# Economic Operation of Cement: A Case of Gautam Buddha Airport Upgrading Component Project

**Anjay Kumar Mishra[1], Rabindra Kumar Yadav[2] & P. S. Aithal[3]**
[1]Associate Professor, Madan Bhandari Memorial Academy Nepal, Urlabari 3, Morang, Nepal
OrcidID: 0000-0003-2803-4918; Email: anjaymishra2000@gmail.com
[2]Asst. Sub Engineer, Purbakhola Rural Municipality, Palpa, Nepal
Email: rabiyd2050@gmail.com
[3]Professor, College of Management & Commerce, Srinivas University, Mangalore, India
OrcidID: 0000-0002-4691-8736; E-mail: psaithal@gmail.com

**Subject Area:** Business Management.
**Type of the Paper:** Research Case Study.
**Type of Review:** Peer Reviewed as per |C|O|P|E| guidance.
**Indexed In:** OpenAIRE.
**DOI:** http://doi.org/10.5281/zenodo.
**Google Scholar Citation:** IJAEML.

**How to Cite this Paper:**
Anjay Kumar Mishra, Rabindra Kumar Yadav & Aithal, P. S. (2020). Economic Operation of Cement: A Case of Gautam Buddha Airport Upgrading Component Project. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 4(2), 188-199. DOI: http://doi.org/10.5281/zenodo.

**International Journal of Applied Engineering and Management Letters (IJAEML)**
A Refereed International Journal of Srinivas University, India.

International Journal of Applied Engineering and Management Letters (IJAEML), ISSN: 2581-7000, Vol. 4, No. 2, October 2020.

SRINIVAS PUBLICATION

# Economic Operation of Cement: A Case of Gautam Buddha Airport Upgrading Component Project

**Anjay Kumar Mishra[1], Rabindra Kumar Yadav[2] & P. S. Aithal[3]**

[1]Associate Professor, Madan Bhandari Memorial Academy Nepal, Urlabari 3, Morang, Nepal
OrcidID: 0000-0003-2803-4918; Email: anjaymishra2000@gmail.com

[2]Asst. Sub Engineer, Purbakhola Rural Municipality, Palpa, Nepal
Email: rabiyd2050@gmail.com

[3]Professor, College of Management & Commerce, Srinivas University, Mangalore, India
OrcidID: 0000-0002-4691-8736; E-mail: psaithal@gmail.com

## ABSTRACT

The cost of cement is very crucial for the effective construction of any project. The aim of the paper is to assess the economic operation of cement used for Gautam Buddha Airport Upgrading Component construction projects. The economic operation of cement in terms of their quality, consumption, and cost ensuring the strength requirements by concrete is done. Tests for magnesia oxide, insoluble residue, setting time, and compressive strength were operated. Compressive strength test was conducted on cement mortar cubes (1:3) and on concrete cubes developed by the design mix at the laboratory at 7 and 28 days. On the basis of the design mix, the cost difference among these brands for those sites is evaluated. Purposive sampling technique was applied to conduct the interview of project managers of each site and lab technician of Multi lab. Magnesia oxide, insoluble buildup, setting time, and compressive quality properties were discovered to be distinctive as guaranteed by the producer in their concrete endorsements. Furthermore, the results of the design mix showed that different quantity of cement is required depending upon the brand for M25 concrete. The average mean of compressive strength of concretes casted at the field of Admin Building, International Terminal Building and Crass Fire Rescue Building sites for M25 were 28.952 N/mm$^2$, 29.032 N/mm$^2$ & 27.924 N/mm$^2$ respectively. Based on quality, content, and rate analysis, 53-grade cement is cost effective. So further grading of Ordinary Portland Cement needs to be specified along with strict inspection of cement for assuring quality. The cement produces must be assured to conform to the stated standard.

**Keywords:** Strength, Grade, Cost, Brands of Cement, Properties

## 1. INTRODUCTION :

Cement is the second most burned-through substance on the planet after water (Elhasia, 2013) [1]. It is utilized nearly in each development. Nepalese cement businesses are constantly flourishing to fulfill the need for concrete (Mishra and Jha, 2019) [2]. It is found that in domestic cement brands the manufacturer has not labeled their cement product whether it is 33-grade or 43-grade or 53-grade. The contractors of Nepal apply available cement brands in the same proportions as stated in nominal mix design to fulfill the strength requirement of concrete (e.g. M20 = 1:1.5:3, and M25 = 1:1:2) without mix design. According to Neville, [3], selection of cement for mix design is significant quality and cost effectiveness as mix design conforms to correct proportion. The Effect of Insoluble Residue on Properties of Portland Cement shows the sensitivity of cement [4] for quality construction. Similarly, Singh, & Marripoodi, K., (2016) [5] highlighted the significant impact of cement content on construction building projects. This type of concreting approach is indirectly increasing the cost of the project in terms of cement cost. Since, there is no study on the selection, purchase procedure of cement, and the effect of handling and storage of cement at sites; it is very important to study and evaluate the impacts caused by these variables on the cost of the infrastructure development projects which is considered as the economic operation of cement (Mishra and Chaudhary, 2018) [6].

Till date for Ordinary Portland Cement, the Nepal Bureau of Standards and Metrology (NBSM) has guaranteed the nature of 33 evaluations as it were. There are no particular prerequisites proposed by the NBSM whether it is 43 or 53 level which brings difficulty for development experts while choosing a brand of concrete. NBSM has not ensured a particular evaluating of over 33 evaluations for OPC (Mishra and

Chaudhary, 2018) [6].
So, irrespective of grading the cement manufacturers are only allowed to maintain the specific requirements needed by the 33 grades of cement. Hence, it is the major job of the professionals to decide based on the market competitiveness to ensure the quality of cement by conducting various tests needed and the cost analysis. The economic operation of cement at international airport construction near to Gautam Buddha birthplace would be significant for the entire Buddhist. The significance of this study is to provide awareness about different grades of cement. The outputs of this study provide a guiding document to the stakeholders. The study provides information about the quantity of wastage of cement and the great expenditure of money. The study and findings can be significant for the professionals to select appropriate cement brands in the Nepalese context. It can also be significant for construction projects to manage their cost by selecting the appropriate brand of cement.

## 2. OBJECTIVES :

The overall objective of the study is to assess the economic operation of different brands of cement used for the Gautam Buddha Airport Upgrading Component (GBAUC) construction project based on cement content, strength, and conditions of site and lab.

## 3. RESEARCH METHODOLOGY:

The objective wise methodology is shown in table 1, the study conforms quality based on brands in lab and site conditions to assure the content of cement followed by cost analysis.

**Table 1:** Research Matrix

| Objective | Data Collected | Source of Information | Interpretation & Analysis |
|---|---|---|---|
| To determine how the strength of cement varies at a construction site and laboratory. | Compressive Strength test results of 7 days and 28 days were collected from each site and the average mean was analyzed cement brands. | Compressive Strength test reports conducted at sites were analyzed to check the quality of concrete. | Qualitative analysis was done and the average means were evaluated |
| To analyze the impacts of different grades of cement on cement content. | Cement certificates from the manufacturer were collected and quantitative requirements of cement content (Kg/m3) were obtained by design mix of M25 to access the concrete requirement using selected cement brands. | Cement certificates issued by the manufacturer, trial mix of M25 in lab. | Experimental and quantitative analysis. Variation in cement content was observed. |
| To analyze the economic implication of using different grade of cement. | Quantitative requirement of cement in bags needed to cast the estimated R.C.C quantity of the project were calculated and Total cost of the cement for the project were analyzed based on their quality and quantity. | Purposive sampling technique was conducted among Project Managers of each site | Quantitative analysis was done and the results were compared and assessed. |

### 3.1 Study Population

Ja, Sv, and Sb are codes used for cement brands to maintain ethical consideration. Cement confirming to NS 49:2041 (NBC101:1994, 2064), were selected as samples as these three brands of cement were used by the GBAUC for its reinforced cement concrete (R.C.C) structures as shown in Table 2. The methods are adopted from (Mishra and Chaudhary, 2018 [2]; Mishra and Sharestha, 2019[7]; based on standard codes).

**Table 2:** Sample Size for Lab Tests

| S. No. | Particulars | Nos. |
|---|---|---|
| 1 | Cement Bags – 1 of each brand for 3 sites | 9 |
| 2 | Fine Aggregates - 20 sacks from each site | 60 |
| 3 | Coarse Aggregates - 20 sacks from each site | 60 |

Fine and coarse aggregates used in the design mix at the lab were obtained from the selected site under case study. Standard aggregate sampling technique was applied for the selection of coarse and fine aggregates. For this research, the sample of cement used for the design mix was obtained from the manufacturer. Design mix with varying cement content for M25 concrete from three brands of cement for sites were made at the lab and their results were analyzed.

Purposive sampling technique was applied to conduct Key Informant Interview of project managers – 1 of site and of lab technician of Multi lab who was involved in lab tests.

**Tests on Cement**; For **Chemical Properties**

**(a) Magnesia Oxide (MgO)**

In this test method, magnesium was precipitated as magnesium ammonium phosphate from the filtrate after removal of calcium. The precipitate was ignited and weighed as magnesium pyrophosphate. The MgO equivalent was then calculated.

MgO (%) = W x 72.4

Where, W = grams of magnesium pyrophosphate (ASTM:C114-07, 2007) [8].

**(b) Insoluble Residue**

The insoluble material is an inactive part of cement. It was determined by stirring 1 gram of cement in 40ml of water and then 10ml of concentrated hydrochloric acid (HCl) was added. The mix was boiled for 10 minutes. Any lump, if present, was broken and the solution was filtered. The residue on filter was washed with disodium trioxide ($Na_2O_3$) solution, water, and HCl in the given order and, finally, again with water. The filter paper was dried, touched off, and weighed to give an insoluble buildup. The base the buildup, the better is the concrete (ASTM:C114-07, 2007) [8].

**Tests on Cement**; For **Physical Properties**

**(c) Setting Time of Cement**

Initial Setting Time and Final Setting Time based on IS:4031(Part-5)-1988, 2002 as adopted from Mishra and Sharestha (2019) [7] were measured.

**(d) Compressive Strength**

Concrete mortar solid shapes (1:3) having an area 5000 mm2 were readied (for example Nine shapes of each brand of concrete) and tried in a compression testing machine. The compressive strength at 3 days, 7 days and 28 days were found out following IS:4031(Part-6)-1988, 2002 [9].

**Procedure of Design Mix**

- Target mean strength for mix design was taken as:

  The target mean compressive strength at 28 days is given by,

  $f_t = f_{ck}+t.s$ ,

  where, $f_{ck}$ = required characteristic compressive strength

  t = 1.65

  s = standard deviation 4N/mm$^2$ obtained for M25 based on IS:456-2000, 2002 [10].
- Water cement ratio was selected as:

  According to IS: 456 – 2000 for minimum cement content 300kg/m$^3$ and maximum water – cement ratio 0.5 for M25 grade of concrete was followed (IS:456-2000, 2002).

  Water content in the mix was selected as:

  For the maximum nominal size of aggregate (e.g. 20mm) = 186 kg/m$^3$ is the maximum amount of water content per cubic meter of concrete from IS: 10262 – 2009 [11]

In the experiment that was conducted, the mix was designed for the pumpable concrete having a maximum nominal size of aggregate 20mm, the slump value ranging from 110mm to 120mm with maximum water content = 170 kg/$m^3$.

- Entrapped air was estimated as: From IS: 10262 – 1982 [12], entrapped air = 2% for maximum nominal size of aggregate 20 mm.

- Cement content was determined as: The cement content was calculated from water – cement ratio and the final water content has arrived after adjustment.
  Cement content = mass of water/ (water/cement ratio).

- Coarse and fine aggregates were determined as:

  V = (W + C/Sc+ (1/P) x (fa/Sfa)) x (1/1000)

  Ca = (1-P)/P x fa x (Sca/Sfa)

  Where,

  Ca = total masses of coarse aggregate/kg.

  fa = total masses of fine aggregate/$m^3$

  C = mass of cement

  W = mass of water

  P = ratio of fine aggregate to total aggregate by absolute volume

  Sfa, Sca = specific gravity of saturated surface dry fine and coarse aggregate.
- Then, the concrete mix proportions for the first trial mix were determined.
- Trial mixes with suitable adjustments were done till the final mix proportions were arrived at (Raj & Ilakkiya, 2014) [13].

**Tests in Hardened Concrete**

**(i) Compressive Strength Test**

Total 54 arrangements of shapes of measurement (150 mm X 150 mm X 150 mm) were made for M25 concrete (for example 18 shapes were produced using 3 brands of concretes for each extraordinary concrete substance of 360 kg/m3, 380 kg/m3& 400 kg/m3strictly following I.S:516-1959, 2002) [14].

**Cost Analysis**

Cost analysis was done into two parts as:

(a) Based on location of sites: - Fromthe interview of project manager the total cement cost of each sites was found. The total cement cost includes the factory cost and the transportation cost. First of all, the factory cost of cement per (50 kg.) bag was tabulated in table – 8which includes the rate with excise duty and VAT per bag. Then, the transportation cost to site from factory was tabulated.

(b) Based on estimated concrete quantities of sites: Again, from the interview of project manager estimated concrete quantities of each site were found and tabulated. Finally, for all three sites; the comparison of cement cost between Ja, Sv, and Sb cements were done.

**Average Mean Compressive Strength of Concrete Cubes at Sites**

Compressive quality reports were gathered from all chosen destinations; for example, 5 test reports for M25 from each of the three destinations. The normal of 28 days compressive quality for each of the three destinations was classified.

*Quality Control Check*

To evaluate the quality of concreting works, source of aggregates, uniformity in aggregates in terms of weights and water cement ratio while mixing in proportions, slump value of fresh concrete while casting, compressive strength test results of concretes casted at sites were analyzed.

**Data Analysis and Presentation**

The main aim of this study was to determine the appropriate cement for building construction on the basis of strength requirement, Cement content and its cost price. After the collection of data from experiments and results obtained from key informant interview, they were analyzed and conclusion and recommendations were drawn by linking those results and data. To further enhance and support the data, elaborations were done using tables 3 and 4.

**Table 3 :** Chemical and Physical Characteristics of Cement

| S. No. | Characteristics | As Per 33 Grade (NS: 49:2041) / (IS: 269:1989) | As Per 43 Grade (IS: 8112:1989) | As Per 53 Grade (IS: 12269:1987) |
|---|---|---|---|---|
| A. | Chemical Characteristics **:** | | | |
| 1 | LSF (Lime Saturation Factor) | 0.66 - 1.02 | 0.66 - 1.02 | 0.66 - 1.02 |
| 2 | AM (Alumina Modulus) | 0.66 (min.) | 0.66 (min.) | 0.66 (min.) |
| 3 | Insoluble Residue (% Mass) | 2% (max.) | 2% (max.) | 2% (max.) |
| 4 | Magnesia (% Mass) | 5% (max.) | 5% (max.) | 6% (max.) |
| 5 | Sulphuric Trioxide ($SO_3$) | 3% (max.) | 3% (max.) | 3% (max.) |
| 6 | Total Loss on Ignition % | 4% (max.) | 4% (max.) | 4% (max.) |
| B. | Physical Characteristics : | | | |
| 1 | Specific surface ($CM^2/g$) | 225m2/Kg. (min.) | 225m2/Kg. (min.) | 225m2/Kg. (min.) |
| 2 | Setting time (minutes) : | | | |
| A | Initial setting time | Not less than 45 minutes | Not less than 30 minutes | Not less than 30 minutes |
| b | Final setting time | Maximum 600minutes | Maximum 600minutes | Maximum 600minutes |
| 3 | Soundness : | | | |
| a | By le-chataller (MM) | 10mm (max.) | 10mm (max.) | 10mm (max.) |
| b | By Auto clave (%) | 0.8% (max.) | 0.8% (max.) | 0.8% (max.) |
| 4 | Compressive Strength ($N/mm^2$) : | | | |
| A | 072±1hour; 3 days | 16 MPa (min.) | 23 MPa (min.) | 27 MPa (min.) |
| b | 168±1hours; 7 days | 22 MPa (min.) | 33 MPa (min.) | 37 MPa (min.) |
| c | 672±4hours; 28days | 33 MPa (min.) | 43 MPa (min.) | 53 MPa (min.) |

(NBC101:1994, 2064), (IS8112:1989, 2005), (IS12269:1987, 1988) [2].

**Table 4:** Grade wise classification of OPC from A to F

| S. No. | Category | 28-Days Comp. Strength (MPa) | Grade of cement |
|---|---|---|---|
| 1 | Class – A | (32.5 - 37.5 MPa) | 33 |
| 2 | Class – B | (37.5 - 42.5 MPa) | - |
| 3 | Class – C | (42.5 - 47.5 MPa) | 43 |

| | | | |
|---|---|---|---|
| 4 | Class – D | (47.5 – 52.5 MPa) | - |
| 5 | Class – E | (52.5 – 57.5 MPa) | 53 |
| 6 | Class – F | (57.5 – 62.5 MPa) | - |

(Duggal, 2009)[15].

## 4. RESULTS AND DISCUSSION :

**Analysis of Cement Properties and Design Mix**

Ja, Sv, and Sb cements were analyzed at laboratory. Design mix of M25 concrete was trailed by varying the cement content and the cubes were tested in lab at an interval of 7 days and 28 days.

**Comparison Based on Cement Properties**

From tests, chemical & physical properties were compared and listed in table 5.

**Table 5:** Comparison Based on Cement Properties

| S. No. | Particulars | Ja | | Sv | | Sb | |
|---|---|---|---|---|---|---|---|
| | | Found at lab | Claimed by Company | Found at lab | Claimed by Company | Found at lab | Claimed by Company |
| 1 | Chemical Characteristics : | | | | | | |
| a. | Magnesia oxide (% by mass) | 4.5 % | 4.72% | 3.32% | 2.72% | 4.1% | 4.81% |
| b. | Insoluble residue (% by mass) | 0.98 % | 1.15% | 0.67% | 0.96% | 1.3% | 1.53% |
| 2 | Physical Characteristics : | | | | | | |
| a. | Initial setting time | 2.20 hours | 2.40 hours | 3.35 hours | 2.50 hours | 1.35 hours | 1.40 hours |
| b. | Final setting time | 4.55 hours | 5.30 hours | 4.55 hours | 4.25 hours | 3.5 hours | 3.10 hours |
| 3 | Compressive Strength (MPa) : | | | | | | |
| a. | 072±1hour; 3 days | 33.4 MPa | 32.60 MPa | 28.10 MPa | 31.11 MPa | 34 MPa | 34.4 MPa |
| b. | 168±1hours; 7 days | 41.46 MPa | 42.0 MPa | 33.55 MPa | 37.21 MPa | 37.2 MPa | 49.2 MPa |
| c. | 672±4hours; 28days | 56.2 MPa | 55.8 MPa | 48.80 MPa | 50.56 MPa | 55.86 MPa | 54.1 MPa |

(Lab Tests, 2019)

The presence of Magnesia oxide in all three brands of cement were found to be within the safe limit allowed by NS and I.S specifications (i.e. max. 5% for 33 and 43 grades, and max. 6% for 53 grade). Among these three brands of cement, Sv cement was found to have magnesia oxide 3.32% by weight of cement which was below 4%. Though the presence of magnesia oxide in these three concretes were not over 5% as permitted by N.S and I.S details, it is better and more secure to pick the concrete having lower magnesia oxide content as the magnesia is one of the significant offenders behind late extension splits improvement in concrete. Ja and Sb types of cement were found to have MgO content 4.5% and 4.1% respectively which was found to be above 4% so, both types of cement were found to have free lime.

It was found that the presence of insoluble residue in these three types of cement was within the safe limit

allowed by N.S and I.S specifications i.e. max 2%. The minimum the presence of insoluble residue, the cement is said to be better. So, Sv cement was found to be better in comparison with Ja and Sb cements as its presence was lower than other two types of cement (i.e. Sv =0.67%, Ja= 0.98% and Sb = 1.3%).
Initial setting time of these three types of cement was found to be much higher than that specified by N.S and I.S specifications i.e. min. 45 minutes for 33 grade and 30 minutes for 43 and 53 grades. Initial setting time of Ja, Sv and Sb types of cement was found to be 2.20, 3.35and 1.35 hours respectively. During the field inspection of GBAUC construction sites, it was found that the contractor had been using the concrete pump to pump the concrete from mixture hopper to the area of placement. The concrete were easily placed in the required area within an hour of mixing the cement with water. Hence, Sb cement was found to be preferable to GBAUC sites in comparison with Ja and Sv types of cement based on the nature of their work.
Final setting time of these three types of cement was again found to be within the safe limit allowed by N.S and I.S Specifications i.e. max. 10hrs. Comparison of these three types of cement showed that final setting time of Ja, Sv and Sb types of cement were 4.55, 4.55 & 3.5 hours respectively. It was found that final setting time of Sb cement was quicker than the Sv and Ja types of cement. Hence, Sb cement was found to be preferable in accordance with Sv and Ja cement for GBAUC sites as because the construction period of GBAUC was found to be short and the contractor have to allocate extra budget for their formworks if final setting was not quicker.
Comparison of compressive strength analysis showed that these three types of cement have passed the N.S Specification of 33 grade. But according to I.S specifications from table – 3 and table – 4, Ja, and Sb types of cement were found to be of 53 grade and in Class- E category whereas Sv cement was found to be of 43 grade and in Class-D category.

**Analysis of the Concrete Strength between Lab and Field Conditions**
During GBAUC project concrete cubes are collected from each of the three sites and compressive strength were tested in its own lab and found to attain the expected compressive strength at 28 days i.e. 25N/mm$^2$for M25. Average means were calculated which showed that:-

a) Admin Building site – At site conditions, the average mean of 28 days compressive strength was 28.952N/mm$^2$.
b) IT Building site – Similarly, the average mean of 28 days compressive strength was 29.032N/mm$^2$.
c) CFR Building site – Also, the average mean was 27.924 N/mm$^2$.

Hence, in all 3 cases, the strength requirement by concrete at the site was found to be achieved by the design of mixed concrete
**Analysis of the impact of different grades of cement on cement content**
Comparison Based on Compressive Strength Test Conducted at Lab can be seen from table 6 below.

**Table 6:** Results of Design Mix Obtained from Lab for M-25 Grade of Concrete

| Name of Cement | 7-days comp. strength (N/mm$^2$) | | | 28-days comp. strength (N/mm$^2$) | | | Targeted Mean Strength at 28-days (N/mm$^2$) | Saturated Surface Dry Weight (Kg/m$^3$) |
|---|---|---|---|---|---|---|---|---|
| | Admin Building | IT Building | CFR Building | Admin Building | IT Building | CFR Building | | Cement |
| Ja OPC | 22.89 | 23.08 | 22.87 | 30.29 | 30.68 | 30.52 | 31.60 | 360 |
| Sv OPC | 21.33 | 22.16 | 21.68 | 29.13 | 29.81 | 29.54 | 31.60 | 360 |
| Sb OPC | 23.48 | 23.59 | 23.26 | 30.17 | 30.41 | 30.52 | 31.60 | 360 |
| Ja OPC | 27.53 | 27.11 | 28.33 | 34.24 | 34.41 | 33.13 | 31.60 | 380 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sv OPC | 24.98 | 25.37 | 25.57 | 32.56 | 32.62 | 31.81 | 31.60 | 380 |
| Sb OPC | 26.93 | 27.35 | 27.26 | 34.21 | 34.32 | 33.18 | 31.60 | 380 |
| Ja OPC | 29.93 | 30.87 | 30.91 | 37.35 | 37.46 | 36.59 | 31.60 | 400 |
| Sv OPC | 27.82 | 28.59 | 27.59 | 35.27 | 35.43 | 35.72 | 31.60 | 400 |
| Sb OPC | 30.51 | 29.97 | 30.11 | 37.33 | 37.39 | 36.44 | 31.60 | 400 |

(Lab Test, 2019)

The results of the compressive strength test conducted at the lab for three brands of cement having a constant source of aggregate, sand and chemical for each different site showed that for M25 grade of concrete all three cement brands passed the targeted mean strength at 28- days, i.e., 31.60MPa. With minimum cement content 380kg/$m^3$. It was found that for M25 concrete, the compressive strength of cubes made by Sv cement with minimum cement content 380kg/$m^3$ at lab environments was very close and had nearly attained the targeted mean strength at 28 days for all the selected sites under case study. Hence, to minimize the risk factor of concrete failure at site conditions, the minimum cement content for Sv cement should be 400kg/$m^3$ if applied otherwise, Ja and Sb types of cement could be applied with a minimum cement content 380kg/$m^3$ for M25 concrete.

**Analysis of Cement Cost**

**Comparison of Cement Costs Based on Site's Location**

Cement store of GBAUC is near to the Admin Building site and IT Building site but 3km away from CFR Building site. So, the cost within GBAUC from store to sites includes the transportation cost. The cost analysis of cement including the excise duty, value added tax (VAT) and transportation cost to the site showed the following results for the construction sites taken into consideration as in table 7.

**Table 7:** Cement Cost According to the Location of Sites

| Particulars | Rate with Excise Duty and VAT Per Bag (50kg) | | | Transportation Cost to Site from Factory Per Bag (50kg) | | | Total Cement Cost to Site Per Bag (50kg) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Admin Building | IT Building | CFR Building | Admin Building | IT Building | CFR Building | Admin Building | IT Building | CFR Building |
| Ja Premium | 720.00 | 720.00 | 720.00 | 6.50 | 6.00 | 8.00 | 726.50 | 726.00 | 728.00 |
| Sv | 780.00 | 780.00 | 780.00 | 75.00 | 75.50 | 77.00 | 855.00 | 855.50 | 857.00 |
| Sb | 704.00 | 704.00 | 704.00 | 16.00 | 16.50 | 18.00 | 720.00 | 720.50 | 722.00 |

It was found that the factory cost of Sb cement was the cheapest one i.e. Nrs.704/- per sack whereas factory cost of Sv and Ja Premium were Nrs.780/- and Nrs.720/- respectively per sack. The price of Sv Cement was found to be highest i.e. Nrs780/- per sack. The cost of Ja Premium and Sb were nearly equal with Nrs.720/- and Nrs.704/- respectively per sack.

Similarly, the total cement cost of Sb cement was found to be lowest including excise duty, Vat and transportation cost for Admin Building and CFR Building sites with price Nrs.720/- per sack and Nrs.722/- per sack respectively. The total cost of Ja Premium cement was found to be Nrs.726/- per sack for IT Building site including excise duty, VAT and transportation cost.

It was also found that though Sv cement if of 43 grades, the price of Sv cement was higher than other cements in the market. It is due to the good marketing strategies of the marketing team of Sv cement and the customers are unaware about the grade of cements.

**Total Cost Analysis of Cement**

The estimated concrete quantities of GBAUC sites were found and then, total cement required to cast these quantities were calculated.

a) GBAUC – Admin Building: The required concrete quantities of M25 were 1,329.00m3. To cast these concrete quantities 10,100 bags of cement were estimated if Ja or Sb cement is adopted whereas 10,632 bags of cement were estimated, if Sv cement is adopted. The difference in cement bags were 531.

b) GBAUC – IT Building: The required concrete quantities of M25 were 8,124.00$m^3$. To cast these concrete quantities 61,742 bags of cement were estimated if Ja or Sb cement is adopted whereas 64,992 bags of cement were estimated, if Sv cement is adopted. The difference in cement bags were 3,249.

c) GBAUC – CFR Building: The required concrete quantities of M25 were 773.00$m^3$. To cast these concrete quantities 5,874 bags of cement were estimated if Ja or Sb cement is adopted whereas 6,184 bags of cement were estimated, if Sv cement is adopted. The difference in cement bags were 309.

**Table 8:** Comparison of Total Cement Cost Based on Estimated Cement Quantities

| Name of Site | Total Cost of Cement to Construction Sites | | | Total Cost Difference from Chosen Brand | | |
|---|---|---|---|---|---|---|
| | Ja | Sb | Sv | Ja Vs. Sb | Ja Vs. Sv | Sb Vs. Sv |
| GBAUC – Admin Building | 7,337,940.60 | 7,272,288.00 | 9,090,360.00 | 65,652.60 | - | 1,818,072.00 |
| GBAUC – IT Building | 44,824,982.4 | 44,485,399.20 | 55,600,656.0 | 339,583.20 | 10,775,673.6 | - |
| GBAUC– CFR Building | 4,276,854.40 | 4,241,605.60 | 5,299,688.00 | 35,248.80 | - | 1,058,082.40 |

From table 7 and 8 cost of cement to construction sites and the cost difference was tabulated, it was found that Sb cement is cheapest for Admin Building and CFR Building sites with estimated cement cost of Nrs. 7,272,288.00/- and 4,241,605.60/- respectively whereas Ja cement is used for IT Building site with estimated cement cost of Nrs. 44,824,982.40/- even Sb cement is cheapest with estimated cement cost of Nrs.44,485,399.20/-. For Admin Building site, if Ja cement was used in case of Sb then the cement cost would have been raised by Nrs. 65,652.60/- and if Sv cement was used then the cement cost would have been raised by Nrs.1,818,072/-. Likewise, for IT Building site the cement cost would have been decreased by Nrs. 339,583.20/- and raised by Nrs.10,775,673.60/- if Sb and Sv types of cement were used instead of Ja cement. Similarly, for CFR Building site the cement cost would have been raised by Nrs. 35,248.80/- and by Nrs. 1,058,082.40/- if Ja and Sv types of cement were used instead of Sb cement.

**Average Cost Analysis of Cements**

Based on estimated total quantities of concretes and cement, costs of cement per cubic meter applicable to sites were found and comparisons were done.

**Table 9:** Average Cost Analysis of Cement

| Name of Site | Cost of Cement to Construction Sites Per Cubic Meter | | | Cost Difference Per Cubic Meter from Chosen Brand | | |
|---|---|---|---|---|---|---|
| | Ja | Sb | Sv | Ja Vs. Sb | Ja Vs. Sv | Sb Vs. Sv |

| | | | | | | |
|---|---|---|---|---|---|---|
| GBAUC – Admin Building | 5,521.40 | 5,472.00 | 6,840.00 | 49.40 | - | 1,368.00 |
| GBAUC – IT Building | 5,517.60 | 5,475.80 | 6,844.00 | 41.80 | 1,326.40 | - |
| GBAUC– CFR Building | 5,532.80 | 5,487.20 | 6,856.00 | 45.60 | - | 1,368.80 |

It was found that Sb cement was cheapest for Admin Building and CFR Building sites with estimated cement cost Nrs. 5,521.40/- per $m^3$ & Nrs. 5,532.80/- per $m^3$ respectively whereas Ja cement was found to be used for IT Building site with estimated cement cost Nrs. 5,517.60/- per $m^3$ even Sb cement was cheapest for this site with estimated cement cost Nrs. 5,475.80/- per $m^3$.
The cost difference was also found for each site as in table 9:
(a) For Admin Building site, the cost differences with respect to Sb were Nrs. 49.40/- per $m^3$ and Nrs. 1368.00/- per $m^3$ if Ja and Sv types of cement were used.
(b) For IT Building site, the cost differences with respect to Ja Premium were Nrs. 41.80/- per $m^3$ and Nrs. 1326.40/- per $m^3$ if Sb and Sv types of cement were used.
(c) For CFR Building site, the cost differences with respect to Sb were Nrs. 45.60/- per $m^3$ and Nrs. 1368.80/- per $m^3$ if Ja and Sv types of cement were used.

## 5. CONCLUSION :

Based on 28 days compressive strength results of design mixed concrete, the minimum cement requirement per cubic meter were found with the selected brand of cements i.e. Ja and Sb types of cement were found to have minimum cement content of 380kg/$m^3$ whereas Sv cement was found to have minimum cement content of 400 kg/$m^3$ for M25 concrete. This showed that Ja and Sb were two cement brands that would be economical than Sv cement for GBAUC project under the case study. Based on the total cost of cement by adding factory cost and transportation cost, it was found that Sb cement was found to be economical for Admin Building and CFR Building sites while Ja Premium was found to be used for ITB site even Sb cement was economical for this site. The grade of cement was found to be the key factor in the cement content requirement for ensuring the required concrete strength in terms of quality. The design mix technique was found to be adopted by the contractor of GBAUC projects. Project manager was found to be aware of the design mix technique and the consequences of change in sources of sand, aggregates, and admixtures. So, the quality control technique for concrete was found to be good at sites since there was a batching plant for effective control in the mixing of ingredients of concrete. It was found that Sb cement was cheapest for Admin Building and CFR Building sites with estimated cement cost Nrs. 5,472/- per $m^3$ & Nrs. 5,487.20/- per $m^3$ respectively whereas Ja cement was used for ITB site with estimated cement cost Nrs. 5,517.60/- per $m^3$ while Sb cement was cheapest with estimated cement cost Nrs. 5,475.80/- per $m^3$. Though Sv cement was of 43 grade the market price of cement was costlier than Ja and Sb types of cement which were of 53 grade.

## 6. RECOMMENDATIONS :

Nepal Bureau of Standards and Metrology needs to provide specifications for 43 and 53 grades of cement so that cement manufacturers will be compelled to follow the N.S guidelines to maintain the quality of their products. Since the grade of cement was found to be the key factor on cement content requirement for ensuring the required concrete strength in terms of quality it is very necessary to aware and advises people to practice the new scientific technique “design mix” so that the optimum benefits could be utilized form the cement during construction. Printing manufacture date and labeling the cement bags according to its grade by the manufacturer needs to be enforced so that consumers can know about the quality of cement and time period of cement after manufacture. The trial mix design technique should be promoted so that the construction activity could become more economical without compromising the quality. Use of batching

plant should be promoted for achieving good control in the quality of concrete while mixing relative ingredients of concrete. Further study on other tests such as Lime Saturation Factor, Alumina Modulus, Sulphuric Anhydride, Total Loss on Ignition, Fineness, and Soundness should be conducted so that cement brands could be compared more effectively and Design mixes for other grades of concretes also should be evaluated.

## 7. REFERENCES:

[1] Elhasia, B. N. a. T., (2013). Approach to innovative supply chain strategies in cement industry; Analysis and Model, Elsevier Ltd.

[2] Mishra, A. K., Jha A. (2019). Quality Assessment of *Sarbottam* Cement of Nepal. *International Journal of Operations Management and Services*, 9(1), 1-22.

[3] Neville, A.M., 2011. Selection of Concrete Mix Proportions (Mix Design). In *Properties of Concrete*. Fifth Edition ed. England, England/London: Pearson Education Limited. Ch. 14. p.2356.

[4] Kiattikomol, K., Jaturapitakkul, C. & Tangpagasit, J., (2000). Effect of Insoluble Residue on Properties of Portland Cement. *Cement and Concrete Research*, 30(8), 1209-1214.

[5] Singh, V. K. & Marripoodi, K., 2016. *Happho*. [Online] Available at:http://www.happho.com/choose-building-materials-estimate-cost-quantities-house-construction/[Accessed 03 August 2020].

[6] Mishra, A. K., Chaudhary U. (2018). Cost Effectiveness Assessment of Different Nepalese Cement Brands for Selected Sites of Supermarket.*J Adv Res Const Urban Arch.* 3(3), 12-33 .

[7] Mishra, A. K., Sharestha, B. (2019). Assessment of Consumer Influencing Factor in Decision Making for Selecting Cement Brands. *South Asain Res J Bus Mgmt*, 1(3), 91-105.

[8] ASTM:C114-07, 2007. *Standard Test Methods for Chemical Analysis of Hydraulic Cement*. Seventh Edition ed. West Conshohocken, Pennsylvania, United States: American Section of the International Association for Testing Materials.

[9] Bureau of Indian Standards, (2002). *Determination of Compressive Strength of Hydraulic Cement other than Masonary Cement*. IS: 4031 (Part - 6) - 1988. New Delhi: Bureau of Indian Standards.

[10] Bureau of Indian Standards, (2002). *Plain and Reinforced Concrete - Code of Practice (4th Revision).* IS: 456 - 2000. New Delhi: Bureau of Indian Standards.

[11] Aldieb, M. A., & Ibrahim, H. G. (2010). Varation of Feed Chemical Composition and Its Effect on Clinker Formation - Simulation Process. *Proceedings of The World Congress on Engineering and Computer Science 2010*, 2.

[12] I.S:269:1989, 1993. *Ordinary Portland Cement, 33 - Grade Specification*. I.S:269:1989. New Dheli: Bureau Of Indian Standards Bureau Of Indian Standards.

[13] Raj, N. & Ilakkiya, D. (2014). M*asterbuilder.co.in*. [Online] Available at: https://www.masterbuilder.co.in/mix-design-m40-grade-concrete-per-102622009/

[14] I.S:516-1959, (2002). *Methods Of Tests For Strength Of Concrete*. New Delhi: Bureau of Indian Standards.

[15] Duggal, S.K., (2009). Materials for Making Concrete-I Cement. In S.K. Duggal, ed. *Building Materials*. Third Revised Edition ed. New Age International. Ch. 5. p.146.

**********