Los Angeles Abrasion Testing: From the meaning of test to the results of test

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ABSTRACT

Los Angeles Abrasion test is widely a common test for abrasion resistance for multiple engineering applications. The test has been developed since 1980s. To understand the test to the result of test, two types of rocks, i.e. metasandstone and gneiss were tested on grades A and B of the test samples for Los Angeles Abrasion (LAA) Test. The LAA values of gneiss vary from 62.13 to 63.19%, and that of metasandstone from 37.30 to 36.65%, showing that relatively consistent results have occurred for different grades A and B of the Test Samples. It shows that the material properties play the main role in abrasion and Los Angeles Abrasion loss than the nominal size selected for different grades of the Test Samples, and in the present study it has been explained by anisotropy in fabric and anisotropy related strength of rock types for LAA loss. It is considered that the aggregates of different petrographic properties have yielded low or high LAA and hence have bearing on quality of aggregates for engineering purposes. A selection of rock type is important to achieve desirable qualities regarding abrasion loss for concrete pavement, asphalt concrete pavement, surface dressing, crushed stone base and subbase courses.

Keywords: Los Angeles Abrasion Testing, Coarse aggregates, Test samples, Anisotropy in fabric

INTRODUCTION

The Los Angeles Abrasion (LAA) is the most common and widely used method to determine aggregate abrasion resistance. Crushed stone of aggregate, which are obtained through breakdown from different type of rocks, e.g. igneous, metamorphic and sedimentary are subject to LAA test for determining resistance to fragmentation of rocks. Crushed stone of aggregate can be used in various engineering purposes: dam, pavement, concrete, and asphaltic pavement, etc. Trend of demand of crushed stone aggregate has increased in worldwide due to lack of the uncrushed stone of aggregates in different sources. To evaluate the quality of crushed stone aggregates, one of the commonly tested parameters is Los Angeles Abrasion (Al-Harthi, 2001).

The grade of aggregate can be determined by physical test methods. The Los Angeles Abrasion test has been developed to provide quantitative method to determine the quality of abrasion resistance of aggregates for the specification of requirements for their specific uses. The resistance of aggregates' fragmentation due to attrition between rock particles and also to impact and crushing by steel spheres (Fernlund, 2005; Kahraman and Fener, 2007; Ugur et al., 2010) is determined in the LAA test.

Methods for determining the LAA tests of aggregates particles have been standardized in various forms in many places around the world. The tests to measure the abrasion resistance of aggregate particles are described in ASTM C131-01 (2003), ASTM C535 -031 (2003), AASHTO T96-02(2006), AS 1141.23 (2009) and ASTM C131 /131M (2014).

In 1870s France developed the Micro Deval test method of testing and was the only accepted method to determine the toughness of aggregates. This method was adopted as a standard test for use on road materials by ASTM in 1908 and revised in 1926. Later on, the LAA test was approximately adopted in 1937 (Sweet, 1948). Because the LAA test is related closer with the performance of aggregates in pavements than the Micro Deval test the LAA test was adopted as a standard test for measuring the wear of aggregates in 1940 (Sweet 1948).

Woolf and Runner (1935) conducted suitability of Los Angeles testing and the test result for specifying limit for coarse aggregate. West et al. (1970) studied tests for evaluating degradation of base course. They concluded that the LAA test appears to be a good indicator of the degradation properties of carbonate rocks, but not of basalt rocks. The grain size and roundness were related to the LA abrasion wear value.

Larson et. al. (1971) reviewed and investigated and presented that the LAA test was satisfactory for determining the resistance of an aggregate to dry abrasion. At the same time some state highway departments had developed tests of their own for determining wear ability of aggregates under wet abrasion conditions. A modification is proposed to the standard LAA test to include 250 revolutions with the aggregate in the dry state plus 250 revolutions after a fixed amount of water has been added.

Wieden et. al (1977) studied to improve the Los Angeles test and concentrated in three aspects, i.e., sample material, test conditions and type of stress. The sample material and test conditions affect test values because of the specific characteristics

of the rock and the particle dimensions. The greatest effect was produced by the number of revolutions of the drums and shown that each tolerance of the revolution speed leads to great errors. An analysis of the stressing process during the Los Angeles test showed the spheres rolling through the sample material may exert a stress similar to an impact stress.

Kazi and Al-Mansour (1980) investigated the abrasion and soundness characteristics of crushed-rock aggregates obtained from a wide variety of igneous rocks of volcanic and plutonic origins. The grain size and the volume of pore spaces were found to be the significant geological factors. Fine-grained rocks when compared with coarse-grained rocks having the same porosity were found to be sounder and more resistant to wear.

Maharjan and Tamrakar (2007) studied natural uncrushed gravels from the Rapati River central Nepal. It was suggested that the gravels were suitable both for road and other concrete structures.

Kahraman and Fener (2007) studied in LAA and some physical and mechanical tests were performed on 32 different rocks, ten of which were igneous, metamorphic and sedimentary.

Khanal and Tamrakar (2009) studied LAA of crushed limestone and siltstone, and suggested their suitability for base and subbase courses based on Nepal Road Standard (DOR, 2001).

Ahmet Teymen (2017) studied thirty-nine igneous rock aggregates to measure the quality of the aggregates and to determine the relationships between the LA values and the mechanical physical properties of the aggregates. The regression analyses indicated strong correlations between LAA and mechanical tests of aggregate.

The value obtained from the Los Angeles abrasion test gives an indication of the abrasion resistance of the material. A low LAA loss% indicates that the material has high abrasion resistance. Conversely, a high LAA loss% indicates that the material has low abrasion resistance. Table 1 shows a list of typical LAA values for different rock types that may or may not be used in road construction.

Table 1: LAA values for different types of rock (Interactive, 2011)

Rock Type	LA Abrasion Loss (by percent weight)
General Values	
Hard, igneous rocks	10
Soft limestones and sandstones	60
Ranges for specific rocks	
Basalt	10 – 17
Dolomite	18 – 30
Gneiss	33 – 57
Granite	27 – 49
Limestone	19 – 30
Quartzite	20 – 35

Table 2: (a) Physical requirement of aggregates interms of LAA (based on Nepal Standard, 2072), and (b) Classes of material quality (after NS, 2072)

(a)

Intended Use	LAA, % max.
Concrete	
High quality	<35
Ordinary quality	<45
Asphalt Concrete	
A	25
B	30
Surface dressing	
High Performance	20
A	25
B	30
C1	35
*C2	35
Crushed stone base and subbase	
Base Course, B	30
Base Course, C1	35
Subbase Course, D1	40

*Uncrushed

(b)

Material classes		LAA, %	AIV, ACV, %	SSS, %	Flakiness index, %	Crushing ratio, %
A		<25	<20	<12	<20	100
B		<30	<20	<12	<25	100
C	C1	<35	<25	<12	<25	80
	C2*	<30	<20	<12	<25	-
D	D1	<40	<30	<12	<30	60
	D2	<35	<20	<12	<30	-
E	E1	>35 & <50	<25	<18	-	-
	E2	>40 & <50	<30	<18	-	-
	E3	>50	<30	<18	-	-

*Classess for rounded materials only

Nepal Standard (2072) has specified limiting loss percentage of LAA for various application of construction aggregates (Table 2).

A CASE STUDY ON EFFECT OF GRADE AND ROCK TYPE ON LAA

Two rock types: metasandstone and gneiss were selected for understanding whether grade of sample and rock types have significant influence on LAA test results. Both rock types selected are metamorphic rocks sourced to terrestrial and are natural (Table 3). Gneiss sample is feldspathic with well-developed foliation, slight feldspar alteration, and with moderate degree of induration. Metasandstone sample is massive and fine-grained one, and is indurated.

The LA test machine consists of a hollow steel drum with an inner diameter of 711 mm, with a 90 mm deep and 25

Table 3: Petrographical description of the Test Samples

Sample No.	Source	Physical Characteristics	Petrological Description
1	Terrestrial	Shape: angular subequant	Monomictic
	Natural	Surface texture: rough and dull Induration: moderately indurated with slight feldspar alteration	Fabric: coarse-grained, gneissose structure, foliated
	Crushed	Surface coatings: negligible	Rock type: Feldspathic Gneiss
2	Terrestrial	Shape: angular subequant	Monomictic
	Natural	Surface texture: rough and dull Induration: indurated	Fabric: massive
	Crushed	Surface coatings: negligible	Rock type: Fine-grained Metasandstone

mm thick shelf inside. Two sets of samples for each rock type were produced to aggregate sizes especially Grade A with a graded mix of 37.5–25 mm, 25–19 mm, 19–12.5 mm, and 12.5–9.5 mm size fractions and Grade B with a mix of two size fractions, 19–12.5 mm and 12.5–9.5 mm, as defined in ASTM C 131–131M (2014). Grades A and B for the Test Samples of each rock types were prepared by crushing the samples by using hammers (Table 4). There were two groups of operators in preparing the samples of different rock types.

Each of the Test Samples were tested for LAA following ASTM C 131–131M (2014). They were then placed in a steel drum, along with 12 and 11 steel spheres (approximately 5000 and 4584 g in total), respectively for Grade A and Grade B Test Samples. The hatch lid was then bolted in place and the drum was rotated for 500 revolutions at a rate of 30–33 rev/min. After the 500 revolutions were completed, crushed aggregate particles and the steel spheres (charge) were emptied into a tray set. The aggregate samples were separated from the steel spheres and then crushed aggregate particles were sieved through a 1.7-mm sieve. Fines were removed from the aggregate coarser than the 1.70 mm sieve and oven-dried to a constant mass at 110ºC for 24h. After cooling, the mass was weighed. The amount of material passing the sieve, expressed as a percentage of the original mass, was calculated as the Los Angeles Abrasion (LAA) and was expressed in percentage.

RESULT AND DISCUSSION

Test results of testing under Los Angeles Abrasion machine after the test exhibit fragmentation by breakage of particles and disintegration into finer particles as well as wearing away of grains from the corners and surface withou significant breaking down (Fig. 1). It can be seen from the result that the Gneiss Samples of Grade A and Grade B respectively yields LAA of 62.13% and 63.19% (Table 5). Metasandstone samples of Grade A and Grade B give LAA of 37.30% and 36.65%, respectively (Table 5). The values of each of the test grade samples A and B are similar to each other. But the LAA % are drastically different between gneiss and metasandstone samples. Both test grade samples were metamorphic rock type as gneiss and metasandstone but their origin is different. Gneiss is sourced to igneous rock and metasandstone is sourced to be originated by metamorphism of sedimentary rock. Besides, two selected rock types also differ in terms of fabric. Gneiss samples were foliated augen gneiss with extreme anisotropy in fabric and perhaps related to strength, showing their tendency of breakage along the foliation. Contrarily, the metasandstone samples were more massive compared to gneiss and showed homogeneity in fabric and also possessed high degree of induration.

The test results exhibit that the variation of LAA has no significance considering preparation of the Test Samples of

Table 4: Selected test grades and total mass of test samples

Material size (mm)		Grades of Test Samples (weight of fraction by sieving in gm)			
		Sample 1		Sample 2	
Passing (mm)	Retained (mm)	Grade A (Gneiss)	Grade B (Gneiss)	Grade A (Metasandstone)	Grade B (Metasandstone)
37.5	25	1270	-	1271	-
25	19	1251	-	1253	-
19	12.5	1254	2508	1257	2501
12.5	9.5	1256	2507	1254	2501
Total mass of test sample (gm)		5031	5015	5035	5002
Number of Charge		12	11	12	11

Fig. 1: (a) Grade A and B Test Samples of gneiss before and after testing, and (b) Grade A and B of Test Samples of metasandstone before and after testing

Table 5: Summary of Los Angeles Abrasion Value (LAV)

Rock type of the Test Samples	Grade of the Test Samples	Original oven-dry weight of the Test samples W1(gm)	Mass of the sample retained on 1.7 mm sieve after the test, W2 (gm)	Los Angeles Abrasion Value%
Gneiss	Grade A	5031	1905	62.13
	Grade B	5015	1846	63.19
Metasandstone	Grade A	5035	3157	37.30
	Grade B	5002	3169	36.65

different grades, Grade A and Grade B, in case of both rock types studied. However, LAA test results significantly vary among the rock types. The higher LAA loss obtained in gneiss samples could be due to development of micro cracks along the foliation along which rock tends to split. In case of massive metasandstone, the interlocking among mineralogical constituents could be good enough to resist abrasion. Absence of prominent and continuous foliation in metasandstone could be another cause to resist degree of abrasion, hence giving lower LAA loss than that of the gneiss samples.

The obtained LAA values of sample of gneiss (62.13–63.19%) suggest that they should be avoided, whereas those of sample of metasandstone (36.65–37.30) suggest its suitability for various concrete and subbase course of pavement. Even the metasandstone sample does not reflect its suitability for base and wearing courses. Compared to natural river gravel tested by Maharjan and Tamrakar (2007) and limestone and siltstone tested by Khanal and Tamrakar (2009), the results of the present study for gneiss and metasandstone have shown inferior quality of hardness and toughness against abrasion. Those gravels tested by Maharjan and Tamrakar (2007) were composed of dominant quartzite, and subordinate schist, carbonate and granite. The LAA loss obtained for those gravel was 30%. Similarly, the LAA values obtained by Khanal and Tamrakar (2009) for crystalline limestone, siliceous limestone and calcareous siltstone were respectively 28.4–30.3%, 26.8–30% and 29.2–30.2%. Therefore, results of all those carbonate and siliciclastic rocks showed their suitability for under the acceptable limit of NRS (DOR 2001) for base and subbase courses.

CONCLUSIONS

1. LAA of gneiss varies from 62.13 to 63.19%, and that of metasandstone varies from 37.30 to 36.65%, showing that somewhat consistent results have occurred for different grades A and B of the Test Samples.

2. Considering the vast different results of LAA between gneiss and metasandstone, it is concluded that the LAA is more dependent on (a) the material properties than on the nominal particle size selected for different Grades of the Test Samples, (b) and anisotropy in fabric and anisotropy related strength of rock types.

3. Considering the LAA results, the tested metasandstone can be used in ordinary concrete and subbase course, while gneiss should be rejected.

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