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Research Article

The Physical Property Values and Suitability of Coarse Aggregates from Various Sources Used in Selected Building Construction Projects in the Kathmandu Valley

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I N F O

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A B S T R A C T

To examine the values of physical properties and suggest suitability of Coarse Aggregates from different Sources used in Selected Building Construction Projects within Kathmandu Valley. Construction of Journalism and Mass Communication Administrative Building, Construction of Central Department of Management Academic Building, Construction of Office of Registrar Building of Tribhuvan University along with Paropakar Woman and Fertility Hospital Service Extension and Research Building have been considered for study. Gradation/Sieve Analysis, Crushing Test, Abrasion Test, Impact Test on Aggregates, Shape Test Specific Gravity and Water Absorption Test and Soundness Test were done at lab. The data collected from both primary and secondary sources were summarized, classified, tabulated, categorized. For the quantitative data like various tests of coarse aggregates from different sources were tabulated, processed and a comparison was made between different physical parameters and values to standard guidelines of IS, DUDBC, NS and NS. The gradation analysis of coarse aggregates from both source lies within the limit values but the coefficient of uniformity were beyond the limit and coarse aggregates from both sources were found to be poorly graded. The LAAV parameter has no significance role in building construction related issues. The Strength, Specific Gravity, Soundness, ACV, AIV for coarse aggregates from source 2 resembles better physical properties than coarse aggregates from source 1. But, the textural parameters like FI and EI of coarse aggregates from source 1 resembles better properties than source 1but does not lie within permissible limits. This was mainly because of using cone and impact crusher for source-1 and only cone and impact crusher 2.

Keywords: Causes, Road, Construction, Projects, Disputes, Laws, Contract, Impact, Time, Cost

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Introduction

The demand for coarse aggregate is increasing rapidly in Kathmandu Valley for the construction of building-related structures. Building construction activities consume a large amount of coarse aggregate. To increase the performance of a structure, the quality of coarse aggregate should be suitable to withstand the design; load effectively and efficiently. Aggregates from different quarry/ aggregate production plants should meet the physical requirement prescribed by Indian Standard (IS), the Department of Urban Development and Building Construction (DUDBC), the National Building Code (NBC), the Nepal Standard (NS-297). Really, it is a challenge to meet the demands at material levels (Khadka, S, Mishra AK, & Aryal B 2021. Adhikari N, Mishra AK, & Aithal PS, 2022. Mishra AK, & Bishal Sharestha, 2019. Mishra 2019) and and product levels (AK Mishra, JS, Sudarsan & S. Nithi Yanantham 2022. Sapkota LP, Mishra AK, 2021. Mishra AK, Jha A, 2019. Mishra AK. 2019 Mishra AK, Thing R. 2019).

Numerous studies have examined the physical properties of aggregates from various quarries and aggregate production sites. In contrast, the perceptions of local people, the effects of aggregate production sites, suggestions for improving the existing conditions of coarse aggregate production have not previously been studied. To fill the gap of study, this research has been conducted.

Objectives

To examine the values of physical properties and suggest suitability of Coarse Aggregates from different Sources used in Selected Building Construction Projects within Kathmandu Valley.

Literature Review

Many studies highlighted the properties in Context of Nepal such as Rabindra Kumar Yadav & Aithal PS, 2020. Mishra AK, Dinesh Gupta, & Aithal PS, 2020: Aryal R, Mishra AK. 2020 and many.

Soundness

The ability of aggregate to resist changes in volume as a result of changes in physical conditions is soundness. Porous and weak aggregates undergo excessive volume changes under these conditions.

Characteristics Requirements for Good Quality Coarse Aggregate

The aggregates which are used in building construction must possess and fulfill the following requirement. The quality of concrete used for concrete making affect the grade of concrete.

- Aggregate must be strong and hard enough to resist the crushing action
- They should not present organic materials, clay and dust which could affect the bonding strength of concrete
- The aggregates used for concrete must be durable
- Coarse aggregates for concrete should be chemically inactive
- They should not contain excessive amount of angular, sharp and hard particles
- The aggregates shape should be ideally spherical or cubical
- Aggregate should not have water absorption more than 5% of their actual weight
- Aggregate used for construction must be free from any disintegrated pieces, alkalis, vegetable matters

Quality of Aggregate in major Nepalese Projects

The recent observation from Sunkoshi Marine Diversion Multipurpose Project, Sinduli, which is also a national pride project, diverting the certain amount of flow from Sunkoshi river through 13.2 km long tunnel into the Marine river with aim of producing electricity of 28.62MW as well as irrigating 12200 hectares of land of 5 neighboring district of Sinduli.

Figure 1.Crusher Plant, SMDMP, Sinduli
(Source: Shrestha, 2022)

Figure 2.Aggregate produced by crusher plant, SMDMP, Sinduli
(Source: Shrestha, 2022)

Table 1.Different Parameter and Values of Coarse Aggregates used in SMDMP, Sinduli

S.No.	Particulars	Values
1	Fineness Modulus	3.1
2	Silt & Clay content	1.15

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3	Specific Gravity	2.68
4	Water Absorption	1.06
5	Elongation Index	4.5
6	Flakiness Index	7.0
7	Aggregate Crushing Value (ACV)	19
8	Ten percent fine value (TFV)	238 KN

The precast slab of tunnel lining has average strength of 53.41 MPa in 7 days and 62.55 MPa in 28 days of having average strength of M50/20 minimum of admixture less than 0.5%. This is because of coarse aggregate which varies with the sources which have such properties to gain mentioned strength (Shrestha, 2022).

Quality of aggregates depends upon type of crusher plant also. Different types of crusher plant have different crushing mechanism through which raw material is passed to form finished product of aggregate which are used in various construction purposes.

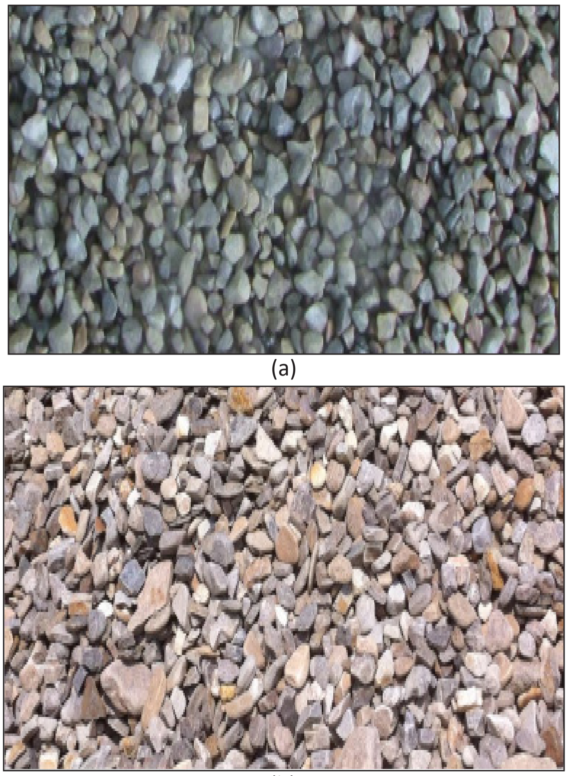
The types of plants used in different projects in Nepal are:

1. **Jaw Crusher:** They are used for primary crushing of rocks to break up larger, harder materials into more manageable pieces. They also produce minimal fine materials and dust, though the finished product with this type of rock crusher almost always requires secondary crushing.
2. **Cone Crusher:** They can accept medium-hard to very hard and abrasive rocks which might be dry or wet and crush the elongated and flaky aggregates.
3. **Impact Crusher:** They are best used with less abrasive rock types. These types of machine break apart material by the impacting forces of certain wear parts. This crusher further shapes the crushed material into a finer consistency with a more cubical nature.

Table 2.Comparison of Crusher Plant & Produced Aggregates in the Major Projects of Nepal

Item	Headworks, SIP, Banke	Headworks, RJKIP, Kailali	Tunnel works, BBDMP, Surkhet
Production	Natural and crushed together (180,000 m^3)	Natural and crushed together (52,000 m^3)	Natural and crushed together (80,000 m^3)
Type	Jaw Crusher only	Jaw Crusher only	Jaw, Cone & Impact Crusher
Sizes	0-5, 5-20, 20-40	0-5, 5-20, 20-40	0-5, 5-20, 10-20
Quality	Flaky & Elongated	Flaky & Elongated	Very less Flaky & Elongated
ACV	Normal ACV		No change in ACV

Figure 3.Crushing and Screening plant, BBDMP, Surkhet



(a)

(b)

Figure 4.Aggregates Produced from Jaw Crusher only (a); Aggregates Produced from Jaw, Cone and Impact Crusher (b), BBDMP

(Source: Shrestha, 2020)

From Table 2.2, aggregates produced from Jaw, Cone and Impact crusher were very less flaky and elongated and have no variation in Aggregate Crushing Value (ACV).

The operation of combined Jaw, Cone and Impact crusher

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as Figure 2.5 in BBDMP helps to crush any category of rocks into desirable sizes of aggregates within short period of time. Since, the project is bounded by time frame, so saving of time is to save resources like minute, manpower, money and machine. The use of Jaw, Cone and Impact crusher in BBDMP reduce operational cost and maintain economy in overall project. In one hand, it helps to maintain quality and provide structural stability of the constructed structure, and in other hand, it has advantages of reducing the use of admixtures, micro-silica in concrete to improve or increase the strength of concrete (Shrestha, 2020).

Gradation of Coarse Aggregates

Coarse aggregate used in concrete making contain various sizes of aggregates. Gradation is termed as particle size distribution of the coarse aggregates. For determining the particle size distribution, sieve analysis is conducted. Grading is determined by sieving a sample successively through the series of sieves mounted one over the other in order of sieve size with larger sieve at top. The fraction of aggregate coarser than sieve retained after shaking are weighed and parameters like coefficient of curvature are calculated.

Proper gradation of coarse aggregates is one of the most important factors in producing workable concrete. Only the proper gradation ensures that a sample of aggregates contains all standard fractions of aggregate in required proportion such that the sample contains minimum voids. A sample of well graded aggregate containing minimum voids will require minimum paste to fill the voids in the aggregates, which means the reduction of use of quantity of cement and less quantity of water, leading to increased economy, higher strength, lower shrinkage and greater durability.

Depending upon the aggregate gradation, there are three categories, they are:

1. **Well Graded:** In a well-graded category of aggregate, the gradation of particle size that fairly evenly spans the size from the finest to the coarsest. If the concrete is cut into a slice core, a well-graded aggregate concrete shows a packed field of many different particle sizes which is characterized by the S-shaped in gradation curve.
2. **Poor Graded:** In a poor-graded category of aggregate, the curve is characterized by small variation in size. It contains the aggregate of particle almost of same size. In other words, the particles are packed together, leaving relatively large voids in the concrete. It is characterized by steep curve and also called 'uniform-graded'.
3. **Gap Graded:** In this category, the aggregate particles in some intermediate size particles are missing. If we cut the concrete core into slice, it shows large aggregate pieces embedded in a small sized aggregate. It is characterized by a gradation curve with a hump in between.

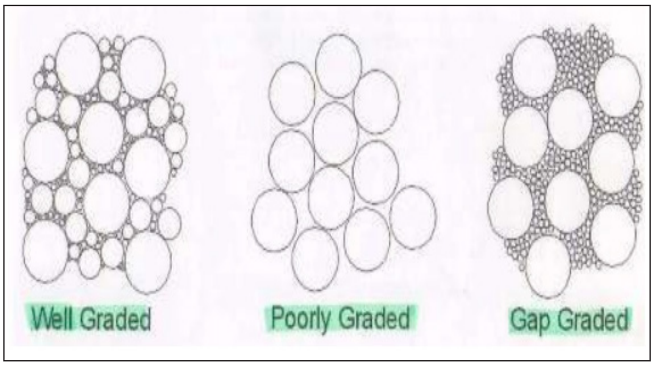

Figure 5.Types of Gradation
(Source: Chirag et al., 2016)

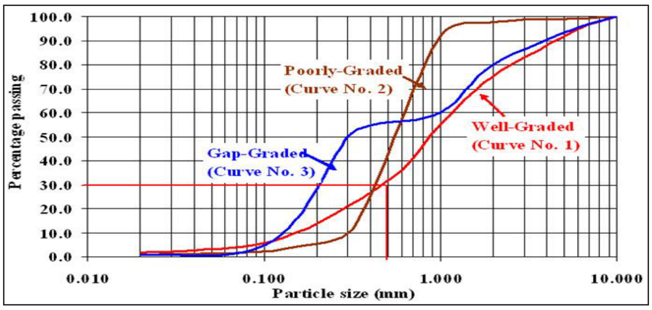

Figure 6.Gradation Curve of Aggregates
(Source: Chirag et al., 2016)

The data collected from both primary and secondary sources were summarized, classified, tabulated, categorized. For the quantitative data like various tests of coarse aggregates from different sources were tabulated, processed and a comparison was made between different physical parameters and values to standard guidelines of IS, DUDBC, NS and NS.

The SSRBW specification is used only for road and bridge works and only used here within for comparison purpose only. Computer software such as MS office tools, MS excels were used for tabulation and comparison. Further, the test results were interpreted and presented in tables, charts, graphs. For the qualitative data, the perception/opinion of contractors, local people residing near the sources was obtained through questionnaire and tabulated in the format. Computer software such as MS office tools, MS excels were used for tabulation and comparison. Further, the test results were interpreted and presented in tables, charts, graphs.

Results and Discussion

Different Physical Properties and Suitability of Coarse Aggregates

The physical properties of coarse aggregates from two sources were determined through different laboratory procedures. For the lab test of two different sources, an adequate amount of coarse aggregate was sampled in three cement bag sacks each of about 50 kg from each source as per sampling procedure described by IS:2430-1986.

The detailed values of different physical properties were discussed below.

Suitability of Coarse Aggregates

The composition of ingredients of coarse aggregate are main factor for determining strength of concrete. Also, the particle shape of the aggregate contributes to the effectiveness of producing a high-performance concrete. Also, crushed rocks, angular in shape creates a much better bond between the paste and the aggregate than a gravel does.

The modulus of elasticity will affect the workability of concrete. A lightweight aggregate will have a lower modulus than the mortar paste. Conversely, a strong aggregate produces a concrete that is stronger than the mortar paste . According to the test result, concrete containing a higher percentage of coarse aggregate results in higher elastic modulus. This is due to the aggregate begin stronger than the mortar . During it several references were take such as S., G. K., Mulu, Z., and S., D., 2018: Shrestha, S., and Tamrakar, N. K., 2013: Alam, M. S., and Ahmed, S. I., 2020: Asseta, G., and Gebregziableer, A., 2020.

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Table 3.Physical Properties Limit Values

Aggregate	Specific Gravity	Unit Weight (KN/m3)	Bulk Density (KN/m3)	Example
Normal Weight	2.5-2.7	23-26	15.2-16.8	Sand
Heavy Weight	2.8-2.9	25-29	>20.8	Scrap iron
Light Weight		12	<11.2	Dolomite

(Source: Mahajan, B., 2022)

Table 4.Maximum Size of Aggregates for Different Structures

Types of Structures	Max. Size of Aggregate
Mass concrete works i.e. Dams, retaining walls, piers and abutments etc.	40 mm
R.C.C work i.e. beams, columns, etc.	20 mm
Flooring	10 mm

(Source: Mahajan, B., 2022)

Sampling of coarse aggregates

We cannot test for whole material used in the field. Small amount of quantity should be taken from whole aggregate which should represent whole material. So, there should need special attention during sampling of aggregate. Sampling in wrong way may affects on reality. There should be three number of samples collection from each one third mid zone from minimum 30cm inside the surface (Bakrania S. 2015: Bhople A, 2020).

(a)

(b)

Figure 7.Sampling Technique; (a)Sikta Irrigation Project, Banke (b) Rani Jamara Kulariya Irrigation Project, Kailali
(Source: Shrestha, 2020)

1. Crushing test
2. Abrasion test
3. Impact test
4. Soundness test

5. Shape test
6. Specific Gravity and Water absorption test

List of Tests on Coarse Aggregates Based on Indian Standard (IS)

According to the Indian Standard, following are the guidelines for testing of aggregate:

Table 5.Test on Aggregates based on Indian Standard

S.No.		Code Reference	Descriptions
1		IS:383-1970	Specification for coarse and fine aggregates from natural sources for concrete (second revision)
2 IS:2386			Methods of test for aggregates for concrete
2	a	IS:2386 (Part I)	Particle size and shape
2	b	IS:2386 (Part II)	Estimation of deleterious materials and organic impurities
2	c	IS:2386 (Part III)	Specific gravity, density, voids, absorption and bulking
2	d	IS:2386 (Part IV)	Mechanical properties
2	e	IS:2386 (Part V)	Soundness
2	f	IS:2386 (Part VI)	Measuring mortar making properties of fine aggregate
2	g	IS:2386 (Part VII)	Alkali aggregate reactivity
2	h	IS:2386 (Part VIII)	Petrographic examination
3		IS:2430-1969	Methods of sampling of aggregates for concrete

List of Codes on Coarse Aggregates Based on

Table 2.Aggregates Specification Code

S.No.	Code reference	Descriptions
1.	NBC 101:1994	Aggregates (Derived from IS:383-1970)
2.	NS:297-1994	Aggregates, Stone Specification Table
3.	DUDBC	Specification of Building Construction Works
4.	SSRBW	Standard Specifications for Road and Bridge Works 2021

The abstracts of NBC 101:1994; NS:297-1994; DUDBC; SSRBW follows Indian Standard (IS:383-1973). The standard tests on aggregates should be based on the procedure and guidelines which are derived from IS 2386.

Impact of Aggregates Production

The study conducted by Asseta and Gebregziableer (2020) in Ethiopia about environmental impact reveals that there was negative impact on land stability, vehicular emissions, deteriorating air quality. The fugitive dust from blasting, noises from vehicular movements, degrades the natural resources, landscapes and biodiversity. This situation created the unsound environment for local people to live in such environment.

The study of riverbed extraction in Tinau river, Rupandehi, Nepal shows that riverbed extraction lowered the water table creating disturbance in the aquatic habitat of wetlands, change in river morphology and loss of aquatic life. Some other common factors for riverbed extraction for aggregates were bank erosion, slope instabilities, river incision, head cutting and damage to the river equilibrium. It also affects the livelihood of fisherman residing near the river. The extraction of riverbed materials benefits the industrialists but it raises the external cost for the general people. More resources should be channelized to save the environment and repair the damaged infrastructures causes by extraction activities (Dahal et al., 2012).

A study from Kotre quarry site, Tanahun district, Nepal and found that there is no dust control system installed in aggregate production crusher plant. Depending upon the specifications of final products of coarse aggregate, the processed material may be washed to remove dust. Aggregates extraction and processing cause environmental impacts including changes to the landscape, noise, dust, vibrations from blasting, vehicular movements and degradation of ground and surface water, settlement of nearby inhabitants.

Methodology

Study Area

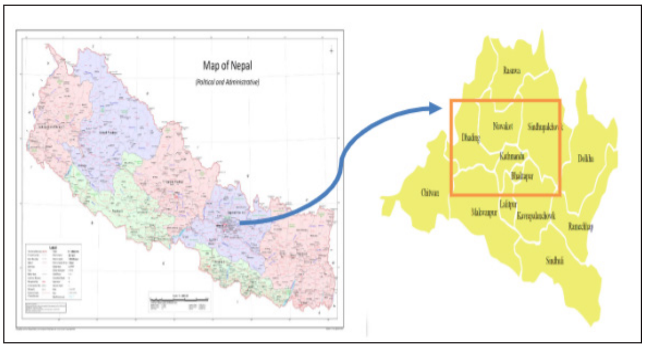

Figure 8.Political Map of Nepal with Study Area

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The study area is within and around the periphery of Kathmandu Valley. The study area was determined by location of building construction project and aggregate Sources, processing plant sites.

The selected building projects executed by Tribhuvan University, Institute of Engineering Consultancy Services, Pulchowk, Lalitpur were taken for study purposes. The Building Construction project's contract amount greater than Twenty Crore Nepalese Rupees were taken into study purposes.

Secondary Data

Secondary data provides additional pre-information and guidance to the study. Different guidelines, permissible limit values and quantity of samples taken for lab test were as follows.

Test on Samples

The different samples are marked by separate index of different sources and following tests wereperformed as per IS 2386: Part I-V guidelines and procedures:

Table 7.List of Building Projects for Study

S. No.	Client	Name of Project	Location	Contract Amount (Rs)	Status
1.	Tribhuvan University	Construction of Journalism and Mass Communication Administrative Building	Balkhu, Kathmandu	21,55,95,973.72	Ongoing
2.	Tribhuvan University	Construction of Central Department of Management Academic Building	Balkhu, Kathmandu	23,48,51,688.4	Ongoing
3.	Tribhuvan University	Construction of Office of Registrar Building	Balkhu, Kathmandu	22,69,45,894.8	Ongoing
4.	Paropakar Woman and Fertility Hospital	Construction of Paropakar Woman and Fertility Hopital Service Extension and Research Building	Kupondole, Lalitpur	38,77,44,158.8	Ongoing

Data Collection Methods

The data collection technique was based on the types of data taken from primary and secondary sources.

Physical Properties

Different physical properties values that were obtained from various lab test served as primary data. Various lab test for determining physical properties were as follows:

1. Gradation/ Sieve Analysis
2. Crushing Test
3. Abrasion Test
4. Impact Test on Aggregates
5. Soundness Test
6. Shape Test
7. Specific Gravity
8. Water Absorption Test

Table 8.Various Physical Tests and Quantity of Samples used for Laboratory

S.No.	Lab Test	Weight of Sample for Lab Test (kg.) based on IS:2430-1986	Remarks
1.	Gradation/Sieve Analysis	7-10	Sample of 3 cement bags of total weight of about 50 kg from each source
2.	Aggregate Crushing Test	3-4	
3.	Aggregate Impact Test	0.3-0.4	
4.	Los Angeles Abrasion Test	10-10.5	
5.	Flakiness Index	8-10	
6.	Elongation Index	5-6	
7.	Soundness Test	8-10	
8.	Specific Gravity	2-3	
9.	Water Absorption Test	2-3	

Data Analysis

The data collected from both primary and secondary sources were summarized, classified, tabulated, categorized. For the quantitative data like various tests of coarse aggregates from different sources were tabulated, processed and a comparison was made between different physical parameters and values to standard guidelines of IS, DUDBC, NS, SSRBW and NS. The SSRBW specification is used only for road and bridge works and only used here within for comparison purpose only. Computer software such as MS office tools, MS excels were used for tabulation and comparison. Further, the test results wereinterpreted and presented in tables, charts, graphs. For the qualitative data, the perception/opinion of contractors, local people residing near the sources was obtained through questionnaire and tabulated in the format. Computer software such as MS office tools, MS excels were used for tabulation and comparison. Further, the test results were interpreted and presented in tables, charts, graphs.

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Different physical properties and suitability of coarse aggregates The physical properties of coarse aggregates from two sources were determined through different laboratory procedures.

For the lab test of two different sources, an adequate amount of coarse aggregate was sampled in three cement bag sacks each of about 50 kg from each source as per sampling procedure described by IS: 2430-1986.

The detailed values of different physical properties were discussed below.

Different Physical Tests for Coarse Aggregates

Sieve analysis and gradation curve

The sieve analysis of the coarse aggregate has been carried as per IS 383:1970 using standard IS sieve. The gradation curve was drawn from the sieve analysis.

Table 9.Standard Guidelines and Limiting Values for Different Physical Test of Coarse Aggregates

S.No.	Physical Properties	Standard Guidelines/Specifications				Test Procedure
		IS Code	NS:297-1994	DUDBC Specifications	SSRBW	
		Permissible Limiting Values Test procedure				
1	Gradation/ Sieve Analysis	C_u>4 and C_c=1-3; well graded	As per IS:383-1970	As per IS:383-1970	As per IS:383-1970	IS:2386-1963
2	Aggregate Crushing Value	≤45% for concrete other than wearing surfaces; ≤30% for wearing, pavement surfaces	≤30% pavement structures; ≤45% for other structures	≤30% pavement structures; ≤45% for other structures	Max 40% for sub base; Max 30% for base	IS:2386-1963
3	Aggregate Impact Value	≤45% for concrete other than wearing surfaces; ≤30% for wearing, pavement surfaces	≤30% forpavement works ≤45% for other concrete works	≤30% for pavement works ≤45% for other concrete works	Max 40% for sub base; Max 30% for base	IS:2386-1963
4	Los Angeles Abrasion Value	≤30% for concrete of wearing course and concrete other than wearing surfaces	≤30% for pavement works ≤50% for other concrete works	≤45% for ordinary concrete; ≤ 35% for high quality concrete	Max 45% for sub base; Max 40% for base	IS:2386-1963
5	Flakiness Index	≤15%	As per IS:383-1970	≤25% for ordinary concrete; ≤15% for high quality concrete	Max 35% for sub base and base course	IS:2386-1963
6	Elongation Index	≤15%	As per IS:383-1970	≤25% for ordinary concrete; ≤15% for high quality concrete	Max 35% for sub base and base course	IS:2386-1963

7	Soundness Value	≤12% for sodium sulphate test	≤12% for sodium sulphate test	As per IS:383-1970	As per IS:383-1970	IS:2386-1963
8	Specific Gravity	2.5-3	As per IS:383-1970	As per IS:383-1970	As per IS:383-1970	IS:2386-1963
9	Water Absorption Value	(0.1-2) %	As per IS:383-1970	≤2%	As per IS:383-1970	IS:2386-1963

Table 10

To examine the values of physical properties and suitability of coarse aggregates of different Sources used in Selected Building Construction Projects within Kathmandu Valley	Primary Data: Coarse aggregate samples; Secondary Data: IS, DUDBC, NBC, NS guidelines	Different lab tests like Gradation Analysis, FI, EI, ACV, AIV, LAAV, Soundness Test, Specific Gravity and Water Absorption Test	Descriptive statistical tools	The values of physical properties and suitability of coarse aggregates

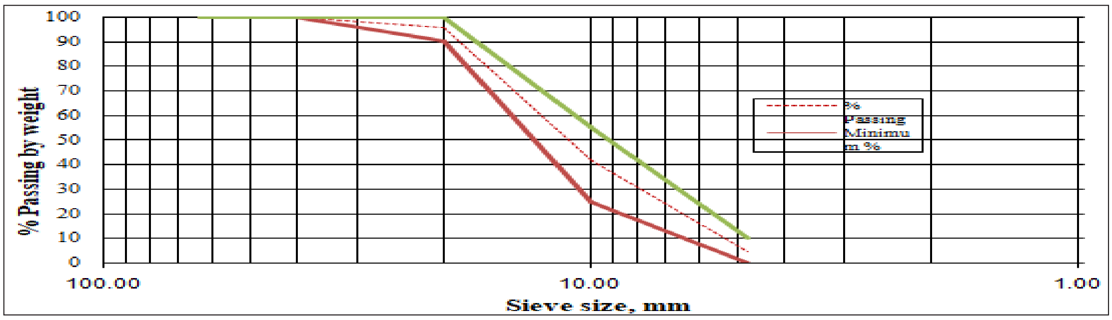

Figure 9.Gradation Curve

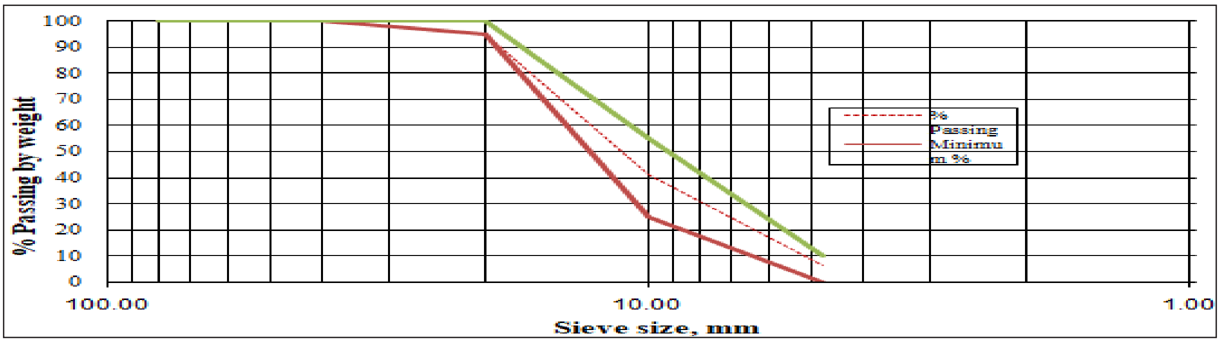

Figure 10.Gradation Curve

From the gradation curve from Figure 10 for source 1 and source 2, both coarse aggregates liebetween maximum and minimum limits. This concluded that, from gradation analysis, both aggregates from source 1 and source 2 were within the permissible limit values With the help of the gradation curve, the Coefficient of Uniformity (Cu) and Coefficient of Curvature (Cc) of both sources were calculated and tabulated in Table 9.

From the Table 10, the coefficient of uniformity (Cu) of both sources does not lies within the standard limit. So, the coarse aggregates from both sources consists of particles with different size ranges. Similarly, coefficient of curvature (Cc) of source 1 and source 2 lie within standard limit The coarse aggregates of both sources were well graded according to coefficient of curvature.

Aggregate Crushing Test

The crushing test was performed to determine the strength of coarse aggregate which affects the overall strength of concrete. The lesser crushing value indicates high strength of the concrete.

From Table 11, the Aggregate Crushing Value (ACV) of coarse aggregates from source 2 has a lower crushing value than source 1. In comparison to IS:383-1970, NS:297-1994; DUDBC and SSRBW specifications, both sources meet the standard requirements. But comparing the two sources, source 2 was found to be relatively better than source 1. Source 2 coarse aggregates have higher strength, concrete produced from coarse aggregates of source 2 have longer service life, economic performance than source 1.

Aggregate Impact Test

The impact test determines the resistance of aggregate against sudden impact or shock. It is also termed as toughness of aggregate. It can be defined as the resistance of aggregate to failure by impact load. The impact load can break aggregate into smaller pieces and which causes failure of concrete structures.

From Table 12, the Aggregate Impact Value (AIV) of both sources lies within the limit value prescribed by IS:383-1970; NS:297-1994; DUDBC; SSRBW.

The Aggregate Impact Value (AIV) of source 2 is lower than source 1. This indicates that coarse aggregates from source 2 have relatively higher resistance to impact, tougher enough to resist disintegration due to impact.

Los Angeles Abrasion Test

The abrasion test is a measure of aggregate toughness and abrasion resistance such as crushing, degradation and disintegration. An abrasion test is used to test the abrasive resistance of solid materials.

From Table 14, the LAAV of source-1 lies beyond the permissible limit prescribed by IS:383- 1970; Ns:297-1994 but lies within permissible limit prescribed by DUDBC and SSRBW. The LAAV of source-2 lies within permissible limits prescribed by IS:383-1970; NS:297-1994; DUDBC; SSRBW.

A comparison of LAAV values from two sources showed that source 2 has a lower LAAV value than source 1. So, coarse aggregates from source 2 were found to be relatively harder, better resistance to wear and tear than source 1. The wide application of LAAV is in road pavement structures where there occurs frequently wear and tear due to vehicle movements.

Table 11.Gradation Result of CoarseAaggregates from Two Sources

S.No.	Sieve Size (mm)	% Passing	Source 1	Source 2
	% passing by weight (gms)			
1	80	100		100
2	40	100		100
3	20	95.43		95.26
4	10	41.6		41.46
5	4.75	4.71		6.58
6	Pan	-		-

Table 12.Different Coefficients Values from Two Source

Coefficients	Values		
	Source 1	Source 2	Specification (IS:383-1970; NS:297-1994; DUDBC and SSRBW Specifications
Coefficient of Uniformity (C_u)	2.403	2.4119	>4
Coefficient of Curvature (C_c)	2.2617	2.2694	1-3

Table 13.Aggregate Crushing Value for Two Sources

S.No.	Source of Aggregate	Aggregate Impact Value (AIV)					
		Specifications				Test Result	Remarks
		IS:383-1970	NS:297-1994	DUDBC	SSRBW		
1	Source 1	≤45% of total weight of aggregate for concrete structures	≤30% pavement structures; ≤45% for other structures	≤30% pavement structures; ≤45% for other structures	Max 40% for sub base; Max 30% for base	28.12	Lower value signifies higher strength, longer service life, economic performance
2	Source 2					13.14	

Flakiness Index

This index is used to determine the particle shape of the aggregate specimen and each particle shapebeing preferred under specific conditions. From Table 4.12, the Elongation Index (EI) of source 1 and source 2 found to lie beyond the permissible limit by IS:383-1970; NS:297-1994. The EI of coarse aggregates from source 1 according to the DUDBC specifications was suitable for ordinary concrete but not suitable for high quality concrete used for building construction. The EI of coarse aggregate from source 2 does not lie within permissible limit value prescribed by IS:383-1970; NS:297-1994; not suitable for ordinary and high strength concrete prescribed by DUDBC. The coarse aggregates from source 2 have a high ratio of surface area to volume than source 1 which reduces the workability of concrete. As the surface area of coarse aggregate is greater, they need more water for wetting their surface, leaving a smaller quantity of water for workability and producing porous concrete which directly affects the strength and durability of concrete.

Table 14.Elongation Index value for two sources

S.No.	Source of Aggregate	Los Angeles Abrasion Value (LAAV)					
		Specifications				Test Result	Remarks
		IS:383-1970	NS:297-1994	DUDBC	SSRBW		
1.	Source 1	≤15%	As per IS:383-1970	≤25% for ordinary concrete; ≤15% for high quality concrete	Max 35% for sub base and base course	19.86	Lower value signifies disturbs in packing reduces work ability of concrete
2.	Source 2					31.83	

Table 15.Los Angeles Abrasion Value for Two Sources

S.No.	Source of Aggregate	Los Angeles Abrasion Value (LAAV)					
		Specifications				Test Result	Remarks
		IS:383-1970	NS:297-1994	DUDBC	SSRBW		
1.	Source 1	≤30% for concrete of wearing course and concrete other than wearing surfaces	≤30% for pavement works ≤50% for other concrete works	≤45% for ordinary concrete; ≤ 35% for high quality concrete	Max 45% for sub base; Max 40% for base	30.53	Lower value signifies hardness, better resistance to wear and tear
2.	Source 2					17.9	

Specific Gravity & Water Absorption Test

Specific gravity test of aggregates helps to measure the strength or quality of material. It is also the indirect measures of porosity and density of coarse aggregate. Water absorption test also signifies the porosity of coarse aggregate. More water absorption shows that coarse aggregates are not densely packed and there are more voids. This results in absorption of water into voids which makes concrete porous.

From Table 14 and Table 15, Specific gravity and water absorption for both sources lie with in the permissible limit prescribed by IS:383-1970; NS:297-1994; DUDBC, SSRBW. In comparison, source 2 has higher specific gravity than source 1. The water absorption value of source 1 was found to be higher than source 2. The coarse aggregates having higher specific gravity are more densely packed having fewer voids which results in high-strength concrete. Whereas, source 1 has a lower specific gravity which indicates high porosity. Some harmful particles are lighter that the good particles in aggregates. So, a specific gravity test can help to obtain a clear figure of change in materials or possible contamination in it.

Soundness Test

Soundness test determines aggregate's resistance to disintegration by weathering action. Aggregate mixed into concrete at external environment are affected by weathering actions like heat, rain, frost, snowfall. Weak and porous aggregate shows a change in weight during soundness test. Khadka S, Mishra AK, & Aryal B, 2021.

From Table 16, the soundness test values for both sources lie within the permissible limitprescribed by IS:383-1970; NS:297-1994; DUDBC, SSRBW. Comparing both sources, source 2 has a lower value than source 1. The coarse aggregates from source 2 were found to be more resistant to weathering action and more durable than source 1. The soaking of coarse aggregate in sodium sulphate solution and oven dried it under specific conditions promotes the growth of salt crystals in the pores of the test sample which produce disruptive internal forces similar to the action of freezing of water or crystallization of salt(Khadka, S., Mishra, A.K., &Aryal, B, (2021).

Suitability of Coarse Aggregates

Based on the physical test performed on coarse aggregates from source 1 and source 2; the suitability of coarse aggregates from the two sources were determined by comparison with standard guidelines prescribed by IS:383-1970; NS:297-1994; DUDBC and SSRBW specifications which have been tabulated in Table 17 as below.

Table 16.Flakiness Index values for two sources

S.No.	Source of Aggregate	Flakiness Index (FI)				Test Result	Remarks
		Specifications/ Standard Value Limits					
		IS:383-1970	NS:297-1994	DUDBC	SSRBW		
1	Source 1	≤15%	As per IS:383-1970	≤25% for ordinary concrete; ≤15% for high quality concrete	Max 35% for sub base and base course	17.63	Lower value signifies less flaky which are sound and requires less water for concrete
2	Source 2					28.29	

Table 17.Elongation Index Value for Two Sources

S.No.	Source of Aggregate	Elongation Index (FI)					Remarks
		Specifications/ Standard Value Limits				Test Result	
		IS:383-1970	NS:297-1994	DUDBC	SSRBW		
1	Source 1	≤15%	As per IS:383-1970	≤25% for ordinary concrete; ≤15% for high quality concrete	Max 35% for sub base and base course	19.86	Lower value signifies disturbs in packing reduces workability of concrete
2	Source 2					31.83	

Table 18.Specific Gravity Values for Two Sources

S. N0.	Source of Aggregate	Specific Gravity					Remarks
		Specification/ Standard Value Limits					
		IS:383-1970	NS:297-1994	DUDBC	SSRBW	Test Result	
1	Source 1	2.5-3.0	As per IS:383-1970	As per IS:383-1970	As per IS:383-1970	2.617	Higher value signifies good strength aggregate
2	Source 2					2.679	

Table 19.Water Absorption Values for Two Sources

S.No.	Source of Aggregate	Water Absorption					Remarks
		Specification/Standard Value Limits					
		IS:383-1970	NS:297-1994	DUDBC	SSRBW	Test Result	
1	Source 1	(0.1-2) %	As per IS:383-1970	≤2%	As per IS:383-1970	0.809	Higher value signifies more porous aggregate
2	Source 2					0.509	

Table 20.Sodium Sulphate Soundness Test for Two Sources

S. No.	Source of Aggregate	Soundness Test (Using Sodium Sulphate solution)					
		Specifications/Standard Value Limits				Test Result	Remarks
		(IS:383-1970	NS:297-1994	DUDBC	SSRBW		
1.	Source 1	(0.1-2) %	As per IS:383-1970	≤2%	As per IS:383-1970	0.42	Lower value signifies better resistance to weathering action.
2.	Source 2					0.33	

Table 21.Comparison of Physical Properties from Two Sources

S.No.	Types of Physical Test Values	Source location/ Lab test Result		Specification/ Standard Value Limits				Relative comparison of Better Source
		Source 1	IS:383-1970 Source 2	NS:297-1994	DUDBC	SSRBW		
1.	Gradation Analysis	C_u=2.403 C_c=2.261	C_u=2.411 C_c=2.269	C_u>4 C_c=1-3	C_u>4 C_c=1-3	C_u>4 C_c=1-3	C_u>4 C_c=1-3	With reference to C_u, coarse aggregates from both sources were poorly graded
2.	Aggregate Crushing Value (ACV, %)	28.12	13.14	≤45% for concrete other than wearing surfaces; ≤30% for wearing, pavement surfaces	≤30% pavement structures; ≤45% for other structures	≤30% pavement structures; ≤45% for other structures	Max 40% for sub base; Max 30% for base	Source 2
3.	Aggregate Impact Value (AIV, %)	20.32	12.24	≤45% for concrete other than wearing surfaces; ≤30% for wearing,	≤30% for pavement works ≤45% for other concrete works	≤30% for pavement works ≤45% for other concrete works	Max 40% for sub base; Max 30% for base	Source 2
4.	Los Angeles Abrasion Value (LAAV%)	30.53	17.9	≤30% for concrete of wearing course and concrete other than wearing surfaces	≤30% for pavement works ≤50% for other concrete works	≤45% for ordinary concrete; ≤ 35% for high quality concrete	Max 45% for sub base; Max 40% for base	Source 2

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5.	Flakiness Index (FI %)	17.63	28.19	≤15%	≤15%	≤25% for ordinary concrete; ≤15% for high quality concrete	Max 35% for sub base and base course	Source 1
6.	Elongation Index (EI, %)	19.86	31.83	≤15%	≤15%	≤25% for ordinary concrete; ≤15% for high quality concrete	Max 35% for sub base and base course	Source 1
7.	Soundness Value (%)	0.42	0.33	≤12% for sodium sulphate test	≤12% for sodium sulphate test	≤12% for sodium sulphate test	≤12% for sodium sulphate test	Source 2
8.	Specific Gravity	2.617	2.679	2.5-3	2.5-3	2.5-3	2.5-3	Source 2
9.	Water Absorption Value	0.809	0.509	(0.1-2) %	(0.1-2) %	≤2%	(0.1-2) %	Source 2

From Table 4.16, the comparison of nine physical properties were done. With respect to gradation analysis and coefficient of curvature (C c), the coarse aggregates from both sources were found to be poorly graded. The ACV, AIV, and LAAV of source 2 have a significantly lower value than source.

The lower value of source 2 signifies that the coarse aggregate was strong enough to bear the impact load, crushing load, abrasion. FI and EI of source 2 were higher than source 1. The specific gravity of coarse aggregates from source 2 was found to be higher than source 1. The water absorption value of coarse aggregates from source 2 was found lower than that of source 1. The sodium sulphate soundness test result was found to be better for source 2. The aggregates from both sources are being used in building construction projects. So, both sources have good physical qualities. Comparing all the nine physical properties, except for FI and EI, the coarse aggregates from source 2 were found to be better than source 1. So, the comparison between nine physical properties of coarse aggregates from both sources were found to have mixed results. The EI and FI of coarse aggregates from source 1 was found relatively lower because of coarse aggregates crushed with Jaw and Cone crusher whereas only Jaw crusher was used to crush the materials into coarse aggregates from source

Conclusions

The different physical tests on coarse aggregates were conducted as sieve and gradation analysis, ACV, AIV. LAAV, FI, EI, Specific gravity, water absorption test, and soundness test on samples collected from two major sources and comparison of different physical properties and suitability of coarse aggregates with standard guidelines prescribed by IS, NBC, NS, DUDBC, and SSRBW were performed. The gradation analysis of coarse aggregates from both source lies within the limit value but the coefficient of uniformity were beyond the limit and coarse aggregates from both sources were found to be poorly graded. The LAAV parameter have no significance role in building construction related issues. The Strength, Specific Gravity, Soundness, ACV, AIV for coarse aggregates from source 2 resembles better physical properties than coarse aggregates from source 1. But, the textural parameters like FI and EI of coarse aggregates from source 1 resembles better properties than source 1 but does not lie within permissible limits. This was mainly because of using jaw and cone crusher for source-1 and only jaw crusher for source 2. So, the physical values result from both sources were found to be complex and mixed result oriented.

From the site visit in SMDMP, Sindhuli, the strength exhibits on average 66.21MPa by using cement from 425 to 450 kg per cubic meter with admixture 0.37% without using any micro-silica and plasticizer. On the observation and conversation with project related to quality control staff, the high strength of concrete was because of using quality aggregate produce from jaw and cone crusher. The author is thankful to all the professionals who took part in discussions. The Author thanks to Nepal

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