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Petrography of fine aggregates from Kaligandaki River, western Nepal: implication for assessment of deleterious constituents

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ABSTRACT

Seven fine aggregate samples from test pits driven at the river banks of the Kaligandaki River and banks of the contributing streams around Kokethanti-Chhyo Bagar area were petrographically analysed as these will be used for concrete aggregates. The aggregates had median grains size of 0.45-1.00 mm and were well graded. They were dominantly composed of carbonate rock fragments and the total QFL modes being $Q_{14.81–28.87}F_{0.63–4.58}L_{66.55–84.15}$. All the samples were classified as medium-grained calc-lithic sands. Quartz grains were dominantly megaquartz. Some chert grains and few quartz grains occurring in siliceous limestones were of microquartz.

Considering deletereous constituents, the sample T1 had chert fragments. The sample T2 had high amount of micas suggesting its low workability. Silt/clay-grade size fraction was the deletereous material to all the samples and this fraction should be removed during processing. The samples T2, T6 and T7 showed greater preferability among the samples as these had lower amount of unsound rock fragments such as carbonaceous schists/phyllite, and other deletereous materials.

INTRODUCTION

Demand of aggregates both for concrete and road is growing rapidly as they are required for development of various infrastructures. Quality of aggregates is of great concern as these are used in concrete structures and road pavement. Therefore, several lab tests and analyses are made to characterise the physical, mechanical and petrographic properties of these aggregates. Petrographic analysis of aggregates is the crucial part of the analysis as it reveals the constituents of the aggregate material and tells about their proportion in the material. Some of the constituents may be deletereous, and the petrographic analysis is the way of identifying them. Several studies on the physical, and Mechanical properties in addition to the petrographic characteristics of rocks and natural aggregates are found (Maharjan and Tamrakar, 2004; Maharjan and Tamrakar, 2008; Khanal and Tamrakar, 2009). This studyconducts petrographic analysis of fine aggregates for determining kinds and amount of mineral constituents including deletereous constituents.

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METHODOLOGY

The aggregate material deposits in the Kaligandaki River were identified in Kokethanti, Dhampu, and Chhyo Bagar, and its tributaries at the Chhaktan Khola and the Ghatte Khola (Fig. 1). The thickness of the deposit is more than 40 m. Test pits for aggregate were excavated gpt 2 to 4 m manually by means of excavation using pick, shovel and crow bar. Sampling was made by collecting about 50 kg of aggregate material from the excavated test pit representing the thickness of the deposit for laboratory testing. The collected samples were dried, weighed and sieved at the site. The representative samples collected from the test pit were packed in water proof bag with label mentioning location of the test pit, test pit name/number, sample number and date before transporting for laboratory testing. The information of sample location is listed in Table 1.

The sand samples were dried and analysed for grains size by sieving. Then they were examined for physical characteristics. Each sample was studied for four separate size fractions (2–4.75 mm, 0.60 mm, 0.25 mm and 0.075 mm). The size fractions 2–4.75

Table 1: Location of samples

Sample No.	Easting	Northing	Elevation, m (amsl)	Location
T1	460669	3172088	2531	Kaligandaki River, near Kokethanti
T2	460181	3171195	2534	At the Chhaktan Khola near its confluence with the Kaligandaki River, near Kokethanti
T3	460686	3169909	2472	Kaligandaki River, Dhampu
T4	461414	3172556	2524	Kaligandaki River, upstream from the Kokethanti suspension bridge
T5	461451	3173058	2538	At the confluence of the Sun Khola and the Ghatte Khola at right bank of the Kaligandaki River
T6	463293	3167953	2408	At the outlet of Paripu Khola, Chhyo Bagar
T7	464249	3168760	2446	At Chhyo Bagar, near the confluence of the Swarga Khola and the Paripu Khola

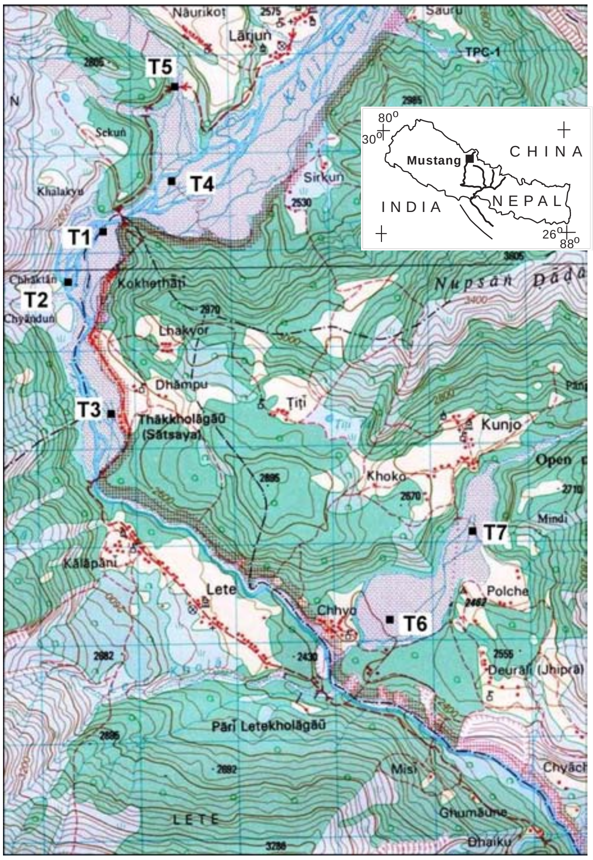

Fig. 1 A map showing sampling sites (Refer Table 1 for coordinates).

mm, and 0.60 mm were examined under a stereoscopic microscope. The size fractions 0.25 mm and 0.075 were thin-sectioned and examined under a petrographic microscope considering ASTM Standard C295-03. About 200–300 counts per sub-sample were made for determining the composition of fine aggregates.

RESULTS OF PETROGRAPHIC ANALYSES

Results of petrographic analyses are shown in Table 1 through 4 and Figs. .

Physical characteristics

Table 2 lists the physical characteristics of fine aggregate samples. The mineral grains in all the samples studied possessed equant, flaky, flaky and elongate forms of the particles. They are subangular to subrounded. Surface textures of particles of almost all the samples were rough due to irregularly brocken surfaces. Colours of the aggregate samples varied from yellowish grey to grey. Based on angularity and roughness of the particles, these aggregate samples were derived to the deposits which are not matured and are characterised by particles brought from intense reworking and breakdown of the older products.

Table 2: Description of physical characteristics of fine aggregates

Physical characteristics	T1	T2	T3	T4	T5	T6	T7
Particle shape	E, F, FE SA, SR	E, F, FE SA, SR	E, F, FE SA, SR	E, F, FE SA, SR	E, F, FE SA, SR	E, F, FE SA, SR	E, F, FE SA, SR
Surface texture	Rough to smooth	Rough	Rough	Rough	Rough	Rough	Rough
Nominal size	<0.075 mm to 4.75 mm	<0.075 mm to 4.75 mm	<0.075 mm to 4.75 mm	<0.075 mm to 4.75 mm	<0.075 mm to 4.75 mm	<0.075 mm to 4.75 mm	<0.075 mm to 4.75 mm
Colour	Grey	Yellow grey	Grey	Yellow grey	Grey	Grey	Grey
Coatings	None	None	None	None	None	None	None

E = Equant, F = flaky, FE = flaky and elongate; SA = subangular, SR = subrounded

Grain size distribution

Table 3 lists the results of grain size analyses. Curves show well grading of the samples (Fig. 2). T3 has lower amount of coarse fraction (>2 mm) compared to the other samples. The samples T3, T6 and T7 have remarkably high amount of pan fraction (<0.075 mm). The median grain size of the samples exhibits that all the fine aggregate samples belong to medium sands.

Composition

Results of compositional analysis of samples are listed in Table 4. Fine aggregates are classified based on their recalculated proportions of quartz, feldspar and rock fragments as indicated in Fig. 3. Composition of individual sand samples is described as below:

Sample T1

Carbonate rock fragments, quartz, rock fragments of schist, slate, granite and gneiss are dominant constituents whereas feldspar, mica and chert are subordinate constituents of the sample T1. Quartz is prodominantly megaquartz. Among the rock fragments, those of carbonate rocks, siliceous limestone, carbonaceous slate and carbonaceous schists predominate (Fig. 4a). Micas are concentrated in a fine fraction (0.075 mm). Few chert grains with both microcrystalline quartz and chalcedonic quartz are recorded. The QFL mode of the sample is $Q_{21.47}F_{2.26}L_{76.28}$. The sample T1 is classified as medium-grained calc-lithic sand.

Sample T2

Major constituents of the fine aggregate are quartz, rock fragments of granite, gneiss, pegmatite and carbonate rocks. Subordinate constituents are micas, feldspars and aphanitic schist and slates. Carbonate rock gragments comprise fragments of limestone, siliceous limestone, marble, etc. This sample has lower amount of lithic fragments compared to the other samples. Few chlorite occurs along with substantial amount of muscovite and biotite. The QFL mode of the sample is $Q_{28.87}F_{4.58}L_{66.55}$. The sample T2 is a medium-grained calc-lithic sand.

Sample T3

Major constituents of the sand are quartz, carbonate rock fragments, and aphanitic rock fragments. The subordinate constituents are phaneritic rock fragments (granite, gneiss, pegmatite), micas, feldspars and chlorite. Carbonate rock fragments comprise fragments of limestone, siliceous limestone, etc. Aphanitic rock fragments include mostly carbonaceous slates and carbonaceous schists. Few chlorite occurs along with little amount of muscovite and biotite. Clay and silt content is remarkably high in the sample. The QFL mode of this sample is $Q_{21.64}F_{0.63}L_{77.74}$. The sample T3 belongs to a medium-grained calc-lithic sand.

Sample T4

Carbonate rock fragments, aphanitic rock fragments and quartz constitute the major portion of the fine aggregate. Subordinately, feldspars, phaneritic rock fragments of granite, gneiss or pegmatite fragments, and mica occur. Carbonate rock fragments are composed of limestone, siliceous limestone, marble, etc. Aphanitic rock fragmetns are characterised by schistose fragments such as schists, carbonaceous slate, etc. Few altered grains are also found. The QFL mode of the sample is $Q_{14.81}F_{1.04}L_{84.15}$. The sample T4 is classified as medium-grained calc-lithic sand.

Table 3: Grain size distribution of fine aggregate samples

	T1		T2		T3		T4		T5		T6		T7	
Size retained, mm	Wt., g	Wt %	Wt., g	Wt %	Wt., g	Wt %	Wt., g	Wt %	Wt., g	Wt %	Wt., g	Wt %	Wt., g	Wt %
2.00	45.959	25.257	45.665	30.231	2.563	2.147	49.012	24.462	31.111	21.445	58.758	29.77	51.414	31.21
0.600	42.834	23.540	41.99	27.795	47.07	39.431	50.553	25.231	27.486	18.946	51.762	26.22	48.344	29.35
0.250	40.201	22.093	22.906	15.163	29.815	24.976	47.095	23.505	41.808	28.818	27.23	13.80	18.736	11.38
0.075	43.741	24.039	32.56	21.553	26.325	22.053	43.849	21.885	38.402	26.470	34.004	17.23	21.181	12.86
Pan	9.227	5.071	7.943	5.258	0.65	11.393	9.851	4.917	6.269	4.320	25.642	12.99	25.038	15.20
Total	181.962	100	151.068	100	119.373	100	200.36	100	145.076	100	197.396	100	164.731	100
% sieve loss	0.29		0.78		0.0.65		0.30		0.67		0.59		0.25	
Median size, mm	0.550		0.800		0.450		0.600		0.450		0.800		1.000	

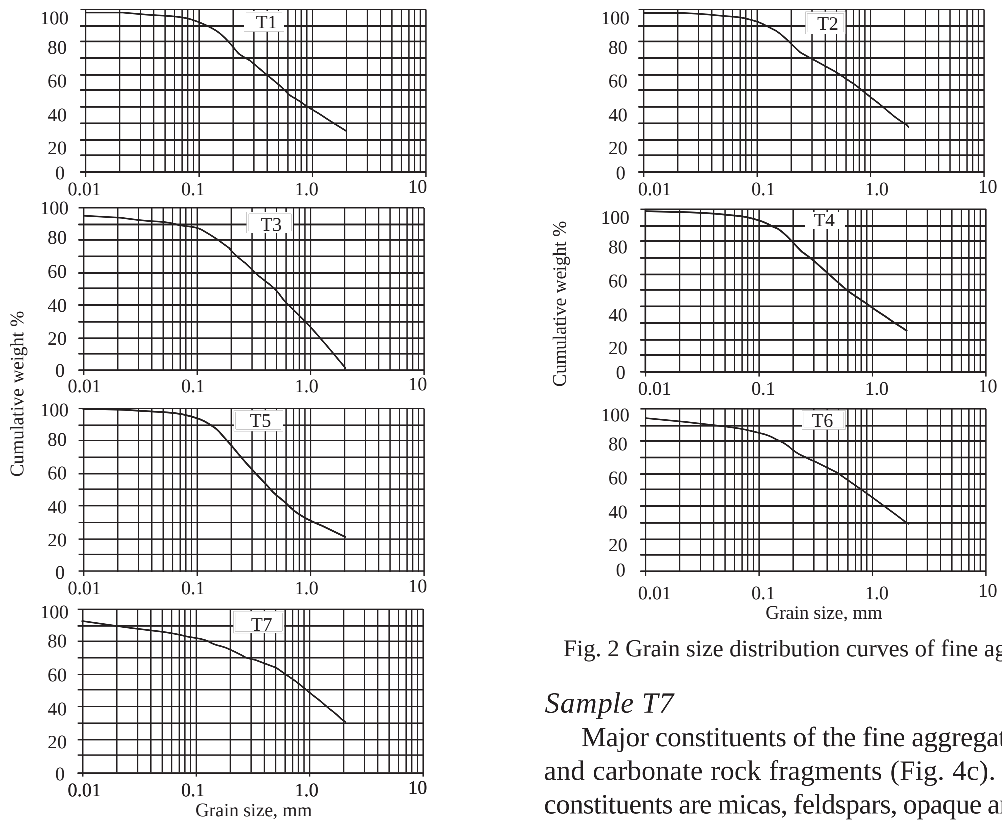

Fig. 2 Grain size distribution curves of fine aggregates.

Sample T5

Major constituents of the fine aggregate are aphanitic rock fragments (schist, slate, etc.), quartz, and carbonate rock fragments (Fig. 4b). Minor constituents are micas, feldspars and phaneritic rock fragments. Carbonate rock fragments comprise fragments of limestone, siliceous limestone, marble, etc and approach 45.95% of the modal composition. The QFL mode is $Q_{16.77}F_{0.79}L_{82.44}$. Organic debris and alterite are present in little amount. Micas also present in little quantity. Silt/clay-grade particles are remarkably present in the sample. The sample T5 is a medium-grained calc-lithic sand.

Sample T6

Quartz, carbonate rock fragment and aphanitic rock fragments are the substantial components. Phaneritic rock fragments, micas, opaques and alterite form minor constituents. Quartz grains found are megaquartz. Carbonate rock fragments include siliceous limestone, limestone, etc. Clay and silt content is remarkably high and approaches 12.99%. Muscovite and biotite form nearly 3%, and the QFL mode is $Q_{22.27}F_{1.25}L_{76.48}$. The sample T6 is classified as medium-grained calc-lithic sand.

Sample T7

Major constituents of the fine aggregate are quartz, and carbonate rock fragments (Fig. 4c). Subordinate constituents are micas, feldspars, opaque and phaneritic schist and slates. Carbonate rock fragments are much more abundant compared to the other rock fragments. QFL mode is $Q_{20.55}F_{3.27}L_{76.18}$. The sample T7 is a medium-grained calc-lithic sand.

DELETEREOUS CONSTITUENTS

Calc-lithic sand, T1

Chert grains in T1 approaches 1.71%, and constitute micro-quartz that are reactive in an alkaline environment. The reaction rate depends on proportion of reactive aggregate in concrete, alkali content of cement, temperature and availability of water (Gillott, 1975). Considering the former factor, presence of reactive constituents is harmful to concrete. Carbonaceous and schistose rock fragments are also present in substantial amount (Table 3). The sample also contains silt/clay-grade material, 5.07%. All these deletereous constituents possibly contribute to the alkali-silica reaction.

Calc-lithic sand, T2

Among the deletereous constituents, total mica contributes 8.14%. Opaques of carbonaceous fragments and iron oxides, and chlorite occur in trace. The sample also contains silt/clay-grade material approaching

Table 4: Weighted percent constituents of fine aggregate samples

Constituent	Weighted percent constituents						
	T1	T2	T3	T4	T5	T6	T7
Quartz	19.86	24.77	18.31	13.86	14.91	18.42	16.73
Feldspar	2.09	3.93	0.53	0.97	0.70	1.03	2.66
Phaneritic: Granite, gneiss	7.38	43.25	7.29	5.21	3.71	7.72	2.87
Aphanitic: Schist/phyllite, slate	13.75	2.73	16.32	15.87	23.36	4.12	6.82
Aphanitic: chert	1.71				0.27		
Carbonate rock fragments	47.73	11.13	42.17	57.68	45.95	51.41	52.32
Mica: Muscovite	1.44	4.08	1.59	0.25	2.31	1.95	0.63
Mica: Biotite	0.96	4.06	1.15		0.78	1.03	0.76
Opaque:		0.31	0.37	0.76	2.66	1.01	1.23
Chlorite		0.48	0.88				
Organic debris					0.29		
Alterite				0.48	0.74	0.32	0.36
Silt/Clay size-grade particles	5.071	5.26	11.39	4.92	4.32	12.99	15.20
	99.997	100	100	100	100	100	100

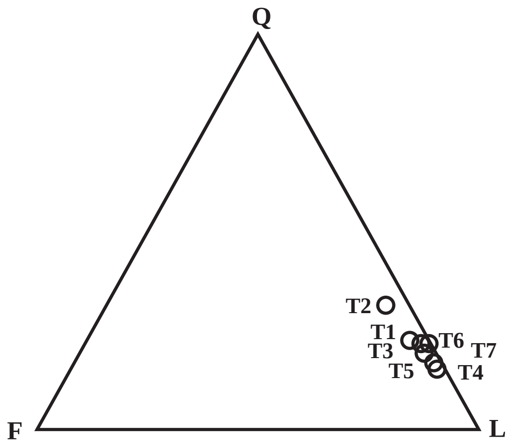

Fig. 3 QFL modes of fine aggregate samples.

5.26%. This sample constitutes remarkably higher amount of micas compared to the other samples. Presence of high amount of mica in sand affects strength and bonding with cement (Fookes and Revie, 1982) and brings about the problem of poping out. High mica content in sand also tends to require more water in the cement and sand mixture. BSI (1973) suggested < 8% mica in sand to be preferable for use.

Calc-lithic sand, T3

The aphinitic rock fragments characterised by carbonaceous slates, schists, etc are present in substantial amount. These materials constitute notable amount of phyllosilicates and carbonaceous material and are unsound. Micas are little in amount. However, the sand sample contains mixture of remarkable conspicuous amount of silt/clay-grade material, i.e.,11.39%. Silt/clay-grade material may have possible effects on swelling upon gaining of moisture particularly if the clay material is of smectite.

Calc-lithic sand, T4

Aphanitic rock fragments of carbonaceous slate and schists constitute major portion of the deleterious material in the sample T4. Silt/clay-grade material that approaches 4.92% is also a deletereous constituent.

Calc-lithic sand, T5

Little amount of micas, alterite, organic debris are present as deletereous constituents. Conspicuous amount of aphanitic rock fragments of carbonaceous nature (carbonaceous slate and schist)) are present. Silt/clay-grade material approaching 4.32% is also a deletereous constituent.

Calc-lithic sand, T6

Micas, alterite, carbonaceous schist/slate, carbonaceous opaques, etc. form deletereous constituents. Besides, the sample also contains very high amount of silt/clay-grade material, i.e., 12.99%. Such an amount of silt/clay-grade material possible aggravate soundness of the aggregate.

Calc-lithic sand, T7

Deleterous materials constitute aphanitic rock fragments, which are more than 50% of carbonaceous schist and slate, and also a silt/clay-grade material that approaches to 15.20%. Such a high amount of silt/clay-

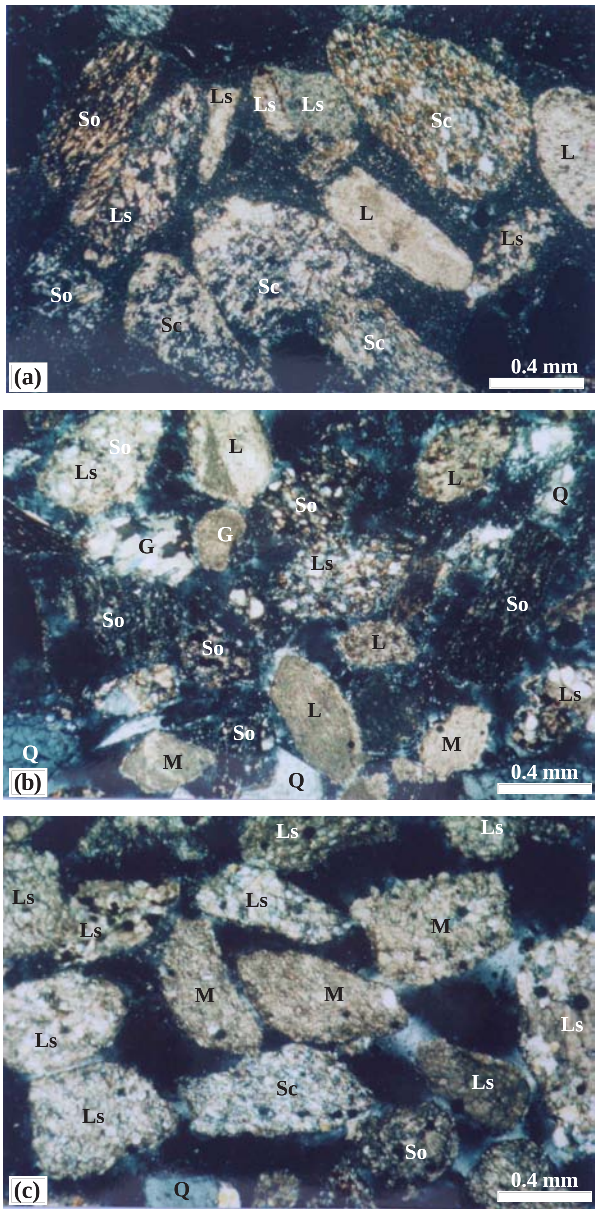

Fig. 4 Particles of fine aggregates. (a) Sample T1, (b) Sample T5, and (c) Sample T7. L = limestone, Ls = Siliceous limestone, M = Marble, Q = Quartz, G = Gneiss, So = Carbonaceous schist, Sc = Calc schist.

grade material can aggravate soundness of the aggregate and contribute to the expansion and cracking of the concrete structure.

CONCLUSIONS

The median grain size of the fine aggregates range from 0.45 to 1.00 mm, and are medium-grained. The size distribution indicates that they are well graded. The sands are dominantly composed of carbonate rock fragments. The range of QFL modes of the fine aggregate samples is $Q_{14.81–28.87}F_{0.63–4.58}L_{66.55–84.15}$. All the samples are classified as medium-grained calc-lithic sands. Quartz grains are dominantly megaquartz. Some chert grains and few quartz grains occurring in siliceous limestones are of microquartz. Feldspars are very low in amount. Carbonate rock fragments dominate over rock fragments of schists/phyllite, and granite/gneiss. However carbonaceous schists/phyllite are remarkable constituents in T1, T3, T4, T5 and T7. Muscovite usually dominates biotite and collectively both are remarkable constituents in the sample T2.

Considering deletereous constituents, the sample T1 bears chert fragments .The sample T2 has high amount of micas and due to which it will have low workability. Silt/clay-grade fraction is deletereous to all the samples and this fraction should be removed during processing. The samples T2, T6 and T7 are more preferable among the samples as these have lower amount of unsoundd rock fragments such as carbonaceous schists/phyllite.

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REFERENCES

BSI, 1973. Specification for aggregates from natural sources for concrete (including grano-lithic): British Standard, BS 882.

Fookes, P.G. and Revie, W.A., 1982. Mica in concrete-a case history from Eastern Nepal. Concrete, v. 16, no. 3, pp. 12-16

Gillott, J.E., 1975. Alkali-aggregate reactions in concrete. Eng. Geol., v. 9, pp. 303–394.

Khanal, A. and Tamrakar, N.K., 2009. Evaluation of quality of crushed-limestone and -siltstone for road aggregate. Bull. Dept. Geol., Tribhuvan University, Nepal, v. 12, pp. 29–42. doi: 10.3126/bdg.v12i0.2248.

Maharjan, D.K. and Tamrakar, N.K., 2004. Quality of siltstones for concrete aggregate from Nallu Khola area, Kathmandu valley. Proceedings of Forth Nepal Geological Congress, Jour. Nepal Geol. Soc., v. 30 (Special Issue), pp. 167–176.

Maharjan, S. and Tamrakar, N.K., 2007. Evaluation of gravel for concrete and road aggregates, Rapti River, Central Nepal Sub-Himalaya. Bull. Dept. Geol., Tribhuvan University, Nepal, v. 10, pp. 99–106. doi: 10.3126/bdg.v10i0.1425