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MIOCENE SANDSTONE OF MUREE FORMATION, RAWALAKOT, AZAD KASHMIR, PAKISTAN: GEOTECHNICAL PROPERTIES EVALUATION OF GEO-MATERIAL

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ABSTRACT

Geological mapping was prepared at the scale 1:12,500 for Rawalakot area about 100 square kilometers. The results show that the material strength is related to the mineral assemblage and the aggregate composition of Muree sandstone. Los Angeles value, impact value, specific gravity, water absorption, flakiness index and elongation index were performed and co-related according to the ASTM standards, and the parameters of the material strength were deduced according to the mineral assemblage of the Muree sandstone. It was seen that the percentage of quartz and cementing material like calcite in favorable conditions provide strength to the material and deleterious material like clays due to its swelling potential, damage the material when in contact with water. Reserves of the Muree sandstone as geo-material at different localities were also estimated for the quarry purpose.

KEYWORDS: Geological Mapping, Engineering Characteristics, Geo-Material, Muree Sandstone

INTRODUCTION

The occurrences and use of Sandstone aggregates are well known in all over the world for centuries and can be studied in old construction by different ways, showing older civilization from past to present (Philbrick, 1950). The potential area of sandstone in Azad Kashmir is Rawalakot valley of Poonch, where sandstones are well exposed and is very hard and the reserves are enough for many years. Huge reserves of sandstone are enough for many years (Zaki, 1980). About seven quarries are presently supplying rock material for aggregates in Rawalakot area. So far, no scientific developments of quarries have been made in the area due to lack of knowledge and commercial reasons. Moreover, the lack of definite knowledge of specific properties, sandstone aggregates are also not develops for reason for the potential source development. The sandstone aggregates studied during the present investigation represent the varieties of sandstone, which differ in color, texture structure hardness and mineralogy, which affect the quality of sandstone present in the surface exposure.

The quarries are present on the roadside. Simple open quarry method could be used to extract the rocks. The material is being quarried for construction of highways and building. Work force and climatic conditions are favorable so the demand of sandstone aggregate is high. The scientific approach and further research is necessary for commercial exploitation. The rocks available in the area have huge reserves of various grades, color and texture. Locally these rocks are being used as building stone or for locally road construction purpose and for aggregates at small scale.

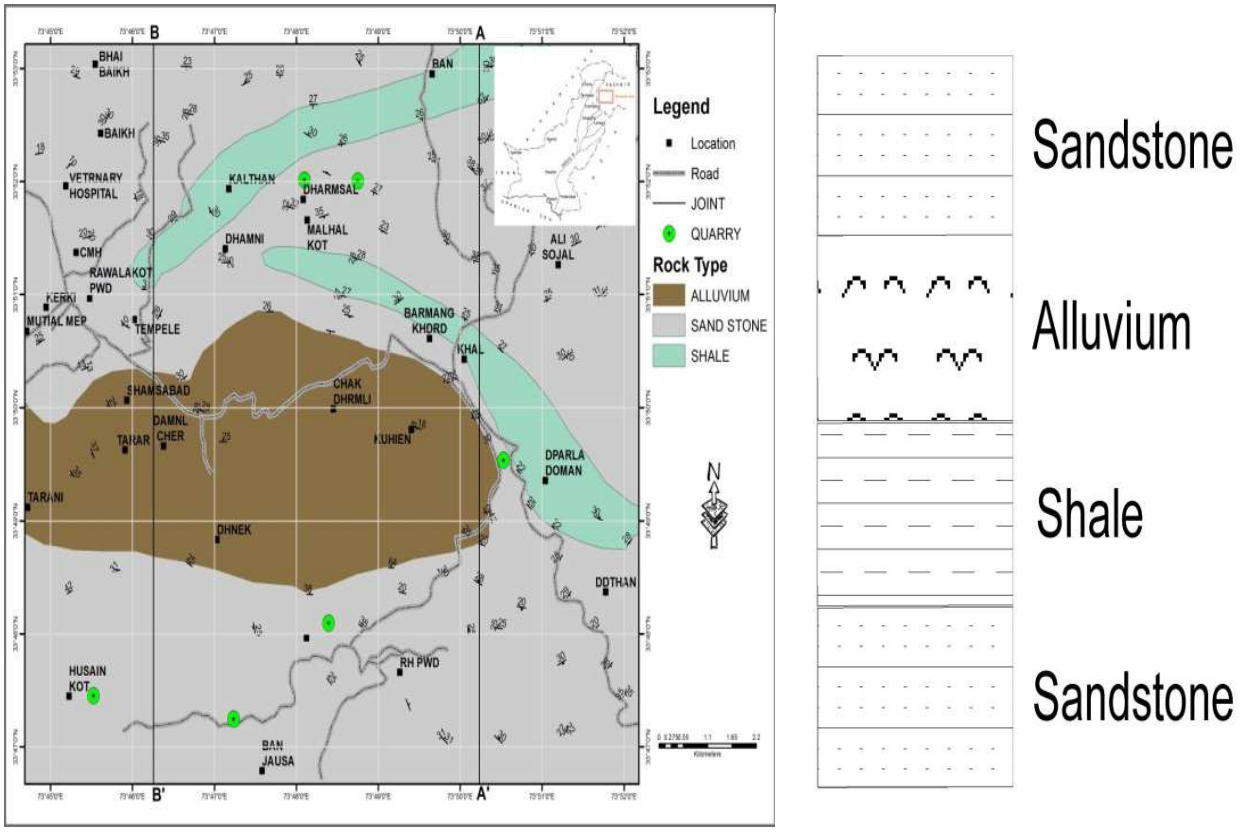

Figure 1: Geological Map of Rawalakot, Azad Kashmir

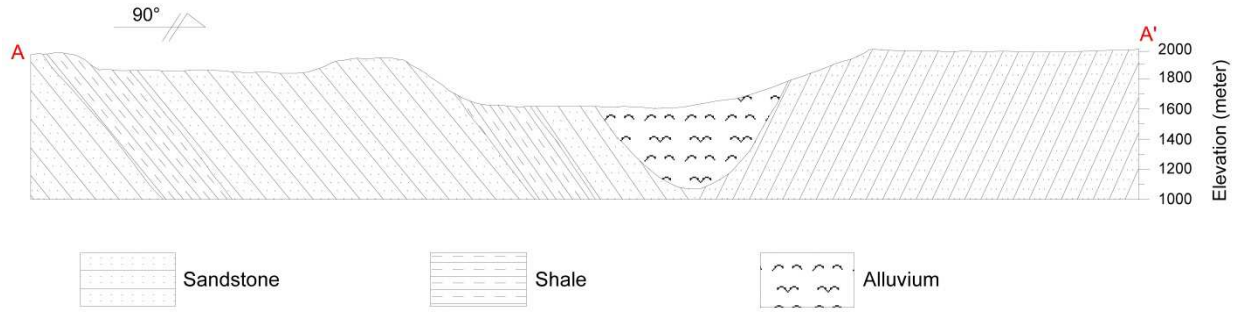

Figure 2:Cross Section Map of Rawalakot, Azad Kashmir

REGIONAL GEOLOGY

The area lying within Middle and Lesser Himalayan zone. Poonch is a rectangle or mountainous area bounded on the East by the central axis of Pir Panjal, South by the glacial lakes of Bhagnar and west by the Channel of Jhelum and its northern boundary is defined by the nameless ridge which form a subsidiary watershed between the waters of Jehlum and those of the water system between Ferozpur and Kohala (Wadia, 1928). In Poonch District exposed rocks range from Precambrian to Pleistocene age. The Precambrian rock formation is Dogra Slate which has been introduced by (Wadia, 1928).Cambrian rocks are correlated with Abbottabad group (Consisting of basal boulder beds and overlain by thick sequence of Surban dolomite/ quartzite). In this area apart from the Cambrian (Abbottabad Group) all the formations of Paleozoic and Mesozoic are missing, neither they were not deposited nor weathered to form bauxite/laterite representing an unconformity. In the tertiary period Patala Formation, Margala Hill limestone, Muree Formation and rocks of Siwaliks

Group were deposited (Ashraf et al., 1983). Siwaliks group consist Chingi Formation, Dohk Patahn Formation and Soan Formation.

Geological Description of the Area

The rocks exposed in the area are mainly Miocene sandstone and shale of Muree Formation (Wadia, 1931; Ashraf, 1989). The sandstone is massive and thickly bedded with inter bedded shales. A detailed description of Muree Formation that occupies about one third of the area of Poonch State has been described. The investigated area is under the influence of Lesser Himalaya (Wadia, 1931; Ashraf et al., 1989). Therefore, the structures found in the area are due to the tectonic activities in the area. The Muree Formation of Miocene consists of sandstone inter-bedded with shales. They are generally light grey to grey in fresh color while dark grey to purple and dark grey to greenish grey in weathered colors. The sand stone is medium to coarse-grained high tenacity, and compact calcite veins are present at some places. Cracks and fractures are present and filled with calcareous and clayey material. Shales are present which are inter-bedded with sandstone. Shales are red, purple, and buff, brown in color. They contain calcite veins and are devoid of fossils (Chaudhary and Ashraf, 1985). Thickness of shales varies from 1 meter to 30 meters. They are red, purple, and brown in color (Ashraf et al., 1983). According to stratigraphic sequence, the sandstone and shales of Muree Formation are of Miocene age. They are light grey to grey in fresh color while dark grey to purple and dark grey to greenish grey in weathered color, medium to coarse grained high tenacity and compact. The sandstone is calcareous and calcite veins l cm to 5cm are present. Small and big-cracks are normally across the bedding planes.

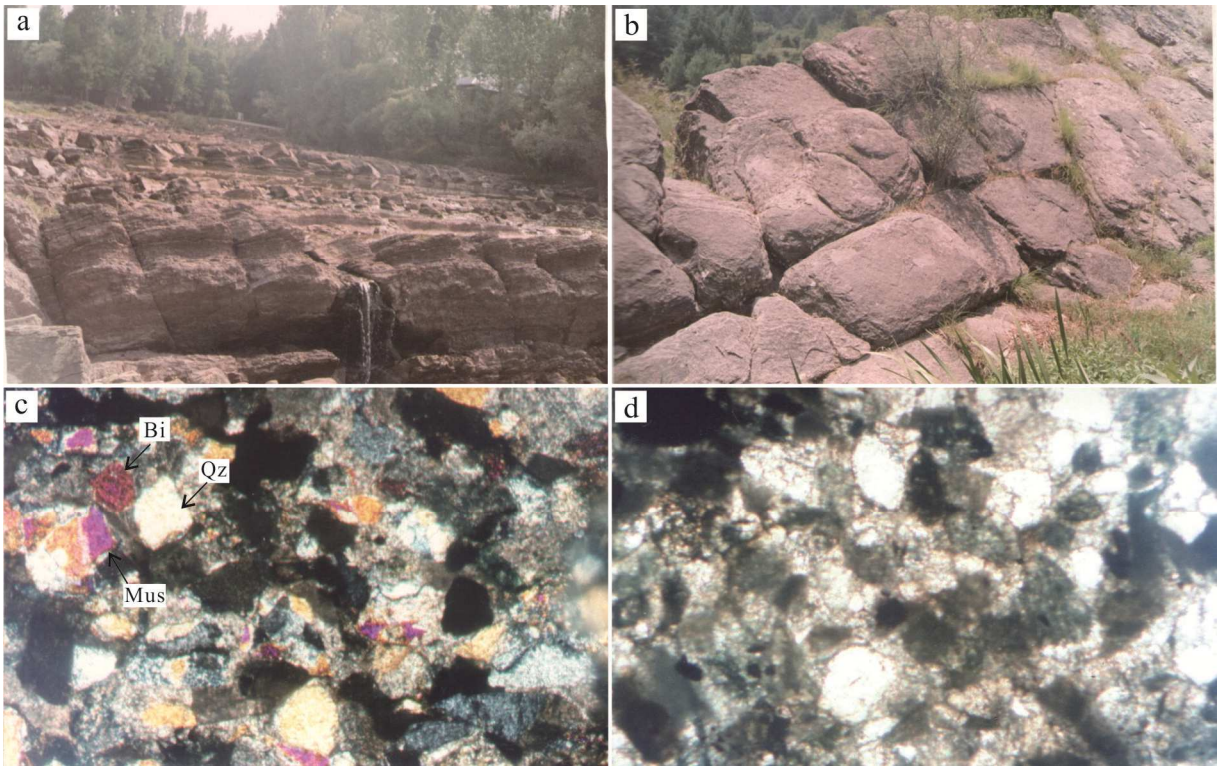

Figure 3a: Photograph Showing Alternate Bedding in Muree Formation Dhok Locality, Rawalakot Area, b: Photograph Showing Fracture Joints in Sandstone of Muree Formation Dhok Locality, Rawalakot Area., c & d: Photomicrograph Showing of Kahigala Sandstone Showing Quartz, Calcite, Plagioclase, Rock Fragments and Iron Minerals

Structure

The investigated area is under the influence of Lesser Himalayas and Sub Himalayas (Wadia, 1931; Ashraf, 1989).Therefore; the structures found in the area are due to the tectonic activities (Bossart et al., 1984). Minor anticlinal and synclinal folding is very common in the area. These show the tectonic forces activated in the area. The difference in the compactness between the shales and sandstone beds of the Muree Formation determines the character and geometry of the structure in the Muree Formation. Normally strata shows the strike and dip directions from NE to SW (Figure l).

METHODOLOGY

A 100 square kilometers area of Rawalakot, Azad Kashmir at longitude73°45'and latitude 33°47', has been mapped at a scale of 1:50000. It extends from Rawalakot to Dothan and surrounding side of Rawalakot, mostly covered with vegetation and alluvium. Main objective of this study was to investigate the geotechnical properties of Muree sandstone as aggregate, because Muree sandstone is extensively used in construction as for preparing concrete blocks, road construction and other civil engineering structure, and to establish relationship between different properties for proper utilization of the rocks. Due to inaccessibility, no remarkable work has yet been done in the past. However, Wadia (1931, 1934) described the geology of the area. Ashraf et al. (1989) has also worked on the geology of the area and described the petrography of the rocks. A geological map has been prepared on 1:50000 scales (Figure l) which are suitable for extracting building material. Quarries have been marked on the map. The properties evaluated are Los Angles Abrasion value, specific gravity, water absorption, crushing value, impact value, flakiness index and elongation index. These properties of rocks are tested with ASTM (American Standard of Testing Material) standards procedure to know the effects of heavy traffic on rock aggregate when used for road construction and environmental effects on mineralogical composition and the damages caused.

The four times enlargement of the relevant portion of the toposheets numbers 43 F/12, 43 F/16 of Survey of Pakistan (Figure 1) were used as a base map at a scale of 1: 12500. During the fieldwork, traverses were made across the strike in order to note the maximum variations. Field observations were plotted on the base map. Contact between Muree sandstone, alluvium and shale was carefully marked (Figure 1). Samples were taken based on color, texture, structure, joints and thickness of rock bed. The samples prepared for mechanical studies were 25kg to 35kg in weight. A part of sample was taken for the evaluation of petrographic studies of the rocks. The name of the sample is given according to the rock type, locality and the number indicates the position of the sample collected in the field. e.g. SKG-1, where S stands for sandstone, KG shows Kahigala and shows the position of the sample. The major traverses were located in Rawalakot, Dharmsal, Damni, Hussain Kot, Banjosa, Khai Galla, Chota Galla, Tarar, Tarani, and Charh Nala (Figure l). The samples were collected from the fresh outcrops, and were not taken from highly weathered places either chemical or mechanical. Geotechnical properties were carried out on fresh samples. Four times i.e. (1:12500) enlarged topographic map of the field area was used for investigation and location of sample sites. Dip, strikes, joints and cracks were plotted on site for the preparation of engineering geological map. The reserves were estimated for working quarries, which were connected to metaled or un-metaled roads.

MECHANICAL PROPERTITES OF ROCK AGGREGATE

The rocks of Muree Formation of Miocene are mainly composed in the field area, is being used as construction

raw material. The objective of this study is to evaluate the rational use of the rocks as concrete aggregate for different civil engineering works. The rocks are thin bedded and often fractured, jointed and cracked. Cracks and fractures are filled with clays and calcites at places. On the other hand, open fractures are filled with clays and calcareous material. These fractures facilitate the excavation of blocks from the quarries that can be used in basement of buildings and walls like retaining wall along the roads, abutments and bridges.

Geotechnical properties of these rocks have been evaluated by performing different tests in laboratory. These tests show the hardness toughness and resistance against the applied load. The tests have been performed, including Los Angeles abrasion value (Av), crushing value(Cv), impact value(Iv), specific gravity(Sg) and water absorption (Wa), flakiness index(Fi) and elongation index(Ei).

Los Angeles Abrasion Value

Aggregate Abrasion value test offer the resistance to rock aggregate against the veering by traffic load and suggest the use of concrete in flowing water channels in pavements and to guide the material for road surfaces and air craft run ways. The aggregate Abrasion value test was conducted on 5Kg crushed sample. Material was used in Los Angeles Machine. The average abrasion value of Muree sandstone ranges from 29.8 to 34.5. Which was below the recommended limits of ASTM (0 to 40). The Abrasion value is strongly affected by the grain size and the binding material of grains, as the grain size increased the Abrasion value also increases. All the values of Los Angeles Abrasion test are listed in (Figure 4).

Aggregate Crushing Value

Aggregate crushing value is being applied in the road construction in the regions that experiences heavy and low traffic areas (Khanna, and Justo, 1983). Muree sandstone is highly crushed, fractured and jointed. The grain size ranges from fine to coarse. The results of the crushing value are comparable and it seems that the aggregate crushing value may be controlled by the texture of the rocks. The Aggregate crushing value of Muree sandstone ranges from (22.6 to 23.8 (Figure 4) and is comparable with recommended values of ASTM (0 to 25) (ASTM, 1968).

Aggregate Impact Value

Aggregate impact value determine toughens of the aggregate. The test was carried out on Muree sandstone to know the behavior of the aggregate impact value ranges from (19.09 to 27.00)(Figure 4).The impact value of Muree sandstone aggregate is within the range of recommended ASTM standards (0 to 30)(ASTM, 1968). The variation is due to the difference in grain size and looseness of the rock at different localities.

Specific Gravity and Water Absorption

Specific gravity and water absorption test of rock aggregate is considered to measure the strength or quality of material. Stones having low specific gravity are generally weaker than those with values of higher specific gravity. The specific gravity test helped in the identification of stones strength, water absorption gives an idea about the strength of rocks. Rocks having more water absorption value are generally unsuitable for road construction.

About 1.5Kg samples of rock aggregates were placed in water filled basket for a period of 24-1+1 hours. After this period the samples were surface dried by a damp cloth and weighed and then placed in an oven for 24 hours. After

drying the sample were again weighed. The specific gravity and water absorption values of samples taken from different localities were determined with the help of given formula. Specific gravity of Muree sandstone ranges from (2.05 to 2.45) (Figure 4) and is below as compared to recommended ASTM standards (2.5 to 3.0) and the water absorption values ranges (1.59 to 2. 29) (Figure 4). The limits of ASTM standards are (0.1 to 2.5) (ASTM, 1968).

Flakiness Index and Elongation Index

The shape of aggregate is determined by the percentage of flaky and elongated particles contained in it. The presence of flaky and elongated particles may cause inherent weakness with possibilities to breaking down under heavy loads. The evaluation of shape particularly with reference to flakiness and elongation is necessary for aggregates to be used for determination of rocks. Under investigation, samples were crushed in to pieces and then they were passed through specified sieves. Each sieved material was then passed through specified thickness gauge and length gauge. Flakiness index was calculated by summing up of all the fractions, which were retained on length gauge. The flakiness index ranges from (10.90 to 14.00) (Figure 4) and are within the ASTM standards (0 to 15)(ASTM 1968)). The elongation index in this area range from (9.61 to 13.00) and is within the range of ASTM standards (0 to 13) (ASTM 1968)

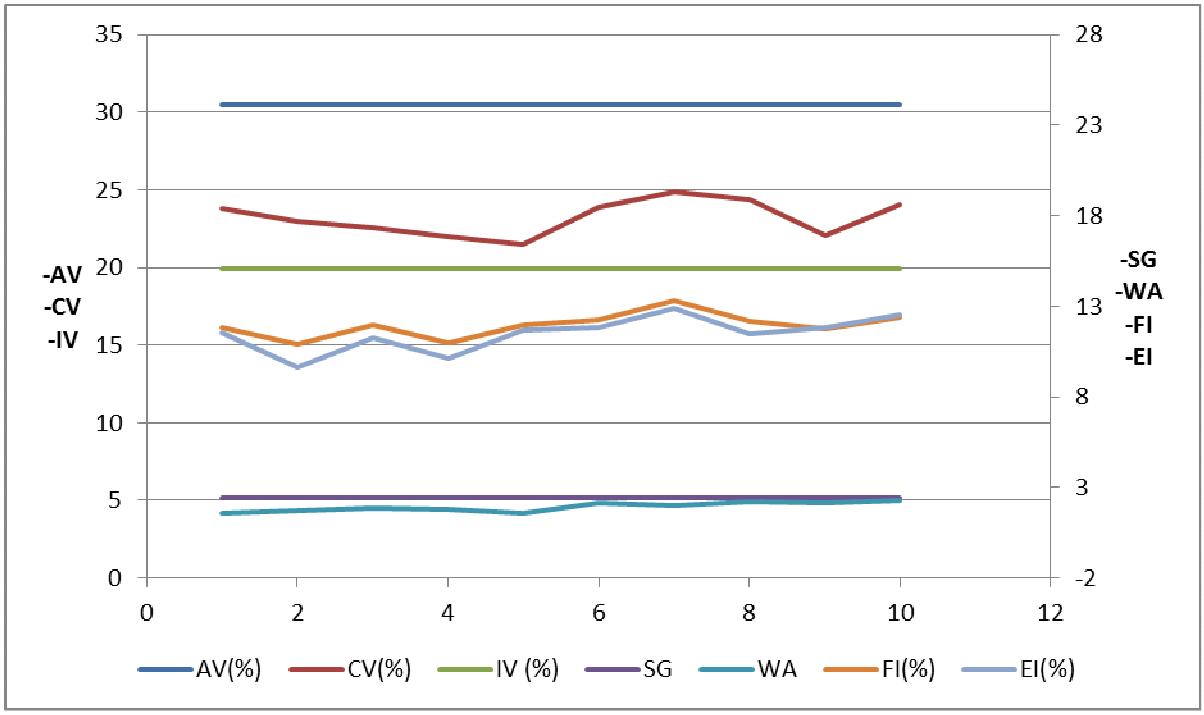

Figure 4: Los Angles Value, Crushing Value, Impact Value, Specific gravity, Water Absorption, Flakiness Index and Elongation Index of *Khaigala, Chottagala, Hussainkot and Benjosa (Poonch, Azad Kashmir).* Los Angeles Abrasion Value (Av), Crushing Value(Cv), Impact Value(Iv), Specific Gravity(Sg) and Water Absorption(Wa) Flakiness Index(Fi) and Elongation Index(Ei)

Petrographic Characteristics of Muree Sandstone

Petrographic studies are required to describe and classify the constituents of the sample to determine the physical and chemical character of each constituent present in rock. During the study of sandstone samples hand specimens were taken which were representative of the beds to determine the physical state and chemical alteration on the surface of the rock. Toughness, hardness, texture and presence of detrital substances in the cracks and joints were also determined. Thin sections were prepared for microscopic examination to estimate the mineral constituents for different types of physical and

chemical failure in the sandstone aggregates. The samples were classified according to the physical state e.g. Fresh, moderately weathered (MW) and highly weathered (HW) dense and porous. For each size range descriptions were made about particle shape, texture, color and presence of detrital substances. The minerals of the aggregates may adversely affect the performance or in service life of the structure as well as the safety of the public. The disfigurement of interior of the concrete structure, structural failure of the concrete structure, short pavement life in wet weather can be seen in sandstone aggregates used. It is considered during microscopic examination that the grain size or crystal size, texture and mineralogy were studied because these parameters control the performance and the service life of the structure. During the study of Muree sandstone high percentage of quartz is achieved.

Petrography

The sandstone of Muree Formation shows rather uneven distribution of constituent minerals even with the limits of hand specimen (Ashraf et al., 1989). Some Muree sandstones are fine grained, but most of them are medium to coarse grained. The grains are mostly sub-rounded to sub angular. The matrix is composed of clay, sericite, small grain and accessory minerals. The binding and cementing material is calcareous, argillaceous, ferruginous and siliceous. Sandstone is compact and greenish grey, grey to dark grey and reddish brown in color.

Mineralogy

The mineralogy of Muree sandstone comprises of quartz, calcite, clays, muscovite, iron minerals, rock fragmentation etc. This mineral found in different ranges in the matrix and varies in composition from place to place. The quartz grains are sub-angular to sub rounded, and show twining at places. Calcite seen cloudy in the thin section. It is medium grained even in hand specimen. Interference color is light grey to white. It is the main binding and cementing material in thin section. It has cubic crystals structure and shows rhombohedral cleavage. Their percentage within the matrix is given in the Figure 5.

Muscovite and sericite often occur in associated form. Sericite is fine grained whereas muscovite is generally fine to medium grained. Some muscovite should be considered as grains and the rest of the muscovite is a part of matrix. Sericite along with clay also occur as an alteration product of feldspar. Magnetite/Hematite and other iron minerals occur as grains the sub-angular to sub-round in shape. In non-incident reflected light they show yellowish brown to brown color. The rock fragments have been found in unstable form. They are mostly medium to coarse grained and sub-angular to sub-rounded. Their distribution is found in throughout the area of Muree sandstone. Clays occur as small specks fine micro crystalline minerals. It may also occur as an alteration product of feldspars. It is an important constituent of the matrix. In Kahigala area quartz percentage ranges from 38% to 40%, calcite ranges from 35% to 39%, muscovite/sericite ranges from 3% to 4%, iron minerals ranges from 3% to 5%, rock fragment ranges from 4% to 6o/o and clays up to 2% to 4% (Figure 5). In Chottagla area quartz percentage ranges from 37% to 38%, calcite ranges from 35% to 39%, muscovite/sericite ranges from 3% to 4%, iron minerals ranges from 2% to 4%, rock fragment ranges from 0% to 3% and clays up to 2o/o to 3% (Figure 5). In Hussain Kot area quartz percentage ranges from 32% to 38%, calcite ranges from 36o/o to 37o/o, muscovite/sericite ranges from 4% to 6%, iron minerals from 2% to 4%, rock fragments ranges from 2% to 6% and clay ranges up to 2% to 7% (Figure 5). In Benjosa area quartz percentage ranges from 34% to 35o/o, calcite ranges from 35% to 37%, muscovite/sericite ranges from 3% to 4o/o, iron minerals from 3% to 4%, rock fragments ranges from 5% to 6o/o and clay ranges up to 3o/o to 6% (Figure 5).

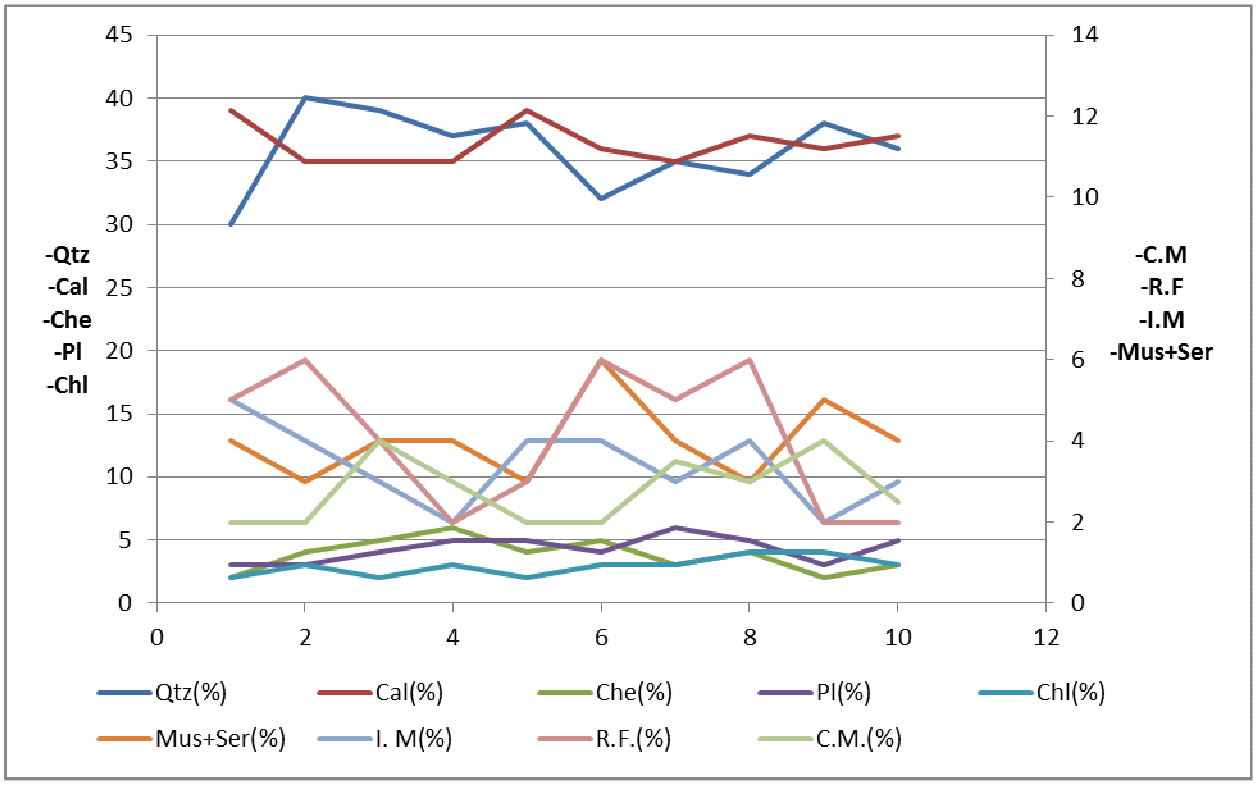

Figure 5: Mineral Composition (w_t%) of Muree Sandstone of Khaigala, Chotagala, Husainkot and Benjosa (Poonch, Azad Kashmir) (Poonch, Azad Kashmir). Cal- Calcite; Che- Chert; Chl- Chlorite; C.M.- Clays and Clay Mineral; Ep- Epidote; Hem- Hematite; I.M.- Iron Mineral; Mt- Magnetite; Mus- Muscovite; Pl- Plagioclase; Qz- Quartz; R.F.- Rock Fragments; Ser- Sericite; "-"- Null

DISCUSSIONS

Deleterious Substances in Aggregates

Harmful substances present in aggregates of Rawalakot District Poonch Azad Kashmir include, clay, silt, some salts, ore minerals, mica and certain lightweight and soft particles. The finer material like clay, taken together as dust, as coating on the aggregate particles. The thin coating of clay and silt has been found on coarse particles, which may be harmful because such coating can weaken the bend between the cement and the aggregate particles. It may be some swelling type of clay or silt but it is difficult in microscopic studies. The absorption test indicates that there is less amount of such particle, but the concrete used in some of the buildings in Rawalakot city has indications of pop-outs, that can be weathered away from aggregates, has chemical impurities distributed uniformly throughout the mass by naturally in deposits which are in layers or particles, may the deposits on top of water table or near streams. Such impurities or mainly chlorides and sulphates in minor quantities, but at places the hydration characteristics of cement" indicate the formation of rust on rock surfaces and on building walls. A comparison of petrography with field performance shows that although the sandstones have less to high argillaceous content. The specific gravity and absorption values (Figure 4), yield unsound aggregate have bulk specific gravity less than 2.5, and absorption values varies from 1-3%edges with sound aggregate have relatively high specific gravity and low absorption values (Figure 4). The relationship between mechanical properties and petrographic characteristics of sandstones investigated include the Rawalakot, Benjonsa, Hussainkot, Khaigala and Chottagala sandstone. Petrographic studies included grain interlocking, grain shape and mineral composition. Results indicate that crushing value, specific gravity absorption and grain to grain contact are closely related. Generally,

Sandstones of the area have higher specific gravity lower percent absorption have higher strength. It seems that petrographic characteristics affect mechanical properties. Two thin sections oriented at right angle to bedding planes were studied for the sandstone. Final values were reported for petrographic characteristics based on average two thin sections. Rawalakot sandstone is sub-angular to sub rounded quartz is dominating which is weakly cemented by siliceous material. Hussainkot is a medium grained moderately to well sort thickly bedded sandstone consisting of angular to sub rounded quartz with an abundant proportion of rock fragments and feldspar grains. It is very well cemented, the cement occurring as patches and over growth of secondary quartz. Benjosa sandstone is fine to coarse grained and moderately sorted. Quartz rock fragments and calcareous cement are the major constituents. Khaigala sandstone is fine grained well sorted and massive. It consists primarily of detrital sub angular to sub rounded, with cement consisting of overgrowths of secondary quartz. The matrix is clayey in nature.

Relationship between Petrographic Characteristics and Engineering Properties

Petrographic characteristics and index properties of sandstones studied are correlated, with specific gravity, percent absorption exhibit strong correlation with impact test and crushing value. The quartz exhibit the best correlation whereas present angular grains, present cement, weakly related to strength and impact. The sandstone with lower value of absorption has higher strength. It is concluded that sandstone with higher specific gravity lower percent absorption exhibit higher values of strength to be used as concrete aggregate.

CONCLUSIONS

The physical, mechanical, mineralogical and textural characteristics were determined to know the grade of aggregate. The properties like specific gravity, water absorption, flakiness index, elongation index, Los –Angeles abrasion, crushing value, impact value were considered for mechanical examination of Muree sandstone. The sandstone of Muree Formation is variable and is different from place to place in its mechanical behavior and mineralogical composition. Pectrographically, the sandstone from different quarries that is most alkali active and poorly crystalline is micro porous. Clay minerals are also present in the sandstone aggregate. When water is contacted with clay minerals, have more tendencies to absorb water and hence they swell and put more pressure on the structure of sandstone aggregates.

The present investigation of sandstone aggregates indicates that all the values do qualify the recommended ASTM standards. In Tarar to Tarani the sandstone is of good quality and the reserves found are 6.6×10^{7} Mt. Sandstone is grey to dark grey in weathered color and light grey in fresh color, medium to fine grained with sub-ordinate shales. In Damsite and Dokhain region, the reserves are up to 5.8×10^{6} Mt. The sandstone is also good in appearance, medium to coarse-grained dark grey to grey in weathered color, cracks and joints are present. It may be suggested under the presence of test results, that the material may be good for construction purpose, but there must be good drainage systems and the measures must be taken to save the aggregate from water. Because the water can damage the sandstone aggregate either in acidic environment or by swelling the clays, which affects the strength and durability of the sandstone aggregate.

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