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A STUDY OF GEO-ENGINEERING PROPERTIES OF RIVER-BORNE COARSE AGGREGATES OF RIVER PAGLADIA, BAKSA DISTRICT, ASSAM AS ROAD MATERIAL

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ABSTRACT

An attempt has been made to study the geological and engineering properties of the river-borne coarse aggregates of river Pagladia, Baksa district, Assam for evaluating their suitability as road material. The investigation were carried out on both natural and crushed form of the coarse aggregates of the river from upstream to gradually downstream to see their probable property variations. The results of various geological and engineering test performed show that both the type of aggregates are suitable as road 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 forward by different authors in their different publications. However, aggregates of both forms are found to be more suitable as road materials gradually from upstream to downstream side of the river.

Keywords: River Borne Aggregates, Quarrying, Aggradations, Mortar Bar, Innocuous, Anti-Ecological.

1. INTRODUCTION

In road construction, the greater part of the body of a road is generally constituted by the aggregates, which are supposed to bear the main stress under all types of traffic without undergoing much surface abrasion. This requires a thorough understanding of the properties which should be possessed by a good road aggregate and comprehensive knowledge of parent rock types that are used as source of these aggregates. Crushed or blasted quarry aggregates are commonly used as coarse aggregates in civil engineering construction works including roads. The quarrying by blasting however creates excessive destruction of both hilly structures and forest materials. Govt. of Assam has also banned on rock quarrying by blasting in most areas which create a huge gap between demand and supply. To full-up the gap it has become necessary to locate the alternative source of locally available natural aggregates. The cheapest among them are the natural sand and gravel which have been reduced to their present size by natural agents. Selection of these materials also depends on- physical properties, availability and economy in construction. In Assam, a large number of rivers are flowing, which carry a huge volume of sediments each year containing gravels. The geological and engineering properties of such river-borne aggregates require proper investigation for their better utility as road material. These aggregates can be used in two forms-(i) natural and (ii) crushed.

With this view in mind a study has been carried out on both natural and crushed form of the aggregates of the river PAGLADIA, a southern tributary of the river Brahmaputra in Assam with particular reference to their utility as road material. The study has been limited to coarse aggregates only.

Study Area: The Pagladia river originates from Southern slopes of Bhutan hills, a latitude of $26^0 59^/$ north and longitude of $91^0 27^/$ east and meet in Brahmaputra near Loopara. The river flows for a length of 19km in hilly track of Bhutan and rest 177.80km flows through the Baksa and Nalbari district of Assam. In course of its flow, the river receives many streams, sub-tributaries and drainage channels. Pagladia river system is one of the most problematic sub-basins so far as the sediment load and chronically flood affected areas are concerned. Transportation of heavy amount of silt and gravel and aggradations of river bed has been observed to be very prominent phenomenon in the Pagladia river. (Master plan of Pagladia sub-basin-Report volume 1996, Govt. of India)

For the present study, aggregates have been collected from four different locations i.e. Chowki, Subabkhata, Nayabasti and Khoirani- from upstream to downstream of the river respectively.

2. EXPERIMENTAL

The following tests have been carried out to evaluate the geological and engineering properties of the rock aggregates and results obtained are shown in tabular form.

2.1 Geological test

2.1.1 Megascopic study: Visual inspection has been done to identify the presence of different rock types that composed the mass, their texture and structure, shape and surface texture etc and is shown in Table-1.

The rock types as shown in table-1 are more or less found to be occurred in all the four locations as mentioned differing only in the percentage of occurrence. Further it is seen that angularity and surface texture of the natural aggregates are gradually decreasing towards the downstream side of the river.

2.1.2 Microscopic study: Microscopic study has been carried out with the help of petrological microscope using computer added software with photometric device to identify the minerals present, texture and structure and other characteristics of each rock type and shown in tabule-2. 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.

2.2 Engineering test:

The following tests have been carried out to evaluate the engineering properties of the rock aggregates and the results are shown in Table-3 and Fig-1.

2.2.1 Aggregate Impact test: - The test has been carried out as per the procedure recommended in IS: 2386(part-iv)-1963. 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.

2.2.2 Aggregate Crushing test: - This test has been carried out as per the procedure recommended in IS: 2386(part-iv) 1963. 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.

2.2.3 Aggregate Abrasion Test: - The Los-Angeles abrasion test was done as per IS: 2386 (part-iv). The samples used in this test conform to the seven grading recommended by the IS code.

2.2.4 Specific Gravity and Water Absorption test: - IS: 2386 (part-iii) 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.

2.2.5 Flakiness Index and Elongation Index: - Standard test procedure as recommended in IS: 2386 (part-1) has been adopted.

2.2.6 Alkali-Aggregate Reactivity: - IS: 2386 (part-vii) 1963 recommended two test procedures- Mortar Bar Expansion test and Chemical test. Only chemical test was adopted and results were plotted in prescribed graph. Alkali Aggregate Reactivity tests are performed only in crushed form.

2.2.7 Slake Durability Test: - The test has been carried out as per procedure recommended by IS: 10050:1981.

2.2.8 The Stripping Test (Bitumen Adhesion test):- Among a number of stripping tests recommended by IS: 6241:1971, 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. (Table-3)

3. RESULTS AND DISCUSSION

The results of both Geological (Table-1 &2) and Engineering (Table-3 & graph-1) test shows that the rock aggregates of the river Pagladia both natural and crushed form are within the prescribed limits for different types of road construction as specified by Indian Standard Institution (Bureau of Indian Standard, BIS), Indian Roads Congress (IRC), and Ministry of Road and Transport and Highways (MORTH).

The following is a summary of the main findings:

3.1 From geological point of view

Geological properties like mineralogy, grain size, texture, surface texture, structure, weathering characteristics etc. have direct bearing on engineering properties. (Deka, Bora and Choudhury,1999). Geological tests would develop a prima facie prior to performing elaborate engineering tests, (State of Art, IRC, New Delhi, 1985). The river borne aggregates of the river Pagladia are composed of metamorphic and igneous rocks except porous sandstone which is sedimentary in origin. Mineralogically all the rock types are hard and strong due to their formation but Quartz and feldspar in higher proportion. Texturally all the mineral grains show interlocking character, except sandstone. From structural point of view, they are devoid of much structural discontinuities except the presence of foliation in granite-gneiss and phyllite. Besides, phyllite shows more slaty behaviour. Phyllite due to its slaty nature and sandstone for its porous nature, are inferior to be use as road materials. Besides, their presents are negligible and hence their influencing affect is considered to be minor. Geologically these river borne aggregates with these properties can be suggested for use as road materials. (Satyanarayanswami,2000).

3.2 From Engineering point of view

(a) 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 pavement 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. (Appendex-1)

(b) Aggregate Crushing value gives a relative measure of resistance of aggregates to crushing under gradually applied compressive load. Aggregates having lower crushing value are preferred for high quality pavements. 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).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. (Appendex-2)

(c) Aggregate Abrasion Value-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 principle of los-Angeles abrasion test is to find out the percentage of wear due to relative rubbing action between aggregates and abrasive charges.

Table 1

Petrographical analysis by visual observation - presence of rock unit and their percentage, texture, structure, shape and surface texture of river borne aggregates of river Pagladia

Rock units	Percentage of rock unit Present (by wt.)	Texture & structure	Shape and surface texture
Quartzite (Metamorphic)	32.25-35.45	Coarse to medium grained, grey to light brown coloured, granulose structure , hard and compact	Sub-rounded to sub-angular, smooth to slightly rough surface, granular
Granite-Gneiss (Metamorphic)	24.00-25.40	Medium grained, shows distinct lineation, gneissose structure with grey colour	Sub-angular to sub-rounded, rough and fractured surface
Granite (Igneous)	23.15-25.25	Medium grained, holocrystalline, light coloured	Sub-angular to sub-rounded, rough to slightly smooth surface with prominent fracture
Pegmatite (Igneous)	4.25-5.10	White coloured, coarse grained, compact and granular textured	Sub angular to sub rounded, smooth surface
Phyllite (Metamorphic)	3.15-4.75	Grey coloured, fine grained, linear structure	Elongated to sub-rounded, smooth to slightly rough surface
Sandstone (Sedimentary)	1.50-3.05	Light brown coloured, medium grained	Sub-rounded to rounded, rough surface

Table 2: PETROGRAPHICAL TEST RESULTS OF COARSE RIVER BORNE AGGREGATES OF RIVER PAGLADIA USING PETROLOGICAL MICROSCOPE WITH COMPUTER AIDED SOFTWARE.

Rock units & their type	Texture & structure	Minerals with percentage	Special characteristics of minerals
Quartzite (Metamorphic)	Coarse- mecium grained, compact, granulose structure	Quartz (88.16,) microcline (2.15), plagioclase(3.09),Biotite(1.72), Muscovite(2.45), accessory minerals (2.43)	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 (Igneous)	Medium- fine grained. Holocrystalline, non-foliated	Microcline(25.36), Plagioclase (21.12), Quartz(36.78), biotite (10.84),hornblende(4.28) accessory minerals(1.62)	Quartz is anhedral to subhedral and shows stressed and unstressed character. Feldspar of both varities shows minor alteration. Some biotite are folded.
Granite Gneiss (Metamorphic)	Coarse- medium grained, foliated, gneissose structure	Quartz(39.56), Microcline(16..87) ,plagioclase (24.98), biotite(10.63), Hornblende(3.46), accessory minerals(4.50)	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	Quartz(43.46), Plagioclase(24.16), Microcline(21.78),biotite(4.98), Accessories(5.62)	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(39.50),chlorite(30.27), Quartz(11.23), feldspar(12.56), Accessories(	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 (88.78),muscovite(3.09), Biotite(2.15), iron oxide(1.89), Accessory minerals (4.09)	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 (Low grade 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.

N.B. Average results of four tests of each rock type collected from four sites of the river are shown.

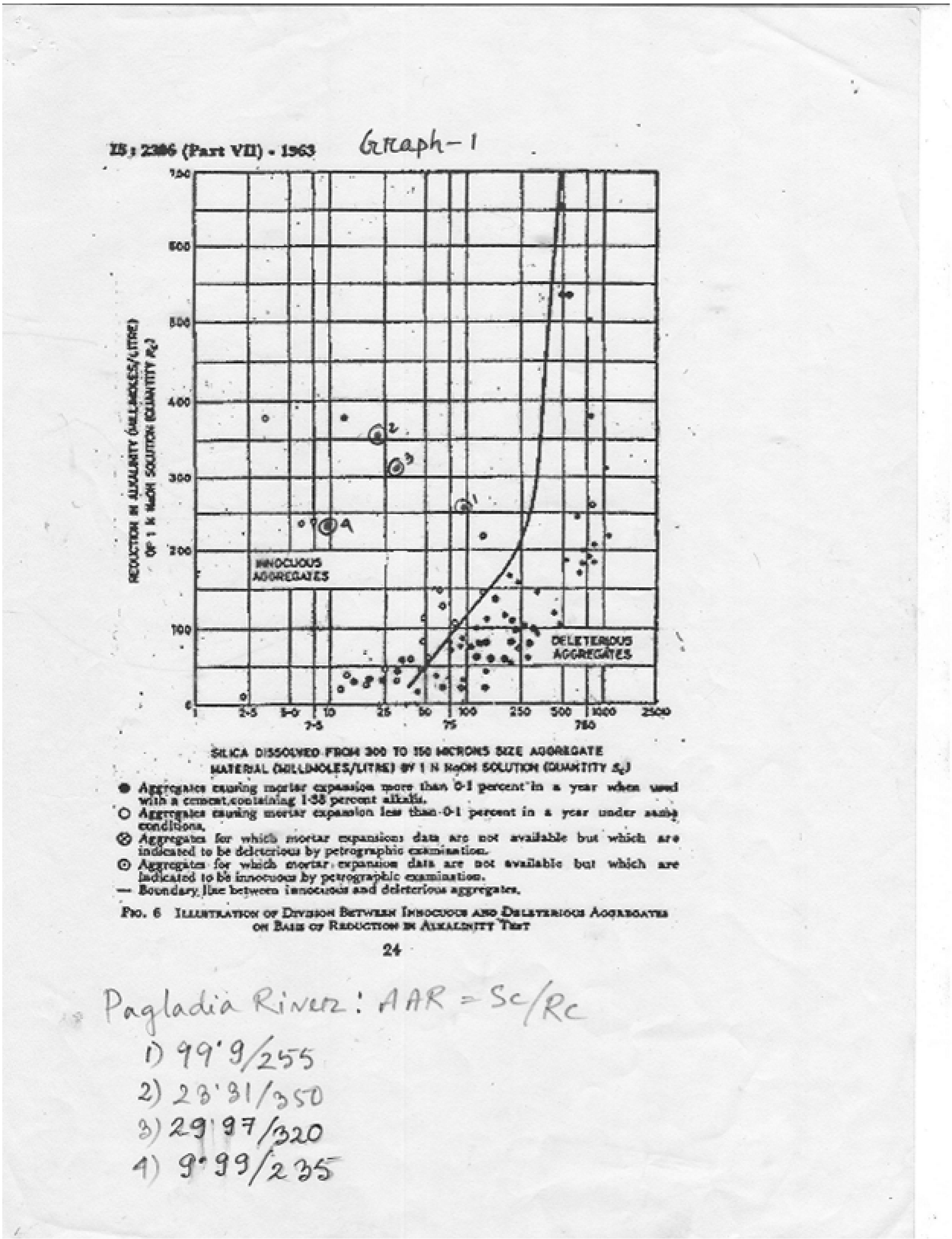
Table 3: COMPARISON OF ENGINEERING TEST RESULTS OF COARSE RIVER-BORNE AGGRGATES OF RIVER PAGLADIA ON NATURAL AND CRUSHED FORM

1. Chowki, 2. Subankhata, 3. Nayabasti, 4. Khoirani

Location u/s to d/s		FI % n_1	EI% n_1	AIV % n_5	ACV% n_5	Sg.Gr. n_5	WA % n_5	SDV % n_5	SV % n_4	AAR= Sc/Rc n_1 mmol/lt.	AAV %						
											A	B	C	D	E	F	G
1	N	17.16	22.20	18.43	26.14	2.72	0.43	98.23	3	99.9/ 255= 0.390	20.56	24.70	27.20	29.56	12.57	11.90	21.51
	C	24.52	29.49	20.13	28.67	2.73	0.64	98.09	6		23.60	27.56	31.74	32.9	13.47	14.51	27.56
2	N	18.61	23.24	18.23	25.29	2.72	0.64	99.50	2	23.31/ 350= 0.066	19.46	23.40	26.90	27.9	12.50	11.82	21.26
	C	26.07	29.49	18.38	28.67	2.74	0.51	99.10	4		23.12	26.20	30.12	32.50	12.75	12.68	25.50
3	N	20.52	23.77	16.97	23.82	2.73	0.58	99.58	2	29.97/ 320= 0.093	19.30	22.64	26.65	27.70	10.86	11.57	19.58
	C	26.84	31.24	17.51	25.42	2.78	0.64	99.18	4		22.46	26.10	29.70	30	11.30	12.09	23.50
4	N	21.10	24.16	16.04	22.21	2,76	0.43	99.67	2	9.99/ 235= 0.042	18.50	18.80	25.34	26.90	10.25	11.52	18.72
	C	28.78	33.17	16.48	22.86	2.79	0.47	99.41	5		21.50	24.20	28.18	29.80	10.51	11.83	22.10

(FI- Flakiness Index; EI-Elongation Index; AIV-Aggregate Impact Value; ACV- Aggregate Crushing Value; Sp.Gr.- Specific Gravity; WA- Water Absorption; SDV- Slake Durability Value; SV- Stripping Value; AAV- Aggregate Abrasion Value, AAR-Alkali Aggregate Reactivity)

N.B. The suffix 'N'indicates natural, Ç'indicates crushed, 'n'indicates no. of samples considered, 'Sc'indicates quantity of concentration of Silica, 'Rc'indicates quantity of reduction in Alkalinity, ú/s'& d/s indicates upstream side and downstream side of the river.



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. (Appendex-3)

(d) 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) are preferred for road material(IRC-1985). The aggregates of both the types from upstream to downstream in all the four locations have higher Sp.Gr. (2.72-2.79) and gradually increasing the values and suitable as road material.

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. The aggregates when mix with bituminous binders, are likely to absorb binder at a rate of about half of the water absorption rate. The usual allowable limit for water absorption is 2% maximum (IRC: 1985). However, (IRC: 23-1966) has specified that for two coat 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 of aggregate is the percentage by weight of particles in it who's least dimension (thickness) is less than three-fifth of their mean dimension. Presence of large amount of flaky particles increases the degradation property of bituminous mixes. (Appendex-4)

The Elongation Index of an aggregate is the percentage of weight of particles whose greater dimension (length) is greater than 1.8 times their mean dimension. (Ministry of surface transport, UK, 1962). Flaky and elongated particles have particularly objectionable influence on the workability, cement requirement and strength in a concrete mixture, as they make poor concrete.
From the comparison and specification laid down by IS, IRC and MORTH, it is seen that flakiness and elongation 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. Flakiness Index and Elongation Index are also depended on crushing technique. In this case, aggregates are manually crushed. For normal mix design, the combined (flakiness and elongation) index for coarse aggregate may be limited to 25%. (Gambhir, 2011)

(f) Alkali Aggregate reactivity (AAR) is the reaction between active silica constituents of the aggregates and alkalis i.e. N_20 and K_2O present in cement. In AAR, aggregates containing reactive silica will react with alkali hydroxide in concrete to form a gel that swells as it absorb water from the surrounding cement paste or environment and induce enough expansive pressure to damage concrete by cracking, joining etc. IS: 2386(part-vii) 1963, describe two methods namely the Mortar Bar Expansion test and the Chemical test for the determination of potential reactivity of the aggregates. In this study, chemical test has been performed to determine the AAR. By plotting the value in the prescribed graph and comparing it with the recommended value in the graph, the aggregates are found to be innocuous; hence they can be used in concrete works in road constructions.

(g) 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. Before using a rock mass, its durability has to be ascertained. To describe the ranking of rock durability, an index to alteration is used known as Slake Durability Index. Gamble (1971) has proposed a test to determine slake durability index. He recommended two cycle but Franklin and Chandra (1972) recommended for only one cycle of revolution (Verma, 2009). 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. (Appendex-5)

(h) Stripping value test (SV) - Bitumen binds well to dry and clean aggregates. If aggregates are wet and cold, bitumen does not coat the aggregate properly and also stripping of bitumen from the coated aggregates due to presence of water. Some aggregates (such as silica, igneous rock) posses weak negative charge and as a result have greater attraction to polar liquid water than to bitumen with polar activity. Mineralogy of the aggregates affects their affinity towards bitumen. Though several tests are available to determine arbitrarily the adhesion of bituminous binder to an aggregate in presence of water- dynamic immersion test has been used in this present study.

From comparison of test results (Table-3) with the standard specifications (Appendix-6) 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. However, natural river-borne crushed aggregates have shown slightly higher affinity towards bitumen than crushed aggregates.

4. 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. The advantage of using river-borne aggregate is that, they are easily available, costly excavation and blasting is not required. Only collection, screening at source, loading, unloading and transportation are the major operations required to get these aggregates from river bed. Ordinary labour can do all these operations. Another major aspect is that there is no hill quarry in the nearby areas in Baksa and Nalbari districts of Assam but river-borne aggregates having lowest cost are easily available. So, collection of rock aggregates from river bed in these areas would also provide a means of livelihood for the local people which will improve the socio-economic condition of the nearby areas and also considerable reduction can be made in the cost of construction. Before collection of huge volume of materials from any river, the environmental and ecological aspect study is most important factor for future of the river and during collection period, proper monitoring is also another essential condition.

5. CONCLUSION

The coarse aggregates of river Pagladia comprises mostly of resistant rock units- Quartzite, Granite gneiss, Granite and pegmatite and less resistant Sandstone and phyllite in small amount. The percentage of Quartzite, granite gneiss and granite are higher than the other rock units. Mineralogical composition, grain size, texture and structure suggest that all the major individual rock units are usable as road materials. However, Phyllite is somewhat inferior due to their mineral constituents and linear structure and likewise Sandstone due to its porous nature, but their presence is negligible.

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 and elongation index values. In crushed form aggregates flakiness and elongation index value is higher and are not suitable for Water Bound Macadam (WBM) and granular base course. FI and EI also depend upon the crushing technique. In this study, the aggregates are crushed by manually, so FI and EI values are higher. 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. Aggregate abrasion values of crushed form are slightly higher due to presence of flaky particles in the mass. Both the form of aggregate is suitable for all types of bituminous pavement. After using mechanical crusher and proper screening, they can also be used in wearing surface of concrete pavement. The alkali aggregate reactivity test (chemical) values show the aggregates innocuous in nature; hence they can be used in surface course in concrete works in road construction. Very negligible amount of stripping value is found in both form of aggregates, hence they can be used in bituminous road construction works. Apart from flakiness index and elongation index in both forms, shows increasing trend in quality towards downstream side of the river Pagladia. So, from geological, engineering and economic point of view, downstream side coarse aggregates, both natural and crushed are more suitable as road material. Besides mort of the test results reveal that natural form of aggregates are marginally superior to the crushed form of river borne aggregates.

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Appendex-1

Specified limits of Aggregate Impact Value

Sl.No	Type of construction	IS specification	IRC specification
1	WBM construction a) Wearing surface b) Lower granular layer Sub-base course Base course	 30% Max 35% Max	 30% Max 50% Max 40% Max (with bituminous surfacing)
2	Concrete construction a)Wearing surface b)Other layers	 30% Max 45% Max	
3	Bituminous penetration macadam(full grout)		30% Max (IRC 20-1966)
4	Two coat bituminous surface dressing		30% Max (IRC 23-1966)
5	Bituminous macadam a) Base course b) Binder course		 35% Max (IRC 27-1966) 30% Max (IRC 27-1966)
6	4(four)cm Asphaltic concrete surface course		30% Max (IRC 29-1968)
7	Built up Spray grout a) Base course b) Binder course		 40% Max (IRC 47-1972) 30% Max (IRC 47-1972)
8	Bituminous Surface Dressing with Precoated Aggregates		30% Max (IRC 48-1972)
9	Dense bituminous macadam		35% Max (IRC 94-1986)

Appendex-2

Specified limit of Aggregate Crushing Value

Type of Road Construction	Aggregate Crushing Value (%)	
(i) Flexible Pavements		
a. Soling	50% Max.	
b. Water Bound Macadam	40 % Max.	IRC 19-2005
c. Bituminous Macadam	40 % Max.	IRC-27-2005
d. Bituminous surface –dressing or thin pre-mix carpet	30 % Max.	IRC 23-1966
e. Dense-Mix carpet	30% Max.	
(ii) Rigid Pavements		
a. Other Than Wearing course	45 % Max.	IS: 2386 part-iv-1963
b. Surface or Wearing course	30% Max.	IS: 2386-part-iv 1963

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Appendex-3

Specified limits of Aggregate Abrasion Value

Sl. No	Type of construction	IS Specification	IRC Specification
1	WBM construction a) Wearing surface b) Lower granular layers Sub-base course Base course		 40% Max 60% Max 50% Max
2	Concrete construction a)Wearing surface b)Other course	 30% Max 50% Max	
3	Bituminous Surface dressing		35% Max
4	Bituminous penetration (grouted) Macadam		40% Max
5	Bituminous Bound Macadam		50% Max
6	Pre-mixed Bituminous Carpet		40% Max
7	Bituminous Concrete		40% Max

Appendex-4

Specified limits of Flakiness Index

Sl. No	Type of construction	IRC specification	IS specification	MOST Specification
1	Water Bound Macadam	15% Max -IRC 19-1977 (Base & binder course)	15% Max	15% (granular base course)
2	Bituminous Penetration Macadam Full Grout	25% Max (IRC 20-1966)		
3	Two coat Bituminous Surface Dressing	25% Max (IRC 23-1966)		
4	Bituminous Macadam (Base and Binder course)	25% Max (IRC 29-1967)		
5	4cm Asphaltic concrete Surface course	25% Max (IRC 29-1968)		
6	Built up Spray Grout	25% Max (IRC 47-1972)		
7	Bituminous Surface Coatings using Precoated Aggregates	25% Max (IRC 48-1972)		
8	Dense Bituminous Macadam	35% Max (IRC 94-1986)		
9	Thick Bituminous Surface coating			35%

Appendex-5

Sub Division of the Slake Durability Scale as per IS: 10050-1981

Slake Durability Index (%)	Classification
0-25	Very low
Over 25-50	Low
Over 50-75	Medium
Over 75-90	High
Over 90-95	Very High
Over 95-100	Extremely High

Appendix 6

Allowable limits of Stripping Value for different purposes as per IS: 6241-1971

Sl. No	Type of construction	IRC specification	MOST Specification
1	Bituminous Penetration Macadam	25% Max (IRC 20-1966)	
2	Two Coat Bituminous Surface Dressing	25% Max (IRC 27-1967	
3	Bituminous Macadam- Base and Binder course	25% Max (IRC 27-1967)	
4	4cm Asphaltic Concrete Surface course	25% Max (IRC 29-1968)	
5	Built up Spray Grout	25% Max (IRC 47-1972)	
6	Bituminous Surface Dressing using Pre-coated Aggregates	25% Max (IRC 48-1972)	
7	Dense Bituminous Macadam	25% Max (IRC 94-1986)	
8	Road and Bridges		25% Max