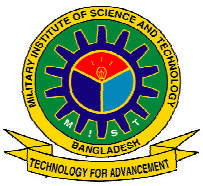
ISSN: 2073-6444



MIST JOURNAL

GALAXY (DHAKA)

THE ANNUAL TECHNICAL JOURNAL OF MIST

VOLUME 3 **NUMBER 3** **FEBRUARY 2011**

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY (MIST)
MIRPUR CANTONMENT, DHAKA-1216.

INAUGURAL CEREMONY OF MIST- 19 APR 1998
HONOURABLE PRIME MINISTER OF PEOPLE'S REPUBLIC OF
BANGLADESH SHEIKH HASINA UNVEILLING THE FOUNDATION PLAQUE

MIST JOURNAL
Technology for Advancement

GALAXY (DHAKA)

THE TECHNICAL JOURNAL OF
MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY

| Volume 3 | Number 3 | February 2011 |

MIST, Mirpur Cantonment, Dhaka-1216, Bangladesh

EDITORIAL BOARD

DISCLAMER

The analysis, opinions and conclusions expressed or implied in this Journal are those of the authors and do not necessarily represent the views of the MIST, Bangladesh Armed Forces or any other agencies of Bangladesh Government. Statements of fact or opinion appearing in MIST Journal are solely those of the authors and do not imply endorsement by the editors or publisher.

ISSN: 2073-6444

INITIAL SUBMISSION

Initial Submission of manuscripts and editorial correspondence should be sent to the MIST, Mirpur Cantonment, Dhaka-1216, Bangladesh. Tel: 88 02 8034194, Fax: 88 02 9011311, Email : info@mist.edu.bd, should consult the Notes for contributions at the back of the Journal before submitting their final draft. The editors cannot accept responsibility for any damage to or loss of manuscripts.

Subscription Rate (Single Copy)

Individuals : BDT 300 / USD 05 (including postage)
Institutions : BDT 375 / USD 08 (including postage)

Published by Military Institute of Science and Technology, Bangladesh

Designed and Published by:

Research and Development Wing, MIST

FOREWORD

Since the inception in 1998, Military institute of Science and Technology (MIST) has continued to pursue to uphold its motto "Technology for Advancement". Within this short span of time MIST emerged as a leader in the high quality education and also became a beacon of light for scientific and technological progress of Bangladesh.

In the annals of MIST, 2010 will be a landmark year. This was the year when MIST implemented "Online Admission System–A Steep towards Digital Bangladesh" in accordance "Government's Vision 2021" to set up Digital Bangladesh. In this year it has been decided that rather than resting on only undergraduate programmes; MIST would embark on postgraduate courses aimed at increasing its profile, enriching its academic offerings and broadening its reach. In this year MIST has introduced "OSMANY MEMORIAL MEDAL" to encourage young talents. It was also the year when MIST introduced "MIST BLUE" for excellent performance in games and sports.

Starting with only 40 military students in civil engineering Department, today within a decade MIST has five engineering departments including Aeronautical Engineering, first of this kind in Bangladesh. Presently MIST has 1172 students from both home and abroad in various departments. So far 1187 students have been graduated from MIST. Many of them are pursuing higher studies in both home and abroad. Some of them are serving in different educational institutes, government and non government organisations. Feedback from employers is encouraging.

It gives me immense pleasure to see the third issue of MIST journal GALAXY (DHAKA)-2011 that marks another milestone in the ongoing growth and progress of MIST. In this journal topics are dealt with great care and in a scientific manner. I would like to express my utmost appreciation to all the contributors of articles, who amidst their busy duties displayed a high standard of commitment. Every page of this publication reflects the merits and wisdom of the writers which will certainly draw the attention of esteemed readers. I hope that MIST will continue its noble effort in publishing the journal every year and all the time earn a new glowing feather in its glittering crown.

I would like to express my best wishes and felicitations to the editorial board and associated personnel, who had put in their sincere efforts for the publication of GALAXY (DHAKA)-2011 in an elegant form.

MAJOR GENERAL MOHD HABIBUR RAHMAN KHAN, ndc, psc

Commandant

Military Institute of Science and Technology.

&

Chief Patron

EDITORIAL

Military Institute of Science and Technology (MIST) is sincerely committed to academic excellence in matters of both instruction and research and guides the student to achieve their career goal in an atmosphere conducive to their all around development. MIST Journal is one such work that truly embodies the qualitative product of its students and faculty members. It contains original technical papers dealing with theory and practice of science as well as different areas of engineering and related fields.

Standard of papers was evaluated on technical quality, relevance and importance of material, interest to reader and timeliness. Some points that were considered for selection of papers are whether they supply significant information or/and are written in a style appropriate for an archive publication. Authors had to certify that the submitted manuscript had not been published previously or submitted for publication elsewhere, and it does not violate any security, proprietary, or copyright restrictions. Articles contained in this issue were prepared according to instructions for authors and were submitted to a rigorous technical review by the appropriate board of reviewers.

We express our deepest gratitude to the chief patron of the journal Major General Mohd Habibur Rahman Khan, ndc, psc the commandant MIST whose valuable guidance, supervision, expertise and counsel were indispensable for publication of this journal. We also thank the advisory board for their valuable guidance and support. I would also express my sincere thanks to all the members of the editorial board for their insights and methodical editing. There is no doubt that this Journal will be of great use to our alumni and readers who wish to get some insight into the profound and sublime mysteries of science. Reviewers have been outstanding and we acknowledge here our debt to each member of that team. Comments on the journal/ articles are welcome and will be considered accordingly. We hope, GALAXY (DHAKA) - 2011 would satisfy the thirst of our esteemed readers.

CAPTAIN M Z ALAMGIR, (L), psc, BN

Director, Research and Development

Military Institute of Science and Technology

&

Editor-in-Chief

TABLE OF CONTENTS

ABOUT MIST

Military Institute of Science and Technology (MIST) is located at Mirpur Cantonment, an Education Village of Bangladesh Armed Forces on the northwest edge of Dhaka City. This unique institution blends military and civil students in order to produce engineers of very high calibres, capable of developing indigenous technology to meet the challenges of Digital Bangladesh. MIST has emerged as a leader in the high quality education and also became a beacon of light for scientific and technological progress of Bangladesh.

MIST started its journey on 19 April 1998 through inauguration by the honourable prime minister of People's Republic of Bangladesh Sheikh Hasina. Starting with only 40 military students in civil engineering programme, today within a decade MIST runs five engineering programmes including Aeronautical Engineering: first of this kind in Bangladesh with 1172 students from both home and abroad. So far 1187 students have been graduated from MIST. Many of them are pursuing higher studies in both home and abroad. Some of them are serving in different educational institutes, government and non government organisations. Feedback from employers is encouraging.

As an institution without any gender bias, MIST is already on steady stride upholding its motto "Technology for Advancement". The institute remains committed to contributing to the wider spectrum of national educational arena and plays a significant role in the development of human resources by infusing leadership qualities into the young talents.

All academic programs of MIST are affiliated with the Bangladesh University of Professionals (BUP). MIST offers bachelor degrees in: Civil Engineering (CE), Computer Science and Engineering (CSE), Electrical, Electronic and Communication Engineering (EECE), Mechanical Engineering (ME) and Aeronautical Engineering (AE).

Focussing on creating a positive, interactive learning environment, the department of CE produces top-notch engineers and leaders for the next generation. An ever-flourishing department of CSE has been providing the technical foundation, scholarly guidance and leadership skills that have resulted in a number of highly qualified and skilled computer graduates, proving their potentiality at home and in abroad. Expertise of the faculty members of ECEE department ranges from power systems to VLSI technology. ME programmes provide excellent technical background by attaching considerable emphasis on the development of systematic procedures for analysis and design, and on the responsible use of technology. In addition to avionics and aerospace engineering AE programme provides an excellent technical background for persons who want to work in the field of fluid mechanics, heat transfer, applied mechanics and other disciplines.

Good numbers of highly-qualified full time faculty members from military as well as civil community including foreign faculties take intensive care of each and every student in guiding them along the path of true professionalism and able leadership. Experienced faculty members of Bangladesh University of Engineering Technology (BUET) and Dhaka University (DU) also take classes in MIST. Guest speakers/teachers from various organisations/institution/universities are also invited to participate in our teaching programs.

MIST is regulated through three regulatory bodies: Council of MIST with honourable education minister of People's Republic of Bangladesh in the chair, Governing Body of MIST and Academic Council of MIST.

The unique features of MIST are: tranquil, pollution free and secure campus life, rigorous online admission and selection process, interactive sessions, training and industrial visits, uninterrupted curriculum, competent faculties through outsourcing, continuous feedback and assessment system, emphasis on code of conduct and dress code and focus to develop students as a good human with all possible attributes of successful leader.

ASSESSMENT OF SOIL COMPACTION–A PROJECT STUDY

Brig Gen Md Gazi Ferooz Rahman[(1)], Major M. D. H. Talukder[(2)] and
Major A. H. M. M. Rahman[(2)]

1. Department of Civil Engineering, Military Institute of Science and Technology, ferooz2603@yahoo.com
2. Corp of Engineers, Bangladesh Army

ABSTRACT

Soil compaction is one of the most important aspects of any earthwork construction. Compaction improves the engineering properties of the fills. Nearly all compaction specifications are based on achieving a certain value of dry unit weight (γ_d). During construction, the geotechnical engineers measure the unit weight of compacted soil in the field to verify the contractor's compliance with the requirement. This paper is a project study of road construction project "Road Zia Colony to Mirpur Cantonment". Soil samples were collected from five different locations. In situ dry density was obtained by Sand Cone Test from each location. The laboratory tests (Standard Proctor Test) were carried out to find out the dry density for each sample. The maximum dry density in relation to moisture content was obtained. Relative compaction (C_R) of soil at each location was then calculated to the soil compaction of the said road project.

KEY WORDS— *Compaction, porosity, density, Unit Weight*

1.0 INTRODUCTION

The behavior of every foundation, roads, airfields etc depends primarily on the engineering characteristics of the underlying deposits of soil or rock. The proper compaction of the soil is intended to ensure that the compacted soil will reliably and safely withstand loads of various kinds. Soil compaction on construction sites occurs either deliberately when foundations and sub grades are prepared or as an unintended result of vehicular traffic (Randrup and Dralle 1997). Soil compaction decreases porosity (e.g. Harris 1971). To determine whether a soil is compacted or not, and thus whether a treatment is necessary for the alleviation of soil compaction, the degree of compaction needs to be quantified.

It has been said that the top three factors in real estate are "location, location and location". It can also be said that the top three factors in road pavement construction are "compaction, compaction, and compaction". Compaction is the process by which the volume of air in a pavement mixture is reduced by using external forces to reorient the constituent aggregate particles into a more closely spaced arrangement. This reduction of air volume in a mixture produces a corresponding increase in unit weight or density (Roberts et al. 1996). Numerous researchers have stated that compaction is the greatest determining factor in dense graded pavement performance (Scherocman and Martenson, 1984; Scherocman, 1984; Geller, 1984; Brown, 1984; Bell et. al., 1984; Hughes, 1984; Hughes, 1989). Among the major causes for failure of roads in the tropics is inadequate compaction during construction. There is, therefore, the need to strictly control the compaction of the pavement layers if the design life of the road is to be attained; thereby eliminating large maintenance costs.

The road, "Zia Colony to Mirpur Cantonment" was an under construction road project on almost filled land. At the time of our study, different parts of the road were being filled up by the imported soils and compaction was going on. A project study was done to the compaction of soils. The study was undertaken to determine the in-situ compaction state of the ongoing Mirpur Cantonment to Zia Colony Road Project and compare with the compaction state obtained from the laboratory test results.

2.0 LITERATURE REVIEW

2.1 GENERAL

Soil compaction occurs when soil particles are pressed together, reducing pore spaces between them (**Figure 2.1**). Soil compaction increases soil strength-the ability of soil to resist the failure.

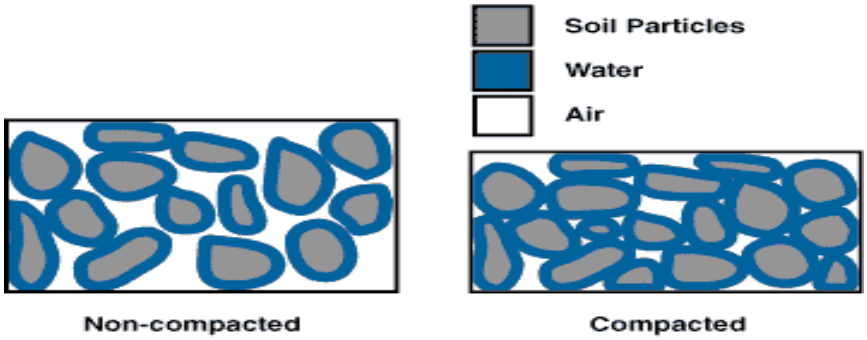


Figure 2.1: Effects of compaction on pore space

Soil compaction changes pores pace, particle size, particle distribution and soil strength. One way to quantify the change is by measuring the bulk density. As the pore space is decreased within a soil, the bulk density is increased (Compaction Handbook, 2008) (**Figure 2.2**).

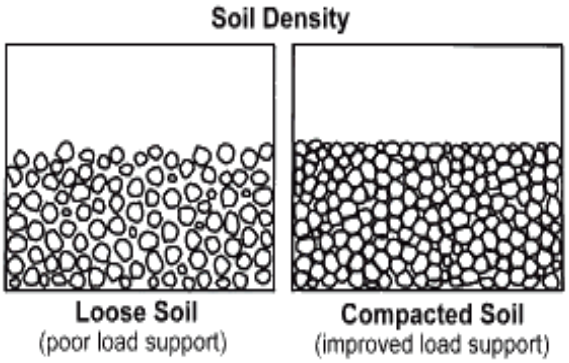


Figure 2.2: Soil density (googles pages)

If compaction is performed improperly, settlement of the soil could occur and result in unnecessary maintenance costs or structure failure. Almost all types earthwork projects and other construction projects utilize mechanical compaction techniques.

2.2 PURPOSE OF COMPACTION

Sir Clement Attlee, Prime Minister of England in the 1950's once remarked about Winston Churchill that "nothing grows under a heavy roller". Soils become compacted by the simple application of pressure from foot traffic, vehicles and even rain drops. The greater this pressure, the greater the soil compaction. The purpose of compaction is to improve the qualities of the soil used either as a sub-grade materials for roads or in the fills of any project. There are five principle reasons to compact soil:

a. Increases load-bearing capacity.
b. Prevents soil settlement and frost damage.
c. Provides stability.
d. Reduces water seepage, swelling and contraction.
e. Reduces settling of soil.

2.3 MEASUREMENT OF COMPACTION

The degree of compaction of soil is measured by its unit weight or dry density, (γ_{dry}) and optimum moisture content (W_c). Dry density is the weight of soil solids per unit volume of the soil in bulk. Knowing the wet unit weight and the moisture content (W_c), the dry unit weight can be determined from:

$$\gamma_{dry} = \frac{\gamma_{wet}}{1 + \frac{w_c(\%)}{100}}$$

The vulnerability of soils to compaction varies with soil texture (% of sand, silt, and clay), moisture content, and the amount of pressure applied.

2.4 MECHANISM OF SOIL COMPACTION

The process of soil compaction is simply expelling the air from the voids or reducing air voids. By reducing the air voids, more soil can be added to the block. When moisture is added to the block, water content, w_c, is increases, the soil particles will slip more on each other causing more reduction in the total volume, which will result in adding more soil and hence, the dry density (γ_{dry}) will increase accordingly (**Figure 2.3**).

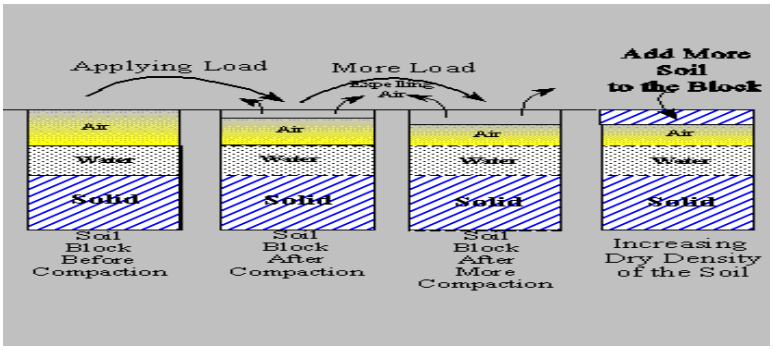


Figure 2.3: Mechanism of soil compaction

2.5 TYPES OF COMPACTION

There are four types of compaction effort on soil or asphalt:

a. Vibration
b. Impact
c. Kneading
d. Pressure

These different types of effort are found in the two principle types of compaction force: static and vibratory. Static force is simply the deadweight of the machine, applying downward force on the soil surface, compressing the soil particles. Static compaction is confined to upper soil layers and is limited to any appreciable depth. Kneading and pressure are two examples of static compaction.

Vibratory force uses a mechanism, usually engine-driven, to create a downward force in addition to the machine's static weight. The compactors deliver a rapid sequence of blows (impacts) to the surface, thereby affecting the top layers as well as deeper layers. Vibration moves through the material, setting particles in motion and moving them closer together for the highest density possible. **Figure 2.4** shows the result of improper compaction.

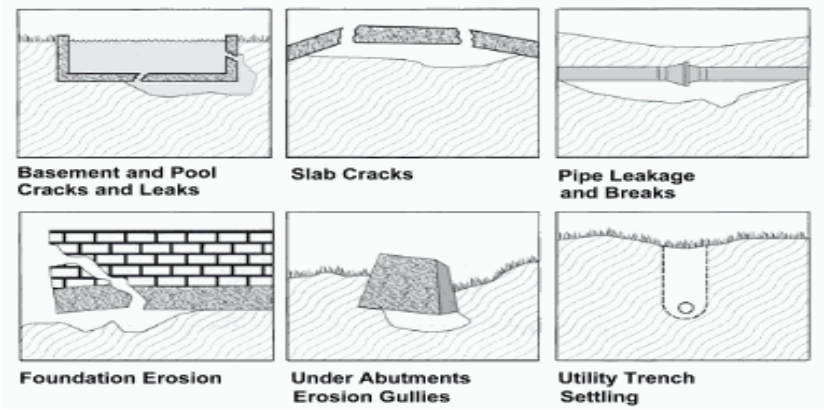


Figure 2.4: Results of poor compaction

3.0 METHODOLOGY

3.1 GENERAL

Methodology incorporates the planning and organization of entire project work **(Figure 3.1)**.

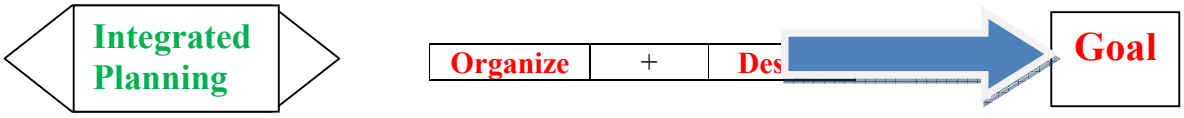


Figure 3.1: Methodology

This Project study is systematically planned under the broad heads illustrated by the following flow chart **(Figure 3.2)**. Data has been collected from the field as well as from the laboratory tests in order to analyze and obtain required result. Obtained result helped us to asses the best possible compaction state.

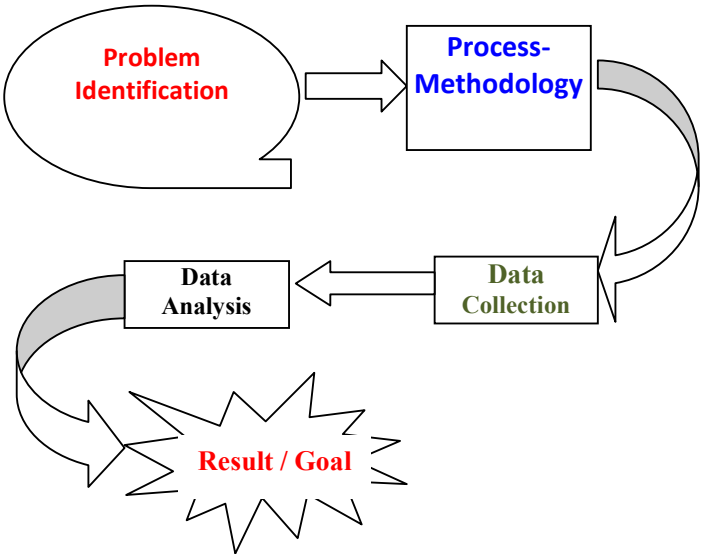


Figure 3.2: Project planning

3.2 DESCRIPTION OF THE SITE

Zia Colony to Mirpur Cantonment road project site is situated on the eastern side of Mirpur Section–12. The site is an open and flat terrain with some enclosed water bodies throughout its length. Originally it was almost a low laying land and presently transformed in to an almost flat and level surface filled by transported soils. Road project works is shown in **Figures 3.3.** Data regarding the project site are furnished below:

a. Total length : 6.30 km
b. Width :18.3 km(including footpath and divider)
c. No of RCC bridge :01 of 42 m length at 2.425 km point
d. No of pipe /Box culvert : 04 nos

BIRDS EYE VIEW OF AIRPORT RD TO MIRPUR CANTT LINK RD

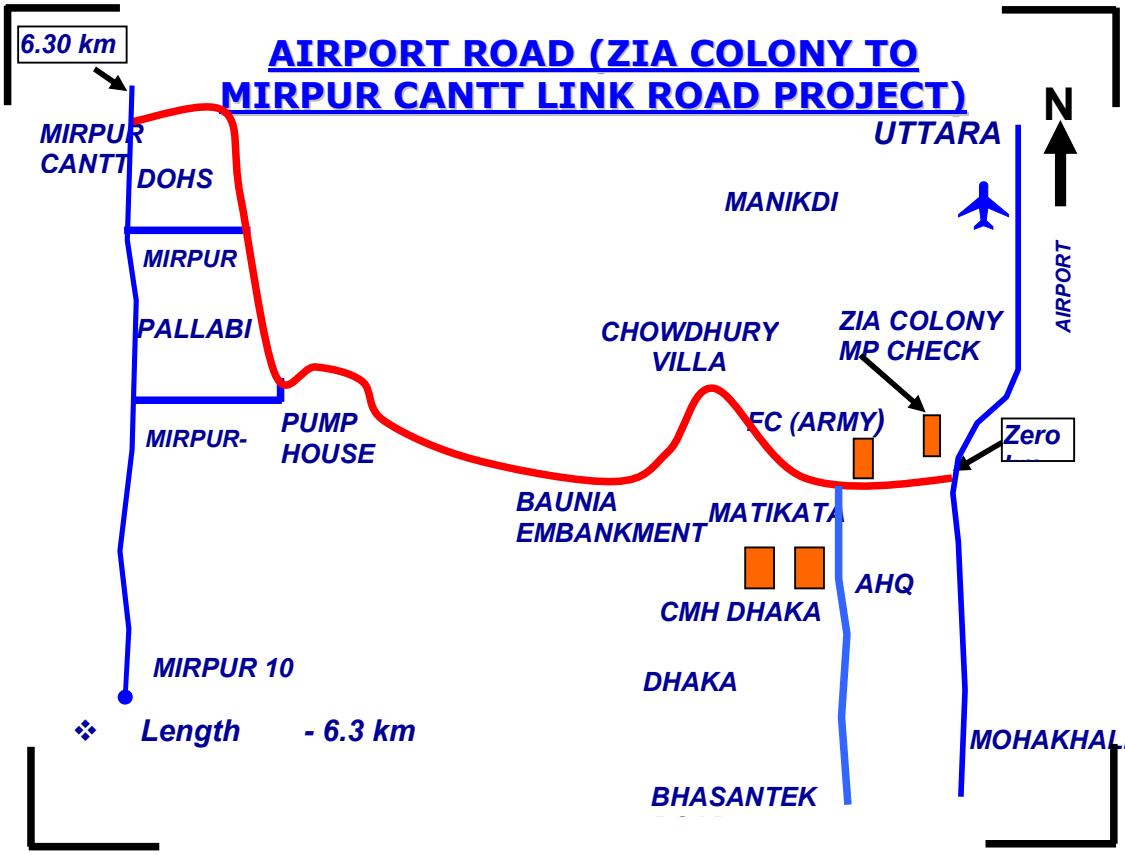


Figure 3.3: Road Zia Colony to Mirpur Cantonment

4.0 FIELD AND LABORATORY INVESTIGATION

4.1 FIELD INVESTIGATION-SAND CONE TEST

One of the most common field density tests methods is the 'Sand Cone Test' (ASTM D1556) and this method is applied in the study (**Figure 4.1**).

Figure 4.1: Typical arrangement of sand cone test apparatus (geotech.org)

4.2 LABORATORY INVESTIGATION-STANDARD PROCTOR TEST

This method consists of compacting the soil in the laboratory to obtain maximum dry unit weight (γ_{dry}), then requiring the compactor to achieve at least some specified percentage of this value in the field by the 'Standard Proctor Test' (**Figure 4.2**)

Figure 4.2: Standard proctor test apparatus (geotech.org)

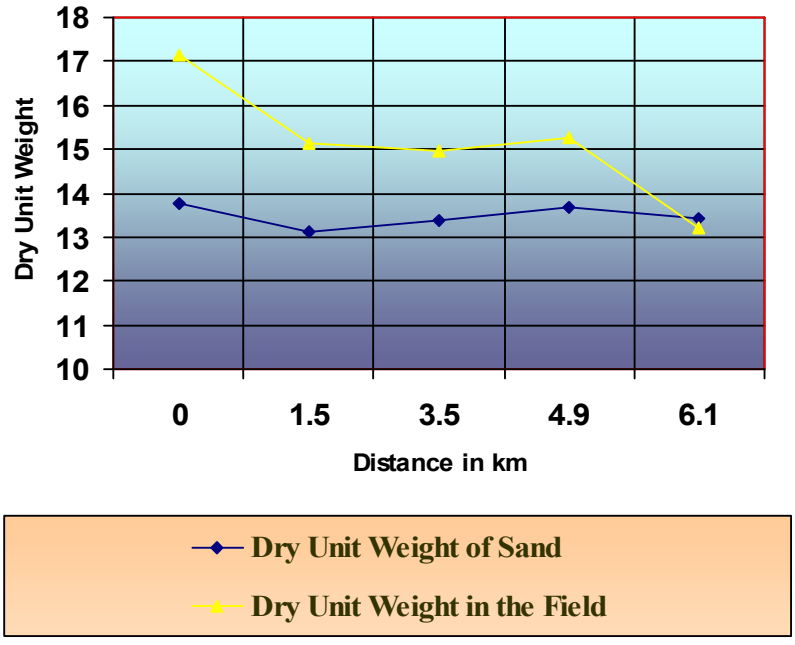
4.3 DATA COLLECTION

4.3.1 FROM THE FIELD TEST

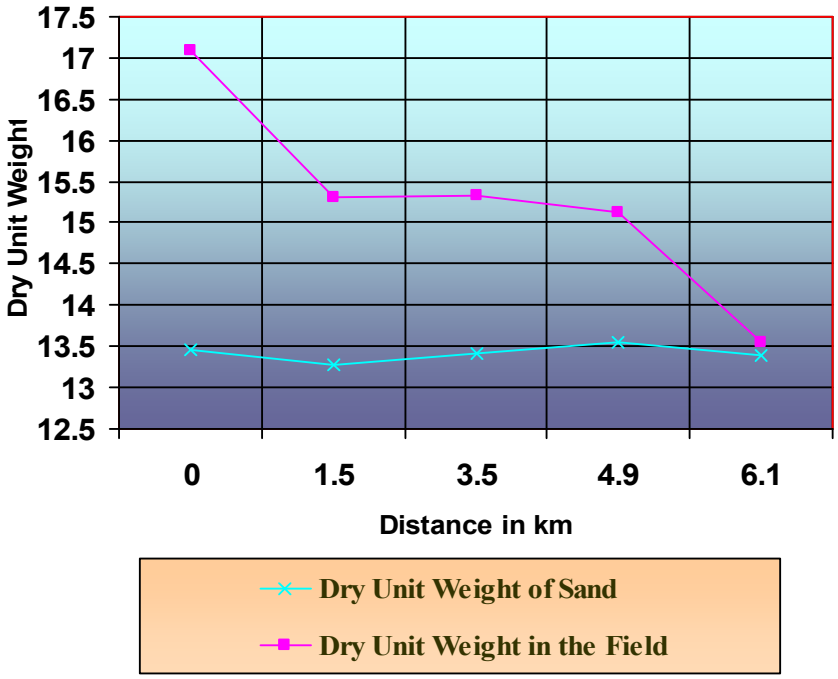
By Sand Cone Method, Dry unit weight in the field (γ_d) was determined. Total ten no of tests were carried out in five different locations along the road project. Location wise "Dry Unit Weight γ_{sand}" and "Dry unit weight in the field (γ_d)" are tabulated below (**Table 4.1** and **Graph 4.1** & **4.2**).

Test No	Location	Dry Unit Weight (γ sand)	Dry unit weight in the field (γ_d)	Test No	Location	Dry Unit Weight (γ sand)	Dry unit weight in the field (γ_d)
01	00 km	13.45 KN/ m ³	17.09 KN/ m ³	02	00 km	13.76 KN/ m ³	17.13 KN/ m ³
03	1.5 km	13.27 KN/ m ³	15.30 KN/ m ³	04	1.5 km	13.14 KN/ m ³	15.14 KN/ m ³
05	3.5 km	13.42 KN/ m ³	15.34 KN/ m ³	06	3.5 km	13.39 KN/ m ³	14.96 KN/ m ³
07	4.9 km	13.55 KN/ m ³	15.12 KN/ m ³	08	4.9 km	13.67 KN/ m ³	15.27 KN/ m ³
09	6.1 km	13.39 KN/ m ³	13.56 KN/ m ³	10	6.1 km	13.41 KN/ m ³	13.21 KN/ m ³

Table-4.1: Dry unit weight of soil obtained in the field



Graph 4.1: Comparisons of field data (side of road way)



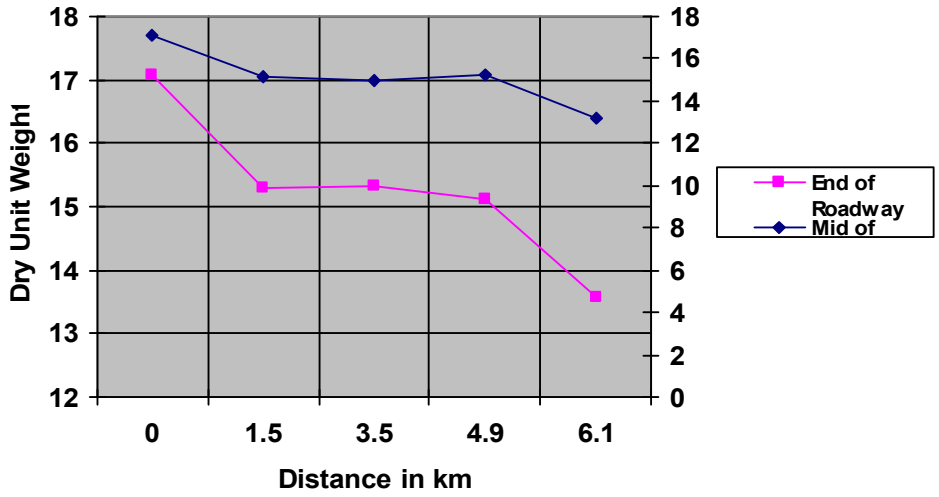
Graph 4.2: Comparisons of field data (centre of road way)

4.3.2 FROM LABORATORY TEST

After determining the dry unit weight in the field, samples from the corresponding locations were brought and analyzed in the laboratory by Standard Proctor Test. For this test, each of the samples is analyzed by adding different amount of moisture content. The obtained dry unit weights were then plotted on the graph and from the graph maximum dry unit weights were obtained. Dry unit weights obtained are shown in (**Table 4.2** and **Graph 4.3**).

Sample No	Location (km)	Dry Unit Weight (KN/M^3)	
		End of Road Way	Mid of Roadway
1	00	17.09	
2	00		17.13
3	1.5	15.3	
4	1.5		15.14
5	3.5	15.34	
6	3.5		14.96
7	4.9	15.12	
8	4.9		15.27
9	6.1	13.56	
10	6.1		13.21

Table 4.2: Variation of dry unit weight (γ_d) obtained from Standard Proctor Test



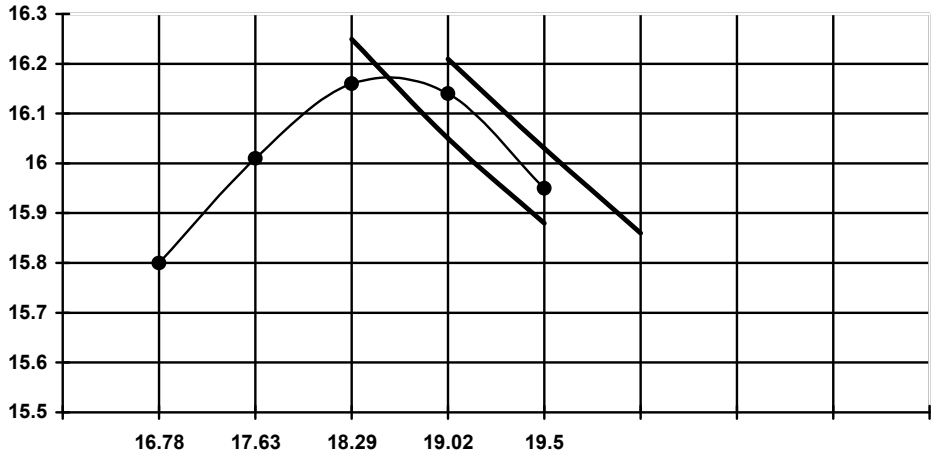
Graph 4.3: Variation of dry unit weight (γ_d) obtained from Standard Proctor Test

For each of the sample, dry density was calculated against maximum moisture content. **Table 4.3 and graph 4.4** shows the dry density of soil sample no, 06

Specific Gravity: 2.77 Sample No: 06
Date: 12.08.2008 Location : 3.5 km

Ser No	Can No	Wt. of Can in gm	Wt. of Can + wet soil in gm	Wt. of Can + dry soil in gm	Wt. of dry soil in gm	Wt. of moisture in gm	M.C in %	Avg MC in %	Wt. of mold in gm	Wt. of mold + compacted soil in gm	Wt. of compacted soil in gm	Wt density kN/ m	Dry density kN/ m
1	8	35	74	68	33	6	18.18	16.78	4312	6140	1828	18.88	15.80
2	9	39	84	78	39	6	15.38						
3	5	34	75	68	34	7	19.59	17.63	4312	6134	1822	18.81	16.01
4	7	31	73	67	36	6	16.67						
5	6	32	74	66	34	8	23.53	18.29	4312	6155	1843	19.03	16.16
6	10	41	87	79	38	8	21.05						
7	24	31	74	67	36	7	19.44	19.02	4312	6162	1850	19.10	16.14
8	23	27	78	70	43	8	18.60						
9	18	31	74	67	36	7	19.44	19.50	4312	6160	1856	19.17	15.95
10	15	31	75	68	37	7	18.92						

Table 4.3: Moisture content and dry density achieved from the compaction test.

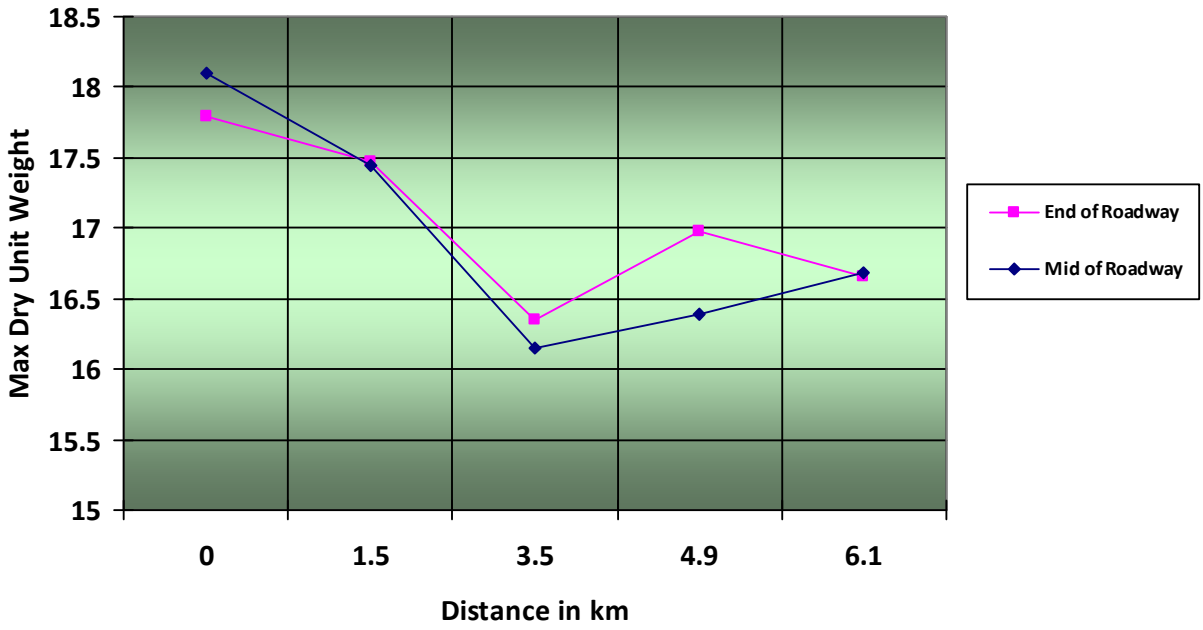


Graph 4.4: Dry unit weight vs moisture content.

Max dry unit weights obtained for all the soil samples are shown in **Table 4.4** and **Graph 4.5**.

Sample No	Location (km)	Max Dry Unit Weight (KN/M^3)	
		End of Road Way	Mid of Roadway
1	00	17.79	
2	00		18.1
3	1.5	17.47	
4	1.5		17.45
5	3.5	16.35	
6	3.5		16.15
7	4.9	16.98	
8	4.9		16.39
9	6.1	16.65	
10	6.1		16.68

Table 4.4: Max dry unit weight ($\gamma_{d\ max}$) achieved from the Graph



Graph 4.5: Variation of maximum dry unit weight (γ_d max)

4.5 RELATIVE COMPACTION

Relative compaction is the percentage ratio of the field dry density of soil to the maximum dry density as determined by standard compaction method. Once the maximum dry unit weight has been established for the soil being used in the compacted fill, we can express the degree of compaction achieved in the field by using the relative compaction, C_R.

$$C_R = \frac{\gamma_d}{\gamma_{d(max)}} X\ 100\%$$

Where:

γ_d = dry unit weight achieved in the field

$\gamma_{d(max)}$ = maximum dry unit weight (from proctor compaction test)

Most earthwork specifications are written in terms of the relative compaction, and require the contractor to achieve at least a certain value of C_R. The minimum acceptable value of C_R listed in a project specification is a compromise between cost and quality. If a low value is specified, then the contractor can easily achieve the required compaction and presumably, will perform the work for a low price. Unfortunately, the quality

will be low. Conversely, a high specified value is more difficult to achieve and will cost more, but will produce a high-quality fill. **Table 4.5** presents typical requirements.

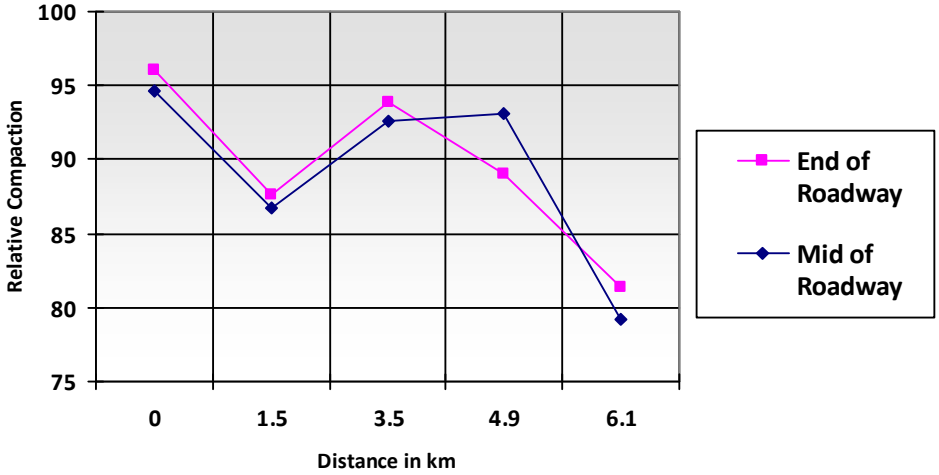
Type of Project	Minimum Required Relative Compaction
Fills to support building or roadways	90%
Upper 150 mm of sub grade below roadways	95%
Aggregate base material below roadways	95%
Earth dams	100%

Table 4.5: Typical compaction requirements

Considering the above compaction requirements, in our specified project area, the required compaction standard should be 95%. But due to various limitations, relative compaction (C_R)as 90% for this road project has been considered. The various data are given and plotted in the **Table 4.6** and **Graph 4.6** below:

Sample No	Location (km)	Relative Compaction(C_R) in %	
		End of Road Way	Mid of Roadway
1	00	96.07	
2	00		94.64
3	1.5	87.58	
4	1.5		86.76
5	3.5	93.82	
6	3.5		92.63
7	4.9	89.05	
8	4.9		93.17
9	6.1	81.44	
10	6.1		79.20

Table 4.6: Values of relative compaction (C_R) in %

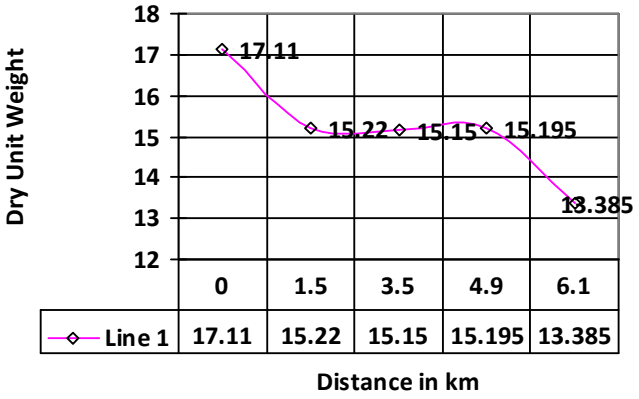


Graph 4.6: Variation of relative compaction (C_R) in %

5.0 TEST RESULTS

5.1 ANALYSIS OF RESULTS OBTAINED BY SAND CONE APPARATUS

In the field, sand cone test was carried out for obtaining field dry unit weight. The various data are shown below (**Graph 5.1**):

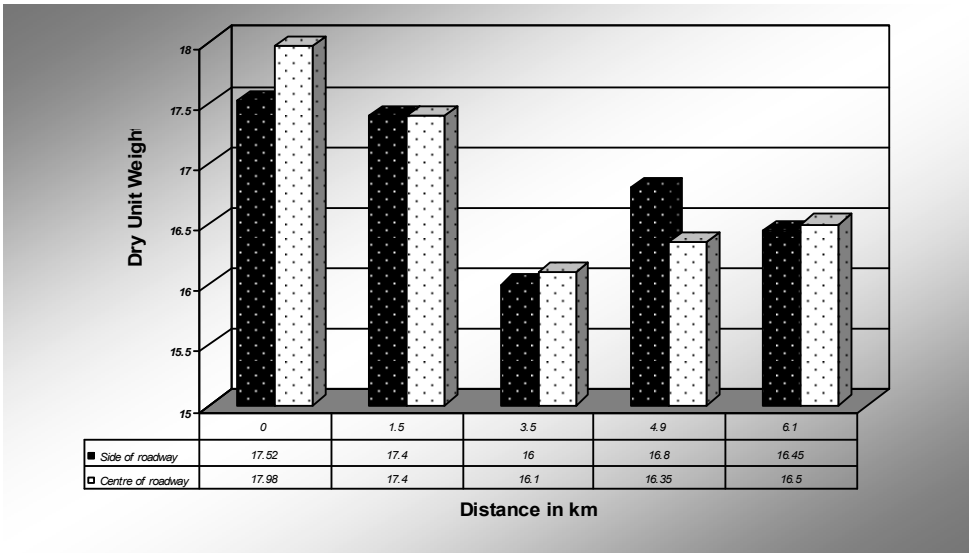


Graph 5.1:Dry unit weight obtained in the field by Sand Cone Test

From **Graph 5.1,** it can be observed that at the starting of the road, the obtained dry density is the maximum. Increasing in the road length shows gradual decrease of dry density. If we visualize with the project works it also shows the similar pattern. The road was well constructed up to 2.5 km. There is a gradual increase of dry density from 3.5km to 5 .00 km point.

5.2 ANALYSIS OF RESULTS OBTAINED BY STANDARD PROCTOR TEST

Various dry unit weights obtained are shown in graphical form in the following **Graph 5.2**.



Graph 5.2: Variation of dry unit weight obtained by Standard Proctor Test

From **Graph 5.2**, it can be observed that the dry density is the maximum at the starting of the road project. Gradual increase of road length shows significant decrease of dry density from 0 km up to 3.5 km. Dry density is the minimum at 3.5 km, after that it is increasing with the gradual increase of road length. It clearly indicates that compaction standard is maximum at beginning of the road and minimum at centre of the road length. In other places, the parameters vary from average to high.

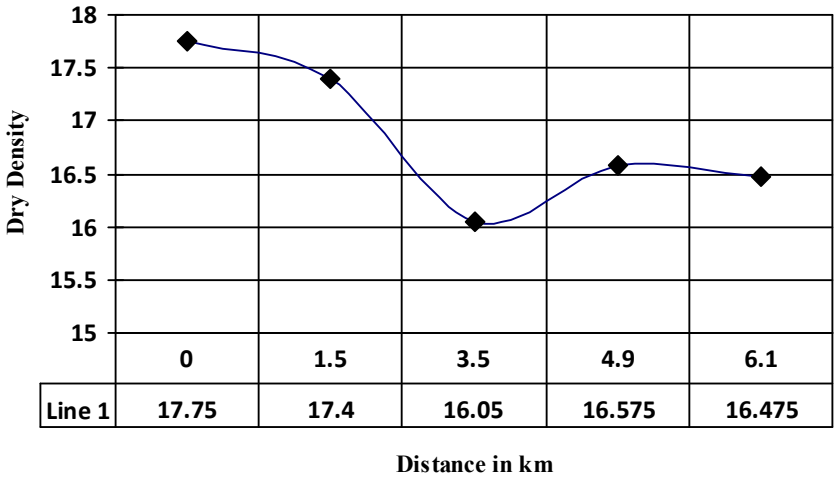
5.3. THE ANALYSES OF OVERALL DATA.

5.3.1 OVERALL DRY UNIT WEIGHTS

The overall dry unit weights are shown in the following **Table 5.1** and **Graph 5.3**.

Ser No	Location	Overall Dry Unit Weight
1	00 km	17.75 KN/ m ³
2	1.50 km	17.4 KN/ m ³
3	3.50 km	16.05 KN/ m ³
4	4.90 km	16.575 KN/ m ³
5	6.10 km	16.475 KN/ m ³

Table 5.1: Overall dry unit weight obtained by Standard Proctor



Graph 5.3: Variation of average dry unit weight obtained by Standard Proctor Test

5.3.2 OVERALL RELATIVE COMPACTION.

The values of relative compaction are shown in **Table 5.2**

Ser No	Sample No	Location (km)	Date of Test	Dry unit weight achieved in the field γd	Max dry unit weight (γd max)	Relative Compaction CR (in %)	Remarks
1	1	0	29.7.2008	17.09	17.79	96.07	CR>90%
2	2	0	29.7.2008	17.13	18.1	94.64	CR>90%
3	3	1.5	6.8.2008	15.3	17.47	87.58	CR <90%
4	4	1.5	6.8.2009	15.14	17.45	86.76	CR <90%
5	5	3.5	12.8.2008	15.34	16.35	93.82	CR>90%
6	6	3.5	12.8.2009	14.96	16.15	92.63	CR>90%
7	7	4.9	16.8.2008	15.12	16.98	89.05	CR <90%
8	8	4.9	16.8.2009	15.27	16.39	93.17	CR>90%
9	9	6.1	27.8.2008	13.56	16.65	81.44	CR <90%
10	10	6.1	27.8.2009	13.21	16.68	79.20	CR <90%

Table 5.2: Overall value of relative compaction.

5.3.3 COMMENTS ON THE OVERALL DATA

From the obtained data plotted in **Graph 5.1** and **Graph 5.2** it is easily apparent that the compaction parameters are the maximum up to 1.5 km point. From 1.5 km point, the parameters start decreasing gradually and reach to minimum at 3.5 km point. After that the parameters again increases and shows a consistent compaction from 4.9 km point up to the end of the road project. It can be easily visualized that from starting of the road up to 1.5 km point, the compaction level is compatible with standard compaction parameters. From 1.5 km point up to 3.4 km point, compaction

level is decreasing gradually with the increase of the road length. From the **Graph 4.6** and **Table 5.2**, it is clearly obvious that relative compaction is at standard compaction level (near about 93%) at 1.6 km point and ultimately reduces to 90% at 3.4 km point. From 3.4 km point up to 3.7 km point, the value of relative compaction is below 90% which indicates poor compaction standard and needs more compaction to reach up to 95% in that road length. After 3.7 km point, again, the value of relative compaction starts increasing up to the end of the road. But more compaction is required to achieve standard compaction parameters. It is observed that greater compaction exists along the middle of the roadway than the sides. This remark coincides with the actual situation. Due to greater no of rolling and movement of various construction/public vehicles and plants through out the road project, compaction is more at centre of the road.

6.0 CONCLUSIONS

The ability to investigate and evaluate the dry density of any road project leads one to determine the state of the relative compaction which ultimately specifies compaction standards. The project study has only dealt with the evaluation of the compaction standards of the under construction road project, which has immense potentiality to judge the condition of the road. Basing on field tests and laboratory test results, the relative compaction tests were calculated. For relative compaction of more than 95%, the road will be usable for heavy vehicle, for 90~95 % road is for all other vehicle movement. For relative compaction of less than 90%, soils may be further compacted.

REFERENCES

[1] Compaction Handbook, 2008. "Soil Compaction –Soil Types, Methods, and Compaction techniques".

[2] Compaction Handbook, 2008. Volume II, Chapter IV.

[3] Craul, P., 1994. Soil compaction on heavily used sites. J. Arboric. 20(2):69–74.

[4] Coduto Donald P., 2003. Geotechnical Engineering - Principles and Practices.

[5] Google pages. Soil Compaction - Causes, Effects, and Control.

[6] Harris W.L., 1971. The soil compaction process. In Barnes, K.K. (Ed.). Compaction of Agricultural Soils. An ASAE Monograph. American Society of Agricultural Engineers, St. Joseph, MI. 471 pp.

[7] Hakansson I., 1985. Soil compaction research in Sweden. Proc. of Soil Compaction Conf. Ohio State University. Columbus, OH. April 1985.

[8] Jones, A.J., R.A. Wiese and E.C. Dickey., 1999. Management strategies to minimize and reduce soil compaction. University of Nebraska, G89-896-A.

[9] Larson, W.E., W.G. Lovely, and V.C. Jamison., 1961. Subsoiling doesn't pay in the Minnesota, 2007.

[10] Minnesota, 2007. Compaction-Soil Management Series 2. University of Minnesota Extension Service, BU-7400

[11] Thesis Paper, 2002. Thesis paper on subsoil investigation and geotechnical design, submitted by Maj Md Anwaruddin, Maj Mohiuddin Ahmed, Capt MM Moazzem Hossain

[12] Wikipedia, 2008, en.wikipedia.org/wiki/Soil compaction.

[13] geotech.uta. http://geotech.uta.edu/lab/Main/SandCone

[14] geotech.org, www.geotech.org\various pages of construction project.

POWER LINE COMMUNICATION AN ESSENTIAL TOOL FOR DIGITAL BANGLADESH

Cdr M Mahbubur Rahman, BN [(1)] and Md. Eliasinul Islam [(2)]

3. Department of Electrical Electronic and Communication Engineering, Military Institute of Science and Technology, E-mail: mr.eece@mist.edu.bd, mahbub549@yahoo.com

4. Department of Electrical Electronic and Communication Engineering, Military Institute of Science and Technology, E-mail: faded_elias@yahoo.com

ABSTRACT

An estimation for the power line communications (PLC) for Bangladesh is made referring various technical research papers and current Journals. The aim of this study is to identify essential aspect of the power line communications for both domestic and outdoor application and the use of consumer communication when various possible services are developed worldwide commercially [1,9]. Possible services, bandwidth, service area, quality, reliability, and the cost are also taken into considerations. The signal in a transmission line is impaired by the presence of unwanted extraneous signals (noise and interference) on the line. The frequency dependent characteristics of the transmission line are also responsible to impair the transmission of signals along the lines. Noise and interference, with its presence tends to impede the reception of the desired signal and is usually the limiting factor in its detection. Noise is usually composed of randomly occurring voltages, which are unrelated in phase or frequency and may sometimes be of a very peak in nature. Interference on the other hand is usually more structured than noise since it arises as unwanted coupling from just a few signals in the network. In this paper a brief discussion of noise in a power line environment and need for power line communication in Bangladesh is presented as an essential tool for digital Bangladesh.

KEY WORDS *– Cyclostationary noise; Attenuation; PDF(probability density function); White noise; Interference; Variance;etc.*

1.0 INTRODUCTION

In the 1990s, companies such as Nortel Networks and Siemens recognized the potential of carrying Broadband communications over power-lines. They launched R&D initiatives to send IP packets over power grids. But technology at the time faced hurdles. For example, to transmit data along noisy electric lines, the signals had to be turned up so high that they interfered with transmissions from other devices such as radios and military equipment. That is why, means to pass the broadband signal through the power transformer between the medium voltage (2.4-35 KV) and low voltage (100-600 V) could not be found [8].

In the past, power line communication techniques were used for voice communication over long distance power transmission lines. However, as power transmission networks grew larger and became more complex and it became necessary to send and receive various information in addition to voice, such as supervisory data and commands for remote control between power plant and control center, separate communication networks were constructed using micro-wave and optical fiber technology. Nowadays, electric utilities do not use PLC over transmission lines; but some do use it over power distribution networks to reconfigure the networks and to measure power consumption in each home is usually confined to lower frequencies. This noise does not propagate very far from the source because it is a low-current phenomenon that does not couple into the adjacent wires.

Based on this view point we consider it important to have an overall view for the application fields of the power-line communications at this stage.

2.0 THE TECHNOLOGY ENVIRONMENT FOR PLC

The power grid is a very hostile environment for higher frequency transmission. The overhead power lines are not insulated and no impedance matching is possible over the broad bandwidth (2-80 MHz) expected to be used for such data transmission. This, along with the tendency by the overhead wiring to pick-up interfering signals since there is no shielding tends to limit the reach of the medium voltage loop though repeaters can be used to extend this range. Although there are some rather gratuitous claims that power-line transmission may be able to extend the reach of broadband to rural areas, it is likely that this technology, if proven to work adequately, will compete with cable technologies in areas with rather high population density.

Some of the systems are to use the low voltage loop direct to the subscriber's house, allowing

broadband connection through the AC outlets. This creates even more challenges with the electric noise generated by any brush electric motors such as those found in vacuum, hair dryer or fan on the same circuit. The local power network is also laid out in branches, with the same wires feeding many customers. That, as well as a collision course of capacitors, switches and other gadgets, will impact on the signal availability.

Reports indicate raw data speeds of up to 45 Mbit/s with real throughputs of approximately 18 Mbit/s to be shared among subscribers on the same medium-voltage circuit. Distance that can be covered on the medium-voltage circuit is about 1.6 km.

All the effects enumerated above are well known and it is expected that, because of the potential market, the various companies will put a lot of effort in optimizing their technology to alleviate these drawbacks [7,8]. The impact will likely be translated in reduced effective throughput and variable availability. An area where the companies are not likely to put as much effort is on the interference aspect, especially interference to other services operating in the same region of the spectrum.

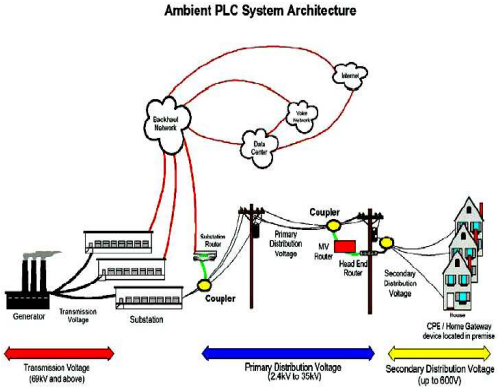


Fig 1: Power line Communication System Architecture

3.0 NOISE AND INTERFERENCE IN PLC

Noise is usually composed of randomly occurring voltages, which are unrelated in phase or frequency and sometimes consists of very peak in nature. Interference on the other hand is usually more structured than noise since it arise as unwanted coupling from just a few signals in the network.

3.1 NOISE

A power line communication network consists of a wired link and a wireless link. The wired link is consists of a pear to pear fiber optical network, with its normal noise and attenuation. The wireless portion is mainly affected by all the noises and alternation of free space/atmosphere. A power line network with associate noise is shown below.

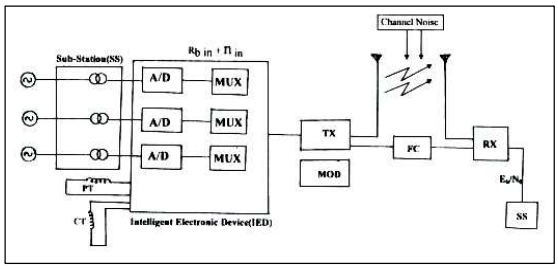


Fig 2: Power Line Communication Network

For the output (in the receiver, fig. 1) the bit error rate is given by [2,3],

$$BER = f\left(\frac{E_b}{N_o}\right)$$

Here N_0, the output noise consists of channel fading, channel noise and Interferences, E_b is the bit energy.

Again $BER = 0.5\ erfc\left[\sqrt{\frac{\gamma}{2}}\right]$

$$\frac{E_b}{N_o} = \frac{P_S T_b}{N_o}$$

$$= \frac{P_S}{N_o\left(\frac{1}{T_b}\right)}$$

$$= \frac{P_S}{N_o R_b}$$

$$= \frac{P_S}{\sigma_n^2}$$

Here, γ = Signal to Noise ratio (SNR)
P_s = Signal power
T_b = Signal period

(Considering AWGN in the channel)

Now the total noise variance,

$$\sigma_n^2 = \sigma_{AWGN}^2 + \sigma_{ps}^2$$

Where, σ_{ps}^2 = noise variance of the wired link.

and σ_{AWGN}^2 = noise variance of the wireless link

Now,

$$\gamma_o = SNR$$

$$= \frac{P_S}{\sigma_n^2 + \sigma_L^2}$$

Where, $\sigma_n^2 = \sigma_{AWGN}^2 + \sigma_{ps}^2$ = Total variance

and σ_L^2 = Power line noise variance

$$\gamma_0 = \frac{P_S / \sigma_n^{\,2}}{\left[1 + \left(\frac{\sigma_L^{\,2}}{\sigma_n^{\,2}}\right)\right]}$$

$$= \frac{\gamma}{\left[1 + \frac{\sigma_L^{\,2}}{\sigma_n^{\,2}}\right]}$$

$$= \frac{\gamma}{[1 + K_n]}, \quad k_n = \frac{\sigma_L^{\,2}}{\sigma_n^{\,2}}$$

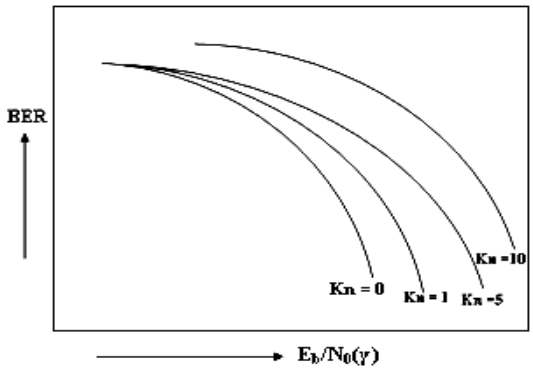


Fig 3: Variation of BER with E_b/N_0 for different values of K_n.

For a power line communication the noise is assume to be cyclostationary i.e. periodically stationary. So, its mean is zero and variance is synchronous to the AC voltage of the mains. The probability density function (PDF) of such noise at time t is given by,

$$P\left(n\left(t\right)\right) = \frac{1}{\sqrt{2\pi\sigma_n^{\,2}t}} \exp\left[\frac{-n^2 t}{2\sigma_n^{\,2}t}\right]$$

This equation can be taken as a basic equation to model power line noise. In our subsequent paper we discussed thoroughly power line noise model in AWGN environment.

3.2 INTERFERENCE

It is likely that extensive signal processing will be used by industry to make the transmitted signal as robust as possible to impairments from the power grid and local power distribution in the houses [4]. This will make the signal robust ingress interference such as that coming from TV, radio and mobile (police radios) communication system transmissions and even garage door openers. It is not clear, however, whether the industry will invest as much energy toward studying interference created by PLC that could affect other communication services operating in the same frequency range (2-80 MHz). In the High Frequency (HF) band (3-30 MHz), a number of communication systems could be affected: HF broadcasting, radio-communications (fixed and mobile) services and amateur radio. Other services in the low VHF band will also need to be protected such as TV broadcasting and fixed and mobile services. The RF signals generated by PLC will easily radiate from the medium voltage overhead wiring and the local AC wiring (except in the case of the Amperion system that utilizes Wi-Fi to bring the signal to homes. The extent of these unintentional radiated emissions will depend on many factors, including differences in the configuration of the AC mains supply systems and the physical layout of the wiring. The management of unintentionally radiated emissions from PLC systems will need to be addressed under the inter-service interference limits and the electromagnetic compatibility (EMC) rules.

4.0 POWER LINE COMMUNICATION OVER HIGH VOLTAGE LINES

Recently a study in Japan has been made to realize automatic reconfiguration of power distribution networks, data and commands are superposed on 6600volts power lines. The structure of that 6600volts power line is shown in fig 4. below [10,12].

Under normal circumstances the section switches (a~e) are kept 'ON' and the interconnection switch (h) is kept 'OFF'. When the power line is short circuited in point A, the replay cuts off the power line and at the same time switches a, b, c, d and e are turned OFF. In a short period, relay α and switches a, b and c turn ON sequentially .When switch c turns on relay α detects the over current again and the short circuit between c and d can be located. At that time relay α and switches a, b and c turn off again. Then relay α and switches a, b, e and h are turn ON. Therefore only those consumers connected to the power line between switches c and d are not supplied with power, but all the other consumers are supplied with.

This process of reconfiguring the distribution network operates automatically so as to shorten the power failure time and minimize the area affected. In this case, PLC technology is used to transmit the data concerning the switches and the commands for controlling switches.

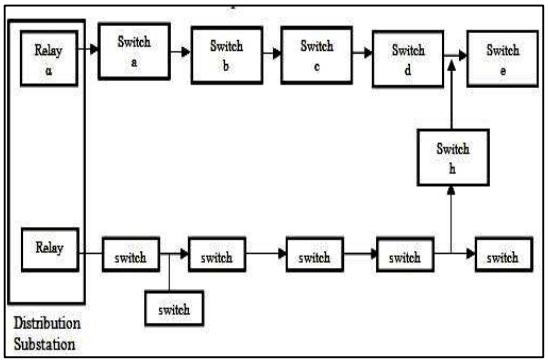


Fig 4: Connections between high voltage distribution lines

The data transmission has the following features:

- **Data**: Electricity current, status of which (ON or OFF);switch control command
- **Transmission control**: half duplex, polling system
- **Frequency shift**: ±100Hz
- **Output power** : 10 watts
- **Modulation** : Frequency Shift keying (FSK)
- **Data speed** : 200bit/s
- **Carrier**:5040Hz+7440Hz;5280Hz+7680hz;… . …7200 Hz + 9600 Hz
- **Transmission length**: up to 10km
- **Power line coupling :** shown in figure 5

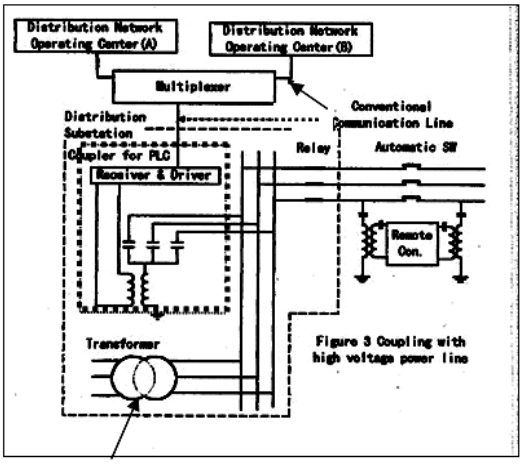


Fig 5: Coupling with high voltage power line

A study is also going over the power line communication through low voltage lines. The authors propose the same study for Bangladesh. With the assistance of appropriate authority and support this can be accomplished in MIST laboratory.

5.0 NEED FOR PLC IN BANGLADESH

Many ideas have been proposed concerning power-line applications as shown below. The authors strongly believe the following the same Bangladesh can move forward to a position of digital Bangladesh. Several novel proposals [12] are:

5.1 INDOOR USE

i. **For home application the proposed uses are:**

- First aid information system use
- Remote control system switched by telephone
- Remote supervise of Mail & Newspaper delivery post
- Electric key
- Interphone system
- Interphone system connected to telephone ')
- Time data transmission to electric appliances
- Home electric appliances switch control system
- Utilization of power-line radiation radio wave
- Home bus TV controller
- VTR timer remote reservation system
- VTR remote control
- Interlocking of TV & VTR electric switches
- Signal transmission from amplifier to speaker
- Air conditioner remote control
- Ventilator remote control
- Boiling pot re-boiling switch remote control system
- Bath hot water supply switch remote control system
- Gas & Water switch indicator 5'
- Window, window curtain remote control system

ii. **Office use.**

- Positioning indicator system
- Personal computer to printer transmission
- Power line facsimile transmission
- Indoor telephone
- Remote lock/unlock automated door system
- Other data transmissions

iii. **Hotel use.**

- Refrigerator drink check system
- Emergency refuge guiding system
- Security check
- Restaurant waiter/waitress calling system

iv. **Factory use.**

- Motor remote control system
- Supervise of machine working time
- Welding machine control
- Protection of machine fault caused by voltage drop

v. **Misc use.**

- Clock remote control
- Light remote control system
- Disaster prevention system(fire sensor, smoke sensors)
- Rain shower warning systems
- Vending machine remote supervising systems

5.2 OUTDOOR USE

- Railway apparatus and ticket checking controlling
- Crane control system

5.3 INTER FACILITY SYSTEMS

- Electric notice board system
- Public address systems
- M.C.A system for inside premises uses
- Temperature and humidity supervise system in a container ship
- Temperature and humidity supervise system in a vinyl pent houses

5.4 POWER DISTRIBUTION LINE CONTROLLING

- Electric switch supervising systems
- Miscellaneous remote controlling systems

6.0 EXPLANATION OF THE USAGES

Short explanations are given to those seems to unfamiliar to the reader in the following [13]:

1. An information is transmitted to the indoor unit when something is delivered into the mail box in the outdoor.

2. Telephone and interphone functions are served by one terminal unit. An extension unit can be used to answer the calling guest.

3. Electric appliances transmit signals indicating their operational state through the power-line. A portable receiver detect roughly classified as follows. The signals radiated from the power-line and indicate the received information.

4. When watching VTR, TV channel switch turn on automatically and change channel to VTR automatically.

5. Electrically connect the Gas & Water meters to an indicator arranged in the entrance room.

6. A cock operates a remote switch to transmit a dish ready signal to an indicator and the waiter/waitress observes it.

7. Several computers are connected to one keyboard and mouse in common and remotely switched. Computer monitors are settled several meters apart from the keyboard and the mouse.

8. A display board in which display figures can be electrically renewed.

9. Data generated each room meter are transmitted to a memory and from the memory a multiplexed signal is transmitted to the AMR center

7.0 CONCLUSIONS

As our main concern for electrical utilities is to decrease the power consumption peak and shift it to the low load hours. A communication system linking consumers and electric utilities is likely to prove particularly helpful in areas such as metering and the lowering of peak loading. The PLC net work as seen in the simplifies and reduces living expenditure as technology advances. Such kind of systems can be realized by some combination of fiber optics, CATV, the public subscriber telephone system and last but no the least PLC. We must continue to search for a better solution hence the BEST SOLUTION one that fits with the variety of business scenarios. While studying technical possibilities we will have to build up those business scenarios as they are for commercial purposes. We look forward for patronizing from the appropriate authority for our new vision “digital Bangladesh”.

REFERENCES

[1] M. Zimmermann and K. Dostert, "Analysis and modeling of impulsive noise in broad-band powerline communications," IEEE Trans. Electromagn. Compat., vol. EMC-44, no. 1, pp. 249–258, Feb. 2002.

[2] A Mathematical Model of Noise in Narrowband Power Line Communication Systems: Masaaki Katayama, Senior Member, IEEE, Takaya Yamazato, Member, IEEE, and Hiraku Okada, Member, IEEE: IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 24, NO. 7, JULY 2006.

[3] M. Katayama, S. Itou, T. Yamazato, and A. Ogawa, "Modeling of cyclostationary and frequency dependent power-line channels for communications," in Proc. 4th Int. Symp. Power Line Commun. Appl., Apr. 2005, pp. 123–130.

[4] A. Voglgsang, T. Langguth, G. Koerner, H. Steckenbiller, and R.Krnorr, "Measurement, characterization and simulation of noise on powerline channels," in Proc. 4th Int. Symp. Power Line Commun.Appl., Apr. 2000, pp. 139–146.

[5] H. Meng, Y. L. Guan, and S. Chen, "Modeling and analysis of noise effects on broadband power line communications," IEEE Trans.PowerDel., vol. 20, no. 2, pp. 630–637, Apr. 2005.

[6] Massaki KATAYAMA, "Introduction to Robust, Reliable and High-Speed Power-Line Communication Systems" IEICE trans. Fundamentals, VOL E84-A, no-12, Dec 2001.

[7] M. Tanaka and R. Someya, "The noise characteristics and transmission characteristics on data transmission using power line," IEICE trans., VOL J69-B, no-10, pp.1147-1149, Oct. 1986.

[8] S. Tachikawa, H. Hokari and G. Marubayashi,"Power line data transmission," IEICE Technical report, SSTA89-7, March 1989.

[9] O.C Hooijen, "A channel model for the low-voltage power line channel: measurement and simulation results" Proc. 1997 Internatonal Symposium on Power line Communications and its Applications, pp.51-56,1997.

[10] Ezio Biglieri, Stefeno Galli, Yong-Hwan Lee, H. Vincent Poor, A. J. Han Vinck and W. H. Tranter,"Power Line Communication" guest editorial, IEEE jounnal on selcted areas in Communications, Vol.24, no.7, July 2006.

[11] Mr. Kazuma Takeshita et. Al, Fundamental study on application of spread spectrum communication systems to power distribution line carrier control (Part 3 & Part 4);Central research institute of Electric power industry report(R91031,R92003.

[12] Juuji Ibuki, Power Line Communication In Japan Tokyo Electric Power Company 4-1 Egasm-Cno,T Ssurlomi-Kuy;O Kohillma 230-8510,Japan

[13] Yasuhito KAIZAWA, Gen MARUBAYASHI "Needs for the Power Line Communications" Institute for Information Systems Science, Soka University 1-236 Tango-cho, Hachioji, Tokyo 192-0003, JAPAN

DEVELOPMENT OF DESIGN AND MANUFACTURING OF A FIXED WING RADIO CONTROLLED MICRO AIR VEHICLE (MAV)

M A Hossain[(1)], F Hasan[(2)], A F M T Seraz[(2)] and S A Rajib[(2)]

1. Asst. Professor, Department of Mechanical Engineering, Military Institute of Science and Technology.

E-mail: ahossain@mist.edu.bd

2. Student, Department of Mechanical Engineering, Military Institute of Science and Technology.

ABSTRACT

Micro Air Vehicles (MAVs) are a new type of aircraft maturing day by day and have reached unprecedented levels of growth recently. Similarly to larger Unmanned Air Vehicles (UAVs), MAVs have enormous potential in applications, both military and civilian, like reconnaissance over battlefields and surveillance of urban areas, data relay, air sampling etc. This article describes the development and selection of a fixed wing MAV with the analysis of simulated results. High wing theory with NACA 4412 aerofoil's analytical data has been used to practically predict the performance of the MAV.

KEY WORDS: *Fixed wing, MAV, NACA 4412, Clark Y.*

1.0 INTRODUCTION

Ever since mans first powered flight, research efforts have continually pushed the envelope to create machines that are faster and/or larger than ever before. Now, however, there is an effort to design aircraft at the other, largely unexplored end of the spectrum, to design aircraft that are as small and slow as the laws of aerodynamics will permit. The desire for portable, low altitude aerial surveillance has driven the development of aircraft on the scale of small birds. Vehicles in this class of small-scale aircraft are known as *Micro Air Vehicles* or *MAVs*, and have great potential for applications in surveillance and monitoring tasks in areas either too remote or too dangerous to send human agents. Equipped with small video cameras and transmitters, MAVs can image targets that would otherwise remain inaccessible. MAVs are also capable of carrying an array of sensors to obtain additional information including, for example, airborne chemical or radiation levels.

Current industry trends toward miniaturization of both electronics and communications devices have enabled many recent advances in MAVs. As the technology improves further, more and more tasks are being considered for potential MAV applications. Operational MAVs would enable a number of important civilian missions, including chemical/radiation spill monitoring, forest fire reconnaissance, visual monitoring of volcanic activity, surveys of natural disaster areas, and even inexpensive traffic and accident monitoring. In the military, one of the primary roles for MAVs will be as small-unit battlefield surveillance agents. As such, MAVs can act as an extended set of eyes in the sky for military units in the field. This use of MAV technology is intended to reduce the risk to military personnel and to significantly enhance intelligence capabilities. MAVs are particularly suited for such surveillance tasks, as they are virtually undetectable from the ground. Even within visual range, they often go unnoticed due to their resemblance to birds. This stealth property also lends itself to non-military applications that require unobtrusive surveillance such as wildlife monitoring.

2.0 CHALLENGES

There are a number of formidable challenges to designing aircraft at the MAV scale that are not present when designing larger scale vehicles. These challenges fall into three broad categories: (a) aerodynamic efficiency, (b) increased wing loading, and (c) stability and control.

As vehicle size decreases, the viscous effects of the airflow, which are generally ignored in the design of large-scale aircraft, begin to have a significant impact on aerodynamic performance. On the MAV scale, the laminar flow that prevails is easily separated, creating large separation bubbles, especially at higher angles of attack [1]. Even the best airfoils on the MAV scale have lift to drag

ratios almost an order of magnitude smaller than their larger scale counterparts [2].

The challenges related to wing loading are a direct result of the scale of these aircraft. As the wingspan of flying vehicles decreases, the mass of the required structures for the vehicle increase relative to the wing area.

Stability and control presents perhaps the most difficult challenge in deploying operational and usable MAVs. The low moments of inertia of MAVs make them vulnerable to rapid angular accelerations; a problem further complicated by the fact that aerodynamic damping of angular rates decreases with a reduction in wingspan. Another potential source of instability for MAVs is the relative magnitudes of wind gusts, which are much higher at the MAV scale than for larger aircraft. In fact, wind gusts can typically be equal to or greater than the forward airspeed of the MAV itself. From the early flight tests, it has become clear that a very robust control system is indeed required for practical flight missions on the MAV scale.

3.0 GOAL OF THE PROJECT

The goal of the project was to develop and exhibit a practical method of building a fixed wing of an MAV. The aircraft described in this study is of a fixed wing design. A fixed wing aircraft is suitable for the above-mentioned category of mission and moreover, it is usually superior in survival if compared to rotorcraft and ornithopters [3, 6]. Because of the lack of experimental data on some of the aerodynamic aspects of MAVs, software base analysis has been carried out in the overall study. The development process is depicted as a flow chart in Fig. 1

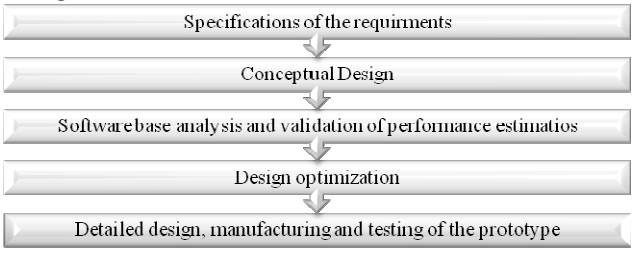


Figure 1: Development process flow chart

4.0 SELECTION OF MISSION PROFILE

4.1 GENERAL REQUIREMENTS

In this work, the requirements of the outdoor mission have been selected with maximum dimensions of 900mm and a maximum take-off weight of 500g. The mission requirements are to fly within a 0.5 km radius of the launch spot.

4.2 FLIGHT PARAMETERS

Cruise and stall speeds are the next important set of parameters which must be chosen during the mission specification. In this case, cruising speed of 10m/s (~36 km/h) has been selected. It may seem rather low, taking atmospheric winds into account [4] it becomes clear that the cruise speed must be well above 10m/s so that winds do not restrict the operations of the MAV to good weather only. But, 4.5-6m/s winds are pretty common in Bangladesh [5] and in case of a rather slow aircraft it might happen that the plane is actually too slow to fly forwards. Stalling speed is selected mainly on the basis of whether the vehicle will be hand-launched or not. In this case, because portability was a major factor, a requirement for stall speed not higher than 6m/s has been made so that the aircraft can be hand-launched and will not require any special equipment.

Once the cruise speed is specified, vehicle endurance can be calculated. With cruise speed of 10m/s it takes about only one minute (~0.8m) to fly a 0.5km distance. To allow for some extra time (in case of increased wind, reduced battery power at the end of the flight etc.), the design endurance was set to be 5 minutes.

4.3 CONTROL SYSTEM

Another important point was to select the way in which MIST-MAV would be controlled. Usually MAVs are controlled in one of 3 ways:

- Fully autonomous
- Pilot-through-vision
- Visual contact

In this case the only viable option was the visual contact system, which means direct control with the pilot looking at the MAV during flying. All the basic requirements are outlined in Table 1

Max Weight	500 g
Max Dimension	900 mm
Stall Speed	6 m/s
Cruise Speed	10 m/s
Endurance	5 minutes
Mission Radius	0.5 km
Control	Visual Contact
Payload	Motor, ESC, Battery, Servo, RC Receiver

Table 1: MAV design requirements

5.0 WING DESIGN PROCESS

There are essentially two approaches to wing design. In the direct approach, one finds the planform and twist that minimize some combination of structural weight, drag, and C_{Lmax} constraints. The other approach involves selecting a desirable lift distribution and then computing the twist, taper, and thickness distributions that are required to achieve this distribution. The latter approach is generally used to obtain analytic solutions and insight into the important aspects of the design problem, but it is difficult to incorporate certain constraints and off-design considerations in this approach. The direct method approach is used in this project. Each parameters involving wing design affects drag and structural weight as well as stalling characteristics, battery weight, off-design performance, and many other important characteristics.

6. CONCEPTUAL DESIGN

6.1 WING LOADING

It is an important parameter in aircraft design and it is different for different class of aerial vehicle. Table 2 gives wing loading for typical MAVs.

Model Type	Wing Loading	Aspect Ratio
High Speed	7 – 8 N/m^2(23 – 26 oz/sq ft)	4-6
Moderate speed sport	4.8-6 N/m^2(16-22 oz/sq ft)	6-8
Low speed trainer	3.1-4.8N/m^2(12-16 oz/sq ft)	8-10
Gliders	2.4-4.2N/m^2 (8-14 oz/sq ft)	8-15

Table 2: Wing loading for different types of MAV

Wing loading is calculated through this equation,

$$wing\ loading = \frac{aircraft\ weight}{aircraft\ area}$$

In this case as the desired MAV can be described as the low speed trainer, therefore wing loading 15 oz/sq ft was taken and as the AUW was assumed as 500gm (18oz), the above equation gives the wing area about 1.2 ft^2 (172.8 sq in).
Again the aspect ratio can be defined as,

$$aspect\ ratio = \frac{wing\ span}{mean\ chord}$$

From Table 2 aspect ratio was taken as 8 for the design, hence above equation gives wing span 37.56 in and mean chord 4.6 in.

The calculation was carried out on web based software Web o Calc. The result is given in Fig 2.

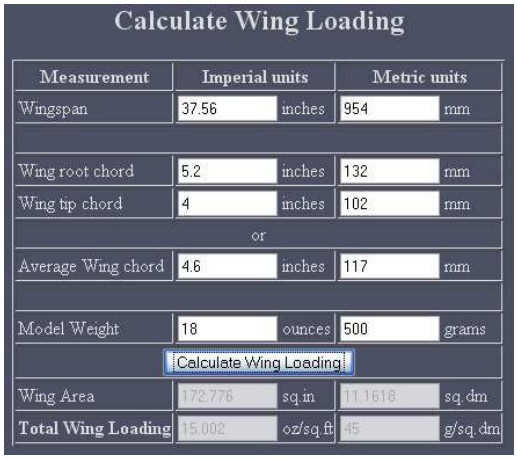


Figure 2: Wing loading calculation

6.2 AEROFOIL SELECTION

Two distinct types of aerofoil were selected initially; their comparative analysis and results are outlined in this segment. Analysis of this aerofoil set was evaluated in AeroFoil2.2. Shapes of the two aerofoils are sketched in Figs. 3-4 and characteristics parameters are outlined in the Table 3.

Figure 3 – NACA 4412 Aerofoil

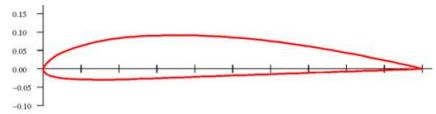


Figure 4 – Clark Y Aerofoil

Parameters	NACA 4412	Clark Y
Thickness, %	12%	11.7%
Camber, %	4%	3.4%
Trailing edge angle	14.4°	15.3°
Lower flatness	76.1%	71.8%
Leading edge radius	1.2%	1.2%
Max C_L	1.507	1.295
Max C_L angle	11	8.5
Max L/D	57.209	51.615
Max L/D angle	5.5	7
Max L/D C_L	1.188	1.18
Stall angle	6	8.5
Zero lift angle	-4	-3.5

Table 3: Comparison characteristics parameters of aerofoil

The above mentioned two configurations were tested at two velocities: 7.72m/s and 10.81m/s which gave Reynolds numbers: 138000 and 193090 at MAC (Eq. 3) for the NACA 4412 and Clark-Y aerofoils. Dependence between coefficients and *Re* is shown in further analysis so that the characteristics of all the planforms can be compared.

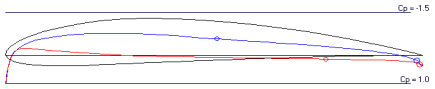
$$Re = {Uc}/{\nu}$$

Where:

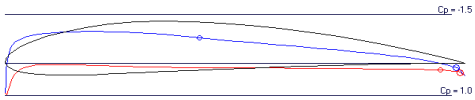
U-Airflow speed, *c*-Wing chord, ν -Air kinematic viscosity.

The results presented in Figs. 5-8 show a set of three graphs containing coefficient of pressure C_p *(x/c)* at various α for each aerofoil tested. Fig. 9 shows a set of two graphs containing C_L *(α)*, C_D *(α)* and C_M *(α)* and Fig. 10 shows another set of two graphs containing v/V_{air} *(α)* analysis. Figs. 11 shows drag polar and Figs. 12 shows lift analysis for both the aerofoil.

NACA 4412 Aerofoil
Reynolds Number: 138,000
Angle of Attack: 0 Degree
Lift Coefficient: 0.461; Drag Coefficient: 0.0125; Pitch Diameter: -0.108
Angle of Zero Lift: -4.151
Aerodynamic Center: x/c= 0.2535, y/c= -0.0003; Pitch Coefficient: -0.105



Angle of Attack: 2 Degree
Lift Coefficient: 0.671; Drag Coefficient: 0.0136; Pitch Diameter: -0.110
Angle of Zero Lift: -4.151
Aerodynamic Center: x/c= 0.2535, y/c= -0.0003; Pitch Coefficient: -0.105



Angle of Attack: 5 Degree
Lift Coefficient: 0.943; Drag Coefficient: 0.0164; Pitch Diameter: -0.113
Angle of Zero Lift: -4.151
Aerodynamic Center: x/c= 0, 2535 y/c= -0.0003; Pitch Coefficient: -0.105

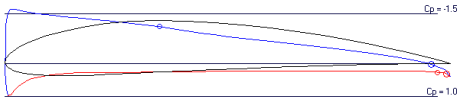
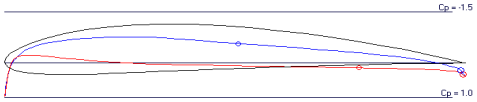
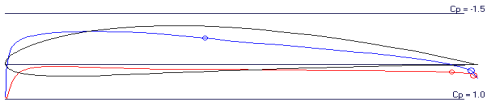


Figure 5: NACA 4412 aerofoil analysis at *Re* 138,000

NACA 4412 Aerofoil
Reynolds Number: 193,090
Angle of Attack: 0 Degree
Lift Coefficient: 0.466; Drag Coefficient: 0.0110; Pitch Diameter: -0.108
Angle of Zero Lift: -4.189
Aerodynamic Center: x/c= 0.2535, y/c= -0.0003; Pitch Coefficient: -0.105



Angle of Attack: 2 Degree
Lift Coefficient: 0.681; Drag Coefficient: 0.0120; Pitch Diameter: -0.109
Angle of Zero Lift: -4.189
Aerodynamic Center: x/c= 0.2535, y/c= -0.0003; Pitch Coefficient: -0.105



Angle of Attack: 5 Degree
Lift Coefficient: 0.965; Drag Coefficient: 0.0145; Pitch Diameter: -0.112
Angle of Zero Lift: -4.189
Aerodynamic Center: x/c= 0.2535, y/c= -0.0003; Pitch Coefficient: -0.105

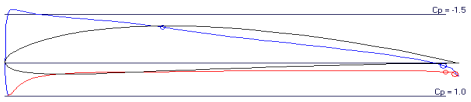
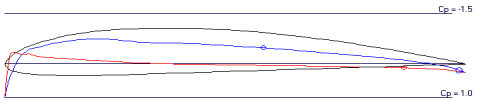
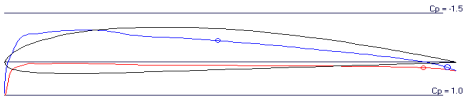


Figure 6: NACA 4412 aerofoil analysis at *Re* 193,090

CLARK Y Aerofoil
Reynolds Number: 138,000
Angle of Attack: 0 Degree
Lift Coefficient: 0.375; Drag Coefficient: 0.0113; Pitch Diameter: -0.086
Angle of Zero Lift: -3.395
Aerodynamic Center: x/c= 0.2527, y/c= -0.0002; Pitch Coefficient: -0.084



Angle of Attack: 2 Degree
Lift Coefficient: 0.592; Drag Coefficient: 0.0125; Pitch Diameter: -0.087
Angle of Zero Lift: -3.395
Aerodynamic Center: x/c= 0.2527, y/c= -0.0002; Pitch Coefficient: -0.084



Angle of Attack: 5 Degree
Lift Coefficient: 0.889; Drag Coefficient: 0.0166; Pitch Diameter: -0.089
Angle of Zero Lift: -3.395
Aerodynamic Center: x/c= 0.2527, y/c= -0.0002; Pitch Coefficient: -0.084

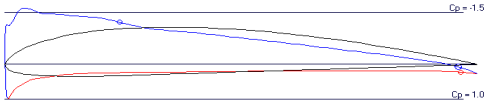
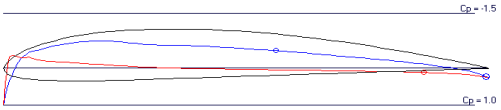
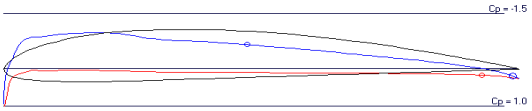


Figure 7: Clark Y aerofoil analysis at Re 138,000

CLARK Y Aerofoil
Reynolds Number: 193,090
Angle of Attack: 0 Degree
Lift Coefficient: 0.387; Drag Coefficient: 0.0099; Pitch Diameter: -0.086
Angle of Zero Lift: -3.419
Aerodynamic Center: x/c= 0.2527, y/c= -0.0002; Pitch Coefficient: -0.084



Angle of Attack: 2 Degree
Lift Coefficient: 0.605; Drag Coefficient: 0.0109; Pitch Diameter: -0.087
Angle of Zero Lift: -3.419
Aerodynamic Center: x/c= 0.2527, y/c= -0.0002; Pitch Coefficient: -0.084



Angle of Attack: 5 Degree
Lift Coefficient: 0.906; Drag Coefficient: 0.0149; Pitch Diameter: -0.089
Angle of Zero Lift: -3.419
Aerodynamic Center: x/c= 0.2527, y/c= -0.0002; Pitch Coefficient: -0.084

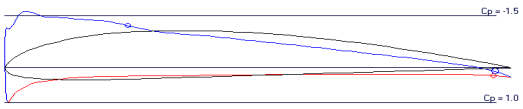
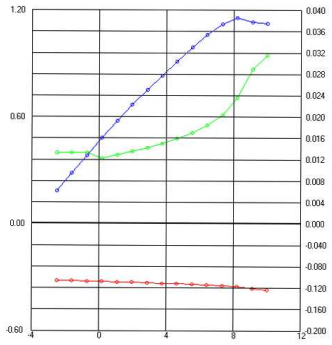


Figure 8: Clark Y aerofoil analysis at Re 193,090

NACA 4412 Aerofoil
Coefficient of Lift; Drag Coefficient; Pitch Coefficient
Reynolds Number: 138,000



CLARK Y Aerofoil
Coefficient of Lift; Drag Coefficient; Pitch Coefficient
Reynolds Number: 138,000

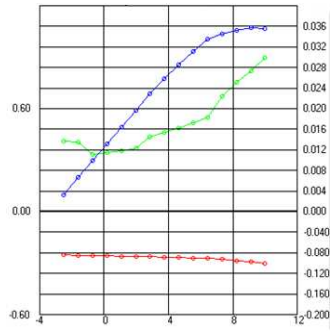
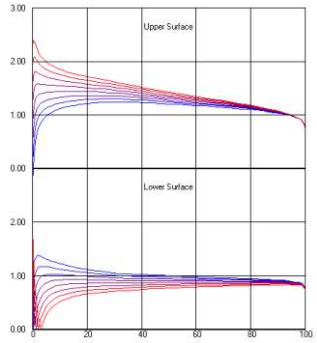


Figure 9: C_L (α), C_D (α) and C_M (α) analysis of NACA 4412 and Clark Y aerofoil

NACA 4412 Aerofoil
v/V_{air} vs Angle of Attack, α
-2.5°, -0.7°, 1.1°, 2.9°, 4.6°, 8.2°, 10°



CLARK Y Aerofoil
v/V_{air} vs Angle of Attack, α
-2.5°, -0.7°, 1.1°, 2.9°, 4.6°, 8.2°, 10°

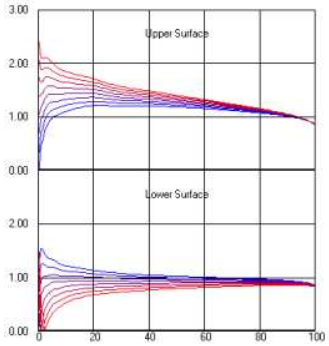
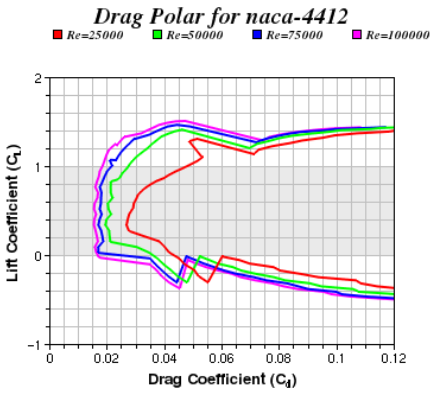


Figure 10: v/Vair (α) analysis of NACA 4412 and Clark Y aerofoil



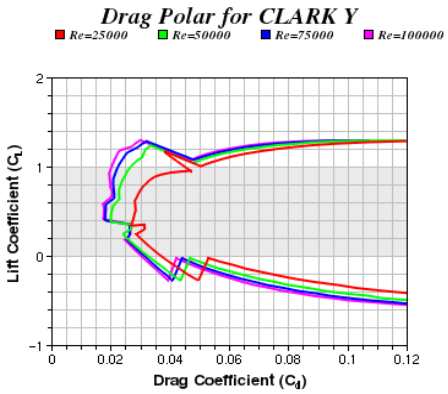


Figure 11: Drag Polar analysis of NACA 4412 and Clark Y aerofoil

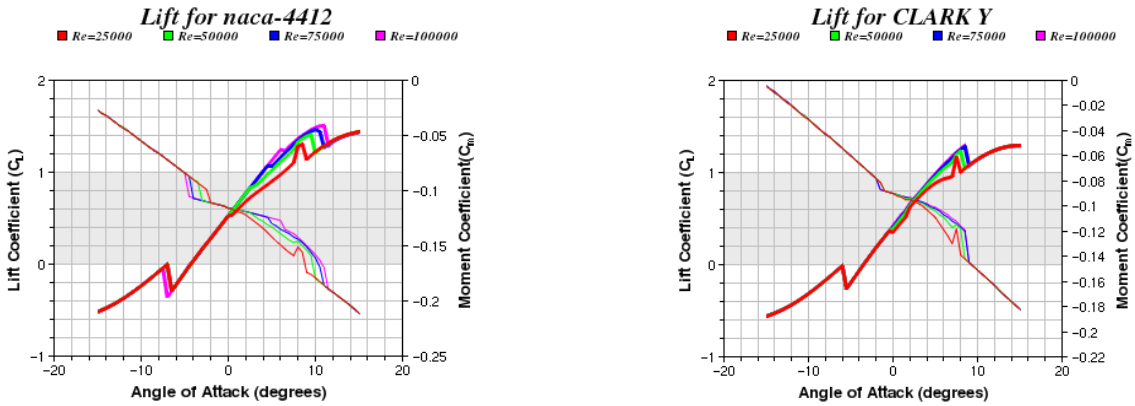


Figure 12: Lift distribution for NACA 4412 and Clark Y aerofoil

6.3 FINDINGS ON AEROFOIL ANALYSIS

Results obtained from the graphical analysis of two aerofoils on showed in Fig. 5 & 7 and Fig. 6 & 8 are outlined in Table 4 & 5 respectively.

Findings are Listed Below

- At low ***Re*** Clark Y shows min value of C_L where at higher ***Re*** it shows similar value of C_L.
- Relatively NACA 4412 shows good C_L values at both low and high ***Re***.
- Polar drag configurations showed in Figs. 11 & $C_L(\alpha)$, $C_D(\alpha)$ **and** $C_M(\alpha)$ analysis of both aerofoils showed in Fig. 9 established that NACA 4412 gives better L/D ratio than Clark Y.

6.4 WING CONFIGURATION

Two designs were considered for the comparison, one was the delta wing with a least tip chord of low aspect ratio (AR=3) and another was the tapered leading-straight trailing wing of moderate aspect ratio (AR = 5). NACA 4412 and CLARK Y aerofoil were used with these two wings respectively. Table 6 and Figs. 13-14 show the conceptual parameters and design of the two wings respectively.

	Clark Y			NACA 4412		
	Re 138000	Air Speed 7.72 m/s		Re 138000	Air Speed 7.72 m/s	
AOA	C_L	C_D	C_M	C_L	C_D	C_M
0°	0.375	0.0113	-0.089	0.461	0.0125	-0.108
2°	0.592	0.0125	-0.087	0.671	0.0136	-0.110
5°	0.889	0.0166	-0.089	0.943	0.0164	-0.113

Table 4: Results of aerofoil analysis with *Re* 138000 and Air Speed 7.72 m/s

	Clark Y			NACA 4412		
	Re 193090	Air Speed 10.81 m/s		Re 193090	Air Speed 10.81 m/s	
AOA	C_L	C_D	C_M	C_L	C_D	C_M
0°	0.387	0.0099	-0.086	0.466	0.011	-0.108
2°	0.605	0.0109	-0.087	0.681	0.0120	-0.109
5°	0.906	0.0149	-0.089	0.965	0.0145	-0.112

Table 5: Results of aerofoil analysis with Re 193090 and Air Speed 10.81 m/s

Specification	Delta Wing	Tapered Leading-Straight Trailing
Area	$250in^2$	$172.8in^2$
AR	3	8
Span	27.38in	37.56in
C_{avg}	231.648mm (9.12in)	179.578mm(7.07in)

Table 6: Conceptual Parameters of Wings

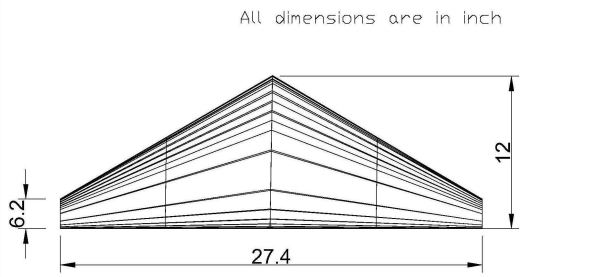


Figure 13: CAD design of wing with Clark Y aerofoil

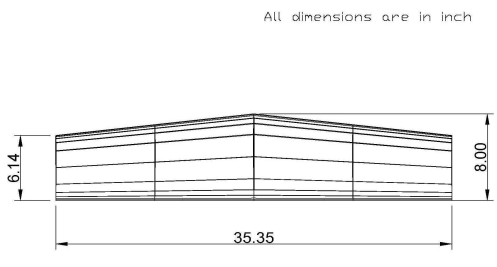


Figure 14: CAD design of wing with NACA 4412 aerofoil

6.5 WING SELECTION

Based on the aspect ratio analysis tapered leading-straight trailing wing was selected of AR=8, the reasons are given below:
Larger induced drag is produced on the aircraft with the smaller wingspan and lower aspect ratio. This property of aspect ratio AR is illustrated in the formula used to calculate the drag coefficient of an aircraft's C_d

$$C_d = C_{d0} + {(C_L)^2}/{\pi e AR} \qquad (4)$$

C_d is the aircraft drag coefficient,

C_{d0} is the aircraft zero-lift drag coefficient,

C_L is the aircraft lift coefficient,

π is the circumference-to-diameter ratio of a circle,

e is the Oswald efficiency number,

AR is the aspect ratio.

Though, there are several reasons why *all* aircraft do not have high aspect wings:

- ***Structural:*** A long wing has higher bending stress for a given load than a short one, which requires stronger structure to withstand.
- ***Maneuverability:*** a high aspect-ratio wing will have a lower roll rate than one of low aspect ratio.
- ***Parasitic drag:*** While high aspect wings create less induced drag, they have greater parasitic drag, (drag due to shape, frontal area, and surface friction). This is because, for an equal wing *area*, the average chord (length in the direction of wind travel over the wing) is smaller.

But those above mentioned reasons are not applicable for this MAV design; hence the moderate high AR wing was selected of NACA 4412 aerofoil.

6.6 SIZING OF HORIZONTAL TAIL

Design of the horizontal tail is so much calculative. Lack of adequate analytical tools prompted an empirical method [7] to be adopted to size the horizontal tail. The empirical rule states that, if an aircraft has a wing of AR of 6 and a tail moment arm (TMA) that is 2.5 times the wing's Mean Aerodynamic Chord (MAC), then a Horizontal Tail Area (HTA) equal to 20% of the Wing Area (WA) is adequate.

$$The\ formula\ being, HTA = {(2.5 \times MAC \times 0.2 \times WA)}/{TMA}$$

Where all linear dimensions are in inches and areas are in square inches. Though the aircraft wings did not meet the AR criteria, this formula

was used. A maximum TMA of 45.26 cm (17.82") was feasible for a fuselage length of 83.82cm (33"). The HTA thus calculated worked out to be 22.5in^2. A tail plane chord of 75% of wing chord was chosen i.e. 3.45inch and the tail plane span was fixed at 6.52inch.

6.7 SIZING OF VERTICAL FIN

Again the empirical rule ` was used to size the vertical fin which recommends an area of approximately 8% of wing area as sufficient for the dorsal fin. In the present design, 8% of the wing area works out to approximately 13.8 sq. in. The fin was sized accordingly.

6.8 FINAL SPECIFICATIONS

The final specifications of the MAV are outlined in the Table 7

Wing Airfoil	NACA 4412
Wing Span	37.56in
Wing Chord	4.6in
Wing Area	172.8in^2
Fuselage Length	83.82cm (33in)
Tail plane span	6.52in
Tail plane Chord	3.45in
Max AUW	500gm
Wing loading	15oz/ft^2

Table 7: Summary

7.0 SPREAD SHEET BASED TOOLS FOR WEIGHT AND CG CALCULATION

A spreadsheet-based tool was setup to calculate the weight and CG of the aircraft. All off-the-shelf equipment was weighed and their weights were entered in the spreadsheet. For the airframe weight estimation, the first step was to weigh and compute the densities of various types of sheets. The weight of the vehicle was estimated at 500 gm whilst the actual fully equipped aircraft weighed in at 377 gm. The CG was estimated 25.8 cm aft of the motor (datum). The actual CG of the aircraft was found to 23.58 cm aft of datum i.e. an error of 8.6 %. The spreadsheet based tool proved quite useful in fixing the location of various equipment onboard the aircraft. A sample printout of the spreadsheet for aircraft CG calculation is placed in Table 8.

Items	Wt (gm)	Arm (cm)	Moment (gm-cm)
Motor + Plug	59.92	0	0
Motor mount + Bolts	1.8	3.2	5.76
Propeller 9x3.8	17.87	-2.5	-44.68
7.2 Volts Battery pack	59.77	20.32	1214.53
Receiver	40.11	25.41	1019.20
Elevator Servo	18.51	41.91	775.76
Aileron Servo	18.51	38.5	712.64
Wing	65.5	35.40	2318.70
Fins	21.2	78.74	1669.29
Fuselage	49.27	41.91	2064.91
Misc linkages and horns	24.74	Distributed	
Total	377.2		9736.11
CG location	25.8 cm aft of motor		

Table 8: Data sheet of CG calculation

8.0 POWER SYSTEM

Webocalc 1.5.2 is used here to estimate the proper need. Surveying the result, as given the ready flight weight 500gm and other specific design data, the Webocalc wizard suggested the suitable propeller size ranging from 6.1 to 10inch. Looking at the thrust comparison result, lowest thrust produces by the 9x6 propeller is 16.4oz which is pretty much higher comparing the required 10oz thrust. As a result propeller size was chosen a smaller one. Other suggested power system equipments were chosen according to the result. Table 9 shows the final selection of the parts with the brand name.

Motor	EnerG Brushless Motor (C28-08 1360RPM/V)
ESC	E-PRO SP20A-BEC-AIR Brushless/ Controller
Battery	Flightpower EVOLITE-0800 2S
Propeller	APC 9 x3.8
Receiver	Futaba FP-R115F
Servo	Futaba S-3117
Transmitter	Futaba 4VF-FM

Table 9: List of parts

9.0 IN-FLIGHT ANALYSIS

In-flight analysis were carried out into MotoCalc to find the optimum MAV's performance and mission constraints. Fig. 14 shows the complete flight analysis of the designed prototype with selected power system components. Findings from the flight analysis are following:

In-flight Analysis - MIST-MAV

15ft above Sea Level, 29.92inHg, 59°F

Motor: EnErG Brushless O/Runner Motor C28-08 ; 1360rpm/V; 1A no-load; 0.1 Ohms.
Battery: EnErG Pro 25C Li-Po (20C); 2 cells; 800mAh @ 3.7V; 0.0228 Ohms/cell.
Speed Control: E-Pro SP20A-BEC-Air; 0.15 Ohms; High rate.
Drive System: APC; 9x3.8 (Pconst=0.7; Tconst=0.92) direct drive.
Airframe: MIST; 238sq.in; 9oz RTF; 5.4oz/sq.ft; Cd=0.057; Cl=0.54; Clopt=0.61; Clmax=1.2.
Stats: 68 Wlb in; 51 Wlb out; 11mph stall; 15mph opt @ 80% (29:11, 89°F); 16mph level @ 84% (27:10, 90°F); 364ft/min @ 15.6°; -139ft /min @ -5.9°.

AirSpd (mph)	Drag (oz)	Lift (oz)	Batt Amps	Motor Amps	Motor Volts	Input (W)	Loss (W)	MGbOut (W)	MotGb Ef(%)	Shaft Ef(%)	Prop RPM	Thrust (oz)	PSpd (mph)	Prop Ef(%)	Total Ef(%)	Time (m:s)
0.0	0.0	0.0	6.2	6.2	6.2	38.2	9.7	28.5	74.7	62.5	7514	6.8	27.0	0.0	0.0	7:47
1.0	0.0	0.0	6.2	6.2	6.2	38.2	9.7	28.5	74.7	62.5	7514	6.7	26.0	2.9	1.8	7:47
2.0	0.0	0.1	6.2	6.2	6.2	38.2	9.7	28.5	74.7	62.5	7514	6.6	25.0	5.7	3.6	7:47
3.0	0.0	0.3	6.2	6.2	6.2	38.2	9.7	28.5	74.7	62.5	7513	6.5	24.0	8.4	5.3	7:47
4.0	0.1	0.5	6.2	6.2	6.2	38.2	9.7	28.6	74.7	62.5	7512	6.3	23.0	11.0	6.9	7:47
5.0	0.1	0.9	6.2	6.2	6.2	38.2	9.7	28.6	74.7	62.5	7511	6.2	22.0	13.5	8.4	7:47
6.0	0.1	1.2	6.2	6.2	6.2	38.2	9.7	28.6	74.7	62.5	7511	6.1	21.0	15.8	9.9	7:47
7.0	0.2	1.7	6.1	6.1	6.2	38.1	9.7	28.5	74.7	62.6	7521	5.9	20.1	18.1	11.3	7:48
8.0	0.2	2.2	6.1	6.1	6.2	37.8	9.6	28.2	74.6	62.7	7548	5.7	19.2	20.2	12.6	7:53
9.0	0.3	2.8	6.0	6.0	6.2	37.3	9.5	27.8	74.6	62.8	7590	5.5	18.3	22.1	13.9	8:01
10.0	0.4	3.4	5.9	5.9	6.3	36.6	9.3	27.3	74.5	63.0	7645	5.3	17.5	23.9	15.0	8:12
11.0	0.4	4.1	5.7	5.7	6.3	35.8	9.2	26.6	74.3	63.2	7715	5.0	16.8	25.5	16.1	8:26
12.0	0.5	4.9	5.5	5.5	6.3	34.7	9.0	25.7	74.1	63.4	7806	4.7	16.1	27.0	17.1	8:46
13.0	0.6	5.8	5.2	5.2	6.4	33.2	8.7	24.5	73.7	63.6	7919	4.3	15.5	28.3	18.0	9:14
14.0	0.7	6.7	4.9	4.9	6.4	31.5	8.5	23.0	73.0	63.6	8051	3.9	15.0	29.4	18.7	9:49
15.0	0.8	7.7	4.5	4.5	6.5	29.5	8.2	21.3	72.1	63.5	8202	3.5	14.5	30.4	19.3	10:37
16.0	0.9	8.7	4.1	4.1	6.6	27.2	8.0	19.2	70.7	63.0	8369	3.0	14.1	31.3	19.7	11:38
17.0	1.0	9.9	3.7	3.7	6.7	24.6	7.7	16.9	68.6	61.9	8551	2.6	13.8	32.1	19.9	13:02
18.0	1.2	11.1	3.2	3.2	6.8	21.7	7.5	14.2	65.4	59.8	8746	2.1	13.5	32.8	19.6	14:57
19.0	1.3	12.3	2.7	2.7	6.9	18.6	7.4	11.2	60.4	56.1	8955	1.6	13.2	33.4	18.7	17:45

Note: Motor performance calculations take ambient temperature and heating effects into account.

Style Key: **Above Stall Speed @ Clmax=1.2** Level Flight @ Clopt=0.61 and Level Flight @ Cl=0.54

Figure 15: In-Flight analysis

9.1 AERODYNAMIC NOTES

- The static pitch speed (27mph) is within the range of approximately 2.5 to 3 times the model's stall speed (11 mph), which is considered ideal for good performance.

- With a wing loading of 5.4 oz/sq. ft, a model of this size will have very sedate flying characteristics. It will be suitable for relaxed flying, in calm or very light wind conditions.

- The static thrust (6.8oz) to weight (9oz) ratio is 0.76:1, which will result in very short take-off runs, no difficulty taking off from grass surfaces (assuming sufficiently large wheels), and steep climb-outs.

- At the best lift-to-drag ratio airspeed, the excess-thrust (2.1 oz) to weight (9oz) ratio is 0.24: 1, which will give good climbs and acceleration. This is a good in-flight thrust to weight ratio for a basic trainer.

9.2 POWER SYSTEM NOTES

- The full-throttle motor current at the best lift-to-drag ratio airspeed (4.1amp) is lower than the motor's maximum efficiency current (8.1amp). A higher current level would improve system efficiency.

- Current can be increased by using more cells, a larger diameter or higher pitched propeller, a lower gear ratio, or some combination of these methods.

10.0 STABILITY

Primary concerns for the MAV were static pitch and roll stability. Dynamic stability was not considered due to complexity, time constraints, and the assumption that static stability would provide acceptable dynamic stability. Two analyses were carried out, these are:

- static pitch stability analysis
- roll stability analysis

11.0 STRUCTURAL MATERIAL SELECTION

There are a few basic qualities that were desired in materials used to build the MAV that was used in the selection of materials. They are:

- **Light weight:** First and for most the material needs to be very light.

- **Crash resistant:** The MAV should be able to survive several crashes before any serious repair is necessary.

- **Structurally sound:** The material should be strong enough to maintain its shape during normal flight.

- **Simple to construct:** It should be possible to make an entire MAV structure in 4-6 hours.

- **Easy to repair:** If damage occurs, it should be possible to fix easily, in order that the most can be learn from each model.

11.1 DETAILED FABRICATION

The manufacturing was to be done using typical RC modeling techniques, with 35mm EPS (Expanded Polystyrene Foam) and covered with heat shrinkable polyurethane film. The fuselage was constructed as simple rounded structure and

was sized to enable installation of all the onboard equipment. Heat shrinkable polyurethane film was applied to the surface of the all structures and Heat Gun (king). Wing was attached using rubber bands and can be dismantled easily.

The final weight breakdown is shown in the Table 10 and Fig. 16

Items	*m [g]*
Misc	74
Motor	43
Battery	51
Speed Controller	22
Receiver	30
Servos (2)	17
Propeller	8
Airframe	255
Total	500

Table 10: MIST-MAV's final weight breakdown

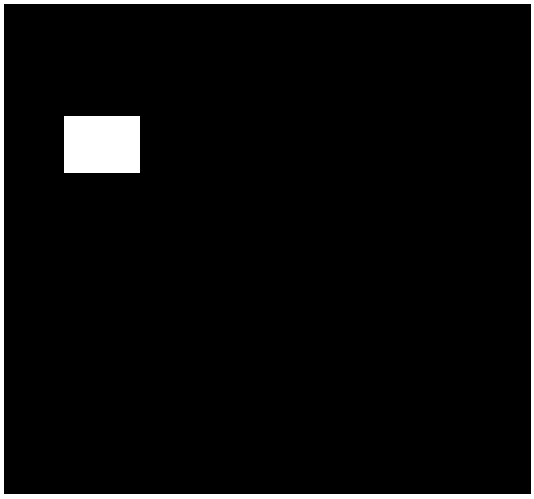


Figure 16: Layout of final weight breakdown

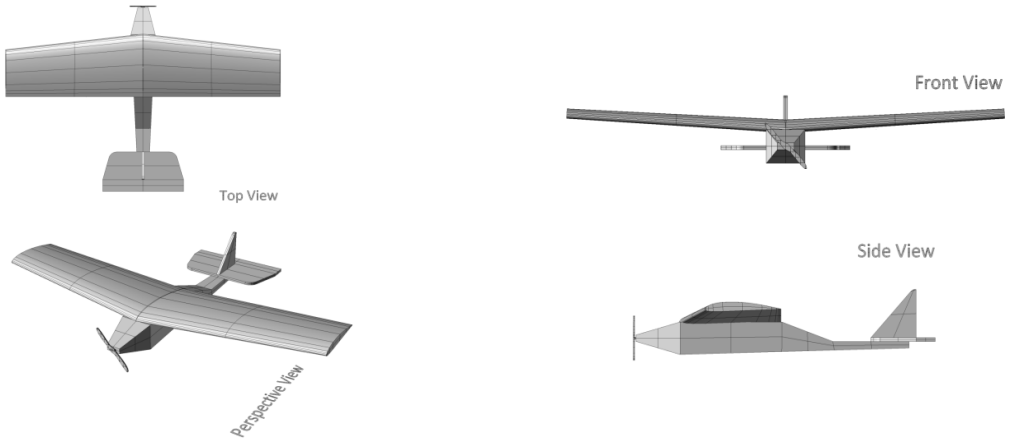


Figure 17: 3D Drawings of an MAV

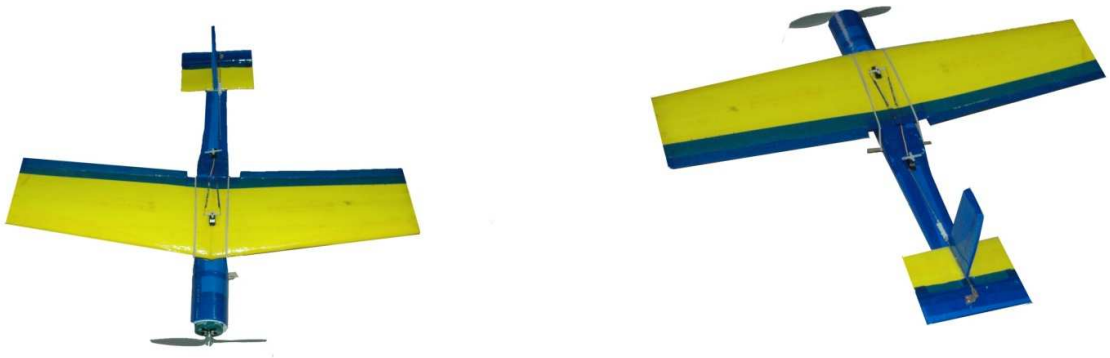


Figure 18: A complete MAV manufactured by the researchers

11.2 PROTOTYPE PHOTOGRAPH

Final development and manufacturing of the prototype was done according to above analysis and research. The photographs of the prototype are given in the fig. 17-18.

12.0 CONCLUSION

The aim of the project was to develop and demonstrate a practical method of designing an MAV. Micro aircraft present a number of unique challenges such as aerodynamics and systems integration and thus require a different design approach from those applied to standard-sized aircraft. The aerodynamic theory used to predict performance of MAVs still needs to be investigated in greater detail as it does not allow the designer to predict the performance with sufficient accuracy in some cases. The wind tunnel tests, which were not carried out as a part of the project, due to some limitations, needs to be carried out in future, which is very efficient in proving various aerodynamics aspect. Two wing planforms tested in the hypothetical manner needs more practical tests. The rapid optimization of the MAV's geometry within given constraints has proven to be an extremely effective method of designing a micro-sized aircraft.

REFERENCES

[1] G. Torres and T. Mueller, "*Aerodynamic Characteristics of Low Aspect Ratio Wings at Low Reynolds Numbers, Proc. of the Conf. on Fixed, Flapping, and Rotary Wing Vehicles at Very Low Reynolds Numbers", Notre Dame University*, pp. 278-305, 2000.

[2] W. Shyy, D. A. Jenkins and R. W. Smith, "*Study of Adaptive Shape Airfoils at Low Reynolds Number in Oscillatory Flows"*, *AIAA Journal*, vol. 35, pp.1545-48, 1997.

[3] Marek, P., Smrcek, L.; *"Development of DART MAV - Fixed Wing Hover-Capable Micro Air Vehicle"*, *Advanced Engineering Design Conference*, Prague, Czech Republic, June 2006.

[4] Watkins, S., et al., *"Atmospheric Winds and Their Implications for Micro air Vehicles"*, *AIAA Journal,* Vol.44, No.11, November2006.

[5] M. J. Khan, M. T. Iqbal and S. Mahboob, *"A wind map of Bangladesh"*, September 2008.

[6] Bohorquez, F. et al. "*Design, Analysis and Performance of a Rotary Wing MAV",* Smart Structures Laboratory, Alfred Gessow Rotorcraft Center, Department of Aerospace Engineering, University of Maryland.

[7] Lennon, A., *"Basics of R/C Model Aircraft Design"*, Air Age Inc., Ridgefield, CT, USA, 1996.

FEASIBILITY OF PRODUCING LIGHTWEIGHT CONCRETE USING INDIGENOUS MATERIALS WITHOUT AUTOCLAVING

M. Shamsuddoha[1], M. M. Islam[2] and M. A. Noor[3]

1. Lecturer, Department of Civil Engineering, Military Institute of Science and Technology

E-mail: doha.ce@mist.edu.bd

2. Instructor Class-B, Department of Civil Engineering, Military Institute of Science and Technology

E-mail: monzur514@yahoo.com

3. Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology

E-mail: mnoor@ce.buet.ac.bd

ABSTRACT

This research shows the feasibility and sequential approach for producing lightweight concrete without autoclaving using indigenous ingredients and appropriate technology of Bangladesh. Ingredients were mixed chronologically using trial-and-error method to reduce unit weight. Specific volume principle was utilized to observe the effect of inclusion of cement, water, sand, lime and aluminium in the mixture to achieve the goal. Molds were used to accommodate volumetric expansion of mixture. Both 50 mm and 150 mm cubic specimens were prepared for tests. Density and compressive strength were determined for specimens. Absorption capacity and thermal conductivity were also determined to get the product performance. From the results, it was seen that density and compressive decreased with increased water-cement ratio. Volumetric expansion was high for higher volume surface ratio. Finally, lightweight concrete with density, compressive strength and thermal conductivity within range of 700-1000 kg/m3, 0.5-2.0 MPa and 0.2-0.5 W/m-k respectively was produced.

KEY WORDS: *Volumetric expansion, Lightweight concrete, Water-cement ratio, Mix design.*

1.0 INTRODUCTION

Diverse use of lightweight concrete is well recognized all over the world. NRMCA (2003) suggested that the best suitable option to reduce dead load of a structure lie within the deduction of self-weight of concrete, which eventually reduces size of structural elements. Studies (Haug et al. 1996; Ahmed et al. 2004; Lijiu et al. 2005; Lo et al. 2006; Arisoy et al. 2008; Mouli et al. 2008) showed that lightweight concrete has wide opportunity not just as structural material but also other decorative elements due to performance and durability. Decoration elements such as timber, plastics are inadequate and their uses are concerned with adverse impacts on environment especially for a developing country like Bangladesh. Lightweight concrete is generally produced by two means (ACI 523.3R-93, ACI 213R-03). One is cellular concretes referred to lightweight concretes, which contain stable air or gas cells uniformly distributed in the mixture. Cellular concretes commonly include natural or manufactured sand aggregate. In other types, aggregates may be added; for example, manufactured lightweight aggregates such as expanded clay, shale, slate, sintered fly ash, perlite, and vermiculite as well as natural lightweight aggregates such as pumice, scoria, or tuff. Air cells can be intruded from outside through rigorous mixing or by chemically by mean of any reaction producing air bubbles. Due to unavailability of lightweight aggregate in Bangladesh, lightweight concrete was produced using chemically induced void in cement mortar matrix in this study. This research is aimed to observe the effect of volume-surface ratio and aluminium content on volumetric expansion of lightweight concrete.

2.0 RESEARCH SIGNIFICANCE

Lightweight concrete and its future prospects are well established but rigorous study has not been done yet on this field. This study is the pioneer feasibility approach for producing lightweight concrete in Bangladesh. This research enumerates possible indigenous materials those can be incorporated in producing lighter concrete for various decorative, infill and partition related constructions. This study will open new approach for improved large-scale super lightweight concrete production. Authors believe that as first of its kind in Bangladesh, the outcome provides

ahead start for the next researchers interested in this field.

3.0 EXPERIMENTAL PROGRAM

GENERAL APPROACH

First phase of this research focused on the feasibility of reducing unit weight of concrete. "Trial and Error" method was utilized for the production of lightweight mortar from locally available materials such as Cement, Local sand, Lime, Aluminium Powder. Specific weight principle was utilized to see the contribution of ingredients in mixture. Although large amount of void was to be inserted in the matrix, specific weight basis analysis approach was applied for the research.

$$\sum \frac{W_i}{S_i} = 1000 \quad \text{.....(1)}$$

Here
W_i = Weight of i materials in kg
S_i = Specific Gravity of i material

Next approach was to improvise production technique to optimize the goal. Effect of mold size on volumetric expansion of produced concrete was also observed.

MIX PROPORTIONS

Five mixture bands were made to compare the effect of inclusion of ingredients to produce lightweight concrete. First band; B-1 was prepared to observe the void intrusion by aluminium in the cement matrix. Cement content and water content were 1071 and 643 kg/m3 respectively along with varied cement-aluminium ratio by weight. Next band of mixture; B-2 was selected to visualize initial condition of mortar mixture without compaction and expansive agent for varying water-cement ratio from 0.40 to 0.85. Constant sand-cement ratio 1.5 was used in this research as this ratio is widely used in normal weight concrete. Mix proportion B-3 and B-4 were implemented to observe the effect of aluminium and lime respectively. To accommodate volumetric expansion, 150 mm cube mold was used in mix band; B-5 and B-6 having cement-aluminium ratio 100 and 50 respectively. B-4 and B-6 were containing identical mix proportion with different mold capacity (50 mm and 150 mm cube respectively). These are reported in Table 1. Water-cement ratio for the mix bands was not identical due to trial and error approach. On affirmation test results of a band another band was formed and tested. Absorption capacity and thermal conductivity were also determined to obtain product properties.

TEST SPECIMEN

Mixtures were prepared in steel bowls mixing the ingredients. Specimens were cast in 50 mm steel cube ($Volume/Surface = \frac{50x50x50}{4x50x50} = 12.5$). No vibration was used on low viscous mixture to avoid segregation and uniform distribution of bubbles. Side and bottom joints of moulds were sealed with grease to resist water leakage. Samples were removed from mould after 24 hours and cut to 50 mm cubes. Figure 1 referred. Samples were allowed to cure for 28 days. Density and compressive strength were determined for samples. Same procedure was applied for 150 mm cube ($Volume/Surface = \frac{150x150x150}{4x150x150} = 37.5$) during second phase of the research, thereby effect of volume-surface ratio on volumetric expansion was observed. Absorption capacity and thermal conductivity of selected samples was determined to get property trend. Samples were cut to size required for thermal conductivity test by apparatus of Lee's method (Young 2006).

Figure 1: Volumetric expansion in cube sample and voids distribution in mortar matrix

4.0 MATERIALS

As prime binder in this investigation commonly available cement CEM II (BDS 197-1); Portland Composite Cement (PCC) with specific gravity 3.0 was used. Cement was tested for strength conforming ASTM C 109 and fineness conforming ASTM C 204. Average compressive strength of PCC for 3-days, 7-days and 28-days were 17, 21 and 30 MPa, respectively. Test by Blaine's apparatus suggests PCC having fineness 330 m^2/kg. Most commonly available sand of Bangladesh is Savar sand. Basic physical properties were determined for Savar sand used for this research. Unit weight was measured as per ASTM C 29, specific gravity and absorption capacity were determined conforming ASTM C 128 and sieve analysis was conducted conforming ASTM C 136. Specific gravity (OD), Specific gravity (SSD), Apparent specific gravity, Absorption capacity, Unit weight (loose), Unit weight (Compact) and Fineness modulus were found 2.14, 2.33, 2.63, 8.67%, 1346 kg/m^3, 1484 kg/m^3 and 1.02 respectively. For this research, lime is used as an expansive agent for its violent volumetric slaking in presence of water (Aziz 1995). Unslaked local lime was finely ground to get fine powder. Specific gravity of lime was 2.40. To ensure uniform fineness, ground lime was screened through #200 ASTM sieve. Aluminium powder was the prime void intruder in this research. Pure aluminium reacts with water as Equation 2 to produce Hydrogen gas (Haque and Alam 2007, Rosa 2009).

$$2Al + 6H_2O = 2Al(OH)_3 + 3H_2(\uparrow) \quad .....(2)$$

Aluminium powder containing 99.9% assay was used to get desired void intrusion.

5.0 EXPERIMENTAL RESULTS

Materials identified as potential ingredients of aircrete were not enough to produce required void inside concrete matrix. Thus a bubble intruder; aluminium powder was introduced. Figure 2 shows effect of aluminium content on strength and density. To get a comparison, cement content and water content were kept fixed as 1071 kg/m^3 and 643 kg/m^3, respectively. Results show that density decreases with increased aluminium content but strength declined. However, this study was done in aim of identifying aluminium content to get desired void intrusion. The aluminium content was selected as 1 gm of aluminium for 50 gm of cement for B-2, B-3, B-4 and B-6. This content was conservative but consideration was kept in mind that sand and other fillers; if required would have to be inserted yet. Cement alone is a

very expensive material and should be associated with other filler like sand or coarse aggregate. As filler, Savar sand was used in this research. Table 1 represents mix proportions and corresponding test results. Compressive strength and density of tested specimens are shown in Figure 3 and Figure 4 respectively. Variation of strength and density are plotted for mix bands B-2, B-3, B-4, B-5 and B-6 with respect to water-cement ratio.

Mix Design	S/C	C/L	W/C	C/A	Compressive Strength[a]	Density[b]	Mold Size
B-1	-	-	0.60	500	4.98	1066	50 mm
				333	4.65	1065	
				250	4.36	1041	
				200	3.97	1035	
				125	2.84	953	
				100	2.07	917	
				67	1.19	836	
				50	0.65	685	
				32	0.37	606	
B-2	1.5	-	0.40	-	8.26	1864	50 mm
			0.45		15.44	2192	
			0.50		15.85	2136	
			0.55		15.06	2216	
			0.60		12.14	2101	
			0.65		11.98	2091	
			0.70		8.87	2192	
			0.75		7.96	2160	
			0.80		6.45	2064	
			0.85		4.93	2013	
B-3	1.5	-	0.40	50	5.52	1851	50 mm
			0.45		7.99	1744	
			0.50		13.67	1829	
			0.55		10.68	1747	
			0.60		6.32	1701	
			0.65		6.01	1627	
			0.70		6.65	1653	
			0.75		5.00	1635	
			0.80		4.39	1488	
			0.85		4.10	1635	

Table-1: Detail Proportion of Concrete Mixes and Properties of Lightweight Concrete

C: Cement Content; S: Sand Content; L: Lime Content; A: Aluminium, W: Water Content
All Content ratios are by weight
[a]kg/m^3
[b]MPa

Table-1: (Continued…)

Mix Design	S/C	C/L	W/C	C/A	Density[a]	Compressive Strength[b]	Mold Size
B-4	1.5	4.0	0.40	50	2.41	1659	50 mm
			0.45		6.21	1885	
			0.50		9.45	1939	
			0.55		8.51	1816	
			0.60		8.66	1840	
			0.65		6.50	1725	
			0.70		4.46	1605	
			0.75		3.49	1549	
			0.80		2.62	1363	
			0.85		2.07	1317	
B-5	1.5	4.0	0.60	100	4.95	1546	150 mm
			0.65		4.62	1574	
			0.70		3.91	1405	
			0.75		3.02	1383	
			0.80		3.38	1355	
			0.85		2.79	1263	
			0.90		2.23	1145	
			0.95		2.78	1215	
			1.00		2.32	1189	
			1.05		2.02	1084	
			1.10		1.32	1102	
			1.15		0.54	1093	
			1.20		0.34	1070	
B-6	1.5	4.0	0.75	50	0.99	1071	150 mm
			0.80		1.05	1010	
			0.85		0.97	1010	
			0.90		0.91	971	
			0.95		0.68	935	
			1.00		0.61	884	
			1.05		0.59	868	
			1.10		0.68	857	
			1.15		0.42	842	
			1.20		0.39	810	

C: Cement Content; S: Sand Content; L: Lime Content; A: Aluminium, W: Water Content
All Content ratios are by weight
[a]kg/m^3
[b]MPa

Significant change in density was observed when mold was changed from 50 mm to 150 mm. B-6 producing low density (<1000 kg/m^3) but low strength (<1 MPa) concrete. Absorption capacity and thermal conductivity (Lee's Method) of aircrete (<1000 kg/m^3) were determined and found within range of 20-25% and 0.2-0.5 W/m-k respectively.

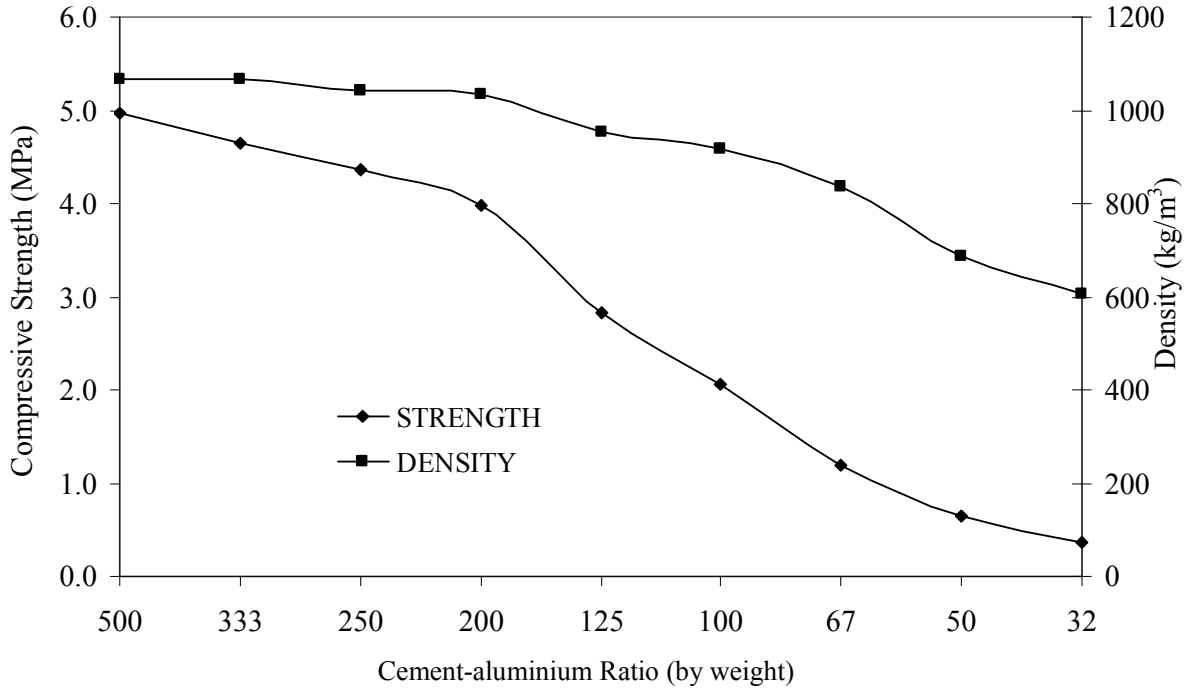


Figure 2: Effect of Aluminium content on density and compressive strength of hardened cement (1071 kg/m^3) with water (643 kg/m^3)

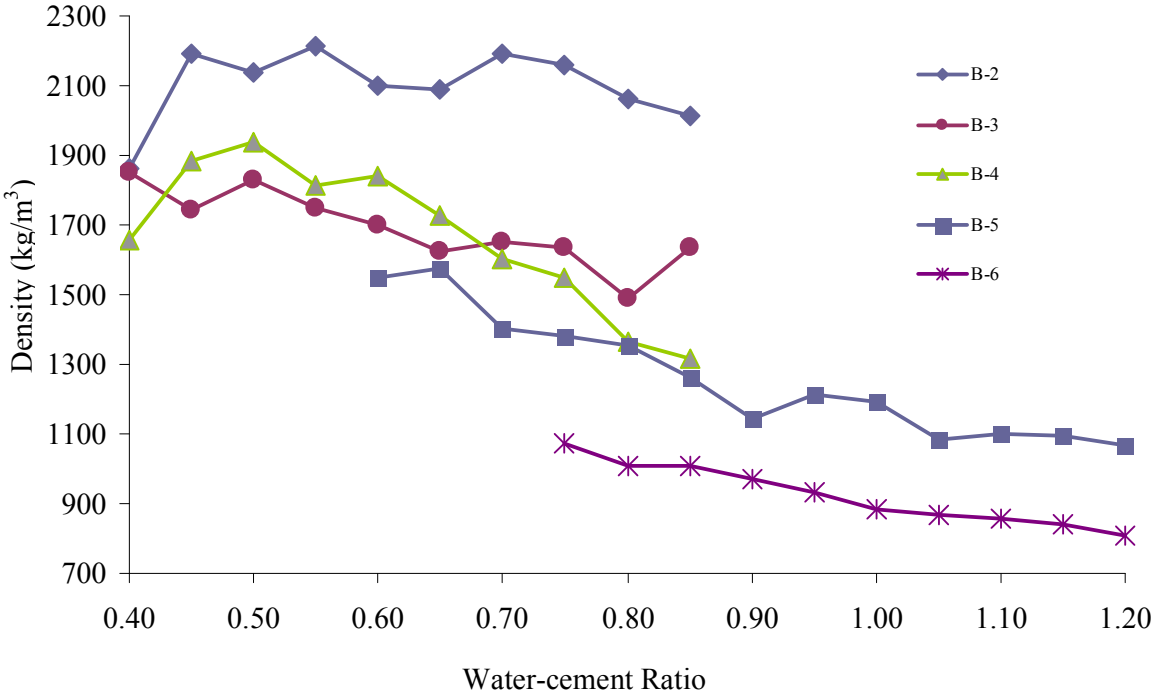


Figure 3: Relationship between density and water cement ratio

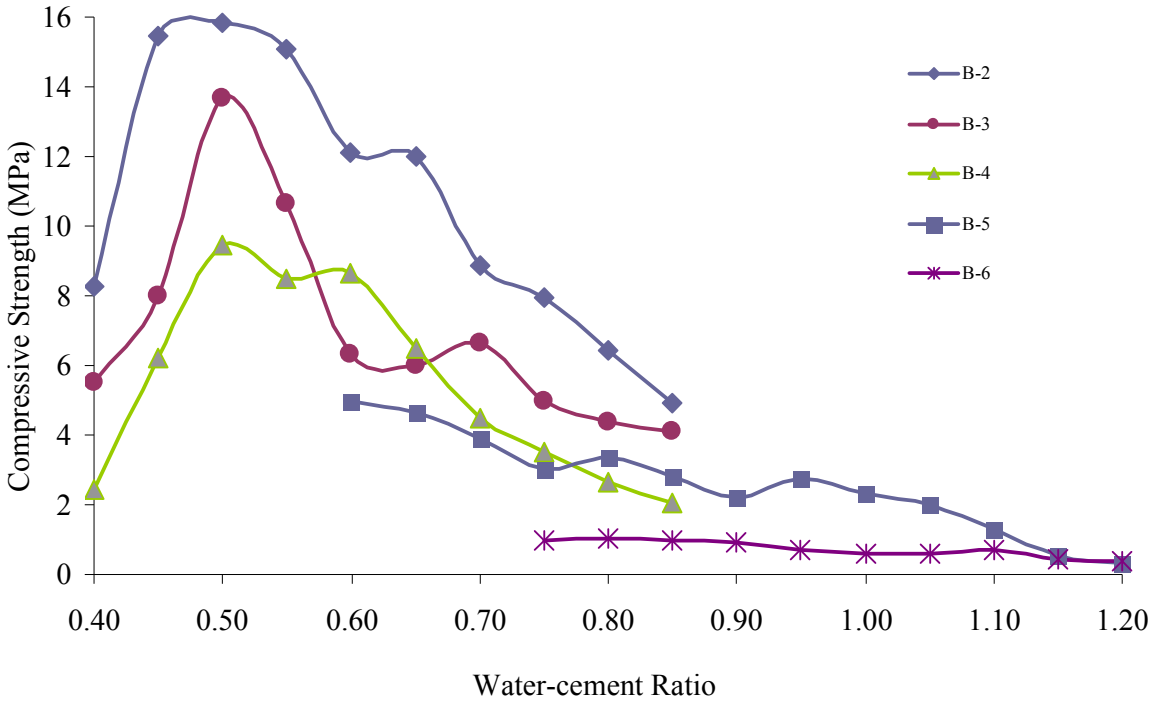


Figure 4: Relationship between compressive strength and water cement ratio

6.0 DISCUSSIONS

Aluminium powder was successfully able to introduce void in the mortar matrix as seen from Figure 2. With the progress of mix bands from B-2 to B-6, density can be reduced up to as low as 1000 to 700 kg/m^3 and subsequently strength reduced up to 2.0 to 0.40 MPa. Increased aluminium content would reduce the density but subsequently reduce the strength of hardened mortar. Mix proportion B-2 showed almost plateau density but sharply decreasing strength starting from water-cement ratio 0.50. No significant behavior could be characterized below water-cement ratio 0.50. This anomalous behavior may be due to zero compaction provided on the mixture thereby leaving large voids. However, water content played vital role in void stabilization in the matrix. Decreasing trend shown by mix proportions B-2, B-3 and B-4 suggested the water cement ratio to higher values up to 1.20. Moreover, density below 1000 kg/m^3 was found for water-cement ratio more than 0.90 in mix B-6. Neglecting anomalous fluctuation of density and compressive strength below water-cement ratio 0.50 of B-4, B-5 and B-6, exponential trend can be imposed on the relation as shown in Figure 5. Statistical comparison with extrapolation was done to idealize the relation between density, strength and water-cement ratio. Containing identical mix proportion, B-4 and B-6 are showing varied volumetric expansion due to increase in volume-surface ratio at a ratio 1:3. Increased cement-aluminium ratio; 100 to 50 led to increased volumetric expansion thereby reduced density as seen from the comparison of B-5 and B-6. However, density trend was more pronounced to characterize than that of strength. Section of cube samples suggested formation of voids 2 to 15 mm in size forming honeycomb structure.

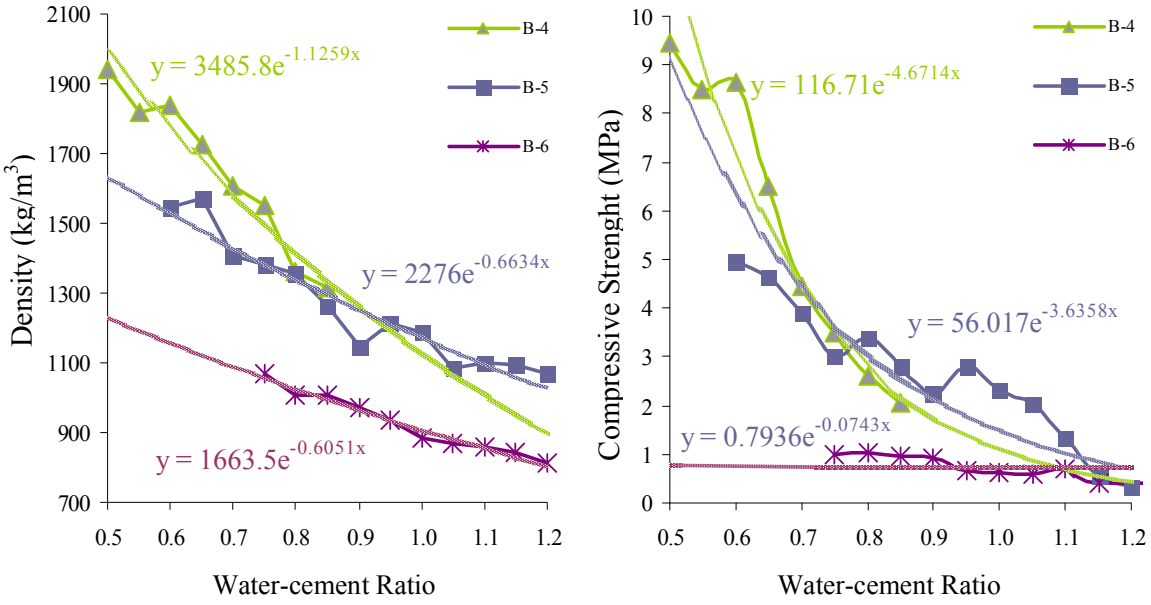


Figure 5: Comparison of Density and Compressive Strength due to increment of Volume-surface Ratio and Aluminium Content

7.0 FURTHER RESEARCH

Due to time and resource constrains, more detail study was not possible. Mix proportions with variable aggregate-cement ratio and cement-lime ratio should be applied to observe wide range of performance. Effort should be made to produce lightweight concrete using improved curing to achieve higher strength. Vapor curing at the initial stage of volumetric expansion may improve product quality. More material options (ordinary portland cement, plasticizer, viscous admixture) may be introduced to enhance performance.

8.0 CONCLUSIONS

The following conclusions can be drawn on the results of this investigation:

After a series of trials comprising indigenous options, density of concrete was able to be reduced within range of 700-1000 kg/m^3. However, strength was very low (0.5-2.0 MPa). Absorption capacity and thermal conductivity was within the range of 0.2-0.5 W/m-k.

As per RILEM classification, lightweight concrete produced in this research can be grouped under class-III and Insulating type lightweight concrete (RILEM 1978).

The reasons behind lower strength are high water-cement ratio, less cementation index and foamy honeycomb structure of hardened mortar.

Within the domain of water-cement ratio 0.50 to 1.20, density and compressive strength trend suggest 10 to 40% reduction in density and 50 to 90% reduction in strength due to increment of volume-surface ratio from 1:3 by introducing 150 mm cube in place of 50 mm cube whereas 20 to 25% density reduction and 0 to 80% strength reduction was observed by increasing cement-lime ratio from 100 to 50.

Finally, it can be concluded that lightweight concrete is feasible using indigenous materials and appropriate technology in Bangladesh.

REFERENCES

[1] ACI (1993), "*Guide for Cellular Concretes above 50 pcf and for Aggregate Concrete above 50 pcf with Compression Strength Less than 2500 psi*," ACI Task Committee 523, Michigan: American Concrete Institute, ACI 523.3R-93.

[2] ACI (2003), "*Guide for Structural Lightweight-Aggregate Concrete*", ACI Task Committee 213, Michigan: American Concrete Institute, ACI 213R-03.

[3] Ahmed A., Fried A. N., Limbachiya M. C. and Roberts J. J. (2004), "Advantages and Implications of High Performance Low Density Aircrete Product for the UK Construction Industry", *13th International Brick and Block Masonry Conference.* Amsterdam, July 4-7, 2004.

[4] Arisoy B. and Wu H.-C. (2008), "Material Characteristics of High Performance Lightweight Concrete Reinforced with PVA." *Construction and Building Materials* [online], 22 (2008), 635-645, Available from: <www.sciencedirect.com> [Accessed 20 Oct 2009].

[5] Aziz, M. A. (1995). "*Engineering Materials.*" Dhaka: Z & Z Publications.

[6] Haque, N., and Alam, Z. (2007). "*Higer Secondary Chemistry.*" 5th ed, Dhaka: Ideal Publications.

[7] Haug, A. K. and Fjeld S., (1996). "A Floating Concrete Platform Hull made of Lightweight aggregate." *Engineering Structures* [online], 18 (11). Available from: <www.sciencedirect.com> [Accessed 16 Aug 2008].

[8] National Ready Mix Concrete Association, (2003). "Structural Lightweight Concrete." *Concrete in Practice* [online], CIP-36. Available from: <http://www.nrmca.org/aboutconcrete/cips/36p.pdf> [Accessed on 24 June 2008].

[9] Lijiu W., Shuzhong Z. and Guofan Z. (2005), "Investigation of the Mix Design of Lightweight Aggregate Concrete." *Cement and Concrete Research* [online]. 35 (2005), 931-935, Available from: <www.sciencedirect.com> [Accessed 16 Aug 2008].

[10] Lo T. Y., Cui H. Z., Abid N. and Li Z. G. (2006), "The Effects of Air Contents on Permeability of Lightweight Concrete." *Cement and Concrete Research* [online], 36 (2006), 1874-1878, Available from: <www.sciencedirect.com> [Accessed 16 Aug 2008].

[11] Mouli M. and Khelafi H. (2008), "Performance Characteristics of Lightweight Aggregate Concrete Containing Natural Pozzolan." *Building and Environment* [online], 43 (2008), 31-36, Available from: <www.sciencedirect.com> [Accessed 20 Nov 2009].

[12] Newman J. B. (1993), "Properties of Structural Lightweight Aggregate Concrete," In: *Structural Lightweight Aggregate Concrete*, Clarke, J. L. Ed. Glasgow: Chapman & Hall, 19-41.

[13] RILEM (1978). "*Functional Classification of Lightweight Concretes."* Recommendation LC2, 1st ed., France.

[14] Rosa, A. V. D. (2009). "*Fundamentals of Renewable Energy Processes.*" 2nd ed., Burlington: Academic Press.

[15] Van Geem M. G. (1990). "Heat Transfer Characteristics of a Recently Developed Structural Lightweight Concrete," In: *Insulating Materials, Testing and Applications Testing and Applications*, Philadelphia: American Society for Testing and Materials, 437-463.

[16] Young P. L. (2006). "A Level Physics." Vol-1, Singapore: Penpac Education Private Limited..

DEVELOPING A SMART CONTROL SYSTEM OF ELECTRICAL APPLIANCES BY COMPUTER INTERFACING

N.K. Das[(1)], Capt. M. Ziauddin Alamgir, BN[(2)], C.K.Das[(3)], M. M. Hasan[(4)], M. M. Rahman[(5)] and M. F. Alam[(5)]

1, 3. Assistant Professor, Department of Electrical Electronic and Engineering, Chittagong University of Engineering & Technology, E-mail: nipu16@gmail.com

2. Senior Instructors, Department of Electrical Electronic and Communication Engineering, Military Institute of Science and Technology, E-mail: naziazafir@yahoo.com

4, 5. Lecturer, Chittagong University of Engineering & Technology, E-mail: mahbub.rahman336@yahoo.com

ABSTRACT

The use of computer interfacing systems for controlling the device is spreading at an increasingly fast pace, with analogous wired system being substituted by computer interfaced systems alternatives in growing number of industries. As the technology progress many control system have been developed ranging from high end stuff to our common daily life. The main objective of this project is to develop a roadmap on communication and control technologies for distributed electrical equipments. Equipments located at any remote place can be monitored and controlled. The process is mainly to communicate between the two remote controlling device and setup connection between devices which are to be controlled. The main hallmark is to get access to the controlling section from any distance location in a convenient way and supervising the system accordingly. The speciality of this project is that the operator will able to control different devices at home/industry by using a single PC. An added advantage of this control system is that the operator will able to know the status of the device to be controlled from a remote place. Here, the algorithm of controlling any kind of electrical equipments is developed. The speeds of a DC motor are controlled as a test case and also monitor the voltage and current during different speed level of the motor.

KEY WORDS— *Distance control, Advance Monitoring, IP addresses based control, Client server interface, Visual basic.*

1.0 INTRODUCTION

A Control System is a very important aspect in modern technology. It is an interconnection of components connected or related in such a manner as to command, direct, or regulate itself or another system. A controller is a control system that manages the behavior of another device or System [11] as shown in figure 1. It is a device or group of devices that serves to govern in some predetermined manner the performance of electric devices. A smarter control makes this transformation possible by bringing the philosophies, concepts and technologies that enabled the internet to the utility and the electric component. More importantly, it enables the industry's best ideas for control modernization to achieve the full potential. The electric industry is poised to make the transformation from a centralized, producer-controlled network to one that is less centralized and more consumer-interactive. The move to a smarter control promises to change the industry's entire business model and its relationship with all stakeholders, involving and affecting utilities, regulators, energy service providers, technology and automation vendors and all consumers of electric power. Examples of control systems can be found all around, and in fact there are very few mechanical or electro-mechanical systems that do not include some kind of a feedback control device. In robotics, control design algorithms are responsible for the motion of the manipulators. In flight applications, control algorithms are designed for stabilization, altitude regulation and disturbance rejection. Cruise control is an interesting application in which the automobile's speed is set at a fixed value. In electronic amplifiers feedback is used to reduce the damaging influence of external noise. In addition, these days control systems can be found in diverse fields ranging from semiconductor manufacturing to environmental regulation.

2.0 METHODOLOGY

This project can be effectively and conveniently utilized for the control of different appliances. As this project could be extended to control about 255 devices, this could be used for computerization of an office, home, or a firm. An added advantage of this project is that the status of the device can be ad monitored & controlled from distance station [7].

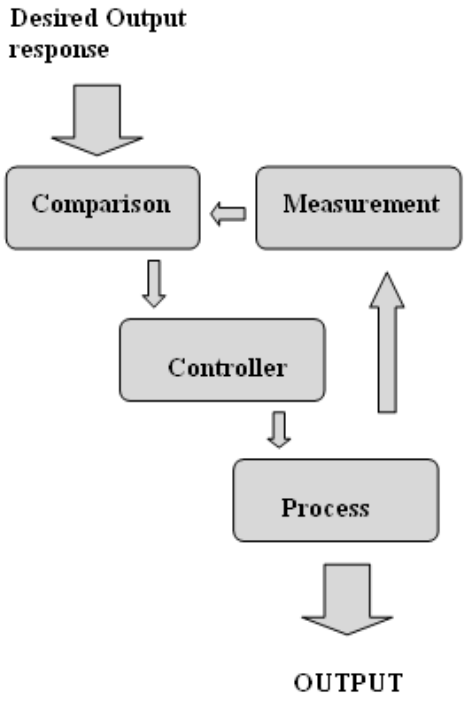


Fig 1: Block diagram of a controller

3.0 EXPERIMENTAL DESIGN

The program to control the appliances is written in C [1]. It is compiled using Turbo C compiler. The flow chart of this program is shown in figure 2 and the program sequence as follows

- On running the program SRC_CODE.C the menu appears asking for the operation to be done.
- The very first option shows the list of the loads that could be controlled using this software along with their codes
- The outstanding part of this software is activating of required PROFILES at once so that the burden of controlling of individual devices is eliminated.
- User defined profile can be set.
- As a basic requirement the control over individual devices is also provided. If the user by mistake tries to switch ON the device which is already ON, the software detects it & the corresponding message is displayed.

The software also allows the user to know the current status of the loads.

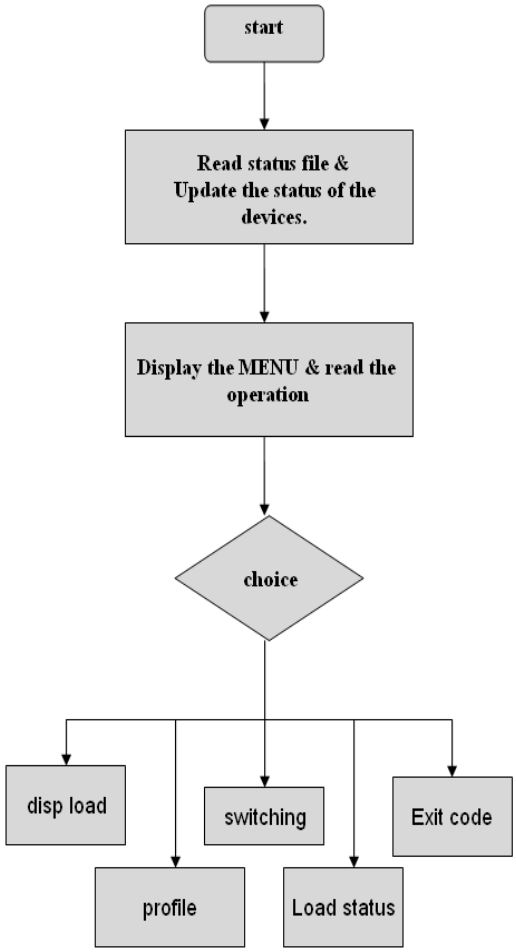


Fig 2: Flow chart of the programme

4.0 SYSTEM OVERVIEW

Electrical equipments are connected with the remote server [10]. In figure 3 shows the interconnection of electrical equipments with remote server which is to be controlled. There are two ways to log in to server PC, one is Microsoft remote assistance system and another is creating a webpage [2-9]. In this project virtual IP used when the system was driven by Microsoft remote assistant mode and In the case of webpage, real IP was used. When the client log in to the server and can easily control the equipments as well as will get status update of them. To view the current status of the electrical component an application has been developed by using this application an end user wail is able to view the live status. In this project it was implemented by visual basic and C language [1, 3]. A TCP/IP listener is responsible for accepting data which is sent by the device via internet to a specific port of the desired address. This data consist of id number of the client pc, which shows the status of the electrical components within an instant.

Fig 3: Interconnection of electrical equipments with remote server

5.0 PROJECT WORK

In this system internet is used to control & collect information of an electrical component at every instant & passes this information to a remote PC. As data being passed to the remote PC containing a private IP address will now listen to a specific port assigned for it. A database created at the server end will store these data. The database now contains all the necessary information it needs to update the information of any particular equipment. This page Contains detailed information of present status of the electrical component. As new data being inserted into the database, it will update the status containing speed, voltage, current, and temperature etc of the component at the client end. In this project we controlled a DC motor through interfacing with a computer. Here microcontroller was used to control and check the status of the DC motor. The programming code for the microcontroller is given in Appendix-A. Equipment arrangement of the project is shown in figure 4 and Stimulated View of Status Checking Unit in figure 5.

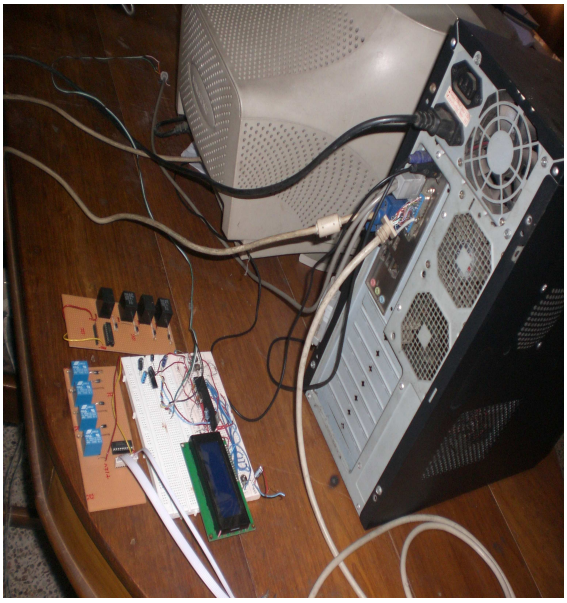


Fig 4: Circuit arrangements for the project

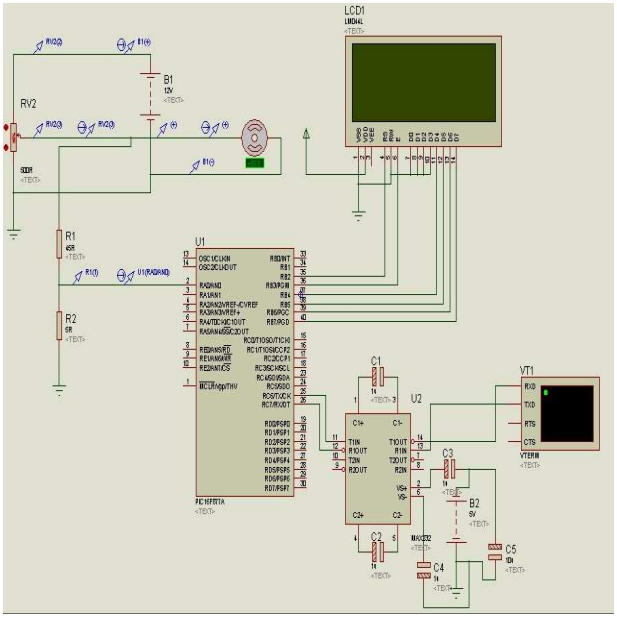


Fig 5: Stimulated View of Status Checking Unit

6.0 APPLICATIONS

Office equipment, medical equipment

There is a wide variety of motorized office equipment such as personal computers, computer peripherals, copy machines and fax machines as well as smaller items such as electric pencil sharpeners. Controllers for these types of equipment are built into the equipment. Some quite sophisticated controllers are used to control the motors in computer disc drives. Medical equipment may include very sophisticated controllers.

Commercial applications

Commercial buildings have larger heating ventilation and air conditioning equipment than

that found in individual residences. In addition, motors are used for elevators, escalators and other applications.

Industrial applications

Many industrial applications are dependent upon motors (or machines), which range from the size of human thumb to the size of a railroad locomotive. The controllers can be built into the driven equipment, installed separately, installed in an enclosure along with other machine control equipment or installed in motor control centres. Control centres are multi-compartment steel enclosures designed to enclose many motor controllers. In this case the controllers communicate with each other so they can work the electrical equipment together as a team.

7.0 CONCLUSION

This project implemented a smart control system by this system the client can control and monitor the electrical equipment from any place effectively and conveniently. As this project could be extended to control about 255 devices, this could be used for computerization of an office, home, or a firm. Though it is quiet costlier, the circuit is simple and the working mechanism could be easily understood. An added advantage of this project is that the will be able to know the status of the device which is to be controlled. The program to control the appliances is written in C language which is more users friendly and easy to understand than other programming languages.

APPENDIX-A

The programming code for the microcontroller which was used to control the DC Motor is given below.

```
unsigned char datav,datai;
unsigned float j,v,k,i;
unsigned char x[6], y[9];
// float to string conversion function (user defined)
   void conv (unsigned short row, unsigned short
col, float b)
   {
   float a;
   if ((b>=0)&&(b<10))       // 0 <= x < 10
   {
   a=b;
   x[0]=   (int)a;
   x[1]=   (int)(a*10) - x[0]*10;
   x[2]=   (int)(a*100) -x[0]*100- x[1]*10;

   y[0]= x[0] + 48;
   y[1]= 46;
   y[2]= x[1] + 48;
   y[3]= x[2] + 48;
   y[4]= 0;
   y[5]= 0;
   y[6]= 0;
   y[7]= 0;
   y[8]= 0;

   }
   if ((b>=10)&&(b<100))       // 10 <= x < 100
   {
   a=b;
   x[0]=  (int)a;
   x[1]=  (int)(a*10) - 10*x[0];
   x[2]=  (int)(a*100) -100*x[0]- 10*x[1];
   x[3]=(int)(a*1000)-1000*x[0]-10*x[1]- 0*x[2];

   y[0]= x[0] + 48;
   y[1]= x[1] + 48;
   y[2]= 46;
   y[3]= x[2] + 48;
   y[4]= x[3] + 48;
   y[5]= 0;
   y[6]= 0;
   y[7]= 0;
   y[8]= 0;

   }
   if ((b>-10)&&(b<0))         // -10 < x < 0
   {
   a=-b;
   x[0]=  (int)a;
   x[1]=  (int)(a*10) - x[0]*10;
   x[2]=  (int)(a*100) -x[0]*100- x[1]*10;

   y[0]= 45;
   y[1]= x[0] + 48;
   y[2]= 46;
   y[3]= x[1] + 48;
   y[4]= x[2] + 48;
   y[5]= 0;
   y[6]= 0;
   y[7]= 0;
   y[8]= 0;
   }
   lcd_out (row, col, y);
   }
   void main (void)
   {
   // ADC initiation
   adcon0=0b00000001;
   adcon1=0b10000000;
   //

   trisb=0;         // LCD output
   trisa=255;       // Voltage input
```

```
// LCD initiation
lcd_init(&portb);
lcd_cmd(lcd_cursor_off);
lcd_cmd(lcd_clear);
//
lcd_out(1,1, "V[V]=");
lcd_out(2,1, "I[A]=");
while (1)
{
j=adc_read(0);
v=(50*j/1024);
k=(v/9.677419355);
i=(50*k/62);
conv (1,6,v);
conv (2,6,i);
Lcd_Out(3,1, "f[Hz]=50");
delay_ms(100);
Usart_Init(8900);
datav=v;
datai=i;
 Usart_Write(datav);          // Send voltage via USART
 delay_ms(500);
  Usart_write(datai);          // Send Amp via USART
}
}
```

Source code for the write operation

```
Private Declare Function Inp Lib "inpout32.dll" Alias "Inp32" (ByVal PortAddress As Integer) As Integer. Private Declare Sub Out Lib "inpout32.dll" Alias "Out32" (ByVal PortAddress As Integer, ByVal Value As Integer)
Dim Value As Integer
Dim PortAddress As Integer
Private Sub cmdWriteToPort_Click()
'Write a byte to a port, read it back,
'& display the result.
Out PortAddress, Value
Text1.Text = Inp(PortAddress)
Value = Value + 1
If Value = 255 Then Value = 0
End Sub
Private Sub Form_Load()
'Test program for inpout32.dll
Value = 0
'Change this value to match the port to write to:
'(Usual parallel-port addresses are &h378, &h278, &h3BC)
PortAddress = &H378
End Sub
```

Source code for the read operation:

```
Dim a
Private Sub Form_Load()
MSComm1.PortOpen = True
End Sub
Private Sub MSComm1_OnComm ()
On Error Resume Next
'mscomm1.RThreshold
a = Asc(MSComm1.Input)
'b = MSComm1.Output
Label1.Caption = a
Label3.Caption = a / 9.677419355
Label2.Caption = 50 * Label3 / 62
Debug.Print a
'MsgBox b
End Sub
```

REFERENCES

C programming for microcontroller by Joe Pardue 2nd Edition, published by smily micro, page-137,273,275,287,289.

Serial port complete by Jan Axelson, 2nd Edition. Lakeview Research LLC, page 43-76.

Visual basic for electronic engineering applications by Vincent Himpe, 2nd edition, page-37-47&99-108.

www. wikipidia.org/remote desktop protocol.

www.electrofriends.com

www.picgallery.com

Device switching using PC's parallel port by Ranjith, page-1-3&6-8.

Muhammad H.R Rashid "Power Electronics" 3rd edition, Page-641.

Wayne Thomasi, "Advanced Electronics Communications Systems", 6th Edition, page-629

Wireless device server-www.lantronic.com

Control System Engineering by NISE, 4th edition.

DESIGN AID FOR CONTINUOUS BEAMS

S.N. Khuda[(1)] and A.M.M.T. Anwar[(2)]

1. Lecturer, Department of Civil Engineering, Military Institute of Science and Technology

E-mail: sarkarnoorekhuda@yahoo.com

2. Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology

E-mail: tanwar@ce.buet.ac.bd

ABSTRACT

Analysis and design of beam is still an important part in Structural Engineering practice. As a major component in structure, it demands due attention and accuracy. At the same time engineers need to achieve economy in time and cost in the design of beams.To assist designers moment coefficients are developed for continuous beams in this work. Existing ACI moment coefficients are applicable only under certain conditions and have some limitations. This study is an attempt to develop moment coefficients for beams which will be applicable beyond ACI limitations. Comparison of developed coefficients with corresponding ACI coefficients has been done and a satisfactory agreement is found. However, ACI coefficients are found to be conservative. Additionally design tables are developed for selection of RC beam section and reinforcement when design bending moment and shear are available. SAP2000 has been used for analysis of beams during the study. Models are used to generate exact moment coefficients for beams of different span ratios and spans under uniform loading. The moment coefficients and design tables generated in this work will be useful for practicing engineers for quick design.

KEY WORDS: *Moment Coefficient; Shear; Continuous Beam; Uniform Loading.*

1.0 INTRODUCTION

The few things that represent a civilization include structural establishment of that time. With advancement of time human inventions have made miracles a simple math. With time, beam column structure is becoming more familiar, convenient and reliable considering time and cost. An approximate method of analysis based either on careful sketches of the shape of the deformed structure under load or on moment coefficients still provides a means for rapid estimation of internal forces and moments. Such estimates are useful in preliminary design and checking more exact solutions for gross errors that might result from input errors. The moment coefficients developed earlier has been supporting engineers so far but still there are lot of dissatisfaction as they impose few rigid restrictions for the designers. Engineering in general practice attempt to understand the response of beams on loading. Because of complicated nature on the distribution of loads, the supporting structural system may differ substantially from that of a set of beams. The behavior of beams under differing loading system, support conditions accompanied with different shapes and sizes has yet large extents to go. Before development of proper approach to analysis and design of various shapes of beams, most of the beams in building design and other types of structure were rectangular. This study represents an honest effort to go out of the set restrictions in case of moment coefficients and present a set of coefficients which stands out of the restrictions. For studying the behavior of beams and develop moment coefficients a well developed program SAP2000 was used. A set of beams of different spans and varying span ratio were analyzed.

2.0 STUDY SIGNIFICANCE

Beams with more than one span are called continuous beams, because they continue over the intermediate spans. Continuous beams are most common in bridges and building structures. Again, the span lengths may be unequal and the moment of inertia of the cross section may be different form one span to another. The analysis of such beams by the force method using reactions as redundant would require the computation of a large number of deflections or slopes in a basic beam with several variations in moment of inertia of its cross-section. Again there are some other processes to analyze the beams for moments, slopes etc.

3.0 NECESSITY OF APPROXIMATE ANALYSIS

In spite of the development of refined methods for the analysis of beams and frames increasing attention is being paid to approximate method of analysis. There are several reasons for this. Prior to performing a complete analysis of an indeterminate structure, it is necessary to estimate the proportions of its members in order to know their relative stiffness, upon which the analysis depends. These dimensions can be obtained on the basis of approximate analysis. Also, even with the availability of computers, most engineers find it desirable to make a rough check of results, using approximate means, to detect gross errors. Further, for structures of minor importance, it is often satisfactory to design on the basis of results obtained by rough calculation. For these reasons, many engineers at some stage in design process estimate the values of moments, shears, and thrusts at critical locations, using approximate sketches of the structure deflected by its loads.

4.0 EXISTING MOMENT COEFFICIENT FOR BEAMS

ACI code 8.3 includes expressions that may be used for the approximate calculation of maximum moments and shears in continuous beams and one way slabs. The expressions for moment take the form of coefficient multiplied by $W_u(L_n)^2$, where W_u is the total factored load per unit length of the span and L_n is the clear span from face of supports for positive moment or the average of the two adjacent clear spans for negative moment. Shear is taken equal to a coefficient multiplied by W_uL_n. The moment coefficients, found in ACI code 8.3.3 are reprinted in a table later on in this paper.

The ACI moment coefficients were derived by elastic analysis, considering alternative placement of live load to yield maximum negative or positive moments at the critical sections. They are applicable within the following limitations:

1. There are two or more spans.
2. Spans are approximately equal, with the longer of two adjacent spans not greater than the shorter by more than 20 percent.
3. Loads are uniformly distributed.
4. The unit live load does not exceed 3 times the unit dead load
5. Members are prismatic.

5.0 GENERATION OF MOMENT COEFFICIENT

For the present study of continuous beam analysis and design SAP2000 software has been used. For analysis cases, Firstly, beams of two spans, three spans, four spans and five spans are considered. Verification has also been performed outside ACI permitted range of span considering longer span greater than 20% of the adjacent shorter span. Various span ratios have been set for analysis of beams. Considering span ratio and number of span parameters has been set for the analysis case. Moment at different points of the beam has been found using SAP2000 software. Moment coefficient has been obtained by dividing the moment by the square of adjacent span length. To perform this calculation a computer based spreadsheet program has been written in EXCEL software. For design of beam both for moment and shear parameters has been set considering loads from slabs of general range. The lower limit has been set considering loads from a 10'x10' slab and the upper limit has been set considering a 32'x32' slab. Finally design of the beam has been done using SAP2000 software.

6.0 PARAMETERS OF STUDY

Assumed variation of parameters for analysis of continuous beams for moment coefficients:
No of spans=2 to 5
Span length for the first span= 10 ft
Uniformly distributed load all over the beam= 1 kip/ft
Span ratio= 1 to 2
Variation in span ratio between two spans= 0.2
Cross-section of the beam= 10 in X18 in
Self weight of the beam is assumed to be negligible.

Assumed variation of parameters for design of beams for moment:
Simply supported beam
Span length=20 ft
Width of beam cross section=10 in
Depth of beam cross section = 12 in to 30 in @ 3 in
Strength of concrete, f_c'= 3 ksi
Strength of steel, f_y= 60 ksi
Uniformly distributed load (kip/ft), all over the beam to create desired moment.
Assumed variation of parameters for design of beams for shear:
Simply supported beam
Span length=20 ft
Width of beam cross section =10 in
Depth of beam cross section = 12 in to 30 in @ 3 in
Strength of concrete, f_c'= 3 ksi
Strength of steel, f_y= 60 ksi
Uniformly distributed load (kip/ft), all over the beam to create desired shear.

7.0 FINDINGS

From the study, moment coefficient (C) has been generated for two span, three span, four span and five span continuous beams with varying span ratio. These moment coefficients are given in Table 1 where, moment coefficients for a selected number of span ratios are shown. As all the first span is taken to be 10 ft, for higher span number and span ratio, the beam span length exceeds the maximum practical limit. Therefore, for four span and five span beams lower span ratio has been considered. Graph of moment coefficient for span ratio variation has been developed (Fig 1- Fig 9). For graphical representation only five span beams are considered. The span ratio variation is provided shown in legend. Beams are also been designed for moment and shear shown in Table 2 and Table 3. Finally, a comparison between the generated moment coefficients and the available ACI moment coefficients has been shown in Table 4. The variation of moment coefficient for cross-section variation is given in Table 5.

General findings are appeared bellow:

- Development of moment coefficient (C) for two span, three span, four span and five span continuous beam with various span ratio.

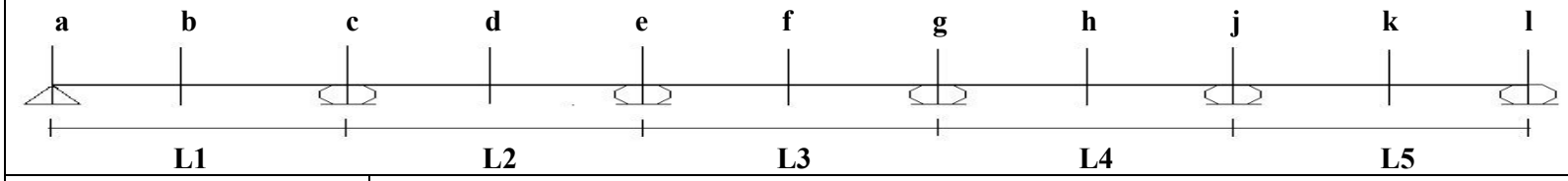
- Table of moment coefficient (C) for two span, three span, four span and five span continuous beam and various span ratio (Table 1).

- Graph of moment coefficient (C) against various span ratio.

- Design of beam for moment (Table 2).
- Design of beam for shear (Table 3).

- Comparison of generated data with available data (Table 4).

- Variation of moment coefficient for cross section variation (Table 5).



SPAN RATIO				MOMENT COEFFICIENT (C) AT DIFFERENT LOCATION											
L2/L1	L3/L2	L4/L3	L5/L4	a	b	c	d	e	f	g	h	j	k	l
1	-	-	-	0	0.0708	-0.123	0.0708	0	-	-	-	-	-	-
1.2	-	-	-	0	0.0588	-0.12636	0.0757	0	-	-	-	-	-	-
1.4	-	-	-	0	0.0429	-0.13389	0.0803	0	-	-	-	-	-	-
1.6	-	-	-	0	0.0315	-0.14349	0.0816	0	-	-	-	-	-	-
1.8	-	-	-	0	0.0195	-0.15424	0.0820	0	-	-	-	-	-	-
2	-	-	-	0	0.0056	-0.16533	0.0828	0	-	-	-	-	-	-
1	1	-	-	0	0.0803	-0.0994	0.0206	-0.0994	0.0803	0	-	-	-	-
1.2	1.2	-	-	0	0.0798	-0.08314	0.020972	-0.11421	0.079475	0	-	-	-	-
1.4	1.4	-	-	0	0.0839	-0.06257	0.016582	-0.12812	0.082362	0	-	-	-	-
1.6	1.6	-	-	0	0.0968	-0.03432	0.016836	-0.14187	0.082321	0	-	-	-	-
1.8	1.8	-	-	0	0.1254	-0.0046	0.020895	-0.15544	0.08239	0	-	-	-	-
1	1	1	-	0	0.0777	-0.1057	0.0344	-0.0727	0.0341	-0.1037	0.0777	0	-	-
1.2	1.2	1.2	-	0	0.072156	-0.09885	0.04202	-0.06851	0.028838	-0.11542	0.080354	0	-	-
1.4	1.4	1.4	-	0	0.060556	-0.1032	0.046814	-0.05243	0.02273	-0.0873	0.081013	0	-	-
1.6	1.6	1.6	-	0	0.038852	-0.12174	0.063266	-0.0255	0.020816	-0.14238	0.082167	0	-	-
1	1	1	1	0	0.079294	-0.10177	0.031235	-0.0801	0.039902	-0.0801	0.031235	-0.10177	0.079294	0
1.2	1.2	1.2	1.2	0	0.074629	-0.09374	0.033464	-0.0862	0.047112	-0.06888	0.028481	-0.11682	0.080008	0
1.4	1.4	1.4	1.4	0	0.074122	-0.07965	0.028806	-0.09755	0.052378	-0.05109	0.023905	-0.12981	0.081852	0

Table 1: Various Moment Co-efficient

Moment coefficient (C) in continuous beams for different span ratio

Moment, $M=CWL^2$

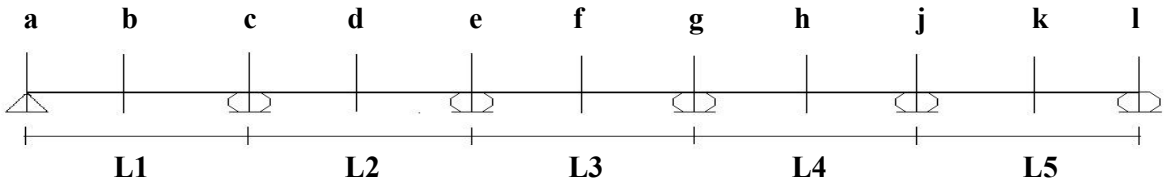
Where, W= Uniform load; L= Respective span length for mid span moment or average of adjacent span lengths for Support moments

MOMENT, k-ft	CROSS SECTION													
	10"X12"		10"X15"		10"X18"		10"X21"		10"X24"		10"X27"		10"X30"	
	REINFORCEMENT, in²/ft													
	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP
20	0.66	-	0.48	-	0.53	-	0.45	-	0.38	-	0.33	-	0.31	-
46	1.73	0.011	1.18	-	0.95	-	0.8	-	0.74	-	0.78	-	0.72	-
72	Fail	-	2.01	-	1.56	-	1.29	-	1.07	-	0.93	-	0.9	-
98	Fail	-	2.73	0.59	2.25	-	1.82	-	1.49	-	1.29	-	1.19	-
124	Fail	-	Fail	-	2.91	0.32	2.4	-	1.94	-	1.66	-	1.53	-
150	Fail	-	Fail	-	3.47	0.91	3.04	0.01	2.41	-	2.05	-	1.88	-
176	Fail	-	Fail	-	4.03	1.49	3.52	0.51	2.92	-	2.45	-	2.25	-
202	Fail	-	Fail	-	Fail	-	4.01	1.02	3.47	-	2.88	-	2.63	-
228	Fail	-	Fail	-	Fail	-	4.49	1.52	3.89	0.35	3.33	-	3.03	-
254	Fail	-	Fail	-	Fail	-	Fail	-	4.29	0.76	3.82	-	3.44	-
280	Fail	-	Fail	-	Fail	-	Fail	-	4.69	1.18	4.23	0.2	3.88	-
306	Fail	-	Fail	-	Fail	-	Fail	-	5.08	1.59	4.58	0.56	4.34	0.02
332	Fail	-	Fail	-	Fail	-	Fail	-	5.48	2.01	4.92	0.92	4.68	0.37
358	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	5.5	1.67	5.02	0.72
384	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	5.87	2.06	5.36	1.07
410	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	5.69	1.42
436	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	6.03	1.78
462	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-	Fail	-

Table 2: Design of Beam for Moment

SHEAR, k	CROSS SECTION						
	10"x12"	10"x15"	10"x18"	10"x21"	10"x24"	10"x27"	10"x30"
	REINFORCEMENT, in²/in						
7	0.008	0.008	0.008	0.008	0	0	0
10	0.008	0.008	0.008	0.008	0.008	0.008	0.008
13	0.015	0.008	0.008	0.008	0.008	0.008	0.008
16	0.022	0.014	0.009	0.008	0.008	0.008	0.008
19	0.03	0.02	0.014	0.009	0.008	0.008	0.008
22	0.038	0.026	0.019	0.014	0.01	0.008	0.008
25	0.045	0.033	0.024	0.018	0.018	0.01	0.008
28	0.053	0.039	0.029	0.022	0.017	0.013	0.01
31	0.061	0.045	0.034	0.027	0.021	0.016	0.013
34	0.068	0.051	0.039	0.031	0.025	0.02	0.016
37	Fail	0.057	0.044	0.035	0.029	0.023	0.019
40	Fail	0.063	0.05	0.04	0.033	0.026	0.022
43	Fail	0.069	0.055	0.044	0.036	0.03	0.025
46	Fail	Fail	0.06	0.049	0.04	0.033	0.029
49	Fail	Fail	0.065	0.053	0.044	0.036	0.032
52	Fail	Fail	0.07	0.057	0.048	0.04	0.035
55	Fail	Fail	Fail	0.062	0.052	0.043	0.038
58	Fail	Fail	Fail	0.066	0.055	0.046	0.041
61	Fail	Fail	Fail	0.07	0.059	0.05	0.044
64	Fail	Fail	Fail	Fail	0.063	0.053	0.047
67	Fail	Fail	Fail	Fail	0.067	0.057	0.05
70	Fail	Fail	Fail	Fail	0.071	0.06	0.053
73	Fail	Fail	Fail	Fail	Fail	0.063	0.056
76	Fail	Fail	Fail	Fail	Fail	0.067	0.059
80	Fail	Fail	Fail	Fail	Fail	0.071	0.063
83	Fail	Fail	Fail	Fail	Fail	Fail	0.066
87	Fail	Fail	Fail	Fail	Fail	Fail	0.07
90	Fail	Fail	Fail	Fail	Fail	Fail	Fail

Table 3: Design of Beam for Shear



Legend

Series 1: No of Span= 5; L2/L1= 1.0; L3/L2= 1.0; L4/L3= 1.0; L5/L4= Variable;

Series 2: No of Span= 5; L2/L1= 1.0; L3/L2= 1.2; L4/L3= 1.2; L5/L4= Variable;

Series 3: No of Span= 5; L2/L1= 1.0; L3/L2= 1.4; L4/L3= 1.4; L5/L4= Variable;

Series 4: No of Span= 5; L2/L1= 1.2; L3/L2= 1.0; L4/L3= 1.0; L5/L4= Variable;

Series 5: No of Span= 5; L2/L1= 1.2; L3/L2= 1.2; L4/L3= 1.2; L5/L4= Variable;

Series 6: No of Span= 5; L2/L1= 1.2; L3/L2= 1.4; L4/L3= 1.4; L5/L4= Variable;

Series 7: No of Span= 5; L2/L1= 1.4; L3/L2= 1.0; L4/L3= 1.0; L5/L4= Variable;

Series 8: No of Span= 5; L2/L1= 1.4; L3/L2= 1.2; L4/L3= 1.2; L5/L4= Variable;

Series 9: No of Span= 5; L2/L1= 1.4; L3/L2= 1.4; L4/L3= 1.4; L5/L4= Variable;

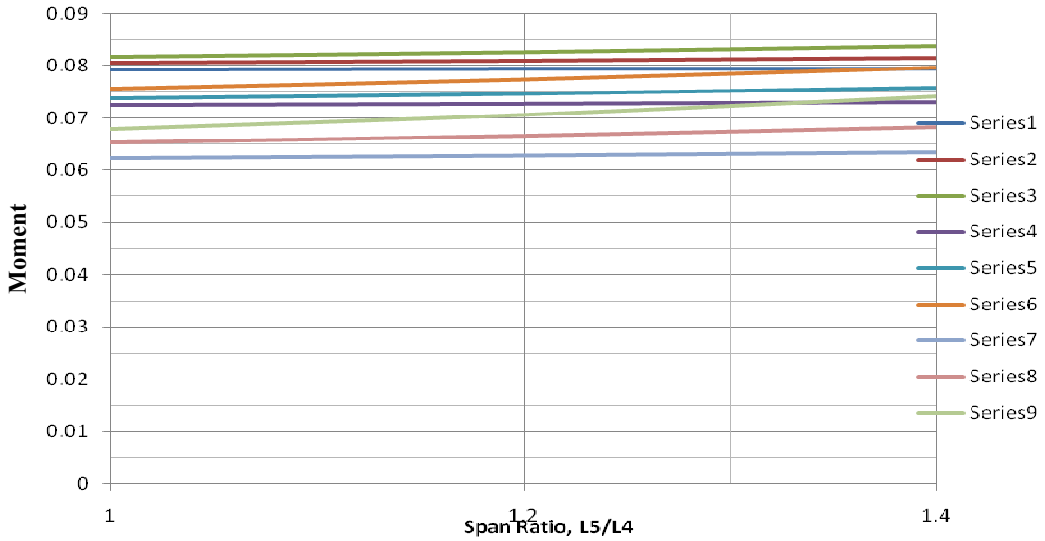


Fig 1: Moment Coefficient for Mid Span of Span L1 (location b) against Span Ratio, L5/L4

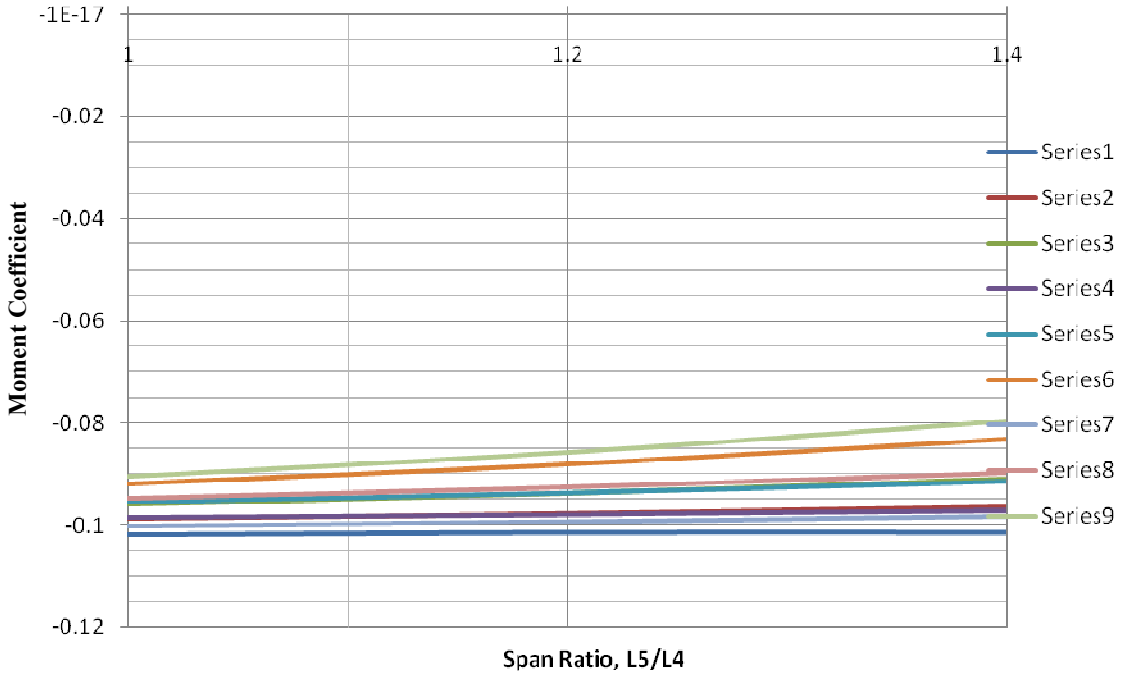


Fig 2: Moment Coefficient for support between Span L1 and L2 (location c) against Span Ratio, L5/L4

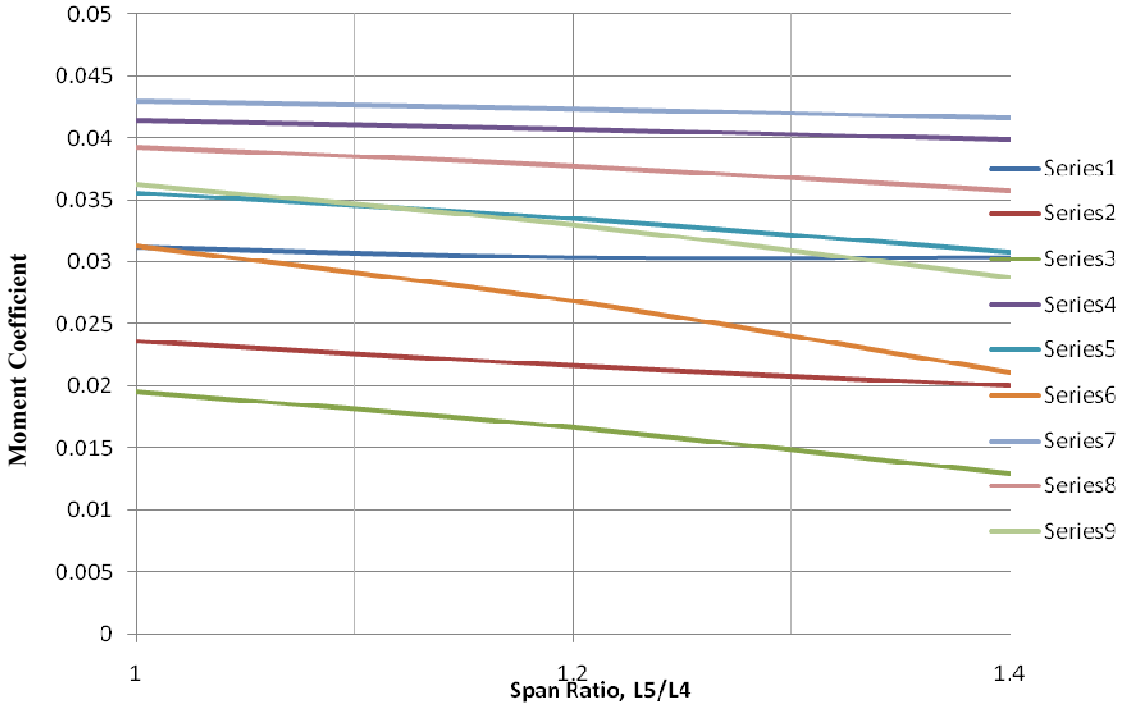


Fig 3: Moment Coefficient for Mid Span of Span L2 (location d) against Span Ratio, L5/L4

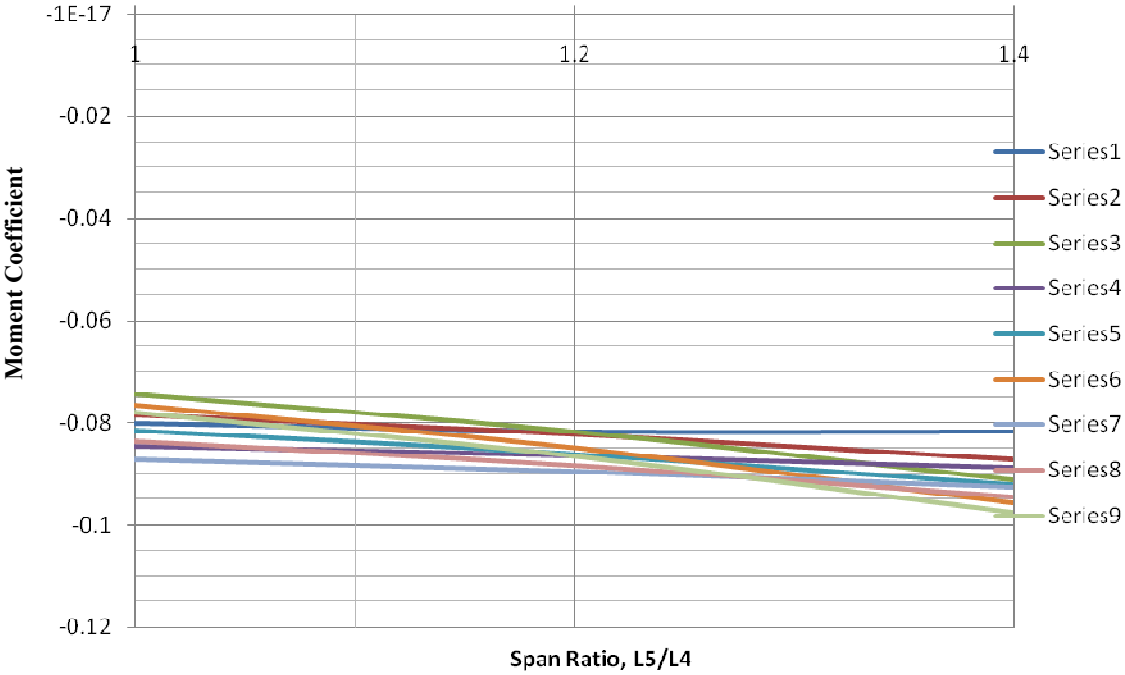


Fig 4: Moment Coefficient for support between Span L2 and L3 (location e) against Span Ratio, L5/L4

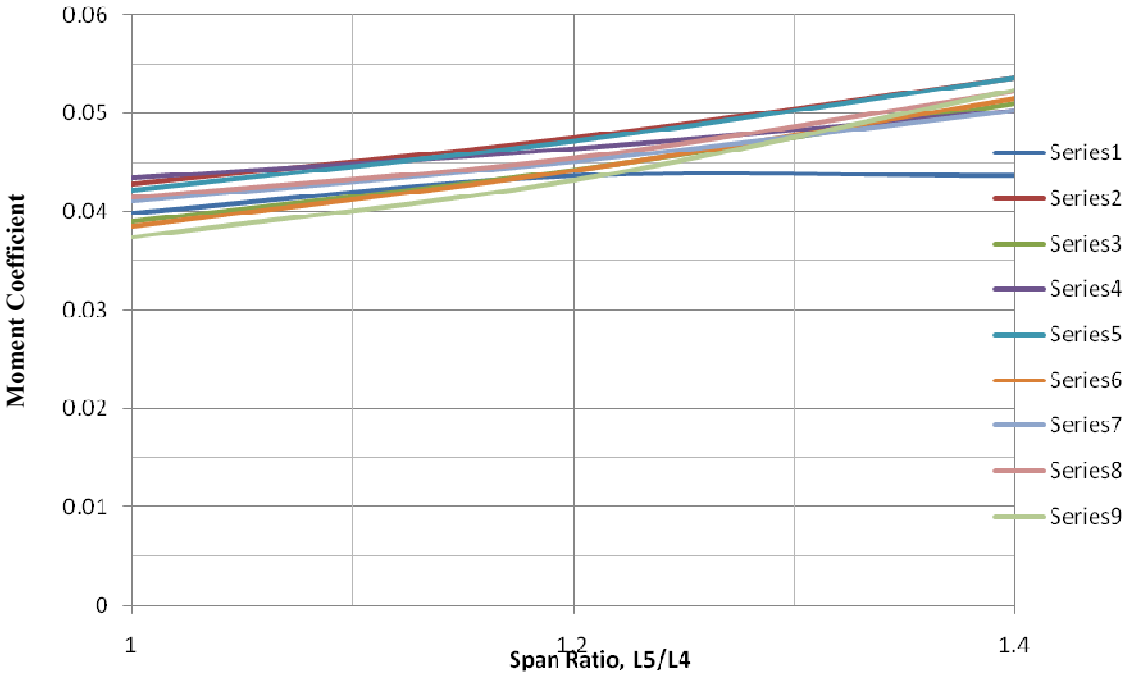


Fig 5: Moment Coefficient for Mid Span of Span L3 (location f) against Span Ratio, L5/L4

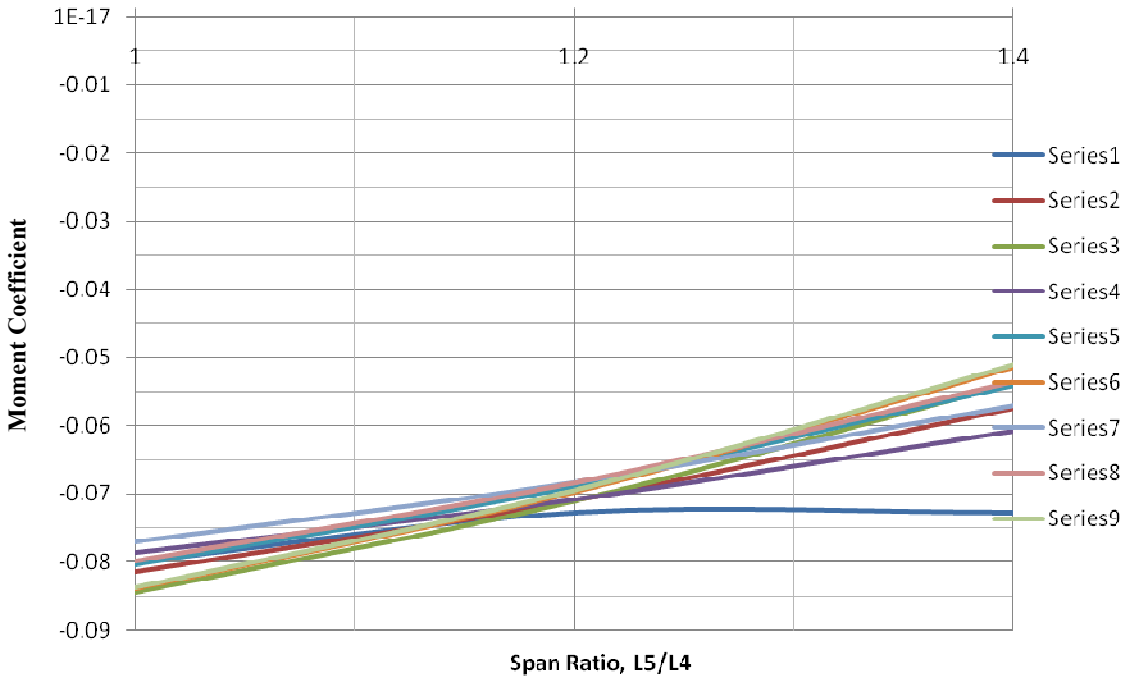


Fig 6: Moment Coefficient for support between Span L3 and L4 (location g) against Span Ratio, L5/L4

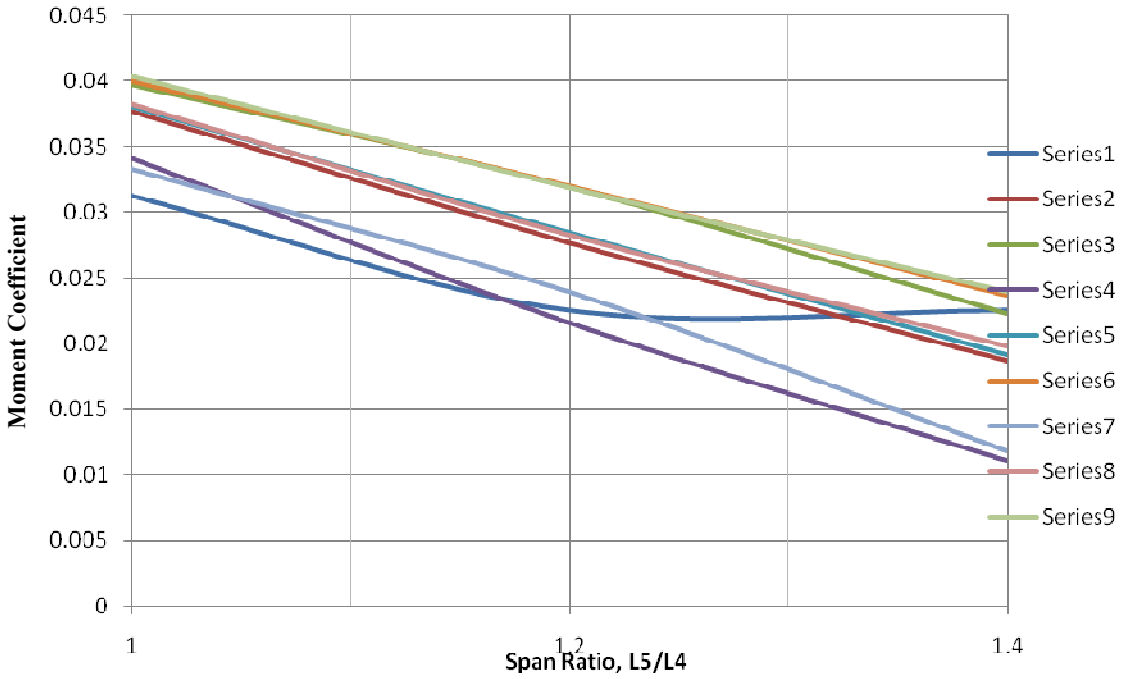


Fig 7: Moment Coefficient for Mid Span of Span L4 (location h) against Span Ratio, L5/L4

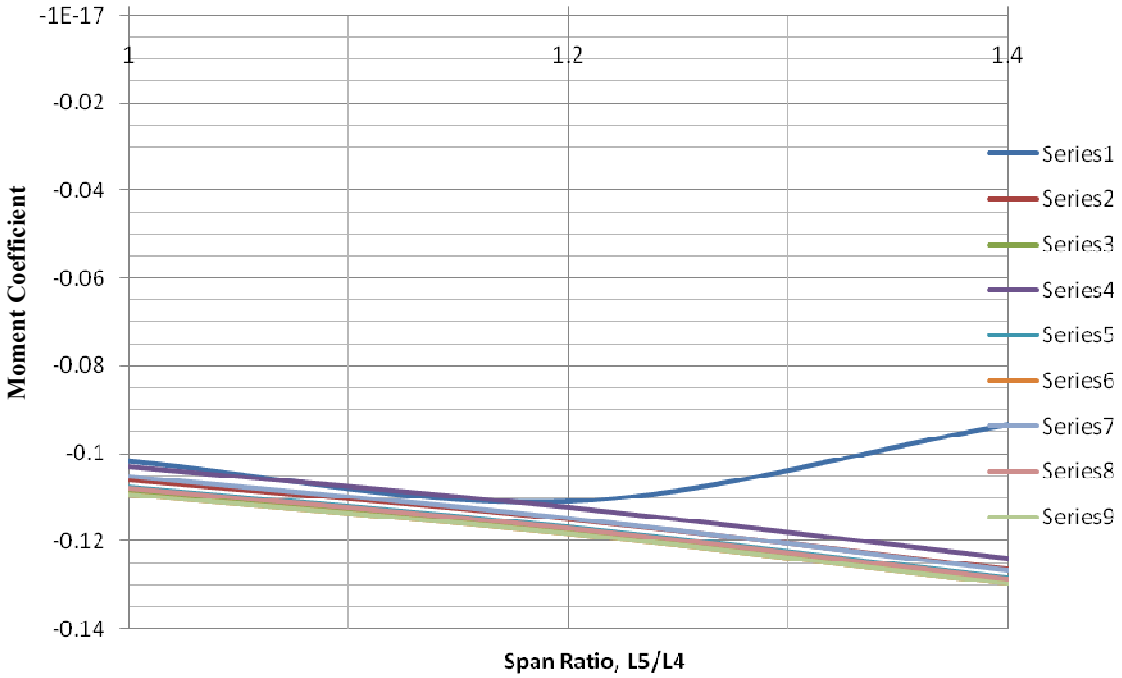


Fig 8: Moment Coefficient for support between Span L4 and L5 (location j) against Span Ratio, L5/L4

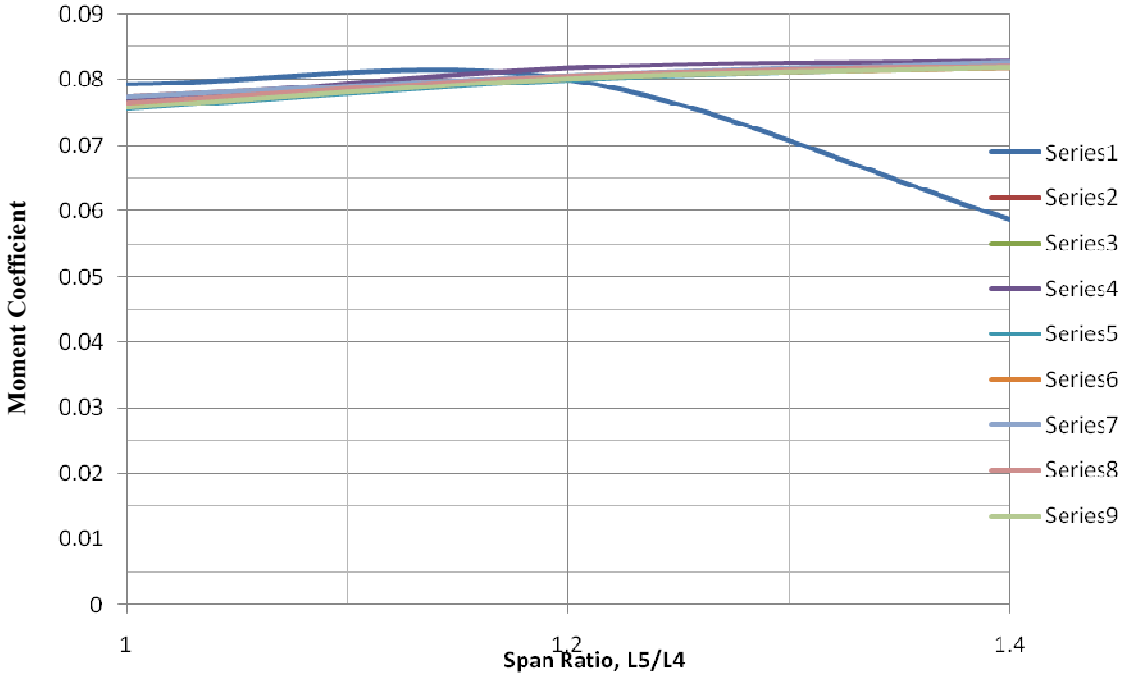
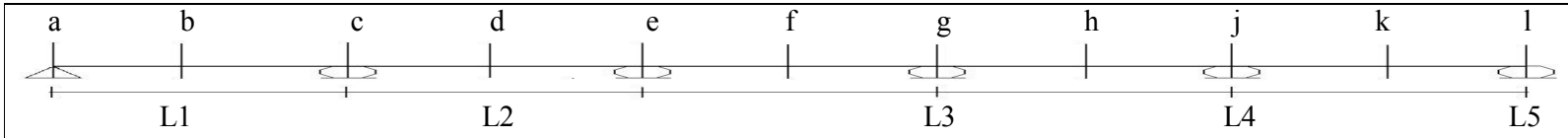


Fig 9: Moment Coefficient for Mid Span of Span L5 (location k) against Span Ratio, L5/L4



DATA TYPE	SPAN RATIO				MOMENT COEFFICIENT (C) AT DIFFERENT LOCATION										
	L2/ L1	L3/ L2	L4/ L3	L5/ L4	a	b	c	d	e	f	g	h	j	k	l
ACI	1	-	-	-	0	0.07	-0.125	0.07	0	-	-	-	-	-	-
Generated	1	-	-	-	0	0.0708	-0.123	0.0708	0	-	-	-	-	-	-
ACI	1	1	-	-	0	0.08	-0.1	0.025	-0.1	0.08	0	-	-	-	-
Generated	1	1	-	-	0	0.0803	-0.0994	0.0206	-0.0994	0.0803	0	-	-	-	-
ACI	1	1	1	-	0	0.077	-0.107	0.036	-0.071	0.036	-0.107	0.077	-	-	-
Generated	1	1	1	-	0	0.0777	-0.1057	0.0344	-0.0727	0.0341	-0.1037	0.0777	-	-	-
ACI	1	1	1	1	0	0.078	-0.105	0.033	-0.079	0.046	-0.079	0.033	-0.105	0.078	0
Generated	1	1	1	1	0	0.079294	-0.10177	0.031235	-0.0801	0.039902	-0.0801	0.031235	-0.10177	0.079294	0

Table 4: Comparison of Generated and Available Moment Coefficients

SPAN RATIO	BEAM CROSS SECTION														
	10”x12”					10”x18”					10”x24”				
	Moment Coefficients (C) at Different Location					Moment Coefficients (C) at Different Location					Moment Coefficients (C) at Different Location				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
1	0	0.0704	-0.1241	0.0704	0	0	0.0708	-0.123	0.0708	0	0	0.0714	-0.1215	0.0714	0
1.2	0	0.0584	-0.1273	0.0754	0	0	0.0588	-0.1264	0.0757	0	0	0.0595	-0.1251	0.076	0
1.4	0	0.0424	-0.1347	0.0801	0	0	0.0429	-0.1339	0.0803	0	0	0.0436	-0.1327	0.0807	0
1.6	0	0.0312	-0.1443	0.0814	0	0	0.0315	-0.1435	0.0816	0	0	0.0319	-0.1424	0.0819	0
1.8	0	0.0192	-0.155	0.0818	0	0	0.0195	-0.1542	0.082	0	0	0.02	-0.1532	0.0823	0
2	0	0.0053	-0.1661	0.0826	0	0	0.0056	-0.1653	0.0828	0	0	0.0061	-0.1643	0.083	0

Table 5: Variation of Moment Coefficient for Cross Section Variation

8.0 LIMITATIONS OF THE STUDY

i. For determining moment coefficients beams of cross section of 10x18 inch. has been used. For small variation of cross section the obtained moment coefficients may be used. But for large variation moment coefficients may vary from those obtained from the analysis.

ii. Span length of the first span has always been considered to be 10 ft. The other span lengths are obtained using the first span length and span ratio. The affect of span length on moment coefficients for two span and three span beams are negligible. But for four span and five span beams moment coefficient is much affected by span length.

iii. For analysis of continuous beams span ratio has been set from 1 to 2 with variation of 0.2. For a span ratio lying within the above range moment coefficients may be calculated by interpolation from table of moment coefficients or from graph.

iv. Moment coefficient has been obtained considering hinge support at both exterior spans of the analyzed continuous beams. But for fixed support at exterior spans moment coefficient will vary from the obtained moment coefficients.

v. The obtained moment coefficients can be used to determine moment of continuous beams for uniformly distributed load only. For point loads the obtained coefficients are not applicable.

vi. Moment coefficient has been obtained considering similar cross section at all the spans. For varying cross section at different spans for the same continuous beam, moment coefficients may vary.

vii. In the design of beam for moment and shear the strength of concrete fc' has been considered to be 3 ksi. With the variation of the strength of concrete fc', design will vary.

viii. In the design of beam for moment and shear the strength of steel fy has been considered to be 60 ksi. With the variation of the strength of steel fy, design will vary.

ix. In the design of beam only ACI-99 design code has been followed.

9.0 CONCLUSIONS

The following conclusions are drawn from the conducted work:

i. Analysis aid for determining moments in continuous beams up to five spans has been developed.

ii. Moment coefficients are presented in this study for ranges of parameters exceeding those of ACI. In this study, moment coefficients are developed for consecutive span ratio up to 2 varying in a set of 0.2 to 1.0.

iii. Moment coefficients developed in this study are compared with those available in ACI and a good agreement was found. However ACI coefficients are found to be more conservative.

iv. Design charts are developed for selection of beam section and reinforcement when the beam moment is available.

v. Design charts are also provided of selection of beam cross section and shear reinforcement when the design shear is known.

vi. Influence of cross section on moment coefficients has been found to be negligible.

RECOMMENDATIONS FOR FUTURE STUDY

Future study may be conducted on the coefficients of continuous beams for the following cases:

i. Development of moment coefficient when loads are not uniformly distributed.

ii. Generation of moment coefficients for lateral load in frames.

iii. Development of moment coefficients for point loads.

iv. Development of moment coefficient for varying cross section at different span for the same continuous beam.

REFERENCES

[1] Nilson A.H. and Darwin D., 1997, Design of Concrete Structures, McGraw-Hill, 12th Edition.

[2] Winter G., Urquart L.C., O'Rourke C.E. and Nilson A.H., 1979, Design of Concrete Structures, McGraw-Hill, 7th Edition.

[3] Wang C.K., 1983, Intermediate Structural Analysis, McGraw-Hill.

[4] Norris C.H., Wilbur J.B. and Uktu S., 1991, Elementary Structural Analysis, McGraw-Hill, 4th Edition.

[5] Reynolds C.E. and Steedman J.C., 1988, Reinforced Concrete Designer's Handbook, E & FN Spon, 10th Edition.

CHALLENGES OF GLOBALIZATION: HOW BANGLADESH CAN ADAPT ITSELF TO REAP THE BEST BENEFITS IN THE 21ST CENTURY

Lt Colonel Sharif Md Abul Hussain

Dir Planning and Development, Bangladesh University of Professionals, E-mail: hussain2682@gmail.com

ABSTRACT

The study investigates specific information regarding the challenges of globalization faced by Bangladesh and how it should prepare itself to coup with the challenges. The result suggest that Bangladesh is not in comfort in coping with the winds of globalization, as it has less access to and use of different opportunities living at the margin in the hierarchies of global order with low technological base, poor infrastructures and governance in most arenas. The study also suggest that Bangladesh needs to be engaged with all its development partners in a healthy and constructive process of interaction on stabilization, reform programme and other critical issues like national capacity building, competitiveness, political stability, cross border terrorism, arms and drug trafficking, climate change and environmental degradation. The policy implication is that various economic policy orientation and utilization of resources should be as such that they can supplement economic growth in a sustainable manner and create avenues for employment.

KEY WORDS: *Benefit, Environment, Globalization, Governance, Infrastructure, Poverty, Population, Policy, Political stability, Resource*

1.0 INTRODUCTION

Globalization is a process of expanding trade and commerce creating borderless market all over the world. Some view it to be the conquest of one by other increasing inequality between nations. Others view it to be benefiting for world economic development and – also inevitable and irreversible.

Bangladesh is exposed to pressure from two major sources in order to bring about changes in domestic governance in the direction of globalization. Primarily it is coming from International Donor Community (IDC), previously through 'Structural Adjustment Programmes' (SAPs) and 'Stabilization Programmes' and currently as a general condition of aid from all external sources, governments to agencies. The transformation of global environment towards market, democracy and individuals with understanding principles of competitiveness is pushing Bangladesh to accept the rules and norms of globalization. Donors are using the concept of "Good Governance" and "Globalization" as part of their global agenda.

The economic benefits of globalization – faster growth, cheaper imports, greater export and investment, and new technologies that the world has enjoyed in recent years are too easily taken for granted. Despite all the gains that globalization brings, it has also created losses – mostly developing countries like Bangladesh whose relative deprivation and marginalization, have led to the perception that globalization is not also irreversible in the aftermath of the failure of the WTO conference, there is a stronger-than-ever perception of the need for deeper exploration of social and political dimensions of globalization – that in order to move forward on the path of free trade and higher economic growth, issues of equity and fairness both within and among nations should be addressed. In fact, the lack of effective governance at national level has prevented the benefits of globalization to reach to the poor peoples of Bangladesh. The impact of globalization, its form, extent and multiple linkages are, therefore, very important in understanding how the process of globalization will unfold in the future, and how Bangladesh will work out its political, social and cultural costs as it tries to reap its benefits in the new millennium.

The significance of globalization differs for individuals, groups and countries. The impact of various global flows varies depending on the stage of economic development of a country, its access to technology, strength of its state and democratic institutions, and cultural characteristics. In other words, the heart of the matter is the "Differential

Access" to power, where power is conceptualized as the capacity to transform material circumstances – whether economic, political or social and to achieve goals based on the mobilization of resources, the creation of the rule system, and the control of infrastructures and institutions. The differential, unequal, and uneven access to the dominant organizations, institutions and processes of the new global order has, therefore, come under increasing attack.

Like many other developing countries, Bangladesh is not in a comfortable position to cope up with the winds of globalization, as it has less access to and use of different opportunities, living at the margin in the hierarchies of global order with low technological base and weak industrial infrastructure. The impact of globalization, its form, extent and multiple linkages are, therefore, very important in understanding how the process of globalization will unfold in future, and how Bangladesh will work out its political, social and cultural costs as it tries to reap its benefits out of it.

This study is descriptive in nature. It aims to find out specific information regarding the challenges of globalization faced by Bangladesh in different sector. The scope of the paper has been kept limited in determining the ways to reap benefits of globalization and a recommended approach to address the challenges faced by Bangladesh in 21st century.

2.0 AIM

The aim of this paper is to study the challenges of globalization faced by Bangladesh to determine the ways to reap the benefit in the 21st century

3.0 THE CHALLENGES OF GLOBALIZATION FACED BY BANGLADESH

3.1 GENERAL

Technology has made the whole world a global family. Sharing of culture, behavior and experiences have overcome the territorial boundaries. The challenges faced by Bangladesh in terms of globalization in social, political, cultural, economic fields are enumerated in the subsequent paragraphs.

3.2 THE STATE OF ECONOMY

The absence of law and order, the rampage by terrorists, the sway of fundamental fanaticism, the desperate situation of education, the crowding by the masses of unemployed people and the misery of millions of poor depict a picture of terrifying hopelessness. The country is singularly resource poor. It does not have enough mineral or natural resources from which income can be easily generated to use for the welfare of its vast masses. The miserable state of human resources is a cause for serious concern. Looking at the deprivation level in the education, nutrition, health and shelter and judging the poverty and unemployment scenario, many observers note the inevitability of the state of nature in Bangladesh.

3.3 LACK OF QUALITY EDUCATION

The learning materials are pedantic and rather formal and do not impart practical knowledge to the students. The teaching methods are archaic and irrelevant. The overall interest in education is limited because female education was not emphasized in the past.

3.4 LOW AGRICULTURAL PRODUCTION

Unbalanced Application of chemical fertilizers can be attributed for degrading soil fertility. Croplands are also depleting fast. The amount of land lost for urbanization every year is not supplemented by the increased productivity.

3.5 THE ENVIRONMENTAL REALITY

The environment of Bangladesh is extremely fragile. The people-resource ratio is very adverse. The pressure of population on the natural resources of the country is very great and on the top of it are constraints of poverty and illiteracy. The needs of poor do not allow for conservation of the environment and lack of education stands in the way of ecological consciousness.

3.6 THE PROBLEMS OF GOVERNANCE

The problems are three levels; firstly, in the political processes which gives the country its government. Secondly, in the structure of the government this determines the various layers of its operation. Finally, in the administrative structure and practices which execute the programmes of the government.

3.7 POVERTY IN BANGLADESH

Bangladesh has been experiencing with a mix of macroeconomic, sectoral, institutional and target oriented strategies to combat the problems of poverty.

3.8 The Weakness in Population Planning Programme

The demand for family planning services is very strong and facilities are not sufficient to meet this demand. The allocation of resources for health and family planning sector is very meager. The total public expenditure on health and population planning is only 0.9 percent of Gross Domestic Product (GDP).

3.9 Cynicism and Disregards

Cynicism and disregard for moral and legal principles are now reigning among a large segment of political activists and general mass and are often sheltered by political parties. The ubiquitous nature of politics has already intensified social insecurity – the organized crime, pervasive violence, lack of confidence in police and corruption in public institutions have undermined the ethics of citizenship and the image of the nation. However, recent steps taken by the present government to improve the law and order situation by reorganizing the law enforcing agencies have brought some positive results and earned good reputation of the international community.

3.10 Lack of Sustaining Democratic Governance

In Bangladesh, political leadership has been falling again and again in sustaining democratic governance. To ensure overall development of the country and to face the challenges of globalization, the present democratic process of governance of Bangladesh needs to be upheld at any cost.

3.11 Foreign Direct Investment

Bangladesh has been trying to attract foreign investment but so far no significant level of investment has been forthcoming due to a number of reasons, political instability being the main. Other reasons are listed below:

a. The linkage between prosperity, choice and freedom creates more tensions and challenges. The challenge before Bangladesh is how to attain this goal in an environment where major economic decisions affecting national life are often determined by the international markets.

b. The basic challenge facing Bangladesh is to comprehend the nature of changes taking place in the international economy and to deal with them through creating conditions and institutions necessary for coping with a dynamic environment.

c. The main objectives of Bangladesh's foreign policy viz upholding its sovereignty, cultural identity, ideologies are challenged by the forces of globalization.

d. In the environment sector Bangladesh faces a number of challenges concerning the control of the flow of Ganges water by India, desertification, deforestation, global warming and so on.

3.12 Garments Sector

It is not easy for Bangladesh to specialize in manufactured exports. Having low wage costs can hardly compensate for its lack of marketing skill, infrastructure and poor overall investment climate. Moreover, the high degree of dependence of domestic industries on imported raw materials and industrial inputs makes it difficult for Bangladesh to satisfy the so called "Rules of Origin" in getting preferential access for its exports in the markets of the developed countries. Most of Bangladesh's garments exports are not eligible for tariff concessions given under the Generalized System of Preference (GSP) in the EU market. The removal of the Multi Fiber Agreement (MFA) quotas now threatens to increase competition in the global garment industry and thus limits Bangladesh's growth. More than 5.9 million people directly or indirectly (Directly 3.4 and Indirectly 2.5) involved with this sector which provides 77 percent of total export earning of the country is threatened by recent workers unrest. Among many minimum wage is the important one such unrest in the garments sector.

3.13 Country Security and Foreign Policies.

In the era of globalization, Bangladesh, like other developing countries, is confronted with threats emanating from both external and internal sources: terrorism, drug trafficking, circulation of light weapons, poverty, political instability, environmental degradation and so on. The main purpose of Bangladesh's foreign policy in the present era should be minimizing the degree of vulnerabilities and reducing threats to its security, as well as possessing the ability to shape its

security environment through an effective and realistic assessment of its national interest, and the promotion thereof through pragmatic and active diplomacy.

4.0 WAYS TO REAP BEST BENEFIT IN THE 21ST CENTURY

4.1 GENERAL

The globalization process offers both opportunities and poses challenge for Bangladesh. It has both positive as well as negative impacts. The positive impacts include influence on parliamentary democracy and adult franchise, a global outlook and modern mindset of the people, the positive effect on education, environment and women emancipation, access to IT, the entrance into global trade, marketing and joint-venture entrepreneurship and the availability of high quality and low cost products. The negative impacts include the downfall of local industries and products and competitiveness resulting in local unemployment, the threats to the survival of culture, community norms, ethics and values, the widening of the gap between the rich and poor; and the foreign dominance and dependency on investors. Bangladesh, although poor in most respect, is not entirely without resources. It has manpower (cheap labour), water resources and mineral resources (coal, gas and oil), if mobilized effectively, its vast but homogeneous and resilient population can take advantage of the information technology that is now available and in the process create a pool of skilled labour force. The per capita low-income in Bangladesh can be attributed to the workers inadequate training, capital and technology. The liberal international trade has led to an increase in the level of employment. Therefore, there is an urgent need for Bangladesh to conduct its economic diplomacy with vigor and vision. The ways to reap benefit from different sectors are enumerated in the subsequent paragraphs.

4.2 FOREIGN POLICY

The foreign policy of Bangladesh should focus to broaden the scope for prosperity through the creation of a modern and efficient economy. It is mandatory for Bangladesh to make diplomatic efforts to make it possible for the Bangladeshi workers to work in other countries where there re better opportunities. In this era of competition, Bangladesh will not necessarily get what it thinks to deserve but only what it can negotiate. If the issue is not negotiated through legal means, it is not impossible that labour would flow out of the country illegally.

4.3 FREE FLOW OF INFORMATION

Bangladesh needs to take advantage of the opportunities that globalization offers through the free flow of information and the use of English as an international language. This would help produce a better-trained workforce capable of competing at the international level. It is well know that productivity is linked to skills and knowledge.

4.4 ACCESS TO MARKETS

Bangladesh has to negotiate preferential access to the markets of the western developed countries, as well as those of India and China, huge trade gap in the bilateral trade relations has to be redressed. In the era of competition, Bangladesh will not necessarily get what it thinks to deserve but only what it can negotiate.

4.5 POVERTY ALLEVIATION

Poverty is a source of insecurity for Bangladesh. But whether globalization as such would alleviate poverty is debatable. However, the alleviation of poverty depends on the capacity of Bangladesh to mobilize resources in an optimum way. There is something that can be achieved if there is political stability inside the country. A truly stable democratic system can function only when there are robust democratic institutions and a vibrant civil society. Inability to achieve political stability would not only result in our failure to take advantage of the positive aspects of globalization but our foreign and economic policy agenda would be set outside the country.

4.6 GOOD GOVERNANCE

Openness in government operations should be the rule rather than the expectations. This has two implications for macro-economic performance. Firstly, it will expedite economic decisions as it will follow an open process and will not be turned in to deal making as it usually is. Secondly, it will secure the commitment of the nation to any programme of action. The measures for open government will be in many areas but most importantly it will mean parliamentary consideration of important issues and many topics, which are now considered secret.

4.7 SUSTAINABLE DEMOCRACY

Certain basic issues such as economic policy framework, foreign policy and international relations, specially water sharing with Nepal and India, transit facility with India, development of growth quadrangle, asset settlement with Pakistan, reform in important economic sectors, public service restructuring and reforms and local government structure and reorganization should be discussed in the parliament. Public representatives should be allowed to finalize policies after ascertaining the views of the civil society through hearings and dialogues. To have constructive discussion in the parliament political parties should be more accommodative in accepting and criticizing others.

4.8 RULE OF LAW

The broad category of issues relating to the rule of law is to be reorganized. This covers human rights, law and order situation and the judicial system of the country. The rule of law is not simply a sine-qua-non for a civilized society but also a precondition for investment growth and economic vitality.

4.9 FUNCTIONAL AREA IMPROVEMENTS

Political reorganization by itself cannot deliver modernization. For modernization and development both political and administrative reforms are equally important for any country. In the field of administration following areas may be addressed:

a. POLICY MAKING FUNCTION.

Policymaking functions must be strengthened. One of the major weaknesses in Bangladesh administration is the policy making and policy planning capacity. The incompetence of the democratic governments, which is so obvious, is partly because of the institutional weakness of policy planning apparatus. This has to be rectified by the practice of the democracy at all levels and induction of political appointees at higher levels of government.

b. POVERTY ALLEVIATION STRATEGY:

Poverty alleviation is both a social and economic imperative in Bangladesh. The deprivation of the vast masses is socially unsustainable and political stability and social peace demand poverty eradication. Bangladesh can be a vast market only when its people are not too poor and have enough purchasing power.

c. POPULATION PLANNING.

Another sector warranting urgent attention is population planning. Unless population growth is arrested, poverty reduction will be a distant dream. Population planning is not only family planning but it covers matters relating to health care and sanitation is particular infant mortality care are of serious significance.

d. INFRASTRUCTURE DEVELOPMENT.

Infrastructure investment deserves priority attention because of its potential for employment generation. Institutional strategies can be pro-poor on the one hand and on the other indifferent to poverty problem if not adverse outright. Institutional reforms aiming at empowering the poor are fundamental to poverty eradication. The various strategic can be in the areas of labour policy, land and tenurial laws, credit system, small and medium enterprise (SME) development and above all restructuring of local governments. The promoters and organizers of poverty programmes must form coalitions or groups of the poor and at the same time legal and regulatory support should be provided by the government. In Bangladesh measures should be taken for the registration of the rights of sharecroppers with a view to providing good support to groups of poor people so that they can put in their best efforts to improve their economic conditions. Such practices are the empowerment of the poor. Above all mass education is the strongest empowering instrument; it is indeed the great leveler.

e. WOMEN EMPOWERMENT.

It is also important that legal provisions are made for affirmative action for the poor and especially women. Representation of women in political and social forum must be ensured empowering them, as they are the most discriminated and deprived class of the society.

f. EMPLOYMENT CREATION.

Targeted programmes are another kind of interventions that can have salutary impact on poverty amelioration. In order to enhance employment creation activities Bangladesh should launch targeted programmes such as package programme for under developed or backward areas or communities. Programmes for income generating activities encompassing matters like training, credit and marketing, schemes of transfer payments to help the poor and the disadvantaged needs to be enhanced. Bangladesh needs

opportunities for employment and for income generating activities. The government and the NGOS working in Bangladesh should undertake the two programmes widely for income generation poor people can be provided with some credit in the form of working capital for whatever they are used do doing.

g. FOOD PRODUCTION.

Food production can be increased under the existing smallholding that we have in the country. Problem lies in the input output prices for the agricultural sector. Growers have no control over any of them. Paddy, potato and vegetable prices go down sharply at harvesting time, as small growers cannot hold them. Farmers mostly sell their output forward to moneylenders and middlemen, as they cannot finance purchase of inputs, seed fertilizer and water from their savings that never accrue to them. The scaling up of MFIs should cover crop production and storage. This will have tremendous impact on the income of farmers and they will in turn invest and consume more of their goods and services.

h. STRENGTHENING OTHER SECTORS.

Bangladesh should utilize revealed strengths in Ready Made Garments (RMGs), NGO-MFIs and give incentives to the farmers to produce more. We must try to reduce our weaknesses in delivery of certain public services such as education and health, law and order.

I. QUALITATIVE EDUCATION.

Enrolling more girls to school and colleges is good provided they obtain certain skills in language and quantitative analysis in the least. Currently very little is learnt and the system loss in failure to public examination is huge. Education must be an essential element in poverty reduction strategy.

4.10 INVESTMENT CLIMATE.

In Bangladesh, high cost sour investment climate. Bangladesh is not the cheapest country in Asia as per as the investment related cost is concerned. The cost of water in Dhaka (US$ 0.32 oer cubic meter) is higher than shenzen (US$ 0.23), Sanghai (US$ 0.15) and Hanoi (US$). The monthly basic charge for mobile phones, price of gasoline and cost of passenger car in Bangladesh is also higher than average cost of those items in Asia. The wage of workers in Bangladesh is the second cheapest in Asia. But a foreign investor considers not only the wage of workers but also the cost of electricity, water, transport, telecommunication, taxation and so on for an overall evaluation before he can make the decision.

4.11 FOREIGN INVESTMENT.

Foreign investment is definitely essential for economic development of Bangladesh. For attracting foreign investment to come to Bangladesh without going to China, Vietnam or to other Asian countries, it is essential to make the investment climate much more attractive than that prevailing in those countries. Bangladesh can take up the following four measures to make the investment climate attractive:

a. Firstly, the costs comparatively higher than other countries should be lowered, as an enterprise will always invest in a country where the return of investment is high.

b. The second suggestion is for continuity of policy matter. An investment is always made in long-term considerations and therefore, it is never desirable that a policy is changed thoughtlessly or a project in progress is suddenly cancelled due to policy change, especially due to change of the power from one political party to another.

c. The third one is improvement of infrastructure facilities. For example, ensuring a steady supply of electricity, gas at a reduced cost.

d. The fourth recommendation is for instituting fairness and speed in approvals given by different government departments.

4.12 FRAMING OF DEVELOPMENT STRATEGY.

Trade policy should not form the basis of an overall growth and development strategy in the policy of Bangladesh. The development strategy must be constructed around country specific characteristics in a manner that efficaciously manages trade associated with globalization. This does not necessarily dictate greater economic integration through increased trade and capital flows. Two shining example of countries that benefited from conscious efforts are Chile (Following the stabilization plan in the 1970s) and Malaysia (following the Asian Financial Crisis). Globalization is an inescapable reality that offers choices for national economic policies. Hence, the policies of Bangladesh must be made consistent within a framework of principles that appreciate individual country characteristics. If policy

makers are able to maintain there perspectives, the best of times are indeed ahead of us.

4.13 GLOBALIZATION AND NATIONAL CULTURE.

Globalization is a process that involves free and unrestricted interactions between nations of the world largely as a result of deregulation and improved communication and media channels/ The fear that globalization will affect our culture adversely by exposing it to foreign and in many cases wholesome influences is not justified. Our traditional values, beliefs and attitudes are not newly acquired possessions and hence, not so delicate as to be corrupted from exposure to foreign influences in he wake of globalization. The process of globalization can bring before the whole world the genuineness, the natural simplicity and the element of humanity that are treated as the fundamental features of our culture. Globalization can also enable us to benefit form the advanced refined cultures of other nations of the world. Something that is good and authentic has nothing fear for its existence and survival. The intrusion of foreign culture should not be any threat to our cultural identity. Because, firstly, there is solidity in it and secondly, it has stood the test of time. We are in possession of a type of culture that has the inherent strength, refinement and robustness to withstand the stand however stupendous they might be.

4.14 INTEGRATION OF NATIONAL ECONOMY.

The increasing integration of national economies into global markets if properly carried out, certainly promises to alter dramatically the volume and character of the gain of Bangladesh from international trade and resources flow in to the economy of Bangladesh. Besides, the increasing size, competitiveness and diffusion of financial markets have the potential to draw the economy of Bangladesh into the global economic mainstream if Bangladesh can create the necessary conditions and also fully exploit the comparative advantage of Bangladesh in specific areas. The phenomenal success of the RMG sector of Bangladesh is a case.

5.0 HOW TO ADDRESS CHALLENGES GLOBALIZATION – SOME RECOMMENDATIONS

Globalization is an economic parallel to international isolation in the form of universal rule of the market, free trade and global flow of capital through spread of information technology. Bangladesh is not in comfort in coping with the winds of globalization, as it has less access to and use of different opportunities living at the margin in the hierarchies of global order with low technological base and poor governance in most arenas. I would like to suggest some ways and mean to address global crises confronting Bangladesh.

6.0 NEED FOR GOOD GOVERNANCE

Bangladesh needs improvement on the normative structural and substantive aspects of policy and political framework. The normative political discourse and ideological question of culture needs to be linked with the issue of political leadership as a factor in regime legitimization.

The entire civil society comprising businessmen, journalist, professionals and intellectuals should mobilize public opinion towards creating the must crucial broad consensus on vital national issues and resolving power conflicts in a peaceful manner. There should be some political reforms so as to make individual politicians or parties responsible for their policies and actions whether in power or out of power.

The good governance hinges mainly on how the law is used by the state as an instrument of public policy that holds moral conduct that would be a matter of rule following and moral relationship to consist of duties and rights determined by rules. The globalization process should be brought to ensure that such moral conduct is reflected in the legal framework of governance. In fact, economic globalization will be fruitless without political liberalization and reduction of social marginalization.

The rule of low is not simply a sine-qua-non for a civilized society but also a pre-condition for investment growth and economic reality. There should be law and order for investment to take place and production to multiply. Participatory governance in Bangladesh should serve to enhance the voice of the poor, thus helping to improve the quality of public health, education and social services delivery.

7.0 NEED FOR IMAGE BUILDING

Bangladesh is misrepresented to the world as a country of natural calamity, violence, and intolerance and population boom. The process of globalization where interaction will be more will

create ample scope to let know the real picture of Bangladesh and its people. The main role in this connection should be played by the media and Foreign Service department in different countries in picturing a good image of the country.

8.0 BENEFITING FROM ENGLISH LANGUAGE

The process of globalization obviously requires a common language for International Communication. For many different reasons, English has achieved the pristine of being that language. As a result it has crossed the national benders to reach people who speak other languages. As more and more people speak English, more and more varieties have emerged which are strongly influenced by the pronunciation, grammar and idioms of respective mother tongues. World English has now moved away from the control of its native speakers. In order to enhance 'mutual intelligibility among users of the English language, English Language training should be designed properly to promote productivity.

9.0 ENHANCING THE MODERN TECHNOLOGICAL BASE

Globalization is now largely based on a strong technological foundation. The electronic transfer of information via Internet has now created an instantaneous and interconnected world of information resulting in a 24 hour trading network. The advancement in information and technology will help disseminate knowledge in the field of study and technology. Globalization is now only what technology makes possible.

10.0 ENHANCING THE CAPACITY FOR WORK IN BANGLADESH

Bangladesh will have to take revolutionary steps for expansion of the capacity for work for its people. The following strategy of energy development may be adopted:

a. Demand and supply of energy should be planned on the basis of discrete areas into which the country should be divided.

b. For electric power generation and distribution, waiting applicants for generation of power should be permitted to undertake a large number of projects. The monopoly of power Board in supply of power to customers should be broken.

c. The policy on trading energy resources must be very pragmatic. Coordinated planning of energy development and supply should enjoy priority in Bangladesh. However, equally gigantic is the need for enhancement of the capacity for work for a huge number of people. If the problem is dealt with on a regional basis, the solution of the problem becomes manageable.

d. The over all investment in the energy sector in Bangladesh is quite low. A total of 1.5 to 1.75 percent of the GDP is the investment of the country on energy development and supply. For the rapid growth of energy sector, Which is an imperative of the highest order, the rate of investment must be accelerated to about 5percent of GDP. For the discovery, exploration and development of energy resources, large and lumpy and long term investments and needed.

11.0 CAPITALIZING THE EXCELLENCE OF PROFESSIONALS :

Globalization is the subject per excellence for the engineers. The engineers have all through played a significant rule; though never dominate one, in the globalization process. Engineers will have to join forces with biologists, chemists, meteorologists, economists, planners, political scientists, ethicist and community leaders in unprecedented ways to lead society on a sustainable path. They must play a much stronger role in the public policy process to provide the right incentives for industry and other to move on a sustainable path so that engineers can be supported and encouraged to design sustainable technology. The engineers of Bangladesh should accept the idea of globalization as an emerging and powerful global reality and to formulate strategies to manage it to minimize the adverse effects and maximize the gains form it.

12.0 HUMAN RESOURCE DEVELOPMENT

The lack of quality education and skilled teachers, poor educational infrastructure and outmoded syllabus are some major impediment to more successful basic education. For raising the standard of education, monitoring and supervision, Bangladesh can establish some sort of institutional framework to enable the private sector to take the lead in investing in the basic education sector. The government should exempt tax on donation in the education sector so that the private sector feels more encouraged to play a

more proactive rote. For an industrial society of flourish, learning must receive the highest priority, a revolution must take place i freethinking and the spirit of enquiry must be all pervasive.

13.0 INCREASING THE PRODUCTIVITY IN AGRICULTURAL SECTOR

Unbalanced application of chemical fertilizers can be attributed for degrading soil fertility. Now the soaring process of TSP and MP act as a disincentive to applying balanced dozes of fertilizer. Croplands are also depleting fast and rice is grown on 75 percent of arable land, which does not augur well for other crops. Seizing the opportunity of globalization, newer technologies should be evolved so that per unit productivity sees a phenomenal growth. The wide gap between rice yields at breeders' plots and farmer's fields needs to be bridged.

14.0 CREATING A CONGENIAL INVESTMENT CLIMATE

For a dynamic investment climate, Bangladesh should confront the following pre conditions considered conducive for investment:

a. Primacy of political pluralism.
b. Establishment of the rule of law.
c. Dominant role for local government and community initiatives.
d. Rapid spread of education.
e. Widespread dynamism in agriculture sector.
f. The environment of an open and competitive economy.

15.0 ATTRACTING THE DIRECT FOREIGN INVESTMENT (DFI)

In a country lake Bangladesh where local investors are shy, it is very difficult to attract foreign investors. Besides, many of the advantages sought by DFI are not readily available in Bangladesh. To cope with the situation, travel must be made free as transactions have recently been made so, energy supply must be efficient and reliable and the regulatory culture must be abandoned, financial and physical infrastructure must be made hospitable and an educated labour force should be created.

16.0 ALLEVIATION OF POVERTY

The poverty problem in Bangladesh is extremely difficult. The only way to overcome this predicament is development of human resources at a rapid pace and acquisition of high-level skills. In order to create employment opportunities for its vast.labour pool and wealth that can be shared by the deprived there must be investment output growth. Social investment must grow to improve the quality of life and enhance the productivity of the human resources of Bangladesh. Local government should be strengthened for social investment, employment programme, environment protection and infrastructure development.

17.0 CONCLUSION

Like many other countries Bangladesh faces the challenges of globalization. It deserves mention that technically deficient developing and least developed countries are at a very disadvantageous position to reap the potential benefit from globalization. Bangladesh has to be engaged with all its development partners in a healthy and constructive process of interaction on our stabilization and reform programme and other critical issues. There are many developing countries that do not benefit from the opportunities offered by globalization. Therefore, Bangladesh should want an inclusive globalization form below and with a human face making consultative mechanisms more focused and effective at all key decision-making points.

The most pressing task before Bangladesh is to achieve political stability. As long as Bangladesh is domestically not in order, it would not be realistic to expect it to have a credible and effective foreign policy.

Bangladesh needs to deal with challenges like transnational economic and financial forces, crops border terrorism, arms and drug trafficking, climate change and environmental degradation through co-operation and coordinated efforts at both regional and international levels. The objective of Bangladesh foreign policy should be to minimize the degree of vulnerabilities and reduce threats to its security as well as possess the ability to shape its security environment though an effective and realistic assessment of its national interests and the promotion thereof through pragmatic and active diplomacy.

Globalization syndromes generate a major policy challenge for the people and government of Bangladesh. Neo institutionalism is a right kind of

approach for Bangladesh, which takes in to consideration the critical issue of national capacity building and competitiveness. The pursuit of transnational integration and convergence will have to be associated with adequate domestic preparedness for competitiveness.

The various economic policy orientation and utilization of resources should be as such that they can supplement economic growth in a sustainable manner and create avenues for employment.

REFERENCES

[1] Baker, Dean et al, "Globalization and Progressive Economic Policy", Cambridge University Press, UK, 1998.

[2] Khan A R, "Globalization and Non-traditional Security in South Asia" Rgional Centre of Str4ategic Studies, Colombo, pp 88-273, 2001.

[3] Scholte, Jan Arta, "Globalization: A Critical Introduction", Mac-Millan Press Ltd, London, 2000.

[4] Bazlul Haque and et el, "The Era of Globalization and Emerging Issue: Challenges and Plolicy Options for Bangladesh", Volume XIV, Number II, p 107 (Science Review), December, 1998.

[5] Nayyar, Deepak, 2000, 'Gloalization and Development Strategies', UNCTAD Discussion Paper X, 2/OO.

[6] Nicholas Crafts, "Globalization and Growth in the Twentieth Century", IMF Working Paper, WP/00/44, Washington DC, April 2000.

[7] Centre for Policy Study, " Independent Review of Bangladesh Development", Volume II page 135, University Press Limited, 1991.

[8] Chowdhury, Toufic A, and Raihan, Ananya, " Implications of WTO on the Banking and Financial sector of Bangladesh", (Unpublished research report). BIBM, Dhaka, 1999.

[9] Dr. Ataur Rahman, " The Concept of Globalization", The Daily Star (Dhakja), January 29, 1999.

[10] M A Muhit, "Bangladesh in the twenty First Century" University Press Limited, p 112, 2003.

[11] Ruksana Kibria, "Globalization and Bangladesh's Security and Foreign Policies", Internet Eddition;2002.

[12] R Sohan and M Ahmed " Public Enterprise in and intermidiate Regime; A study in Political Economy of Bangladesh", BIDS, Dhaka, 2004.

[13] World Bank, " Private Capital Flows in Developing Countries", Oxford University Press, pp 9-13, 1997.

[14] "Globalization and Engineers of Developing Countries", The Daily Star, January 16, 2003.

[15] Rehman Sobhan, Interview with Sabir Mustafa, " The Daily Star" March 3, 2002.

[16] "Some Effects of Globalization", The Bangladesh Observer, January 23, 2001.

[17] Asian Development Outlook 2001 – Part III Asia's Globalization Challenge – ADB org.htm.

[18] Centre for Plicy Dialogue " The Daily Star (Dhaka)", March 15, 2004.

[19] http://www.GlobalEnvision.org

STRENGTH BEHAVIOR OF MORTAR USING SLAG AS PARTIAL REPLACEMENT OF CEMENT

Md. Moinul Islam[(1)], Dr.Md.Saiful Islam[(1)], Md. Aftabur Rahman[(1)] and Amrita Das[(2)]

1. Department of Civil Engineering, Chittagong University of Engineering and Technology

E-mail: moinul91@yahoo.com

2. Graduate, Department of Civil Engineering, Chittagong University of Engineering and Technology

ABSTRACT

This paper presents an experimental investigation carried out to study the effects of Ground Granulated Blast Furnace Slag (GGBFS) on strength development of mortar and the optimum use of slag in mortar. Cement was partially replaced with seven percentages (10%, 20%, 30%, 40%, 50%, 60% and 70%) of slag by weight. Ordinary Portland cement (OPC) mortar was also prepared as reference mortar. A total of 400 cube and briquet mortar specimens were cast and compressive as well as tensile strength of the mortar specimens were determined at curing age of 3, 7, 14, 28, 60, 90 and 180 days. Test results show that strength increases with the increase of slag up to an optimum value, beyond which, strength values start decreasing with further addition of slag. Among the seven slag mortars, the optimum amount of cement replacement is about 40%, which provides 19% higher compressive strength and 25% higher tensile strength as compared to OPC mortar.

KEY WORDS: *Slag, Cement, Mortar, Compressive Strength, Tensile Strength, Hydration.*

1.0 INTRODUCTION

Portland cement is and will remain a major construction material of choice in Civil Engineering construction. It is the most important constituent of concrete. Unfortunately, cement manufacturing consumes large amount of energy amounting about $7.36*10^6$ kJ per ton of cement (Tarun, 1996). Also, approximately 1 ton of CO_2 is released into the atmosphere during the production of 1 tonne of cement (Min-Hong, 2001). Thus partial replacement of Portland cement in mortar / concrete by mineral by-products such as slag, fly ash, silica fume, etc, can significantly reduce CO_2 emission (Ozkan, 2009).

Blended cements contain, in addition to Portland cement clinker and calcium sulfate, a latently hydraulic component such as granulated blast furnace slag or Class C fly ash, or a pozzolanic component such as natural pozzolan, Class F fly ash, condensed silica fume, calcined clay or a filler component such as limestone. The most common reason for blending ordinary Portland cement with these additions is economic. However, blended cements can be formulated to perform better than ordinary Portland cement and it offers a number of potential advantages to the manufactures: (a) increased plant capacity without the installation of a new kiln (b) reduced fuel consumption per ton of cement (c) reduced CO_2 emissions per ton of cement (d) control of alkali-silica reactivity even with high-alkali clinker (e) reduced production of cement kiln dust if the alkali content of the clinker is increased (f) improved durability due to the replacement of $Ca(OH)_2$ with additional C-S-H.

Blast furnace slag is a by-product obtained during the manufacture of pig iron in the blast furnace and is formed by combination of earthy constituents of iron ore with limestone flux. When the molten slag is swiftly quenched with water in a pond or cooled with powerful water jets, it is formed into a fine, granular, almost fully non crystalline, glassy form known as granulated slag having latent hydraulic properties. Such granulated slag when finely ground and combined with Portland cement, has been found to exhibit excellent cementitious properties (Hwang, 1986). The reactivity of ground granulated blast furnace slag (GGBFS) is considered to be an important parameter to assess its effectiveness in concrete composites (Smolczyk, 1978).

Slag is used in concrete to achieve energy conservation, economic, ecological and technical benefits. It is used as pozzolanic mineral admixture in concrete and also has the hydraulic properties. According to ASTM C125, Pozzolan is a siliceous or siliceous and aluminous material which itself possesses little or no cementitious value but in finely divided form and in the presence of moisture, chemically reacts with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. According to ASTM C125, blast furnace slag is defined as the non-metallic product consisting essentially of silicates and aluminosilicates of calcium and other

bases that is developed in a molted condition simultaneously with iron in a blast furnace.

ASTM C989, adopted in November 1982, provides for three strength grades of slags, depending on their respective mortar strengths when blended with an equal mass of Portland cement. The classifications are Grade-120, Grade-100 and Grade-80, based on the slag-activity index expressed as SP/P X100, where SP is the average compressive strength of slag cement mortar cubes and P is the average compressive strength of reference cement mortar cubes made without slag. Grades 100 and 120 are the most commonly used as admixtures in concrete. The chemical constituents of most of the blast furnace slags fall within the ranges shown in Table-1.

2.0 HYDRATION CHARACTERISTICS AND STRENGTH DEVELOPMENT OF SLAG MORTAR

When GGBF slag is mixed with water, initial hydration is much slower as compared with Portland cement. Therefore, Portland cement or alkali salts are used to increase the reaction rate. In the hydration process, GGBF slag produces calcium silicate hydrate cement paste. This valuable contribution from GGBF slag improves the paste-to-aggregate bond in concrete. GGBF slag mixtures with Portland cement typically result in greater strength and reduced permeability. The principle constituents of blast furnace slag are silica, alumina, calcium and magnesia (reported as oxide), which comprise 95% of slags total makeup. Minor elements include manganese, iron and sulfur compounds as well as trace quantities of several others. Like Portland cement, most of the calcium oxide (CaO) found in GGBFS is tied up as calcium silicate, calcium aluminates and calcium aluminosilicate. Although these compounds are not identical to those found in Portland cement (i.e., tricalcium silicate, tricalcium aluminate, etc.), they hydrate when activated by calcium hydroxide (lime) which is one of the by-product of Portland cement hydration.

Slag blended cement increases the compressive and flexural strength of conventional concrete and is often a vital component in producing high strength concrete. 28-days concrete strengths generally increase as the percentage of slag content increases up to about 50 percent of cementitious material. When Portland cement reacts with water, it forms calcium silicate hydrate (CSH) and calcium hydroxide ($Ca(OH)_2$). CSH is the glue that provides strength and holds concrete together while $Ca(OH)_2$ is a by product of Portland cement hydration that does not contribute to strength. When slag cement is used as part of the cementitious material in a concrete mix, it reacts with water and $Ca(OH)_2$ to form more CSH. The additional CSH densifies the concrete matrix thereby enhancing strength.

The reactivity of slag, to a great extent, depends on its composition. In general, the more basic the slag, the greater its hydraulic reactivity in the presence of alkaline activators; the higher the glassy phase, the lime, alumina and magnesia contents, the higher the hydraulic reactivity. In many specifications basicity is quantitatively defined as a mass ratio between the sum of ($CaO+Al_2O_3+MgO$) and SiO_2, which is known as the basicity factor. For instance, a basicity factor of ≥ 1 is used in Germany to evaluate slags for use in blended cements. A high MgO content in some North American slags may sometimes be of concern for the formation of expansive particles. However, Stutterheim (1960) investigated concretes made from blended cements containing 50% slag having up to 20% MgO and found that these cements were as sound as comparable Portland cements, although he recommended that high MgO slags to be checked for soundness before use.

According to ACI Committee 226 (1994), the greater solid volume and higher fineness of slag allow more coarse aggregate to be used without a loss of workability. This often reduces the stickiness of the mix. Meusel and Rose (1983) investigated highly active slag at contents of 30%-50% in concrete and found that the slag improved the workability in all cases, but greater improvement was obtained with higher slag contents. High fineness of the slag component did not have a significant effect on the workability. Stutterheim (1968) observed that slag concretes had appreciably better workability than Portland cement concretes allowing for reductions in water content. According to Roy (1982), the effect of slag on workability is less pronounced than that of fly ash.

According to Gee (1979), early strength development in slag cement is affected by the chemistry of the clinker since the manner in which it releases calcium and alkali cations affects the rate of hydration of the slag. Clinker can be formulated with high lime content for use in blends with high slag contents. Hooton and Emery (1983) found that the compressive strength of slag cement mortars could be related to the chemical composition, fineness of grinding and degree of vitrification of the slag. Meusel and Rose (1983) observed that replacing 30% - 50% of the cement with a highly

active slag increased the concrete strength at 7 days and beyond. They recommend the optimizing of the slag content on the basis of mortar strengths.

When slag blended cement and water are mixed, a chemical reaction called hydration initiates, resulting in the creation of calcium-silicate-hydrate (CSH) and calcium hydroxide (CH). CSH is a gel that is responsible for strength development in Portland cement pastes. Also, through pozzolanic activity, slag combines with free lime to produce the same cementitious compounds formed by the hydration of Portland cement. Hydration rate of slag is slower than that of Portland cement. So the blending of slag and Portland cement leads to retard the rate of strength development at early ages of curing.

3.0 HEAT OF HYDRATION

The hydration of cement is an exothermic reaction. High amount of heat is generally developed during this reaction. The generated heat causes the rise in temperature and accelerates the setting time and strength gain of mortar. In many structures, the rapid heat gain of cement increases the chances of thermal cracking leading to reduce concrete strength and durability. The applications of replacing cement by high percentage of slag can reduce the damaging effects of thermal cracking.

The hydration mechanism of slag is different from that of cement. When cement comes into contact with water, the dissolution of some phases takes place quite rapidly. But when slag is mixed with water, initial hydration is much slower than cement mixed with water. Hydration of slag in the presence of cement depends upon the breakdown and dissolution of the glassy slag structure by hydroxyl ions released during the hydration of cement and also the alkali content in cement. The hydration of slag consumes calcium hydroxide and uses it for additional CSH formation. According to Regourd (1980), Vanden Bosch (1980) and Roy and Idorn (1982), hydration of slag, in combination with cement, at normal stage, in general, is a two stage reaction. Initially and during the early hydration, the predominant reaction is with alkali hydroxide, but subsequent reaction is predominantly with calcium hydroxide. As a result the rate of heat liberation is correspondingly slow.

4.0 RESEARCH SIGNIFICANCE

Concrete is a commonly used construction material all over the world since last century. Concrete consumption in the year of 2000 was 12 billion tons (Mehta, 2002). World population in the year 2000 was six billion. Based on this population, two tons of concrete is used per capita per year. Due to rapid development of infrastructures of developing countries, it is expected that in year of 2050, annual consumption of concrete would reach 18 billion tons per year. Typically concrete contains about 15% of cement by mass. Thus to produce such amount of concrete, 2.3 billion tons of cement will be necessary. Accordingly, a huge amount of CO_2 will be added to green house gasses from such a huge amount of cement production. Although typical concrete contains less than 15% cement by mass, cement manufacturing accounts for about 80% of the total concrete industry's electricity use and approximately 66% of its fuel consumption. In order to reduce the emission of harmful green house gasses and fuel consumption, use of cement must be replaced with other environmentally friendly and efficient cementitious material (Mark Reiner, 2006). The local climate of Bangladesh is hot and humid with an average temperature of approximately 30°C. This high ambient temperature is favorable for the early hydration of slag and also ensures the proper utilization of slag in an effective way which otherwise been dumped making environmental hazard. In the present study, slag mortar specimens were made with different cement replacement levels and cured up to 180 days. Compressive as well as tensile strength tests were carried out at different period to observe the performance of slag mortar.

5.0 EXPERIMENTAL PROGRAM

The experimental program was planned to predict the compressive strength and tensile strength of mortars using slag as replacement of cement. Cement replacement at various percentage levels were used in this investigation to observe the effects of different slag levels in mortar in contributing the compressive and tensile strength at various ages of curing.

6.0 MATERIALS USED

(a) Cement: ASTM Type I Portland Cement conforming to ASTM C-150 was used as binding material. The physical properties and chemical compositions of OPC are given in Table-2.

(b) Slag: Ground granulated blast furnace slag (GGBFS) was used for this investigation. The physical properties and chemical compositions of slag are given in Table-2. The slag activity indices at 7 and 28 days are 78.3 and 103.9%, respectively. The slag meets the classification requirement of ASTM C989 for Grade 100.

(c) Sand: Locally available natural sand passing through 4.75 mm sieve and retained on 0.015 mm sieve was used for this program. Gradation of the fine aggregates is given in Table-3.

7.0 VARIABLES STUDIED

(a) Mortar quality: Seven different mix proportions of cement:slag (90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70) were used as cmentitious material. Cement slag mix ratio of 100:0 i.e. plain cement mortar specimens were also cast as reference mortar for comparing the properties of slag mortars.

(b) Exposure period: Specimens were tested periodically after the specified curing periods of 3, 7, 14, 28, 60, 90 and 180 days.

(c) Size of specimens: 50 mm x 50 mm x 50 mm cube specimens for compressive strength and briquette specimens of standard size for tensile strength tests were prepared as per ASTM standard.

(d) Mortar mix ratios: The mix ratio of cementitious material and sand was 1:2.75 for compressive strength and 1:3 for tensile strength test specimens. Details of mix proportion and materials are shown in Table-4.

(e) Curing environment and testing: A total of 400 mortar specimens were cast in the laboratory. After casting, the specimens were kept at 27°C temperature and 90% relative humidity for 24 hours. After demoulding, all the specimens were cured in water in a curing tank at room temperature. After specific exposure period, specimen was tested for compressive strength and tensile strength in accordance with test procedure ASTM C190-85 and C190-87.

8.0 RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH

The compressive strength of OPC and slag mortars as listed in Table-5, has been graphically presented in Fig.1. Also for the ease of comparison, the relative compressive strengths are plotted in Fig.2. Among all the mixes and for 3 days and 7 days compressive strength, no slag concrete achieved maximum strength. Test results showed that the 3 days compressive strength for OPC mortar is 12%, 14%, 20%, 21%, 31%, 51% and 58% higher than slag mortar of replacement level 10%, 20%, 30%, 40%, 50%, 60% and 70% respectively. Up to curing period of 14 days, compressive strength is seen to decrease with the increase in slag content when compared with no slag mortar.

Test results for 28 days compressive strength of the specimens up to 50% replacement level were very similar with OPC mortar strength. Compressive strength are slightly higher by 1%,4%, 9% and 10% for slag mortar of cement slag ratio 80:20, 70:30, 60:40 and 50:50 respectively. 28 days strength for the 60% and 70% slag replaced mortar was lower by 14% and 25% respectively when compared with no slag mortar.

90 days compressive strength data obtained for 10%, 20%, 30%, 40% and 50% slag replaced mortar were respectively 3%, 4%, 14%, 16% and 8% higher than no slag mortar and almost same for slag mortar of cement slag ratio of 90:10. 60% and 70% replacement level mortar strength were lower than no slag mortar by 7% and 15%. After 180 days, maximum compressive strengths were obtained for 30%, 40% and 50% slag replaced mortar specimens with an increase in strength of 17%, 19% and 12% respectively as compared to OPC mortar. Also 10% and 50% replacement level provided an increase in strength of 4% and 5% respectively when compared with no slag mortar.

In the presence of slag, C_3S hydration is slightly delayed, while hydration at later ages is accelerated (Ogawa, 1980). Slag also acts as a retarder to the hydration of C_3A (Uchikawa and Uchida, 1980). The setting time of slag-blended cement is delayed as compared to ordinary Portland cement by 10 to 20 minutes per 10% addition of slag (Hogan and Meisel, 1981). It has also been reported that the chemical composition of the calcium silicate hydrate formed in hardened blended cement paste was different form that of Portland cement hydration products. Uchikawa (1986) also reported a higher alkali retaining capacity of the hydration product of the slag blended material. For this reason, mortar made with slag will have lower strength than cement mortar at early ages and substantially higher strength at longer ages of curing.

TENSILE STRENGTH

The tensile strength of mortar mixes made with and without slag was determined at the ages of 3, 7, 14, 28, 60, 90 and 180 days. Fig.3 shows the development of tensile strength with age for different slag mortars. These values are also presented in Table-6. Also for the ease of comparison, the relative tensile strength is plotted in Fig.4. The tensile strength of the specimens is seen to increase with age. At early ages of curing (3 days and 7 days), the tensile strength decreases with

increase in slag content in mortar. However, the rate of decrease diminished with the increasing age of curing. The slag mortar specimens shows that tensile strength results are almost identical with that of reference mortar up to cement replacement of 50% at 28 days. Tensile strength values are 101%, 102%, 107%, 109% and 106% for slag mortar of replacement level of 10%, 20%, 30%, 40% and 50% for the curing age of 28 days. 60% and 70% replaced slag mortar achieved 85% and 70% strength of OPC mortar.

After 90 days, a maximum tensile strength of 6.1 MPa was achieved for the slag mortar of 40% replacement level with an increase of 18% higher than the no slag mortar. Even 30%, and 50% slag mortar showed higher tensile strength of 13% and 12% respectively than OPC mortar. After 180 days, a maximum tensile strength of 7.4 MPa was also achieved for 40% replacement mortar, which is 25% higher than the reference mortar. Even 30% and 50% slag replaced mortar showed 19% and 18% higher strength. However, 60% and 70% slag mortar provides a decrease in strength of about 8% and 15% respectively. According to Mehta (1986), pozzolan cements are generally somewhat slower to develop strength than slag cements. Given long-term continuous curing, the ultimate strengths of slag cement mortar will be higher than that of Portland cement. According to Gee (1979), early strength development in slag cement is affected by the chemistry of the clinker, since the manner in which it releases calcium and alkali cations affects the rate of hydration of the slag. As slag cement takes time to produce $Ca(OH)_2$ by hydration of cement, strength gaining rate slows down at initial ages of curing but increases for later age of curing.

9.0 CONCLUSION

Based on the results of the investigation conducted on different slag mortars made with various level of cement replacement and cured for various curing period up to 180 days, the following conclusions can be drawn:

(1) Slag mortar mix having various cement replacement level up to 50% exhibited satisfactory results for both compressive and tensile strength.

(2) The optimum use of slag in the mortar is observed to be 40% of cement. Slag mortars with 40% cement replacement shows 19% higher compressive strength than OPC mortar after 180 days curing. The corresponding increase in tensile strength is reported to be 25%.

(3) Use of high volume slag as a replacement of cement, in any construction work, provides lower impact on environment (reduced CO2 emission) and judicious use of resources (energy conservation, use of by-product etc.)

(4) Use of slag reduces the amount of cement content as well as heat of hydration in a mortar mix. Thus, the construction work with slag concrete becomes economical and also environmentally safe.

(5) Slower Rate of hydration in case of slag cement concrete/mortar lower the risk of thermal cracking.

Chemical constituents (as oxides)	Composition (% by mass)
SiO_2	32-40
Al_2O_3	7-17
CaO	29-42
MgO	8-19
S	0.7-2.2
Fe_2O_3	0.1-1.5
MnO	0.2-1.0

Table 1: Chemical Composition of Blast Furnace Slags Produced in the United States and Canada (ACI 226, 1987)

Physical properties	ASTM Type-I Cement	Slag
Fineness		
Passing #200 Sieve, %	95%	99%
Blains, cm^2/gm	3400	4100
Compressive Strength, MPa		
3 days	17.3	--
7 days	24.3	--
28 days	33.0	--
Specific gravity	3.13	2.99
Chemical analysis, %		
Calcium Oxide, CaO	64.50	41.3
Silicon Dioxide, SiO_2	20.58	32.7
Aluminum Oxide, Al_2O_3	6.42	18.4
Ferric Oxide, Fe_2O_3	4.53	1.3
Magnesium Oxide, MgO	1.12	4.2
Sulfur Trioxide, SO_3	1.45	--
Sulfer, S	--	1.8
Loss on Ignition	0.9	--
Insoluble Residue	0.5	--

Table 2 : Physical Properties and Chemical Composition of Ordinary Portland Cement and Slag

	Cumulative % Passing (for Compressive Strength)	Cumulative % Passing (for Tensile Strength)
১.১৮ সস (ঘড়. ১৬)	১০০	১০০
৮৫০ ক্রস (ঘড়. ২০)	--	৮৮
৬০০ ক্রস (ঘড়. ৩০)	৯৫	০
৪২৫ ক্রস (ঘড়. ৪০)	৭৫	--
৩০০ ক্রস (ঘড়. ৫০)	২৯	--
১৫০ ক্রস (ঘড়. ১০০)	২	--

Table 3: Grading of Fine Aggregate

Sl. No	Specimen Type/ Materials	For Compressive strength test	For Tensile strength test	Remarks
1.	Specimen	50 mm Cube*	25 mm Briquette**	Materials required for 6 specimens
2.	Cementitious materials (Cement + Slag)	500 gm	300	
3.	Sand	1375 gm	900	
4.	Water	242 ml	132 ml***	

* ASTM C190-85 ** ASTM C190-87 *** Normal Consistency = 27%

Table 4: Mix Proportions of Various Ingredients of Cement: Slag Mortar

Replacement Level	Ce:Sg							
Curing Period (days)	**100:0**	**90:10**	**80:20**	**70:30**	**60:40**	**50:50**	**40:60**	**30:70**
3	17.3	15.3	14.8	13.9	13.7	11.9	8.4	7.3
7	24.3	22.8	21.9	21.1	20.6	17.3	13.5	12.3
14	27.6	26.8	25.9	25.4	24.9	22.9	20.5	19.6
28	33.0	32.5	33.4	34.4	36.0	33.1	28.2	24.8
60	40.9	41.5	42.3	44.9	46.5	43.6	37.4	34.1
90	43.3	44.4	45.2	49.4	50.2	46.9	40.4	36.7
180	47.5	49.5	50.0	55.6	56.4	53.3	45.8	41.1

Ce : Cement Sg : Slag

Table 5 : Compressive Strength (MPa) of Cement : Slag Mortars for Various Replacement Level of Cement

Replacement Level	Ce:Sg							
Curing Period (days)	**100:0**	**90:10**	**80:20**	**70:30**	**60:40**	**50:50**	**40:60**	**30:70**
3	3.0	2.8	2.7	2.4	2.4	2.1	1.4	1.3
7	3.6	3.3	3.3	3.2	3.1	2.5	2.0	1.8
14	3.8	3.7	3.6	3.5	3.5	3.3	2.8	2.7
28	4.2	4.3	4.3	4.5	4.6	4.5	3.6	3.2
60	4.9	4.9	5.1	5.3	5.5	5.3	4.4	3.9
90	5.2	5.3	5.4	5.8	6.1	5.8	4.7	4.3
180	5.9	6.1	6.3	7.0	7.4	7.0	5.4	5.0

Ce : Cement Sg : Slag

Table 6 : Tensile Strength (MPa) of Cement : Slag Mortars for Various Replacement Level of Cement

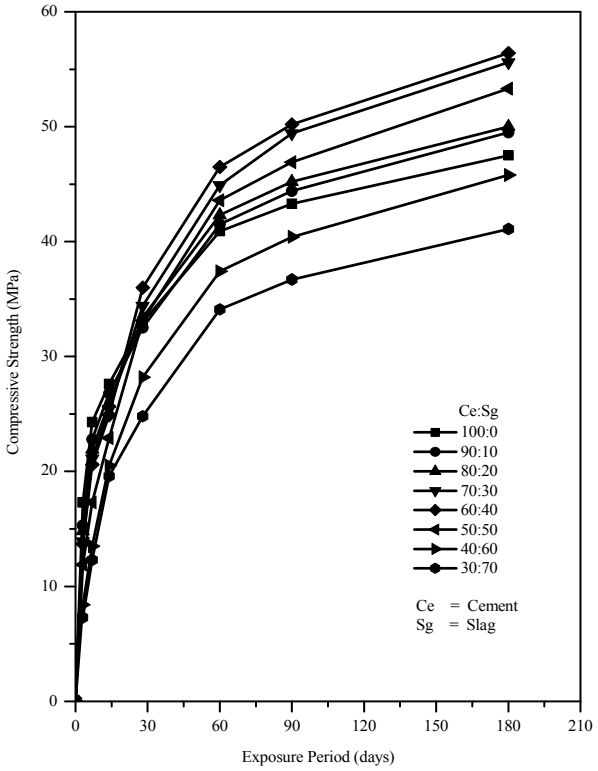


Fig.1: Compressive strength- exposure time relation for slag mortars

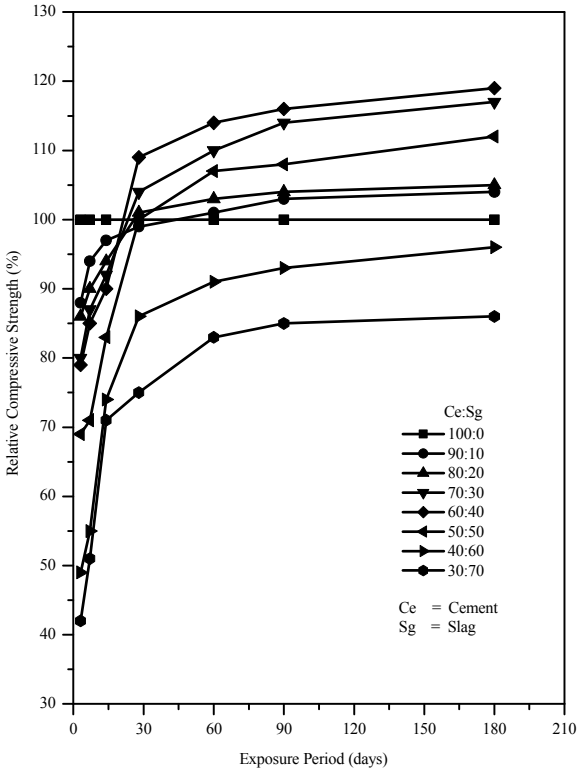


Fig.2: Relative compressive strength-exposure time relation for slag mortars

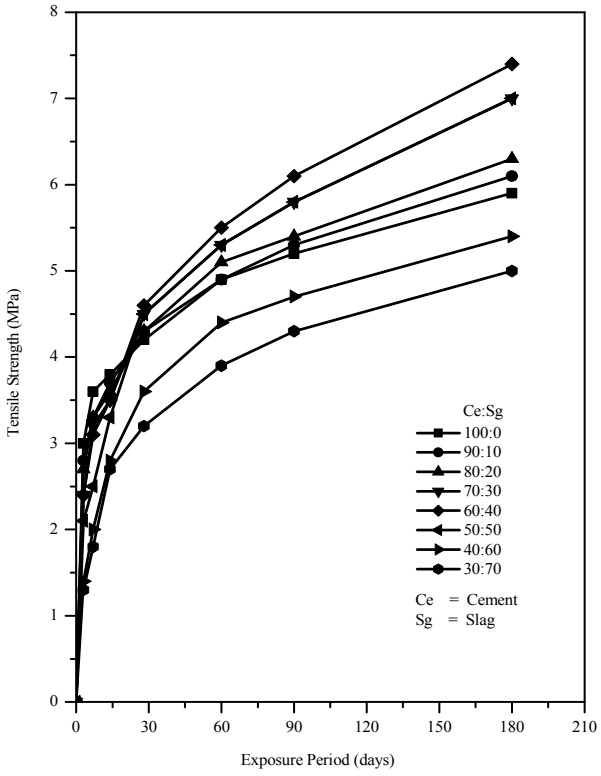


Fig.3: Tensile strength- exposure time relation for slag mortars

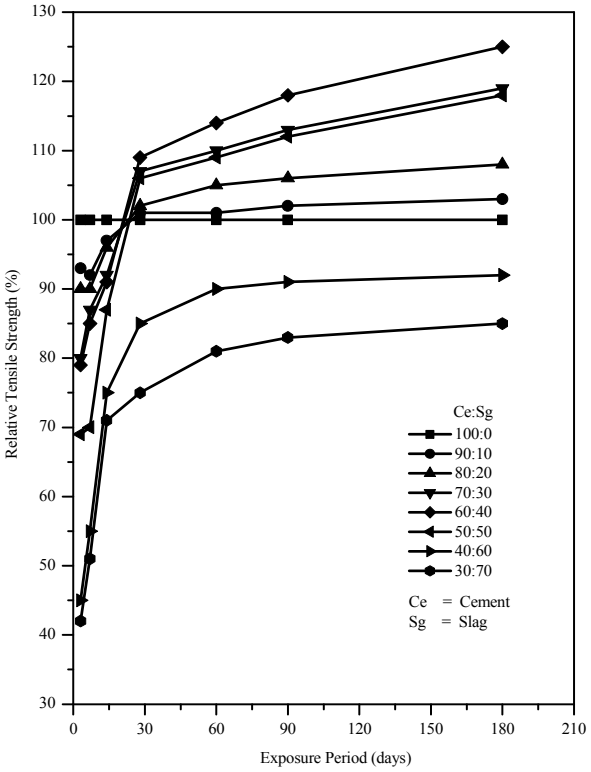


Fig.4: Relative tensile strength-exposure time relation for slag mortars

REFERENCES

[1] Gee, Kenneth H.(1979) "The potential for slag in blended cements," Proceedings, 14th International Cement Seminar, Rock Products, pp. 55-53.

[2] Hwang, C.L., Lin, C.Y.,(1986) "Strengrh development of blended furnace slag cement mortars," SP 91-65, Proceedings of the 2nd International Conference on Fly Ash, Silica Fume, Slag and Natural Pozzolans in concrete, Vol. 2, American Concrete Institute, USA, pp. 1323-1340.

[3] Hogan, F. J. and Meusel, J. W.(1981) "Evaluation for durability and strength development of a ground granulated blast furnace slag", Cment, Concrete and Aggregates, CCAGDP, Vol. 3, No. 1, pp. 40-52.

[4] Hooton, R. D. and Emery, J.J.(1983) "Glass Content Determination and Strength Development Predictions for Vitrified Blast furnace Slag," Fly Ash, Silica Fume, Slag & Other Mineral by-roducts in Concrete, ACI SP-79, pp.943-962.

[5] Mark, Reiner., and Kevn, Rens.(2006), High-Volume Slag Concrete: Analysis and Application, Practice Periodical on Structural Design and Construction, Vol.11, No.1, pp.58-64.

[6] Mehta P. K.(1986) "Effect of fly ash composition on sulfate resistance of concrete," Journal of the American Concrete Institute, Vol. 83, No.6, pp.994-1000.

[7] Mehta, P. K.,(2002) Greening of the Concrete Industry for Sustainable Development, ACI Concrete International, Vol.24, No.7, pp. 23-28.

[8] Min-Hong, Zhang., Marcia, C. Blanchette., and V, M. Malhotra.,(2001), Leachability of Trace Metal Elements from Slag Concrete: Results form Column-Leaching and Batch Leaching Tests, ACI Materials Journal, Vol.98, No.2, pp.126-136.

[9] Meusel, J. W. and Rose, J. H.(1983) "Production of Granulated Blast Furnace Slag at Sparrows Point, and the Workability and Strength Potential of Concrete Incorporation the Slag," Fly Ash, Silica Fume, Slag & Other Mineral By- Products in Concrete, ACI Sp-79, pp.867-890.

[10] Ogawa, K.; Uchikawa, H.; Takenoto, K., and Yasui, I,(1980) "The mechanism of the hydration in the system CS Pozzolana," Cement and Concrete Research, Vol.10, No.5, pp. 683-696.

[11] Ozkan, Sengul., and Mehmet, Ali. Tasdemir., (2009), Compressive Strength and Rapid Chloride Permeability of Concretes with Ground Slag and Slag, Journal of Materials in Civil Engineering, Vol.21, No.9, pp.494-501.

[12] Regourd, M., (1980)"Characterization of thermal activation of slag cements," Proceedings of the 7th International Congress on the chemistry of cements (Paris) 2 (III-3), pp.105-111.

[13] Roy, D. M. and Idorn, G.M.(1982) "Hydration, Structure and Properties of Blast Furnace Slag Cements, Mortars and Concrete," ACI Journal, Vol. 79, No. 6, pp.444-457.

[14] Tarun, R. Naik., Shiw, S. Singh., and Mohammad, M. Hossain., (1996), Permeability of High Strength Concrete Containing Low Cement Factor, Journal of Energy Engineering, Vol.122, No.1, pp.21-39.

[15] Smolczyk, H.G., (1978)"The effect of chemistry of slag on the strength of blast furnace cements", Zem-Kalk-Gips 31 (6), pp.294-296.

[16] Stutterheim, N.,(1960) "Properties and Uses of High Magnesia Portland Slag Cement Concretes," Journal of the American Concrete Institute, Proceedings V:56, Vol.31, No.10, pp.1027-1045.

[17] Stutterheim, Niko.(1968) "Portland Blast furnace Cements- A Case for Separate Grinding of Slag,"Supplementary Paper IV-113, fifth International Symposium of the Chemistry of Cement, Tokyo, pp.270-276.

[18] Uchikawa,v H.(1986)"Effect of blending components on hydration and structure formation," 8th International Congress on the Chemistry of Cement, Rio de Janeiro, I, 249-280.

[19] Uchikawa, H. and Uchida, S.(1980) "Influence of pozzolans on the hydration of C3A," 7th international Congress on the Chemistry of Cement, Paris, III, pp.IV-23-IV-29.

[20] Vanden Bosch, V.D., (1980) "Performance of mortar specimens in chemical and accelerated marine exposure, performance of concrete in Marine Environment," ACI SP-65, American Concrete Institute, pp. 487-507.

[21] Roy, D.M., and Idorn, G. M.,(1982) "Hydration, structure and properties if blast furnace slag cements, mortars and concrete, Proc.-Am, Concrete International 79 (6), pp. 445-457.

VIRTUAL POWER PLANT AS A REMEDY TO THE POWER CRISIS OF BANGLADESH: A CASE STUDY-CUET

C. K. Das[(1)], N. K. Das[(1)], M. M. Islam[(1)] and S.M. Sazzad Hossain[(1)]

1. Department. of Electrical & Electronic Engineering, Chittagong University of Engineering & Technology

E-mail: choton46@yahoo.com, nipu16@gmail.com, muin_028@yahoo.com, shuvo_eee05@yahoo.com

6.

ABSTRACT

A virtual power plant is a cluster of distributed generation installations (such as microchip, wind-turbines, small hydro, back-up genets etc.) which are collectively run by a central control entity. The concerted operational mode shall result in an extra benefit as to deliver peak load electricity or load following power at short notice. Bangladesh is facing acute power crisis like other developing countries. As we have limited resources we have to think economically.VPP is playing good role in European & American market. So we have taken VPP as a solution for power crisis. In this thesis, we have taken CUET as a reference model. To solve the power crisis in CUET & to supply power to the main grid a small virtual power plant is designed .Whole CUET is divided into three regions for designing purpose. By using MATLAB simulink environment machine characteristic curves are derived & cost is calculated.

KEY WORDS: *VPP, MATLAB, DG, CUET, MCCB, DER, LDC.*

1.0 INTRODUCTION

The small scale power generating technology, such as micro hydro, photovoltaic, wind turbine and micro turbine are gradually replacing conventional/traditional technologies in various applications. They are identified as distributed generation (DG), the DG technology is often lumped with distributed storage and their combination is referred to as distribution energy resources (DER) modular electric generation or at storage installed at customer site. The distributed generations have many benefits, such as low transmission losses, high fuel efficiency, short construction lead time, modular installation and low emission, which all contribute to their growing popularity and DG offers great value. It provides a flexible way to choose a wide range of combination of cost and reliability that means it can play a vital role in the impending distributed generation market [1].

Furthermore, penetration/deployment of DER at main grids emerged new concepts such as Micro grids and Virtual Power Plant (VPP). These concepts are radically different methods for designing operating power system and also hold the potential for providing the high reliability, quality, security, and availability of electrical service required by emerging digital society.

2.0 CONCEPT OF VPP

VPP DEFINITION:

Virtual power plant are formed by a mix of decentralized generation ,storage & load units on particular supply areas that show similar reliable, plan able & controllable behavior as larger central generators or loads. This is in spite of different profiles of the units that form these balanced supply areas the adherence to schedules (import & export energy) that have been communicated in advance to higher level management systems. There are different possibilities for vertical & horizontal integration of these VPP. Thus one VPP can be included into an overlaying VPP. It is possible to connect several different VPP to existing distribution management systems [2].

TYPES OF VPP:

CENTRALIZED VPP & DECENTRALIZED VPP

In Centralized System Topology, DG units are controlled by control coordination centre which is located right in the figure. The load signals are transmitted to CCC where it is processed by means of logic algorithm [1]. In decentralized system topology, each DG unit is locally controlled by local controller (LC) [3]. To perform an integrated system, the local controllers are connected/linked to each other forming ring network architecture through communication to allow signals exchange [1].The communication system will be SCADA [4].

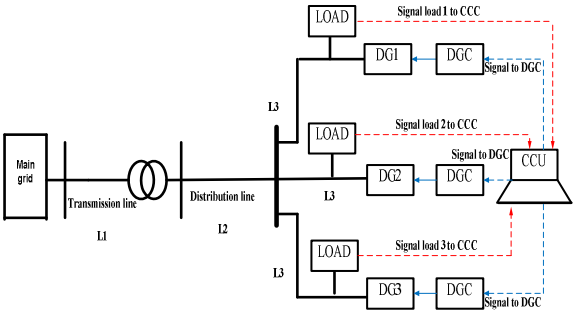


Figure 1: Centralized VPP

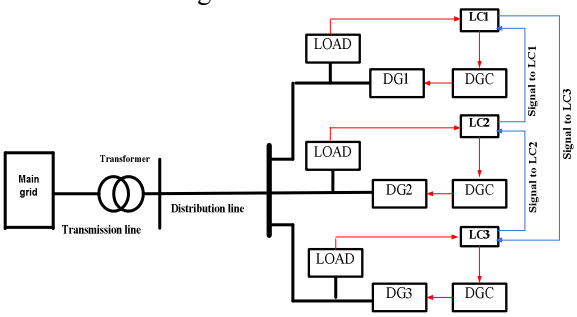


Figure 2: Decentralized VPP

3.0 System Design

3.1 A Case Study for CUET:

As CUET is situated in rural area, here load shedding occurs frequently. So power crisis solution is necessary. It is easy to calculate total connected load & also to measure the peak & off-peak load. As CUET is small region we can easily install a VPP in low cost.

3.2 Reason of Choosing Centralized VPP for CUET:

Centralized Controlled VPP requires the control over each of the DER being part of the VPP, including access to their relevant real-time performance data. Obviously the centralized controlled model requires that the owners of the production units are willing to let go of the control of their units. Therefore the model would perhaps apply better to a scenario where the VPP owned the distributed production units instead of private individuals or companies. Centralized Controlled VPP seems to be best fitted for integrating existing DER into a VPP and best at handle relatively small amounts of DER since the amount of data in the VPP increases significantly with every DER added to the VPP. In a small region like CUET decentralized VPP will less economical benefits compare to the centralized VPP because it will require more control centre & communication infrastructure. Besides this, it will require more trained person to operate. For this reason centralized VPP will be best fitted.

3.3 Present Power Distribution in CUET Campus:

A main transformer of 500 KVA step downs the 11 kV transmission line into 0.415 kV in substation located near the CUET ladies hall. Power is provided from the substation to CUET Campus through 0.415 kV, transmission lines that terminate from CUET main distribution switchgear. The main bus of the switchgear is arranged in a way to allow no interruption of continuity of power to the campus. 0.415-kV distribution throughout the entire CUET campus is accomplished by eleven distribution circuit breakers present in the CUET main switchgear. A MCCB circuit breaker of 800 amps controls the other ten circuit breakers and these breakers controls the power supply to different buildings of the campus.

4.0 Centralized VPP for CUET:

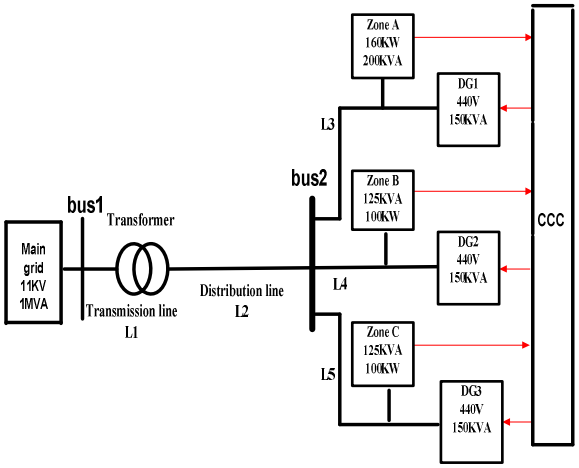


Figure 3: Block diagram for centralized VPP for CUET.

We divided the whole CUET in three zones
Zone A: EME,CE+CSE building,12 storied building, PEB, Academic section, Workshop, Library, Gallery, Medical centre, Post office, Bank, Transport section, Mosque, CUET school & college.
Zone B: student halls & extension
Zone C: Residential area, Anser camp, guard shed, street light & water pump

Zone	Peak Hour	Peak Load	Off Peak hour	Off peak Load
A	8.00AM-5.00PM	160KW (approx)	5.00PM-8.00AM	30KW (approx)
B	7.00PM-12.00AM	100KW (approx)	12.00AM -7.00PM	30KW (approx)
C	7.00PM-12.00AM	100KW (approx)	12.00AM -7.00PM	30KW (approx)

So we need three synchronous generator of rating 200kva (zone A) & 125kva (for zone B&C)
We assume the transformer rating 450kva & 11kv/440v

CALCULATION OF R-L-C:

All branches in simulation are represented by three phase parallel RLC branch.
The length of overhead lines (L1) is 500 m, thus the R-L-C value can be obtained:
R_1 = 0.356 ohm/km x 0.5 km = 0.178 ohm
$X_1 = 2.\pi.f.L$ = 0.3226 ohm/Km = 0.3226 × 0.5 ohm =0.1613 ohm

$$L_1 = \frac{X}{2.\pi.f} = \frac{0.3226}{2*3.1416*50} = 1.027e^{-03} \text{ H/Km} = 1.027e^{-03} \text{ H/Km} \times 0.5 \text{ Km} = 5.13e^{-04} \text{ H}$$

C_1 = 235 Nf/Km ×0.5 Km =117.5 Nf
The R-L-C value of overhead line (L2 =100 m) can be calculated:
R_2 = 0.2426 ohm/Km × 0.1 Km = 0.02426 ohm
X_2 = 0.3614 ohm/Km × 0.1 Km = 0.03614 ohm

$$L_2 = \frac{0.03614}{2*3.1416*50} = 1.150e^{-04} \text{ H}$$

C_2 =10.12 Nf/Km × 0.1 Km = 1.012 Nf
The R-L-C value of overhead line (L3 =100 m) can be calculated:
R_3 = 0.437 ohm/Km × 0.1 = 0.0437 ohm
X_3 = 0.302 ohm/Km × 0.1 = 0.0302 ohm

$$L_3 = \frac{0.0302}{2*3.1416*50} = 9.613e^{-05} \text{ H}$$

C_3 = 10.2 Nf/Km × 0.1 Km = 1.02 Nf
The R-L-C value of overhead line (L4 =1Km) can be calculated:
R_4 = 0.437 ohm/Km × 1 = 0.437 ohm
X_4 = 0.302 ohm/Km × 1 = 0.302 ohm

$$L_4 = \frac{0.302}{2*3.1416*50} = 9.613e^{-04} \text{ H}$$

C_4 = 10.2 Nf/Km × 1 Km = 10.2 Nf
The R-L-C value of overhead line (L5 =1Km) can be calculated:
R_5 = 0.437 ohm/Km × 1 = 0.437 ohm
X_5 = 0.302 ohm/Km × 1 = 0.302 ohm

$$L_5 = \frac{0.302}{2*3.1416*50} = 9.613e^{-04} \text{ H}$$

C_5 = 10.2 Nf/Km × 1 Km = 10.2 Nf

Resistance and Inductance of Transformer:

For each winding the per unit resistance and inductance are defined [5] as:
$R_{pu} = R(\Omega)/R_{base}$
$L_{pu} = L(H)/L_{base}$
The base resistance and base inductance used for each winding are
$R_{base} = (V_n)^2/P_n$
$L_{base} = (R_{base})/(2.\pi.f_n)$

For the magnetization resistance R_m and inductance L_m, the p.u values are based on the transformer rated power and on nominal voltage of the winding one.

$$R_{base} = ((11/\sqrt{3})^2/450) \times 1000 = 89.63\ \Omega$$

$$L_{base} = \frac{89.63}{2\times3.1416\times50} = 0.285 \text{ H}$$

Data from grid reference for R=.178 ohm and X= 0.1613 ohm. Therefore to obtained L:

$$L_1 = \frac{X1}{2\times\pi\times f} = \frac{0.1613}{2\times3.1416\times50} = 0.0005 \text{ H}$$

Supposed that the windings transformer (R_1) = 0.178 Ω & (L_1) = 0.0005 H, the corresponding values to be entered in the simulation block are:

$$R_1 = \frac{0.178}{89.63} = 0.002 \text{ p.u}$$

$$L_1 = \frac{0.0005}{0.285} = 0.002 \text{ p.u}$$

To specify a magnetizing current of 0.3% (resistive and inductive) based on nominal current. Thus the per unit values of 1/0.003 = 314 p.u for resistance and the inductance of the magnetizing branch.

5.0 SIMULATION

MATLAB SIMULINK DESIGN:

We have used MATLAB 7.6 for simulation. The components are available in power system library in Matlab Simulink and each model parameters are fulfilled with the proper data from grid reference.

5.1 THE THREE-PHASE AC SOURCE BLOCK:

The Three-Phase Source block implements a balanced three-phase voltage source with internal R-L impedance. The three voltage sources are connected in Y with a neutral connection that can be internally grounded or made accessible. The source internal resistance and inductance are either by directly entering R and L values or by indirectly specifying the source inductive short-circuits level and X/R ratio. The base voltage is 11 $kV_{(rms)}$ and the frequency system is 50 Hz.

5.2 TRANSMISSION AND DISTRIBUTION LINE:

This section describes each of the branches that transmit electrical power. The branches are usually lines or cables.
There are aerial lines at the 11 kV and 0.44 kV voltage level which is responsible for distributing power at lower voltage levels. Each branch is described in detail with explanation of the values used for the electrical parameters. The three-phase parallel RLC branch block implements three balanced branches consisting each of a resistor (in ohms-Ω), an inductor (in henries-H), a capacitor (in

farads-F) , or a parallel combination of these. Each branch data is described in table 1.

No	Type	X (ohm/ km)	R (ohm/ km)	C (nF/ km)
1	Overhead line (L1)	.3226	.356	235.00
2	Overhead line (L2)	.3614	.2426	10.12
3	Distribution line (L3, L4 & L5)	.302	.437	10.2

Table 1: Data lines parameters

The typical data line parameters as shown above particularly for low voltage line is simulation are represented by three phase parallel RLC branch. The lengths of overhead lines L1 is 0.5 km. At low voltage level, the length of distribution line (L2) from step down transformer to distribution bus is 0.1 km and length distance from distribution bus to each loads/DG units are 0.1km for L3, 1km for L4 & L5.

5.3 STEP DOWN TRANSFORMER:

As shown in figure, the system has only one transformer. The three-phase transformer (two windings) block implements a three-phase transformer using three single-phase transformers. The nominal power rating of the transformer is in volt-amperes (VA), and nominal frequency in hertz (Hz). The primary side bus bar is 11 kV, and the secondary bus bar is 440 V. The secondary bus bar is connected to distribution line 440 V. Table2 describes data of the transformer.

No.	Primary volt (kV)	Secondary volt(kV)	Rating (kVA)	Connection
1	11	.44	450	$D_{11}Y_g$

Table 2: Transformer data

In order to comply with simulation, the specified resistance and inductance of the windings are in per unit (p.u). The values are based on the transformer rated power P in VA, nominal frequency f in Hz, and nominal voltage V in volt of the corresponding winding.

5.4 THE FIX LOADS:

The fixed loads are represented by resistive load. The nominal phase to phase voltage of the load is in volts RMS (Vrms) and three phase active power of the load is in watts (W).

5.5 DISTRIBUTED GENERATION [6]:

This model consists of a unit synchronous machine (SM) equipped with distributed generation controller (DGC). The DGC is consisted of two important parts: hydraulic turbine governor and excitation. The SM model is a dynamic model of a three-phase round-rotor or salient-pole synchronous machine and operates in generator or motor modes. The operating mode is dictated by the sign of the mechanical power (positive for generator mode, negative for motor mode). The model SM provides a set of predetermined electrical and mechanical parameters for various synchronous machine ratings of power (kVA), phase-to-phase voltage (V), frequency (Hz), and rated speed (rpm) etc. Three DG units are connected at low voltage (400 V), with each capacity 150 kVA, 50 Hz and maximum active power output is 120 kW.

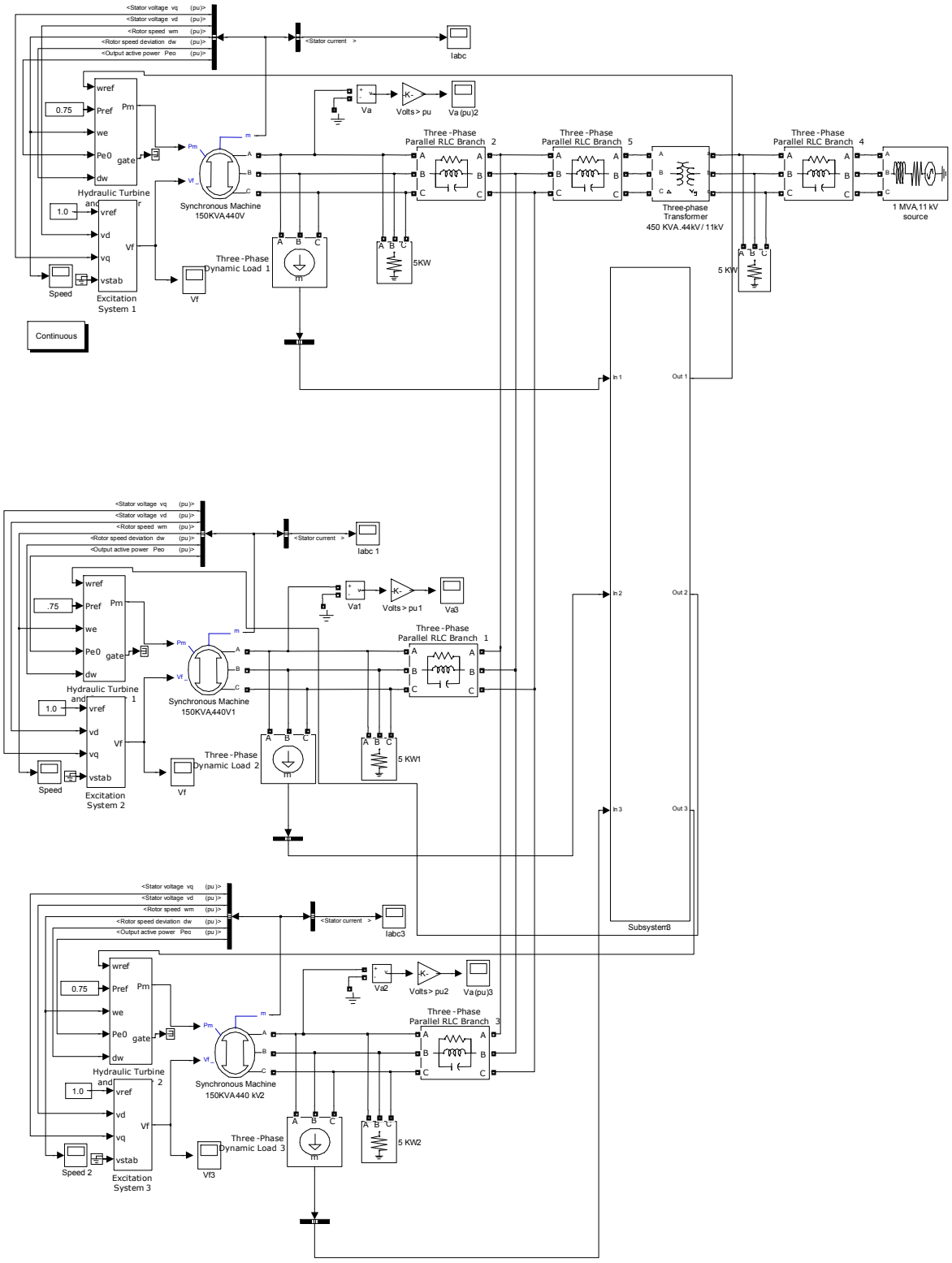


Figure 4: MATLAB design of centralized VPP for CUET

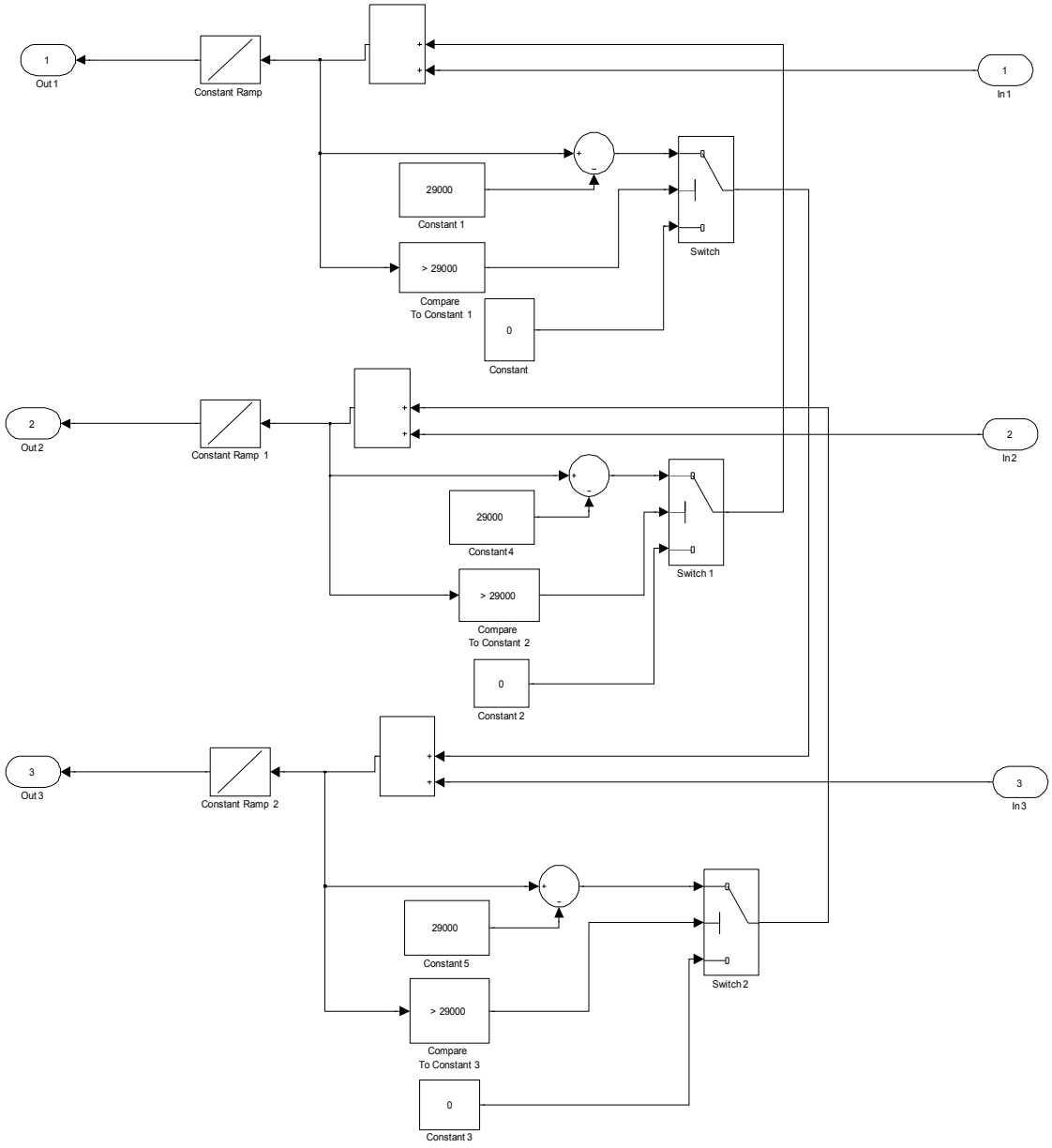


Figure 5: MATLAB design of subsystem.

6.0 RESULT AND DISCUSSION

6.1 CURVE OF STATOR CURRENT:

The stator is the stationary part of a rotor system, found in an electric generator or electric motor. The rotating magnetic field induces an AC voltage in the stator windings. Often there are three sets of stator windings, physically offset so that the rotating magnetic field produces three phase currents, displaced by one-third of a period with respect to each other.

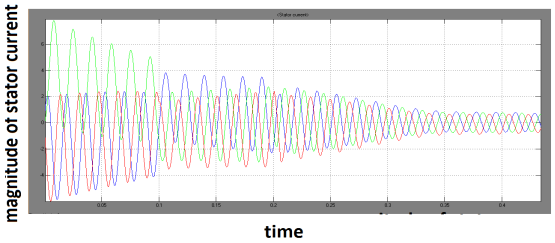


Figure 6a: Starting period of stator current.

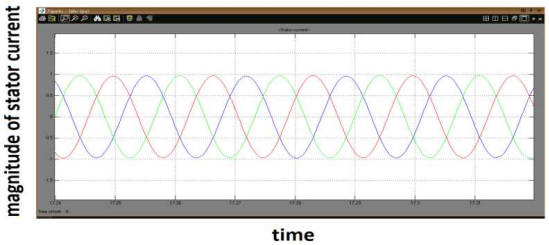


Figure 6b: Running period of stator current.

6.2 CURVE OF TERMINAL VOLTAGE:

The initial terminal voltage and field voltage are set respectively to 1.0 and 1.291 pu. The terminal voltage Va is 1.0 pu at the beginning of the simulation. It falls to about 0.4 pu during the fault and returns to nominal quickly after the fault is cleared. This quick response in terminal voltage is due to the fact that the Excitation System output Vf can go as high as 11.5 pu, which it does during the fault and returns to nominal slowly after the fault is cleared.

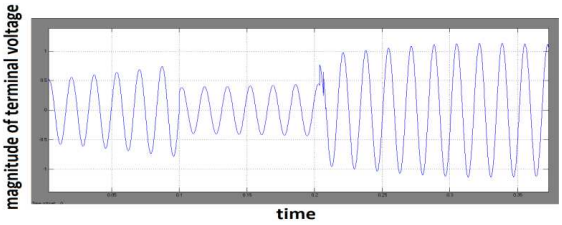


Figure 7a: Starting period of terminal voltage.

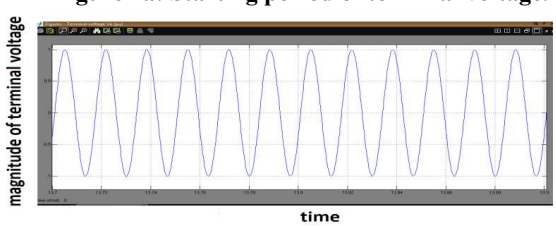


Figure 7b: Running period of terminal voltage.

6.3 CURVE OF FIELD VOLTAGE:

Alternators generate electricity by the same principle as DC generators, namely, when the magnetic field around a conductor changes, a current is induced in the conductor. The rotor magnetic field may be produced by induction (in a "brushless" alternator), by permanent magnets (in very small machines), or by a rotor winding energized with direct current through slip rings and brushes. The rotor magnetic field may even be provided by stationary field winding, with moving poles in the rotor [7].

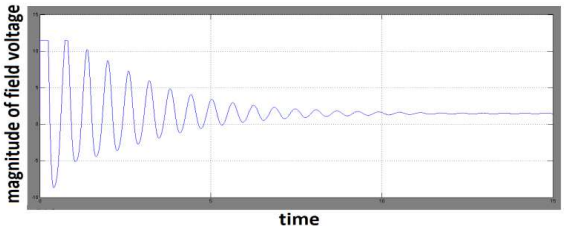


Figure 8: Curve of field voltage.

6.4 CURVE OF ROTOR SPEED:

The output frequency of an alternator depends on the number of poles and the rotational speed. The speed corresponding to a particular frequency is called the *synchronous speed* for that frequency. From observation we can say that rotor speed varies with demanding load.

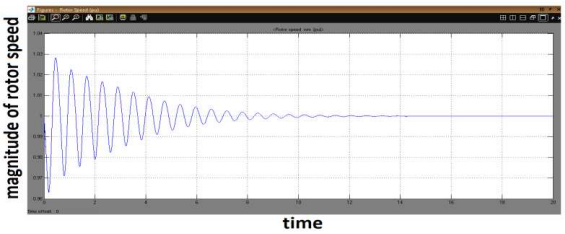


Figure 9: Curve of rotor speed.

The initial terminal voltage and field voltage are set respectively to 1.0 and 1.291 pu. The terminal voltage Va is (in figure 7a) 1.0 pu at the beginning of the simulation. It falls to about 0.4 pu during the fault and returns to nominal (in figure 7b) quickly after the fault is cleared. This quick response in terminal voltage is due to the fact that the Excitation System output Vf can go as high as 11.5 pu (in figure 8), which it does during the fault and returns to nominal slowly after the fault is cleared. The speed of the machine (in figure 9) increases to 1.01 pu during the fault, then it oscillates around 1 pu as the governor system regulates it. The speed takes much longer than the terminal voltage to stabilize, mainly because the rate of valve opening/closing in the governor system is limited to0.1 pu/s. The initial stator current (in figure 6a) is distorting before the stabilization is done and oscillate around 1pu after the stabilization is done (in figure 6b).

6.5 BUS VOLTAGE & ANGLE MEASUREMENT:

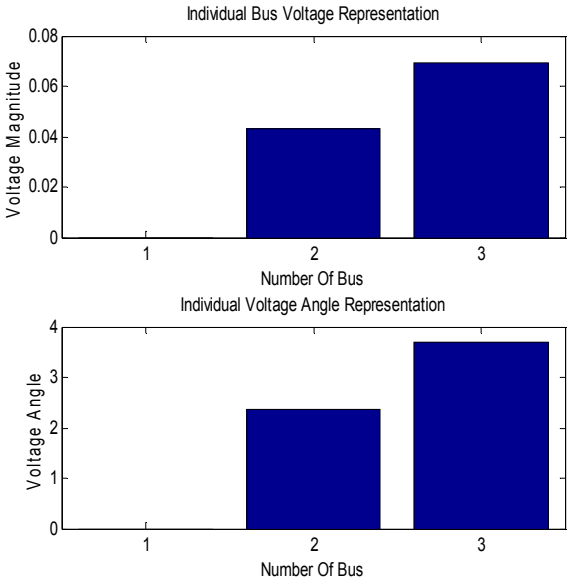


Figure 10: Individual bus voltage and angle representation.

In above figure bus1 is slack bus, bus2 is PV bus and bus3 is PQ bus. As a result bus2 has lower voltage magnitude than bus3.Voltage angle is also smaller than bus 3.

7.0 LIMITATIONS

LIMITATIONS OF THE SYSTEM: [8]

1. Comparatively higher cost for Transmission capacity, physical grid & energy infrastructure
2. Communication & information amount/speed may vary.
3. Fault may occur through communication channel.
4. Generic in hardwiring but partly application specific, e.g. Micro CHP, wind turbine, NG

Limitations of the simulation:

1. The speed of the simulation is unstable due to the memory acquisition problem caused by the MATLAB.
2. When we use Synchronous Machine blocks in discrete systems, we have to use a small parasitic resistive load, connected at the machine terminals, in order to avoid numerical oscillations. Large sample times require larger loads. The minimum resistive load is proportional to the sample time.

8.0 FUTURE POSSIBILITIES OF THE SYSTEM

The system can provide great flexibility to the power production and distribution. It can provide a greater advantage in the developing country like Bangladesh, Nepal, and Bhutan etc. [9]

For emergency power supply aggregation of generators are needed. On this perspective Aggregated Emergency power supply is foot-in-the-door.

Electricity exports are possible in facilities with very high thermal demands. This structure could enable investments in energy efficiency as part of the market for saved electricity.

By proper research any kind of renewable energy sources can be used to install it.

9.0 CONCLUSION

Bangladesh is now facing acute power crisis. To compete with the new millennium power crisis solution is immediately needed. As CUET is situated in rural area, load shedding occurs frequently. We have designed our vpp in such a way that it will not only reduce power crisis in CUET but also supply power to the main grid. Policymakers need to recognize the suffocating cost of allowing the power crisis to persist. Short-term solutions may involve importing fuel to run smaller rental power units. But long-term, developing an effective public-private partnership, transparent procurement, constructing VPP and clear incentives for foreign investment along with greater integration with Burma, India and the Asian energy network should be an absolute priority for this government and the next .As VPP playing a good role in European & American market, Our policy maker should take immediate steps about VPP.

REFERENCES

[1] Morten Decker: "Analysis and Design of an SOA for Virtual Power Plant" , s011921 Kongens Lyngby 2008, *page 4-5*

[2] VPP concept, available at: http://www.newscientist.com/article/dn17290-virtual-power-plants-could-tame-coming-grid-chaos.html

[3] Sameer Shailesh Mundkur: "Design and implementation of a Digital Controller for High Power Converters",North CarolinaState University Raleigh, North Carolina 2008 *page 13-15*.

[4] SCADA, available at: http://en.wikipedia.org/wiki/SCADA

[5] Ashfaq Hussain: "Electrical Power Systems" 4th edition *page:177*

[6] "Distributed Generation Architecture and Control", available at: http://www.rand.org/scitech/stpi/Evision/Supplement/sonderegger.pdf

[7] Stephen J. Chapman: "Electric machinery Fundamentals", 4th edition, page*: 308-314.*

[8] "Virtual power plant: basic requirements & experience in practice", available at: www.ptius.com/pti/company/enewsletter/.../Virtual%20Power%20Plants.pdf

[9] Virtual power plant feasibility study: Federation of Canadian Municipalities, Final Report March 31st, 2006. *page 28*

MODELING OF PHOTOELASTIC CONSTANT DEPENDENT ON ARBITRARY CRYSTAL ORIENTATION

Lubna Jahan Rashid Pinky[(1)] and Abu Naim Rakib Ahmed[(2)]

1. Lecturer, Electrical Electronic and Engineering Department, IUBAT, Dhaka
2. Lecturer, Electrical Electronic and Engineering Department, Khulna University of Engineering & Technology

ABSTRACT

A mathematical model is proposed to determine the photoelastic constants in arbitrary crystal orientation of Zincblende crystal structure. Tensor rotation technique is applied using Euler's rotation theorem to develop the model. The model is applicable to evaluate photoelastic constants in terms of P11-P12 and P44 in any crystal plane by controlling the rotation angle using the model. P11-P12 and P44 are calculated for Silicon crystal and found that the values of these constants are strongly dependent on crystal orientations. The outcome of this research enables us to evaluate quantitative amount of strain in polycrystalline silicon material (solar cell material) using Scanning Infrared Polariscope.

KEY WORDS - *Photoelastic constant, polycrystalline silicon, tensor rotation, crystal orientation, scanning infrared Polariscope method.*

1.0 INTRODUCTION

The application of an external stress to solid produces a change in crystal symmetry and lattice parameters, which results in significant change in optical properties. By the application of external stress an optically isotropic semiconductor becomes birefringent. This phenomenon is known as photoelasticity. Photoelastic constant is very important to determine the strain in semiconductor devices using the experimental technique known as Scanning Infrared Polariscope. In this technique the absolute values of the residual strain components: $|S_{yy} - S_{zz}|$ and $2|S_{yz}|$, which are the difference of the tensile strains along the radial and tangential directions in a cylindrical coordinate system, that along the y and x axes in the crystallographic Cartesian coordinate system and the shear strain between the y and z axis can be quantitatively characterized by knowing the photoelastic constants. The relationship with the strain components and photoelastic constants for the method is [1]

$$|S_{yy} - S_{zz}| = k\delta \left| \frac{\cos 2\phi}{p_{11} - p_{12}} \right| \qquad (1)$$

$$2|S_{yz}| = k\delta \left| \frac{\sin 2\phi}{p_{44}} \right| \qquad (2)$$

Where, $k = \frac{\lambda}{\pi d n_0^{\,3}}$

P_{ij} = Photo elastic constant

n_0 = the refractive index

$|S_{yy} - S_{zz}|$ =the difference of the tensile strains along the crystallographic y and z axes

$2|S_{yz}|$ =the shear strain between the y and z axes

Photoelastic constant depends on the crystalline orientations. Crystal orientation changes randomly in polycrystalline material. Polycrystalline silicon is a key component of solar panel construction. Monocrystalline silicon is higher priced and more efficient than polycrystalline. But low cost solar cell can be fabricated by polycrystalline silicon though its performance is very poor which is assumed to be due to the strain induced in the material during the growth and cooling processes. Since the strain in semiconductor material is highly dependent in crystal orientations, to characterize the strain in solar cell material by the Scanning Infrared Polariscope, it is very much important to know the photoelastic constant in different crystal orientations. Photoelastic constant can only be determined experimentally in (100) and (111) crystal orientations. But to characterize the quantitative amount of strain in polycrystalline silicon-based solar cell, it is needed to know the photoelastic constants in arbitrary crystal direction. In this work, a mathematical model is proposed to determine photoelastic constants in arbitrary crystal orientation using tensor rotation technique. Finally, quantitative amount of photoelastic constants in terms of P'_{11} - P'_{12} and P'_{44} are calculated in different orientations for Si crystal as an example. However, the formulations can be applied to evaluate photoelastic constants in any Zincblende crystal structure.

2.0 PROPOSED SYSTEM MODEL

For the determination of photoelastic constants in arbitrary crystal orientation two system models are proposed.

2.1 SYSTEM MODEL 1

To determine photoelastic constant in any direction at XY plane or in any plane from XY to $X'Z'$ plane, we have developed a system model based on the relationship of the general (hkl) coordinate system to the conventional (001) crystal coordinate system. At first the X axis is rotated in XY plane keeping Z axis constant by an angle ϕ and so the Y axis is also rotated by the same angle, ϕ. After the first rotation, the new positions of X axis and Y axis are denoted as X' and Y'. Again the X' axis is rotated by an angle θ about the Y'axis and so the Z' axis is also rotated by the same angle θ. The final position of X'' and Z'' is obtained after the second rotation.

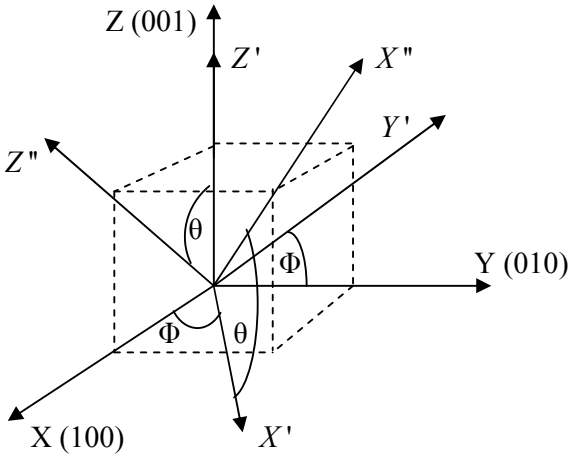


Fig.1: Relationship of the general (hkl) coordinate system to the conventional (001) crystal coordinate system-

The angles, ϕ and θ of the (hkl) direction relative to a coordinate system fixed onto the (100), (010) and (001) axes, can be given by the following relationships [2]

$$\tan\varphi = \frac{k}{h} \qquad (3)$$

$$\tan\theta = \frac{\sqrt{h^2+k^2}}{l} \qquad (4)$$

Where, the indices h, k, and l are the real integers for the case when the crystalline surface is specified in terms of the azimuthally angle, ϕ and polar angle θ.

2.2 SYSTEM MODEL 2

Since the above model can not be applied to determine photoelastic constants in any crystal plane between (100) and (011), a new system model is developed which is based on the relationship among the angles ϕ, θ and α.

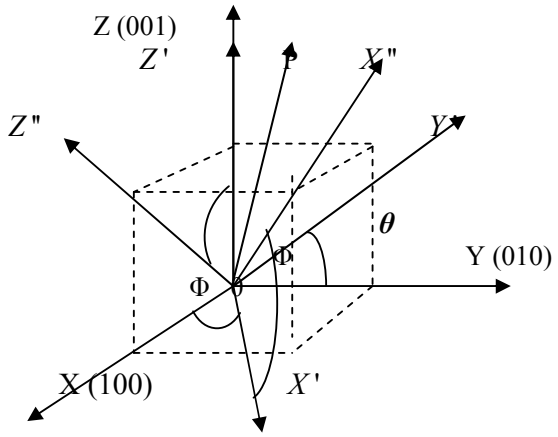


Fig.2: System model for evaluating photoelastic constant in some special orientations

Consider a unit vector P is moving from (100) direction to (011) direction. For a particular position of P, it makes an angle α with X axis. Let any point in XY plane is $(x, x\tan\phi, 0)$ after rotating by an angle Φ and then the same point rotates from $X'Z'$plane by an angle θ about Y' axis. So the final position is now $(x, x\tan\phi, x\tan\phi)$. The direction cosine ratio between these two points is

$$\cos\theta = \frac{\sec\phi}{\sqrt{\sec^2\phi + \tan^2\phi}} \qquad (5)$$

If we express $\cos\theta$ in terms of $\tan\theta$ then it can be written as

$$\tan\theta = \sin\phi \qquad (6)$$

The position of P meets in the same point which was obtained by the angles Φ and θ rotation. So the direction cosine between the point at X axis (x, 0, 0) and the point $(x, x\tan\phi, x\tan\phi)$ is

$$\cos\alpha = \frac{1}{\sqrt{\sec^2\phi + \tan^2\phi}} \qquad (7)$$

So the relation among the angles ϕ, θ and α can be found by the equations (6) and (7) which is

$$\cos\alpha = \cos\phi\cos\theta \qquad (8)$$

3.0 MATHEMATICAL ANALYSIS

Here we have developed a mathematical model based on tensor rotation technique to determine photoelastic constants in arbitrary crystal orientation.

3.1 MATHEMATICAL ANALYSIS FOR SYSTEM MODEL1

From the tensor rotation technique, the rotation matrixes for the first and second type rotation shown in figure (1) are respectively

$$C=\begin{bmatrix}\cos\phi & \sin\phi & 0\\ -\sin\phi & \cos\phi & 0\\ 0 & 0 & 1\end{bmatrix},\ B=\begin{bmatrix}\cos\theta & 0 & -\sin\theta\\ 0 & 1 & 0\\ \sin\theta & 0 & \cos\theta\end{bmatrix}$$

According to Euler's rotation theorem, the general rotation matrix M for two types of tensor rotation can be written as [3],

M=BC

$$=\begin{bmatrix}\cos\theta\cos\phi & \cos\theta\sin\phi & -\sin\theta\\ -\sin\phi & \cos\phi & 0\\ \sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta\end{bmatrix} \qquad (9)$$

The relation between photo elastic constant, P_{ijkl}, stress, X_{ij} and change in refractive index, Δn in the semiconductor material is [4]

$$\Delta n=-P_{ijkl}X_{ij} \qquad (10)$$

When equation (10) is expanded, it yields 81 P_{ijkl} components. According to tensor rotation rule, symmetry transformation results in equivalent 36 components form those 81 photoelastic constant [4]. Again by employing an additional Symmetry element for the cubic system we can have further reduced set of three independents components.

If photoelastic constant in any direction is known, its value in other direction can be calculated using Tensor rotation rule which is [4]

$$P'_{mnop}=\sum_{i,j,k,l=1}^{3} a_{mi}a_{nj}a_{ok}a_{pl}P_{ijkl} \qquad (11)$$

Where, $a_{mi}, a_{nj}, a_{ok}, a_{pl}$ are the respective direction cosines between the two sets of coordinate axis before and after symmetry transformation, respectively, in the case of Cartesian tensors which are expressed in the form of rotation matrix shown in equation (9). P_{ijkl} is the value of known photo elastic constant and P'_{mnop} indicates the value which is to be evaluated. By expanding equation (11) using the independent components of photoelastic constant we get

$$P'_{11}=P_{11}(\cos^4\theta\cos^4\Phi+\cos^4\theta\sin^4\Phi+\sin^4\theta)+2P_{12}(\cos^4\theta\cos^2\Phi\sin^2\Phi+\cos^2\theta\cos^2\Phi\sin^2\theta+\cos^2\theta\sin^2\Phi\sin^2\theta)+P_{44}(\cos^4\theta\cos^2\Phi\sin^2\Phi+\cos^2\theta\sin^2\Phi\sin^2\theta+\cos^2\theta\cos^2\Phi\sin^2\theta) \qquad (12)$$

$$P'_{12}=P_{11}(\cos^2\theta\cos^2\Phi\sin^2\Phi+\cos^2\theta\sin^2\Phi\cos^2\Phi)+P_{12}(\cos^2\theta\cos^4\phi+\cos^2\theta\sin^4\Phi+\sin^2\theta\sin^2\Phi+\sin^2\theta\cos^2\Phi)+P_{44}(-\cos^2\theta\cos^2\Phi\sin^2\Phi) \qquad (13)$$

$$P'_{13}=P_{11}(\cos^2\theta\cos^4\Phi\sin^2\theta+\cos^2\theta\sin^2\theta\sin^4\Phi+\sin^2\theta\cos^2\theta)+P_{12}(\cos^2\theta\sin^2\Phi\sin^2\theta\cos^2\Phi+\cos^4\theta\cos^2\Phi+\cos^2\theta\sin^2\Phi\sin^2\theta\cos^2\Phi+\cos^4\theta\sin^2\Phi+\sin^4\theta\cos^2\Phi+\sin^4\theta\sin^2\Phi)+P_{44}(\cos^2\theta\cos^2\Phi\sin^2\Phi\sin^2\theta+\cos^2\theta\sin^2\Phi\sin^2\theta-\cos^2\theta\cos^2\Phi\sin^2\theta) \qquad (14)$$

$$P'_{44}=P'_{1212}=P_{11}(\cos^2\theta\cos^2\Phi\sin^2\Phi+\cos^2\theta\sin^2\Phi\cos^2\Phi)+P_{12}(-2\cos^2\theta\cos^2\Phi\sin^2\Phi-2\cos^2\theta\cos^2\Phi\sin^2\theta)+P_{44}(\cos^2\theta\cos^4\phi+\sin^2\theta\sin^2\Phi) \qquad (15)$$

$$P'_{44}=P'_{2323}=P_{11}(\sin^2\Phi\sin^2\theta\cos^2\Phi+\cos^2\Phi\sin^2\theta\sin^2\Phi)+P_{12}(-2\sin^2\Phi\cos^2\Phi\sin^2\theta)+P_{44}(\sin^4\Phi\sin^2\theta+\cos^2\Phi\cos^2\theta) \qquad (16)$$

$$P'_{44}=P'_{3131}=P_{11}(\cos^2\theta\cos^4\phi\sin^2\theta+\cos^2\theta\sin^4\phi\sin^2\theta+\sin^2\theta\cos^2\theta)+P_{12}(2\cos^2\theta\cos^2\Phi\sin^2\Phi\sin^2\theta-2\cos^2\theta\cos^2\Phi\sin^2\theta-2\cos^2\theta\sin^2\theta\sin^2\Phi)+P_{44}(\cos^2\theta\sin^2\Phi\sin^2\theta\cos^2\Phi+\sin^4\theta\sin^2\Phi+\cos^4\theta\cos^2\Phi) \qquad (17)$$

According to Scanning Infrared Polariscope method, the photoelastic constants need to be evaluated in the form of $P'_{11}-P'_{12}$ and P'_{44}. Therefore, after employing some mathematical manipulation, we have derived the photoelastic constants in the form given below;

$$P'_{11} - P'_{12} = (P_{11} - P_{12})\,[1-3\cos^2\theta \sin^2\theta - 3\cos^4\theta \cos^2\Phi \sin^2\Phi] + \frac{3}{2}P_{44}\,[\cos^4\theta\cos^2\Phi\sin^2\Phi + \cos^2\theta\sin^2\theta] \quad (18)$$

$$P'_{44} = \frac{1}{3}(P_{11} - P_{12})\,[2\cos^2\Phi\sin^2\Phi + 2\cos^2\theta\sin^2\theta - 2\cos^2\theta\cos^2\Phi\sin^2\Phi\sin^2\theta] + \frac{1}{3}P_{44}\,[\cos^2\theta\cos^4\phi + \sin^2\theta\sin^2\Phi + \sin^4\phi\sin^2\theta + \cos^2\Phi\cos^2\theta + \sin^2\theta\cos^2\Phi\cos^2\theta\sin^2\Phi + \sin^4\theta\sin^2\Phi + \cos^4\theta\cos^2\Phi] \quad (19)$$

3.2 Mathematical Analysis for System Model2

For the second system model, to express the angle ϕ in terms of α from the two equations (6) and (8), after employing some mathematical manipulation we get

$$\phi = \cos^{-1}\sqrt{\frac{2\cos^2\alpha}{1+\cos^2\alpha}} \quad (20)$$

We can also write θ in terms of α by equation (6)

$$\theta = \tan^{-1}\left[\sin\left(\cos^{-1}\sqrt{\frac{2\cos^2\alpha}{1+\cos^2\alpha}}\right)\right] \quad (21)$$

Substituting equations (20) and (21) into equations (18) and (19) the photoelastic constants can be represented as

$$P'_{11}-P'_{12} = (P_{11}-P_{12})\left[1-3\cos^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\sin^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\} - 3\cos^4\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\cos^2\left\{\cos^{-1}\beta\right\}\sin^2\left\{\cos^{-1}\beta\right\}\right] + \frac{3}{2}P_{44}\left[\cos^4\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\cos^2\left\{\cos^{-1}\beta\right\}\sin^2\left\{\cos^{-1}\beta\right\} + \cos^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\sin^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\right] \quad (22)$$

And,

$$P'_{44} = \frac{1}{3}(P_{11}-P_{12})\left[2\cos^2\left\{\cos^{-1}\beta\right\}\sin^2\left\{\cos^{-1}\beta\right\} + 2\cos^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\sin^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\} - 2\cos^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\sin^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\} + \frac{1}{3}P_{44}\left[\cos^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\cos^4\left\{\cos^{-1}\beta\right\} + \sin^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\sin^2\left\{\cos^{-1}\beta\right\} + \sin^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\sin^4\left\{\cos^{-1}\beta\right\} + \cos^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\cos^2\left\{\cos^{-1}\beta\right\} + \sin^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\cos^2\left\{\cos^{-1}\beta\right\}\cos^2\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\} + \sin^2\left\{\cos^{-1}\beta\right\} + \sin^4\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\left[\sin\left(\cos^{-1}\beta\right)\right] + \cos^4\left\{\tan^{-1}\left[\sin\left(\cos^{-1}\beta\right)\right]\right\}\cos^2\left\{\cos^{-1}\beta\right\}\right] \quad (23)$$

Where, $\beta = \sqrt{\frac{2\cos^2\alpha}{1+\cos^2\alpha}}$

4.0 Results and Discussions

We have determined some numerical values of the unknown photoelastic constants for different crystal orientations with the known values of photoelastic constant along with a graphical representation. Here photoelastic constants are calculated using equations (18), (19), (22) and (23) for Si crystal as an example.

4.1 Determination of photo elastic constant from (100) to (110)

By putting θ equal to zero and varying ϕ from 0° to 45^0 in equation (18) and (19), values of P'_{11} - P'_{12} and P'_{44} in XY plane are calculated.

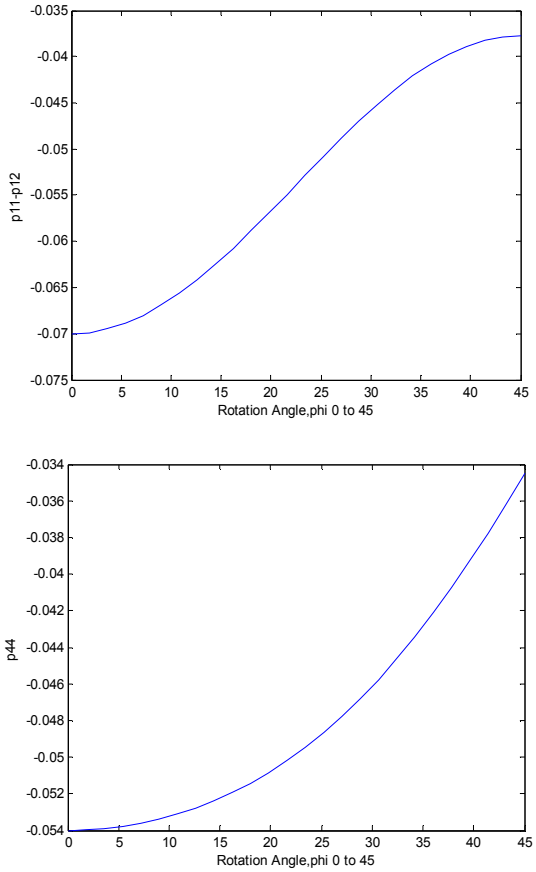


Fig.3: Variation of P'_{11} - P'_{12} and P'_{44} with respect to different rotation angles

4.2 DETERMINATION OF PHOTO ELASTIC CONSTANT FROM (110) TO (001)

Here we have calculated the values of P'_{11} - P'_{12} and P'_{44} in XZ plane by putting ϕ equal to 45 and varying θ from $0°$ to 90^0 in equations (18) and (19). A graphical representation is given below.

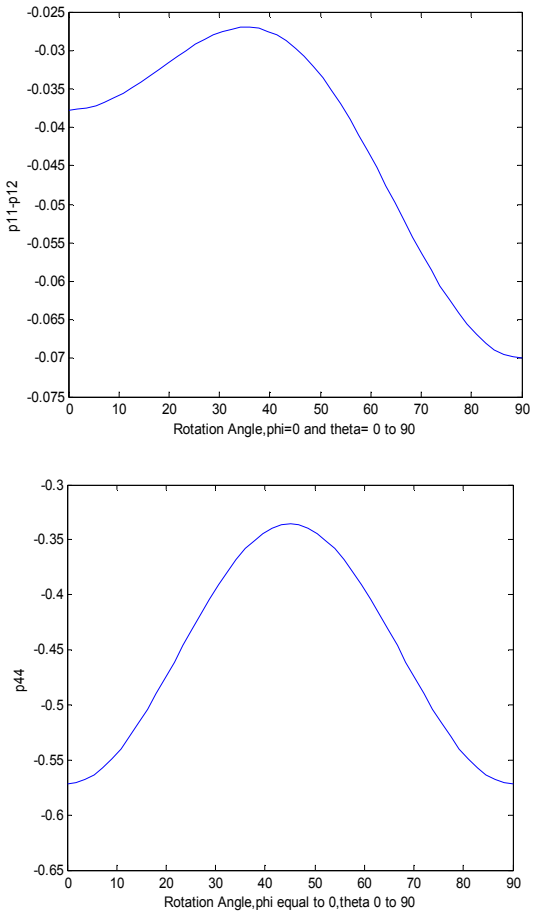
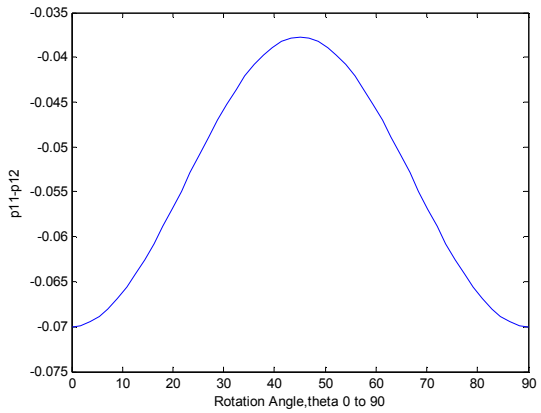


Fig 4: Variation of P'_{11} - P'_{12} and P'_{44} with respect to different rotation angles

4.3 DETERMINATION OF PHOTO ELASTIC CONSTANT FROM (100) TO (001)

In this case by putting ϕ equal to 0 and varing θ from $0°$ to 90^0 in equations (18) and (19), the values of P'_{11} - P'_{12} and P'_{44} are calculated. A graphical representation is given below.



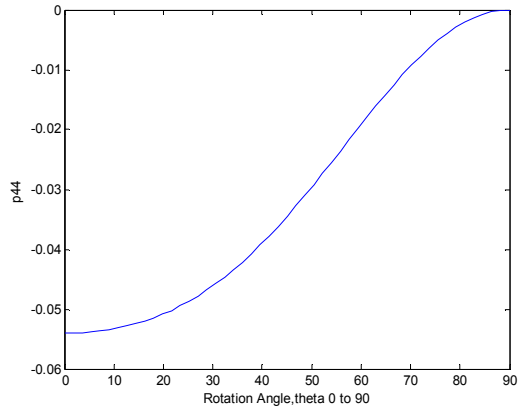
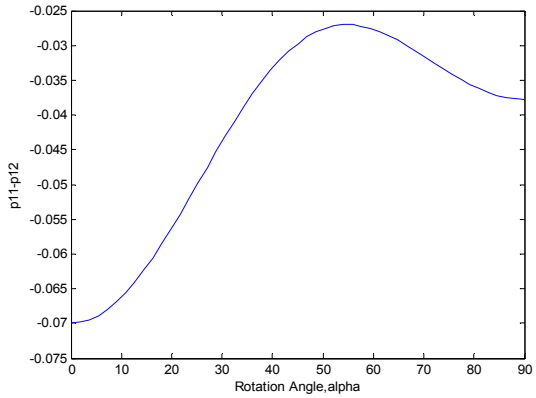


Fig. 5: Variation of P'_{11} - P'_{12} and P'_{44} with respect to different rotation angles

4.4 DETERMINATION OF PHOTO ELASTIC CONSTANT FROM (100) TO (011)

Here we have calculated the values of photoelastic constants by equations (22) and (23). By varying α from $0°$ to 90^0, the values of P'_{11} - P'_{12} and P'_{44} are calculated. A graphical representation is given below.



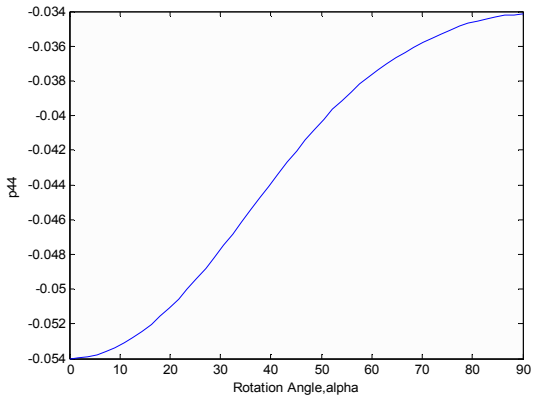


Fig. 6: Variation of P'_{11} - P'_{12} and P'_{44} with respect to different rotation angles

From the above figures, it is clear that the photoelastic constant P'_{44} and P'_{11} - P'_{12} vary nonlinearly with the angle of rotation. The values of P'_{44} and P'_{11} - P'_{12} give sinusoidal variation, exponential variation or harmonic variation with respect to rotation angles. This demonstrates that photoelastic constants, P'_{11} - P'_{12} and P'_{44} are strongly dependent on crystal orientation. By putting the numerical values of photo elastic constants, P'_{11} - P'_{12} and P'_{44} from the above figures in equation (1) and (2), we can characterize the components of strain with the help of Scanning Infrared Polariscope (SIRP) method.

5.0 CONCLUSION

In this work, we have derived mathematical formulations based on tensor rotation technique to determine the photoelastic constants in the form of P'_{11} - P'_{12} and P'_{44} in arbitrary crystal orientations. Using these formulations, P'_{11} - P'_{12} and P'_{44} can be determined in any particular crystal orientation by choosing the values of rotation angles. To characterize the strain induced in the polycrystalline material during the growth and cooling processes by means of Scanning Infrared Polariscope method it is very important to know the values of photoelastic constants corresponding to the crystal orientation. Though the model is showed for silicon material, it can also be applied for any material of Zincblende group.

REFERENCES

[1] M. Yamada, Quantitative photoelastic characterization of residual strains in LEC-grown indium phosphide (100) wafers, Proc. Of 5th Int. Conf. on InP and Related Materials, Paris France, IEEE Cat. #93CH3276-3, pp. 69-72, (1993)

[2] Henderson R.H. & E. Towe, Journal of applied physics 79 (4), 15 February 1996.

[3] "Euler's Rotation Theorem", http:// mathword.wolfram.com/Euler Angles.html

[4] T. S. Narasimhamutry, Photoelastic and Electro-Optic Properties of Crystals, Plenum press New York.

[5] Jun Chen, Bin Chen, Takashi Sekiguchi, masayuki Fukuzawa and Masayoki Yamada, Applied Physics Letters 93, 112105 (2008).

[6] Atsuko Niwa, Tsukuru Ohtoshi and Takao Kuroda, "Orientation Dependence of Optical Properties in Long Wavelength Electrical Electronic and Engineering Department Strained Quantum-Well Lasers", IEEE journal of selected topics in quantum electronics, Vol. 1, No. 2, June 1995.

.

AN EFFICIENT IMAGE WATERMARKING SYSTEM BASED ON ERROR CORRECTING CODES IN DCT DOMAIN

Pranab Kumar Dhar[(1)], Mohammad Ibrahim Khan[(1)] and Sujan Chowdhury[(1)]

1. Department of Computer Science and Engineering, Chittagong University of Engineering and Technology.

E-mail: pranab_cse@yahoo.com, muhammad_ikhancuet@yahoo.com, sujan_cse_04@yahoo.com

ABSTRACT

Digital watermarking has drawn extensive attention for copyright protection of multimedia data. This paper proposes a new watermarking system for digital images using efficient systematic linear block codes (SLBC) in discrete cosine transform (DCT) domain. The proposed watermarking system using SLBC generates a code sequence of {0, 1} that provides error correction capabilities and then replaces it with a binary watermark sequence of {-1, 1}. This achieves more robust invisible image watermarks and requires a small storage unit for binary sequence numbers. The generated watermark sequence is then used as an input for our proposed watermarking system which consists of watermark embedding process and watermark detection process. Experimental results indicate that the invisible watermark embedded with the proposed system are very robust against various kinds of attacks such as white Gaussian noise, JPEG compression, median, and mean filtering, by showing similarity values ranging from 0.7 to 0.8.

KEY WORDS: *Digital Watermarking, Linear Block Code, Copyright Protection.*

1.0 INTRODUCTION

In recent years, rapid development of information technology and computer networks, the privacy of copyrighted digital data has become an important issue in the digital industry. Multimedia data such as audio, video or image can be easily distributed over the Internet. However, many publishers may be reluctant to show their work on the Internet because multimedia data can be easily duplicated without the owner's consent. In order to overcome this copyright-protection issue, digital watermarking techniques have received considerable attentions. A digital watermark is an invisible signature embedded inside an image to show the authenticity and ownership. An effective digital watermark should be perceptually invisible to prevent obstruction of the original image. It should also be robust against many image manipulations, such as filtering, noise attack, and compression.

A significant number of watermarking techniques have been reported in recent years. Some methods embed the watermark in the spatial domain of an image [1-2]. Other watermarking techniques use transform methods, such as the fast Fourier transform (FFT) [3], discrete cosine transform (DCT) [4-6], to embed the watermark. Recent implementations have also used the human visual system (HVS) to improve the watermark performance [7-8].

In this paper, we propose efficient systematic linear block codes (SLBC) for the invisible image watermarking in the DCT domain. SLBC has been widely used in digital communication since it performs well for error correction when information is transmitted over a noisy channel [10]. However, SLBC generates a code sequence of {0, 1} which is not effective for embedding in DCT components since the watermark 0's cannot change the DCT components in (5) on Section 3.1. Thus, we replace the code sequence of {0, 1} with a binary watermark sequence of {-1, 1} which not only provides robustness to generate new watermarked DCT coefficients but also requires minimal storage for binary sequence numbers. The generated watermark sequence is then used as an input for our proposed watermarking system which consists of watermark embedding process and watermark detection process. Simulation results indicate that our proposed system shows strong robustness against several image processing attacks such as white Gaussian noise, JPEG compression, median, and mean filtering. It achieves similarity values ranging from 0.7 to 0.8.

The rest of the paper is organized as follows. Section 2 discusses the background information regarding linear block code, generator matrix, and error correction using SLBC. Section 3 introduces our proposed watermarking system including watermark embedding process and watermark detection process. Section 4 presents our experimental results, and finally section 5 concludes this paper.

2.0 BACKGROUND INFORMATION

2.1 SYSTEMATIC LINEAR BLOCK CODE

Systematic linear block code is a parity check code that can be characterized by the (n, k) notation where a block of k message bits is encoded into a longer block of n codeword bits. The encoding procedure assigns to each of the 2k message to one of the 2n code word [10].

2.2 GENERATOR MATRIX

Since a set of code word which forms a linear block code is k dimensional subspace of n dimensional binary vector space (k<n), it is always possible to find a set of n-tuples, fewer than 2k, that can generate all the 2k code words of the subspace. In general a generator matrix for systematic linear block codes of (n×k) dimension is defined as:

$$\mathbf{G} = \begin{pmatrix} \mathbf{P} & \mathbf{I_k} \end{pmatrix} = \begin{pmatrix} p_{11}\ p_{12} \cdots \cdots p_{1,(n-k)} & 1\ 0 \ldots \ldots 0 \\ p_{21}\ p_{22} \cdots \cdots p_{1,(n-k)} & 0\ 1 \ldots \ldots 0 \\ \cdots \quad \cdots \qquad \cdots & \cdots\cdots \\ p_{k1}\ p_{k2} \cdots \cdots p_{k,(n-k)} & 0\ 0 \ldots\ldots 1 \end{pmatrix} \quad (1)$$

where P is the parity check matrix and Ik is the (k×k) identify matrix. Let [m1, m2, m3,……,mk] be the message word and [u1, u2, u3,……,un] be the code word. Then, the relationship between the message and code words is given by

$$\begin{pmatrix} u_1, u_2, \ldots\ldots u_n \end{pmatrix} = \begin{pmatrix} m_1, m_2, \ldots\ldots m_k \end{pmatrix} \cdot \begin{pmatrix} p_{11}\ p_{12} \cdots \cdots p_{1,(n-k)} & 1\ 0 \ldots \ldots 0 \\ p_{21}\ p_{22} \cdots \cdots p_{1,(n-k)} & 0\ 1 \ldots \ldots 0 \\ \cdots \quad \cdots \qquad \cdots & \cdots\cdots \\ p_{k1}\ p_{k2} \cdots \cdots p_{k,(n-k)} & 0\ 0 \ldots\ldots 1 \end{pmatrix}$$

where

$$u_i = m_1 p_{1i} + m_2 p_{2i} + \ldots\ldots + m_k p_{ki} \quad \text{for } i=1, \ldots\ldots,(n-k)$$
$$= m_{i-n+k} \quad \text{for } i=(n-k+1), \ldots\ldots, n \qquad (2)$$

2.3 ERROR CORRECTION USING SLBC

Let **e** be the error vector and **r** be the received vector resulting from the transmission of **U**. Therefore, **r** can be defined as **r**=**U**+**e**. The syndrome of **r** is defined as **S**= r$\mathbf{H}^T$, where **H** is the parity check matrix such that $\mathbf{UH}^T$ =0. We then have

$$\mathbf{S} = (\mathbf{U}+\mathbf{e})\ \mathbf{H}^T$$
$$= \mathbf{UH}^T + \mathbf{eH}^T \qquad (\mathbf{UH}^T=0) \qquad (3)$$
$$= \mathbf{eH}^T$$

If the syndrome vector is zero, we suppose that no errors are detected. In other words, if it is not zero then errors will be detected in the decoder. To detect the error pattern from the syndrome vector, a reserved syndrome table is used. The error is then corrected by utilizing the error pattern with the received vector.

3.0 PROPOSED WATERMARKING SYSTEM

3.1 WATERMARK EMBEDDING PROCESS

The proposed watermark embedding process is shown in Figure 1. In this process, the input message is encoded by a systematic linear block encoder and the generator matrix of linear block code is used as a watermark key. The output of the watermark encoder is a bipolar sequence of {0, 1}. This bipolar sequence of {0,1} is then mapped to the watermark sequence of {-1, 1} for the effective watermark embedding in the DCT domain. Thus, the watermark sequence X(n) is a sequence of n binary numbers of ±1. The embedding process is implemented in the following three steps:

Step 1: The original image is transformed to the DCT domain to calculate DCT components F(u,v) of original image I(m,n), by the following equation:

$$F(u,v) = \frac{C(u)C(v)}{\sqrt{2N}} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\frac{(2x+1)u\pi}{2N} \cos\frac{(2y+1)v\pi}{2N} \qquad (4)$$

where C(u) = $1/\sqrt{2}$ for u = 0 and C(u) = 1 for u > 0.

Step 2: Embed the watermark in the n higher magnitude coefficients in the transform matrix excluding the DC component. This ensures that the watermark is located at the most significant perceptual components of the image. If the watermark is embedded in less significant components, it may be considerably destroyed by compression or other forms of attacks. When the watermark X(n) is embedded into DCT components F(u,v) to obtain new watermarked DCT coefficients F*(u,v), we specify a scaling parameter α which determines the extent to which X(n) alters F(u,v), shown in the following equation [4]:

$$F^{*}(u,v) = F(u,v)[1 + \alpha X(n)] \quad (5)$$

Step 3: Insert back n modified DCT components $F^{*}(u,v)$ and take an inverse DCT transform to get the watermarked image $I^{*}(u,v)$.

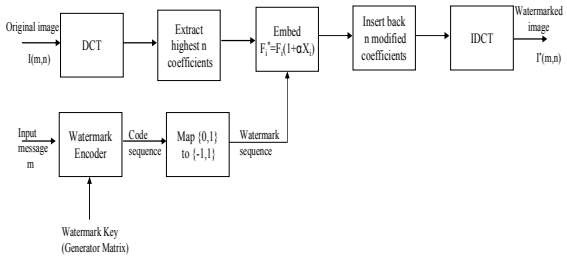


Fig 1: Watermark embedding process

3.2 WATERMARK DETECTION PROCESS

The proposed watermark detection process is shown in Figure 2. The detection process is implemented in the following four steps:

Step 1: Calculate the DCT components of the attacked watermark image $I^{*}(u,v)$ and extract n coefficients of the transform matrix which are located at the same position in the embedding process above.

Step 2: The watermark is then extracted by performing the inverse function of (6), shown in the following equation:

$$Xi^{*} = (F_i^{*} / F_i - 1)/\alpha \quad (6)$$

Step 3: Replace the extracted watermark sequence of {-1, 1} with the code sequence of {0, 1} and then apply to the watermark decoder as an input.

Step 4: Correct the sequence {0, 1} using SLBC which provides error correction capabilities and extract the watermark X*(n) from the corrected sequence.

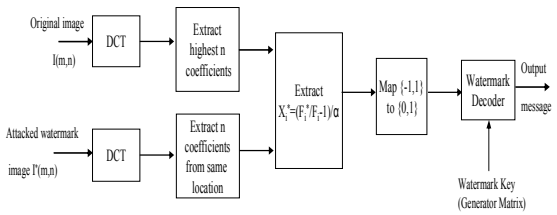


Figure 2: Watermark detection process

4.0 SIMULATION RESULTS

In order to evaluate the performance of the proposed watermarking scheme in terms of the robustness of watermark detection, the correlation coefficient between the original watermark X(n) and the extracted watermark $X^{*}(n)$ is calculated by the following similarity function:

$$SIM(X, X^{*}) = \frac{\sum_n X(n).X^{*}(n)}{\sqrt{\sum_n [X(n).X(n)]}\sqrt{\sum_n [X^{*}(n).X^{*}(n)]}} \quad (7)$$

It is highly unlikely that $X^{*}(n)$ is identical to X(n). To decide whether X(n) and $X^{*}(n)$ match, we determine whether the $SIM(X, X^{+}) > T$, where T is a detection threshold.

In this study, the selected length of the watermark sequence and message signal is 512 and 64, respectively. The structure of the SLBC encoding process used in this simulation is given below:

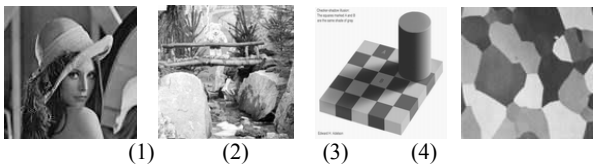
[1×16 bit code sequence] = [1×2 bit message] × [2×16 bit generator matrix]

This encoding process can generate 16 bit code sequence at a time by using two-bit message signal and 2×16 bit generator matrix. By executing this encoding process 32 times, it can generate 32×16= 512 bit code sequence by using two-bit message sequence and 2×16 bit generator matrix.

The generator matrix used in this simulation is

$$\mathbf{G} = \begin{pmatrix} 1\,1\,0\,1\,0\,1\,0\,1\,0\,1\,1\,1\,0\,1\,1\,0 \\ 1\,0\,1\,0\,1\,1\,1\,0\,1\,0\,1\,0\,1\,1\,0\,1 \end{pmatrix} \quad (8)$$

Figure 3 shows four different original images used in this study. Figure 4 shows a qualitative evaluation of the original 128x128 "Lena" image with a watermarked output image in which the watermark is invisible in the watermarked image.



(1) (2) (3) (4)

Fig.3: Four different original images used in the study

Fig.4: Original Lena image, watermarked Lena image and difference image

Fig. 6 and 7 shows the original message signal and detected message signal when no attack is applied to watermarked Lena image.

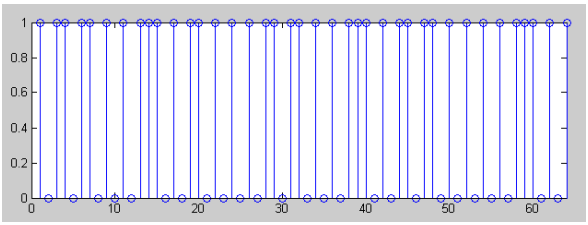


Fig.6: Original message signal

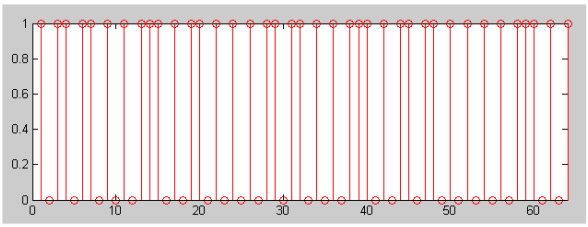


Fig.7: Detected message signal

Fig. 8 shows the original watermark sequence and detected watermark sequence represented by a 32×16 image when no attack is applied to watermarked Lena image.

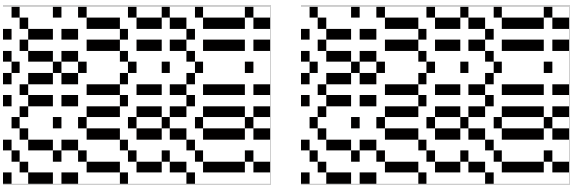


Fig.8: Original watermark sequence and detected watermark sequence

Table 1 shows the results of the watermark detection when no attack is applied to four different types of watermarked images as shown in Fig. 7. Thus, our proposed system can perfectly detect the watermark sequence when no attack is applied to each watermarked image.

No Attack	SIM
Image 1	1
Image 2	1
Image 3	1
Image 4	1

Table 1: Watermark detection without attack

In addition to the qualitative evaluation, a quantitative evaluation must be done because the similarity between the original watermark X(n) and the extracted watermark $X^*(n)$ is the best subjective measure for determining the robustness of the proposed watermarking scheme. In order to evaluate the performance of our proposed scheme, it is tested against several kinds of image processing attacks such as white Gaussian noise, JPEG compression, mean, and median filtering.

4.1 NOISE ATTACK

For the noise attack, white Gaussian noises with zero mean and different variances (100, 300, 600, and 900) were added into the watermarked Lena image as shown in Figure 9. Table 2 illustrates the similarity results of the proposed scheme against the white Gaussian noise attack. Our proposed system achieves similarity values ranging from 0.77 to 0.80.

Fig 9: Results of adding different Gaussian noises to the watermarked Lena image

$N(\mu, \sigma^2)$	SIM			
	Image 1	Image 2	Image 3	Image 4
N(0,100)	0.8077	0.8051	0.8093	0.8084
N(0,300)	0.8052	0.8019	0.8071	0.8068
N(0,600)	0.7927	0.7969	0.7968	0.7868
N(0,900)	0.7868	0.7747	0.7936	0.7742

Table 2: Similarity results of the proposed system against the white Gaussian noise attack

4.2 JPEG COMPRESSION ATTACK

Figure 10 shows results of applying JPEG compression to different watermarked images.

Table 3 shows similarity results of the proposed system against the JPEG compression attack. Our proposed system achieves similarity values ranging from 0.80 to 0.81.

Fig 10: Results of applying the JPEG compression attack to different watermarked images

JPEG Compression	SIM
Image 1	0.8019
Image 2	0.8060
Image 3	0.8077
Image 4	0.8101

Table 3. Similarity results of the proposed system against the JPEG compression attack

4.3 MEDIAN FILTERING ATTACK

For the median filtering attack, watermarked images were filtered by a 3×3 median filter as shown in Figure 11. Table 4 shows the similarity results of the proposed system against the median filtering attack. Our proposed scheme achieves similarity values ranging from 0.79 to 0.80.

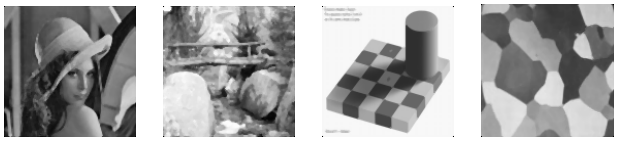


Fig 10: Results of applying the median filtering attack to different watermarked images

Median Filtering	SIM
Image 1	0.7967
Image 2	0.8009
Image 3	0. 8077
Image 4	0. 8043

Table 4: Similarity results of the proposed system against median filtering attack

4.4 MEAN FILTERING ATTACK

For the mean filtering attack, watermarked images were filtered by a 3×3 mean filter as shown in Figure 9. Table 5 shows similarity results of the proposed system against the mean filtering attack. Our proposed scheme achieves similarity values ranging from 0.7 to 0.8.

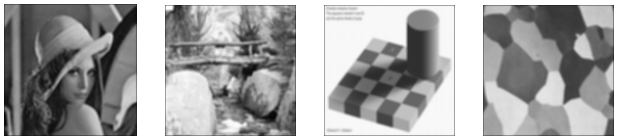


Fig 11. Results of applying the mean filtering attack to different watermarked images

Mean Filtering	SIM
Image 1	0.8109
Image 2	0.7635
Image 3	0. 7927
Image 4	0. 8026

Table 5: Similarity results of the proposed system against mean filtering attack

Overall, the proposed watermarking system shows strong robustness against several kinds of image processing attacks including white Gaussian noise, JPEG compression, median, and mean filtering.

5.0 CONCLUSION

In this paper, a new image watermarking system using efficient systematic linear block codes (SLBC) in DCT domain has been proposed for image copyright protection. Experimental results show that the watermark embedded with the proposed system is invisible. In addition, our proposed system is highly robust against several kinds of image processing attacks including white Gaussian noise, JPEG compression, median, and mean filtering. It achieves similarity values ranging from 0.7 to 0.8. These results demonstrate that our proposed watermarking system can be a suitable candidate for image copyright protection.

REFERENCES

[1] R. Schyndel, A. Tirkel, and C. Osborne, "A Digital Watermark," in Proceedings of IEEE International Conference on Image Processing, Vol. 2, pp. 86-90, Nov. 1994.

[2] I. Pitas, "A Method for Signature Casting on Digital Images," in Proceedings of IEEE International Conference on Image Processing, Vol. 3, pp. 215-218, Sept. 1996.

[3] J. O'Ruanaidh, W. Dowling, and F. Boland, "Phase Watermarking of Digital Images," in Proceedings of IEEE International Conference on Image Processing, Vol. 3, pp. 239-242, Sep. 1996.

[4] I. Cox, J. Killian, F. Leighton, and T. Shamoon, "Secure Spread Spectrum Watermarking for Multimedia Data," IEEE Transactions on Image Processing, Vol. 6, No. 12, pp. 1673-1687, Dec. 1997.

[5] S. Craver, N. Memon, B. Yeo, and M. Yeung, "Resolving Rightful Ownerships with Invisible Watermarking Techniques: Limitations, Attacks, and Implications," IEEE Journal on Selected Areas in Communications, vol. 16, No. 4, pp. 573-586, May 1998.

[6] C. C. Wai, "DCT-Based Image Watermarking Using Subsampling," IEEE Transaction on Multimedia, Vol. 5, No. 1, pp. 34-38, 2003.

[7] S. H. Yang, "Filter Evaluation for DWT-domain Image Watermarking," Electronics Letters, Vol. 39, No. 11, pp. 840-841, November 2003.

[8] J. Huang and Y.Q. Shi, "Adaptive Image Watermarking Scheme Based on Visual Masking," Electronics Letters, Vol. 34, No. 8, pp. 748-750, 1998.

[9] J. Delaigle, C. D. Vleeschouwer and B. Macq, "Psychovisual Approach to Digital Picture Watermarking" Journal of Electronic Imaging, Vol. 7, No. 3, pp. 628-640, 1998.

[10] B. Sklar, Digital Communications Fundamentals and Applications, Second Edition, Pearson Education, 2002.

MIST JOURNAL

Technology for Advancement

Notes for Contributors

Manuscripts Submission on Compact Disc / Removable Disc

Authors are requested to submit two hard copies of their manuscript in English. The length of manuscripts should not normally exceed 7,000 words (including footnotes) within 25-30 double-spaced A4 size papers. Manuscripts are accepted subject to editorial revision. The manuscripts should be typed on one side of white A4 paper.

The submitted manuscripts should contain: name(s) of the author(s) including complete mailing address, an abstract of approximate 150-200 words and acknowledgements (if any) should appear after the abstract.

Once a manuscript is accepted for publication, the author(s) should submit a copy of the manuscript on a computer Compact Disc labelled with the title of the article, the name(s) of the author(s) and the word processing software used.

Footnotes and Quotations

Footnotes should be numbered consecutively with superscript Arabic numerals. They should be typed single-spaced and should be placed at the foot of each page. Footnotes should not be used solely for citing references. They may cover illustration/ explanation of a point the author thinks the readers should be made aware of.

Tables & Figures

All tables should be numbered consecutively with Arabic numerals. Full source(s) should appear below the table followed by notes, if any, in lower letters.

All figures should be numbered consecutively. Figures should be planned to fit the proportions of the printed page. Full source(s) should be provided below each figure.

All maps should be numbered consecutively. Full sources should be provided below each map.

Military Institute of Science and Technology (MIST)
Mirpur Cantonment, Dhaka-1216.
Bangladesh

ISSN: 2073-6444

MIST JOURNAL

Technology for Advancement

Postal Address	:	MIST, Mirpur Cantonment, Dhaka-1216, Bangladesh
e-mail	:	info@mist.edu.bd
Fax	:	+88-02-9011311
Web	:	www.mist.ac.bd

Military Institute of Science and Technology (MIST)
Mirpur Cantonment, Dhaka-1216.
Bangladesh

ISSN: 2073-6444