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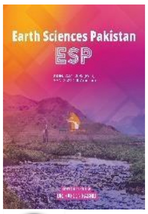

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*RESEARCH ARTICLE*

# KAMLIAL SANDSTONE AS AN AGGREGATE PROBLEM FOR CONSTRUCTION INDUSTRY, PALANDRI AZAD KASHMIR

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**ABSTRACT**

Study area concedes the compressional stresses caused by the collision of Indian and Eurasian plates molded the northwest- southeast trending faults which are Riasi Fault (RF), Palandri Fault (PF), Godri Badshah Fault (GBF) and Chhechhan Fault (CF). This study intended to analyze the Kamlial sandstone as an aggregate problem for construction industry while sedimentary structure, stratigraphic sequence and geology of the study area were also destined. The study area comprised Nakar, Chhechhan, Holar, Tallian and Sarsawah of Palandri Azad Kashmir. The Impact value, Los Angeles Abrasion resistance, Specific gravity and Water absorption test were evaluated for kamlial sandstone. The samples were collected from Garata Sarsawa, Panjeera, Telyan, Kharran, Jabbri kass, Kand Gora, Parasgali, Garrala, Hollar, Chhechann and Nakar near Pallandri. Impact value of Kamlial Sandstone recorded 25.2, Abrasion Resistance of Kamlial Sandstones is 41.4 % which is less than AASHTO value i.e 50 percent. The Apparent Specific gravity initiate 2.1 percent which is less than ASTM standards i.e between 2.6-2.9. and the Water Absorption value recorded 2.24%. The results intimate that the Kamlial sandstone does not qualify ASTM specification for aggregate.

**KEYWORDS**

*Kamlial, Sandstone, AASHTO, AST, Faults, aggregate Tests, Palandri*

## 1. INTRODUCTION

The Himalayan Foreland Basin considered as one of the largest and potent terrestrial basin. It is diverging into a number of sub basins distinguish by several pre-Tertiary basement highs/lineaments (Raiverman, 2002). Pakistan has been divided into two leading sedimentary basins, that are the Indus and the Baluchistan basin, have been identified. The antecedent restrains excellent exposures of the Middle to Late Miocene Kamlial Formation in the Kohat and Potwar plateaus (Kadri, 1995).The sedimentary sequence of the Kamlial Formation conserve the record of the tectonic processes and climatic conditions of the Western Himalayan orogeny and sedimentation pattern and drainage organization at the sub basin level for that time period (Kumar et al., 2003).

The targeted area lies in the Sub-Himalayas, folded and thrust process is the result of Indian and Eurasian collision in Himalayan territory. The project area is bounded by Main Boundary Trust (MBT) to the East, Jhelum Fault (JF) to the West, Salt Range Thrust (SRT)to the South and it lies in the south of Bagh Basement Fault (BBF) focused area is the part of Plandri Azad Kashmir (Figure1).The study area including Nakar, Chhechhan, Holar, Tallian and Sarsawah. The area is about 79 Sq.km$^2$ at the height of about 1400 meter from sea-level, and lies between longitudes 73°36'35"E to 73°52'6"E and latitudes 33°44'59"N to 33°33'43"N (Figure 2) The area lies inthe geological survey of Pakistan Topo sheet No $^{43G}/_{10}$ and 43 $^{G}/_{16}$ at 1.50,000 scale the project area is previously investigated for geology by various geologists like (Wadia, 1998; Lawrence, 1987; Wells and Gingreish, 1987). The main purpose of the recent study is to evaluate the Siwalik Sandstone of Kamlial Formation as aggregates for construction industry. The field work was accomplished in 8 days, traverses were made across the strike and along the dip. The traverses were made along roads, streams, Nalas, and highly exposed rocksin the area. The structural data was collected by GPS, hand Lense, Brunton compass and Geological Hammer. There are different kinds of sedimentary structures present in the area. These sedimentary structures are helpful to determining the facing of the stratigraphic units.

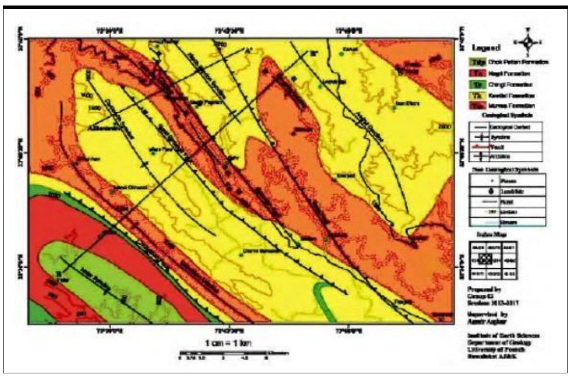

**Figure 1:** Structural and stratigraphic investigation of Namb Peprian, Chhechhan, Holar, and Sarsawah areas of Sudhnoti and Kotli, Azad Jammu and Kashmir, Pakistan

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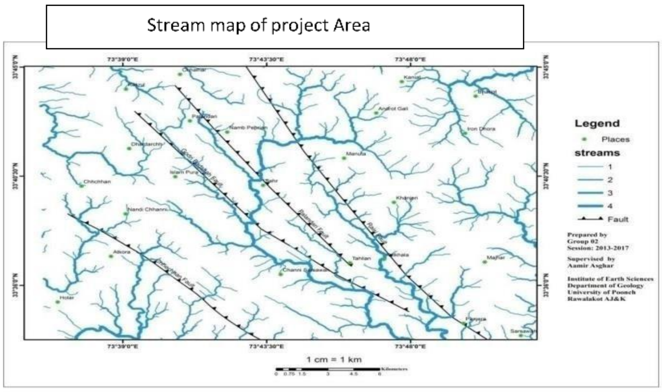


**Figure 2:** Figure shows the Stream Map of Project Area Prepared on Q GIS (Geographic Information System) at 1;1000 between Coordinates N33 36 0 – N 33 450 and E 73 39 0 – E 73 480.

### 1.1 Geology and Tectonic Setting of the study area

The project area lies between Jhelum fault on left side and Himalayan Frontal Thrust fault on right side in the core of Hazara Kashmir Syntaxes. The area is mountainous and structurally deformed due to the local and regional faults.

### 1.2 Structure

The project area is situated in Sub-Himalayas of Pakistan. It is delimited by Riasi Fault to the East, Jhelum Fault to the West, Salt Range Thrust to the South and it enters in the south of Hazara Kashmir Syntaxes. The area fall into faults and folds. The area is highly deformed due to Late Tertiary Himalayan orgeney in Figure 3.

**Figure 3:** Shows the picture of ripple marks from Kamlial Formation in Chhechan area at Coordinates N33 40 984, E73 38 588 collected during Field work.

### 1.3 Faults

The rocks in the project area are highly deformed due to the collision of Indian Plate and Eurasian Plate in the Himalayas. In the study area compression stresses caused by the collisional of Indian and Eurasian plates developed the North West – South East trending faults which are Riasi Fault, Palandri Fault, and Chhechhan Fault. The major faults of the area are Riasi Fault, Palandri Fault, and Chhechhan fault.

### 1.4 Major folds

The major folds in the project area, are Palandari Anticline, Chhechhan Anticline and HolarSyncline. The Holar Syncline is signified by the folding of Dhok Pathan formation and Nagri Formation. The Dhok -Pathan Formation posture in the core whereas the Nagri Formation is on the limbs Figure 4. The Palandri Anticline is a North West to South East trending regional anticline extend from the west of Jehlum River to the east of Azad Pattan area and finally truncate along Palandari Fault. The Palandari Anticline is signifier by the folding of Kamlial Formation and Murree Formation. The Murree Formation posture inthe core whereas the Kamlial Formation is on the limb Figure 5. The Chhechhan Anticline is signifier by the folding of Kamlial Formation and Murree Formation. The Murree Formation posture in the core whereas the Kamlial Formation is on the limb Figure 1.

**Figure 4:** Show the picture of Ripups from kamlial formation in Nakkar area at Coordinates N 33 43 642, E 73 42 228 collected during Field work.

**Figure 5:** Show the picture of Intra formation conglomerates in Kamlial formation collected from the area of Kand Gora at Coordinates N 33 46 432, E73 42 778.

### 1.5 Cracks

Cracks are also present in Murree Formation near Jabbri kass. These cracks are one per meter. The cracks are filled with quartz, Calcite and clays as secondary material. Cracks are present in Kamlial Formation near Taliyan. These cracks are filled with clay and silty material.

### 1.6 Joints

Joints are present in contact between Murree and Kamlial Formation near Nara Bazaar. These rocks are highly jointed. These joints are filled with clay, silty material and calcite veins.

### 1.7 Lithology

Geology of project area mainly contain sandstone, siltstone, and clay the color of sandstone is gray mainly fine to medium grained and medium to thick bedded. Likewise, Kamlial formation consist of Mainly sandstone, clay and intra formational conglomerates. The stratigraphic sequence of project area shown in Table 1.

**Table 1:** Stratigraphic sequence of the project area. (The Stratigraphic sequence of Kashmir Basin area Shah A.T (1977).

| Formation | Age | Description |
|---|---|---|
| Dhok Pathan Formation | Late Miocene | Dominantly consist of sandstone, siltstone, and clays. Sandstone is grey, fine to medium grained and medium to thick bedded. |
| Nagri Formation | Late Miocene | Dominantly it consists of greenish grey sandstone, siltstone and mudstone. Sandstone has massive beds and has medium to coarse grained texture. Sandstone alternates with clay and are 60 percent and 40 percent espectively. |
| Chingi Formation | Middle to Late Miocene | Red to purple, greenish grey, ash grey sandstone and siltstone and purple and redish brown mudstone. 70 percent clay and 30 percent sandstone. |
| Kamlial Formation | Early to middle Miocene | Mainly sandstone, clays and intra Formational conglomerates. |
| Murree Formation | Early Miocene | Mostly clays, shales and sandstone. Sandstone is red and purple red in colour and is fine to medium grained |

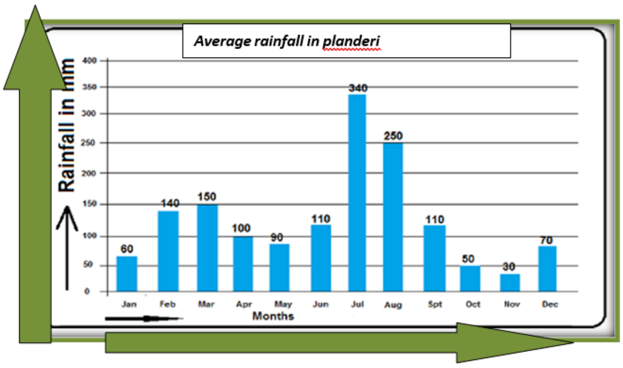


**Figure 6:** Show the Average 10 years rainfall data, which has been recorded by Metrological department in Muzaffarabad A J & K.

### 1.8 Location and Accessibility

The location marks by GPS, Brunton compass. We marked the various areas like Chhechhan, Kharan, Talyan, Holar, Panjera, and Nakkar. The Kamlial sandstone is accessible by metalled roads man made tracks and un metaled roads.

### 1.9 Climate

The climate of the project area is mild to warm during the spring and autumn, humid temperature during summer and cold to snowy during the winter. The temperature can rise as high as 38 °C during the mid-summer months and drop below −2°C during the winter months. Snowfall can occur in December and January, while most rainfall occurs during the monsoon season from July to September.

## 2. Field Characteristics of Rocks

### 2.1 Kamlial Formation

Largely consists of sandstone and inter-bedded clay mudstone. The sandstone is mediumto coarse grained greenish grey color and cross bedded. Minerals in Kamlial Formation were quartz, feldspar, biotite, muscovite, garnet, tourmaline. Wood and leave prints are also observed during field work. In the study area Kamlial formation is well exposed in Nakkar, Androt Gali, Dhardarchh and Tahlian. In these area Formation consist of dark brick- red sandstone and intraformational conglomerates. Wood fossils and leaves prints are also present near Tahlian by Pilgrim (1910), Lewis (1937).

The rock bed is mainly exposed as sandstone bed with conglomerates. It consists of nearly equal ratio of sandstone and clays moderately cemented, soft and cross-bedded with conglomeratic bed between sandstone beds. It is coarse grained sandstone with granite and granite gneiss by Pilgrim (1910), Lewis (1937). The rocks are highly cracked, fractured and faulted. Joints are North-South trending and dip at an angle of 45-85 degree. In crakes and joints clayey, silty and calcitic material has been found. DhokPathan and Chinji sandstones are very loose and weather easily. Tenacity of these rocks are low. These rocks are dulled sound under hammering. Upper portion of the rocks is eroded but at places it is stacked with calcareous material.

There are some honey combed structures found in this area but not common in all the formations. Rocks are highly folded and cracked along the fold axis striations and load casts have been found in the rocks. The core of the rocks is hard and not breakable with hammer. At Coordinates N 33 45 33 - E 73 42 511 Murree formation thursted over Kamlial Formation as a contact. In the area of Paras gali at N 33 46 941 - E 73 42 424 there is gradational contact between Kamlial Formation and Murree Formation. Big blocks of 2 and 4 meters have been found on slopes which always falls on the road and block the road for several days. Slope are very high at least 50-85 degree. Road cut destabilizes and damage the rocks. The rocks cannot be stabilized due to the nearness of faults which run from the area of study. Earthquake resistance structures should be made to stabilize.

### 2.2 Dhok-Pathan Formation

Dhok-Pathan formation comprise of sandstone, clays and compact conglomeratic level. Sandstone is light grey, grey and raddish brown. The proportion of sandstone and clay in Dhok -Pathan formation are equally divided. Sandstone in Dhok-Pathan formation is soft with respect to Nagri formation. The pieces of volcanic, metamorphic and older sedimentary rock is also present in Dh0k-Pathan Formation. The sandstone is composed of feldspar, quartz, mica and red garnet, tourmaline and biotite is also present. The Dhok-Pathan formation exposed in Holar and consists of sandstone, clays and compacted conglomerate level. The sandstone in Dhok-Pathan Formation is relatively soft with respect to Nagri formation. The sandstone is grey, light grey and reddish brown. Flaser bedding is characteristic features of Dhok Pathan formation. The lower and upper contact of Dhok- Pathan Formation with Nagri formation and Soan formation are gradational. The age of Dhok-Pathan formation is Early to Middle Pliocene Pascoe (1963).

### 2.3 Sedimentary Structures

Different kind of structures present in the area. These Sedimentary structures are helpful to determiningthe facing of stratigraphic unit. The observed sedimentary structures under study area were cross bedding, Ripple marks, Gradded Bedding, Rip- ups and Spheroidal Weathering. Cross bedding is the primary sedimentary structure. It is accommodating to recognize the facing of sedimentary strata. Cross bedding well developed in the Kamlial Formation and Dhok-Pathan Formation under study area. Ripple marks usually form in condition with flowing water, in the part of the Lower Flow Region. Ripple marks are use to find out the top and bottom of stratigraphic unit (Figure 1). Rip ups are the clasts of shale's and clay of underlying rock at the base of overlying sandstone. The rip ups are formed at the bottom of the sandstone beds in the Murree Formation. Ripups indicate the bottom of the sedimentary strata. (Figure 2). Gradded bedding is a sorting particle according to clast size and shape on a lithified horizontal plane.

Graded bedding is use to identify the top and bottom of a sedimentary strata. Chemical weathering transforms the original material in to a substance with a different composition and different physical characteristics. The new substance is typically much softer and more susceptible to agents of erosion than the original material. The rate of chemical weathering is greatly accelerated by the presence of warm temperatures and moisture. Therefore some minerals are more vulnerable to chemical weathering than others. For example, feldspars more reactive than quartz. Physical weathering, also called mechanical weathering or disintegration, is the class of processes that causes the disintegration of rocks without chemical change. The primary process in physical weathering is abrasion (the process by which class and other particles are reduced in size). Physical weathering can occur due to temperature, pressure, frost etc. Mechanical weathering, there also parts of rock which breaks from original rock as aresult of water enters in cracks show mechanical weathering of rocks.

### 2.4 Objective

To analyze the mechanical properties of Kamlial Sandstone and its comparison with ASTM with the implementation of aggregate tests.

### 2.5 Problem statement

Siwalik group is a major mass of Himalaya's belt that constrain distinct compositional and depositional environment, research has shown that Siwalik sandstone is mainly sub litharenite, lithic arenite and subarkose the Kamlial sandstone of Sawlik group is medium to coarse grain greenish grey color and cross bedded mineralized with quartz, feldspar, biotite, muscovite, garnet, tourmaline. There is least research conducted on Kamlial sandstone of Siwalik group especially in Kashmir basin. Therefore it is imperative to analyze the mechanical properties of Kamlial sandstone before using as an aggregate in construction industry.

## 3. Methods

### 3.1 Selection of sample site

The selection of sample site is a technical process during field work. The samples are selected from the area which is easily accessible and best outcropped. The samples were selected to find out the physical and chemical properties of rock. The selection of samples were made on the basis of texture, structure, color and Weathering conditions. We used compass for location and dip strike likewise hydrochloric acid and hammer used to identify the rock type. After collection of field date samples are tested in the lab. For date analysis we used Microsoft excel and Q GIS for the interpretation of tests date.

## 4. Results

### 4.1 Impact value test

It indicates the relative measurement of the aggregate to a sudden shock or an impact. The classification of road aggregate on the basis of impact value reveals that good road aggregate must have an impact value in between 10 to 30% and less than 10% will give us exceptionally strong having maximum toughness and flexibility. From 10 to 30 % impact value give us satisfactory aggregate class for roads. This test is done by using Impact test machine consist of hammer of 13.5kg - 14kg weight which is drop from 380mm height into a cup of the diameter 102 mm, in which aggregates are fill up to a height of 50mm.

The aggregates which are used are passing from 12.5 mm sieve and retained on 10 mm sieve and their weight in gram should be note as W1. The aggregates are filled in the cup by three layers and each layer will tamped with 25 blows. Than sample should be subjected to the total of 15 blows in Impact testingmachine with one second time interval. Now resulting fraction should team from 2.36 mm sieve and weight the passing fraction as W2. By Using formula that is W2 / W1 * 100 percentage of toughness of aggregates can be determined. The impact value of some of the Kamlial sandstones are between 10-30 % but some are more higher as 37.57, 32.16, and 42.34 for sample number 2, 8, and 10 respectively so it could not be used in road construction. Table 2 represents the Aggregates Impact Values after Lab- testing of samples from Kamlial Sandstone collected from study area.

**Table 2:** Represents the Aggregates Impact Values after Lab- testing of samples from kamlial Sandstone collected from study area.

| S/ N | Sample | Coordinate s | Total weight (g) | Passing weight (g) | Present value | Average value | ASTM standard value |
|---|---|---|---|---|---|---|---|
| 1 | PNKS-01 | N 33 58 260 E 73 83 186 | 600 | 182 | 30.33 | *25.2%* | 10-30% |
| 2 | TKKS-02 | N 33 61 034 E 73 77 983 | 660 | 248 | 37.57 | | |
| 3 | KHKS-03 | N 33 38 376 E 73 44 734 | 400 | 86 | 21.5 | | |
| 4 | KGKS-04 | N 33 45 337 E 73 42 511 | 600 | 133 | 22.33 | | |
| 5 | KGKS-05 | N 33 46 432 E 73 42 778 | 600 | 114 | 19 | | |
| 6 | GRKS-06 | N 33 47 452 E 73 44 031 | 600 | 124 | 20 | | |
| 7 | CHKS-07 | N 33 39 164 E 73 37 148 | 670 | 70 | 10.44 | | |
| 8 | NNKS-08 | N 33 43 642 E 73 42 228 | 572 | 184 | 32.16 | | |
| 9 | NKS-09 | N 33 43 490 E 73 42 962 | 650 | 104 | 16 | | |
| 10 | BGKS-10 | N 33 44 931 E 73 39 495 | 392 | 166 | 42.34 | | |

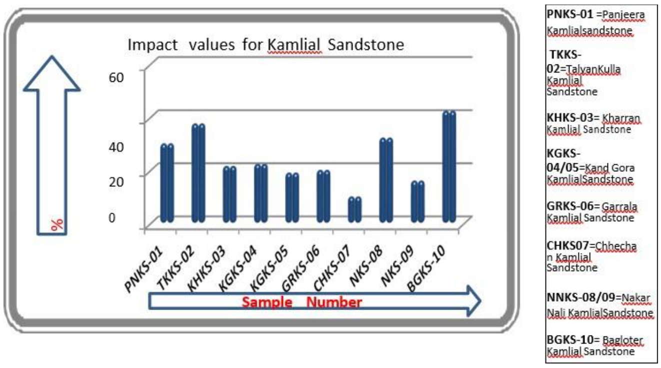


**Figure 7:** Shows the Graph for Aggregates impact Values using lab data from Table 1

## 4.2 Los Angles Abrasion resistance Test

Los Angeles Abrasion resistance test carried out to indicate crushing, degradation, Disintegration and toughness of aggregates. Principally, this test produce Abrasive action on aggregates by using standard steel balls in revolving hollow cylinder of Los Angles Abrasion resistance testing machine to determine the Percentage wearing of aggregates. Sample should be prepared by using 20mm, 12.5mm and 10mm Sieves. The machine contain a hollow cylinder closed at one end having a diameter of 700 mm and a length of 500 mm. In this cylinder 5kg of aggregates are filled with the steel balls of size 40mm & weight 390-445kg each. After mixing the cylinder is allowed to rotate with the speed of 30-33 RPM with total of 500-1000 revolutions as selected by category. Then with the help of formula, Weight of aggregate pass through 1.7 mm sieve divided by Total Weight of Sample multiply by 100 we can get the percentage value for Los Angles Abrasion resistance of aggregates.

| Sieve size( squre hole) | | WT in g Sample for grade | | | | |
|---|---|---|---|---|---|---|
| Number of Steel balls to b used | | 12 | 11 | 8 | 6 | |
| Passing (mm) | Retained (mm) | A | B | C | D | G |
| 80 | 63 | | | | | |
| 63 | 50 | | | | | |
| 50 | 40 | | | | | |
| 40 | 25 | 1250 | | | | 5000 |
| 25 | 20 | 1250 | | | | 5000 |
| 20 | 12.5 | 1250 | 2500 | | | |
| 12.5 | 10 | 1250 | 2500 | | | |
| 10 | 6.3 | | | 2500 | | |
| 6.3 | 4.75 | | | 2500 | | |
| 4.75 | 2.36 | | | | 5000 | |

**Figure 8:** Shows the grading table for test of samples for Los Angles Abrasion Resistance test.

**Table 3:** Shows Los Angeles Abrasion Resistance Test values after lab-testing of samples of kamlial Sandstone collected from study area.

| S/ N | Sample | Coordinates | Dry Weight (g) | Retain Weight (g) | Loss Weight (g) | Abrasion Value | A/ V Average value | ASTM standard value |
|---|---|---|---|---|---|---|---|---|
| 1 | PNKS-01 | N 33 58 260 E73 83186 | 4982 | 2720 | 2262 | 41 | *41.4 %* | 90-120% |
| 2 | KGKS-02 | N 33 45 337 E 73 42 511 | 4996 | 1590 | 3406 | 67 | | |
| 3 | CHKS-03 | N 33 40 981 E 73 38 581 | 4996 | 3035 | 1961 | 39 | | |
| 4 | NKS-04 | N 33 43 895 E 73 43 195 | 4992 | 3502 | 1490 | 26 | | |
| 5 | CDKS-05 | N 33 43 491 E 73 42 963 | 4750 | 2988 | 1762 | 34 | | |

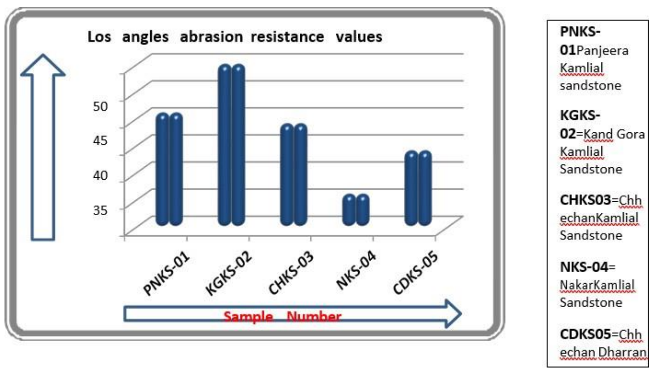


**Figure 9:** Shows Graph of Los Angles Abrasion Resistance, values abrasion Values using Lab-Data from Table 2.

## 4.3 Specific Gravity Test

Specific Gravity Test for aggregates use to calculate the specific gravity of coarse aggregates by determining the ratio of the weight of a given volume of aggregates to the weight of an equal volume of water. The coarse aggregates specific gravity test measures coarse aggregates weight under three different sample conditions (A) Oven - dry (no water in sample), (B) Saturated surface - dry, (C) Submerged in water (underwater). Using these three weights and their relationships, a sample's apparent specific gravity and bulk specific gravity as well as absorption can be calculated.2000g sample choose after passing from 12.5mm Sieve and retained on 4.75 mm Sieve, then after wash and dry place in water and again dry the sample in SSD condition and weight as A , Now Place in underwater and weight as B, Finally placed in an oven at 110 degree centigrade and weight as C. Apparent Specific gravity can be calculate by (A) divided (A-C ) where Ais the oven dry weight of the sample B is the Saturated surface dry weight of the sample and C is the Submerged Weight of the sample. Moreover, average value for Specific gravity from test results as 2.1 percent.

**Table 4:** Shows the values of Specific Gravity values from Lab-Data for kamlial Sandstone collected from study area.

| S. N | Sample Name | Coordinates | O. Dry Wt (g) | S.S.D Wt (g) | Wt in Water (g) | App S.G | Mean Value | ASTM |
|---|---|---|---|---|---|---|---|---|
| 1 | TKKS-01 | N 33 61 034 E 73 77 983 | 990 | 1004 | 458 | 1.9 | | 2.6 - 3.0 |
| 2 | KHKS-02 | N 33 38 376 E 73 44 734 | 908 | 1012 | 532 | 2.4 | | |
| 3 | KGKS-03 | N 33 45 337 E 511 | 992 | 1002 | 564 | 2.3 | *2.1* | |
| 4 | KGKS-04 | N 432 E 778 | 958 | 1076 | 430 | 1.8 | | |
| 5 | GRKS-05 | N 452 E 031 | 965 | 1060 | 440 | 1.8 | | |
| 6 | CHKS-06 | N 164 E 148 | 988 | 1082 | 208 | 1.3 | | |
| 7 | NNKS-07 | N 642 E 228 | 952 | 1122 | 438 | 1.8 | | |
| 8 | NKS-08 | N 33 43 490 E 73 42 962 | 982 | 1006 | 274 | 1.4 | | |
| 9 | BGKS-09 | N 931 E 495 | 988 | 1028 | 540 | 2.2 | | |
| 10 | CDKS-10 | N 33 43 491 E 73 42 963 | 906 | 1018 | 674 | 3.9 | | |

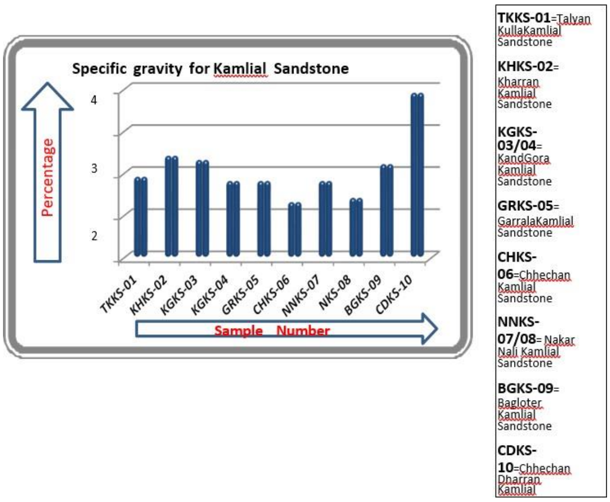


**Figure 10:** Shows the Graph of Specific gravity values Using Lab-Data for samples of Kamlial Sandstone collected from study area from Table 3.

## 4.4 Water Absorption Test

Water Absorption test and Specific Gravity test both can be conducted by same method. For Water Absorption values the formula B-A divided by A is used where B is the saturated surface dry weight of the sample after submerging in water for 24 hours and A is the oven dry weight of the sample. Water Absorption values from test results as 2.24 as an average which is higher than ASTM (American Society of Testing and Material) standard value for water Absorption which is 0.1-1.0 or 0.6 per unit weight.

**Table 5:** Shows the values from Lab- Data for the Water. Absorption Test of KamlialSandstone samples collected from study area.

| S.N | Sample Name | Water Absorption values | Mean values | Standard value for water absorption |
|---|---|---|---|---|
| 1 | TKKS-01 | 2.42 | *2.24* | Less than 0.6 per unit by weight |
| 2 | KHKS-02 | 2.3 | | |
| 3 | KGKS-03 | 1.7 | | |
| 4 | KGKS-04 | 2.1 | | |
| 5 | GRKS-05 | 1.9 | | |
| 6 | CHKS-06 | 2.3 | | |
| 7 | NNKS-07 | 2.1 | | |
| 8 | NKS-08 | 2.33 | | |
| 9 | BGKS-09 | 2.82 | | |
| 10 | CDKS-10 | 2.5 | | |

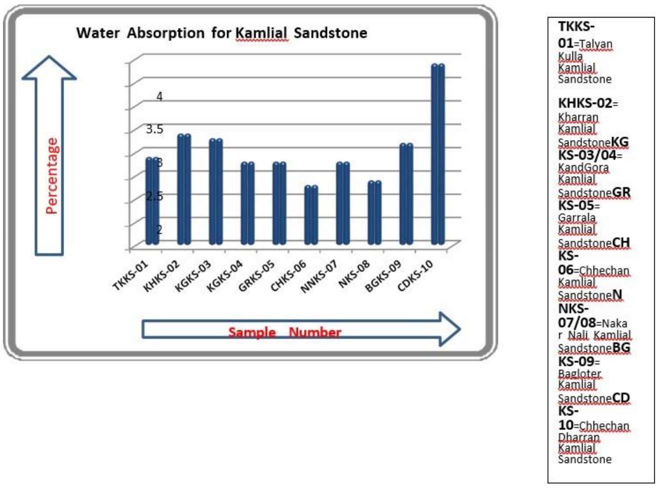


**Figure 11:** shows the graph for Water Absorption values from Lab-Data of the samples of Kamlial sandstone collected from study area.

**Table 6:** Shows the comparison between Impact Test Values and Los Angles Abrasion resistance test values from Lab- Data of the samples of Kamlial Sandstone collected from study area.

| S/N | Sample | Impact Values | Abrasion Values |
|---|---|---|---|
| 1 | PNKS-01 | 30 | 41 |
| 2 | KGKS-02 | 19 | 67 |
| 3 | CHKS-03 | 10.44 | 39 |
| 4 | NKS-04 | 16 | 26 |
| 5 | CDKS-05 | 32.5 | 34 |

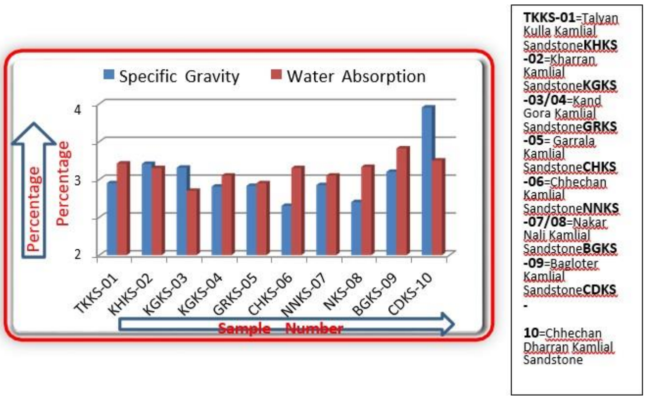


**Figure 12:** shows the Comparison Graph of specific gravity and Water Absorption from Lab-Data of the samples of Kamlial Sandstone.

## 5. Discussion

The Kamlial sandstone is coarse grain sandstone with intra formational conglomerates. The kamlial sandstone is easily breakable. The sample were collected from kamlial formation to know the, Impact value, specific gravity Water absorption and abrasion resistance of the aggregate to examine its strength to be used in construction industry.

**Table 7:** shows the comparison between Impact Test Values and Los Angles Abrasion resistance test values from Lab- Data of the samples of Kamlial Sandstone collected from study area.

| S/N | Sample | Impact Values | Abrasion Values |
|---|---|---|---|
| 1 | PNKS-01 | 30 | 41 |
| 2 | KGKS-02 | 19 | 67 |
| 3 | CHKS-03 | 10.44 | 39 |
| 4 | NKS-04 | 16 | 26 |
| 5 | CDKS-05 | 32.5 | 34 |

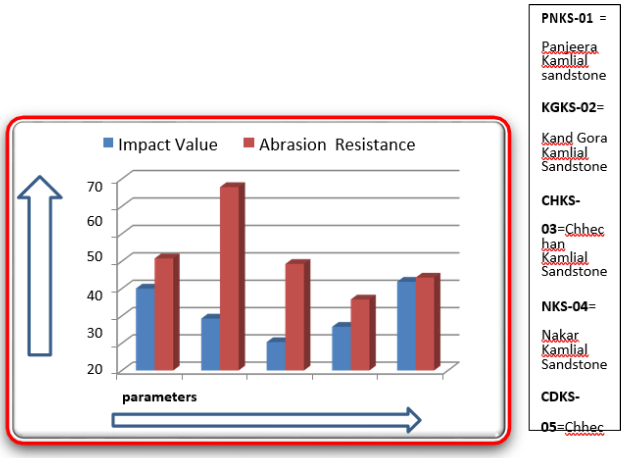


**Figure 13:** Represents the Graph showing the relation between Aggregates Impact Values and Los-Angeles Abrasion Resistance values for the samples of kamlial Sandstone collected from Panjeera , Kand Gora, Chhechan and Nakar areas.

The data from the test show that the Kamlial sandstone from study area has Aggregate Impact value of 25.2% which reflects its satisfactory condition. The ASTM standard value is 30 %. The Mechanical studies shows that Abrasion Resistance of Kamlial Sandstones is 41.4 percent which is greater than American Association of State Highway and Transportation Officials (AASHTO) standard value i.e The AASHTO standard value for Abrasion resistance of aggregates is 40 percent that is Abrasion Resistance value should not more than 40% percent. The Apparent Specific gravity test results as an average of 2.1 percent which is less than ASTM (American Society of Testing and Material) standards that is between 2.6 - 2.9. The low specific gravity implies that clay content in sandstone is higher which degrade the sandstone. The values obtained through experiments shows that this sandstone are not good as aggregates. Likewise, water Absorption values from test results as a mean value of 2.24 percent, which is significantly greater than to the ASTM standard value i.e 0.1-1.0 or 0.6 per unit weight. The values obtained from aggregate tests do not qualifying ASTM abrasion, impact, and absorption values. It is imperative to avoid the use the Kamlial sandstone as aggregate.

## 6. Conclusion

The physical, mineralogical, mechanical and textural characteristics were determined to know the grade of aggregates. The mechanical investigation of the Kamlial Sandstone are determined by analyzing the properties like Impact value, Los Angeles abrasion resistance, Specific gravity and Water Absorption. This investigation indicates that some samples of Kamlial Sandstone have aggregate Impact value in satisfactory condition whilst some samples of Kamlial Sandstone as Aggregate Impact value in weak condition whereas Specific gravity, Water Absorption and Abrasion resistance values do not qualify ASTM standard for aggregates and can't be used for aggregate structures.

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