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FOREWORD

Since the establishment of Military Institute of Science and Technology (MIST) the quest for better understanding of science and technology is being continued in full swing. This institute receives undergraduate students, from both civil and military background of home and abroad as well. They are transformed into a capable graduate, who are ready to undertake greater responsibilities in the fields of science, business, and administration as well as in defence preparation. MIST is working on the formulation of the post graduate curriculum and to start the courses of advanced technology and research.

In this contemporary world of globalization the acquirement of superior technology and scientific know-how provides the advantageous leverage over its rivals in the relevant fields. The continuous improvement and development of the technology creates an obligation to this institute to further the research and development of the basics and applied engineering sciences.

The academic curriculum is designed in such a way that faculty and students are to study and document results of their investigations in the practical fields. The students who are future teachers, researchers and executors in their career to be adopted; needed to be trained in the process of methodology of research and publications.

MIST engaged in creating leaders for the country. So, the effort to develop the potential of those students into its full quota needs a deliberate plan and process to transform those youngsters into matured faculty/executives. MIST involved in the cooperation of different activities with the public and private engineering universities/institutes. These are paying great dividends in sharing the knowledge and experience of their research and study. MIST also has involved itself in utilizing the technical facilities of on-line library, books and publication exchanges, organizing joint seminars etc.

I am happy to note that the publication of the 1st issue of MIST journal in the professional form has taken place. A number of selected written works of engineering research carried out by the faculty and students are included in this journal. Obviously the articles have been concise to this condensed from its original in order to manage space. Despite that the articles would be able to generate interest and divulge relevant information to the readers' interest.

I congratulate the writers and editorial board of this journal for their tireless endevour to make publication process a success. I wish that our alumni and readers find this technical journal be useful in furthering their knowledge level in order to achieve the motto of this institute '*Technology for Advancement.'*

Dr ABDUL WADUD
Major General
Commandant
Military Institute of Science and Technology

EDITORIAL

Military Institute of Science and Technology is one such premier institute of Bangladesh whose mission is energized towards cultivating and sharpening the storm of intellectual passion within its members. 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. The *Journal* seeks to foster the exchange of significant new ideas and information. The Scope of the *Journal* covers the full range of research, analysis, design, manufacturing, test, operations, and support. A constantly growing list of specialty areas is included within that scope. These range from the classical fields of engineering to more recent priorities and to practical issues like computational and experimental techniques solving scientific and engineering problems.

Acceptance of papers was judged on technical quality, relevance and importance of material, interest to reader, and timeliness. Some points that were considered for selection of papers are whether it reports significant information and is written in a style appropriate for an archive publication. Authors had to certify that the submitted manuscript has not been published previously or submitted for publication elsewhere, and does not violate any security, proprietary, or copyright restrictions. Papers contained in this issue were prepared according to instructions for authors and was subjected to a rigorous technical review by the appropriate Technical Committee.

The editorial would not be complete if we do not record our gratitude to the Chief Patron of the Journal, Major General Abdul Wadud, ndu, psc,PhD, the Commandant, MIST. He gave us invaluable guidance in our editorial responsibility. We forward our deepest appreciation of the hard work, and relentless support by members of the editorial board. We also thank the advisory board for their valuable guidance and support. Despite all efforts, toils and sincerity, unintentional errors in whatever form may not be unlikely in the appearance of the journal. We fervently beseech the readers to pardon us of such unnoticed slights.

Comments on the Journal, articles as well as opinions on MIST technical or editorial policy are welcome and will be considered. We hope that the journal will prove its worth to a reader with an investigative mind, an intellectual zeal, an assiduous learning and an academic yearning.

M Z ALAMGIR
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- To make provisions for research and development and dissemination of knowledge and technology.

OBJECTIVES

- To establish a prestigious academic institute for studies in different fields of engineering and technology for military personnel and civil officials/ students of home and abroad at degree and postgraduate level.

- To organize courses on military science, technology and management in various areas of interest.

- To hold examinations and confer certificates of diplomas/degrees, other academic distinctions, to and on persons who have persuaded a course of study and have passed examinations conducted by the institute.

- To confer research degrees, award fellowship, scholarship, exhibition, prizes, medals and honorary degrees to persons who have carried out research work under conditions as prescribed in the MIST regulations.

- To make provisions for advisory, research and consultation service including supervision, material testing and to enter into suitable agreement with any persons/organizations for this purpose.

- To co-operate with universities/ technical institutions (both military and civil) including Signing Memorandum of Understanding (MOV) at home and abroad, in the manner and purpose as the institute may determine.

- To do such other acts, related to above-mentioned objectives, as may be required in order to expand the objectives of the institute.

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INTREGRATION OF TELECOMMUNICATION IN PASSPORT MAKING PROCESS - A PSEUDO MEANS TO REDUCE TRAVEL DEMAND AND OTHER SUFFERINGS

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ABSTRACT

Telecommunication or Information Communication Technologies (ICT) that is changing rapidly every aspects of life, is also bringing significant changes in the traditional concept of transportation. Like other telecom enabled services (1), telecom enabled passport making process has the potential to reduce significant travel demand and associated sufferings of the clients, hence of the society. On this consideration, existing passport making, renewal, amendment processes have been critically analyzed in this paper to identify the amount and pattern of physical trips and associated sufferings involved in these processes as well as to explore the way of how telecommunication or ICT can gainfully be integrated with the system. The analysis found that for the purpose of passport making, renewal and amendement process daily approximately 18,000 trips are made around Dhaka passport office. Most of these trips are made during the peak periods availing the highly congested city transport network spending huge amount of fuel, time, money and labor. It is further estimated that effective integration of ICT in the existing system can reduce or convert 63-75 percent physical trips to Fuel Free (FF) electronic trips. In addition, ICT enabled system can also speed up and simplify the process, minimize massive paper works and corruptions, ease up the social sufferings, and increase the productivity of the system. It is expected that this study would help the transport planners and policy makers' better way of understanding how the ICT can reduce the need for travel demand in different fields and thereby solve local traffic induced problems.

Keywords: Telecommunication, ICT, Peak period trip, Fuel Free Trips, Electronic Trips, Travel Demand

1. INTRODUCTION

Passport making, renewal or amendment processes involve certain steps fulfilling of what demands numbers of physical trips to passport offices, banks and other related offices/ organizations. In Bangladesh, there are 15 passport offices all over the country including one at Dhaka who is responsible for the people of six districts namely Dhaka, Narayanganj, Munshigang, Narshigdi, Gazipur, and Manikganj. The statistics reveals that every year more than a million of passports (new making, renewal and amendment) are being issued to the people all over the country from these 15 offices. Dhaka office alone issues 47 percent passport and rest 14 offices of the country issues 53 percent passport i.e. each of the rest of the 14 offices issues only 4 percent passports (1). This implies that about 12 times more people are visiting only Dhaka office than any other office of the country. As such huge amount of trips are generated around Dhaka Passport office. These trips are made using already overburdened and insufficient transport network and transport mode of the city. They aggravate the already unmanageable city traffic congestion and environmental/health hazards. Parking of cars and mass gathering of people in the office premises impose incredible distress for other people of the city too. In addressing these issues, the scope of expanding road network by traditional measures is difficult and expensive due to the acute scarcity of space. The possibility of augmenting roadway capacity by introducing low cost traffic management measures is also limited.

On the other hand, thorough literature review reveals that Telecommunication or Information Communication Technologies (ICT) has huge transport potential to manage urban traffic problems (2, 3, 4, 5). It can be used effectively to replace vehicle or physical traffic on the streets and highways into digital traffic through national information infrastructure (NII). Other countries mainly developed countries have been successfully exploiting the transportation potentiality of it (6, 7, 8). Unfortunately hardly any initiatives in this regard have been taken in Bangladesh though the country's ailing ICT scenario is getting healthier since last few years. From these perspectives, it was necessary to make an endeavor to harness the transport potential of ICT in reducing the traffic induced problems related with the present passport making process.

The specific objective of this study is to carry out a comprehensive system analyses of the existing passport making, renewal or amendment process to identify the amount of physical trips involved as well as to identify the physical trips that could be minimized or converted to e-based Fuel Free (FF) trips by making the system ICT enabled with a view to solve a part of the existing transportation problems of Bangladesh particularly of Dhaka city. Here an endeavor is also made to explore the ICT status of the country as a whole and concerned

offices in particular to see whether the ICT can be gainfully integrated with system.

In this paper, the evaluation is made basing on the use of existing (Option 1-short term evaluation) and improved ICT options (Option 2- long term evaluation). Considering higher intensity of trips and more critical traffic condition, the investigation is kept limited around Dhaka city only. This study is expected to help policy makers' better way of understanding how the ICT can gainfully be integrated in the passport making, renewal or amendment process to reduce the travel demand and associated sufferings.

2. DATA COLLECTION

Study specific various data are collected mainly from primary sources by conducting comprehensive surveys (questionnaire, telephonic and photographic surveys) among different categories of clients. Valuable information are collected through face to face interview with number of officials designated as Director General (DG), Deputy Director, Deputy Assistant Director, Officer in Charge (OIC) of passport section, and other staffs particularly those working in different counters (reception counter, delivery counter, inquiry cell etc) of the office. In order to get clear picture and most accurate information surveys were conducted on different categories of clients in different dates and time (during morning, noon and afternoon) in the passport office premises. Number of photographs and video clips were also captured as the evidence of few events. Besides the physical survey, different personnel were contacted over telephone time to time to learn their experiences and sufferings.

In this study work, existing local situation of ICT infrastructures and its usage in the whole process by passport office and other related offices/organizations have been assessed by gathering relevant data/information both from primary and secondary sources (inventory list and by face to face interviews with the clients and officials). In this connection, people from other concerned sectors and fields were asked both closed and open-ended question to get their opinion regarding the prospect and limitation of introducing ICT based passport making process in Bangladesh.

3. SYSTEM ANALYSIS - PASSPORT MAKING PROCESS

3.1 STEPS INVOLVED IN THE PROCESS

Though passport office is the sole authority to deliver the passport, the investigation unveiled that one has to visit several other institution or offices like banks for payment of fees, Special Branch (SB) of police offices for pursuing or verification, brokers and authorized person for filling up and attestation etc. The whole system, through which a passport is made as envisaged from the system analysis is outlined by the flow diagram as shown in Figure 1.

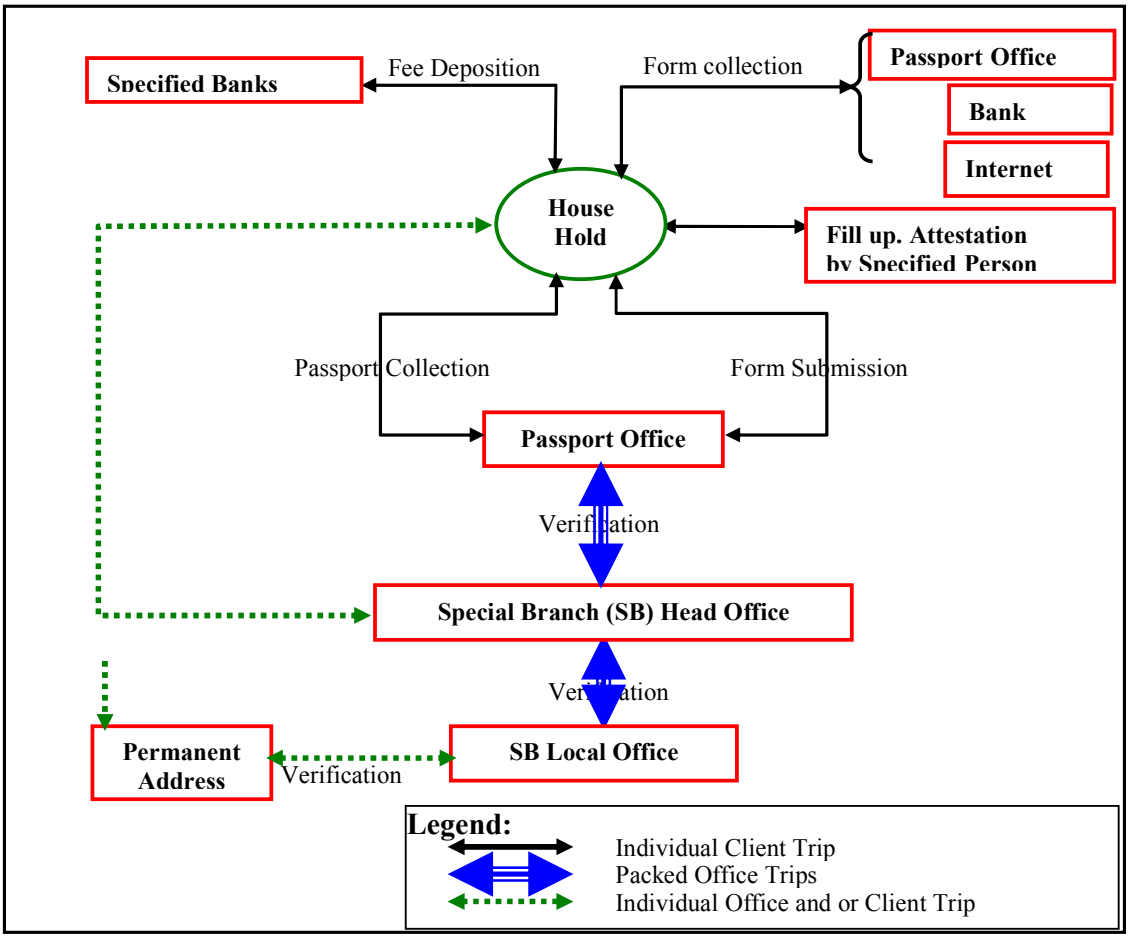


Figure 1: Actual Passport Making Procedure

Close observation of Figure 1 reveals that clients are to make at lest one round trip for each of the following purposes (indicated by solid thin black arrows):

- Form collection
- Deposition of fee to bank
- Attestation / certification by specified person
- Submission of Form
- Passport collection

Trips (indicated by broken/dotted lines) to SB offices may be needed for verification and necessary pursuance. Trips indicated by solid thick triple lined arrows are supposed to be in a packed form for following purposes:

- Sending applications from passport office to SB office and back
- Forwarding of the same from SB office to local offices and back
- Trip by police personnel to applicants addresses or back

Keeping in mind the objectives of the study, deliberate efforts are made to investigate the above procedures in details in the subsequent paragraphs.

3.2 APPLICATION FORM COLLECTION

As shown in Figure 1 application Forms may be collected from passport office, few prescribed branches of Sonali bank located in Dhaka or downloaded from internet (recently made available). Most of the surveyed personnel were found to collect the Forms from passport office, very few were found to collect the same from the prescribed banks making physical trip, but none among the surveyed clients were found to download the Form from internet. Surprisingly, some of the officials were not also sure whether the Forms were available on internet or not. Few clients said if they would know the availability of Forms in internet, they would download the same from internet. Many are found not very familiar with the internet and have traveled to Dhaka from even other districts to collect the Form. When they are told that they could collect the Forms from the phone/fax/internet café without traveling down to banks or passport office, most of them agreed to do so if knew earlier. Very few knew the availability of Form in internet but did not get it from there. the analysis revealed that ignorance about the availability of Forms in the internet, fear of unknown, negligence and lack of knowledge for not availing the internet option.

3..2 FILL UP AND ATTESTATION

Out of seven sections, at least three have to be completed by the applicants and two by the office. Most people are not expert in filling up the Forms as this is not a regular phenomenon in the daily activities thereby found seeking help from others mainly brokers. Questionnaire survey among clients reveals that most of the clients make physical trips for filling up and certification of application Forms. However, few clients said that, if the Forms with a specimen were made available on internet, they would fill up by themselves or could seek help from cyber café personnel for the needful. It is confirmed from General Secretary of Cyber Café Owners Association of Bangladesh that they are capable of doing so (1). It is unveiled from the questionnaire survey that, most of the clients (60-80%) depend on brokers for filling up of Forms and certification or attestation. Clients and officials said that many are involved in making fake attestation in lie of 50-100 taka thus directly or indirectly doing forgery. This is also educated to be true from other sources **(9).** Few officials as well as many clients claimed to omit the provision of certification or attestation. They said "Officials in the counter can easily verify the client by seeing the photographs during submission of Form and if necessary by tallying the signature." This provision would minimize physical trips, effort and cost involved in the process and prevent people from doing forgery.

3..3 DEPOSOTION OF FEE TO BANKS

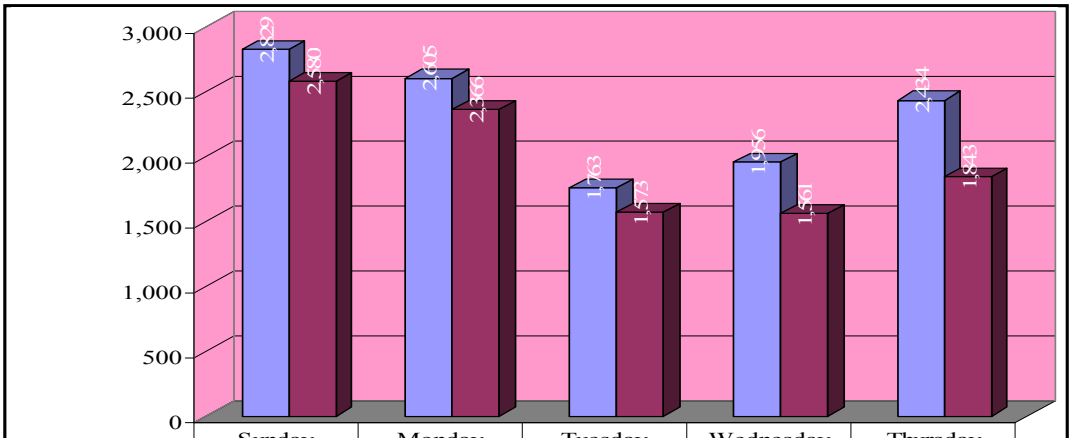
It is learned that, fees for new passport or renewal need to be deposited to 10 branches of Sonali Bank located in Dhaka only from 0900 to 1500 hours (1). People from six districts have to make trips to these 10 branches to deposit fees. During field survey, there were found long queues in most of the branches specially Agargaon branch for this purpose. About one in every ten people is found to come here to deposit fees for second days. Most people spend whole day here. Many claimed to come here early in the morning with a view to deposit fees to bank and submit the Form to passport office on the same day. However, questionnaire survey reveals that hardly anybody could do these two tasks at one go. When the clients were asked about the suggestion to get rid of these sufferings, many proposed to increase the number of banks and counters. Few demanded to increase the duration of money deposition period. When the author explained the on-line money transfer system and its benefits, most of the clients agreed to use the option if offered.

3..4 SUBMISSION OF APPLICATION FORM

Two copies duly filled up and attested Forms attached with photographs and a counter foil of fee deposition to be submitted physically to the passport office in every official day from 1000 to 1300 hours. Everyday thousands of applications are received and passports are delivered by Dhaka Passport office as shown by the bar diagram in Figure 2.

During field survey it is found that actual number of people visiting the passport office for submitting application is more that that shown in the Figure. From the questionnaire survey, it is found that two to three in every ten surveyed clients (i.e. about 20%-30% clients) go back unsuccessfully with a desire to come in the next day. During field survey, hundreds of people were found standing under the scorching sun in front of the passport office for submitting their application. Photograph 1 shows a part of queue in front of passport office. Clients explained their bitter experience of long time standing, pushing and pulling, fighting with each other in and around the counters. On receiving the Form the recipient

hand over an initialed Receipt (Photograph 2) to the applicants sealed with the delivery date of passport.



	Sunday	Monday	Tuesday	Wednesday	Thursday
No. received	2,829	2,605	1,763	1,956	2,434
No. delivered	2,580	2,366	1,573	1,561	1,843

Figure 2: No. of Application Received and Passport Delivered by Dhaka Passport Office, 04 to 08 Mar 2007

3..5 SENDING A COPY OF APPLICATION FORM TO SB OFFICE

One copy of the Application Form is then sent to SB of police at Malibagh, Dhaka and this office in turn send the same to applicant's present and permanent addresses. After necessary verification by SB authority, the Forms are sent back to the passport office again. Officials of the passport office inquiry cell said that in most cases by the time verification report come back to the passport office; a long time expires and in many cases report come after the scheduled date of delivery. In depth investigation unveils that many clients visit to SB offices number of times to expedite the verification process and some one need to give bribe to the concerned Inspector. Many claimed that SB office do not send the verification report in time if they are not physically contacted.

Photo 1: Clients in queues for Form submission and passport collection, Apr 07

3..6 PREPARATION OF PASSPORT BY THE OFFICE AND COLLECTION BY THE CLIENTS

It is learned from the authority that after getting the positive verification report from SB office and after receiving the bank scroll of fee deposition, passport division starts making the passport. Finally, on completion, the passport is handed over to the applicants on scheduled date. Though passports are scheduled to be delivered from 1400 to 1700 hours, clients were observed to stand in line since morning. The lines extend from the front of delivery counter to the main gate

(Photograph 1) and at times beyond main gate. More clients are found fighting for their position in the line inside the hall room where few are found faint due to congestion, heat, and beating of security personnel. Every day about 1500 – 2500 passports are delivered, but number of people found gathering in front of the counters is much higher than the number of passport to be delivered. Many clients are found returning home without the passport after wasting whole day in the passport office. Questionnaire survey unveiled that almost all the clients visit the passport office and approach to the delivery counters on the scheduled date but around 50 percent clients fails to get their passport on due date. On reaching the delivery counters, many clients come to know that the passports are not ready and a fresh delivery date is given. It is educated from the clients that there are no scope to learn about the state of passport over telephone or by any other means before reaching and talking to the person sitting in the delivery counter. Therefore, delivery counters had to go through extra pressure and clients themselves not only had to make unnecessary travel involving extra effort, labor and cost but also put others who get their passport on due date into troubles. Many clients claim that they are coming to the office several times since few months to get the passport, but not getting the same. As a proof, they produced their receipts that are in Photograph 2.

Photo 2: Initialed Receipt with the Delivery Dates. Dates have been changed several times. Even very urgent passport are not issued on the scheduled date

A close look to Photograph 2 discloses the fact that the deliveries dates are changed several times even for very urgent case. Mere promulgation of the passport delivery list prior to the delivery date could save the sufferings of the clients and could reduce the pressure on counters. On interview, authority inform that since recent past passport delivery list is being promulgated in main gate 'Sheba Kendra' on the same day in the morning. Practically no such list was found in the gate though all clients opined that such list could save their valuable time and sufferings. Truly speaking this provision may relieve few from standing in long queue and may reduce extra pressure on delivery counters but will pay hardly any benefit from transportation point of view, as already they have made trip to the site. However, actual transportation benefit could be obtained by making a clientele based inquiry system or by making the delivery list available on-line beforehand.

From survey, it is discovered that clients who do not get the passports on scheduled date make trips again on next scheduled date and undergo similar troubles every time.

For many people this going and coming continues several times. In the mean time, many tries to know the reasons for delay and in doing so they need to go to an inquiry cell (functions from 1000 to 1300 hours). Practical observation found that the personnel sitting in the inquiry desk taking long time to handle a single case as they works in a traditional way to find out the disputed files from the rack where thousands of files are stacked. Staffs working in this cell said that they could give attention to 800-1000 clients per day though around 1000-1500 clients are coming for the inquiry everyday. Besides, about 40-50 people are always found standing in front of OIC passport office who tries to solve many anomalies, but people from all classes cannot reach him. She (OIC) claimed to attend 100-150 clients per day.

Objective conversation with the clients as well as discussion with the officials of inquiry cell, it is unveiled that delay in delivery is caused mainly due to following reasons:

- Improper submission of Forms
- Delay in getting police verification report or

Negative verification report

- Failure to make the passport ready by the authority on scheduled date
- Failure to deliver ready passport to the clients due to time limit
- Failure to receive bank scroll of fee deposition in time by passport office. It takes a day or more for bank scroll to reach to the passport office even from the bank 100 meter away. This problem could be reduced if passport office would be linked with banks having real time/on-line banking facilities. **(10).**

Whatever may be the reasons of delay; all these unnecessary trips and sufferings would be eliminated if clients could confirm the delivery date on-line beforehand. Almost all clients desired to use on-line inquiry system before making trips to passport office. Every surveyed client agreed with the mobile phone based inquiry desk, majority also voted for land phone based one. Very few, favored internet based system.

4. ALTERNATIVE SYSTEM ALREADY THOUGHT OF BY THE AUTHORITY TO GET RID OF THE PROBLEMS

Face to face interview with numbers of officials unveiled that, there were number of alternative proposals from their side to ease up the condition. They are as follows:

4.1 MACHINE READABLE PASSPORT

This is well known as MRP. This would mostly benefit the authority in term of security, data management etc. It is less likely to reduce the trips and other sufferings of the clients.

4.2 DECENTRALIZATION OF PROCESS

This was aimed to distribute the concentrated pressure on the single passport office at Dhaka. But this would require more manpower, more infrastructures etc. This system is less likely to have much transportation benefit other than to reduce the travel length.

4.3 AGENT BASED SYSTEM

The authority proposed a system in which number of agents would be given the responsibility for processing of passport. Clients instead of coming to the passport office directly can visit the authorized agents. This system may suffer from reliability problems. Trips or trips length reduction will depend on the number and location of the agent offices or their representatives.

Recently (10 June 2007) government has taken a decision to decentralize the passport making system. From 15 July 2007 passport will be provided through 17 district commissioners office in addition to existing 15 passport offices. It is also decided that whole passport making process will be done through agents in the near future[a].

5. STATE AND USE OF ICT

5.1 COUNTRY PWERSPECTIVE

Though ICT infrastructure of Bangladesh's was not in a good shape even before few years, the scenario is changing fast as private telecom operators are taking aggressive initiatives to provide internet, telephone as well as various ICT enabled services to the people. Some of the indicators are as follows:

- At present six mobile and 15 (10 functioning) PSTN operators are there in the country.
- Mobile subscribers have reached to 40.34 million in April 2008[b].
- Teledensity (fixed and mobile) has reached to nearly 30 i.e. 30 people in every 100 people of the country has a cell/telephone.
- Both BTTB and private and mobile operators are providing internet facilities. Mobile internet has reached to the most remote area of the country.
- Cyber center or internet café, phone / fax shop etc. are available at walking distance of the city people at present.
- About 85% offices have internet connectivity and overall 60% offices have own websites.
- Efforts have been taken to introduce on-line banking, on-line education, on-line shopping etc. General banking services as cash deposit or withdraw, inquiry, statement, regular bill payment etc. can be performed through internet, ATM, SMS etc. any time round the clock.
- Fund transfer through Flexiload, i-top etc. is effectively introduced by the mobile operators countrywide.
- Some information and Forms are made available on line like the Forms for passport, tax, BTTB's phone and internet connection etc.

5.2 IN THE PASSPOPRT MAKING SYSTEM

from investigation it is found that Dhaka passport office is equipped with number of computers, telephones, Fax, internet connection which is not used directly for passport making process. But in the whole system use of IT facilities are very much limited or almost nil. It is seen that Fax is used for correspondence from SB head office to some district offices mainly in case of urgent cases. Most of the staff do not know the existence of fax and internet in this office what to talk about the use of the same. Staffs are found to move physically up and down stairs, left and right rooms for passing any information, which could very well be done by local area networking among the computers. It takes long time for processing a matter. Days together are taken to provide any simple information which would be possible by pressing simply a button as found in case of some private organization like banks.

6. ESTIMATION OF TRIPS AND ASSOCIATED SUFFERINGS

6.1 DAILY TRIPS TO PASSPORT OFFICE

One can say that, the number of visitors to the passport office should be the sum of the clients coming to deposit the application and clients coming to collect the passport. Above system analysis is enough to prove this assumption wrong. For better understanding, some of the findings of the above system analysis are mentioned below:

- About 20-30% clients were found to go back failing to deposit the application Form.
- Around 50% clients do not get their passport on scheduled delivery date.
- Around 1000-1500 clients come for inquiry for knowing the reason or facts for delay in delivery.
- OIC passport office claimed to attend 100-150 clients per day.
- Few clients mainly women, sick and elderly (about 12%) are accompanied by one or two additional persons.

Based on above considerations, the number of visitors on a typical weekday is estimated [i.e. (1.2*b + 2*c + 1,000 + 100)*1.12] and presented in Table 1.

Table 1: Daily Estimated Trips to Passport Office, April 07.

Date	Number received	Number delivered	Total visitors
(a)	(b)	(c)	(d)
4/3/2007	2,829	2,580	10,814
5/3/2007	2,605	2,366	10,033
6/3/2007	1,763	1,573	7,125
7/3/2007	1,956	1,561	7,358
8/3/2007	2,434	1,843	8,632
Average	**2,318**	**1,985**	**8,793**

Source: Islam., M. K., (2007)

It is seen that the number of trips to passport office varies approximately in the range of 8,600 - 11,000 per day and on average can be considered as 9000 per day. Actual people visiting the passport office are likely to be more as some clients are accompanied by additional people. The estimated visitors make 9,000 round trips or 18,000 individual trips daily to the passport office. The number of trips would be more if trips for fee deposition to the banks and for pursuance to the SB office would have been considered.

6.2 MODAL SHARE OF THE TRIPS

Questionnaire survey revealed that around 23 percent people used CNG, Taxi or Private car, 23 percent used bus plus rickshaw, 44 percent used only bus and 10 percent availed other means like rickshaw, tempo, Motorcycle etc. which is presented in the pie chart (Figure 3).

Critical observation of the pie chart implies that 56 percent clients are mostly coming and going by using individual mode. It is also learned from the clients that many have used CNG, Taxi or car at least for one trip among total trips made by them. Private car users are parking their car on the road in the east of the office thus occupying half of the road. Most of the women, elderly or sick are found to avail CNG, Taxi or Private car. It is estimated that about 4,140 automobiles (Car/CNG/Taxi) trips are taking place on the city roads during the peak hours and around 4,680 (4,140 + 540) rickshaws are also plying on the roads in and around the passport office (1).

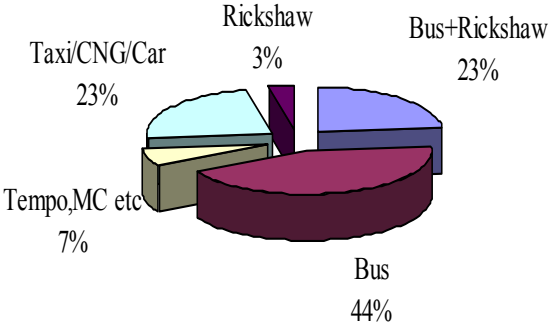


Figure 6.9: Modal Share of the Trips
Source: Islam., M. K., (2007)

6.3 TRIP PATTERN

From the system analysis, it is learned that application Forms are received from 0900-1000 hours, passport are delivered from 1400-1700 hours, inquiry cell remain open from 1000-1400 hours and banking transaction from 0900-1500 hours. questionnaire survey among the clients unveil that most people starts in the morning to reach passport office or bank in time to get the desired services. And they starts falling back after the office or concerned branch ceases their function.. These travel patterns reveal that most of the daily trips take place during morning peak (0800– 1000 hours), afternoon peak (1300 – 1400 hours) and evening peak (1600-1800 hours).

6.4 OTHER SUFFERINGS

Most of the people (officials and clients) failed to visualize how the existing systems are imposing restriction on the city transportation system. However, when explained the facts, everybody understood the reality. During field survey, following other irregularities are also observed:

- It is observed that gathering of people and parking of vehicles on the road reduces the effective width and causes hindrance to other people and vehicles movement which can easily be understood from Photograph 3.
- Temporary kiosk established on the footpath around the office also cause obstruction to other's movement.
- There are no sitting arrangements and shed nearby. Clients get tired standing hours together under the scorching sun as well as rain.

- It becomes very difficult for security personnel to maintain the discipline of human wave in front counters. At times they are found to apply forces.
- People waiting long at times become aggressive and involves into quarrelling.
- Women, children and elderly are found innocent during collection of passport.
- It was observed that few personnel (in coordination with few officials sitting at delivery counter) were involved in collecting the passport through backyard.
- Innocent and inexperienced people are being fraud by the brokers as well as by some dishonest staffs of the office.
- Delay in dealing any matter reduces the office efficiency and compel clients to make more trips wasting valuable time, labor and money, availing limited transports through limited and already congested city road network.
- Clients coming to passport office spend 3 to 10 working hours including journey period. Most of the clients said, by coming to the passport office they loss the whole day and cannot do any other job on that day. They also claimed to spend daily 200-300 taka for the purpose of journey and refreshment in addition to the loss of working days.
-

Photo 3: Clients outside main gate along the road (Left) and vehicles on the road (right) adjoining Passport office. They are hindering through movement clients and causing congestion in and around.

7. IDENTIFICATION OF REDUCIBLE TRIPS

Rigorous system analysis implies that some of the existing physical trips can be reduced and some of them can be converted into Fuel Free electronic trips if telecommunication or ICT can be integrated with the system. Scopes are also there to improve the system, speed up the process and reduce the sufferings of the clients and the concerned authority. From the questionnaire survey, it is unveiled that present system demands approximately 4-12 physical trips for making a new passport as shown in Table 2. It is evident that adoption of Option 1 and Option 2 would reduce the trip by 63 to 75 percent respectively.

Table 2: Comparison of Present and Trip Reducible ICT Enabled System

Events	**Round Trip in Present System**	**Round Trip in Proposed System**	
		Option 1	**Option 2**
Form collection	Physical Trip (PT) (1)	On-line fill by seeing a specimen filled up Form (to be made available on-line) or by taking help from café personal, get printed out	
Fill up	PT (0-1)		
Attestation	PT (0-1)	No attestation	As option 1
Fee deposition	PT (1-2)	PT (1)	On-line
Form submission	PT (1-2)	PT (1)	PT (1)
Any inquiry	PT (0-3+)	On-line	As option 1
SB visit (if require)	PT (0-1)	On-line	As option 1
Passport delivery	PT (1)	(1)	PT (1)
Total trips required	**4-12**	**3**	**2**
Average trip required	**8***	**3**	**2**
Trips Reduction %		**63%**	**75%**

Notes: *Numeric figure within bracket indicates the number of trips likely to be made by clients.*

Source: Islam., M. K., (2007

Most of the trips are required for inquiry purpose. The clientele based inquiry system and provision of on-line delivery list beforehand will allow the clients to know any information like deficiencies, state of passport and will be able to confirm about the delivery date etc. on-line/over telephone hence they will not make any unnecessary trips. During survey, few personnel were found in the PS to DG office and OIC passport offices, came for renewal and amendment on the passport. By talking to them, it was learned that the officials were

known to them and they came after confirming the readiness of the passport over telephone. This implies that IT is being used and trips are being minimized but it was possible for personal relation. Physical trips required for Form collection can also be reduced, if the availability of Forms in internet are widely publicized and the availability of same in the banks and passport office are prohibited. Attestation of Forms and photographs may be omitted. Signature and photograph of the applicant can easily be checked during submission by the person to whom it is submitted. Moreover, the provision of police verification is also there. This system can be implemented immediately with no or negligible investment and would reduce the trips to 3 as shown in third column of Table 2 (Option 1). Smooth functioning of this system may need some prohibitory measures like prohibiting the physical contact for Form collection, inquiry etc.

If some more efforts are taken, the required trips could be reduced to only 2; one for Form submission, other for passport collection as shown in column 4 of Table 2 (Option 2). This involves linking of all concerned offices or branches through internet and introduction of secured on-line payment system. Clients get the desired services their own internet or they can visit a cyber café/internet/mobile shop/bill pay centers presently available within walking distance of the city people. These services will be available round the clock; hence, if someone even desires to do these tasks during off peak hour, he or she will be able to do so.

Trip for passport collection can also be reduced if a reliable courier or mail service can be introduced. Trip for Form submission cannot be eliminated because recipient needs to verify the photographs, signatures etc. of the applicants. However, trip for Form submission is not even required in case of renewal, amendment as application and other details can be fed to passport office through internet, and old passport can be send through reliable courier or mail service. The graphical representation of ICT enabled systems as discussed above is portrayed in Figure 4.

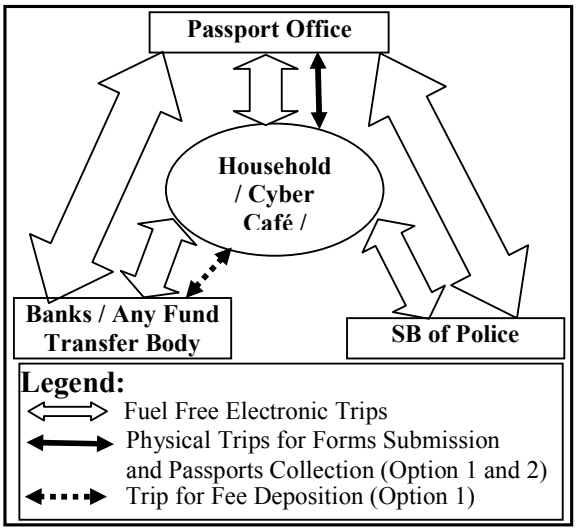


Fig 4: Graphical representation On-line System

Broad arrows in Figure 4 indicate potential electronic trips in lieu of physical trips presently taking place. Thin solid line represent the two physical trips between household and passport office required for both Option 1 and Option 2. Thin broken line indicates trip for fee deposition required for Option 1 but not required Option 2 which would allow on-line payment system.

Summary of the trips requirement based on the rigorous system analysis is present in Table 3. It is evident from Table 3 that of total 18,000 daily physical trips, about 11,340- 13,500 trips including 6,350–7,560 individualized vehicular trips would be converted into e-based fuel free trips depending on the state of integration of ICT with the system.

Table 3: Mode wise Trip Pattern (Existing and ICT Enabled Reducible Trips)

Modal Share	Existing Trips	Reducible Trips (ICT Enabled System)	
		Option 1 (63%)	Option 2 (75%)
Automobile (23%)	4,140	2,608	3,105
Rickshaw & Bus (23%)	4,140	2,608	3,105
Others (tempo, MC etc.) (7%)	1,260	794	945
Rickshaw (3%)	540	340	405
Subtotal (56%)	**10,080**	**6,350**	**7,560**
Bus (44%)	7,920	4,990	5,940
Total Daily trips (100%)	**18,000**	**11,340**	**13,500**
Monthly trips (22 days)	**396,000**	**249,480**	**297,000**

Source: Islam., M. K., (2007

8. CONCLUSION AND RECOMMENDATION

8.1 SUMMARY OF FINDINGS

The study was aimed at exploring the way of how telecommunication or ICT can gainfully be integrated with the existing passport making, renewal, amendment processes with a view to reduce the travel demand and associated sufferings by eliminating or converting existing physical trips. Accordingly an inclusive system analysis has been undertaken within the scope of the study work. The primary findings of the analysis are:

- This is estimated that daily approximately 9,000 clients are visiting Dhaka passport office making around 18,000 trips including 56 percent individualized and 44 percent bus trips.. It is also unveiled that almost all trips are made during the peak periods and in the process huge amount of fuel, time, working hour are lost.

- Presence of clients and the transport in and around the passport office induce troubles to others movement in or through that area. The study explored that many of these drawbacks could be reduced to great extent if an ICT would have been integrated with the system.
- ICT enabled system as described in this paper, would relieve city's highly congested road network to reasonable extent by reducing or converting 63-75 percent physical trips to Fuel Free electronic trips.
- On-line system will increase the overall productivity. The whole system would be cost effective, and savings of trip would save huge amount of working hours and fuel.
- This system would have many other advantages like elimination of harassment by touts or brokers, savings of bribe or tips money and travel cost, tremendous savings of time and effort, great relieve of mental anxiety and uncertainty etc.
- Initially most of the clients were not interested on ICT enabled system. However, when benefits of such system were explained, all claimed that the system would be better, economical and less laborious than the existing system. They agreed that the system would give maximum benefits; people would get the services with minimum travel provided the officials are sincere, honest and dedicated to their responsibilities and if they are made answerable to the authority.

8.2 RECOMMENDATIONS

Based on the findings of the study work, following recommendations are proposed to get desired travel related benefit of ICT:

- ICT or Telecommunication should not be thought merely as a means of communication rather it should be considered as a modern and effective tool to reduce travel demand.
- In order to reduce unnecessary and avoidable trips and associated sufferings, the government should give necessary directive to passport offices and other concerned organizations like SB office) to
  - establish a clientele based enquiry system and encourage the clients to use this facility.
  - make available all sorts of Forms, circulars, notices etc. on-line covering all details leaving no scope to make unnecessary physical trips.
  - undertake appropriate measures to raise public awareness so that the culture of contacting over phone before making any physical trip (for Form collection, inquiry etc.) is established.
- As the signature and photograph of the applicant can easily be checked physically during submission by the person to whom it is submitted and as there are provision of police verifications, government should give necessary steps to discontinue the provision of attestation of Forms and photographs.
- In order to get maximum benefit of ICT government should
  - assist all concerned institutions/ department/organizations (public and private) in developing the telecommunication infrastructure and skill required for complete integration of ICT in the passport making system.
  - enact cyber crime laws and establish special enforcement agency to make on-line data transfer particularly on-line payment system secure and hacking free.
  - prohibit the availability of Forms in the banks and passport office and prohibit the physical contact for Form collection, inquiry etc.

9. ACKNOWLEDGEMENTS

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10. REFERENCES

1. Islam, M.K., (2007), 'Potential of ICT in Managing Service Related Travel Demand of Bangladesh'.

2. Niles, J.S., (1994), 'Beyond Telecommuting: A New Paradigm for the Effect of Telecommunications on Travel', Global Telematics,

3. Victoria Transport Policy Institute, 'Telework: Using Telecommunications to Substitute for Physical Travel'. TDM Encyclopedia (www.vtpi.org), May 2005

4. Golob, T.F. and Regan, A.C., (2000), "Impacts of Information Technology on Personal Travel and Commercial Vehicle Operations: Research Challenges and Opportunities", University of California, Irvine.

5. Mokhtarian, P.L., et. al, (2004), 'Does Telecommunications Affect Passenger Travel, or Vice Versa? Structural Equation Models of Aggregate U.S. Time Series Data Using Composite Indices' .
6. Canadian Telework Association, 'Telework', Inno Visions Canada, (www. ivc.ca/), 1997- 2005
7. U.S. Department of Transportation, (1997), "Successful Telecommuting Programs in the Public and Private Sector; A Report to Congress",
8. UK Department for Transport, Local Government and the Regions, Virtual Mobility Website (http://www.virtual-mobility.com/)
9. Kamol, E., (2005), "Fake attestations an open secret-Stamps and seals available at groceries even!", The Daily Star, Star City, Vol. 5 Num 464, Wed. Sep 14, 2005
10. Jabbar, M., (2006), "E governance of passport fees and mobile internet", Technology Today, December 2006.

11. AUTHOR'S SHORT BIOGRAPHY

Major Md. Kabirul Islam has joined in Bangladesh Army with 26 BMA Long Course in the corps of Engineers in Jun 1992. He was honored with Dr Kudrati Khuda Gold medal from BMA for becoming 1st in B. Sc. (pass) examination. Besides number of military courses, he has completed B. Sc. in Civil Engg. (Structure & Transportation) with honors from BUET in Feb 2004 taking 8 regular terms. He earned a CGPA 3.82 on a scale of 4.0 and was honoured as the Dean listed student in every level for his academic performance. He has also completed M. Sc. in Civil and Transportation Engg. from BUET in Sep 2007 with CGPA 3.83. In M. Sc. Engg. under the supervision of Dr. Md. Shamsul Hoque**,** Professor, Department of Civil Engineering, BUET, he undertook a nontraditional thesis work titled "Potential of ICT in Managing Service Related Travel Demand in Bangladesh",. Major Kabir is married and having a son. Presently he is serving as Instructor Class 'B' of Civil Engg Dept of MIST.

COUNTRYWIDE INTERNET CONNECTIVITY USING WIMAX DEPLOYMENT CAN BOOST RURAL DEVELOPMENT OF BANGLADESH

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Abstract: Being a popular mechanism for access based networks; wireless access medium has found its growth potentials unmatched against wired medium in areas which require rapid rollout and has constraints to infrastructure. Right now Bangladesh is experiencing a boom in Internet usage starting from 2002 when prices of access devices started to be slashed, providing options to home users to dream on wireless connectivity. After the establishment of the NFAP, it is possible to create a structured wireless access network throughout Bangladesh. A developing country which has limited infrastructure will find it increasingly difficult to compare WiMAX with access network technologies such as CDMA and GSM. In this article, I have tried to provide information which would make it logical for the development of rural people for a nationwide WiMAX deployment. As networks such as WiMAX require large bandwidth as well as supporting infrastructure, therefore the deployment of fiber optic infrastructure throughout the country would enhance the WiMAX network flourish. Fiber @ Home is the first company which acquires the NTTN (Nationwide Telecommunications Transmission Network) license in Bangladesh, issued by the BTRC is responsible to cover Bangladesh by laying out fiber optic network that will eventually become the major backbone for all kinds of telecommunications and electronic entertainment services, we are enjoying these days. A WiMAX based infrastructure deployment of such a large scale is principally dependent on the frequency allocation for the operator. And the operator will use 2.5GHz or 3.5GHz for the nationwide WiMax deployment.

Key words: WiMAX, CDMA, GSM, BTCL, OFDMA, Rural Development,

1.0 Introduction

Bangladesh is one of the most densely populated countries of the world and has recently been experiencing a boom in the telecommunication & IT sector. Lack of proper infrastructure investment by private sector entrepreneurs have led to the foreign investment invasion of our telecom sector, thanks to which, access to telecommunication has become readily available to all the classes. Along with telecommunication, Internet based services have started to boom after the pricing model of the Internet bandwidth [which is controlled solely by the Bangladesh Telecommunication Company Limited (BTCL)] were slashed down and provision of Internet services were made available by mobile telecom operators.

Recently the Bangladesh Telecommunication Regulatory Commission (BTRC) has been keen in exploring the potentials of WiMax in Bangladesh. A number of developed and developing countries are progressing towards WiMax as an access technology and create a suitable infrastructure based deployment to cater high speed Internet based applications. In such countries the licensing itself has become an extremely expensive tool to propagate the technology itself.

WiMax as a technology is still at its infancy and requires a number of modification / tweaking along with industry experience to become an industry standard and acceptable for Internet and telecommunication applications. At present a number of vendors are propagating the technology which is based on OFDMA and others are joining in the bandwagon to increase the acceptability for the technology itself. At present vendors such as Alcatel Lucent, Huawei, Cisco, Alvarion, SR Telecom, Cisco, Nokia Siemens Networks are backing up the WiMax forum with its requirements. The projection for WiMax need is provided as below:

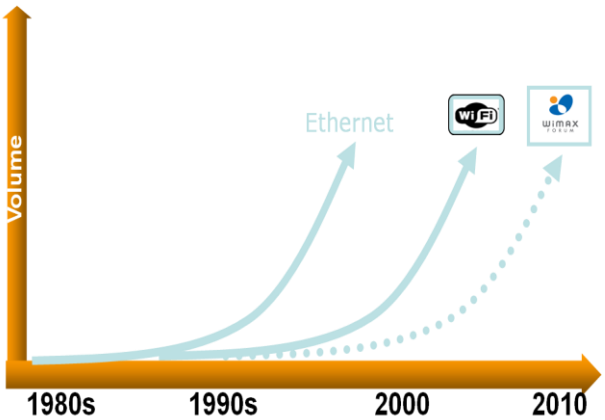

Figure 1: Projection of WiMAX as an access technology by 2010 [1].

From the figure above it can be seen that the wireless revolution has brought about a change in technology presenting WiMax as an option for high speed data communication applications such as video, video and Internet. The evolution of the WiMax industry started from the late 1990's when the need of high speeds was realized for wireless access mediums. When Wi-Fi was becoming a

standard requirement in the ICT industry, scientists were quick to realize the potentials of an OFDM based technology which would cater the needs to high speed data in the future.

2.0 Feasibility Study

A nationwide WiMax deployment is considered as an ambitious project. Being a national infrastructure a project of such huge stature needs to be carefully planned and implemented to ensure proper rollout and business growth. WiMax as an access medium allows for a number of applications considering urban and rural environments.

Bangladesh is a rapidly upcoming nation considering the development of the ICT sector. In recent times a number of new technologies have been welcomed through the telecom regulator BTRC, which have made their way to the service providers. Compared to the GSM and CDMA technology, WiMax as an access network will require sometime for popularity in comparison to its wireless rivals and needed to be harvested for few years.

There are a number of concerns that needs to be considered before the deployment of a network of such epic proportions can take place. The components which are essential for business include: Population of the nation, Population density, Average household income, Technological penetration, and Statistics of education.

The GDP of the nation (according to the Bureau of Statistics) shows that in 2006-2007 fiscal year, the GDP of Post & Telecommunication sector stood at BDT 68.288 billion and this figure is ever increasing. The telecommunication sector saw an overall growth of 24.9% during this period and has attracted new foreign investment. In April 2008, Etisalat of Dubai, SA Telecom of Korea and Vodafone turned their eyes on Bangladesh for a chance to participate as a WiMax operator in Bangladesh. With over 150 million populations, the country has already been able to achieve a 25% penetration in mobile phone services through the help of telecommunication operators presently playing in the markets.

The opportunities for WiMax in Bangladesh can be identified in a number of ways. The application for WiMax in divisional cities will be limited to residential broadband services for wireless Internet connectivity for the masses. Else than that the corporate society will also subscribe itself to WiMax technology to harness requirements of office Internet and corporate VPN based intranet services.

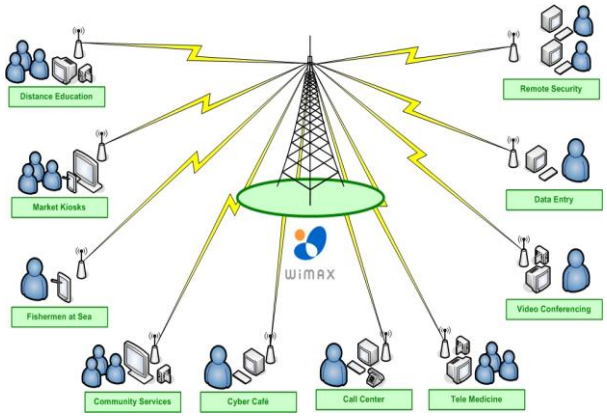

Figure 2: The diagram above portrays the possibilities in application level for WiMax in rural communities of Bangladesh.

3.0 How can WiMAX deployment enhance rural communities of Bangladesh?

As the business case for WiMax in urban environment has been justified, the deployment in rural areas will be a major challenge. To achieve a greater penetration for WiMax throughout the nation the applications have to be custom tailored to meet the requirements of the rural community. At present the rural communities in Bangladesh are hugely deprived from the benefits of technology due to which dependency amongst the rural community remains a major hazard. The digital divide can be bridged once the community is educated. This is why a number of education institutes needs to be set up in the rural communities and ensure quality education for the rural communities. The applications of WiMax in rural Bangladesh will principally look into the following:

a. Distance education: As the rural Bangladesh is deprived of quality education, latest technology can help in creating a wonderful atmosphere which will help bridge the digital divide. High bandwidth applications such as video conferencing will be possible through distance education and such applications would help rapidly develop remote communities properly. A qualified instructor from city can simultaneously communicate a class full of students through

video conferencing aided by qualified volunteers to aid in the remote classroom concept development. Students educated through such infrastructure would definitely be able to provide quality output for the nation.

b. Kiosk based deployment in Markets: 2007 saw some of the worst food crisis in not only Bangladesh but also throughout the world. This could have been easily mitigated if a properly planned out supply chain was placed throughout the nation by the government detailing the extent of food stock and pricing in rural markets. For instance it was seen that pricing of daily consumable vegetables in cities skyrocketed whereas in rural areas the prices were lower which exploited the farmers creating artificial crisis in the markets, where a group of ill minded businessmen profited in between. WiMAX based kiosks in rural communities would greatly help in reporting the quantity of consumables which can be collected properly and distributed throughout the nation through an efficient supply chain management system initiated by the government.

c. Fishermen catch at sea: Everyday a great number of fishermen have to venture into the waterways for fish which serves as a principal requirement of the population of the country, especially the lower mass. These fishermen are exploited by middlemen, which can be easily overcome if WiMAX access point and handheld terminals are provided to fishermen who can update a database of fish catch to the local market. Similarly an effective supply chain management can ensure that these fishes are brought at proper prices from the fishermen maintaining the market stability.

d. Connectivity for 'Community Services': Community based services such as Internet surfing, foreign remittance services, Internet TV applications for community such as for agriculture can be catered through WiMax terminal and PC deployments. Remote schooling for household members such as the elders who have not been exposed to proper education through schooling can be helped through such technological deployment. Especial emphasis needs to be put for proper education as education can help in the proper upbringing of a nation. Not only that a number of businessmen from city can directly interact with rural communities and place order for specific commodities and ensure collection through proper channels.

e. Cyber café / hubs in rural areas: Cyber cafés and cyber hubs in rural communities will greatly be benefited by Internet. This will greatly help communities to start interaction helping in education. As the Internet is a great tool for communication, collaboration & education, rural communities can browse the Internet and promote the usage of Internet in the rural communities as well as contribute in various sectors of the economy by harnessing its benefits. Cyber café's will allow high speed Internet browsing as well as communication such as video, voice and chatting services to enhance interactivity experience. Even emails can be exchanged with dear ones living in cities or abroad as and when required.

f. Call center applications: Call centers & telemarketing have become a very popular industry in the Asian region, especially India which has seen a tremendous growth in the call center industry. Utilizing call center services university graduates as well as locals with fluency in dialect can help in call center services providing remote support or telemarketing services to a number of industries. These applications will help generate good revenue for not only the nation but also start promoting ICT as a tool which can help generate earning.

g. Telemedicine: Statistics of the health ministry shows that Bangladesh lacks proper medical infrastructure as well as lack of quality doctors who can help diagnose any illness. With the help of telemedicine applications using WiMax patients in rural communities can ensure proper diagnostic services for their illnesses and also export their medical data in real time by scanning. Since Voter ID cards have now been introduced, introduction of digital medical files could also help doctors remotely retrieve patient data. This way patient's medical treatment can be properly ensured and would help in saving more lives.

h. Video conferencing for remote communities: Video conferencing for communities through WiMAX will greatly help the foreign community to communicate with their relatives in Bangladesh. A prepaid system can be introduced where the caller would be charged for video calls being made to a specific terminal in rural areas. This will encourage video conferencing and other high

bandwidth applications to slowly develop in rural communities encouraging foreign remittance. Else than that once the video conferencing culture picks up, it will become more popular as a medium of communication as it allows for more interaction compared to telephonic conversation and chatting.

i. Data entry: The data entry sector has matured greatly in our neighboring India with an estimated couple of hundred million dollars worth data entry works being conducted every year throughout the country. Home makers and students make a part-time income by such data entry services and medical transcription services. WiMAX technology can help such services to rapidly develop in rural areas creating an inflow of data entry works for Bangladesh. Else than that the nation's educated unemployed population can be employed under such services.

j. Remote security: Many of the developed nations of the world deploy powerful monitoring systems to secure operations of its mission critical architecture. CCTV based security systems deployed in such nations require a 24/7 NOC based operation for instantaneous monitoring, which involves expensive man hour. With the help of the Internet such solutions are now outsourced to other countries. People in rural communities can use WiMAX to observe live video streaming of such CCTV appliances and raise the alarm as and when required using interactive console from the remote end. This will not only promote rural communities to get involved with ICT based activities but will also engage the unemployed group for social activities and making a positive earning.

k. Financial Services: It is possible to run e-commerce activities such as remote branch banking which will allow for penetration of commercial activities to Thana Level. This will encourage more remittance services as well as encourage inter-district financial services where people can send money instantaneously to their relatives and can remotely receive cash from them and authenticate themselves through video conference if necessary.

l. E-Commerce in Rural Bangladesh: A number of international fashion houses and boutiques are increasingly focusing on local culture and as a result South Asian countries are seeing a slow and steady growth in exports of handicrafts. Through financial institutions, each of the rural entrepreneurs or workers can directly interact with foreign entities and sell local handicraft commodities to foreign buyers. This will allow WiMAX users to engage in video conferencing services as well as foreign transaction services through foreign currency inward remittance.

m. Transportation Sector Development: Online ticketing services can be developed for bus services along with tracking services. Else than that to enhance the journey in-bus services such as browsing the Internet and video conferencing on the move will enhance the journey experience creating a strong demand for travel industry. WiMax terminals connected to the internal network within the buses will ensure maximum flexibility in connectivity in the level of such luxury services.

n. E-Government Services: The government of Bangladesh will be greatly helped with the deployment of WiMax throughout Bangladesh if e-government services are introduced. Each of the respective departments of the government can be connected at the field level to create a fully automated decision making process, thus ensuring an interactive government. Remote offices can exchange documents, communicate easily using telephone and also conduct video conferencing as well between each other making it possible for a totally interactive government model running e-governance throughout the country.

o. IP-TV (optional): Internet based TV can also become an interactive learning tool for rural communities and interacting in a number of issues. Starting from on demand TV applications, rural communities can view programs as and when required using WiMax as a tool for such applications. Though the amount of bandwidth that is require for such services needs to be properly calculated because the number of BTS and the bandwidth throughput per BTS will actually determine the allowance of such applications.

p. E-Agriculture: Bangladesh is principally an agriculture centric country with a vast amount of population in the rural community being engaged in agriculture, technology such as WiMax can be made available to the farmers in order to interact with them. Each of the farmers can provide up to the mark information regarding their crops to the ministry of agriculture which will have an

interactive database which will update daily information. Farmers can be provided with laptops and mobile WiMax terminals to interact and provide up to the mark information, and get video conferencing facilities for support from the ministry.

Considering such applications it will be a long and sustained effort that needs to be slowly cultured to harness the benefits of technologies such as WiMax in Bangladesh. According to the Bureau of Statistics, there is a population of 124 million (census of 2001) in Bangladesh spread across 64 districts, showing that around 6.84% of the population totaling to 8.5 million residents live in the capital city of Dhaka. The comparison ratio for the area of land in cities in comparison to rural Bangladesh stands at 11.84%. This means a far greater majority of the land of the country remains outside the city limits and require development [4].

This means when the deployment will be concerned, such technology has to find its way to cover 88% of the land outside the cities where business feasibility would require to be justified.

4.0 Conclusion

This article is concentrated upon the benefit for the deployment of countrywide WiMax network in Bangladesh. To meet information regarding the aspects of WiMax based network deployment, the following needs to be studied in-depth: Network Architecture, Frequency Planning in 2.5GHz & 3.5GHz, Human resource planning for the network, Business feasibilities of Customer Premises Equipment manufacturing in Bangladesh, Longevity of WiMax network components in rural environments, Customer behavior in rural communities, and Wireless architecture available in rural areas which may be leased. I have tried to highlight a brief of the feasibility of the deployment of WiMax network in Bangladesh

By the year 2010, it is believed that WiMax will be a much matured technology and will be able to provide a much matured vision along with roadmap to business entrepreneurs who are interested in the deployment of WiMax technology. Bangladesh is a potential country in terms of technology but a sophisticated technology such as WiMax has to be properly considered before a decision is taken on the deployment in Bangladesh.

References:

[1] *A Comparative Analysis of Mobile WiMAX™ Deployment Alternatives in the Access Network*. WiMAX Forum. http://www.wimaxforum.org/technology/downloads/mobile_wimax_deployment_alternatives.pdf. May 2007.

[2] *WiMAX Deployment Considerations for Fixed Wireless Access in the 2.5 GHz and 3.5 GHz Licensed Bands*. WiMAX Forum. http://www.wimaxforum.org/technology/downloads/DeploymentConsiderations_White_PaperRev_1_4.pdf.June 2005.

[3] www.btrc.gov.bd

[4] www.bbs.gov.bd

FIELD ORIENTED SPEED CONTROL OF INDUCTION MOTOR DRIVES

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ABSTRACT

This paper presents the field oriented control of a three phase induction motor up to base speed to investigate the improved performances of an induction motor driven by a PI controller by using a commercially available software package Matlab/Simulink. The concept of field – orientated control (FOC), an indirect method of vector control method, has been selected to be the motion control technique because it produces controlled results that have a better dynamic response to torque variations in a wider speed range compared to other scalar methods. A PI type speed controller has been designed to investigate the performance of IM drives.

Keywords: *Field-oriented control (FOC), PI controller and Induction motor (IM) drives.*

1. INTRODUCTION

Applications of field oriented control techniques [1-5], in particular, offer an excellent opportunity of using ac motors in modern variable speed drive systems. The main objective of this control method is, as in separately excited DC machines, to independently control the torque and the flux, choosing a d-q rotating reference frame synchronously with the rotor flux space vector does this[1-2]. Now -a- days, it is a common practice to evaluate the system performances through computer simulation before real time implementation. For this purpose, we simulate IM below base speed using PI controller by vector control method.

The coupling between the flux and the torque component currents in the ac motor has been pointed out as one of the main reason for the sluggish response of a closed loop control. If, for example, the torque is increased by incrementing the frequency, the flux tends to decrease. The vector control technique has been accepted as one of the most effective methods for decoupling the flux and torque. The main objective of this control technique is that an ac machine is controlled like a separately excited dc machine. In dc machine, neglecting the armature demagnetization effect and field saturation, the torque is given by [1]

$$T_e = KI_a I_f \qquad (1)$$

Where is I_a the armature or torque component of current and I_f is the field or flux component of current. In a dc machine, the control variables I_a and I_f can considered as orthogonal or decoupled vectors. In normal operation, the field current I_f is set to maintain the rated field flux and torque is changed by changing the armature current. Since the current I_f or the corresponding field flux is decoupled from the armature current I_a, the torque sensitivity remains maximum in both transient and steady- state operations. This mode of control can be extended to an induction motor if the machine operation is considered in a synchronously rotating reference frame where the sinusoidal variables appear as dc quantities.

2. FIELD ORIENTED CONTROL TECHNIQUE PRINCIPLES

The equivalent circuit of IM in the synchronously rotating d-q axis rotor reference frame [1].

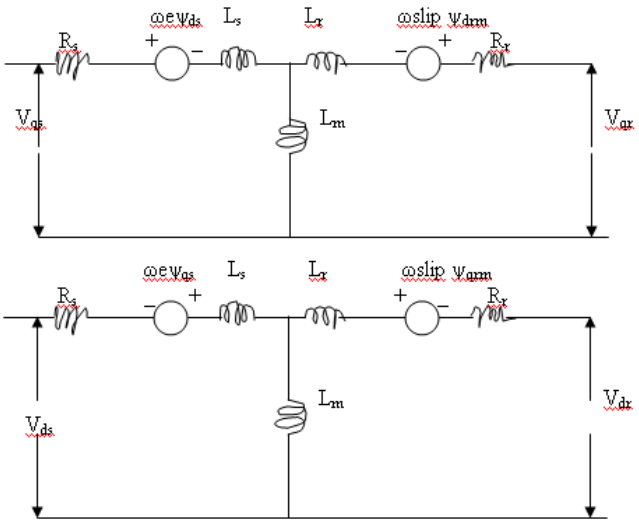

Fig. 1 Equivalent circuit of IM in synchronously rotating rotor reference frame

$$V_{qs} = R_s i_{qs} + \frac{d\psi_{qs}}{dt} + \omega_e \psi_{ds} \qquad (2)$$

$$V_{ds} = R_s i_{ds} + \frac{d\psi_{ds}}{dt} + \omega_e \psi_{qs} \qquad (3)$$

$$V_{qr} = R_r i_{qr} + \frac{d\psi_{qr}}{dt} + (\omega_e - \omega_r)\psi_{dr} \qquad (4)$$

$$V_{dr} = R_r i_{dr} + \frac{d\psi_{dr}}{dt} - (\omega_e - \omega_r)\psi_{qr} \qquad (5)$$

$$\frac{d\psi_{qr}}{dt} + R_r i_{qr} + (\omega_e - \omega_r)\psi_{dr} = 0 \quad (6)$$

$$\frac{d\psi_{dr}}{dt} + R_r i_{dr} - (\omega_e - \omega_r)\psi_{qr} = 0 \quad (7)$$

Again, $\psi_{qr} = L_r i_{qr} + L_m i_{qs}$ (8)

$$\psi_{dr} = L_r i_{dr} + L_m i_{ds} \quad (9)$$

from equation (8) and (9)

$$i_{qr} = \frac{1}{L_r}\psi_{qr} - \frac{L_m}{L_r} i_{qs} \quad (10)$$

$$i_{dr} = \frac{1}{L_r}\psi_{dr} - \frac{L_m}{L_r} i_{ds} \quad (11)$$

The rotor currents from equation (2) and (3) can be eliminated by substituting equation (10) and (11) as

$$\frac{d\psi_{qr}}{dt} + \frac{R_r}{L_r}\psi_{qr} - \frac{L_m}{L_r} R_r i_{qs} + \omega_{sl}\psi_{dr} = 0 \quad (12)$$

$$\frac{d\psi_{dr}}{dt} + \frac{R_r}{L_r}\psi_{dr} - \frac{L_m}{L_r} R_r i_{ds} + \omega_{sl}\psi_{qr} = 0 \quad (13)$$

Where $\omega_{sl} = \omega_e - \omega_r$

For decoupling control it is desirable that

$$\psi_{qr} = \frac{d\psi_{qr}}{dt} = 0 \quad (14)$$

$$\psi_{dr} = \psi_r = \text{constant}$$

$$\frac{d\psi_{dr}}{dt} = 0 \quad (15)$$

Substituting the first two conditions, equations (12) and (13) can be simplified as

$$\omega_{sl} = \frac{L_m}{\psi_r}\left(\frac{R_r}{L_r}\right) i_{qs} \quad (16)$$

$$\frac{L_r}{R_r}\frac{d\psi_r}{dt} + \psi_r = L_m i_{ds} \quad (17)$$

$$\psi_r = L_m i_{ds} \quad (18)$$

Again the torque as a function of rotor flux and stator current can be derived as follows. The stator flux linkage relations can be written as

$$\left.\begin{aligned} \psi_{qs} &= L_m i_{qr} + L_s i_{qs} \\ \psi_{ds} &= L_m i_{dr} + L_s i_{ds} \end{aligned}\right\} \quad (19)$$

Substituting equation (19) in equation (8) and (9), we get

$$\psi_{qs} = \left(L_s - \frac{L_m^2}{L_r}\right) i_{qs} + \frac{L_m}{L_r}\psi_{qr} \quad (20)$$

$$\psi_{ds} = \left(L_s - \frac{L_m^2}{L_r}\right) i_{ds} + \frac{L_m}{L_r}\psi_{dr} \quad (21)$$

The torque equation as a function os stator currents and rotor flux is

$$T_e = \frac{3}{2}\left(\frac{p}{2}\right)\left(i_{qs}\psi_{ds} - i_{ds}\psi_{qs}\right) \quad (22)$$

Equation (3.19) and (3.20) can be substituted in equation (3.21) to eliminate stator fluxes. Therefore,

$$T_e = \frac{3}{2}\left(\frac{p}{2}\right)\frac{L_m}{L_r}\left(i_{qs}\psi_{dr} - i_{ds}\psi_{qr}\right) \quad (23)$$

Substituting $\psi_{qr} = 0$ and $\psi_{dr} = \psi_r$, the torque expression is

$$T_e = \frac{3}{2}\left(\frac{p}{2}\right)\frac{L_m}{L_r} i_{qs}\ \psi_r \quad (24)$$

The relation above, together with the mechanical equation

$$\left(\frac{2}{p}\right) J \frac{d\omega_r}{dt} = T_e - T_l \quad (25)$$

describes the machine model in decoupling control. If this orientation is correctly achieved, the torque producing current that is q-component of the stator current controls the torque and at the same time, the flux is controlled by the flux producing current, which is the d-axis component of stator current.

3. IMPLEMENTATION STRATEGY FOR THE VECTOR CONTROL SCHEME FOR INDUCTION MOTOR

The practical configuration of a FOC controlled IM drive is shown in figure 3.3. The basic configuration of the drive system consists of an induction motor (IM) fed by a pulse width modulation inverter.

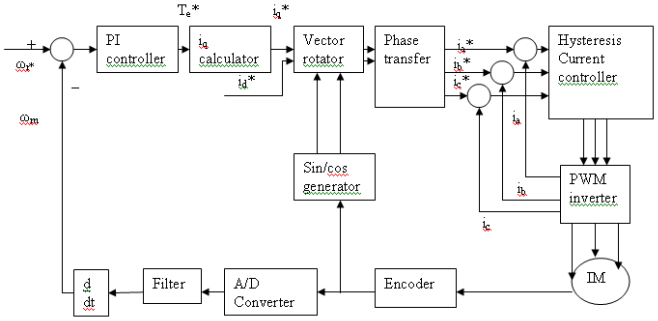

Fig. 2 Block diagram of PI based IM drive

The command torque is obtained from a PI type speed controller. Using equation (3.23) reference q-axis current i_q* is computed first, subsequently reference d-axis current i_d* is Calculated using equation (3.17). Using these reference currents three phase currents are determined by vector rotator. The hysteresis current controller compares the reference three phase current with actual currents and generates base signals for the transistorized inverters.

4. SIMULATION RESULTS

Figure 5(a) shows the speed response of IM drive for flux weakening control with reference speed of 220 rad/sec. It is seen from Fig. 3(a) that the actual speed follows the reference speed without any steady state error and the speed reaches steady state condition after .6 sec. Figure 5(b) shows the current response of IM drive for flux weakening control with reference speed of 220 rad/sec. The current reaches steady state within .1 second.

Figure 6 (a) shows the speed response with step change of reference speed. Initially motor started at a reference speed of 190 rad/sec but after 1sec latter, the reference speed is increased to 300 rad/sec. Figure 6(b) shows the current response of IM drive for flux weakening control with step change of reference speed.

The actual speed of the IM drive almost follows the change of speed. The controller algorithm was promptly able to respond to the speed change. So the transient and steady state performance of the controller is very impressive.

Figure 3 (a) shows the speed response at no load for vector control or field oriented control (FOC) of IM drive using the proposed PI controller. It is seen from Fig. 3 (a) that the actual speed follow the reference speed quite accurately and without any steady state error, the speed reaches steady state condition after .5 sec. Figure 3 (b) shows the current response under no load condition. Current reach steady state within .1 sec. Figure 4 (a) and Figure 4(b) show the speed and current responses under full load condition. Figure 5(a) shows the speed response with step change of reference speed at no load. Initially motor started at a reference speed of 50 rad /sec but after 1sec latter, the reference speed is increased to 120 rad /sec. Figure 5(b) shows current response of IM drive with step change using PI controller at no load. Figure 6(a) and Figure 6(b) show the speed and current response with step change of reference speed under full load condition.

The actual speed of the IM drive almost follows the change of speed. The controller algorithm was promptly able to respond to the speed change.

Figure 7(a) shows the speed response with sudden change in load torque. The motor starts from standstill without load and at 1sec, a sudden full load is applied. The motor speed drops somewhat but within .4 sec it again returns to its set point. So the transient and steady state performance of the controller is very impressive.

Figure 8 shows simulated torque of IM drive with step change of reference speed using PI controller.

The actual speed of the IM drive almost follows the change of speed. The controller algorithm was promptly able to respond to the speed change. So the transient and steady state performance of the controller is very impressive.

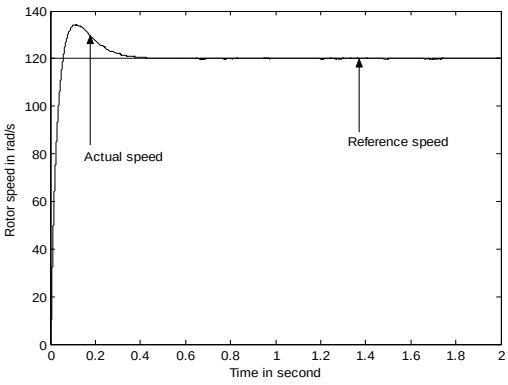

Fig. 3 (a) Simulated speed of IM drive with a reference speed of 120 rad/sec using PI controller at no load.

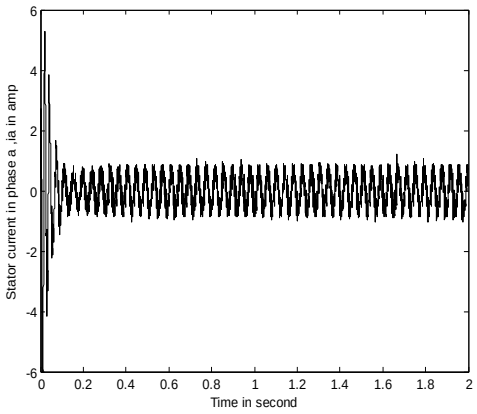

Fig. 3(b) Simulated current of IM drive with a reference speed of 120 rad/sec using PI controller at no load

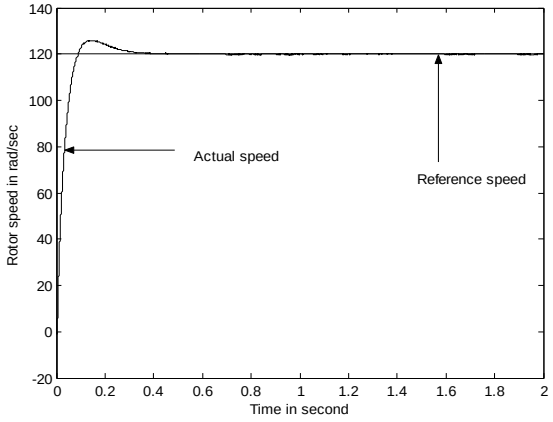

Fig. 4 (a) Simulated speed of IM drive with a reference speed of 120 rad/sec using PI controller at rated load.

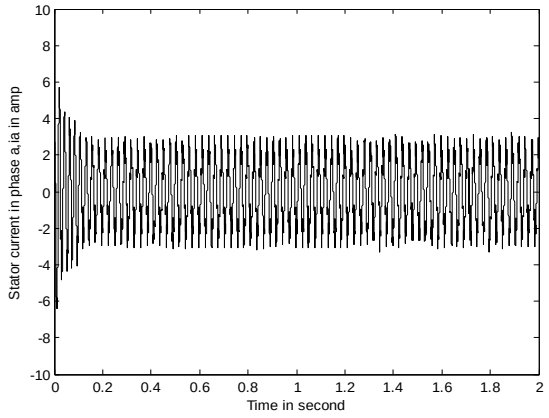

Fig. 4(b) Simulated current of IM drive with a reference speed of 120 rad/sec using PI controller at rated load.

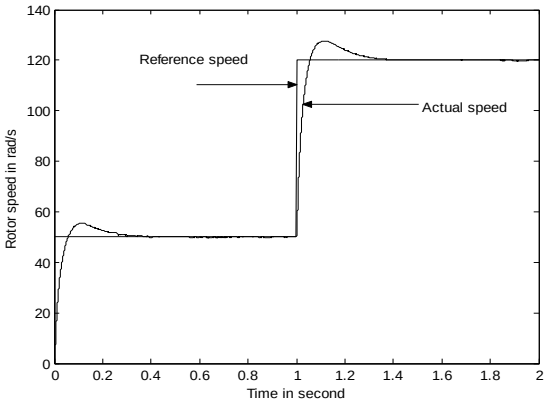

Fig. 5 (a) Simulated Speed of IM drive with step change using PI controller at no load.

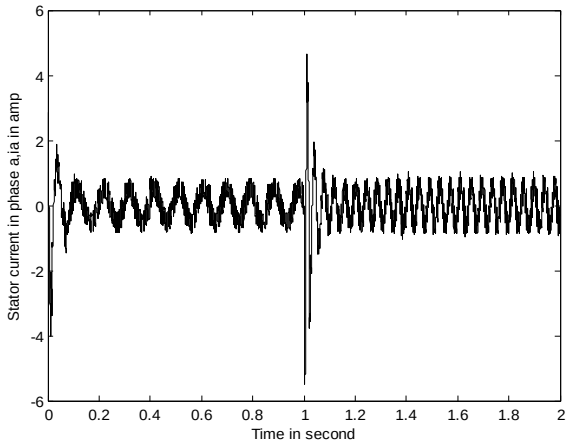

Fig. 5 (b) Simulated current of IM drive with step change using PI controller at no load.

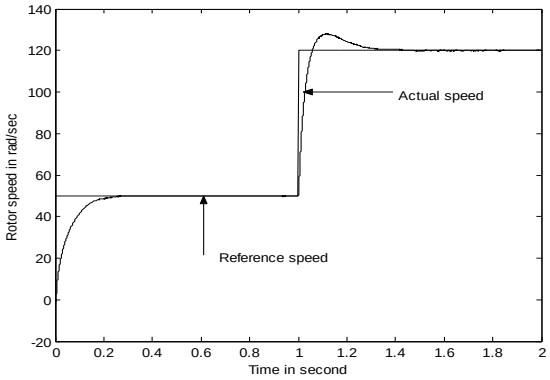

Fig. 6 (a) Simulated Speed of IM drive with step change using PI controller at rated load.

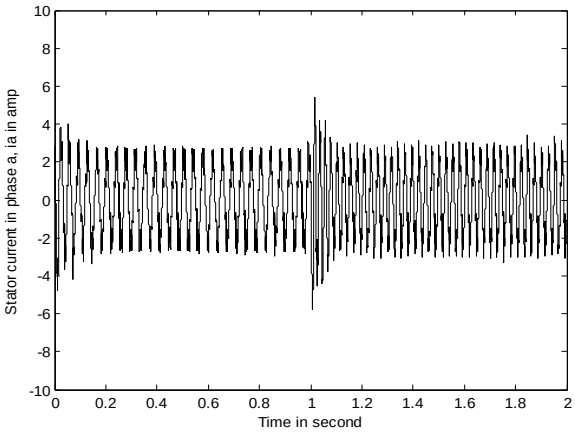

Fig. 6 (b) Simulated current of IM drive with step change using PI controller at rated load.

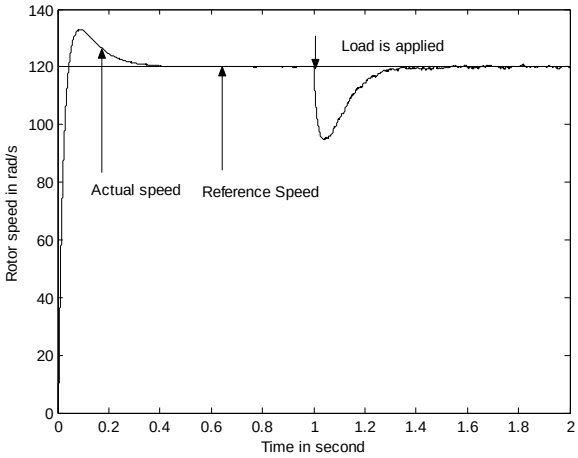

Fig. 7 (a) Simulated speed of IM drive with step change of load torque using PI controller.

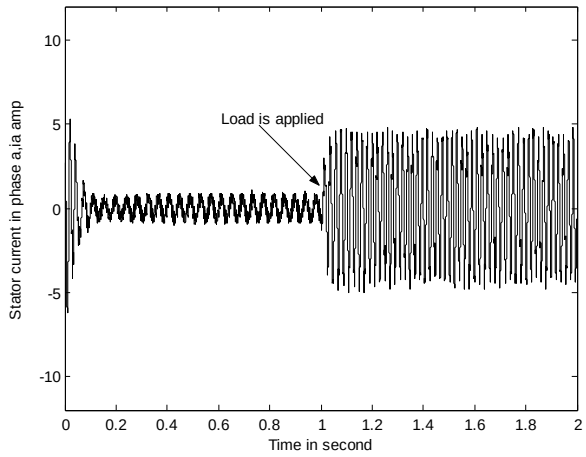

Fig. 7 (b) Simulated current of IM with step change of load torque using PI controller.

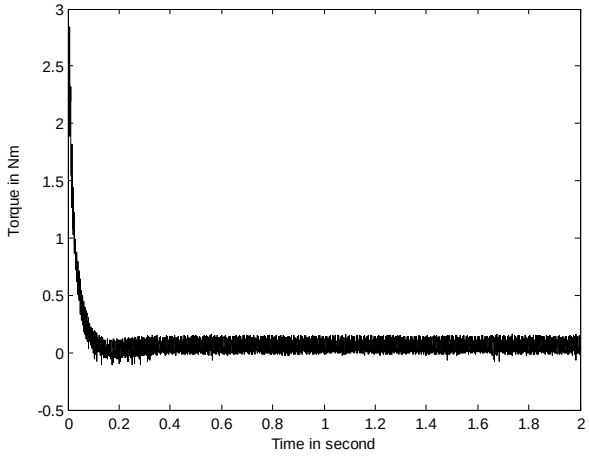

Fig. 8 simulated torque of IM drive with step change of reference speed using PI controller.

5. CONCLUSION

The FOC method of control presents a good speed response with an adequate stability. The after FOC speed response closely resembles the input speed command. The amount of overshoot has been perfectly acceptable. On the whole the simulation result is positive. The operating capability at and above the base speed has also been verified successfully. From the simulation results, it has seen that the drive system has fully capable of operating at base speed.

REFERENCES

[1] B. K. Bose, "Power Electronics and AC Drives".

[2] G. R. Slemen, "Electric machines and drives", Addition–Wesley Publishing Company, 1992.

[3] "Implementation of a Speed Field Orientated Control of Three Phase AC Induction Motor using TMS320F240", Literature Number: BPRA076, Texas Instruments Europe, March 1998.

[4] Gareth Stephen Roberts "Design and Implementation Of a Three Phase Induction Motor Control Scheme", October 2001.

[5] Texas Instruments Inc, Field Oriented Control of 3-phase Ac Motors, www.ti.com, Texas Instruments Literature number BPRA073, Europe, 1998

STUDY OF AERODYNAMICS OF A CRICKET BALL

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ABSTRACT

This research is concerned with the nature and aerodynamic behavior on cricket balls in flight. It is written to determine the aerodynamic characteristics of a cricket ball with a mass of 156 gm and approximate diameter of 70 mm, where a sample cricket ball was fixed with a shaft in a wind tunnel. The aerodynamic characteristics have been analyzed by varying the rotational rpm of the cricket ball, where the axis of rotation for seam and shaft is same and the pressure difference between the upper and the lower surface of the cricket ball determine by the help of static manometer. Some experimental works have also been carried out and compared with those of the results obtained numerically. The upward pressure, which creates lift, has increased almost linearly with the increase of ball position angle to approximately 15^o to 30^o and it also decrease with increase of ball rotational speed. Finally some conclusions have been drawn on the basis of the experimental result.

Keywords: Lift, Drag

1. INTRODUCTION

A cricket ball has six rows of prominent stitching, which are known as primary seam. There are typically 60-80 stitches in each row. The seam is along the "equator" of the two-hemisphere ball. Better quality balls are made of 4 pieces of leather so that each hemisphere has a line of internal stitching forming the "secondary seam". The secondary seams of the two hemispheres are at right angles to each other.For such construction different types of swings are generated and for different speed of rotation direction lift and Magnus effect occurs.The key to making a cricket ball swing is to cause a pressure difference between the two sides of the ball. The air pressure depends on the flow of the air over each side of the ball. Swing is generated when blowers, by accident or design, disrupt the flow of air over one side of the ball.The lift generated by a cricket ball depends on factors such as the speed of the airflow, the density of the air, the total area of the ball, rotational speed of ball.Researches in Bangladesh were carried out to visualize the flow over the cricket ball in steady and rotational (manual rotation) condition without airflow. But here in this study, considerable effort is given to visualize the air flow pattern over the cricket ball across the seam in steady and various rotational conditions with airflow. Effort is also given to determine the pressure difference between the upper and lower surface of the sample cricket ball during lift and Magnus effect.

2. EXPERIMENTAL SET UP

Figure 1-2 shows the design and photograph of the complete experimental set up. The wind tunnel made by 8 mm think transparent “Acrylic plastic sheet”. This wind tunnel has four parts as air inlet section, test section, diffuser section and blower section.

A 1 hp, 3 phases, 220 V, AC blower used at the end of diffuser section whose maximum rpm is 1400. For rotating the sample cricket ball in test section one AC motor is used, whose maximum rpm is 9500. A regulator used to control the motor rpm.

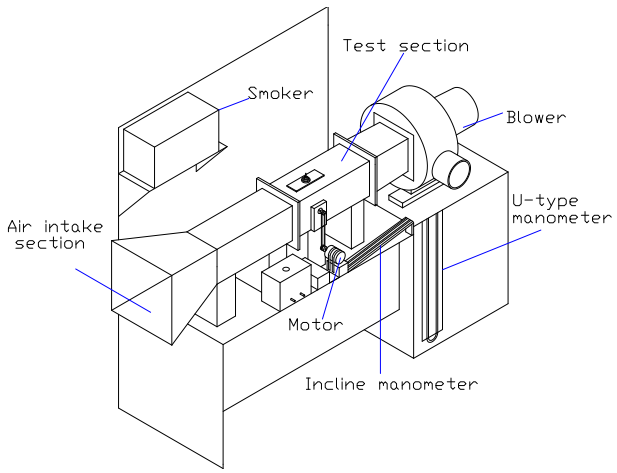

Figure 1: Schematic diagram of Experimental Set-Up

Figure 2**:** Photograph of Experimental Set-Up

3. EXPERIMENTAL RESULT

The research was conducted test in the low speed subsonic wind tunnel. The free stream airflow (v) is kept constant at 2.62 m/s and the other parameters are atmospheric pressure (P_o) is 101365 Pa; density of air (ρ) is 1.1774 kg / m^3, absolute viscosity (μ) is 1.79 x 10^{-5} kg/m-s, Reynolds Number (R_e) is 35053. Here the effect of temperature is neglected. The lift has been calculated from the experimental data based on the consideration of 2-D cricket ball.

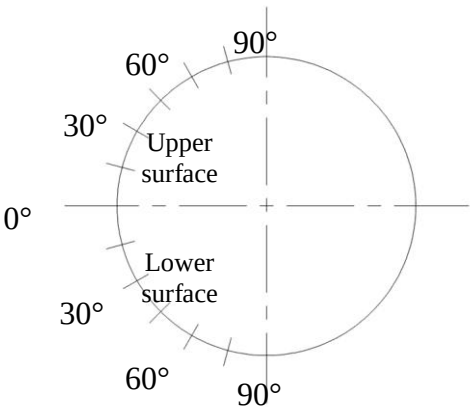

Figure 3: Angular position of the cricket ball where the manometer reading was taken.

3.1 Aerodynamic Characteristics of cricket ball with steady position.

There are no pressure differences in upper and lower surface of the sample cricket ball, when it is steady.

3.2 Aerodynamic Characteristics of cricket ball with rotation.

The variation of lift pressure with ball position for a sample cricket ball with 2624 rpm rotational speed is shown in Figure 4. At zero degree, the pressure difference is almost zero and increases linearly with the increase of ball position angle up to approximately 30^o. After wards, lift pressure decreases with further increase of ball position angle. It is also observed that the maximum pressure difference (lift pressure) is approximately 94 Pa.

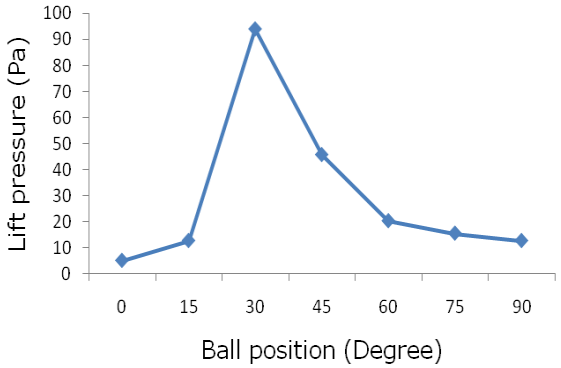

Figure 4: Ball position Vs lift pressure curve at ball rotational speed (2624 rpm)

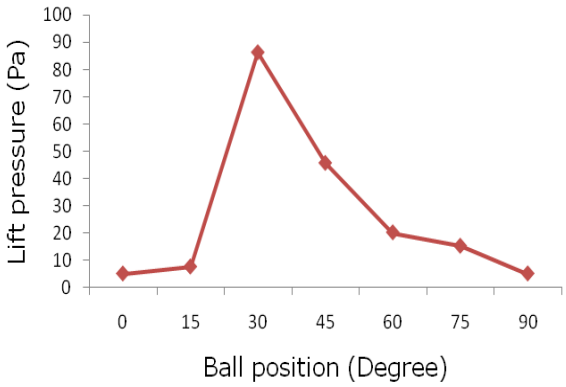

Figure 5: Ball position Vs lift pressure curve at ball rotational Speed (3043 rpm)

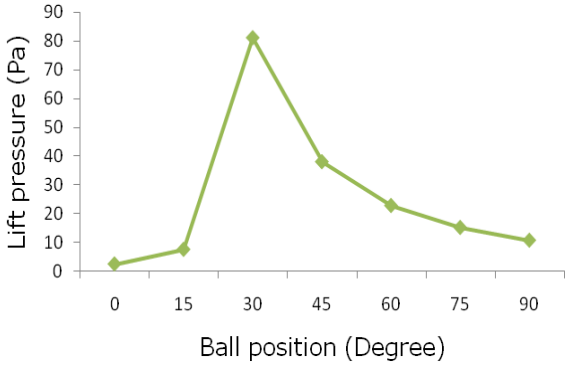

Figure 6: Ball position Vs lift pressure curve at ball rotational Speed (3365 rpm)

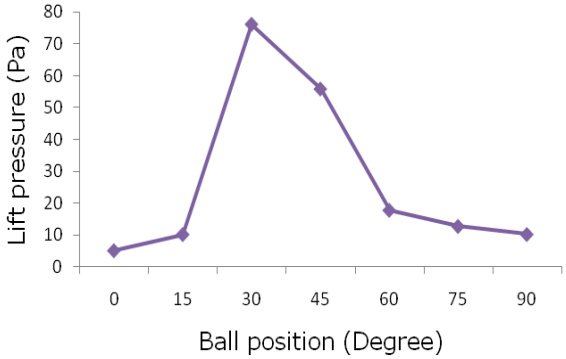

Figure 7: Ball position Vs lift pressure curve at ball rotational Speed (5879 rpm)

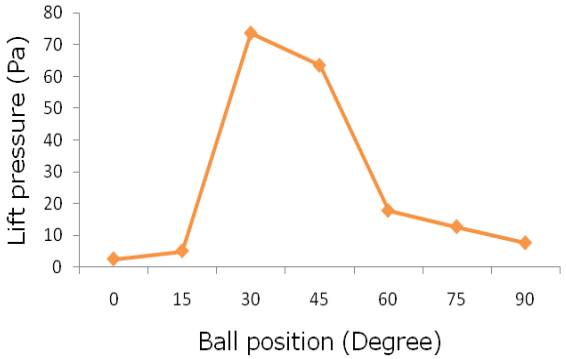

Figure 8: Ball position Vs lift pressure curve at ball rotational Speed (6178 rpm)

Figure 5-8 shows the variation of lift pressure with ball position for a sample cricket ball for rotational speeds of 3043, 3365, 507 and 6178 rpm respectively. The results are similar with only difference is maximum pressure difference and these were 86 Pa, 81 Pa, 76 Pa and 73 Pa respectively at 30° ball position.

4. RESULTS AND DISCUSSION

The variation of upward pressure (pressure difference i.e lift) with ball position for a sample cricket ball with different rotational speed is shown in Figure 9. At zero degree, the pressure difference is almost near to zero and it increases slowly at surface area's 0 to 15 degree from the horizontal axis of the ball.

Pressure difference increases linearly with the increase of ball position angle up to approximately 30^o. After wards, upward pressure decreases with the further increase of ball position angle. Also lift pressure decrease with increasing ball rotation.

It is also observed that the maximum lift pressure 94 Pa was found for minimum ball rotation 2624 rpm at 30^o ball position.

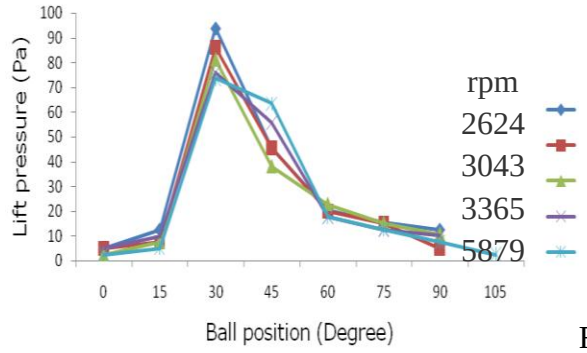

Figure 9: Ball position Vs lift pressure curve in different rpm

5. CONCLUSIONS

The experimental observation includes study of aerodynamic behavior of both stationary and rotating cricket ball placed in a wind tunnel. No pressure difference was found in between upper and lower surface of the sample cricket ball, when it is steady. In this research, various lift pressures was measured from experimental numerical data. Number of graphs are plotted to study the characteristics of lift pressure with rotational speed. The magnitude of the experimental lift pressure varies with cricket ball's rotational speed and position. Pressure difference increases linearly with the increase of ball position angle up to approximately 30^o Maximum lift pressure was found in 30^o ball position angle at lower rotational speed.

6. REFERENCES

Anderson J.D. (1991) Fundamentals of Aerodynamics, McGraw-Hill Companies; 2nd edition.

Clancy L. J. (1975) Aerodynamics, New York, John Wiley.

Dr. Maglub Al Nur (1999) Flow over a cricket ball, BUET.

K.L. Kumar, "Engineering Fluid Mechanics".11^{th}-ed, pp-230-234.

Mehta, R.D. and Wood, D.H. (1980) Aerodynamics of the Cricket Ball. Cover Article for New Scientist.

7. NOMENCLATURE

Symbol	Meaning	Unit
θ	Ball position (in angle)	Degree
P_L	Upward presser	Pa
R_e	Reynolds number	None
ρ_o	Density of air	kg/m^3
P_o	Atmospheric pressure	Pa
μ	Absolute viscosity	kg/m-s
v	air velocity	m/s

AN ALGORITHM TO DETERMINE OPTIMAL PATH FOR GIS BASED ROAD NETWORK

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ABSTRACT

Traffic congestion is becoming a serious problem in modern cities across the globe. With the complex network of a modern city, finding optimal path for road user is a challenging task. Network analysis in Geographic Information Systems (GIS) provides strong decision support for users in searching shortest route, which considers only a single network weight. Unlike other shortest path algorithm, the author developed an algorithm which could be extensively used for GIS based global position of transport network to determine optimal path. A network matrix were generated using adjacent nodes (vertices) and travel cost (travel time). Another turn matrix was generated using adjacent nodes of intersection to estimate intersection delay and turn control. The algorithm was implemented in C++ environment.

Key words*: Algorithm, Congestion, GIS, Optimal, Matrix.*

1.0 INTRODUCTION

A broad range of diverse technologies, known as Intelligent Transport Systems (ITS), holds the answer to many of these transport problems (Kumar et al., 2003, Rao et al., 2003;ESRI, 2004). A route planner to provide advance traveler information, in this regard, is considered to help a traveler to make the desired trip effectively and efficiently. The present study thus intends to develop a methodology/technique to determine optimal route based on shortest travel time / lowest impedance between a selected pair of origin and destination for GIS based road network (road network of Dhaka City would be used as a case study). Relevant key issues are mentioned in the following paragraphs.

For a given origin and destination, one is always tempted to use the shortest distance route (Kumar et al., 2003; Wu et al, 2005; Inro Consultants Inc., 2003). But this need not always is the best (optimal) route, especially in emergency situations, wherein shortest travel time is to be preferred over shortest distance. A shorter route does not always translate to shorter travel time, because it may be narrow in width or it may have higher volume of traffic, or more numbers of signals and turns and so on (Thirumalaivasan,Guruswamy,2006). Weighted graphs (Cormen et al., 2002; CDA International Ltd.,2006), which are a pervasive data structure in computer science and algorithms (Shekhar and Fetterer,1996) for working with them are fundamental for the problems of computing optimal routes between nodes when each edge has an associated length or "weight" to represent the road and traffic condition.

An optimal path/route algorithm can be describe as a (directed) graph G= (N,E,C) consists of a node set N, a cost set C, and an edge set E (Shekhar and Fetterer,1996). The edge is a subset of the cross product N*N. Each element (u,v) in E is an edge that joins node u to node v. Each edge (u, v) is associated with a cost C (u, v). Cost C (u,v) takes values from the set of real numbers. A node v is a neighbor of node u if edge (u,v) is in E. An optimal path from node u to node v is the path with the smallest cost.

However, optimal path algorithms are very rarely available in literature, which explains only the conceptual framework (Zografos and Androutsopoulos, 2006; Liao,2004). Furthermore, literature reveals that most route selection techniques are based on shortest path on the basis of distance or travel time not considering road type, road geometry, land use, intersection queue length, signal timing, flow restriction, etc. Also most of them need to install specific GIS software in the computer for their visual display.

To implement the algorithm some database regarding traversing nodes and travel cost is essential. Sections 2 through 4 briefly discussed the basic database acquisition procedure in brief.

Travel cost (travel time) data was calculated using the Equation 1.1.

Travel time is the sum of the mid –block travel time and intersection travel time, and can be formulated as :

$$T = \sum_{i=0}^{n} (T_m + T_d) \quad \text{.....(1.1)}$$

Where,

T = total travel time, sec

i = total number of segment (s) to be traversed between O-D pairs

Tm = time required to traverse mid-block segment (s), sec

Td = intersection delay adjacent to mid-block segment, sec

2.0 SPATIAL NETWORK

There are 6608 arcs those represents road network of the study area. The study network was the selected road Network of Dhaka City Corporation (DCC, 2003) as shown in Figure 2.1. The spatial network is composed of Primary road and secondary road only. Other types of road network and railway were excluded in the study.

Figure 2.1: Spatial Network of the Study

3.0 METHODOLOGY

The methodology is presented in the flow chart as shown Figure 3.1 below.

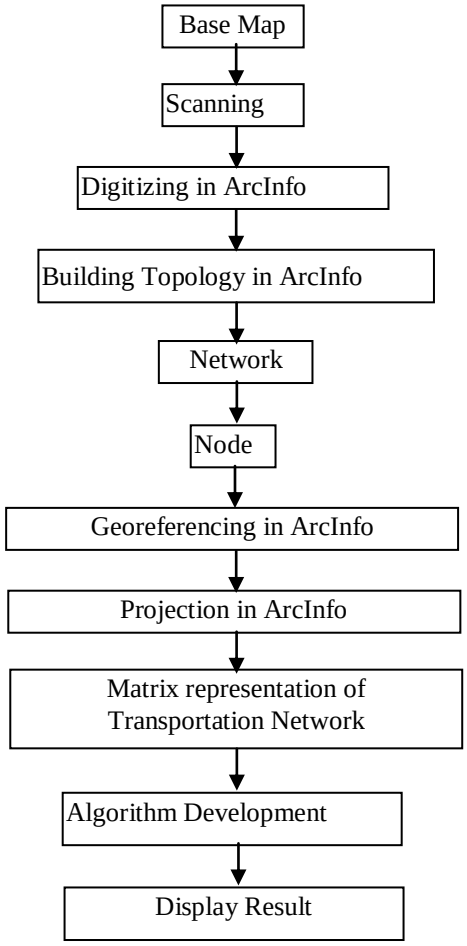

Figure 3.1: Framework of the Methodology

3.1 Spatial (GIS) Database Development

DCC base map of scale 1:30000 (DCC, 2005) would be the main source of the spatial data. Basic steps for acquisition of spatial database development are base map collection, scanning, digitization, building topology, missing data collection, georeferencing and projection.

3.2 Non-spatial Database Development

Travel regarding free flow speed, intersection delay, signal cycle time, signal green time, restriction on vehicle movements, restriction on u-turns, stops, barriers, etc., would be considered as non-spatial data and stored in predefined dBASE tables in MS Access format. Some of the data have been collected from STP (The Louis Berger Group, Inc. and Bangladesh Consultants Ltd ,2005) and (DUTP, 1998). Appropriate delay function have been developed in this regard (TRB,1985 and Chung and Akcelik,1992). Moreover, further traffic and road network data have been collected from relevant institutions (BRTA, RHD, etc.) and through small scale physical survey.

4. REPRESENTATION OF TRANSPORT NETWORK

The transport network is composed of adjacent vertices. The GIS based transport network is showed in Figure 2.1. Each individual road segment is consists of adjacent vertices.

4.1 Vertices of the network

There are 4458 nodes (vertices) available in the study area network. The vertices have been generated from the transportation network as shown in Figure 2.1 using ArcInfo GIS and showed in Figure 4.1 as below (ArcInfo, 2008).

Figure 4.1: Adjacent Nodes of the Study Network

4.2 Tabular format of vertices

Ultimately the vertices need to convert into tabular format, the table of vertices has been generated in ArcInfo. Travel cost (network weight) has been obtain from different analytical result (HCM, 2000). The prototype of the attribute table is showed in Table 4.1 below. The whole Table is available in the database.

Table 4.1: Node Attribute Table

FNode	TNode	Duration		Travel Cost (Time,sec)
		From	To	
1886	1836	6:00	7:00	73.38
1886	1836	7:00	8:00	73.38
1886	1836	8:00	9:00	73.38
1886	1836	9:00	10:00	73.38
1886	1836	10:00	11:00	73.38
1886	1836	11:00	12:00	73.38
1886	1836	12:00	13:00	73.38
1886	1836	13:00	14:00	73.38
1886	1836	14:00	15:00	73.38
1886	1836	15:00	16:00	73.38
1886	1836	16:00	17:00	73.38
1886	1836	17:00	18:00	73.38
1886	1836	18:00	19:00	73.38
1886	1836	19:00	20:00	73.38
1886	1836	20:00	21:00	73.38
1886	1836	21:00	22:00	73.38
1886	1836	22:00	23:00	73.38
1886	1836	23:00	0:00	73.38
1886	1836	0:00	1:00	47.70

Source: Node Coveage

To determine optimal path that network was converted in matrix format. The prototype of matrix is showed in Figure 4.2. Similarly, individual turn matrix was generated as shown in Figure 4.3.

$$\begin{vmatrix} V_1 & V_2 & C_1 \\ . & . & . \\ . & . & . \\ V_{n-1} & V_n & C_n \end{vmatrix}$$

Figure 4.2: Network Matrix

$$\begin{vmatrix} v1 & v2 & v3 & c1 \\ . & . & . & . \\ . & . & . & . \\ vn\text{-}2 & vn\text{-}1 & vn & cn \end{vmatrix}$$

Figure 4.3: Turn Matrix

Where
$v_1, v_2, v_3, \ldots \ldots v_n$, represents nodes of network
$c_1, c_2, c_3, \ldots \ldots c_n$, represents network cost (weight)

5.0 ALGORITHM

An algorithm is a finite set of instructions that, if followed, accomplishes a particular task. In addition, all algorithms must satisfy the criterias: Input, Output, Definiteness, Finiteness, Effectiveness.

5.1 Notations

Notations used in the algorithm are mentioned below:

∈	Belongs to
←	Assignment
==	Equal
+	Addition

5.2 Elements

The proposed algorithm composed of set of vertices (V) and edges (E). Another element is the network cost, which is the time require to traverse between vertices.

5.3 Proposed Algorithm

The proposed algorithm is based on the back tracking, because of ranked paths are to be calculated. The proposed algorithm is also involved with integration of network impedances, landuse, etc., so that optimal path can be achieved. The algorithm notations, it's elements have mentioned in sections 5.1 and 5.2.

Algorithm Ranked Optimal Path (Input: edge list E, vertex list V, source)

1. For every vertex v∈V
2. Color [v] ← white
3. Parent [v] ← -1
4. Cost [v]] ← 0
5. Call Backtrack (source)
6. End

Algorithm backtrack (input: source vertex v)

5. Color [v] ← gray
6. While there is any vertex u adjacent to v
7. Begin
8. if (color [u]==white)
9. Begin
10. Parent [u] ← v
11. Cost [u] ← Cost[v] + Cost (v,u)
12. Backtrack(u)
13. Color [u] ← White
14. END
15. END
16. END
1. if v is destination node
2. begin
3. save path from source to v
4. END

5.3.1 Execution procedure of the proposed algorithm

A step-by-step procedure to execute the algorithm describes below. At each step of the algorithm, the contents of the reached table and the scanned table will be shown along with a map showing the progress of the algorithm.

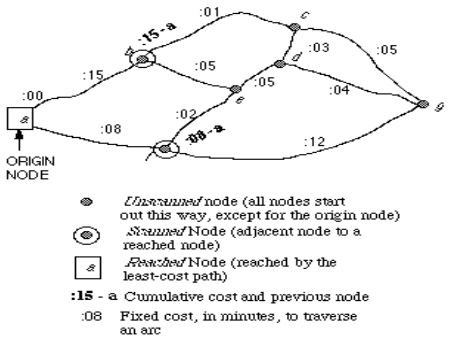

Figure 5.1: Spatial Network and O-D Node Used for Executing Algorithm

Step1 :Set the origin node as reached. Scan the adjacent nodes (nodes b and f)
Step 2:Pick the scanned node with the lowest cumulative cost
Step 3: Scan all the nodes adjacent to the node just reached
Step 4: Pick the scanned node with the lowest cumulative cost
Step 5: Scan all the nodes adjacent to the node just reached
Step 6:Repeat steps 3 and 4 until reaches in the destination node

The only entries left on the scanned table are for node g. There are no nodes adjacent to node g that has not been reached. That is, there is nothing left to scan, and this phase of the path finding algorithm is complete. The scanned table can be thrown away at this point. The algorithm has now determined the least-cost path from all nodes to the origin node.

To trace the least-cost path from a to g, it is necessary to follow the previous node. Starting at node g (Step [1]), go to node d (Step [2]), to node e (Step [3]), to node f (Step [4]), to node a (Step [5]).

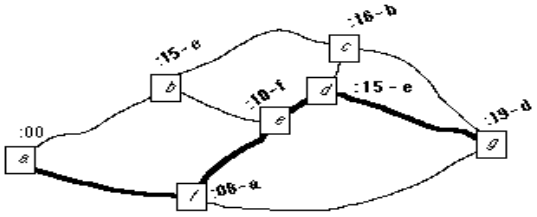

Figure 5.2: The Least-cost Route (optimal route) from a to g.

6.0 EXPERIMENTAL RESULTS

A GIS road network for Dhaka city is contain 4458 nodes and 6230 arcs as shown in Figure 2,1 and 4.1 respectively. When implemented the algorithm in C++ environment ranked optimal path were found as in Figure 6.1 below. A prototype of the ranked path between origin node to destination node were found as shown in Figure 6.1 below.

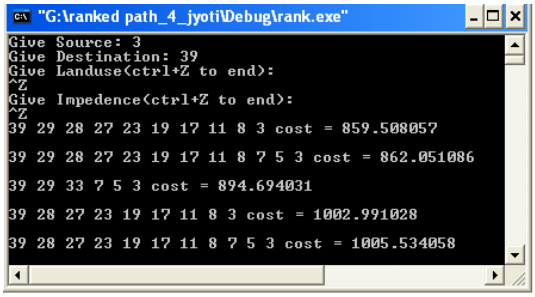

Figure 6.1: Optimal Path Between Given Origin and Destination

6.0 CONCLUSIONS

The main objective of the paper was to discuss the feasibility of the algorithm. Due to test of experimental results spatial and non-spatial data acquisition procedures were also discussed in brief. The developed algorithm is ideally expected to find a set of ranked optimal paths. When works with huge vertices it is essentially be used higher configured processor and RAM to obtain result quickly. Back tracking is an important criteria to determine ranked optimal path using the algorithm.

REFERENCES

ArcInfo 7.2.1 (2008). “Arc-Node Topology”. On-line help of ArcInfo 7.2.1, Environmental System Research Institute, 380 New York Street, Redlands, California, USA

CDA International Ltd. (2006). “ Manifold® System Release 7.x”. http://exchange.manifold.net/manifold/manuals/manifold/manifold.htm#networks/graph_theory/graph_theory_glossary.htm

Chung, E., Young, W., and Akcelik, R. (1992)."Comparisonof Roundabout Capacity and Delay Estimates From Analytical and Simulation Models". 16th conference Proceedings -Part5, Australian Road Research Board (ARRB) Limited

Cormen, T.H., Leiserson, C.E, Rivest, R.L, and Stein, C. (2002). “Introduction to Algorithms”. The MITPress,Cambridge, Massachusetts, London, England

DCC (2003). “Road maintenance plan of DCC road network for 2002-2003”. Dhaka City Corporation, Dhaka

DCC (2005). “Base Map of Dhaka City Corporation”.DhakaCity Corporation, Dhaka

DUTP (1998). “Dhaka Urban Transport Project, Phase II(1998), Draft Final Report”. PPK, Mot DocDonald andDevelopmentDesign Consultant (DCC), Dhaka

ESRI (2004). "ESRI GIS Partner Solutions and Services for the Transport Industry". www.esri.com/Transportation/ library/brochure/pdfs/ transportation_bps.pdf

HCM (2000). “Highway Capacity Manual”. Transportation Research Board, National Research Council, Washington, DC, USA

Inro Consultants Inc. (2003). "EMME/2 User's Manual Software Release 9". Inro Consultants Inc., Montreal (Quebec), Canada.

Kumar, P., Reddy, D., Singh, B. (2003). "IntelligentTransport System Using GIS".Map India Conference 2003, © GIS Development.net

Liao,T. (2004). "Tabu Search Algorithm for Dynamic Vehicle Routing ProblemsUnderReal-Time Information".Transportation Research Record: Journal of the TransportationResearch Board, No. 1882, Washington, D.C., pp. 140-149.

Rao, V., Trinadha, Bhardwaj, Alok, and R,Ch.V.S.(2003).“Intelligent Transport Systems (ITS): A Technology Solution For 21st Century Public Transport System Management”. www.tcs/0_practices/transportation/download/intelligenttransportation_system.pdf

Shekhar, S. Fetterer, A. (1996). “Path Computation in Advanced Traveler Information Systems”. Computer Science Department, EE/CS 4-92 UniversityofMinnesota, Minneapolis, MN, 55455 www.cs.umn.edu/research/shashi- group

The Louis Berger Group, Inc. and Bangladesh Consultants Ltd (2005). "Strategic Transport Plan (revised final draft)". Ministry of Communications, Government of the People's Republic of Bangladesh.

Thirumalaivasan, D., and Guruswamy,V. (2006). "Optimal Route Analysis Using GIS". AnnaUniversity, India www.gisdevelopment.net/application/utility/transport/index.htm

TRB (1985).“HighwayCapacity Manual. Spacial Report 209". Transportation Research Board, National Research Council, Washington, D.C

Wu, Yi-Hwa, Miller, H.J., and Hung, M.C. (2005). “ A GIS-based Decision System For Analysis of Route Choice in Congested Urban Road Networks”. Digitally Integrated Information Laboratory & Department of Geography, University of Utah, 260 S. Central Campus Dr. Room 270, Salt Lake City, UT 84112-9155. E-mail:{wu.yi-hwa, Harvey.miller, mhung}@geog.utah.edu

Zografos, K.G and Androutsopoulos, K. N.(2006)."Algorithmsfor Determining Optimum Itineraries inaMultimodalUrban Transportation Network". TRB 2006 Annual Meeting CD-ROM, USA.

EXPLORING ALTERNATIVE ENERGY TO MEET ENERGY CRISIS OF BANGLADESH

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ABSTRACT

The explosive growth of worldwide energy demand has made it painfully clear that our traditional sources of electricity can no longer be expanded without creating a major environmental tragedy. Coal burning during the industrial revolution created localized disasters but the massive scale today is creating disaster on a global scale. Fuel costs are growing exponentially as the limits of our planet's resources is reached. Oil and natural gas supplies are running short but coal supplies were thought to be plentiful and cheap. The problem is that every ton of coal burned produces 3.7 tons of CO2! The idea of transporting and hiding forever that much CO2 was ludicrous from the start. To make matters worse, coal prices have quadrupled since 2003. Even if we ignore CO2, coal is an environmental nightmare. Mercury emissions make it dangerous to eat many fish today and may be responsible for our epidemic of autism. It will bring an end to the denial of coal's unsolvable problems. Already new laws are being considered to ban coal outright. But what is the alternative? Solar power works mainly during midday and wind power can stop almost completely from late night through morning. Weather conditions can completely disable both wind and solar. Geothermal power uses no fuel, produces no pollution and works reliably and steadily all day and every day. To choose the best alternatives for power solution, resource, capability, economic condition, geographic location, politics demand, growth rate, environmental factors etc are very vital. These factor are the prime consideration for power modeling.

Keywords - *Photophysical energy, Fossil fuels, Pyrolysis, Minihydro, Windmill, Photovoltaics, OTEC, Geothermal energy etc*.

INTRODUCTION:

1. Modern lifestyles demand a steady, reliable supply of energy: it lies at the heart of our mobility, our prosperity and our daily comfort. But we should not take this energy security for granted. Energy sources can be divided into three broad categories. The first
derives from chemical or photophysical energy
that relies on oxidizing some reduced substance, usually a hydrocarbon, or absorbing sunlight to generate either heat or electricity. The energy involved is that of a chemical bond or fractions of an electron volt (eV).

The second involves nuclear reactions that release energy either by splitting heavy nuclei or by fusing light nuclei. The energy involved in nuclear reactions is in the region of 106 electron volts (MeV) per nuclear reaction.

The third is thermomechanical in the form of wind, water, or geological sources of steam or hot water. The energy involved is in the milli-electron-volt (meV) region from, for example, water falling several tens of metres each energy source has some undesirable characteristics. Any process using fossil fuels produces carbon dioxide, and perhaps also other contaminants, such as nitrogen oxides, sulphur oxides and ash. Nuclear plants produce radioactive fission products. Hydroelectric plants require dams and large lakes. Solar energy and wind energy require large areas and are limited geographically. Geothermal sources are limited to very few locations. Schemes using small temperature gradients in the earth or oceans have low thermal efficiencies, and hence require very large heat-exchanger areas. At present most of the world's energy supply comes from fossil and nuclear sources. And although mankind is increasingly having to face the issues of resource limitation and environmental pollution, these sources will continue to be important in providing energy worldwide for the next few generations.

ALTERNATIVE ENERGY CONSIDERATIONS

2. Power crisis in the world has compelled mankind to think for alternative energy. But all the alternative sources have not yet been exploited. From many ongoing researches, it reveals that if all the alternative energy sources are exploited, the energy crisis of the world would be reduced to a great

extent. Many alternative energy technologies today are well developed and they are reliable and cost competitive with the conventional fuel generators. There are many alternative sources of energy such as biomass, wind, solar, minihydro and tidal power. The most important advantage offered by alternative energy sources is their potential to provide sustainable electricity in areas not served by the conventional power grid. Most of the alternative energy technologies produce DC power, and hence power electronics and control equipment are required to convert the DC power into AC power.

Fossil fuels or mineral fuels are fossil source fuels, that is, hydrocarbons found within the top layer of the Earth's crust. There are three major forms of fossil fuels: coal, oil and natural gas. All three were formed many hundreds of millions of years ago before the time of the dinosaurs - hence the name fossil fuels.

They range from volatile materials with low carbon:hydrogen ratios like methane, to liquid petroleum to nonvolatile materials composed of almost pure carbon, like anthracite coal. Fossil fuels currently supply most of the world's energy needs, and however unacceptable their long-term consequences, the supplies are likely to remain adequate for the next few generations. Scientists and policy makers must make use of this period of grace to assess alternative sources of energy and determine what is scientifically possible, environmentally acceptable and technically promising.

SAVING FOSSIL FUELS

3. Fossil fuels take millions of years to make. We are using up the fuels that were made more than 300 million years ago before the time of the dinosaurs. So, it's best to not waste fossil fuels. They are not renewable; they can't really be made again. We can save fossil fuels by conserving energy. Once we've burned them all, there isn't any more, and our consumption of fossil fuels has nearly doubled every 20 years since 1900.

SEA POWER

4. The Earth is covered mainly by water. The seas as we call them have currents and tides that circulate round the world. This vast amount of moving water produces immense

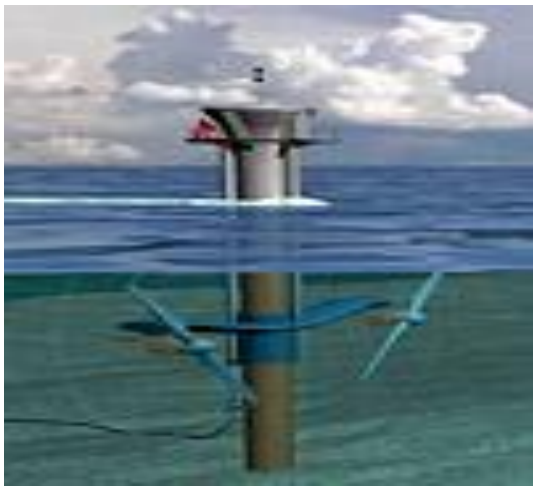


Fig 1: Sea Generator set

amount of energy. Countries like Britain that are surrounded by powerful seas and oceans are ideally placed to convert the energy of tides, sea currents and waves to produce electrical energy. Tidal power utilization is also considered to be a very reliable source of energy due to its predictability. Compared to other sources of energy such as wind or solar energy, tidal changes are easier to predict. They're also sure to occur consistently. Unlike solar or wind energy, tidal power does not depend on the season or the weather type. Instead, tidal energy relies purely on the orbital kinetic energy that the sun exerts as the earth orbits around it. The same goes with the moon and earth orbital system. As the moon orbits around the earth, a gravitational force is experienced by both bodies.

The incoming and outgoing tides of the sea can be harnessed to produce electrical power. Tides are often very powerful and the sea can move very quickly when the tide is coming into land. When the tide approaches toward land the amount of water rushing forwards can be measured in terms of millions of gallons. This is an immense force of moving water.

TIDAL ENERGY

5. The gravitational energy produces tidal that range from 25 to 30 ft in many places in the world. Potential energy in water increases as height is increased. More energy is stored by an object as it goes

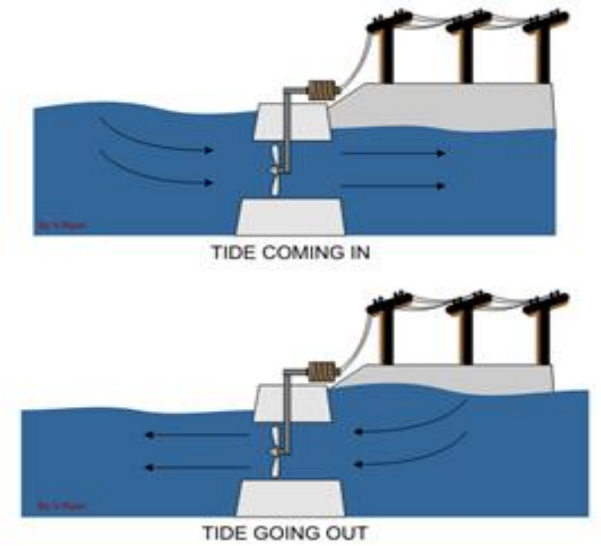


Fig 2: Utilizing tidal energy

higher and higher. This potential energy could then be released and then converted into electricity through the use of proper devices and modern technology. Tidal energy would be most effective and economical to produce, therefore, if water levels between tides are significant. Water could be trapped or held within specially made structures during high tide. A water containment reservoir called a tidal lagoon is constructed. The lagoon is filled with water as the tide goes up the reservoir.

As the tide shifts from high to low, there exists a difference in pressure between the water in the higher containment structure and that in the open water source. This will form a head pressure (also known as hydrostatic pressure) on the containment structure. The difference in water levels between the open water source and of the contained water will result to potential energy which could be utilized when the contained water is released. This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both direction.

When the natural body of water (water outside the containment) reaches a very low level due to the low tide, the water within the reservoir is released using specially made outlets that are usually equipped with turbines. The force of the rushing water would spin the turbines which would in turn power generators that would produce electricity. There are three tidal electric systems have been constructed in the world. A 20-MW_e system at Kislaya Guba in Russia, a 20-MW_e system at Nova Scotia in Canada and a 240-MW_e tidal systyem in France. A diagram of 10-MW_e reversible hydraulic turbine tidal system is shown in the following figure:

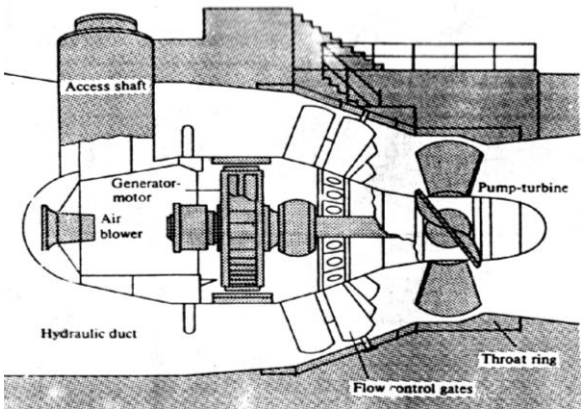


Fig 3: Reversible Hydo -Turbine Power Plant

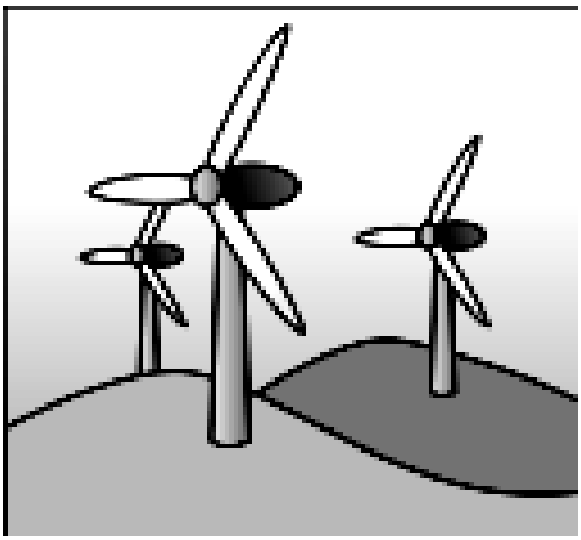


Fig 4: Wind Turbine

BIO OIL

6. BioOil is an alternative fuel made using Dynamotive's pyrolysis process of biomass. It is a dark brown, free flowing liquid fuel with a smoky odour reminiscent of the plant from which it was derived. BioOil is formed in a process called

pyrolysis wherein plant material (biomass), such as sawdust or bagasse from sugar cane, is exposed to 400-500 degrees Celsius in an oxygen free environment. BioOil contains up to 25% water. The water component in BioOil is not a separate phase and is important because it lowers the viscosity of the fuel. BioOil is not a hydrocarbon-water mix like Orimulsion. Another feature of BioOil is its propensity to change slowly over time. This is not to be considered an instability because it can take months.

BioOil is a fossil fuel substitute. It pumps well, ignites, and burns readily when atomized. Recently, Bio Development Company, Bangladesh has proposed to produce bio fuel from a locally available plant (named Jatropa) at cheaper cost. Certainly it is encouraging and needs patronizing from the Government for further research and development.

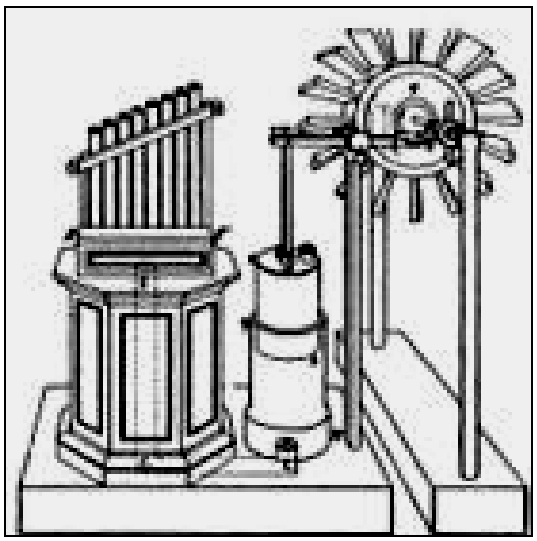
WI**NDMILL**

7. Wind power can be an excellent complement to a solar power system. Here in Colorado, when the sun isn't shining, the wind is usually blowing. Wind power is especially helpful here in the winter to capture both the ferocious and gentle mountain winds during the times of least sunlight and highest power use. In most locations (including here) wind is not suitable as the ONLY source of power--it simply fills in the gaps left by solar power quite nicely. A windmill is a machine that is powered by the energy of the wind. It is designed to convert the energy of the wind into more useful forms using rotating blades or sails. The term also refers to the structure it is commonly built on.

A wind turbine is a rotating machine which enables the conversion of kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill.

If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill.

(a)



(b)

Fig 5: Wind power setup to produce electricity

If the mechanical energy is then converted to electricity, the machine is called a wind generator, wind turbine, wind power unit (WPU) or wind energy converter WEC).

SOLAR ENERGY

8. Solar energy is energy from the Sun in the form of radiated heat and light. It drives the climate and weather and supports life on Earth. Solar energy technologies make controlled use of this energy resource.

Solar power is a synonym of solar energy or refers specifically to the conversion of sunlight into electricity by photovoltaics, concentrating solar thermal devices or various experimental

technologies. The solar cells that you see on calculators and satellites are photovoltaic cells or modules (modules are simply a group of cells electrically connected and packaged in one frame). Photovoltaics, as the word implies (photo = light, voltaic = electricity), convert sunlight directly into electricity. Once used almost exclusively in space, photovoltaics are used more and more in less exotic ways. They could even power your house. How do these devices work?

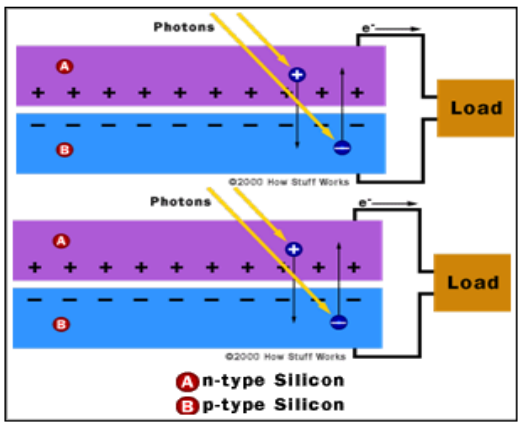


Fig 6: Photovoltaic Cells: Photons to Electrons

Photovoltaic (PV) cells are made of special materials called semiconductors such as silicon, which is currently the most commonly used. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely. PV cells also all have one or more electric fields that act to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is a current, and by placing metal contacts on the top and bottom of the PV cell, we can draw that current off to use externally. For example, the current can power a calculator. This current, together with the cell's voltage (which is a result of its built-in electric field or fields), defines the power (or wattage) that the solar cell can produce. concentrating solar thermal devices or various experimental technologies.

That's the basic process, but there's really much more to it. Let's take a deeper look into one example of a PV cell: the single-crystal silicon cell.

OCEAN THERMAL ENERGY CONVERSION (OTEC)

9. The utilization of temperatures gradients in ocean by some sort of system called OTEC is now-a-days an advance technology used in developed countries to

meet the growing demand of electricity all over the world. In recent years, it is well discussed and studied for further development. The first operational OTEC was a 40 KW_e power plant built in Cuba in 1926. This system uses the worm surface waters of the ocean to boil a working fluid in a Rankin cycle power plant and then uses the cooler deep water to condense the vapor leaving turbine.

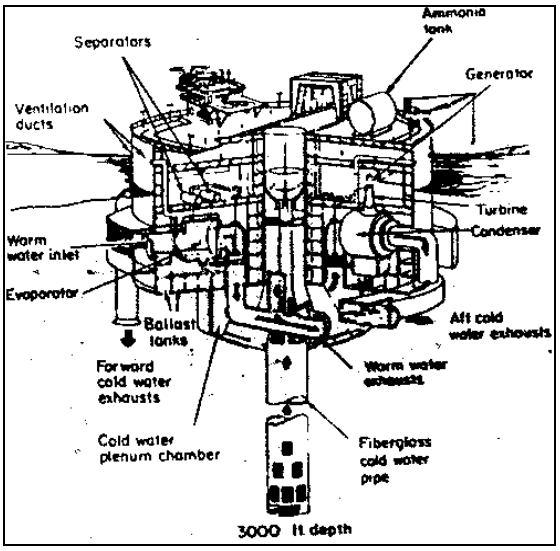


Fig 7: Diagram of OTEC plant

GEOTHERMAL ENERGY

10. The final major source of fuel energy available to the human race is geothermal energy. This is thermal energy trapped beneath and within the solid crust of the earth. This energy exists in the form of steam, hot water, and/or hot and molten rock. It is released naturally as geysers, hot springs, and volcanic eruptions. Geothermal energy comes from two sources. It includes the primordial thermal energy which was present when the earth was formed as well as the thermal energy produced from the decay of heavy radioisotopes.

There are tremendous reserves of thermal energy trapped beneath the earth's crust. However, to date, it has not been possible to drill through the earth's crust despite several attempts. In 1904, the

first successful geothermal steam drilling was carried out at Larderello, Italy. The present electrical capacity of that plant is around 400-MW_e. There are a number of geothermal plants existing around the world including USA, Mexico, Iceland, New Zealand, Japan and Russia. All these are located on or near major geological faults. A schematic diagram of a typical geothermal power plant is shown below:

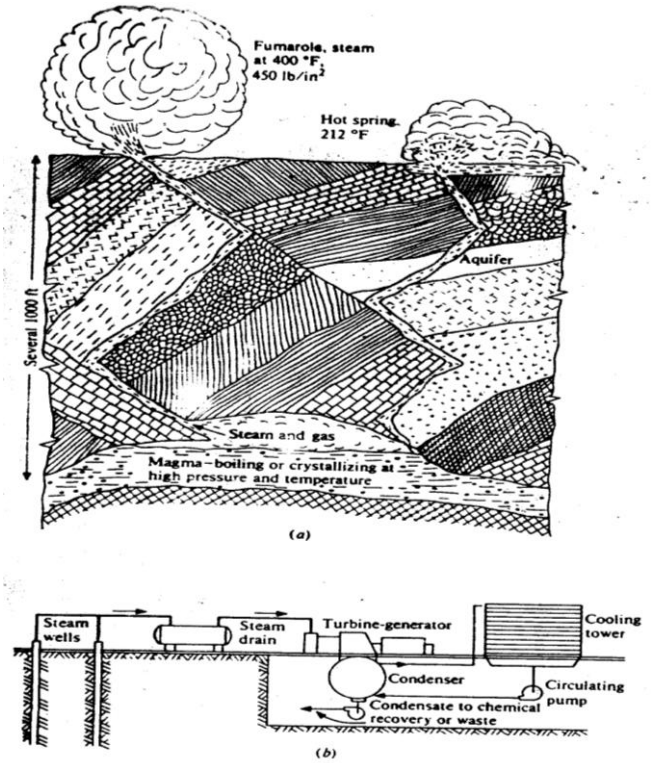


Fig 8: Schematic diagram of a geothermal power system:

(a) Schematic diagram of a typical geothermal deposit.

(b) Schematic diagram of a typical geothermal plant.

NUCLEAR ENERGY: ENERGY FROM ATOMS

11. Nuclear Energy is energy due to the splitting (fission) or merging together (fusion) of the nuclei of atom(s). The conversion of nuclear mass to energy is consistent with the mass-energy equivalence formula $\Delta E = \Delta m.c^2$, in which ΔE = energy release, Δm = mass defect, and c = the speed of light in a vacuum (a physical constant).

Nuclear energy is released by three exoenergetic (or exothermic) processes:

Nuclear energy can be used to make electricity. But first the energy must be released. It can be released from atoms in two ways: nuclear fusion and nuclear fission. In nuclear fusion, energy is released when atoms are combined or fused together to form a larger atom. This is how the sun produces energy. In nuclear fission, atoms are split apart to form smaller atoms, releasing energy. Nuclear power plants use nuclear fission to produce electricity.

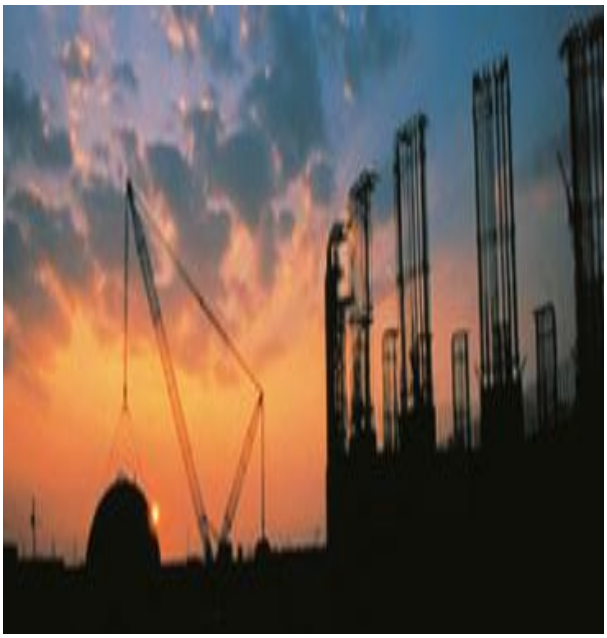
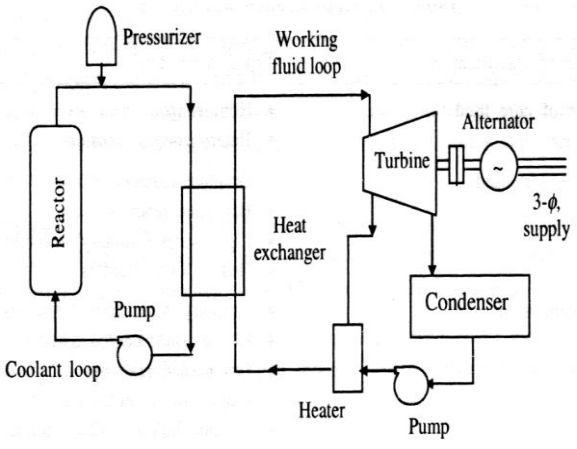


Fig 9: Typical Nuclear Power Plant

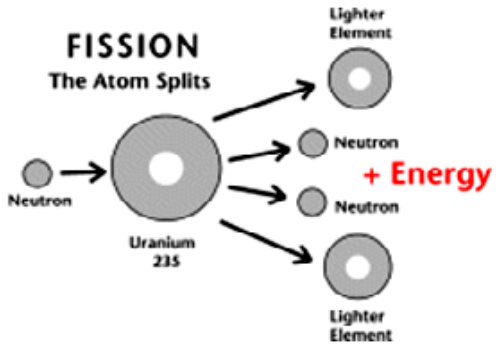
After years of stagnation, many countries have announced plans to build new nuclear power plants. More than 30 reactors are under construction. Demand is also growing in Asia. Facing energy shortages, China and India are building several reactors, and intend to increase their nuclear capacity several times over in the next 15 years. The power unleashed by nuclear fission has no equal on Earth, but the world's 439 nuclear reactors only produce around 6 percent of the world's energy and between 12 and 15 percent of its electricity. This small number has less to do with limited resources, technological problems, or geopolitical constraints, than the low cost of fuel alternatives like gas and widespread fears over the safety of nuclear power plants.

Many poor countries, on the other hand, simply have no access to nuclear power, because of the high costs of building a nuclear power plant, the complicated technology involved, or political restrains on nuclear material that can be used both for a power plant and nuclear weapons.

During nuclear fission, a small particle called a neutron hits the uranium atom and splits it, releasing a great amount of energy as heat and radiation. More neutrons are also released. These neutrons go on to bombard other uranium atoms, and the process repeats itself over and over again. This is called a chain reaction.



(a)



(b)

Fig 10 : (a) Schematic of a Nuclear Power Plant (Pressurized Water Reactor)
(b) Fission Process

ELECTRICITY FROM COAL

12. Electricity from coal is the electric power made from the energy stored in coal. Carbon, made from ancient plant material, gives coal most of its energy. This energy is released when coal is burned. Coal is a fuel that is found in the ground. It is made of the remains of plants that died millions of years ago. Soil piled up on top of the remains and that weight compacted it into a more dense material, called coal. The energy in the coal came from the sun and was stored in the plants. When the coal is burned, it gives up that energy as heat. The coal's heat energy can then be turned into electrical energy. This happens at a power plant.

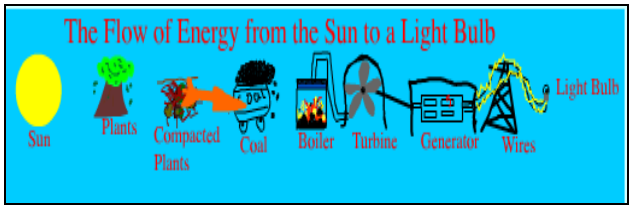


Fig 11: Energy Cycle for Coal to produce Electricity

RELEASING COAL'S ENERGY

13. The process of converting coal into electricity has multiple steps and is similar to the process used to convert oil and natural gas into electricity:

a. A machine called a pulverizer grinds the coal into a fine powder.
b. The coal powder mixes with hot air, which helps the coal burn more efficiently, and the mixture moves to the furnace.
c. The burning coal heats water in a boiler, creating steam.
d. Steam released from the boiler powers an engine called a turbine, transforming heat energy from burning coal into mechanical energy that spins the turbine engine.
e. The spinning turbine is used to power a generator, a machine that turns

mechanical energy into electric energy. This happens when magnets inside a copper coil in the generator spin.

Fig 12: Typical Coal Power Plant

f. A condenser cools the steam moving through the turbine. As the steam is condensed, it turns back into water.
g. The water returns to the boiler, and the cycle begins again

POWER MODEL OF BANGLADESH

14. Keeping the present requirement of the country into purview, a power model for the year 2014 is proposed in the following figure: (In 2014, the total power requirement is taken to be 6000MW (approx).

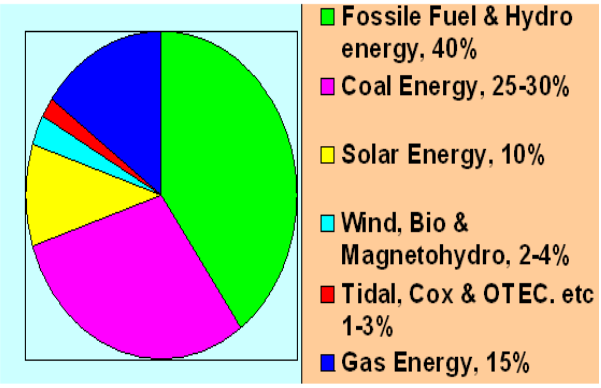


Fig 13: Power Model of Bangladesh in 2014 (proposed)

ANALYSIS OF THE POWER MODEL

15. The power model is analyzed in the following:

a. The price hike of fossil fuel has stopped all prospects of fossil fuel generators all over the world. So, existing generators may be continued for its maximum service but any future planning should avoid the consideration of such plant. Analysis shows that current installations including the ones in the pipeline to be established soon, may meet the demand of approximately 40% in the year 2014.

b. The Nuclear Plant is yet to be established; the proposed site is in Ruppur. If it is possible to install such plant the energy crisis could be minimised to a great extent. But fuel for the plant is a prime consideration. The present world's political scenario dictates that for such nuclear plant we are too ambitious.

d. The reserve coal of our coal mines are very sufficient to install 3-4 coal power stations in addition to the exixsting ones, if the it is possible to collect the coal in proper manner. A study shows that within next 5-6 years it is possible to share 25-30% load of the total demand on the year 2014.

c. Solar power in an intermediate solution of the power crisis. It can adequately serve the purpose of rural and remote areas. But this sector is to be patronized by the government to reduce the price of the solar panel. The manufacturing organizations may be given incentive and if required, to be subsidized by the government. The local people are to be encouraged to use solar. If so happens, it may take the load upto 10%.

d. Other alternative source is to be encouraged equally. Research may continue to establish windmill, production of Bio Fuel, Picohydo/Magnatohydro plants, even Geothermal plant wherever geographically suitable may be setup to reduce the load on national grid. With our current situation it is possible to produce 3-5% power from these plants.

e. The height of tide in the Karnaphully river (also in some other rivers of Coastal area) varies between 12-18 ft during high tide and low tide. This height of water may be trapped in some basin individually or collectively to produce electric power. There are some countries in the world like Cuba, Canada, Russia etc. which produce significant amount of power from same system. 1-2% load can be meet up by tidal/cox's power.

RECOMMENDATIONS

16. The recommendations from the above analysis are:

a. The power model shown above may be taken as a proposed solution of the existing power crisis.

b. All efforts are to be made to diversify the dependency of common mass to the national grid power, as such alternative source power (like solar power) is to be encouraged and subsidized if required.

c. As the prospect of fossil fuel plant is discouraging, also the alternative power

source can not face the bulk/mass demand the also establishment of Nuclear Plant is not feasible in the present world's political scenario, coal power may be explored to the best of our capacity to meet the growing demand.

d. As Solar power is an intermediate solution of the power crisis, efforts may continue to supply solar panel in a cheap and easy way to the common mass.

References:

[1] Gregory J., "Financing Renewable Energy Projects," IT Publications, UK, 1997.

[2] Britton, Peter. "Tapping the tides for power," Popular science, Vol 277, no 1, January 1985.

[3] Russel C. R.: "Elements of Energy Convesion" Pergamon press, Long Island City, N. Y., 1967.

[4] Archie W. Culp, Jr.,Ph.D. "PRINCIPLES OF ENERGY CONVERSION" 2nd Edition, McGraw-Hill Inc. New York.

[5] Okoro O. I., and Madueme T.C., "Solar energy: a necessary investment in a developing economy", International Journal of Sustaunable Energy" Volume 25, Number 01/March 2006.

[6] Skrotski, B.G. A, and W. A. Vopat: "Power Station Engineering and Economy," McGraw-Hill, New York, 1960.

[7] http://upload.wikimedia.org/wikipedia/ commos.

EXPERIMENTAL VERIFICATION OF THE INSIDE INTEGRATION METHOD (IIM) FOR THE SIMULATION OF SHALLOW WATER FLOW RUNNING ONTO A SLOPING GROUND

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Military Institute of Science and Technology [(1,2,4)]
Institute of Water Modeling [(3)]

This study shows the validation of a new numerical scheme with hydraulic experiment. The proposed scheme is a new computational scheme to solve shallow-water equations for surface waves shoaling on a slope. Experiment was carried out in a wave tank set on an oscillating bed, which can be moved, uniformly equal in both directions. Used flume had a flat bed of 50.5 cm and having a constant slope of 11.3^0 in one end whereas the other end is fixed with a vertical wall. As initial condition, water depth was 2cm, wave period was 3.5 s and the movement of the oscillating bed was 6 cm. From the comparisons of the time variation of the moving boundary and the water level along the tank, numerical computation was found to provide good agreement with laboratory experiments.

Keywords: Moving boundary, Numerical Computation, Wave Shoaling, Hydraulic experiment

1. INTRODUCTION

The behavior of long-wave shoaling on sloping beaches has received intensive study by many scientists and engineers. Primary impacts of the behavior of wave shoaling with a moving boundary are inundation in the form of tsunamis and storm surge, causing exacerbation of flooding and beach erosion. These impacts, in turn, cause higher ordered impacts in a wide range of coastal system. Since there exist highly productive ecosystems, large portion of the world population, and intensive socioeconomic activities in the coastal zone, it is crucial to predict the degree and range of the possible impacts of wave shoaling in a wide coastal area.

Several studies had been carried out to solve shallow-water equations to waves shoaling on a slope. Carrier and Greenspan (1958) derived a nonlinear transformation from Stoker non-linear theorem to reduce the two equations to a single linear equation and solved several initial value problems. But the analytical solution is obtained under some simplifications, like a uniform slope. The approach can solve some initial value problems, which is not conclusive for all the cases of wave shoaling.

Eulerian scheme is used in the time varying fluid domain in the past. The common practice was either use wet-dry interface or a coordinate transformation technique. Gopalakrishnan and Tung (1983) developed a finite element model for one horizontal dimension, whish used a fixed grid, except at the coastline where an element was allowed to deform to follow the shoreline and to split into two elements if it became too stretched. Some other implementation of fixed grid method can be found in Liu et al. (1995) and Balzano (1998). These methods determine the position of the shoreline as one of the fixed grid points, which means shoreline is moved one or more Δx at a time. This makes the wet-dry methods more prone to instabilities.

Most of the models used Lagrangian frame of scheme use fixed computational grid exclusively since the independent variables are the initial coordinates of the fluid particles, the computational grid does not distort, even as the shoreline moves that is the motivation for performing the computation in this frame of reference. Zelt and Raichlen (1989) describe a finite element technique to study the propagation of long waves in two dimensions in regions of arbitrary shape with vertical or shopping boundaries.

DeSilva et al. (1996) include effect of surface tension, in his model. R.S.Prasad, I.A. Svendsen (2003) used two different ways to solve in two steps, the first is to establish an equation that determines the motion of the shoreline based on the local momentum balance then to develop and implement into a shoreline model the capability of accommodating a changing computational domain.

Ishikawa et al. and Nakayama et al. proposed a new computational algorithm where hydraulic boundary conditions are taken as constraint conditions at the moving shoreline at fixed regular grid and partially integrating the weighted residual equations to deduce its weak form in which the constraint conditions are embodied. Detail of the model is given in the succeeding chapter.

2. MODEL DESCRIPTION

2.1 Governing equations

Assuming the uniformity of horizontal velocity (in a water column) and the hydrostatic pressure, we obtain shallow-water Equations (1) and (2), in which Equation (1) is the equation of continuity and Equation (2) is the momentum equation.

$$\frac{\partial h}{\partial t}+\frac{\partial (uh)}{\partial x}=0 \quad (1)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+g\frac{\partial (h+z)}{\partial x}=0 \quad (2)$$

Where t is time, x is the distance toward the shore, h is the water depth, z is the bed elevation and u is the water velocity in x direction.

2.2. Time splitting

In a numerical simulation of wave shoaling, accurate estimation of the shoreline motion, which coincides with the water particle, is important essentially. Accordingly, Lagrangean tracing of the shoreline motion will be implemented more easily by introducing the "time splitting" of the governing equations because the procedure of tracing can be included in the advection phase calculation of flow field.

Non-advection phase

$$\frac{\tilde{h}-h^n}{\Delta t}+h\frac{\partial u}{\partial x}=0 \quad (3)$$

$$\frac{\tilde{u}-u^n}{\Delta t}+g\frac{\partial (h+z)}{\partial x}=0 \quad (4)$$

Advection phase

$$\frac{h^{n+1}-\tilde{h}}{\Delta t}+\tilde{u}\frac{\partial \tilde{h}}{\partial x}=0 \quad (5)$$

$$\frac{u^{n+1}-\tilde{u}}{\Delta t}+\tilde{u}\frac{\partial \tilde{u}}{\partial x}=0 \quad (6)$$

2.3 Calculation of non-advection phase

2.3.1 Shape and weight functions

To satisfy the boundary condition on a moving boundary, the finite-element method is applied to solve advection phase. For an element with a moving boundary, linear or higher order functions have to be used as shape and weight functions to include the condition on a moving boundary. In this paper, we decided to apply linear function as shape and weight functions.

[Shape Function]

$$\psi_l(\xi)=(1-\xi)=\tilde{\phi}_1(\xi),\psi_r(\xi)=\xi=\tilde{\phi}_2(\xi) \quad (7)$$

Where ξ is a local coordinate in an element $\xi=(x-x_i)/\Delta x$, $\Delta x=x_{i+1}-x_i$ is the length of element and x_i and x_{i+1} is the locations of the left and right ends of the element, respectively.

[Weight Function]

For an element with a moving boundary, we decided to use linear function as weight function. In contrast to an element with a moving boundary, it is not needed for an element filled with water to be solved with linear function as weight function because there are no moving boundaries and using simpler weight function enables computation time to be shortened. Delta function is, thus, applied to an element filled with water.

For element filled with water

$$w_l(\xi)=\delta(\xi)=\bar{\phi}_1(\xi),w_r(\xi)=\delta(1-\xi)=\bar{\phi}_2(\xi) \quad (8)$$

For elements on the moving boundary

$$w_l(\xi)=w_l(\xi)=(1-\xi)=\tilde{\phi}_1(\xi),w_r(\xi)=\xi=\tilde{\phi}_2(\xi),(1-\xi)=\bar{\phi}_2(\xi) \quad (9)$$

Elementary matrix for inside water elements

Substitution of Equations (7) to (9) into Equations (3) yields

$$\sum_{j=1}^{2}\Delta\tilde{H}_j\int_0^1\tilde{\phi}_j\bar{\phi}_i d\xi\approx-\frac{\Delta t}{\Delta x}\sum_{j=1}^{2}\sum_{k=1}^{2}\tilde{H}_j{}^n\tilde{U}_k{}^n \quad (10)$$
$$\int_0^1\tilde{\phi}_j\frac{\partial\bar{\phi}_k}{\partial\xi}\bar{\phi}_i d\xi$$

Where

$$h=\sum_{j=1}^{2}\tilde{H}_j{}^n\tilde{\phi}_j(\xi) \quad (11)$$

$$u=\sum_{j=1}^{2}\tilde{U}_j{}^n\tilde{\phi}_j(\xi) \quad (12)$$

$$z=\sum_{j=1}^{2}\tilde{Z}_j{}^n\tilde{\phi}_j(\xi) \quad (13)$$

and $\tilde{H}_1 = h_i, \tilde{H}_2 = h_{i+1}, \tilde{U}_1 = u_i, \tilde{U}_2 = u_{i+1},$
$\tilde{Z}_1 = z_i, \tilde{Z}_2 = z_{i+1}.$

Equations (10) can be modified for an element filled with water as

$$\begin{vmatrix} 1/2 & 0 \\ 0 & 1/2 \end{vmatrix} \begin{bmatrix} \Delta\tilde{H}_1 \\ \Delta\tilde{H}_2 \end{bmatrix} = \frac{\Delta t}{2\Delta x} \begin{bmatrix} \tilde{H}_1^{\,n}(\tilde{U}_1^{\,n} - \tilde{U}_2^{\,n}) \\ \tilde{H}_2^{\,n}(\tilde{U}_1^{\,n} - \tilde{U}_2^{\,n}) \end{bmatrix} \quad (14)$$

In the same way for the momentum equation we can obtain the elementary equations.

$$\sum_{j=1}^{2} \Delta\tilde{U}_j \int_0^1 \tilde{\phi}_j \bar{\phi}_i d\xi = -g \frac{\Delta t}{\Delta x} \sum_{j=1}^{2} (\tilde{H}_j^{\,n} + \tilde{Z}_j) \int_0^1 \frac{\partial \bar{\phi}_j}{\partial \xi} \bar{\phi}_i d\xi \quad (15)$$

The matrix of the elementary Equations (15)

$$\begin{vmatrix} 1/2 & 0 \\ 0 & 1/2 \end{vmatrix} - \begin{bmatrix} \Delta\tilde{U}_1 \\ \Delta\tilde{U}_2 \end{bmatrix} = - \frac{\Delta t}{2\Delta x} g \begin{bmatrix} -(\tilde{H}_1^{\,n} + \tilde{Z}_1) + (\tilde{H}_2^{\,n} + \tilde{Z}_2) \\ -(\tilde{H}_1^{\,n} + \tilde{Z}_1) + (\tilde{H}_2^{\,n} + \tilde{Z}_2) \end{bmatrix} \quad (16)$$

Runge-kutta gill method was used for time integration.

2.3.2 For an element with a moving boundary

We used linear functions as shape and weight functions. Here we defined x_s to as the location of a moving boundary and integration is done in the area filled with water, $x_i \le x \le x_s$. (Figure 1)

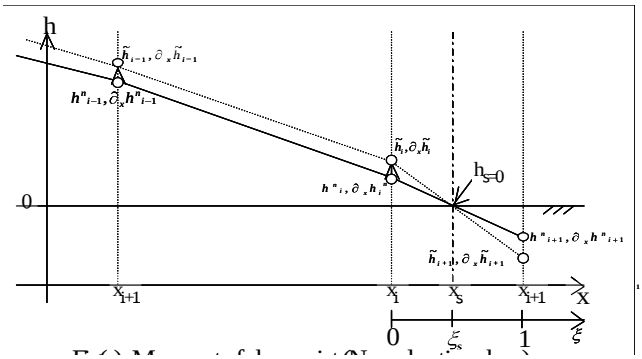


Figure 1. Movement of shoreline non-advection phase

The boundary condition at the moving boundary ($x=x_s$) is h=0. Equation (3) becomes

$$\sum_{j=1}^{2} \Delta\tilde{H}_j \int_0^{\xi_s} \tilde{\phi}_j \tilde{\phi}_i d\xi = -\frac{\Delta t}{\Delta x} \sum_{j=1}^{2} \sum_{k=1}^{2} \tilde{H}_j^{\,n} \tilde{U}_k^{\,n} \int_0^{\xi_s} \tilde{\phi}_j \frac{\partial \tilde{\phi}_k}{\partial \xi} \tilde{\phi}_i d\xi \quad (17)$$

Where ξ_s is the position of the shore point on the local coordinate ($= x_s / \Delta x$)

By taking a partial integral of the term of the right hand side, substituting the first boundary condition at $\xi = \xi_s$, and taking the return process, we get the weak form of weighted residual equation.

$$\sum_{j=1}^{2} \Delta\tilde{H}_j \int_0^1 \tilde{\phi}_j \tilde{\phi}_i d\xi = -\frac{\Delta t}{\Delta x} \sum_{j=1}^{2} \sum_{k=1}^{2} \tilde{H}_j^{\,n} \tilde{U}_k^{\,n} \int_0^1 \tilde{\phi}_j \frac{\partial \tilde{\phi}_k}{\partial \xi} \bar{\phi}_i d\xi + \frac{\Delta t}{\Delta x} [hu\tilde{\phi}_i]_{\xi=\xi_s} \quad (18)$$

Where, $\xi_s = (x_s - x_i)/\Delta x$

The above equation can be written in a matrix form

$$\begin{vmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{vmatrix} \begin{bmatrix} \Delta\tilde{H}_1 \\ \Delta\tilde{H}_2 \end{bmatrix} = \frac{\Delta t}{\Delta x} \begin{bmatrix} B_{13} \\ B_{23} \end{bmatrix} \quad (19)$$

Where the matrix elements are as follows

$$B_{11} = \xi_s - \xi_s^{\,2} + \frac{\xi_s^{\,3}}{3} \quad (20)$$

$$B_{12} = \frac{\xi_s^{\,2}}{2} - \frac{\xi_s^{\,3}}{3} \quad (21)$$

$$B_{21} = \frac{\xi_s^{\,2}}{2} - \frac{\xi_s^{\,3}}{3} \quad (22)$$

$$B_{22} = \frac{\xi_s^{\,3}}{3} \quad (23)$$

$$B_{13} = (1 - 2\xi_s + 2\xi_s^{\,2} - \frac{2\xi_s^{\,3}}{3})\tilde{U}_1^{\,n}\tilde{H}_1^{\,n} + (\xi_s - \frac{3\xi_s^{\,2}}{2} + \frac{2\xi_s^{\,3}}{3})\tilde{U}_1^{\,n}\tilde{H}_2^{\,n} + (-\xi_s^{\,2} + \frac{2\xi_s^{\,3}}{3})\tilde{U}_2^{\,n}\tilde{H}_1^{\,n} + (\frac{\xi_s^{\,2}}{2} - \frac{2\xi_s^{\,3}}{3})\tilde{U}_2^{\,n}\tilde{H}_2^{\,n} \quad (24)$$

$$B_{23} = (\xi_s - \frac{3\xi_s^{\,2}}{2} + \frac{2\xi_s^{\,3}}{3})\tilde{U}_1^{\,n}\tilde{H}_1^{\,n} + (\xi_s - \frac{2\xi_s^{\,3}}{3})\tilde{U}_1^{\,n}\tilde{H}_2^{\,n} + (\frac{\xi_s^{\,2}}{2} - \frac{2\xi_s^{\,3}}{3})\tilde{U}_2^{\,n}\tilde{H}_1^{\,n} + \frac{2\xi_s^{\,3}}{3}\tilde{U}_2^{\,n}\tilde{H}_2^{\,n} \quad (25)$$

In case of momentum Equation (4) from $x=x_i$ to $x=x_s$ gives

$$\sum_{j=1}^{2} \Delta\tilde{U}_j \int_0^{\xi_s} \tilde{\phi}_j \tilde{\phi}_i d\xi = -g \frac{\Delta t}{\Delta x} \sum_{j=1}^{2} (\tilde{H}_j^{\,n} + \tilde{Z}_j) \int_0^{\xi_s} \frac{\partial \tilde{\phi}_j}{\partial \xi} \tilde{\phi}_i d\xi \quad (26)$$

The matrix form of the equation (25)

$$\begin{vmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{vmatrix} \begin{bmatrix} \Delta\tilde{U}_1 \\ \Delta\tilde{U}_2 \end{bmatrix} = g \frac{\Delta t}{\Delta x} \begin{bmatrix} A_{13} \\ A_{23} \end{bmatrix} \quad (27)$$

Where, $B_{11}=A_{11}$, $B_{12}=A_{12}$, $B_{21}=A_{21}$, $B_{22}=A_{22}$ and

$$B_{13} = (-\xi_s + \frac{\xi_s^{\,2}}{2})(\tilde{H}_1^{\,n} + \tilde{Z}_1) + (\xi_s - \frac{\xi_s^{\,2}}{2})(\tilde{H}_2^{\,n} + \tilde{Z}_2) \quad (28)$$

$$B_{23} = -\frac{\xi_s^{\,2}}{2}(\tilde{H}_1^{\,n} + \tilde{Z}_1) + \frac{\xi_s^{\,2}}{2}(\tilde{H}_2^{\,n} + \tilde{Z}_2) \quad (29)$$

Construction of the set of overall equations

Total matrix is constructed from Equation 19 and Equation 27 the total matrix become as below

$$\begin{vmatrix} 1/2 & 0 & & & & \\ 0 & 1 & & & & \\ & \cdot & & & & \\ & & \cdot & & & \\ & & & 1 & & \\ & & & \cdot & 5/6 & 1/6 \\ & & & & 1/6 & 1/3 \end{vmatrix} \begin{vmatrix} \dot{U}_1 \\ U_2 \\ \cdot \\ \dot{U}_i \\ \cdot \\ U_{N-1} \\ U_N \end{vmatrix} = \begin{vmatrix} 1/2\{(H_1+F_1)-(H_2+F_2)\} \\ 1/2\{(H_1+F_1)-(H_3+F_3)\} \\ \cdot \\ 1/2\{(H_{i-1}+F_{i-1})-(H_{i+1}+F_{i+1})\} \\ \cdot \\ 1/2\{(H_{N-2}+F_{N-2})-(H_N+F_N)\} \\ 1/2\{(H_{N-1}+F_{N-1})-(H_N+F_N)\} \end{vmatrix} \quad (30)$$

2.3.3 Calculation for advection phase

In the advection calculation, the water surface elevation is changed through the process of conventional CIP at each grid point in the water (x_i). Simultaneously, the moving boundary (x_s) moves. Water depth at the outside grid point (x_{i+1}) is extrapolated from the values at x_i and x_s. Velocity field is also shift in the same way. Velocity interpolated from the values at x_i and x_{i+1}.

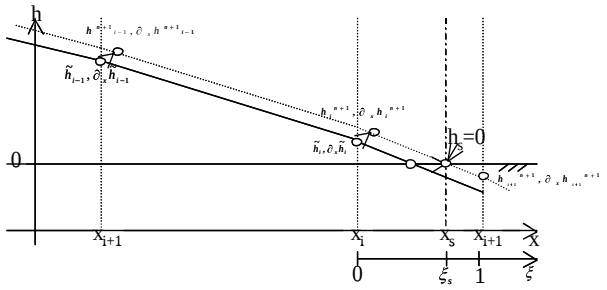


Figure 2.Movement of shore line advection phase.

Modeling of wave breaking to shallow-water equations

Because wave nonlinearity is not large in this study, linear mild-slope assumptions by Watanabe and Dibajnia (1988) may be applied to this problem. The simplified damping term due to wave breaking in shallow-water equations is given as

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = -g\frac{\partial h}{\partial x} - \frac{M_D}{h} \quad (31)$$

$$M_D = \alpha_D s\sqrt{\frac{g}{h}uh} \quad (32)$$

Where M_D is the damping term α_D (damping co-efficient) is 2.5 and s is the gradient of slope. Using bottom friction enables the second term in the right hand side of Equation (32) to define as

$$\frac{M_D}{h} = f_{bottom}\frac{u^2}{h} \quad (33)$$

From Eq. (31) and (32)

$$\alpha_D s\sqrt{\frac{g}{h}}u = f_{bottom}\frac{u^2}{h} \quad (34)$$

$$\alpha_D s\frac{\sqrt{gh}}{u} = f_{bottom} \quad (35$$

Wave breaking is considered to occur when the horizontal velocity is larger than wave speed, which corresponds to that the Froude number is more than 1. Because wave breaking disables shallow-water assumption to be satisfied, the Froude number may be
assumed to be 1 in a wave-breaking zone to apply shallow water equations to this problem.

$$f_{bottom} = \alpha_D s \quad (36)$$

In numerical computations, we define the wave-breaking zone as the area from the wave-breaking point toward inshore and use Equation (35) to model wave breaking in a wave-breaking zone. Experimental works in this study are followed from the succeeding section.

3. EXPERIMENTAL WORKS

3.1. Experimental set up

Extensive experiments had been carried out for checking the position of moving boundary and the flow profile at the time of run up and run down flow on a sloping beach. Figure 3 shows the dimensional sketch of the experiment set up.

The wave tank is 2 meter long, 0.7m high and 0.3 m wide, which is equipped with a motor that is controlled by a computer. The bottom bed of the wave tank is oscillating type, which can be move uniformly equal distance in both directions as a pair of rail track is fixed in the bottom for smooth movement of the bed.

A flume is fixed in the bed of the wave tank, which is shown in Figure 4. The length of the flume is 80.5cm, height is 13.5 cm and width is 22.5 cm. One grid of 1 cm square is attached on the flume to read the value of the flow profile at different point.

One scale is also fixed on the top of the flume to measure the oscillation and another scale fixed on the bed of the slope to read the value of the moving boundary. One side of the flume is fixed with a rigid vertical wall where as in the other end of the flume has a constant slope of 11.3^0.

One mirror is fixed just above the flume (shown in figure 3) to locate the value of the moving boundary while using movie camera from the orthogonal view of the flume. Colored water is used and proper lighting was assured for betterment of analyzing flow profile. Special care was taken to locate the position of the flow accurately and to locate the position of the moving boundary at the edges due to flow running on both directions just before reaching the top.

Image processing technique was used to locate the position of the flow profile inside the grid to reduce the eye estimation error. Many trials had been given to find a uniform weakly nonlinear flow on the slope. The positioning of the video camera was poised just in the middle of the flume and bed elevation of the bed and moving camera made equal. By changing the different initial condition set the program we could change out wave period and oscillation of the flume.

The desire initial condition was achieved by giving many trials, using the same initial condition the experiment had been carried out several times to enhance its accuracy. Before reaching the pick some turbulence at the moving edge was observed and energy dissipation calculate was needed to match the simulation result with the actual phenomena of the experiment.

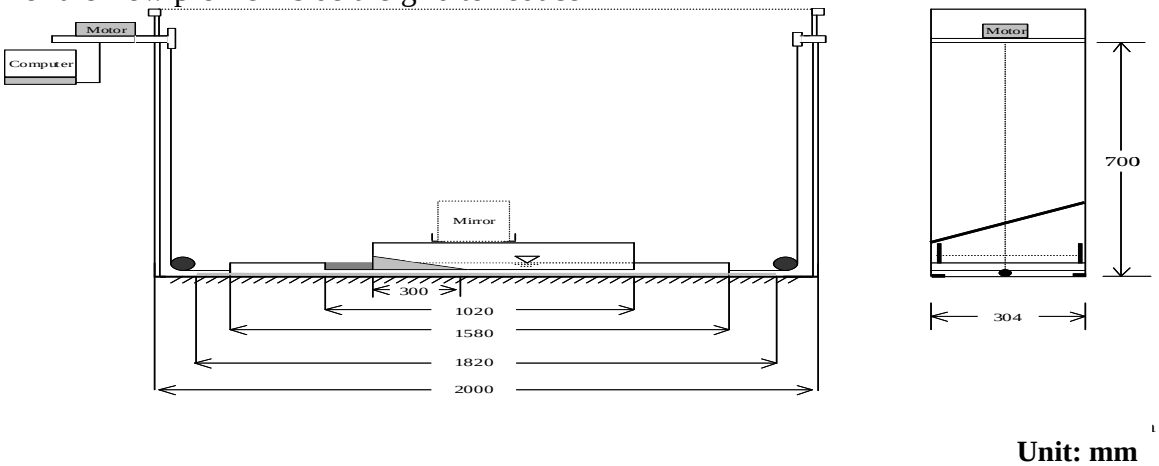


Figure 3. Dimensional sketch of the experimental setup

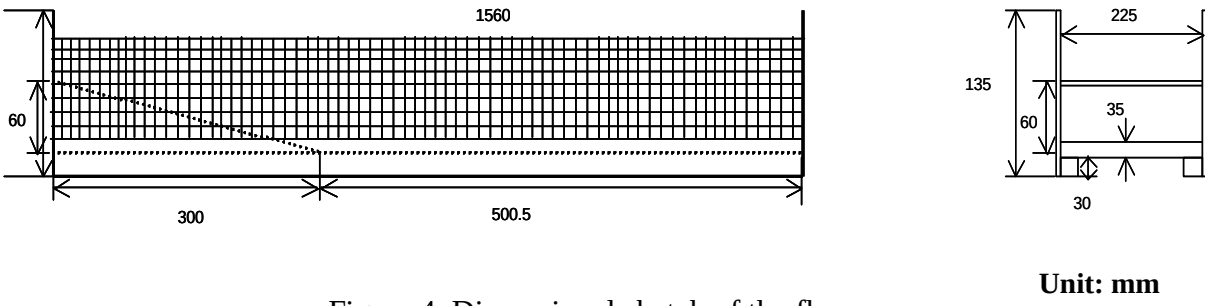


Figure 4. Dimensional sketch of the flume

3.2 Experimental results

From the experiment, it was found that the depth of water around 2 cm to 2.5cm, wave period of 3 to 3.5 sec produce desire flow profile on the slope. In the study case used depth of water is 2 cm, wave period is 3.5 second and oscillation of the flume is 6 cm.

Consistent 4 cm interval data of the whole flume was analyzed. The moving boundary varies 5.5 cm in its run-up and rundown process therefore amplitude variation of the wave is 1.1 cm which is quite big considering the initial water head, moreover before reaching the pick some turbulence at the moving edge was observed and energy dissipation calculate was needed to match the simulation result with the actual phenomena of the experiment.

Another important fact of this experiment is finding the uniform wave profile with respect to the moving flume. Figure 5 shows the variation of moving boundary with respect to the flume position. From this figure we can understand the initial high frequency flow is not uniform with the movement of the flume. After 10 sec of movement of the flume the variation of the moving boundary becomes uniform.

Figure 6 (a) to (d) of show the flow profile in run up and run down process on the sloping ground. From these figure we can understand more than one wave pick was found on the sloping ground in any instance of time. Consistent 4 cm interval data of the whole flume was analyzed. The moving boundary varies 5.5 cm in its run-up and rundown process therefore amplitude variation of the wave is 1.1 cm which is quite big considering the initial water head, moreover before reaching the pick some turbulence at the moving edge was observed and energy dissipation calculate was needed to match the simulation result with the actual phenomena of the experiment.
Most of previous approaches made by many authors the use gauge to measure the depth of at some interval points therefore there is a possibility not to have consistent data but in the present study we use 4 cm uniform interval throughout the whole flume which good consistence data throughout the whole flume.

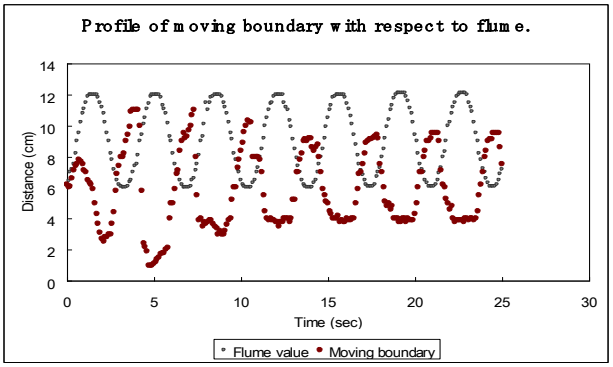
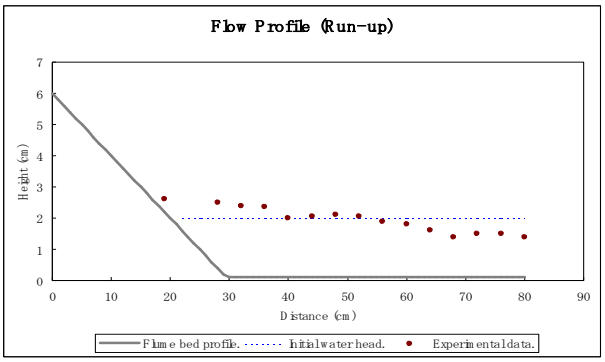
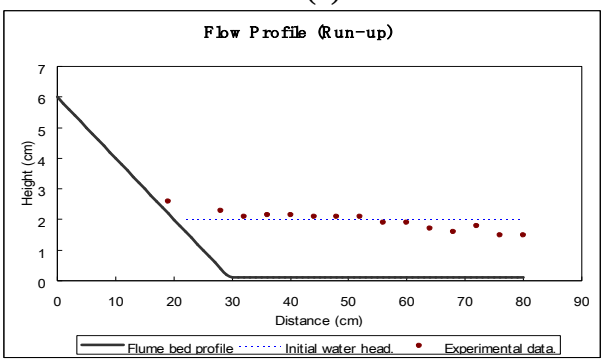


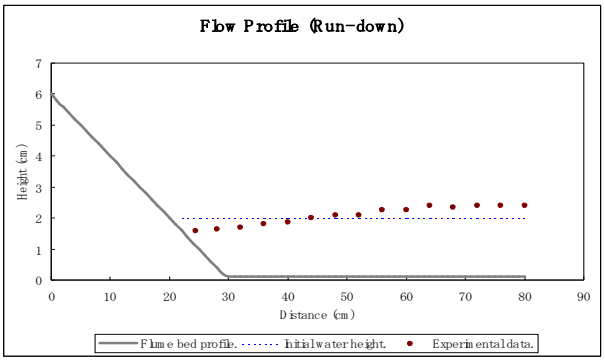
Figure 5. Variation of moving boundary with flume



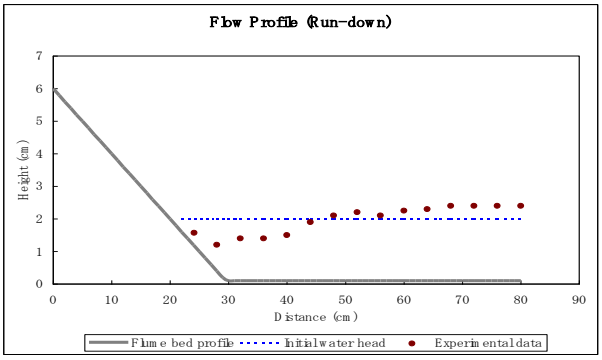
(a)



(b)



(c)



(d)

Figure 6. Flow profile in run up and rundown process on the sloping ground

4. VALIDATION OF THE MODEL

Many previous studies have applied shallow-water equations to solve the problem with a moving boundary, Carrier and Greeenspan (1958), Sielecki and Wurtele (1970), Gopalakrishnan and Tung (1983) R.S.Prasad, I.A.Svendsen (2003). Using the present model surface waves shoaling on a slope was solved successfully by comparing with the analytical solution derived by Carrier and Greenspan (1958). However, most of all previous studies have been verified by comparing with the theory, and the models have not been applied to reproduce the laboratory experiments whose results may include energy dissipation due to a wall and wave breaking. Therefore, we apply the proposed model to reproduce the laboratory experiment results by including the energy dissipation due to a wall and wave breaking.

4.1. Comparisons of results

Two tests were used to verify the proposed model, the time series of the location of a moving boundary and water level along a tank. We used the same parameters for the modeling of wave breaking in all cases. With regard to the time series of the location of a moving boundary, the computation and experiment results agreed well (Figure 7). Higher frequency waves were also found to occur with the same phase between the computations and experiments. However, the peak values from computations were slightly larger than the experiments while the stable cyclic variations appeared Figure 8 (a) to (f). It may be because of the surface tension effect. As the depth of water is only 2cm the effect affect significantly the outcome of the result (Desilva et al 1996).

The used value of the theoretical bottom friction for calculating wave breaking is another factor that might influences the results. The delay time of the flume at the two edges might also influence the outcome of the results moreover the eye estimation error due to measuring gauge is also another factor to need to be noted.

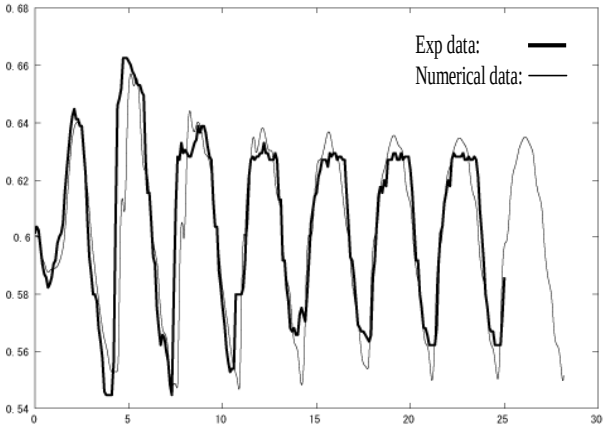
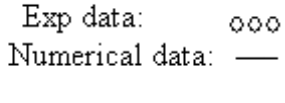
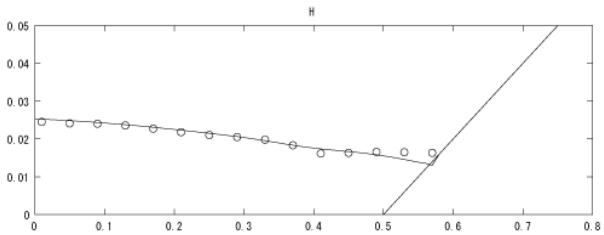


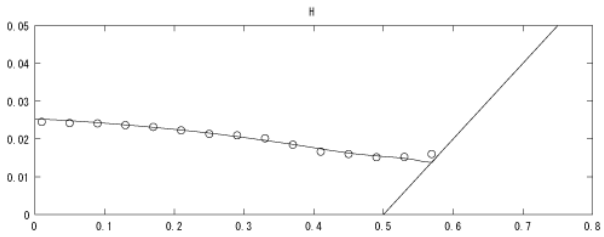
Figure 7. Time (s) vs height (cm) curve of the moving boundary

The following figure shows the comparison of the numerical and experimental data.

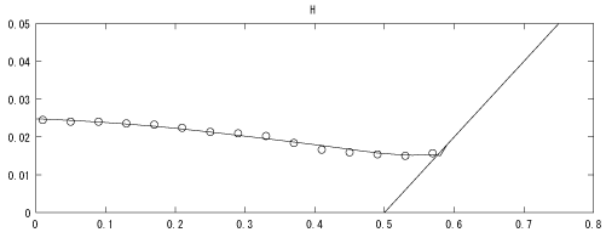




(a)



(b)



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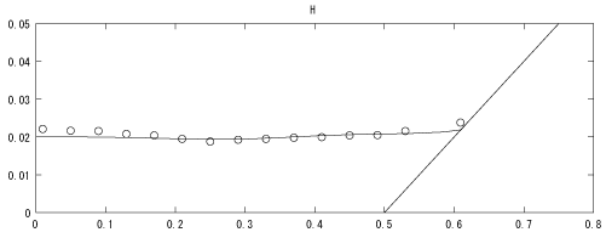
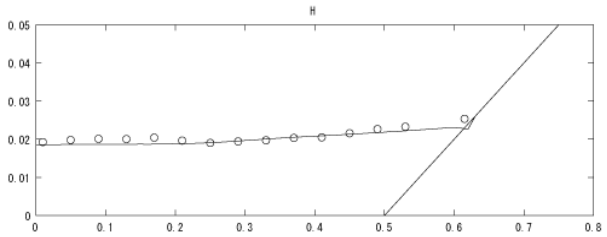
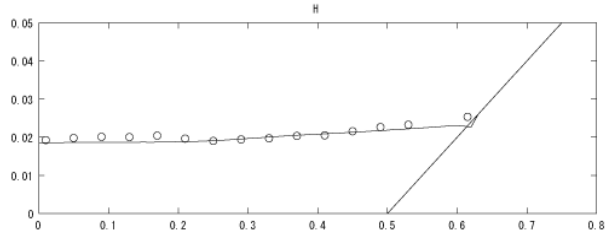
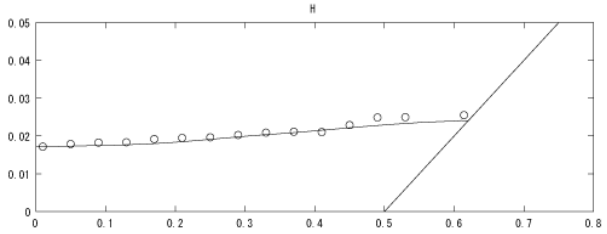


(d)





(e)



(f)

Figure 8. Run down and run up of long wave shoaling on to a sloping ground. Here distance of flow is in x directions whereas height of water is in y directions

4.2. Discussion of the results

Good agreements between the numerical simulation and laboratory experiment had been found. It should be noted that the parameters for wave-breaking model were determined from literatures in the numerical computations to reproduce the different experiment results with different conditions; the water depth, the oscillation period of the tank, and the amplitude of the oscillation.

Some errors may have appeared due to the lack of accuracy of the measuring gauge. The delay time of the flume at the two edges might also influence the outcome of the results. Adhesion force between water and flume due to surface tension also may reduce the agreement between computations and experiments.

4.3. Conclusion

At the time of the experiment, we observed the flume stopped for a fraction of seconds before moving to the opposite directions. Therefore, special attention was given to measure the location of the moving boundary.

Although high attention has been given to minimize eye estimation error, some irregularities of matching were found. Moreover, surface tension is quite significant at the edges because the water depth is relatively small with amplitude variation.

Although there were some irregularities between the numerical computation and experimental results, most part of the result from laboratory experiments agreed with computation results. Therefore, the proposed model could be applicable to solve wave-shoaling problem.

References

[1] K. Nakayama, K. Kudo and T. Ishikawa (2004): A new model to solve long waves shoaling on a sloping rectangular grids. *Journal of Hydraulic Engineering, JSCE,* 48,1.

[2] K. Nakayam, T. Ishikawa and K. Kudo (2000): IIM for surface waves shoaling on a slope. *International Journal for Numerical methods in Fluids* 00:1-6

[3] A. Balzano (1998) Evaluation of methods for numerical simulation of wetting and drying in shallow water flow models.. *Coastal Engineering* 34,83-107

[4] *P.J. Lynett, T.R. Wu, P.L.-F. Liu (2002)* Modeling wave run up with depth-integrated equations. *Coastal Engineering* 46, 89-107.

[5] B. Johns *(1982)* Numerical Integration of the shallow water equations over a sloping shelf. *International Jouranl for Numerical Methods in fluids*,2, 253-261.

[6] Sielecki, A; Wurtele, M.G (1970) The numerical integration of the nonlinear shallow-water equations with sloping boundaries. *Journal of Computational Physics*, 6, 2, 219-236.

[7] R.S. Prasad and I.A. Svendsen (2003) Moving Shoreline boundary condition for nearshore models. *Coastal Engineering*, 49, 4, 239-261.

[8] V.V. Titov and C.E. Synolakis (1998) Numerical Modeling of Tidal Wave Run up.. *Journal of Waterway, Port, Coastal, and Ocean Engineering/ July/August*, 157-171

[9] V.V. Titov, C.E.Synolakis (1995) Modeling of Breaking and Nonbreaking Long-wave evolution and Run-up using VTCS-2. *Journal of Waterway, Port and Coastal and Ocean Engineering, November/December* 308-316.

[10] A. Balzano (1998) Evaluation of Methods for numerical simulation of wetting and drying in shallow water flow models. *Coastal Engineering , 34, 1-2, 83-107*.

[11] T.C. Gopalakrishnan, C.C. Tung (1983) Numerical Analysis of a moving boundary problem in coastal hydrodynamics.. *International Journal for numerical methods in Fluids*, 3, 179-200.

[12] J.A. Zelt and F.Raichlen (1990)A Lagrangian model for wave-induced harbour oscillations. *J.Fluid Mech*, 213, 203-225.

[13] G. Pedersen and B. Gjevik (1983) Run-up of solitary waves. *J. Fluid Mech*, 135, 283-299

[14] P.L-F. Liu, Y. S.Cho, M.J.Briggs, U.Kanoglu, C.E. Synolakis (1995) Run-up of Solitary waves on a circular island. *J.Fluid Mech*, 302, 259-285

[15] Career and Greenspan. J (1958) Water waves of finite amplitude on a sloping beach. *Fluid Mech*. 17, 97-110.

[16] C.E.Synolakis (1987) The runup of solitary waves. *J.Fluid Mech*, 185, 523-545.

[17] A. Sielecki and M.G.Wurtele (1970) The numerical integration of the nonlinear shallow-water equations with sloping boundaries. *Journal of Computational Physics* 6, 219-236.

[18] W.C.Thacker. (1981) some exact solutions to the nonlinear shallow-water wave equations. *J.Fluid Mech*, 107, 499-508.

[19] N. W. Scheffner, L.E. Borgman, D.J.Mark (1996) Empirical Simulation Technique Based Strorm Surge Frequency Analyses *Journal of Waterway, Port, Coastal, and Ocean Engineering / March / April* 93-99.

[20] S.J.Desilva, R.B.Guenther and R.T.Hudspeth. Irregular points in 2-D free surface flows with surface tension for the wavemaker boundary value problem. *Applied Ocean Research* 18, 293-302.

AN ANALYSIS OF ALTERNATIVE INDUSTRIALIZATION STRATEGIES FOR DEVELOPING ECONOMIES

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Abstract: Industrialization is the process of social and economic change whereby a human group is transformed from a pre-industrial society into an industrial one. Import Substitution Industrialization (ISI) is an industrialization policy based on the premise that a country should attempt to reduce its foreign dependency through the local production of industrialized products. Because of limitations of ISI, the concept of Export-led industrialization was supported by economists. Export-led industrialization (ELI) is an industrialization policy aiming to speed-up the industrialization process of a country through exporting goods for which the nation has a comparative advantage. Export-oriented industrialization is often contrasted with import substitution industrialization. The objective of this paper is to critically appraise the role of Easy ISI strategy in economic development.

Keywords: *Gross Domestic Product (GDP), Import Substitution Industrialization (ISI), Export-led Industrialization (ELI), Protected Industry*

1.0 INTRODUCTION

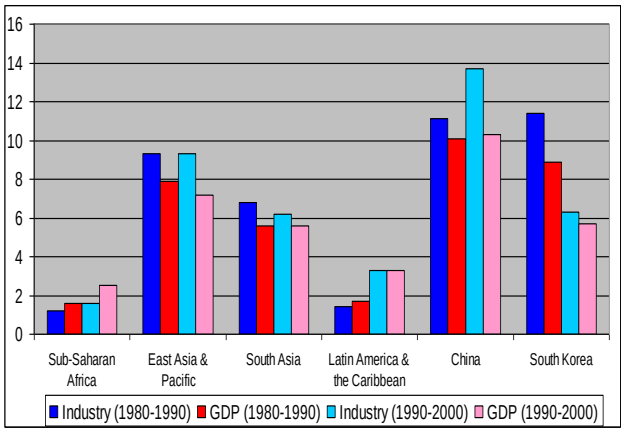
Economic growth or development may ensure better standard of living for citizens of any country. Development in the agriculture, industry and service sectors contribute to the overall economics growth of all economies. Most economists believe that industrial development is crucial for economic development of any nation. In order to initiate and expedite industrialization, governments can adopt many strategic maneuvers including Import Substitution Industrialization (ISI) policy.

In this paper we will try to critically appraise the role of Easy ISI strategy in economic development. In the first part of this paper, we will try to find a relationship between economic progress and the growth of industrial sector. Secondly, we will explain the basics of ISI strategy and arguments favoring this strategy. In later parts of this paper, we will outline some limitations of Easy ISI strategy and few alternative trade policies relevant for industrialization.

2.0 ECONOMIC PROGRESS AND INDUSTRIALIZATION

Economic progress of any nation is claimed to be associated with the growth of industrialization. Economic Growth can be measured by the growth of total output or income generated by any country over a period of time. On the other hand, level of industrialization can be understood by looking at the contribution of industrial sector to the country's total output. In simplest terms, many economists define industrialization as the higher rate of growth of manufacturing sector.

The following illustration shows "historically-proven" positive correlation between the rate of growth of industry and the rate of growth of total national output. For example, in South Korea when annual growth rate was 8.9% the growth rate of industry was 11.4%. Later overall growth reduced to 5.7% whereas the industrial growth reduced to 6.3%. Hence, the direction of industrial and overall economic growth is positive though critics would definitely say there may be other underlying reasons that resulted in such positive trend.



(Source: World Bank 2002: 406, Table 4.1)

Figure 1. Industrialization & Economic growth (percentage annual growth)

However, more empirical studies and trend analysis have tried to prove that industrialization is associated with rising national income. In other words, increased share of industrial sector in GDP is likely to result in higher per capita income. Many development economists defined this pattern as "Structural Transformation", which goes beyond mere industrialization. Industrialization may result in decreased contribution of agricultural sector in national output, increased exports of manufacturing goods and rising employments in the manufacturing sector (Chenery and Syrquin, 1975).

Besides the apparent positive association between industrial expansion and economic growth, there is a further reason for pursuing industrialization. According to the Presbisch- Singer hypothesis, countries which predominantly produce and export primary products and import the bulk of their manufactured goods are apt to experience instability in their terms of trade, that is, in the purchasing power of their exports in being able to buy imports. In fact, there can be a long-term deterioration in the purchasing power of these exports relative to the manufactured goods these countries import.

Industrialization is therefore can be a means to create not only a more productive domestic economic structure which raises domestic incomes, but also to create the possibility for an import and export pattern more similar to that of the "already-developed" nations. Hence, the importance of industrialization may never be underestimated.

3.0 EASY ISI: AN INTRODUCTION

After understanding relative importance of industrialization for development, we will now focus on policies that governments may pursue to promote industrial sector. Import-Substitution Industrialization (ISI) strategy is one of the most talked-about maneuvers to promote industrialization. ISI strategy is known as policy to promote domestic production of goods that will substitute import demand. There are two stages in ISI Strategy. The first stage known as "Easy ISI" involves the import substitution of consumer goods. And the second stage involves the substitution of imports of intermediate or capital goods.

ISI begins with support to increase the domestic production of non-durable consumer goods, the demand of which is currently being met primarily by import from other countries. The production of non-durable consumer goods would require low technological know-how, moderately skilled tabor force and tabor-intensive production process. Hence, a poorer economy which has relatively less experience and success in industrial sector would be able to promote some manufacturing sub-sectors for the growth of industrialization. More importantly, since the industries will concentrate on (non-durable consumer) products which have proven market demand, it will create a situation in which industrial entrepreneurs of poor country would face lower risk and higher probability of increased profit. This first stage of ISI has been defined as the easy, primary or horizontal ISI.

4.0 ARGUMENTS FOR ISI STRATEGY

After scrutinizing the basics of Easy ISI strategy, we may look into the arguments that were put forward by the proponents of Easy ISI strategy.

- **The Historical Argument:** Except for United Kingdom, most modern industrialized countries protected domestic industries from import competition with success. Some economists uphold their success as an argument in favor of promoting ISI strategy. This historical argument is weak since it assumes that economic realities (cause and effect phenomenon) will persist irrespective of its place of occurrence. In reality, Easy ISI strategy that was successful in one country

may not be suitable in other economies that have different conditions (such as, endowments of factors of production). However, in the past, many countries in the world experienced both industrial and economic growth as a result of successful implementation of Easy ISI strategy.

- **The Income Elasticity Argument:** According to Presbisch-Singer hypothesis (that we discussed earlier) productivity growth in the richer country lead to higher income. In the poorer country (that primarily export primary products), productivity growth leads to lower levels of employment, lower wages and lower prices. More importantly, as income rises in poor countries, their demand for import from rich country rises. On the other hand, income increases in the rich country would not result in more demand of primary goods export from poor country. Hence, the importance of industrialization in import substitution sector cannot be underestimated.

- **The Employment Argument:** In order to promote import-substitute industry, government may require to provide subsidy, tariff protection and equity or debt financing to the local entrepreneur. If the government gives tariff protection (by taxing import competition) to import-substitute industry, the entrepreneurs are likely to benefit from "artificial" profit because of increased price of imported goods. Such profitability would invite more suppliers in the industry as a whole and subsequently may result in greater employment. However, the success of ISI strategy in terms of employment generation should be compared against that of alternative trading strategies for industrialization. For example, an economy may generate more employment with Export-led Industrialization strategy in stead of ISI strategy.

- **The Infant Industry Argument:** This argument suggests that domestic manufacturing cannot fight with import competition from the outset. The new industries of relatively poorer country need time and assistance to learn to develop them. Hence, protection for a limited time period would help them to capitalize on experience and learning. If the industry can utilize this protected learning period, then the economy as a whole may gain from externalities which may spread into other linked industries. Skills, teaming and technical progress developed by infant industry can be shared by the similar industries of the economy. In many cases, development in one industry automatically develops its backward and forward industries. For example, development in Knitting Sector may result in growth in Spinning Sector (Backward Linkage) as well as Garments Sector (Forward Linkage). Hence, ISI strategy may assist the economy like ours to get benefit from positive externalities and backward and forward linkages.

5.0 LIMITATIONS OF EASY ISI

As we have found out many issues against historical argument, employment argument and income elasticity argument, we may also need to extend our analysis on limitations of ISI and Infant Industry Argument in order to have a balanced appraisal of ISI strategy. Economists would agree that all poor countries do not just have the social and economic infrastructure that is prerequisite for successful ISI. Economies of scale require certain level of production that will result in lower cost per unit of production.

Infant industries of a poorer country may not be able to reach lower cost level (in comparison to its international competitors) only because of its size of plant and size of domestic market. Some industries may need input that is not locally available. In the case of many infant industries, dependence on imported inputs would result in lower local value-addition and lower foreign exchange savings. Because of protection, infant industries may feel complacent to improve efficiency and lower cost. Unless they learn to fight in the international market, infant industries may fail to realize the benefits of ISI strategy.

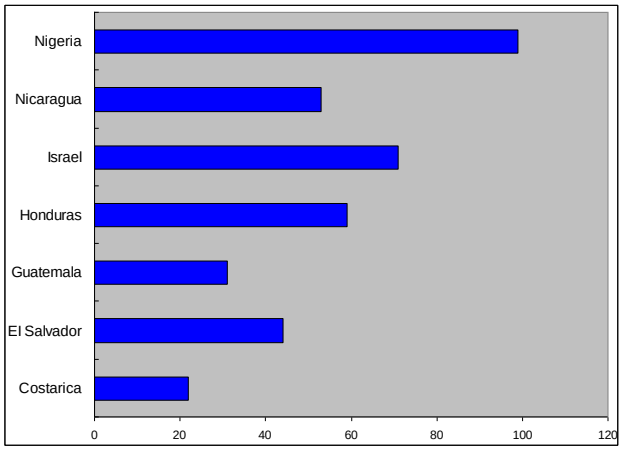
Because of increased pace of technological development in recent days, industrial growth may not be achieved with prolonged investment in "time and protection". Governments may need to abruptly invest in technological capacity to develop its industry. Hence, periods of protection may not increase the growth of industrialization. ISI strategy, if deployed, has to be managed by the government. Tariff protection or subsidy to infant industries is part of strategic public policy. And implementation and formulation of government

policy, particularly in third world country, is associated with bureaucracy, corruption and inefficiency.

Although under ISI initially infant industry can grow faster than domestic demand for manufacturing goods, LDCs may soon run out of import substitution possibilities. After that growth rates can only be maintained by a growth in domestic demand or in exports: but by then the structure and inefficiency may stand in the way of conquering export markets.

The existence of import restrictions or tariff on imported goods decreases aggregate import demand. As a result the exchange rate of the country concerned may become overvalued and the existing exporters may loose income. Hence, ISI strategy can be biased against exports. In addition, protection to industry may decrease the relative price of agricultural products and receipts from agriculture exports. That is, ISI strategy may also be biased against agricultural sector.

Many empirical studies identified more pitfalls of ISI strategy. A study by Corden and Balassa (1971) used the term "Effective Rate of Protection" (ERP) to appraise the potential of protected industry. ERP shows the percentage increase in value added afforded by protection over the value added which would prevail in a non-protected situation. The following table illustrates the ERP for different countries in the year 1968.



(Source: *Schmitz, H. (1984) 'Industrialisation Strategies in Less Developed Countries: Some Lessons of Historic Experience', Journal of Development Studies 21 (1): 1-21)*

Figure 2: Average ERP in Manufacturing Industry of LDCs (1968)

This study of ERP revealed levels of protection substantially higher than those ever enjoyed by the existing developed countries. Since one can assume that most of this protection was actually used by LDC producers, above illustration provides a general picture of the magnitude of inefficiency as measured by effective rates of protection[3]. Hence, implementation of ISI strategy sometimes may lead to inefficient industrialization.

6.0 EXPORT-LED INDUSTRIALIZATION: AN ALTERNATIVE STRATEGY

Many economists believe Export-led industrialization is more efficient than ISI strategy. Because of limitations of ISI, the concept of export-led industrialization and substitution was supported by these economists. "Export Substitution" implies the export of non-traditional products or manufactured goods. Export-led Industrialization may overcome some limitations of ISI strategy.

By exporting to world market, LDCs can achieve higher economies of scale. In order to serve the world market, domestic industry will be required to learn to achieve "sustained" efficiency as compare to the international standard. Intense competition in the world market would compel domestic industries to embrace advanced technological know-how. In addition, the value of exports that could be produced with a given use of scarce factors is frequently greater than the value of imports that could be replaced.

Many proponents of Export-led Industrialization gave credit to export promotion strategy of Newly Industrialized Countries of East Asia for their industrial growth in 1970s. However, critics of export-promotion argue that the same economic strategies cannot achieve desired objective every time. Since countries differ in terms of their infrastructure, same (export-promotion) strategies cannot earn the same outcome (industrialization) for different economies.

Different economies face different external and domestic conditions as well. According to Hubert Schmitz, the government in NICs intervened to control selected imports. He questioned the role of export promotion strategy as a catalyst of industrialization during 1970-1980 in NICs in

East Asia. Under ever-changing external conditions, export-led strategy may not always be right the strategy industrialization growth.

7.0 SELECTIVE PROTECTION FOR INDUSTRY

Since both "Export Promotion" and "Easy ISI" have their own advantage and limitations, some economists came up with new strategy known as selective protection strategy. Selective protection of industry is known as the trade strategy of export promotion via import substitution. The theory may be applicable to industries that require human-capital and knowledge-based initiative. For many LDCs, some sectors (such as Information Technology) do have too small a market to make profit. If high-tech companies of richer countries get support and protection from governments, they will have relatively larger advantage over companies from LDCs. Hence, LDC governments require to provide protection to firms in these strategic industries. However, selective protection strategy has also been criticized. Critics identified that this strategy is not relevant to most of LDCs that do not have infrastructure to nurture industries which are knowledge-intensive.

8.0 CONCLUSION

Development, in the simplest term, can be defined as the increase in average income of citizens of any country. For every country to move forward economic development is an imperative. Agriculture, Industry and Service - all these sectors do contribute to the development or growth of output. Though relative importance may differ at different phases of an economy, one country may not always put emphasis on one sector without regard for another sector. Every economist in the world, perhaps, would agree that industrialization is at least relevant for growth and development of any economy. However, the best policies and strategies to promote industrialization would be dissimilar for different economies at different periods of time. Both Import Substitution Industrialization and Export-led Industrialization have their own benefits and drawbacks. Moreover, changing domestic and external conditions would provoke different policies. Even within the same economy different industrial sector may require different strategic treatment. Hence, there are no universally accepted policies for industrialization and economics development. One might wonder the relevance of analyzing the "traditional" debate for finding suitable strategies for industrialization. However, since we are heeding towards "A vision for 2021", we do believe strategic public policy regarding industrialization needs to be given due importance and to be supported by well-designed analysis and synthesis.

References:

Cypher, James M., and James L. Dietz. *The Process of Economic Development*.
2nd ed. London; New York: Routledge, 2004.

G. M. Grossman and K. Rogoff (eds). *Handbook of International Economics* Vol. 3 (North-Holland, 1995)

Schmitz, H. (1984) 'Industrialization Strategies in Less Developed Countries: Some Lessons of Historic Experience', *Journal of Development Studies* 21 (1): 1-21.

Stern, Nicholas. 1989. "The Economics of Development: A Survey." *Economic Journal* 99(397): 597–685.

Weiss, J (1991), *Industry in Developing Countries: Theory, Policy and Evidence*, Routledge, London 1988.

ANALYSIS OF MODELING RESULTS FOR RIVER BANK PROTECTION OF THE MOST VULNERABLE PART OF TAZUMUDDIN UPAZILA UNDER BHOLA DISTRICT

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ABSTRUCT :

Bhola is the largest Island of Bangladesh situated in the south central region (latitude approximately from 430000N to 525000N and longitude 555000E to 590000E) of Bangladesh in the highly dynamic Meghna Estuary. In recent years the erosion along eastern shoreline of Bhola Island has become a serious issue. Attempts are taken to establish the base line condition to simulate the natural phenomena. Baseline condition for Tazumuddin Upazilla (under Bhola district) has been developed based on hydrodynamic and morphological modelling and historical data of bank line shifting, thalweg line shifting, bathymetric data, char movement etc. To calibrate and validate the model water levels and discharge are successfully calibrated. From modeling result, erosion/deposition pattern at and outside the protective works, new vulnerable areas due to revetment have been identified. Hydrodynamic (HD) simulations during ebb tide the maximum depth integrated near bank velocity is found within the range of 1.5-3.0 m/s along the riverbank of Tazumuddin and 1.0-1.5 m/s along the riverbank of Lalmohan. Morphological simulation shows the channel is further extended towards the south-east part. Further computational simulation showed that channel in front of Tazumuddin become deeper and it is extended more towards the south-east direction. From bathymetry survey data in May, 05 it is found that there is a tendency to deepen the channel in front of Tazumuddin where protective work was suggested and the deep channel is further extended towards south-east direction like simulation result. So it can be concluded that simulation result and real condition near Tazumuddin follows the same trend of channel development.

Keywords: Embankment, bank line shifting, erosion deposition process, char movement

1. INTRODUCTION

Tazumuddin Upazilla is located on the eastern shoreline of Bhola island beside Shahbazpur Channel. Bhola island which is situated in the morphologically dynamic Meghna Estuary. The physical setting of the area has been changed remarkably over the last 200 years. Riverbank erosion and related sedimentation and land loss hazards are a resource management problem of global significance (Darby et al. 2000). Eventually the water related environment in the estuarine network is in the process of continuous changes. Currently the erosion along eastern shoreline of Bhola Island has become a serious issue in the recent years. In the year 2000 about 600 m land was eroded by the Shahbazpur channel during July to November within km 36 to km 71.425 of embankment and in 2001 about 400m of land was eroded at the same location during June to November. During the monsoon 2003, severe erosion occurred at Tazumuddin upazilla and several hundred meters of land were devoured in the river within a month.

Both bank erosion and morphological processes lie at the center of understanding fluvial geomorphological processes (Lawler 2005). To explain river channel processes with bank erosion, several fundamental studies have been conducted over the past several decades including the bend theory proposed by Ikeda et al. (1981) and Parker et al. (1982) that gives useful criteria for bend development and a method to predict temporal changes in the plan form of meandering channels. Blondeaux and Seminara (1985) modified the bend theory and derived a solution for the bed configuration of a bend in an equilibrium state. Their solution corresponds to the approximate solution proposed by Hsegawa and Yamaoka (1980), and re calculated by Parker and Johannessor (1989). However, these theories assumed constant width and a simple bank erosion model they cannot be applied to process in channels with various plan forms.

Bank erosion is the most significant and fundamental processes involved in channel migration and formation of flood plains (Hooke 1979). Most important mechanism is the hydraulic forces exerted by the flow (Hardy 2006). The erosion processes in the Meghna Estuary is mostly related to bank failure. Crosta and di Prisco (1999) found seepage erosion causing liquefaction and rapid slope failures by analyzing field failure process and the evolution of the saturated domain using a numerical model. In the present study two types of bank failure generally observed: liquefaction and flowage of material, shearing away of bank materials. The former type of bank failure occurs below the low water level or in the zone of low and high water level. Generally, they occur during the

recession of flood hydrograph. Recession rates of water level directly influence the rate of failure. The most common processes of bank failure along the Lower Meghna Estuary is due to shearing, caused by flow attacking the bank or over-steepening of the bank by a thalweg approaching the bank. In that case the flow in a river bend attacks the toe of the riverbank, removing the sediment from the toe, resulting in an over-steepening of the riverbank and causing the bank failure by slumping. Seepage effects are usually considered limited in the existing literature (Burgi and Kraki 1971). The impact of seepage erosion has not been widely reported or understood despite occurrence of seepage erosion in numerous geographical locations (Hagerty 1991; Wilson et al. 2007; Fox et al. 2007). An important factor of erosion is the near bank flow pattern, which is determined by the flow and the channel geometry. Rockwell (2002) found the greatest weakness to understand of bank failure mechanism both seepage and soil water pressure studies has been the lack of direct, local, and precise instrumentation. Quantitative data are not available at the point of erosion. This limitation could basically conduct field studies during wet periods when seepage is active (Huang and Laften 1996; Wilson et al. 2007). Figure 1 shows the studied area where data are collected for water level and discharge measurement.

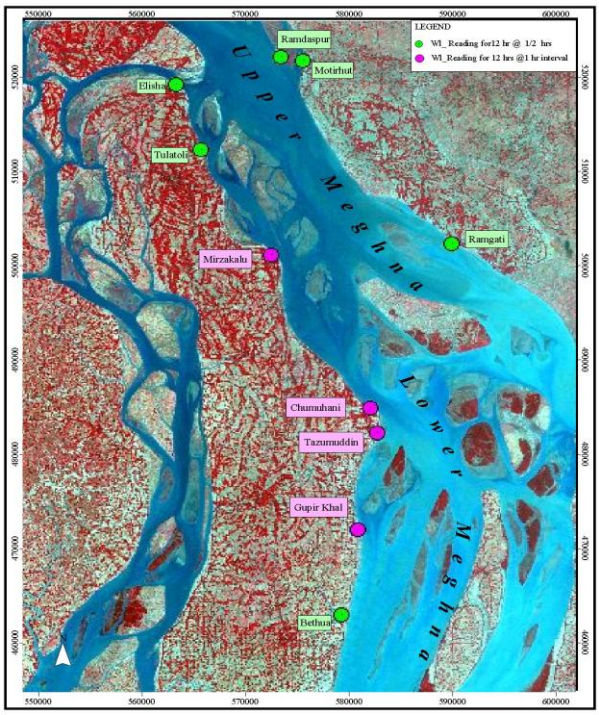

Figure 1: The project area

The objective of the study is to carry out hydraulic investigations using mathematical modelling and survey techniques in order to evaluate the performances of under constructed and completed bank protection works. This study would address the following issues:

- Understanding of the erosion/deposition processes during monsoon 2005;
- Development of baseline bathymetry;
- Identification of probable erosion prone areas from model simulation

2. BACKGROUND

Several studies had been carried out with respect to river morphology, sediment transport, river erosion carried out on Bhola and around Meghna Estuary. Problem of riverbank erosion also reported on Muramoto and Fujita (1992), Mosselman et al. (1995) and Tingsanchali and Chinnarasri (1997). Moreover existing literature on river bank erosioin in different parts of the world were also reviewed. Regarding bank movement simulation, Mosselman (1998), Nagata et al.(2000), Duan et al. (2001), and Darby et al. (2002) bank erosion models using coupled physical based with two-dimensional, depth-averaged models of flow and bed topography was considered. Due to computational complicacy imperial approach was selected in the present study.

Report of the National Committee on Erosion of Bhola (April, 1988) consider emergence of the Shabazpur channel as the main carrying channel of the fluvial flows brought by the Ganges-Brahmaputra-Meghna river system; large accretion of land in the area south of Noakhali mainland; formation and movement of chars in the river and changes in tidal characteristics of the Shabazpur channel. Regarding protective measure by constructing of spurs or groynes found in the Meghna Estuary Study (MES), (March 1999), the permeable spurs or groynes consisting of one or several rows of piles are considered perpendicular to the riverbank. Conventionally, these piles are to be driven into the riverbed with water borne equipment. To find the long term hydrodynamic and morphology of the project area it was found in Meghna Estuary Study, Technical Note MES-022, (September 1998) describe the long-term hydraulic and morphological processes in the Meghna Estuary can be stirred by gravitational circulation due to salinity gradients in the pre-and post-monsoon period. Moreover Meghna Estuary Study, Technical Note MES-001, (Tidal Volume and Sediment Transport Patterns, June 1997) explain the study determined the tidal flow characteristics and sediment transport patterns

during spring and neap tide conditions in the Lower Meghna Estuary that prevailed during Land Reclamation Project (LRP) period. In particular a tendency of higher sediment concentration during spring tides was observed. Maximum sediment concentration of 9.74 gm/l at 0.5 m above channel bed during spring tide was recorded at the north of Urir Char. At West Shabazpur Channel the concentration is found between 1.3 gm/l and 2.2 gm/l. Furthermore Meghna Estuary Study (MES II), Hydro-Morphological Dynamics of the Meghna Estuary, (June 2001 report) analysis hydro-morphological environment of the Meghna Estuary by dividing into three zones where separate driving forces could be distinguished. Morphological processes involved in three zones were described as Marine-dominated, Mixed-dominated, or River-dominated. Energy conditions governing the erosion sedimentation processes differ significantly from those in the dry season. Compression of the Mixed-energy zone results in a situation where the energy dissipation takes place in a smaller area, resulting in higher energy conditions, which lessen the change in permanent sedimentation. In other reports observing the wave characteristics including Hydraulic Modelling Study, Second Coastal Embankment Rehabilitation Project, (SWMC May 2002) suggest to measure wave in the coastal area, especially in the eastern coast where wave height is significant. In addition to this technical feasibility Study with Hydraulic Modeling for Riverbank Protection Project at Tajumuddin of Bhola District reported to select probable area of erosion, location and alignment of the riverbank protection, evaluation of suitable options for riverbank protection, impact on erosion deposition, preliminary design and cost estimation. Some of the major technical recommendations to improve of erosion mitigation measures were considered for detail analysis and design they are bank revetment, submergible solid spur (Geo Bag), permeable spur (R.C.C Pile) and Closure at Tazumuddin. Considering cost and construction difficulties in deep channel and high flow velocities, revetment option were found suitable for erosion management. From the existing literature it was found that the huge dynamic loading in the research area require frequent analysis of the hydrodynamic and morphological characteristics. Therefore an extensive study had been carried in the project area.

3. APPROACH AND METHODOLOGY

One of the key importances to formulate the methodology in the project is to establish baseline bathymetry. In order to assess the performances of newly constructed and completed bank protection works at Tazumuddin Upazila, baseline condition is essential to compare the scenario with and without protective works. Baseline condition for Tazumuddin area has been developed based on hydrodynamic and morphological modelling and historical data of bank line shifting, thalweg line shifting, bathymetric data, char movement etc. Under the hydrodynamic and morphological modelling, the advanced two dimensional curvilinear grid models for Tazumuddin have been developed. The boundaries of this model have been generated from 2D rectangular Bay of Bengal (Bob) model. To establish hydrodynamic baseline condition simulations have been carried out for one month covering neap and spring tide during monsoon 2004 (1-15 August 2004). From hydrodynamic model result velocity field during spring and neap tide, flow pattern, maximum tidal range, tidal level variation, discharge distribution without protective works have been obtained. For morphological base line condition, morphological simulation has been carried out from April, 2004 to November 2004 in order to identify erosion/deposition pattern, maximum erosion and deposition, erosion prone area etc. Moreover bank line shifting and char movement during the period 1996-2006 has been analyzed from historical satellite images and bank line survey.

The model simulation results successfully reproduce water level and discharge at the model domain. Water level calibration of the model is done at Tazumuddin, Daulatkhan where as discharge calibration is done at Mirzakalu and Hatia (calibration of discharge at Mirzalu is shown in the figure 2).

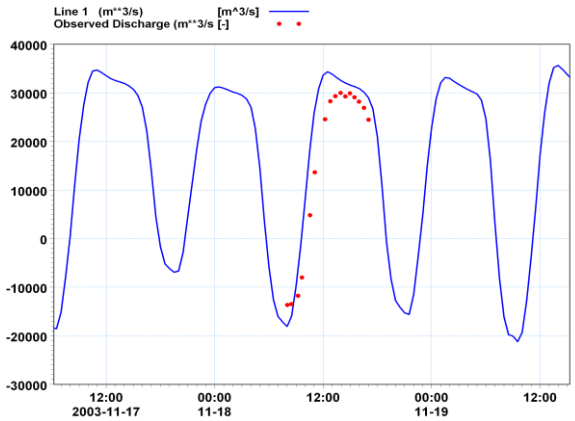

Figure 2: Observed and Simulated Discharge at Mirjakalu in November, 05

4. RESULT AND DISCUSSION

The results had been analyzed in two major catagories of hydrodynamic and morpholigical simulation. Moreover analysis from survey data and satellite image analysis has also been incorporate in the project area. Hydrodynamic (HD) simulations, water level and discharge data analysis have been carried out to determine baseline condition during monsoon 2004 (26 July-25 August). Figure 3 shows the velocity field and speed contour at Shahbazpur channel during spring ebb tide of monsoon 2004 (on 01/08/2004 13:00:00). At this time the maximum depth integrated near bank velocity is found within the range of 1.5-3.0 m/s along the riverbank of Tazumuddin and 1.0-1.5 m/s along the riverbank of Lalmohan. The figure also shows the water level near Tazumuddin varies within 0.20 m PWD to 2.95 mPWD. Maximum tidal range is found about 2.9 m during monsoon spring tide and minimum tidal range is found about 1.00 m during neap tide.

Figure 3 shows the discharge into the west Shabazpur channel (infront of Tajumuddin) and East Shabazpur channel. During the one month simulation period the model results shows that about 60% of the Lower Meghna river flow passes through the channel in front of Tajumuddin (in the West Shahbazpur channel) and a significant part of the flow hits Daulatkhan-Tajumuddin bank line at an angle about 45° during ebb tide, which is causing severe erosion at Tazumuddin.

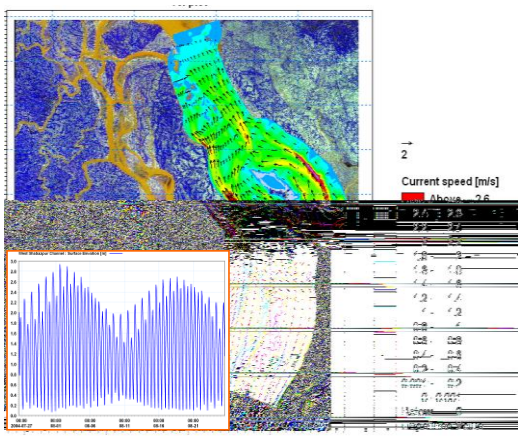

Figure 3: Velocity contour during spring tide ebb in monsoon 2004 and WL near Tajumuddin in Shabazpur channel.

The complex flow pattern during turning of spring flood tide to Ebb Tide is shown in Figure 4. At that moment in the East Shabazpur channel near Char Gazaria the flow direction is upward but in the West Shabazpur channel it is downward.

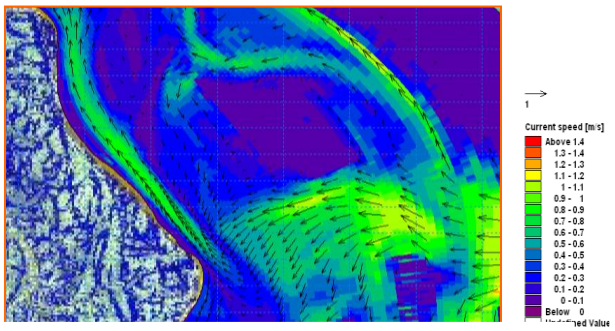

Figure 4: Flow pattern during the turning of Flood tide to Ebb tide

The baseline condition is established to have a clear idea about the erosion-deposition trend near the project area. To achieve this, the base bathymetry was developed based on cross-section data of December 2003 and Meghna Estuary study survey. The base bathymetry of the whole model domain is shown in the Figure 4 (left). Morphological simulation was done from April, 04 to Nov, 04 to find the morphological behavior of the estuary before construction of the protective work. The new bathymetry developed after 8 months simulation is presented in the middle of the Figure 4. Bathymetry survey was carried out during May, 05 near Tazumuddin adjacent to the protective work with fine resolution to increase computational accuracy and near the protective work with coarse resolution to reduce the computational time in order to monitor the critical location before and after applying the protective work. The base bathymetry was further updated with May, 05 bathymetry survey data. Bathymetry with 2005 may survey data is presented at the right side of the Figure 5.

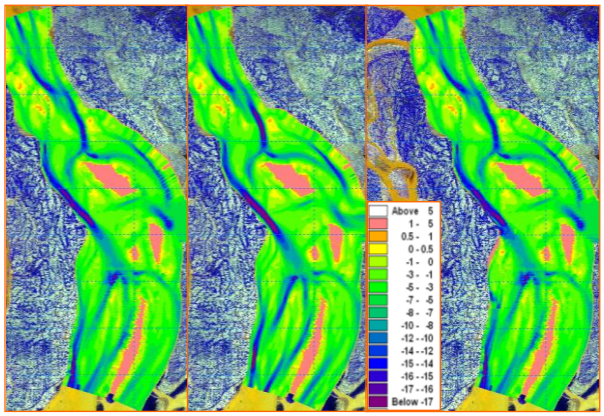

Figure 5: Shows model domain in the Figure 5 (left). The middle bathymetry is the new bathymetry Bathymetry with 2005 May survey data is presented at the right side.

From base bathymetry it is found that there is deep channel from Daulatkhan to Tazumuddin. The depth of the channel is more than 10 meter. The channel is further extended towards the south-east part. After the simulation it has been concluded that channel in front of Tazumuddin become deeper and it is extended more towards the south-east direction. From bathymetry survey data in May, 05 it is found that there is a tendency to deepen the channel in front of Tazumuddin where protective work was suggested and the deep channel is further extended towards South-East direction like that of the simulation result. So it can be concluded that simulation result and real condition near Tazumuddin follows the same trend of channel development i.e. bathymetry change.

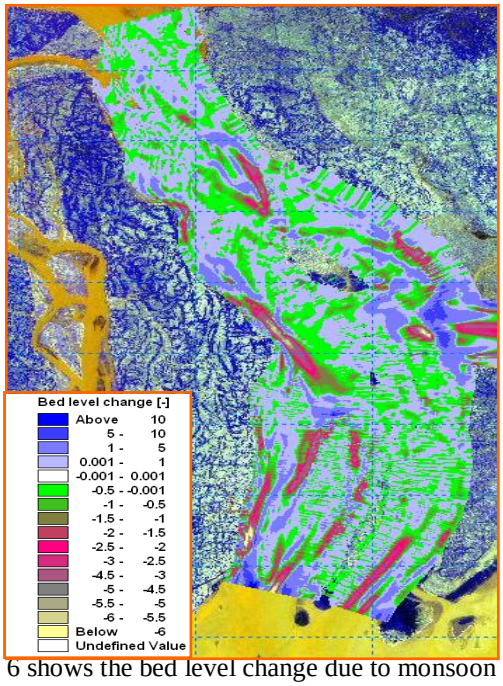

Figure 6 shows the bed level change due to monsoon 2004.

From the computation result it is found that erosion-deposition has been occurred almost every part of the estuary. Most of the part, the deposition varies from 0.001m to -1.00m and erosion (scouring) is 0.001-0.50 m. Significant scouring is found along the riverbank near Tazumuddin and Daulatkhan. Also significant scouring is found along the riverbank at Char Fasson and some portion of Lalmohon. Near Tazumoddin, scouring varies from 0.50 m -6 m and near Daulatkhan it varies from 0. 05 m -4 m. Comparing the deep channel near bank line, erosion prone area near Daulatkhan is less compare to Daulatkhan. Also high scouring is observed near Char Fassion.

Bank line shifting and char movement during the period 1996-2004 are presented in Figure 6.4. It can be visualised from the figure that the widening and the development of char in front of Tajumuddin and Lalmohan causing increase of bank erosion at these locations.

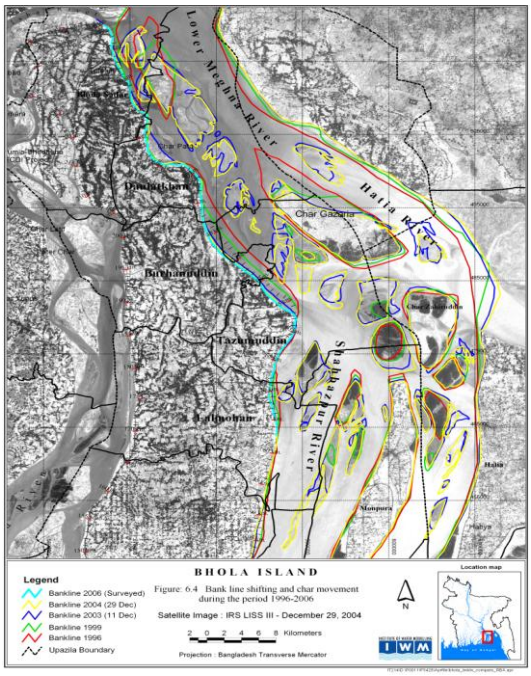

Figure 7 shows the location of thalweg line in May, July and December 2005 and the bankline of January 2006. This Figure also shows the location and amount of completed and proposed protective work.

Thalweg line is the movement of the deepest point on the project area. Figure 7 shows the movement of the thalweg line during May (pre-monsoon), June (monsoon) and December (post monsoon) 05. Also bathymetry survey was carried out along 30 km river surrounding the protective work to have a clear idea about the scour development and thalweg shifting with and without protective work. From the survey data, thalweg line movement in different period in front of the revetment and other location was identified. Figure 8 shows the thalweg line movement in front of the protective work. From the Figure it can be concluded that generally thalweg line is far in May and is closer in December from the bankline 2006. Although some different trend observe at some location where thalweg line is not shifted significantly or behave opposite.

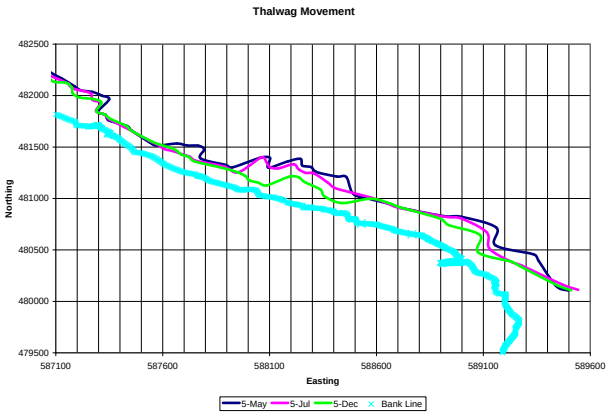

Figure 8: Movement of the thalweg line before, during and after monsoon 2005.

From the cross-section data it has been found that there is no significant change of the river bank slope here during this period (May, 05 to December05). But scour depth is changed significantly. In May average scour depth is 18 m and maximum scour depth is 19.45m. In July these are 18.8 m and 20.18m. In December, the scour depth is maximum. The average scour depth is about 26 m and maximum scour depth is 30.69 m.

The morphological pattern in the shahbazpur channel is very complicated due to char movement, very mobile river bed and tidal characteristics of the river. To analyze the morphological pattern especially after construction of the revetment, three different simulated results have been analyzed. For this simulation was carried out without revetment from April, 04 to Nov, 04, with revetment from May, 05 to October, 05 and an extreme event, 1:100 flood event, (May, 98 to Nov, 98) .

After simulation monsoon 2004 without revetment it has been observed that long deep channel has developed near Tazumuddin (middle part of the Figure 4) and the deep channel is very close to bank and from Figure 3 it has been found that high velocity attacked the river bank of Tazumuddin at an acute angle. So bank might subjected to severe erosion without revetment works. Due to revetment works in Tazumuddin thalweg line came closer to the bank adjacent to the revetment work followed by deposition but the bank line is fixed.

This model result can be successfully reproduced the morphological pattern around the revetment. From the post monsoon survey data (December 2005), it is found that immediate after the revetment work, scouring occurred near the riverbank but just after the scouring deposition is found. From the model result it is also observed the same pattern of erosion followed by deposition in the river bed.

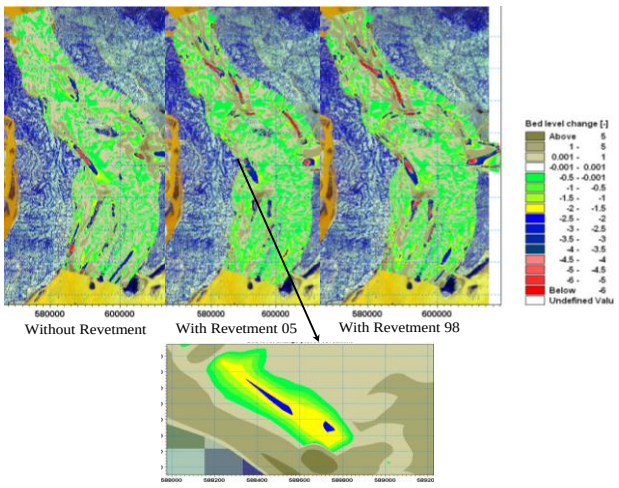

Figure 9: Model result shows the erosion deposition pattern in the project area

Survey transect just after the revetment works and simulation result followed the same trend of erosion-deposition pattern. This is shown in the Figure 10 below:

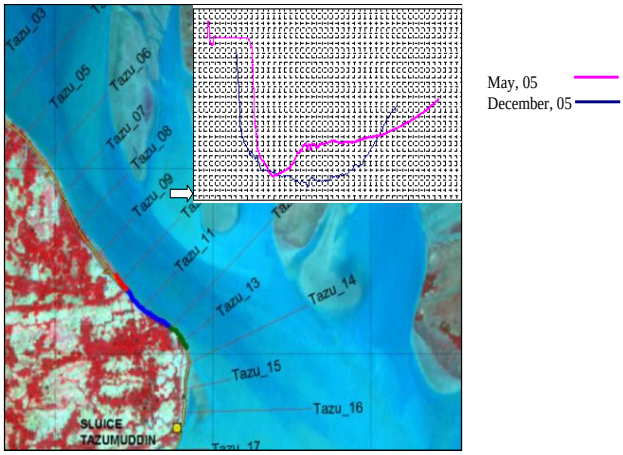

Figure 10: Shows comparison of cross section before and after monsoon.

Due to flow deflected from the revetment (predicted on the study "Technical Feasibility study with Hydraulic Modelling for Riverbank Protections Project at Tazumuddin of Bhola District") and highly mobile up stream flow deep channel is formed little downstream of the revetment work. Although erosion trend is increased on the upstream of the revetment but severe erosion is not observed near upstream of the revetment work. Furthermore severe erosion trend is observed on the upstream of Char Gazaria, which may took place due to char movement and hydro morphological changes in the river though such changes may not cause much threat to river bank erosion. In the extreme flood condition most of the morphological changing pattern matches with revetment 2005 condition but the erosion trend is prolonged due to huge upstream flow.

In the present study, direct bank line survey and satellite image analysis have been applied to identify bank line migration of Shabazpur channel. In order to find the trend of erosion, annual erosion rate and bank line shifting characteristics of the river time series satellite imageries from 1996 to 2004 and bank line survey data 2003 and 2006 were analyzed. The images were digitized to make boundary between land and water. The erosion/accretion of different years was determined at certain interval. It is mentionable that the shifting of riverbank line was measured perpendicular to the riverbank line of the reference year, the bank line of the year 1996

is considered as the reference bank line. The riverbank line shifting is shown in Figure 9. However, the erosion rate in the recent year is quite significant and a large area of land has already been eroded. From the previous study it has been observed that Shahbajpur Channel shifted about 2 km into Bhola island over the last 10 years. The erosion during the last two monsoons (2003 and 2004) is about 600m along the right bank of Shahbazpur channel at Burhanuddin Upazila.

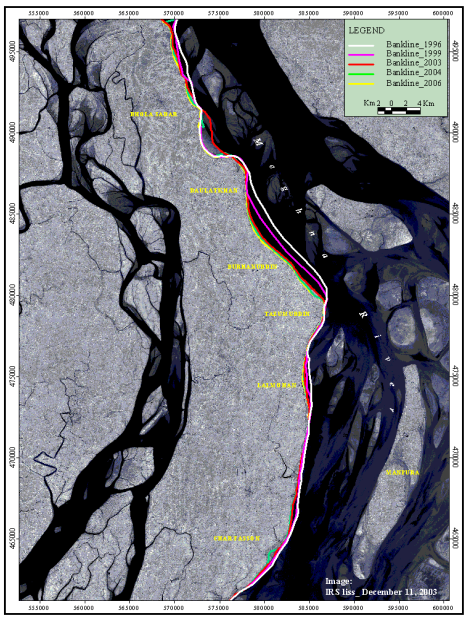

Figure 11 shows bank line shifting in the project area

From the recent Bank line survey data and Satellite images analysis it is found that from 2003 erosion tendency is observed from Tazumuddin to Daulatkhan maximum bank erosion from 2003-2006 is 370 m and from 2004-2006 is 330m near Tazumuddin. So it can be concluded that maximum recent erosion rate near Tazumiddin is about 124 m per year. No significant erosion found near Lalmohan. But erosion trend was found further downstream. From the bankline survey data January 2006 it is observed bankline adjacent to the revetment is fixed but immediate after the revetment bank line is eroded. From satellite images analysis from 1973 and from other analysis it has been found that North-Eastern shoreline of Bhola Island has been changed a lot due to the riverbank erosion since 1973. Shahbazpur Channel has 19 km bank line (Km 49 to Km 68) in Tazumuddin upazila and another 19 km bank line (Km 68 to Km 87) in Lalmohan upazila. Bank lines of 1973, 1979, 1984, 1990, 1996, 2002, 2003 and 2004 have been analyzed and found that the bank line is shifted about 5.4 km at Km 51 of BWDB embankment in Tazumuddin Upazila and retreated about 1.5 km at Km 74 in Lalmohan Upazila during the period of 1973 to 2004 i.e. within 31years. Analysis of time series satellite imageries from 1973 to 2002 shows that more than 130 km^2 land has been eroded along the north-eastern shoreline of Bhola Island (right bank of the Shahbazpur channel) from Ilisha ghat to Tazumuddin with an annual average erosion rate of 90m .

5. CONCLUSION

Hydraulic modelling study for the vulnerable location at Tozimuddin upazilla had been carried out for the assessment of impact of 1 in 100 years flood on surrounding water environment and identification of probable vulnerable location were identified. The study is based on the data and mathematical model. The model simulates the tide, current speed, and accretion/deposition. The model is calibrated and validated against measured water level and discharge both for dry and monsoon season. Both physical and environmental monitoring programme, during and after construction of embankment is suggested for the design of corrective measures through adaptive approach.

References:

1. Darby, S.E., Gessler, D., and Thorne, C.R. (2000). “Computer program for stability of steep cohesive riverbanks.” Earth Surf. Processes Landforms, 25, 175-190.

2. Lawler, D. (2005). “The importance of high-resolution monitoring in erosin and deposition dynamics studies: Examples from estuarine and fluvial systems.” Geomorphology, 64, 1-23.

3. Ikeda, S., Parker, G., and Sawai, K. (1981). “Bend theory of river meanders: Part I: Linear development.” J. Fluid Mech., 112, 363-377

4. Parker, G., Sawai, K., and Ikeda, S. (1982). “Bend theory of river meanders, Part II: Nonlinear deformation of finite-amplitude bends.” J.Fluid Mech., 115, 303-314.

5. Blondeaux, P., and Seminara, G. (1985). “A unified bar-bend theory of rivermeanders.” J. Fluid Mech., Cambridge, U.K., 157, 449-470.

6. Hasegawa, K., and Yamaoka, I. (1980). “The effect of plane and bedforms of channels upon the mender development.” Proc.JSCE, TOKYO,296, 143-152.

7. Johannesson, H., and Parker, G. (1989). “Velocity redistribution in me andering rivers.” J. Hydraul. Eng., 115(8), 1019-1039.

8. Hooke, J. M. (1979). “An analysis of the processes of river bank erosion.” J. Hydrol., 42, 39-62.

9. Hardy, R. J. (2006). “ Fluvial geomorphology.”

Prog. Phys. Geogr., 30(4), 553-567.

10. Crosta, G., and di Prisco, C. (1999). "On slope instability induced by seepage erosion." Can. Geotech. J., 36, 1056-1073.

11. Burgi, P.H., and Karaki, S. (1971). "Seepage effect on channel bank stability." J. Irrig. and Drain. Div., 97, 59-72.

12. Hagerty, D. J. (1991a). "Piping/sapping erosion. I: Basic considerations." J. Hydraul. Eng., 117(8), 991-1008.

13. Wilson, G. V., Periketi, R. K., Fox, G. A., Cullum, R. F., and Shields, F. D. (2007). "Seepage erosion and properties contributing to streambank failure." Earth Surf. Processes Landforms, in press.

14. Fox, G. A., Wilson, G. V., Simon, A., Langendoen, E., Akay, O., and Fuchs, J.W. (2007). " Measuring streambank erosion due to ground water seepage: Correlation to bank pore water pressure, precipitation, and stream stage." Earth Surf. Processes Landforms, 32(10), 1558-1573.

15. Rockwell, D. L., (2002). "The influence of groundwater on surface flow erosion processes." Earth Surf. Processes Landforms, 27(5), 495-514.

16. Huang, C., and Laflen, J. M. (1996). "Seepage and soil erosion for a clay loam soil." Soil Sci. Soc. Am. J., 60(2), 408-416.

17. Wilson, G. V., Periketi, R. K., Fox, G. A., Dabney, S. M., Shields, F. D.,and Cullum, R. F. (2007). "Seepage erosion properties contributingto streambank failure." Earth Surf. Processes Landforms, 32(3), 447-459.

18. Muramoto, Y., and Fujita, Y. (1992). "Recent channel processes of the major rivers in Bangladesh." Annuals of the Diaster Prevention Res. Inst., Kyoto Univ., Kyoto, Japan, 35 B-2, 89-114 (in Japanese).

19. Mosselman, E., Huisink, M., Koomen, E., and Seijmonsbergen, A. C.(1995). " Morphological changes in a large braided sand-bed river." River Geomorphology, E. J. Hickin, ed., Wiley, Chichester, U.K., 235-247.

20. Tingsanchali, T., and Chinnarasri, C. (1997). "Desing of Mekong river bank protection." Proc., Conf. on Mgmt. of Landscapes Disturbed by Channel Incision, University of Mississippi, Miss., 345-348.

21. Mosselman, E. (1998). "Morphological modeling of rivers with erodible banks." Hydrolog. Process., 12, 1357-1370.

22. Nagata, N., Hosoda, T., and Muramoto, Y. (2000). "Numerical analysis of river channel processes with bank erosion." J. Hydraul. Eng., 126(4), 243-252.

23. Duan, J. G., Wang, S. S. Y., and Jia, Y. (2001). "The applications of the enhanced CCHE2D model to study the alluvial channel migration processes." J. Hydraul. Res., 39, 469-480.

24. Darby, S.E., Alabyan, A. M., and Van de Wiel, M. J. (2002). " Numerical simulation of bank erosion and channel migration in meandering rivers." Water Resour. Res., 38(9), 2-1-2-12.

25. Report of the National Committee on Erosion of Bhola, Ministry of Irrigation, Water Development and Flood Control, April 6, 1988

26. Meghna Estuary Study, Draft Development Plan, Volume 6, Reconnaissance Studies Erosion Control, March 1999, DHV Consultants BV in association with Kampsax International, Danish Hydraulic Institute, Development Design Consultants, Surface Water Modelling Centre, Aqua Consultants and Associates Ltd.

27. Meghna Estuary Study, Technical Note MES-022, Gravitational Circulation Shahbazpur Main Channel, September 1998, DHV Consultants BV in association with Kampsax International, Danish Hydraulic Institute, Development Design Consultants, Surface Water Modelling Centre, Aqua Consultants and Associates Ltd.

28. Meghna Estuary Study, Technical Note MES-001, Tidal Volume and Sediment Transport Patterns, June 1997, DHV Consultants BV in association with Kampsax International, Danish Hydraulic Institute, Development Design Consultants, Surface Water Modelling Centre, Aqua Consultants and Associates Ltd.

29. Meghna Estuary Study (MES II), Hydro-Morphological Dynamics of the Meghna Estuary, BoB-MoWR, GoN-DGIS, June 2001, DHV Consultants BV in association with Devconsultants Ltd. and Surface Water Modelling Centre.

30. Hydraulic Modelling Study, Second Coastal Embankment Rehabilitation Project, SWMC May 2002.

31. Technical Feasibility Study with Hydraulic Modeling for Riverbank Protection Project at Tajumuddin of Bhola District.

32. Technical Feasibility Study with Hydraulic Modeling for Meghna-Tentulia River Bank Protection Project

PERFORMANCE ANALYSIS OF A MIMO-OFDM WIRELESS LINK WITH SPACE-TIME BLOCK CODE (STBC)

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ABSTRACT

Multiple–Input Multiple Output (MIMO) antenna architecture has the ability to increase capacity and reliability of a wireless communication system. Orthogonal Frequency Division Multiplexing (OFDM) is another popular technique in wireless communication which is famous for the efficient high speed transmission and robustness to frequency selective channels. Therefore the integration of the two technologies probably has the potential to meet the ever growing demands of future communication systems. MIMO-OFDM technology is the trend of the next generation WLANs, because of the demand of the higher transmission data rate and better transmission quality. Due to the aforementioned merits of these two techniques, this paper is based on MIMO-OFDM system. It has investigated the performance of MIMO-STBC system. Maximum likelihood decoding is achieved in a simple way through decoding of the signals transmitted from different antennas rather than joint detection. This uses the orthogonal structure of the space–time block code and gives a maximum likelihood decoding algorithm which is based only on linear processing at the receiver. In the first part, the STBC system was calculated for different antenna configuration using simulation software for different modulation schemes. The result proved that the reliability of the wireless link increase as the number of transmits and received antenna increases. At the next stage the performance of MIMO-OFDM system was investigated both with STBC and Convolution coding with the significant improvement of performance.

Key Words-Rayleigh and Rician fading, multiple-antennas, space-time block code, code rate, maximum likelihood detector, Timing Jitter.

1. Introduction

Physical limitations of the wireless medium create a technical challenge for reliable wireless communication. [1] Techniques that improve spectral efficiency and overcome various channel impairments [2] such as signal fading and interference have made an enormous contribution to the growth of wireless communications. The need for high-speed wireless Internet has led to the demand for technologies delivering higher capacities and link reliability than achieved by current systems. Multiple-input multiple output (MIMO) [3], [4] based communication system are capable accomplishing these objectives. MIMO system take advantage of spatial diversity [1] obtained through the spatially separated antennas in a dense multi-path scattering environment. Spatial diversity can increase the gain diversity consequently increases the reliability of the wireless link Theoretical studies indicates that the capacity of MIMO systems grows linearly with the number of transmit antennas used.

The multiple antennas configuration exploits the multi-path effect to accomplish the additional spatial diversity. However, the multi-path effect also causes the negative effect of frequency selectivity of the channel. OFDM [2] is a promising multi-carrier modulation scheme that shows high spectral efficiency and robustness to frequency selective channels. In OFDM, a frequency selective channel is divided into a number of parallel frequency-flat sub channels, thereby reducing the receiver signal processing of the system. The combination of MIMO and OFDM [3] is a promising technique to achieve high bandwidth efficiency and system performances. In fact, MIMO-OFDM [5] is being considered for the upcoming IEEE 802.11n standard, a developing standard for high data rate WLANs [1]

In many situations, however, the wireless channel is neither significantly time-variant nor highly frequency selective. This forces the system engineers to consider the possibility of deploying multiple antennas at both the transmitter and receiver to achieve spatial diversity. Considering the fact that receivers are typically required to be small, it may not be practical to deploy multiple receive antennas at the remote station. This motivates us to consider transmit diversity.

In addressing the issue of decoding complexity, Alamouti discovered a remarkable scheme for transmission using two transmits antennas [6]. Space–time block coding, [7], [8], and [9] introduced in generalizes the transmission scheme

discovered by Alamouti to an arbitrary number of transmit antennas and is able to achieve the full diversity promised by the transmit and receive antennas. These codes retain the property of having a very simple maximum likelihood decoding algorithm based only on linear processing at the receiver. For real signal constellations (such as PAM), they provide the maximum possible transmission rate allowed by the theory of space–time coding [7]. For complex constellations, space–time block codes can be constructed for any number of transmit antennas, and again these codes have remarkably simple decoding algorithms based only on linear processing at the receiver.

The purpose of this paper is to evaluate the performance of the space–time block codes with MIMO-OFDM in fading [9] environment and with the application of different modulation schemes as [10], [11] including timing jitter effect [12]. We begin by transmit diversity [8], [1] and then considering encoding and decoding algorithms for some of these codes. Then we provide simulation results confirming that with space–time block coding and multiple transmit antennas, a significant performance gain can be achieved at almost no processing expense.

2. SYSTEM MODEL

The model of a Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) system [4], [5] with Space-Time Block Code (STBC) considered for analysis is shown in fig.1.

The input serial data stream b[n] is formatted into the word size required for transmission by **serial to parallel conversion**, e.g. 2 bits/word for QPSK, and shifted into a parallel format. The data is then transmitted in parallel by assigning each data word to one carrier in the transmission. The data to be transmitted on each carrier is **mapped** into a Phase Shift Keying (PSK modulation) format. The data on each symbol is then mapped to a phase angle based on the modulation method. For example, for QPSK the phase angles used are 0, 90, 180, and 270 degrees. For DQPSK and DPSK (DBPSK) modulation, [10], [11] differential coding is performed in the time domain. The data is encoded by Space-Time Block Code (STBC) to achieve coding and diversity gain.

The guard period/cyclic prefix [2] is a copy of the last part of the OFDM symbol that is Prepended to the transmitted symbol and removed at the receiver before the demodulation. The length of the cyclic prefix is made longer than the experienced impulse response to avoid Inter Symbol Interference (ISI) and Inter Carrier Interference (ICI). After the guard has been added, the symbols are then

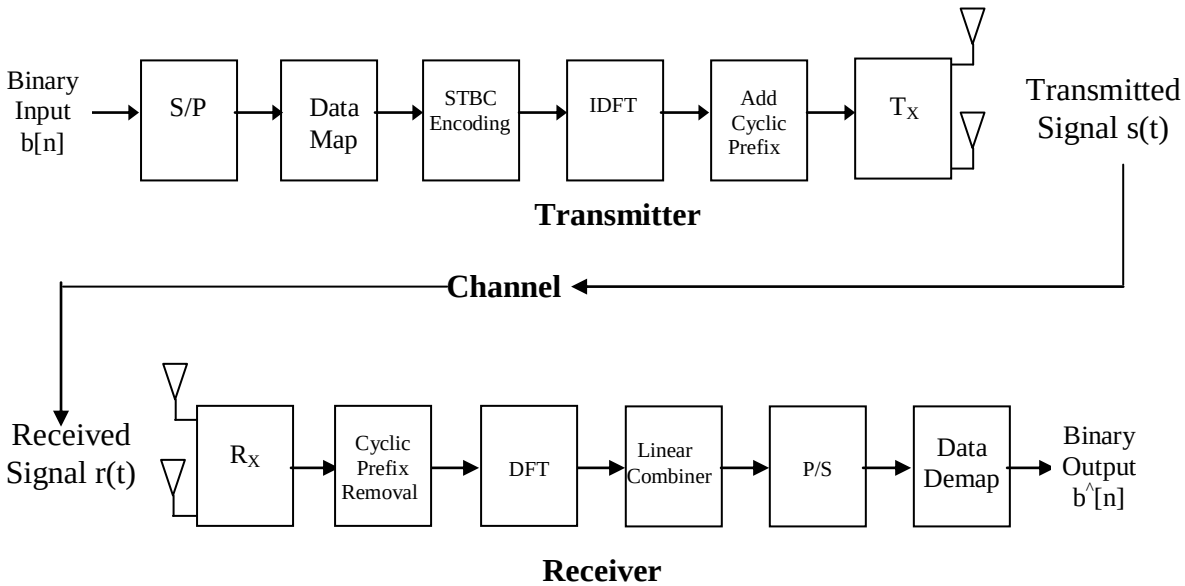

Fig.1: Block Diagram of a MIMO-OFDM System with STBC

converted back to a serial time waveform. This is then the base band signal for the OFDM transmission. Cyclic Prefix (CP) is added to remove ISI and to cancel ICI.

IDFT is the Inverse Discrete Fourier Transform of the input signal. Using Inverse Fast Fourier Transform (IFFT), OFDM modulation is computed on each set of symbols, resulting in time-domain samples. The IDFT is given by:

$$x_n = \frac{1}{N}\sum_{k=0}^{N-1} X_k e^{\frac{2\pi i}{N}kn} \qquad n = 0, \ldots, N-1. \tag{1}$$

A simple description of these equations is that the complex numbers X_k represent the amplitude and phase of the different sinusoidal components of the input "signal" x_n. The Discrete Fourier Transform (DFT) computes the X_k from the x_n, while the IDFT shows how to compute the x_n as a sum of sinusoidal components $X_k \exp(2\pi i k n / N) / N$ with frequency k / N cycles per sample. The diversity in transmission is achieved by multiple transmit antennas which helps to utilize the space diversity also. The channel is time-selective Rayleigh/Rician fading with AWGN.

The **receiver** does the reverse operation to the transmitter. The guard period is removed. The DFT of each symbol is then carried out to find the original transmitted spectrum. This returns N parallel streams. The phase angle of each transmission carrier is then evaluated and converted back to binary stream by demodulating the received phase. These streams are then re-combined into a serial stream, b^[n] which is an estimate of the original binary stream at the transmitter.

3. OVERVIEW OF OFDM, MIMO AND STBC

3.1 Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is a modulation technique where multiple low data rate carriers are combined by a transmitter to form a composite high data rate transmission. Digital signal processing makes OFDM possible. To implement the multiple carrier scheme using a bank of parallel modulators would not be very efficient in analog hardware. However, in the digital domain, multi-carrier modulation can be done efficiently with currently available Digital Signal Processing (DSP) hardware and software. Not only can it be done, but it can also be made very flexible and programmable. This allows OFDM to make maximum use of available bandwidth [3] and to be able to adapt to changing system requirements.

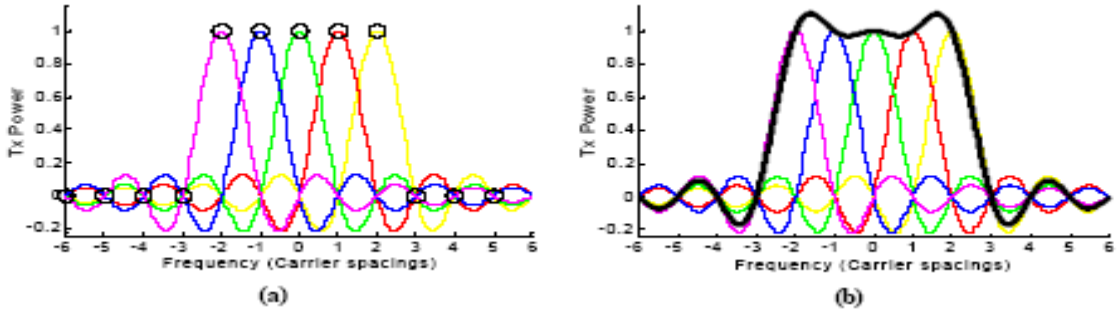

Fig. 2: Frequency Response of Sub-carriers in a Five-tone OFDM Signal

a. Shows the spectrum of each carrier, and the discrete frequency samples seen by an OFDM receiver. Each carrier is sinc, sin(x)/x, in shape. b. Shows the overall combined response of the five sub-carriers (thick black line)

Each carrier in an OFDM system is a sinusoid with a frequency that is an integer multiple of a base or fundamental sinusoid frequency. Therefore, each carrier is like a Fourier series component of the composite signal. In fact, it will be shown later that an OFDM signal is created in the frequency domain, and then transformed into the time domain via the Discrete Fourier Transform (DFT). Two periodic signals are *orthogonal* when the integral of their product, over one period, is equal to zero. This is true of certain sinusoids as illustrated in equation (2).

Continuous Time :

$$\int_0^T \cos(2\pi n f_0 t) \times \cos(2\pi m f_0 t) dt = 0 \quad (n \neq m) \tag{2}$$

Discrete Time :

$$\sum_{k=0}^{N-1} \cos\left(\frac{2\pi kn}{N}\right) \times \cos\left(\frac{2\pi km}{N}\right) = 0 \quad (n \neq m)$$

The carriers of an OFDM system are sinusoids that meet this requirement because each one is a multiple of a fundamental frequency. Each one has an integer number of cycles in the fundamental period.

3.2 MULTIPLE INPUT MULTIPLE OUTPUT (MIMO) SYSTEM

3.2.1 Understanding of SISO, SIMO, MISO and MIMO

MIMO is an acronym that stands for Multiple Input Multiple Output. It is an antenna technology that is used both in transmission and receiver equipment for wireless radio communication. There can be various MIMO configurations. In radio, **multiple-input and multiple-output**, or **MIMO** (pronounced *mee-moh* or *my-moh*),[4] is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna (SA), and the state of the art of SA technology.

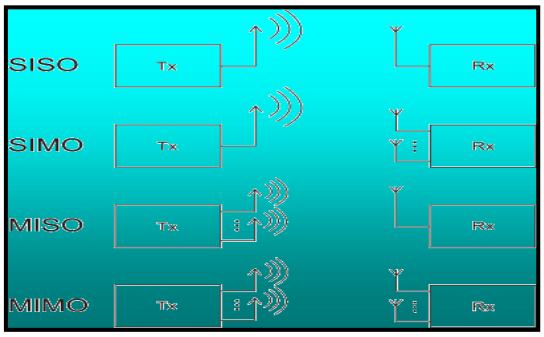

Fig.3: Understanding of SISO, SIMO, MISO and MIMO

MIMO technology has attracted attention in wireless communications, since it offers significant increases in data throughput and link range without additional bandwidth or transmit power. It achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced fading). Because of these properties, MIMO is a current theme of international wireless research.

Up to now, multi-antenna MIMO (or Single user MIMO) technology has been mainly developed and is implemented in some standards, e.g. 802.11n (draft) products. SISO/SIMO/MISO is degenerate cases of MIMO

a. Multiple-Input and Single-Output (MISO) is a degenerate case when the receiver has a single antenna.

b. Single-Input and Multiple-Output (SIMO) is a degenerate case when the transmitter has a single antenna.

c. single-Input Single-Output (SISO) is a radio system where neither the transmitter nor receiver have multiple antenna.

3.3 Space–Time Block Code (STBCs)

Most work on wireless communications had focused on having an antenna array at only one end of the wireless link, usually at the receiver. For the highly-scattering environment substantial capacity gains are enabled when antenna arrays are used at both ends of a link. An alternative approach to utilizing multiple antennas relies on having multiple transmit antennas and only optionally multiple receive antennas. The Space–Time Codes (STCs) achieve significant error rate improvements over single-antenna systems. The original scheme was based on trellis codes but the simpler block codes were utilized by Siavash Alamouti, and later Vahid Tarokh, Hamid Jafarkhani and Robert Calderbank to develop STBCs. [7] STC involves the transmission of multiple redundant copies of data to compensate for fading and thermal noise in the hope that some of them may arrive at the receiver in a better state than others. In the case of STBC in particular, the data stream to be transmitted is encoded in blocks, which are distributed among spaced antennas and across time. While it is necessary to have multiple transmit antennas, it is not necessary to have multiple receive antennas, although to do so improves performance. This process of receiving diverse copies of the data is known as diversity reception. An STBC is usually represented by a matrix. [4] Each row represents a time slot and each column represents one antenna's transmissions over time.

$$\text{time-slots} \downarrow \quad \overrightarrow{\text{transmit antennas}}$$
$$\begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n_T} \\ s_{21} & s_{22} & \cdots & s_{2n_T} \\ \vdots & \vdots & & \vdots \\ s_{T1} & s_{T2} & \cdots & s_{Tn_T} \end{bmatrix}$$

Here, s_{ij} is the modulated symbol to be transmitted in time slot i from antenna j. There are to be T time slots and n_T transmit antennas as well as n_R receive antennas. This block is usually considered to be of 'length' T.

4. ANALYSIS OF TRANSMIT DIVERSITY OF MIMO-OFDM WITH STBC

4.1 Two-Branch Transmit Diversity with One Receiver

At a given symbol period, two signals are simultaneously transmitted from the two antennas. The signal transmitted from antenna one is denoted by s_1 and from antenna two by s_2. During the next symbol period signal $(-s_2^*)$ is transmitted from antenna one, and signal s_1^* is transmitted from antenna two where $*$ is the complex conjugate operation. This sequence is shown in Table-1. [8], [3] the encoding is done in space and time (space–time coding).

Table-1: The Encoding and Transmission Sequence for the Two-Branch Transmit Diversity Scheme

	antenna 1	antenna 2
time t	s_1	s_2
time $t+1$	$-s_2^*$	s_1^*

The channel at time t may be modeled by a complex multiplicative distortion $\alpha_1(t)$ for transmit antenna one and $\alpha_2(t)$ for transmit antenna two. Assuming that fading is constant across two consecutive symbols, we can write

$$\alpha_1(t) = \alpha_1(t+1) = \alpha_1 = \partial_1 e^{j\theta_1}$$
$$\alpha_2(t) = \alpha_2(t+1) = \alpha_2 = \partial_1 e^{j\theta_2} \qquad (3)$$

Noise and interference are added at the receivers. The resulting received baseband signals are

$$r_1 = r(t) = \alpha_1 s_1 + \alpha_2 s_2 + \eta_1$$
$$r_2 = r(t+1) = -\alpha_1 s_2^* + \alpha_2 s_1^* + \eta_2 \qquad (4)$$

Where, r_1 and r_2 are the received signals at time t and $t+1$, η_1 and η_2 are complex random variables representing receiver noise and interference.

Assuming η_1 and η_2 are Gaussian distributed, the maximum likelihood decision rule [3] at the receiver for these received signals is to choose signal s_i if and only if (in case of s_1)

$$d^2(r_1, \alpha_1 s_i) + d^2(r_2, \alpha_2 s_i^*) \leq d^2(r_1, \alpha_1 s_k) + d^2(r_2, s_k^*) \; \forall i \neq k$$

Choose; signal s_i if and only if (in case of s_2)

$$d^2(r_1, \alpha_2 s_i) + d^2(r_2, -\alpha_1 s_i^*) \leq d^2(r_1, \alpha_2 s_k) + d^2(r_2, -\alpha_1 s_k^*) \; \forall i \neq k \qquad (5)$$

Where, $d^2(x, y)$ is the squared Euclidean distance between signals x and y calculated by the following expression:

$$d^2(x, y) = (x - y)(x^* - y^*) \qquad (6)$$

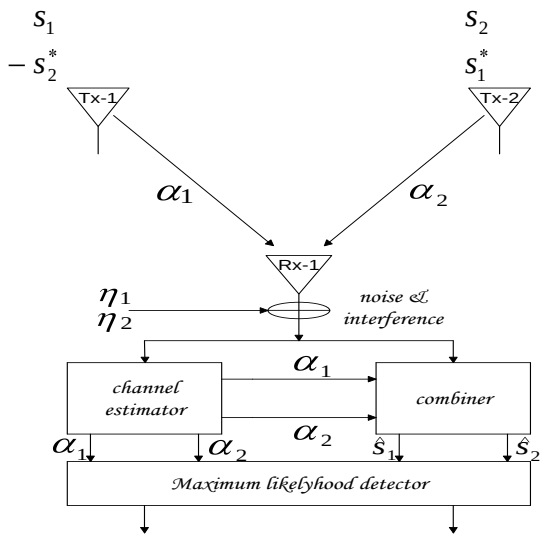

Fig 4: Two-Branch Transmit Diversity with One Receiver

The combiner shown in Fig.1 builds the following two combined signals that are sent to the maximum likelihood detector:

$$\hat{s}_1 = \alpha_1^* r_1 + \alpha_2 r_2^*$$
$$= \alpha_1^*(\alpha_1 s_1 + \eta_1) + \alpha_2(\alpha_2 s_1^* + \eta_2)^*$$
$$= (\partial_1^2 + \partial_2^2) s_1 + \alpha_1^* \eta_1 + \alpha_2 \eta_2^*$$
$$\hat{s}_2 = \alpha_2^* r_1 - \alpha_1 r_2^*$$
$$= \alpha_2^*(\alpha_2 s_2 + \eta_1) - \alpha_1(-\alpha_1 s_2^* + \eta_2)^*$$

$$= (\alpha_1^2 + \alpha_2^2)\hat{s}_2 - \alpha_1\eta_2^* + \alpha_2^*\eta_1 \qquad (7)$$

Expanding (5) and using (6) and (7) and some manipulation, we get

choose, signal s_i if (in case of s_1)

$$(\alpha_1^2 + \alpha_2^2 - 1)|s_i| + d^2(\hat{s}_1, s_i) \le$$

$$(\alpha_1^2 + \alpha_2^2 - 1)|s_k| + d^2(\hat{s}_1, s_k) \quad \forall\ i \neq k$$

choose, signal s_i if (in case of s_2)

$$(\alpha_1^2 + \alpha_2^2 - 1)|s_i| + d^2(\hat{s}_2, s_i) \le$$

$$(\alpha_1^2 + \alpha_2^2 - 1)|s_k| + d^2(\hat{s}_2, s_k) \quad \forall\ i \neq k \qquad (8)$$

For PSK signals (equal energy constellations) $|s_i|^2 = |s_k|^2 = E_s \quad \forall\ i,k$ (9)

Where, E_s is the energy of the signal. Therefore, for PSK signals, the decision rule in (8) may be simplified to,

choose, signal s_i if (in case of s_1)

$$d^2(\hat{s}_1, s_i) \le d^2(\hat{s}_1, s_k) \quad \forall\ i \neq k$$

Choose signal s_i if (in case of s_2)

$$d^2(\hat{s}_2, s_i) \le d^2(\hat{s}_2, s_k) \quad \forall\ i \neq k \qquad (10)$$

The maximal-ratio combiner may then construct the signal $\hat{s}_1$ and $\hat{s}_2$, as shown in Figure 1, so that the maximum likelihood detector may produce $\tilde{s}_1$ and $\tilde{s}_2$, which is a maximum likelihood estimate of s_1 and s_2.

4.2 Three-Branch Transmit Diversity with One Receiver

At a given symbol period, three signals are simultaneously transmitted from the three antennas.

s_1	s_2	s_3
$-s_2$	s_1	$-s_4$
$-s_3$	s_4	s_1
$-s_4$	$-s_3$	s_2
s_1^*	s_2^*	s_3^*
$-s_2^*$	s_1^*	$-s_4^*$
$-s_3^*$	s_4^*	s_1^*

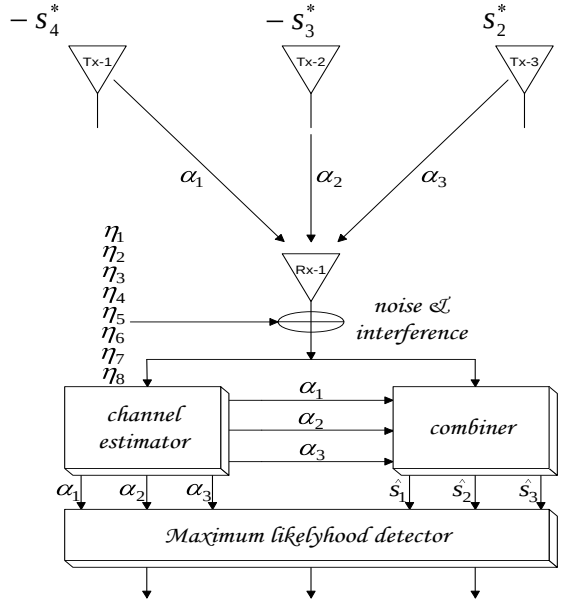

Fig 5: Three-Branch Transmit Diversity with One Receiver

The combiner shown in Figure 5 builds the following three combined signals that are sent to the maximum likelihood detector:

$$\begin{aligned}
\hat{s}_1 &= 2(\alpha_1^2 + \alpha_2^2 + \alpha_3^2)s_1 + \alpha_1^*\eta_1 + \alpha_2^*\eta_2 \\
&\quad + \alpha_3^*\eta_3 + \alpha_1\eta_5^* + \alpha_2\eta_6^* + \alpha_3\eta_7^* \\
\hat{s}_2 &= 2(\alpha_1^2 + \alpha_2^2 + \alpha_3^2)s_2 + \alpha_2^*\eta_1 - \alpha_1^*\eta_2 \\
&\quad + \alpha_3^*\eta_4 + \alpha_1\eta_5^* - \alpha_1\eta_6^* + \alpha_3\eta_8^* \\
\hat{s}_3 &= 2(\alpha_1^2 + \alpha_2^2 + \alpha_3^2)s_3 + \alpha_3^*\eta_1 - \alpha_1^*\eta_3 \\
&\quad - \alpha_2^*\eta_4 + \alpha_3\eta_5^* - \alpha_1\eta_7^* - \alpha_2\eta_8^* \\
\hat{s}_4 &= 2(\alpha_1^2 + \alpha_2^2 + \alpha_3^2)s_4 - \alpha_3^*\eta_2 + \alpha_2^*\eta_3 \\
&\quad - \alpha_1^*\eta_4 - \alpha_3\eta_6^* + \alpha_2\eta_7^* - \alpha_1\eta_8^* \qquad (11)
\end{aligned}$$

After some manipulation we get,

choose, signal s_i if (in case of s_1)

$$(\alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_i| + d^2(\hat{s}_1, s_i)$$

$$\le (\alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_k| +$$

$$d^2(\hat{s}_1, s_k) \quad \forall\ i \neq k$$

choose, signal s_i if (in case of s_2)

$$(\alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_i| + d^2(\hat{s}_2, s_i)$$

$$\le (\alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_k| +$$

$$d^2(\hat{s}_2, s_k) \quad \forall\ i \neq k$$

choose, signal s_i if (in case of s_3)

$$\left(\left(\alpha_1^2+\alpha_2^2+\alpha_3^2\right)-1\right)|s_i|+d^2\left(\hat{s}_3,s_i\right)$$
$$\le\left(\left(\alpha_1^2+\alpha_2^2+\alpha_3^2\right)-1\right)|s_k|+$$
$$d^2\left(\hat{s}_3,s_k\right)\quad\forall\, i\neq k$$

choose signal s_i if (in case of s_4)

$$\left(\left(\alpha_1^2+\alpha_2^2+\alpha_3^2\right)-1\right)|s_i|+d^2\left(\hat{s}_4,s_i\right)$$
$$\le\left(\left(\alpha_1^2+\alpha_2^2+\alpha_3^2\right)-1\right)|s_k|+$$
$$d^2\left(\hat{s}_4,s_k\right)\quad\forall\, i\neq k \qquad (12)$$

For PSK signals (equal energy constellations) $|s_i|^2=|s_k|^2=E_s \quad \forall\ i,k$

The maximal-ratio combiner may then construct the signal $\hat{s}_1,\hat{s}_2,\hat{s}_3$ and $\hat{s}_4$ as shown in Fig-5, so that the maximum likelihood detector may produce $\tilde{s}_1,\tilde{s}_2,\tilde{s}_3$ and $\tilde{s}_4$, which is a maximum likelihood estimate of s_1,s_2,s_3 and s_4.

4.3 Four-Branch Transmit Diversity with One Receiver

At a given symbol period, four signals are simultaneously transmitted from the four antennas.

s_1	s_2	s_3	s_4
$-s_2$	s_1	$-s_4$	s_3
$-s_3$	s_4	s_1	$-s_2$
$-s_4$	$-s_3$	s_2	s_1
s_1^*	s_2^*	s_3^*	s_4^*
$-s_2^*$	s_1^*	$-s_4^*$	s_3^*
$-s_3^*$	s_4^*	s_1^*	$-s_2^*$
$-s_4^*$	$-s_3^*$	s_2^*	s_1^*

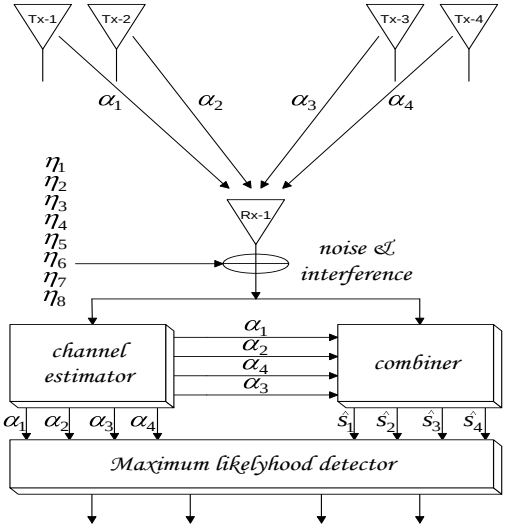

Fig. 6: Four-Branch Transmit Diversity with One Receiver

The combiner shown in Fig. 6 builds the following four combined signals [8], [3] that are sent to the maximum likelihood detector:

$$\hat{s}_1=2\left(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2\right)s_1+\alpha_1^*\eta_1$$
$$+\alpha_2^*\eta_2+\alpha_3^*\eta_3+\alpha_4^*\eta_4+\alpha_1\eta_5^*$$
$$+\alpha_2\eta_6^*+\alpha_3\eta_7^*+\alpha_4\eta_8^*$$
$$\hat{s}_2=2\left(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2\right)s_2+\alpha_2^*\eta_1$$
$$-\alpha_1^*\eta_2-\alpha_4^*\eta_3+\alpha_3^*\eta_4+\alpha_2\eta_5^*$$
$$-\alpha_1\eta_6^*-\alpha_4\eta_7^*+\alpha_3\eta_8^*$$
$$\hat{s}_3=2\left(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2\right)s_3+\alpha_3^*\eta_1$$
$$+\alpha_4^*\eta_2-\alpha_1^*\eta_3-\alpha_2^*\eta_4+\alpha_3\eta_5^*$$
$$+\alpha_4\eta_6^*-\alpha_1\eta_7^*-\alpha_2\eta_8^*$$
$$\hat{s}_4=2\left(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2\right)s_4-\alpha_4^*\eta_1$$
$$-\alpha_3^*\eta_2+\alpha_2^*\eta_3-\alpha_1^*\eta_4-\alpha_4\eta_5^*$$
$$-\alpha_3\eta_6^*+\alpha_2\eta_7^*-\alpha_1\eta_8^* \qquad (13)$$

After some manipulation we get,

choose, signal s_i if (in case of s_1)

$$\left(\left(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2\right)-1\right)|s_i|$$
$$+d^2\left(\hat{s}_1,s_i\right)\le$$
$$\left(\left(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2\right)-1\right)|s_k|$$
$$+d^2\left(\hat{s}_1,s_k\right)\qquad\forall\ i\neq k$$

choose, signal s_i if (in case of s_2)

$$(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2-1)|s_i|^2 + d^2(\hat{s}_2, s_i) \le (\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2-1)|s_k|^2 + d^2(\hat{s}_2, s_k) \quad \forall\ i \neq k$$

choose, signal s_i if (in case of s_3)

$$(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2-1)|s_i|^2 + d^2(\hat{s}_3, s_i) \le (\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2-1)|s_k|^2 + d^2(\hat{s}_3, s_k) \quad \forall\ i \neq k$$

choose signal s_i if (in case of s_4)

$$(\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2-1)|s_i|^2 + d^2(\hat{s}_4, s_i) \le (\alpha_1^2+\alpha_2^2+\alpha_3^2+\alpha_4^2-1)|s_k|^2 + d^2(\hat{s}_4, s_k) \quad \forall\ i \neq k \qquad (14)$$

For PSK signals (equal energy constellations)

$$|s_i|^2 = |s_k|^2 = E_s \quad \forall\ i,k$$

The maximal-ratio combiner may then construct the signal $\hat{s}_1, \hat{s}_2, \hat{s}_3$ and $\hat{s}_4$ as shown in Figure-3, so that the maximum likelihood detector may produce $\tilde{s}_1, \tilde{s}_2, \tilde{s}_3$ and $\tilde{s}_4$, which is a maximum likelihood estimate of s_1, s_2, s_3 and s_4.

5. MIMO-OFDM

STBC-OFDM with transmitting diversity is transformed into MIMO-OFDM by addition of receiving diversity. The block diagram of a MIMO system is shown in fig.7

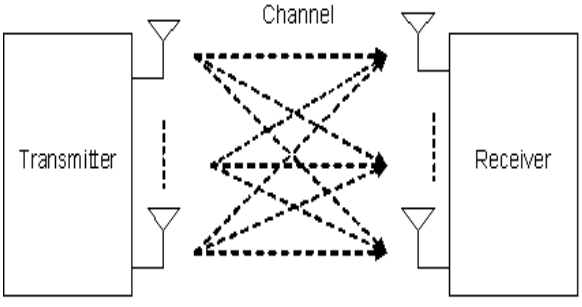

Fig. 7: Block diagram of a MIMO system

To utilize the receiving diversity scheme diversity combining is required. For selective diversity combining the instantaneous processed bit SNR/SIR at the output of the combiner is given by [4]

$$\gamma = \max\{\lambda 1, \lambda 2\} \qquad (15)$$

Here λ is the instantaneous Signal to Interference power Ratio (SIR) at each receiving antenna and γ is the instantaneous SIR of the combined branch. For a single antenna the pdf of λ is obtained as follows

$$P_1(\lambda) = \frac{A}{(\lambda + A)^2} \qquad (16)$$

Where, A denotes the average valueλ. The pdf of γ for the selection combining method is

$$P_2(\gamma) = \frac{2A}{(\lambda + A)^2} - \frac{2A}{(2\lambda + A)^2} \qquad (17)$$

The average Bit error probability without diversity is $Pe_1(A)$ and with diversity is Pe2(A)

$$Pe_1(A) = \int_{-\infty}^{\infty} Pe(\gamma) P_1(\gamma) d\gamma = \int_{-\infty}^{\infty} Pe(\gamma) \frac{A}{(\lambda + A)^2} d\gamma \qquad (18)$$

$$Pe_2(A) = \int_{-\infty}^{\infty} Pe(\gamma) P_2(\gamma) d\gamma = \int_{-\infty}^{\infty} Pe(\gamma) \{ \frac{2A}{(\lambda + A)^2} - \frac{2A}{(2\lambda + A)^2} \} d\gamma \qquad (19)$$

$$Pe2(A) = \int_{-\infty}^{\infty} Pe(\gamma) \{ \frac{2A}{(\lambda + A)^2} - \frac{2A}{(2\lambda + A)^2} \} d\gamma =$$

$$\int_{-\infty}^{\infty} Pe(\gamma) \frac{2A}{(\lambda + A)^2} d\gamma - \int_{-\infty}^{\infty} Pe(\gamma) \frac{2A}{(2\lambda + A)^2} d\gamma =$$

$$2 \int_{-\infty}^{\infty} Pe(\gamma) \frac{A}{(\lambda + A)^2} d\gamma - \int_{-\infty}^{\infty} Pe(\gamma) \frac{(A/2)}{(\lambda + \frac{A}{2})^2} d\gamma = 2 Pe_1(A) - Pe_1(A/2)$$

So for SIR=A, the relationship becomes:

$$Pe_2(A) = 2Pe_1(A) - Pe_1(A/2) \qquad (20)$$

For SNR=A the same result is found: $Pe_2(A) = 2Pe_1(A) - Pe_1(A/2)$

From the expressions we can conclude that for SINR=A the same relationship will hold. In this case, $Pe_1(A)$ represents BER for average SINR=A with single receiving antenna and $Pe_2(A)$ represents BER for average SINR=A with diversity combining of two receiving antennas. Substituting the unconditional BER of STBC-

OFDM with single receiving antenna in Equation (20) we obtain the unconditional BER for MIMO-OFDM with two receiving antenna. The convoultional coded BER for MIMO-OFDM systems can also be calculated deriving the equations.

5. RESULTS AND DISCUSSIONS.

5.1. MIMO-OFDM with STBC System

5.1.1 Bit Error Rate (BER)

The diversity gain is the function of many parameters, including the modulation scheme and the Forward Error Correction (FEC) coding. The information source is encoded using a apace-time block code, and the constellation symbols are transmitted from different antennas. The receiver estimates the transmitted bits by using the signals of the received antennas. Following the analysis in section 4 a multiple-antenna wireless communication system is evaluated under the assumption that fading is quasi-static and flat so that the path gains are constant.

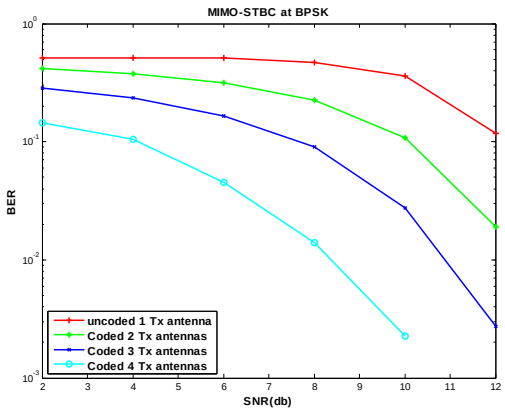

Fig. 8: BER versus SNR for MIMO-STBC at BPSK.

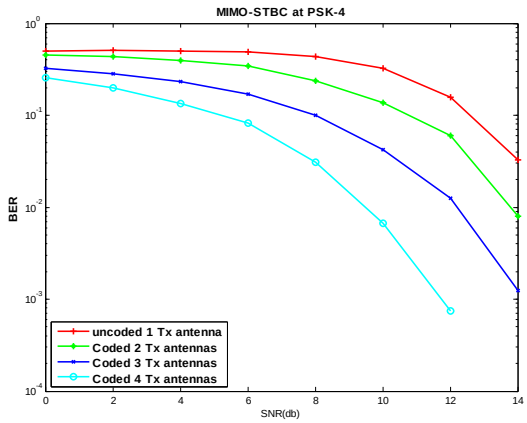

Fig. 9: BER versus SNR for MIMO-STBC at PSK-4

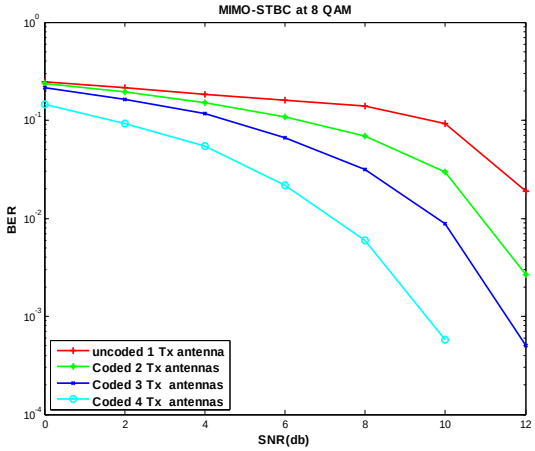

Fig. 10: BER versus SNR for MIMO-STBC at 8QAM

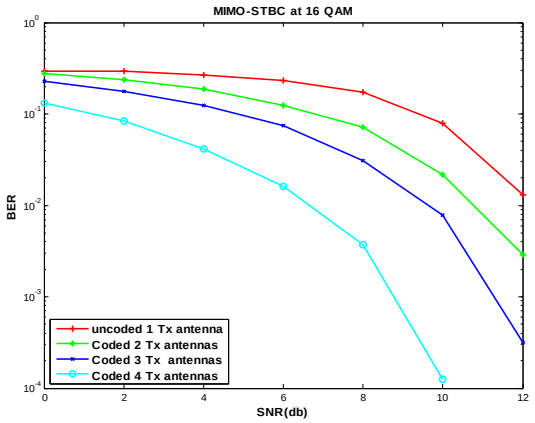

Fig. 11: BER versus SNR for MIMO-STBC at 16-QAM

Fig. 8, 9, 10 and 11 shows bit error rate, the result reported for BPSK, PSK-4, QAM-8, QAM-16 respectively and STBC using one, two, three and four antennas transmit antennas and one receive antenna. BER for uncoded transmission is maximum in all the above cases and reduces consecutively with the use of STBC. Since the code rate of uncoded and G_2 are 1 and the code rate of G_3, G_4 are ½. In all the above cases, the BER performances have improved significantly. The BER is minimum for four transmit antennas and lowest in case of 16-QAM. About 4-dBm power penalty can be achieved from BPSK to 16-QAM coded transmission. The transmit diversity with space-time block code and multiple transmit antennas, a significant performance gain is achieved at almost no processing expense.

The transmission rate for BPSK uncoded and $\mathcal{G}_2$ is 1 bits/s/Hz and transmission rate for $\mathcal{G}_3$, $\mathcal{G}_4$ is 0.5 bits/s/Hz, in case of PSK-4 transmission rate for uncoded and $\mathcal{G}_2$ is 2 bits/s/Hz and transmission rate for $\mathcal{G}_3$, $\mathcal{G}_4$ is 1 bits/s/Hz, in case of QAM-8 transmission rate for uncoded and $\mathcal{G}_2$ is 3 bits/s/Hz and transmission rate for $\mathcal{G}_3$, $\mathcal{G}_4$ is 1.5 bits/s/Hz, in case of QAM-16 transmission rate for uncoded and $\mathcal{G}_2$ is 4 bits/s/Hz and transmission rate for $\mathcal{G}_3$, $\mathcal{G}_4$ is 2 bits/s/Hz.

5.1.2 Symbol Error Rate (SER)

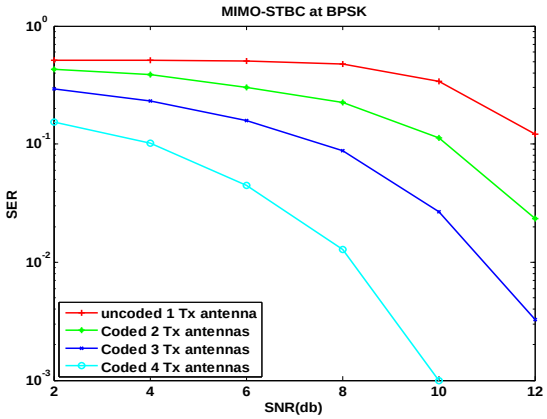

Fig. 12: SER versus SNR for MIMO-STBC at BPSK

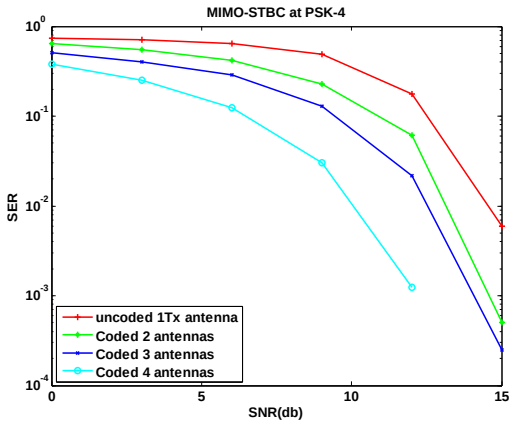

Fig. 13: SER versus SNR for MIMO-STBC at PSK-4

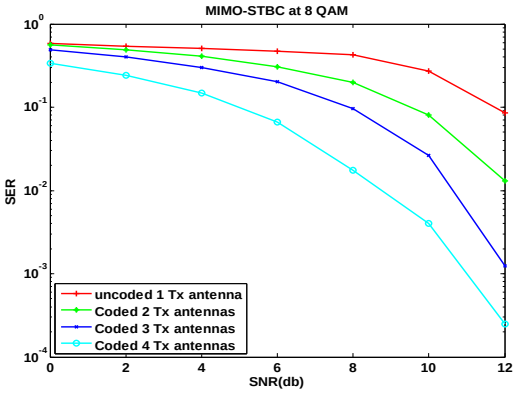

Fig. 14: SER versus SNR for MIMO-STBC at 8-QAM

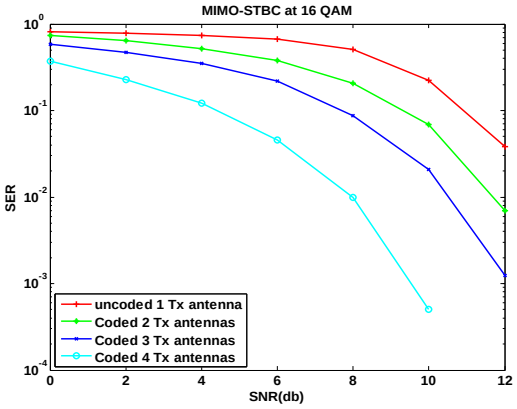

Fig. 15: SER versus SNR for MIMO-STBC at 16-QAM

The simulated results reported on fig. 12, 13, 14 and 15 shows symbol error rate (SER) for BPSK, PSK-4, QAM-8, QAM-16 respectively with STBC using one, two, three and four transmit antennas and one receive antenna. [9], [10] It is to be noticed here that, the SER is minimum for BPSK, in case of four transmit antennas with one receiver. For uncoded transmission, SER is maximum for BPSK and minimum for 16-QAM. [8] BPSK performs the best, considering the SER and the power penalty with multiple transmit diversity. The code rate of uncoded and $\mathcal{G}_2$ are 1 and the code rate of $\mathcal{G}_3$, $\mathcal{G}_4$ are ½. In all the above cases, the Symbol Error Rate (SER) performances have improved significantly in general with multiple transmits diversity.

The above simulation results displayed that, significant gain can be achieved by increasing the number of the transmit antennas with very little deciding complexity at the receiver. In all the cases it is to be noted that, the three and four transmit antennas sacrifice some transmission rate compare to uncoded and two transmit antennas where the transmission rate is 1.

5.2 MIMO-OFDM Link with STBC, with and without Receiving Diversity.

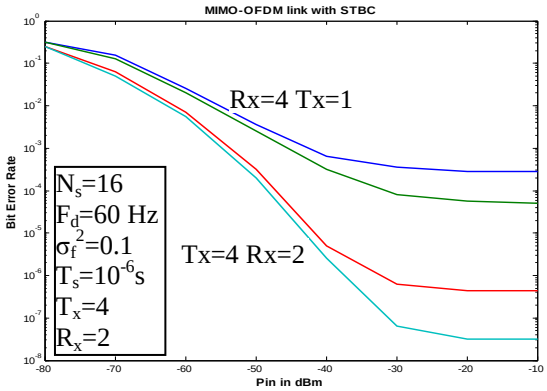

Fig.16: Plots of BER vs. P_{in} (dBm) for MIMO-OFDM Link with STBC with & without receiving diversity (DQPSK)

The performance comparison of MIMO-OFDM link with STBC [3] with and without receiver diversity are shown in fig. 16 based on the analysis in section 5 There is two pair of curves, each containing one without jitter and another with jitter variance of 0.2. The significant improvements of performances are noticed with the antenna diversity in the receiver side. The plot shows that the BER reduces from 10^{-3} to 10^{-6} in presence of jitter σ_ϵ^2=0.2 and $10^{-4.25}$ to $10^{-7.5}$ in absence of jitter by deploying diversity combining in receiving side with **two receiving antenna**. The BER floors at $10^{-6.25}$ in presence of jitter [12] and at $10^{-7.5}$ in absence of jitter with four transmit and two receive antennas. This shows that the diversity at the receiving end shall also improve the performances significantly. The performances with the increase of receiver diversity may further improve sacrificing the cost effectiveness and complexity at the receiver end.

5.3 MIMO-OFDM Link with Convolutional Coding with Receiving Diversity

The performances of **MIMO-OFDM link with STBC** are shown in fig. 17. The plots is the DQPSK modulation system with and without Convolutional coding in presence of jitter considering four transmitting and two receiving antenna. For convolution code of rate ½, the coding gain is 35 dB for constraint length K=6 and 36 dB for K=7 at an uncoded BER of 10^{-6}. The BER floors at 10^{-6} for uncoded, at 10^{-27} for Convolutional coded with R=1/2 and K=6 and at 10^{-35} with R=1/2 and K=7 which is the **minimum** amongst all the cases as discussed above. It is also reflected that, the coding gain is substantially higher in K=7 than in K=6 for higher amount of input power.

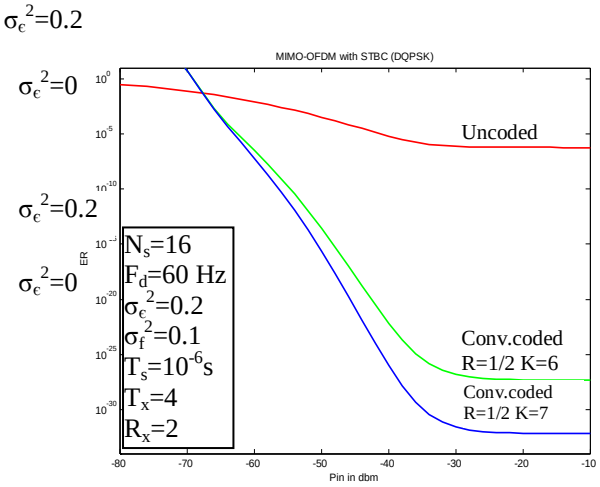

Fig. 17: BER vs. P_{in} (dBm) with and without Coding for STBC MIMO-OFDM (DQPSK)

We have shown the diversity scheme with two, three and four transmit antennas with one and two receive antenna. The systems may differ in the practical implementation process. Some of the differences amongst the schemes are power requirements, sensitivity to channel estimation error, the delay effects, antenna configuration, soft failure and impact on interference. The important conclusion is that, new scheme provides significant performance improvement due to STBC/Convolutional coding and multiple antenna diversity.

6. CONCLUSION

The reliability of the wireless link can improve using MIMO-STBC system. Increasing the number of antenna at both ends can enhance the reliability of the system proportional with diversity gain. This result can be achieved with no increase in transmitted power and with no cost of extra bandwidth. The robustness of the system in fading channel environment made it as a possible candidate technology fro new generation of wireless system.

The performance of MIMO system is highly depending on channel estimation algorithms. The high performance channel estimation can improve the performance efficiency of the system by 3 dB. Therefore the application of high performance and efficient channel estimation in order to increase

the performance of MIMO or MIMO-OFDM system is essential.

There is a lot of technical point which should be considered in designing real MIMO system. As an example in real condition with high relative mobility the channel is time varying. Therefore, the quisi-static assumption can not be made. Another issues is the assumption of synchronization of the receive signal at different receive of antenna. This problem is very critical while doing decoding in the receiver. Rich scattering environment is another assumption which is usually made in MIMO-OFDM system, therefore the application of MIMO-OFDM system in outdoor wireless application raise the technical problem which is need to be addressed.

The above simulations and analytical results demonstrate that significant gains can be achieved by increasing the number of transmit antennas with very little decoding complexity. In all cases three and four transmit antennas sacrifice some transmission rate compare to uncoded and two transmit antennas. The important conclusion is that the new schemes provides performance gain with increasing transmit and receive antennas.

References:

[1] Grag V.K. "Wireless Communication and Networking" Morgan Kaufmann Publishers-Printed on 2007.

[2] Hanzo L., Munster M., Choi B. J. and Keller T. "OFDM and MC-CDMA for Broadband Multi-User Communications, WLANs and Broadcasting" Reprinted March 2004, June 2004.

[3] Abdolee R. "Performance of MIMO Space-Time Coded system and training based channel estimation for MIMO-OFDM system" Universiti Teknology Malaysia -2006/2007

[4] WIKIPEDIA, the free Encyclopedia, and Websites based on MIMO-OFDM with STBC, different Multiplexing and Multiple accesses, Diversity and different codes.

[5] Peng J. Y. "Design an implementation of a MIMO-OFDM system for WLANs"- College of Electrical Engineering and Computer Science, National Central University, Taoyuan, Taiwan, Republic of China.

[6] Alamouti S.M. " A simple transmitter diversity scheme for wireless communications," IEEE J. Select. Areas Commun, Vol. 16, pp. 1451-1458, oct. 1998.

[7] V. Tarokh, H. Jafarkhani, and A. R. Calderbank, "Space–time block codes from orthogonal designs," *IEEE Trans. Inform. Theory*, to be published

[8] Kar A., Majumder S.P. "Performance study of space-time block code for wireless communication" Department of EEE, BUET, Dhaka-1000, Bangladesh.

[9] Zhang Y. and Liu H. "Impact of Time-Selective Fading on the Performance of Quisi-Orthogonal Space-Time Coded OFDM System" IEEE Transactions in Signal Processing, vol. 54 no. 2, February 2006.

[10] SASAMORI F., HANDA S. and OSHITA S. "A Simple method of BER Calculation in DPSK/OFDM Systems over Fading Channel" IEICE Trans Fundamentals. vol. E88-A no 1
January 2005.

[11] Sasamori, F., Umeda, H., Handa, S., Maehara, F., Takahata, F., and Oshita, S., "Approximate Equation of Bit Error Rate in DQPSK/OFDM Systems Over Fading Channels", European Wireless 2002, pp 602-607, February 2002.

[12] Tomba, L., Krzymien, W. A., "A Model for the Analysis of Timing Jitter in OFDM Systems", IEEE International Conference on Communications (ICC 98), Vol-3, pp 1227-1231, 7-11 June 1998.

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