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Research Article

COMPARATIVE ASSESSMENT OF COARSE AGGREGATE COLLECTED FROM TINAU RIVER AND BANGANGA RIVER

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Abstract

This study focuses on the physical and mechanical parameters among various properties of coarse aggregates from Tinau River and Banganga River, studies the variation in compressive strength of concrete cubes made of coarse aggregates from respective sources and their economic assessment for use in various construction projects. The result show that in terms of physical and mechanical properties, aggregates of Tinau River were found slightly better than those of Banganga River. The variation in compressive strength of concrete mix due to change in source is significant for rich mix concrete (1:1.5:3) while there is less significant variation in case of lean mix concrete (1:3:6) and (1:2:4) which shows that the variation increases with the rise in grade of concrete. The economic analysis conducted on the basis of mix design concluded that the difference in cost for producing 1m^3 of concrete using coarse aggregate from Tinau River and Banganga River is Rs. 20.40 and the percentage of saving in cost of concrete is only 0.22%. Overall, this research can be valuable to engineers and researchers working in the field of infrastructure development projects.

Keywords—coarse aggregate, concrete, source, effect

INTRODUCTION

1.1Background

Construction material plays a vital role in development of infrastructures in the nation. From few years, sediments of the Tinau River and Banganga River area are being used as concrete aggregates, which have markets in the west Nepal. Quality of aggregates, which are used in concrete structures, is of great concerns. Smith and Collis identified the main factors influencing aggregate behavior in various operational and environmental conditions, and concluded that the performance of aggregates depends upon their intrinsic properties [1]. The unbound aggregates in road construction have showed that for Icelandic basalt, the durability and abrasion were dependent on the degree of alteration while the fragmentation was dependent on porosity [2]. The dry density and porosity were correlated well with uniaxial compressive strength, point load index and modulus ratio [3]. Maharjan and Tamrakar evaluated quality of siltstone samples of the Tustung Formation for concrete aggregate [4].

The freeze–thaw experiments on the limestones and sandstones from Japan, and dolomite and schist from Nepal showed that the rock samples were resistant to deterioration and breaking [5]. They also concluded that initiation and extension of cracks and subsequent wearing and deterioration occurred faster in high porosity rocks. The quality assessment of the river gravel from the Rapti and the Narayani Rivers concluded that the majority of gravels of both rivers were of high roundness and high sphericity, and of diverse chemical groups, and were compositionally sound with good workability for road and concrete aggregates [6]. Therefore, the studies of properties of aggregates are important to evaluate their usefulness in various uses as aggregates. The main aims of the present study are to analyze the physical and mechanical properties of the material to evaluate their potential uses as construction aggregates.

1.2 Objective

This study aims to analyze the properties of coarse aggregate extracted from Tinau River and Banganga River, to analyze the strength of selected grade of concrete using the tested aggregates and to assess the economic suitability of aggregates extracted for various construction projects.

Methodology and test setup

The methodology presented in the experiment provides an overview of the laboratory tests conducted and research techniques used in the investigation. Upon enquiry, the major sources of coarse aggregate being used in Rupandehi district were found to be extracted from quarry and river sources of Tinau river, Banganga river, Rapti river and Turia river. Among these sources of coarse aggregates, Tinau and Banganga were selected for the research work. The crushed coarse aggregate required for the study was collected from SASEC Roads Improvement Project Bhairahawa-Lumbini-Taulihawa Road in Rupandehi district. The aggregates obtained by the project for crushing were mostly from various river banks along Tilottama Municipality and Shuddhodhan Municipality for Tinau River and river banks of Banganga Municipality for Banganga River.

The laboratory required for testing the properties of aggregates was the respective laboratory of the construction project. Aggregate Impact Value Test, Aggregate Crushing Value Test, Los Angeles Abrasion Test, Flakiness Index Test, Elongation Index Test, Specific Gravity Test and Water Absorption Test as specified by IS code were conducted on coarse aggregates of both sources.

Quantitative approach was applied to assess and analyze the compressive strength test data of concrete cubes. Concrete with three different nominal mix ratios 1:3:6, 1:2:4 and 1:1.5:3 by weight were prepared considering W/C ratio 0.45. A total of 36 cubes (18 cubes each for 2 coarse aggregate sample types) were casted and the compressive Strength of 7 and 28 days concrete cubes were determined as per IS 516-

1959.

Figure 1: Concrete production and compressive strength test

Concrete Mix Design was carried out as per IS 456:2000 and IS: 10262-2009 and the economic analysis was assessed on the basis of result data from the mix design.

Overall, the methodology provides a clear and detailed explanation of the materials and methods used in the investigation and gives understanding of the experiment and the results obtained.

Test Results

This chapter focuses on the results of the various conducted lab tests and their analysis. The result of various test conducted are graphically represented in this chapter. Mechanical and Physical properties of coarse aggregates were analyzed and compared with one another with the help of graphs and charts.

3.1 Summary of Coarse Aggregate Tests

Table 1: Summary of coarse aggregate test

SN.	Description	Source		Permissible Limit (IS)
		Tinau	Banganga	
1	Aggregate Impact Value (AIV)	11.23	17.6	< 25%
2	Los Angeles Abrasion Test (LAAV)	21.54	23.04	≤ 35%
3	Flakiness Index	12.63	12.55	≤ 25%
4	Elongation Index	15.36	14.83	≤ 25%
5	Aggregate Crushing Value (ACV)	21.95	19.73	<45%
6	Specific Gravity	2.719	2.724	2.5-3.0
7	Water Absorption	0.88	1.29	0.1-2%

Above Table 1 shows the summary of various tests conducted for coarse aggregates. All the tests are within the permissible limit as per Indian Standard.

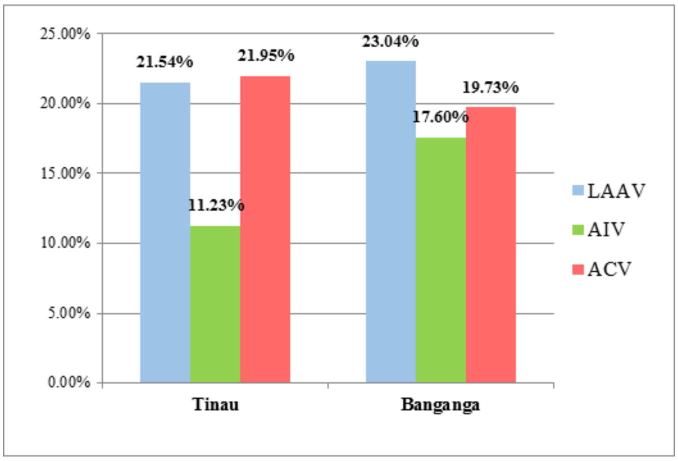

Figure 2: Comparison of mechanical properties

Figure 2 shows that the aggregates from Tinau River have lower LAAV and AIV values compared to those from Banganga, River indicating that they are more resistant to wear and sudden impact or shock. However, the aggregates from Tinau River have a higher ACV value compared to those from Banganga River indicating that they are less resistant to crushing.

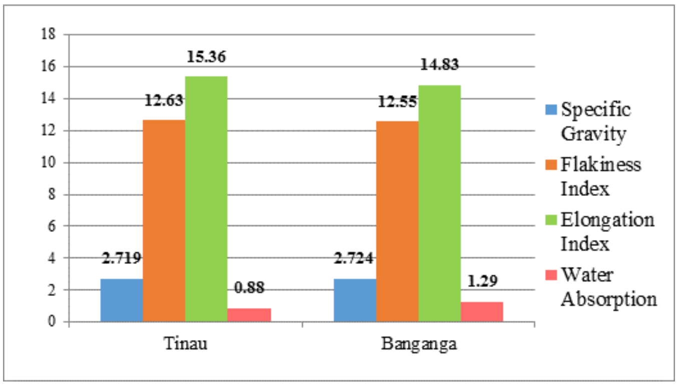

Figure 3: Comparison of physical properties

Figure 3 shows that the aggregate from Tinau River has less specific gravity which means the weight to volume relationship of aggregate from Tinau River is lower than that of Banganga River which is important for concrete mix design and proportioning. Similarly, Tinau River also has less water absorption rate which is an important factor to consider in the concrete mix design process, as it can affect the workability, strength, and durability of the concrete. Banganga River has a slightly lower flakiness index and elongation index than Tinau River which indicates that they are more cubical or well-rounded particles.

3.2 Compressive Strength Test

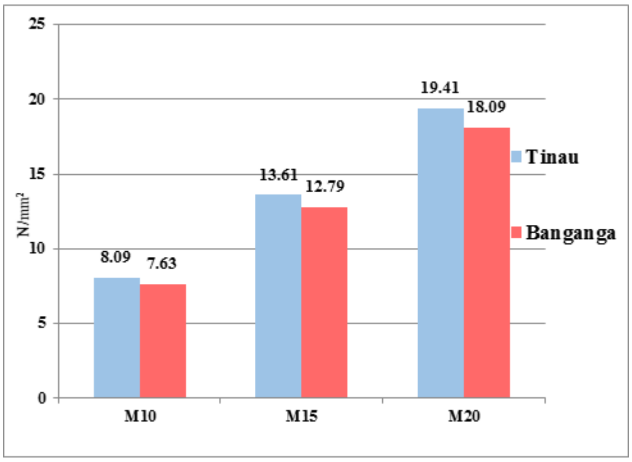

Figure 4: compressive strength values for 7 days with various mixes

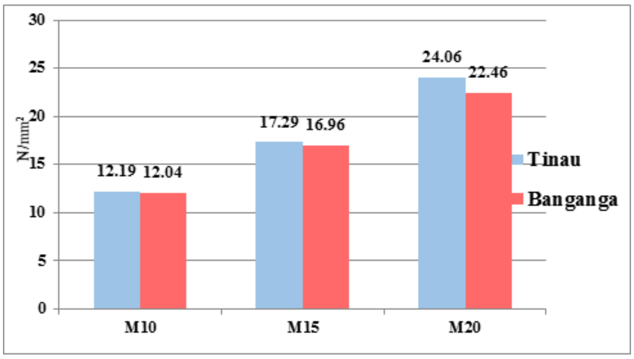

Figure 5: compressive strength values for 28 days with various mixes

Figure 4 and 5 shows that, for all the nominal mixes 1:3:6(M10), 1:2:4(M15), 1:1.5:3(M20) the compressive strength (7 days and 28 days) of concrete made out of Tinau River aggregate has higher values than that of Banganga River aggregate. The difference in compressive strength between Tinau River and Banganga River for M10 mix is minimum, while the difference is maximum for M20 mix.

The difference in compressive strength (7 and 28 days) between Tinau River and Banganga River gradually increase as the strength of concrete increases.

Table 2: Variation of compressive strength for 28 days

Mix Ratio	(A)Target Mean Strength (N/mm2)	(B)Minimum strength (N/mm2)	(C)Maximum strength (N/mm2)	((B-A)/A)*100%	((C-A)/A)*100%	Variation %
1:3:6	10	12.04	12.19	20.40	21.90	1.50
1:2:4	15	16.96	17.29	13.07	15.27	2.20
1:1.5:3	20	22.46	24.06	12.30	20.30	8.00

The results from the above table 2 show that the change in source has a significant effect on 7 days and 28 days compressive strength of concrete mix. The variation in compressive strength of concrete mix due to change in source is significant for rich mix concrete (1:1.5:3) while there is less significant variation in case of lean mix concrete (1:3:6) and (1:2:4).The test result shows that the compressive strength of Tinau River based coarse aggregate is found to be maximum for all types of nominal mix.

3.2 Economic analysis of concrete

Economic analysis of concrete involves the evaluation of the costs and benefits of using concrete as a building material. For cost analysis of concrete only material quantity and rate was included in this study. Other material transportation, labor, tools, plant and other cost was not included. The analysis of per unit cost of concrete was calculated based on rates available locally in Rupandehi district which included cost of cement, sand and coarse aggregate.

Table 3: Cost of per m^3 concrete with Tinau River coarse aggregate

Description	**Unit**	**Quantity**	**Rate (Rs)**	**Amount (Rs)**
Cement	Bags	8	650	5200
Coarse aggregate	m^3	0.9119	3000	2735.7
Sand	m^3	0.4218	3000	1265.4
			Total	**9201.1**

Table 4: Cost of per m^3 concrete with Banganga River coarse aggregate

Description	**Unit**	**Quantity**	**Rate (Rs)**	**Amount(Rs)**
Cement	bags	8	650	5200
Coarse aggregate	m^3	0.9187	3000	2756.1
Sand	m^3	0.4218	3000	1265.4
			Total	9221.5

Table 3 and Table 4 shows the cost of per m^3 concrete with Tinau River and Banganga River aggregates. The quantities of the materials taken are the results obtained from concrete mix design and the rates used are obtained from the road project itself.

From the cost calculated with Tinau River aggregate and Banganga River aggregate in, the cost saving is Rs. 20.40 per cubic meter concrete and the percentage of saving in cost of concrete is 0.22%.

Discussion and Conclusion

This study was done to investigate various properties of coarse aggregate collected from Tinau River and Banganga River, compare their effect on compressive strength of different grade of nominal mix concrete and to observe their economic suitability based on experimental analysis.

The gradation values for both Tinau River and Banganga River are within specified limits because the coarse aggregate collected for laboratory tests were crushed as per the projects requirement. The significant difference in Aggregate Impact Value and Aggregate Crushing Value of Tinau River and Banganga River might be due to the difference in composition, density, texture and structure of the aggregate itself. There is a marginal difference in values of Flakiness Index, Elongation Index and Specific Gravity. The difference in Los Angeles Abrasion value might be because aggretates from Tinau undergo more wear and tear throughout their river course giving them more resistance to crushing, degradation and disintegration compared to Banganga River. The water absorption value of Banganga River is higher than Tinau River because of its porous nature which might be related to its geological properties.

The economic analysis is conducted on the basis of cost difference for producing 1m3 of concrete using respective sources aggregates. The percentage saving is 0.22% which is calculated only considering the rates of the cement, sand and coarse aggregate which may vary if all material, labor, equipment, transportation and other cost considered.

Similar test was conducted by Prajapati and Karanjit [7] on 5 different types of coarse aggregate sources (Panauti, Melamchi, Chaukidada, Khopasi and Kaaldhunga). In their case, the variation in compressive strength of concrete mix due to change in source is significant for lean mix concrete (1:2:4 and 1:2:3) while there is less significant variation in case of rich mix concrete (1:1.5:3) but in our research the variation in compressive strength of concrete mix due to change in source is significant for rich mix concrete (1:1.5:3) while there is less significant variation in case of lean mix concrete (1:3:6) and (1:2:4) which shows that the variation increases with the rise in grade of concrete.

The variation in the result between our research and their might be due to the difference in geological properties of the aggregates as Tinau and Banganga flows through the Siwalik and Terai region while Panauti, Melamchi, Chaukidada, Khopasi and Kaaldhunga lies in the Lesser/Mahabharat Himalayan region. The difference in rock type might be the reason for the difference in the strength of concrete. [8][9].

Based on the findings from the comparative assessment of coarse aggregate collected from Tinau River and Banganga River, it can be concluded that both coarse aggregates are good enough to be used for various construction projects as both have passed the permissible limit for both mechanical and physical test, change in source is significant for rich mix concrete (1:1.5:3) while there is less significant variation in case of lean mix concrete (1:3:6) and (1:2:4) which shows that the variation increases as the grade of concrete increase, both aggregates are barely different in economic aspect to each other and it is recommended to use coarse aggregate from Tinau River for high grade concrete especially in bridge, tunnel and high rise building construction.

References

[1] M. R. Smith and L. Collis, "Sand, Gravel and Crushed Rock Aggregates for Construction Purpose," Geo. Soc. London, pp. 5–263, (1993).

[2] G. Bajarson, P. Petursson, and S. Erlingsson, Aggregate resistance to fragmentation, weathering and abrasion. Unbrand Aggregates in Road Construction (UNBAR) (2000).

[3] N. K. Tamrakar, S. Yokota, and S. D. Shrestha, "Physical and geomechanical properties of the Siwalik sandstones, Amlekhganj-Suparitar area, central Nepal Himalaya," J. Nepal Geol. Soc., 26, (2002).

[4] D. K. Maharjan and N. K. Tamrakar, "Quality of siltstones for concrete aggregate from Nallu Khola area, Kathmandu valley," J. Nepal Geol. Soc., vol. 30, 2004.

[5] G. P. Dhakal, J. Kodama, and T. Goto, "Freezing-Thawing effect and slake durability of some rocks from cold regions of Nepal and Japan," Journal of Nepal Geological Society, 33, 45–54 (2006).

[6] S. Maharjan and N. K. Tamrakar, "Study of Gravel of the Narayani and Rapti River for Construction Materials," Bulletin of Department of Geology, 10, 99–106 (2007).

[7] J. Prajapati and S. Karanjit, "Effect of coarse aggregate sources on the compressive strength of various grade of nominal mixed concrete," Jnl Sci. Engg., 7, 52–60 (2019).

[8] A. Kılıç, A. Teymen, O. Özdemir, and C. D. Atiş, "Estimation of compressive strength of concrete using physico-mechanical properties of aggregate rock," Iran. J. Sci. Technol. Trans. Civ. Eng., vol. 43(S1), 171–178 (2019).

[9] S. K. Al-Oraimi, R. Taha, and H. F. Hassan, "The effect of the mineralogy of coarse aggregate on the mechanical properties of high-strength concrete," Constr. Build. Mater., 20 (7),499–503 (2006).