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ENERGY PERFORMANCE ANALYSIS OF AN OFFICE BUILDING USING BIM: A CASE STUDY ON JANATA BANK BUILDING AT KUET, BANGLADESH.

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ABSTRACT
Nowadays emphasis on construction of energy efficient building has increased and the relevant studies have been high priority worldwide, especially in developed country. As a developing country, the practice on energy efficient building in Bangladesh is not as much as in developed countries. High-energy consumption is a major issue concerning in climate change, global worming etc. This study executes the energy performance analysis and optimization of an existing building. The aim of this study is to deal with the BIM (Building Information Modeling) grounded energy performance analysis and optimize utilizing Revit and Green Building Studio. The building model was developed in Revit and then energy analysis was performed in Green Building Studio. Performing the energy simulation of the building a comprehensive data of energy performance was obtained in terms of heating load, cooling load, electricity and fuel consumption. Life cycle energy cost is $80555 and annual carbon emission is 14 tons per year. After optimizing the energy system annual electricity consumption reduced by 9% and annual carbon dioxide emission reduced by 3 tons per year.

Keywords: BIM; Energy Efficient Building; Energy simulation; Office Building; Bangladesh

INTRODUCTION
The rapidly developing global energy usage has already raised issues over supply problems, exhaustion of electricity assets and solar energy and heavy environmental impacts. Climate change, global worming, environmental degradation these are the result of increasing of consumption of energy. So energy consumption has been a vital issue globally. There are various institutions as like the European Environment Agency (EEA), the U.S. Energy Information Administration (EIA) and the International Energy Agency (IEA), which record and publish energy data periodically. Energy consumption from buildings globally, both in residential and commercial, has increased and it lies between 20% and 40% in developed countries (Pérez-Lombard, Ortiz, & Pout, 2008). The increase in population, demand of building services and comforts level will contribute to the continuing of rise of energy consumption. So demand for energy efficient building is increasing day by day. The main cause of using energy efficient materials is to reduce the use of artificially generated power (Moon & Kim, 2010). Due to assessing the building energy performance, Building Information Model (BIM) Tools are used. It helps to analyze the energy consumption, to identify the alternative energy solution and energy saving substitutions in the design phase (Zhou, Zhang, Zuo, Huang, & Zhang, 2015). BIM is the digital execution of the physical and functional features of building project and its life cycle (Wu, 2013). Over the past couple of decades different types of building energy simulation and analysis tools as like EnergyPlus, BLAST, TRACE, eQUEST, DOE2, Ecotect, Integrated Environmental Solution (IES-VE) and Green Building Studio has developed and implemented in the building industry (Cowie, Hong, Feng, & Darakdjian, 2017; Crawley, Hand, Kummert, & Griffith, 2008). According to a survey of 91 design and construction firms in the United States found that there are three commonly used BIM-based

sustainability analyses software like Autodesk Ecotect, Autodesk Green Building Studio (GBS), and Integrated Environmental Solutions (IES-VE) (Azhar, Brown, & Sattineni, 2010). In the recent years, the use of Building Information Modeling (BIM) has increased in the construction industry (Jalaei & Jrade, 2015). There are different types of inter-operable file format for BIM tools as like Industry Foundation Classes (IFC), Extensible Markup language (XML). These are used to share information from one BIM tool to another. According to the study of (Jrade & Jalaei, 2013), gbXML has a simplified schema for energy analysis. Revit is used for visualizing the 3D views of the proposed building, which executes the complex geometric or functional information. In this Study to optimize the energy consumption some passive measures were taken as like green roof, high insulated materials(Expanded polystyrene) related to low thermal conductivity, change of window wall ratio about less than 30% (Wang, Zmeureanu, & Rivard, 2005). The following table-1 executed the thermal conductivity of different materials that is used for insulation and the lowest thermal conductive material is Expanded Polystyrene (EPS). The following table's data is in accordance with DOE (US. Department Energy) and (Heravi & Qaemi, 2014).

Table 1: Thermal conductivity of different materials

Name of materials	Thermal conductivity(W/mK)
Earth	0.837
Expanded Polystyrene(EPS)	0.033
Glass, Clear Glazing	1.100
Glass-Marvin-IG Low E II with Argon	0.753
Glazing -glass	0.209
Gypsum Wall Board	0.650
Jute Fiber	0.067
Plastic	0.502
Rock Wool	0.034
Natural Rubber Foam	0.042
Concrete	1.750

Energy performance analysis would be helpful for the designers and owners to take the decision about energy related facts that is involved with building life cycle energy cost (Kriegel & Nies, 2008). It also collaborates the respective person involving with building design to have a decision about sustainable building design.

Since energy consumption and CO_2 emission due to building is increasing worldwide, energy efficient building has been key concern to prevent the negative consequences of vast amount of energy consumption (Nejat, Jomehzadeh, Taheri, Gohari, & Majid, 2015). Bangladesh is not out of this significant need to contribute in creating a green, sound and safe world. Therefore, this analysis was conducted on an office building at Khulna University of Engineering and Technology (KUET) campus, in Bangladesh to analyze the building energy performance of an existing building using Green Building Studio and Revit and compare the base run results with optimized results.

BUILDING DESCRIPTION

It is a well-furnished two-storied office building that is used for performing activities related a bank. It is located in Khulna, Bangladesh. It considered for a case study analysis. The gross floor area of the house is 3,963 Square feet (sf).Exterior wall area is 2,219 sf. Each story has an internal height of 10 feet and 6 inches. Windows of the building are of high performing double glazing aluminum frame. A staircase connects the two stories.

RESEARCH METHODOLOY

A systematic way followed due to analyzing the energy performance of a proposed building. In initial stage, the relevant information was collected of the existing building to prepare a 3D model of the building to visualize the different views of the building. Then the interior energy analysis was performed using Green Building Studio (GBS). Due to analyze the energy performance in Green Building Studio, the Revit file was transferred to Green Building Studio as gbXML file format.

Energy Analysis Process and Optimization

The [Fig. 1 and 2] executed the overall process of energy performance analysis. Total energy evaluation system is categorized in two issues, one is the influencing factors and another is energy analysis. Again, the influencing factors include climate, design and occupant. Occupant and climatic information are taken to the BIM tool as location is specified. Design factors depend on the building orientation, building types like whether it is office building, residential building or others. Materials information that were used in preparing the 3D model of the building in Revit-2017 are extracted in the form of gbXML file format and imported in the energy analysis tool.

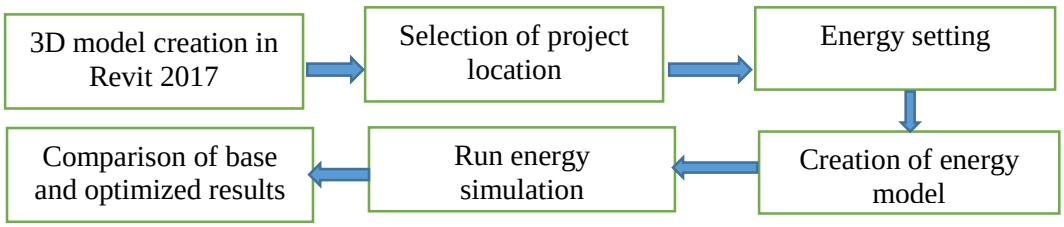

Fig. 1: Flow diagram of energy performance analysis

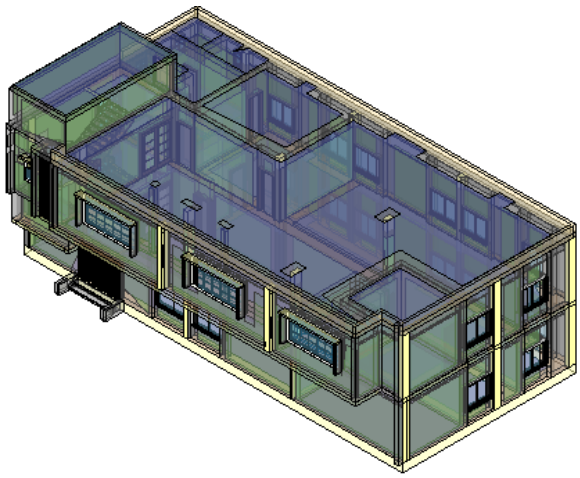

Fig. 2: Energy analytical model of the analyzed building

Two BIM tools were used to analyze the energy. After preparing the energy model in Revit-2017, energy analytic model was prepared by selecting the building location, building type as office building and operating schedule as 12 hours per day and 5 days per week (12/5).

After performing the energy analysis, the following items were determined.

- LCEC- Life Cycle Energy Cost
- EUI- Energy Use Intensity
- CO_2 emission

Finally, due to performing energy optimization by high-insulated materials (Expanded Polystyrene) with low thermal conductivity, high performance glass (double-glazing), green roof, reduction of window wall ration (WWR) (less than 30%) was considered. In this context, the main items for optimization was wall insulation, roof, WWR, glass performance, orientation as a measure passive optimization. Then the base run analysis and optimized results are compared.

RESULTS AND DATA ANALYSIS

After analysis the building model at the initial and optimized condition incorporating all the relevant information following results were found and compared each other. There are considered some factors by default in accordance with building type and location of the building as like occupants, average lighting power, electricity unit cost, fuel cost per unit etc.

Energy Use Intensity (EUI)

According to Table 2(a) & 2(b), it was found that the energy use intensity for electricity is 17 kWh / sf / year and fuel is 2 kBtu / sf / year. As a whole, energy use intensity is 59 kBtu / sf / year. (1 kWh = 3.14 kBtu, sf= square feet). After optimizing, the building electricity use intensity reduced about 1 kWh/sf/year and total EUI decreased to 56 kWh/sf/year.

Table 2 (a): Base Run (EUI)

Electricity EUI:	17 kWh / sf / year
Fuel EUI:	2 kBtu / sf / year
Total EUI:	59 kBtu / sf / year

Table 2 (b): Optimized Run (EUI)

Electricity EUI:	16 kWh / sf / year
Fuel EUI:	2 kBtu / sf / year
Total EUI:	56 kBtu / sf / year

Life Cycle Energy Cost (LCEC)

According to Table 3(a) & 3(b), it was found that the total life cycle energy cost is about $80,555. Life cycle time period is considered by the tool is about 30 years. (1kWh = 0.034 Therms). After optimizing, life cycle energy cost for about 30 years reduced from $80555 to $73,279. Life cycle electricity usage decreased in 170276 kWh and fuel consumption decreased in 48 Therms.

Table 3 (a): Base results (LCEC)

Life Cycle Electricity Use:	1,872,490 kWh
Life Cycle Fuel Use:	2,050 Therms
Life Cycle Energy Cost:	$80,555

Table 3(b): Optimized results (LCEC)

Life Cycle Electricity Use:	1,702,214 kWh
Life Cycle Fuel Use:	2,002 Therms
Life Cycle Energy Cost:	$73,279

Renewable Energy Potentials (REP)

From the Table 4(a) & 4(b), it was found that there is better renewable energy potential using roof mounted photovoltaic (PV) cell and it is about 40001 kWh/year. There is also another energy generation potential from using single 15 feet wind turbine. PV efficiencies are assumed 5%, 10% and 15% for low, medium and high efficiency systems. After optimizing the building energy system, renewable energy potential has increased. Maximum amount of energy potential has increased by high efficiency roof mounted photovoltaic cell system and it is about 320 kWh/ year than previous. There is no change for wind turbine system. In the case of optimization, some measures like WWR, orientation of the building, insulating materials and so on were considered. These measurements increased the amount of renewable energy potential like increasing the space by decreasing WWR helps to set more PV system. Renewable energy sources, like solar energy, have not been incorporated to optimize the energy. Analysis by BIM tools of the building model only showed the potentiality of renewable energy sources.

Table 4 (a): Base run results (REP)

Roof Mounted PV System (Low efficiency):	13,334 kWh / year
Roof Mounted PV System (Medium efficiency):	26,667 kWh / year
Roof Mounted PV System (High efficiency):	40,001 kWh / year
Single 15' Wind Turbine Potential:	436 kWh / year

Table 4(b): Optimized results (REP)

Roof Mounted PV System (Low efficiency):	13,440 kWh / year
Roof Mounted PV System (Medium efficiency):	26,881 kWh / year
Roof Mounted PV System (High efficiency):	40,321 kWh / year
Single 15' Wind Turbine Potential:	436 kWh / year

Annual Carbon-dioxide Emission

[Figure 3(a)] showed that net carbon dioxide (CO_2) emission at existing condition is 14 tons per year. There is great potential of energy generation using photo-voltaic cell is 24 tons per year and carbon dioxide emission by electricity consumption is 38 tons per year. In case of optimized result, there annual carbon emission has decreased. The following [Fig. 3(a) & 3(b)] showed the reduction of carbon emission per year is 3 tons. It occurred due to reduction of electricity consumption.

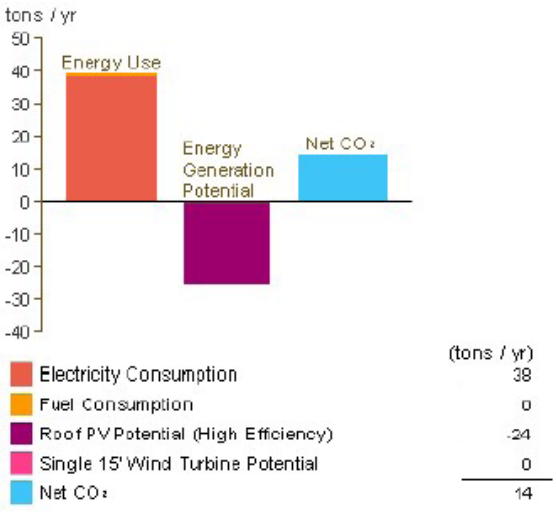

Fig. 3 (a): Base run of CO_2 emission

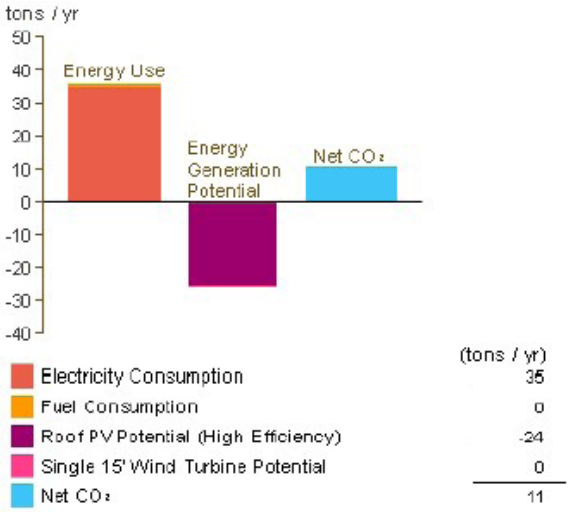

Fig. 3 (b): Optimized CO_2 emission

CONCLUSIONS

The faster increase in global energy usage has developed some vital issues over supply problems, exhaustion of electricity assets and solar energy and heavy environmental impacts. About 40% of the total energy is consumed by building. Therefore, energy efficient building has great impact to reduce the harmful effect of building energy consumption. Due to designing of energy-efficient and high-performance buildings equates that building performance and simulations tools are utilized. The aim of this research was to document the energy performance analysis of existing building and comparative analysis of base run simulation and optimized simulation results. According to the analysis in current situation, Life cycle electricity and fuel consumption is 1872490 kWh and 2050 Therms respectively. After optimization, energy consumption is reduced by taking some optimizing measures as like building envelop, green roof, changing window wall ratio etc. Life cycle electricity consumption reduced by 9% and it is about 170276 kWh. It also reduced carbon dioxide emission about 3 tons per year. Analysis also executed the renewable energy potentiality and maximum amount 40321KWh/year was gained through use of high efficiency roof mounted PV. This analysis would assist the designers and owners to some significant decisions over reducing the energy consumption and CO_2 emission to approach in an energy efficient building and they can use the lesson learn from this analysis in their future works.

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FACTORS AFFECTING THE BIM ADOPTION IN THE CONSTRUCTION INDUSTRY OF BANGLADESH

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ABSTRACT
Building Information Modeling (BIM) empowers organizations in architecture, engineering and construction (ace) industries to change a chain of technological improvements to improve the chain of construction. Considerable effects through BIM execution might be accomplished all through all phases of the development procedure. This exploration shows by means of 40 responses from an example of BIM users that coordinated effort perspectives create the most elevated positive effect. The paper quantifies BIM use throughout the project lifecycle, assuring BIM is largely used in the design phases. BIM requires investment in software and training however, smaller practices can manage the cost of it. Stakeholder's contribution for BIM adoption is ranked concluding that project managers contribute most to adopt BIM. The main reasons currently used for the BIM have been identified and the results indicate a lack of training for existing non-BIM personal and efficiency of BIM software. It will help Government agencies of Bangladesh government to properly plan to take BIM in the life cycle of construction projects and support implementation.

Keywords: Building Information Modelling; BIM adoption; Key factors; Project Management; Project life cycle.

INTRODUCTION
BIM (Building Information Modeling) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. To simulate the planning, design, construction and maintenance phases of a project it requires the development and use of a computer-generated model(Azhar, 2011). UK Government thinks that its use brings many advantages in the project(Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013). BIM is much more than three-dimensional (3D) perception or exchanging the electronic renditions of paper records. Through BIM execution, risks are decreased, plan expectation is kept up, the construction is streamlined(Azhar, 2011; Goedert & Meadati, 2008; Nath, Attarzadeh, Tiong, Chidambaram, & Yu, 2015; Qian, 2012; Tse, Wong, & Wong, 2005).BIM is an up and coming innovative apparatus through which digitized data can be utilized keeping in mind the end goal to help enhancements in profitability and accomplish successful and efficient administration for the duration of the existence cycle of a facility. With the help of BIM, clients may assess possible conflicts ahead of time so as to accomplish best construction (Azhar, 2011; Chien, Wu, & Huang, 2014; Nath et al., 2015; Qian, 2012). It is accounted for that the wreath of BIM adoption in Singapore in years 2009, 2012, 2014 was 20%, 32%and 65%, respectively (Qian, 2012). In a review directed in 2007, the use of BIM and IFC consistent BIM applications in Finland was assessed to be 33% (Kiviniemi, Sulankivi, & Mäkelä, 2007). In a similar overview, it was watched that in Finland, 93% of the designer firms were utilizing BIM for a few

sections in their tasks though the architect's use was almost 60%. The usage of BIM in Denmark is increasing. According to the survey which was done in 2006 (Kiviniemi, 2009), the most commonly used BIM application among architects was Architectural Desktop with approximately 35% of the firms using it. It also expressed that about 50% of the architects, 29% of clients and 40% of engineers in Denmark were using BIM for several portions of their projects in 2006. In this research, Key Factors will be the essential factors that significantly affect BIM adoption in Bangladesh's AEC industry. In this investigation, the information were gathered through a survey-based overview directed for construction firms in Bangladesh.

LITERATURE ANTICIPATING TO BIM

A. BIM application across the project lifecycle

This study explored the use of BIM at the different steps in the construction lifecycle and analyzing the significance of the impacts in the application of BIM. For the objectives of this exploration, the undertaking lifecycle is characterized as incorporating feasibility, design, construction, operation and maintenance. Key literature characterizes the different steps utilizing BIM as feasibility (Azhar & Brown, 2009; Cheung, Rihan, Tah, Duce, & Kurul, 2012), design (Azhar & Brown, 2009; Azhar, Carlton, Olsen, & Ahmad, 2011), preconstruction (detail design and tender) (Azhar, 2011; Azhar et al., 2011; Ibrahim, Krawczyk, & Schipporeit, 2004), construction (Azhar et al., 2011) and operation and management (Ibrahim et al., 2004). BIM is referred to as being valuable and giving advantages at these stages be that as it may, precluded from the literature is the recurrence of utilization by associations at each phase of the project lifecycle.

B. Stakeholders contribution on BIM adoption

The viewpoint of the stakeholders with respect to BIM in the AEC area is essential since they achieve direct benefits from its adoption. The BIM approach can exceptionally enhance the coordinated effort among them conveying an additional incentive to their business. For sure, as per (Arayici et al., 2011) the joint effort among stakeholders can increment authoritative limits which improve the execution of the task administration amid the design and construction process. In any case, each stakeholder of AEC division has their individual work process and demands, so their BIM offer is extraordinary. As a rule, it changes in view of specialization of a stakeholder or phase of the building process (design, building supply, construction, etc.). Different stakeholders concur on the basic issue of interoperability between software that can upset the capacity to encounter an incentive from BIM. Architects are the significant clients of BIM(Travaglini, Radujković, & Mancini, 2014)and they encounter an abnormal state of significant worth additionally as far as Return-of-Investment (ROI). Engineers like architects encounter high an incentive from BIM and in addition saw Return-of-Investment (ROI).

C. Barriers for not using BIM

The barriers for not using BIM on some projects were observed. The following important barriers were selected from study outlined below:

- Lack of expertise within the project team (Ku & Taiebat, 2011; Mayo, Giel, & Issa, 2012)
- Lack of client demand (Birkeland, 2009)
- Investment cost (Giel, Issa, & Olbina, 2009)
- Lack of additional project finance to support BIM (Bazjanac, 2006)
- Training in BIM software for using BIM (Christensen, McNamara, & O'Shea, 2007)

D. Key factors for BIM adoption

Key factors are the influence factors that are most imperative to the conduct of the framework and most impact the prosperity of the procedure in the industry. Key factors are the influence factors that successfully affect on decision making (Ogilvy & Schwartz, 1995). The following important key factors were identified from literature outlined below:

- BIM Training for Existing Non-BIM Personal
- Efficiency of BIM Software

- Initial Investment Cost
- Potential Benefits of BIM
- Organizations Financial Resources
- Facility Management
- Government Support
- Site Layout Planning and Site Safety
- Software and Hardware Upgrading and Maintenance Cost
- Prequalification of Team Member

METHODOLOGY

The questionnaire was planned from literature review and stakeholder's interviews. An online/email-based survey was used to collect data from respondents. The survey was conducted among the construction stakeholders in Bangladesh, such as architects, engineers, main contractors as well as the facility managers. The participants included have past involvement with CAD and are additionally during the time spent relocating towards a BIM-based approach and using BIM instruments.

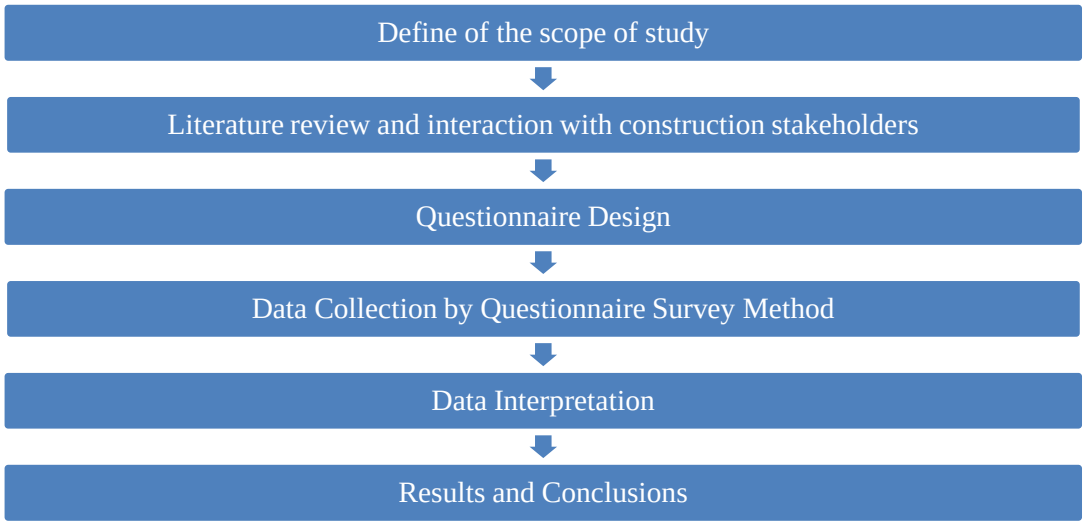

Fig.1: Methodology of the study

DATA ANALYSIS

Relative Importance Index (RII) was used for analysis of data. It helps to rank the factors from collecting data.

RII is defined by the following formulae:

Relative Importance Index (RII) = $\frac{\sum W}{AxN}$ $(0 \leq \text{index} \leq 1)$ (1)

Where, W is the weight given to each factor by the respondents and ranges from 1 to 5.

W ranges

1 = Least important
2 = Somewhat important
3 = Moderate
4 = Important
5=Very Important

A is the highest weight = 5.

N is the total number of respondents.

RESULTS AND DISCUSSION

BIM application across the project lifecycle

Table 1: BIM use during the construction stages

Use during the construction project stages	Rank 5	Weight 5	Rank 4	Weight 4	Rank 3	Weight 3	Rank 2	Weight 2	Rank 1	Weight 1	Total	∑W	RII	Rank
Design	18	90	13	52	3	9	3	6	3	3	40	160	0.8	1
Construction	9	45	20	80	5	15	3	6	3	3	40	149	0.745	2
Operation & Maintenance	3	15	20	80	8	24	3	6	6	6	40	131	0.655	3
Preconstruction	6	30	17	68	3	9	4	8	10	10	40	135	0.625	4
Feasibility	0	0	22	88	1	3	6	12	11	11	40	114	0.57	5

The results in Table-1 indicates that BIM is most used in the design stage (RII 0.8), rank 1. The second-place ranking of application across the project lifecycle of BIM is construction stage (RII 0.745). BIM is least used in the operation and maintenance stage as RII 0.655, rank 3. The preconstruction stage is ranked 4 (RII 0.625). Feasibility stage is a potential area for future research to adapt BIM software (RII 0.57), rank 5.

Barriers for not using BIM

Table-2: Ranking of barriers for not using BIM.

Reasons for not using BIM	Rank 5	Weight 5	Rank 4	Weight 4	Rank 3	Weight 3	Rank 2	Weight 2	Rank 1	Weight 1	Total	∑W	RII	Rank
Training in BIM software	17	85	15	60	8	24	0	0	0	0	40	169	0.845	1
Expertise with the project team	6	30	31	124	3	9	0	0	0	0	40	163	0.815	2
Investment cost	3	15	15	60	16	48	3	6	3	3	40	132	0.66	3
Client demand	3	15	12	48	21	63	0	0	4	4	40	130	0.65	4
Additional project finance	0	0	21	84	7	21	3	6	9	9	40	140	0.60	5

Table-2 indicates that the top two barriers for not using BIM are “Training in BIM software” (RII, 0.845) and “Lack of expertise within the project team” (RII, 0.815). BIM has some lack of adoption and it can be filled by potential education and essential training. Investment cost as a reason for not using BIM was ranked third (RII, 0.66). Client demand was less important in the construction and ranked fourth (RII, 0.65). The RII value given to “additional project finance” (0.60) indicates that finance is less needed for BIM adoption on the project.

Stakeholder’s contribution in BIM

Table-3: Ranking of Stakeholder’s contribution in BIM

Stakeholder’s	Rank 5	Weight 5	Rank 4	Weight 4	Rank 3	Weight 3	Rank 2	Weight 2	Rank 1	Weight 1	Total	∑W	RII	Rank
Project Managers	9	45	25	100	6	18	0	0	0	0	40	163	0.815	1
Consultants	8	40	17	68	9	27	3	6	3	3	40	144	0.72	2
Main Contractors	11	55	12	48	11	33	0	0	6	6	40	142	0.71	3
Clients	3	15	17	68	11	33	6	12	3	3	40	131	0.655	4
Sub-Contractors	6	30	10	40	17	51	0	0	7	7	40	128	0.64	5
Suppliers	6	30	3	12	17	51	8	16	6	6	40	115	0.575	6

Table-3 indicates that the top two stakeholder’s contributions in BIM on projects are “Project Managers” (RII, 0.815) and “Consultants” (RII, 0.72). Project managers contribute most to adopt BIM on projects. Client’s contributions to adopt BIM on projects are less important (RII, 0.655). The RII value given to “Suppliers” (0.575) indicates that suppliers are not important for BIM adoption on projects.

Identify key factors for BIM adoption

Table-4: Key Factors for BIM adoption:

Key factors	Rank 5	Weight 5	Rank 4	Weight 4	Rank 3	Weight 3	Rank 2	Weight 2	Rank 1	Weight 1	Total	∑W	RII	Rank
BIM Training for Existing Non-BIM Personal	9	45	13	52	18	54	0	0	0	0	40	151	0.755	1
Efficiency of BIM Software	4	20	25	100	8	24	3	6	0	0	40	150	0.75	2
Initial Investment Cost	3	15	21	84	16	48	0	0	0	0	40	147	0.735	3
Potential Benefits of BIM	0	0	26	104	14	42	0	0	0	0	40	146	0.73	4
Organizations Financial Resources	3	15	24	96	5	15	8	16	0	0	40	142	0.71	5
Facility Management	0	0	24	96	13	39	0	0	3	3	40	138	0.69	6
Government Support	12	60	9	36	6	18	10	20	3	3	40	137	0.685	7
Site Layout Planning and Site Safety	6	30	9	36	19	57	1	2	5	5	40	130	0.65	8
Software and Hardware Upgrading and Maintenance Cost	0	0	21	84	13	39	0	0	6	6	40	129	0.645	9
Prequalification of Team Member	0	0	18	72	14	42	5	10	3	3	40	127	0.635	10

The results in Table-4 shows that the top three key factors for BIM adoption are “BIM Training for Existing Non-BIM Personal” (RII, 0,755), “Efficiency of BIM Software” (RII, 0.750) and “Initial Investment Cost” (RII, 0.735). Organizations financial resources (RII, 0.71) are less important as a key factor for BIM adoption. The RII value given to “Prequalification of Team Member” (0.60) indicates that prequalification is less needed for BIM adoption on the project.

CONCLUSSION

The output of this research revealed that BIM has been widely used in the design and construction stages while rarely used in the operation and management stage, which is stood ranked third. BIM is little used in the pre-construction phases (ranked fourth). Moreover, the study has been incorporated the level of stakeholder’s contribution in projects. From the survey results, it has been found that top two stakeholder’s contributions in BIM adoption on current projects are “Project Managers” and “Consultants” which is stood rank respectively. On the other hand, Client’s contributions to adopt BIM on projects are less important in the construction industry in Bangladesh.

From the survey results it also been identified some influencing factors that affecting BIM adoption and execution in Bangladesh’s AEC industry and the most influencing factors for all phases are identified as follows: BIM training for existing non-BIM personal, efficiency of BIM software and initial investment cost.

Finally, it can be recommended that new course modules associated with Building Information Modeling (BIM) could be incorporated in undergraduate and postgraduate students that will assist to create more BIM expert in the future. Bangladesh Government as well as private firms should take some necessary steps such as increase awareness, training and education to BIM to improve the BIM adoption in the construction industry.

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DELAY FACTORS ANALYSIS IN CONSTRUCTION PROJECT: A CASE STUDY ON TSC BUILDING (GROUND FLOOR) AT KUET CAMPUS, BANGLADESH

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ABSTRACT
In construction sector, delay of a project execution is an important issue worldwide and acute in developing country like Bangladesh. Delay of a construction project arises some disputes which hamper the completion of the project. The aim of this paper is to identify some major factors which affect in delaty of construction of TSC buiilding in KUET,Bangladesh. A questionnaire survey was done to find out the important factors.This survey only involves with labor, contructor, designer and client.This study exhibited the burning factors which caused delay of the project like bad weathering condition, delay in approving change in scope of work , delay in materials delivery, frequent change in drawing so on.The result of this analysis will help the practitioners to attain a successful project and make the project policy.

Keywords*:* TSC construction project; Construction Delay; Factor affecting in delay; Bangladesh.

INTRODUCTION
Delay of construction project is a common problem in construction projects. Delay in construction industry is defined as the time overrun completion date that is specified in a contract and in another sense time exceed the specified date for delivery of a project (Assaf and Al-Hejji 2006). According to the owner perspective, delay is refers to the loss of revenue due to scarcity of production facilities and rent-able space. In case of contractors point of view, delay refers to the higher overhead expenses because of longer period of work and higher material costs through inflation. Construction delay is acute worldwide and it happens mostly due to slow decision-making, lack of communication between different parties, frequent change in drawing etc. (Zidane and Andersen 2018). (Sweis, Sweis et al. 2008) studied the causes and effects of delay in public construction projects in Jordan. In this study it was found that delay was occured mostly due to frequent change order, bad weathering condition etc. Another study carried out in Jordan by (Assbeihat 2016). In this study most of the Jordian projects were taken into consideration. The result has showed here on the basis of average rate and prepared a ranking of delay factors. In this Case, most dominant factors were shortage of manpower, delay in approval of document, shortage of materials etc. A study performed in Saudi Arabia by (Assaf and Al-Hejji 2006). In this study different types of projects were taken into consideration. Total of 73 factors were identified. The prominent factor of delay was change order. (Islam, Trigunarsyah et al. 2015) studied the key factors that contributed to delay of construction project in Bangladesh. This paper revealed some important factors of construction delay like poor aite management, change order, contractors work load etc. In Bangladesh construction industry has great influence in economic growth and it contributes about 20% of national GDP (Islam, Trigunarsyah et al. 2015). Therefore, Delay in construction project is one key concerns in Bangladesh. The significant thing in the construction industry is how to alleviate delays and cost overruns which is great matter of concern for the clients, professionals and the policy makers. In Bangladesh, construction projects have had problems with delay in completion and this is due to lot of facts. A local example is the construction

of TSC building of KUET, Khulna that has already crossed 4 month from the specified date of completion. The aim of the research was to analysis the factors affecting in delays and cost overruns on construction projects in KUET TSC building's project. Specifically, this study aimed at identifying and ranking the factors of delays on construction project in KUET, Khulna. It is expected that the outcomes from this study will be helpful for the project managers, consultants, contractors and students of engineering and construction management.

METHODOLOGY

At the very beginning a set of articles, journal paper, research paper, open discussion with the respondents and websites were selected to identify and analysis the factors affecting in construction delay. A questionnaire was prepared with a view to evaluating the frequency of occurrence and importance of selected causes. Then the questionnaire were asked to the main individuals responsible for the project (designer, contractor, sub-contractor, site engineer, engineers from owner site) and labors. The questionnaire were asked and convinced in Bangla to the labor in order to have the answers more accurately. Then the effect of each factor has been evaluated by adopting a four-point scale of 1 to 4. Where the numerical values are representing as follow: '1 = No effect; 2 = Seldom; 3 = Moderate; 4 =Severe. This scale was defined empirically based on the discussion with professionals. Most of construction workers involved in this survey research had at least 8 years of experience.

DATA ANALYSIS & RESULTS

The ranking of cause of delays in terms of occurrence, severity and importance of delay problems was established by taking the average value of the responses of the respondents. Then the average rates were ranked in descending order according to the highest average value. The ranks are presented in Table 1 and in [Fig. 1] in accordance with the responses from the labors, designer, subcontractor, contractors and site engineers.

Table 1: Ranking of delay factors

Delay Factors	Average rate	Ranking
Bad weather	3.40	1
Frequent change in drawing	2.40	3
Unclear & inadequate detail in drawing	1.87	11
Delay in approving change in scope of work	2.43	2
political issues	1.43	13
Poor communication between owner and other parties	1.40	14
Poor site management & supervision	2.27	6
Delay in materials delivery	2.37	4
Unqualified workforce	1.90	10
Frequent change of sub-contractors	1.00	15
Delay in progress of payment by owner	2.23	7
Lack of communication between contractors and sub-contractors	1.90	10
Conflict in sub-contrators schedule in execution of project	2.33	5
Delay in sub-contrators work	2.07	8
labor strike	1.00	15
Late in reviewing and approving design document by consultant	2.03	9
Delay in producing design document	1.60	12

In accordance with Table 1 & [Fig. 1], we remarked from the analysis that Bad weathering condition was the major problem in delay of the construction project from the contractor, labors and consultants point of view. Owner suffers a lot due to bad weathering condition. It hampers the total construction process greatly and results in delay. Delay in approving change in scope of work is a noticeable factor and it is the second major factor which caused delay in the project. When scope of work was changed, approval process was too slow.Frequently change of drawing is another vital reason. Another most

significant factor was delay in materials delivery that suspended the construction process and consequently it yielded in delay of works. There were some other factors that had a great influence in delay of the project like poor site management and supervision, unqualified workforce, conflict in subcontractor execution of work so on which hampered the entire project work greatly.

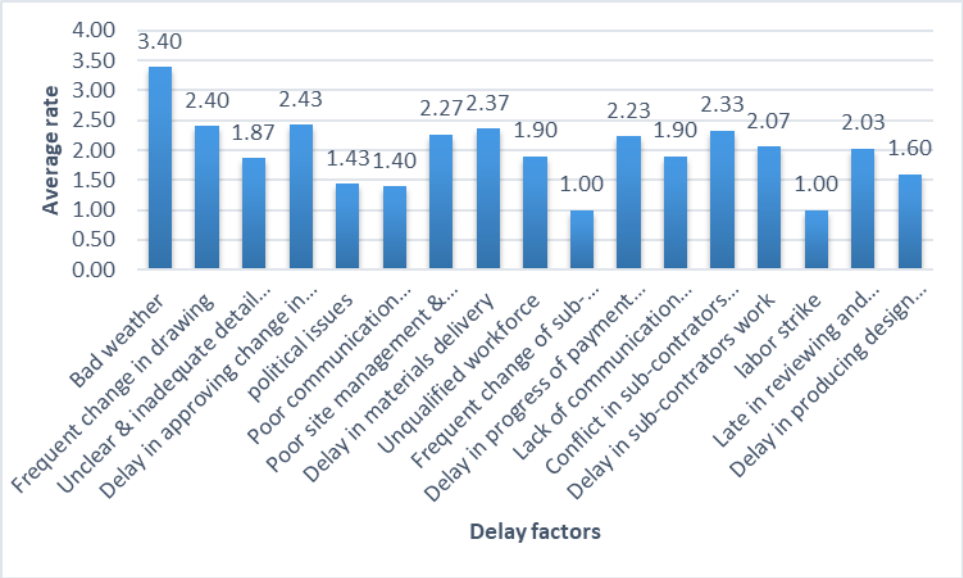

Fig. 1: Bar Diagram for the delay factors

The following [Fig. 2] illustrated the comparative analysis of delay factors between the responses results from designer, contractors, site engineers who provided intellectual labor (series 1) and from labors who provided physical labor (series 2). Both of them made liable the worse weathering condition for construction delay. The top three factors from intellectual persons point of view were bad weathering condition, frequent change in drawing and delay in approving change of scope of work. From labors perspective, major delay factors were worse weather, delay in materials delivery, delay in approving change in scope of work, frequent change in drawing so on. Both of the cases, two factors like change of subcontractor and labor strike were the negligeable factors.

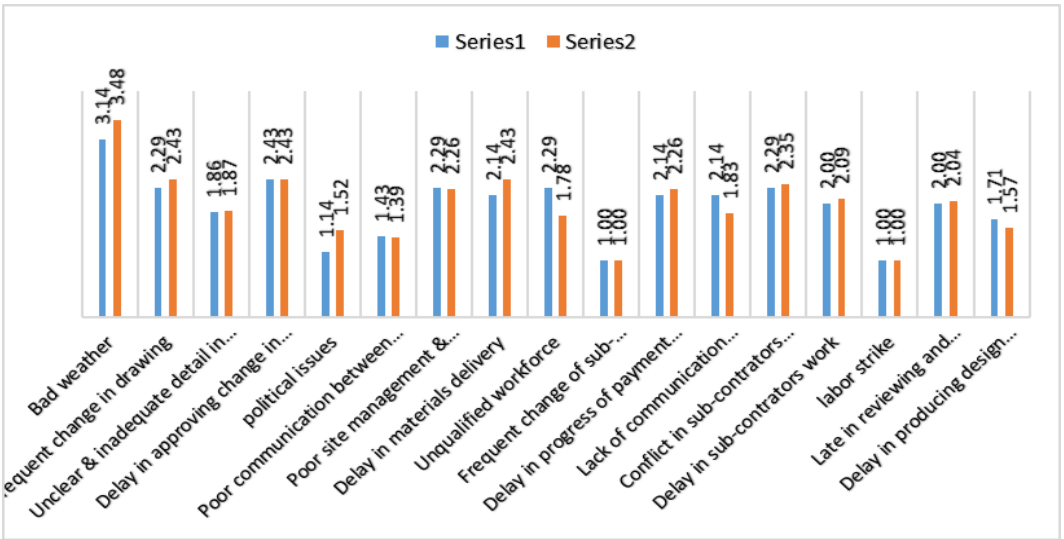

Fig. 2: Bar diagram for comparative analysis of delay factors from two perspective

CONCLUSIONS AND RECOMMENDATIONS

The main purpose of the study was to specify the major causes of delay that affect in the performance of public works in south zone of Bangladesh. A literature review was conducted to notify the causes of delay specified in the literature. The average rate of each of the delay factors was calculated and

then the values were given in a ranking on the basis of average rate as a descending order. Seventeen major factors were specified through this research. The field work involved designer, contractors, subcontractor, site engineers who were professionals in the construction sectors and labours. The result of this survey work indicated that bad weathering condition, delay in approving change in scope of work, delay in materials delivery, conflict in sub-contractors schedule in execution of project, frequent change in drawing were the major factors that affect in delay in public project.

The following steps can be recommended due to mitigate and maintain the causes of delay in construction projects.
-Proper drainage system, shading system may be provided due to bad weathering condition.
-Develop strong communication between contractors and subcontractors.
-Maintain a healthy site management keeping up to date with the every step of construction process.
-Avoid delay in approving change in scope of work.
-Employing trained and experienced labor in the construction phase.

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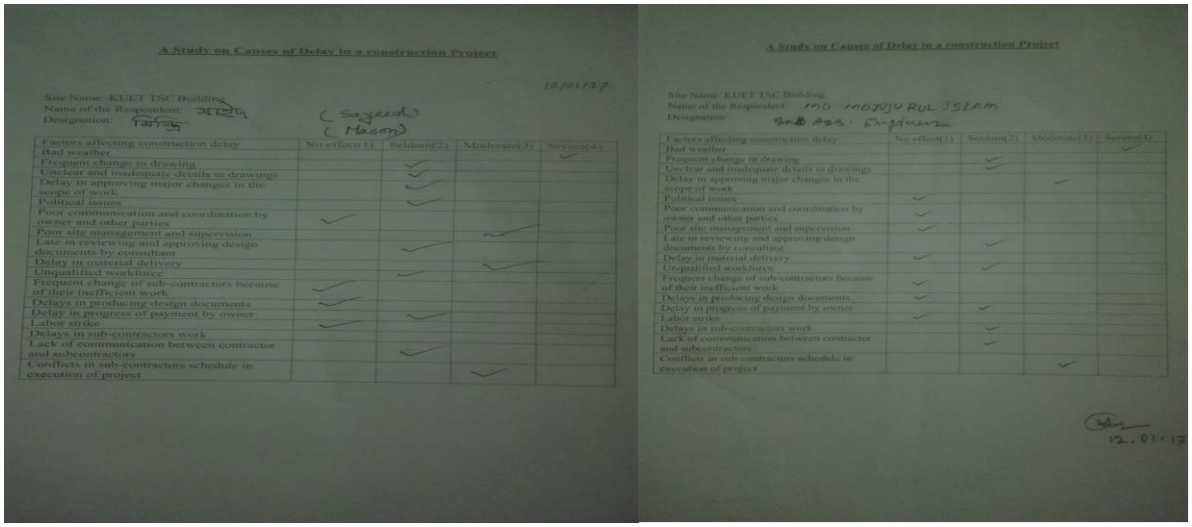
ANNEX
The following pictures showed the surveyed data from the respondents.



A Study on Causes of Delay in a construction Project

12/01/17

Site Name: KUET TSC Building
Name of the Respondent: [illegible] (Sajeed)
Designation: [illegible] (Mason)

Factors affecting construction delay	No effect(1)	Seldom(2)	Moderate(3)	Severe(4)
Bad weather				✓
Frequent change in drawing		✓		
Unclear and inadequate details in drawings		✓		
Delay in approving major changes in the scope of work		✓		
Political issues		✓		
Poor communication and coordination by owner and other parties	✓			
Poor site management and supervision			✓	
Late in reviewing and approving design documents by consultant		✓		
Delay in material delivery			✓	
Unqualified workforce		✓		
Frequent change of sub-contractors because of their inefficient work	✓			
Delays in producing design documents	✓			
Delay in progress of payment by owner		✓		
Labor strike	✓			
Delays in sub-contractors work				
Lack of communication between contractor and subcontractors		✓		
Conflicts in sub-contractors schedule in execution of project			✓	

A Study on Causes of Delay in a construction Project

Site Name: KUET TSC Building
Name of the Respondent: MD: MOJIU RUL ISLAM
Designation: Sub Ass. Engineer

Factors affecting construction delay	No effect(1)	Seldom(2)	Moderate(3)	Severe(4)
Bad weather				✓
Frequent change in drawing		✓		
Unclear and inadequate details in drawings		✓		
Delay in approving major changes in the scope of work			✓	
Political issues	✓			
Poor communication and coordination by owner and other parties	✓			
Poor site management and supervision	✓			
Late in reviewing and approving design documents by consultant		✓		
Delay in material delivery	✓			
Unqualified workforce		✓		
Frequent change of sub-contractors because of their inefficient work	✓			
Delays in producing design documents	✓			
Delay in progress of payment by owner		✓		
Labor strike	✓			
Delays in sub-contractors work		✓		
Lack of communication between contractor and subcontractors		✓		
Conflicts in sub-contractors schedule in execution of project			✓	

12.01.17

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FADING IN GREENERY IN THE LAST 10 YEARS: A CASE STUDY IN SYLHET CITY

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ABSTRACT
Modernization and urbanization are inseparable for the development of a country or a city. But the consequence of unplanned and improper urbanization may trigger the green environment of that city. This study focuses on supervising the reduction in green cover in the last 10 years using Remote Sensing (RS) and Geographic Information System (GIS) in Sylhet city, Bangladesh. Sylhet, an old city of scenic beauty, has been steadily losing its greenery and turning into a jungle of buildings and infrastructures day by day. To detect the decrease in vegetation, Geospatial data i.e. Landsat 7 Enhanced Thematic Mapper (ETM) (level 1) were extracted from USGS earth explorer for the year 2007 and 2017. Images were preprocessed in ERDAS imagine and then Normalized Difference Vegetation Index (NDVI) was determined for both the images using ArcGIS. By exporting data from the NDVI classified images, this study explores that the green cover in Sylhet city decreased from 12.75 km^2 to 6.76 km^2 in the last 10 years. The paper alludes the causes and effects of losing greenery in Sylhet city. This study is actually an attempt to highlight the loss in green cover and indicates the necessity of taking proper initiatives regarding this problem.

Keywords: Greenery; GIS; RS; NDVI; SCC.

INTRODUCTION

Bangladesh is the world's 11th most populous country (United Nations, 2017) and one of the fastest urbanized countries in Asia (SAARC, 2004). Though urbanization is inevitable for the development of this country, the rapid urban area growth has dispensed heavy pressures on land and resources. The prime reason of losing the green cover is urbanization and it is influenced by the aptitude that cities and towns have more advantages than the rural areas. Due to the advanced facilities in city area especially in education and job sectors, people always prefer city abidance which is the key reason behind shifting to the Sylhet city, after the establishment of Sylhet City Corporation (SCC) in 2002.

Sylhet, a major city of Bangladesh is located at 24.8917°N 91.8833°E, in the north-eastern region within the Sylhet Division, within the Sylhet District and Sylhet Sadar Upazila [Fig. 1]. At 9th April 2001, Sylhet was changed to a city corporation from a municipal board and was granted metropolitan city status in March 2009. Due to massive deforestation Sylhet city is fading its greenery day by day and also decreasing the capacity of the existing nine (Chowdhury, 2005) natural drainage channels (locally called Chhara).

The loss of trees and other vegetation can cause various environmental problems like climate change, increased greenhouse gases, desertification, soil erosion, flooding, etc. Again, vegetation reduction affects the biodiversity and micro climate pattern by decreasing rainfall and increasing surface temperature. The pace and pattern of urban area growth monitored using Geospatial techniques (RS and GIS) enables to report the overall landscape dynamics at a detailed level (Kachhwala, 1985). Change analysis of features of Earth's surface is important for better understanding of the interactions between human activities and natural phenomena.

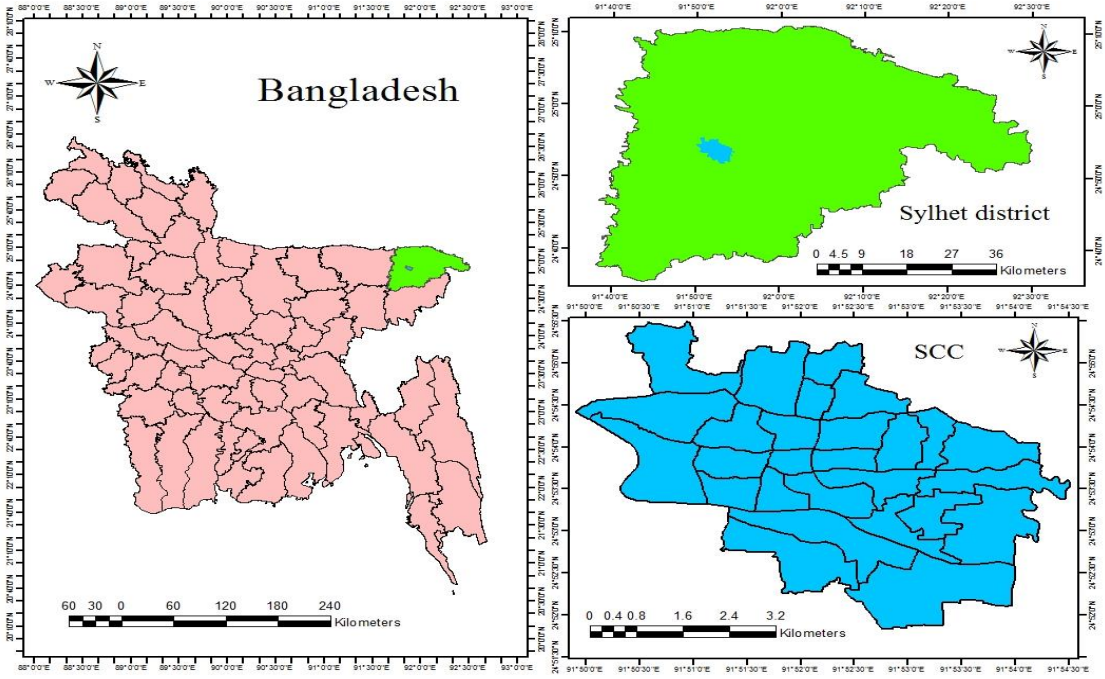

Fig. 1: Study area

Previous study shows that land cover is being changed significantly over the world and urban area growth is the main reason behind this. Though there are lot of works to detect land use change and urban area growth using RS and GIS in various countries over various time frame, no significant study has been done on the effect and impact of the urban area growth especially on the green cover in Sylhet city. Haque et al. (2008) conducted a study on land use pattern change and its causes in Sylhet city. The impacts of land use changes are also demonstrated in this study. This study includes both the digital image processing and field survey to detect changes from 1988 and 1997. A study on evaluation of land-use pattern change over a period of 18 years (1988–2006) in West Bhanugach Reserved Forest, (Moulavibazar district, Sylhet Forest Division, Bangladesh, using remote sensing and GIS techniques was performed by Halim et al. (2008).

According to Esau et al. (2016), NDVI deeds the contrast between the red and NIR reflectance of vegetation, as chlorophyll is a strong absorber of the red light, while the internal structure of leaves reflects highly in the NIR. Vegetation generally yields positive NDVI values, which approach +1 with growing plant chlorophyll contented or green aboveground biomass. NDVI with the values below 0.2 generally corresponds to non-vegetative surfaces, whereas green vegetation covers have NDVI greater than 0.3.

Without an operating Scan Line Corrector (SLC), the images after 2003 in Enhanced Thematic Mapper (ETM) line of sight marks a zig-zag pattern (stripping) along the satellite ground track. The consequence of the SLC failure is that about 20% (Pringle et al., 2009) or 22% (Chen et al., 2011; Scaramuzza and Barsi, 2005) of the pixels in an image are not scanned. As a result, the width of the images increases toward the scene edge and imaged area is replicated. However, the Landsat and ETM+ still has the capability of taking useful images with the SLC turned off (Scaramuzza and Barsi, 2005),

specifically within the interior part of any desired area. The Band designation for ETM+ (Barsi Julia A. et al, 2014) are shown in Table 1.

Table 1: Band Designation for Landsat Enhanced Thematic Mapper Plus (ETM+)

	Landsat 7	Wavelength (micrometers)	Resolution (meters)	Useful for mapping
Enhanced Thematic Mapper Plus (ETM+)	Band 1	0.45-0.52	30	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
	Band 2	0.52-0.60	30	Emphasizes peak vegetation, which is useful for assessing plant vigour
	Band 3	0.63-0.69	30	Discriminates vegetation slopes
	Band 4	0.77-0.90	30	Emphasizes biomass content and shorelines
	Band 5	1.55-1.75	30	Discriminates moisture content of soil and vegetation; penetrates thin clouds
	Band 6	10.40-12.50	60 (30)	Thermal mapping and estimated soil moisture
	Band 7	2.09-2.35	30	Hydrothermally altered rocks associated with mineral deposits
	Band 8	.52-.90	15	15-meter resolution, sharper image definition

The objective of this study is not only to monitor the reduction in green cover in Sylhet city but also to evaluate its causes and impact on the environment.

METHODOLOGY

This study includes both software analysis to detect the changes and field-based observation of the causes and effects of reduction in greenery in Sylhet city.

Software used

In order to conduct the study, the following softwares were used:

- ERDAS Imagine 2015 (Hexagon)
- ArcGIS v10.3.1 (ESRI)

Data Acquisition

For analysis, data have been used are Landsat images which are of spatial type and collected from USGS (U.S. Geological Survey) Earth Explorer.

Table 2: Data Properties

Data sets	Type of Data	Year	Application	Source
Land use	Spatial Data	2007,2017	Pre-processing, NDVI classification, Post classification smoothing, Accuracy assessment.	USGS Earth Explorer (http://earthexplorer.usgs.gov/)

The images were taken in dry season and cloud cover was specified as less than 10%. Data collected to develop the land use map is summarized in Table 2. Projection for all the downloaded images were UTM (Universal Transverse Mercator), Zone 46N and the images were in GeoTIFF file format.

Image preprocessing

All the bands without thermal (Band 6) and panchromatic (Band 8) were stacked using the layer stack tool in ERDAS imagine. Raw images obtained from Landsat satellite contains effect of solar radiance, reflectance, dust, haze, smoke which eventually can lead to error in classification results. In this study, images were corrected in ERDAS imagine by using focal analysis tool to fill the gap of Landsat 7 images recurrently. Then atmospheric correction was done prior to haze reduction. After that, the subsetting was done on the basis of area of interest (AOI). The shapefile of Sylhet district and Sylhet City Corporation (SCC) was projected into WGS 1984 UTM Zone 46N before subsetting.

Change detection using NDVI

False color composite (FCC) image [Fig. 2] was used in this study because in true color image, the features cannot be distinguished clearly. Bands (Band 2,3,4) were called (Red, Green, Blue) according to the requirement of FCC from the stacked image.

The NDVI index algorithm was generated in ArcGIS v10.3.1 by using the following the Eq. (1).

$$NDVI = (NIR-RED)/(NIR+RED) \quad (1)$$

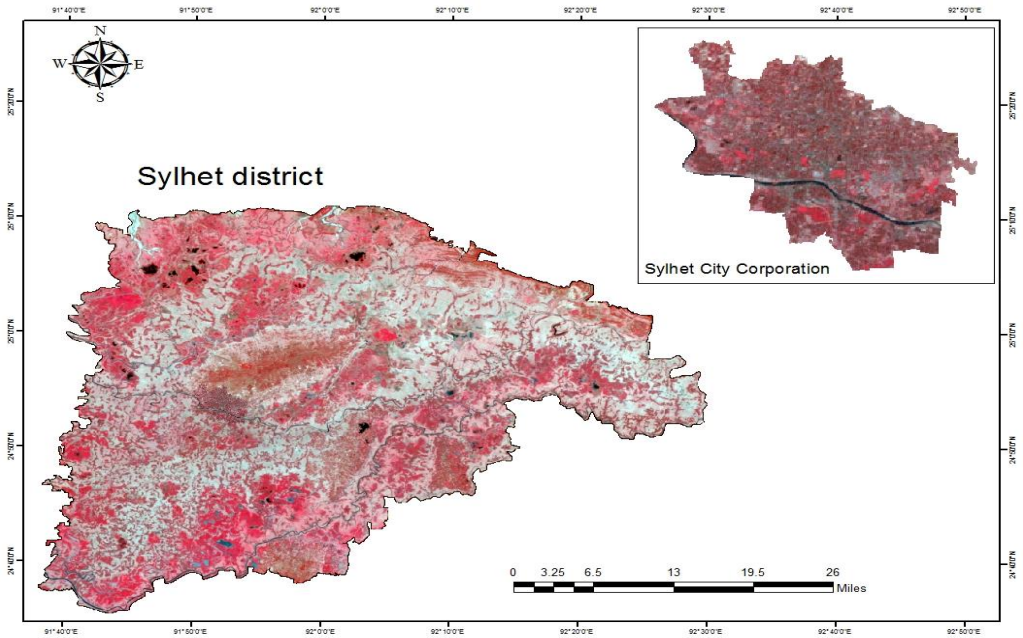

Fig. 2: False color composite image of study area

With the help of the study by Hardy and Anderson (1973), the NDVI classified images were categorized into five major classes, viz. waterbodies, vegetation and forest, built up area, sand fill and crop land with seasonal fallow land.

Accuracy assessment and map representation

Assessment of classification accuracy of the images has been carried out to justify the validity of information revealed from the NDVI classified images. KAPPA coefficient (Cohen, 1960) measures the agreement between predefined producer values and user defined values. A total of 40 users' value were generated using the stratified random sampling method for each image based on visual interpretation. Again, 40 producers' value were obtained from reference images based on ground truth data. For the year 2017, ground truth data have been obtained from the Google Earth. Using error matrices KAPPA coefficient and overall accuracy have been carried out using Eq. (2) and Eq. (3) respectively.

$$KAPPA = (\text{Observed accuracy} - \text{Chance agreement}) / (1 - \text{Chance agreement}) \quad (2)$$

$$\text{Overall accuracy} = (\text{Total correctly classified sample points} / \text{Total sample}) \times 100 \quad (3)$$

After completing the accuracy assessment, map layout has been made in ArcGIS for the two classified maps of year 2007 and 2017 respectively. Then the maps have been exported for presentation.

RESULTS AND DISCUSSIONS

Results

For the years 2007 and 2017, Landsat images were classified using the Normalized Difference Vegetation Index (NDVI) algorithm to assess the reduction in green cover of Sylhet City [Fig. 3 and Fig. 4.].

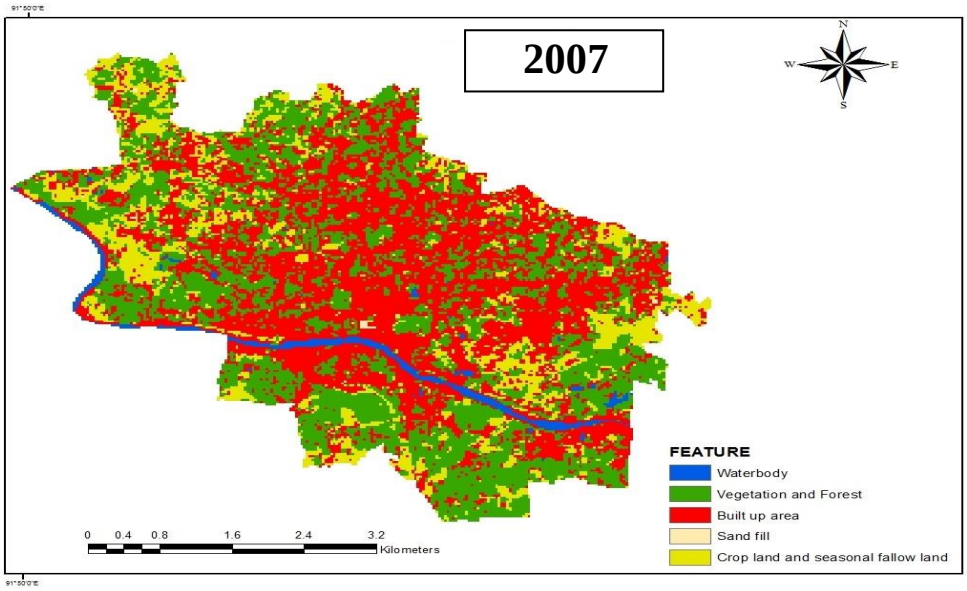

Fig. 3: NDVI classified image of the year 2007

Area have been calculated in the Attribute table of ArcGIS and then exported for analysis the change. According to the result found, green cover i.e. vegetative areas in Sylhet city has faced a remarkable change and decreased from 12.75 km^2 to 6.76 km^2 in the last 10 years.

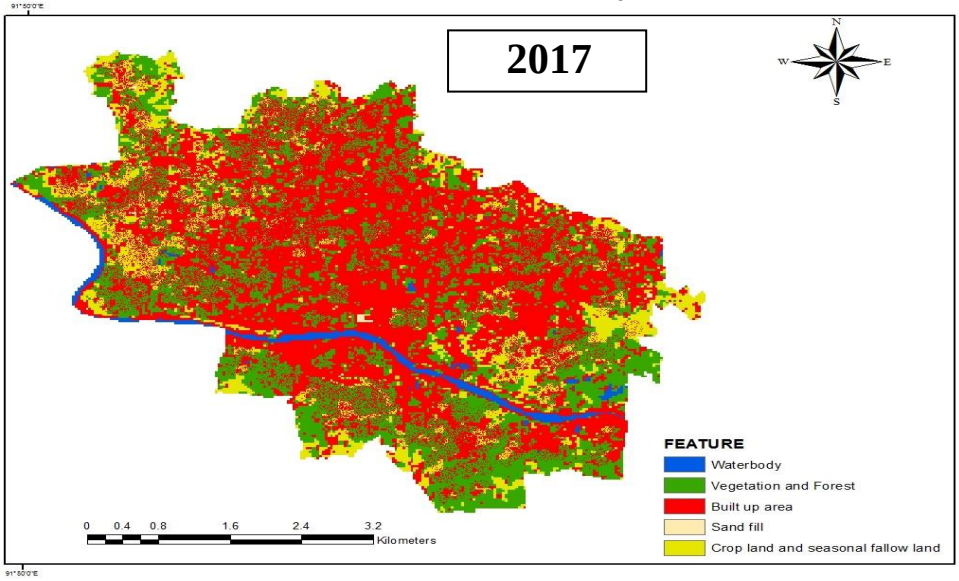

Fig. 4: NDVI classified image of the year 2017

The KAPPA coefficient for classified image of 2007 and 2017 are 0.91 and 0.89 with overall accuracy 92.5% and 91.25% respectively.

Findings from the field observation

Causes of fading greenery in Sylhet city are-

1) Rapid urbanization
2) Facilitating agriculture, homes and industries for the rapidly growing population,
3) Commercial misuse of immature trees for sale on the market for more profit,
4) Burning of wood for cooking.

There are widespread effects of fading in greenery are-

1) Soil erosion in some areas which has secondary effects as the soil ultimately washes down to the existing Chharas and Surma river and causes flood in the local areas.
2) Reduction of rainfall which results from the lack of evaporation from leaves, as none remain. This causes drought in some areas.
3) Climatic changes are the most devastating effect of deforestation which is a major reason for global warming.
4) Loss in beauty of Sylhet city as a tourist spot.

Discussion

The study reports that Sylhet city is losing its green cover remarkably and facing a massive urban area growth. It is audited from the NDVI images that, land use in Sylhet city has changed a lot with a large urban area growth decreasing the vegetative area of 46.98%. Again, the field observation indicates that rapid unplanned urbanization and necessity of meeting the needs of the ever-increasing population are the main reason behind the reduction in green cover in Sylhet city.

CONCLUSIONS

The study was conducted in Sylhet city with a view to detecting the reduction in green cover. As per analysis, it is found that land use in Sylhet city changed a lot in the last 10 years causing loss in green cover from 12.75 km^2 to 6.76 km^2. It is to be frightened that if this process continues, Sylhet city will turn into a place unsuitable for healthy living. This study suggests that, proper planning for land use should be schemed. Furthermore, deforestation and unplanned urbanization must be prohibited by admonishing the residents about the future.

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THE MAIN FACTORS WORKING BEHIND THE CONSTRUCTION DELAY IN KHULNA CITY

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ABSTRACT
Now-a-days construction delay has become one of the biggest problems construction firms facing in Bangladesh. This problem is affecting in every developing steps of the country. The aim of this study is to investigate every possible reasons that is working behind the construction delay in Khulna city. The factors related to delay has been selected by literature review and the survey data has been collected through face to face interview with construction experts. Forty-two factors have been selected and divided into eleven categories and these are materials, laborer, lengthy procuring process, owner, contractor, Subcontractor, machines and equipment, engineer, construction, political situation, miscellaneous. The factors are sorted by their impacts on delay. According to the investigations and analysis of survey data the top five reasons are: (1) Number of construction training center is very little; (2) Lack of skilled laborer; (3) If the budget crossed; (4) Lack of planning;(5) Not practicing the construction law. This investigation has been done through all over the Khulna city. This study can significantly contribute to the construction sector of Khulna city.

Keywords: Construction delay, Factors, Khulna City, Construction project.

INTRODUCTION
Bangladesh is dreaming of becoming a middle-income country by 2021 (Star 2017). Bangladesh is also going for mega infrastructure projects worth billions of dollars, so their management is becoming ever more important for ensuring the maximum benefit for Bangladesh. Almost 2.4 million people are working in highly invested construction industry, which contributes about 20% to the national GDP (Islam et al. 2015). This means the construction projects developing in Bangladesh is related to a huge amount of money and people's profession and livelihood. But due to improper management, the construction of the projects is getting delay and Bangladesh is facing a huge amount of losses every year (Islam and Ahmed). Construction delay affects the project owners by losing revenue and the contractors by losing money (Islam et al. 2015). Because of improper management, delays in construction may arise at feasibility stage of the project and continue till to the end of construction work.
During the last 50 years, applications of principles and techniques of modern project management have spread from their origins in major engineering projects to an ever-widening variety of corporate endeavors (Partington, Pellegrinelli, and Young 2005). Which gives a clear indication that the environment of the system of construction management is changing and people are concerned about the upcoming construction process of the world and are trying to find the most suitable way to run a project without having any delay in schedule. In construction industry delay is a term which refers to a difference between estimated time and actual time to complete a project (Rahman, Lee, and Ha 2014). Delays can be happened for any parties direct and indirect action who are related with the construction of a project. In addition, some other factors for example country's general economy, inflation of

resource prices, lack of managerial service, environmental factors etc. are the causes of project delays (Islam and Trigunarsyah 2017). So, as a under developing country before going for mega infrastructure projects or high-rise projects, it has become necessary to find out the actual reason that are working behind the delay in construction.

According to the above discussion, the aim of this study is to find out the actual reasons that are impacting negatively to the construction industry and influencing the development of Bangladesh through Khulna city. The local factors and geographies position of Khulna city are also considered in this study.

LITARETURE REVIEW

In recent days the amount of construction projects is increasing in large rate. So the necessity of developing the projects in a fixed time in also increasing. For this reason, the factors that hamper the time of construction work is needed to be identified. With the aim of identifying the factors, many studies have been done till now. Kumaraswamy and Chan (1998) carried out a survey in Hong Kong depending on 83 factors. They concluded that improving productivity is a useful approach to controlling delays. Ramanathan, Narayanan, and Idrus (2012) presented a review paper on construction delay by reviewing around 41 studies. They collected a list of 113 causes for delays categorized into 18 different groups. Singh (2010) carried out a study based on a large dataset of 894 projects from 17 infrastructure sectors, attempts to answer certain important questions on time and cost overruns in publicly-funded infrastructure projects. Assaf and Al-Hejji (2006) has done a survey on time performance of different types of construction projects in Saudi Arabia. Owolabi et al. (2014) conducted a study on delay in construction projects in Nigeria depending on 43 causes. Study by Duy Nguyen, Ogunlana, and Thi Xuan Lan (2004) on large construction projects in Vietnam identified 62 causes of delay, which were grouped into four categories, i.e organizational, project attributes, coordination, and environmental. Fugar and Agyakwah-Baah (2010) identified 32 factors of delay in building construction projects in Ghana.

However, construction delay factors are also identified in many countries by a number of researchers. Akogbe, Feng, and Zhou (2013) in Benin, Doloi et al. (2012) in India, Abd El-Razek, Bassioni, and Mobarak (2008) in Egypt, Morris and Hough (1987) in UK, Haseeb, Bibi, and Rabbani (2011) in Pakistan, Shrestha, Burns, and Shields (2013) in USA, Abdul-Rahman et al. (2006) in Malaysia, Kikwasi (2013) in Tanzania, Pourrostam and Ismail (2011) in Iran, Gündüz, Nielsen, and Özdemir (2012) in Turkey, Enshassi, Al-Najjar, and Kumaraswamy (2009) in Gaza, Toor and Ogunlana (2008) in Thailand, Gidado and Niazai (2012) in Afghanistan are examples of such studies.

A number of studies have been also carried out in Bangladesh to investigate the actual reasons of construction delay. Anamul (2012) has identified the overall condition of the construction management of Sylhet city. Rahman, Lee, and Ha (2014) carried out the main causes of schedule delay in construction project in Bangladesh. Risk assessment of construction projects in Bangladesh is founded by Islam and Ahmed . Also Jabeen (2013), Salam et al. (2001), Islam (2014) are the studies which are done according to the geographies condition and political crisis of Bangladesh.

RESEARCH METHODOLOGY

Questionnaires Design: Before going on this study a lot of articles related to causes of delay in construction projects, published in various technical journals are reviewed. During the literature search, some keywords like construction delay, delay in project delivery, developing countries, and the name of an individual developing country were used. Based on the literature review, a survey questionnaire was designed for this study. 42 factors are selected to design the questionnaire which are given in table 1. The questionnaires are measured on their impact level on delay. A likert scale is designed to measure the impact level of the factor on construction delay. The five-point Likert scale with value ranging from 0 to 4 was used as the followings: '0 = no; 1 = rarely; 2 = sometimes; 3 = often; and 4 = always'. The question composed to ask the respondent is, "what is the impact level of this factor on construction delay?". Thus the questionnaires are designed for this study.

Data Collection: The designed questionnaires are distributed to the respondents who have much experience in construction management in Khulna city. The data are collected from the respondent by two process. (1) by face to face interview. (2) by electronic mail. The respondents were selected from

the catalogue of KDA (Khulna Development Authority). More than 60% of all the respondent have more twelve years of experience in this sector. A total 50 data set are collected from the respondent. After eliminating the uncompleted and improper data set, 43 data set are taken to use in this study.

Data Analysis: All the data set which are collected from the respondent are gathered and their impact on construction delay are measured by their mean value of each factor. The raking is also done from largest to smallest mean value. The following equation Eq. (1) is used to find the mean value.

$$\text{Mean} = \frac{\text{sum of all value for each factor}}{\text{N}} \qquad (1)$$

where, N= no of total respondent. To test the data reliability SSPS software is used. In this test the value of alpha is more acceptable when it is too much near to one. According to Cronbach's alpha test the value is 0.812 with is very much acceptable. Data interpretation is also done by SSPS. The rank of the delay factor is also determined by their mean value.

RESULTS AND DISCUSSIONS

This study has shown a result by finding the main factors working behind the construction delay of Khulna city. From 42 factors examined by 43 respondents, the top five factors are identified. The result of this study in shown in table 1. The ranking of these factors are also given there. According to the study the top five reasons behind delay are: (1) Number of construction training center is very little; (2) Lack of skilled laborer; (3) If the budget crossed; (4) Lack of planning;(5) Not practicing the construction law.

Table 1: Ranking of Factors According to Their Mean value

No	Delay Factors	Category	Mean	Rank
1	Resources of materials at a long distance from the construction site	Materials	3.2222	23
2	Frequent change of the price of the materials	Materials	3.0000	28
3	Waste of materials during construction time	Materials	2.3333	42
4	Lack of skilled laborer	Laborer	4.1111	2
5	Low wages	Laborer	2.6667	36
6	Lack of safety	Laborer	3.5556	11
7	Communication problem between the worker and field engineer	Laborer	3.6667	6
8	Discrepancies in contract documents	Lengthy procuring process	3.4444	18
9	Viciousness in the tendering process	Lengthy procuring process	3.5556	12
10	Carelessness of the procuring entity	Lengthy procuring process	3.1111	24
11	Bad behavior of the owner with the employees	Owner	2.6667	37
12	Take too much time to make a decision	Owner	3.6667	7
13	Poor understanding between the owner and contractor	Owner	3.5556	13
14	If the contractor does not get money in time	Contractor	3.0000	29
15	If the contractor runs more than one contract at a time	Contractor	3.5556	14
16	Carelessness of the contractor	Contractor	3.5556	15
17	Lack of effective and adequate machines	Machines and Equipment	3.6667	8
18	Moldering of machines and equipment during working time	Machines and Equipment	3.1111	25

19	If old machines with low efficiency are used	Machines and Equipment	3.1111	26
20	Poor quality estimation	Engineer	3.5556	16
21	Lack of planning	Engineer	3.8889	4
22	Delay to respond to RIF (request for information) of the engineer	Engineer	3.1111	27
23	Poor coordination and supervision	Engineer	3.4444	19
24	Inconsistencies in drawing specification	Engineer	3.0000	30
25	Errors in project schedule	Engineer	3.0000	31
26	Change of project manager or any member during construction time	Construction	2.7778	35
27	Termination of contract during construction time	Construction	2.8889	32
28	Change in plan during construction time	Construction	3.5556	17
29	Lake of sufficient subcontractor	Subcontractor	2.8889	33
30	Delay in bill submission by the subcontractor	Subcontractor	3.3333	21
31	Poor understanding between the contractor and subcontractor	Subcontractor	3.6667	9
32	Change in government	Political situation	2.6667	38
33	Influence of pubic strikes	Political situation	2.6667	39
34	Influence of worker strikes	Political situation	2.5556	40
35	Direct political interference	Political situation	3.3333	22
36	Not practicing the construction law	Miscellaneous	3.7778	5
37	Climatic disaster	Miscellaneous	2.8889	34
38	Act of god	Miscellaneous	2.4444	41
39	Lack of construction technology	Miscellaneous	3.4444	20
40	Delay to get permission from the local authorities	Miscellaneous	3.6667	10
41	Number of construction related training center is very little	Miscellaneous	4.2222	1
42	If the budget crossed	Miscellaneous	3.8889	3

The first factor says that there is not enough construction related training center in Khulna city. And the second factor is related with the first factor. If there is not enough construction related training center, then it is quite difficult to provide sufficient skilled worker. The third factor says that when the amount of budget is crossed, delay occurs. And the budget is crossed when the execution plan is not happened properly in the site, which is the fourth factor. So planning should be done properly to avoid the budget crossed. And the fifth factor says that the construction is not practiced in here. There are many legal matters related to a construction project. So if these matter are not handled in a proper way then delay could happen to solves these matters in improper way.

Comparing the top five factor of this study with other studies top five factor, some similarities are identified between the factors. Doloi et al. (2012) says that in their study, fourth ranked reason was improper planning and this study also says that lack of planning is ranked as fourth. Akogbe, Feng, and Zhou (2013) also mentioned in their study about the impact of inadequate planning. Rahman, Lee, and Ha (2014) ranked shortages of skilled worker third in their study and this study ranked lack of skilled laborer in second. The shortage of skilled labor is also mentioned by Islam and Trigunarsyah (2017) and Islam and Ahmed in their study. This mean the impact of unskilled labor is very dominating. The other factors are also in their list, but not in top five.

CONCLUSION

This study has identified the main factor working behind the construction delay of Khulna city. After reviewing different study on this subject 42 factors are selected for this study. The factors are examined by the most experienced people on this subject of Khulna city. Depending on their judgement the rank on the factor has been sorted on the basis of their impact level on construction delay. Finally, the factors

are compared with the other studies done by the researchers of different country. And according to the entire study, the parties related to delay factors should give extra attention on the following things:

- Sufficient construction training center should be established to create skilled worker so that then can able to handle responsibility in the projected time.
- Planning before executing the work should be done without having any discrepancies so that the budget not crossed the projected value for design change.
- The practice of construction law should increase in the construction field, in terms of legal aspects.

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BARRIERS TO ADOPTION OF SUSTAINABLE CONSTRUCTION PRACTICES IN KHULNA CITY

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ABSTRACT
Project Management is very vital in the construction industry and sustainability is concerned with minimization of negative environmental impacts and overwhelming unease over climate change. Nowadays, sustainable construction has become a key demand in the construction industry globally. However, sustainable construction in Bangladesh still facing obstructions, as there is a deficiency of efficient project management framework. This study aims to identify the most influencing barriers to implement the sustainable practices in the construction industry of Khulna city of Bangladesh. Questionnaire survey and interviews have been conducted among various stakeholders and industry experts in the Khulna city area. This study has revealed that lack of knowledge on sustainable construction, lack of qualification of project manager, unfamiliarity with sustainable technologies are the main barriers for implementation of sustainable construction in Khulna city. So, this study will help the stakeholders for the implementation of sustainable construction practices.

Keywords: Sustainable Construction, Sustainability, Barriers, Stakeholders, Khulna City.

INTRODUCTION
Sustainable improvement refers to take care and minimize the potential negative environmental impacts. Sustainable construction aims to meet present day needs without compromising the ability of future generations to meet their own needs in times to come. It incorporates the best use of resources. Sustainable construction is concerned with the issues of building's design and management, material and construction technology concerning over energy efficiency.

A review of the relevant literature reveals that the condition of the sustainable construction in developing countries is not up to the mark. "Inadequate level of awareness" and "the lack of knowledge of stakeholders" are the main barriers (Serpell, Kort, & Vera, 2013) . The review has also found that the main factors hindering the implementation of sustainability in the construction industry are "lack of education and training on sustainable construction (SC), technologies, capacities and, more importantly, policies for the development and successful implementation of sustainability practices."

Yang and Yang (2015) have conducted a quantitative questionnaire study. It is a qualitative interview study to establish a hierarchical model that encompasses critical factors affecting the execution of sustainable housing in Australia.

Chan, Darko, Ameyaw, and Owusu-Manu (2016) have researched with a aim to examine the criticality of various barriers preventing the wider adoption of Green Building technologies. "Resistance of stakeholders to change" and "higher cost" are identified as the most critical barriers to implementing Green Building technologies.

Darko and Chan (2017) have presented a systematic review of literature on barriers to GB adoption. It has been found that "lack of information, cost, lack of incentives, lack of interest and demand, and lack of GB codes and regulations" are the most reported barriers in the literature.

Du Plessis (2007) has addressed sustainable problems in a way that is socially and ecologically responsible. The paper has described the meanings of the implementation the suggestions of "Agenda 21 for Sustainable Construction in Developing Countries" at a local level by developing regional and national action plans.

Warnock (2007) has conducted a literature review to find out the integrating instruments to achieve sustainable construction and buildings. Finally, that article has advised a straightforward, realistic structure and instruments, aiming at facilitating sustainable construction and buildings.

Singh, Murty, Gupta, and Dikshit (2009) has stated that there had been number of initiatives subsist on indicators and frameworks for sustainable development. This article is focused on general idea of various sustainability indices to measure sustainable development.

Waris, Liew, Khamidi, and Idrus (2014) have conducted a research on on-site sustainable construction equipment selection, using both the qualitative and quantitative research methods. The authors has stated that "during the construction phase, selection of right equipment are always a key factor in the success of any sustainable construction project."

Ali and Al Nsairat (2009) have studied on international green building assessment tools such as such as LEED, CASBEE, BREEAM, GBTool, for a better understanding of the concept of green building assessment tool and its role for achieving sustainable development through developing an effective green building rating system for residential units in Jordan.

Robichaud and Anantatmula (2010) have conducted a comprehensive analysis using matrix present specific adjustments to traditional project management practices. The aim of this paper is to propose specific modifications to conventional building practices to optimize the delivery of cost-efficient green building projects.

Van Bueren and Priemus (2002) have conducted a paper on "Institutional barriers to sustainable construction". In this paper, they have added that it is not technical factors but institutional factors that underlie to implement sustainable construction.

Shelbourn et al. (2006) have made a research on "managing knowledge in the context of sustainable construction". This paper shows that "although indicators, checklists and assessment tools for sustainability in construction is readily available, there is still a need for a structured approach for the implementation of sustainability practices and methods within construction projects".

Shen, Tam, Tam, and Ji (2010) has introduced a new approach for conducting project viability study by implementation the principles of sustainable development practice with reference to the Chinese construction industry. The study explained and suggested that "there is a need for shifting the traditional approach of project feasibility study to a new approach that embraces the principles of sustainable development."

Powmya and Abidin (2014) has conducted a survey among construction practitioners in Oman focusing on the current progress and barriers of implementation of green construction. "The lack of demand for green construction" and "lack of pressure by government" were the top two.

Hwang, Zhu, and Tan (2017) made a study and questionnaire survey in Singapore. The study revealed that the top three barriers were "perceived higher initial capital costs", "uncertain tradeoff between environmental and financial benefits" and "lack of government support".

Durdyev, Zavadskas, Thurnell, Banaitis, and Ihtiyar (2018) has been used a questionnaire survey targeting local construction professionals. The study has shown that "the industry-wide adoption of SC practices is poor, which is believed to be due to a lack of awareness and knowledge and reluctance to adopt new sustainable technologies".

Bourdeau (1999) has represented an international study to find the relationship and defined links between the principles of sustainable development and the construction sector. The study has

identified main issues, constraints and current policies, predicted changes and adaptations for the construction sectors in each country.

The building construction industry is considered as one of the fastest and biggest sector in Bangladesh. It has a significant role within the overall infra-structural improvement of the Bangladesh and its economic system. Many research has been conducted around Bangladesh about the safety issue, cause of delay, risk analysis, accident analysis. There is much more similarities of this research but it is different according to the socio-economic condition of Bangladesh. The intention of this survey-based research is to identify the barriers to sustainable construction practices in Khulna City. It is hoped that the outcomes of this study will enrich knowledge about the current state of barriers to sustainable construction in Khulna City and form a platform for future SC work within the country.

METHODOLOGY

The methodology applied in this research is a questionnaire survey and direct interviews. The flow diagram of this research has been stated in figure 1.

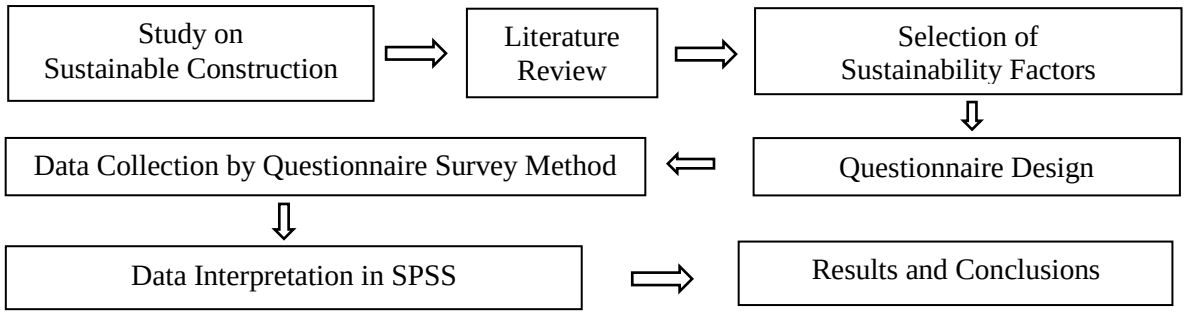

Fig. 1 Flow Diagram of Methodology

Firstly, Sustainability study has been performed. Then the literature review on sustainable construction has been accomplished and the sustainable factors has been selected. Then the questionnaire format was developed and the survey was executed. Finally, it has been analysed in SPSS. This study has adopted a Likert scale rating of influence level from 1 to 5 where 1 stands for "Very less" and 5 for "Very high" influence of the drivers and barriers.

This study is aimed to prioritize the identified drivers and barriers of Sustainable Construction in Khulna according to their importance, using the RII method. For each driver and barrier, the RII was calculated using eq. (1):

$$RII = \frac{\sum W}{N \times A} \quad \ldots\ldots\ldots (1)$$

Where,

W= weighting of each driver or barrier given by respondents;
A = highest weight, which is 5 for this study;
N = total number of respondents.

The study has adopted questionnaire survey as a method to identify the fundamental factors affecting the implementation of sustainable construction in construction projects. Surveys through questionnaires were found appropriate for achieving the objectives of this study. Based on the literature cited various factors have been selected. The study was conducted by developing a questionnaire and collecting the responses from 100 individuals (40 workers, 30 Contractors, 30 Engineers) from construction sites around residential area in Khulna City.

DATA RELIABILITY

The required data for this study was collected from stakeholders of construction industry. So it is necessarily essential to analysis to check the reliability and validity of the independently collected data. The Cronbach's Alpha test is conducted by the software of Statistical Package for the Social Science (SPSS). Table 1 represent the Cronbach's Alpha test result of this research which is greater

than 0.7 and it satisfies the standard value.

Table 1: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized items	N of Items
0.825	≥ 0.7	100

RESULTS AND DISCUSSIONS

The data has been collected through questionnaire survey. The mean value of the survey result has been calculated in SPSS. Finally, the Relevant of Importance Index (RII) was determined according to eq. (1). From worker's, contractor's and engineer's perspective, the most influencing barrier in order to adopt sustainability is 'Lack of knowledge on sustainable construction', 'Unfamiliarity with sustainable technologies' and 'Lack of Qualification of project manager' respectively. Without having the knowledge of sustainability and sustainable technology, it is very difficult to implement sustainable construction framework. As an expert sailor is needed to reach its destination, similarly an expert and qualified project manager is also needed for the implementation sustainable goal. Table 2 represents the result of responses on respect to worker, contractor and engineer respectively. In table-2 top three obstacles according to the stakeholders has been highlighted. The reason behind these barriers are to be top, mostly because, the ineffective and insufficient cautiousness about sustainable construction.

Table 2: Survey Response Result According to Worker, Contractor and Engineer with RII

	Sustainability Factors	Worker's perspective	Contractor's perspective	Engineer's perspective
		RII	RII	RII
1	High Cost of Projects	0.0250	0.0333	0.0317
2	Lack of knowledge on sustainable construction	0.0294	0.0361	0.0361
3	Is familiar with the word sustainability?	0.0206	0.0222	0.0244
4	Lack of Government Support	0.0250	0.0319	0.0297
5	Due to different contract forms of project delivery	0.0228	0.0292	0.0286
6	Lengthy approval process for new sustainable technologies	0.0253	0.0194	0.0336
7	Unfamiliarity with sustainable technologies	0.0244	0.0377	0.0239
8	Lack of communication and interest required amongst project team members	0.0241	0.0292	0.0256
9	More time required to implement sustainable construction practices on site	0.0247	0.0292	0.0275
10	Client does not agree with the proposal	0.0281	0.0306	0.0317
11	Lack of sustainable Planning	0.0241	0.0376	0.0358
12	Labor related challenges	0.0231	0.0236	0.0328
13	Lack of sustainable materials	0.0225	0.0306	0.0250
14	Lack of Qualification of project manager	0.0275	0.0361	0.0367
15	Lack of Qualification of construction engineer	0.0278	0.0361	0.0311
16	Weather Condition	0.0200	0.0222	0.0181
17	Lack of Qualified Consultants	0.0266	0.0361	0.0244
18	Lack of Political Stability	0.0200	0.0250	0.0214
19	Workers' unaware of the correct methods and procedures	0.0266	0.0375	0.0328
20	Conflict with the architect over the type of material to be used	0.0128	0.0167	0.0197

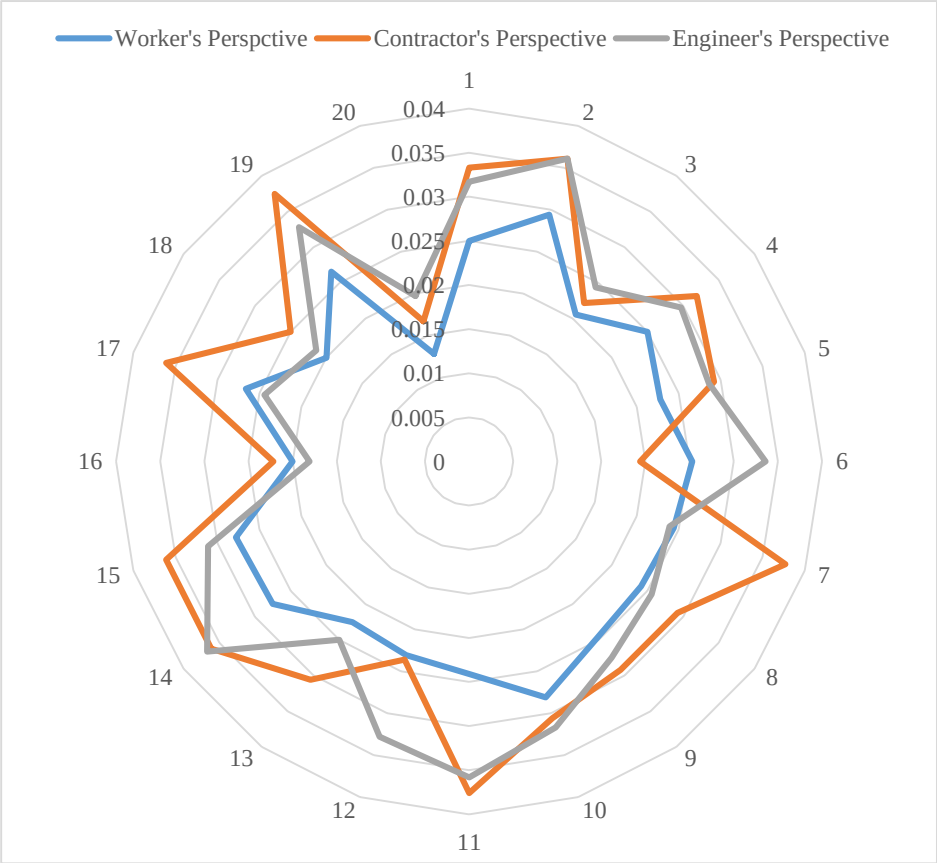

Fig. 2 Comparison of sustainability factor of three stakeholders

Figure 2 represents the position of sustainability factor with respect RII.. The perimeter values is defined as the serial no of table-2 and y-axis is defined with the RII of respective factors. Mainly, from this radar chart the impact of the sustainability factor can be compared with respect to stakeholders. For example: sustainability factor 1 is most influencing for contractor's perspective where as it is less impacted on worker's perspective.

CONCLUSIONS AND RECOMMENDATIONS

This study has focused on the obstacles for sustainable construction in Khulna City, Bangladesh. Contractor, Worker, Engineer are the major and driving stakeholders in this research. The data has been collected through questionnaire survey and direct interviews. 20 factors have been selected as a barrier or obstacles to sustainable construction. The results has been interpreted on the basis of RII. From the perspective of major parties the results is described. Among the barriers, Lack of knowledge on sustainable construction is the most influencing barrier according to worker's perspective. Conflict with the architect over the type of material to be used have been counted as less persuading barrier according to the worker's outlook. Similarly with the help of the table-2 with the help of RII according to the contractor's perspective Unfamiliarity with sustainable technologies is the most influencing barrier. Conflict with the architect over the type of material to be used was counted as less effected barrier from contractor's perception. And, the last stakeholder's viewpoint, who is the major driver of this research, is Lack of Qualification of project manager- concluded as the main obstructions and Weather Condition has been identified as less influencing. Finally, the study limits only on Khulna city. The scenario may be similar in whole Khulna region but can not be encountered to whole country. It will be very praisedworthy if some one can integrate the overall condition of obstacles of Bangladesh.

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PROJECT COST RISK ASSESSMENT IN BANGLADESH

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ABSTRACT
Cost uncertainty is a major concern in construction industry. Project cost risk assessment will help the decision makers to focus on the factors that affect the funding disclosure and finally compute the genuine project cost. The main aim of this paper is to analyze the incertitude of the project cost which includes breaking down the total project into small cost items and probabilistically finding out the incertitude of each items. It presents a scheme for construction related risk management using a Bayesian belief network and a questionnaire survey consisting of 12 major risks criteria, was conducted in many areas of Bangladesh among the professionals. In the process of questionnaire survey, the numerical values from (1-10) had been used to illustrate the probability and the consequences of each risk, then categorized them into Very High, High, Probable, Low and Very Low categories. The findings of the study revealed that project manager's inadequate knowledge and insufficiency of materials are the main causes of delay in the field of construction of projects in Bangladesh. It establishes a risk management framework that suggested all risk criteria should be avoided, accepted, mitigated or transferred which will enhance the execution speed of construction procedures in any developing country like-Bangladesh. The enhanced execution speed will be in the way of providing successful project within the required time and budget by lessening project cost and maximizing project quality.

Keywords: Risk assessment; Bayesian network; Cost incertitude analysis; Successful project.

INTRODUCTION
Cost control is a fundamental step in the management of risks in construction projects. Whether the project is small or large, risk and incertitude are inherent in all construction works. Risk is a complex phenomenon that has physical, monetary, cultural and social dimension (Loosemore, Raftery, Reilly, & Higgon, 2012). Risk is the probability of occurrence of uncertain, unpredictable and even undesirable events that would change the prospects for the profitability on a given investment (Kartam & Kartam, 2001). Uncertainty is defined as a context for risks as events having a negative impact on the project's outcomes, or opportunities, as an event that have beneficial impact on project performance (Perminova, Gustafsson, & Wikström, 2008). This definition stresses dual nature of uncertainty in potentially having both positive and negative influence on the project's outcomes. Uncertainty can arise from sources both internal and external to the project (Perminova et al., 2008). Therefore, uncertainty comes where the established information are questioned and as a result of that the basis for evaluating of risks (known negative events) or chances (known positive events) are questioned.
Change in project cost can be occurred form many events. Some of the events are connected to each other. By determining the existence and influence of these factors, the possibility of occurring project overrun and delays can be reduced.
This paper is an attempt to show the firm relationship among the analysis of risk assessment of and success of the project. The project managers, in other words, decision makers usually have three possible options: to take immediate action for the avoidance of risk or for the reduction of its impact or

to prepare appropriate contingency plans. In this way project team will always be ready to face the unwanted events and their impacts and be capable to manage the risk that can come up. The objectives are: to recognize the necessary risk factors in developing countries, to find out the influence of these factors on the success of the project, to help the decision makers to take the right decision for the improvement of performance and success of the project.

Project cost risk assessment is not yet widely used in Bangladesh and most estimators do not consider the cost associated with risks. For this reason, the actual project cost generally overruns what it was previously calculated which results in delays and performance problems in the project. So it is high time to adopt risk assessment technique for better performance and avoidance loss of time and cost. Risk management will not take aside all the risks from the project but its aim is to manage the risks in the most efficient way.

METHODOLOGY

In this paper Bayesian network (BN) has been used which visually represents the probabilistic relationship among variables responsible for risk occurrence. The BBN approach is essentially a framework for modelling the relationships between variables, and for capturing the uncertainty in the dependencies between these variables using conditional probabilities (Van Der Gaag, 1996). This study was performed into two parts. The first part is again subdivided into two parts. The first part contains the general information about the cost items and all possible common causes of variation of cost items. The second part consists of the questionnaires based on the "The ePMbook" information and the calculation of the 'Quantify Risks and Justifying Avoidance Actions'. The information was collected from "The ePMbook" and secondary information was collected from internet. Quantify Risks and Justifying Avoidance Actions has been calculated in the following method:

Formula: Bayes rule can be expressed as follows (Vick, 2002):

P[cause] = [P[effect/cause]*P[cause]]/ P[effect] … … **(1)**

Where:

P[cause] = probability that the cause occurs,

P[effect] = probability that the effect occurs,

P[effect/cause] = conditional probability of the effect, given the cause,=

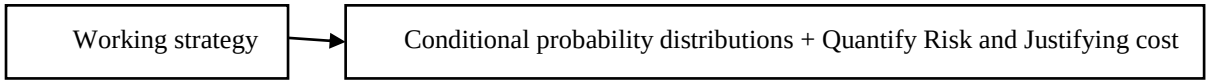
P[cause/effect] = conditional probability of the cause, given the effect.

For Quantify Risks and Justifying Avoidance Actions:

Probability of the risk * additional cost if it happens =

Expected cost from the risk… …. **(2)**

Overall working strategy has been presented in the following flow chart:



The first category comprises the factors that surrounds the ability to enhance performance level, such as owner's efficiency, commitment, expertise and disputes among project members, lack of experience, knowledge and skills of the project managers, adverse socioeconomic circumstances and uncertainty in the selection of members of project team. Moreover, the effect of sudden orders of variations enhances the actual cost and duration of the project because they can bring changes in the original contract. In this network analysis research, risk and schedule uncertainty analysis is conducted. There are existence of some factors that have great impact in lengthening project duration, it is not only necessary to identify these factors but to assess their effect on the project duration as well. Most of the engineers, project managers, planners, decision makers and agencies in Bangladesh usually relies on their experience to estimate project cost and time contingencies. It is very difficult to predict some uncertain events because of the uniqueness of some construction projects. For this reason, the completion date of a project is often missed. To avoid these situations some strategies can be adopted for negative and positive risks. Negative risks or threats should be avoided, transferred, mitigated or accepted. On the other side, positive risks should be exploited, enhanced or accepted. For the purpose of finding out the effect of the risk on the project, the probability of risk is classified according to the table which is shown in Table 1:

Table 1: Risk Probability Definitions (Curtis & Carey, 2012)

Probability Category	Probability	Description
Very High	0.90	Risk event expected to occur
High	0.70	Risk event more likely than not to occur
Probable	0.50	Risk event may or may not occur
Low	0.30	Risk event less likely than not to occur
Very Low	0.10	Risk event not expected to occur

With the help of Table 1, the different risk factors have categorized from the probability values using Bayes rule. From the risk probability descriptions, the following table provides us the definitions of risk impacts over each of the probable impacted project sectors, such as: cost, schedule, scope, and quality. While analyzing the probable impacts of each risk, an appropriate impact level (0.05, 0.10. 0.20, 0.40, or 0.80) is taken from the table below:

Table 2: Definition of Risk Impact Scales (PMI, 2008)

Project Objective	Very Low 0.05	Low 0.10	Moderate 0.20	High 0.40	Very High 0.80
Cost	Insignificant cost impact	< 10% cost impact	10-20% cost impact	20-40% cost impact	> 40% cost impact
Schedule	Insignificant schedule impact	< 5% schedule impact	5-10% schedule impact	10-20% schedule impact	> 20% schedule impact
Scope	Barely noticeable	Minor areas impacted	Major areas impacted	Changes unacceptable to sponsor	Product becomes effectively useless
Quality	Barely noticeable	Only very demanding applications impacted	Sponsor must approve quality reduction	Quality reduction unacceptable to sponsor	Product becomes effectively useless

To get more accurate result which will be applicable for Bangladesh, a questionnaire survey was conducted. The questions were designed on the basis of construction risks in Bangladesh. This research paper has focused on 12 major criteria which are major causes of construction delay in this country. The risk criteria are: environment, equipment, owner, material, engineering and design, labor, contractor, financial, site location, project management, schedule, political. Out of 40 questionnaire, we have got 20 questionnaire forms filled by site engineers, 10 forms filled by contractors or labors and 10 forms filled by general people.

Questionnaire Design and Distribution

The questionnaire survey was consisted of 12 major risks criteria and the respondents were requested to answer 45 polar questions whose expected answer is either “yes” or “no”. Each criteria consists of 3 questions for clarifying percentage of risk of that criteria. These data were collected from different construction sites in Bangladesh.

Table 3: Positive and negative Responses (%) From Questionnaire

Risk Criteria	Positive Response (%)	Negative Response (%)
Environmental	58	42
Owner	38	63
Equipment	71	29
Material	54	46
Engineering and Design	65	35
Labour	60	40
Contractor	50	50
Financial	58	42
Site Location	50	50
Project Management	73	27
Political	29	71

After calculating the probabilities from these data, we will use Bayesian probability for calculating various types of risks reducing related analysis. From these analyses, we will get insightful information that can help decision makers to take better decisions regarding project cost.

RESULTS AND DISCUSSIONS

By analysing the data collected from questionnaire survey, the impact level of those criteria on the construction work can be easily found. After using BBN network, all probable project cost is presented in a histogram which is given below:

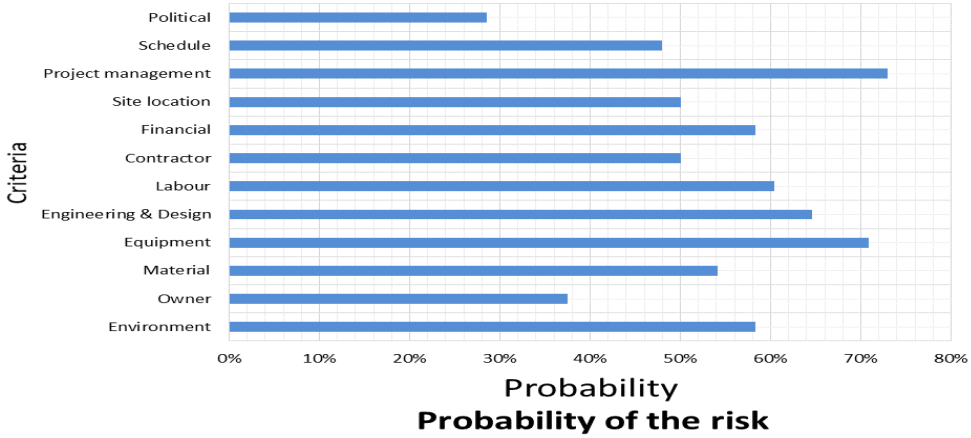


Fig. 1: Survey report of probability of the risk

From the Fig. 1, it is showed that management skills and equipment have the highest impact on probability of risk. Other criteria also have great impact on the probability of risk. But in case of Bangladesh, owner and politics have least impact on the risk occurrence. A survey was also conducted on impacts of individual risks and then classified them into Very High, High, Probable, Low and Very Low. Some numerical scales were also used to rate each risk in term of impact and probability of occurrence. The outcome of these assessments will give an overall measure of severity of each kinds of risks. In this way, the higher risk rating score will illustrate the more possibility of occurrence of risk. At the questionnaire procedure, the numerical scores from (1-10) was used to illustrate the probability and the impact of each risk on construction work and the probability-impact scores are shown in the Fig. 2:

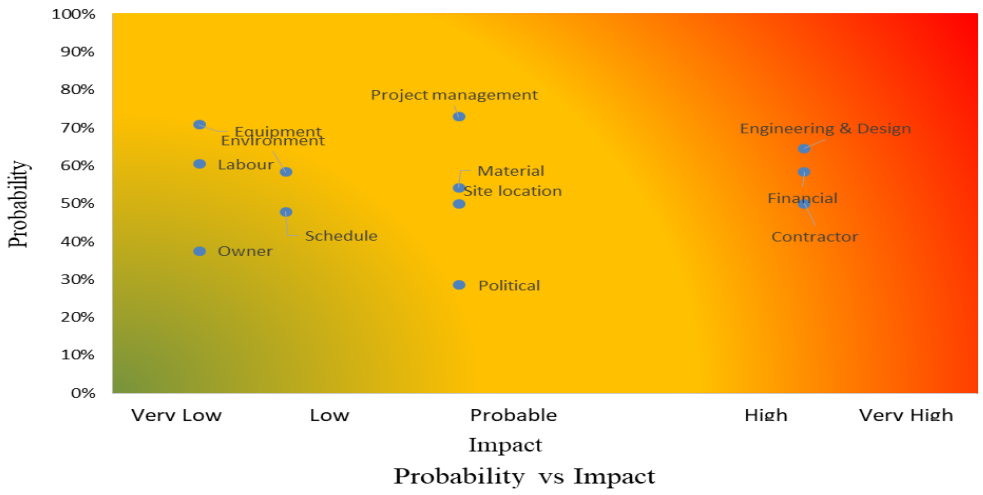


Fig. 2: Survey report of Probability vs. Impact

From the Fig. 2, it can be analyzed which risk criteria should be considered as positive or negative risk. To reduce the difficulty in case of taking decisions, both the impact and probability of a risk is classified into high and low categories. Then a matrix is created for positive risks and positive risks:

Table 4: Matrix for negative and positive risks (PMI, 2013)

Probability	Impact	Strategy (-)	Strategy (+)
High	High	Avoid	Exploit
Low	High	Transfer	Share
High	Low	Mitigate	Enhance
Low	Low	Accept	Accept

From Table 4, the decision makers can adopt proper strategies in case of negative risk. When the risk is low in terms of impact and probability, he should whether simply take into account it or not. Taking into account a risk does not mean neglecting it: risks in these categories that are taken into account should be kept in a watch list. On the other side, when the impacts and probabilities are high, he should avoid that risk. By clarifying requirements, some risks can be reduced or avoided so that the probability of high-risk sections can be excluded, or when the risk is to the schedule, he should extend the schedule at the right time.

Table 5: Strategies for negative risks (PMI, 2013)

Avoid **(Eliminate cause of risk)**	THREATS	**Mitigate** **(Reduce probability or impact of risk)**
Accept **(Contingency plan for risk)**		**Transfer** **(have third party take on ownership)**

In the second case of the Table 4, the time when the impact is high and the probability is low, he might want to transfer the risk to another third party. The last case occurs when either the impact or the probability is high, he wants to mitigate the risk by lowering the probability of its occurring, or reducing its effect on the project when it appears.

Table 6: Strategies for positive risks (PMI, 2013)

Exploit **(make sure opportunity occurs)**	OPPRTUNITIES	**Enhance** **(increase likelihood or impact of risk)**
Accept **(allocation of reserves to the project)**		**Share** **(give third party ownership of opportunity)**

In the graph, the risk's levels were prioritized (using Table 4) to find out the most important risks and to engage appropriate funds for the higher ranked risks. Previously mentioned 12 criteria have different impact on cost, schedule, scope and quality. In this step, the impact of each risk event on the project was evaluated. Then we considered how an event could have effect on cost, schedule, or technical performance activities. The probability (chance) of each risk event was also evaluated. This procedure involved the usage of subjective probability evaluation techniques. The effect of 12 risks criteria (political, schedule, project management, site location, financial, contractor, labor, engineering design, equipment, material, owner and environment) on cost of the project is shown by the Fig. 3.

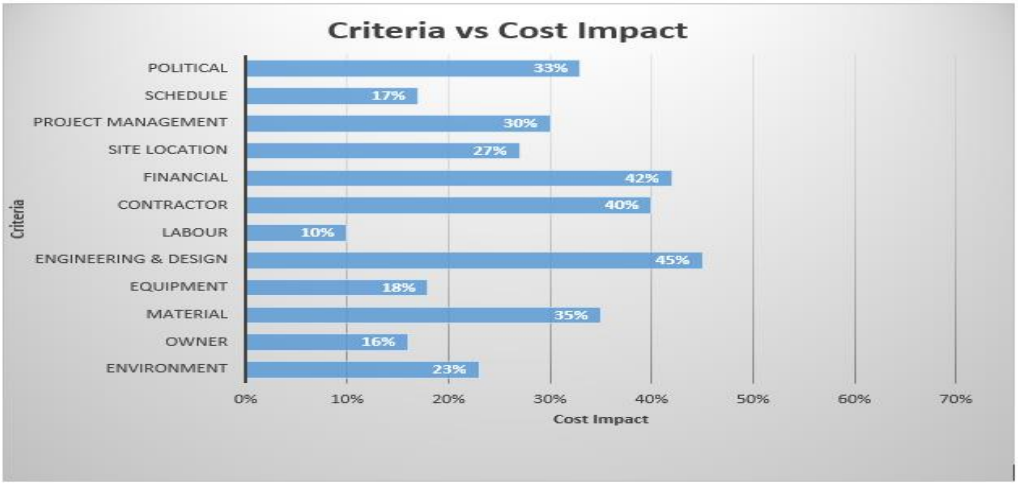


Fig. 3: Criteria vs. Cost Impact

It is found that if the probability of a risky event and its' impact on the project is low, the decision maker should not actively look for it because that could cause a wastage of resources, but undoubtedly he should be careful about it and try to take benefit from it if it happens. In another case, it is seen that when the probability of an opportunity is high, the positive impact on the project would also be high, so he should try to recognize and maximize the probability of occurrence of those events at first because that would trigger an opportunity in order to receive benefits from it. In case of low possibility of occurrence, but having a high positive effect on the project, he would try to share the risk with another third party that could best take the opportunity in order to receive advantages for the project. If there is another opportunity occurs that has low probability of occurring, then it might be best to sum up resources to increase the possibility of its occurrence

Finally, it is also observed that risk factors having great impact on the monetary view of the project, as like deficiency of financial resources of the contractor, financial permanency of the client and cost exceeds due to delay are supposed as most necessary by contractors and that risk response methods are favored for risk avoidance, risk reduction, risk retention and risk transfer.

CONCLUSION

From the analysis, it is found that most of the foreseeable risks can be predicted and the severity of those risks can also be pre-determined. Moreover, impacts of 12 risks possible criteria on cost of exposure risks management, owner, engineer or any criteria would experience uncertainty by the time of these carried extra cost impact on a project. In case of developing country like Bangladesh, about 45% of the expected cost impacts from the risk depending on engineering and design criteria. For this reason, it is recommended to take proper prevention measures to reduce the errors of the engineering and design field. It will reduce the unnecessary costs caused by sudden design changes at the construction phase. By the time, a project manager (if not prepared for this risk) can face major cost funding problem due to construction risk. As all the foreseeable risks cannot be eliminated, the effect of risk can be reduced by mitigation, avoidance, acceptance or transferal process. The risk analysis data should be preserved for further cost risk assessment. This preserved data will play an exigent role in the risk prevention actions. Using this procedure of risk analysis, the project manager can find out total budget of the project with a nearly approximate probability.

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PROPERTIES OF PLASTIC AS A BINDING MATERIAL IN BUILDING BLOCKS

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ABSTRACT
Plastic is a non-bio-degradable substance which takes thousands of years to decompose that creates land as well as water pollution to the environment. This study aims to evaluate plastic to use as building blocks. Selection of plastic from different sources and then melted it to give a form of a brick for charactering its suitability for building material. The study showed that the brick made form plastic waste has the Potential to be used as a brick having average compressive strength 4 N/mm^2, water absorption less than 1%, nil efflorescence effect. Also hardness, fire resistance & soundness respectively are observe as high quality, good & gives ringing sound which indicates that it could be used as a compressive block. In comparison to normal clay brick the plastic made brick can be used as civilian brick replacement.

Keywords: Non-bio-degradable, Blocks, Efficiency, Comparison, Brick.

INTRODUCTION
Plastic is a very common material that is now extensively used by everyone in this world. At the time of need, it is seen that the plastic is very useful, but is discarded only after its use, all the risks made of plastic are not biodegradable and it is a dangerous element for more than a century. Nowadays, it is impossible to work effectively in a key sector without using plastic from agricultural and industrial. Therefore, we cannot ban the use of plastic, but the recycling of plastic waste is used in building construction, industries are considered to be the most effective applications. In a remote area like Saint Martin which is a tourist area, there are many plastic bottles are wasted and they cannot be recycled. It's harmful to the marine environment. So if we can collect them and recycled in manufacturing bricks, it will be more effective for the people of the area. This project will aware the people about the recycle way of plastic as well as it will be cost effective for construction. To fulfil the above need, this study is based on two objectives, namely: to characterize plastic waste's potential for reuse in civil construction and to compare its properties with conventional brick used in civil construction.

METHODOLOGY
2 sacks of plastics had been collected from the different CUET canteen. Natural river sand was used as a fine aggregate. This had been collected from a construction site in CUET. Plastic PET categories such as bottles as water, soft drinks, juice, etc. were collected from CUET canteens. Mould had been made according to Bangladesh standard specification for brick, tiles, and compression test. Collected plastics were clean with water and dried in sunlight. Collected sand was sieved through #50 sieve. After batching the plastics were taken for melting in which the plastic bottles were thrown one by one into the

pan and allowed to melt. The mixture was stirred with a steel rod. When all plastics had melted the mixture was poured into the mould. After 4 hours specimen was being demoulded. Then the tests required for standard brick and tiles were conducted on Plastic sand blocks
Mould size and tests list are given in the roadmap of the study.

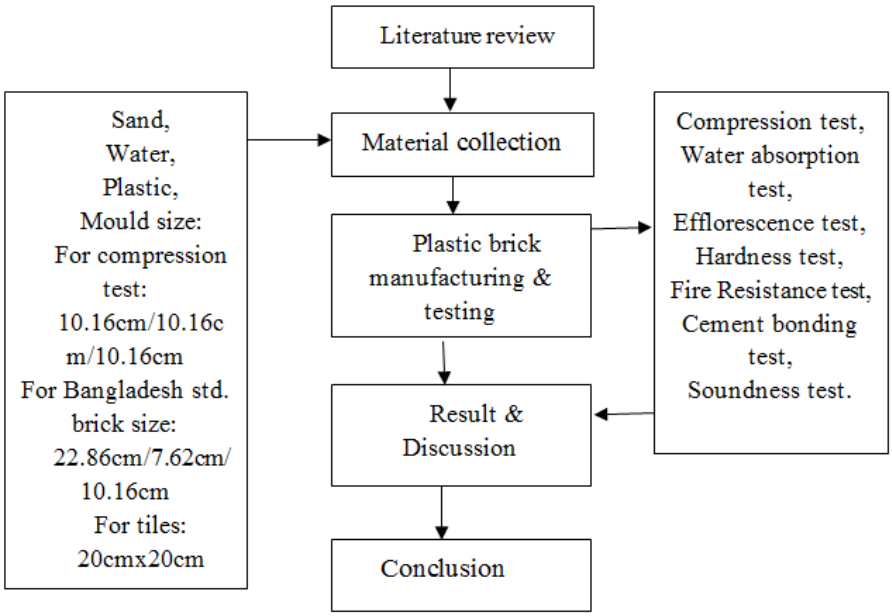

Fig.1: Roadmap of the adopted method.


Fig 2: Demolded specimen.


Fig 3: Bangladesh standard sized Bricks


Fig 4: Cemented plastic sand bricks


Fig 5: Cemented plastic sand brick

Materials Specifications:

Sand:

Table 1:Properties of sand

Serial number	Tests	Results
1	Specific Gravity	2.53
2	Bulk Density	1578 kg/m3
3	Fineness Modulus	2.31

Plastic properties:

Table 2 : Plastic properties. (For general plastic)

Serial	Properties	Results
1	Density at 23˚C	0.958 kg/m^3
2	Elastic modulus	9 N/m^2
3	Tensile creep strength	8 N/m^2
4	Bending creep modulus	1 N/m^2
5	Tensile strength at 23˚C	2 N/m^2
6	Thermal conductivity	0 W/(m. K)
7	Ignition temperature	3ºC

Equations

Compressive Strength $=\frac{P}{A}$ (1)

Water absorption $= \frac{W_2 - W_1}{W_1} \times 100$ (2)

Where, W_1= Weight of dry brick (kg)
W_2 = Weight of wet brick (kg)

RESULTS AND DISCUSSIONS

Table 3: Test results of Plastic Sand blocks

Test Name	Result
Compressive strength test For difference plastic sand ratio	4 N/$mm^2$for 1:3 5 N/$mm^2$for 1:4 5.57 N/mm^2 for 1:5
Water absorption test	0.921% for 1:3 0.701% for 1:4 1.04% for 1:5
Efflorescence test	Nil
Hardness test	Hard (tested with steel rod)
Fire resistance test	Increase due to presence of sand
Soundness test	Ringing Sound (Good)
Cement bonding test	Good
Physical properties	Size: 22.86 cm/7.62 cm/10.16 cm Weight: 3000 gm. Colour: Deep Brown

According to test plastic sand blocks give satisfactory results. The minimum compressive strength of clay bricks is 3.5 N/mm^2 . A grade (1st Class) bricks compressive strength is 7 to 14 N/mm^2 .Result show that the plastic sand bricks compressive strength is minimum 4 N/mm^2. It is increased with the plastic ratio. Hence it can be used as a compressive block. Also plastic sand blocks durable, long lasting and recyclable.

COMPARISON:

Table 4 : Comparison of Plastic-sand bricks & Clay bricks.

Compressive strength			
Plastic sand bricks		Clay Bricks	
Plastic: Sand	Strength	Category	Strength
1:3	4 N/mm^2	1st Class	>10 N/mm^2
1:4	5 N/mm^2	2nd Class	>7 N/mm^2
1:5	5.57 N/mm^2	3rd Class	>3.5 N/mm^2
Remarks: Required Strength can be gained by controlling plastic sand ratio.			
Water absorption			
Plastic sand bricks		Clay Bricks	
Plastic: Sand	Percentage	Category	Percentage
1:3	less than 1%	1st Class	<12%
1:4	less than 1%	2nd Class	<20%
1:5	less than 1%	3rd Class	<25%
Remarks: Plastic sand bricks showed the significant reaction of water absorption.			
Efflorescence			
Plastic sand bricks		Clay bricks	
Nil		Can be slight, moderate and heavy.	
Remarks: Resist salt attack			
Hardness			
Plastic sand bricks		Clay bricks	
No impression on the surface while scratching.		1st class bricks are good but 3rd class isn't.	
Remarks: Hard.			
Soundness			
Plastic sand bricks		Clay bricks	
Ringing sound.		Ringing sound by 1st class bricks.	
Remarks: Good.			
Fire resisting ability			
Plastic sand bricks		Clay bricks	
Not good. Slightly increased by the presence of sand.		Excellent fire resisting ability.	
Remarks: Not good.			

CONCLUSIONS

From the studies and tests results we came to the conclusion

(I) It is seen that plastic blocks made of waste plastic bottles have its suitability for civil construction uses with a few reservations. The made-up blocks showed strength similar to 3rd class clay brick as per Bangladesh standard in accordance with other properties, is provable.

(II)The plastic that used in making bricks will not pollute the water. It is highly recommended that controlling the melting of the plastic while mixing because of the burning of plastic can cause an environmental effect by emitting harmful gas. For this reason Plastic should be grinded into small pieces to control the burning of plastic.

(III)Since plastics are volatile to fire and heavy weight it is recommended that according to the test result, not to use these blocks in the residential building, factory, hospital, school, market, etc. We can use it as a pavement block in footpath and decoration purpose like a garden wall.

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A GIS-BASED ANALYSIS ON "EMERGENCY DISASTER RESPONSE" -A CASE STUDY ON CHITTAGONG CITY CORPORATION

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ABSTRACT
Chittagong city is located on the south-eastern coast of Bangladesh and called the "commercial" capital of the country. It is vulnerable to natural disasters such as earthquake, flood etc. And for the compact urban populations, geographical location, and infrastructure, it creates an even higher risk. People and their property are often affected. If there is an emergency response plan, it will help people to take shelter in a secure place such as hospitals. Geographic information system (GIS) is used to identify probable areas of high, moderate and low risk in case of an earthquake occurs. High risk areas involve regions that are vulnerable to slope failure, close to the locations of transformers. It is mapped out the regions within Chittagong that are at high risk of slope failure, electrical surges and measure the best possible (least cost) routes for the city dwellers to reach the assumed safe destinations such as hospitals. Thus, the outcome of the research can be used for further research and analysis to make an android application of emergency disaster response.

Keywords: Vulnerable; Disaster Response; GIS Analysis; Risk Assessment; Least Cost Path;

INTRODUCTION
Climate change and its effects are the current burning issues in the world and the greatest warning to the humankind, its challenges are multi-dimensional, multi-sectoral, and have immediate as well as long-term effects. Natural disasters are defined to be environmental phenomena such as earthquake or flood that lead to the disruption of a community and its livelihood. Such catastrophes had led to the deaths of 22,773 people and 98.6 million people were affected (EMDAT & UNISDR, 2015). Every year Bangladesh faces many natural disasters like drought, flood, water-logging, cyclone and tidal surge, tornado, thunderstorm, river/coastal erosion, landslides, salinity intrusion, hailstorm, extreme weather events etc. Asia Pacific Disaster Report (2015) showed that Bangladesh is one of the most vulnerable among 15 countries with high exposure to and its risk position is 5th (Islam, 2016). In fact, about 97% of all reported disasters-related deaths occur in these developing countries (IFRC, 2004). Emergency management is the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies-preparedness, response, and recovery in order to reduce the harmful effects of all hazards, including disasters. The World Health Organization (WHO) describes an emergency as the situation in which normal activities are hindered, and instant solutions must be taken to prevent that situation forwarding a disaster. Thus, emergency management is crucial to avoid the disruption transforming into a disaster, which is harder to recover from (WHO/EHA, 2002). Chittagong city is located on the banks of the Karnaphuli River between the Chittagong Hill Tracts and the Bay of Bengal. It is vulnerable to natural disasters such as earthquake, flood etc. and for the compact urban populations, geographical location, and infrastructure of, it creates an even higher risk. Chittagong city is situated at Earthquake Zone II. An earthquake of a magnitude of 6.1 occurred in Chittagong at November 21, 1997 (DDM, 2014). If there is an emergency response plan of the city, it

will help city dweller to take shelter in a secure place such as hospitals. The goal of the study is to find least cost path during earthquakes from a random point to the nearest hospital. To fulfil the goal, certain objectives are taken. These are- to make hospital coverage area map, to make a risk assessment map and to measure least cost path from a random point to the nearest hospital. The outcome of the research can be used for further research and analysis.

METHODOLOGY

Data Collection

Primary data such as geographical locations of hospitals, transformers were gathered using GPS device. Secondary data e.g. geological data were collected from the Geological Survey of Bangladesh (GSB). Digital Elevation Model (DEM) dataset was collected from the USGS website. A Digital Elevation Model (DEM) is a specialized database that represents the relief of a surface between points of known elevation. GIS dataset was collected from the Chittagong Development Authority (CDA).

Methodological procedures for Hospitals

I. In this study, hospital is assumed a safe place for people during emergencies to turn back in case of injuries and other health issues. II. Buffer zones were created around hospitals to measure their coverage areas and distance adjacent from one another. So that, the city dwellers can make the right choices to go based on their locations. Thiessen polygon defines an area of influence around a point. Thiessen polygons can be used to demarcate geographical areas for facilities such as subway stations, and thus define the area's most accessible to each station (Caliper Corporation, 2018). Thiessen polygon was used in this analysis process. Since regular radial buffers tend to overlap a lot and hospital locations are almost clustered; this would make it hard to analyze because the overlaid buffers would cover some of the hospitals visually. When the Thiessen tool was applied, it did not cover the whole region of Chittagong because the automatic algorithm did not take in consideration water areas and coastlines of the Bay of Bengal. For this, it was manipulated using editor tool and covered those areas disregarded by Thiessen polygon calculation.

Methodological Procedures for the Multi-criteria Evaluation (MCE) Map /Risk Assessment Map

In order to identify most vulnerable and safe areas in Chittagong in case of earthquake occurrence, an MCE analysis was conducted within the scale and context of this work. Factors that were considered for the MCE analysis includes:

I. Transformer locations (high-risk location) II. Slope (slope > 35 degrees = high risk) (Doolin, J. E. 2011).

Weighted value: Slope: 50% (0.50), Geology & Transformer location: 25% (0.25)

The evaluation of the MCE was performed by using weighted sums where by:

I. Values below 0.5 were considered relatively 'safe'
II. Values between 0.5 and 1 were considered 'risk'
III. Values above 1 were considered 'high risk'.

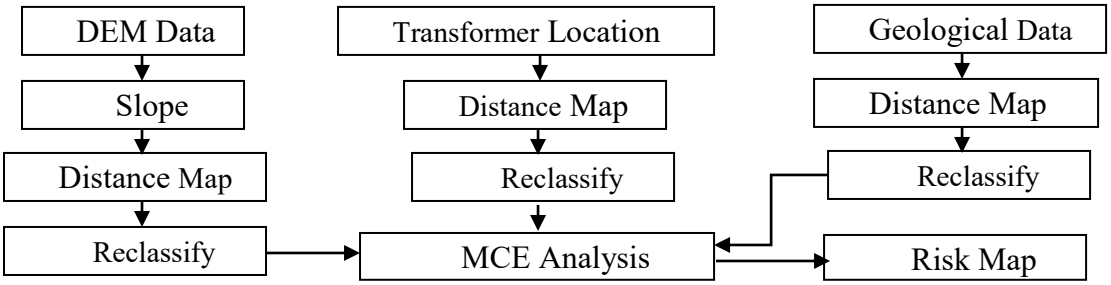

Fig. 1: Multi-criteria evaluation procedure with a flowchart.

Methodological Procedures for Least Cost Path Analysis

First of all, two arbitrary points were taken on the risk assessment map. Then cost distance analysis, cost distance raster and cost backlink were performed sequentially. After that, cost path analysis was done. At last, least cost path were determined.

STUDY AREA PROFILE

Chittagong is the largest port city of Bangladesh. Geographically, it lies at 22.3375° N latitude and 91.8389° E longitude. The area of the city is 168.07 square kilometres. The total population is more than 2.5 million. Chittagong City Corporation (CCC) is the responsible authority for governing municipal areas of the Chittagong Metropolitan Area. It is divided into 11 thanas, 41 wards and 211 mahallas (BBS, 2013).

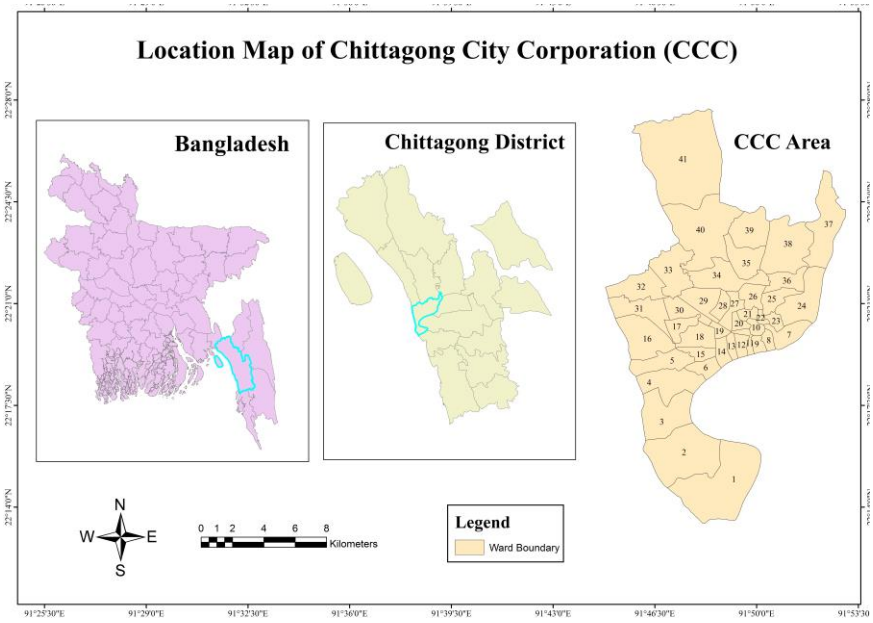

Fig. 2: Location ap of Chittagong City Corporation

RESULTS AND DISCUSSIONS

Hospital Coverage and Geology Mapping of CCC

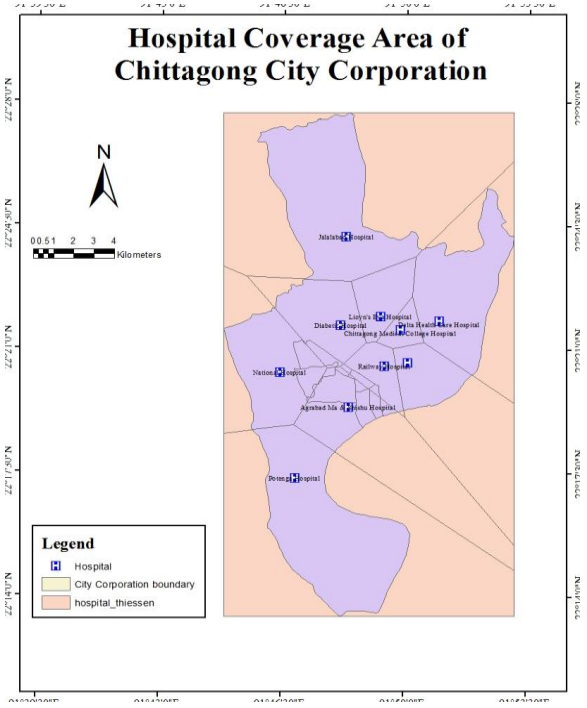

Fig. 3: Hospital coverage area

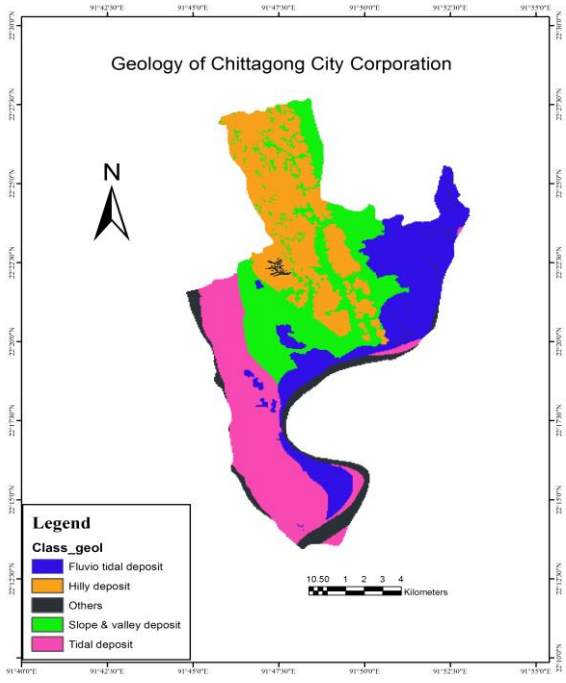

Fig. 4: Geological map of CCC

The hospital coverage area map was prepared using the Thiessen polygon tool. Geographical locations of ten hospitals were collected using Global Positioning System (GPS). There are 117 hospitals situated within the city (BBS, 2013). Only ten hospitals, which have adequate facilities during emergencies were considered in this study. Besides, these ten hospitals are considerably safe places because these are located at secure places. Fig. 3 shows the influenced geographical area of hospitals. Fig. 4 illustrates the geological map of the city. This map includes fluvial tidal deposit, hilly deposit, slope and valley deposit, tidal deposit etc. geological process in which sediments, soil and rocks are added to a landform.

Risk Assessment and Least Cost Path Analysis

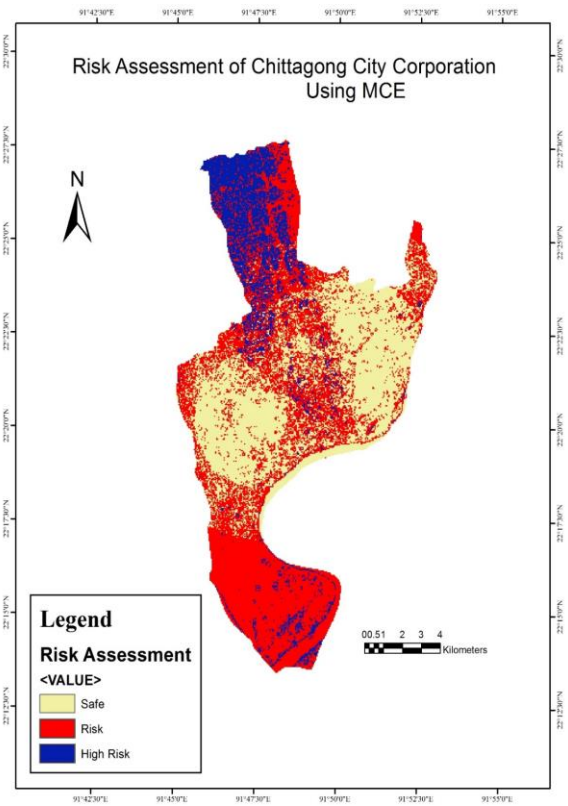

Fig. 5: Risk assessment map

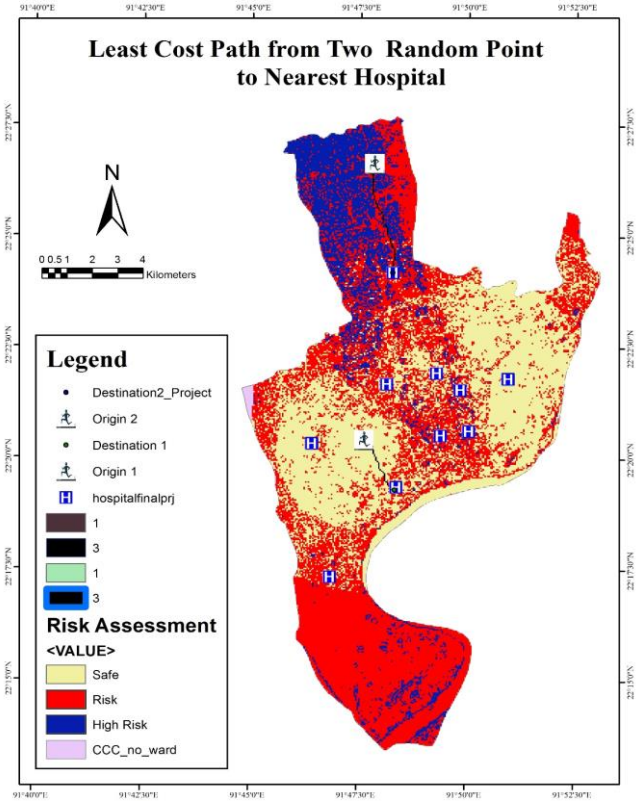

Fig. 6: Least cost path analysis

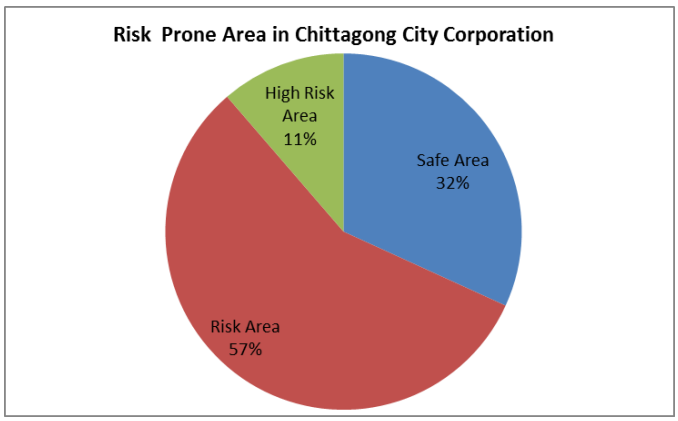

Fig. 7: Risk prone area in CCC

Fig. 5 illustrates a risk assessment map of CCC in three categories i.e. safe, risk and high-risk. Output values after using MCE analysis less than 0.5 were considered as 'safe' and coloured yellow in the map.

Again, values between 0.5 and 1 were considered 'risk' or kind of dangerous and coloured red in the map. In addition, values above 1 were considered 'high risk' or dangerous and coloured violate in the map. It is seen (from Fig. 7) that risk area is the largest portion and it is 96.84 square kilometers, which covers 57% area of total area. The safe area is 54.20 square kilometers which cover 32% area of the city corporation and the high-risk area is 19.31 square kilometers which covers 11% area. Fig. 6 demonstrates the application of the least cost path analysis of only two routes. In this study, two arbitrary points indicating as 'man' symbol in the map (the upper point on the map is 'origin 1' and lowest points is 'origin 2') were taken within the city boundary using the Arc Catalogue to generate two new point layer files and edit tool to add arbitrary points on the map. Then cost distance analysis was done from the created points. After that, cost distance raster and cost back link were generated. Subsequently, cost path analysis was performed after selecting the nearest hospital (Jalalabad hospital for origin 1 and Agrabad Ma & Shishu hospital for origin 2) using ArcMap tools. Finally, the output raster was converted into vector polylines for better optical depiction of measured least cost path routes. Specifically, it is asserted that this analysis idea could be used by Smart-phone application developers or any other GPS device developers to develop applications whose algorithms will be including this analysis to display a visual, live and interactive map that could be helpful to individuals to figure out which route to take to get to the nearest safe destination safely from a risky location using their GPS receiver devices.

CONCLUSIONS

An emergency disaster response plan may play a crucial role for people to take shelter to the nearest hospital during the earthquake and other natural disaster. One can easily reach secure place such as hospitals using a smart phone or GPS device based on the response plan. It will reduce the effect of the disaster. It may be expected that implementation of this study in field level might be a great blessing for the inhabitants of the city.

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PERFORMANCE EVALUATION OF ENGINEERED CONCRETE MIXED WITH RECYCLED WASTE POLYPROPYLENE AS A PARTIAL REPLACEMENT OF COARSE AGGREGATE

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ABSTRACT
This study aims at evaluating structural and durability performance of engineered concrete mixed with recycled waste polypropylene (PP) as a partial replacement of coarse aggregate with various water cement ratios. Performance of concrete is evaluated in terms of compressive strength and chloride penetration test at different ages. A set of control sample is also prepared with stone chips as coarse aggregate only to compare the results. In order to determine the optimum proportion of PP concrete samples are prepared with 0%, 10% and 20% replacement of polypropylene as coarse aggregate for two different water cement ratios. It has been observed that concrete with 10% PP as partial replacement of coarse aggregate can produce satisfactory strong and durable concrete. At higher water-cement ratio (such as 0.50) this reduction is about 17% for 20% PP replaced concrete. Furthermore, more than 33 MPa strength has been gained by 20% PP replaced concrete. In case of durability, all the concrete sample has been fallen under moderate category according to our test method which indicates adequate durability of the concrete sample.

Keywords: Engineered concrete; Polypropylene; Compressive strength; Chloride penetration.

INTRODUCTION
With the technological advancement around the world, disposal of wastes and waste management has gotten to be a major natural issue within the world. Among all these waste materials, plastic-based waste materials are worst as they don't effectively debase or decayed (Frigione, 2010). Plastic is accessible nearly all over and its utilization around the world expanded from 5 million tons to almost 335 million tons amid the year 1950–2016 (Statista, 2016). In America alone around 31.75 million tons of plastic wastes was presented within the municipal solid waste in 2012. Amid the year 2010 – 2011, a few 750 thousand tons of reused plastic was produced and devoured in Bangladesh (Islam et.al, 2016). Construction industry is getting a quick expansion every day, so researchers are always working to develop a cleaner, cheaper and energy efficient construction material to cope up with the advancement. The use of waste product like plastics in concrete not only makes it economical but also helps in reducing disposal problems. Developing and establishing a new construction element requires extensive research on Material, structural and durability performance.
The use of polypropylene (PP) due to its low unit weight reduces the unit weight of concrete which results in a reduction in the dead load of a structural concrete member of a building. Reduction in the self-weight of a building will help to reduce the seismic risk of the building since the earthquake forces linearly dependent on the dead-weight. Furthermore, it can also be concluded that the use of recycled PP as a partial replacement of coarse aggregate in concrete provides some advantages, i.e., reduction in the use of natural resources, disposal of polymer wastes, prevention of environmental pollution, and energy saving.

Polypropylene (PP) is a cheap and plentiful thermoplastic used in a wide variety of applications including food packaging, textiles, laboratory equipment, automotive components, and polymer banknotes. It is slightly harder, more heat resistant, mechanically rugged material; and has a high chemical resistance (Whiteley et.al, 2005). It is the second-most widely produced commodity plastic and can be used in making composite concrete for its excellent material property (Bagherzadeh et.al, 2013). The melting point of polypropylene is exceptionally high compared to numerous other plastics at 320°F (160°C). PP has great and alluring physical, mechanical and thermal properties when utilized at room temperature. Polypropylene chemical resistance can be depicted as an amazing resistance to weaken and concentrated acids, alcohols and bases, great resistance to aldehydes etc. There were several researches done on such types of composites in recent years. But in terms of durability, the question still arises if it is durable against hazard like fire or chloride penetration (Sugandhini et.al, 2016). This research emphasizes on finding out physical properties and durability performance of engineered concrete with polypropylene replacing coarse aggregates at various proportion.

METHODOLOGY

Using Polypropylene (PP) in construction is an economical and green concept of modern civil engineering (Islam et.al, 2016). To achieve the objectives, a number of experiments have been done in the laboratories. The concrete samples were prepared with 0%, 10% and 20% replacement of polypropylene (PP) as coarse aggregate with two different water cement ratios (0.45 and 0.50). Samples were prepared as per requirement of the test methods according to ASTM or AASHTO (Sosa et.al, 2014). After adequate curing, samples were tested for compressive strength ASTM C39 (2005) and chloride penetration by surface resistivity meter AASHTO TP 95(2012) at 90 days.

Materials:

For the experimental work, stone chips and recycled waste polypropylene were used as two different types of coarse aggregates. According to the ASTM C33 (2013), the gradation of the coarse aggregates was performed. Ordinary Portland Cement (OPC) has been used as binding material for this research work. Sylhet sand has been collected and used as fine aggregates. Crushed stones were purchased from local market according to desired quantities. Shredded polypropylene (PP), as shown in Figure 1, was used as partial replacement of coarse aggregate. Polypropylene was prepared through a process of scraping, then collection and washing. After that, it had been melted and cooled into certain shape. Those cooled plastic bars were shredded into specific sizes. Materials properties have been found out by performing specific tests in the laboratory according to the ASTM standards. Materials properties of the aggregates are summarized in Table 1.

Fig. 1: Recycled Polypropylene Aggregate

Table-1: Properties of Coarse and Fine aggregates

Description	Crushed Stone	Polypropylene (PP)	Sand
Maximum Size (mm)	19	12	-

Apparent Specific Gravity	2.61	0.85	2.7
Water Absorption Capacity (%)	0.36	0.3	2.8
Fineness Modulus	8.115	6.770	2.457

Mix Design:

Mix design for the concrete specimens was proposed considering stone chips with three different partial replacement of PP (0%, 10% and 20%) along with two different water cement ratios (0.45 and 0.50). A large number for sample were prepared and stored for testing. Table 2 shows the mix proportion for 1 m^3 of concrete.

Table 2: Mix Design for 1 m^3 concrete (Stone chips replaced with 0%, 10% & 20% PP, Water cement ratio 0.45 and 0.50)

Designation	PP Percentage	Water (kg)	Cement (kg)	CA-Stone (kg)	CA-PP (kg)	FA (kg)	Admixture (ml)	Total
P0W45	0	205	456	972.2	0	605.0	0	2238.2
P0W50	0	205	410	972.2	0	642.7	0	2229.9
P1W45	10	205	456	875.0	38.8	592.1	0	2166.9
P1W50	10	205	410	875.0	38.8	629.8	0	2158.5
P2W45	20	205	456	777.8	77.5	579.3	0	2095.5
P2W50	20	205	410	777.8	77.5	617.0	0	2087.2

RESULTS

For evaluating the durability performance of PP in concrete two tests have been performed, namely compressive strength and chloride penetration by surface resistivity tests at 90 days. Figure 2 and 3 show the process of compression and surface resistivity tests, respectively.

Figure 2: Compression Test

Figure 3: Surface Resistivity test of Concrete cylinder

Effects on Compressive Strength:

The compressive strengths at 90 days after casting were measured according to ASTM C39(2005) for all type of concretes. Based on the test data it can be said that concrete with PP will produce lower strength compare to the regular concrete with no PP content. This is expected as synthetic PP does not bond well with the binding material used in content. However, reduction of compressive strength is not

that significant nor is linearly variable with PP content. For the water cement ratio of 0.45, concrete compressive strength reductions for 10% and 20% PP replaced concrete compare to 0% PP replaced concrete is only 26% and 30%, respectively as shown in Figure 3. On the other hand, for the water cement ratio of 0.50 compressive strength reductions for 10% and 20% PP replaced concrete compare to 0% PP replaced concrete is only 26% and 17%, respectively as shown in Figure 4. The results of the PP replaced concrete gives the indication of adequate strength of the concrete.

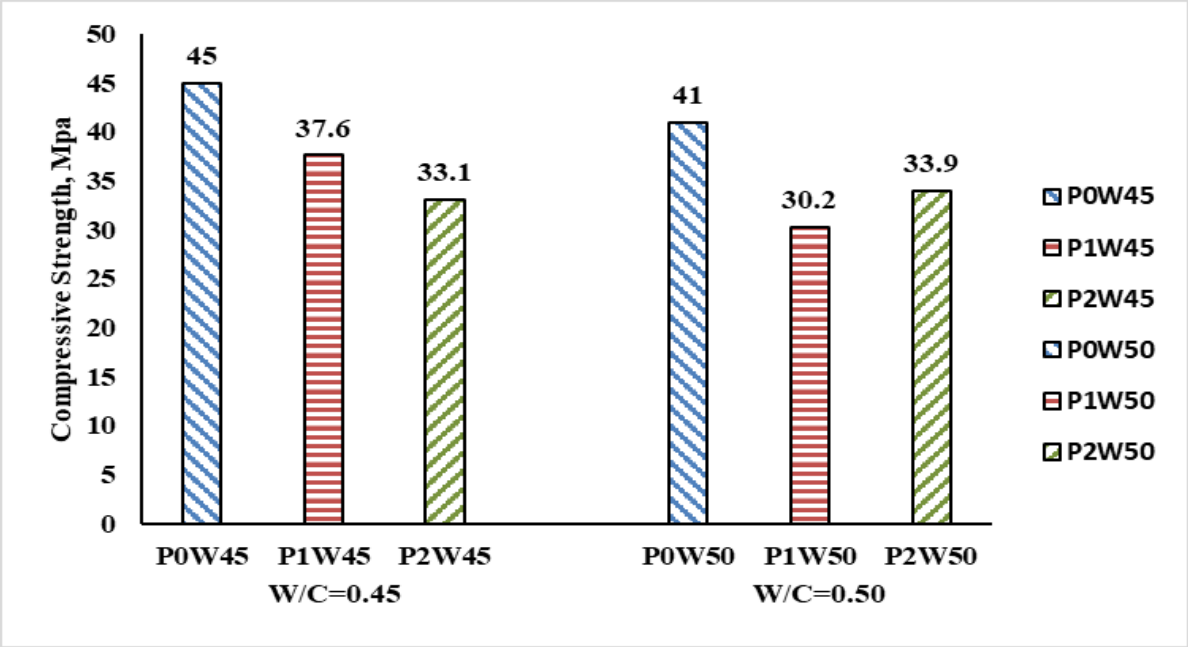

Figure 4: Compressive strength comparison for various PP replaced concrete sample

Effects on Chloride Penetration:

The surface resistivity test was performed according to AASHTO TP 95(2012). In this test method, the surface resistivity of concrete was measured by surface resistivity meter and the data was correlated to the chloride penetrability classification of the concrete. According to this test method, specific resistance value of 12 KOhm-cm to 21 KOhm-cm is considered as moderate category. Figure 5 shows the specific resistance in KOhm-cm for two different water-cement ratios and three different PP replacement percentages. For the all the cases, chloride ion penetrability of concrete falls under moderate category. For the water cement ratio of 0.45, specific resistance reductions for 10% and 20% PP replaced concrete compare to 0% PP replaced concrete is only 14% and 21%, respectively as shown in Figure 5. For the water cement ratio of 0.50, specific resistance reductions for 10% and 20% PP replaced concrete compare to 0% PP replaced concrete is only 20% and 12%, respectively as shown in Figure 5. The results of the PP replaced concrete gives the indication of adequate durability of concrete.

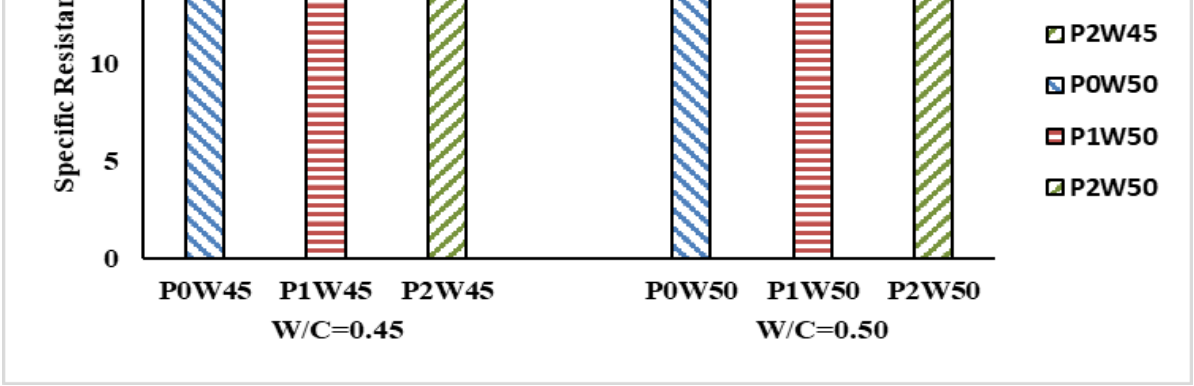

Figure 5: Chloride ion penetrability comparison for various PP replaced concrete sample

CONCLUSION

Compared with regular concrete, PP concrete has the lower compressive strength as well as the lower surface resistivity. With the increasing amount of PP percentage in the concrete, both compressive strength and surface resistivity of the concrete is decreasing albeit in lower percentage. It is to be expected as the synthetic nature of the PP provides lesser bonding with the cement mortar compare to the natural stone aggregate. However, at higher water-cement ratio (such as 0.50) this reduction is about 17% for 20% PP replaced concrete. Furthermore, more than 33 MPa strength for 20% PP replaced concrete gives the indication that PP can be used for structural concrete safely. Besides, PP concrete is more economical due to its low cost and adequate availability. The structure, made by PP concrete is lighter than regular concrete due to the lower unit weight of PP. Therefore, it can be concluded that the recycled PP can be adopted as partial replacement of coarse aggregate in concrete used for structural purposes.

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DESIGN OF A ZERO-ENERGY BUILDING IN ROMANIA: A CASE STUDY

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ABSTRACT
Net Zero Energy Building designates the collaboration of energy efficient building and renewable energy utilization to reach a balanced energy budget over a yearly cycle. Sustainability of the construction has the major concern about the sustainable energy used. It is the energy that is consumed at insignificant rates compared to its supply and with manageable collateral effects, especially environmental effects. In other sense, sustainable energy is an energy system that serves the needs of the present without compromising the ability of future generations to meet their needs. The energy consumption and production should be equal for sustainable development. The self-production of energy in the building for the consumers by different modern technology to fulfill the Net Zero Energy Building concept. Photovoltaic system, wind turbine system, lighting system, energy storage system, floor heating technology, water heating system are the main modern technology to make a building zero energy building. The increasing use of the residential and industrial area of photovoltaic systems has led to a growing market for implementation, Europe has reached 100 GWs installed and in Romania it has reached 1.3GW install. In the residential area there is an increasing demand for a self-production implementation, i.e. the energy produced is also consumed locally.
The study is a part of design and construction of sustainable building at the borders of Oradea, Romania. This building is constructed by the help of European Union funded project for hajdu-bihar and bihor counties. The objective of this building is to promote the development of renewable energies and related economic sectors. The design, optimization, implementation and monitoring of advanced and cost-effective solutions for achieving nearly zero energy (NZE) and positive energy settlements by developing renewable energy sources. This building is also used to organize seminars, workshops, exhibitions and presentations on topics related to renewable technologies to promote the technology through the other part of the country.

Keywords: Zero-Energy building, Floor resistance, GHG emission, Photovoltaic system, DHW heating, VRFB.

INTRODUCTION
Recently, the emission of greenhouse gas increasing rapidly due to industrialization and to meet up the demand of energy consumption rate is increasing very fast and this problem is considered one of the world's greatest concern [8]. Globally, buildings consume over one third of all final energy and half of all electricity, and as a result they are also responsible for about one third of global carbon emissions [3; 10]. The European Union has established specific policies aimed at reducing fossil fuel consumption and their related greenhouse gas (GHG) emissions. The Europe 2020 strategy adopted by the European Commission stipulates three targets to be met by the year 2020: a reduction in GHG emissions of 20%, an increase in energy efficiency of 20%, and an increase in the contribution of renewable energy sources equivalent to 20% of final energy consumption, in relation to those of 1990. By simultaneously reducing consumption and relying on "clean" production, all new buildings will be

"nearly" zero-energy. It implies that the energy demand for heat and electrical power is reduced, and this reduced demand is met on an annual basis from renewable energy supply [2]. Practically, this means that energy consumption decreases over time and is eventually matched by an equivalent supply of energy from renewable sources (Fig. 1). Net zero-energy buildings (nZEB) are thus intended to have very high energy performance, and the low amount of energy that they require comes from sustainable non-fossil resources. According to one recent definition by Voss [1], "Net Zero Energy Building" describes the "synergy of energy efficient building and renewable energy utilization to reach a balanced energy budget over a yearly cycle." Member countries are directed to establish their own schemes for setting and achieving specific performance requirements for buildings and related systems.

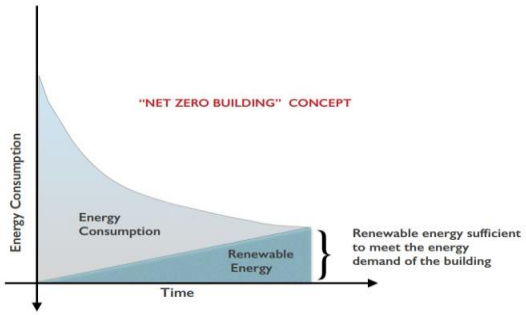

Fig. 1: The net zero-energy building concept, by which energy consumption decreases over time and is eventually matched by an equivalent supply of energy from renewable sources [1].

On regional, national and international levels, energy policy is considering energy efficiency in buildings as a future target for the building design. This is why Zero-Energy Building design is recently taking a leading role in all the architecture, the architectural engineering, and the building physics sectors and having a significant importance among researchers on these fields [4]. The European Energy Performance of Buildings Directive (EPBD) has published a recast on 2010 that defines some of its goals including that by 31 December 2020 all new buildings must be nearly zero-energy buildings (nZEB) in the Member States [5]. Also, the US Department of Energy (DOE) has proposed ‘marketable Zero-Energy Homes in 2020’ as a strategic goal to be achieved [6]. Following the same pattern, the Solar Heating and Cooling Program (SHC) of the International Energy Agency (IEA)-that has 20-member countries from all over the world- approved the Task 40 (Towards Net Zero Energy Solar Buildings) in 2008 [4].

The BMS system provides the management of the home / of a remote building (on-line) through a web-based interface, accessing applications from anywhere in the world through Internet services. The system is modular and is based on fast and efficient exchange of information between all components and devices involved. The system is a set of hardware and software equipment designed for automated control, centralized and local surveillance of the various subsystems that house the dwelling. The BMS system works automatically, without the need for permanent human intervention [Fig. 2].

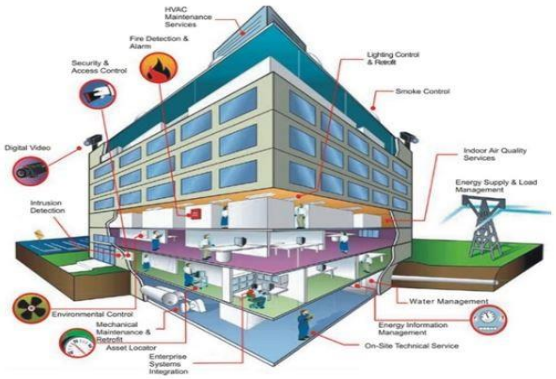

Fig. 2: The BMS system provides the management of the home.

CASE STUDY AREA

The sustainable zero-energy building is located at the outskirts of Oradea, Romania. This building is a part of European Union funded project for hajdu-bihar and bihor counties. This building is used to organize seminars, workshops, exhibitions and presentations on topics related to renewable technologies. The building is mainly steel building. The basic structural element for the building is IPE 300 and HEB 320 hot rolled steel section for beam and column respectively. The slab is composite and carbon is used in floor for heating the floor automatically. Basically, slab has three layers: concrete, steel sheeting, carbon fiber. The thickness of underfloor heating carbon fiber 5 mm. A maximum surface heating element can be $25m^2$. Carbon fiber is flexible, does not oxidize and not produce hazardous electromagnetic emissions during the flow of electricity, not change dimensions due to temperature variations and not change their ohmic resistance. The floor does not wear out and require no maintenance during the service period. The material used in the floor with high resistance that allows electricity savings by producing more temperature in the floor automatically [9]. All steel joints are welded joints. The main 3D architectural plan for the building is shown in Fig. 3.

According to Law 372/2005, modified by Law 156/2016, the study on the possibility of using alternative high efficiency systems is requested by the Town Hall through the Urbanism Certificate, in obtaining the Building Authorization. This study is issued for new buildings/assemblies of new and existing buildings (single-family houses, dwelling blocks, offices, educational buildings, hospitals, hotels and restaurants, sports activities, trade buildings, other types of energy-consuming buildings).

By issuing an urban planning certificate issued by the competent local/county public authorities, in order to obtain the building permit in compliance with the law, besides the obligation to meet the minimum energy performance requirements, a study will be required on the possibility of using some systems high efficiency alternatives, depending on their technical, economic and environmental feasibility.

The certificate includes recommendations for reducing the energy consumption of the building, estimating energy savings by implementing measures to increase the building's energy performance, including where to obtain more detailed information, such as the cost-effectiveness of the recommendations made, the procedure to be followed for the implementation of recommendations, financial or other incentives and funding opportunities.

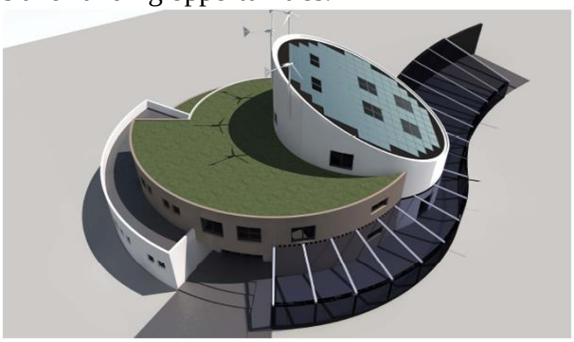

Fig. 3: 3D view of the BIOREN building.

RESEARCH METHODOLOGY: INNOVATIVE TECHNOLOGIES

Innovative energy conservation and renewable energy generation technologies are applied and tested, in order to achieve better results than conventional technologies do and a better integration of the technologies in the houses, which can help the installation and maintenance processes. Thermal insulation, solar shading, wind and solar energy generation systems as well as ventilation systems, are among the most common methods used [7], for the energy efficiency of buildings. The detail description of the most common innovative technologies used in the building are:

161 KW Photovoltaic panels

Installation of about 704 photovoltaic panels DSTech 230 W (polycrystalline) and 8 Inverters 20 kW RefuSol [Fig. 4] on the roof to generate the solar energy during summer session. To get the maximum day light, it is most important to maintain proper slope of these panels. The maximum capacity of generation of power is 161 KW power from this panels.

Fig. 4: Photovoltaic on grid system 161 kWp.

60 KW Photovoltaic panels

Photovoltaic system composed of 84 Photovoltaic panels AE-Solar 235W (polycrystalline), 186 Photovoltaic Panels AE-Solar 210W (Monocrystalline), 4 Inverters 20K Refusol and Wind turbine 3 KW-5 KW. This panel is about circular in shape. It is located on the roof but, the position is higher than the flat photovoltaic panel [Fig. 5]. The slope and the arrangement of these two panels are totally different. The slope is maintained is about 45º-60º for this panel. The main goal is to get the maximum sun light to produce maximum solar energy. The maximum capacity of generation of power is 60 KW power from this panels.

Fig. 5: Photovoltaic system on grid system 60 KWp.

Annual consumption of electricity of the proposed area on 2015 is 13,237 MW, taking into account that the whole house is only electricity-consuming [Fig. 6]. The production of electricity through the photovoltaic system is done to cover the annual consumption, during this period it is a total production of 11.68 MWh. The system was sized for annual consumption. The production graph shows the high productivity in July, about 1631.6 kW produced and the highest production per day of 68.8 kW. From the chart below, the consumption during the cold period of the year is largely insured from the network. Consumption is not covered over the year, but the high productivity of panels and renewable energy helps reduce electricity costs. The implementation of a self-consumption and energy management system will be proven by the next year's report.

Horizontal axis wind turbine

This wind tower is located at the right part of the building [Fig. 7]. It is moving always about the horizontal axis and produce 3kWp. The height of the tower is almost equal to the height of building.

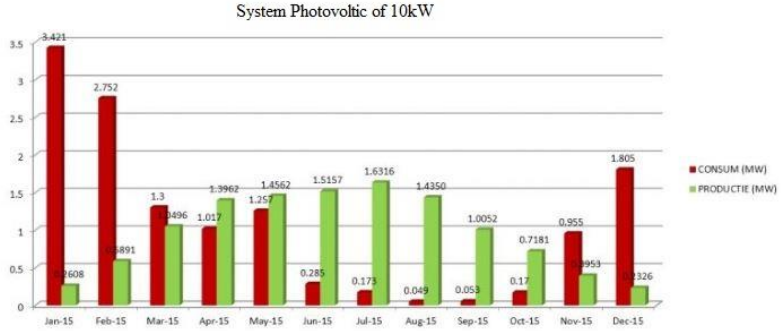

Fig. 6: Electricity production and consumption of Photovoltaic system on grid system.


Fig. 7: Wind turbine with horizontal axis

Vertical axis wind turbine

This wind turbine has been mounted on the roof of the 1st floor of the building [Fig. 8]. This turbine rotates around the vertical speed. Hydraulic braking system has been used for this turbine to limit the maximum rotating speed of the turbine. The power generation of this turbine is around 5kWp.

Fig. 8: Wind turbine with vertical axis

Advanced VRFB auto concentration system

In the project, the opportunity to offer a complete solution for covering the electricity consumption through photovoltaic production of 26 kWp and a self-contained component composed of batteries with Vanadium Redox Flow Battery (VRFB) and integrated a management system of energy. Electricity production consists of a 26kWp system with high performance 250W polycrystalline panels produced in Germany. The 25kW inverter has integrated the Speed wire component for on-line monitoring of in-house production, production history and other data needed to analyze efficiency. Positioning on a special aluminum system for photovoltaic structures with a 30º inclination and positioning on the South-South West axis ensures efficient occupancy of the building's terraces and the elimination of unused spaces and a minimal shading system for surface ration and panel requirements, 104 pieces. True innovation is through the Vanadium Redox Flow Battery (VRFB) technology [Fig. 9] that provides Romania with the second project implemented with this technology and the first Romanian project with the new class of liquid electrolyte accumulators. To highlight the advantages and performance of this battery system, the primary technical data must first be exposed:

i. Number of discharge cycles: minimum 20,000
ii. Load capacity: minimum 40 kWh;
iii. Maximal rated continuous charging power: minimum 10kW;
iv. Maximum continuous rated discharge power for a 10-hour cycle: minimum 10kW;
v. Usable capacity (at 80% discharge): minimum 32 kWh;
vi. Planned discharge time: at least 4 hours at 8 kW;
vii. Power lost by self-discharge in "shut down" mode: maximum 1%;
viii. Power lost by self-discharge in "hot stand-by" mode: maximum 0.15 kW;
ix. Maximum discharge possible without battery damage: 100%;
x. Global efficiency: up to 85%;
xi. Capacity decrease with number of cycles: 0;
xii. Protection class: IP 54;
xiii. Operating conditions: Ambient temperature range (-20, +40) 0ºC or greater to allow location outside the building;
xiv. Lifetime: minimum 10 years, with the possibility of major repairs and reuse.

The integrated download loading system is automated by installing Smart Meters on the consumer-to-use side to maximize the use of batteries and photovoltaics. The backup component is provided by an island-type system that automatically intervenes in the event of a power grid interruption. Thus, the consumers connected to the system are active all the time of the electricity interruption and are kept depending on the photovoltaic production and the total consumption; it can provide a long independent network time. This solution will be a major step in addressing the need for energy and backup for large-scale consumers to provide a long-lasting technology for storing surplus energy from photovoltaic systems and automating the intelligent energy management process.


Fig. 9: VRFB auto concentration system

Lighting system OFF GRID BIOREN

Illumine at off grid system with two-lamp leds, 250W unpa photovoltaic system and a battery system with controller [Fig. 10]. It has sensors of crepuscidation for the efficiency of the consumption.

Energy storage device

Solar water heating system has been used for this building. The sun facing heating collector heats the fluid which moves up and ultimately heats the water. The fluid heats the water and comes back to its original position and repeats the process. To store the energy, Cell Cube energy storage system, Li-ion storage system and gel batteries system has been installed. It is decisive factor in the history of renewable energy management and it works with photovoltaic panels, the wind, the biogas in parallel-energy storage system with vanadium redox flow guarantees uninterrupted power supply. The objective of this cube is to support the main network, back up, and investment protection.


Fig. 10: Lighting system Off Grid BIOREN

Heating floor

For the under-floor heating, carbon films have been used. The carbon films give low resistance as compared to the copper and are thus more efficient in terms of efficiency. Above the carbon fibers, concrete layer has been placed which in turn increase the heat concentration time in the building and thus it requires large time to lose heat energy. Similarly, the floor has been divided into different zones with separate temperature controls [Fig. 11].

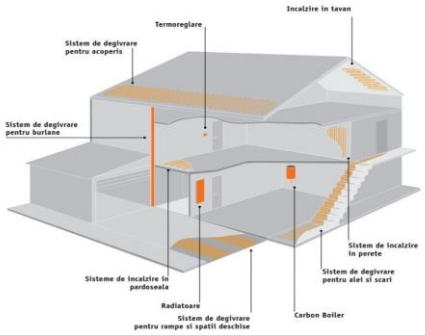

Fig. 11: Systems of modular and personal heating based on carbon fiber

Thermal radiation represents the heat exchange through infrared waves. Two bodies or objects with different temperatures exchange radiation naturally and thus the heat flow passes from the warmer to the coldest body. Radiation emitted into a room by a floor heating system turns into heat when it comes into contact with an object, wall, or person, the infrared waves are not lost in the air but are absorbed by solid bodies that in turn transform into the heat transmitted in the ambient. This creates optimal conditions for the comfort of the people in the room.

The system is ideal for all types of buildings: houses, blocks, schools, hospitals, shops, new or refurbished buildings. The heating system based on carbon fiber technology can be easily adapted to all requirements. The heating elements are incorporated into the floor, so the walls are released by the massive radiators, and more space is provided for room fitting.

The heat spreads uniformly and homogeneously from the floor to the ceiling, guaranteeing a stable temperature in the room. The temperature can be easily adjusted in each room.

The heating system is directly connected to the electrical grid, it does not require boilers, other tanks or mechanical elements that could disturb the quiet of the room.

In each room, a thermostat can be installed to adjust the temperature according to preference and timing. No pipes, pumps or other pipes are required, mandatory for water-based heating systems.

Thanks to the uniform and homogeneous distribution of heat, the GENIUS CARBON system allows a reduction of the ambient temperature by about 1-2°C compared to other heating systems. A reduction in ambient temperature by 1°C is reflected in a 7% decrease in consumption [Fig. 12].

The system does not require periodic technical revisions because it does not wear out in time.

Carbon fiber floor heating systems do not require double temperature control (floor sensor and ambient sensor). It is sufficient to control the ambient temperature with a simple thermostat. For consumption efficiency, an electronic control element can be installed that allows:

i. system operation in modulation in accordance with outdoor temperature
ii. controlling and managing the charge of the electrical installation
iii. setting of time slots

The floor heating panel is ideal for both new floors and renovations. The radiant heating principle of the system does not cause the air to move, so the bodies are heated directly, avoiding the circulation of dust and mites. The panel has customized power and dimensions. Due to the multilayer panel composition, the heat is evenly spread, resulting in a minimum heat dispersion at the bottom of about 5%.

Technical Features The panel is applied on clean and smooth surfaces. The extremely low thickness of the heating layer, about 5 mm, allows interventions of a minimal size. All heating elements are connected to the network in parallel, so the system can work even in case of partial faults, excluding the supply of 1.00 m².

Carbon Fiber Carbon fiber is flexible, does not oxidize, does not produce dangerous electromagnetic emissions during electricity flow, does not change its dimensions during temperature variations, and does not change its ohmic resistance. It does not wear out and does not require maintenance. The high resistivity of the material allows for significant energy savings. Composition Heat-insulated heat-insulated carbon fiber cables on the bottom, fastened to a fiber-optic netting support. The total thickness is 4mm.

Temperature control Switching on and off the heating system can be automated by using the electronic control element, which works in combination with a temperature probe to be installed in the heating zone. Some situations require the installation of a power splitter to half the installed power if a

reduced amount of total power is available. Moreover, installing a thermostat or chrono thermostat is sufficient for efficient room temperature control.

Fig. 12: Temperature control floor device

DHW (Domestic Hot Water) heating device

There is a water heating system on the roof [Fig. 13]. They mainly used gasses to heat water automatically. It runs along horizontal axis. It also maintains the total amount of water using in the different floor. It is controlled by somehow, so that water cannot overflow when it is not used. The Kerberos system provides domestic hot water heating by using photovoltaic power directly to the boiler's electrical resistance. The Kerberos system ensures maximum use of photovoltaic power and minimizes power consumption through a smart heating control system water. This level of efficiency is obtained thanks to advanced technologies to control optimum power (MPPT-Maximum Power Point Tracking).

Fig. 13: Heating ACM

CONCLUSIONS

The paper has demonstrated a valid approach to meeting EU targets outlined in the introduction and discussion. The NZE buildings satisfy the specific objectives of the project, which are a reduction of the net regulated energy and as well as a generation of energy in the building. The energy generates from the building that to meet the specific targets set out for the project aligned with the EU Directive, buildings built to current Energy Performance of Buildings Regulation in Romania. The concept of the building is one of the best examples for zero energy building. The building is also self-sustainable in terms of energy. Every component of the building is done accurately as per the description. It is the initial phase of the structure. When they run the building in full phase, the inhabitants and the surrounding people will get more benefit from this project. The environment around this project will not be hampered in future. As it is the initial stage of the project it has some drawbacks in the system. The main drawbacks are: The wind turbine mounted on the tower is too low height. It is now only for people perceptions. During operation horizontal axis wind turbine produces a lot of noise. The vertical axis wind turbine is located quite close to the building due to which it also does not produce the energy as per its capacity. They used the carbon fiber in the heating floor but carbon fiber has low resistance. So, it will not produce heat quickly. For heating it requires less energy, but it will take longer time for heating. If they use copper instead of carbon, then floor will be heated quickly. The water heating device on the roof will not work in the night time. The building is constructed in the land fill area, so some issue for settlement. After one year, some cracks are noticed in the main gate wall and water problem on the ground floor. In model building, fire system in electricity control room is necessary to resolve the problem immediately.

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STUDY ON PRODUCTION AND AVAILABILITY OFCONSTRUCTION MATERIALS

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ABSTRACT
Construction is one of the major economic activities as well as an important sector of the economy. It is the main component of gross fixed capital formation (GFCF) in Bangladesh and represents about 70 to 75 percent of the total investment. Nearly 75 to 85 percent of the construction raw materials or commodities are being produced by the local manufacturing industries. Most of the construction materials are locally produced and certain percentage of materials are imported. A good number of manufacturing industries are producing these construction commodities to meet up the local demands as well as for exports. There is no adequate and reliable annual production data on various types of construction materials. Besides there is no comprehensive and time series data on annual production as well as availability of various construction commodities. This study is carried out to determine the proportion and production of major construction materials. Several steps are done step-by-step to accomplish on production and availability of construction materials. Hope that this report will help policy makers, planners, national accounts compliers, researchers and many others who are concerned with the volume and trend of capital formation in the country.

Keywords: Construction; Gross Fixed Capital Formation (GFCF); Construction Materials; Production Data; Availability.

INTRODUCTION

Construction is an important sector which contributes greatly to the economic growth of our country. Construction sector represents about 7% of our country GDP and is the major component of Gross Fixed Capital Formation (GFCF). Capital formation is one of the important factors for increasing productive capacity of a country. The relationship between capital formation and economic growth and poverty alleviation is well-established. Economic development of a country is not possible without adequate capital resources and therefore, reliable estimate of volume and trend of capital formation is important. The construction sector plays an important role in economic growth. More importantly, construction produces different type of structures that add to productivity and quality of life. On the other hand, construction activities are labor intensive and when this sector works in full swing, a significant part of the nation's work force are active. For the purpose of different types of construction and engineering works and other structures; various construction materials are used as inputs. Mainly most of the materials are produced locally and certain percentage of materials are imported. A handsome number of manufacturing industries are producing these construction commodities. Actually, there is no reliable and adequate production data on various types of construction materials. In this study, therefore, an attempt has been made to study the production and availability of major construction materials.

METHODOLOGY

A draft questionnaire was designed on the basis of the objectives of the survey. It was a structured questionnaire and mainly pre-coded covering several questions on number of the issues such as

- characteristics of the construction materials manufacturing establishment,
- person engaged, source of raw materials and type of energy used,
- type of goods produced and marketing system,
- production capacity and annual production and
- fixed assets by type etc.

Data processing is one of the important steps of the survey undertaking and editing of raw data is the major task of data processing. Both primary and secondary sources were investigated for collection of data. The detailed methodologies of the above tasks for conducting the Survey on production and availability of construction materials are highlighted bellow:

- **Prepare a list of construction materials**
  A comprehensive list of construction materials was prepared on the basis of construction materials lists of PWD and LGED.
- **Prepare a list of export and imported construction materials**
  A list of export and imported construction commodities for construction were prepared.
- **Making a list of secondary sources**
  A list of secondary sources was prepared for collecting data on major construction materials.
- **Prepare a list of construction materials manufacturing industries**
  A list of construction material manufacturing industries was identified for collection of production and other information.
- Develop a sample design for undertaking the survey on construction materials manufacturing establishments for collection of production data;
- Developed data collection instruments such as questionnaire, form and data collection etc.

RESULTS AND DISCUSSIONS

- **Fixed assets**
  The following figure shows the fixed assets by ownership of establishments

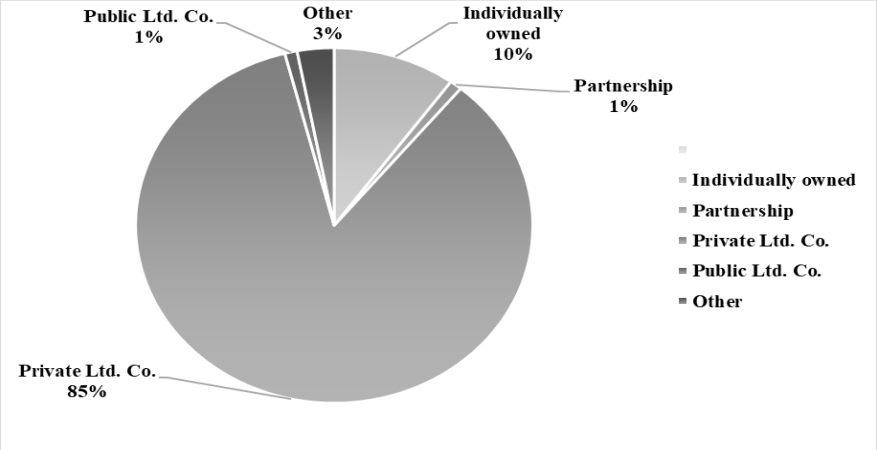

Fig. 1: Fixed assets by ownership

- **Production of major construction materials**
  The following figure shows the production of major construction materials

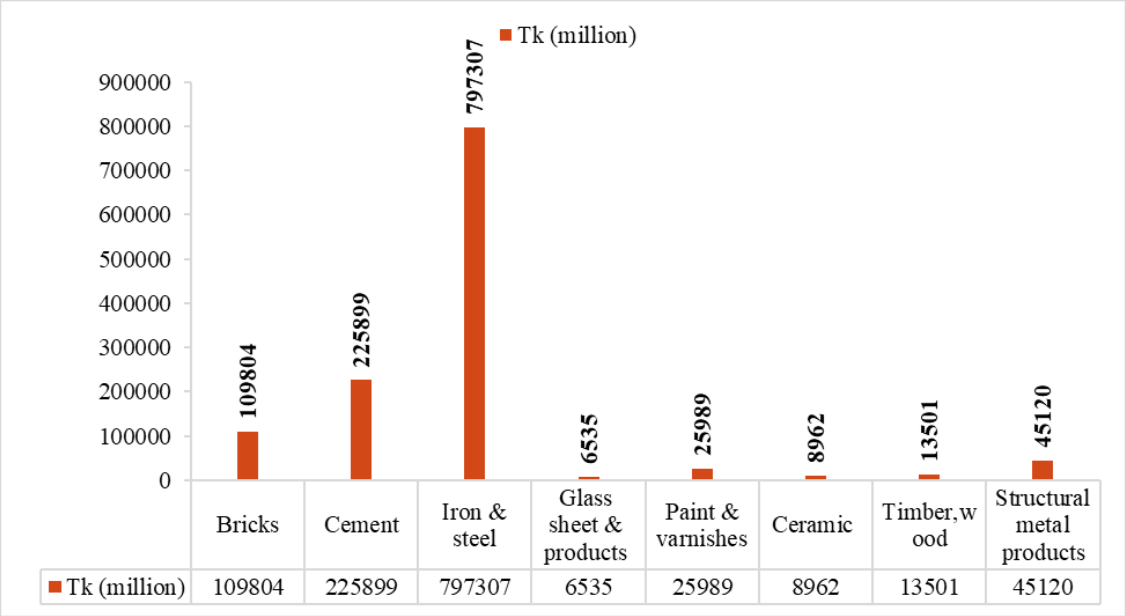

Fig. 2: Production of major construction materials

- **Production estimates of selected materials**

  Both primary and secondary sources were investigated to come up a realistic production estimate for selected construction materials particularly of major construction materials. Production estimates of various construction materials obtained from survey of manufacturing industries data, baseline survey of production and availability of construction materials, offices of the concerned associations of the construction materials manufacturing industries, annual reports of the establishment/industry etc.

- **Brick production**

  Brick is a very important and basic input for construction. There is no any dependable estimate of annual production of bricks in the country.

  There are primarily two types of bricks such as

  a) Ordinary brick and
  b) Ceramic brick used in construction

  The price of ceramic brick is more than double than the price of the ordinary brick. Brick is now producing in the formal manufacturing industry/establishment i.e. in the brick fields.

  Generally, no brick is produced at household level. Coal is used as fuel for brick manufacturing/burning. Through it is illegal to burn brick by using wood as fuel, almost 5 % of the bricks are being manufactured by using wood as fuel according to the perception of Owners of the Brick Manufacturing Industries. The number of ceramic brick manufacturing establishments are very few and the production of ceramic brick is not so significant. The ceramic brick factories belong to both public and private sector.

  It is relevant to mention that according to Bangladesh Brick Manufacturing Owners' Association (BBMOA) there were 6500 brick manufacturing establishments or brick fields engaged in brick manufacturing. The BBMOA also pointed that the annual average number of brick production was 35 lakhs per brick field and 18-20 metric tons of coal was needed for hundred thousand (one lakh) brick manufacturing/burning. They also said that average 45-5-lakh metric tons of coal are needed per year for the brick fields. But according to the Department of Environment (DoE), there were 6400 brick fields in production in the country. Coal might be used as a proxy parameter for estimation of brick production.

- **Category of bricks production**

  Information regarding category of bricks produced in the brick field were also collected for proper valuation of bricks used in construction.

The following table shows the proportions of the categories of bricks produced in the brick fields.

Table 1: Average percentage category of bricks production by division

Division	Category of bricks (%)				Total
	Class-I	Class-II	Class-II	Picket	
Barishal	65.0	22.5	9.0	3.5	100.0
Dhaka	71.2	18.5	7.9	2.4	100.0
Chattagram	69.4	20.2	8.6	1.8	100.0
Rajshahi	65.0	20.0	12.2	2.8	100.0
Rangpur	66.3	20.0	11.0	2.7	100.0
Khulna	66.0	23.2	8.3	2.5	100.0
Sylhet	65.0	20.8	12.1	2.1	100.0
All	66.2	21.4	9.8	2.6	100.0

It is observed from the data that two-third (66.2 %) of bricks were manufactured as Class-I bricks followed by Class-II (21.4 %) and Class-III (9.8 %) only. The proportion of picket brick was as high as 2.6 percent.

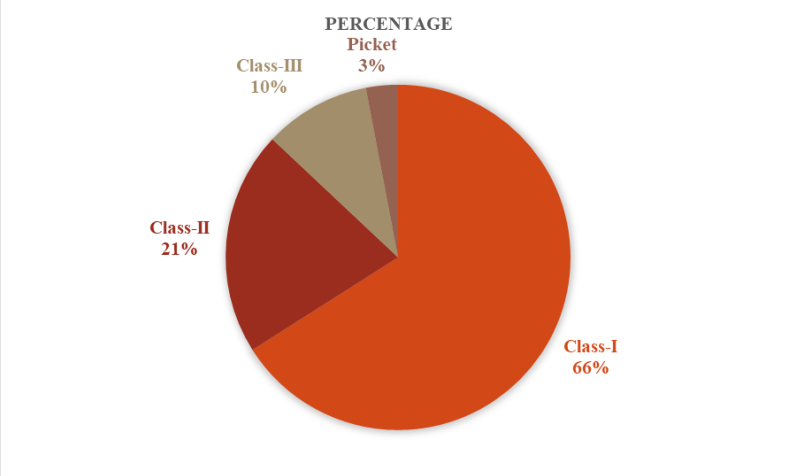

Fig 3: Percentage category of bricks production

- **Cement**

  Cement is another important input or material for construction. There are mainly two types of cement namely

  a) Portland cement
  b) White cement

  White cement is not produced here and its availability completely depend on import. The use of white cement is not significant as compared to the Portland cement.

  Bangladesh is self-sufficient in cement production and it is being exported now. The main raw material of cement is clinker which is imported primarily from neighbouring countries. Most of the cement factories are now in private sector and only few are in public sector.

  Cement may be the only proxy indicator which could be applied for estimation of output of construction. Expenditure for construction works is estimated on the basis of the availability of cement along with the estimate of 'average cost of construction per ton of cement used'. There are about 120 cement factories engaged in production in the country and some of them are very large.

  The estimate of cement production based on different sources is shown below:

Table 2: Estimate of cement production

Source and period	Quantity (million metric ton)	Value (million Tk.)	Growth rate (%)	
			Quantity	Value

SMI 2012	Na	225,580	-	-
BSPCM 2013-14	22.0	225,899	-	-
Bangladesh Cement Manufacturers Association:				
2012-13	17.5	145250	-	-
2011-12	16.0	124800	9.4	16.4
2010-11	14.5	106430	10.3	17.3

It is seen form the above table that there are significant variations in production data available from different sources. As a result, it is difficult to come up to actual or reliable estimate of cement production. It is known that, clinker is the main raw materials or input for cement production and its input-output ratio is 100:90 i.e. 90 tons of cement is produced from 100 tons of clinker.

- **Sand**

  Sand is a common and essential material/input of construction. There are three types of sand such as

  a) Local /course sand
  b) Sylhet sand and
  c) Vetibalu/dust soil

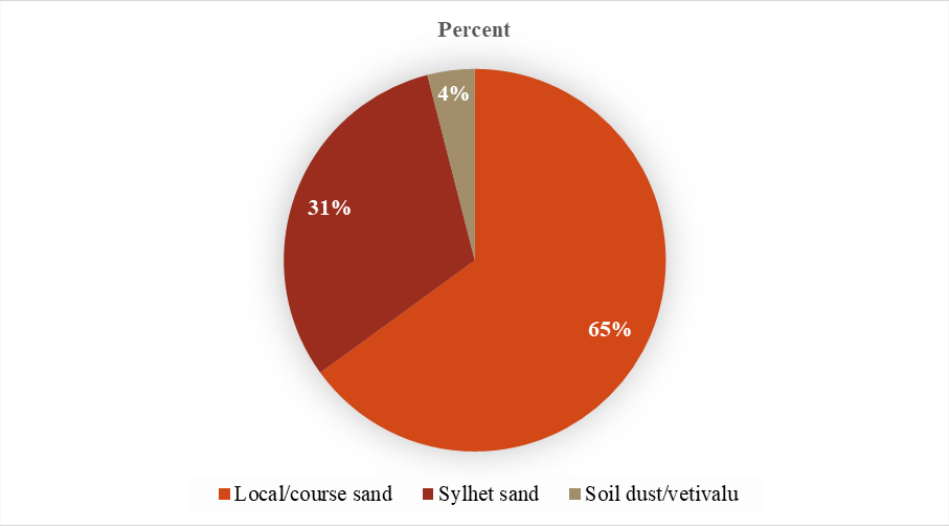

Fig 4: Type of sand used in building construction

Table 3: Proportion of sand use in construction works by type of sand and by division

Division	Local sand	Sylhet sand	Total
Barishal	67.50	32.50	100.00
Chattagram	70.00	30.00	100.00
Dhaka	71.20	28.80	100.00
Khulna	69.50	30.50	100.00
Rajshahi	68.30	31.70	100.00
Rangpur	70.00	30.00	100.00
Sylhet	60.00	40.00	100.00
Total	68.07	31.93	100.00

- **Production of iron and steel**

  Iron and steel is also a key element of any kind of construction. The basic raw materials of iron and steel products are scrap iron or iron blades. These are imported and different types of iron and steel products are produced by there-rolling and auto-steel mills of the country. Iron and steel production is quite sufficient to meet up the local demand. The production data is almost

fragile. Annual production estimate of iron and steel products is significantly different from one source to another. Scrap iron is the major raw materials the local re-rolling and steel mills. According to the Bangladesh Ship Breakers Association, they are producing about 24-27 lac tons scrap iron per year.

The following table shows the annual production estimates based on various sources.

Table 3: Production and availability of iron and steel products

(in metric ton)

Period	Production of scrap iron	Import	Total availability
2010-11	2,314,649	55,358	2,370,007
2011-12	3,602,573	72,334	3,674,907
2012-13	3,120,000	159,574	3,279,574

CONCLUSIONS

This is a comprehensive construction thesis in the perspective of Bangladesh and it is unique by its type and features. The information presented in this report will act as a guideline to planners, engineers, researchers and policy makers who need to know the level and trend of gross fixed capital formation for starting new business and for formulating macroeconomic policies of the country. This is an interesting and multi-disciplinary area to study that makes for a varied and stimulating experience, giving the tools to make a real difference in various sector. In this new century, sustainability and environmental impact lie at the core of materials development and application In the race to make things stronger, cheaper, lighter, more functional and more sustainable, the manipulation of materials, their properties and processes is key.

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COMPRESSED STABILIZED EARTH BLOCK: A GREEN ALTERNATIVE TO FIRED BRICK IN DEVELOPING COUNTRIES LIKE BANGLADESH

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ABSTRACT
In the growing concern of awareness regarding climate change and sustainable development, Compressed Stabilized Earth Block (CSEB) gives the view of energy efficient and environment friendly alternative to fire-burnt clay molded brick which is the chief building material in most of the developing countries like Bangladesh. The strength of CSEB can be improved considerably by the addition of different stabilizers. This study comprises a comparative and detailed survey on compressive strength of different types of CSEB where Portland cement was used in all of them as soil primary stabilizing agent and two types of admixtures were used as cementitious additive with local soil and sand. It was observed that blocks stabilized with cement, 12% moisture content and resin type admixture exhibited better result compared to that of non-resin type admixture where water cement ratio was 0.84. However, this main objective of this study is to aspire future research and possible replacement of fired bricks, shifting to a green and sustainable development.

Keywords: Stabilized; CSEB; Sustainability; Compressed; Earth block

INTRODUCTION

Oldest Building material known to man is earth block. Raw earth was one of the first, oldest and most traditional building materials to be used by man and it has a heritage dating back over at least 10,000 years (Hossain, 2015). Even though earth buildings fell out of popularity when modern building materials and methods were discovered. But following the energy crisis, earth blocks grow more and more reliable solution as building materials in recent times. With the purpose of finding a sustainable solution to the environmental impacts and immense consumption of fuel causing the release of carbon dioxide (CO_2) for creating Fire Burnt Bricks, Compressed Stabilized Earth Block (CSEB) is being evaluated in terms of compressive strength and environmental impact. Walls have always been a primary element of human establishment and structures. The use of CEBs in construction accomplishes completely the necessities from the eco-development, because of the great usefulness of the natural capability from each region, the ample availability of raw materials, the lack of specialized labour and the low use of energy (Deboucha et al., 2002). Faster and easier construction requires less skilled labour and providing good strength less energy emission and embodied energy, up to 80%, in the production phase (Heath et al., 2009).

In Bangladesh, brick making is extensively energy incentive. 95% of kilns in Bangladesh are 150 years old Bull's Trench Kiln (BTK) (Pope et al., 2002). To meet the demand of 17 billion bricks Brick Kilns burn nearly 3.5 million tons of coal and 1.9 million tons of wood annually causing severe air pollution as 38 percent of particulate matter around Dhaka (Gomes and Hossain, 2003). Environmental impacts

can be largely overcome by the use of compressed earth blocks as it is energy efficient and can lead to green and sustainable development. Compressed Stabilized Earth Block (CSEB) have the lowest embodied energy of any building material with the smallest carbon footprint and no emission of toxic gases. It is also able to regulate temperature and humidity naturally so less energy is required to maintain a comfortable indoor environment.
In this Study, compressive strength of Compressed Stabilized Earth Block (CSEB) with two different admixtures is evaluated along with the correlation of change between other properties to check the feasibility of long-term use of CSEB in Bangladesh.

METHODOLOGY

The soil sample was collected from a construction site in Dhaka. GPS location of this site is 23.760748 N, 90.400714 E. The clay was taken about 10m below the surface. Then the clay was oven dried, pulverized and screened with No. 04 sieve. Grain size distribution of the soil is given below in Figure 1. To find out soil properties, ASTM standards (ASTM, 2006) are maintained. Specific gravity of the soil is obtained 2.71. Plastic limit and liquid limit are found respectively 23 and 35. Plastic index is 12. From plastic index and liquid limit, according to ASTM D 2487-06 the soil sample is classified as CL. Optimum moisture content was found 16%. From the grain size distribution main constituent particles are silt and clay. To make compressed stabilized earth block, cement is used as stabilizer. Ordinary Portland cement is used for making CSEB.

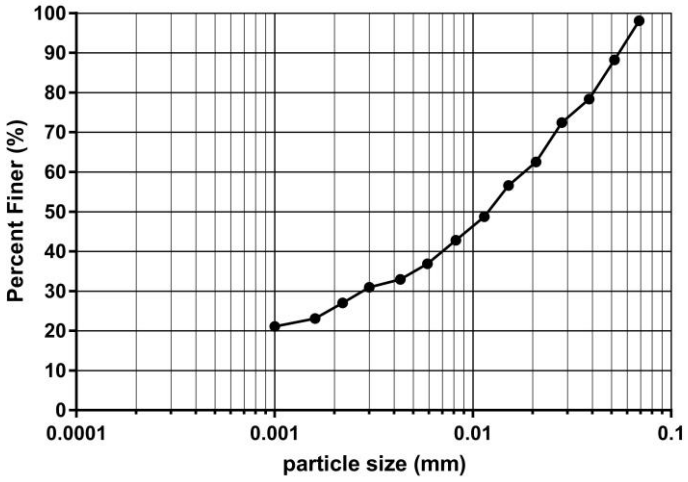


Fig 1: particle size distribution of the soil

9 mixes were prepared in the laboratory. Where clay, cement and sand percentages were respectively 71.4%, 14.3%, 14.3%. For 12%, 16%, 20% moisture content were used to make CSEB. To gain strength and durability two types of admixtures were applied for this research, Admixture 1 and Admixture 2. Admixture 1 is ECO 5000 and Admixture 2 is Flat Plug Resin 1000 and 70 times dilution was applied. For mixing the materials properly a rotary concrete mixture machine was used. Every material is weighed properly and then put into the machine for mixing. Dry mixing time was 2 minutes. After dry mixing, water and admixture were added gradually and mixed properly around 4 minutes. For this study, specially designed mold was used. Each mold consists of four parts such as base plate, two L shaped sections and top plate. Each part is made of mild steel. Two L shaped sections are joined together by 4 fasteners and then the jointed L shaped sections are placed on the base plate connected by 2 fasteners. L shaped section height is 8 inch. Total 6 fasteners are used in to setup a mold. After the setup, inner dimension of the mold becomes 6 inch by 6 inch by 8 inch. In Fig. 2, mold used for this research is represented.

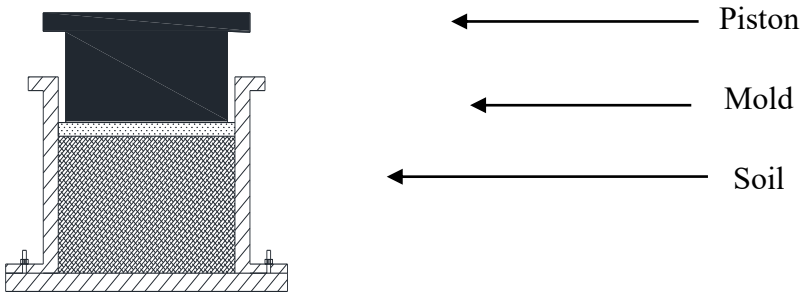


Fig. 2: Casting Mold

Universal testing machine was used as the mechanical compactor to prepare CSEB. The casting mold was designed such a way that it is compatible with the Universal testing machine. After preparing CSEB, self-curing was preferred. Each specimen was wrapped with plastic polythene and any kind of loss of moisture was strictly prohibited. Specimens were stored in room temperature.

(a) (b) (c)

Fig. 3: (a) After preparing CSEB (b) Wrapped CSEB for self-curing (c) compressive strength test on CSEB

Materials composition and their percentage of nine mixes, which were used throughout the study, are shown in table 1. Compressive strength test has been conducted on these mixes respectively after 7 days, 28 days, 60 days and 90 days of sample preparation.

Table 1: Testing scheme and mixture design

Specimen ID	Clay (%)	Cement (%)	Sand (%)	Moisture content (%)
T1	71.4	14.3	14.3	12%+no admixture
T2	71.4	14.3	14.3	16%+no admixture
T3	71.4	14.3	14.3	20%+no admixture
T4	71.4	14.3	14.3	12%+admixture 1
T5	71.4	14.3	14.3	16%+admixture 1
T6	71.4	14.3	14.3	20%+admixture 1
T7	71.4	14.3	14.3	12%+admixture 2
T8	71.4	14.3	14.3	16%+admixture 2
T9	71.4	14.3	14.3	20%+admixture 2

RESULTS AND DISCUSSIONS

Effect of admixture

Results obtained from the strength test of CSEBs of different mixture types with cement only and cement with two different admixtures are shown in Fig4. It was found that for 12% moisture content, specimens stabilized with cement and specimens stabilized with cement and admixture 1 shows almost similar result within 28 days, but differs slightly at 60 and 90 days of test. Specimens stabilized with cement and admixture 2 exhibited better results at early strength, having almost double compressive

strength than that of specimens stabilized only with cement. It is also shown that Specimens stabilized with 12% moisture content shows increment in compressive strength with time.
For specimens stabilized using 16% moisture content, it is shown in fig.4 (b) that all three types of specimens exhibited a decrease in compressive strength. For specimens stabilized with cement only, strength reduction from 60days to 90days was 22% whereas specimens stabilized with cement and admixture 1, it was about 3.24% for 28days to 60 days and 0.63% for 60 days to 90 days. Specimens stabilized with cement and admixture 2 was consistent in terms of compressive strength at early age, up to 28 days and shows an increase in compressive strength of about 33% from 28 days to 60 days.
From fig.4(c), it is observed that specimens stabilized with 20% moisture content are of no different in terms of admixture usage at long term durability though specimen stabilized with cement and admixture 2 have double compressive strength than only cement stabilization.

Effect of moisture content on density

Effect of moisture content on density is presented in the fig.4 (d). It is obtained that density of the specimens prepared with 16% moisture content is higher than the density of specimens with 12% and 20% in case of stabilization with cement, and cement + admixture 1. But density decreases along with addition of moisture content in case of specimens stabilized with cement+ admixture 2. This implies use of cement and admixture 2, which is resin type, is preferable method of stabilization with 12% moisture content. For specimens prepared with 20% moisture content, there is no effect of adding admixture on the specimen density as 20% moisture content is higher than the optimum moisture content of clay used in this study. Though higher density exhibits more durability but the difference in density

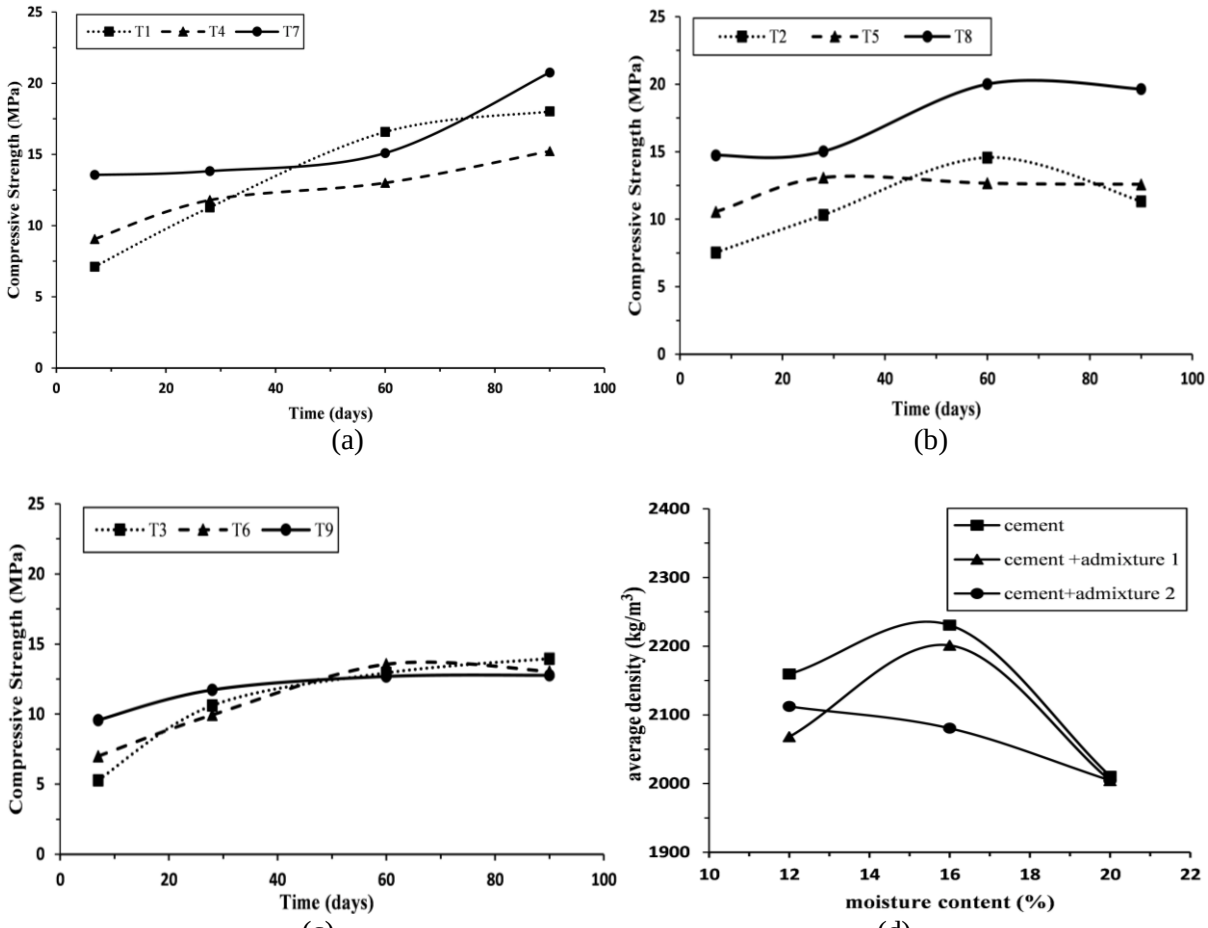
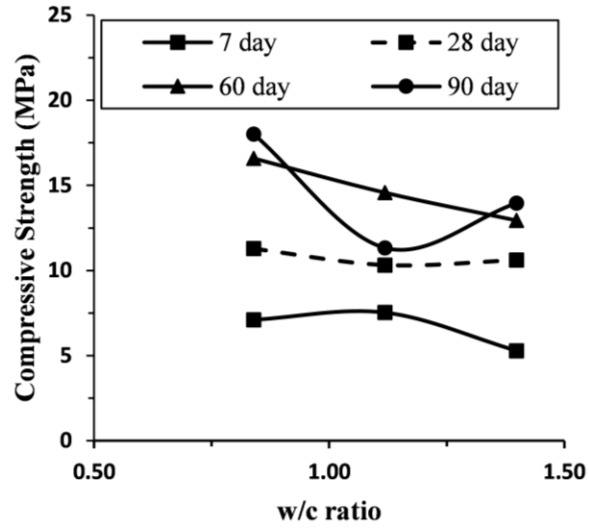


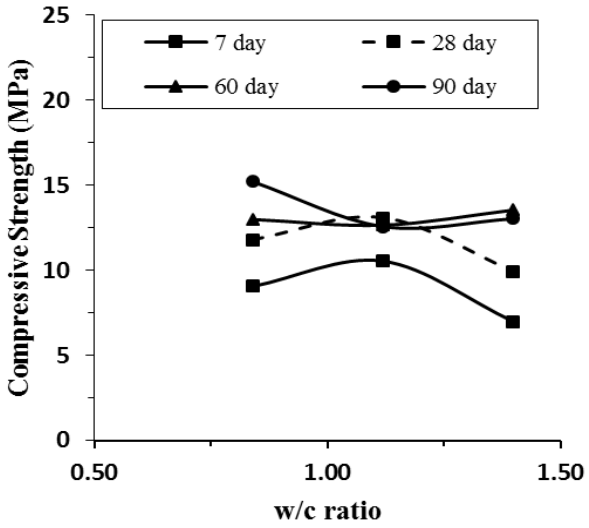
Fig. 4: (a) Strength of 12% moisture content specimens (b) Strength of 16% moisture content specimens (c) Strength of 20% moisture content Specimens (d) Change in density with respect to moisture content percentage

Effect of water-cement ratio

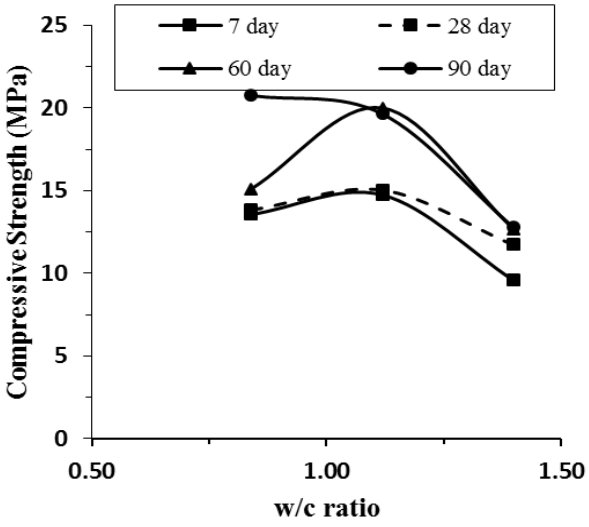
From three different water-cement ratio used in this study, the effect of this ratio on strength and stabilization with cement, cement+ admixture 1 and cement+ admixture 2 is shown in Fig. 5 along with difference in sample age. From fig. 5(a), strength of 90 days are much higher than other sample age tpyes in specimens with w/c ratio 0.84. Effect of w/c ratio on compressive strength is much less for specimens stabilized with cement+ admixture1,seen in fig.5(b). On the other hand, Specimens stabilized with cement+ admixture 2 shows increase in compressive strength at water-cement ratio of 1.12 , but 90 days compressive strength is lower here. Due to preferable long-term durability, w/c ratio of 0.84 is desired.



(a)



(b)



(c)

Fig. 5:
a) only cement stabilization
b) stabilized with cement and admixture 1
c) stabilized with cement and admixture 2

CONCLUSIONS

Based on the results obtained from the study that the, the conclusion can be drawn that soil earth blocks have to be stabilized with cement and resin type admixture, with 12% moisture content and 0.84 water-cement ratio for better durability and compressive strength which is nearly as same as compressive strength of local fired brick, offering a better climate for our future generation and less polluted environment. By considering low cost and energy efficiency, fired brick can much be replaced with compressed stabilized earth blocks in near future by improving strength and other physical properties ensuring durability and safe transportation.

ACKNOWLEDGMENTS
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