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Assessment on Quality of Coarse and Fine Aggregate of Riverbed Quarry as Construction Material Used in Kaski District of Nepal

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Abstract

Quality of the composite material and ingredient of the materials in composite material plays a vital role in the sustainable infrastructure development. The quality of concrete is conformance to technical requirements as per specification or fitness for uses having minimum acceptance level to use the products. Among the various properties of fine and coarse aggregate of sampled quarry, only physical and mechanical properties of coarse and fine aggregates were

tested in the laboratory, analyzed and compared with IS code and Standard Specification for Road and Bridges Works-2073 (with second amendment-2078) of Department of Roads (DoR), Nepal. Results revealed that physical properties of all the sampled quarry on gradation of coarse and fine aggregate lies within the IS code provision, whereas only source of Rato Pairo Mishi Tunda Shanik Ghat and Gahara Ghat comply the specifications defined by Standard Specification for Road and Bridge Works -2073 (with second amendment-2078), The specific gravity and water absorption of all the sampled quarry satisfied as per the Standard Specifications for Road and Bridge Works-2073 (with second amendment-2078). The mechanical properties such as crushing value of coarse aggregate of all sampled quarry satisfied standard value, impact value of sampled aggregate from Babya Tara, Mahari Ghat and Chuina Pahara Ghat dosen't comply within standard value, and abrasion value of sampled aggregate from Mahari Ghat and Chuina Pahara Pasupati Ghumari Ghat does not meet the standards as defined by the Standard Specifications for Road and Bridge Works-2073 (with second amendment-2078). The properties of fine and coarse aggregate have significant influence on performance, quality and serviceability of concrete mix & finally influence durability of the engineering structures.

Keywords: *mechanical and physical Properties, quality assurance, quality control, specification.*

Introduction

Concrete is a heterogeneous & versatile construction material in construction industries having a wide range of properties if produced with exercising quality control. Aggregate is the collective term of inert materials such as sand, gravel and crushed stone that are used for preparation of composite construction materials, aggregates may be natural or artificial. Natural aggregates generally are obtained from rock quarry or direct extract from river. Excavated rocks are reduced to required sizes by mechanical crushing or screening, thus artificial aggregates are by-products of industries. Aggregates produced in a quarry or mine whose basic purpose is to switch in situ rock into aggregate with specified characteristics. Generally the rocks are blasted or dug from the quarry walls then converted into required size using a series of screens and crushers. Few quarries are able to wash the finished aggregate product. Manufactured rocks generally consist of industrial by-products such as slag or sphere rocks that are produced to have a particular physical characteristic not found in natural rock like light weight aggregate which involved in making quality concrete. Aggregates

are not truly inserted because its properties manipulate the recital of concrete (Neville & Brooks, 2010). Sound properties of aggregates influence on strength of concrete (Naville & Brooks, 2010; Donza, Cabrera & Irassar, 2002). The quality of concrete depends upon the quality of the paste and aggregate, and the bonding between the aggregate and paste (Mc Nally, 1998). The quality of aggregate may vary to a great extent due to the change in structure and texture of the parent rock from place to place. As per IS:383-1970 defines that aggregate from igneous rocks are highly satisfactory because of hard, tough and dense. Depending upon the particle distribution of IS 383-1970 has divided the fine aggregate into four grading zones which are progressively finer from I to IV grading zone.

The owner of private house construction has not been considered worthy for use of local area materials and preparation of concrete mix. The owners of private house construction are blindly following contractors, supervisors and masons recommendation for concrete construction, and use of local construction materials hence creates financial losses and wastages of resources. The contractor, supervisor & mason who are not engineers by profession, recommend construction material & types of concrete without any knowledge about theoretical and laboratory test results. This scenario reflects lack of quality and quality assurance of construction material and concrete products to the client of any project. The durability of concrete structures remains as a question mark to the users of construction material. The use of sound construction material is a major determinant of true economy in construction, efficiency, real prosperity, social justice, and health of the natural environment. The purpose of study is whether coarse and fine aggregates from river bed as construction materials used in Kaski district of Nepal are as per quality standard or not?, and explore their lacking parameters on quality.

Buildings are also our personal environments, products in which we are constantly immersed. With this study; contractors, clients and consultants and various stakeholders will assure about the quality of material as they are using that supplied in Kaski district from riverbed quarry for construction purpose in the study meet technical standard or not. Even the government organization and private developers also are aware about quality of material at each quarry site whereas the suppliers may understand their lacking parameters and improve the quality of the construction materials. The local people will also be aware about quality of materials at different sources, designers will aware on the specification writing. This research is carried out to aware local people, suppliers of construction materials, private developers, local institution and government institution that construction materials which are used by them whether meet

technical requirements or not?, if not then will search others quarry material that meet technical requirements to get sound construction material at reasonable cost.

2.0 Materials and Methods

The methodology employed in this study being specific laboratory test as per IS code & procedure define in Manual for Standard Tests-2016 of Department of Roads, Nepal. Data analysis and interpretation with the comparison as per code provisions was done. Both primary and secondary test result information was collected and analyzed qualitatively and quantitatively comparing with standard test results.

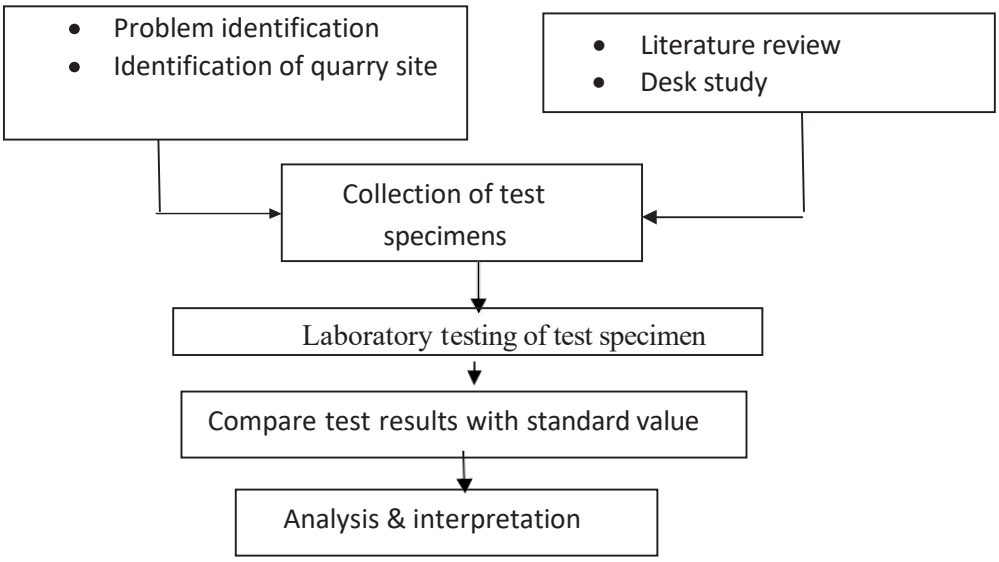

Fig. 1: Methodological flow chart of study

There are presently nineteen quarry sites as sources for supply of coarse and fine aggregate in Kaski district. On the basis of public tender notice advertised by local municipality of Kaski in fiscal year 2079/080, the quarry site of the aggregate that supply in the Kaski district for construction were chosen for research purpose. There are in total 19 quarries located in Kaski district of Nepal, which supply fine and coarse aggregate as construction material in Kaski district. Only six quarries from Seti river bed were selected which supply construction material in Kaski district on the basis of permissible extraction capacity of fine and coarse aggregate which having greater than 10000 cubic meter in each fiscal year. The sampled sources are listed below.

Table1: List of sampled sources, location and extraction capacity.

S.N.	Name of the Quarry Site	Location	Extraction Capacity (in Cum)
1	Ram Ghat	Pokhara-9,10	24750
2	Rato Pairo Mushi Tunda Shanik Ghat	Lekhnath-12	22500
3	Gahara Ghat	Hemja-1	35250
4	Babya Tara Mahari Ghat	Hemja-9	11000
5	Chuina Pahara Pashupati Ghamuri Ghat	Bharatpokhari-5	15000
6	Gosta Ghat	Lamachaur-16	11200

Source: Tender Notice by Local Municipality, 2022.

Three specimen samples for each test of physical & mechanical properties were collected from six different sampled quarries, whose fine and coarse aggregates were used in the Kaski district of Nepal. Laboratory tests for the physical & mechanical properties of each sample were carried out in laboratory which is calibrated and certified by the Government of Nepal, Nepal Bureau of Standards, for material testing. In this research, the physical and mechanical properties of coarse and fine aggregate of sampled quarry site were tested, the average value as obtained from three samples was calculated and compared with IS code or Standard Specifications for Road and Bridge Works-2073 (with second amendment 2078) of Department of Road (DoR), Nepal.

Physical properties of sample such as gradation of fine and coarse aggregate, finer than 75 microns of coarse and fine aggregate, specific gravity and water absorption of fine and coarse aggregate, and flakiness index of coarse aggregate were carried out as per procedure specified in Manual for Standard Tests -2016 of Department of Roads, Nepal. The mechanical properties of sample such as los angles abrasions value, aggregate impact value, and aggregate crushing value of coarse aggregate, were carried out as per the method & procedures specified in the Manual for Standard Tests -2016 of Department of Roads, Nepal The entire laboratory testing was conducted under normal temperature and pressure of laboratory as it is condition, seasonal variation on properties of sample, and geological properties of aggregate sample was not taken into consideration.

3.0. Result and Discussion

3.1 Physical Properties of fine & coarse aggregate

The properties which can be appreciated by physical examination of fine and coarse aggregate which are of:

a. Gradation

The particle size distribution of an aggregate as determined by sieve analysis is termed as grading of the aggregate.

i. Fine Aggregate

Aggregates size lie between 10 mm to 0.15 mm sieve are fine aggregate.

Table 2: The gradation of fine aggregate of sample quarry.

Name of Quarry Site	Gradation Zone of the Fine Aggregate
Ram Ghat	Lies in Zone III
Rato Pairo Mushi Tunda Shanik Ghat	Lies in Zone II
Gahara Ghat	Lies in Zone II
Babya Tara Mahari Ghat	Lies in Zone III
Chuina Pahara Pashupati Ghamuri Ghat	Lies in Zone I
Gosta Ghat	Lies in Zone III

The gradation of fine aggregate of sampled quarry of Rato Pairo Mushi Tunda Shanik Ghat and Gahara Ghat are within the gradation zone as prescribed by DoR Specification-2078 and Ram Ghat, Babya Tara Mahari Ghat, Chuina Pahara Pashupati Ghamuri Ghat, and Gosta Ghat does not lie within gradiation zone as per DoR Specification-2078. The DoR Specification-2078 specified that fine aggregate should be in gradation zone II of IS code 383:2016.

ii. Coarse Aggregate

Aggregate size lies between 20 mm to 4.75 mm sieve is coarse aggregate.

Table 3: The gradation of coarse aggregate of sample quarry.

Name of Quarry Site	Gradation of Coarse Aggregate
Ram Ghat	Single size 20 mm down aggregate
Rato Pairo Mushi Tunda Shanik Ghat	Single size 20 mm down aggregate
Gahara Ghat	Graded size 20 mm down aggregate
Babya Tara Mahari Ghat	Single size 20 mm down aggregate

Chuina Pahara Pashupati Ghamuri Ghat	Graded size 20 mm down aggregate
Gosta Ghat	Graded size 20 mm down aggregate

The gradation of coarse aggregate of all sampled quarry site lies on the 20 mm down aggregate of DoR Specification-2078. The DoR Specification-2078 specified that the coarse aggregate should be of limit in single size of 20 mm and graded size 20 mm down for structural concrete.

b. Finer than 75 microns of coarse and fine aggregate

The material passing from the 75-micron IS sieve constitutes the portion that can be classified as silt and clay. These materials may be considered undesirable as constituents in aggregates because of their fineness and other physical characteristics, the presence of which may affect strength, workability, durability, and long-term performance of concrete. The average value of coarse aggregate finer than 75 micron of each sample is tabulated as:

Table 4: Coarse and fine aggregate finer than 75 micron of sampled quarry

Name of Quarry Site	Particles Finer Than 75 Micron Average Value		Standard Value
	Fine Aggregate	Coarse Aggregate	
Ram Ghat	3.76 %	2.51%	3%
Rato Pairo Mushi Tunda Shanik Ghat	2.71%	1.61%	
Gahara Ghat	2.64%	1.32%	
Babya Tara Mahari Ghat	6.3%	2.72%	
Chuina Pahara Pashupati Ghamuri Ghat	1.0%	1.1%	
Gosta Ghat	3.6%	2.1%	

Coarse aggregate from all the sampled quarries lies within the limit of finer particles smaller than 75 micron. But, fine aggregate from Ram Ghat, Babya Tara Mahari Ghat, and Gosta Ghat doesn't comply within the limit of finer particles finer than 75 micron. The standard value of coarse and fine aggregate finer than 75 micron is 3 % maximum.

d. Specific gravity and water absorption of coarse and fine aggregate

The specific gravity of an aggregate is defined as the ratio of the mass of a solid in a given volume of sample to the mass of an equal volume of water at the same temperature. Water absorption of coarse and fine aggregate defines percentage of water absorption, by weight as well as by volume. It is also used to define percentage of porosity. The water absorption value for aggregate described the percentage increase in weight between dry aggregate and the saturated aggregate. Therefore, the water absorption value is the amount of water which the aggregates are able to hold. The percentage of water absorbed by an aggregate when immersed in water is termed the water absorption of aggregate. The average value of specific gravity and water absorption of coarse and fine aggregate is tabulated below

Table 5: Specific gravity and water absorption of coarse aggregate

Name of Quarry Site	Specific Gravity	Water Absorption (%)
Ram Ghat	2.51	1.56
Rato Pairo Mushi Tunda Shanik Ghat	2.56	1.19
Gahara Ghat	2.87	1.06
Babya Tara Mahari Ghat	2.87	1.85
Chuina Pahara Pashupati Ghamuri Ghat	2.79	1.95
Gosta Ghat	2.52	1.56
Standard Value	2.5-3	less than 2

The table shows that water absorption and specific gravity of coarse aggregate of all the sampled quarry site lies within the limit as per DoR Specification-2078. The standard value of specific gravity is 2.5-3 and water absorption is 2% maximum.

Table 6: Specific gravity and water absorption of fine aggregate

Name of Quarry Site	Specific Gravity	Water Absorption (%)
Ram Ghat	2.61	2.56
Rato Pairo Mushi Tunda Shanik Ghat	2.51	2.44
Gahara Ghat	2.83	2.47
Babya Tara Mahari Ghat	2.85	2.44
Chuina Pahara	2.68	2.41

Pashupati Ghamuri Ghat		
Gosta Ghat	2.6	2.38
Standard Value	2.5-3	Less than 3

This table reveals that water absorption and specific gravity of fine aggregate of all the sampled quarry site satisfied within the limit as per DoR Specification-2078. The standard value of specific gravity and water absorption of fine aggregate is 2.5-3 and 3% maximum respectively.

3.2 Mechanical Properties of Coarse Aggregate

The properties which govern the behavior of coarse aggregate when external forces are applied. The aggregate of indexes that characterize the resistance of a material to a load acting on it, the degree to which it will deform under the load and its behavior in the process of failure. The rate of development of the process of failure may be under a static or repeated load. The mechanical properties of materials are determined in mechanical tests of specimens of various shape. Some of the mechanical properties of coarse aggregates are Los Angeles Abrasion Value, Impact Value, and Crushing Value. The mechanical properties of coarse aggregate are tabulated below.

Table 7: Abrasion value, impact value and crushing value of sampled quarry site of coarse aggregate

Name of Quarry Site	Average Los Angles Abarsion Value	Average Aggregate Impact Value	Average Aggregate Crushing Value
Ram Ghat	30	25	20.4
Rato Pairo Mushi Tunda Shanik Ghat	35	30	23.15
Gahara Ghat	32	28	21.11
Babya Tara Mahari Ghat	38	35	22.3
Chuina Pahara Pashupati Ghamuri Ghat	39	38	21.83
Gosta Ghat	31	31	20.17
Standard Value	35-45 % Maximum	30-45 % Maximum	30-45 % Maximum

This table attributes that the Los Angles Abrasion value of all the sampled quarry site of coarse aggregate lies within limit defined by DoR Specification-2078. The standard value defined by

DoR Specification-2078 as the aggregate shall have of Los Angles Abrasion value not more than 45% for ordinary concrete, and not more than 35% for high quality concrete. Also, it assigned that aggregate impact value of the coarse aggregate from all the sampled quarry site lies within the limit defined by DoR Specification-2078. The standard value defined by DoR Specification-2078 that the aggregate shall have aggregate impact value not more than 30% for pavement structure, and not more than 45% for other structure. Similarly, the aggregate crushing value of coarse aggregate from all the sampled quarry site is found to be within limit defined by DoR Specification-2078. The standard value defined by DoR Specification-2078 as as the aggregate shall have aggregate impact value not more than 30% for pavement structure, and not more than 45% for other structure.

4.0 Conclusion

The fine aggregate of quarry site of Ram Ghat, Gahara Ghat and Gosta Ghat lies in zone III, this shows that fine aggregate need to be washed properly before use in concrete works. The fine aggregate of Ram Ghat, Gahara Ghat and Chuina Pahara Pashupati Chamari Ghat having more than 15% of finer material less than 75 micron, which is suggested to wash before use for concrete works. The quarry site of Ghara Ghat, Babya Tara Mahari Ghat and Chunia Pahara Pashupati Chamuri Ghat has specific gravity less than 2.5 which needed to wash before use in concrete works. The quarry site of Ghara Ghat, Babya Tara Mahari Ghat, Chuina Pahara Pashupati Chamari Ghat and Gosta Ghat has more than 30% of impact value, then suggested for not use in concrete pavement works, but Los Angles value and aggregate crushing value are within the limit of standard value.

Recommendation

The implementing agency should be familiar with quality of fine and coarse aggregate of quarry site, whether it meets code provision or not. The use of fine aggregate of quarry site Rato Pairo Mushi Tunda Shanik Ghat, and Gahara Ghat only recommend for concrete works and quarry site of Ram Ghat, Babya Tara Mahari Ghat, and Gosta Ghat for plaster works as per DoR specification-2078. The quarry site of Babya Tara Mahari Ghat and Chuina Pahara Pashupati Ghamuri Ghat are not found feasible due to loss in mechanical properties of coarse aggregate for concrete works as prescribed in DoR specification-2078. The suppliers of construction materials have to review the quality of construction materials by internal quality testing, quality

control, quality surveillance, quality assurance & quality audit to get total quality management of the products.

The suppliers of construction materials and investor of quarry site where material are extracted from should know that anything less than what is in the specification will not be acceptable to the client. Therefore, the investor of quarry site should be aware, understand, and implement the total quality management technique and clarify their understanding of the issue on quality, and move forwards on the road to achieve total quality.

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References

Andres, K. Camron; Smith, C. Ronald; *Principles and Practices of Commercial Construction;* Sixth Edition; Prentice Hall, Upper Saddle River, New Jersey.

Department of Roads (2016). *Manual for Standard Test-2016*. Department of Roads Government of Nepal, Ministry of Physical Infrastucture and Transport, Babarmahal, Kathmandu, Nepal.

Department of Roads (2073). *Standard Specification for Road and Bridge Works-2073 (with second amendment-2078),* Department of Roads, Government of Nepal, Ministry of Physical Infrastructure and Transport, Babarmahal, Kathmandu, Nepal

Donza H., Cabrera, O., & Irassar, E. (2002). *High Strength Concrete with Different -Fine Aggregate*, Cement and Concrete research, 32 (II) 1755-1761

Gambhir, M.L, (2006). *Concrete Technology*, Third edition, Tata McGraw Hill Publishing Company Limited, New Delhi, India.

Indian Road Congress (2012). *Journal of the Indian Road Congress*, Volume 73-2, New Delhi, India.

IS:383-1970 *Specification for Coarse and Fine Aggregate from Natural Sources of Concrete (Second Revision)*, Bureau of Indian Standard, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 10002

Khadka, S. et al. (2021). *Analysis of Coarse Aggregate Sources Effects on Compressive Strength of Cement Concrete*. Efflatounial, 5(1), 2988 – 3000.

Mc Nally, G.(1998). *Soil & Rock Construction Material (First Edition)*, New York: Routledge

Naville, A., & Brooks, J. (2010). *Concrete Technology (Second Edition)*, London, Prentice Hall.

Sharma, Rajendra Raj. (2013). *Using Prestressed Precast Concrete in Bridge Construction for Prosperous Nepal*, Thirteen National Convention Seminar Papers, Nepal Engineers' Association, Kathmandu, Nepal.

Sneak, S., Nirmala, M., and Dhanalakshmi, G. (2018). *Size Effect of Aggregate in the Mechanical Properties of Concrete*. International Research Journal of Engineering and Technology, 5(2), 2093- 2096.

Banstola, R.; GC, S. (2023). *An Assessment of Aggregate Quality from Crusher Plant As Construction Material Used in Kaski District of Nepal*. *J. Eng. Iss. Solut.* **2023**, *2*, 111-119.

Web Sites

https://www.researchgate.net/publication/346347740_experimental_study_on_the_effect_of_different_coarse_aggregate_sizes_on_the_strength_of_concrete, cited on 16/09/2022.

https://www.researchgate.net/publication/354926696_Analysis_of_Coarse_Aggregate_Sources_Effects_on_Compressive_Strength_of_Cement_Concrete, cited on 7/09/2022.

https://www.researchgate.net/publication/364101424_Analysis_of_the_Aggregate_Strength_Variation_along_Different_Sections_of_the_River_Basin, cited on 9/09/2022.