

ASSESSMENT OF ABRASION CHARACTERISTICS OF CRUSHED AGGREGATE FROM MURREE FORMATION OF MIOCENE AGE

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ABSTRACT: The stability and durability of the infrastructures are directly dependent on quality of aggregate shape and strength. To investigate quality of aggregate, physical characterization and Los Angeles Abrasion Tests were performed on 15 samples collected from Murree Formation of Miocene age. The results indicate that with respect to abrasion the Murree Formation can be divided into two categories, in the first category sandstone and siltstone can be included where as in second category mudstone and compact shale are placed. The Los Angeles Abrasion loss for sandstone and siltstone range 5.76 to 22.72 %, hence can be used as crushed aggregate for roads and other construction requirements

Key words: Murree Formation, sandstone, siltstone, aggregate, Loss Angeles abrasion test.

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INTRODUCTION

Aggregates are essential component of all types of infrastructure such as highways train tracks, buildings and dams. Natural aggregates are silt, sand and gravel mostly obtained from quarries of alluvial deposits. The rock crushed aggregate of limestone, sandstone and other hard rocks are also very common. Many researchers have investigated abrasions of rock aggregate by Los Angeles abrasions (LAA) test and determined various abrasions contributing factors such as grain size, shape and strength. Investigators established very useful correlations between Los Angeles abrasions (LAA) and uniaxial compressive strength (Shakoor and Brown, 1996; Kahraman and Fener, 2007; Kahraman *et al.*, 2010 and Ozelik, 2011) predicted Los Angeles abrasion of rocks from some physical and mechanical properties and reported correlation between LAA and some physical properties of rocks.

Generally the quality of rock crushed aggregate is estimated on the basis of physical and mechanical properties of rock such as durability, abrasion, petrography (Khan *et al.*, 2013; Dhakal *et al.*, 2002; Kolay and Kayabali, 2006; Kabbaman and Toraman, 2008; Zaidi and M.S. Ali 2015; Johansson *et al.*, 2008) and further reported that good quality aggregates are those which meet the standards for use in making concrete with high strength for construction of buildings, paving roads railway tracks and manufacturing industrial products. Mostly the quality is determined by the size and shape of their individual grains, the minerals from which aggregates are composed of and other physical and chemical properties.

The sandstone of Murree Formation is being locally used in Muzaffarabad and surrounding areas as

construction material such as stone walls for houses. It is useful material for construction of retaining walls to control landslides and aggregate for pavements. In the outcropped areas, the sandstone is inter-bedded with mudstone layers. The overall behavior due to presence of alternate shale beds and orientation of discontinuities has resulted reduction in rock mass strength but the intact rock has good strength (Saleem *et al.*, 2006).

Millions of tons rock fragments are being produced as muck from Neelum Jehlum Hydropower Project which can be utilized as aggregate in the mountain areas of the country where there is great need of aggregates for construction. Due to good strength and blocky nature of the sandstone, its potential use as aggregate in construction of buildings, roads and other applications are required to be explored. This study was being carried out to assess the abrasion characterization of crushed rock aggregate obtained from Murree Formation of Miocene age outcropped in Murree Hills and Azad Kashmir areas of Pakistan.

MATERIAL AND METHODS

By adopting the recommended method of American Society for Testing and Materials (2006), Los Angeles Abrasion Tests were performed with LA Abrasion machine model 2005 to determine the resistance of coarse aggregate to impact in a rotating cylinder containing metallic spheres. The Los Angeles abrasion test measured the degradation of a coarse aggregate sample placed in a rotating drum with steel spheres. As the drum rotated the aggregate degraded by abrasion and impact with other aggregate particles and the steel spheres.

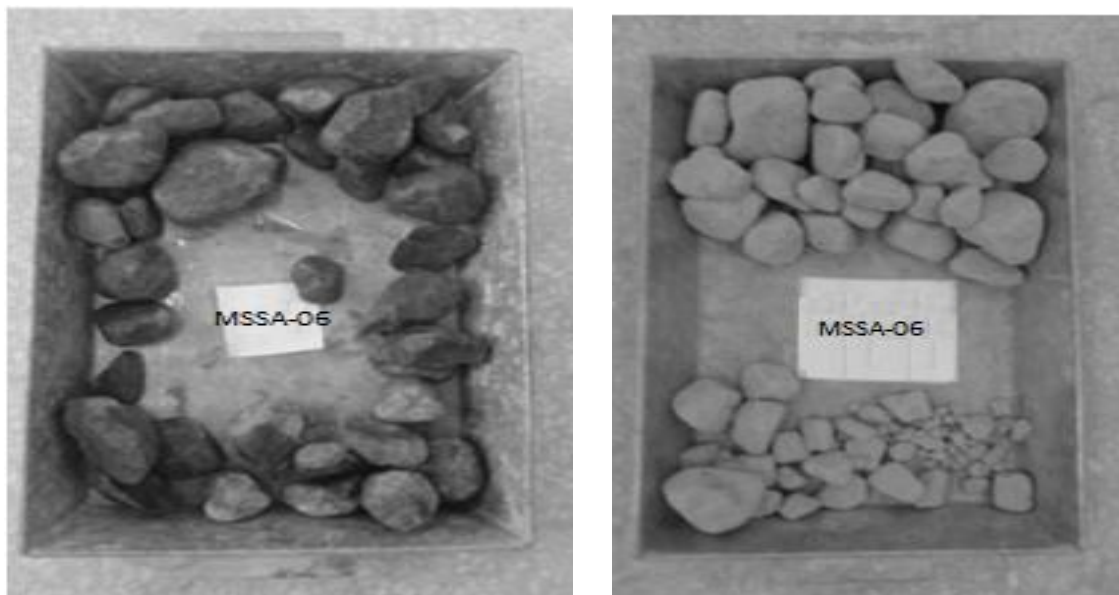
The Los Angeles Abrasion Test machine (Fig. 1) consisted of hollow steel cylinder, close at both ends having diameter of 0.7 m and length 0.52 m which was filled with 48 mm diameter cast iron spherical balls along with the aggregates (5- kg). The cylinder mounted on a sturdy frame on ball bearings. The opening was closed dust-tight with a removable cover bolted in place. A detachable shelf which extended through the drum caught the abrasive charge and did not allow it to fall on

the cover. The drum was rotated at a speed of 30-33 rotations per minute by an electric motor to obtain 500 revolutions.

After completion of 500 rotations the material was sieved through 1.7mm sieve and the passed fraction was expressed as a percentage of the total weight of the sample which is called Los Angeles abrasion value. The shape and size of the aggregate was changed after completion (Fig. 2).



Figure 1. Los Angeles abrasion machine used for determination of abrasion of the rock aggregate



a) Crushed aggregate before test b) Effect of abrasion after test

Figure 2. Effect of abrasion on the shape and size of aggregate

RESULTS AND DISCUSSION

The lower Los Angeles abrasion loss values indicated that aggregate was tougher and more resistant to abrasion. The Los Angeles abrasion test was an empirical test; it was not directly related to field performance of aggregates. Field observations generally do not show a good relationship between Los Angeles abrasion values and field performance.

The physical characterization of the formation showed that it was composed of medium grained, light brown to yellowish brown sandstone with thin layers of shale. Along the exposed sections the degree of weathering was also variable over horizontal spreading. The samples were collected from Muzaffarabad and surrounding areas from the upper to the lower horizon of formation so that it covered vertical variation due to depositional environment.

The Murree Formation was composed of four major rock units, sandstone, siltstone, mudstone and clays

along with soft shale. There was a great variation of strata within the formation. Mostly the hard and soft rock units were alternating each other. In some of the outcrops along Kohala- Muzaffarabad road the clay was dominating and the sandstones were embedded in clay matrix where as near to Muzaffarabad and along the route of Neelum Jhelum tunnel sandstone and siltstone were dominating. Some of the physical properties of the major rock units are shown in Table (1).

In a study Shah (2009) described the geology of the Murree Formation as, "the formation was composed of a monotonous sequence of dark red, purple clay, purple grey and greenish grey sandstone with subordinate intra formational conglomerate". The mineralogical studies carried out through thin section (Fig. 3) indicated very high percentage of quartz which was one of the most resistant mineral of sedimentary rocks. The low abrasively of the sandstone and siltstone of Murree Formation was directly related to the presence of high percentage of quartz.

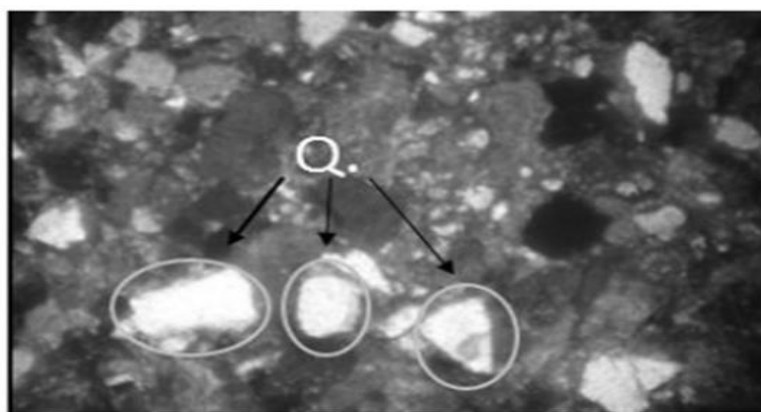


Figure 3. Photomicrograph of sandstone showing moderately high percentage of quartz

Table 1. Physical characterization of rock units of Murree Formation.

Sr. No	Sample identity No.	Name of rock unit	Grain size	Shape of fragmentation
1	MSSA-01	Siltstone	Fine grain	Chips with blunt edges
2	MSSA-02	Mudstone	Fine grain	Angular lumps, mostly elongated
3	MSSA-03	Sandstone	Medium to coarse grain	Breaks in blocky fragments
4	MSSA-04	Sandstone	Fine grain	Breaks in blocky fragments
5	MSSA-05	Siltstone	Medium to fine grain	Angular fragments, the lumps have sharp edges
6	MSSA-06	Sandstone	Coarse grain	Breaks in layers
7	MSSA-07	Mudstone	Medium to fine grain	Angular lumps
8	MSSA-08	Sandstone	Medium to coarse grain	Angular lumps
9	MSSA-09	Sandstone	Medium to fine grain	Angular and blocky lumps
10	MSSA-10	Sandstone	Medium to coarse grain	Breaks in blocky fragments
11	MSSA-11	Siltstone	Fine grain	Breaks in blocky fragments
12	MSSA-12	Siltstone	Fine grain	Angular fragments, the lumps are sharp
13	MSSA-13	Siltstone	Fine grain	Angular fragments, the lumps are sharp
14	MSSA-14	Mudstone	Fine grain	On crushing breaks into thinly platelets
15	MSSA-15	Mudstone	Fine grain	On crushing breaks into thinly platelets

The results of the abrasion values for various rock units are given in Table-2. The abrasion values for sandstone ranged from 5.76 to 18.93%, for siltstone the range of abrasion value was 18.74 to 19.45% and for mudstone it was 16.59 to 22.72%. It was also clear from abrasion percentage of various samples that there was a great variation in toughness and strength of various rock units within the formation. For example the range of 5.76 to 18.93 abrasions in sandstone showed that some of the beds of Murree Formation were very tough and hard other beds were comparatively less tough and more abrasive Table-2.

Jamil (2014) reported LA abrasion loss values for sedimentary rocks such as khewra Sandstone, Sandstone of Kussak and Baghawala formations from Salt Range. The average values range from 50-57 % for Khewra Sandstone, 15-19 % for Kussak and 23-28 % for

sandstone of Baghawala Formation. Hence our results are similar to the results of Jamil (2014) and Jamil and Khan (2014) for sandstones of Kussak and Baghawala Formations. However the result of Khewra Sandstone is different, because Khewra Sandstone is a soft rock compared to sandstone of Murree Formation. Arsalan *et al.*, (2014) made quantitative estimation of abrasive loss from strength for sandstones wherein the results are similar to our findings.

As the availability of natural aggregate was limited in the mountainous areas, therefore to meet the requirements the crushed aggregate was obtained from low lying areas with very high costs. Hence the crushed aggregate from Murree Formation was a good source, especially the muck generated by Neelum Jhelum tunnel which could be crushed to suitable sizes for construction and other purposes.

Table 2. Estimation of abrasion of the samples of Murree Formation collected from various outcropped.

Sr. No	Sample identity No.	Type of rock	Original aggregate mass tested (g)	aggregate mass after abrasion	Abrasion value %
1	MSSA-01	Siltstone	5000	937	18.74
2	MSSA-02	Mudstone	5001	830	16.59
3	MSSA-03	Sandstone	5000	655	13.10
4	MSSA-04	Sandstone	5003	573	11.45
5	MSSA-05	Sandstone	5004	288	5.76
6	MSSA-06	Sandstone	4008	560	11.47
7	MSSA-07	Mudstone	5000	1100	22.00
8	MSSA-08	Sandstone	5001	947	18.93
9	MSSA-09	Sandstone	4999	460	9.20
10	MSSA-10	Sandstone	5001	380	7.60
11	MSSA-11	Sandstone	5000	485	9.70
12	MSSA-12	Mudstone	5005	1075	21.47
13	MSSA-13	Mudstone	5003	1137	22.72
14	MSSA-14	Siltstone	5002	973	19.45
15	MSSA-15	Siltstone	5000	967	19.34

Conclusion and Recommendation: On the basis of field investigations and tests performed in the laboratory the following conclusions were made.

- There were four rock units in the Murree Formation i.e sandstone, siltstone, mudstone and clays and a large variation was observed in the abrasion value of these rock types.
- The shape of the crushed aggregate was also different for various rock units of Murree formation which was probably controlled by depositional environment, mineralogy and degree of cementation
- The abrasion values of aggregate on the basis of Loss Angeles abrasion tests of Murree formation ranged from 22.72 to 5.76 % which showed that all the rock units tested of the formation and has good strength.

- On the basis of abrasion values, the formation could be categorized into two groups, i.e. Low abrasive sandstone/siltstone and high abrasive mudstone.
- It is suggested that instead of dumping large amount of waste material being generated from Neelum Jhelum tunnel, It must be investigated in detail for possible utilization as aggregate in roads and concrete bricks for building construction.

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