Assessment of Cement Consumption Pattern: A Case from Pokhara, Nepal

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ABSTRACT

Purpose: Cement is a major construction material used in civil engineering works due to which its demand is very high. The consumers and suppliers of the cement market may feel that every brand they are buying and selling is of good quality. The study has been focused to assess the consumption of different cement brands available in the Pokhara Metropolitan city.

Design/Methodology/Approach: cement suppliers' data and field data were collected. Cement suppliers within the study area were considered during the survey. The different brands of cement in use at the site were examined by field survey and analysis was conducted on SPSS software to obtain the results.

Findings/Result: Maximum cement suppliers prefer Shivam (18.18%) in OPC type and Brij cement (17.53%) in PPC type. A positive increasing trend of annual cement consumption was observed from 2070 BS to 2076 BS. Annual cement consumption of OPC and PPC were separately studied. Cement consumption data from mass concreting areas were collected. High rise buildings, Pokhara international airport, midhill highway section in the study area, siltation dams, and cement consumption in bridges near the study area were taken into consideration for the study. All RMC suppliers' cement consumption in study area was studied differently from the establishment period. Descriptive statistics was used to study the association between cement preference and the price of cement. Preference of suppliers of cement was not found to be associated with the price of cement. Preference for cement in RMC was not found to be associated with price of cement.

Originality/Value: It is action research to analyze cement consumption pattern

Paper Type: Ex-Post Facto Research

Keywords: Cement brands, SPSS, Survey, RMC, Statistics

1. INTRODUCTION :

Cement is a material having adhesive and cohesive properties enabling it to form a good bond with other materials. Calcium, silica, aluminum and iron are mixed in proportions for cement production. A high temperature kiln heats the raw materials, transforming them chemically into clinker. This grey, pebble-like material comprises the special compounds that give cement its binding properties. Clinker is then mixed with gypsum and ground to a fine powder to make cement. Concrete is the second most consumed substance in the world after water. In concrete, cement is the main constituent which is the only active binding media and the only component scientifically controlled. Cement gets the property of setting and hardening by virtue of chemical reactions with water at normal temperature (Mishra and

Chaudhary, 2018) [1]. Cement is most important material for construction and manufacturing. It is almost used in every construction.

Cement Industry Federation of Australia (CIFA) mentioned that construction of a typical family home requires around 14 tons of cement, and a kilometer of freeway contains as much as 2,500 tons of cement. Mix of cement, sand and aggregate may vary which enables concrete to be used in a wide range of applications. Any product can be designed, colored and shaped to accommodate a variety of environmental conditions, architectural requirements and to withstand a wide range of loads, stresses and impacts (Banstola et al., 2021) [2].

Fig. Error! No text of specified style in document.**:** Common Nepali Brands of Cements
Available in Market
(Source: http://ahakhabar.com/) [3]

2. OBJECTIVES :

The objectives of the study are to assess the cement consumption level of different brands in Pokhara Metropolitan city.

3. LITERATURE REVIEW:

3.1 Cement:

Cement is a material having adhesive and cohesive properties enabling it to form good bond with other materials. In concrete, cement is the main constituent which is the only active binding media and the only component scientifically controlled. Cement has got the property of setting and hardening by virtue of chemical reactions with water at normal temperature. Ordinary Portland Cement (OPC) is the most common type of cement in general use around the world because it is a basic ingredient of concrete and mortar. It is a fine powder produced by grinding Portland cement clinker (more than 90%), a limited amount of calcium sulfate (which controls the set time) and up to 5% minor constituents (as allowed by various standards). The OPC or the Ordinary Portland Cement is the most widely produced cement in Nepal. Also due to high consumption of cement, the production is also high which causes the increase in duration between manufacturing and use of the cement on construction work (Mishra & Chaudhary, 2018) [1]. Infrastructure being the major indicator of development and the R.C.C structurers being the most common, popular, easy and durable method of construction, demand of cement is increasing every year. Mostly, cement is used as a mortar in masonry, precast pipes and elements, pointing and plastering works and for different type of concreting the structural elements. It is manufactured through a closely controlled chemical combination of calcium, silicon, aluminum, iron and other ingredients in the required temperature. Chemical composition between the ingredients, their sufficiency and the temperature during its manufacturing process highly influences its consistency of strength development. Thus, the manufacturing process of different cements such as Ordinary Portland Cement (OPC), Pozzalana Portland Cement (PPC) and Portland Slag Cement (PSC) differs from each other as per their property related with their strengths. Based on the property of cement, they are used for different

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purpose in different places considering the climatic factors that affects the quality of cement (Mishra and Jha, 2019) [4].

3.2 History of Cements Use in Nepal:

The use of cement in Nepal as binding material came into effect from beginning of early 1950. As there was not indigenous manufacturing industry existing, early users of cement were dependent on import in commercial scale in early 1970 from China, Scotland, North Korea, Myanmar, Indonesia, Thailand, Japan and other country (Baral and Thapa, 2014) [5]. After 2015, government restricted different grading of cement and mostly used cement nowadays is OPC and PPC of 33 grades.

3.3 Global Demand of Cement:

In 2019, the global cement industry was expected to post a demand growth of more than 3%, in line with the previous year. This growth was almost entirely driven by a surge in Chinese consumption. Outside of China, slowing growth in most regions was mainly offset by a sharp decline in Middle East demand. In 2020, the trend indicated a more balanced growth across regions – moderate growth in Western Europe, North America and China with a recovery in Asia, Africa and Latin America. India is expected to post the fastest growth in cement demand of any major national market, advancing 8.0% per year. Many other developing countries in the Asia/Pacific region will post similarly strong growth, including Vietnam, Indonesia, and Pakistan. The pace of gains in China will slow considerably from that of recent years, and growth in cement demand will actually trail the global average. Countries such as Spain, Italy, and Ukraine will all achieve significantly improved performances relative to contractions that occurred between 2004 and 2014 (Mishra et. al., 2020 [6]; Mishra and Sharestha, 2020 [7]; Mishra et al.,2020 [8]).

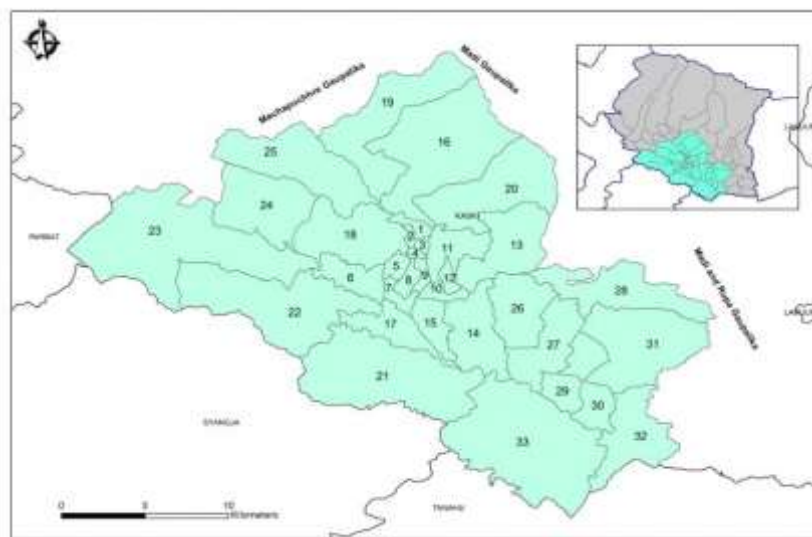**4. RESEARCH METHODOLOGY :**

4.1 Selection of Study Area:

Fig. 2: Study Area: Pokhara Metropolitan City Including Wards
(Source: http://pokharamun.gov.np [9])

Pokhara Metropolitan City is the headquarter of Gandaki Province of Nepal. It is one of the most popular tourist city in Nepal. It lies at latitude of 28°13' N and longitude of 83°57' E with altitude of 872m above the sea level. It is located at 200 Km west of Kathmandu (Banstola et al., 2021) [2]. As Pokhara is the largest metropolitan city of our country, there have been many constructions such as airport, hospitals, hydropower, cable car as well as star hotels. The much-awaited international airport is under construction. From the religious point of view stupas, temples, mosques are also under construction. Population growth is causing increase in construction of engineering structures like buildings, roads etc. Though construction works are being carried out

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in the study area, it was observed that stakeholders and public are unaware of effect of concrete use to environment.

4.2 Design and Data Collection:
The research is ex-post facto research-based field performance as documentary study. For the conduction of the market survey the hardware's that are registered in 'Pokhara Hardware Association' were taken in account. There are total 204 hardware's are registered. Out of 204 there are 148 hardware's from the study area. Participants of the study cover the responsible cement supplier in the study area with total number of 148(N). Questionnaire was tried to distribute to the maximum number as per formula sample size of 53. The sample size calculated using coherent formula:

$n = "z^2pqN"/"e^2(N - 1) + Z^2pq"$

Where *n* is the sample size, z=1.645 for 90% confidence level,

P represents percent of picking choice expressed decimal (0.5)

q represents percent of picking choice expressed decimal (0.5)

e=0.08, and N represents whole sample size

Chi square test uses the following formula

$\chi^2 = \sum (O- E)^2 / E$

Where,

O = Observed value

E = Expected Value

The Fisher Exact test uses the following formula:

$P = ((a+b)!(c+d)!(a+c)!(b+d)!)/a!b!c!d!N!)$

'a,' 'b,' 'c' and 'd' are the individual frequencies and 'N' is the total frequency.

The Fisher Exact test uses this formula to obtain the probability of the combination of the frequencies that are actually obtained. It also involves the finding of the probability of every possible combination which indicates more evidence of association. There are certain assumptions on which the Fisher Exact test is based. It is assumed that the sample that has been drawn from the population is done by the process of random sampling. This assumption is also assumed in general in all the significance tests.

4.3 Cement Consumption Analysis in SPSS:
The classified data was presented by using the suitable diagram like histogram, pie chart, trend chart etc. The data collected was qualitative and quantitative in nature or the combination of both. For the analysis of the quantitative data, various statistical tools (SPSS) were used in order to get the useful results. The statistics was used only for the quantitative data.

4.4 Validity and Reliability:
The presence of researcher at working site and documents verification gives validity of research and comparison with literature provides reliability.

5. RESULTS AND DISCUSSION :

5.1 Annual Cement Consumption:
The annual cement consumption data from 2063 to 2069 B.S. was taken from the literature and annual consumption data from 2070 to 2076 BS was collected as primary data sources from direct field survey in the study area. During data collection, consumption of different brands of cement within study period was taken. Data obtained from field survey were entered in SPSS software and checked for errors if possible. Yearly cement consumption was calculated from market survey data where questionnaire have been attached in Annex. Cement consumption from 2063 to 2069 B.S. (2006 AD to 2012 A.D.) was taken from studied done previously and from 2070 to 2077 data were collected. Collected data were analyzed in SPSS software which output is shown in (Table 1).
Table 1: Annual Cement Consumption

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Fiscal Year (B.S.)	Cement Consumption (Ton)
2063/64	44,845.00
2064/65	50,152.00
2065/66	56,815.00
2066/67	70,775.00
2067/68	85,992.50
2068/69	96,175.00
2069/70	94,148.20
2070/71	92,121.40
2071/72	104,115.60
2072/73	116,125.00
2073/74	133762.45
2074/75	169049.75
2075/76	173125.32
2076/77	187347.05

The graphical representation of cement consumption is shown in bar diagram of (Figure 3). Figure 3 shows that there was linear increase of cement consumption.
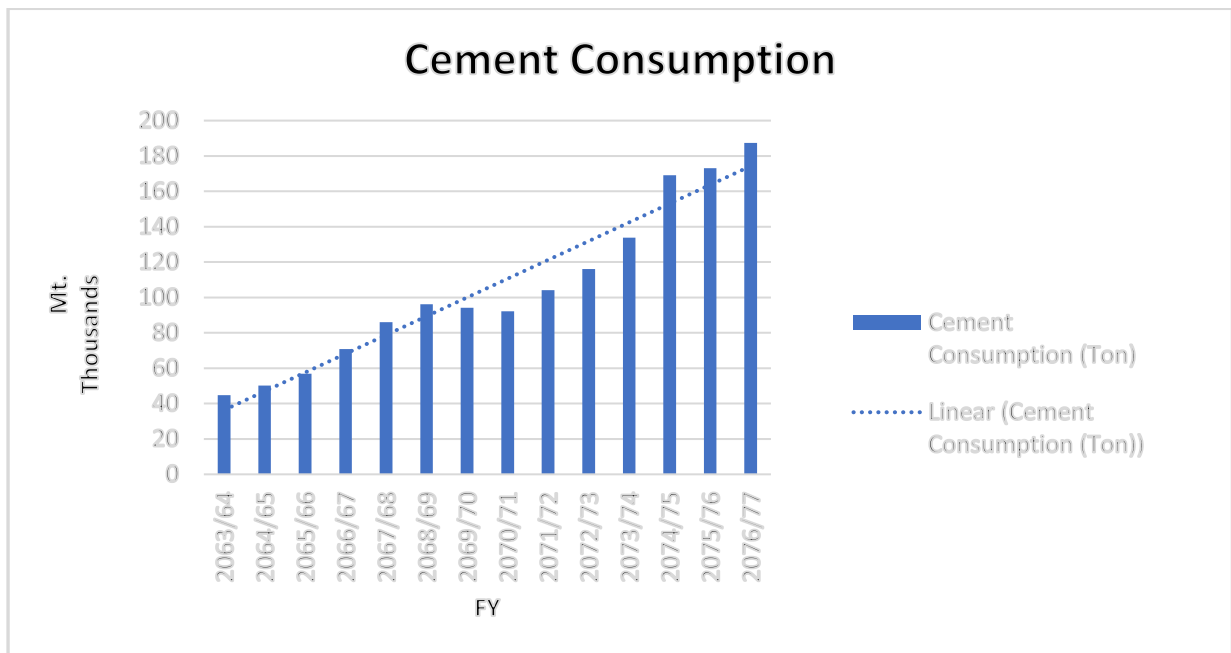

Fig. 3: Cement Consumption (Ton) Graphical Representation

5.2 OPC and PPC Cement Consumption Table:

OPC cement consumption and PPC cement consumption were analyzed differently for obtaining precise result including maximum sector (road, dams, airport etc.) as far as possible. Cement consumed in every fiscal year is presented below in (Figure 4).
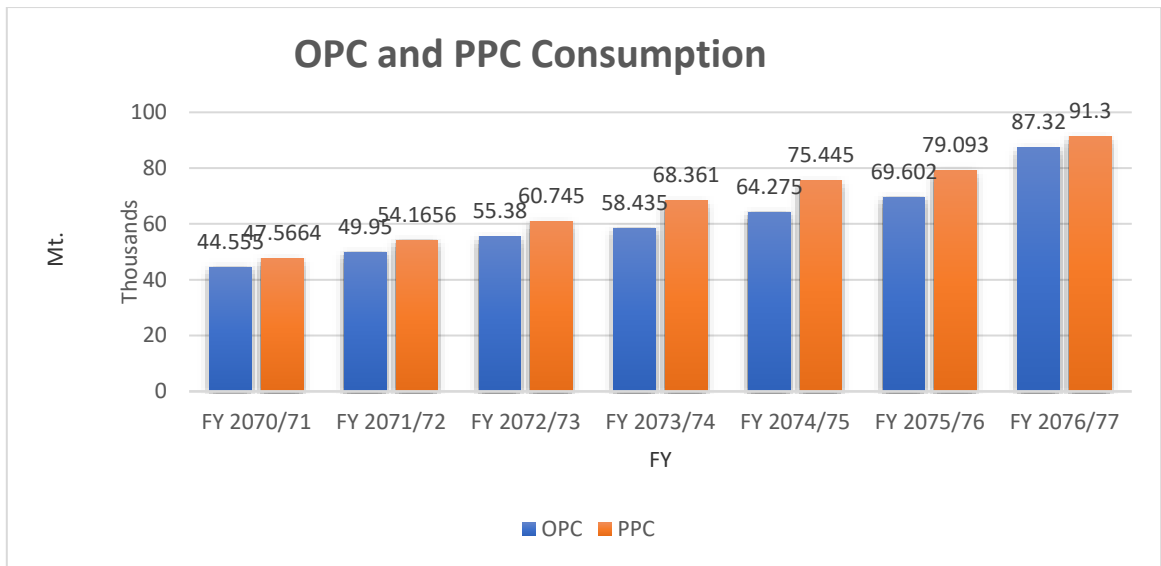
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Fig. 4: Annual OPC and PPC consumption (Ton)

Annual OPC and PPC consumption (%) in the study area is shown in (Figure 5). As a whole there was high percentage of PPC consumption than OPC consumption.
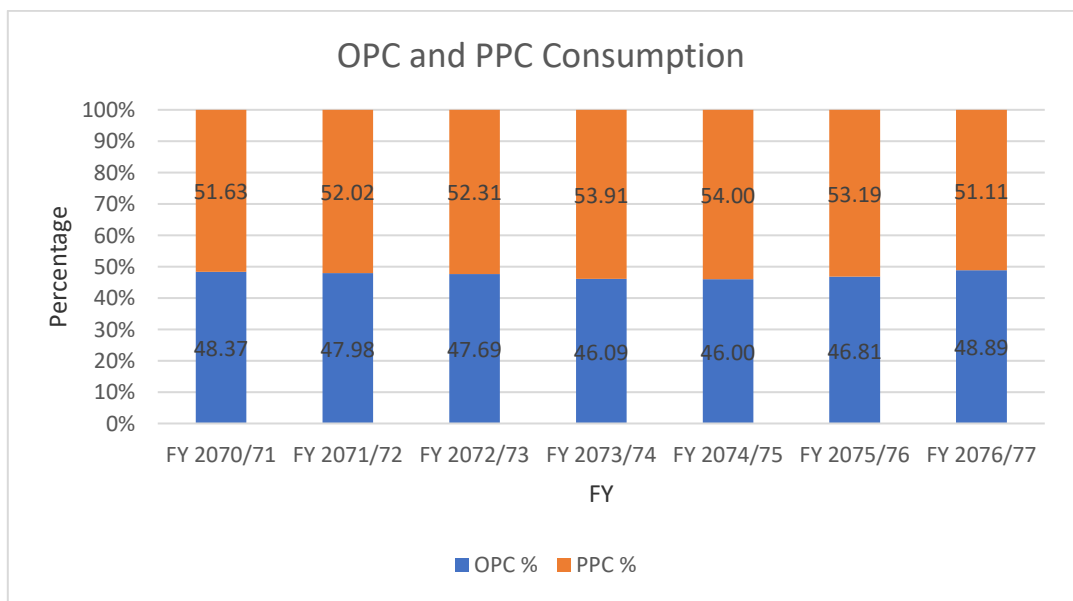

Fig. 5 : Annual OPC and PPC consumption (%)

5.3 RMC Cement Consumption:

RMC suppliers are supplying Ready Mix Concrete in various concrete ratios as per demand. RMC company are supplying Ready Mix in household construction, bridge construction, road construction etc. People prefer RMC due to easiness, no dirt around sites, less number labours for casting, etc. People also feel RMC is expensive than normal casting of concrete. RMC suppliers of study were visited which are listed below.

1   Hemja RMC
2   Sapta Gandaki RMC
3   Pokhara RMC
4   7 lake RMC
5   Fewa RMC
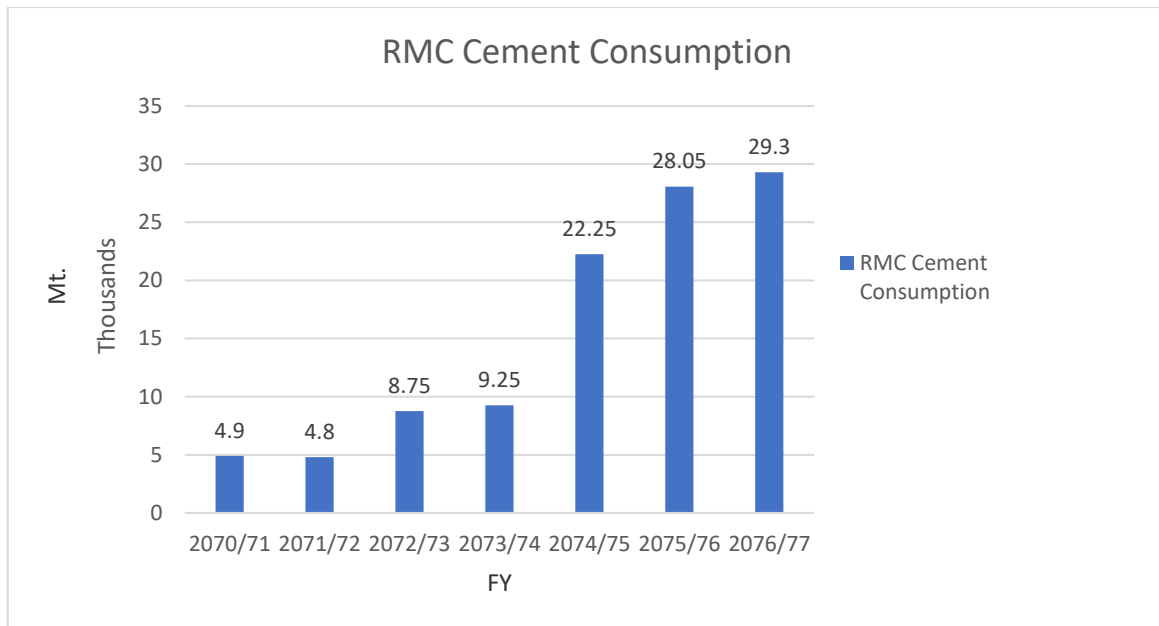
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Fig. 6: RMC Cement Consumption (Ton)

5.4 RMC Cement Preference:

Among five RMC, Four RMC company choose Shivam and only one RMC chose Agrakachi OPC for their operation. Cement used in RMC are directly brought from cement factory. Loose cement is brought in trucks.

5.5 Cement Consumption in High Rise Buildings:

Pokhara is center for Gandaki province. Many developmental works are going on the city like building of high-rise apartments, villas etc. Comfort Goodwill Developers Pvt. Ltd. which is building twelve store with around one lakhs thirty six Sq.ft floor area in Tersapatti, Pokhara. Cement used are directly brought from cement factory. Shivam and Sgarmatha (OPC/PPC) cement is being used with following quantity in Metric ton as shown in (Figure 7).
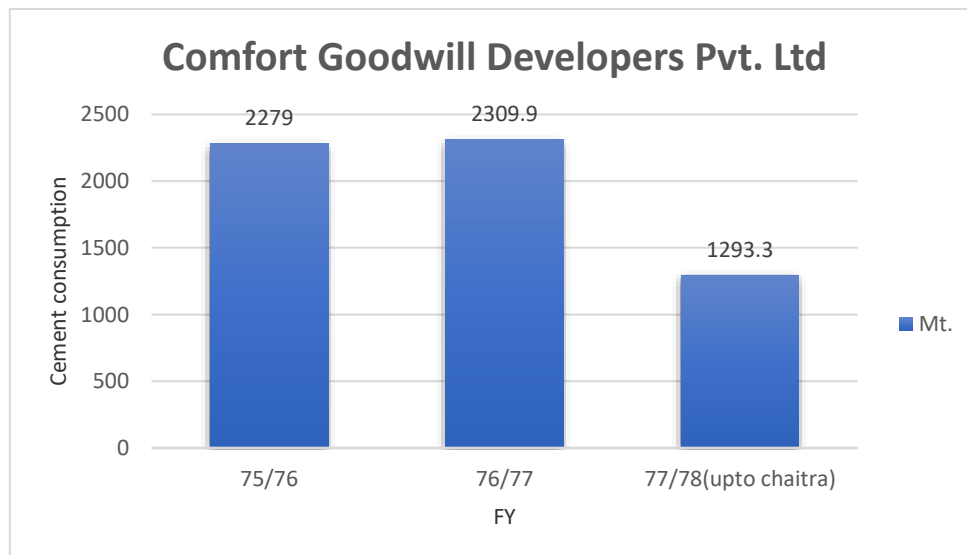

Fig. 7 : Cement Consumption (Ton) in Comfort Goodwill Developers Pvt. Ltd.

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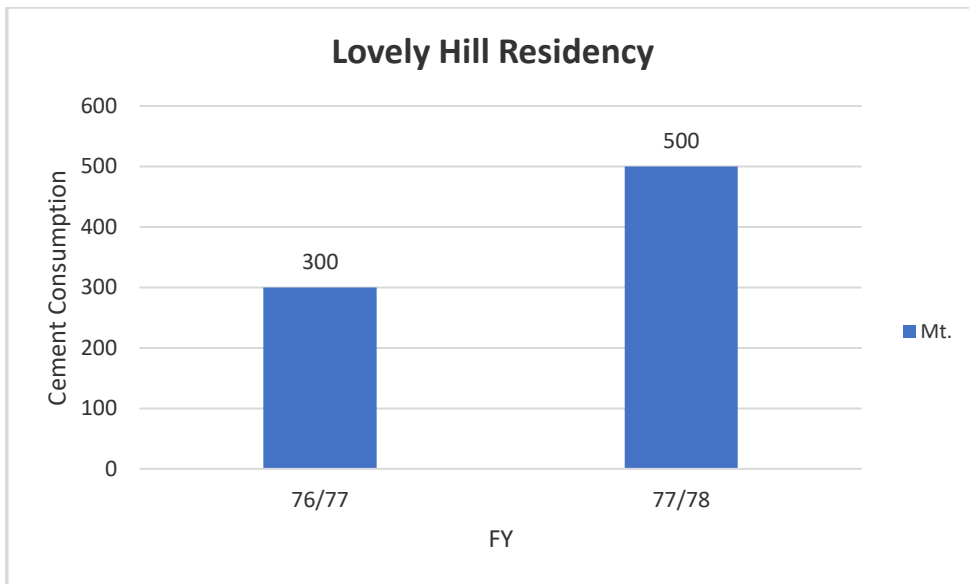
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Fig. 8: Cement Consumption (Ton) in Lovely Hill Residency

Lovely Hill Residency is located in Lovely hill, Pokhara-18. Riddisiddi (OPC/PPC) cement is used in construction. Total floor area is around One lakh twenty-five thousand Sq.ft. Cement consumed in the construction is shown in (Figure 8).

5.6 Cement Consumption in Pokhara International Airport:

In Pokhara International Airport, Dalmia (OPC) cement has been used in important structural construction. Dalmia cement is of Indian brand cement which is directly brought from factory to airport. Hongshi PPC cement has been used in PPC type.
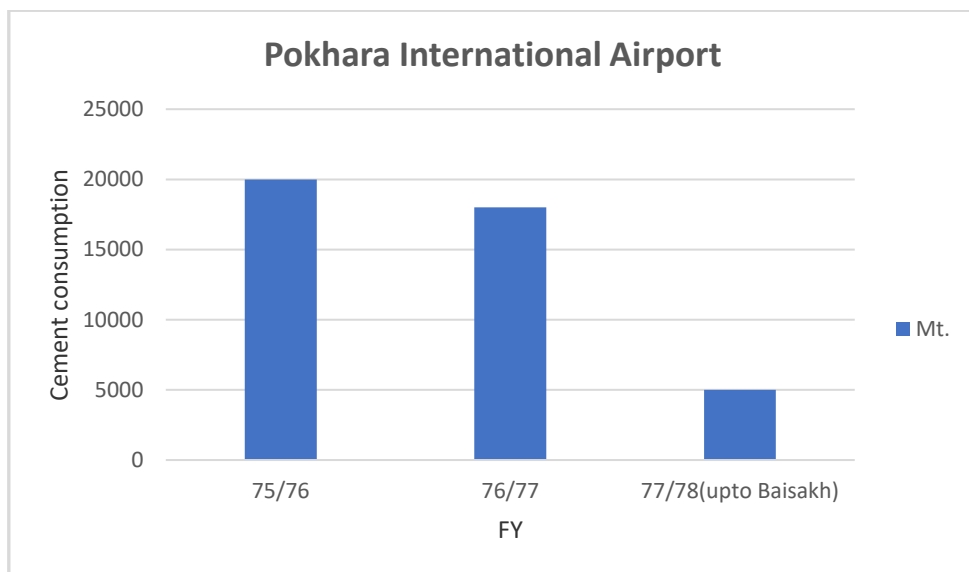

Fig. 9: Cement Consumption (Ton) in Pokhara International Airport

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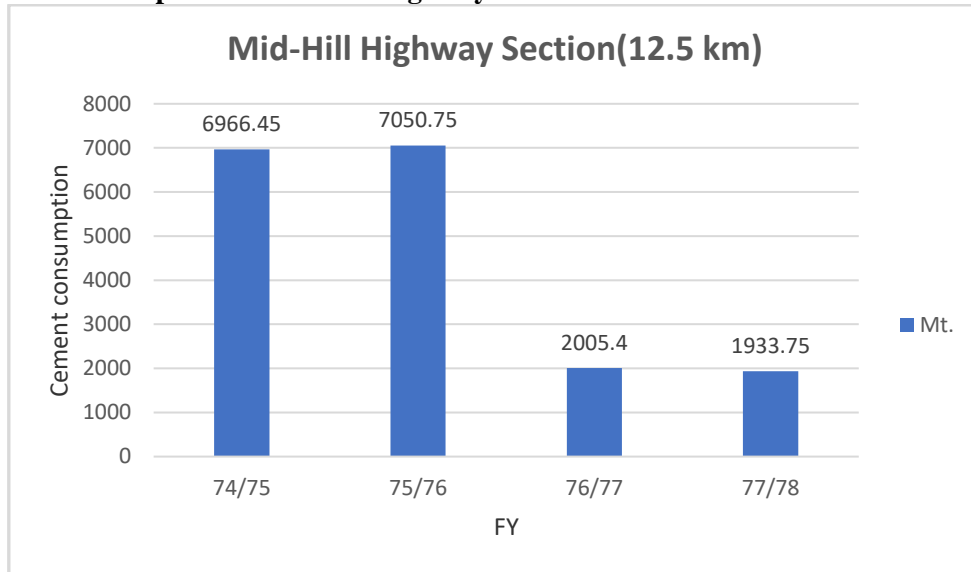**5.7 Cement Consumption in Mid-Hill Highway Section:**

Fig. 10: Cement Consumption (Ton) in Mid-Hill Highway Section

Mid hillway section of 12.50 KM is taken into consideration for assessing cement consumption data. In road construction, cement is mainly used in constructing retaining structures, dividers, drainage, etc. Shivam cement and Ultra tech (OPC/PPC) is used in this Mid hill highway section. Overall annual cement consumption is shown in (Figure 10).
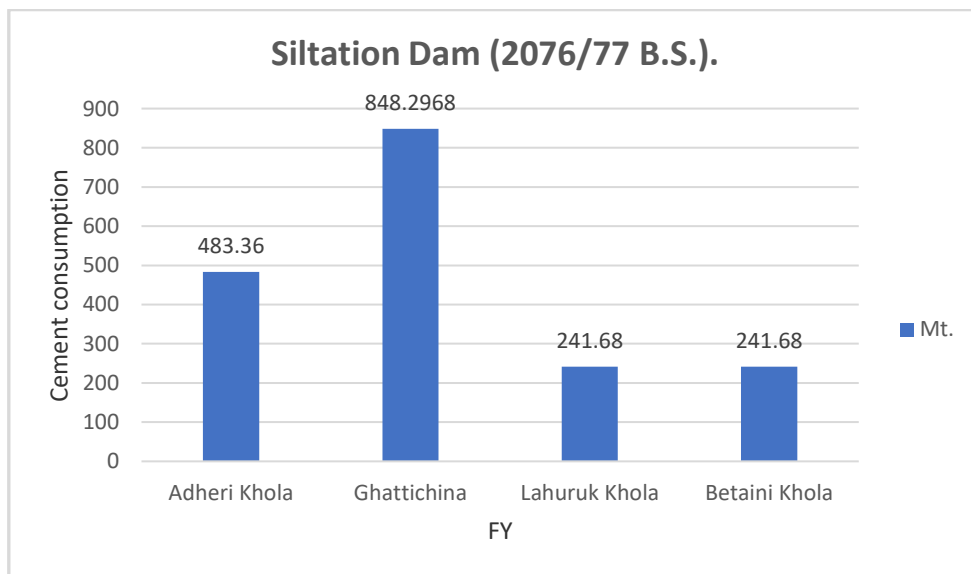
5.8 Cement Consumption in Siltation Dam:

Fig. 11: Cement Consumption (Ton) in Siltation Dam

Siltation dam was constructed in 2076/77 B.S. Dam is constructed in Adheri Khola, Ghattichina, Lahuruk Khola and Betaini Khola. During this construction Sona OPC cement was used. Cement was mainly used for random rubble masonry. Overall cement consumption is shown in (Figure 12).

For assessing cement consumption in construction of bridges, bridges around the study area are taken into consideration. Data collection was done from Gandaki provincial government office within the study period.

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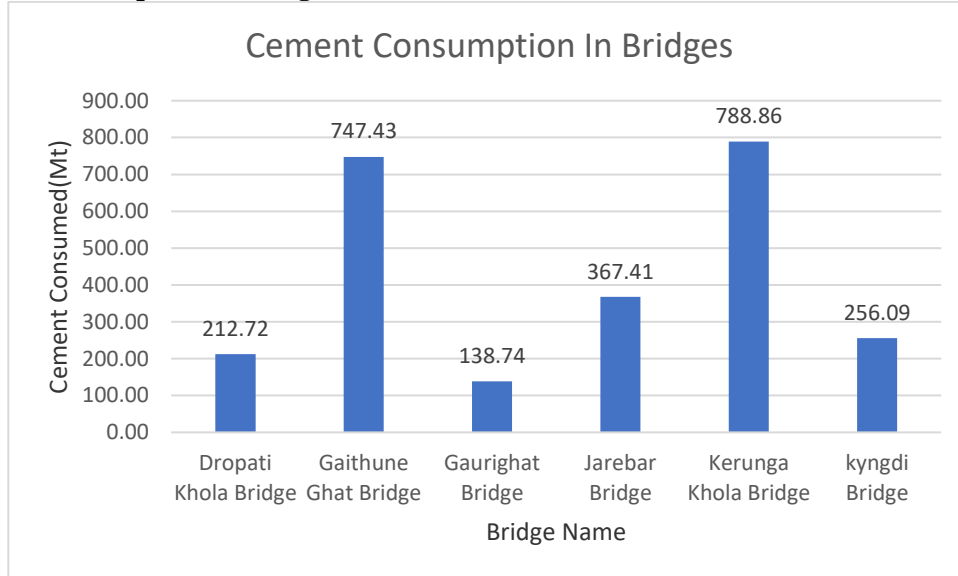
5.9 Cement Consumption in Bridges:

Fig. 12: Cement Consumption (Ton) in Bridges

5.10. Association between Preference of Supplier and Price of Cement:

Average price of cement was NRs 747. Among all players 45% was below average price and remaining was above average price. 9.899 values represent the difference between the actual data and data expected if there is no difference. Degree of freedom (r-1)*(c-1) is found to be 11. A two-sided alternative hypothesis was used as sample mean can be higher or lower than a given value. Table 3 shows that preference of supplier was not found to be associated with price of cement.

Table 3: Association between Preference of supplier and Price of Cement

Variables	Preference of supplier	Test of significance	p-value
Price of cement ≤747 >747	9 (45%) 11 (55%)	$X^2_{11} = 9.899$	0.539

*p value significant at >0.05

5.11 Association between Preference of RMC and Price of Cement:

Average price of cement was NRs 801. Between 2 players, one was below average price and remaining was above average price. Fisher's Exact Test is used instead of Chi-Square test because 4 cells (100.0%) have expected count less than 5. Table 2 shows that preference of RMC was not found to be associated with price of cement.

Table 2: Association between Preference of RMC and Price of Cement

Variables	Preference of RMC	Fisher's Exact Test
Price of cement ≤801 >801	20% 80%	p-value = 1

*p value significant at >0.05

6. CONCLUSION:

Quantity of annually consumed cement used in Pokhara valley was in increasing order and various parameters affect the cement consumption. Construction trend of pokhara valley was increasing abruptly. Market trend of various cements are obtained. Top players of cement market as per consumption were obtained. Field survey shows that Shivam cement is highly preferred in RMC of pokhara. Annual cement consumption data is obtained from 2070 BS to 2077 BS. Cement consumption

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in different sectors like household, bridges, dams, roads etc. showed increasing trend in cement consumption.

Preference of suppliers of cement was not found to be associated with price of cement. Preference of cement in RMC was not found to be associated with price of cement. It is recommended that date of manufacture of cement should be properly checked before buying of cement. Quality check of cement in lab and field is necessary before use in any construction of structures. Though big projects focus on quality assurance of construction materials, during construction public are paying less attention about cement quality and its test. Public people are mainly influenced by contractors and hardware while purchasing cement and blindly relying on them. Government bodies should also be aware and focus on less use of concrete in the growing city like pokhara.

7. ACKNOWLEDGEMENT :

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