A Study of River-Borne Aggregates of River Nanoi as Construction Material

Indira Baruah Gogoi[1], Dr. Diganta Goswami[2], Dr. Girindra Deka[3]
[1]Associate Proffssor in Geology, [2]Associate professor in civil Engg. [3]Retired Associate Professor,
Deptt. of Civil Engineering, Assam Engineering College, Guwahati, Assam, India

***ABSTRACT*: *Aggregate is indispensable in all civil engineering construction works. Due to increase in infrastructure developmental works, demand for aggregate is also increases and so a thorough study of the properties is essential to select the best quality aggregates available as per the standards set by different organisations at economical rate. In North-Eastern region of India there are a number of rivers which carry innumerable aggregates. Proper use of these aggregate are economical if available near the construction site. So, a study has been carried out on Geological and Engineering properties of the river borne aggregates of the river Nanoi, Darrang district, Assam, both natural and crushed form to evaluate their suitability as construction material. The results of various geological and engineering test performed show that both the type of aggregates are suitable as construction material as per specification laid down by Indian Standard Institutions (Bureau of Indian Standard), Indian Roads Congress and Ministry of Surface Transport and various suggestions put forwarded by different authors in their different publications. However, from geological, engineering and economic point of view, aggregates of both forms from downstream side are found to be more suitable as construction materials.*

Keywords- *Allowable limit, geo-engineering, megascopic, river-borne aggregates, workability.*

Aggregate is a very important constituent of concrete and pavement construction. Due to increase in infrastructure developmental activity in Assam, demand for aggregates also increased day by day which necessitates the study and utilization of aggregates from other sources than the common hill quarry aggregates to ascertain their suitability as construction material. Naturally occurring river-borne aggregate is found to be the best one if they are available near the work site. A large number of rivers are flowing through the state Assam, each of them carry huge amount of sediments containing gravels. These aggregates can be collected from the rivers easily and used in different construction works such as building, roads, bridges, culvert etc. They are now extensively used in many parts of Assam but no detailed and systematic Geo-engineering study has been done so far on these river-borne aggregates except some organization like Road Research Laboratory, Public Works Department, Assam and some other private organizations only for specific utility of aggregates for particular constructional purposes.[1].With this view in mind "A study of river borne aggregates of river Nanoi as construction material" has been carried out on the coarse aggregates of the river both natural and crushed form.

1. INTRODUCTION

1.1 Study area

Amongst the many rivers flowing through Assam, the river Nanoi have been considered for the present study depending on the large scale occurrences of commercially viable aggregates that carry by the river. The name of the river "Nanoi"(Na-new, noi-river) itself explain that the river is relatively young or of later origin. The river originates from the Southern part of Bhutan at Khaling Wildlife Sanctuary (lat $26^{0}86^{/}80^{//}$N, lon.$92^{0}01^{/}64^{//}$E). It comes out from Tongsha (height 1220m) and enters Assam near the border Pillar No. 103. After flowing through different track and taking numbers of tributaries finally merges with Brahmaputra River at "Biringabari" in Darrang district. The total length of the river is approximately 104km. The river carries huge volume (41 hectare meter) of sediments annually in its course. The basin of the river approximately covers 504 Sq.km. The flood danger level of the river is 52.12km. [2]. For the present study aggregates have been collected from four locations from upstream to downstream of the river Nanoi-

1) Jalimukh, 2) Nanoi Forest Range office, 3) Bhutiachang, 4) Gitibari.

2. METHOD OF WORK

The following methods have been adopted:

i. Field work
ii. Laboratory work

2.1 FIELD WORK

The field work involves mostly visiting the river at different times, selection of site for sampling and collection of aggregates from different locations. Aggregates are collected manually using shovels and other hand tools so that representations of all required sizes are present. Field equipment such as GPS (Global Positioning System) has also been used to get the latitude, longitude and elevation of the study area.

2.2 LABORATORY WORK

2.2.1 Geological study and results

The megascopic geological study has been carried out to identify the different petrological characteristic such as rock type, shape and size, texture and structure, Surface texture etc by visual observations. Thin section are made from the samples and are studied with the help of Petrological microscope using computer aided software to identify constituent minerals present, microstructure and texture, size and shape of the minerals etc. As these microscopic characters do not vary in short distance transportation of the river, these are considered to be as the common characters of the rock types in all the four locations.

The aggregates of the Nanoi comprises of individual resistant rock units like Quartzite, Granite, Granite-Gneiss and Pegmatite. They are hard, compact and have interlocking grains. Essential mineral constituent in these rocks are Quartz and Feldspar. Texturally, much discontinuity is not observed in these rocks except gneissose structure in Granite-Gneiss. Small amount of Phyllite, Sandstone and Slate are also present in the aggregates but their presence is negligible in comparison to other rock units. Mineralogical composition, grain size and texture suggest that all the major individual rock units are usable as construction material except phyllite, sandstone and slate. Phyllite and slate have linear structure and sandstone is porous in nature [3]. As individual rock units are suggested to be usable as construction material the rock mass that is composed of them will definitely be usable as construction material. The geological test results are shown in Tabular form in TABLE-1.

2.2.2 Engineering test results and observations

The following tests have been carried out to evaluate the engineering properties of the rock aggregates and the results are shown in TABLE-2.

(a) Aggregate Impact test: - The test has been carried out as per the procedure recommended in IS: 2386(part-iv)-1963.[4]. The mean result of five tests of a sample has been determined. All such values of the samples of a particular site have been averaged and this result has been presented. Aggregate Impact value gives relative measure of the resistance of an aggregate to impact. The aggregates of both the forms have aggregate impact value below the specified limit and they are suitable for use in all types of construction works. Aggregate Impact values are also gradually decreasing from upstream to downstream and thereby quality is increasing. This may be due to the removal of unwanted and soft materials from the aggregates during their transportation from upstream to downstream by the river action.

(b) Aggregate Crushing Value test**:** - This test has been carried out as per the procedure recommended in IS: 2386(part-iv) 1963.[4]. The test were carried out on standard size aggregates i.e. passing 12.5mm IS sieve and retained on 10mm IS sieve. The mean result of five test of a sample has been determined. All such values of the samples of a particular site have been averaged and result has been reported. Aggregate Crushing value gives a relative measure of resistance of aggregates to crushing under gradually applied compressive load. The aggregate crushing value should not be more than 45% for aggregates used in concrete other than wearing surfaces such as highways, runways and field pavements (IS: 383-1970).[5]. Both types of aggregates from upstream to downstream having aggregate crushing value below the specified limits and they are suitable for all types of pavement wearing surface and concrete works. Aggregate crushing value is gradually decreasing from upstream to downstream in both forms of aggregates and the quality is increasing.

(c) Aggregate Abrasion Value Test**: -** The Los-Angeles abrasion test was done as per IS: 2386 (part-iv)-1963[4]. The samples used in this test conform to the seven grading recommended by the IS code. Rock aggregates when used as road material should be hard enough to resist the abrasion caused by traffic load. Los-Angeles abrasion test is carried out to test hardness property of aggregates. The abrasion value should not be more than 30% for wearing surfaces and 50% for concrete other than wearing surfaces. It is observed that aggregate abrasion value of both natural and crushed form from upstream to downstream are within the specified limits and values are gradually decreasing and quality is increasing. Both forms of aggregates can be used for all types of bituminous pavements.

(d) Specific Gravity and Water Absorption: IS: 2386 (part-iii) 1963[6] recommended four methods for determination of Sp.Gr. and W.A values. Method-11 as prescribed by IS was adopted with size of aggregates in between 40mm-10mm.

Specific gravity is one of the important physical properties of aggregate and considered to be a measure of quality and strength of the material. The allowable limits of specific gravity are not specified. However, rock having higher Sp.Gr. (2.5-2.9) is preferred for road material (IRC-1985).[7] The aggregates of both the types from upstream to downstream in all the four locations have higher Sp.Gr. (2.65-2.68) and gradually increasing the values and suitable as road material and other construction work.

Water Absorption of an aggregate is usually accepted as a measure of its porosity. Porosity and water absorption affect the water-cement ratio and the workability of concrete and bituminous binder. The usual allowable limit for water absorption is 2% maximum (IRC: 1985).[7]. However, (IRC: 23-1966) [8] has specified that for two coats bituminous surface dressing, maximum value of water absorption is 1%. Aggregates of both the types show water absorption below the allowable limit and suitable as road material. From upstream to downstream of the river in all four locations, identical water absorption values have been found.

(e) Flakiness Index**:** Standard test procedure as recommended in IS: 2386 (part-1)-1963[9] has been adopted. Presences of large amount of flaky particles increases the degradation property of bituminous mixes and have objectionable influence on the workability, cement requirement and strength in a concrete mixture, as they make poor concrete. [10]. From the comparison and specification laid down by IS, IRC and MORTH, it is seen that flakiness index are found to be higher in both the forms of aggregate. It is gradually increasing from upstream to downstream of the river. In crushed form, it is found to be much higher than natural aggregates and thus not suitable for WBM (Water Bound Macadam) and granular base course. For normal mix design, the combined (flakiness and elongation) index foe coarse aggregate may be limited to 25 %. [11]. Flakiness Index is also depends on crushing technique. In this study manual crushing have been done. By using modern crusher this property can also be improve.

(f) Slake Durability Test**:** The test has been carried out as per procedure recommended by IS: 10050-1981.[12]. Slake Durability test (SD) is regarded as a simple test for assessing the influence of weathering on rock and its destruction. It depends on climate and atmosphere and amount of exposure of rock mass. To describe the ranking of rock durability, an index to alteration is used known as Slake Durability Index. [13]. Both the forms of aggregates from upstream to downstream side of the river, values are increasing and found to be extremely durable and can be used in all types of constructions.

(g) The Stripping Test (Bitumen Adhesion test): Bitumen binds well to dry and clean aggregates. Among a number of stripping tests recommended by IS: 6241:1971[14], the film stripping device test that is a type of dynamic immersion test was adopted. The mean of four test results was determined as the stripping value of each sample of a particular location. All such values of all samples of a particular location were averaged and this result has been reported. From comparison of test results with the standard specifications indicates that both the types of aggregates shows stripping value within the specified limits and they are suitable for use in all types of pavement works.

3. ECONOMIC ASPECTS

Economy is the prime factor for implementation of any civil engineering project and the cost of aggregates takes a major share of it. In case of river-borne aggregates the nature has already converted the rock into required sizes and can be collected easily which will considerably reduce the material cost and as a whole minimize the construction cost of any civil engineering project. Before collection of huge volume of materials from any river, the environmental and ecological aspect study is another most important factor for future of the river.

Table 1

Petrographycal Test Results of coarse river borne aggregates of river Nanoi by visual observation and Microscopic study with computer aided software

Rock unit	Texture & structure	Minerals with percentage	Special characteristics of minerals
Quartzite (metamorphic)	Medium-fine grained, compact, granular	Quartz (87.15), plagioclase (4.02), microcline (3.07), Biotite(2.16), muscovite(2.20), accessory minerals (1.50).	Quartz-anhedral, shows undulose extinction, Feldspar comprising of both plagioclase and microcline are tabular, plagioclase shows polysynthetic twinning whereas microclines exhibits cross-hatch twinning. Mica comprising of Biotite and muscovite are flaky in nature. Biotite is brown in colour with one set cleavage, muscovite is colourless.
Granite Gneiss (metamorphic)	Coarse –medium grained, foliated, gneissose structure	Quartz(42.15), microcline (23.06), plagioclase(24.98), biotite(7.21), hornblende(3.46),, accessory minerals(3.40)	Quartz is anhedral to subhedral and shows stressed and unstressed character. Feldspar of both varities shows minor alteration. Some biotite are folded.
Granite (igneous)	Medium-fine grained, holocrystalline, non-foliated,	Quartz(32.10), plagioclase(23.59), microcline (20.30), biotite(11.91) ,hornblende(5.75) accessories(6.55)	Quartz is anhedral to subhedral, Biotite-flaky, irregular boundary, pleochroic-light to dark brown. XBoth plagioclase and microcline are prisomatic, horblendes are green in colour and shows two sets of cleavages.
Pegmatite (Igneous)	Coarse grained ,compact ,equigranular, interlocking grains	Quartz(41.43), plagioclase(25.02), microcline(23.04), biotite(5.46), accessories(5.05)	Quartz-sub-hedral; plagioclase and microcline show lamellar and cross-hatch twinning, biotite is light brown in colour with one set of cleavage and shows straight extinction.
Phyllite (metamorphic)	Fine grained, foliated,	Sericite(38.51), chlorite(35.12), quartz(10.38) , feldspar(12.64), accessories(3.10)	Quartz and feldspar found as inclusion in sericite, colour-white to dirty white, medium grain size,sericite-greyish to light greenish coloured, chlorite-greenish, fine grained
Sandstone (sedimentary)	Medium grained, clastic	Quartz(89.67), muscovite 2.02), biotite(2.58), iron oxide(1.46), accessories(4.27)	Quartz-rounded, shows undulose extinction; muscpvite-light grey; biotite-light brown; both are flaky, irregular grain boundary, basal cleavage; iron oxide-black coloured, irregular shape.
Slate (metamorphic)	Fine grained, slaty cleavage	Mica(38.31), quartz(27,35), feldspar(15.27), iron oxides(3.42), chlorite(12.05), others(3.60)	Mica-dark coloured, flaky with irregular boundary, Quartz-anhedral to sub-hedral, dirty white coloured, feldspars are dirty coloured, iron oxide- black coloured, irregular shape, chlorite- green coloured.

Table-2 Engineering Test Results Of Coarse River-Borne Aggregates of River NANOI (Natural & Crushed)
Sample collected from: 1) Jalimukh, 2) Near Forest Range Office, 3) Bhutiachang, 4) Gitibari

Site u/s to d/s	sample type	FI % n_1	AIV% n_5	ACV% n_5	SDV% n_5	SP.Gr n_5	W.A % n_5	SV% n_4	AAV % n_1						
									A	B	C	D	E	F	G
1	N	13.74	19.96	21.37	98.47	2.656	o.608	6	17.90	21.04	28.62	30.12	12.88	13.73	17.12
	C	24.16	20.61	24.09	98.64	2.642	0.556	8	21.12	23.56	28.7	31.32	15.78	13.75	17.43
2	**N**	16.84	14.64	19.09	99.41	2.663	0.586	6	15.16	20.5	27.78	29.06	11.76	12.37	16.85
	C	28.06	16.99	22.23	99.27	2.651	0.60	8	21.02	22.92	28.58	29.96	14.37	12.58	16.90
3	**N**	17.31	13.73	18.39	99.48	2.672	0.371	5	13.5	19.75	27.12	28.62	10.58	11.26	15.83
	C	30.19	16.16	20.78	99.42	2.660	0.43	6	19.90	22.18	28.42	29.3	13.96	11.88	15.96
4	**N**	18.83	12.90	17.75	99.76	2.684	0.41	5	13.16	19.12	26.54	27.82	10.21	10.89	14.79
	C	31.68	15.86	20.18	99.70	2.681	0.37	6	18.72	21.12	27.78	28.36	12.56	11.37	15.08

(FI= Flakiness Index; AIV= Aggregate Impact Test; ACV= Aggregate Crushing Value; SDV= Slake Durability Value; Sp.Gr. = Specific Gravity; WA= Water Absorption; SV= Stripping Value; AAV= Aggregate Abrasion Value.)

N.B. The suffix 'N' indicates natural, 'C' indicates crushed, 'n' indicates number of samples considered, 'u/s' &'d/s' indicates upstream side and downstream side of the river.

3. Conclusion

The availability of aggregates in close vicinity of the construction site will be the prime factor which will govern the use of natural river aggregates or crushed quarry aggregates as construction material. The river-borne aggregates of river Nanoi in all four locations consist of resistant rock like Quartzite, Granite, Granite-gneiss and pegmatite. A negligible amount of Phyllite, Slate and Sandstone are also observed. Major rock units are hard, compact and durable in nature and the rock mass consisting of these aggregates are also usable in all civil engineering construction works. It is observed that there are a less variations in engineering properties between the natural and crushed aggregates in all the four locations except flakiness index values which is marginally higher in crushed form and is not suitable for Water Bound Macadam (WBM) and granular base course. This may be due to manual crushing. By using modern mechanical crusher, the flakiness can also be reduced. Specific gravity does not show much variation in both forms of aggregates and gradually increasing from upstream to downstream of the river. Both forms of aggregates from upstream to downstream shows almost identical water absorption value for all four locations which are below the allowable limit and suitable for road and concrete works. Aggregate impact, aggregate crushing and aggregate abrasion values are gradually decreasing from upstream to downstream in both forms of aggregates and quality is thereby increasing and suitable for use in all types of pavement and concrete construction works. Very negligible amount of stripping value is found in both forms of aggregates; hence they can be used in bituminous road construction works. Apart from flakiness index in both forms, other properties shows increasing trend in quality towards downstream side of the river Nanoi.

So, from geological, engineering and economic point of view, downstream side coarse aggregates, both natural and crushed form are more suitable as construction material. Besides most of the test results reveal that natural form of aggregates are marginally superior to the crushed form of river borne aggregates of river NANOI.

REFERENCES

1 .G. Deka, P.K. Bora and P.K. Chowdhury, Some studies on correlation between Geological characteristics and Engineering properties of road aggregates, *Journal, Indian Road Congress, Highway Research Board, New Delhi*, 1998.

2. J.N. Sarma (2008): *Asomor Nad-Nadi* (Assam Sahity Sabha, Jorhat).

3.Parbin Singh, *A text book of Engineering and General Geology (*Theory & Practice, S. Chand & Company Ltd, Ram Nagar, New Delhi), 2004.

4. IS: 2386-(part- IV) 1963: *Indian Standard Methods of Test for aggregates for concrete*

5. IS: 2386(part-iii) 1963: *Indian Standard Methods of Test for aggregates for concrete.*

6. IS: 383-1970: *Indian Standard Specification for coarse and fine aggregates from natural sources for concrete.*

7. IRC-1985: *Specification for road and bridge works,* Ministry of Road and Highway (MORTH)

8. IRC-23-1966: *Tentative specification for two-coat bituminous surface dressing,* Indian Road Congress, New Delhi

9. IS: 2386(part-i) 1963: *Indian Standard Methods of Test for aggregates for concrete.*

10. M.S. Shetty (2012, reprint), *Concrete Technology, Theory and Practice* (S. Chand & Co. Pvt Ltd, New Delhi).

11.M.L. Gambhir (2011), *Concrete Technology, Theory and Practice* (Tata MacGraw Hill Education Private Limited, New Delhi).

12. IS: 10050-1981: *Indian Standard Methods for Slake Durability of aggregates*.

13. Dr. B.P. Verma, Rock *Mechanics for Engineers*,(Khanna publishers, Nai Sarak, Delhi-110006).

14. IS: 6241-1971: *Indian Standard Methods of test for determination of Stripping value of road aggregates*