INTERRELATIONSHIP BETWEEN THE MICROFACIES CONTENT AND MECHANICAL BEHAVIOUR OF LOCKHART LIMESTONE AT SHAH ALLA DITTA, ISLAMABAD, PAKISTAN.

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A thesis submitted to Bahria University, Islamabad in partial fulfillment of the requirement for the degree of BS in Geology

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ABSTRACT

The study aimed to find out geo-technical properties and correlation of micro facies and mechanical properties of Lockhart limestone, in Shah Alla Ditta region. Performed couple of fields for sampling and samples that were obtained on field were further processed towards laboratory testing for carrying out different geo-technical tests, that include uniaxial compressive strength, specific gravity, Los Angeles abrasion test and water absorption or porosity test, which later on gave some particular results, through which derived certain results and deduced geo-technical properties of Lockhart Limestone and by using previous work of microfacies and correlate microfacies with mechanical properties of Lockhart limestone. Performed each and every task with proper care and attention by keeping the health and safety factor constant. From the results of Geo-Technical tests that were performed on samples acquired from Lockhart limestone tend to be good and can be used for minor Engineering purposes, and as UCS value seems to be weak so this could not handle heavy loads but can be used in the minor construction projects like Road pavements and ramping etc.

ABBREVIATIONS

ASTM	The American Society of Testing Materials
PMD	Pakistan Meteorological Department
UCS	Uniaxial Compressive Strength
MBT	Main Boundary Thrust
MMT	Main Mantle Thrust
MFT	Main Frontal Thrust
HKS	Hazara Kashmir Syntaxes

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Engineering Geology, under the control of loading forces, is the study of rock and soil behavior and their interaction with water. Adding to this experience is the design of foundations, retaining walls, earth dams, clay liners, and geosynthetics for waste containment. Engineering geologists' goals could range from the construction of foundations and temporary support for excavation, through the selection of routes for railways and highways, to the increasingly significant areas of landfill waste disposal and groundwater contamination. Engineering geologists are engaged in field and laboratory research to determine the engineering properties of site soils and other geomaterials and their subsequent use in the analytical study of the problem at hand. Geological considerations, proper site characterization, sound fundamental principles of soil mechanics, advanced knowledge of all available resources, acute observation and engineering judgment are often needed for the best geotechnical engineering work (Briaud, 2013).

For engineering geologists, knowledge of both rock mechanics and soil mechanics is important. In rock mechanics, the properties of rock are studied by engineering geologists, while in soil mechanics, engineering geologists are concerned with the properties of soil. Engineering geologists research the properties of the subsurface and materials of the earth's surface. Geotechnical measurements must be taken for the stability of civilian structure, geological engineers use various scientific methods to study the stability and strength of earth materials (Holtz R and Kovacs, 1981).

Pakistan has enormous quantities of calcareous aggregates formed by the crushing of intact rocks (Ghaffar et al., 2010). Rocks are used and excavated in Pakistan, rarely knowing their engineering actions. This is not a good practice both from the point of view of protection and economic (Din et al., 1997). Mineral composition, grain size, cement and grain interaction are significantly affected by the physical and mechanical properties of rocks (Meng and pan, 2007).

1.2 Engineering geology and its applications

(i) Engineering geology is the geology branch and is used in civil and mining engineering practices to ensure that geological factors for any form of construction may affect a site.

(ii) Awareness of geological engineering is important for residential, commercial and industrial growth.

(iii) Engineering geology is needed for the exploration and evaluation of groundwater resources, their quality and quantity of accessibility.

(iv) It is also used in the detection of threats, such as excavation sites, mountain roads for stability of slopes and settlement constructions.

(v) Used for the identification of soil conditions, such as soil type, thickness and strength of the soil.

1.3 Limestone and its importance in Engineering Geology

Limestone is an important chemical sedimentary rock made up of more than 50 percent of minerals such as calcite and aragonite that are carbonated. Limestone is very important because of its flexibility in the building industry. It is used in bridge, house and dam construction. For road building, crushed limestone is used as an aggregate. It is used as an ornamental stone and it is often used in sculptural materials due to its softness and porosity (Yen et al., 2015).

Millions of tons of calcareous stone are used every day to boost soil at building sites or building roads and for various other construction purposes. Limestone improves soil characteristics for building steps, such as reducing soil wettability, reducing soil plasticity and increasing soil strength (Ankit Sing et al., 2013).

Other important uses of limestone are listed below;

(i) The value of limestone in geological formation is recognized as the best reservoir of petroleum.

(ii) Pulverized limestone is used in agriculture to increase soil alkalinity in order to neutralize acidic soil.

(iii) Limestone is also used for underground mining operations, for example, to prevent explosions of methane.

(iv) For the extraction of iron and other essential metals, limestone combined with silica and other impurities is used.

1.4 Microfacies Analysis

All the conditions of sedimentology and paleontology that can be classified into polished peels and slabs in thin pieces refer to the term micro facies in carbonate rocks.

A large range of deposition environments in which carbonate rocks form with intermediate coastal, coral, basinal habitats which are lacustrine and shallow to deep-sea. In all these conditions, the number of controlling variables is determined by the presence, thickness of carbonates and compositional differences. At the origin of the carbonate rocks, organisms play a crucial role and the types or facial distribution of carbonate rock represent unique physical characteristics, In all the depositional environments in which they are produced, the chemical and biological characteristics.

These features are so important to identify for the understanding of depositional history and the setting. Therefore, microfacies study is useful to assess the environmental conditions based on field relationships and forms of textural and faunal parameter beds. 24 standard microfacies SMF with distinctive features were recognized by Flugel 1982 and Wilson 1975 of unique marine environments (meso and micro) and established different requirements for the study of microfacies. The size and shape of the carbonate grains, lithology and a lot of fauna are important requirements in paleo-ecological and paleo-environmental interpretations.

1.5 Study Area

At Shah Alla Ditta, Islamabad, the Lockhart Limestone is revealed. The research area is surrounded by Margalla hills, part of the North West Himalayan foreland and the thrust belt created by the Indian plate's southward movement that collided with the Eurasian plate (Monalisa et al., 2005). The convergence process is still going on. The NW Himalayan sequence is divided into the deformed southern zone known as the foreland zone and as the hinterland the deformed and metamorphosed area known as the fault of Panjal Khairabad. In this area, Miocene to Eocene stratigraphy is present, but in the study area, Paleocene stratigraphy is well exposed.

1.6 Location and Accessibility

Shah Alla Ditta is located at coordinates 33° 43' 12"N, 72° 54' 40"E and 33° 43' 14" N, 72° 54' 53"E slightly west of the capital territory Islamabad.

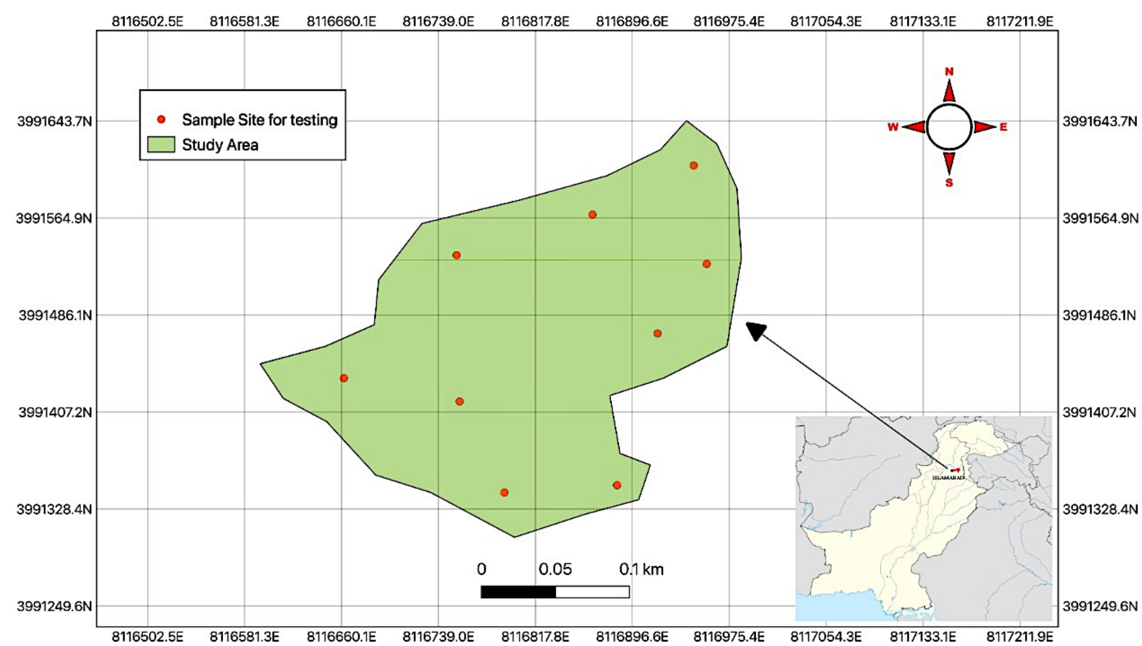

Figure 1.1. Location and accessibility of Lockhart Limestone, Shah Alla Ditta

1.7 Aims and Objectives

Following are the aims and objectives of the study:

(i) To investigate Lockhart Limestone's geotechnical properties

(ii) To correlate the mechanical properties and microfacies of the Lockhart Limestone

1.8 Methodology

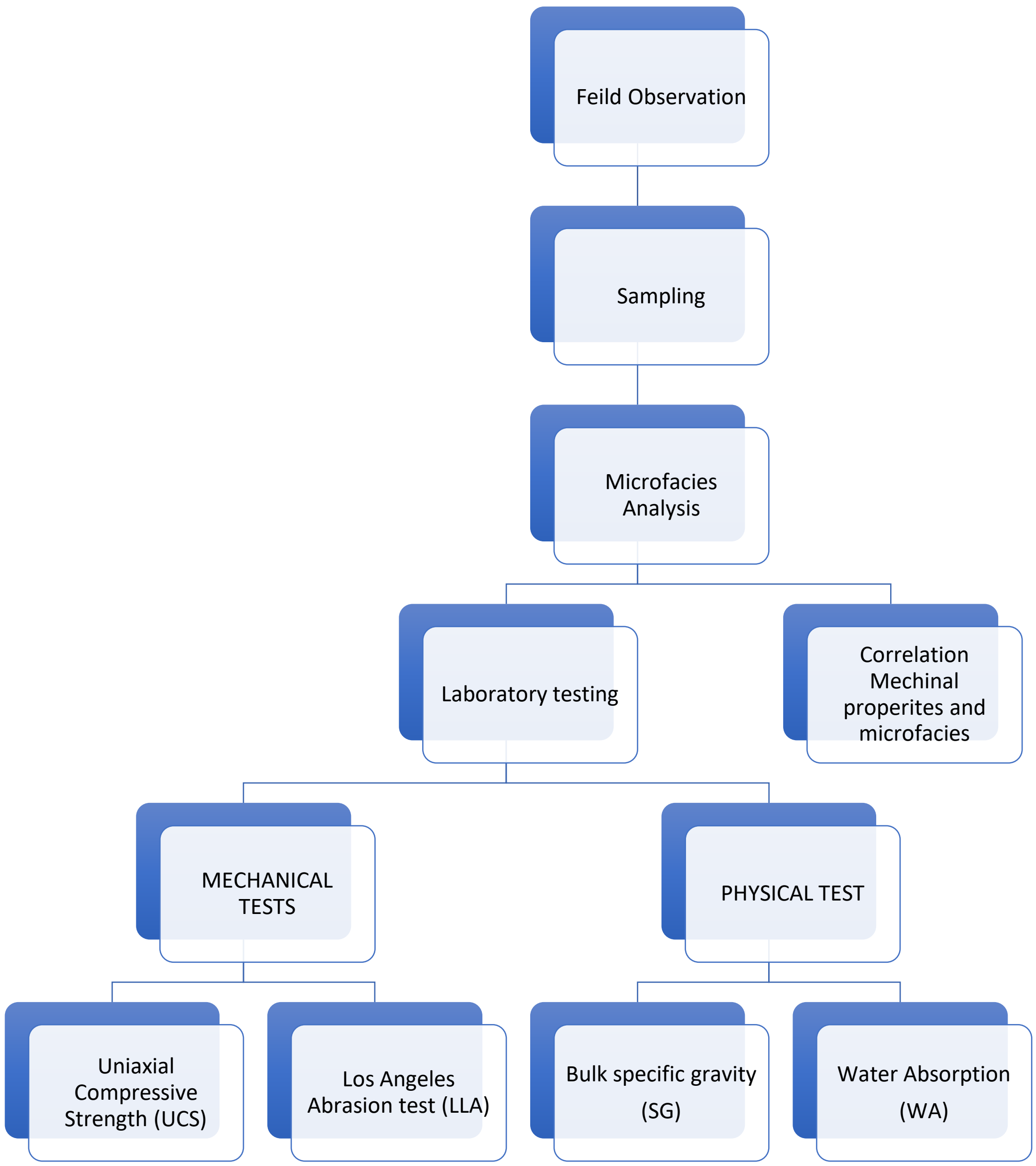

Figure 1.2. Flowchart of Methodology.

CHAPTER 2

TECTONIC SETTING OF PAKISTAN

2.1 Tectonic setting

Pangea was a super continent during the Paleocene and Early Paleocene, divided into two super continents around 175 million years ago, Gondwanaland and Laurasia, and these two continents were separated by the Paleo-Tethys Ocean. India's plate was split from Gondwanaland around 130 million years ago and began to drift northward. As a consequence of the Indian plate Neo-Tethys Ocean northward drift, which was situated between the Indian plate and the Eurasian plate, it began to shrink. It finally collided roughly 55 to 65 million years ago with the Eurasian plate. In India and EW, along the western part of Pakistan, the Himalayan belt has a North West trend to NS (Ahmed, 2003; Kazmi and Jan, 1997).

As a result of the collision of the Eurasian and Indian plates during the Eocene, the Himalaya originated. Intra-oceanic subduction collided form the Kohistan-Ladakh arc, with the Eurasian plate forming the largest Karakorum Thrust Boundary (MKT) 70-100 million years ago (Coward et al., 1986).

Under the Kohistan-Ladakh arc, the Neo-Tethys Ocean is subdued. The Indian plate collided with the Kohistan-Ladakh arc following the full subduction of neo-Tethys (Powel, 1979). The main mantle thrust in this collision was about 65-50 million years ago (Coward et al., 1986).

2.1.1 Main Boundary Thrust (MBT)

The main boundary thrust is the Himalayan range's main frontal thrust, which can be accompanied by the syntax of Hazara-Kashmir, truncates the formation of Murree from east, north and west, and borders the Mesozoic and earliest rocks against the formation of Murree. Between 25-20 Ma, the Main Boundary Thrust was formed. MBT represents the Himalayan deformation from southward migration and marks the border between crystalline and marine sediments. The thrust zone consists of a series of parallel thrust defects that break the North West Himalayan sequence into a deformed and metamorphosed northern zone (Meigs et al., 1995).

2.1.2 Tectonic setting of study area

Shah Alla Ditta is present in the region where MBT separates from the thrust of Punjal (Fig 2.1). Punjal thrust is an MCT extension (R.A.K. Tahirkheli and Riaz, 1991). MBT is well exposed in the southern portion of Shah Alla Ditta. The lithology revealed in this region ranges from Mesozoic to Cenozoic to (Fig 2.2). The lithology present in this field has a strong influence on the faulting style. It consists of the formation of Jurassic Samanasuk that lies above the formation of Miocene Murree.

Paleocene Lockhart Limestone has incompatible interaction with the formation underlying Samanasuk and has upper contact with the formation of Paleocene Patala (Zeeshan et al., 2016).

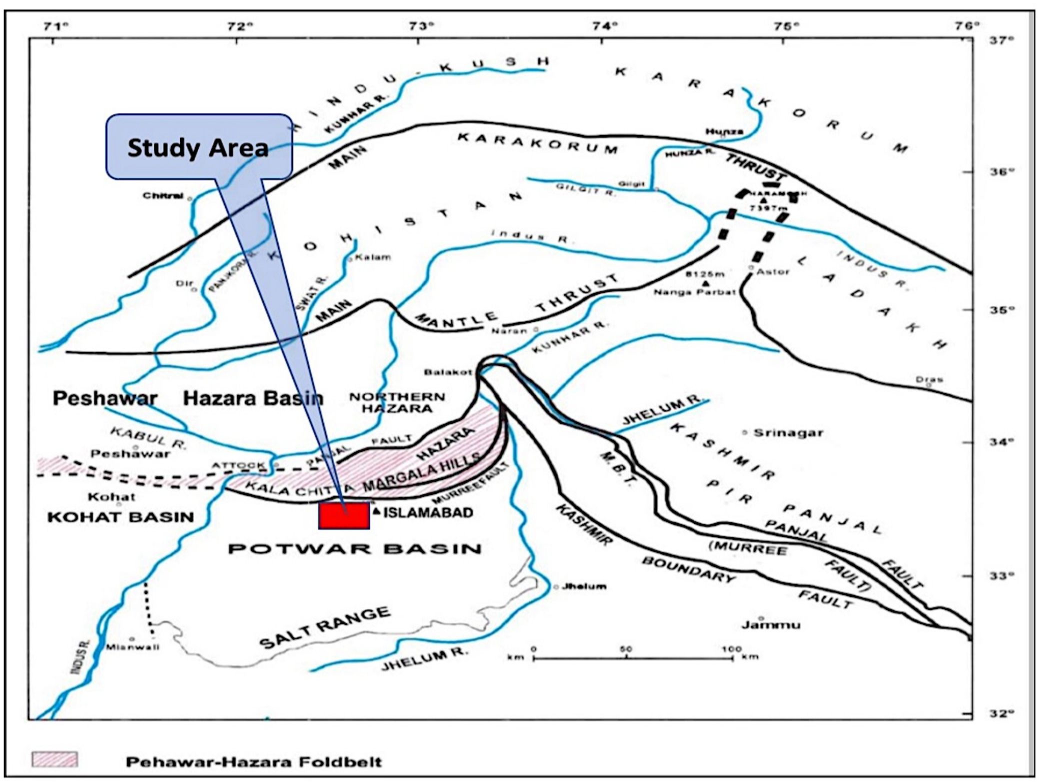

Figure 2.1. Tectonic setting of study area (Modified from Kazmi and Jan, 1997)

2.2 Generalized Stratigraphy of study area

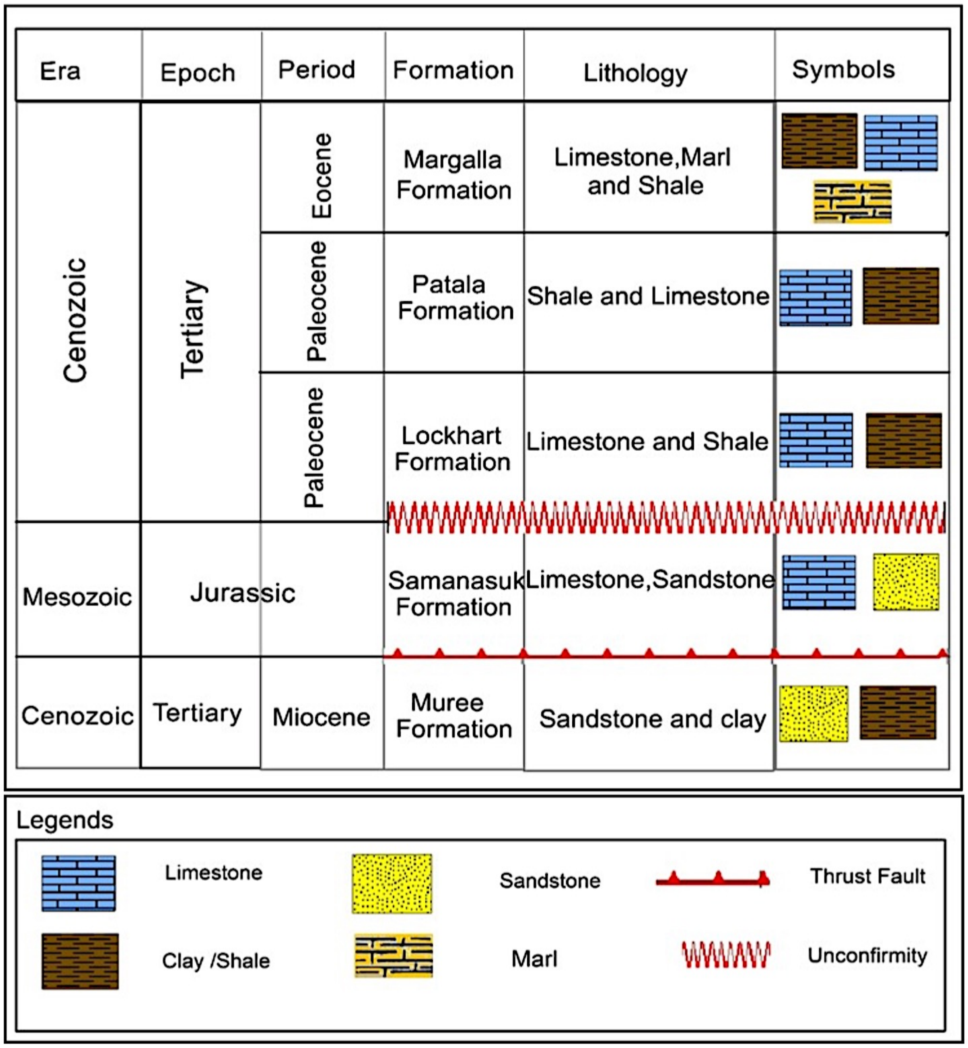

Figure 2.2. Stratigraphy of study area (Modified from Zeeshan et al., 2016)

CHAPTER 3

LITERATURE REVIEW OF MICROFACIES OF LOCKHART LIMESTONE

Three types of microfacies of various textures, fossil materials, allochemical forms and sedimentary structures are recognized on field-based and laboratory research. Foraminiferal are such microfacies, Microfacies of Wackestone/Biomicrite, Mixed Bioclastic Mudstone microfacies, Algal Foraminiferal Wackstone microfacies, and Lockhart calcareous microfacies from the basis of formation upwards.

3.1 Foraminiferal Wackestone/Biomicrite microfacies

The total thickness of such microfacies is up to 15 m and it took place at the core of the formation. In places with all these facies, the limestone is light gray to dark gray in color and black. It occurs as separate thin nodular beds with thin interbeds of dense clay/marl of a few centimeters. With a mean length of 5-10 cm, the nodules present during formation are very irregular in shape. The matrix is lime mud in both of those microfacies, and no spark calcite is present throughout.

Microfacies are distinguished mainly by skeletal allochem, the only allochemical constituents marked by a mild variety of organisms. Larger benthic foraminifers, gastropods, ostracods, pelecepods, and rare dasycladaccan algae are available. Skeletal allocehems are Miscellinae, Lockhartia hameii, Lockhartia conditi, Ranikothalia trochodiformis comprise the benthic foraminifers that constitute 20-45 percent of the skeletal constituents. Textularia and Bioclasts, Ranikothalia sindensis. In microfacies, the concentration of other bioclasts is <10%. As a matrix, the microfacies are entirely lime mud, comprising 40-45% of the rocks and lacking cement spar.

These microfacies show poor sorting of components marked by large variance in deposition conditions of size and shape and wave base conditions, suggesting less than the absence of any current-oriented fabric.

3.2 Algal Foraminifer Wackestone microfacies

There are dark gray, thin bedded Algal-Foram Wackestone Microfacies. Minor clay marl interbeds of nodular limestone. In Shah Alla Ditta, these microfacies are present. The microfacies have an average thickness of 5m. Larger and smaller benthic foraminifera, combined with dasycladacean algae, molluscs, gastropods and ostracods, differentiate it. The dasycladacean algae range from 10-15 percent. Like Lockhartia sp., Rotalia sp., agglutinated foraminifera Textularia, Quenquloclina sp., Miscellanea sp., benthic foraminifera make up 20-25% of the skeletal constituents. With Assilina sp. With a dominant lime mud matrix, the ratio of allochems to micrite is usually 3:1 relative to other microfacies.

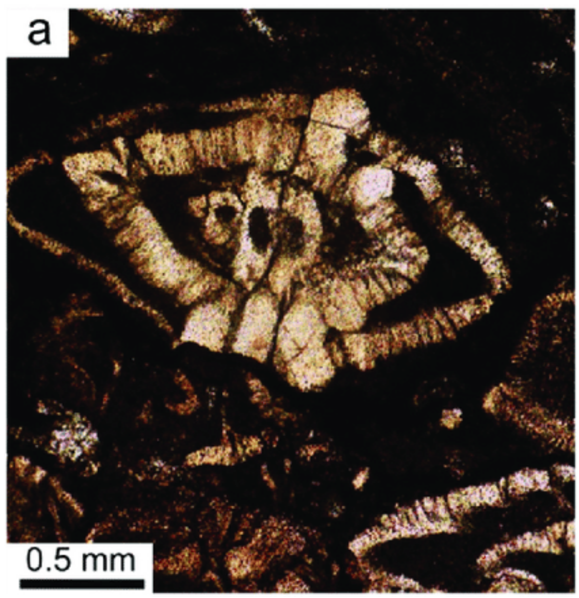

Figure 3.1. Photomicrograph showing Miscellane miscella

3.3 Mixed bioclastic Mudstone

In the Shah Alla Ditta area at 20 to 30 m, the total thickness of this microfacies is about 10 m and is located from top to bottom. Just skeletal fragments showing mudstone depositional fabrics from Dunham 1962 and poorly washed Biomicrite fabrics from Folk 1959 are the allo-chemical components. In this segment, calcite veins are observed. Also noted are the presence of algae, In these parts, miscellaneous miscella, fractures and very few smaller benthics. The proof of the tectonic or highly fractured area is this form of cross cutting, mainly the bioclasts that are present parallel to sub parallel and are cross-cutting each other were replaced by calcite veins.

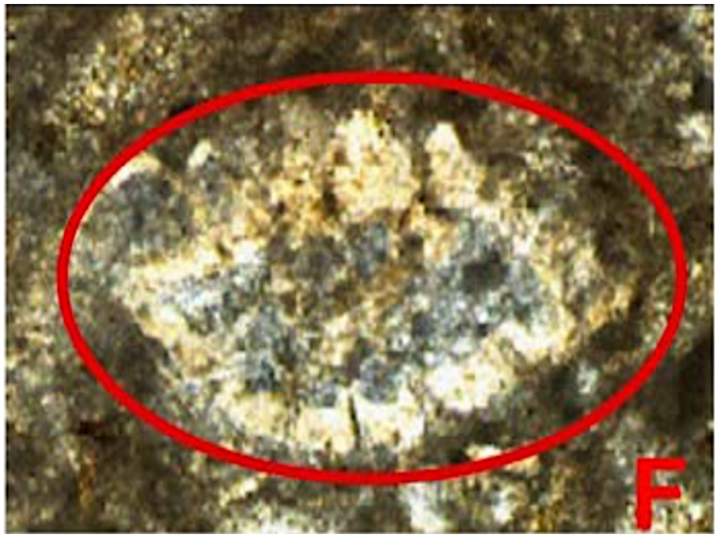

Figure 3.2. Photomicrograph showing Lockartia hameii

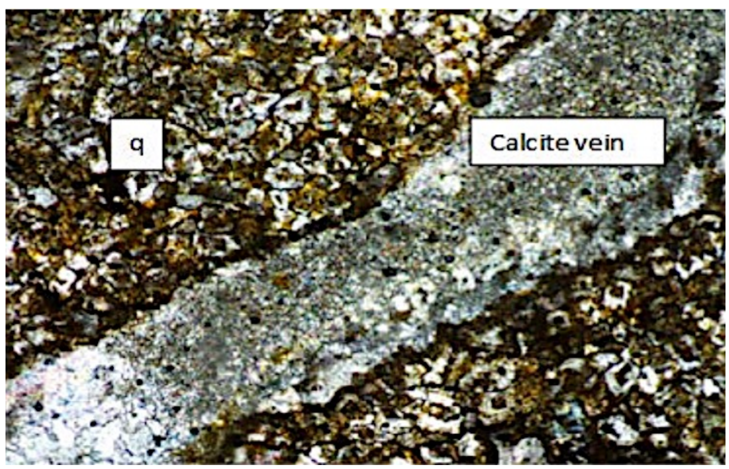

Figure 3.3. Photomicrograph showing calcite veins and quartz crystal in mixed bioclast mudstone facies

3.4 Depositional environment of Lockhart Limestone

The identification of microfacies indicates that the deposition in the near shore, internal to middle shelf deposition condition is represented by Lockhart Limestone in Figure 5.1.

Microfacies distribution, distinguished by the presence of shallow marine conditions, indicates shifts in the level of the water. Foraminiferal wackestone/biomicrite microfacies were still-standing at sea level during deposition. The deposition of blended bioclastic mudstone microfacies is correlated with periods of steady sea level rise. In the middle of Lockhart Limestone, the algal forum wackestone indicates a drop in sea level and the subtidal setting of the inner shelf.

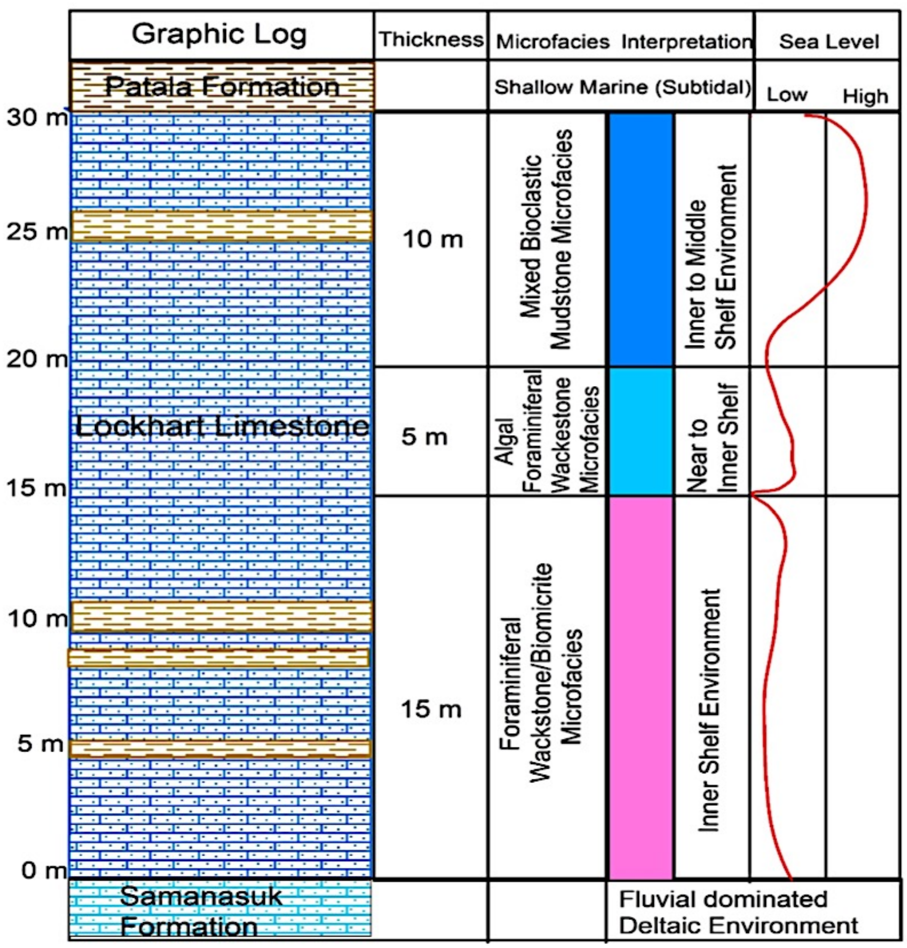

Fig 3.4. Showing the depositional environment of microfacies with respect to sea level rise and fall.

CHAPTER 4

GEOMECHANICAL PROPERTIES

4.1 Introduction

Engineering for is essentially a geological science appliance for engineering exercise to ensure that the construction site, design, activity affected by the geological factors and engineering job protection is understood and properly provided for. Knowledge of the geological strata, rock type, structure of rock, any alteration of minerals that shape rock, the phenomenon of faulting and joining in the rock on small and large scales, The hydrogeological regime and the state of pressure in situ and any engineering-relevant geological parameters are the main knowledge base for engineering activities in engineering geology. Natural rock conditions provide an intense impact on the structure of engineering. This is essentially regulated in general engineering structure's location is such that if a structure is built on the surface, excavation of the surface rock, or maybe it's underground. The strength of near-surface structures is influenced by fractures in the rocks, while the stability of deep structures is regulated by natural in situ stresses. The stability of the dam base, for instance, depends on the existence and isolation of discontinuities. Its mechanical properties and its resistance to water penetration and weathering can be influenced by geological events. For study of geo-mechanical properties of an area, the engineering geological conditions of an area can best be resented on a map, including the character and variety of engineering geological conditions, their individual components and their inter-relationships. Geological engineering research, environmental impact analysis, civil or structural engineering design can be carried out during planning. Benefit of the engineering and design phases of public and private work projects and of the post-building and forensic project phases. Several experiments are being carried out in order to assess the engineering properties of rocks.

4.1.1 Scope and importance of present work

By using the proposed testing techniques and requirements, the most important and critical scope of rock mechanics is the measurement and determination of rock properties and behavior. These include the engineering features of rocks, such as their strength, deformation and failure mode, and elasticity modulus.

4.2 Field observation

As we had to collect samples and perform other activities, which mainly included field observations, we organized a field trip to our study area. We studied the lithology of the formation along with its weathering and fresh color on file. We gathered samples from the field with the aid of a hammer in order to conduct geo-technical lab research. In order to obtain reliable and useful observations, it took several field trips to complete those studies and conduct the task with sufficient concentration.

4.3 Sampling

We maintain no. of samples from the field with the aid of a hammer in order to conduct Geo-Technical Lab research.

4.4 Laboratory testing

In engineering applications, the mechanical properties of rocks play a very significant role. In their use as aggregate sources and dimensional stones, the mechanical characteristics of rocks are of prime importance. The mechanical properties of rocks are based on the composition and texture of the rocks that reflect their deposition environment through digenesis, erosion and sedimentation. A variety of studies have analyzed the mechanical properties of the formation of Lockhart Limestone, which are as follows:

(i) Uniaxial Compressive Strength Test (UCS)
(ii) Los Angeles Abrasion Test (LAA)
(iii) Specific Gravity (SG)

(iv) Water Absorption (WA)

4.4.1 Uniaxial Compressive Strength (UCS)

The compressive strength of the rock and its actions under loading are calculated by the UCS test. Especially when dealing with geotechnical investigation of rocks, it is very important laboratory testing program.

Figure 4.1. Uniaxial compression test machine

4.4.1.1 Procedure

For UCS, the core is separated from the bulk sample and the core sample is cut to a ratio of 2 inches in length to diameter. Both ends of the heart are flat-machined. The center is mounted in a frame and there is a constant axial load until the full load eventually fails. It should be kept in mind during sampling that the sample selected should reflect the average type of rock under consideration.

This will be done through visual examination of minerals, grain size, pores and fractures. There are four other main factors that affect the test results, other than rock properties, fraction between the plate and end surface, specimen composition, loading rate and water content in the rock sample. At the time of the test, if the moisture content is high, it can have a significant impact on rock deformation. To eliminate this uncertainty, the laboratory test should be performed under conditions, which are representative of field conditions.

Since the UCS is a destructive test, several rocks fail violently during the test when load is added to them. To avoid the injury of failing rocks, a shield should be built around the spacemen. Uniaxial compressive strength is determined by dividing the maximum load at failure by sample cross-sectional area (ASTM D 2938-95).

$$CS = P/A$$

CS = compressive strength

P = maximum load

A = cross section area

4.4.1.2 Rock strength based on UCS

Rock intensity dependent on UCS of a sample is graded by the International Society of Rock Mechanics (Table 4.1). The value of uniaxial compressive strength of all samples taken from Lockhart Limestone was of high strength, according to (ISRM, 1980).

Table 4.1. Description of rock strength (ISPM, 1980)

ISRM	
Description	UCS (MPa)
Very low	<6
Low	6–10
Moderate	20–60
High	60–200
Very high	Over 200

4.4.2 Los Angeles Abrasion test (LLA)

This test measures the mineral aggregate loss when added into the charge-containing tank. Loss is calculated after introduction, charging, grinding, by the abrasion of the aggregate in the drum. The amount of charge that is used depends on the grading of the specimen.

As the drum rotates, the sample and the steel spheres are selected by the plate, bringing them around to the opposite side of the drum until they are reduced, causing an impact crushing effect and repeating the cycle. The sample is extracted from the drum after the specified number of revolutions and the aggregate part is sewn up to measure the deterioration as a percentage loss.

4.4.2.1 Apparatus

Apparatus consist of Los Angeles Abrasion machine, sieves, balance and charge.

Figure 4.2. Machine of Los Angeles abrasion test

4.4.2.2 Procedure

Shift the substance initially and then measure the sample weight with the aid of balance. Place the sample and the charge in the testing unit in Los Angeles, and then rotate the rig for 500 revolutions. The drum rotates at a speed of 30 to 33 rounds/min and then integrates 8 spheres of steel into the test machine according to the material classification of ASTM C131-03.

Discharge the material from the device and sieve it after the specified number of revolutions using the 1.70 mm coarse aggregate sieve. Use the formulas, and then calculate the loss in percentage.

4.4.2.3 Los Angeles Abrasion test formula

% Loss = (Original mass of test sample - Final mass of test sample) x 100/Original mass of test sample`

4.4.3 Bulk specific gravity

Specific gravity is a useful function for studying rock, and it also helps to classify the form of rock. The basic gravity of the rock aggregate must be between 2.5 and 2.8. Specific gravity is important for different purposes. Few of the dangerous aggregates are lighter than the useful ones. Relevant gravity also shows us pieces of material. Relevant gravity variance served to reduce the downside of modifying fragments through utilizing heavier liquid. In determining the yield estimation of the percentage of pore and grain volume of rock aggregates, In concrete, the basic gravity of rock aggregates is beneficial. A rock aggregate's appropriate range of specific gravity is between 2.6 and 2.8. ASTM-D6473).

Formula for calculation;

Bulk specific gravity = (Oven dry wt.)/ (Surface Saturated Dry wt. in air - wt. in water)

4.4.4 Water Absorption

A significant property of a specific rock is the determination of the absorption of water. There was water absorption and the sample was put in the water for a period of 24 hours. The weight before and after drying the sample and the percentage of water absorbed are determined following that note. When faxing the absorption percentage must be smaller, a better rock, If more than 5 percent is adequate, this shows that the rock is extremely porous and not appropriate for building methods. To resist absorption, it must be sufficiently competent to use rocks as building material. When rock pores are full, The rainwater plunges into the rock during rain and rock causes reactions with water that later matches at higher altitudes in sheared form, In the pores, water freezes, and it causes rock to disintegrate later when it melts. Minerals link together in their crystal structure to create a rock that absorbs water. This process of absorption also contributes to rock swelling because of changes in its crystal structure. This includes different rocks, such as sandstone and pumice.

Water Absorption = Weight in air - Oven-dried weight

Percent Absorption = (Water Absorption * 100)/ Oven-dried weight

4.4.5 Porosity test

The porosity test is important for measuring a rock's pore percentage. The average porosity of a rock is between 1% and 1.5%. As a building material, rock with less porosity is used more significantly. Grain size and grain form are largely influenced by porosity and water absorption (WA) (Bell, 1978). The smaller the grains, the more irregular their borders are, the porosity of a rock would be much lower, and vice versa. As a common observation, the number of pores that reduce their intensity due to absorbed water in a rock's pores is rising. The following formula determined it.

Porosity (Φ) = (Weight in air - Oven-dried weight)/ (Weight in air - Weight in water)

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

There were certain results that mainly include mechanical properties or geo-technical test results and correlation of mechanical properties and microfacies of Lockhart Limestone. Mechanical properties of rocks refer to the response of rocks to applied loads (Pressure). The mechanical and correlation are described below.

5.2 Geotechnical results

5.2.1 Uniaxial Compressive Strength (UCS)

Rock strength basically indicates the level of stress required to cause failure and compressive strength is the compressive stress required to break a rock sample. The unconfined (uniaxial) compression test is the power of a material to withstand axially directed pushing force. In this test the rock sample is unconfined at its side while the load is applied vertically until the failure occurs. Materials are crushed when the compressive strength limit is reached.

UCS is one of the most important rock strength parameters and the most common determination performed for predictions of bore power. The rock UCS is the function of the sample size, shape, confining strain, ratio of height to diameter, loading rate, rock porosity, and content of moisture. By performing UCS on the samples of Lockhart Limestone, we acquired following results:

Table 5.1. UCS results of sample

Sample no.	Weathering	Diameter (mm)	Length (mm)	L/D ratio	Weight (g)	Loading Rate (kN/min)	Failure Load (kN)	Bulk Density (g/cm^3)	UCS (Mpa)
1.	Fresh	52	101.5	1.95	495	34.62	45.00	2.03	21.19
2.	Fresh	52.5	101.5	1.93	480	29.23	38.00	2.18	17.55
3.	Fresh	52	123.5	2.38	515	25.31	35.00	1.91	19.52
4.	Fresh	52.5	124.8	2.38	518	30.77	40.00	1.92	18.48
5.	Fresh	52.5	115.5	2.20	505	32.31	42.00	2.02	19.40
6.	Fresh	52	117	2.30	510	19.80	34.00	1.89	18.01
7.	Fresh	51	102	2.00	495	23.08	30.00	2.38	14.69
8.	Fresh	51.5	107	2.20	501	23.10	32.00	2.39	15.67

5.2.2 Los Angeles Abrasion (LAA)

The Abrasion Test of Los Angeles is commonly used as a measure of the relative consistency of aggregates. It tests the deterioration of regular aggregate grades when exposed to abrasion and impact with an abrasive charge of steel balls in a revolving steel drum. By performing Los Angeles Abrasion on the samples of Lockhart Limestone, we acquired following results:

Table 5.2. Los Angeles abrasion results of sample

Sample No.	Los Angeles Abrasion (%)
1.	12
2.	12.80
3.	13.41
4.	13.21
5.	12.32
6.	12.70
7.	13.30
8.	12.40

5.2.3 Specific Gravity

The physical properties of rocks affect the design and construction in rock. Specific gravity is one of the significant physical progenies of rock. Specific gravity is used in computing other rock properties, like density and porosity. These properties of rocks are of potential economic value in oil, mineral and water exploration, as well as for construction purposes. By performing specific gravity on the samples of Lockhart Limestone, we acquired following results:

Table 5.3. Specific gravity results of sample

Sample No.	Specific Gravity (Kg/m^{-3})
1.	2.71
2.	2.74
3.	2.70
4.	2.73
5.	2.71
6.	2.72
7.	2.73
8.	2.76

5.2.4 Water Absorption

Absorption of water refers to the amount of water that a rock can readily absorb. Fractures and other rock defects are the easiest passage of entrance for groundwater in the rock. By performing water absorption on the samples of Lockhart Limestone, we acquired following results:

Table 5.4. Water absorption results of sample

Sample No.	Water Absorption (%)
1.	0.51
2.	0.57
3.	0.56
4.	0.50
5.	0.53
6.	0.50
7.	0.55
8.	0.58

5.3 Correlation of microfacies with mechanical properties

The identification and analysis of microfacies reveals that the Lockhart Limestone reflects deposition in near-shore, inner to middle shelf habitats, while the Foraminiferal Wackestone/Biomicrite Microfacies is deposited at sea level still standing. The deposition of mixed bioclastic mudstone microfacies is correlated with cycles of steady sea level rise. In the center of the Lockhart Limestone, the Algal Foram Wackestone shows the decline in sea level and subtidal settings of the inner shelf.

The mechanical properties of Lockhart limestone, in terms of unconfined compressive strength (UCS), were calculated by a laboratory geotechnical examination. Previous petrographic analysis reveals that these rocks are mudstones and wackestones. The key components are calcites and bioclasts, which have a major effect on the mechanical properties of these limestones. Inferior mechanical properties (UCS) are correlated with comparatively higher bioclasts and porosity. The mechanical properties of these limestones would be influenced by the main components of calcite and bioclasts, while the minor minerals have a marginal effect on the strength of these rocks.

While limestone has very little porosity, it has a negative effect on these rocks mechanical properties (UCS). The comparatively higher porosity of the former can be correlated with the higher quality of its bioclasts.

CONCLUSION

(1) The mechanical properties of Lockhart Limestone, in terms of unconfined compressive strength (UCS), were calculated by a laboratory geotechnical examination. The key components are calcites and bioclasts, which have a strong effect on the mechanical properties of these Limestones. Inferior mechanical properties (UCS) are correlated with comparatively higher bioclasts and porosity.

(2) While calcareous stones have very little porosity, they have a negative effect on these rocks' mechanical properties (UCS). The comparatively higher porosity of the former can be correlated with its higher content in bioclasts.

(3) Mechanical properties of Lockhart Limestone after several strength test reveals that the average value of water absorption is 0.53%, the average value of specific gravity is 2.72, the average value of Los Angeles is 12.76 and the average value of Uniaxial Compressive Strength is 18.06 MPa.

(4) So, from the results of Geo-Technical tests that were performed on samples acquired from Lockhart limestone tend to be good and can be used for minor Engineering purposes, and as UCS value seems to be weak so this could not handle heavy loads but can be used in the minor construction projects like Road pavements and ramping etc.

RECOMMENDATIONS

We only did a limited sample test due to the shortage of time and financial support, and only few tests were carried out on the basis of a limited sample numbers. It is recommended that more samples be used to test and more practical work should be done, like analyzing geotechnical properties and examining microfacies, for a better understanding and better results.

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