funnel Test and V-Funnel at T5minsTest results

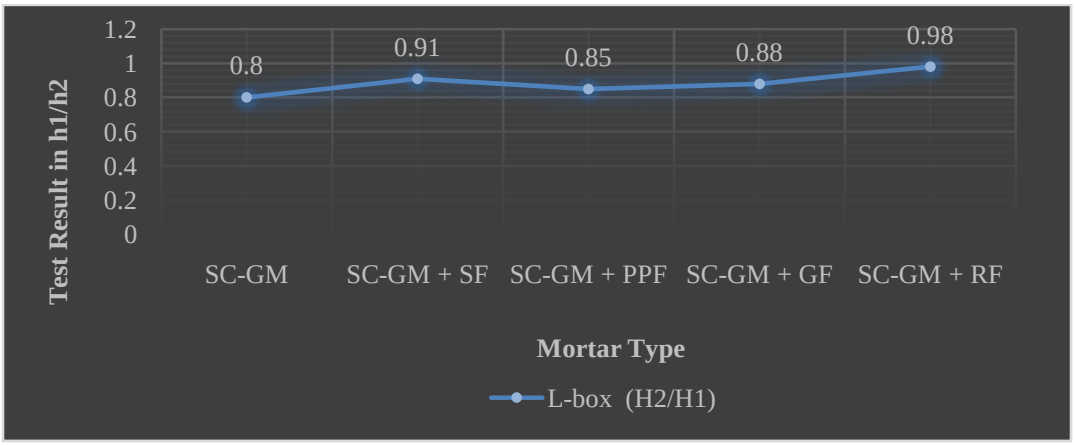

Fig 3: L-Box Test results

4.2 Compressive Strength

Compressive strength is one of the most important parameters of mortar and is considered as the characteristics material value for the classification of mortar. Table 8 shows the Compressive strength for all type of mortar with solution / binder ratio of 0.45 and mix proportion of 1:1

Table 7 Compressive Strength of Mortar Cubes

S.No	Mix ID	Compressive Strength (N/mm2)
1	GM	43.41
2	GM +SF	52.16
3	GM + PPF	54.67
3	GM + RF	52.9
4	GM + GF	52.5
5	SC-GM	52.4
6	SC-GM + SF	54.43
7	SC-GM + PPF	55.7
8	SC-GM + RF	53.53
9	SC-GM + GF	53.13

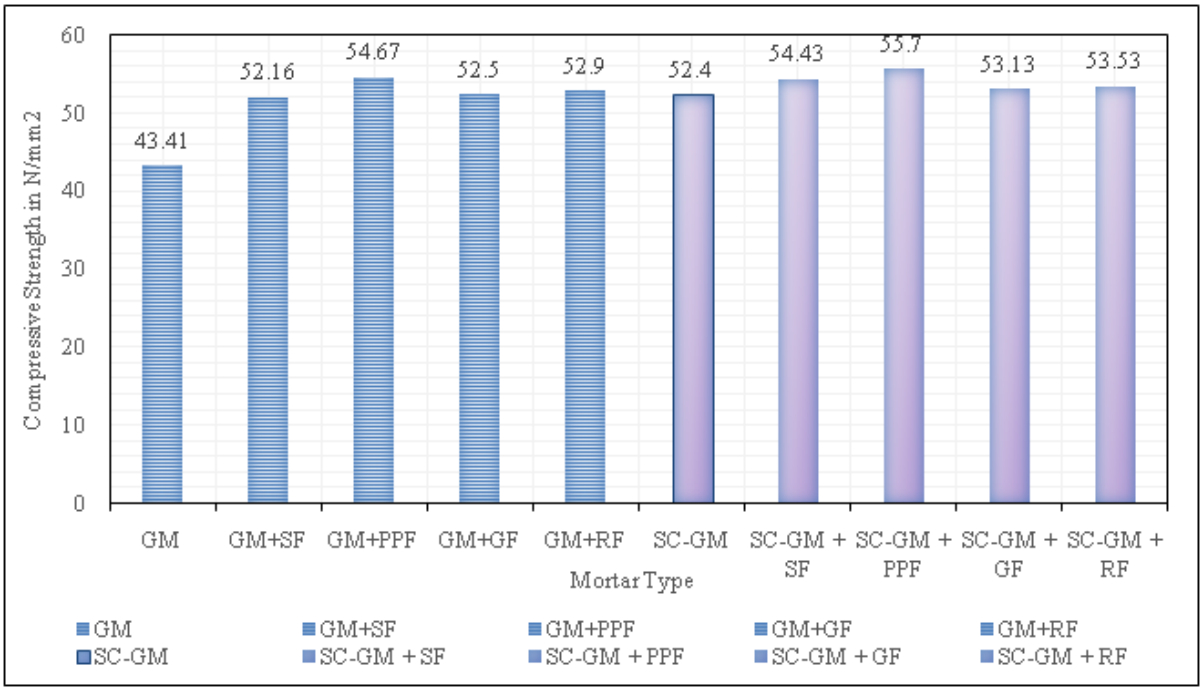

Fig 4: Compressive Strength Test results for various Mix Proportions

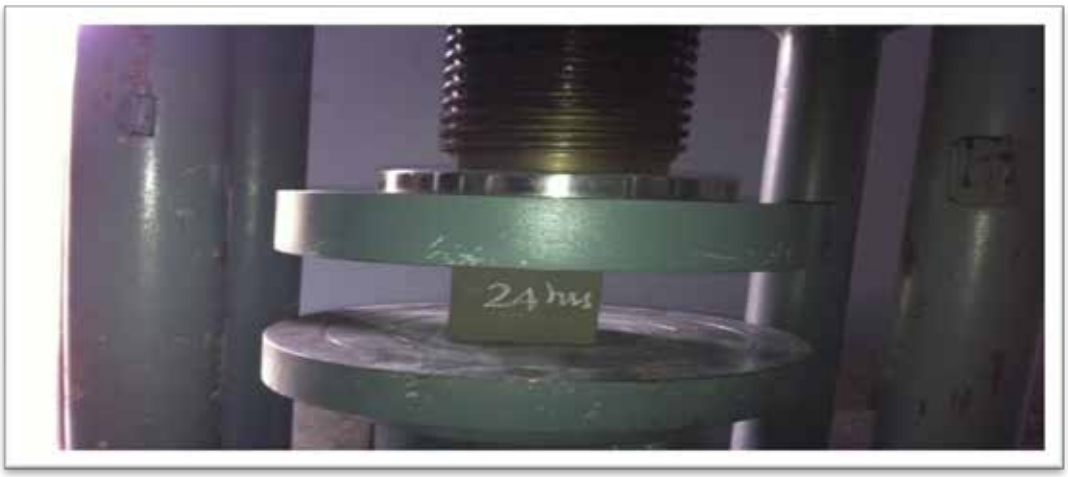

Fig 5: Compressive Strength Test on Mortar Cubes

V. CONCLUSION

Based on the experimental study and analysis of test results obtained, the following conclusions are drawn:

1. Geopolymer Mortar with Polypropylene Fiber gives more compressive strength when compared with Cement Mortar of same mix proportion.
2. Self-Compacting Geopolymer Mortar with Polypropylene Fiber having 0.45 solution/binder ratio shows more compressive strength and also satisfies the workability properties of Self-Compacting Mortar as per EFNARC Guidelines, when compare with Cement Mortar of same mix proportions.

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FRESH AND DURABILITY STUDIES OF POLYPROPYLENE FIBER REINFORCED SELF-COMPACTING CONCRETE (SCC)

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ABSTRACT

Self-Compacting concrete is one main type of innovation of concrete and gets compacted by its own weight and without Segregation; there is no additional vibration required. The SCC has a brittle characteristic in nature and this will be overcome by adding uniformly distributed fiber in the concrete mix. The cost and demand of natural sand are also increasing day by day; this problem will be solved by replacement of river sand by manufactured sand as fine aggregate. Though the concrete has more advantages, the main problem of concrete is durability. In this investigation, the addition of fiber into SCC significantly improved the structural properties for instance compressive strength, ductility, and tensile strength. SCC with polypropylene fiber aids considered in this present work. Initially the mechanical properties are determined. Later the influence of Polypropylene fiber in the SCC durability properties has been studied by sorptivity, acid attack, and sulphate attack. The results show that the addition of polypropylene fiber up to 0.15% enhanced the durability property in concrete.

Key words - Durability, Fly-ash, M-sand, Polypropylene fiber, Self-compacting Concrete (SCC)

I. INTRODUCTION

Concrete is the most widely used construction material in worldwide. So it is important to consider the durability of concrete indirect of economy, serviceability, and maintenance. The concrete is durable means it must able to resist the chemical aggression, mechanical action, weathering action without any loss of strength, and deterioration during their expected service life. Concrete is not fully resistance to acids is the main problem of durability. The durable concrete structure requires adequate compaction and placing [1]. In congested reinforcement areas the compaction and placing is very difficult.

Self-Compacting Concrete (SCC) can be compacted into every corner of formwork, due to its own weight there is no need for additional vibration. The cracking also plays an important role in durability of the concrete structure. From this fact it is necessary to measures in order o maintain the cracks under limit that imply a non-significant risk for the durability of structural elements [2]. The addition of fiber to reinforced self-compacting concrete improves compressive strength, Impact resistance, reduces the cracking and spalling risk at high temperature [3]. The Polypropylene fiber (PPF) was used in this present study. The PPF has good ductility; they can restrain the plastic cracks [4].

River sand availability is depleting and also it affects the ecological balance of the rivers. The requirement of sand for producing concrete is on the increasing order. Under such circumstances, producing manufactured sand from the aggregates and using it in the concrete as 100% replacement of natural sand is the requirement of the day [5]. So far, manufactured sand has not been used much in India for the reason that generally they are flaky

and rough textured. The natural sand provides good workability due to its cubical, rounded, and smooth textured particles. In the last decade Vertical Shaft Impact (VSI) crushers are being used for producing v cubical, comparatively smooth textured, well-graded sand from the stone aggregates, which are found to be good enough to replace the natural sand.

II. EXPERIMENTAL PROGRAMME

2.1 Material Properties

2.1.1 Cement

The Ordinary Portland Cement of 43 grade was used and tested for physical properties and found to be conforming to various specifications [6] as per IS: 8112:1989. The Table: 1 shows the Physical properties of Cement.

Table 1 Physical properties of Cement

S.No	Tests on Cement	Observations
1	Specific gravity	3.10
2	Normal consistency	30%
3	Initial Setting Time	35 Min
4	Final setting time	400 min

2.1.2 Manufactured Sand

Manufactured sand confirming to [7] IS: 383-1970 is used in this study for making of SCC. The sand was confirming to zone-II. The physical properties of fine aggregate like specific gravity, bulk density and fineness modulus is tested in accordance with [8] IS 2386-1975. The M-sand was obtained from local sources. The Table:2 shows the Properties of Fine aggregate.

Table 2 Properties for Fine aggregate

S.No	Tests for Fine Aggregate	Observations
1	Specific Gravity	2.71
2	Fineness Modulus	2.72
4	Bulk Density	1709.47 Kg/m^3

2.1.3 Coarse Aggregate

The crushed coarse aggregate of size 12.5 mm was used. The physical properties of coarse aggregate like specific gravity, bulk density and fineness modulus is tested accordance with [8] IS 2386-1975. The Table:3 shows the Properties of Coarse aggregate.

Table: 3 Properties for Coarse aggregate

S.No	Tests for Coarse Aggregate	Results
1	Specific Gravity	2.78
2	Bulk density	1592.295 kg/m^3
3	Compaction Factor	0.921
4	Flakiness Index	12.162%
5	Elongation Index	28.72%

2.1.4 Fly Ash

Fly ash (ASTM Class –F (Low Calcium Fly-Ash)) was used for making the SCC. The physical properties of fly ash like specific gravity, fineness modulus is tested in accordance with IS 3812-2003**.** The Fly ash was obtained from Thoothukudi Thermal Power Plant. Table: 4 shows the chemical and physical property of Fly-ash respectively**.** The chemical properties were tested at Department of Industries & Commerce, Regional Testing Laboratory, Madurai.

Table: 4 Chemical & Physical Properties for Fly ash

S.NO	Properties	Characteristics	Results
1	Chemical	Silicon di Oxide (Sio_2) plus Aluminium Oxide (Al_2O_3) plus Iron Oxide (Fe_2O_3), percent by mass	95.95
		Silica (as SiO_2), percent by mass	59.71
		Magnesium Oxide (as MgO), percent by mass	106
		Total Sulphur as sulphur tri Oxide (Na_2O), percent by mass	Nil
		Available Alkalis as sodium Oxide (Na_2O), percent by mass	0.63
		Loss on Ignition, percent by mass	0.91
		Moisture	0.32
		Calcium Oxide as CaO	0.50
2	Physical	Specific Gravity	2.36
		Fineness	4%

2.1.5 Super plasticizers & Viscosity Modifying Agent

The chemical admixture based on Polycarboxylic ether, which is known commercially (Master Glenium SKY 8233) was used as a superplasticizer admixture in producing SCC. The master matrix 2 (Glenium stream 2) was used as a viscosity modifying agent.

2.1.6 Fiber

Polypropylene fiber was used for making fiber reinforced SCC. The PP fiber having more advantages such, easy to disperse, good ductility, non-corrosive, not affected by atmospheric conditions, [4] not expensive, inert in high pH cementitious environment and easy to disperse [9]. In this research, Monofilament polypropylene with 18µm diameter, and 12 mm length, this is having 0.91 g/cm^3 density**.**

Fig: 1 Polypropylene Fiber (PPF)

2.1.7 Water

Potable fresh water available from local sources was used for making the concrete.

2.2 Mix Proportions

Table: 5 Symbol and Grade of SCC Mix

S.No	Mix Designation	Grade of Concrete mix
1	M1	M20
2	M2	M30

Table: 6 Mix proportions for M1

Materials	Volume fraction of polypropylene fiber			
	0.00%	0.05%	0.1%	0.15%
Polypropylene fiber (kg/m^3)	0	0.45	0.90	1.36
Cement (kg/m^3)	375	375	375	375
Fine aggregate (kg/m^3)	870.97	870.97	870.97	870.97
Coarse aggregate (kg/m^3)	712.62	712.62	712.62	712.62
Fly ash (kg/m^3)	175	175	175	175
Water (lt/m^3)	209	209	209	209
Superplasticizer (kg/m^3)	5.04	5.04	5.04	5.04
VMA (kg/m^3)	1.93	1.93	1.93	1.93

Table: 7 Mix proportion for M2

Materials	Volume fraction of polypropylene fiber			
	0.00%	0.05%	0.1%	0.15%
Polypropylene fibers (kg/m^3)	0	0.45	0.90	1.36
Cement (kg/ m^3)	375	375	375	375
M-sand (kg/ m^3)	870.97	870.97	870.97	870.97
Coarse aggregate (kg/ m^3)	712.62	712.62	712.62	712.62
Fly ash (kg/ m^3)	175	175	175	175
Water (lt/ m^3)	209	209	209	209
Super plasticizer (kg/m m^3)	5.04	5.04	5.04	5.04
VMA (kg/ m^3)	1.93	1.93	1.93	1.93

III. EXPERIMENTAL METHODS & DISCUSSION ON DURABILITY RESULTS

3.1 Fresh State Properties

The mix design was tested by more than one method for different workability parameters. J ring test, L-box test, V-funnel test, V-funnel at T5 minutes were used for the assessment of fresh properties of SCC in this study. The fresh properties of plain SCC and polypropylene fiber reinforced SCC were tested by the procedure of EFNARC (European guidelines for self-compacting concrete) [10]. The addition of polypropylene in SCC affected the passing ability and filling ability. The SCC mixes with PP fiber increases the resistance to flow and reduces the flow ability due to increasing the interlocking and friction between fibers and aggregate.

Table: 8 Results of Fresh concrete tests for M1

Workability Tests	Volume fraction of polypropylene fiber			
	0.00%	0.05%	0.1%	0.15%
V-funnel (sec)	6	8	9	13
J-Ring (mm)	4.5	6	7.4	10.5
L-Box (h_2/h_1)	0.7	0.8	0.83	1.3
V-Funnel at T5 min (sec)	7	10	11	17

Table: 9 Results of Fresh concrete tests for M2

Workability Tests	Volume fraction of polypropylene fiber			
	0.00%	0.05%	0.1%	0.15%
V-Funnel (Sec)	8	9	10	13
J-Ring (Mm)	5.5	6.5	8.3	11.6
L-Box (H_2/H_1)	0.8	0.87	0.9	1.5
V Funnel at T 5min(Sec)	9	11	13	18

Table: 8 and Table: 9 shows the effect of polypropylene (PP) fibers addition on three key characteristic of SCC in the fresh state to evaluate its workability criteria for both M1 & M2. Figure 2, 3, 4, and 5 shows the effect of PP fiber content for both M1 and M2 on Flow ability, passing ability, segregation resistance of the fresh concrete respectively. From the test results the addition of PP fibers results in deterioration of fresh properties of SCC. It is clearly seen that Flow ability (V-funnel test), Passing ability (J-Ring-Box), segregation resistance (V-Funnel at T5 min), [10] decreases when the presence of PP fiber increased. Based on workability test results it can be assessed that polypropylene fiber addition up to 0.1% by volume of concrete meet the requirements of Flow ability, Passing ability, Segregation resistance of SCC as per EFNARC Guidelines[11] .

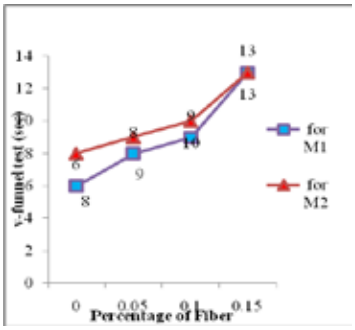

Fig: 2 V-Funnel Test

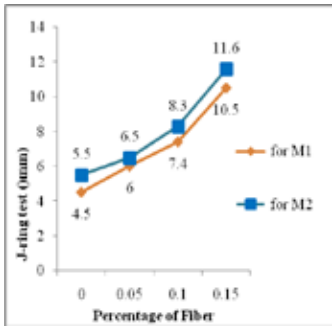

Fig: 3 J-ring Test

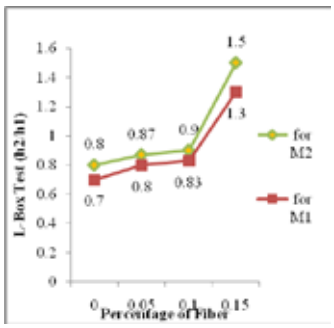

Fig: 4 L-Box Test

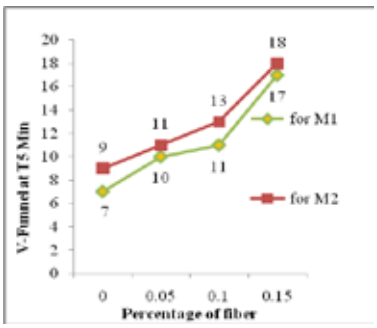

Fig: 5 V-Funnel at T5 min Test

3.2 Durability Study

3.2.1 Sorptivity

The Sorptivity test was used to determinate the rate of absorption as well as the cumulative amount of water absorbed by concrete specimens. The sorpitivity test was done by using the 60 mm height and 100 mm dia cylindrical size self -compacting concrete specimens. After the casting, the specimen was immersed in water for curing and then the specimen was dried in oven at a temperature of 100+10 ºC, then wet weight of the specimen is noted (W1). The epoxy was applied on curve side of the specimen. The absorption of water is only in the bottom of specimens. Then, the specimens were immersed in water and supported in such a way that about 1 cm of the lower part of the specimen was in water. After 30 min, the specimen was weighted. The sorptivity values were calculated by using the following formula.

$$S = I/\sqrt{t} \;\; ; \qquad I = \Delta W/(A * D)$$

Where; S= sorptivity in mm, t= elapsed time in mint, Δw = change in weight = W2-W1, W1 = Oven dry weight of cylinder in grams W2 = Weight of cylinder after 30 minutes capillary suction of water in grams. A= surface area of the specimen through which water penetrated. d= density of water

Table: 10 Effect of Polypropylene Fiber for Sorptivity Test Results for M1& M2

Grade of mix	Volume Fraction of PP Fiber	Dry weight in grams	Wet weight in grams	Sorptivity value in 10^{-5} mm/$\sqrt{Min}$
M1	0	1352.2	1355.70	0.0813
	0.05%	1346.6	1348.80	0.0511
	0.1%	1334.4	1336.35	0.0453
	0.15%	1316.8	1318.4	0.0371
M2	0	1326.5	1329.85	0.0778
	0.05%	1314.3	1316.84	0.0590
	0.1%	1309.1	1310.85	0.0406
	0.15%	1292.7	1294.47	0.0214

Table 10 shows the effect of Polypropylene in sorptivity of the samples respectively. Generally, SCC has lower porosity and sorptivity values compared to conventional concrete [12]. In wide-ranging Polypropylene fiber has very low water absorption this means the wet and dry properties of fiber are identical. Therefore, the addition of polypropylene fiber up to 0.15% in SCC reduced the rate of absorption of water in concrete.

3.2.2 Acid Attack

The specimens were immersed in 5% of HCL solution for the determination of acid attack. The various specimen sizes were 150 X 150 X150 mm. The deterioration of the specimen was determined by loss of weight and reduction in compressive strength of the specimen at 28 days. The Table 11 shows the effect of the polypropylene fiber in acid attack for both M1& M2 grade.

Table: 11 Effect of Polypropylene fiber in Acid Attack Test

Grade of Mix	Volume fraction of PP Fiber	Weight before acid curing	Weight after acid curing	Compressive Strength before curing	Compressive Strength after curing	Reduction of Strength (N/mm^2)

		(Kg)	(Kg)	(N/mm^2)	(N/mm^2)	
M1	0	8.120	7.908	27.070	24.043	3.027
	0.05%	8.007	7.886	29.120	27.158	1.962
	0.1%	8.001	7.915	31.350	29.890	1.460
	0.15%	7.903	7.876	26.540	25.508	1.032
M2	0	8.080	7.754	39.00	36.076	2.924
	0.05%	7.987	7.923	41.30	39.220	2.08
	0.1%	7.971	7.935	42.80	41.191	1.609
	0.15%	7.968	7.946	38.69	37.963	0.727

Fig 6 & Fig 7 shows the effect of Polypropylene fiber in Acid attack. The increasing of PP fiber content up to 0.15 % does not affect the concrete in the acid solution. The weight reduction and lose of strength were also low compare to the plain SCC. The Polypropylene fiber has excellent chemical resistance & it resist most of the acids & alkalis due to its non-Polar structure. The non-Polar structure refers the bond between the atoms.

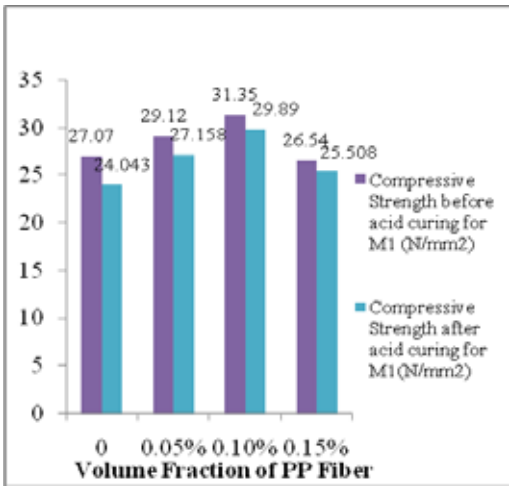

Fig: 6 Acid Attack Test result for M1

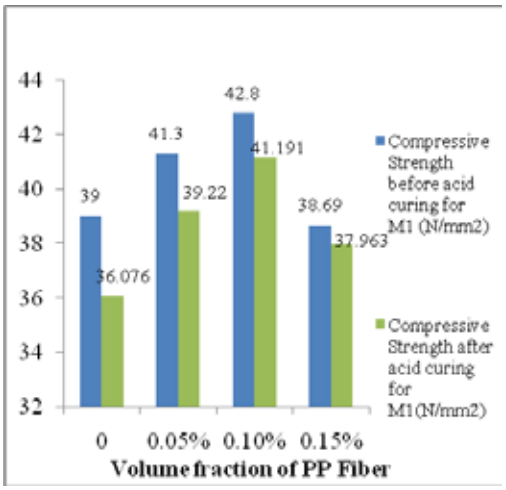

Fig: 7 Acid Attack Test result for M2

3.2.3 Sulphate Attack

The specimens are immersed in 5% of $MgSO_4$ solution for sulphate attack. The various specimens size was 150 X 150 X150 mm. The deterioration of the specimens was determined by loss of weight and reduction in compressive strength of the specimen at 28 days. The Table 12 shows the effect of the Polypropylene fiber in Sulphate attack for both M1& M2 grade.

Table: 12 Effect of Polypropylene fiber in Sulphate attack in M1 & M2 grade

Grade of Mix	Volume fraction of Fiber	Weight before acid curing (Kg)	Weight after acid curing (Kg)	Compressive Strength before curing (N/mm^2)	Compressive Strength after curing (N/mm^2)	Reduction of strength (N/mm^2)
M1	0	8.130	8.105	27.070	24.843	2.227
	0.05%	8.015	8.004	29.120	27.168	1.952
	0.1%	8.007	7.997	31.350	30.320	1.03

	0.15%	7.968	7.976	26.540	25.698	0.842
M2	0	8.075	8.048	39.00	36.676	2.324
	0.05%	7.977	7.964	41.30	39.812	1.488
	0.1%	7.964	7.939	42.80	41.591	1.209
	0.15%	7.956	7.946	38.69	37.753	0.937

From the Fig:8 & Fig:9 shows the effect of Polypropylene in sulphate attack .The PP fiber content was increased up to 0.15%, it was not affected the concrete after sulphate curing. The fiber content increase, the resistance of penetration for sulphate solution also increased. There is no chemical interaction between fiber and paste matrix and good physical adhesion between them.

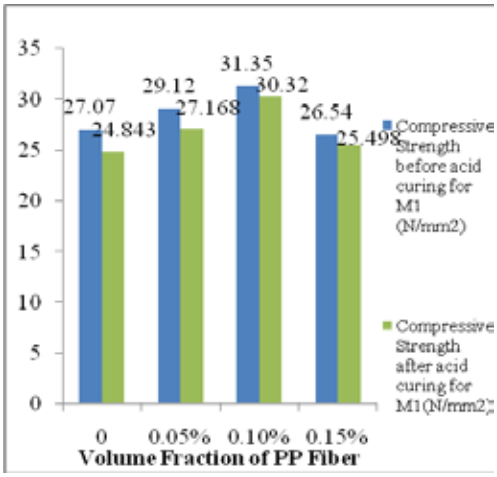

Fig: 8 Sulphate Attack Tests Results forM1

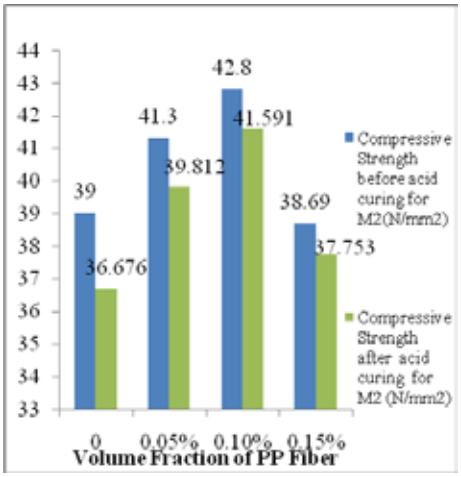

Fig: 9 Sulphate Attack Tests Results for M2

IV. CONCLUSION

1. The addition of fiber and its increased percentage in SCC decreased the flow ability, passing ability, segregation resistance. However polypropylene fiber in SCC up to 0.1% by Volume of concrete still meet the requirements of Flow ability, Passing ability, Segregation resistance in both M1 & M2 as per EFNARC guidelines.

2. The compressive strength of concrete was increased with an increase the amount of fiber up to 0.1 percent by concrete volume and then addition of fiber 0.15 percent by concrete volume decreases the compressive strength for both M1 & M2.

3. From the Sorptivity test result the addition of fiber up to 0.15% into SCC decreased the rate of absorption of water in concrete. SCC with PPF, the rate of water absorption was low compared to plain SCC. Because of the non-Polar structure of fiber.

4. From the test results of acid attack and Sulphate attack, the uniformly dispersed Polypropylene fiber (PPF) restricts the penetration of acids in the concrete. The loss of weight and compressive strength loss was decreased, the addition of fiber up to 0.15% by volume of concrete compared to the plain SCC.

5. The Polypropylene fiber into the SCC up to 0.1% by volume of concrete was satisfied the workability prosperity as per EFNARC guidelines and the mechanical property such as compressive strength, Tensile strength, and Impact resistance increased. Therefore, the optimum content of PPF was 0.1% for Mechanical properties as well as workability. The addition of fiber content up to 0.15% was not affect the weight of

concrete, compressive strength and reduces the water absorption rate in durability test. The investigation test results indicate durability properties were not affected by the addition of polypropylene fiber in to the SCC. The Polypropylene fiber content increased the durability properties also increased.

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