ENGINEERING PROPERTIES, RESERVES ESTIMATION AND EVALUATION OF LANDIKOTAL SLATES AS STRUCTURE LIGHTWEIGHT CONCRETE AGGREGATE, KHYBER RANGE, NORTH-WEST, PAKISTAN

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ISLAMABAD.

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A thesis submitted to Quaid-i-Azam University Islamabad in partial fulfillment of requirement for the degree of Master of Philosophy in Geology.

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Abstract

In order to meet the rising demand for housing, in the current era industrialization has forced the world's housing market to move vertical by creating high-rise structures and skyscrapers. Due to worries about planning and erecting such heavy building foundations and the potential for their settlement, lightweight concrete has expanded the capabilities of concrete technology. Such issues have been resolved by lightweight concrete made from either synthetic or natural lightweight aggregates (LWA). Since bloated slate utilized as LWA has produced impressive results in many industrialized nations, the Pakistani construction industry, which is still developing, may easily adopt it. In this study, Paleozoic slate from the Khyber Ranges has been used to examine its geochemistry, petrography, and physical-mechanical characteristics for usage as a lightweight aggregate concrete. Its reserves have also been estimated by accurate geological mapping. These rocks are described as dark greenish-gray and dark grey in colour and have a fine-grained texture from a petrographic perspective. Major mineral phases include quartz, biotite, and muscovite, while minor to accessory phases include hematite and chlorite. SiO_2 (71%), Al_2O_3 (19.282%), Fe_2O_3 (4.247%), and K_20 (3.405) are the principal oxides that are present in the examined slate according to the average XRF geochemical concentration (in%Wt), whereas the remaining oxides (CaO, TiO_2, MnO, ZrO_2, WO_2, V_2O_5, SrO, Cr_2O_3, ZnO, Rb_2O, and Y_2O_3) are only present Similar to this, XRF elemental analysis reveals that the primary elements identified by the specimen's results are Si, Fe, AL, K, and Ca. When compared to the sample's overall percentage, the values of Ti, Mn, Zr, V, W, Rb, Zn, Sr, Cr, Y, and Nb range from very low to low percentages. These swollen specimens had neither Loss on Ignition nor any organic contaminants. To obtain the greatest bloating, the samples were burned in a rotary furnace at temperatures between 1050C° and 1250C°. Following bloating, physical tests were performed in accordance with the requirements of the American Standards for Testing Materials (ASTM). The results of numerous tests, including those for water absorption, bulk density, Los Angeles abrasion, specific gravity, clay lumps and friable particles, soundness, sieve analyses, fineness modulus, flat and elongated particles in aggregates, slump test, and compressive strength, demonstrate that the material is suitable for use as a light aggregate for structural purposes and meets the requirements of concrete. This study successfully carried out volumetric quantitative

mapping of slate and discovered that there are approximately 2214.28 megaton of mineable slate are present in the Khyber Range.

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CHAPTER # 01

INTRODUCTION

1.1 General Statement

Materials with densities between 320 and 1840 kg/m^3 are considered lightweight aggregates (http://www.nrmca.org). Normal aggregates frequently have a density of 2400 kg/m^3. These aggregates are either manufactured from materials that exist naturally including tuff, pumice, or scoria, or by mean of bursting goods like the low grade metamorphic rocks slates, fly slag, fire heated clays, or fine grain sedimentary rocks like Shales (Holm & Ries, 2007). However these days, the majority of lightweight aggregate is made from materials like clay, shale, or slate (R.de Gennaro, 2005). It has several advantages over conventional aggregate concrete, including a large percentage of strength to the weight, superior tension power, a minimal thermal dilation index, and high protection against temperature and also has soundproof qualities, which are mostly attributable to the existence of air voids (Mouli & Khelafi, 2008). By delivering low dead weight, strong seismic react of structures to earthquake oscillation, also a prolonged building's life span, it offers flexibility in structure design and is much more cost-effective (Holm & Ries, 2007). These light weight aggregate are used all over the world in the construction of floating docks, offshore oil platforms, bridge decks, dams, high rise buildings, and girders, among other structures. The lightweight aggregate concrete (LWAC) is utilized to build running tracks, sports fields, and other structures in the US, Canada, and other developed nations due to its improved anti-slipping properties. Massive slate resources that can be used as light weight aggregate (LWA) are exposed all throughout Pakistan, but they have never been used in the local construction sector, perhaps due to a lack of understanding and skills. Early researchers have conducted some exploratory investigations on several slate deposits, including LWA. With an annual contribution of more than 2.5% to national gross domestic product, Pakistan's construction industry has grown more than nine times over the previous 20 years (Pakistan Bureau of Statistics, 2018). Pakistan is currently home to a massive development project known as the China-Pakistan Economic Corridor (CPEC). This project offers more than 70 countries a variety of trade routes, including highways, railroads, and fiber optics. Additionally, this project includes building local infrastructure and industrial zones in Pakistan. This project requires a considerable amount of building supplies. Furthermore, the majority of Pakistan's population lives in seismically active areas with moderate to high risk (Magsi, 2014), and several significant fault lines intersect the country (Kazmi & Jan, 1997). As a result, Pakistan frequently experiences severe earthquakes like the one that struck Kashmir on October 8. Taking into account the demand for this and the need for it for the above two reasons, The Ordovician Slate of the Khyber range (Shah, 2009), District Khyber, Khyber Pakhtunkhwa, Pakistan, will be analyzed and investigated for its engineering qualities in this research work to determine its viability for LWA in order to exploit our abundant resources for producing structural light weight aggregate, which is currently frequently used in the developed world.

1.2 Literature Review

Aggregates that are lightweight have been employed since the dawn of humanity. Lightweight aggregate material was employed in the construction of the Roman Colosseum as well as Viking-era watercraft. The manufacturing of lightweight aggregate concrete products, such as structure concrete, pavements, and concrete blocks, uses lightweight aggregate (Holm and Ries, 2007). The majority of materials used to create lightweight aggregates are clay, shale, or slate. Lightweight aggregates include vermiculite, natural pumice, perlite, and blast furnace slag. With the exception of pumice, these natural materials can expand by almost doubling their native volume at high temperatures (Boateng et al, 1997). Researchers discovered a solid connection between wet cement paste and light-weight particles (Neville, 1995). The internal curing of the cement improved the hydration processes (ACI 213R-14). The efficiency of per-wetted, saturated lightweight aggregates for internal curing was assessed by (Browning et al., 2011). Lightweight aggregate concrete offers strong isolating qualities because of its higher porosity and lower amount of solid ingredients (Ennequin, 2009) and (Asamoto et al. 2008) found that the shrinkage of lightweight aggregate concrete and conventional weight aggregate concrete was comparable. Lightweight aggregate concrete has lower heat conductivity than regular weight aggregate concrete; hence its buildings have superior fire resistance. This helps to provide steel bars with long-lasting insulation (Lindgard and Hammer, 1998). The first bloating investigations in Pakistan were conducted in 1969 by Kinniburgh at the Building Research Station using various Punjab clays and organic ingredients. Some expanded clay aggregates were subjected to crushing strength and other testing by (Hassan 1970; 1972) and (Khan and Parker 1970). (Hussain et al 1983) started reconnaissance research for the light-weight raw material in and around Peshawar (KPK). In Pakistan, there are plenty of Bloatable (expandable) argillaceous raw materials that can be used to create lightweight aggregate (LWA) (Asrarullah, 1972). (Bilqees et al 2011) did preliminary research on the Precambrian states of the Attock and Cherat mountain ranges to examine the engineering characteristics of lightweight concrete. Recently, (Qureshi, et al. 2017) studied the characteristics of light weight aggregate concrete for structural purposes on the Akkock, Manki, and Kaka Sahib Slates. Research on fine bloated slate was also conducted by (Alamet et al. 2012) to determine its mechanical characteristics, such as density, compressive strength, young modulus, stress-strain behaviour, etc. In addition to using slate as a lightweight aggregate, (Khan, 2000) has also done research on shale from Naka Pabni.

1.3 Problem Statement

The demand for constructing more structures and infrastructure has always increased along with the population. The need for high-rise structures arises from the fact that land size in a specified zone cannot be expanded, making them the only viable option. Therefore, there is a requirement for building materials that are lighter in weight to reduce dead weight without sacrificing strength and durability. Materials that weigh less than the typical aggregates of gravel and crushed rock are referred to as lightweight concrete aggregates. Concrete should be designed to provide equivalent strength and durability to reduce the dead load. Pakistan is fortunate to have access to rocks that can be utilized as construction materials. In addition to the common sedimentary and metamorphic rocks, there are significant deposits of metamorphic aggregates, such as schist, phyllites, and slates, identified in many parts of the world. However, in Pakistan, despite the abundance of slate and shale resources, no substantial use has been attempted yet. Slate from the Landikotal area (Khyber Ranges) was chosen for the current effort to examine its engineering properties, geochemistry, petrography, and reserve estimation for its usage as lightweight aggregate, considering this favorable purpose. High-temperature treated swelled metamorphic rocks (slate) can be used for building purposes due to the factors mentioned below.

- Despite the fact that a lot of area of the Pakistan is located in a severe earthquake region, using lightweight concrete to build large structures would lessen the consequences of ground shaking before an earthquake even occurs.
- According to studies, lightweight concrete satisfies the minimal requirements for a concrete in terms of strength and durability.

- ❖ Due to less dead weight, less steel is needed to stiffen the structure, which lowers the cost and increases the efficiency of the construction process.
- ❖ Expanded slates have good insulating qualities because of their cellular structure.
- ❖ If determined to be acceptable, the vast supply of slates in the Khyber Ranges may be utilized as a replacement for other commonly utilized construction material.

1.4 Location and Accessibility

The research region, which is located in Pakistan's Landikotal Tehsil District Khyber KPK, spans a region of six to seven hundred square miles and includes all of the territory next to the Peshawar to Torkham road under this broad term. Resides just behind the Koh-e-snow-covered Safaid's hills at a height of roughly 7,400 feet (1072 m). It is located about 40 kilometers from Bara Bazaar and about 47 kilometers from Peshawar City. 71°16'34.20"E 34°1'15.14"N, 71°17'44.47"E 34°0'36.10"N, 71°17'13.51"E 34°0'33.55"N, and 71°19'38.09"E 33°59'59.93"N are the longitudes and latitudes of our sample locations on the GPS, respectively.

1.5 Aim and Objectives

- To evaluate and find the engineering properties of Landikotal Slates from Khyber Range.
- To find its feasibility use as a structure lightweight concrete aggregate.
- To carry out geological mapping of the Landikotal Slate, using Arc GIS, tool.
- To find reserve estimation of the Landikotal Slate.
- To carry out its geochemical and mineralogical composition.
- To study its petrography.

1.6 Research Methodology

To find and achieve the above aims and objective the following method will be used.

1.6.1 Field work

An extensive geological field was undertaken in the given location in Khyber Range to conduct a detailed analysis of the geological formations present. The Landikotal Slates exposed at different outcrop sites were thoroughly examined and studied in hand specimens using a hand lens to classify their respective rock types and to study their feature. Four specific sampling points, namely LS1, LS2, LS3, and LS4, were selected to collect representative samples for further analysis and characterization. A total of 200 kg sample were collected 50 kg from each point.

1.6.2 Lab works

In the present research the lab works are divide into different categories based on their method, procedure and need.

1.6.2.1 Physio-mechanical and chemical engineering test

- Bloating test

After bloating the following physio-mechanical and chemical tests will be carried out according to the American Standards for Testing Materials (ASTM) specifications.

- Water absorption
- Specific gravity
- Bulk density
- Organic impurities
- Soundness
- Specific gravity
- Loss Angeles abrasion
- Sieve analysis
- Fineness modulus
- Flat & elongated particle
- Clay lumps & friable particle
- Loss on ignition

1.6.2.2 Geochemistry

All the samples selected for engineering tests will analyzed chemically. These analyses will be carried out using XRF and XRD.

1.6.2.3 Petrographic study

The petrographic study is typically performed to assess the aggregate mineralogical composition, grain size, grain type.

1.6.2.4 Concrete mix design

Then concrete mix design for structural concrete will be designed according to ACI 211.2-98 and ASTM 330; concrete cylinders will be casted and their slumps and compressive strength will be determined

1.6.3 Mapping and reserve estimation

By using Google Earth Pro and GIS software we mapped the Landikotal Slates and prepared its geological map in order to find out its reserve estimation which is mineable. For reserve calculation we use volumetric method.

1.7 Equipment required

To perform the above lab works in this research and to achieved the mention amis and objective we need the following lab or research instrument.

1.7.1 Instruments needed for petrography

- Rock cutting and thin section preparation lab.
- Transmitted Light Petrography Microscope
- Reflected Light Petrography Microscope

Instruments required for geochemical analysis

- X-ray Difractometer (XRD)
- X-ray Fluorescence Spectroscopy (XRF)

Instruments used for engineering study

- Need geotechnical and material testing lab

Software for mapping

- Google Earth Pro software
- GIS software

CHAPTER # 2

TECTONIC AND STRATIGRAPHIC SETTLING OF THE STUDY AREA

2.1 General Statement

Although the fear of trouble during work was much greater before the subcontinent was divided under brutish rule, it is still possible to make proper arrangements before travelling through Trible territory in order to prevent the rare untoward incident. District Khyber (agency) is a part of the (Trible belt) that forms the northwestern boundary of Pakistan. In 1972, Shah and Siddiqui of the Pakistani Geological Survey were able to operate for a while in the Trible belt and finished reconnaissance mapping, section measuring, and rock sampling. Since everything had to be completed quickly, many questions and caveats remained.

Stauffer undertook the first survey mapping of the region in 1968. He could only move a few steps on either side of the Khyber Pass. His mapping was primarily based on the assessment of photographs of the local units. End of 1968 saw Shah begin his physical and photographic geological mapping effort. Problematic district Khyber (agency) geology is the reason why there are differences among the personnel (Shah, 2009).

2.2 Regional geology

The Himalayan Orogenic Belt, which stretches over 2300 km from Afghanistan to Burma and has an average elevation of 6100 m, was created in the Early Tertiary as a result of the head-on N-S collision of India and merged Cimmerian blocks (Pogue et al. 1992; Frisch et al. 2011). Based on lithology and local thrust faults, the Himalayan Orogenic Belt has been separated into the Greater Himalaya, Lesser Himalaya, and sub-Himalaya. Between the Main Mantle Thrust (MMT) and Main Central Thrust lie the Greater Himalayan rocks (MCT). Pakistan's MCT is comparable to the Khairabad/Panjal Thrust fault. These rocks have undergone several metamorphoses and have been penetrated by igneous rocks that date from the Cambrian to the Tertiary (DiPietro and Pogue 2004). The Khyber Range is divided from the Kohistan Island Arc (KIA) in the north by the Main Mantle Thrust and from the Lesser Himalaya (which is located between the Main Boundary Thrust and the Khairabad/Panjal Thrust) in the south (Fig 2.1). Major Khyber Range geological structures that are trending E-W reveal a potential kinematic connection to the dominant N-S Himalayan compression (Fig. 2.1). Local NNE-SSW trending anticlines and synclines overprint the Himalaya's regional scale E-W tectonic grain (Fig. 2.1). The Paleozoic to the Miocene strata of the Khyber fold and thrust belt is invaded by magmatic rocks (Fig. 2.2). The Khyber anticline's central area is where the Early Devonian Khyber Limestone is exposed (Fig. 2.2). The eastern side of this major anticline, which contains parasitic folds that transform into a major syncline with its fold axis running through the Warsak-Ghundai Sar-Ghund Ghar, is more curved than the western flank (Fig. 2.2; Khan et al. 2010).

2.3 Tectonic Setting of the Area

A piece of topographic sheet no.38 K from the Pakistani Geological Survey contains the study region under consideration, which is located in northwest Pakistan, close to the Afghan border. Tectonically, the Khyber area lies at the junction of two major tectonic zones of northern Pakistan;

(i) Northwest Himalayan fold and thrust belt
(ii) Himalayan Crystalline Nappe and Thrust Belt.

The Khyber Lower Hazara Metasedimentary Fold and Thrust belt includes the Khyber Ranges (Figure 2.1). This metasedimentary fold and thrust belt extends eastward from the Khyber Pass region to Garhi Habibullah and is located north of the Khairabad-Panjal Thrust. Precambrian to early Mesozoic sediments makes up a substantial portion of the Khyber-Hazara Metasedimentary Belt. The Precambrian series, which is found in the southern portion of the belt, is primarily made up of slates and Phyllites with little quartzite and marbles.

Mafic dykes, sills, and granitic rocks have penetrated the Khyber-Hazara Metasedimentary fold and thrust belt, with the enormous Ambela pluton and Warsak granite standing out. The Late Paleozoic through the Early Mesozoic is the ages of these intrusive rocks. This Metasedimentary Belt is marked by numerous thrust faults imbricating tight, asymmetrical, or isoclinal folds (Shah et al., 1971; Pogue et al., 1992).

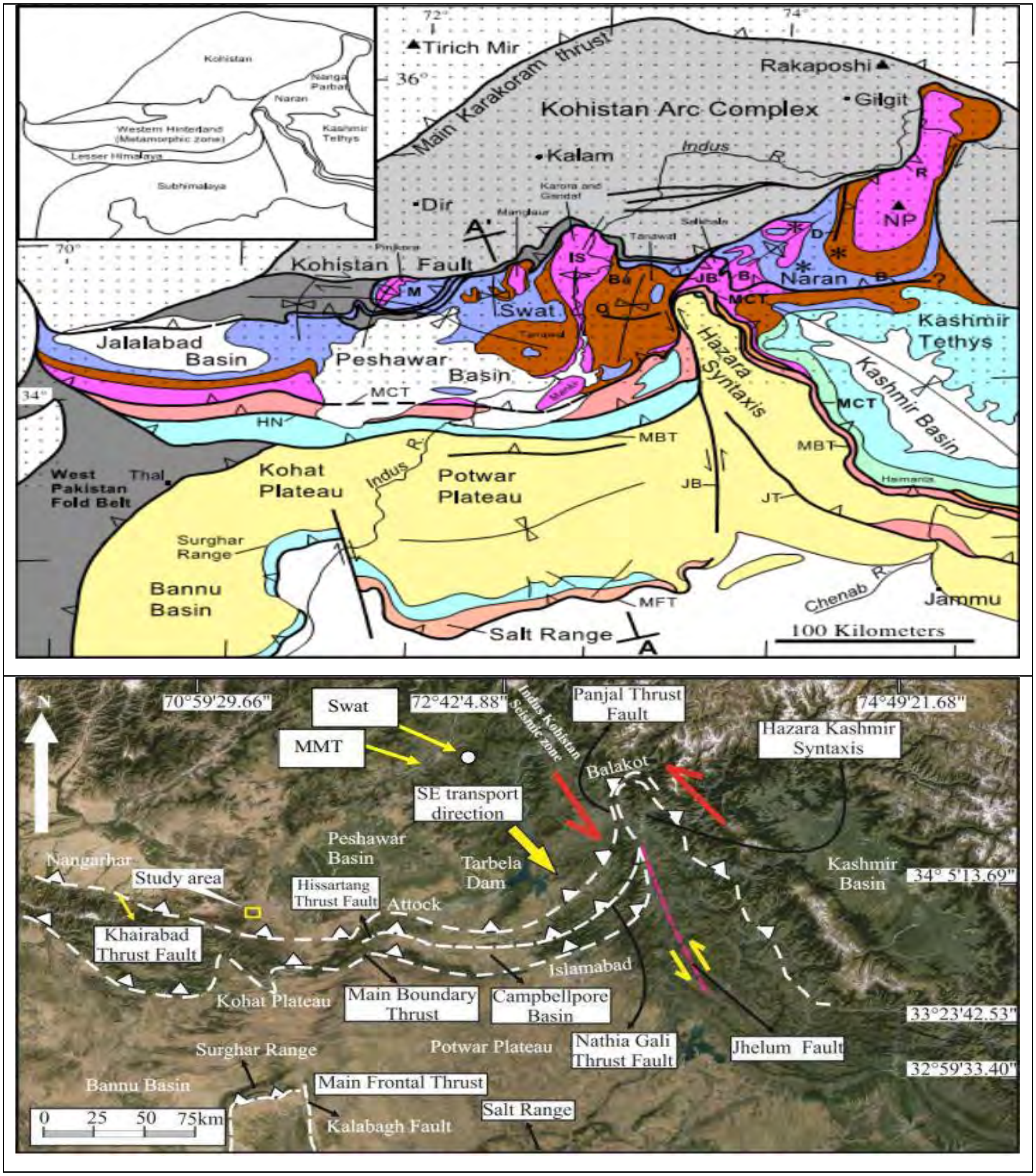


Figure.2.1 Regional tectonic map of North Pakistan showing geological setting of the Khyber Range area. MCT- Main Central Thrust; MBTMain Boundry Thrust; MFT- Main Frontal Thrust; JB- Jhelum Balakot Fault; JT- Jammu Thrust; HN- Hissartang-Cherat-Nathia Gali Thrust; IS- Indus Syntaxis; O- Oghi Fault; Ba- Banna Fault; b- Batal Fault; R- Raikot Fault; NP- Nanga Parbat;M- Malakand Slice (After, Dipietro and Pogue, 2004).

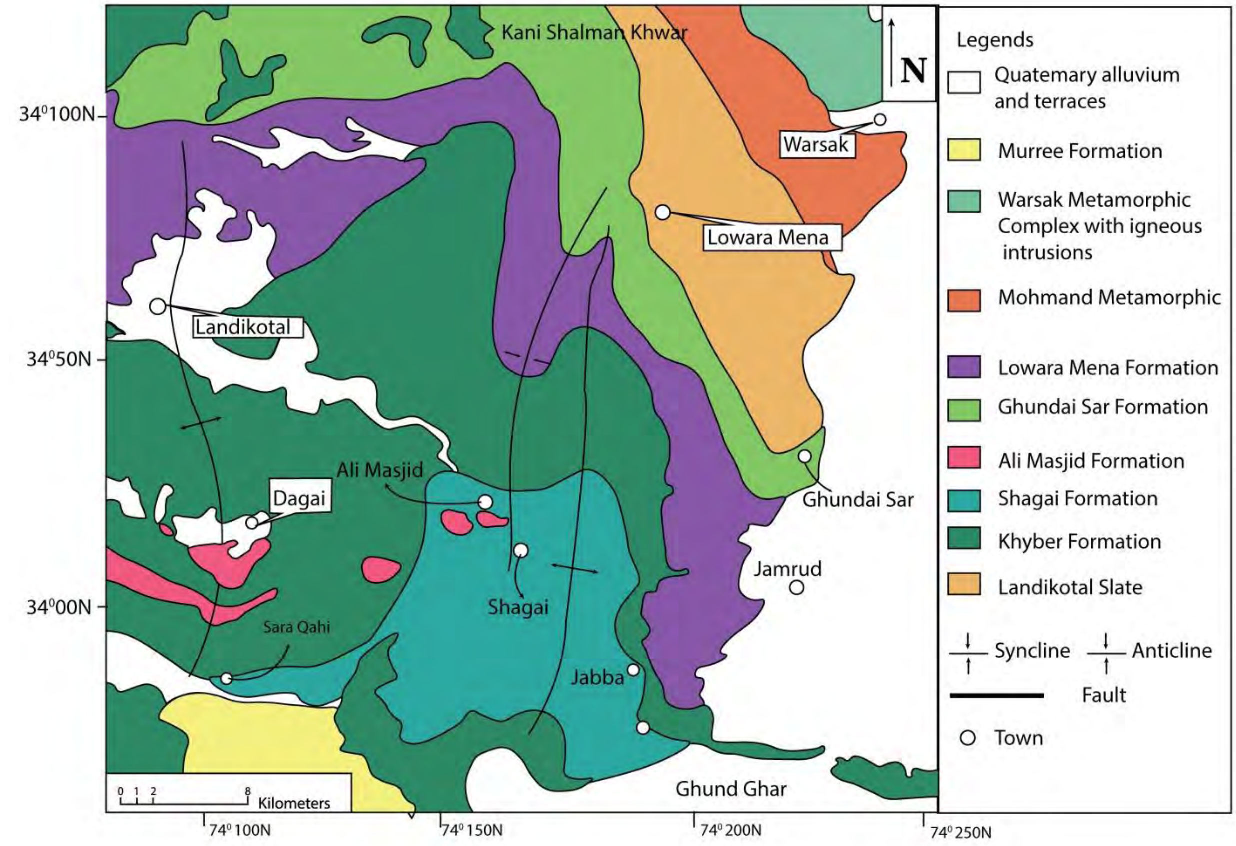


Fig. 2.2 Geological map of the District Khyber showing the major lithological units from Paleozoic to Miocene and location of the study area (modified after Shah et al. 1980).

2.4 Geography of the area

District Khyber Former the Khyber Agency lies in Pakistan's northwest. Khyber's entire area is 2576 km^2, and it shares borders with Nangarhar Afghanistan Province in the west direction, Peshawar City in the east, Khurram to the south and west side, upper Orakzai (formerly an agency) in the south side, and Mohmand area in the north. Forests cover 8.22% of its total land. It largely comprises of mountainous terrain with a few short stretches of valleys. It is the intersection of several mountains, including the Koh-e-Safaid, a branch of the impressive Hindukush Mountains. Some of the mountains in district Khyber are Lacha Ghar, Karagah Ghar, Surghar, Tor Ghar, Morgah, and Kalauch. It has a few lovely valleys with plain agricultural land, such the valleys of Rajgal, Maidan, Bara and Bazaar. The Bara and Chora rivers are the two important rivers. The river Kabul divides the Districts Khyber and Mohmand on the northern boundary between the regions of Shalmanis and Mullagoris. All of these rivers flow Into

Peshawar Valley. Harsh winter and summer temperatures can be found in the District Khyber, as well as moderate to sweltering summers. The warmest days are May and August, while November to January is the coldest. However, there is relatively little rainfall. Westerly winds are responsible for the winter rain, whereas the monsoon is responsible for the summer rain. About 400 mm of rain falls on average each year. The majority of District Khyber is sandy, with limited farmed land located along the valleys, as it receives little rainfall. A total of 20,075 hectares are cultivated, compared to 237,579 hectares of uncultivated land and 2070 hectares of woodland. 19,365 hectares are cultivated in total. (Source: FATA Development Statistics, 2012).

2.5 Stratigraphic of the study Area

Four distinct stratigraphic units can be found in the Khyber Pass region. The oldest is Landikotal Slate, which is followed by Shagai Limestone, Ali masjid Formation, and Khyber Limestone at the top, as shown in the (table 2.4). These four formation range in age from the Ordovician to the Permian and are entirely unifosiliferous according to earlier workers. The stratigraphy of the research area is listed below.

1) Landi Kotal Formation
2) Shagai Limestone
3) Ali Masjid Formation
4) Khyber Limestone

2.5.1 Landi Kotal Formation

Stauffer (1968) described a thick sequence of slates in the landi kotal region and suggested the term "landi Kotal Slate." Other names for landi kotal slates, such "Khyber Slates" and "Attock Slates," are also used in literature. Phyllites, slate, quartzite, and limestone make up the majority of the formation's lithology, with dolomite occasionally being intruded by igneous bodies. This overall unit is exposed in the region of Landi Kotal, which is also regarded as the type location, to the north and east. The Landi Kotal Formation, which underlies the remainder of the geological sequence in District Khyber, fossils less. The connection with the underlying formation is faulty in several locations. The Ali Masjid Formation and Shagai Limestone are absent from the typical site, where the overlying Khyber Formation faults with the Landi Kotal Formation. While Shagai Limestone is absent, there is a direct contact between the Landi Kotal Formation and the Ali Masjid Formation in the Loe Shalman area. The Khyber region exhibits repeated strata and is structurally and tectonically disturbed, making it impossible to calculate the precise thickness of the region. (Stauffer., 1968) estimated that the area was 1600 meters thick. Although (Shah et al. 1969) claimed that the formation may be up to 1600 meters thick, it is crucial to note that nowhere is the formation's base exposed. The Landi Kotal Formation extends toward Afghanistan; a German geologist called it Logar Formation in the region of Afghanistan. Ordovician conodonts were discovered in the Logar Formation. The Landi Kotal Formation is believed to be between Ordovician and Silurian in age (Shah et al., 1969).

2.5.2 Shagai Formation

Shagai Formation is situated close to Khyber Pass. (Stauffer., 1969) was the first to suggest using the name of the Shagai Fort as the name of the formation. (Shah et al., 1970) conducted a thorough investigation of the region and focused on its physical stratigraphy. Northeast of the Shagai Fort, the formation is normally exposed at a distance of around one kilometer. (Stauffer., 1968) and (Shah et al., 1970) claim that the limestone strata in the Shagai Formation are situated between the Landi Kotal Slate and the Ali Masjid Formation. Massively bedded micritic limestone makes up the majority of the Shagai Formation's lithology. It continued westward to the Shagai fort while extending eastward from Bigiari Picket to the Khyber Pass region. Shagai Limestone has a mostly grey tint with light grey and greyish yellow weathering. While it contains large beds in the upper half, the beds in the lower half are almost all medium to thin beds. However, this divide is rarely completely upheld, and in several areas, only thick bedded limestone has been seen. The dolomite formation in the type locality is micrite-like, extensively fractured, and fine-grained. At the type locality, extremely thinly laminated, less metamorphosed limestone overlies the dolomitic limestone with a sheared laminated shale zone in the middle. This unfossiliferous, thinly laminated limestone is a part of the Shagai Limestone. The Shagai Formation is faulted, thrusted, and absent at the majority of locations in the Misrikhel area, although it is still existent at a few locations in this region and is in normal contact with Landi Kotal Slate. Both the Khan Bekhel area and the Chirgarch Greh part of Misrikhel expose these sections. The lower contact is seemingly typical and is located at the foot of 0.7m thick limestone, while the upper contact of the Shagai Formation with the Ali masjid Formation is located at the top of a thick limestone bed. Brown limestone has white blobs that may be recrystallized biogenic material, according to (Shah et al., 1970). Recrystallized and unidentified brachiopod shale has also been observed in the formation. The age of the Shagai Limestone has been dated as early Devonian to Silurian.

2.5.3 Ali Masjid Formation

(Stauffer., 1968) suggested the name for the formation in honour of the nearby village with the same name on the Khyber Pass road. The formation contains a variety of lithologies, including beds of quartzite, siltstone, sandstone, shale, and limestone. (Shah., 1969) conducted a thorough investigation of the region and found many fossiliferous horizons there. The Ali Masjid Formation is mostly red in colour at the type locality, with yellow, white, and grey serving as subordinate colours. Shale with a red tint and the alteration of many lithologies are the formation's key characteristics. Individual beds, lithology, and even colour changes within short distances are characteristics of the formation. In the formation's base, siltstone with shale beneath it is found. The greyish yellow tint of the calcareous beds in the base shifts upward to a reddish tone because of ferruginous material. These calcareous beds were followed by a sequence of quartzite with fine to medium grain and heavy bedding. At the top of this joint, thick conglomerate layers are also present, indicating a brief pause in the accretion of material. It is made up of several quartzite fragments and limestone pebbles that were probably extracted from Shagai Limestone. Several calcite veins were found at the type site, however not quite as numerous as in the Shagai Limestone. The key characteristic that sets the unit apart from Shagai Limestone is the worn, rough surface. The Khyber district is entirely covered by the Ali Masjid Formation. Khyber Limestone forms its upper contact, and Shagai Limestone forms its lower contact. On the western side of Misrikhel, limestone is revealed in the top part with small clay particles and a sequence of arenaceous quartzite in the lower half. Mashkani Mela village is recognised as the type site of the Ali Masjid Formation. The entire unit is fossiliferous in Tauda Mela Cave, Bazar Valley, and Chora. The unit's exposed thickness is 220 m, albeit it fluctuates depending on the location. The formation is believed to be Late Devonian based on fossil evidence.

2.5.4 Khyber Limestone

Stauffer first used the name Khyber Limestone in 1968. Along the Khyber Pass road District Khyber KPK, the Khyber Limestone is exposed. The Khyber Limestone is a carbonate platform that protrudes to the northwest of Peshawar in a region that stretches into Afghanistan (Figure 2).

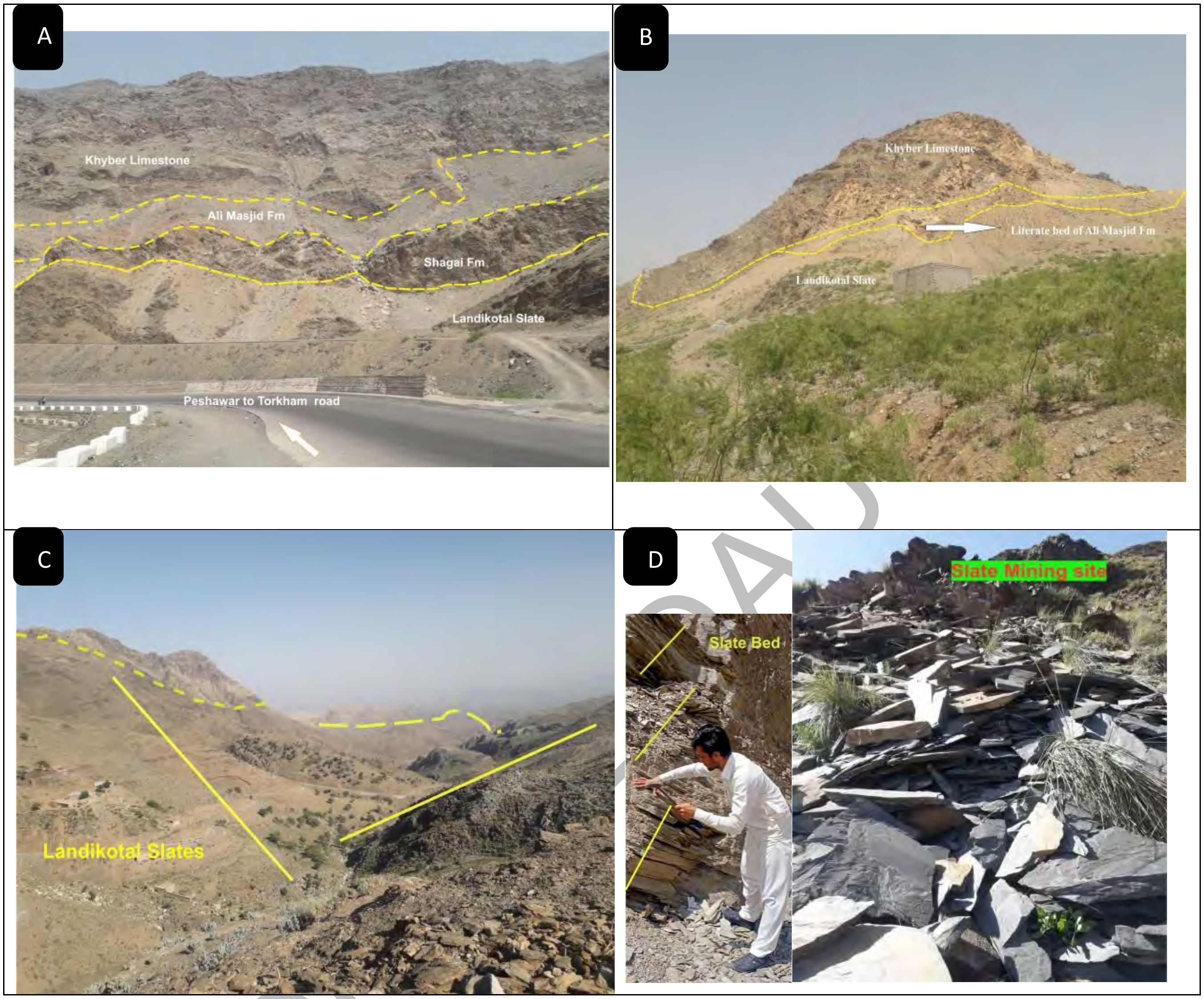
The Khyber Limestone contains dolerite intrusions from the middle Carboniferous period that cover an area of roughly 100 km^2 and range in thickness from 10 to 25 m. (v.vandeginste et al, 2014). The Khyber Limestone is about 1000 meters thick in the research region, although it reaches a maximum thickness of 1300 meters in the type location close to the settlement of Ali Masjid (Figure 2.4).

This grey, medium-to-thickly bedded, medium-to-fine-grained limestone transitions locally into medium-crystalline, massive dolomite and medium-crystalline, coarse marble (A.H Kazmi et al, 1997). Basic dykes and sills (5–6 m thick and traceable for hundreds of metres), which occur in the upper part of the formation, cut across the northern portion of the Khyber Limestone (S.M.I Shah et al, 1980). Upper and lower faulted contacts between the Khyber Limestone and the Landi Kotal and Shagai Formations, respectively (A.H Kazmi et al, 1997).

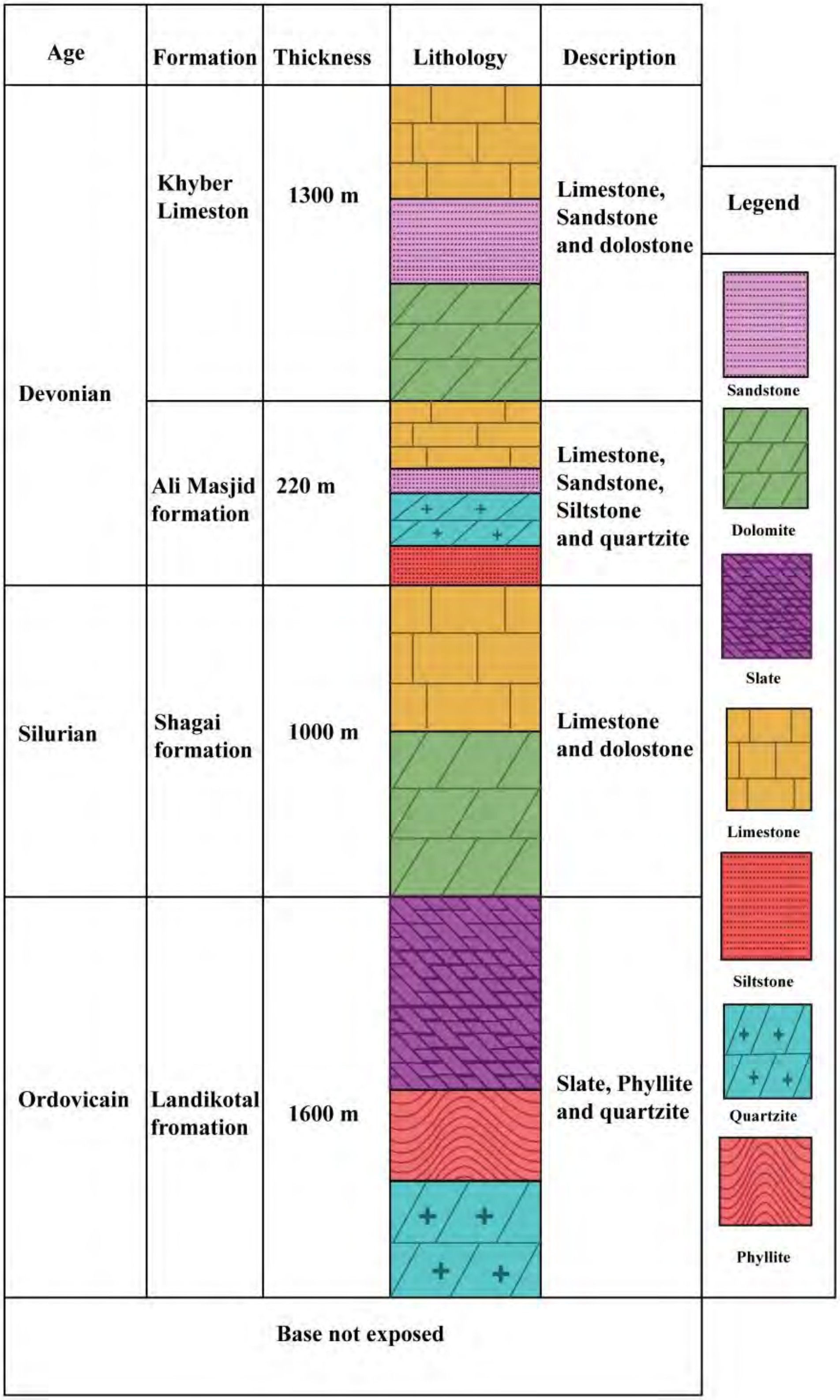
2.6 Observation in field

A detail three days geological field work was carried out to the different sites, in Khyber area. The rocks faced in the field were saw at the outcrop and then in the hand specimen under a hand lens to characterize their rock type. We collect samples from four different points (LS1, LS2, LS3 and LS4).

The Landikotal slates were one of the thick formations in Khyber Range and exposed on the both side of the Sur Kamir Khwar. In the research area the Landikotal Slates is present in the form of small rolling hills. The Landikotal Formation was in dark gray and dark greenish gray slates, some phylite, schist, sandstone and siltstone was also present in interbedded form. In the study area the slates was fine grain and mostly weather to long thin splinters. The grade of metamorphism is increased in north direction where schist and Phyllites are present in large amount. In the study area the Landikotal Slates was highly intruded by sills of dolerite, gabbro, and highly weathered granite. In some places the sills was 160-200 feet thick. Quartz vein was also present in the in some places which is later also study in thin section. In the research area the true stratigraphic base is not exposed on the surface and upper contact was with Shagai Formation.



Figs 2.3 field photographs of the study area.



Age	Formation	Thickness	Lithology	Description
Devonian	Khyber Limeston	1300 m		Limestone, Sandstone and dolostone
	Ali Masjid formation	220 m		Limestone, Sandstone, Siltstone and quartzite
Silurian	Shagai formation	1000 m		Limestone and dolostone
Ordovicain	Landikotal fromation	1600 m		Slate, Phyllite and quartzite
Base not exposed				

Figure 2.4 stratigraphic column of the study area

CHAPTER # 3

ENGINEERING STUDY OF SAMPLE

3.1 Introduction

The engineering characteristics of aggregates, which are mostly mechanical in nature and are carried out in line with national requirements, are what determine their quality assurance and in-service performance. However, in Pakistan, these tests are carried out in line with British Standards (BS) or the American Society for Testing and Materials (ASTM). Materials that are strong and durable enough can successfully withstand the loss of cohesiveness and strength. These substances can form strong connections with cement and endure impacts (Neville., 2000).

3.2 Lightweight aggregate manufacturing

The process of manufacturing and preparing light-weight materials is somehow change or differ from the preparation of commonly used concrete ingredient. The commonly use ordinary aggregate such as from sedimentary rocks and some others aggregate materials which are collect from mining site are just break it to various size on other process are carry out in its preparation and production. While for production and preparation of lightweight aggregates, following steps are needed for the procedure: (Holm and Ries, 2007)

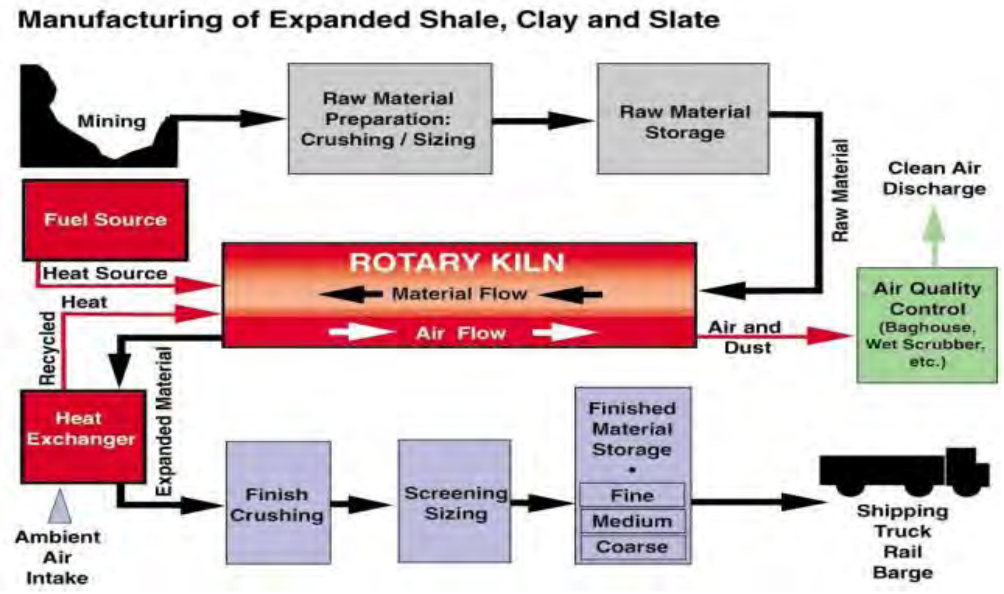


Fig 3.1 Manufacturing process of expanded slates

Steps

1 Collection of samples

2 Breakdown of samples

3 Grouping of samples

4 Heating of samples in hot oven

5 Grouping of samples

6 Stocking

3.2.1 Collection of Samples

The Department of Earth Science Quaid-E-Azam University Islamabad arranged research field for the collection of representative samples of slates along Peshawar Torkham routes. According to the field plan four fresh samples (LS1, LS2, LS3, and LS4) were collected from the outcrop. Different chemical and physical tests were processed on these samples to see if they meet the criteria for the LWCA as per specification. The material testing laboratory of the PCSIR Peshawar Complex was use for heat treatment and size reducing processes of the selected samples.

3.2.2 (Breakdown of samples) Crushing

The weight of the samples was determined before crushing in order to determine the mass deduction during the processes of samples breakdown and sample classification. A machine called Jaw Crusher was utilizes in this research works in order to reduce the size of the selected samples upto three inches (fig 3.2).

Fig: 3.2 Blake Jaw Crusher machine at PCSIR lab Peshawar.

3.2.3 Grouping of samples

The screening unite was used for screening or for the classification of the crushed materials in this research study. Here the samples were classified according to the size of the particle in Rotating classifier. This electromagnetic machine is designed for the purpose of classification of aggregate into different fraction. There is a feeder at the one end of the rotating classifier, which pours out the samples into the rotating unite. The rotating unite is divided into four sections and sieves are installed in each parts from finer to courser pore size. (Fig 3.3)

The first portion of rotating classifier contains all the material small than ½ inch and these pass into a tray through special pores. Then the sample is send to second portion for obtaining of material which pass from ½ inch and retain on ¼ inch. The process was carried on and material between ½, 1-3 inch sieve opening were gained. The samples were classified into three categories after screening. Samples of size ½ -3 inches are best for bloating. Less than ½ inches particles were turned down. The samples which have size large then three inches were breakdown and classified again and at the end the mass of the materials were find out location wise and size wise.

Fig 3.3 rotating classifier machine

3.2.4 Bloating

Next to classification processes the selected materials were shift to heat treating unites for bloating processes. The Rotary kiln is a heat treatment oven in a cylindrical shape which move around its fix points. The slates samples were added into the overhead portion of the oven the material will move slowly toward the center where it will be mixed. Methane gas is used as a hot flame from the lower side for heat treatment processes (Fig 3.4).

Bloating of the selected slates materials was done at Material Testing laboratory PCSIR Peshawar. The slates specimens were heated for one hour when temperature of Rotary kiln reached 1050 to 1250c˚. The bloating maximum temperature reached to1200c˚. The processes of heating are continuous for one hour and after completion the slates specimens were then collect from the oven. Samples were cooled down in containers for further processes. After 24 hours cooling the expanded slates specimens were weighted in order to determine the mass loss or deduction during the heat treatment processes (tab 3.1). The samples with good cellular structure and excessive expansion are selected further studies.

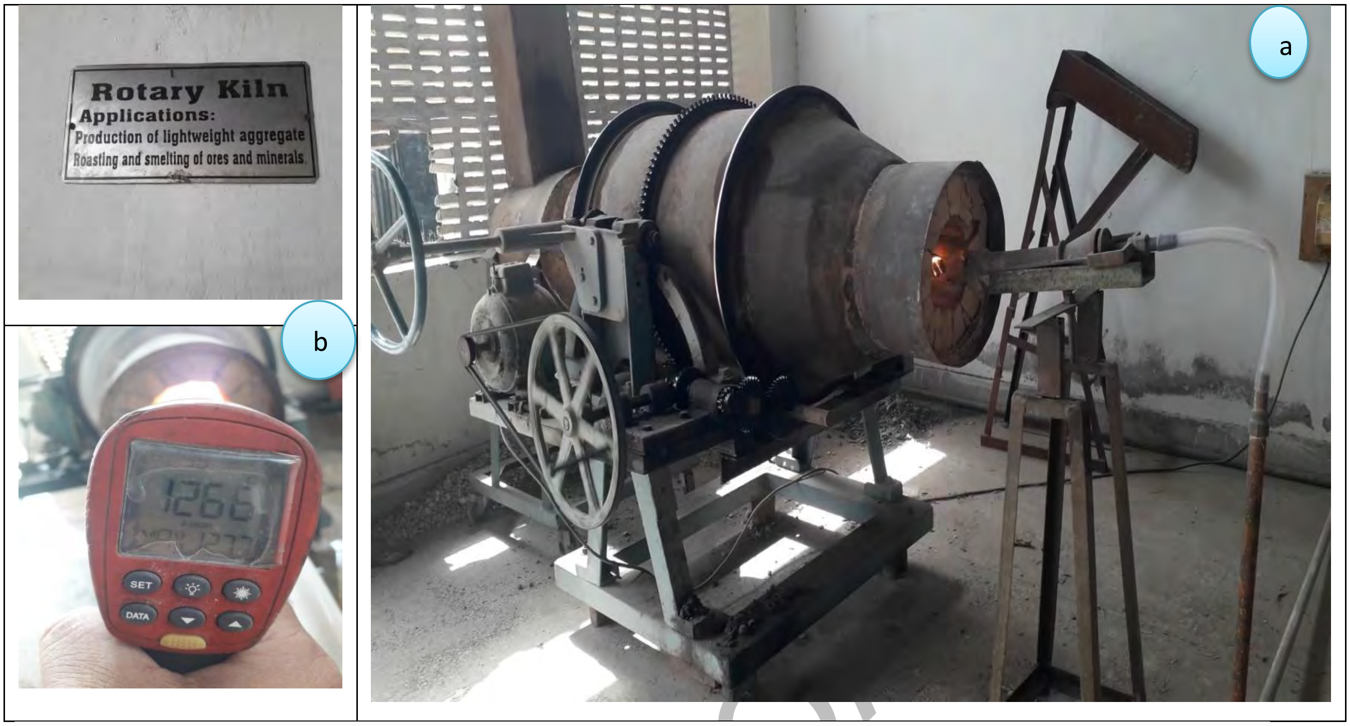


Fig 3.4 (a) Rotary Kiln (b) High Temperature IR Thermometers

3.2.5 Screening

The expended slates again brought to screening unite; here there classification was done into required fraction using Rotating Classifier. The expended Slates aggregate which are retained on 3 inch sieve were break down again in jaw crusher and sieve again.

3.2.6 Stocking

Samples bags were used for pouring the expended slates samples. The samples bags were labeled with a specific id for identification in the next processes.

3,2.7 Calculation

Formula for loss percentage

Loss % = weight loss ÷ total weight × 100

Table 3.1 Tabular description of weight loss during crushing and bloating

Weight = W	**LS1**	**LS2**	**LS3**	**LS4**
Weight of sample before bloating Kg = A	25.4	18.80	18.55	28.75
Weight of sample after bloating Kg = B	22.60	17.1	16.45	25.10
Weight loss Kg C= A-B	2.8	1.7	2.1	3.65
Loss percentage % %= C/A × 100	11.022 %	9.04 %	11.32 %	12.69 %

3.3 Light materials for construction mortar standard specification

The criteria which are mention in American Society for Testing and Materials ASTM 330 are utilized in this research works. The main concern was lowering concrete density without compromising its compressive strength. Two categories of lightweight aggregates are covered under the aforementioned standard:

1. Artificial materials which are treated or prepared in lab such is expanded low grade metamorphic rocks slates, sedimentary rocks shale etc.
2. Normal materials, which are made by natural processes, include pumice and tuff etc.

In this research study the following physical and chemical tests were carrying out on the selected slates samples and on their concrete sample.

3.4 Physical tests

The selected slate samples with good bloating properties were passed from the following physical test to find out their engineering properties and quality.

3.4.1 Sieve analyses test (ASTM C-136-01)

To find course and fine aggregate in a sample we sieve this sample through a series of arrange sieve this technique is called sieve analysis.

Significance and Use

In rocedure determination of materials properties for use as aggregate occurred. After the result are calculated, they are used to find out the compliance of the particles size distribution with such specification that is applicable and providing necessary data for control of the production of several aggregate products and mixtures that contain aggregate. The data may help to develop like about porosity and packing.

Procedure for Coarse Aggregate

Using the American Society for Testing and Materials ASTM C-702, exemplary slates specimen were handled in a proper manner for mixing, dividing, and cutting into portion. Drying of sample carried out till the sample achieved a specific weight at a 110 ± 5c° temperature. The sieve having proper opening for furnishing the required opening and information were selected. Installed the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitation was carried on manually or through electric apparatus for a specific time period. The quantity of material limited on a given sieve in order to have the opportunity for all particles for reaching the opening of sieve many times during the sieve operation. To prevent an overloading of material on an individual sieve we will use one of the following methods:

Additional sieve is inserted with the intermediate opening size between the sieves that may be overloaded on the sieve at once above that sieve in the original set of sieve.

The sample is separated in to two or more portions and each portion is sieved individually. The retained several portion is combined on a specific sieve before calculated the percentage of the sample on the sieve. Sieve the samples till the weight of material retain in the individual sieve become less than one percent to the total weight of the sample within one minute of continuous sieving processes (Tab 3.2).

Table 3.2 Tabular presentation of sieve analysis of coarse aggregate.

Designated Sieve in inch		**Retain Weight (g)**	**Cumulative retain Weight (g)**	**Cumulative retain Weight %**	**Passing %**
Inch's	Mm	A	B	C	D
2″	50.8	0	0	0	100
1.5″	37.5	75	75	1.5	98.5
1″	25.4	1050	1125	22.5	77.5
¾″	19.0	1470	2595	51.9	48.1
½″	12.5	1820	4415	88.3	11.7
3/8″	9.5	475	4890	97.8	2.2
#4	4.75	100	4990	99.8	0.2

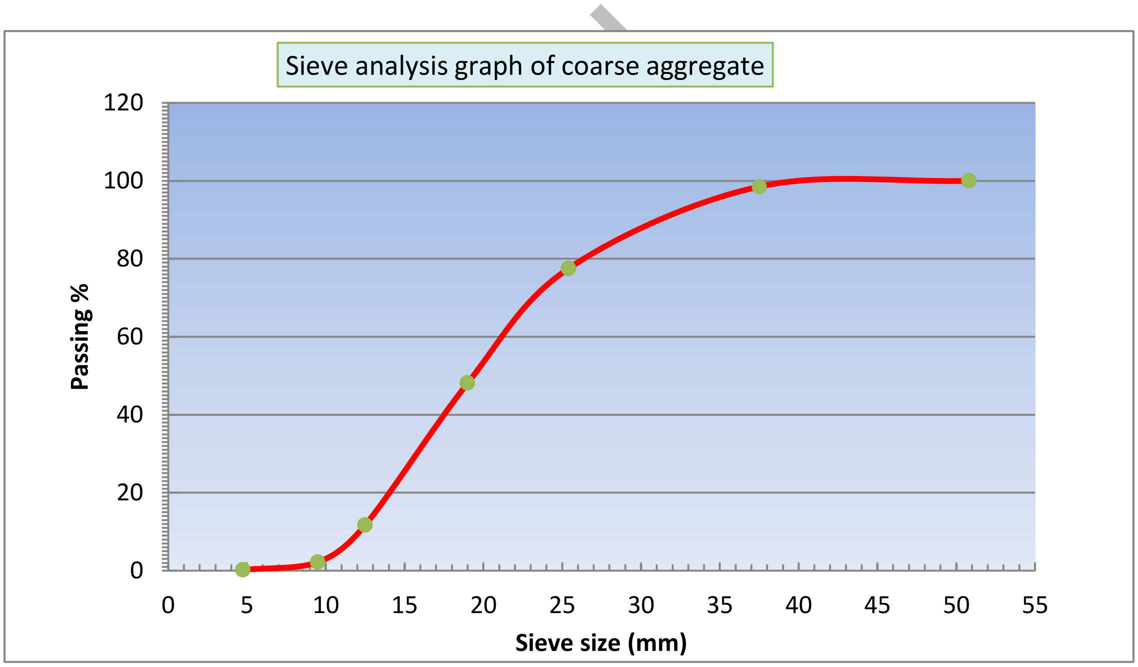


Fig 3.1 graphically representation of sieve analysis of course aggregate

Procedure for Fine Aggregate (ASTM C-117-03)

Drying of the sample was processed for reaching a specific mass at 110 ± 5c° and the mass was calculated with near value of 0.1 percent of the experimental specimen. The aggregate specimen is cleaned in a specific way with fresh water. The treated wastewater was removed carefully and put through a sieve measuring 75 micro meters. The reduction in the specimen weight was calculated in percentage in a total weight of the initial test specimen. This loss in weight show the percentage of specimen which are less than 75 micro matter sieve. The sample will be heated in an oven at a temperature 110 ± 5c° to gain a standard weight. The heated specimen was sieved on a same way as follow for coarse samples. Result is showed in (tab 3.3). Total weight taken 1000g

Table 3.3 table show the retain and passing percentage of fine aggregate.

Designated Sieve		**Weight Retained (g)**	**Cumulative Weight Retained (g)**	**Cumulative Weight Retained percentage%**	**Passing %**
mm	**No.**				
4.75mm	#4	0	0	0	100
2.36mm	#8	100	100	10	90
1.18mm	#16	250	350	35	65
0.6mm	#30	350	700	70	30
0.3mm	#50	200	900	90	10
0.15mm	#100	100	1000	100	0
Total	#200			275	
Remarks;		This fine sand belong to zone 1 as show in table 3.4 according to IS 383-1970			

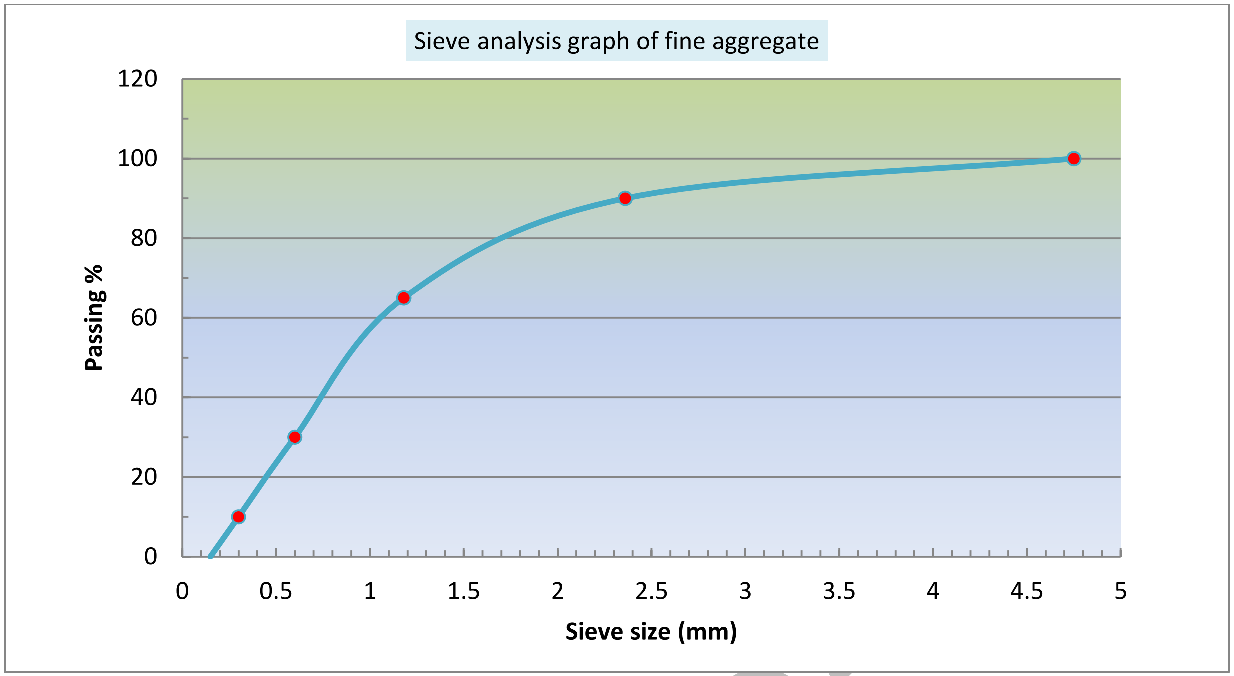


fig 3.2 graphically representation of sieve analysis of fine aggregate.

3.4.2 Fineness modulus test

Comparative coarseness or fineness in dimension of aggregate is known as fineness modulus. Those aggregate which show large value of fineness modulus is best to utilizes in warm and cold mixes (Siddique., 1991).

Procedure

I. Arranged a specific set of sieve in descending which is required and fixed it in a mechanical shaker.
II. Take a known weight of aggregate sample and put on the top of first sieve.
III. After sieving calculate the weight of retained particle on each sieve.
IV. Also calculate the cumulative weight of the retained samples and also find cumulative percentage of retained particle on each sieve.

Formula

Fineness modulus of Sand = (Cumulative % retained) / 100

From table no. 3

Cumulative retained percentage is = 275

FM = 275/100 = 2.75

Table 3.4 Fineness modulus with respect to various zones of sand according to IS 383-1970 are given below.

Sieve size	**Zone1**	**Zone2**	**Zone3**	**Zone4**
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
0.6mm	15-34	35-59	60-79	80-100
0.3mm	5-20	8-30	12-40	15-50
0.15mm	0-10	0-10	0-10	0-15
Fineness Modulus	4.0-2.71	3.37-2.1	2.78-1.71	2.25-1.35

3.4.3 Los Angeles abrasion test ASTM (C 131-3)

Aggregate hardness and erosion tolerance, such as breaking, degradation, and decomposition, are evaluated using the Los Angeles abrasion test.

Significance and Use

The quality and life spine of the construction project or a structure depend upon the materials which is used in the project and one of the important material is the course aggregate which play important rule in the quality of the project there for the above mention technique is used to find out the quality of aggregate material.

Procedure

According to the procedure ASTM (C 131-3), the Los Angeles Abrasion test is categorized into four group (A, B, C, D) as per the aggregate being tested and number of balls used, For this research process, class A was used as LWA maximum size was 1/2″. In this class, 12 steel balls were used, each weighting from 390g to 440g, having diameter of 46.8mm. The sample get ready for test was washed, Oven dried and then sieve as per class "A". The prepared sample having weight 5000g was put in Los Angeles Abrasion machine with respective 12 steel balls and the machine was revolved for 500 times as the rate of 30-33 revolution per minutes. All revolution took approximately 15 to 17 minutes. After this process, the samples after having been crushed was taken out from Los Angeles Abrasion machine and sieved with sieve no. 12. (1.70mm). after washing and drying then it was weighted for calculated percentage loss as show in (table 3.5).

Calculation

LA = (total wt. of sample(X) – Retained wt. on sieve no. 12 (Y) / (X) total wt. × 100

LA = $X - Y/X \times 100$

Table 3.5 tabular description of four classes of loss Angeles Abrasion test.

Sieve size		**A**	**B**	**C**	**D**
Passing	Retain	1250g			
1-1/5″	1″	1250g			
1″	¾″	1250g			
¾″	½″	1250g	2500g		
½″	3/8″		2500g		
3/8″	¼″			2500g	
¼″	No.4			2500g	
No.4	No.8				5000g
Total weight		5000g	5000g	5000g	5000g

Table 3.6 show loss Angeles Abrasion test result of sample no. A

Sample no. A				
1	Weight of the sample before test		=	5000g
2	Weight of the sample after test		=	3575.1g
3	Percentage loss		X-Y/X× 100	28.5%

Table 3.7 show loss Angeles Abrasion test result of sample no. B

Sample no. B				
1	Weight of the sample before test		=	5000g
2	Weight of the sample after test		=	3650.2g
3	Percentage loss		X-Y/X× 100	26.99%

Table 3.8 show loss Angeles Abrasion test result of sample no. C

Sample no. C				
1	Weight of the sample before test		=	5000g
2	Weight of the sample after test		=	3720
3	Percentage loss		X-Y/X× 100	25.6%

Average loss = A% + B% + C% /3 → 28.5+26.99+25.6/3 = 81.09/3 = **27.03%**

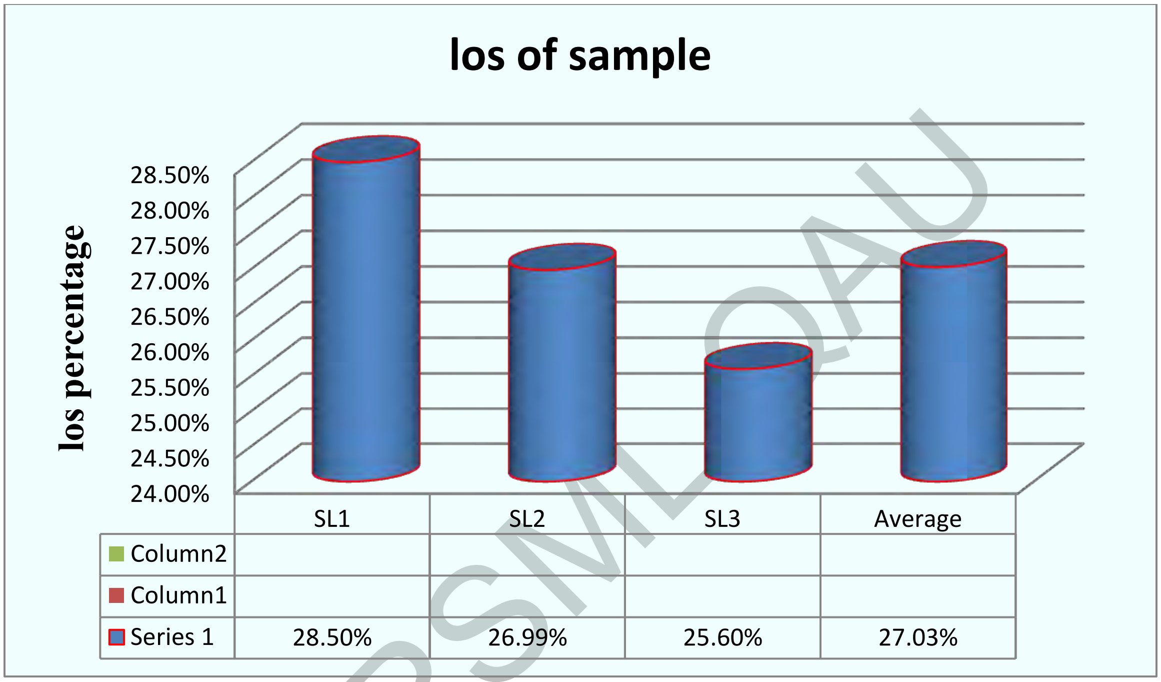


Fig 3.3 graphically representation of loss in weight.

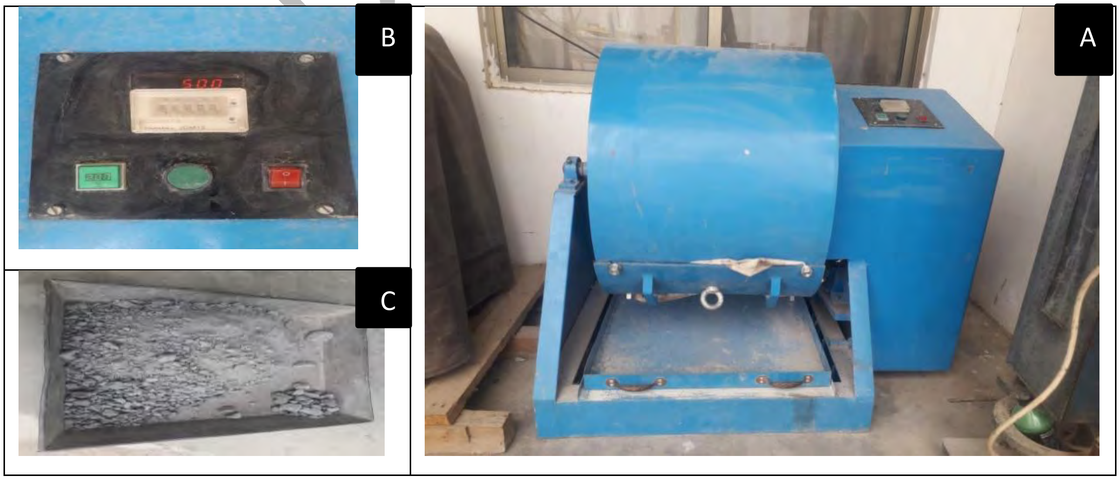


Fig 3.5 (a) LA machine (b) reading display (c) aggregate after crushing

3.4.4 Water absorption (ASTM C 121 – 90; Reapproved 1999)

It is desired to have some knowledge of the porosity of a material in question. For actual determination of the pore space, we need the use of elaborate and well-refined tool as well as enough precision for processing the test. For comparative means a simple and sufficiently out of flows methods of obtaining the desired information is afforded through water absorption test. Appling to slate, more care and precision is needed through this test than other materials due to its dense nature and resultantly the small quantities to be dealt with. The property of slate's cleavage, which enables it to be divided into thin sheets of uniform thickness, must also, be taken into account when this test is conducted. Due to unintentional cleavage fissures in the specimens, false results are sometimes obtained on cubical specimens. The following procedure's recommendation for specimen forms and a higher number of specimens aims to substantially reduce the possibility of inconsistent results when working with this material.

Significance and Use

Water absorption is a term used to describe how porous an aggregate is, and it can be used to assess a rock's strength (Siddiqui, K. H., 1991). This number is taken into account as a gauge for both enduring weathering activity and resistance to frost action. Except in cases when they pass the strength, soundness, and hardness tests, rocks with a higher water absorption rate are typically regarded as being unsuitable.

Procedure

The left over sample of sieve no. 4 for course aggregate was thoroughly washed so that it becomes clean from dust and other coverings from the particles. The specimens were dried in ventilated oven for 48 h at a temperature of 60-62°C. Weight was ensured at 46th, 47th, and 48th hour, if the weight drop continuously, dry the samples further till three successive hourly readings with the same weight.

After drying, the sample were cooled down for 15 minutes and weighed. The specimens are placed at desiccator in case they cannot be weighted immediately after cooling. The weight is calculated to the near 0.01 gram.

The samples are immersed completely in filtered or distilled water at temperature 20-25°C for 48 h, and remove it at a time, the surface is dried with a less damp and absorbent towel. Then each sample is weighted immediately to the near 0.01 gram.

Formula

Measure percentage of absorption as follows:

1) Water Absorption = mass of material (SSD) (X) – mass of heated dry material (Y)
2) Absorption % = X-Y /Y × 100 or
3) Weight of saturated surface (SS) dry sample in air - Weight of oven dry sample in air/ Weight of oven dry sample in air × 100

3.4.5 Specific Gravity (ASTM C 127 – 01)

The ratio of the density of a material to the density of liquid (water) at a room temperature is called specific gravity. It is a quantity which has no unites. This ASTM standard is used to calculate the specific gravity of the aggregate materials.

Significance and Use

I. Specific gravity values can be utilizes for quality determination of the aggregate.
II. The aggregate materials which have less specific gravity value are weak and vies versa.
III. Specific gravity values are used when we calculating the volume of aggregate material that makes different mixtures.
IV. Its values are also used for the measurement of porosity of the aggregate materials.

Procedure

- Take a specific and wished it with pure water to remove the dust particles and then dry it in oven to gain it normal weight.
- Filled basket with the clean aggregate and suspend it in a container full of water and leave it for twenty four hours.
- Note the weight of the sample plus basket when it is suspended in water container at a room temperature.
- Now remove the sample from the basket and dry it with cloth.

- Note the weight of the sample which is surface dried already.
- Now completely dry the sample in oven at a temperature 110c˚ for specific standard time duration.
- Completely cool down the sample and note its weight.

Calculations

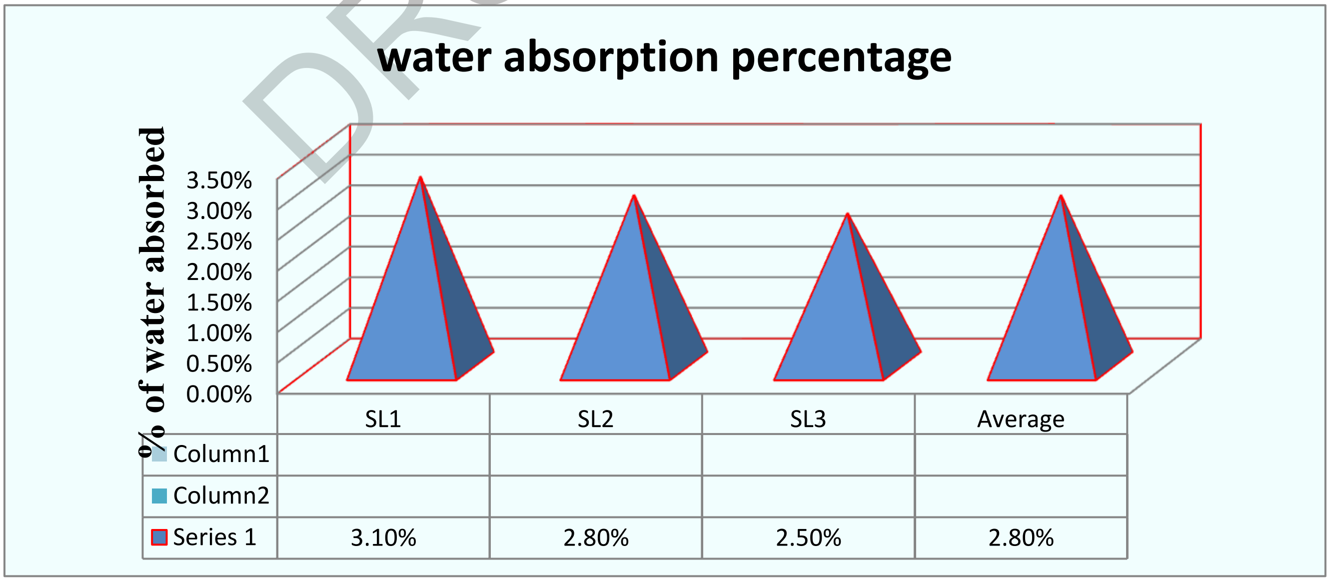
- **Specific gravity** = weight of aggregate (X)/ (weight of aggregate – weight of aggregate in water). OR

Saturated surface dry (**SSD) Specific gravity** = SSD Weight /SSD Volume

- **Apparent specific gravity** = oven dry weight / apparent volume
- **Saturated surface dry (SSD) Volume** = SSD weight – weight in water
- **Apparent volume** = oven dry weight – weight in water

Table 3.9 show tabular description of specific gravity and water absorption.

1	**Trial No**		**1**	**2**	**3**	**Average**
2	Weight of saturated surface (s.s) dry sample in air	(g)	2539.5	2701.1	2664.1	
3	Weight of oven dry sample in air	(g)	2462.1	2627.1	2599.7	
4	Weight of sample in water	(g)	941.0	990.5	957.8	
5	Absorption	(g)	77.4	74	64	
6	% absorption	(%)	3.1	2.8	2.5	2.8%
7	Volume					
8	saturated surface dry (SSD) volume		1598.5	1710.6	1706.3	
9	Apparent volume		1521.1	1636.6	1641.9	
10	Gravity					
11	saturated surface dry (SSD) specific gravity		1.589	1.579	1.561	1.57
12	Oven dry specific gravity		1.540	1.536	1.524	1.532
13	Apparent specific gravity		1.619	1.605	1.583	



Graph 3.4 water absorption percentage representations

3.4.6 Flat and Elongated Particles in Aggregates test (ASTM D 4791-99)

In this procedure, percentage of flat and elongated sediments in large size aggregate was determined. In order to conduct the processes, solitary slates pieces of particular mesh sizes were evaluated in order to calculate the proportions of width-thickness and length-thickness.

Elongated piece of aggregate

Aggregate pieces whose circumscribing rectangular prism's length to width has a ratio larger than a predetermined value.

Flat piece of aggregate

Aggregate pieces whose circumscribing rectangular prism's ratio of width to thickness above a given value.

Significance and Use

For some building applications, flat or elongated aggregate particles may prevent consolidation and produce harsh, challenging-to-install materials. The above mention technique offers way for finding relative form properties of coarse material or to verify compliance with standards that restrict such particles.

Procedure

According to ASTM-C 702, the specimens were ready by properly combining, dividing, and subdividing the descriptive slates specimen. According to American Society for Testing and Materials C 136, the slates specimens were sieved after being heated to a consistent weight at 100C˚. The 4.75mm (No. 4) sieve's retain material was applied. A hundred or more particles were collected for each required size fraction after each size fraction was lowered to 10% of the original sample. To assess the level of particle flatness and elongation, a proportional caliper device that was positioned at the ratio was utilized. Particles were permitted to pass freely through the device openings to test the device's flakiness. The particle was regarded as non-flaky if it passed through the apertures from all directions, and vice versa. Particles were allowed to pass through the ruffle apertures both vertically and horizontally to test the elongation. A particle is regarded as non-elongated if it passes through both vertically and horizontally, while the opposite is true. Following the grouping of the particles, the sample proportion in each group was calculated by counting the particles. According to IS regulation aggregate sizes lower than 6.3 mm are not applicable for flakiness and elongation index tests.

Table 3.10(a)

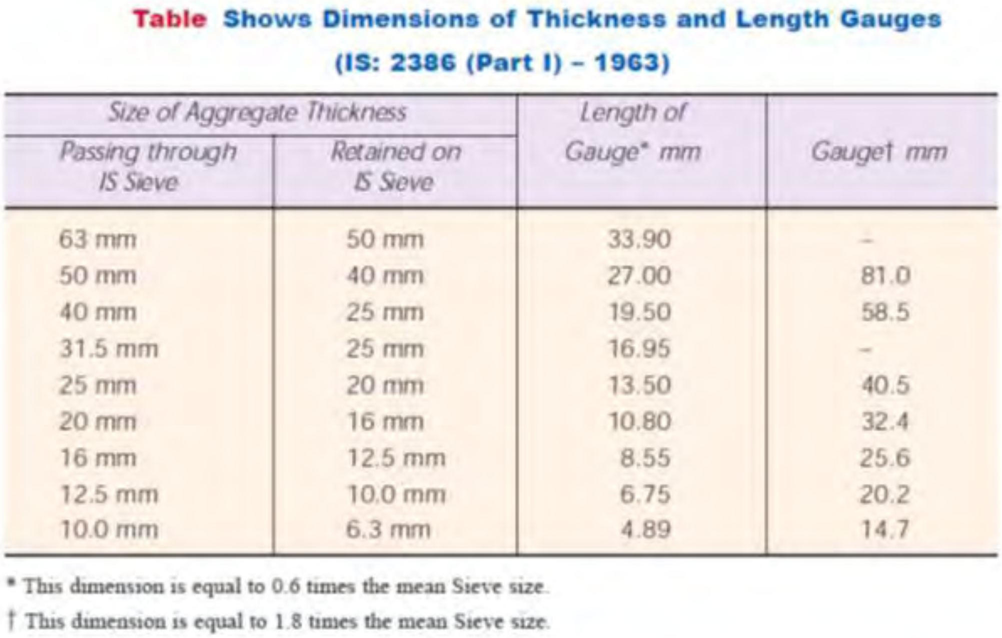


Table Shows Dimensions of Thickness and Length Gauges (IS: 2386 (Part I) – 1963)

Size of Aggregate Thickness		Length of Gauge* mm	Gauge† mm
Passing through IS Sieve	Retained on IS Sieve		
63 mm	50 mm	33.90	–
50 mm	40 mm	27.00	81.0
40 mm	25 mm	19.50	58.5
31.5 mm	25 mm	16.95	–
25 mm	20 mm	13.50	40.5
20 mm	16 mm	10.80	32.4
16 mm	12.5 mm	8.55	25.6
12.5 mm	10.0 mm	6.75	20.2
10.0 mm	6.3 mm	4.89	14.7

* This dimension is equal to 0.6 times the mean Sieve size.

† This dimension is equal to 1.8 times the mean Sieve size.

Table 3.11(b) The mass of the test sample shall conform to the following:

Nominal Maximum Size Square Openings, mm (in.)	Minimum Mass of Test Sample, kg. (lb)
9.5 (⅜)	1 (2)
12.5 (½)	2 (4)
19.0 (¾)	5 (11)
25.0 (1)	10 (22)
37.5 (1½)	15 (33)
50 (2)	20 (44)
63 (2½)	35 (77)
75 (3)	60 (130)
90 (3½)	100 (220)
100 (4)	150 (330)
112 (4½)	200 (440)
125 (5)	300 (660)
150 (6)	500 (1100)

Calculation

Total weight of the sample = W1 = 1150

- Flakiness index = $W_2/W_1 \times 100$
- Elongation index = $W_3/W_1 \times 100$

Where:

W_2 is Weight of aggregate pass through thickness Gauge.

W_3 is Weight of aggregate retain through length Gauge

Table 3.11 showing the flat and elongated particle test result.

SIEVE SIZE (mm)		**Corresponding thickness Gauge size (mm)**	**Corresponding length Gauge size (mm)**	**Weight of aggregate pass through thickness Gauge = W2 (g)**		**Weight of aggregate retain through length Gauge = W3 (g)**	
				C		**D**	
Passing	Retain	A	B	1	2	1	2
20	16	10.80	32.4	68	54	96	90
16	12.5	8.55	25.6	242	210	258	249
12.5	10	6.75	20.6	80	92	64	61
10	6.3	4.89	14.7	28	36	22	27
Total				418	392	440	427
Average							
Flakiness index = 35.15 % Elongation index = 37.65 %			**Remarks:**	Flakiness index in excess of 35 – 40% is considered undesirable			

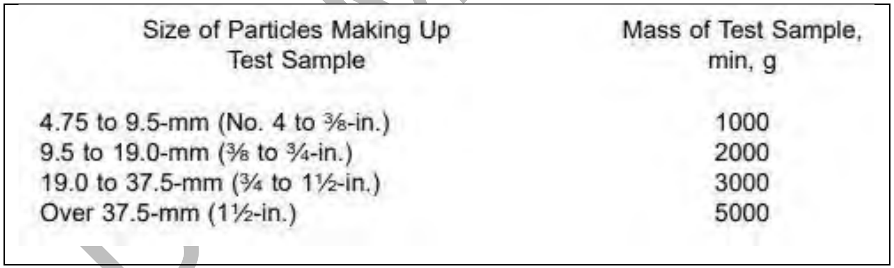
3.4.7 Clay Lumps and Friable Particles test (ASTM C 142-10)

This method is used for a rough estimation of clay lumps and friable particles in the selected slates samples.

Procedure:

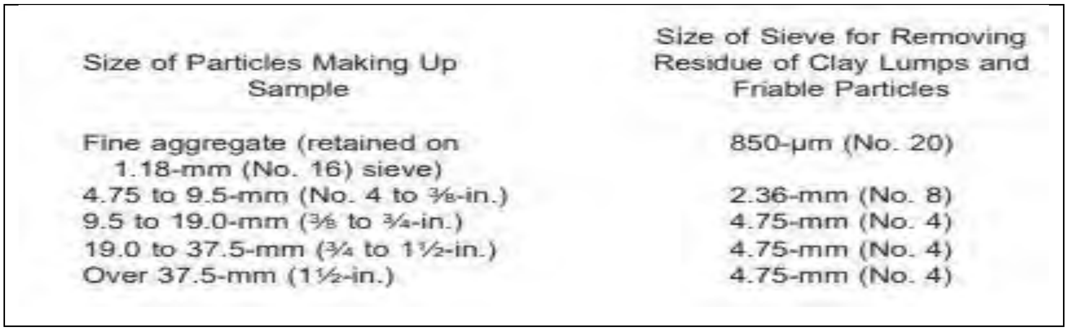
I. Take the sample to test according to the (table 3.13) and add to bottle.
II. Add distilled liquid (water) to the bottle which already contain the sample and leave for twenty four hours.
III. After a specific time period pressed each and every partial by using your finger to crush the particle into small pieces. In this way all the clay particle and friable pieces will be broken down from the other sediment.
IV. Remove the detritus from the other remaining material by a proper sieve sets as mention in (table 3.13).
V. Dry the retain material in over at 115C° temperature.
VI. After cooling determine the mass of the material.

Table 3.12 showing mass determination of the test sample to the accuracy specified.



Size of Particles Making Up Test Sample	Mass of Test Sample, min, g
4.75 to 9.5-mm (No. 4 to ⅜-in.)	1000
9.5 to 19.0-mm (⅜ to ¾-in.)	2000
19.0 to 37.5-mm (¾ to 1½-in.)	3000
Over 37.5-mm (1½-in.)	5000

Table 3.13 arrangement of sieve for separation of detritus.



Size of Particles Making Up Sample	Size of Sieve for Removing Residue of Clay Lumps and Friable Particles
Fine aggregate (retained on 1.18-mm (No. 16) sieve)	850-μm (No. 20)
4.75 to 9.5-mm (No. 4 to ⅜-in.)	2.36-mm (No. 8)
9.5 to 19.0-mm (⅜ to ¾-in.)	4.75-mm (No. 4)
19.0 to 37.5-mm (¾ to 1½-in.)	4.75-mm (No. 4)
Over 37.5-mm (1½-in.)	4.75-mm (No. 4)

Formula: $C \% = W - Wr / W \times 100$

C % = Show clay lumps and friable particles percent

W = mass of test sample

Wr = retain weight on a specific sieve

Table 3.14 showing the percentage of Clay Lumps and Friable Particles.

Sieve Size (inch)	**Dry weight (grams)**		**Loss in weight (grams)**	**Percentage loss**
	Before test	After test		
¾″	2344	2342.5	1.5	0.06
½″	2075	2072.5	2.5	0.12
3/8″	1163	1161	2	0.17
Total				0.35 %
Remarks: All the samples met the requirements of ASTM C33 (less than 2%).				

3.4.8 Bulk Density (ASTM C 29/C 29 M 97)

This procedure is used for finding the unit weight of compressed and uncompressed aggregate and the empty space among sediments is also calculated. The above procedure is used for sediments or aggregate materials whose size is not large then five inches.

Significance and Use

- Bulk density values required for use in several techniques of choosing proportions for concrete mixtures are frequently determined using this test procedure.
- In purchase agreements, the mass/volume relationships for conversions may also be determined using the bulk density.
- The value of density achieve through this procedure can be used to find out the percentage of free spaces or porosity among the aggregate materials.
- Compaction of the surface can also be calculated by using the value of this test method.

Procedure:

Bulk density can be determined by using the one of the following method.

1) Roding
2) Jigging
3) Shoveling

In this research we use the Roding procedure to determine the bulk density.

I. Take a container of 6×6×6 inches size plus a steel road which use for stocking.
II. Fill the container in four portions each of twenty five percent of the total size.
III. Compress each layer for giving them twenty five stokes.
IV. After completion the processes of stocking remove the extra material above the collar of the container.
V. At the end find the different weight accordingly.

Calculation

$$E = (C - B) / A$$

Where:

A = container volume (ft^3)

B = container weight (lb.)

C = container + material weight (lb.)

D = material weight (lb.)

E = material bulk density ($lb./ft^3$)

Table 3.15 showing tabular description of bulk density test

Volume of mold = A		**1/10 f^3**	
Mass of mold = B		**2.5 pound**	
S/No. of sample	Wt of samples + mold (Ib) C	Mass of sample (Ib) D	Bulk density (Ib/f^3) E
1	7.6	5.1	51
2	7.24	4.74	47.4
3	7.43	4.93	49.3
4	7.85	5.35	53.5
Average			50.3
Remarks:	Lightweight aggregate has bulk density of less than 74.9 Ib/f^3		

3.5 Chemical tests

The below mention chemical analysis were carry out in order to find out the quality of the slates specimen which showed better swelling characteristics.

3.5.1 Soundness test (ASTM C 88_90)

This testing procedure outlines a process for determining an initial assessment of an aggregate's soundness for use in concrete and other applications.

Significance and Use

A soundness test for aggregates is an important procedure used to assess the quality and durability of aggregates used in construction materials such as concrete and asphalt. The test is designed to evaluate the resistance of aggregates to weathering, degradation, and potentially harmful reactions that can occur over time. By dipping the aggregate sample in a saturated solution of $NaSO_4$ or $MgSO_4$, the resistance of the aggregate to breaking is investigated.

Procedure

For Coarse Aggregate:

Material that has had particles less than the No. 4 sieve is detached from it and must be used coarse material for this procedure. The sample's size must be such that it will provide the amounts listed in (Table 3.17) that is readily obtainable in quantities of 5% or more:

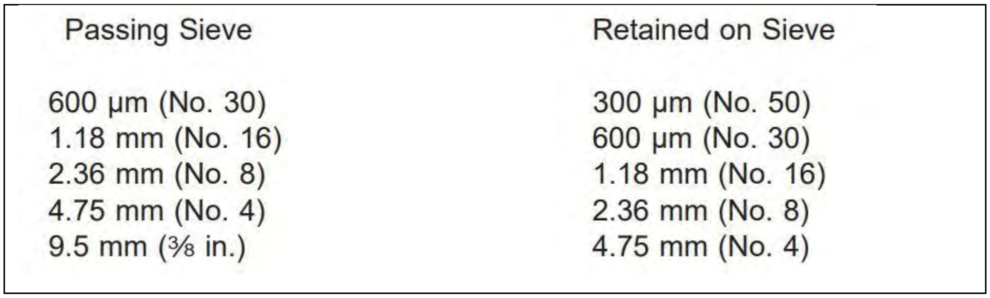
Table 3.16 The mass size according to sieve size.

Size (Square-Opening Sieves)	Mass, g
9.5 mm (⅜ in.) to 4.75 mm (No. 4)	300 ± 5
19.0 mm (¾ in.) to 9.5 mm (⅜ in.)	1000 ± 10
Consisting of:	
12.5-mm (½-in.) to 9.5-mm (⅜-in.) material	330 ± 5
19.0-mm (¾-in.) to 12.5-mm (½-in.) material	670 ± 10
37.5-mm (1½-in.) to 19.0-mm (¾ in.)	1500 ± 50
Consisting of:	
25.0-mm (1-in.) to 19.0-mm (¾-in.) material	500 ± 30
37.5-mm (1½-in.) to 25.0-mm (1-in.) material	1000 ± 50
63-mm (2½ in.) to 37.5-mm (1½ in.)	5000 ± 300
Consisting of:	
50-mm (2 in.) to 37.5-mm (1½-in.) material	2000 ± 200
63-mm (2½-in.) to 50-mm (2-in.) material	3000 ± 300
Larger sizes by 25-mm (1-in.) spread in sieve size, each fraction	7000 ± 1000

For Fine Aggregate

To ensure that the aggregate passes through a 9.5-mm (3/8-inch) sieve, it should have a size that is large enough to yield an output of approximately 100 grams or more for each of the mentioned sieves.

Table 3.17 passing and retain sieve size.

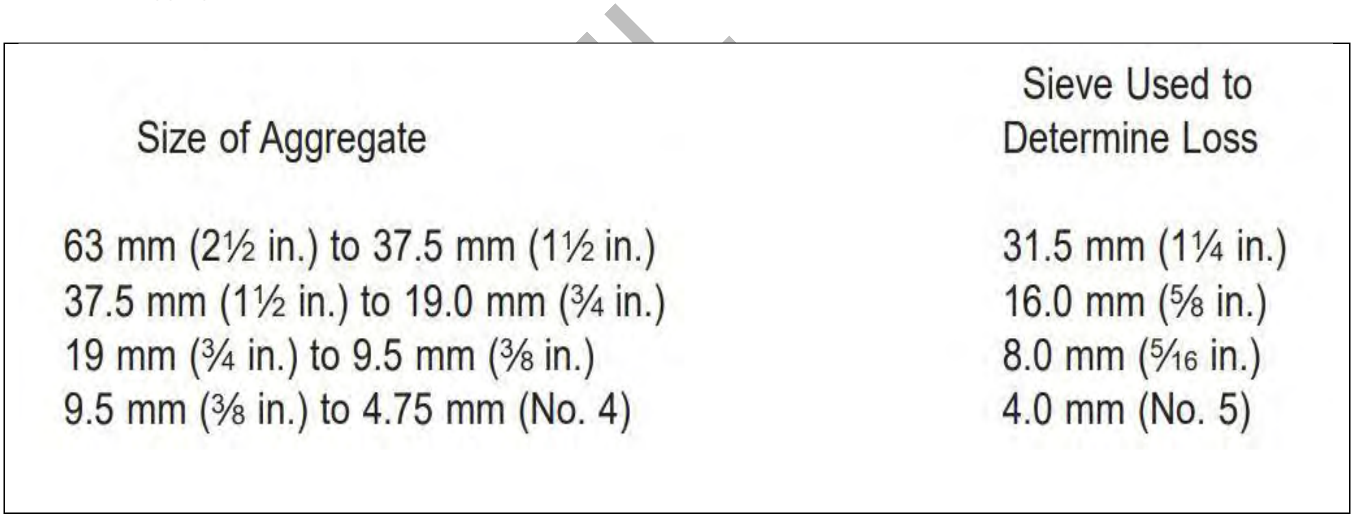


Passing Sieve	Retained on Sieve
600 µm (No. 30)	300 µm (No. 50)
1.18 mm (No. 16)	600 µm (No. 30)
2.36 mm (No. 8)	1.18 mm (No. 16)
4.75 mm (No. 4)	2.36 mm (No. 8)
9.5 mm (⅜ in.)	4.75 mm (No. 4)

Steps

I. Suspend sample container in the solution tank with the help of racks in such a way that the sample completely submerge in the solution and leave it for 17 ± 1 hour.
II. Take the samples out of the solution, and then let them drain for about 15 minutes.
III. At temperature of 110 C˚, dry the sample in the oven to constant mass then let it to cool down.
IV. Five consecutive cycles of dipping, drying, and cooling should be conducted sequentially.
V. At the end of test procedure wish the sample with clear water to remove the sodium sulphate.
VI. Barium chloride ($BaCl_2$) is used to determine whether there is sodium sulphate in the wash water. Sodium sulphate is present when there is cloudiness.
VII. Now sieve all the sample with a proper sieve sets which is shown in (table 3.19).
VIII. Calculate the mass of the particles that were retained on this filter by weight.

Table 3.18 aggregate size vs. sieve used to determine loss chart.



Size of Aggregate	Sieve Used to Determine Loss
63 mm (2½ in.) to 37.5 mm (1½ in.)	31.5 mm (1¼ in.)
37.5 mm (1½ in.) to 19.0 mm (¾ in.)	16.0 mm (⅝ in.)
19 mm (¾ in.) to 9.5 mm (⅜ in.)	8.0 mm (5⁄16 in.)
9.5 mm (⅜ in.) to 4.75 mm (No. 4)	4.0 mm (No. 5)

Calculation

To determine the loss in weight of the sample according to their particle size the below mention formula is used.

$$Loss = \left(\frac{M_B - M_A}{M_B}\right)100$$

In the above formula

M_B = represent mass of the sample before the test procedure.

M_A = represent mass of the sample after the test completed.

Table 3.19 showing the results of coarse aggregate for soundness test.

ASTM Sieve size		**% Retained of original sample**	**Weight of samples (g)**		**Loss in weight after test**	**% loss after test**	**Actual average % loss**
			Before test	**After test**			
Passing	**Retain**	**A**	**B**	**C**	**D**	**E**	**F**
No.4							
3/8″	No.4	9.5	300	295	5	1.7	0.1615
3/4″	3/8″	43.5	1000	985	15	1.5	0.6525
1-1/2″	3/4″	47	1500	1480	20	1.3	0.611
2″	1-1/2″						
Total		100					1.4165
Note: **D=B–C** **E=D/B×100** **F= A × E / 100**			**Remarks:**	Maximum allowed loss is 10% in cause of Na_2SO_4 solution.			

Table 3.20 showing the results of fine aggregate for soundness test.

ASTM Sieve size		**% Retained of original sample**	**Weight of samples (g)**		**Loss in weight(g) after test**	**% loss after test**	**Actual average % loss**
			Before test	**After test**			
Passing	**retain**	**A**	**B**	**C**	**D**	**E**	**F**
No.100							
No. 50	No. 100	16.5	100	94	6	6	0.99
No. 30	No.50	27	100	93.5	6.5	6.5	1.755
No. 16	No. 30	23	100	96	4	4	0.92
No. 8	No. 16	12.8	100	95.8	4.2	4.2	0.5376
No. 4	No. 8	11.5	100	98	2	2	0.23
Total		90.8					4.4326%
Note: **D=B–C** **E=D/B×100** **F= A × E / 100**			**Remarks:**	Maximum allowed loss is 12% in cause of Na_2SO_4 solution.			

Fig 3.6 chemical sodium sulfate

3.5.2 Loss on Ignition (ASTM C 114 – 04)

To find out the amount of volatile material in the aggregate material this technique is used. It is one of the most useable techniques in analytical chemistry. This test needs very high safety and inert environment in laboratory.

Procedure

In a platinum crucible coated with tar, ten grams of sample were added. Sample was heated to 950 ± 50 C˚ in a muffle furnace under cover for 15 minutes. The sample was taken out of the muffle furnace, placed in desiccators, and cooled to room temperature while being weighed. The following calculations were used to determine the weight loss percentage during ignition:

Calculation

Loss on ignition percentage = mass of specimen – mass of heat dried specimen divide by mass of specimen × 100

Requirement

The loss of ignition is not more than five percent for Lightweight aggregate.

Table 3.21 showing tabular description for loss on ignition test.

S no.	Sample	Weight of sample before test	Weight of sample before test	Loss on ignition percentage
1	SL1	10g	10g	0%
2	SL2	10g	10g	0%
3	SL3	10g	10g	0%
Remarks:			No loss on ignition was recorded because samples were already bloated at 1250 c˚.	

3.5.3 Organic impurities (ASTM C 40_04)

This technique consists of 2 processes to estimating whether fine aggregates intended for use in hydraulic cement mortar or concrete contain harmful organic contaminants. A glass colour standard is used in one operation while a standard colour solution is used in the other.

Significance and Use

I. This test method's main benefit is to provide a signal that potentially harmful levels of organic contaminants may be present.
II. This analysis is preform to find out the impact of organic contaminates on the strength of concrete according to ASTM C-87 standard.
III. The fine material is accepted and reject for a concrete material based on the value of this test.

Procedure

I. Add the sample into glass bottle until it is filled to a volume of roughly 130 ml.
II. Add sodium hydroxide solution to the sample to fill the bottle up to 200 ml.
III. Shake the glass bottle with the help of shaker machine or by hand till the solution and the sample mixed completely.
IV. Leave the glass bottle for twenty four hours in a room temperature.

Determination of Color Value

On the next day compare the colour of the glass bottle filled with samples and solution with a standard organic color chart which contain five colors.

Table 3.22 showing the result for Organic impurities test.

Gardner color standard No.	**Organic plate No.**	**Remarks:**
5	1	Same as chart No. 1. No organic impurities.
8	2	
11	3 (standard)	
14	4	
16	5	

3.6 Design parameters for Structure Lightweight Concrete (ACI 211.2-98)

Structure lightweight aggregate concrete meets the following requirements:

1: It is made with lightweight aggregate that cooperates with ASTM C-330.

2: The Structure lightweight aggregate concrete cylinder has more than 17.24 mega pascal (2500.45 psi) compressive strength at 28 days periods when testes using ASTM C-330 technique.

3: Structure lightweight concrete samples have an air dry mass not more than one hundred fifteen (115) lbs. per cubic foot (ft^3). This specification is met by concrete that has a portion of the lightweight aggregate replaced with conventional weight aggregate. It should adhere to ASTM C-330 specifications.

3.7 Quantify the trial mixture proportions

There are two approaches to alter the percentages of lightweight aggregate in structure grade concrete. Utilized in the weight (pycnometer) approach is the specific gravity factor. A displacement pycnometer test is used to determine it (method 1). For the purpose of calculating the weight per yd^3 or m^3 of concrete, this approach also uses the specific gravity factor. While the damp, loose volume method uses the link between cement content and strength to construct sand- and lightweight concrete (Method 2). Only the weight method, which is recommended by ACI standard, was employed to conduct this study.

3.7.1 Weight technique (specific gravity pycnometer)

In this research, normal mass fine material and light mass coarse slates aggregate are utilizes for the preparation of structure lightweight concrete. For the purpose of estimating the required batch weights for lightweight concrete, the ASTM C 127 was used to calculate the lightweight coarse aggregate's absorption and specific gravity factor. The experimental activity incorporates the following processes in order to calculate the weight per unit volume of concrete.

1: Choosing a slump

The ACI standard 211.2-98, slump of 5–6 inches was selected as it was practical to work with.

Table 3.23 ACI standard slump selection table.

Slump (inch)	**Water, Ib/yd^3 of concrete for indicated nominal maximum size of aggregates**		
	3/8″	**1/2″**	**3/4″**
	Non-air-entrained concrete		
1 to 2	350	335	315
3 to 4	385	365	340
5 to 6	400	375	350
Approximate amount of entrapped air in non-air entrained concrete, percent	3	2.5	2

2: Selecting the nominal maximum size for light-weight material

Slates aggregates sizes that were chosen had a nominal limit of $\frac{3}{4}$ inch (19mm). To reduce voids, the aggregate was well graded. Because less mortar is needed per unit volume of concrete, Large -size aggregate was chosen.

3: calculating the mixture of both water and air amounts

The calculation of water quantity in a specific volume of concrete needed to achieve the specific slump based on the aggregate's gradation, the shape of the particles, the volume of trapped air, the presence of chemical additive, and the nominal maximum size. In this study, it was suggested to build non-air entrained concrete; hence 350 Ib/yd^3 of predicted mixing water was used as given in ACI 211.2-98 standard chart (table 3.24).

4: Water-cement ratio selection

For the ongoing study, three thousand (3000) pound per square inch was set as the minimum strength requirement. According to ACI standard 211.2-98, the estimated water cement ratio (w/c) used for the design was 0.68, as indicated in Table (3.25). The mix design utilizes cement from the Kohat Company, which is accessible locally.

Table 3.24 ACI standard w/c ratio selection table.

Compressive strength at 28 days, psi	**Approximate water cement ratio, by weight**	
	Non-air-entrained concrete	**Air-entrained concrete**
6000	0.41	-
5000	0.48	0.40
4000	0.75	0.48
3000	0.68	0.59
2000	0.82	0.74

5: Estimating the quantity of cement

The bellow mention equation is used to find out the quantity of cement which is needed for a unite volume of concrete.

Cement amount = water amount / (water/cement ratio).

For the present study the amount of cement is determine as.

Cement = $\frac{350}{0.68} =$ 514.7 pound pre cubic yard

6: Calculation of lightweight coarse aggregate amount

The proportion of coarse aggregate in a unit volume of concrete reflects only on the nominal maximum size and the fineness modulus of the normal weight fine aggregate for equal workability of the concrete. The amount of aggregate chosen was 0.62 per unit volume of concrete, taking the nominal maximum size and fineness modulus of fine aggregate into consideration as show in table (3.26). The lightweight coarse aggregate was estimated as follows in per unit volume (yd^3) of concrete:

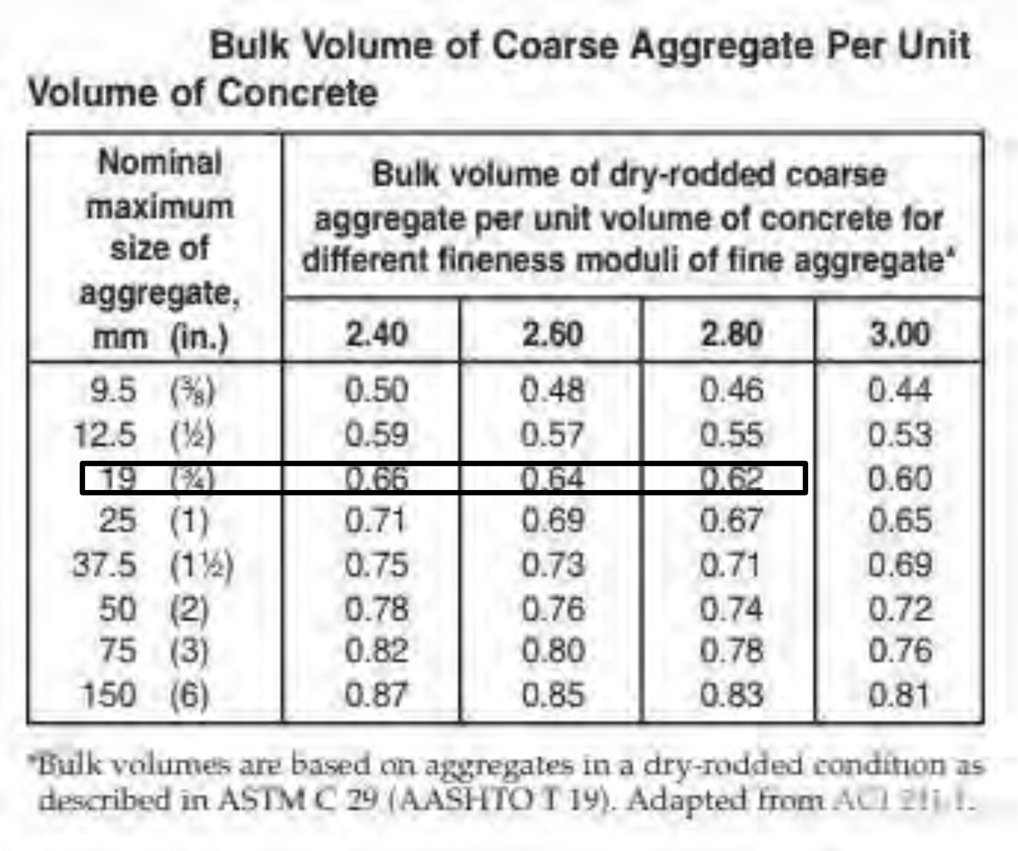
Coarse aggregate = 1 × 0.62 = 0.62 cubic yard

As we know 50.3 pound pre cubic feet is the unite weight of this lightweight aggregate.

50.3 pound pre cubic feet × 27 = 1358.1 pound pre cubic yard

Coarse aggregate = 0.62 × 1358.1 = 842 pound pre cubic yard

Table 3.25



Bulk Volume of Coarse Aggregate Per Unit Volume of Concrete

Nominal maximum size of aggregate, mm (in.)	Bulk volume of dry-rodded coarse aggregate per unit volume of concrete for different fineness moduli of fine aggregate*			
	2.40	2.60	2.80	3.00
9.5 (⅜)	0.50	0.48	0.46	0.44
12.5 (½)	0.59	0.57	0.55	0.53
19 (¾)	0.66	0.64	0.62	0.60
25 (1)	0.71	0.69	0.67	0.65
37.5 (1½)	0.75	0.73	0.71	0.69
50 (2)	0.78	0.76	0.74	0.72
75 (3)	0.82	0.80	0.78	0.76
150 (6)	0.87	0.85	0.83	0.81

*Bulk volumes are based on aggregates in a dry-rodded condition as described in ASTM C 29 (AASHTO T 19). Adapted from ACI 211.1.

7:

Calculation of fine aggregate amount

Sand and total amount of air were the only components left after the ratio of cement, pure water, and coarse materials were established. This difference was used to calculate the necessary amount of sand on a weight basis.

According to (ACI 211.2-98) standard, 2989 pound is the anticipated mass of a cubic yard of air-entrapped concrete built with light-weight material and a coefficient of specific gravity 1.57 (211.2-98). Existing mass per cubic yard includes:

Pure Water = 350 Ib/yd^3

Cements = 514.7 Ib/yd^3

Lightweight coarse aggregate = 842 pound /yd^3

The saturated surface dry mass of sand, therefor, was estimated to be 2980 – 1706.7 = 1273.3 Ib/yd^3.

The oven dry mass of sand was $\frac{1273.3}{1.01}$ = 1260.6 pound /yd^3.

8 Trial batch

To make things easier, the masses were reduced to create at least 1.0 cubic feet of concrete.

For a 1.0 cubic feet sample, the following batch masses were estimated:

Per cubic yard masses for each quantity were divided by 27 to get per cubic feet mass.

Cement 514.7/27 = 19 pound /ft^3

Fine aggregate (SSD) 1260.6/27 = 46.7 pound /ft^3

Coarse aggregate (SSD) 842/27 = 31 pound /ft^3

Water (net mixing) 350/27 = 12.96 pound /ft^3

Total 109.6 pound /ft^3

After that modified the moisture content of the fine aggregate and water absorption for course material which achieved form the analysis. For the fine material, the moisture content was 6.0 percent, while the moisture content for the lightweight coarse material it was zero percent because it was already treated on high temperature during bloating processes and the water absorption of course aggregate was 2.8%.

So

Weight of course aggregate is 842 pound /yd^3 and water absorption is 2.8%

2.8 × 842 / 100 = 23.576

Weight of fine aggregate is 1260.6 pound /yd^3 and the moisture content is 6.0 %

6 × 1260.6 / 100 = 75.6

Add the amount of absorbed water and subtract the amount of moisture content from the total amount of water used.

350 + 23.576 – 75.6 = 297.9 pound /yd^3

The masses being utilized for one cubic feet trial batch were

Cement = 19.0 pound

Water (net mixing) = 11 pound

Coarse aggregate = 31 pound

Fine aggregate = 46.7 pound

Total = 107 pound

9: As the calculated water amount being added was 11 pound, but to attain five to six inch slump 12.5 pound water was utilized. As a result, the batch was prepared with the following components:

Cement = 19 pound

Water (net mixing) = 12.5 pound

Coarse aggregate = 31 pound

Fine aggregate = 46.7 pound

Total = 109.2 pound

For a unit volume of concrete, the final calculated weights were 109.2 x 27 = 2948.4

Consequently, the modified batch masses per cubic yard were:

Cement = 513 pound

Water (net mixing) = 337.5 pound

Coarse aggregate = 837 pound

Fine aggregate = 1260.9 pound

Overall = 2948.4 pound

To increase the durability and strength of the concrete add 0.8 percent weight of cement.

For samples LS1, LS2, LS3 calculated the trial batch value by applying the same method as follow above.

Table 3.26: Tabular presentation of suggested trial concrete-mix for sample CS-1.

LS-1 trial batch 1ft^3	**LS-1 trial batch 1yd^3**
Cement =19.03 pound	Cement = 514 pound
Fine aggregate =47.02 pound	Fine aggregate = 1315 pound
Coarse aggregate =34.3 pound	Coarse aggregate = 756 pound
Water (net mixing) =10.34 pound	Water (net mixing) =355.3 pound
Total Ibs = 110.69 pound	Total Ibs = 2940 pound

Table 3.27: Tabular presentation of suggested trial concrete-mix for sample CS-2.

LS-2 trial batch 1ft^3	**LS-2 trial batch 1yd^3**
Cement = 19.03 pound	Cement = 514 pound
Fine aggregate = 46.9 pound	Fine aggregate = 1265 pound
Coarse aggregate = 29.7 pound	Coarse aggregate = 802.5 pound
Water (net mixing) = 13.29 pound	Water (net mixing) = 359 pound
Total Ibs = 108.9 pound	Total Ibs = 2940 pound

Table 3.28 Tabular presentation of suggested trial concrete-mix for sample CS-3.

LS-3 trial batch 1ft^3	**LS-3 trial batch 1yd^3**
Cement = 19.03 pound	Cement = 514 pound
Fine aggregate = 48.7 pound	Fine aggregate = 1320 pound
Coarse aggregate = 30.5 pound	Coarse aggregate = 800.6 pound
Water (net mixing) = 13.50 pound	Water (net mixing) = 353.9 pound
Total Ibs = 111.6 pound	Total Ibs = 2955.6 pound

3.8 Analysis for Concrete

Cement and aggregates (such as sand and gravel) are effectively bonded together by water to form the composite material known as concrete. Concrete must be tested for quality in order to identify its state because it is a necessary part of the construction process. The following two tests were carry out in this research works.

3.8.1 Slump test (ASTM C 143/C 143M – 03)

The "slump" of fresh concrete refers to its solidity prior to setting. The slump depends upon the amount of water if water is more in the concrete sample the slump value will also be large. This procedure is performing both in the field and in the material testing lab. The concrete sample used to create the sample was according to standard of ASTM C 172 guidelines and served as a representative sample of the entire batch.

Significance and Use

- To calculate the slump of concrete sample this method is used.
- This technique is carrying out to find the water ratio in the concrete mix sample.
- This technique is sample and very low cost.
- This test method is used for those concrete samples which contain particles of 1-$\frac{1}{2}$ inches or smaller.
- The very course particle will be removing according to ASTM C 127 standard.

Procedure

I. Fixed the mould on a plane and non-rough site.
II. Fill the mould with the concrete sample in four parts.
III. Use the steel road to press each layer of concrete in the mould by giving twenty five stocks
IV. When the mould is completely filled then remove the extra sample from the upper collar.
V. Now uniformly handover the mould from the concrete in upward direction.
VI. Now find the difference between the top of the mould and the upper part of the concrete sample with the help of measuring tape.

Result

The average slump test result is 5.4 inch (137.16mm)

3.8,2 Compressive Strength test (ASTM C-39/C -39 M-3)

This technique is used to find out the compressive strength of sample such as rocks core concrete cube or cylinder. This method is used for that concrete sample which have unite weight more than 800 kilogram pre cubic matter.

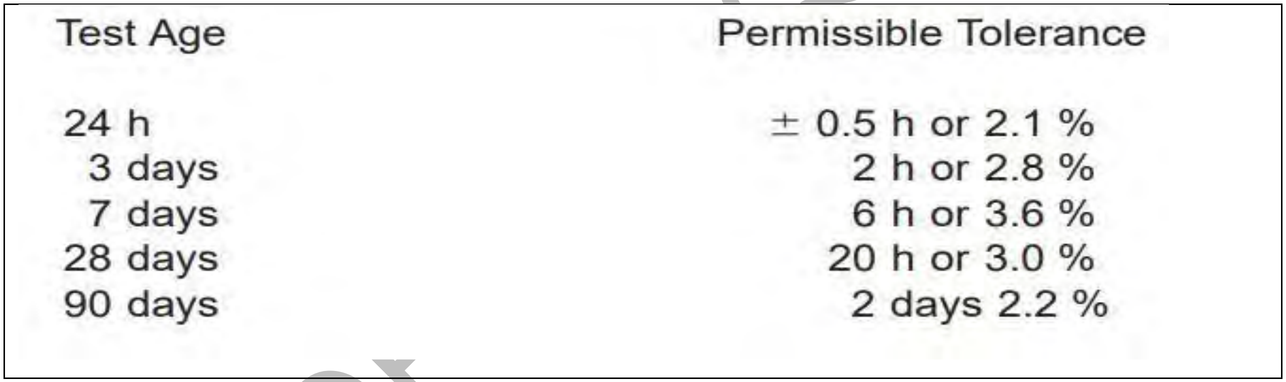
Significance and Use

- The results of this test technique provide a basis for quality control of concrete ratio, mixing, and installation operations as well as for assessment of requirements compliance, control for calculating admixture efficacy, and some other related uses.

Method

- Precede the test without wasting of time when the cylinders remove form the water container.
- Keep the tested cylinder sample in moist condition when the test is carrying out.
- All test specimens should be broken within the allotted time limits specified in the test age (table 3.29).

Table 3.29 time limitations for a specific test age.



Test Age	Permissible Tolerance
24 h	± 0.5 h or 2.1 %
3 days	2 h or 2.8 %
7 days	6 h or 3.6 %
28 days	20 h or 3.0 %
90 days	2 days 2.2 %

- Fixed the cylinder in the compressive machine in a proper way and applied the load which is already fixes in the machine.
- When the cylinder crushed note this reading in your notebook this reading show the ultimate load.
- The same procedure is follow for the other samples too.

Formula

Compressive strength = ultimate load / area of specimen

If the sample length-diameter ratio is 1.75 or low then multiply the below factor with the resultant value of the compressive strength.

L/D	1.75	1.50	1.25	1.00
Factor	0.98	0.96	0.93	0.87

Cylinder diameter = 6″

Cylinder length = 12″

Area of cylinder = $\pi D^2/4$

Volume of concrete specimen $V = \pi r^2 h$

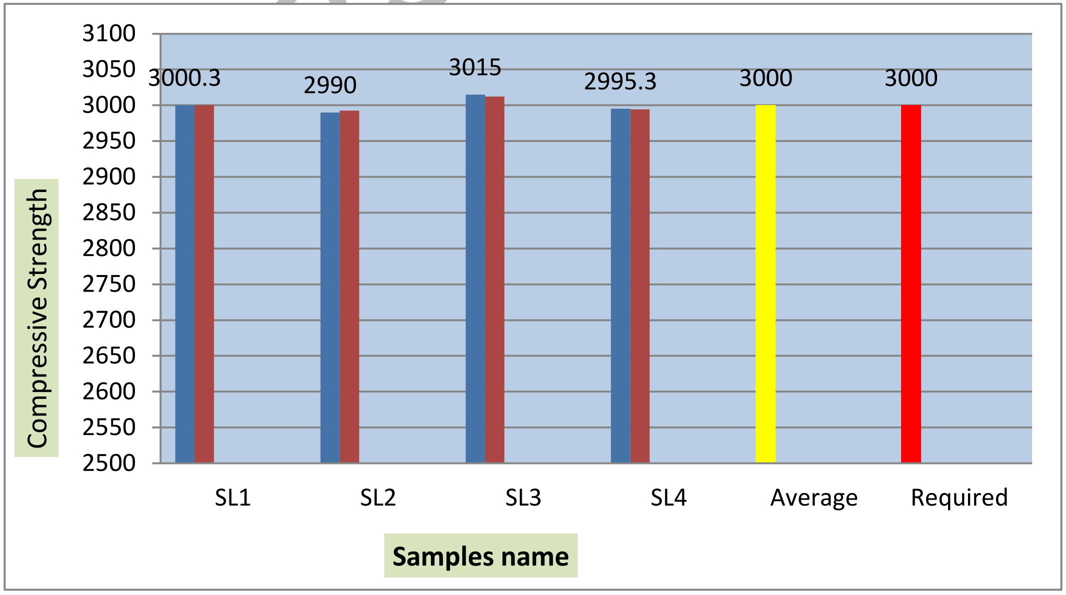
1 KN = 101.971 Kg

1 Kg = 2.2046 pound

1 MPa = 145.038 Psi

Table 3.30 showing Results of concrete cylinders crushed after 28 days.

S/No.	**Date**	**Slump (inch)**	**Sample dimensions (inch)**	**Cross section area (inch)^2**	**volume (inch)^2**	**ultimate load (KN)**	**Compressive strength (psi)**
sample No. 1	3/9/2022	5-6	6 × 12	28.27	339.29	377.16	3000.2
	=	=	6 × 12	28.27	339.29	377.16	3000.2
sample No. 2	=	=	6 × 12	28.27	339.29	375.87	2990
		=	6 × 12	28.27	339.29	376.18	2992.5
sample No. 3	=	=	6 × 12	28.27	339.29	379.01	3015
	=	=	6 × 12	28.27	339.29	378.68	3012.3
sample No. 4	=	=	6 × 12	28.27	339.29	376.54	2995.3
	=	=	6 × 12	28.27	339.29	376.44	2994.5
Average							3000



Graph 3.5 graphically representation of compressive strength

Fig 3.7 (a,b) Cone filling (c) concrete cone (d) concrete machine assembly

CHAPTER # 4

GEOCHEMICAL AND PETROGRAPHIC STUDY

4.1 General Statement

In this study, we use the geochemical and petrographic data to determine the chemical and mineralogical makeup of the sample of aggregate we chose, as well as the suitability of the aggregate for use in building.

4.2 Geochemical investigation by XRF

X-ray fluorescence is a commonly adopted method in various experimental studies that can analyze major and trace elements and their corresponding major and trace oxides quickly and precisely. Rocks and soils are routinely analyzed using this technique (Revenko 2002). Utilizing Philips Perl'X 3 (Panalytical) machine, samples for the essential components were prepared by cutting into quarters, crushing, sifting, and reducing to 0.075 millimeter in order to fit in a fusion ring. To measure the amounts of minor and trace elements, specimen were made utilizing a press to make specimen slides that were 40 mm in diameter and fixed inside an aluminum plate. These quantitative assessments of samples (LS1, LS2, LS3, and SL4) were carried out in line with (ASTM C1271 2012). Analytical's Pro Trace software was utilized to look over and trace small components. The above technique provides a quantitative evaluation of each mineral composition by revealing the proportion of primary plus trace elements and their oxide present in each sample.

4.2.1 Result

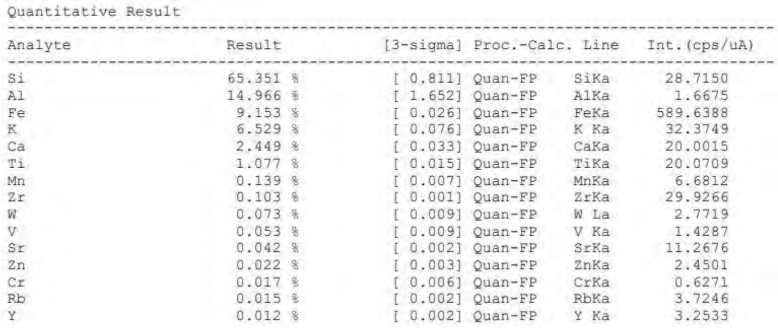
In order to identify the main and trace elements, as well as their oxides, present in a reference slate sample from the Landikotal Formation, four samples SL1, SL2, SL3, and SL4 were subjected to a qualitative X-Ray Florescence spectrometry study. The known forms of all the major and minor elements, and their oxides, are given in (Table 4.1 and 4.2). SiO_2, Al_2O_3, FeO_3, and KO_2 were discovered to be major oxides, while CaO, TiO_2, MnO, ZrO_2, WO_3, V_2O_5, SrO, Cr_2O_5, ZnO, Rb_2O, and Y_2O_3 were minor oxides. SiO_2 was identified as a significant oxide in the chosen slate sample, with values ranging from high to extremely high, from 69.202% to 72.351%. The second most prevalent oxide, Al_2O_3, was found to have values between 18.363% and 20.272%. The third significant oxide identified in the sample was FeO_3, which was present in all representative samples and displayed low to medium concentrations ranging from 4.104% to 4.390%. However, the value of KO_2 in the full typical sample spans from extremely low to medium, or 2.962% to 3.881%, despite the fact that it is also found as a considerable oxide. These are all the major oxides that the representative sample of slate's XRF examination of the four samples identified. In all typical samples, it was discovered that CaO, TiO_2, MnO, ZrO_2, WO_3, V_2O_5, SrO, Cr_2O_5, ZnO, Rb_2O, and Y_2O_3 were all minor oxides, with levels ranging from extremely low to low percent, as shown in (table 4.2). The primary and minor components present in the representative sample of slate were identified by qualitative X-ray fluorescence spectrometry analysis, as shown in the (table 4.1). The elements in the specimen that have main element values include Si, Fe, AL, K, and Ca.

Table (4.1) show XRF Quantitative elemental analysis results.

X-ray fluorescence elemental analysis						
S/no.	**Elements**	**Samples results %**				
		LS1	**LS2**	**LS3**	**LS4**	**Average**
1	Si	61.771	65.351	62.275	64.351	63.437
2	Al	15.991	14.966	15.881	15.833	15.667
3	Fe	9.433	9.153	9.511	9.33	9.356
4	K	8.391	6.529	7.999	6.234	7.288
5	Ca	2.973	2.449	2.891	2.440	2.688
6	Ti	0.880	1.077	0.870	1.01	0.959
7	Mn	0.274	0.139	0.276	0.299	0.247
8	Zr	0.083	0.103	0.082	0.101	0.092
9	V	0.046	0.053	0.055	0.038	0.048
10	W	0.045	0.073	0.040	0.033	0.0477
11	Rb	0.030	0.015	0.029	0.011	0.0212
12	Zn	0.028	0.022	0.029	0.010	0.0225
13	Sr	0.022	0.042	0.025	0.033	0.030
14	Cr	0.017	0.017	0.020	0.011	0.0162
15	Y	0.013	0.012	0.015	0.088	0.032
16	Nb	0.004	00	0.002	0.0099	0.0039

Table (4.2) show XRF Quantitative oxides analysis result

X-ray fluorescence oxides analysis						
S/No.	**Oxides**	**Samples results %**				
		AL1	**SL2**	**SL3**	**SL4**	**Average**
1	SiO_2	72.351	69.202	71.352	71.132	71.009
2	Al_2O_3	18.363	20.272	19.362	19.131	19.282
3	Fe_2O_3	4.272	4.390	4.222	4.104	4.247
4	K_2O	2.962	3.881	3.011	3.765	3.405
5	CaO	1.231	1.504	1.432	1.132	1.324
6	TiO_2	0.627	0.515	0.511	0.445	0.524
7	MnO	0.060	0.119	0.050	0.117	0.086
8	ZrO_2	0.040	0.032	0.030	0.020	0.030
9	WO_2	0.026	0.016	0.0100	0.044	0.024
10	V_2O_5	0.026	0.028	0.0011	0.048	0.0257
11	SrO	0.014	0.008	0.011	0.018	0.0127
12	Cr_2O_3	0.011	0.010	0.0012	0.019	0.0098
13	ZnO	0.009	0.010	0.008	0.0099	0.0092
14	Rb_2O	0.005	0.009	0.004	0.008	0.0065
15	Y_2O_3	0.004	0.005	00	0.007	0.004



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Quantitative Result
---------------------------------------------------------------------------------
Analyte               Result           [3-sigma] Proc.-Calc. Line   Int.(cps/uA)
---------------------------------------------------------------------------------
Si                    65.351 %         [ 0.811] Quan-FP     SiKa      28.7150
Al                    14.966 %         [ 1.652] Quan-FP     AlKa       1.6675
Fe                     9.153 %         [ 0.026] Quan-FP     FeKa     589.6388
K                      6.529 %         [ 0.076] Quan-FP     K Ka      32.3749
Ca                     2.449 %         [ 0.033] Quan-FP     CaKa      20.0015
Ti                     1.077 %         [ 0.015] Quan-FP     TiKa      20.0709
Mn                     0.139 %         [ 0.007] Quan-FP     MnKa       6.6812
Zr                     0.103 %         [ 0.001] Quan-FP     ZrKa      29.9266
W                      0.073 %         [ 0.009] Quan-FP     W La       2.7719
V                      0.053 %         [ 0.009] Quan-FP     V Ka       1.4287
Sr                     0.042 %         [ 0.002] Quan-FP     SrKa      11.2676
Zn                     0.022 %         [ 0.003] Quan-FP     ZnKa       2.4501
Cr                     0.017 %         [ 0.006] Quan-FP     CrKa       0.6271
Rb                     0.015 %         [ 0.002] Quan-FP     RbKa       3.7246
Y                      0.012 %         [ 0.002] Quan-FP     Y Ka       3.2533
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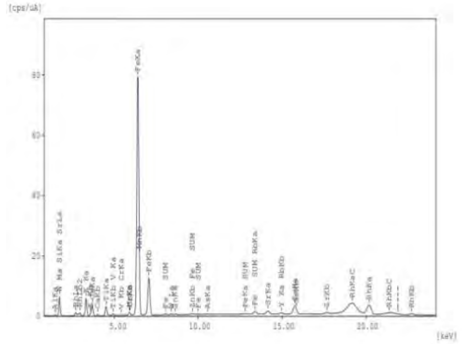
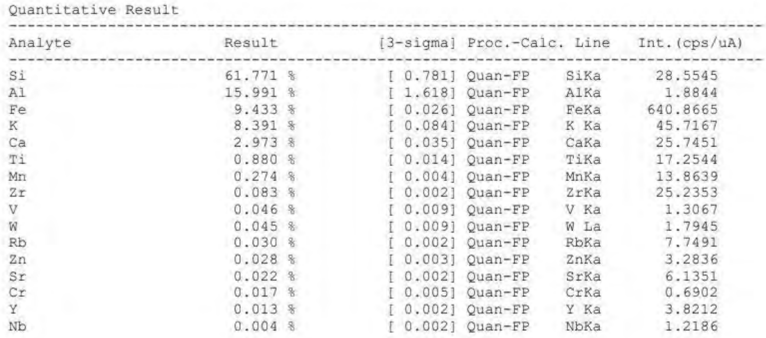
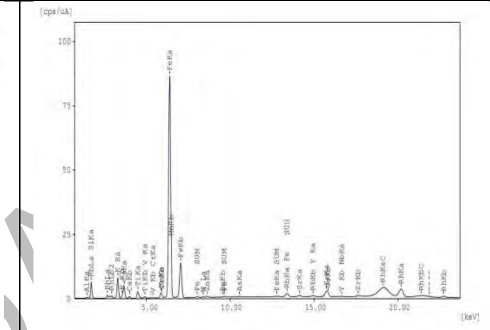
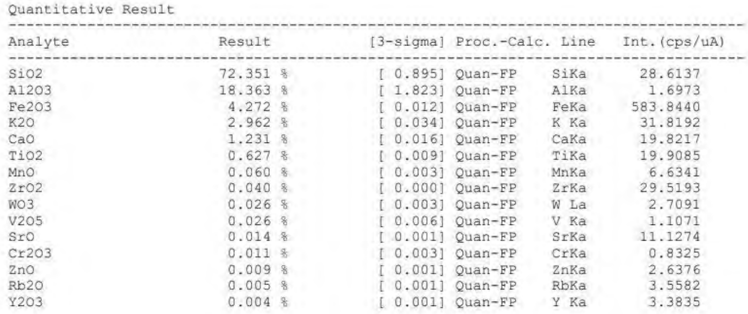


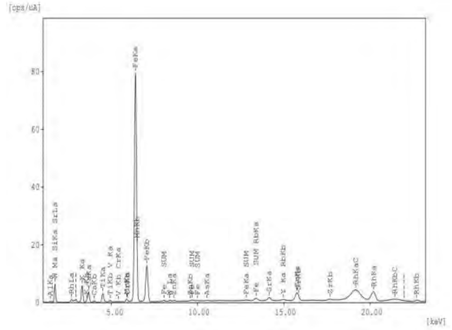


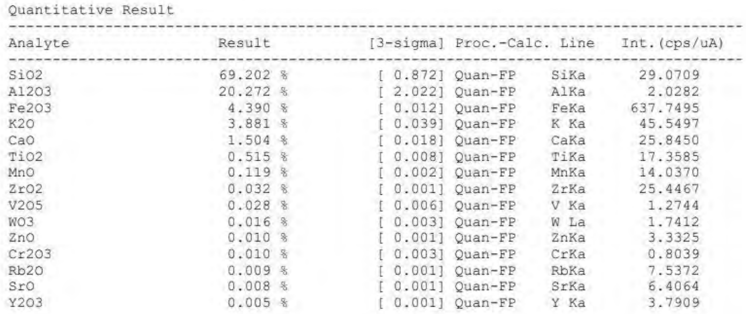
```
Quantitative Result
---------------------------------------------------------------------------------
Analyte               Result           [3-sigma] Proc.-Calc. Line   Int.(cps/uA)
---------------------------------------------------------------------------------
Si                    61.771 %         [ 0.781] Quan-FP     SiKa      28.5545
Al                    15.991 %         [ 1.618] Quan-FP     AlKa       1.8844
Fe                     9.433 %         [ 0.026] Quan-FP     FeKa     640.8665
K                      8.391 %         [ 0.084] Quan-FP     K Ka      45.7167
Ca                     2.973 %         [ 0.035] Quan-FP     CaKa      25.7451
Ti                     0.880 %         [ 0.014] Quan-FP     TiKa      17.2544
Mn                     0.274 %         [ 0.004] Quan-FP     MnKa      13.8639
Zr                     0.083 %         [ 0.002] Quan-FP     ZrKa      25.2353
V                      0.046 %         [ 0.009] Quan-FP     V Ka       1.3067
W                      0.045 %         [ 0.009] Quan-FP     W La       1.7945
Rb                     0.030 %         [ 0.002] Quan-FP     RbKa       7.7491
Zn                     0.028 %         [ 0.003] Quan-FP     ZnKa       3.2836
Sr                     0.022 %         [ 0.002] Quan-FP     SrKa       6.1351
Cr                     0.017 %         [ 0.005] Quan-FP     CrKa       0.6902
Y                      0.013 %         [ 0.002] Quan-FP     Y Ka       3.8212
Nb                     0.004 %         [ 0.002] Quan-FP     NbKa       1.2186
```





```
Quantitative Result
---------------------------------------------------------------------------------
Analyte               Result           [3-sigma] Proc.-Calc. Line   Int.(cps/uA)
---------------------------------------------------------------------------------
SiO2                  72.351 %         [ 0.895] Quan-FP     SiKa      28.6137
Al2O3                 18.363 %         [ 1.823] Quan-FP     AlKa       1.6973
Fe2O3                  4.272 %         [ 0.012] Quan-FP     FeKa     583.8440
K2O                    2.962 %         [ 0.034] Quan-FP     K Ka      31.8192
CaO                    1.231 %         [ 0.016] Quan-FP     CaKa      19.8217
TiO2                   0.627 %         [ 0.009] Quan-FP     TiKa      19.9085
MnO                    0.060 %         [ 0.003] Quan-FP     MnKa       6.6341
ZrO2                   0.040 %         [ 0.000] Quan-FP     ZrKa      29.5193
WO3                    0.026 %         [ 0.003] Quan-FP     W La       2.7091
V2O5                   0.026 %         [ 0.006] Quan-FP     V Ka       1.1071
SrO                    0.014 %         [ 0.001] Quan-FP     SrKa      11.1274
Cr2O3                  0.011 %         [ 0.003] Quan-FP     CrKa       0.8325
ZnO                    0.009 %         [ 0.001] Quan-FP     ZnKa       2.6376
Rb2O                   0.005 %         [ 0.001] Quan-FP     RbKa       3.5582
Y2O3                   0.004 %         [ 0.001] Quan-FP     Y Ka       3.3835
```





```
Quantitative Result
---------------------------------------------------------------------------------
Analyte               Result           [3-sigma] Proc.-Calc. Line   Int.(cps/uA)
---------------------------------------------------------------------------------
SiO2                  69.202 %         [ 0.872] Quan-FP     SiKa      29.0709
Al2O3                 20.272 %         [ 2.022] Quan-FP     AlKa       2.0282
Fe2O3                  4.390 %         [ 0.012] Quan-FP     FeKa     637.7495
K2O                    3.881 %         [ 0.039] Quan-FP     K Ka      45.5497
CaO                    1.504 %         [ 0.018] Quan-FP     CaKa      25.8450
TiO2                   0.515 %         [ 0.008] Quan-FP     TiKa      17.3585
MnO                    0.119 %         [ 0.002] Quan-FP     MnKa      14.0370
ZrO2                   0.032 %         [ 0.001] Quan-FP     ZrKa      25.4467
V2O5                   0.028 %         [ 0.006] Quan-FP     V Ka       1.2744
WO3                    0.016 %         [ 0.003] Quan-FP     W La       1.7412
ZnO                    0.010 %         [ 0.001] Quan-FP     ZnKa       3.3325
Cr2O3                  0.010 %         [ 0.003] Quan-FP     CrKa       0.8039
Rb2O                   0.009 %         [ 0.001] Quan-FP     RbKa       7.5372
SrO                    0.008 %         [ 0.001] Quan-FP     SrKa       6.4064
Y2O3                   0.005 %         [ 0.001] Quan-FP     Y Ka       3.7909
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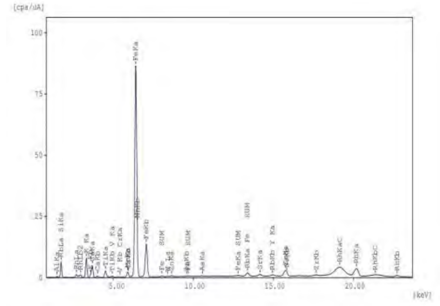


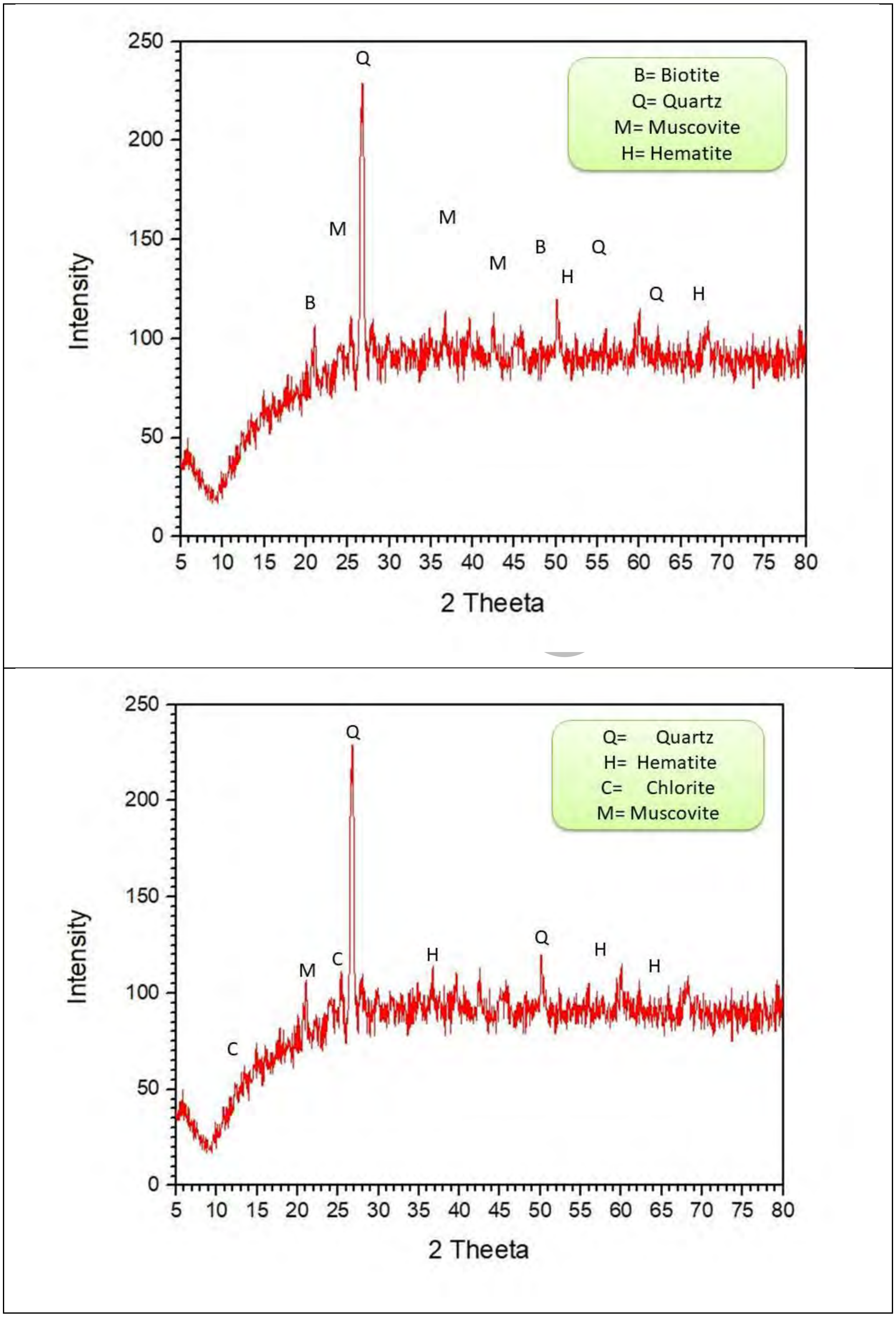
Fig 4.1 showing the XRF peaks.

4.3 Mineralogical investigation by XRD

Despite the fact that X-ray diffraction has frequently been used in specialized research, current developments in data processing automation have the chance to make it a frequently used method for earth science material investigation (Uvarova et al, 2014). To prepare the sample for this inquiry, they were split, crushed, and ground to a sample size smaller than 0.04 millimeter, then placed above a glass plate. Four samples (SL1, SL2, SL3 and SL4) were analyzed to identify their mineralogical composition utilized a machine called Philips X'Pert Pro diffractometer with a copper anode tube operating at fourth Kelvin-Volts – thirty mill ampere electricity. The Origin pro 9.0 software was used to interpret the findings. By matching every peak above the background of the examined samples with a collection of accepted cited minerals, mineral phases were determined. This tool estimates the mineral phase content in a qualitative and semi-quantitative manner.

4.3.1 Result

Rock sample's mineralogical composition might be determined quantitatively and qualitatively through X-ray diffraction instruments. Every rock sample displayed a similar mineralogical makeup. The XRD investigation revealed the mineral phases quartz, muscovite, biotite, chloride, and hematite. All representative slate samples contain these minerals, but in varying concentrations. Quartz made up the majority of the rock's bulk (>55%), while muscovite, a clay mineral, and biotite were determined to be minor or accessory elements (between 15 and 25%). Additionally, a trace amount of chlorite mineral (up to 10%) was found. Hematite was also listed as a minor mineral, accounting for 5 to 10 % of the total mineral composition of the rock and the remaining percent was the ground mass. The graphs below list every mineral that was identified via XRD analysis.



Graph 4.1 XRD results

4.4 Petrographic study

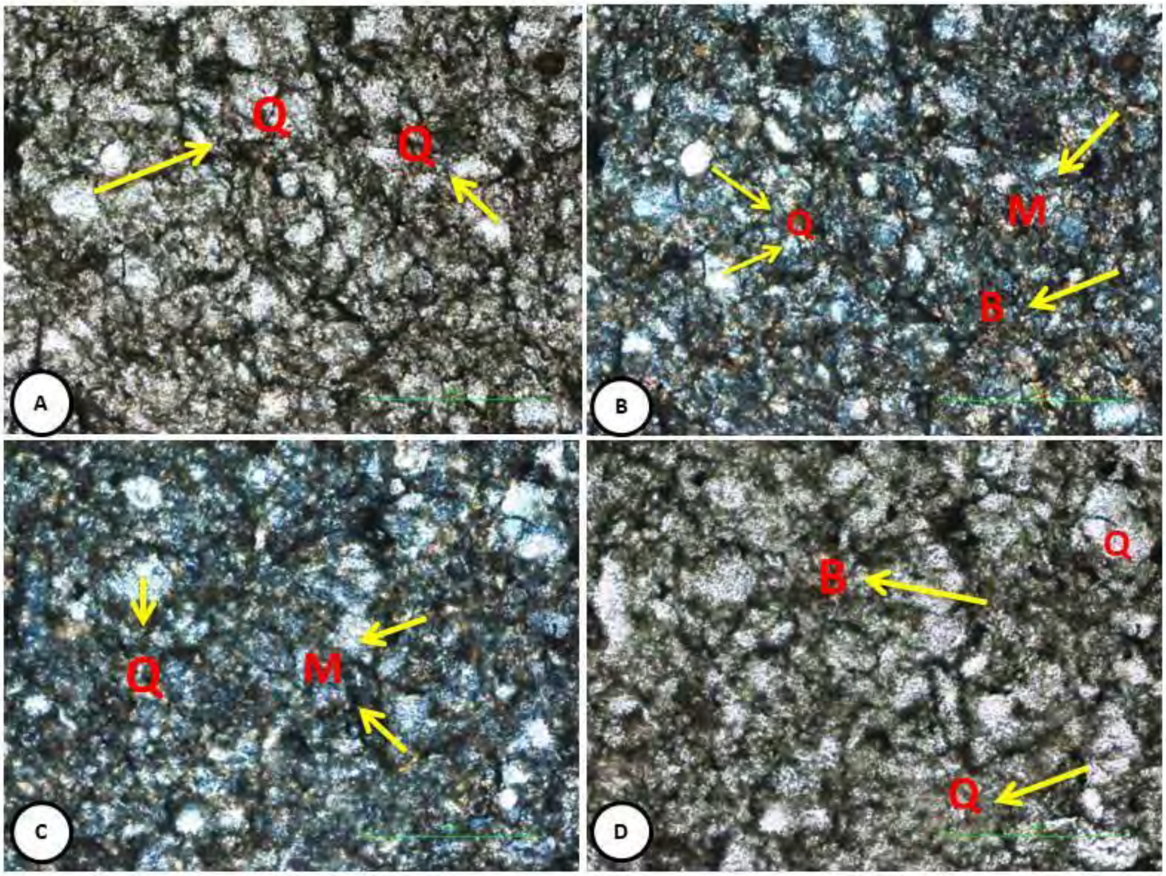
It is common knowledge that a rock's petrography directly affects its qualities. It was found that the petrographic characteristics that had the most influence on rock strength were porosity, texture, and particle size (Seif et al, 2018). Using an optical microscope and cross- and plane-polarized light, 16 thin sections were examined for the petrographic study. According to a petrographic analysis of the samples, iron ore, quartz, chlorite, Biotite, and muscovite are all present. (Figs 1-16)

4.4.1 Preparation of thin sections

Using a diamond cutter called the "Discoplan-TS," 16 thin slices of the Landikotal Slates were cut for petrographic investigation. The representative rock part (chip) specimen's surface area was roughly one square inch when it was cut using a diamond cutter. Using a glass slide, a representative slice of the sample was attached using epoxy gel before the glass was cut on a rock cutting machine. For the final polishing, corundum powder with mesh numbers of 400, 1000, and 1200 was used to obtain the standard thickness for a thin section, or 30 microns.

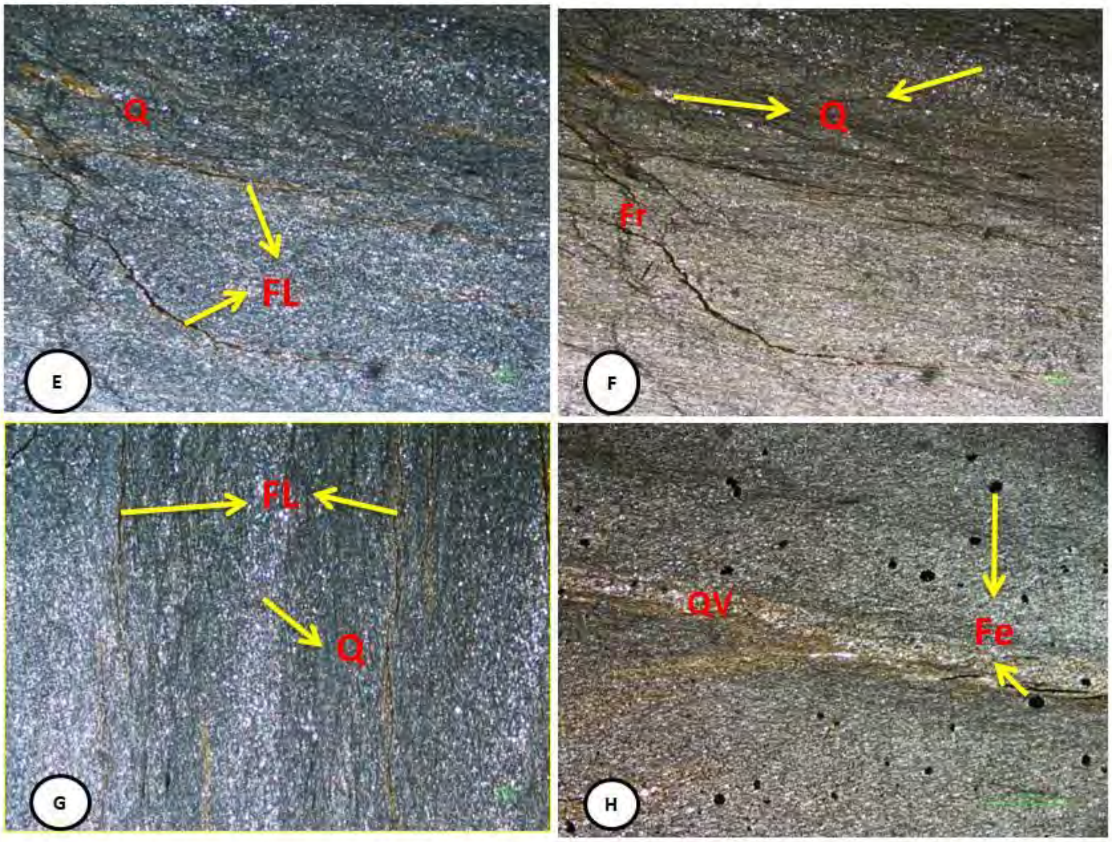
4.4.2 Results

According to the microscopic analysis, the Landikotal Slates are composed of the minerals quartz, muscovite, biotite, hematite, and chlorite. It is made of fine-grained and slates in dark greenish grey and dark grey in color (figs. 1–16). The matrix is primarily composed of phyllosilicates, which is very fine-grained minerals such white mica and chlorite. However, some areas also include substantial amounts of quartz, muscovite, and biotite. These slates contain a fine-grained matrix or ground material as their primary textural component. The grain is pointed and floating to tangential contact. The fractures in the slates are sometimes filled with ferruginous minerals and occasionally with fine-grained quartz. There is also alternate ferruginous and quartz lamination. (Figs. 1–16, Tables 1-4).



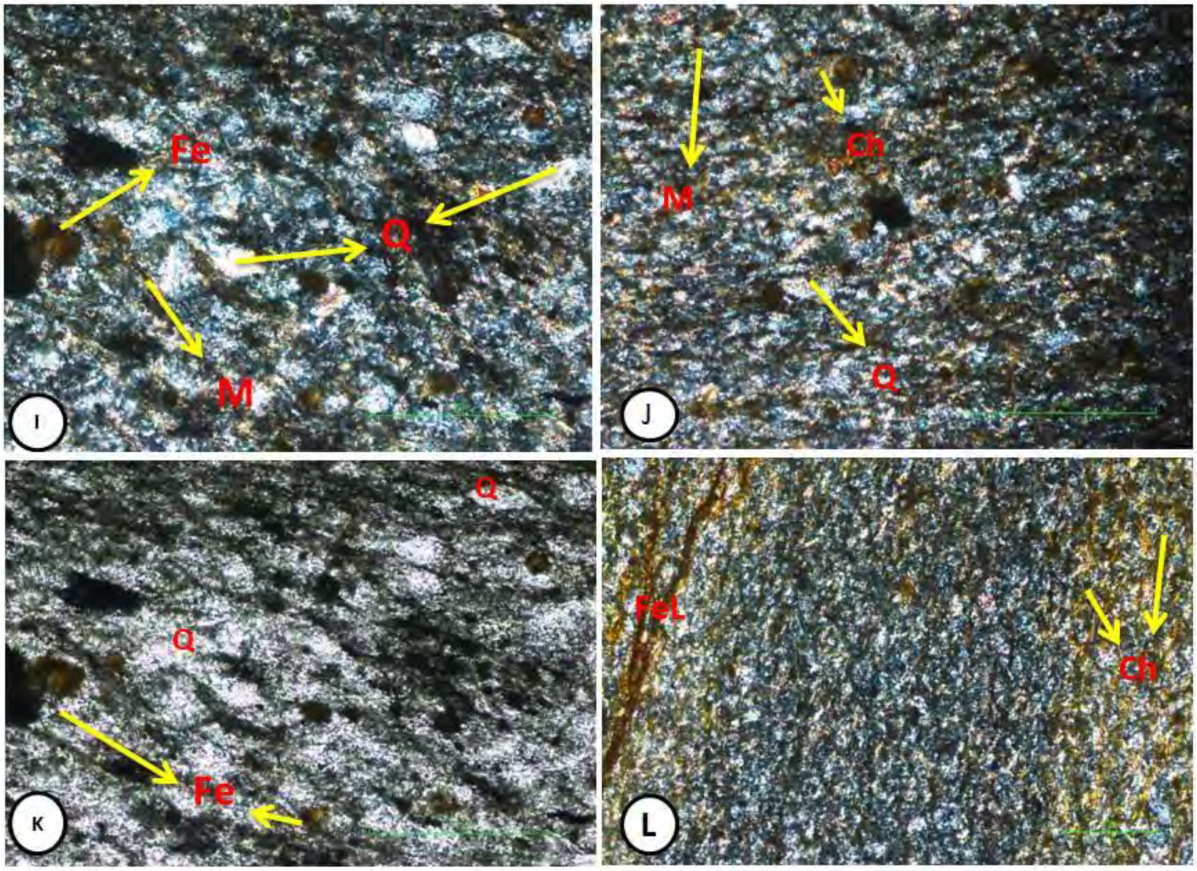
Q= quartz, M= muscovite, B= biotite

S. No	Texture	Mineralogy	Rock Types
SL1 A,b,c, d	Fine grain having Point to floated contact.	• anhedral, subequant quartz • elongated Muscovite • sub to anhedral Biotite flakes • Ground mass	Fine grain dark greenish- gray and dark-gray Slates



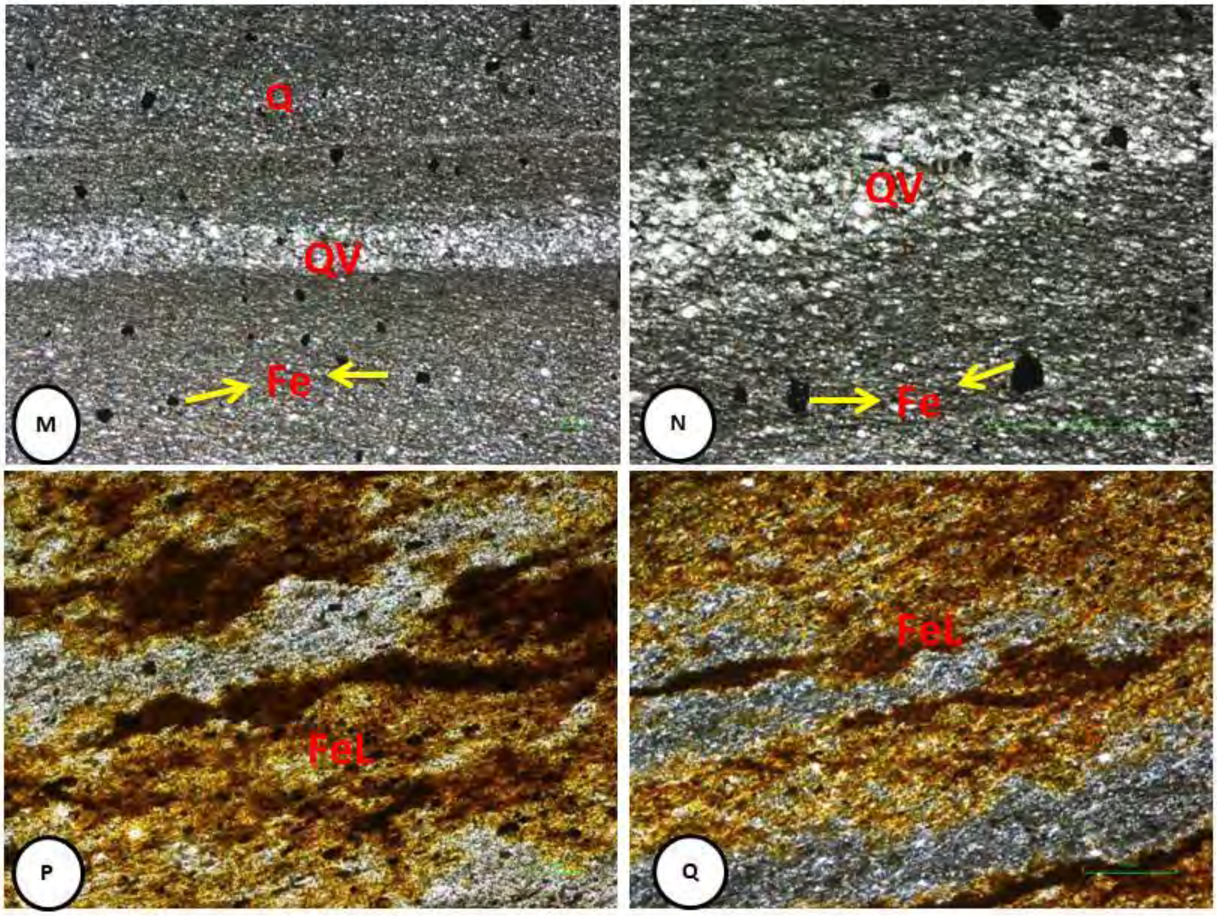
Q= quartz, FL= iron leaching, QV= quartz veins, Fe= iron

S. No	Texture	Mineralogy	Rock Types
SL 2 E,F,G ,H	Alternate quartz and farraginous lamination. Fracture fail with farraginous minerals.	• anhedral, subequant quartz • Hematite • Ground mass	Fine grain dark greenish- gray and dark-gray Slates



Fe= iron, Q= quartz, M= muscovite, Ch= chlorite, FeL= iron leaching

S. No	**Texture**	**Mineralogy**	**Rock Types**
SL 3 I,j,k,l	Fine grain having point to tangential contact. Iron leaching along fracture.	• anhedral, subequant quartz • elongated Muscovite • Chlorite • Hematite • Ground mass	Fine grain dark greenish- gray and dark-gray Slates



Q= quartz, Fe= iron, QV= quartz veins, FeL= iron leaching, Fe= iron

S. No	Texture	Mineralogy	Rock Types
SL 4 M,n,o,p	Fine grain. Quartz lamination. Iron leaching.	• anhedral, subequant quartz • hematite • Ground mass	Fine grain dark greenish- gray and dark-gray Slates

CHAPTER # 05

MAPPING AND RESERVE ESTIMATION OF LANDIKOTAL SLATES

5.1 General statement

Natural resources include marble, fluorite, laterite, barite, calcite, limestone, coal, slates, and a variety of other minerals are potentially present in District Khyber. Slates from the Landikotal Formation, which are found in the research region, are based on the geological Map of (Shah et al. 1980). In order to determine the range of the amount of material slates quarry in Jamrud and Landikotal Village, it is required to map the area and calculate the reserve. Slates have the potential to be used as a lightweight aggregate. This study focuses on the quantitative mapping of slates, which are frequently used in construction as lightweight aggregates. The deposits of slates in the study area are determined using the volumetric approach.

5.2 Mapping

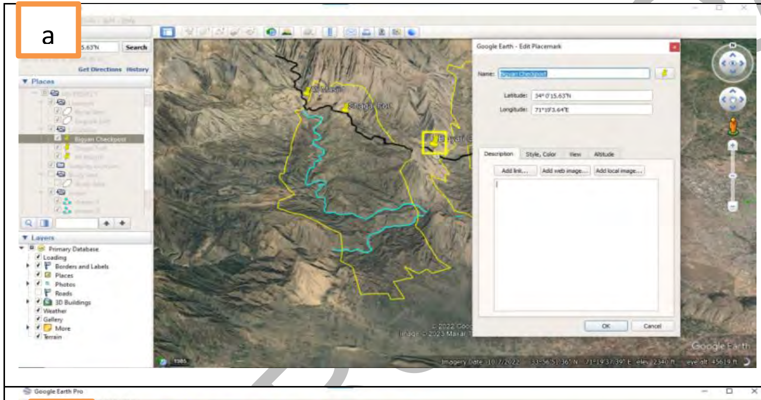
A map designed to display geological features is called a geologic map. To identify where rock units or geologic formations are exposed at the surface, they are represented by colour or symbol. To represent bedding planes and structural characteristics including faults, folds, foliations, and alignments in three dimensions, strike and dip or trend and plunge signs are utilized. Stratigraphic contour circles being utilize to represent topography of the strata beneath the surface of a chosen geologic horizon. Our ability to detect and develop oil, mineral, and water resources, measure and analyses reservoir quality, locate infrastructure and hazardous sites, and identify and prepare for evaluations are all made possible by geologic maps and the products that are derived from them. Geologic maps can also display the effects of human activity on the physical environment. Geologic maps improve our capacity to recognise dangers, find infrastructure such as railroads, pipelines, utilities, dams and locks, structures, and foundations, and to make more informed and planned decisions. Geologic maps are essential tools for informing national, state, and local policy choices.

5.2.1 Method

We build the geological map of the study region using field data, Google Earth Pro, and Geographic information system (GIS) software since geological mapping is crucial for displaying your fieldwork on a map for geologists and others. The next set of procedures will be carried out in order to create the geological map.

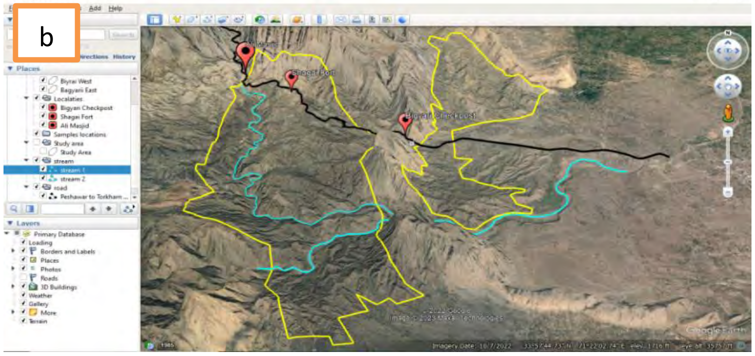
5.2.2 Steps

- In the handpicked research area, thorough fieldwork is carried out to record geological features, rock types, contacts, and we take latitude and longitude values along the contact of Landikotal Slates using GPS. Following the fieldwork, all latitude and longitude values are plotted in a Microsoft Excel spreadsheet.
- The Google Earth Pro software is used to paste every latitude and longitude value from a Microsoft Excel sheet in order to create a polygon of the research region and the Landikotal Slates figure (5.1, a). Use the path and placemark feature in Google Earth Pro to mark roads, streams, and other locations (5.1, b) Google Earth Pro has saved all of these works.



Name: Bigyan Checkpost
Latitude: 34° 0'15.63"N
Longitude: 71°19'3.64"E

P/No	Longitude	Latitude
1	71°20'13.49"E	34° 4'11.74"N
2	71°20'28.94"E	34° 3'51.22"N
3	71°21'10.80"E	34° 2'30.39"N
4	71°22'1.21"E	34° 2'1.73"N
5	71°21'36.83"E	34° 1'17.48"N
6	71°19'56.14"E	34° 0'33.90"N
7	71°20'39.80"E	33°58'28.55"N
8	71°19'30.97"E	33°59'54.57"N
9	71°19'37.57"E	34° 2'30.49"N
10	71°20'17.16"E	33°59'45.58"N



P/No	71°18'39.72"E	34° 0'11.52"N
1	71°17'30.99"E	34° 1'7.95"N
2	71°15'48.83"E	34° 1'30.05"N
3	71°19'16.36"E	33°56'54.19"N
4	71°18'1.69"E	33°56'18.05"N
5	71°17'29.52"E	33°57'18.61"N
6	71°17'29.05"E	33°59'58.86"N
7	71°17'21.13"E	34° 0'13.11"N
8	71°18'15.80"E	33°59'54.72"N
9	71°17'12.57"E	34° 0'20.87"N
10	71°17'38.46"E	34° 0'26.24"N

Fig 5.1 show Google Earth Pro setting for latitude and longitude value uploading.

- Load Geospatial data into GIS, in this step the already save data in Google Earth Pro software will be loaded in GIS by clicking on Arc Toolbox window next, click in conversion tools, next click on From KML button and select the data of Google Earth Pro fig (5.2 ,c).

- The data (picture) is already georeference and next we will create shapes file for formation, stream, location etc. in the form of polygon, polyline and points by clicking on catalog the new window will open and click on the folder where you want to create a shapes files fig (5.2 , c).
- Click on editor option then click on creates features and draw polygon, polyline and points respectively for formation, stream, and location as show in base map at the end save and stop editing option.
- Now click on shapes file (formation, stream, location) which showed in Layer window and give name, symbols and colour to the feature which is draw already.

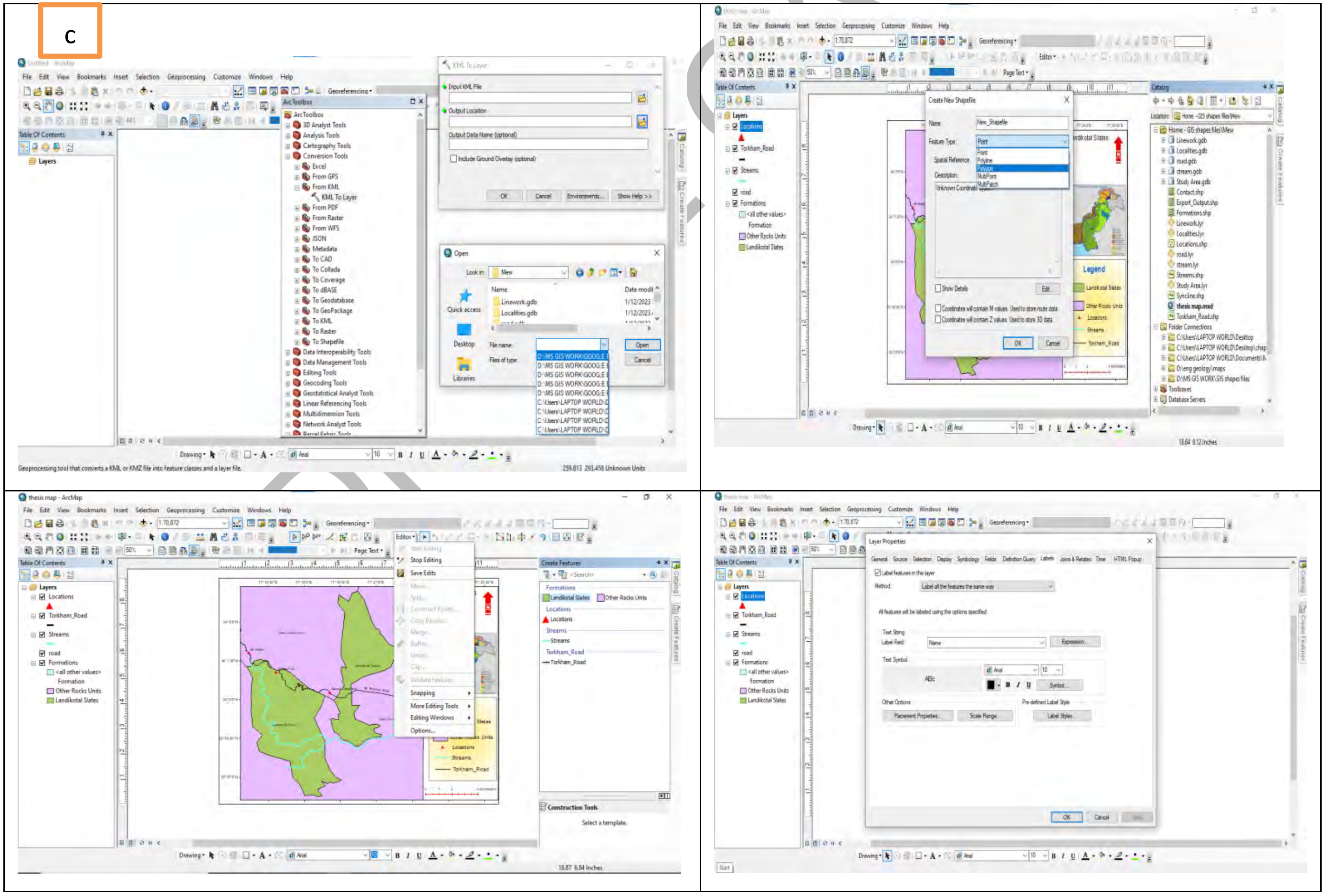


Fig 5.2 showing shapes file, editor option, Arc Toolbox window

- Now change the data view into layout view and add scale bar, legends, title, image, north logo, etc. into the map by clicking on the insert window now our map is ready now click on file window and then on export map option this will change the GIS map into JPEG PND or PDF format fig (5.3).

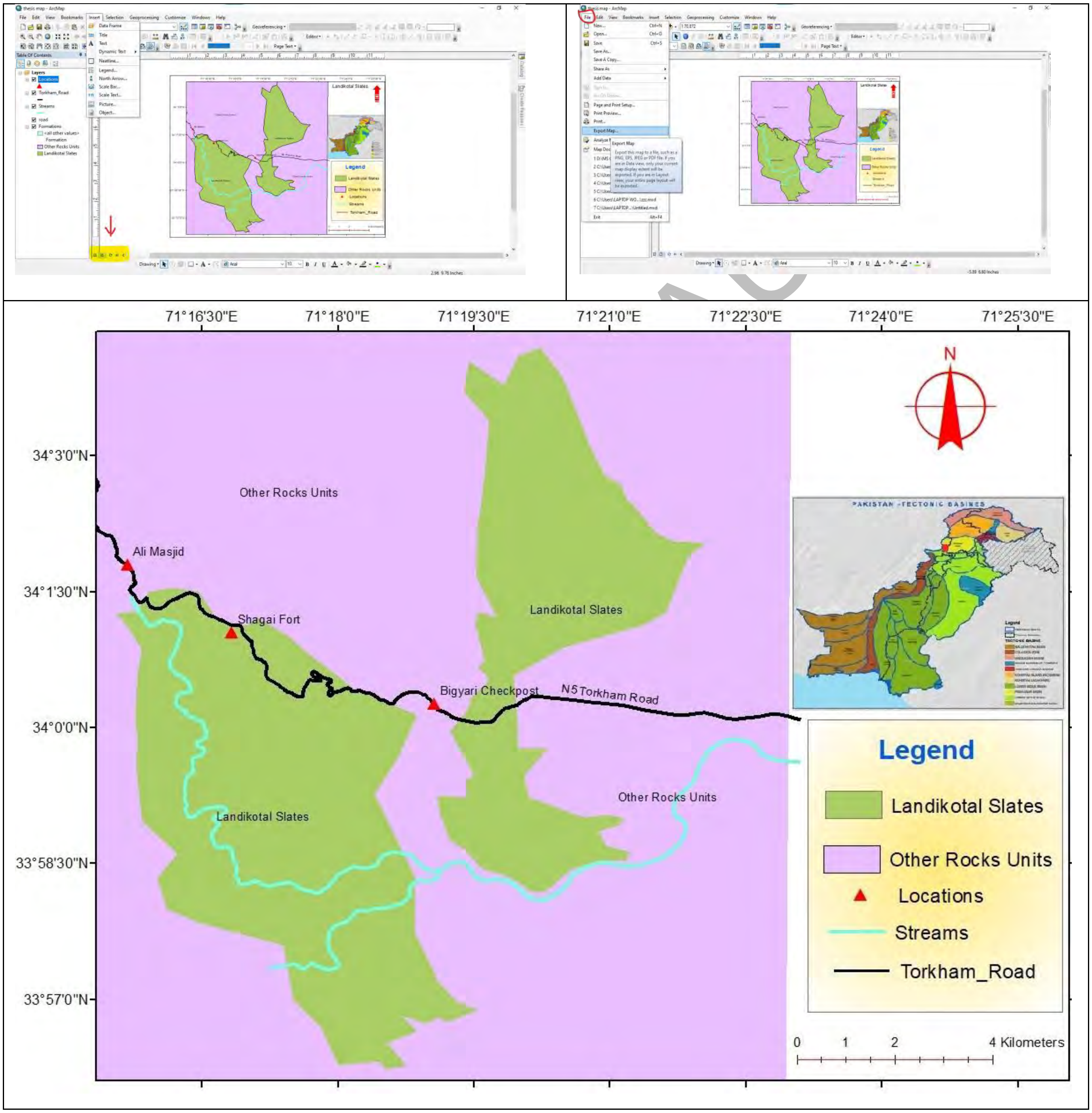


Fig 5.3 showing layout view, JPEG format of the final map

5.3 Reserve assessment

The reserve calculation is the reasonably accurate measurement of the valuable rocks that are existing in the earth's surface or subsurface. Additionally, it requires calculating the grade, thickness, and other qualitative factors needed for the commercial exploitation of the economic rocks (minerals). The need for construction projects will fuel growth in the construction industry, which will lead to an increase in the utilization and exploration of aggregate deposits. When deciding whether to open new mines or to plan future investments for mines that is already running, the economic appraisal of mineral reserves is a key consideration. Tonnage and grade must be precisely known for both short- and long-term planning in mining projects, particularly those involving profitable resources. This is frequently challenging to establish because thorough exploration efforts, which are necessary to provide an exact description of the deposit, are expensive and time-consuming. The methodologies used by geologists and mining engineers to estimate the quantity and quality of mineral reserves are often different.

5.3.1 Method

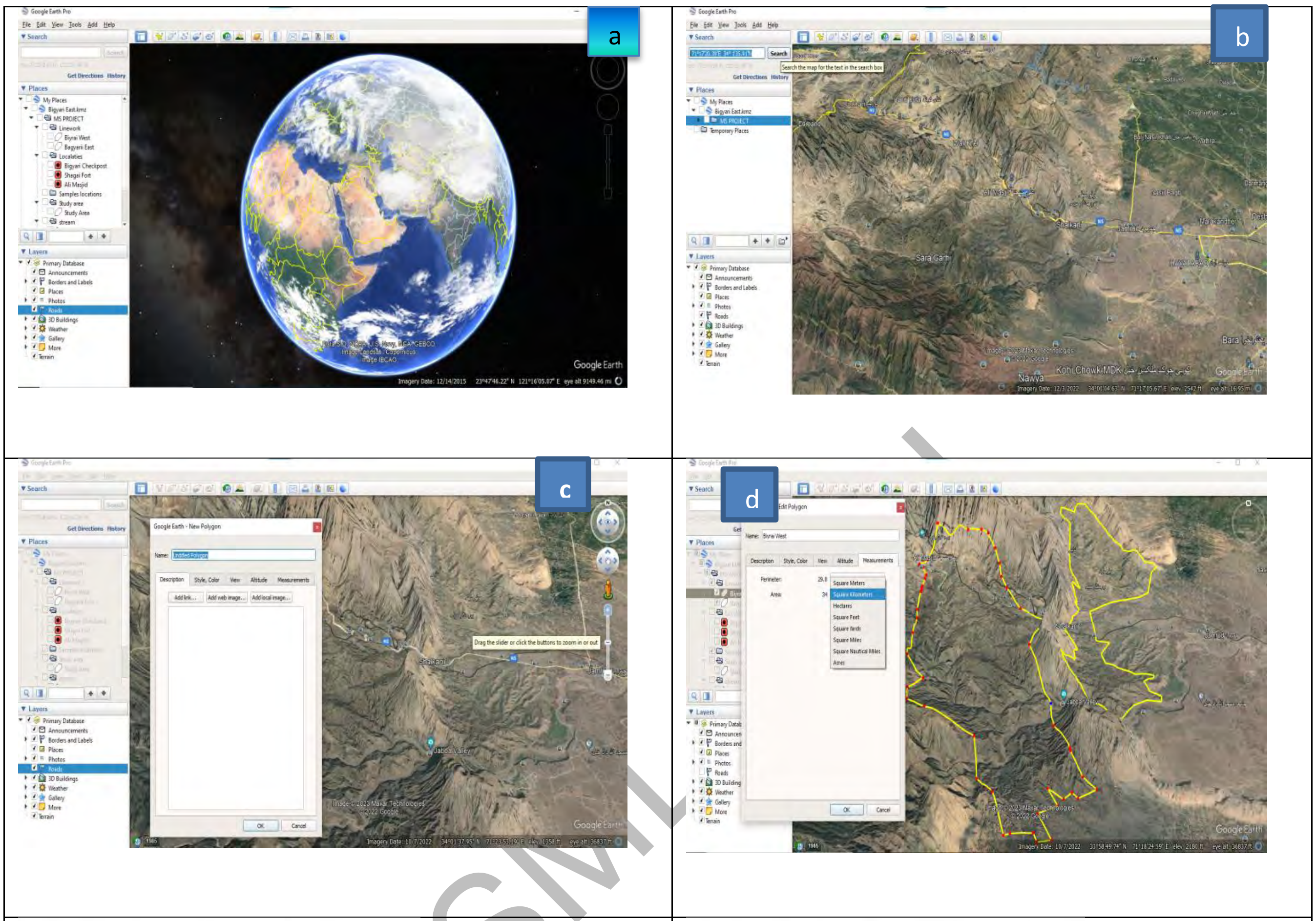
To find the quantity or amount of the slates reserve the following equation is used in calculation.

Tonnage (t) = volume x specific gravity (Bulk density)

V = volume = area (A) x thickness (depth)

Area (A) is calculated by using Google Earth Pro software the procedure as following.

- Open Google Earth Pro software on our laptop
- All latitude and longitude value from Microsoft Excel sheet are past in the Google Earth Pro software in order to make a polygon of the research area and the Landikotal slates.
- Select the polygon symbol and draw a polygon of the selected research area by connecting all the latitude and longitude points.
- Then select the measurement box and choose kilometers units for perimeter and square kilometers for area.
- By following this procedure, we will find out the area in square kilometers unit for our selected research site (Landikotal Slates)



P/No	Longitude	Latitude
1	71°20'13.49"E	34° 4'11.74"N
2	71°20'28.94"E	34° 3'51.22"N
3	71°21'10.80"E	34° 2'30.39"N
4	71°22'1.21"E	34° 2'1.73"N
5	71°21'36.83"E	34° 1'17.48"N
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7	71°20'39.80"E	33°58'28.55"N
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P/No	71°18'39.72"E	34° 0'11.52"N
1	71°17'30.99"E	34° 1'7.95"N
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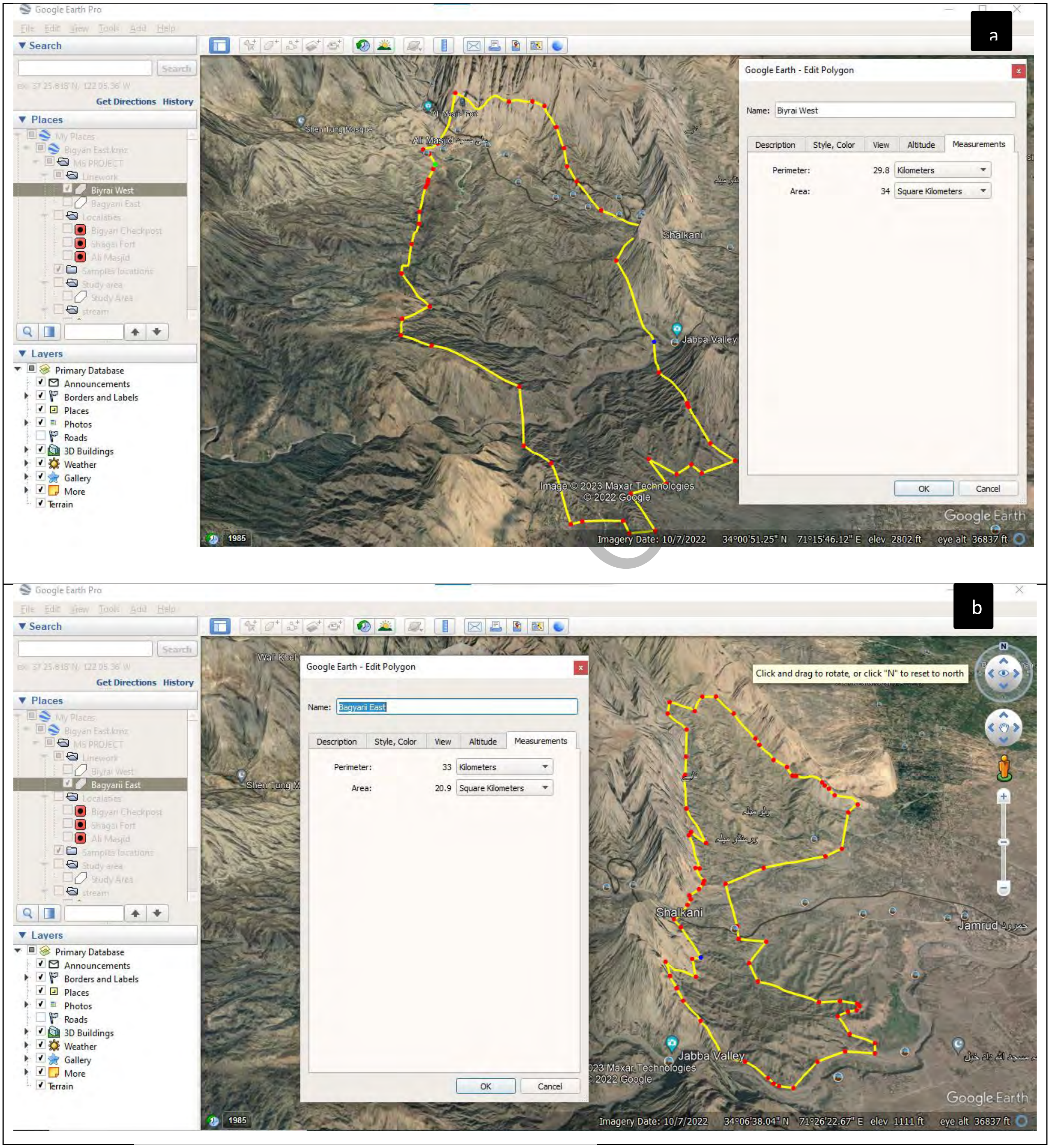
8	71°18'15.80"E	33°59'54.72"N
9	71°17'12.57"E	34° 0'20.87"N
10	71°17'38.46"E	34° 0'26.24"N

Fig 5.4 (a,b,c,d) show Google Earth Pro software setting



Google Earth - Edit Polygon

Name: Biyrai West

Description | Style, Color | View | Altitude | Measurements

Perimeter: 29.8 Kilometers

Area: 34 Square Kilometers

Google Earth - Edit Polygon

Name: Bagyarii East

Description | Style, Color | View | Altitude | Measurements

Perimeter: 33 Kilometers

Area: 20.9 Square Kilometers

Fig 5.5 Google Earth Pro software showing area calculation setting.

5.2.3 Calculation

Area (A) is calculated by using Google Earth Pro software = 34 km^2 + 20.9 km^2

Area (A) = 54.9 square kilometers 54,962,803m^2

Thickness (D) (minable) = 50m

Volume V = Area (A) × Thickness (D)

Volume = 2,748,140,150 m^3

Tonnage (t) = V x SG (Bulk density)

Tonnage (t) = 2,748,140,150 m^3 × 0.8057378960 ton/m^3

Tonnage (t) = 2,214,280,662 ton.

Tonnage (t) = 2214.28 megaton.

CHAPTER # 06

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Over the past few decades, the building of megastructures has made the dead load problem one of the most critical and expensive issues in construction. Design development and concrete aggregate cost effectiveness are just a couple of the problems. Cost issues, which currently run into the millions of dollars each year, have prompted the industry to explore for better alternatives in the form of lightweight concrete aggregate. This study suggests using Landikotal Slates, which are exposed in a region of around 21 square miles in Jamrud and Landikotal Tehsil in District Khyber, NW, Pakistan, as a lightweight aggregate. Lightweight aggregate reduces the dead load in engineering structures since it is less dense. For utilization as a lightweight aggregate in structures, Landikotal Slates from the Khyber Range were analyzed chemically, mechanically, and petrographically in the current study. Through numerous testing, engineering characteristics and application potentials for structures were investigated. Slump and compressive strength testing was done on a concrete mix design. This study work also includes the quantitative mapping and reserve calculation of the slates.

5.1 Results

These rocks are described as dark greenish-gray and dark grey in colour and feature fine-grained textures from a petrographic and mineralogical perspective. Major mineral phases include quartz, biotite, and muscovite, while minor to accessory phases include hematite and chlorite. SiO_2 (71%), Al_2O_3 (19.282%), Fe_2O_3 (4.247%), and K_20 (3.405) are the principal oxides that are present in the examined slate according to the average XRF geochemical concentration (in%Wt), whereas the remaining oxides (CaO, TiO_2, MnO, ZrO_2, WO_2, V_2O_5, SrO, Cr_2O_3, ZnO, Rb_2O, and Y_2O_3) are in bits. Similar to this, XRF elemental analysis reveals that the primary elements identified by the specimen's results are Si, Fe, AL, K, and Ca. When compared to the sample's overall percentage, the values of Ti, Mn, Zr, V, W, Rb, Zn, Sr, Cr, Y, and Nb range from very low to lower amounts.

Los Angeles Abrasion, Water Absorption test, Specific Gravity test, Gradation (Sieve Analysis) test, Fines Modulus, Flakiness and Elongation test, Clay lumps test, and Bulk Density test for Course Aggregate were among the physical tests conducted. The Los Angeles Abrasion test tracks the deterioration of aggregate-producing rocks. In order to pass the abrasion test, the maximum value for the slates under test was discovered to be 27.03%. The range of water absorption values, which fell within ASTM standard limits, was 2.5% to 3.1%. The bulk SSD specific gravity and the bulk oven dried specific gravity both are taken into account. For bulk oven-dried specific gravity, the values varied from 1.524 to 1.536, while for bulk SSD specific gravity, they ranged from 1.561 to 1.589, both values falling within the ASTM standard deviations. According to ASTM standards, sieve analysis of coarse and fine aggregate and fineness modulus is within prescribed parameters. The samples used for this study included no clay lumps. The bulk density test was performed in accordance with ASTM standards, and the results (50.3 Ib/f^3) fell within the acceptable range. The only physical test in this research that yields results that are not sufficient for high strength aggregate is the Flat and Elongated Particles test. The flakiness index value is 35.15%, and the elongation index value is 37.65%. According to ASTM, a flakiness index value greater than 35 to 40% is undesirable.

In this research project, chemical tests for soundness, organic impurities, and loss on ignition are conducted. Both the course and the fine aggregate of the chosen samples underwent the chemical test to verify their soundness. The loss should not exceed 10% for fine aggregates and 12% for coarse aggregates, according to the ASTM standards. This study's findings for coarse aggregate were 1.42%, and for fine aggregate, they were 4.433%, all of which were within acceptable ranges. Since the samples were already cooked at 1150 C˚ while bloating, no loss on ignition was observed. A test for organic impurities was also run, and the outcomes were declared ok.

Concrete cylinders were cast, and their slump and compressive strengths were assessed. This was done in accordance with the ACI 2112-98 and the ASTM 330. When intended to reach 3000 PSI strength, the average compressive strength findings were based on 3000 PSI for 28 days.

In the current study, the petrography, geochemistry, and geotechnical properties of the Landikotal Slates were assessed. The outcome of all the analysis were match with the American Society for Testing and Materials normal results (ASTM C330/330M), that show that these slates are suitable for usage as light-weight material in constructions. Slate reserves in the Landikotal region totaled 2214.25 megatonne after quantitative mapping of the slates was done.

5.2 Conclusions and Recommendations

In this study, the potential of Landikotal slates for producing lightweight concrete aggregate was investigated through a range of physical, chemical, and concrete tests. The conclusions are as follows.

- The Khyber Range Landikotal Slate samples displayed better bloating characteristics, making them ideal for use as LWAC.
- The chemical tests that were carrying out to find the value of the LWA were done in agreement with ASTM standards, and the results met the standards for the LWAC.
- All of the physical tests used to determine the quality of expanded Landikotal Slates samples were determined to be within ASTM standards' allowable ranges.
- The extended Landikotal Slates representative samples, which matched the ASTM criteria for the lightweight aggregate and weighed 108.9 to 111 lbs./ft3, were used to create the Concrete Mix Design (CMD).
- This swell Landikotal slates can be utilized as a light-weight concrete material in all building purpose, such as blocks, panels, and concrete slabs, because a required concrete compressive strength of 3000 PSI was also reached on crushing of cylinders.
- Increasing the amount of coarse lightweight aggregate would probably raise the compressive strength values for the lightweight concrete mixtures. Additionally, altering various mixture qualities could assist increase the strength of concrete for usage in superstructures as high performance lightweight concrete.
- The light-weight slates test results were satisfactory, and it is possible to investigate and test them further for utilized it as tiles, slabs, roadways, and fencing rocks.
- To fully understand the spectrum of manufacturing and building applications of Landikotal slates as light-weight material, to show how cost-effective they are, and to learn more about their seismic behaviour more research should be done.

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