Analysis of Different Rock Aggregates for Civil Engineering Properties using GSI Map in Parts of Rishikesh Area and Map of Wadia Institute of Himalayan Geology- A New Approach Towards Sustainable Development

Zoha Jafar[1], Irshad Ali[2]

[1]*Assistant Professor, Jamia Millia Islamia, New Delhi*
[2]*HOD, Department of Civil Engineering, IFTM*

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ABSTRACT: With increase in the infrastructural development in the country like India there is build up pressure on the construction industry to provide adequate amount of aggregates, sand etc. As the major source of aggregate in India comes from the parts of Rajasthan it has become all the more difficult to abstract such large amount of aggregates in short time. The state of Rajasthan is also likely to face crises in the coming times because of over exploitation of their resources. Thus, research should be done on the locally available material for the use as aggregate.

1. INTRODUCTION

As the world population continue to increase there is a tremendous pressure on the construction industry to produce more houses therefore to extract and process large quantity of raw material. The extraction, processing and transporting of raw material at site consumes a lot of energy and in turn is responsible for large amount of pollution. This study focuses on harnessing the locally available material as building construction material. By doing so the energy consumption by the construction industry will tend to reduce and it opens a new subject for research in the future.

Idea of this study is based on the concept that the local rock material especially fine aggregate and coarse aggregate do not show the appropriate properties for the manufacturing of concrete. The property specially like compressive strength, crushing strength and tensile strength do not satisfy the strength criterion generally followed for the manufacturing of concrete. Most of the raw material used by the construction industry today come from Rajasthan, India as they prove to be satisfying the national and international testing standards. Thus, using the local material results in low strength of the house which falls below the expectation of the user and need constant maintenance.

For example, in the areas like Rishikesh the properties of local rock aggregate like workability, water cement ratio, water absorption is basically leading to segregation and bleeding by virtue of which the proper strength of the concrete is not been achieved with time. As a result, in the Himalayan zone we are mostly dependent on Rajasthan for the raw material. Due to this exact difference between Himalayan rocks and the Rajasthan rocks, the local material of Rishikesh was considered as unfit for construction use but this study will focus on the properties of some local raw materials and will try to conclude whether or not those can be used as building material in houses.

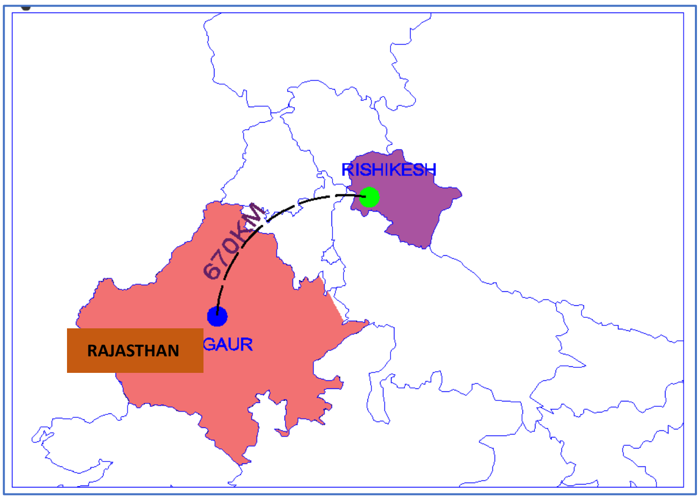

Figure 1 Distance between Naguar (Rajasthan) and Rishikesh

Over the period of time not much attention is given towards the locally available materials as building material. It is largely due to the fact that consumer is generally biased towards the local building material as there is generally a feeling that houses made with locally available material lacks strength and are not very durable.

The objective of the paper is to identify the physical and engineering properties of locally available construction material which can be used as coarse and fine aggregates. The physical and engineering properties of all such aggregates are analysed and compared for their optimal use in industry as building material. Most of the stratigraphic units identified are done by using GIS map and few information is collected from Wadia Institute.

II. STUDY AREA

Rishikesh is popular city in the state of Uttarakhand and lies in the foothills of Himalayas, Shivalik range. The entire state is hilly terrain and comprises of 13 districts grouped divided into two division called Garhwal and Kumaon. Rishikesh is in Tehri Garhwal region in the tensil of Dehradun and is surrounded by river Ganga from three sides.

This region is chosen for this study because in the entire mountainous ranges of Rishikesh building material like shales, limestone, siltstone etc. are fond in abundance. This study will find out the engineering properties of these rocks to ascertain whether these can be used as building material in the construction industry.

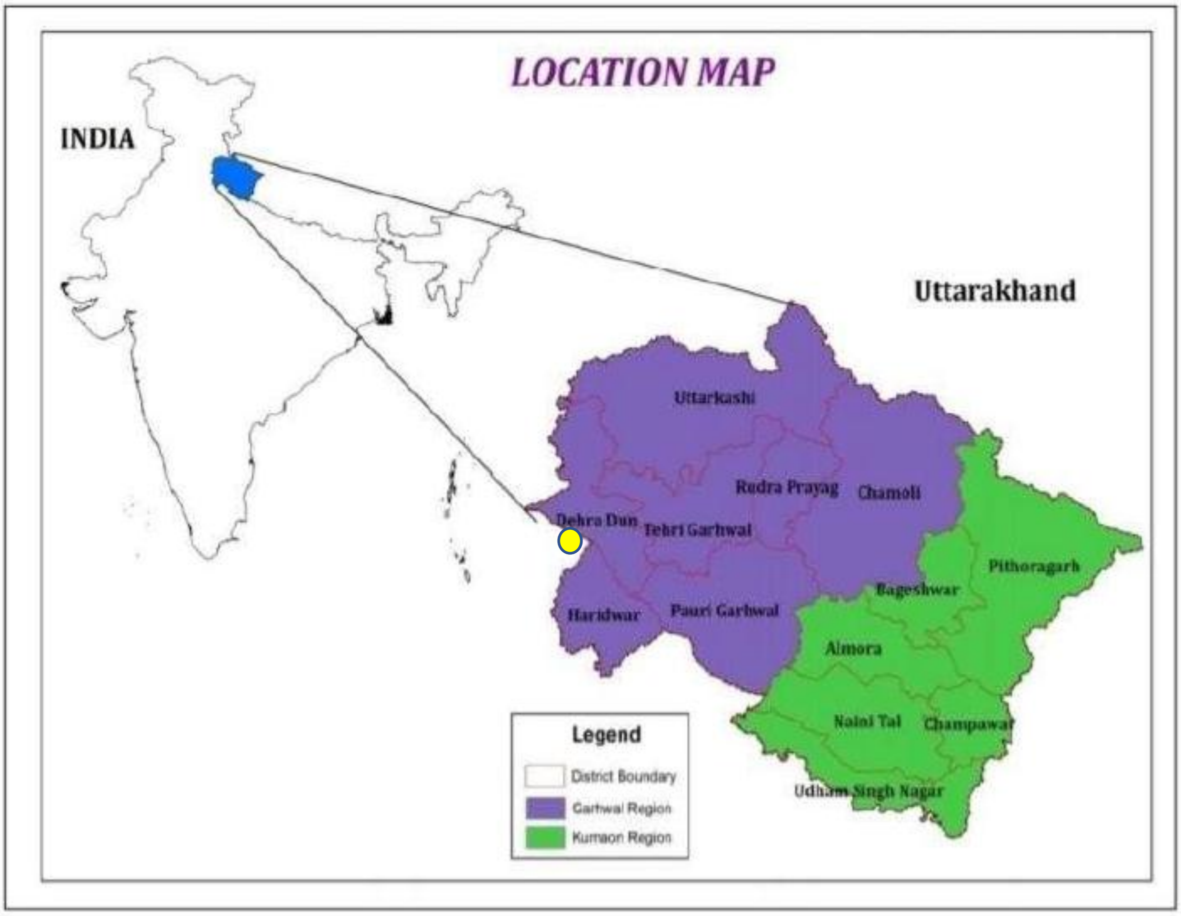

Figure 2 Political map of Rishikesh

Aims n Objectives

1. To establish the geological system of the Rishikesh area using local strati graphical unit and sub unit.
2. To establish the physical properties of rock formation of local strati graphical units and sub units.
3. To establish the engineering properties of rock formation of local strati graphical units and sub units.
4. Finally, to suggest the best use of rock material for the proper manufacturing of concrete to avoid the import of the material from Rajasthan

Methodology

The following methodology was adopted in order to establish the local stratigraphy as well as the sub surface strata condition and analysis if rock sampling for their physical and engg properties.

1. The strati graphic units were established with the help of GSI mapping and literature and research material and also the mapping of Wadiya Institute of Himalayan Geology along with their research papers. In this regard the annual report generated by these organizations were also considered.
2. The physical properties of the rock samples were established with the help of megascopic investigation.
3. The engineering properties were established with the help of IS code of practices and through published research papers.
4. Finally, after establishing the strati graphical units and local units along with physical and engineering properties of the rock materials the integrated properties for the best use of concrete were recommended.

Experimental study

The experimental study was intended to replace the natural coarse aggregate with locally available coarse aggregate in the Rishikesh area to prepare the concrete design mix. The cement used in this study was Ordinary Portland Cement-43 grade. The locally available aggregates used were phyllite, slate and limestone with maximum nominal size of 20 mm and natural available sand was used as fine aggregate. The physical properties of fine aggregate (sand) used are presented in Table 1 along with properties of cement used.

Physical properties of cement and aggregates used

1.

Property of Fine used

Aggregate Type	:cific Gravity	Water Absorption(%)	Grading Zone
Natural Aggregate	Fine	2.0	Zone II As per Table 4 of IS 383

Table 1 Property of Fine Used

2.

Property of Cement used

Cement Type	**Ordinary Portland cement**
Grade	43- Grade
Admixture Used	Nil

Table 2 Property of Cement Used

Results and Discussion

Workability

The compaction factor test as per IS 1199 (1999) was carried out for measurement of workability of concrete. The curve in Figure 3 to 4 shows change in workability by replacing of natural coarse aggregate by phyllite, slate and limestone aggregate respectively.

The compaction factor value for natural aggregate for M30 concrete was calculated as 0.82.

- **Phyllite Aggregate**

Phyllite is a metamorphic rock with a shiny surface. The lustre is caused by the mica particles present within the rock. It is primarily composed of quartz, mica, and chlorite.

M30 concrete was prepared by replacing coarse aggregate in proportion of 10%, 20% and 30% with phyllite as the aggregate. The below graphs compares the workability achieved by concrete with Phyllite aggregate to concrete with natural aggregate.

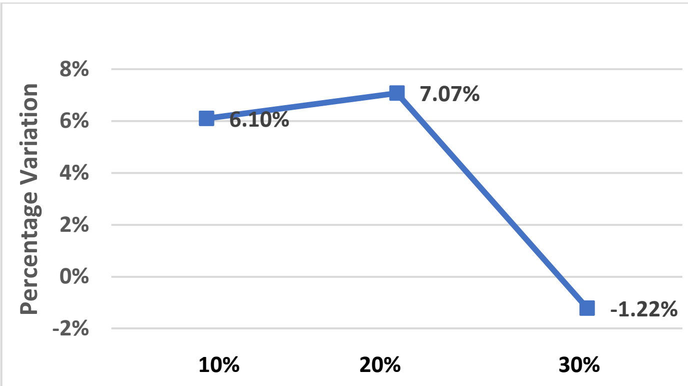

Figure 3 Percentage variation of workability of concrete with Phyllite aggregate and natural aggregate

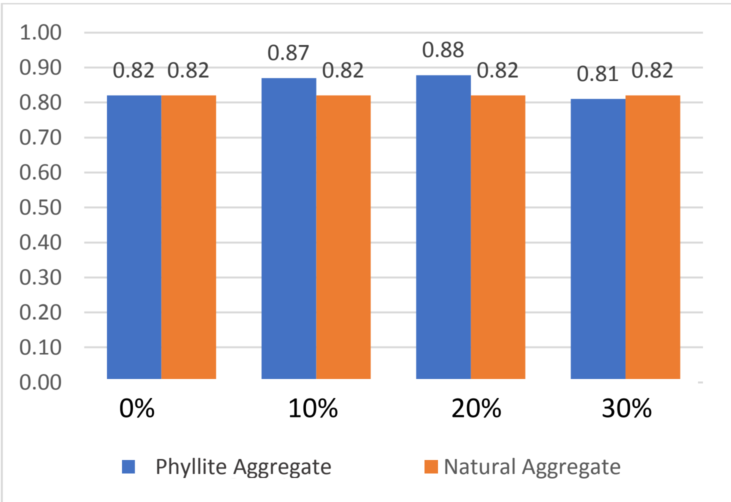

Figure 4 Result for compaction factor test of concrete with Phyllite aggregate

From the Figure 4 it can be seen that, the workability obtained from 10% replacement and 20% replacement increased with increased in phyllite aggregate proportion in the concrete mix. An increase of 6.10 % in compaction factor was observed when conventional coarse aggregate was 10 % replaced by phyllite aggregate and an increase of 7.1 % in compaction factor was observed when conventional coarse aggregate was 20 % replaced by phyllite aggregate.

- **Slate Aggregate**

Slate is a metamorphic rock with blackish grey colour and has a smooth texture. It known for its high hardness and abrasion property.

M30 grade of concrete were prepared by replacing coarse aggregate with 10%, 20% and 30% by proportion of slate as the aggregate. The below graphs compares the workability achieved by concrete with slate aggregate to concrete with natural aggregate.

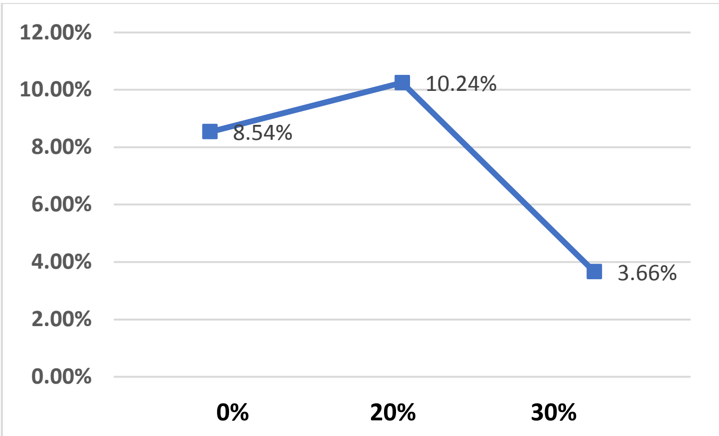

Figure 5 Percentage variation of workability of concrete with Slate aggregate and natural aggregate

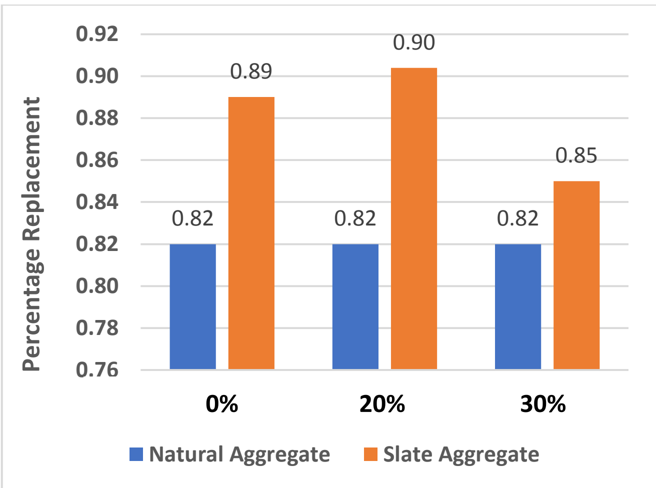

Figure 6 Result for compaction factor test of concrete with Slate aggregate

From the Figure 6 it can be seen that, the workability obtained from 10% replacement and 20% replacement increased with increased in slate aggregate proportion in the concrete mix. An increase of 8.54 % in compaction factor was observed when conventional coarse aggregate was 10 % replaced by slate aggregate and an increase of 10.24 % in compaction factor was observed when conventional coarse aggregate was 20 % replaced by slate aggregate.

- **Limestone**

Limestone is a sedimentary rock and is used as primary ingredient in the manufacturing of the cement.

M30 grade of concrete were prepared by replacing coarse aggregate with 10%, 20% and 30% by proportion of limestone as the aggregate. The below graphs compares the workability achieved by concrete with limestone as aggregate to concrete with natural aggregate.

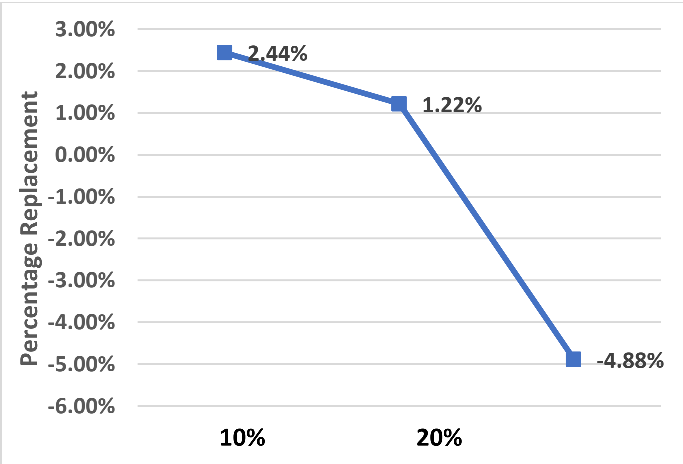

Figure 7 Percentage variation of workability of concrete with Limestone and natural aggregate

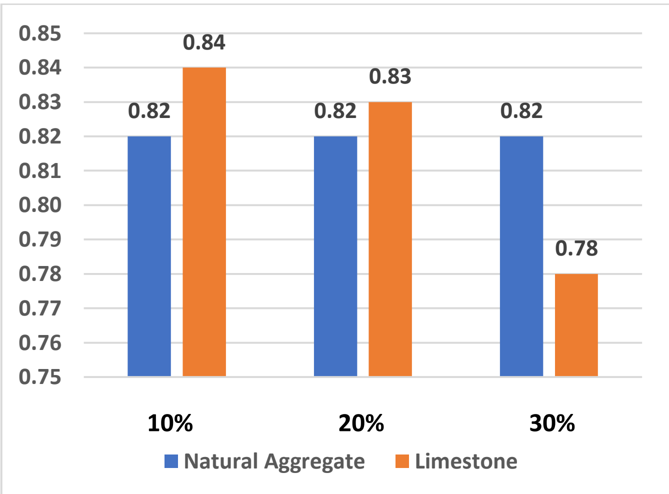

Figure 8 Result for compaction factor test of concrete with Limestone aggregate

From the Figure 8 it can be seen that, the workability obtained from 10% replacement and 20% replacement increased with increased in Limestone aggregate proportion in the concrete mix. An increase of 2.44 % in compaction factor was observed when conventional coarse aggregate was 10 % replaced by Limestone aggregate and an increase of 1.22 % in compaction factor was observed when conventional coarse aggregate was 20 % replaced by Limestone aggregate.

COMPRESSIVE STRENGTH

The concrete cube specimens were cast and tested as per IS 516 (1999). The specimens were tested at 7 and 28 days of curing age and the results are presented below. It can be seen that, the use of slate aggregate resulted in increase in compressive strength. This increase was prominent in 7 days and 28-days strength. The compressive strength test results of concrete for different proportion of concrete are shown below. Design mixed used for this study is M30.

Table (a) 7 Days cube compressive strength (N/mm²) of concrete

Grade of Concrete	Average Compressive Strength of OPC Natural Aggregate (N/mm²)
M 30	20.0

Table (a) 28 Days cube compressive strength (N/mm²) of concrete

Grade of Concrete	Average Compressive Strength of OPC Natural Aggregate (N/mm²)
M 30	30.0

PHYLLITE

Table (a) 7 Days cube compressive strength (N/mm²) of concrete

Grade of Concrete	Percentage Replacement	Average Compressive Strength Phyllite Aggregate (N/mm²)
M 30	10%	22.1
	20%	24.34
	30%	19.81

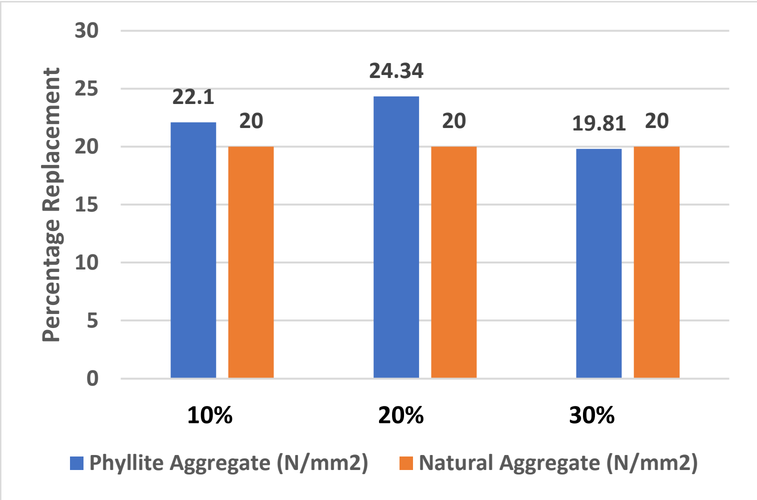

Figure 9 Average Compressive strength of phyllite aggregate and Natural aggregate

Table (a) 28 Days Cube compressive strength (N/mm²) of Concrete

Grade of Concrete	Percentage Replacement	Average Compressive Strength Phyllite Aggregate (N/mm²)
M 30	10%	33.8
	20%	34.56
	30%	29.1

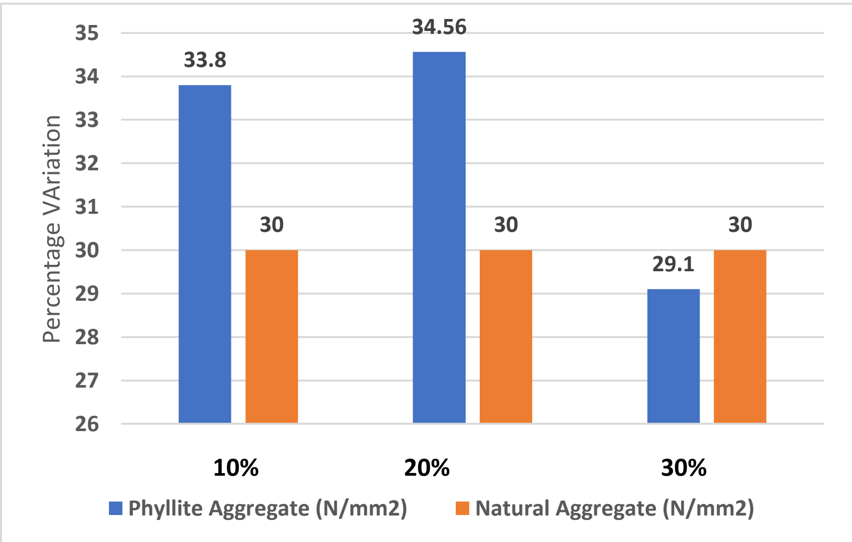

Figure 10 Result for compressive test of concrete with Phyllite aggregate

The compressive strength test results of concrete for M 30 grade is shown in table. It presents the comparison of 7-day and 28-day compressive strength (mean). The compression load was applied at a rate of 3kN/s using a compression machine of the capacity of 2000 kN.

SHALE

Table (a) 7 Days cube compressive strength (N/mm²) of concrete

Grade of Concrete	Percentage Replacement	Average Compressive Strength Phyllite Aggregate (N/mm²)
M 30	10%	23.41
	20%	25.49
	30%	19.9

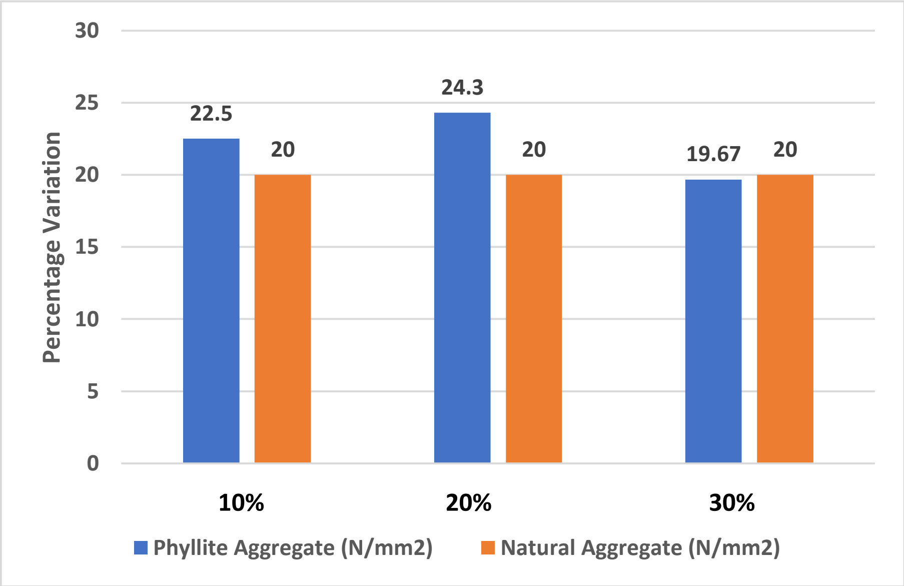

Figure 11 Average Compressive strength of Land Natural aggregate

Table (a) 28 Days Cube compressive strength (N/mm²) of Concrete

Grade of Concrete	Percentage Replacement	Average Compressive Strength Phyllite Aggregate (N/mm²)
M 30	10%	34.51
	20%	35.2
	30%	28.1

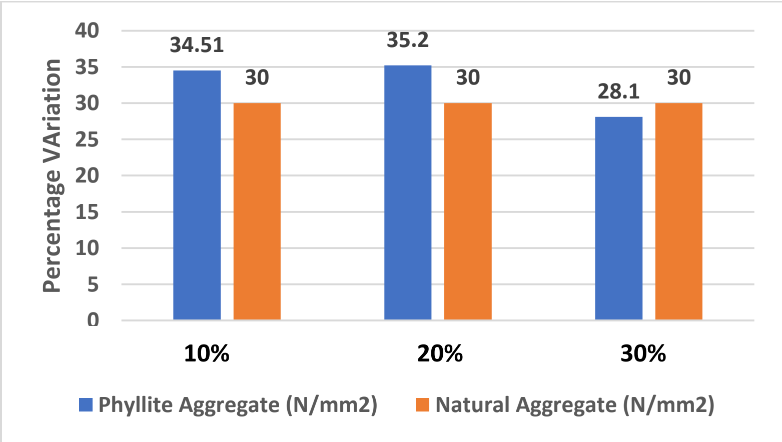

Figure 12 Result for compressive test of concrete with Marble aggregate

The compressive strength test results of concrete for M 30 grade is shown in table. It presents the comparison of 7-day and 28-day compressive strength (mean). The compression load was applied at a rate of 3kN/s using a compression machine of the capacity of 2000 kN.

LIMESTONE

Table (a) 7 Days cube compressive strength (N/mm²) of concrete

Grade of Concrete	Percentage Replacement	Average Compressive Strength
		Phyllite Aggregate (N/mm²)
M 30	10%	22.56
	20%	24.5
	30%	19.84

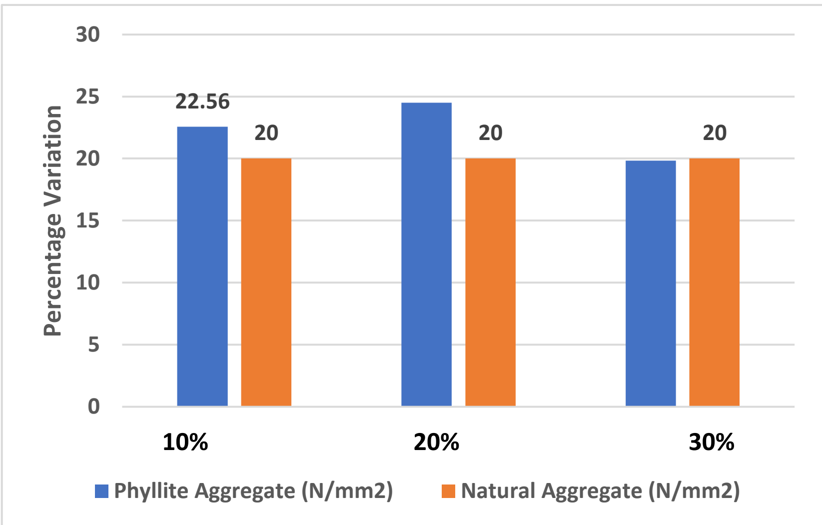

Figure 13 Average Compressive strength of Limestone and Natural aggregate

Table (a) 28 Days Cube compressive strength (N/mm²) of Concrete

Grade of Concrete	Percentage Replacement	Average Compressive Strength Phyllite Aggregate (N/mm²)
M 30	10%	34.1
	20%	34.8
	30%	28.5

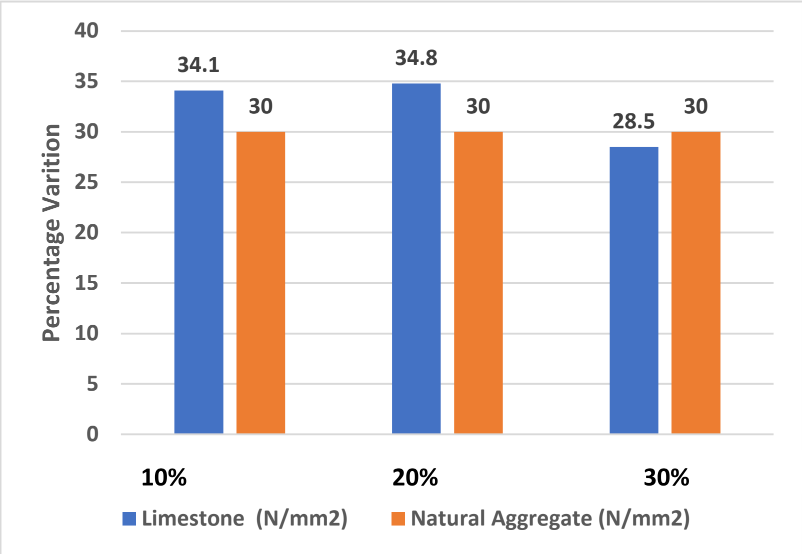

Figure 14 Result for compressive test of concrete with Limestone aggregate

The compressive strength test results of concrete for M 30 grade is shown in table. It presents the comparison of 7-day and 28-day compressive strength (mean). The compression load was applied at a rate of 3kN/s using a compression machine of the capacity of 2000 kN.

CONCLUSIONS

In this study, the effect of replacing phyllite aggregate, slate aggregate and limestone aggregate respectively on the properties of concrete were investigated and it can be concluded that

I. The fresh concrete property i.e. workability increases with increased in phyllite aggregate proportion in the concrete mix. Increase of 6.10% in compaction factor was observed when 10% phyllite aggregate was replaced by conventional coarse aggregate and an increase of 7.1 % in compaction factor was observed when 20% phyllite aggregate was replaced by conventional coarse aggregate of all concrete mixes.

II. The workability obtained from 10% replacement and 20% replacement increased when slate aggregate proportion increased in design mix. An increase of 8.54 % in compaction factor was observed when 10 % slate aggregate is replaced by conventional coarse aggregate and an increase of 10.24 % in compaction factor was observed when 20 % slate aggregate is replaced by conventional coarse aggregate.

III. An increase in workability of 2.44 % was observed when 10 % of Limestone aggregate was replaced by conventional coarse aggregate and an increase of 1.22 % is observed when conventional coarse aggregate was 20 % replaced by Limestone aggregate.

IV. The maximum increase in the workability was seen during the partial replacement of natural aggregate with phyllite aggregate. It was further followed by slate aggregate and then Limestone aggregate. The reason for such increase in workability is the matter for further research.

V. Compressive strength for 10% and 20% replacement of aggregate in concrete mixes containing phyllite aggregate, slate aggregate and limestone aggregate shows upward trend. However, the increase in compressive strength was seen the most in the case of addition of phyllite aggregate in place of natural aggregate.

VI. Decreasing trend in compressive strength was observed when 30% of the natural aggregate was replaced. Hence, replacement of natural aggregate beyond 20% is not recommended as per this study.

It concludes that, the natural aggregates can be partial replaced by phyllite aggregate, slate aggregate and limestone aggregate in concrete mixes. More studies will be required to use this waste material as construction material in concrete mixes.

REFERENCES

1. Ziaur Rehman Ansari, "Detail analysis of digital elevation model for geological and geomorphological studies in Sitla Rao watershed area of Dehradun district, Uttarakhand, India"
2. Kewal K Sharma, "Geologic and tectonic evolution of the Himalaya before and after the India-Asia collision"
3. IS 456:2000, Plain and Reinforced Concrete Code of Practice, 2000.
4. IS 1199: 1959, Methods of Sampling and Analysis of Concrete, 1959.
5. IS 10262: 2009, Concrete Mix Proportioning – Guidelines, 2009.
6. IS 516: 1959, Method of Tests for Strength of Concrete, 1959.
7. Anikoh G.A.; Olaleye B.M, "Estimation of Strength Properties of Shale from Some of Its Physical Properties Using Developed Mathematical Models"
8. Pedro Santare´m Andrade; Anto´nio Almeida Saraiva, "Physical and mechanical characterization of phyllites and metagreywackes in central Portugal"
9. Ram Jivan Singh; K. Milankumar Sharma; Pankaj Kumar; T. Ghosh, "Lithostratigraphy, trace fossils and palaeoenvironment of Paleogene sequences in Parwanoo-Subathu sector of Himachal Himalaya, India"
10. Abdulmageed Osunkunle; Ogwuche Audu Henry Lollini, "Harnessing local building materials in building construction for sustainable development in the 21st century"
11. Iwuagwu Ben Ugochukwua; Iwuagwu Ben Chioma Mb, "Local building materials: affordable strategy for housing the Urban poor in Nigeria."
12. J.C. Morela; A. Mesbaha; M. Oggerob; P. Walker, "Building houses with local materials:means to drastically reduce the environmental impact of construction."