Ascertaining the Suitability of the Quarried Samples for Use in Concrete for both Wearing as well as Non Wearing Surfaces for Turga Pumped Storage Scheme,West Bengal

S.L. Gupta, Raj Kumar, Rajeev Gupta , Anil Rustagi

Abstract— **Exponential increase in energy requirement due to rapid industrialization has resulted in all-round exploitation of available resources of energy. Fast depletion and pollution aspects of fossil fuels have restricted their use. Apart from traditional hydroelectricity solar and wind resources are undoubtedly finding prominence but for their perennial reliability. Alternatively pumped storage hydro electric energy is a proven technology which is providing solution to energy scarcity problems. This technology is a mechanical storage of the energy similar to charging the batteries for future use. Ample perennial rainfall characteristics, rainfall harvesting potential, suitable topographical and geological condition of the area are the prime factors which are considered for constructing a closed loop Pumped Storage Project. In order to improve the peaking power scenario many such projects are either running or being planned in the state of West Bengal,, India. One of such projects in the Ayodhya Hills area in Purlia District on Turga Nala, a tributary of River Subarnarekha is being contemplated. Based on availability of competent foundation rock at shallow depth, construction material availability considerations and land requirement considerations, possibility of a concrete dam is being investigated. This paper deals with the construction materials survey and laboratory investigations of coarse & fine aggregates samples for assessing their suitability for use in concrete works for the proposed Project.**

Index Terms—**Aggregate Abrasion Loss, Aggregate Crushing Value, Alkali Aggregate Reactivity, Impact Value, Petrographic Analysis.**

I. INTRODUCTION

Turga Pumped Storage Project (TPSP) is bounded by latitude $23^0 11' 30"$ N and $23^0 14' 25"$ N and Longitudes $86^0 03' 30"$ E and $86^0 03' 59"$ E respectively. The topographical conditions facilitate construction of twin dams in the near vicinity with a considerable difference of elevation. Existing facilities like water reservoir, dam, etc. provide additional benefit of generating clean and green peak power annually at a viable cost. The project would generate maximum 1000 MW of Hydropower.

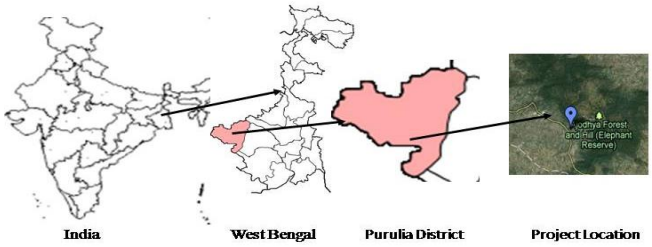


Fig. 1: Details of site Location

Based on availability of competent foundation rock at shallow depth (in the range of 5-10m only), construction material availability considerations and land requirement considerations, possibility of a concrete dam is being investigated. Coarse & fine aggregates [1] samples were collected for conducting laboratory investigations for assessing their suitability for use in concrete for both wearing as well as non wearing surfaces.

II. MATERIALS AND METHODS

A. Sampling Locations

Eight different locations were selected for construction materials survey (Table 1). Samples were collected from these locations for carrying out various suitability tests. [5]

Table 1: Details of Sampling Locations

Sl. No.	Rock quarry	Location	Field sample No.	Lab. No.
1	Turga Nallah rock quarry	at Low reservoir area	TNRQ	CA-52
2	Dulgubera rock quarry	about 1.2 km from proposed Turga upper dam	DRQ-A	CA-53
3	Malti rock quarry	about 40 km from project site on Purulia-Tatanagar National Highway 32	MRQ	CA-54
4	Kudna rock quarry-A	about 5 km from proposed Turga lower dam	KRQ-A	CA-55

Manuscript received.
SL Gupta, Central Soil and Materials Research Station, New Delhi, India, 9868118211 (slgupta@nic.in)
Raj Kumar, Central Soil and Materials Research Station, New Delhi, India, 9868119485 (rajkumar_csmrs2010@yahoo.com)
Rajeev Gupta, Central Soil and Materials Research Station, New Delhi, India, 9891443126 (rajeev21267@gmail.com)
Anil Rustagi, Central Soil and Materials Research Station, New Delhi, India, 9717815777 (akrus1960@yahoo.co.in)

5	Kudna rock quarry-B	about 5 km from proposed Turga lower dam & about 5.150 km from proposed Turga lower dam	KRQ-B	CA-56
6	Kudna rock quarry-C	about 5 km from proposed Turga lower dam & about 5.3 km from proposed Turga lower dam	KRQ-C	CA-57
7	Kudna rock quarry-D	about 5 km from proposed Turga lower dam & about 5.45 km from proposed Turga lower dam	KRQ-D	CA-58
8	Hadhadi Nallah rock quarry	about 3km away from bagmundi village near proposed dam drift site	HNRQ	CA-59

B. Codes and Practices

- The physical tests were conducted as per IS: 2386-1963 (Reaffirmed 1997) [2]
- Assessing the suitability for use as coarse aggregate in concrete as per IS: 383-1970 (Reaffirmed 1997) [3]
- Alkali Aggregate Reactivity Test by Accelerated mortar bar method as per ASTM C-1260 [4]

III. LABORATORY INVESTIGATIONS

To ascertain the suitability of the quarried samples for use in concrete for both wearing as well as non wearing surfaces Specific Gravity, Water Absorption (%), Soundness Loss (%) 5 cycles in Na_2SO_4 Solution, Aggregate Impact Value (%), Aggregate Abrasion Loss (%), Aggregate Crushing Value (%), Alkali Aggregate Reactivity was determined. In addition Petrographic Analysis was also carried out. [5]

IV. DISCUSSION OF TEST RESULTS

A. Specific Gravity and Water Absorption

Specific gravity of the collected samples ranges between 2.62 to 2.79 and water absorption varies between 0.23% to 0.57% (Table 2). The specific gravity was determined for the rock shows that all the samples have specific gravity of heavy weight aggregate (>2.6).

Table 2: result of the specific gravity test and water absorption test

Sl No.	Lab. sample No.	Specific gravity	Water Absorption (%)
1	CA-52	2.66	0.33
2	CA-53	2.62	0.28
3.	CA-54	2.70	0.23
4	CA-55	2.79	0.26
7	CA-58	2.64	0.57
8.	CA-59	2.64	0.41

Based on these results the rock samples are sound because the specific gravity of rocks have inverse relationship with the porosity and strongly correlate with strength of rocks [6], [7].

B. Soundness Loss

Soundness loss (5 cycles in Na_2SO_4 solution) has been determined is found to be in the range 0.83 to 4.46. The result for the tests on different samples is presented in Fig. 2.

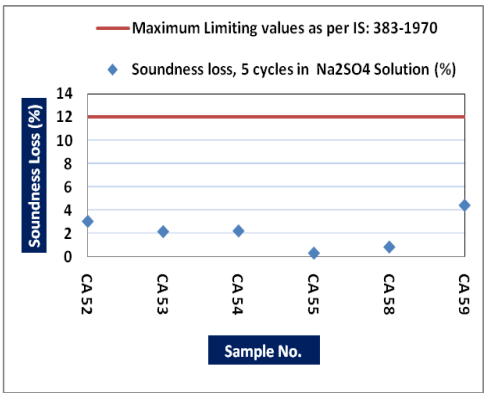


Fig 2: Soundness loss (5 cycles in Na_2SO_4 solution)

C. Aggregate Impact Value (%)

Aggregate Impact Value (%) has been determined is found to be in the range 12.17 to 38.61. The result for the tests on different samples is presented in Fig. 3.

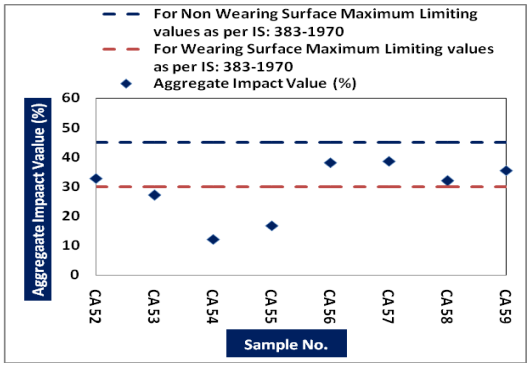


Fig 3: Aggregate Impact Value (%)

D. Aggregate Abrasion Value (%)

Aggregate Abrasion Value (%) has been determined is found to be in the range 15.2 to 52.4. The result for the tests on different samples is presented in Fig. 4.

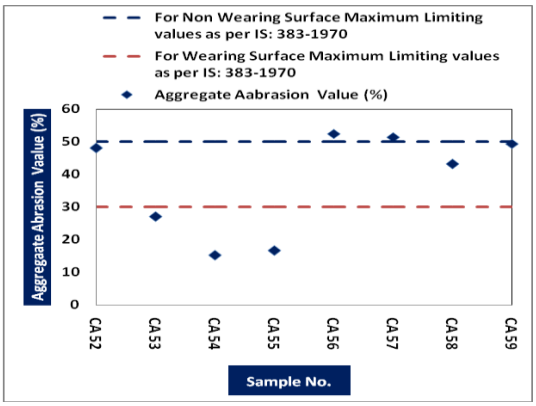


Fig 4: Aggregate Abrasion Value (%)

E. Aggregate Crushing Value (%)

Aggregate Crushing Value (%) has been determined is found to be in the range 11.92 to 31.73. The result for the tests on different samples is presented in Fig. 5.

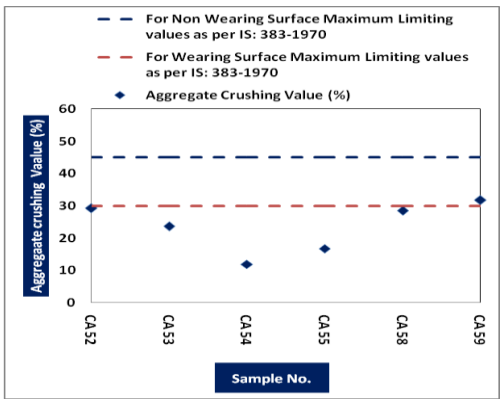


Fig 5: Aggregate Crushing Value (%)

4.6 Alkali Aggregate Reactivity

* Testing Regime : Accelerated Method in 1 N NaOH soln. at 80^0 C temp
* Cement used : CE-15/71
* Total alkali content of cement : 0.56 % by equivalent weight of Na_2O
* Protocol followed : ASTM C1280

The alkali aggregate reactivity test was conducted on sample nos. CA-52 TO CA 55, CA-58 and CA-59 as per ASTM C-1260. The percentage expansion of mortar bar at 14 (16 days after casting) is presented in Fig. 6. Except for sample CA 54 the expansion ranges between 0.021% - 0.027%, while tat in case of sample CA 54 it is of the order of 0.213%.

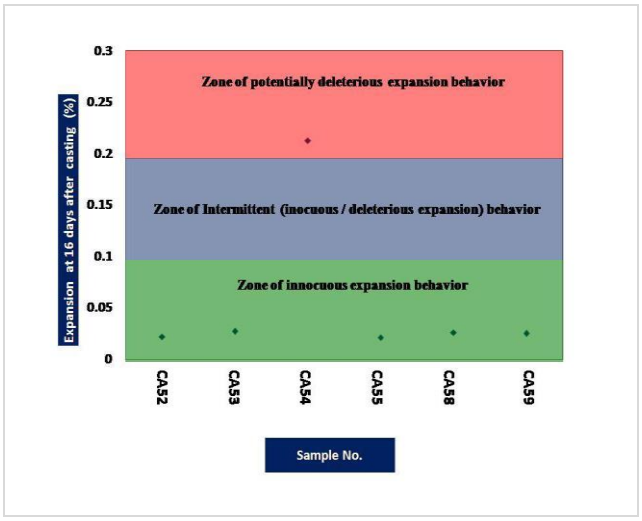


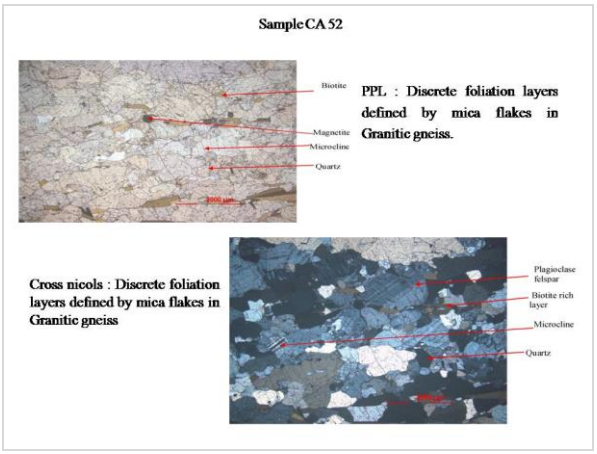
Fig. 6: Percentage expansion of mortar bar (16 days after casting)

F. Petrographic Study

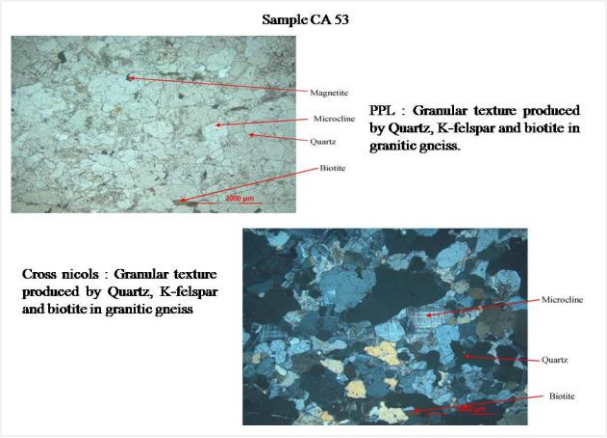
Results of petrographic studies are presented in Table 3 and Fig. 7a to 7e

Table 3: Results of Petrographic studies

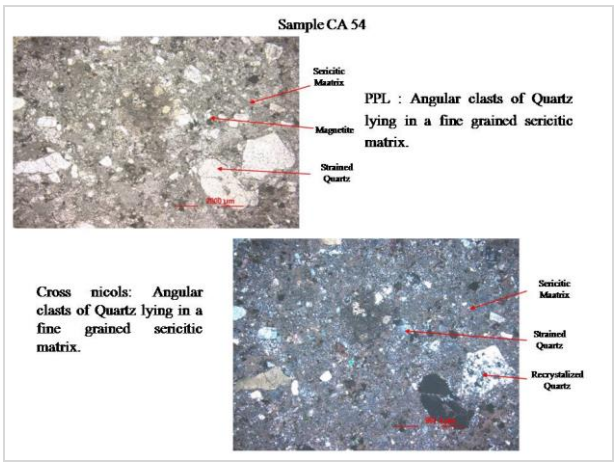
Mineralogy	CA 52	CA 53	CA 54	CA 55	CA 58	CA 59
Quartz%	30-40	35-40	-	-	35-40	30-35
Strained Quartz%	1-2	0-1	25-30	-	1-2	1-2
Recrystallised quartz%	-	-	5-10	-	-	-
K-Feldspar %	30-35	30-35	-	-	30-35	35-40
Feldspar %	-	-	1-5	-	-	-
Plagioclase feldspar%	12-15	12-15	-	40-50	13-17	12-15
Mica%	10-15	10-12	3-6	-	10-15	10-15
Magnetite%	3-7	3-7	55-60	5-15	1-3	3-4
Sericite %	-	-	-	-	-	-
Amphibole %	-	-	-	20-25	-	-
Pyroxene%	-	-	-	15-20	-	-
Biotite%	-	-	-	1-10	-	-
Rock Type	Granitic gneiss	Granitic gneiss	Rhyolite	Meta-Gabbro	Granitic gneiss.	Granitic gneiss.



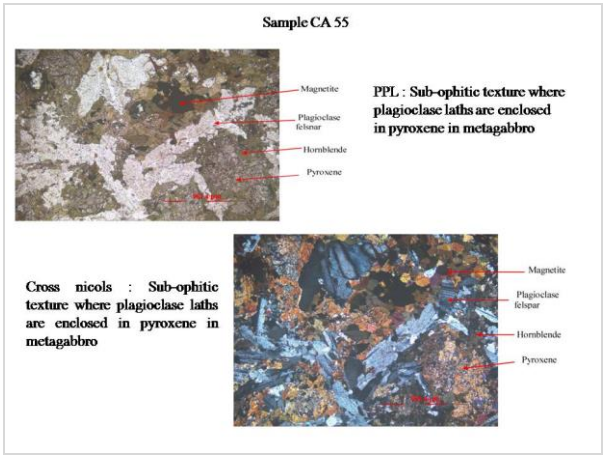
a



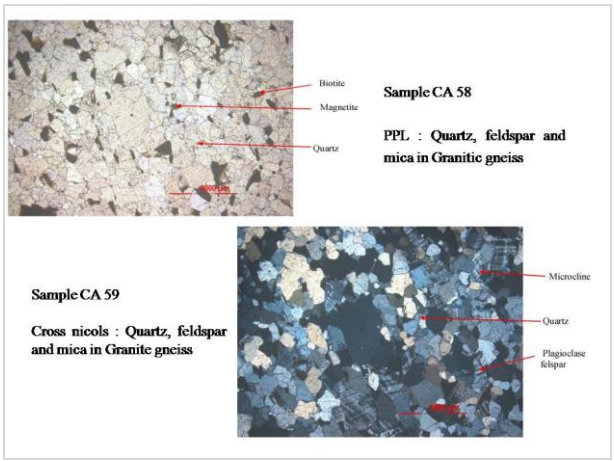
b



c



d



e

Fig. 7: Photomicrographs of Samples

V. INTERPRETATION AND CONCLUSION

A. Coarse Aggregates

- Based on physical test results three nos, rock samples bearing CSM lab. no CA-53, CA-54 & CA-55 are conforming to the codal requirements in respect of physical properties for use in concrete for both wearing as well as non wearing surfaces.
- Samples no. CA-52 , CA-58 & CA-59 conform the suitability requirements only for non wearing surfaces
- Sample no. CA-56 & CA-57 do not conform the suitability requirements hence, both the samples are not suitable for making concrete.
- Percentage expansions of mortar bar at 14 which is less than the prescribed limit of 0.10% at 16 days after casting is indicative of innocuous behavior for all the samples except sample no. CA 54 which shows higher expansion i.e. 0.213 and is beyond the prescribed limit which indicate its deleterious behavior
- Petrograpic studies classify the rock samples as CA 52, 53, 58 and 59 as **Granitic gneiss while** CA 55 as **Rhyolite** and CA 56 as **Meta Gabrro**

B. Fine Aggregate

- Since sufficient quantity of natural sand is not available in project vicinity sand has to be obtained by crushing of the same rock quarry. FM of the sand should be 2.5 to 3.0 & it should be conforming the grading zone-II / III as per IS: 383-1970. While crushing the rock for making the sand the loss should not more than 20% on 150 micron sieve.

ACKNOWLEDGMENT

The authors extend their sincere gratitude to Director, Central Soil and Materials Research Station for his constant guidance and encouragement. We also extend our sincere thanks to Sh. M.A. Ansari, Assistant Research Officer, Sh. V. K. Vaidh, Supervisor, Sh. Rajendra Kumar, Sh. Vinod Naudiyal, Lab. Assistant and Sh. Devender Singh, Lab. Assistant for their timely assistance. We also extend our sincere gratitude to all the authors whose publications provided us directional information from time to time.

REFERENCES

[1] I.S., 1975. Indian Standard Specification for coarse and fine aggregates from natural source for concrete.

[2] IS: 2386-1963 (Reaffirmed 1997) "METHODS OF TEST FOR AGGREGATES FOR CONCRETE"

[3] IS: 383-1970 (Reaffirmed 1997).Assessing the suitability for use as coarse aggregate in concrete

[4] ASTM C-1260 Alkali Aggregate Reactivity Test by Accelerated mortar bar method as per

[5] CSMRS report no. 02/C-I/CSMRS/E/01/2016 on "construction materials survey and laboratory investigations of coarse aggregate samples for assessing their suitability for use in concrete works for proposed Turga Pumped Storage Project, WB"

[6] Tamrakar, N.K., Yokota, S., and Nakamura, M., 1999, Some mechanical properties of the Siwalik sandstones and their relation to petrographic properties. Geoscience Rept. Shimane University, 18, pp. 41–54.

[7] Tamrakar, N.K., Yokota, S. and Shrestha, S.D., 2007. Relationships among mechanical, physical and petrographic properties of Siwalik sandstones, Central Nepal Sub-Himalayas. Engineering Geology, v. 90, pp. 105–123.

SL Gupta M.Tech (Civil), presently holding post of Scientist E in CSMRS, have 27 years of experience in the field of geotechnical engineering and concrete technology, have more than 60 publications. Worked as Quality control expert in Salma Project, Afganistan.

Raj Kumar M.Sc. (Chemistry), presently holding post of Scientist C in CSMRS, have 30 years of experience in the field of concrete technology, have more than 25 publications. Worked as Quality control expert in Salma Project, Afganistan

Rajeev Gupta BE holding post of Scientist B in CSMRS, have 25 years of experience in the field of concrete technology, have more than 10 publications.

Anil Rustagi Dip. (Civil) holding post of Assistant Research Officer in CSMRS, have 28 years of experience in the field of concrete technology, have more than 10 publications.