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Construction Development Board joins the rest of the nation in conveying our sincerest felicitations and best wishes for the long life, peace and happiness of His Majesty The King, on the auspicious year of His Majesty's 40th Birth Anniversary.

We commit and dedicate ourselves to serve the nation with loyalty, unity and compassion.

Gross National Happiness Journal of Construction Technology and Management aims to disseminate information, provide a glimpse of the scenario, and issues relating to construction and measure the contribution of the construction industry on the socio-economic development of the country. It publishes wide range of papers in english broadly on the topics related but not limited to construction, procurement, design, architecture, engineering, management, manufacturing, business, urban planning, green and sustainable technology, OHS, human settlement, human resource, construction projects, contract administration and traditional architecture. The journal focuses to publish high quality papers following a system of blind peer review and supported by Editorial Board members existing of academicians, field experts, civil servants, etc. The target audience includes scholars, academicians, policy makers, manufacturers, designers, engineers, urban planners and others interested in research and scholarship relevant to the construction industry in Bhutan.

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Introduction

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Despite the economic importance of the construction industry, it is often reflected with having lower levels of productivity and quality and often under the limelight for negative reasons. Thus, the Construction Development Board is hopeful that this journal and its literature will disseminate information to the people, provide evidence of the issues relating to construction and ascertain the contribution of the construction industry on the economic progress of the country and build a community of people that will play an active role, as and individual and as a community, in the development and improvement of the quality of infrastructure of Bhutan.

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Finally, we would like to wish our valued readers an enjoyable read, and render the resources the journal is expected to deliver.

CONTENTS

Gender Responsive Physical Infrastructure and Facilities: The Case of Secondary School Under Thimphu Thromde

Tshewang Dorji

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Abstract: Gender responsive infrastructure and facilities in schools such as toilets, clean water and sanitation play a crucial role in effective participation of boys and girls in the teaching learning process. Many girls start their first period between the ages of 10 to 15. This study was carried out in three secondary schools under Thimphu Thromde using a mixed method approach. The study involved assessment of toilets, clean water supply and sanitation and the data was obtained through observation of the same in the secondary schools. Desk review of relevant materials was carried out. Triangulation of the findings was done with quantitative and qualitative data. The findings from this study reveal that toilets and water are inadequate for oversized schools and limited recess time. Girls' toilets are not conducive for girls to change their sanitary wears. The study recommends mounting workshops for schools to create awareness of gender responsiveness infrastructure and facilities. The school should construct adequate gender friendly toilets with adequate clean water, soap, sanitary wear and bins for menstrual hygiene.

Keywords: Teaching learning; gender responsive toilet; clean water: sanitary wear and bins

Introduction

Education has always been a priority in every Five-Year Plan of the Royal Government of Bhutan. The country's quality of happiness and development hinges on the quality of education (GNHC, 2019) and equal participation of male and female in the development process. The success of quality teaching learning process and activities in schools are influenced by many factors. The availability of infrastructure and educational facilities among others are identified as the success of educational goals in accordance with the National Education Standards (Marmoah, Adela, & Fauziah, 2019). School facilities include academic buildings, school equipment, playground, toilets, health room, water, sanitation and canteens.

There is a direct relationship between learning outcome and physical infrastructures. Students learn better if there is direct availability of good infrastructure and facilities (Ngwaru & Oluga, 2015). Indeed, physical infrastructure such as toilets, clean water, and sanitation facilities are important elements in the pedagogical process. According to

Marmoah et al. (2019) all the infrastructure and facilities can be used as tools or media for learning activities. In addition, many literatures have proven that better physical infrastructure such as toilet, clean water and sanitation facilities in the schools improve teaching learning process and the nation building process (Saitis & Saiti, 2004). As per the Kihara, Kamau & Gichuhi (2018), the infrastructure and facilities in a school is directly linked with learning satisfaction, poor infrastructure and school facilities can contribute to learning dissatisfaction among students.

A toilet with adequate clean water can keep students healthy and make them feel at home and not tired of carrying out different activities in the school. In relation to this, FAWE (2005) states that the major obstacle facing schools today is a lack of gender friendly physical infrastructure and facilities that make the school environment friendlier in addressing gender inequality in education. Inadequate water, sanitation and hygiene facilities, including dirty toilets, impact girls more than boys, especially once they reach puberty (UNICEF, 2015a). Girls have been reported to have dropped out of school due to a lack of water and sanitation facilities (World Bank, 2014). Teenage girls are more likely to repeat a grade in schools without adequate sanitation due to absenteeism during menstruation (Agol & Harney, 2018; Sommer, 2010; Jewitt & Ryley, 2014). Repetition then impacts on self-esteem for girls who are unable to proceed with their classmates to the next grade. In Bhutan, according to a study by Ministry of Education (MoE) in 2018, health issues were identified as one of the causes of girls dropping out of school and repeating grades. Studies by Agol and Harvey (2018) found that schools without toilets mean that girl's mobility is highly restricted during their menstrual cycle, most likely due to stigma, which often surrounds menstruation such as impurity, indignity and embarrassment.

According to MoE (2018), girls outnumber boys in terms of dropout in the schools in Bhutan. REC (2011) highlights the need for immediate attention in providing gender friendly toilet, increasing and improving the school water and sanitation facilities with special focus on girls. Such gender responsive infrastructure address gender inequality and gender gap in education. Currently, many schools do not sufficiently address gender constraints such as toilet, clean water and sanitation. Even in schools with separate toilets for boys and girls, they are found too close together and does not provide adequate privacy for boys and girls. Girls' toilets are not conducive for girls to change their sanitary wear or to dispose them off properly. School facilities do not address special needs of girls, nor provide any means to manage menstrual hygiene like privacy, water, incineration, soap, sanitary towels and bins due to sheer size of students, teachers and staff. This affects classroom concentration for girls (FAWE, 2005). Yet, in Bhutan, such issues are unfortunately viewed as a normal practice and are therefore widely tolerated. Thus, teachers are not aware and do not have necessary skills to detect and

handle toilet, clean water and sanitation in the school or even recognize its impact on the teaching learning process. Many girls miss regular classes due to menstrual problems such as menstrual pains, lack of clean water, sanitary towels and toilets in the school. The Bhutan Education Blue Print 2014-2024: Rethinking Education (MoE, 2014) recommends the education sector to construct enabling facilities and conditions to enhance quality teaching learning among girls in secondary schools. Immediate attention was toilets, water supply, and health rooms to achieve gender equality in Bhutan and to close gender gap in education. Water and sanitation in school have a significant positive impact on students' education outcomes and address waterborne and hygiene related diseases. Adequate water supply in schools can have a positive impact on student attendance and health in the school (MoE, 2019).

A school can be converted to a gender responsive school by ensuring a gender responsive environment and by providing separate and adequate toilets for boys and girls, adequate clean water, soap and sanitation especially to enhance menstruation management and the overall health of the school community. Many schools in Africa such as Burkina Faso, Gambia, Namibia, Kenya, Rwanda, Tanzania and Senegal have transformed their ordinary school into a school with gender responsive environment, physically, socially and academically (FAWE, 2005). Gender responsive infrastructure and facilities are available- separate adequate toilet, water and sanitation for boys and girls. However, education officials, school management and teachers have a bigger role to play in the process of maintaining toilet with continues supply of clean water, soap, sanitary wear and sanitary bin (FAWE, 2005).

Objective

The objectives of the study were to:

1) examine the adequacy of toilets, water and sanitation facilities for both boys and girls in the secondary schools.
2) assess the level of awareness on gender responsive infrastructure and facilities in the secondary schools.
3) examine if the existing toilets, water and sanitation facilities in school's address gender needs.

Research question

Based on the objective and literature review the following were the research questions:

1) How adequate are the toilets in secondary schools for ensuring the health and

hygiene of boys and girls?

2) Do the toilets for girls in secondary schools address the health and hygiene of girl students?

Data and Method

The study adopted a mixed method approach. The quantitative data of number of boys and girls, number of toilets was obtained from the respective secondary schools. The qualitative data was obtained through observation of boys' and girls' toilets, water supply and sanitation. Desk review of relevant materials were done. The qualitative findings were triangulated with the findings of the quantitative findings and the result of desk review of materials.

Sample size

All public schools in Bhutan have a uniform governance and management structure. There are 12 public secondary schools (4 Lower Secondary Schools, 5 Middle Secondary Schools, 3 Higher Secondary Schools) under Thimphu Thromde. Only 3 Secondary Schools (1 Lower Secondary School, 1 Middle Secondary School, and 1 Higher Secondary School) were randomly selected for the study through non-probability convenient sampling technique.

Data analysis

The quantitative data collected from schools included number of boys and girls, number of toilets for boys and girls, number of functional toilets, availability of continuous clean water. Toilets were assessed for cleanliness, functional taps, lighting, water availability, presence of dust bins, and soaps and pictures were taken. The schools were coded as 001, 002 and 003 to hide their identity. The analysis of the qualitative data was done using basic content analysis or thematic analysis. Desk review of relevant materials was analysed to support quantitative and qualitative data.

Results and findings

According to MoE (2019), there are different types of toilets in the schools. As seen in Figure 1, 58% of schools have pour flush toilets, 22.2% have pit latrine toilets and 16.6% of schools have aqua privy toilets while 1.7% of schools have no toilet facilities.

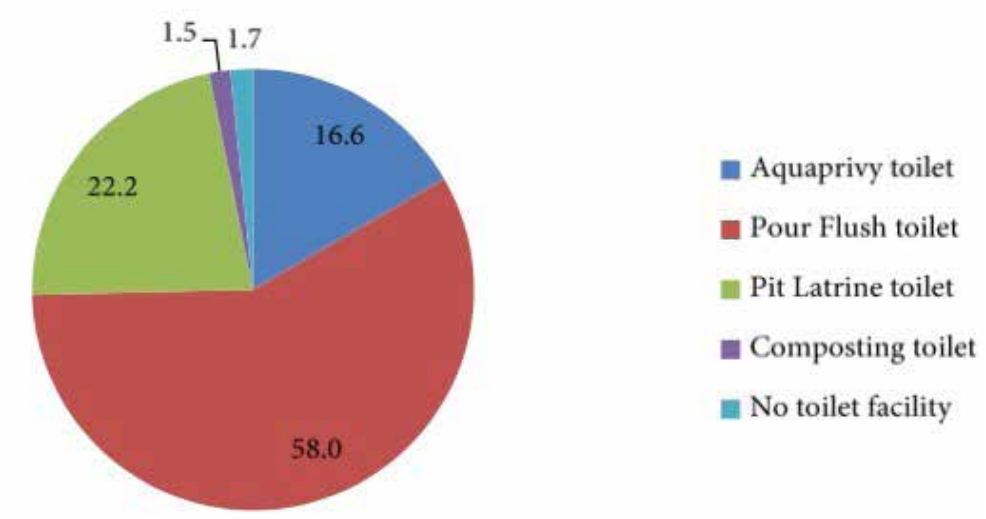

Figure 1. Types of toilets in schools [Source: MoE, 2019]

Table 1: Toilet condition in the three sample schools

School 001			
No. of boys	475	No. of girls	646
No. of boys' toilets	16	No. of girls' toilets	23
No. of broken windows in the toilet	10	No. of broken windows in the toilet	18
Observation of boy's toilet	· Drains broken and blocked · Cracks on the wall · No light bulbs	Observation of girl's toilet	· No light bulbs · Crack on the wall · broken toilet · Drains broken and blocked

School 002			
No. of boys	456	No. of girls	454
No. of boys' toilets	24	No. of girls' toilets	24
No. of broken windows in the toilet	20	No. of broken windows in the toilet	15

Observation of boy's toilet	· Cracks on the wall · Located near the footpath · leakage of water from the pipe on the wall · 2 broken doors · Switches are hanging · Latches are broken · Drains broken and blocked	Observation of girl's toilet	· Cracked on the wall · No light · One toilet is out of order · Two toilets have no door · Some latches are broken · Toilets are near the boys' toilets · Toilets are located near the footpath · Drains broken and blocked

School 003			
No. of boys	844	No. of girls	861
No. of boys' toilets	14	No. of girls' toilets	24
No. of broken windows in the toilet	18	No. of broken windows in the toilet	19
Observation of boy's toilet	· Smelly · Urine stagnant in the drainage inside the toilets · No light · Drains broken and blocked	Observation of girl's toilet	· 10 doors without latches · No light · Drains broken and blocked · Crack on the wall · 2 toilets closed · 1 toilet located near two toilets for boys

Table 1 summarizes the number of toilets available in the schools and their conditions. All the schools had separate toilets for boys and girls. In all the schools most windows were broken, there were no lights, and drains around the toilets were broken and blocked. Considering the huge student size, the number of toilets is inadequate and the situation is worsened when some toilets are without or with broken doors, no latches and some were out of order. The recess periods in school are between 10 to 15 minutes, which is quite less. In School 002, the toilets are very close to the footpath and with broken windows, it undermines privacy for users.

The observations reveal that the toilets were not gender responsive and do not address the needs of boys and girls. The schools were more of ordinary school expected to fulfil certain basic standards outlined by the Ministry of Education (MoE, 2019). As mentioned in Table 1, the researcher too made observations of some non-functional toilets in the schools. The toilet corridor floors were wet and slippery from serving water from the storage barrels as students used water in improvised jerry cans to flush the toilet after use. There were poor lighting facilities inside the toilets.

If toilets are not cleaned properly, there is an increased risk of poor hygiene and infection. According to MoE (2019), 80.1% of toilets for boys are functional and 70.6% of toilets for girls are functional.

Figure 2. Condition of toilets in secondary schools [Photo courtesy: Author]

Similarly, MoE (2018) states that boys' toilet ratio in all schools meet the national standard of 1 toilet compartment for every 40 boys except for middle secondary schools, where the ratio is 1 toilet compartment for every 42 boys. However, girls' toilets in lower, middle and higher secondary schools do not meet the national standard of 1 toilet compartment for every 25 girls as shown in figure 3.

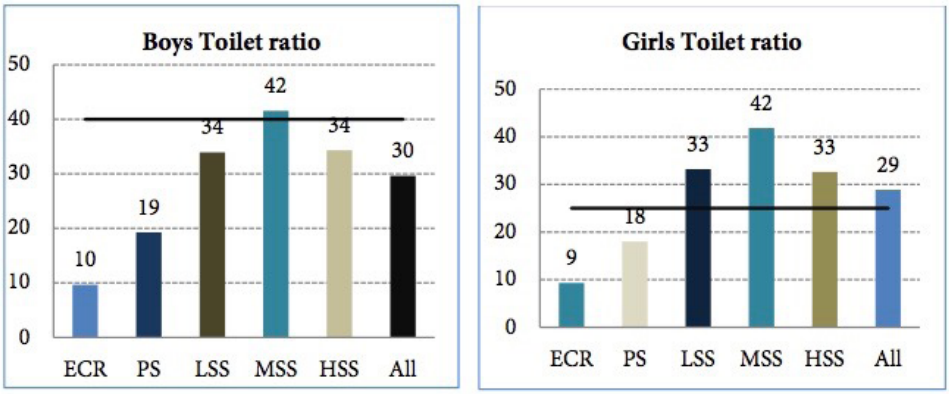

Figure 3. Student toilet ratio by level [Source: MoE, 2019]

In the three sample schools, girls' toilets were found not conducive for girls especially during menstruation. Toilets lack provision for dustbins for proper disposal of used sanitary pads. Used sanitary pads were seen strewn around waste bins and near toilets or were directly disposed hygienically in the municipal waste disposal truck. In school 003 boys' and girls' toilet are close to each other and does not have adequate privacy for girls.

Regarding student tap ratio, MoE (2018) outlined that student tap ratio 1:50 is the national standard of student tap ratio. Figure 3 shows that all schools have met the national standard except lower secondary schools. However, most of the taps found in secondary school are non-functional. 001 and 003 schools have irregular water supply even though there are enough taps.

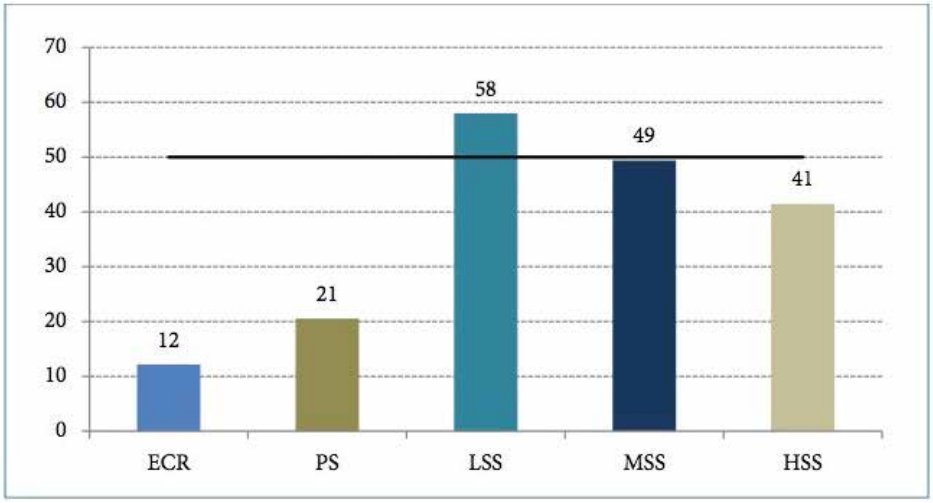

Figure 4. Student tap ratio [Source: MoE, 2018]

The schools observed had inadequate supply of clean water with broken taps. The broken water taps with continuous leakage of water kept the toilet floors wet. Figure 4 shows the adequacy of water for various purposes in all levels of schools. Compared to the adequacy of water for drinking and handwashing, water for bathing and sanitation appears to be inadequate in all schools especially in lower and middle secondary schools.

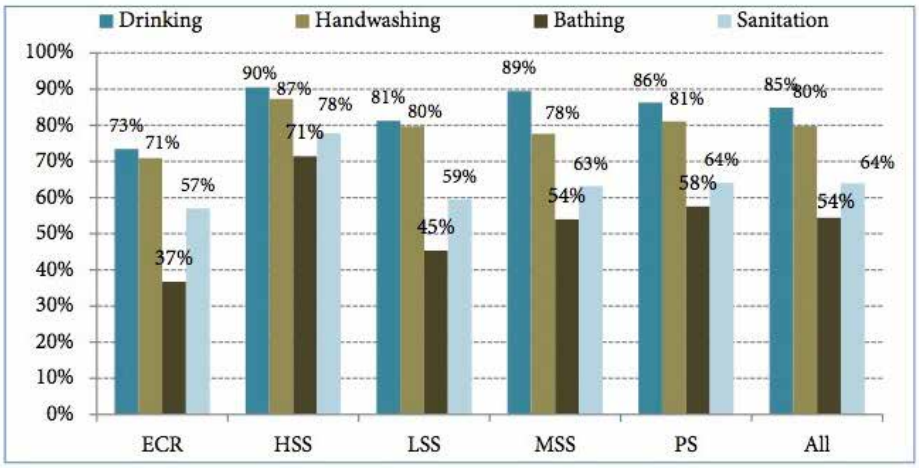

Figure 5. Water adequacy [Source: MoE, 2018]

Conclusion and Recommendation

Although there are separate toilets for boys and girls in the secondary schools, the toilets were inadequate considering the huge number of students in the schools. Toilets for girls are constructed close to that of boys' hampering normal use of toilets by girls, without proper disposal system of used sanitary pads, in addition to insufficient water for sanitation make such infrastructure and facilities not gender responsive.

Students need to be educated on the proper use of toilets and create awareness on the value of clean and dry toilet for hygiene and safety of users. There should be a proper dumping place for the sanitary items. The MoE provides basic facilities and infrastructure in schools based on national guidelines and available budget but the responsibility for the management of such facilities in schools are the mandate of the schools. Schools should ensure proper monitoring and maintenance of toilets, water pipes, water taps, drainage, doors and windows. Schools should provide user education to students on the proper use of facilities.

To address gender inequality and gender gaps in education, schools should work in close collaboration with MoE, relevant non-governmental organizations, and students through the identification of needs of boys and girls and availing technical support. Awareness programmes to create awareness on gender responsive infrastructure and facilities for relevant education officials, school management and teachers can address gender related issues in infrastructure development and management.

Planners, engineers and constructors need to ensure quality in the construction of toilets. Wet toilets are not only unhygienic but pose a serious threat for young students from falling. Elevation of the ground needs to be considered to ensure proper flow of water in the drains and urine in the urinals. The stench from stale urine can be very unpleasant. Doors should be made of durable materials to ensure long life in situations such as schools where there are more users.

Limitation and suggestion for future studies

Due to limited resources, time, and expertise, this study was carried out in only three secondary schools under Thimphu Thromde, Bhutan. Although sample was few, all secondary schools in Bhutan have similar structures except few private schools. However, the management of infrastructure and facilities could vary among schools. The view and opinion of students, teachers, school management, education officials and policymakers were not taken. There is an opportunity for an in-depth study on the quality of infrastructure and its impact on student performance, especially girl student. However, findings from this study have practical as well as policy implication.

Disclosure statement: Researcher declare there is no potential conflict of interest.

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A Case Study on the Effectiveness of a Waste Management and Cleanliness in the School

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Abstract: Realizing the importance of waste management for the overall health of the school, Dechencholing Higher Secondary School (DHSS) constructed a waste segregation and storage warehouse in the school. The waste segregation and storage warehouse acts as the 'Waste Bank' for the school where students collect waste from their classrooms and school compound. The study on the effectiveness of the storage warehouse to maintain school cleanliness was carried out in DHSS. DHSS has the highest student enrolment, teachers and staff. Waste management had been a challenge for many years. The data collection method included survey questionnaires, face to face semi-structured interviews and observations. The study revealed that the waste segregation and storage warehouse played an important role in the management of waste and cleanliness in the school. However, student and teacher habits and behaviours had not been impacted by the warehouse. There is a need for awareness and sensitization programmes on waste management for teachers, students and staff of the school.

Keywords: Waste segregation and storage warehouse, 6 Rs Club, waste management, cleanliness

Introduction

Dechencholing Higher Secondary School (DHSS) is a co-educational day school under Thimphu Thromde. There are 1813 students (850 boys and 863 girls) studying from Pre-Primary to class XII, 74 regular teachers (21 male and 53 females), 6 contract teachers (5 male and 1 female), 1 male substitute teacher, 8 student teachers (4 male and 4 female), 9 non-teaching staff (4 male and 5 female) and 6 support staff (3 male and 3 female). The school offers Science, Commerce and Arts streams in classes XI and XII. Waste disposal has become one of the biggest issues of many urban schools and the problem is growing. Indeed, DHSS is faced with a similar challenge. Wastes generated in DHSS range from packaged food wrappers, packed lunch leftovers, fruit remains, leaves and twigs, dust from sweepings, water and juice bottles and ice cream covers, pencil shavings, plastic from book covers, charts and crayons from classes, papers, pages from magazines, posters, commercial domino cards, food and vegetable wastes from the school canteen among others. Although class wise waste segregation at source, systematic collection, storage and proper disposition of recycling wastes has been tried but it did not turn out successful since the waste was heaped in the open air which

exposed it to wind, rain, dogs and cattle. The large number of people on the school campus meant an increased amount of waste generation in the school and the rising challenges of waste management.

Wastes pose serious damage to environment, human and animal health when it is not collected, transported and disposed properly. Therefore, as stated by MoE (2016) waste management requires organized strategy among administrators, finance providers, planners, engineers, transporters, and disposers. Schools frame various waste policy, strategy, plans and schemes to address the issue of the waste but fail during implementation due to improper waste disposal set-up, lack of knowledge of waste management and due to the sheer size of students, teachers and staff. According to Wangdi and Tshomo (2017), "the crisis of waste management is still an issue and more acute in schools across Bhutan, largely because of the improper waste disposal set-up and lack of knowledge of waste management despite laudable initiatives from the schools". Proper waste management is important to protect the environment, promote sustainable development, and to reduce air pollution, water contamination and breeding of waterborne diseases (Kolbe, 2015). In DHSS, the school made arrangements with Clean City to collect the wastes once a month. Since the waste was heaped in the open air it was exposed to the wind and rain, dogs and cattle. There was frequent occurrence of waste scattering in the school campus and clogging of drains. The risk of environmental pollution, health hazards and health problems among the students, teachers and the school community were high.

A clean, secure, safe and conducive learning environment is a prerequisite for the academic potential and good health of students (Ana et. al, 2011). Moreover, education is a powerful means to change the behaviour and mind set of the people on waste management (Mishra, 2008). To induce behavioural change among students, active-learning approach and experiential learning through participatory waste management activities and classroom lecture were explored. It is very important to sensitize and educate students, and inform them on waste management. Good practices of waste management must begin with the individual or the family (MoE, 2016). Therefore, a participatory approach to waste management could be a powerful way to change the mind set of people by promoting behavioural change in children which in turn could greatly impact a gradual change in the mind set and behaviour of parents. In fact, educating children early and building awareness on the importance of managing waste properly at an individual and family level is expected to contribute to creating responsible citizens.

To solve the problem, the school constantly sought for a sustainable solution, but due to inadequate knowledge on waste management and not having the required funds,

the school continues to endure the problem. The school was concerned with the health and environmental hazards from wastes. Eventually, DHSS constructed a waste segregation and storage warehouse with financial assistance from the Bhutan National Bank Limited and Bhutan Power Corporation Limited. In about two months, the waste segregation and storage warehouse were ready for use. The school management and the school's 6Rs Club maintained the warehouse. The Teacher on Duty (ToD) and the 6Rs Club coordinated and supervised the proper segregation of waste at source, the classrooms, offices, and the canteen. Wangmo (2019) also suggest segregation of waste at source and recycling as the best waste management method. Waste disposal practice was supervised by the 6Rs Club to ensure that wastes were properly put in bins labelled "Plastic, Bottle, Paper, and Food". Every Tuesday and Friday, all the classes and the school canteen dump their segregated waste in the containers kept inside the storage warehouse. When the waste containers were full, Clean City collected the wastes.

Objectives

This study was carried out to:

1. examine the effectiveness of waste segregation and storage warehouse in managing waste and cleanliness of the school.
2. see the change in behavioural and mindset in students towards waste management.
3. observe the change in the attitude of 6 Rs Club members and teachers on waste management.

Research question

The research questions of the study were:

1. How effective is the use of waste segregation and storage warehouse in managing waste and cleanliness of DHSS?
2. How has the behaviour and attitude of 6 Rs Club members and teachers changed due to the practice of waste segregation before disposal into the warehouse?

Data and Method

The study adopted a mixed method approach. The quantitative data was collected through 5 point-Likert scale survey questionnaires to understand the views and opinions on the effectiveness of waste segregation and storage warehouse in the school. The survey questionnaire consisted of 10 items. Each item was assigned a score ranging 5-1 where 5 stood for 'Strongly Agree', 4 for 'Agree', 3 for 'Not Sure', 2 for 'Disagree' and 1 for 'Strongly Disagree'. The qualitative data was collected through face to face semi-structured interviews with teachers and observation of student behaviour, cleanliness of the school and feedback from the ToD.

Sample size

The participants involved in the survey questionnaire are 6Rs Club members ranging from classes VII to XI through non-probability convenient sampling technique. Of the 28 students in the 6Rs Club 26 students completed the survey questionnaire. Similarly, 4 teachers out of 74 volunteered for the face to face interviews. Observation of school cleanliness was carried out over 6 months from 06 June to 30 November 2019. The observation included waste segregation practice, timing for waste disposal, and use of the three dustbins in the classroom and cleanliness of classroom. The researcher collected feedback from the ToD about the cleanliness of the classrooms and the school surrounding.

Data analysis

Descriptive analysis of the quantitative data was carried out on SPSS version 16. Face to face semi-structured interviews was recorded, transcribed, and analysed for themes. The observation notes of anecdotal records and feedback from ToD were analysed for themes. Data collected through survey questionnaires, interviews and observations were triangulated to confirm results and findings.

Results and findings

Survey questionnaire

6 students out of 28 in the 6 Rs Club completed the survey questionnaire as shown in Table 1. The summary of 6Rs Club students from Table 2 revealed that 80.3% of 6 Rs Club members strongly agree that waste segregation and storage warehouse was useful and important for maintaining the cleanliness of the school. 80.8% of the students strongly agree on the statement "waste segregation and storage house in the school was useful and important for us." Students remarked that waste segregation and storage house help them to keep their classroom and school clean. 88.5 % of students were happy with the waste management practice in the school. 80.8% of the students also strongly agree on the statement "I recommend waste segregation and storage house in other schools".

Table 1: Survey respondents by class

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	VII	7	26.9	26.9	26.9
	VIII	1	3.8	3.8	30.8
	X	6	23.1	23.1	53.8
	XI	12	46.2	46.2	100.0
	Total	26	100.0	100.0	

Table 2: Views and opinions of 6Rs Club members

SN		N	Frequency	Percent	Item
1	Gender	26	26	100	
2	Class	26	26	100	
3	Waste segregation and storage house in the school is useful and important for us.	26	21	80.8	Strongly Agree
4	I segregate waste in the class before we dump in the waste segregation and storage house in the school.	26	15	57.7	Strongly Agree
5	The classroom and school became clean after the implementation of waste segregation and storage house in the school.	26	20	76.9	Strongly Agree
6	Students are mindful regarding waste in the school.	26	4	15.4	Strongly Agree
7	Students were sensitized on waste management during assembly.	26	17	65.4	Strongly Agree
8	I am happy with the waste management practice in the school.	26	23	88.5	Strongly Agree
9	Waste from source is reduced in the school.	26	3	11.5	Strongly Agree
10	6Rs club promotes entrepreneurship culture in the school.	26	3	11.5	Strongly Agree
11	I acquired skills of 6Rs club: reinvent/ rethink, refuse, reduce, reuse/repair, recycle, replace/rebuy for environmental care.	26	14	53.8	Strongly Agree
12	I recommend waste segregation and storage house in other schools.	26	21	80.8	Strongly Agree

Only 11 – 16 % of students reported positively on the statements "Students are mindful regarding waste in the school. Waste from source is reduced in the school. 6Rs club

promotes entrepreneurship culture in the school." The use of waste segregation and storage warehouse and the waste segregation at source in the school has not changed students' behaviour and mind set. It also proves that it is often difficult to change the behaviour and habits of people.

Table 3: Descriptive Statistics of items in Likert Scale

SN		N	Minimum	Maximum	Mean	Std. Deviation
1	Waste segregation and storage house in the school is useful and important for us.	26	1	5	4.6154	0.94136
2	I segregate waste in the class before we dump in the waste segregation and storage house in the school.	26	1	5	4.2308	1.1422
3	The classroom and school became clean after the implementation of waste segregation and storage house in the school.	26	1	5	4.4615	1.06699
4	Students are mindful regarding waste in the school.	26	1	5	2.7692	1.47804
5	Students were sensitized on waste management during assembly.	26	1	5	4.4231	1.10175
6	I am happy with the waste management practice in the school.	26	4	5	4.8846	0.32581
7	Waste from source is reduced in the school.	26	1	5	2.7308	1.48479
8	6Rs club promotes entrepreneurship culture in the school.	26	1	5	2.0769	1.32433
9	I acquired skills of 6Rs club: reinvent/ rethink, refuse, reduce, reuse/repair, recycle, replace/rebuy for environmental care.	26	1	5	4.3077	0.97033
10	I recommend waste segregation and storage house in other schools.	26	3	5	4.6923	0.67937

The mean for almost all items were 4 out of 5 except for a few items as shown in Table 3. This shows 6 Rs Club members' views and opinions towards the effectiveness of waste segregation and storage warehouse fall in 'Strongly Agree' on the Likert scale. However, 6 Rs Club or coordinator need to take intervention on students who were not being mindful regarding waste in the school, waste from the source are not reduced in the school, 6Rs club has not promoted entrepreneurship culture in the school.

Interview with teachers

During the face to face semi-structured interviews, four teachers favoured the use of the waste segregation and storage warehouse for waste management in the school. The participants shared that the waste segregation and storage warehouse helped the school and community to dispose their waste properly on Tuesdays and Fridays. One teacher said,

> "*so far 6Rs club is the only club successfully functioning in the school. The 6Rs club played an important role in implementing the waste management policy in the school".*

The use of waste segregation and storage warehouse helps us to keep class, school and surrounding clean. Two teachers mentioned that,

> *"the waste segregation and storage warehouse were valuable for the school. The school can promote entrepreneurship culture and advocate waste issues".*

The construction of the waste segregation and storage warehouse was a great way to involve students, teachers and school management in educational process and the project. One teacher made a positive comment on the waste segregation and storage warehouse that 'best initiative', and 'brilliant idea'. The same teacher said,

> *"If students are sensitized and aware of proper waste management practices, their waste management will be a regular good practices and students will appreciate waste reduction, reuse or recycle and so on. Un-proper and unhygienic waste disposal in open dumping will disappear in the long run".*

One teacher remarked

> *"The 6Rs club shall use the fund generated from the sale of non-degradable waste for repair and maintenance of the waste storage warehouse as well as to explore and try out new ideas and innovation. The school should also allocate funds for the maintenance of the waste segregation and storage warehouse through its school maintenance fund".*

One teacher remarked,

> *"Honestly speaking, in addition to the waste segregation and storage warehouse, 6Rs club, teachers and school management should reduce waste from the source. The school should observe 'zero*

waste' policy in the school so that national goal can be achieved in the long run".

Observation

Initially, it was observed that all classes dumped waste in the waste containers, which were kept in the open air. There were no waste disposable timetables in the school. Classes did not segregate waste and all waste were dumped together in the container. Cattle and dogs were found to feed on the wastes. The school management and ToD had to remind students about waste management in the school. Very often dustbins in the classrooms would overflow with waste which sometimes released pungent smell.

After the inauguration of warehouse, all the classes followed a timetabled schedule of emptying their class dustbins accordingly. Students were seen to show more interest to manage wastes in the school except for a few classes. Ten ToD groups found school environment and classroom neat, clean and tidy except during few occasions such as school variety show, school magazine competition, school Rimdro (annual puja) and parent-teacher meeting when many people outside the school came to attend such events.

Data triangulation from the three sources, survey questionnaire, face to face semi-structured interview and observation confirm positive result on the cleanliness. The 6 Rs Club members marked positive views and opinions towards waste management and cleanliness of the school and its environment. The 6Rs club students had acquired life skills of 6Rs such as reinvent/ rethink, refuse, reduce, reuse/repair, recycle, replace/ rebuy for environmental care. Since the waste is a global problem, waste management programs through the construction of waste segregation and storage warehouse like the one constructed in this study may be usefully transferred to other schools. The teachers were in favour of the use of the waste segregation and storage warehouse to manage waste and maintain cleanliness in the school. The construction of waste segregation and storage warehouse was a great way to involve students, teachers and school management in educational process.

Conclusion and Recommendation

It was observed that the waste segregation and storage warehouse has benefited the school and nearby community of the Royal Body Guards in managing wastes through enforcement of waste segregation practices and having access to the waste segregation and storage warehouse. The community and students learn about wastes and its management including recycling and generating income from it. The practice and program created civic consciousness among students and the community around and might influence the mindful consumption patterns. The waste segregation and storage warehouse might have minimized the environmental pollution and health problems.

Waste heaps and littering around the school campus is a thing of the past with the use of waste segregation and storage warehouse in the school.

To change the mind set and behaviour of students and teachers, proper awareness, sensitizing and practice of waste management with proper follow up need to be instituted.

The school should adopt 'Zero Waste Policy' so that waste can be reduced from the source. It is important to involve students in developing 'Zero Waste Policy' to empower students in keeping school and classroom neat and clean.
The school should invite guest speakers to give a talk on the management of waste in the school. Such talks and message will bring positive impact to their family in addressing waste in school and community.

Limitation and suggestion for future studies

Since waste management is a complex subject and that this study focused mainly on the waste segregation and storage warehouse, further research and investigation in other areas of concern relating to waste management are called for to enhance creativity and problem-solving skills of students and foster teacher-student competency in the 21st century.

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Quality Control of Concrete in Bhutanese Construction Industry and the Requirements of Indian Standards

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Abstract: With the rapid socio-economic growth of the country, the construction industry in Bhutan has become one of the largest employing sectors. The construction of any infrastructure is monitored by relevant public sector agencies that are also responsible for formulating construction guidelines and overseeing the quality of works. Most of the guidelines enforced and used by Bhutanese engineers are mainly based on the Indian Standard Codes for the design and execution of construction works. In the current paper, we described the application of the codal provisions for quality control in terms of slump and cube tests and highlighted the acceptance criteria for the test results. However, it is observed that the guidelines provided in the code are not followed strictly in the field, which might compromise the quality of the structures.

Keywords: Slump test, Cube Test, IS codes, Acceptance criteria, Quality control

Introduction

Construction Industry plays a major role in the economic growth of a nation and occupies a pivotal position in the nation's development plans. To ensure a vibrant and robust construction sector, monitoring the results of specific project to determine if they comply with relevant standards and identifying ways to eliminate the cause of unsatisfied performance is of great importance. The key aspects of any man-made structure are strength, serviceability, and durability of the structure. To achieve these aspects, i) all the materials that are to be used in the construction must meet the quality requirements criteria as per standard code provisions and ii) the operational techniques and activities that are used to fulfil requirements for quality should be within the specified conditions of execution, operation, and maintenance. Quality is essentially defined as the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs. Here, stated and implied needs refer to the workmanship and integrity of people working to execute the construction activities (Minami, 2012). One must make sure that these operational activities are as per the technical guidance provided by various national or international agencies. The Ministry of Works and Human Settlement has initiated several reforms to streamline several policies, rules and regulations, and procedures to enhance and promote quality

construction in the country (MoWHS, 2018). In Bhutan, Indian Standard code and the specifications therein are used extensively for both design and construction of most structures. According to the National Population and Housing Survey, 2017, 32.3% of the total housing units in the country are made with cement/RCC walls, bricks or cement blocks (Chettri, Thinley, & Koirala, 2019; National Statistics Bureau, 2018). The data doesn't include the construction of institutional buildings, RCC bridges, retaining walls, drains and other structures that involve concreting in one form or the other. Since most construction activities in the country are concrete based, it is imperative that quality control and quality assurance practices in concreting are strictly implemented so that the structures meet the requisite standards and ensure effective economic returns. Concrete has to be evaluated in both fresh states as well as in the hardened state. This paper aims to highlight the salient points in the IS codes and present some observations in the field practices of concreting that deviate from the code provisions and its impact.

Quality control of Concrete as per codal provisions

Evaluation of quality of concrete has to be done in both fresh and hardened state before the casting of each structural element. For fresh, the quality of concrete is monitored using slump test for workability. In its hardened state, mechanical properties like compressive strength, modulus of rupture, splitting tensile strength, etc are evaluated. However, in low rise buildings, short-span bridges, retaining walls and other reinforced structures, compressive strength test suffices to meet the quality criteria.

Monitoring Concrete Quality in Fresh State

The percentage composition of ingredients must be such that concrete must be of adequate workability in placing conditions and can properly be compacted. IS 1199 (clause 7) must be checked for various degree of workability in different placing conditions along with its slump values (BIS, 1959). However, the discrepancy in the test results and its usefulness in the field practices may arise due to the number of samples tested and the method of sampling used. For this, IS 4905-1968 methods for random sampling have to be strictly followed to ensure that each concrete batch has a reasonable chance of being tested. This will also provide a reasonable degree of accountability to the person who enforces quality control at that work (BIS, 1968).

1) To determine the acceptance of a batch of concrete mix, we use the random sampling method based on the above mentioned codal provision as illustrated in the following example: Let us assume, the slump values noted randomly from the batch/mixer machine/lots during the casting of slab of a buildings are: 76, 74, 70, 66, 78, 80, 86,75, 70, 68, 79, 80, 75, 69, 70, 74, 70, 68, 68, 70, 76, 75, 80, 70, 75, 68, 70, 75, 78,74, 68, 70, 75, 78, 80, 85, 85, 75, 70, 70, and 70 mm. First, find mean of data set which is given by,

$$\dot{X}=\frac{\sum_{i=1}^{n} Xi)}{n}$$

or

$$\dot{X}=\frac{1}{n}\sum Xi$$

or

$$\dot{X}=\frac{1}{n}(X_1+X_2+X_3+X_4+\ldots+X_n)$$

For the given example $\dot{X}$ =75mm

2) Next, find the standard deviation of the data set,

$$S=\sqrt{\frac{\sum_{i=1}^{n}(Xi-\dot{X})^2}{n-1}}$$

or

$$S=\sqrt{\frac{(X_1-\dot{X})^2+(X_2-\dot{X})^2+\ldots+(X_n-\dot{X})^2}{n-1}}$$

For the given example s=5.09mm

3) Find the coefficient of variation, C.V of the data set,

$$V=\frac{s}{\dot{X}}\times 100$$

For the given example V= 6.9%

This implies that the acceptable range of the measured slump values is 75 – 5.09 = 69.91 or say 70 mm and 75 + 5.09 = 80.09 or say 80 mm. Hence, measured average slump values less than 70 mm or more than 80 mm should invite corrective action. The Coefficient of Variation, C.V. of 6.9% corresponds to 'good' level of quality control (≤15%).

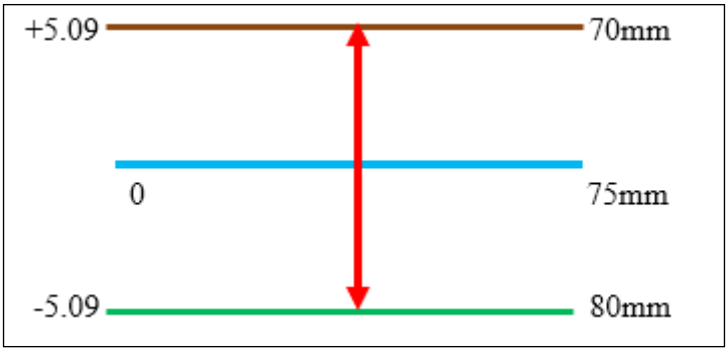

Figure 1: Limits of workability for the above example

Monitoring Concrete Quality in Hardened State

In the hardened state, the compressive strength test is the most important parameter. IS 4905-1968 methods for random sampling have to be followed to select the samples from various batches and of such number as depicted in Table 1 depending on the volume of the work.

Table 1: Number of samples as per IS 456-2000 (BIS, 2000)thus enlarging the scope of use of this code to structures other than general building construction also. The third revision was published in 1978, and it included limit state approach to design. This is the fourth revision of the standard. This revision was taken up with a view to keeping abreast with the rapid development in the field of concrete technology and to bring in further modifications/improvements in the light of experience gained while using the earlier version of the standard. This revision incorporates a number of important changes. The major thrust in the revision is on the following lines: a

Quantity of concrete in a particular work (m^3)	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51+	4 plus one additional samples for each additional 50m^3 or part thereof

Note:1 sample consists of 3 specimens

For example, let the total volume to be concreted in one batch be 110 m^3. From table 1, the number of samples required for 28-day strength testing= 4+1+1 = 6, such that

the number of cubes to be collected for 28-day strength testing is 18. If early age strength testing has to be done, then an additional 18 cubes have to be collected for 7-day strength testing. Therefore, total number of cubes required to be collected for strength compliance= 18 + 18 = 36. Once we know the number of sample cubes to be tested, we will need to determine how to carry out the random sampling. IS 4905-1968 presents different types of random sampling i.e. simple random sampling, stratified random sampling, systematic random sampling, cluster random sampling, and two-stage random sampling. We will explain the method of simple random sampling with the following example.

For example, the number of samples required for 28-day strength testing is 4 if 50 m^3 of concrete has to be deposited in one continuous operation in 10 batches of 5 m^3 (Figure 2). To determine the machines from which the four randomly selected samples need to be collected, we will consider the random sampling table (Figure 3) from IS 4905- 1968

10 batches of concrete (each batch =5m³)									
									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Figure 2: Illustration of simple random sampling

Consider any starting point in Figure 2. Pick up any four (M=4) numbers whose last two digits (since N=10 i.e. it has 2 digits. If N=200 then chose last 3 digits) are between 0 and 10. Repetitions are not allowed in the selected numbers.

As indicated in Figure 3, three specimens each from truck numbers 1, 4, 5 and 7 are chosen to cast the cubes. Their 28 days compressive strength test is carried out. It clearly shows that each of the 10 trucks had a reasonably equal degree of getting selected preventing sampling bias and discrepancies. This also prevents manipulation by engineers and contractors and assures accountability from quality control authority.

The samples collected by the process discussed above is to be evaluated for 7 days or 28 days strength depending on the requirements at the site. In preparation for the cube tests and filling the cube mould with sample IS 516-1959. Methods of test for the strength of concrete has to be followed. Clause 2.10 explains the two methods of compaction namely compaction by hand and by vibrator. Site engineers must be aware that improper compaction leads to significant strength reduction. The procedure for latter is known to all field engineer whereas for the former IS 516-1959 states that:

"2.10.1 Compacting by Hand — When compacting by hand, the standard tamping bar shall be used and the strokes of the bar shall be distributed in a uniform manner over the cross-section of the mould. The number of strokes per layer required to produce specified conditions will vary according to the type of concrete. For cubical specimens, in no case shall the concrete be subjected to less than 35 strokes per layer for 15cm cubes or 25 strokes per layer for 10cm cubes. For cylindrical specimens, the number of strokes shall not be less than thirty per layer. The strokes shall penetrate into the underlying layer and the bottom layer shall be rodded throughout its depth. Where voids are left by the tamping bar, the sides of the mould shall be tapped to close the voids."

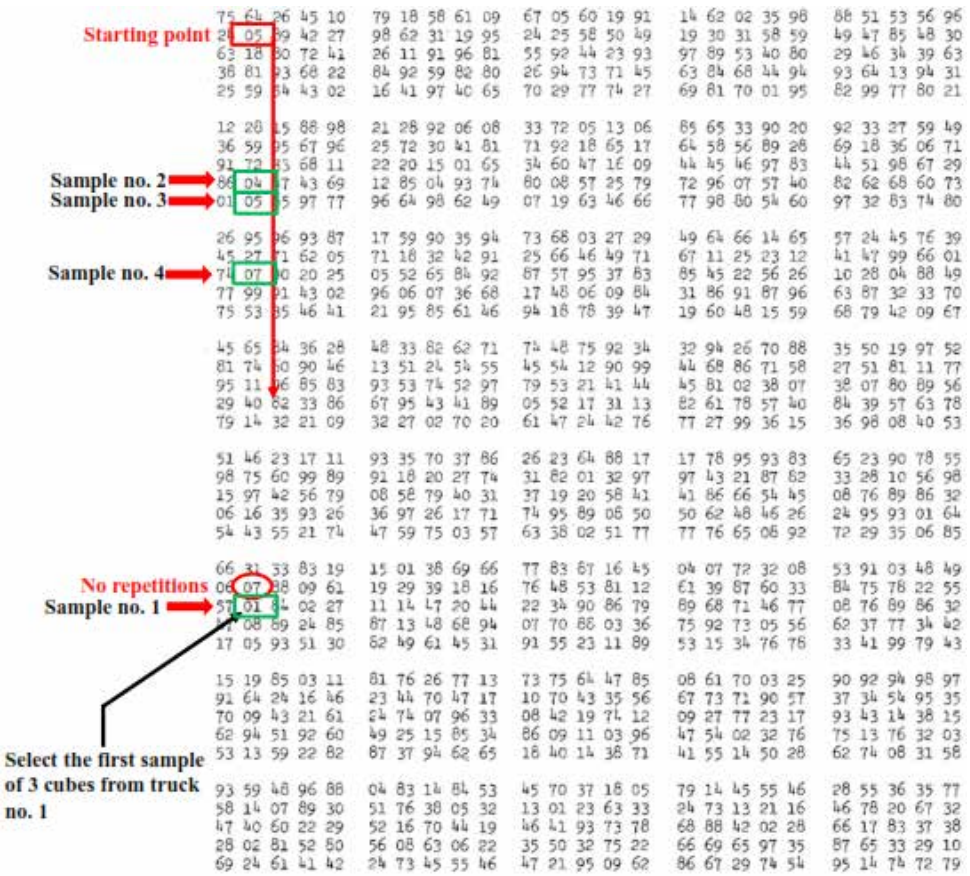

Figure 3: Random sampling table from IS 4905-1968.

Also, clause 3 (particularly 3.3) and clause 5.5 from IS 516-1959 which describes the precaution that needs to be taken during curing of the cubes and process involved in placing the specimen in testing machine respectively should be particularly noted and practiced by all involved.

Interpretation of 28 days Characteristics Strength test Result

It is important to understand the significance of the values of the tests results and interpret it to ascertain its acceptability or otherwise. Let us assume that the samples collected from above batch i.e. batch 1, 4, 5 and 7 are tested (let's consider the grade of concrete =M20) and results obtained are as given in Table 2:

Table 2: Illustrative example of compressive tests results showing ±15% variation

Sample no.	Sample identification (date of casting)	Date of testing	Cube no.	Mass (kg)	Max. Stress (MPa)		Limit of acceptance (MPa)
					Individual	Average	
1 (batch 1)	Concrete cube (01/11/2019)	28/11/2019	1	8.22	20.4	20.13	0.85*Avg.=17.11
			2	8.20	19.8		1.15*Avg.=23.15
			3	8.25	20.2		(accepted)
2 (batch 4)	Concrete cube (01/11/2019)	28/11/2019	1	8.23	20.2	20.27	0.85*Avg.=17.23
			2	8.22	20.5		1.15*Avg.=23.31
			3	8.26	20.1		(accepted)
3 (batch 5)	Concrete cube (01/11/2019)	28/11/2019	1	7.99	16.5	19.93	0.85*Avg.=16.94
			2	8.23	20.6		1.15*Avg.=22.92
			3	8.22	22.7		(rejected)
4 (batch 7)	Concrete cube (01/11/2019)	28/11/2019	1	7.90	18.9	20.60	0.85*Avg.=17.51
			2	8.24	20.7		1.15*Avg.=23.69
			3	8.25	22.2		(rejected)

From Table 2 it must be noted that clause 15.4 (to control results variation with the specimen) of IS 456 is respected which mentions that characteristics compressive strength of each specimen must be within the limit ±15 % of the average (those specimens out of the limit in above example is highlighted in Table 2). The cognizable weight of each cube must be 8.25kg (i.e. 0.15^3 *24*1000/9.81). Any cube with lesser weight shows the improper compaction and gives lower strength as shown in Table 2. Once the internal variation of specimens is determined the acceptability criteria must be imposed on all the samples. The acceptance criteria (Table 3) are given in clause 16, table 11 of the IS 456-2000. Due to the problems of practical feasibility the table 11 of IS 456-2000 was amended and reproduced in its amended form as Table 4:

Table 3: Acceptance criteria from IS 456-2000

Specified Grade	**Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm²**	**Individual Test Results in N/mm²**
(1)	(2)	(3)
M15	≥ f_{ck} + 0.825 × established standard deviation (rounded off to nearest 0.5 N/mm²) or	≥ f_{ck} -3N/mm²
	Or	
	f_{ck} + 3 N/mm², whichever is greater	
M20 or Above	≥ f_{ck} +0.825 × established standard deviation (rounded off to nearest 0.5 N/mm²)	≥ f_{ck} -3N/mm²
	Or	
	f_{ck} + 3 N/mm², whichever is greater	
NOTE- In the absence of an established value of the standard deviation, the values give in Table 8 may be assumed, and attempt should be made to obtain result of 30 samples as early as possible to establish the value of standard deviation.		

Table 4: Acceptance Criteria-Amendment No. 4

Specified Grade	**Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm²** *Min*	**Individual Test Results in N/mm²** *Min*
(1)	(2)	(3)
M15 and above	≥ f_{ck} +0.825 × established standard deviation (rounded off to nearest 0.5 N/mm²) or	≥ fck -3N/mm²
	Or	
	f_{ck} + 3 N/mm², whichever is greater	
NOTE		
1. In the absence of an established value of the standard deviation, the values give in Table 8 may be assumed, and attempt should be made to obtain result of 30 samples as early as possible to establish the value of standard deviation.		
2. For concrete of quality up to 30 m³ (where the number of samples to be taken is less than four as per the frequency of sampling given in 15.2.2), the mean of test results of all such samples shall be f_{ck} + 4 N/mm², minimum and the requirement of minimum individual test results shall be f_{ck}-2 N/mm², minimum. However, when the number of samples is only one as per 15.2.2, the requirement shall be f_{ck} + 4 N/mm², minimum.		

In order to explain the acceptance criteria of IS 456-2000, examples in Table 5 are tabulated (with assumed values) as per amendment 4.

Table 5: Example to demonstrate acceptance criteria as per IS 456-2000

Sample No.	Group. No.	Avg. compressive strength of 3 cubes (MPa)	Mean of 4 non-overlapping consecutive test results	Standard deviation (Sd) up to the last sample of the group	Fck+3	Fck+ 0.825*Sd	Fck-3	Remark
1		23.00						Accepted
2		25.00		IS 456-2000,				Accepted
3	1	24.50	24.125	Table 8 Sd for M20=4	23	23.3	16	Accepted
4		24.00						Accepted
5		21.20						Rejected
6		21.00						Rejected
7	2	21.50	21.450	4	23	23.3	16	Rejected
8		22.10						Rejected
9		25.88						Accepted
10	3	25.89	23.41	4	23	23.3	16	Accepted
11		25.98						Accepted
12		15.89						Rejected

Note: The results shown in the table do not fulfil the acceptance criteria (although it fulfils internal variation of ±15%) and therefore has to be discarded.

The following example will illustrate the acceptance criteria as per IS 456-2000.

For the construction of multi-level RCC parking in Phuentsholing M30 grade of concrete is mix designed with standard deviation of 3MPa. The compressive strength of 24 samples (72 specimens) and satisfying the ±15% internal variations are given in below. Apply IS 456:2000 acceptance criteria to the test results.

28.00, 29.77, 31.10, 27.13, 30.27, 29.80, 27.33, 30.07, 26.57, 27.73, 28.10, 28.03, 30.70, 29.23, 30.47, 25.57, 36.27, 35.40, 34.10, 31.93, 32.60, 34.47, 31.10, 33.50

Application of Acceptance criteria

The total number of samples=24 in groups of 4 non-overlapping consecutive samples as given in Table 6.

Acceptance criteria for individual test result (Amendment 4, IS 456-2000); F_{ck} - 3 i.e. 30 - 3 = 27 MPa. Therefore, group 3 and 4 are rejected.
Acceptance criteria for group test result (Amendment 4, IS 456-2000); F_{ck} + 3 i.e. 30 + 3= 33 MPa and F_{ck} + 0.825*S_d i.e. 30 + 0.825*3= 32.475MPa.

Therefore, the concrete of group 5 is acceptable. In the final cube or cylinder test result

interpretation, one must know the multiplying factor to interchange their respective results. For the same concrete mixture, due to the effect of platen restraint and Saint-Venant's principle, cube strength will always be larger than cylinder strength. Cylinder strength = 0.80 times the cube crushing strength.

Table 6: Application of Acceptance criteria for the above example

Group no.	**1**	**2**	**3**	**4**	**5**	**6**
Non overlapping consecutive samples	28.00, 29.77, 31.10, 27.13	30.27, 29.80, 27.33, 30.07	26.57, 27.73, 28.10, 28.03	30.70, 29.23, 25.57, 36.27	36.27, 35.40, 34.10, 31.93	32.60, 34.47, 31.10, 33.50
Mean	29.00	29.37,	27.61	28.99	34.43	32.92

Observation of quality control activities performed in the field

The followings are some of the operational activities observed in the field. These are observation noted by the authors at certain project sites and does not imply to all the construction projects in the country. However, the operational techniques explained below with respect to quality control practices, might be useful for engineers, contractors and quality control implementing agencies.

1. Most of the time concrete casting is done without any test on the rheology of the material. In some large projects' workability test is conducted during the initial casting of footing pads and the same material is used for the entire project.
2. It was also observed that the client enforces one workability test during the construction of each structural elements i.e. a set of workability tests during casting of footings, another set during columns followed by beam and slab.
3. In addition to the description stated in serial number 1, one set of compressive strength tests on a sample of cubes (three specimens) was conducted.
4. Only one sample of cubes (three specimens) is taken from any structural element for the compressive strength test.
5. Only one sample of cubes (three specimens) in all structural elements are tested for compressive strength
6. A set of compressive strength test on a sample of cubes (three specimens) and the test mentioned in the serial number 2.
7. Workability test and a set of compressive strength test on a sample of cubes (three specimens) in each structural element.

Conclusion

The guidelines prescribed in the Indian standard codes are presented in this paper to simplify the contents to help field engineers in monitoring the quality of concreting works. The technical procedures for workability and compressive strength tests are elaborated with suitable examples to enable the reader to put the code guidelines into practice. While the IS code provisions as reflected in this paper require testing of concrete samples from various batches by random sampling, it has been observed by the authors that its provisions are not strictly adhered to in the Bhutanese construction industry. This might have long term implications on the strength, durability, and performance of the various structural members.

Conflict for interest: The authors declare no conflict of interest. However, any discrepancies with respect to any clause and examples may be directly discussed with the authors.

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Construction Constraints imposed by Traditional Bhutanese Architecture on Building Construction

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Abstract: The identity of Bhutan is shaped by its unique art and tradition. The traditional architectural features incorporated in building construction today, have been instrumental in promoting and preserving the art of construction passed down from our ancestors. Since these are very complex form of art, there are likely construction constraints associated with it. Therefore, the current study aims to evaluate the various construction constraints that would arise from incorporating these features. The likely constraints were evaluated from questionnaire surveys conducted amongst practising engineers and architects in the country. The responses were tabulated, analysed and interpreted to draw conclusions based on the Bhutanese Architectural Guidelines. The major factor contributing to construction constraints was found to be Economic constraints followed by time constraints in Bhutanese Building construction.

Keywords: Bhutanese architecture, Time constraint, Design constraint, Economic constraint

Introduction

Traditional Bhutanese architecture is said to be developed from the Tibetan tradition of Buddhist architecture. It was an integral part of dzong construction in the past but was gradually incorporated in the construction of residential buildings. Traditional Bhutanese architecture showcases the rich tradition and culture of our country and is one of the unique characteristics of Bhutan reflecting the religious as well as cultural beliefs. However, this practice of traditional architecture and its continuity is under pressure due to rapid urbanization and modernization in construction technologies. Therefore, to uphold the unique cultural identity associated with the traditional construction practices, the Royal Government of Bhutan has recognized the promotion of traditional architecture and methods of construction as one of the pillars of Bhutan's pursuit of Gross National happiness (Ura et al., 2012) in the face of the evolving challenges.

The efforts to preserve and promote traditional construction practices are impacted by the lack of standardised specifications. The Bhutanese Architecture Guidelines (2014) does not specify the standard dimensions of the traditional construction components

in detail (Department of Human Settlement, 2018; Ministry of Works and Human Settlement, 2014). Since the traditional architecture is mainly limited to two to three storeys building, we hypothesize that there will be constraints in incorporating the traditional architectural features in the construction of the modern high-rise buildings even though it serves as an important tool in conserving our unique culture and traditions and provides an aesthetic view.

Constraints associated with a construction project can be defined as any factor or condition that impedes the progress of construction projects (Mayer et al., 1995). Identification and description of construction constraints during the early stages include the idea of the interrelation of different construction constraints and understanding the risk factors due to those constraints (Lau & Kong, 2006). Thereby it serves as a useful tool to manage and overcome their potential risk.

Different types of construction constraints include design constraints, economic constraints, time constraints, technical constraints, legal constraints, and environmental constraints (Lau & Kong, 2006). Design constraints can be defined as factors limiting the adoption of potential design method during the construction. It is difficult to identify the design constraints during the beginning of the construction, but it becomes clearer with the progress of the construction. Some of the design constraints include unavailability of technology, material, labour, presence of nearby infrastructures, the deadline of the project and climatic conditions of the area.

The economic constraint is another important constraint. For the construction to be a success, one of the main contributing factors is the budget allocation for the project. If the budget is inadequate or insufficient for construction purposes, it can have negative impacts on construction. It is important to understand how the Bhutanese architecture feature contributes to economic constraints.

For the completion of the project, there are certain key dates on the project schedule. The inability or limitation imposed to reach the predetermined date of construction due to shortage of time is termed as a time constraint. Usually, the time constraint is known by determining all necessary tasks that are mandatory to start a project until the completion of it. Planning is one of the main factors affecting the time. If one fails to do proper planning of the project before the start, the project is likely to be delayed.

Therefore, the current study focuses on evaluating the Constraints imposed on building construction due to incorporation of Traditional Bhutanese Architecture in terms of design, construction, time, and economics constraint. Even though Bhutanese architectural features serve as an important tool in conserving our unique culture and

traditions and provides an aesthetic view, it adds to construction constraints on building construction.

Data Collection

The information required for the study was collected from a questionnaire survey. The questions in the survey were developed in consultation with the field engineers after a few focus groups interviews about the traditional Bhutanese architecture. A pilot testing with some of the site engineers enhanced the efficiency of the survey through interview. The survey questionnaire focused on three construction constraints and few aesthetic effects imposed by the traditional features in the modern-day construction. In the field, it was found that there were few shortcomings while incorporating the traditional features in the modern building construction especially while constructing Glass blazed buildings.

The participants involved in the survey questionnaire were the practising Architects and Civil Engineers in Bhutan sampled by non-probability convenience sampling technique since data on the number of Professional were not available. The survey was conducted in May and June 2019 and out of 76 respondents, 75 respondents completed the questionnaire. Due to the limited number of the respondent in the area, the study concludes its analysis in term of frequency and percentages to determine the views on construction constraint.

Analysis and Interpretation

Time constraints

For analysis of the time constraint, it was classified into two categories in terms of designing and construction of building with Bhutanese architectural features and time constraint due to unavailability and procurement of construction materials. In case of designing and construction, 46.95% of the responses disagreed to the statement that there is time constraint while incorporating the architectural features while 30.15% of the responses agreed to the statement that there is time constraint due to the incorporation of these features and 28.60% of the responses were neutral [Figure 1]. Therefore, in accordance with the percentage obtained from the responses, we concluded that time constraint due to the design and construction of the building with the architectural features are negligible.

In the case of procurement and unavailability of construction materials, 65.70% of the responses agreed to the statement that there is time constraint due to the unavailability of construction materials. Whereas 17.20% of the responses disagreed to the above statement and the rest of the responses were neutral. Hence, we concluded that the

unavailability of construction materials affects the procurement of the materials which in turn delays the building construction [Figure 2]

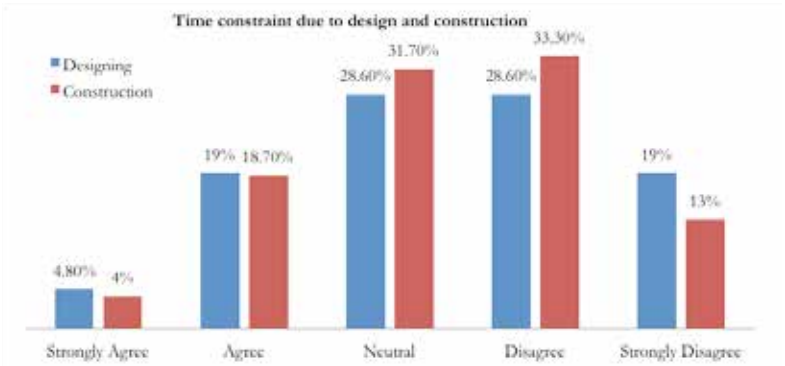

Figure 4: Time constraint due to design and construction

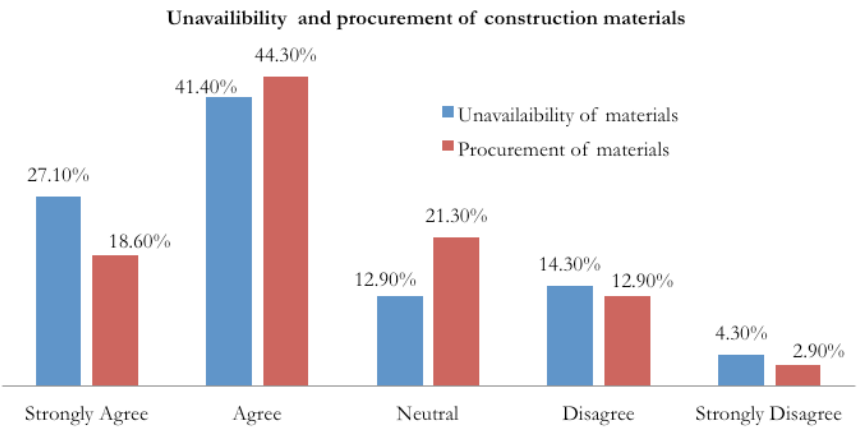

Figure 5: Unavailability and procurement of materials

Design Constraints

Among the 75 respondents, 50.1% of them agreed to the statement that it is not difficult to adopt and incorporate Bhutanese architectural features in building construction. However, 28.5% of them disagreed to this statement and 21.4% of the responses were neutral [Figure 3]. Thus, we concluded that the adoption and incorporation of architectural features can be done easily. Since the incorporation of the traditional features has come a long way, people are more familiarized unlike the olden days, Bhutanese architectural guidelines have also been introduced and put into practice. This has led to the ease in the incorporation and adoption of the traditional features.

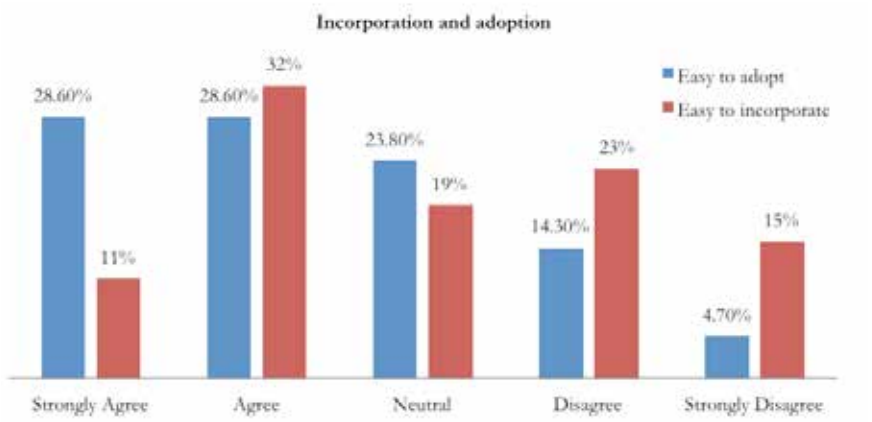

Figure 6: Incorporation and adoption

For the development of a design, load calculation is one of the necessary factors. As per the research objectives, the architectural features impose extra load on the building and hence this statement was supported by majority of the respondents (52.9% agreed).

Economic constraints

As stated above, one of the main factors contributing to the successful completion of the project is the budget and allocation. Under economic constraint, we have defined the need of labourers for the completion of the project as a key requirement of the project since it affects the performance of construction based on their level of skill and this affects the rate of charge in return. For a traditional feature to look appealing they need to be painted which in return imposes a certain amount of cost on the building construction. So, the budget allocated for the painting of these features contributes to the economic constraints. To define the shape of certain traditional features, formworks are used. A separate budget should be allocated for the procurement of the materials for the formwork which affects the economic constraint. Now from the data collected from the questionnaire, the following charts are obtained, and the results are interpreted in Figure 4.

65.70% of the respondents agree that skilled labourers are required for the construction of traditional architectural features, in turn, correlates to the high labour charge imposed which is supported by 91.40% of the respondent agreeing to the statement i.e., high labour charge is imposed while incorporating traditional features. Hence, the correlation drawn from the above two charts is strongly positive stating that employing skilled labourers requires more budget since high charges will be imposed by them.

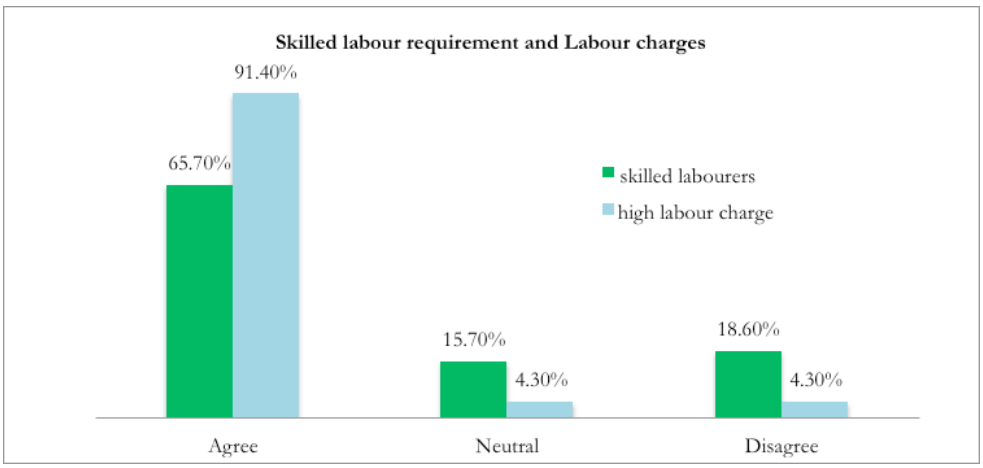

Figure 7: Skilled labour requirement and labour charge for traditional Bhutanese components

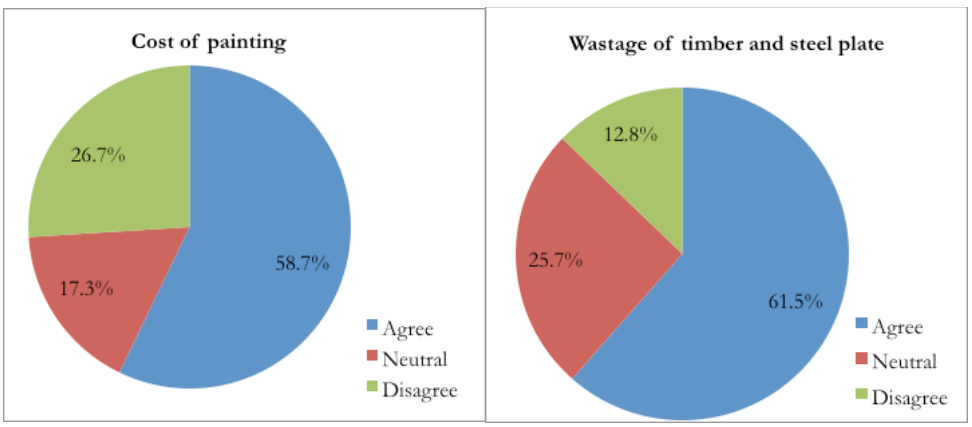

Figure 8: Cost of painting (L) and Wastage of Timber (R)

58.70% of the respondent agree that costs escalate due to painting the traditional features [Figure 5]. Since there are different varieties of traditional features, to make it aesthetically pleasing, different ranges of dynamic paints are used, which in turn contributes to the allocation of the required budget during the project planning. Therefore, we can conclude that the high cost of paintings and skilled labour required contributes to the economic constraint imposed.

One of the most diverse elements required for the construction of the traditional feature is the formwork and as per the respondent, 61.50% agree to the above statement. After the completion of the constriction, the formworks are rendered useless, which in turn

waste the investment done to procure the materials required for the formwork.

Result and discussion

The economic constraint due to added cost incurred because of limited skilled labour was the main constraint as per the survey. The cost of construction increases with the intricate detailing of the architectural features which requires skilled labour for construction and painting. Further single-use formworks used for constructing traditional features results in additional costs. Therefore, it is imperative that craftsman and technicians be encouraged to acquire skills that will meet the demands of the construction of traditional features.

The paintings on the traditional features are not only for mere decorations rather they are prayers and mediations expressed in lines and colours (Department of Works, Housing and Roads, 1993). Due to intricate artwork and painting details, costs of such works result in the escalation of the construction costs. Since the painting expenses cannot be compromised to maintain the quality of finish work.

The unavailability of the materials in the locality poses a major setback in the timely completion of construction work. During the planning phase, if a certain time frame is allocated for the procurement of the materials as per the availability, then the delay in the construction can be minimized.

While most of the respondent expressed no difficulties to design and construct buildings with traditional features, the lack of regulation and detailed guidelines to incorporate the traditional features in a building might interfere with the continuity of the construction methods. Comprehensive guidelines and standards will prove useful for novice professionals as well to uphold the perpetuity of Bhutanese traditional architecture.

Conclusion

The significance of the constraints imposed on the construction of buildings incorporating the traditional architectural features in Bhutan has been highlighted in the current study. The three main construction constraints identified were time, design, and economic constraints. Construction works are generally a balance between time, cost, and design quality. A change in one will impact the other two.

From the data and responses collected from the survey, the most important constraint imposed on the building construction with Bhutanese traditional architectural features was found to be the economic constraint. The economic constraint was mainly attributed to the cost of painting, the labour charges and the procurement of formwork materials. Another constraint imposed was time which was found to be valid

only in certain circumstances. The delay in the procurement of formwork materials and the unavailability of these materials during the time of construction hampers the deadline of a project whereas there is no time constraint imposed due to the design and building construction. In case of design and construction, there is no difficulty while incorporating the traditional features in the building but there is a certain load imposed by these features on the building construction.

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Study, Analysis and Estimation of Rainwater Harvesting Network in Jigme Namgyel Engineering College

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Abstract: Alternative source plays an important role to meet the rising demand. As the surface water resources are depleting, rainwater harvesting is the only alternative way to solve the water problem (Julius et al., 2013). Water is always in high demand as there is an increasing number of students and staff at Jigme Namgyel Engineering College with the introduction of every new programme. If this demand is not met, then it might lead to an unhealthy and low livelihood of students and the staff residing there. To solve this problem, the Rain Water Harvesting System (RWHS) could be considered. Moreover, owing to its simple technique, it is cost-effective and easy to implement. It will not only be helpful to meet the high demand for water supply but also improve the quality of water if properly filtered. TIn the focus of this paper is to locate the suitable catchment area, quantity of water that can be obtained from each catchment area and design tank size to store rainwater from the rooftop. The estimation of tanks and distribution networks of the collected rainwater is identified. Finally, the cost of the project is also calculated. Given these positive aspects, the Rain Water Harvesting System is highly recommended for the college.

Keywords: Rainwater harvesting system, catchment area, tank size, rainwater test, demand, distribution network.

Introduction

One of the biggest challenges in this 21st century is to overcome the growing water shortage worldwide. Rainwater harvesting (RWH) has thus regained its importance as a valuable alternative or supplementary water resource. Water shortages can be relieved if rainwater harvesting technique is practised more widely (Ali & Jain, 2014). Jigme Namgyel Engineering College is located at an elevated area where there are no sources of water available nearby. The current water supply from two sources i.e. Lemsorong and Donglayphug are not sufficient for the existing population. The number of students in the college is estimated to increase up to 1700 by the year 2030 as per the student projection of the college (2016). Thus, rainwater harvesting system is one of the most suitable methods as an alternative source for meeting the growing water demand.

Jigme Namgyel Engineering College is located in the tropical region which receives heavy rainfall during the monsoon season, rainwater can be a potential source of alternative water supply in the campus. As per the data collected from meteorological stations at Dewathang, the average yearly rainfall in Dewathang varies from 2200 to 5200 mm, 75% of which occurs between April and October. The high rainfall intensity provides a good opportunity for rainwater harvesting. Thus rainwater can be tapped during rainy seasons for storage and supplement the existing water supply during water shortages.

Literature Review

Rinchen Bumpa Temple in Kurtoe, Lhuentse has used the technique of rainwater harvesting because the temple has been plagued by the scarcity of water. That system has the gutter fitted in the eaves of the temple which collects rainwater during the monsoon between April to September and store it for late autumn and winter when the rain stops (Kuensel, 2015).

As per Kuensel Online (By Nirmala Pokhrel), eight years ago, day-scholar students of Goenpasingma lower secondary school in Pemagatshel had to carry five litres of drinking water for the school kitchen, which served meals for boarding students and lunch for day-scholar. The school was located 20Km from Pemagatshel town and did not have enough of the most needed water supply. After two years with the support of Public Health Engineering Division (PHED), Ministry of Health, the school received Nu 500,000 from UNICEF to improve the existing water supply. Six water tanks with a storage capacity of 1,000 litres each, two 500 litres tanks and two 200 litres tanks were installed to harvest rainwater. The water tanks were connected to gutter pipes, which let rainwater flow from the roof into the tanks. The rainwater collected was used by students for washing and bathing whereas the water from the spring source, were used for cooking and drinking. Since then the quantity of the tank size has improved and brought immense benefit to the school (Pokhrel, 2016).

There was a great demand of water in the college of engineering, Ananthapuramu, mainly for laboratories used in Civil Engineering, Mechanical Engineering, Chemical Engineering, Chemistry, Physics etc. The water was used in cleaning the building floors, labs, classes, and also for use in horticulture purposes, sprinkling in the dry land of C.O.E for preventing the oil dust particle in the air especially in summer season. To meet those demand, they adapted the rainwater harvesting technique (Kumar, 2015).

Data and Method

Study Area

The study area is Jigme Namgyel Engineering College which is about 19 km away from Samdrup Jongkhar town. It is located in the southeastern part of Bhutan with latitude 26° 51' 37" N and longitude 91° 27' 50" E. The total area of the college is 56.2 acres. There are 11 boarding hostels, 9 self-catering hostels and 15 teacher quarters. The study area is selected based on the water demand, the economic feasibility of the catchment area and space for tank design. The selected study areas are divided into five zones and are shown in the figure below.

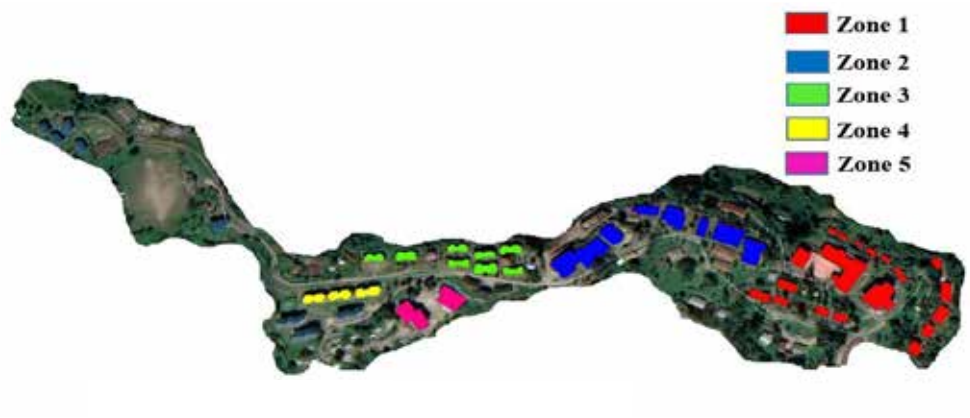

Figure 1. The study area for Rain Water Harvesting System

Zone I: Duekhor Khangzang
Duekhor Khangzang is located at 26°35' E and 91°45' N. It comprises of six blocks (D-A to D-F) which are used as self-catering hostels for 311 students. The existing water is supplied approximately two hours in a day which is not sufficient to fulfil the daily water requirement of an individual.

Zone II: Namsey Khangzang
Namsey Khangzang is located at 26°36' E and 91°46' N. It comprises of two blocs (N-A & N-B) housing 144 students. The two hours of water supply is insufficient for the students, thus the additional supply of water is needed.

Figure 2. Duekhor Khangzang

Figure 3. Namsey Khangzang

Zone III: Jampel Khangzang
Jampel Khangzang is located at 26°45' E and 91°45 N. It comprises of nine blocks (J-A to J-I) and are used as boarding hostels for 248 students.

Zone IV: Lecture Theater Hall
It is located at 26°45' E and 91°45'N. The water demand is calculated considering the number of students residing at Zoelnoen Khangzang (Z-A & Z-B) and college canteen.

Figure 4. Jampel Khangzang

Figure 5. Lecture Theater Hall

Zone V: Information Technology and Library Building
It is located at 26°45' E and 91°45'N. The water demand is calculated considering the water used in the IT building and staffs' quarter.

Figure 6. Information Technology and Library Building

Data collection

1) Daily rainfall data was obtained and the data was processed to obtain the average monthly rainfall.

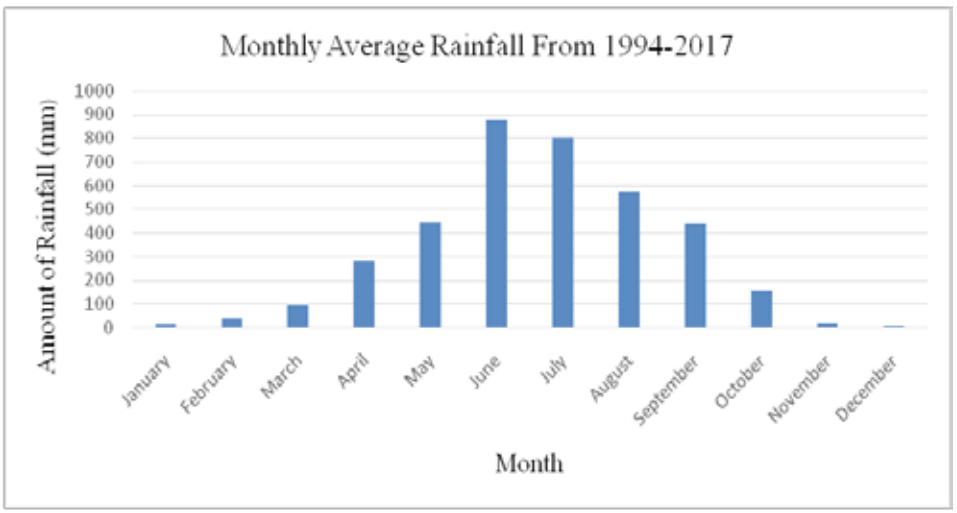

Figure 7. Average monthly rainfall of Dewathang

2) Population Forecasting

The student population forecasting is estimated based on student projection-for College (2016) as given below. This data is used for determining the increasing demand of water with increasing population.

3) Roof Catchment Area

The catchment area was manually obtained using a Laser Meter and the data is used in the calculation of the tank size.

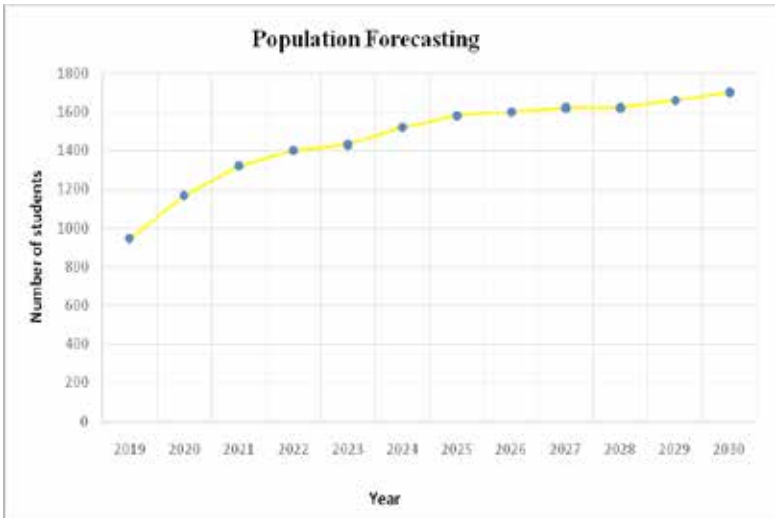

Figure 8. Population forecasting

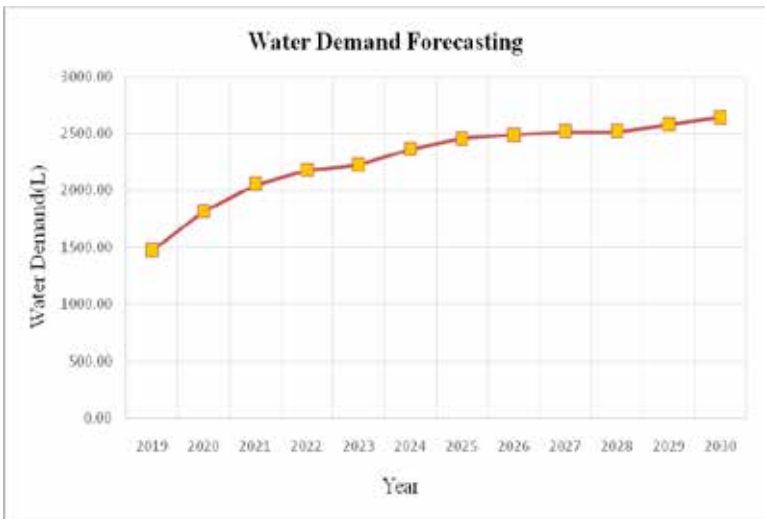

Figure 9. Water Demand Curve

Table 1: Catchment Areas

Sl. No.	Location	Roof Area(sq.m)
1	Namsey Khangzang (N-Block)	1427.83
2	Duekhor Khangzang (D-Block)	404.34
3	Jampel Khangzang (J-Block)	400.91
4	Information and Technology Department and Library Building	1180.36
5	Lecture Theatre	737.38

Rainwater quality test

The rainwater samples were collected from different zones and the water quality test was performed for three months, i.e. for March, April and May. Some samples were stored for one week and tested while others are tested within twenty-four hours and compared with the standard of the World Health Organization (WHO). The results are given below.

Table 2: Water quality test result

Locations		Parameter		
	PH	**conductivity (mS/m)**	**Dissolved oxygen (ppml)**	**Turbidity (NTU)**
Permissible Limits	6.5-8.5	5.0-50.0	2.0-7.0	5.0-10.0
Civil Block	5.30	0.12	-0.09	2.33
MPH	5.20	0.12	-0.09	2.00
Self catering	4.73	0.04	-0.10	2.00
IT building	4.83	0.10	-0.09	3.00
Lecture Theatre	4.88	0.04	-0.09	2.00
J-block	4.99	0.39	-0.09	1.00
NA block	4.37	0.09	-0.10	2.00

The total quantity of water that can be harvested

Runoff=C*I*A

Where, C=Runoff coefficient; I=Rainfall intensity (mm/hour); A=Catchment area (m2); The runoff coefficient of 0.9 was used for this study since the rooftop is pitched.

Storage tank capacity

The storage tank size is calculated based on the three months demand (dry months) supplying two days a week. As per the survey, the water needs to be supplemented in three zones namely Duekhor Khangzang (DA-DC), Jampel Khangzang (JA) and Namsey Khangzang.

For each zone, the amount of water required by each individual residing was obtained.

So the tank size is equal to the average demand of water required by the people residing in that particular zone over three months.

Three months study is considered because the study area faces three months of water shortage in a year thus the rainwater harvested can be stored during the rainy season and supplemented during the dry season when water is scarce.

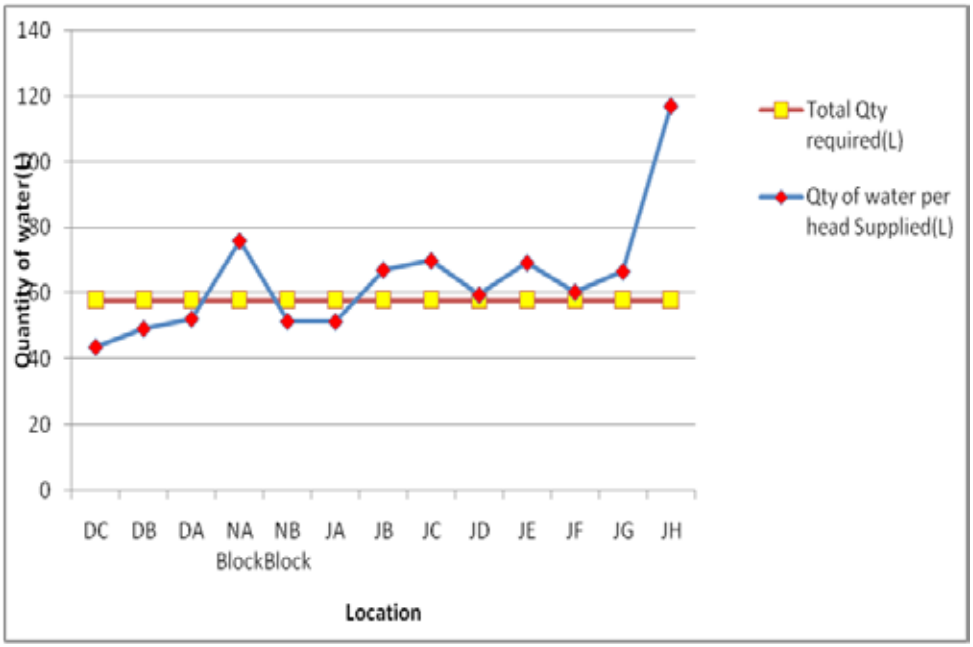

Figure 10. Relationship between total water quantity required and supplied

Considering the factor of safety of 20% the actual size of the tank is 50000 L for Duekhor Khangzang. Similarly for Jampel Khangzang and Namsey Khangzang the actual size of the tank is 5000 L and 20000 L respectively.

Table 3:Determination of Tank size

Months	Collected water(L)	Demand(L)	Water collected per day(L)	Tank size(L)
January	5131.07		171.04	
February	12680		422.67	
March	33470	1472.8	1115.67	
April	102250		3408.33	
May	161190		5373.00	
June	318360		10612.00	
July	292320		9744.00	35347.2
August	208610		6953.67	
September	158680		5289.33	
October	56420		1880.67	
November	6200		206.67	
December	2420		80.67	
Total	1357731	1472.8	45257.70	

Distribution Network

The water stored can be distributed by connecting the tank through the existing pipe thus, saving resources and fund. When the harvested water is supplied, a valve should be used to stop the flow of little water coming from the source and the people residing shall be notified about it. The drinkable water from the main source can be stored in the existing storage tank and can be supplied for a specific period, before or after the rainwater is supplied, as per the convenience of the residents.

Figure 11. Tank connection for Jampel Khangzang

Figure 12. Tank location for Duekhor Khangzang

Result

- There is insufficiency of water in the Duekhor Khangzang, Namsey Khangzang (NB-Block) and Jampel Khangzang Block (JA-Block).
- The rainwater is not suitable for drinking.
- The tank size is estimated based on the demand from each block.
- The maximum rainwater can be collected between May to July and can be supplied during insufficiency period.

Figure 13. Tank location for Namsey Khangzang

Conclusion and Recommendations

Rain Water Harvesting is the technique through which rainwater is captured from the roof catchments and stored in reservoirs for future use. Harvested rainwater can be stored in the sub-surface groundwater reservoir by adopting artificial recharge techniques to meet the demand during the dry season through storage in tanks and reservoirs (Dwivedi et al., 2013).

Rain Water Harvesting System (RWHS) is found to be technically feasible based on the prevailing rainfall pattern. The catchment areas (i.e., rooftop) are constructed out of corrugated galvanized iron (CGI) sheet which is technically appropriate materials for collecting rainwater. The rainwater quality test conducted for three months indicated that the rainwater cannot be used for consumption because of high turbidity and acidic. As per the survey conducted and determination water demand, the three zones namely Khangzang are selected for supplying rainwater. The reinforced cement concrete (RCC) tank of 50,000 L is required for Duekhor Khangzang. The syntax of 20,000 L and 10,000 L are required for Namsey Khangzang and Jampel Khangzang respectively.

The estimated cost for adopting rainwater harvesting system in the Jampel is Nu.178573.95 and for Namsey Khangzang Nu.350000, for Duekhor Khangzang is Nu.356, 352 and for Material Estimation it is Nu.202473.7 and overall Cost of the project is Nu.1087400.

- Researchers can further study the proper filtration process of the rainwater, making it safe for drinking and cooking.
- The catchment areas (rooftop) have to be kept clean for a better quality of harvested water.
- The gutter has to be fixed during the construction to have an easy installation of a rainwater harvesting system.
- It is also important to find more hygienic ways of storing water, since long term storage may encourage the spread of water-borne diseases. Improvements in this direction will reduce the prevalence of water-related diseases.
- The analysis of roof areas and rainfall data of the college will help future researchers.
- Future researchers may improve the existing system of our research by further extending the system with filtration (treatment plant).

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Evaluation of Factors Causing Delays in Construction Projects in Bhutan

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Abstract: The construction projects in Bhutan are facing serious issues of delays leading to incompletion of project within the given period as per contract document. Delays occur in almost all construction projects and has become a global phenomenon. The cost of the constructions is directly related to the project delays although time extension is considered to complete the project. This study, therefore, is intended to identify and evaluate the main causal factors and rank the most common factors contributing to delays in construction projects in Bhutan. Based on the review of literature in understanding the factors, a total of 37 delays factors were identified based on appropriateness to Bhutanese construction Industry. The survey was conducted with a structured questionnaire to seek views and opinions from the contractors and clients on the issues of delay. The respondent comprises of 28 clients and 21 contractors in the country. The survey questionnaire was analysed using Relative Importance Index (RII), and 7 factors were identified under the top-ranking category in the country. The study shows that delay in material delivery at the site on time is ranked number one followed by shortage of construction materials and labour upon integrating the broad factors pointed out by literature and responses from contractors and clients in the country. Further, some recommendations are provided to minimize such issues in construction projects.

Keywords: *Construction Projects, causes of delaying factors, important index, clients, contractors*

Introduction

Generally, the construction projects are mainly divided into three phases, namely inception of the project, designing phase and construction phase. The mainstream project delays happen within the construction stage, where enormous unseen causes are constantly involved. Delays can seriously impact on any project investors, such as owner, shareholders and contractors. In the process of socio-economic development in the country, an increasing number of construction projects both small and large were noted in recent times. One of the most common issues observed is the delay in the construction project leading to many other unfavourable consequences. Construction

delays are reported as a common hindrance in most of the construction projects across the world. Although there might be differences in the factors causing delay in the construction depending on the multiple conditions, this study has identified numerous factors from literature and analysed it in relation to the Bhutanese context and ranked them from highest to least factors. In most cases, it is learnt that the completion time goes beyond the stipulated time agreed between the parties upon delivery of construction any construction project (Kumar, 2016). It means definite loss of economy for the country, owner and shareholders due to non-availability of operational facilities. Due to the rise in overhead cost, there will be a loss of profit for the contractors (Al-Khalil and Al-Ghafly, 1999). Such delays in the construction project can be triggered either by the client or by the contractors.

Project delays can occur in all types of projects (small, medium and large) either in developing or developed countries, accompanied by cost overturns. Therefore, delays in constructions projects become destructive consequence on contractors, clients, consultants and nation as a whole in terms of project development, relationships and on financial aspects, which sometimes leads to court for legal battles (Mahamid et al., 2012). The completion of a project in time is an indicator of effective management, however, this does not happen most of the time in day to day life, since the construction development is subject to several elements and erratic causes rising from numerous sources. The project delay becomes a universal phenomenon; however, it is observed more severe in underdeveloped and developing nations (Azhar and Farouqui, 2008).

This study expects to identify, evaluate and rank the factors causing the delay of construction projects in Bhutan. Suggestion and recommendations will also be provided based on the findings to minimalize the construction project delays in Bhutan. The targeted respondents were limited to stakeholders such as clients and contractors since they are mostly involved in every stage of construction. The analysis of the results is based on the comparative study of factors from a broad literature review and integrating perception of respondents as per their experiences and observations in the ongoing projects related to construction in Bhutan.

Literature Review

It is vital to identify and to rank the causes of delays factors for construction project and all stakeholders must be educated about this issue to complete the project on time. There are numerous factors which contribute to delays of the project and to identify the causes of delays is an indispensable task to avoid any possible conflicts (Schumacher 2007).

The comparative studies on delays for the international projects show that India

performed worst among the countries such as China, Thailand, and Bangladesh (Ahsan & Gunawan, 2010). Similar studies were carried and compared between the UK and Libya's construction project delays through a questionnaire survey. The results showed that developing countries undergo more delays than developed nations may be due to lack of advanced technology in the underdeveloped and developing countries (Shebob, Dawood & Xu, 2011).

The study on the performance of diverse nature of projects was carried out through a questionnaire survey to evaluate the causes of delay in construction in Saudi Arabia (Mahamid, et al., 2012). The study showed that more than 75% and 55% of time overrun is in between 10% and 30 % from the original duration as indicated by the contractors and consultants respectively.

Similar studies have been carried out by accepting the importance of examining delays in construction. Some focuses on general construction projects and others have shown interest in specific projects like building construction projects, highway construction projects whereas few focuses specifically on large projects (Anuradha & Rajeev, 2016).

Causes of Delays

To ascertain numerous factors as causes of delay in the construction projects in the country, extensive literature was reviewed and analysed from various sources. The study has identified 37 different causes that are grouped under 7 broad categories [Table 1]. Upon identifying the factors, the survey questionnaire was designed to obtain critical responses from targeted respondents (Contractors & Clients) of Bhutanese construction industries. The questionnaire is therefore linked to the identified causes.

Methodology

Data Collection

The survey questionnaire was designed to obtain relevant information from targeted respondents (Contractors and Clients) as primary data. The survey questionnaire was administered through the issue of printed copy as well as an online survey to stakeholders (Contractors and Clients) in the country. To formulate the questionnaire to be used in the survey, the secondary data were used after receiving the expert's opinions through personal interviews and group discussions. Accordingly, the questionnaire was designed using the Likert Scale to evaluate data collected. The Relative Importance Indices (RII) was used as a method to analyse qualitative data based on the reliability of this tool. According to Johnson, (2004), it is defined as the proportionate contribution each predictor makes to R2, considering both the unique contribution of each predictor

by itself and its incremental contribution when combined with the other predictors. The Relative Importance Index (RII) is calculated for each indicator and ranked accordingly with the mathematical expression given by:

$$RII = (\sum W/H \times T)$$

Where, RII= Relative Importance Index, W=Weightage of an individual attribute, $\sum W$= Summation of all weight of each attribute, H= Highest score and T= Total respondents.

In this study, the RII range is set in between 0 to 1 ($0 \leq RII \leq 1$). The value 1 is the highest importance rated for the cause of delay. W = weighting (1 to 5) assigned by each respondent like, strongly disagree = 1, Disagree = 2, Moderate =3, Agree = 4 and Strongly Agree = 5. H= highest score, and T = total respondents (49 in this case).

Table 1: 37 different cause of delays under 7 categories:

Factors related to client's delays	**Factors related to contractors' delays**	**Factors related to consultants' delays**	**Factors related to labours delays**	**Factors related to materials delays**	**Factors related to equipment delays**	**Factors related to external delays**
Change orders during construction	Poor qualification of contractors	Inadequate experience	Shortage of labour	Delays in material delivery	Lack of high technology	Effect of surface and ground conditions
Delays in payment	Difficulties in financing projects	Insufficient data collection	Low productivity level	Shortage of construction materials	Low productivity equipment	Weather conditions
Lack of communication & coordination	Lack of communication and coordination	Lack of communication and coordination	Working permit of labour	Change in the material during construction	Low-level operator's skills	Traffic condition at the job site
Slow decision making	Inadequate experience of contractors	Lack of clarity in drawings	Personal conflict among the labourers	Damage of materials	Shortage of equipment	Accident at the construction site
Conflicts among joint ownership	Rework due to errors in construction	Improper design documents	Lack of appropriate technical knowledge	Delay the procurement of materials	Equipment breakdown	Changes in policies
	Conflict among contractors and other parties	Un-use of engineering software				

Data Analysis and Result Discussions

A total of 82 questionnaires were circulated to the targeted respondents across the country (Clients & Contractors), however, responses from 49 respondents (28 clients and 21 contractors) from across the country as shown in Table 2.

Table 2: Number of respondents

Respondents	Frequency	Percentage (%)
Clients	28	57.14
Contractors	21	42.86
Total	**49**	**100**

Delay factors ranked from clients' perception

A total of 28 clients responded to the questionnaire provided. Table 3 shows the questionnaire survey analysis results of five major factors that contribute to delays in construction in Bhutan ranked through Relative Importance Index from clients' perception.

In table 2, out of 37 delaying factors identified for the study, five major factors are shown using Relative Important Index to calculate. The delays in material delivery with 0.86 relative importance indices score (Rank 1) is perceived as the highest and most observed factor causing a delay of construction works of Bhutan. This is closely followed by a shortage of construction materials with 0.8 (Rank 2), and then a shortage of labour with 0.78 scores of RII. The difficulty in financing project and low productivity level of labours are rated the same as 0.76 RII score from the clients' point of assessment. Figure 1 also shows the five major factors in percentage as perceived by the clients.

Table 3: Factors causing delays from clients' perception

Sl. No.	Five Major Factors	RII	Rank	Percentage (%)
1	Delays in material delivery	0.86	1	21.71
2	Shortage of construction material	0.8	2	20.2
3	Shortage of labor	0.78	3	19.69
4	Difficulties in financing project	0.76	4	19.19
5	The low productivity level of labour	0.76	4	19.19
	Total	**3.96**	**5**	**100**

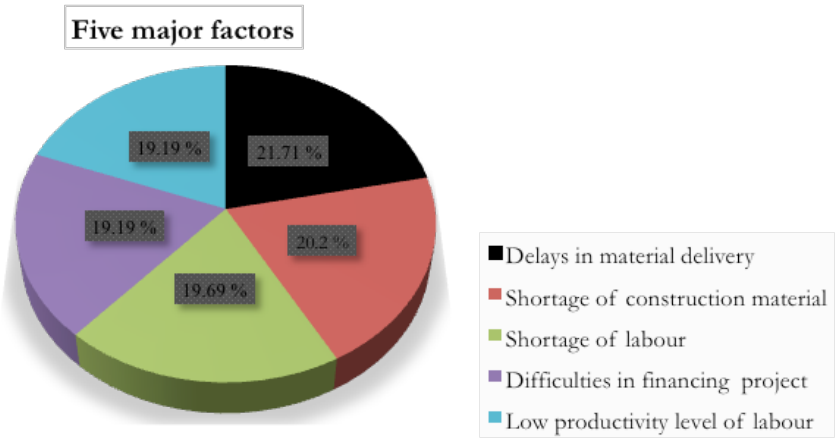

Figure 1. Five major factors causing delays (%) from clients' perception

Delay factors ranked from contractors' perception

A total of 21 contractors responded to the questionnaire provided. Table 3 shows the questionnaire survey analysis results of five major factors that contribute to delays in construction in Bhutan ranked through RII from contractors' point of assessment.

The top five major factors that causes delays are ranked according to the contractors' perception calculated through RII as shown in table 4. From the contractors' point of view, the weather condition was ranked 1 scoring 0.8 from the relative important Index, followed by slowness in the decision-making process as second most factor contributing delays of construction works in Bhutan. Delays in material delivery and shortage of equipment with RII value of 0.75 as perceived by the contractors. Labour is essential during the execution of the project as well as when a contract is in operation. However, the shortage of labour is ranked as 5th with RII value of 0.74. Figure 2 also shows the five major factors in percentage as perceived by the contractors.

Table 4 Factors causing delays from contractor' perception.

Sl. no.	Five Major Factors	RII	Rank	Percentage (%)
1	Weather Conditions	0.8	1	21.05
2	Slowness in decision-making process	0.76	2	20
3	Delays in material delivery	0.75	2	19.73
4	Shortage of equipment	0.75	4	19.73
5	Shortage of labor	0.74	5	19.47
	Total	**3.8**	**5**	**100**

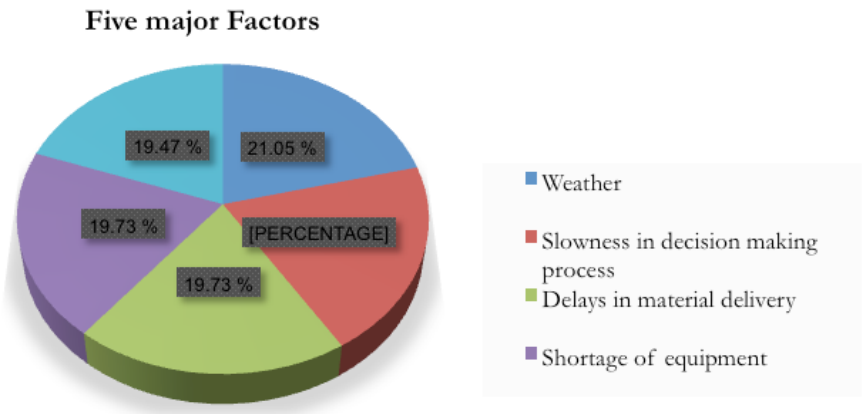

Figure 2. Five major factors causing delays (%) from contactors' perception

Delay factors ranked in overall

In this study, a total of 37 different factors causing delays in construction project across the globe were identified based on extensive literature review. Table 5 shows the combined survey analysis results of the top seven factors that contribute to delays in construction projects in Bhutan ranked through Relative Importance Index agreed by contractors and clients.

From the overall survey analysis results, the material delivery, shortage of construction materials, shortage of labour, weather conditions, shortage of equipment, difficulties in financing project and low productivity level of labour are among top seven ranked factors contributing to delay of a construction project in our country from the clients and contractors' point of view. Figure 3 also shows the top seven ranked delays factors in percentage from the overall analysis.

Table 5 Factors causing delays agreed by contractors and clients

Sl. no.	Five Major Factors	RII	Overall Rank	Percentage (%)
1	Delays in material delivery	0.81	1	15.39
2	Shortage of construction material	0.77	2	14.63
3	Shortage of labor	0.76	3	14.44
4	Weather Conditions	0.73	4	13.38
5	Shortage of equipment	0.73	4	13.38
6	Difficulties in financing project	0.73	4	13.38
7	The low productivity level of labour	0.73	4	13.38

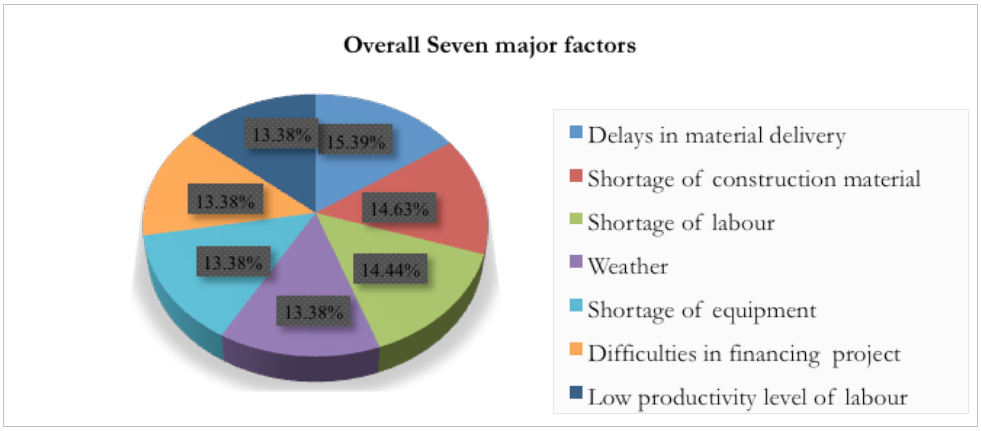

Figure 3. Top seven delays factors causing in percentage (%)

Conclusion

The factors causing delays in construction projects were identified and ranked based on Relative Importance Index (RII) from the assessment made by the contractors and clients. The study showed a difference in the view on the factors causing the delays in construction as pointed out by respondents (contractor and clients). Weather condition is noted as a significant factor impeding the construction delay from the contractors' view whereas material delivery is considered as the most significant causes for delay as per the clients with the view that weather condition may not be the top factors. However, the combined analysis results show that the delays in materials delivery as the most major factor from among 37 identified factors. The study also identified and ranked top seven factors contributing to delays in construction projects in the country that includes material delivery, shortage of construction materials, shortage of labour, weather conditions, shortage of equipment, difficulties in financing project and low productivity level of labour are revealed from this study. Based on the findings, to minimize the construction project delays, effective strategy for the award of contracts, proper planning of construction projects cycles and proper site management and supervision are recommended. The present study report should be understood with some limitations as there might be differences depending on the nature of the project and small sample size, yet the study tried to include all possible factors that are causing delay and examined the broad factors concerning the constructions activities in Bhutan.

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