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Subject Geotechnical Engineering

Submitted to Sir Liaqat Ali

ID # 7793

Ans Different Softwear which are Used in Geotechnical Engineering are

1) **SAP Softwear**

It is Used for effective buisness operation. It is Used for Supply chain Mangment & Product life cycle Mangment.

2) **Slope Stability:-**

This Program is Used to Perform slope Stability Analysis. The Slip Surface is Consider as Circular

3) **Z-soil:-**

A windows Based Tool offering a unified approach to numericals Simulation of soil & rock mechanics above & underground Structures, excavations & underground flow

ID # 7793

4) Abcus Softwear

A Standard abacus is used for addition Subtraction, multiplication & division. It is an effective mechanical device used for Counting.

5) All pile

All pile is a window based analysis program that handles virtually all types of piles including Steel pipes, H piles, pre cast Concrete etc.

6) CLARA-W

It is program for geotechnical Slope Stability analysis in two or three dimensions

7) XSTABL

It provided an Integrated environment for Performing Slope Stability.

CHAPTER 1
INTRODUCTION

1.1 Introduction to study area

Islamabad is the capital of Pakistan and is located at coordinates of 33.7294° N, 73.0931° E and 33.717°N, 73.067°E.The elevation of Islamabad is 507 meters from mean sea level. Islamabad is known as one of the beautiful cities of the world and the most beautiful and developed city of Pakistan. Islamabad is the city full of greenery and lush area which increases its beauty. It is categorized into different sector on the basis of industrial, housing, governmental and foreigner areas. The area of Islamabad is about 906 square kilometers. A further specified area of Islamabad is 2,717 square kilometers with the Margalla Hills in the north and northeast. The southern portion of the city is drained by the Kurang River on which the Rawal dam is located. The three artificial reservoirs; Rawal, Simli, and Khanpur Damprovide the water needs for the city of Rawalpindi and Islamabad.

Islamabad Expressway provides a quick access between Islamabad and Rawalpindi and connecting the capital to N-5 National Highway. The total length of Expressway is 28 kilometers. The width varies from three to five lanes and has three interchanges; Zero Point Interchange, Highway Interchange and Faizabad Interchange. In order to overcome the traffic problem, CDA has approved a new project of Koral Interchange Islamabad.

The Koral Interchange project includes the expansion of 8.5 kilometers road from Faizabad to Koral Chowk. The road split into five lanes and construction of four lanes 12.5-kilometers road from Koral to Grand Trunk road. The project started by Zaheer Khan and Brothers contractors with a cost of Rs21.8 billion. The five interchanges would be constructed at five different localities including, Khanna, Sohan, Koral, Japan road and GT road on the Islamabad Expressway. The total three underpasses are being constructed on the Koral Interchange in which two underpasses have been completed while the laying of cement concrete on third underpass would be started soon

1.2 Location and accessibility

Koral Chowk is located at latitude of 33° 36’ 17”N and longitude of 73° 7’ 49”E on the Islamabad Highway at a distance of about 12.7 kilometers from Zero point Islamabad as shown in figure1.1. The Koral Chowk is a link between Islamabad and Rawalpindi and is easily accessible both from Rawalpindi and Islamabad. Our project area is situated near the Benazir Bhutto International Airport Islamabad.

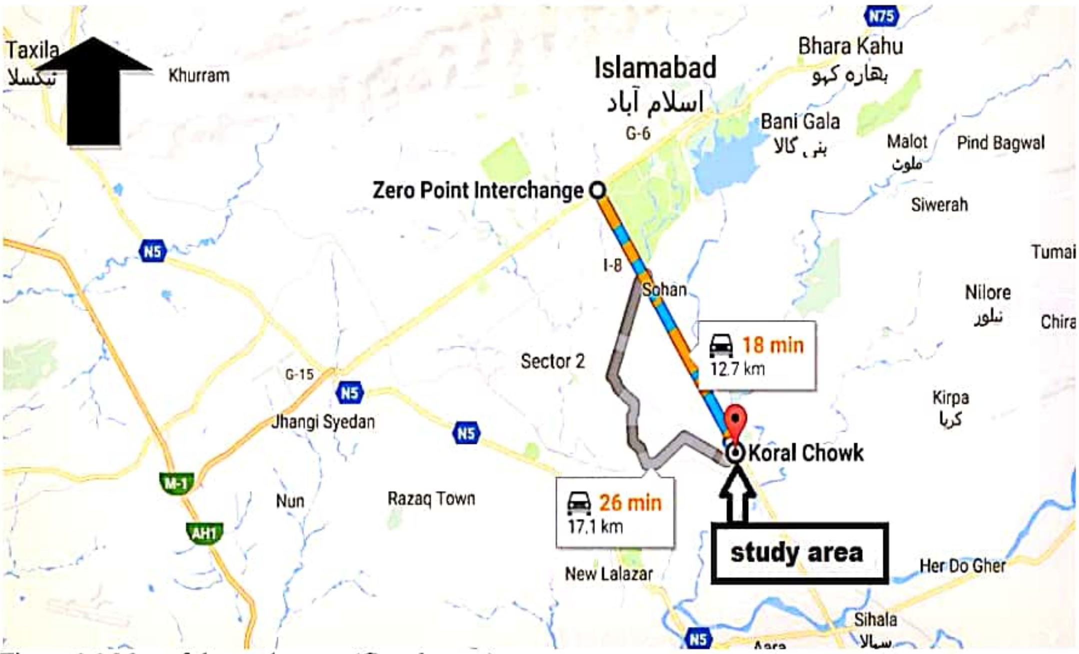

Figure 1.1.Map of the study area. (Google map).

1.3 Objectives of research project

The objectives of the research were:

(1) To determine the geotechnical behavior of material used in Koral Chowk Islamabad.

(2) Comparison of materials with national and international standards.

(3) To check suitability of aggregates being used as base course material.

1.4 Methodology

Numbers of soil and aggregate tests were carried out to evaluate the quality of material used for Koral Chowk Islamabad. The results of different geotechnical tests were compared with international standards to check suitability for road construction. The aggregate base course test includes Plastic Limit and Liquid Limit, Sieve Analysis, CBR (California Bearing Ratio), Modified Proctor Test, FDT (Field Density

Test), Sand Equivalent and Los Angeles of Abrasion. Samples of aggregate base course having weight of one to eight kilograms were taken from the site for the conduction of tests. Each test requires a single sample of aggregate base course but varies in weight and sieves. E.g. the sample taken for CBR was twenty four kilograms sieved through sieve no ¾" and 4", similarly sample taken for specific gravity and water absorption was five kilogram and sample taken for the Sand Equivalent was 500 grams.

CHAPTER 2

TECTONIC OF PAKISTAN AND GEOLOGY OF STUDY AREA

2.1 Tectonic settings

Himalaya, the youngest and perhaps the most magnificent of all the continent-continent collisions on the earth was created due the collision between the Eurasian plate in the North and the Indian plate in the south at about 65-50 Ma.

The Indian plate separated from the Gondwanaland about 130 Ma ago and drifted towards north. As a result of the northward drift of the Indian plate, the Neo-Tethys Ocean which was located between the Indian and Eurasian plate started to shrink. An intra-oceanic subduction at the closure time of Tethys gave birth to Nuristan, Kandahar, and Kohistan-ladakh Island Arcs . The arc magmatism continued at a time of about 40 Ma. The Kohistan-Ladakh Arc collided with Eurasian plate in the north forming an Andean type of continental margin as a result of the back-arc basin closure. The collision of the Kohistan-ladakh Arc with the Eurasian plate gave birth to the boundary named as Main Karakoram Thrust (MKT) at 70~100 Ma ago. The Main Karakorum Thrust separated the igneous, metasedimentary and deformed sedimentary rocks of the southern Eurasian plate from the Kohistan Island Arc situated in the north.

The subduction of the Neo-Tethys beneath the Kohistan-Ladakh Island Arc continued till the complete consumption of the leading edge of the Indian plate and finally collided the remnant of Kohistan-Ladakh Arc. The collision between the Indian plate and the Kohistan-Ladakh Island arc gave birth to boundary named as Main Mantle Thrust (MMT)

The litho-tectonic domains of Pakistani Himalayas have been explained briefly as below.

2.1.1 Main mantle thrust

The Main Mantle Thrust (MMT) lies in the north of the Northern Deformed Fold and Thrust Belt (NDFTB). It involves the lower crust and is dipping towards north at an angle of about 25-45 degree. However, the formation of MMT did not stop the convergence and continued at a rate of about 5mm per year since Eocene that resulted continent-arc-continent collision (Karakorum-Kohistan-India).

2.1.5 Punjab Foredeep

The Punjab Foredeep rims the southern-most extension of Himalayan mountain chain in Indo-Pakistan shield. Unconsolidated Quaternary sediments overlie the Punjab Foredeep and are the present day epicenter for the eroded debris from the Himalayan chains in the north (Ahmad, 2003).

2.2 Stratigraphy of Islamabad area

The rocks found in Islamabad region are mostly of sedimentary origin such as limestone, shale and sandstone being the main constituent. These rocks exposure are lying in front of MBT (Main Boundary Thrust) which usually distinguish the sedimentary rocks from the metamorphic and igneous rocks. These rocks belong mainly to Jurassic, Paleocene and Eocene ages of Potwar basin as shown in figure 2.1. The major formations which come under these ages are Margalla limestone, Samanasuk Formation, Patala Formation, Hungu Formation, Lockhart Limestone and Kawagarh Formation as shown in figure 2.1. The project site mainly comprised of recent thick alluvium cover, in which the gravel, sand, silt and mud, are usually dominant.

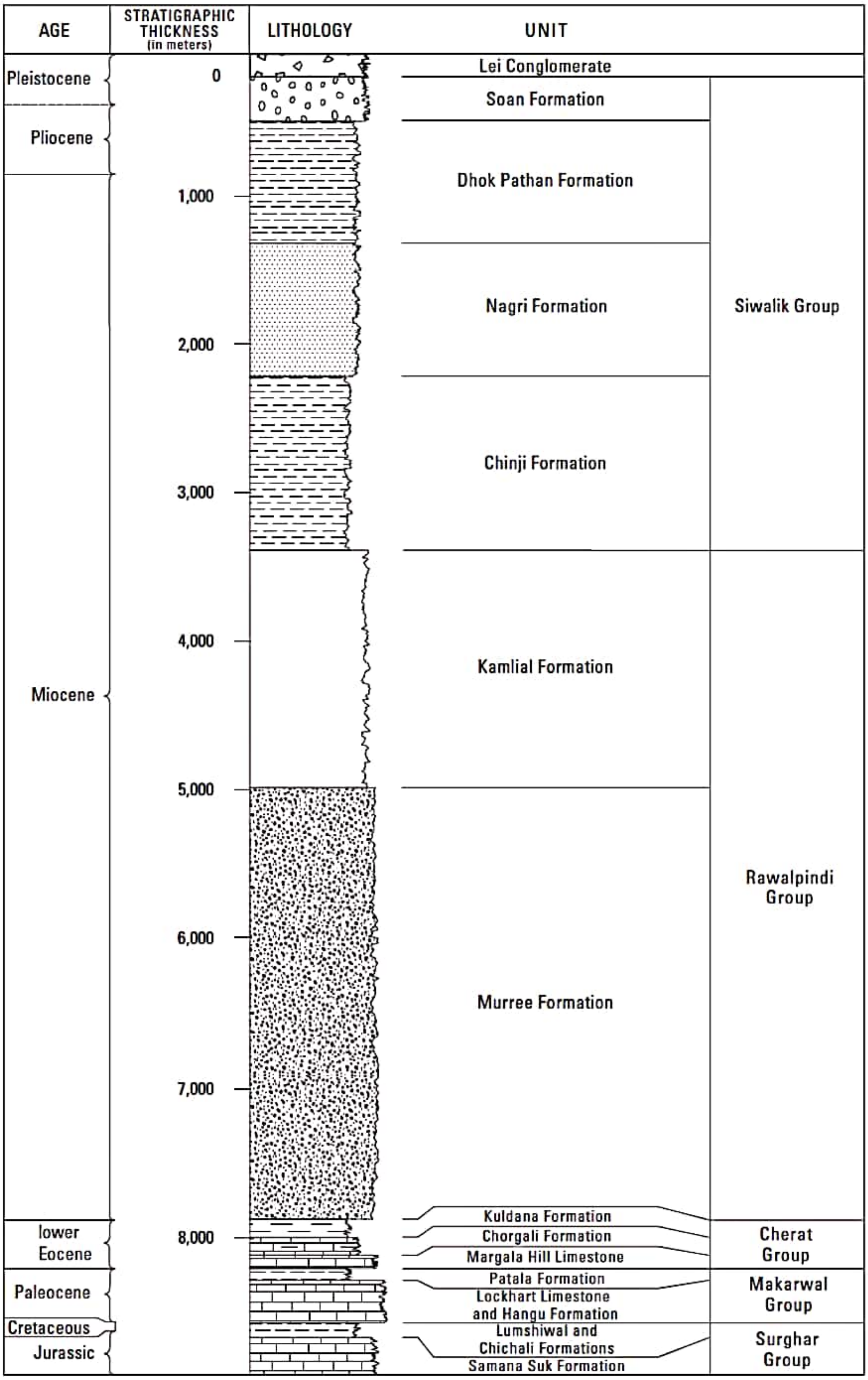

Figure 2.1.Stratigraphy of Islamabad area (Williams, V., Pasha, M. and Sheikh, I. (1990)

CHAPTER 3
AGGREGATES AND SPECIFICATION STANDARDS

3.1 Introduction

Aggregates are defined as inert, granular, and inorganic materials that normally consist of stone or stone-like solids. Aggregates can be used alone (in road bases and various types of fill) or can be used with cementing materials (such as portland cement or asphalt cement) to form composite materials or concrete.

The most popular use of aggregates is to form portland cement concrete. Approximately three-fourths of the volume of portland cement concrete is occupied by aggregate. It is inevitable that a constituent occupying such a large percentage of the mass should have an important effect on the properties of both the fresh and hardened products. As another important application, aggregates are used in asphalt cement concrete in which they occupy 90% or more of the total volume.

3.2 Classification of aggregate

Aggregates can be divided into several categories according to different criteria.

3.2.1 Based on aggregate size

3.2.1.1 Coarse aggregate

Aggregates predominately retained on the No. 4 (4.75 mm) sieve. For mass concrete, the maximum size can be as large as 150 mm.

3.2.1.2 Fine aggregate (sand)

Aggregates passing No.4 (4.75 mm) sieve and predominately retained on the No. 200 (75 μm) sieve.

3.2.2 Based on aggregate source

3.2.2.1 Natural aggregates

This kind of aggregate is taken from natural deposits without changing their nature during the process of production such as crushing and grinding. Some examples in this category are sand, crushed limestone, and gravel.

3.2.2.2 Manufactured (Synthetic) aggregates

This is a kind of man-made materials produced as a main product or an industrial by-product. Some examples are blast furnace slag, lightweight aggregate (e.g. expanded perlite), and heavy weight aggregates (e.g. iron ore or crushed steel).

3.2.3 Based on aggregate unit weight

3.2.3.1 Light weight aggregate

The unit weight of aggregate is less than 1120 kg/m3. The corresponding concrete has a bulk density less than 1800 kg/m3. (Cinder, blast-furnace slag, volcanic pumice).

3.2.3.2 Normal weight aggregate

The aggregate has unit weight of 1520-1680 kg/m3. The concrete made with this type of aggregate has a bulk density of 2300-2400 kg/m3.

3.2.3.3 Heavy weight aggregate

The unit weight is greater than 2100 kg/m3. The bulk density of the corresponding concrete is greater than 3200 kg/m3. A typical example is magnesite limonite, a heavy iron ore. Heavy weight concrete is used in special structures such as radiation shields.

3.3 Physical properties

The physical properties of aggregates are those that refer to the physical structure of the particles that make up the aggregate.

(1) Absorption

(2) Porosity

(3) Permeability

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid. Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

3.3.1 Surface texture

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or Portland cement concrete.

Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of portland cement concrete.

Some aggregates may initially have good surface texture, but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category. Dolomite does not, in general, when the magnesium content exceeds a minimum quantity of the material.

3.3.2 Strength and elasticity

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle. High strength and elasticity are desirable in aggregate base and surface courses. These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

3.3.3 Density and specific gravity

Density is the weight per unit of volume of a substance. Specific gravity is the ratio of the density of the substance to the density of water. The density and the specific gravity of an aggregate particle are dependent upon the density and specific gravity of the minerals making up the particle and upon the porosity of the particle. These may be defined as follows.

(1) All of the pore space (bulk density or specific gravity)

(2) Some of the pore space (effective density or specific gravity)

(3) None of the pore space (apparent density or specific gravity)

Determining the porosity of aggregate is often necessary; however, measuring the volume of pore space is difficult. Correlations may be made between porosity and the bulk, apparent and effective specific gravities of the aggregate. As an example, specific gravity information about a particular aggregate helps in determining the amount of asphalt needed in the hot mix asphalt. If an aggregate is highly absorptive, the aggregate continues to absorb asphalt, after initial mixing at the plant, until the mix cools down completely. This process leaves less asphalt for bonding purposes; therefore, a more porous aggregate requires more asphalt than a less porous aggregate. The porosity of the aggregate may be taken into consideration in determining the amount of asphalt required by applying the three types of specific gravity measurements. The bulk specific gravity includes all the pores, the apparent specific gravity does not include any of the pores that would fill with water during a soaking, and the effective specific gravity excludes only those pores that would absorb asphalt. Correlation charts and tables provide guidance to asphalt quantities or acceptability of the aggregate.

3.3.4 Aggregate voids

There are aggregate particle voids, and there are voids between aggregate particles. As solid as aggregate may be to the naked eye, most aggregate particles have voids, which are natural pores that are filled with air or water. These voids or pores influence the specific gravity and absorption of the aggregate materials. The voids within an aggregate particle should not be confused with the void system which makes up the space between particles in an aggregate mass. The voids between the particles influence the design of hot mix asphalt or portland cement concrete.

3.3.5 Hardness

The hardness of the minerals that make up the aggregate particles and the firmness with which the individual grains are cemented or interlocked control the resistance of the aggregate to abrasion and degradation. Soft aggregate particles are composed of minerals with a low degree of hardness. Weak particles have poor cementation. Neither type is acceptable. The Mohs Hardness Scale is frequently used for determination of mineral hardness (Figure 3-2). Although there is no recognizable Indiana Department Of Transportation (INDOT) specification or requirement which pertains to Mohs Hardness Scale, the interpretation, concept, and use of this scale is useful for the field identification of potentially inferior aggregates.

3.4 General characteristics

Aggregates have three primary uses in highway construction.

(1) As compacted aggregates in bases, sub bases and shoulders.

(2) As ingredients in hot mix asphalt.

(3) As ingredients in portland cement concrete.

Aggregates may also be used as special backfill material, riprap, mineral filler, and in less significant uses.

3.4.1 Compacted aggregates

Compacted aggregates without the addition of a cementing material may be used as a base or sub-base for hot mix asphalt and portland cement concrete pavements. portland cement concrete pavements are rigid pavements. For these types of pavements, the purpose of the base may be to improve drainage, to prevent pumping, or to cover a material that is highly susceptible to frost. Consequently, gradation and soundness are the primary considerations in selecting or evaluating aggregates for bases under rigid pavements. The load-carrying capacity is a primary factor in the selection of aggregates for hot mix asphalt pavements. A hot mix asphalt pavement does not carry the load; help from the underlying base courses is required. In addition to gradation requirements, the aggregates are required to also possess the strength to carry and transmit the applied loads.

Aggregates are sometimes used to make up the entire pavement structure. In this type of pavement, aggregates are placed on the natural soil to serve as a base course and surface course. Again, the primary requirement is the gradation.

In many instances, compacted aggregates are also used to construct roadway shoulders and berms. In these applications, gradation and stability are very important.

3.4.2 Aggregate for hot mix asphalt

INDOT uses hot mix asphalt in a number of different ways. In all cases the aggregates used should meet five requirements:

(1) Strong, tough and durable

(2) The ability to be crushed into bulky particles, without many flaky particles, slivers or pieces that are thin and elongated
(3) Low porosity
(4) Low permeability
(5) Correct particle size and gradation for the type of pavement

3.4.3 Aggregate for portland cement concrete

There are many uses of Portland cement concrete in highway construction. Some of the major uses of aggregates are in rigid-pavement slabs, bridges, concrete barriers, sidewalks, curbs, slope walls, and other structures. Aggregates in Portland cement concrete are required to always be physically and chemically stable. Other factors to be considered include:

(1) The size, distribution, and interconnection of voids within individual particles
(2) The surface character and texture of the particles
(3) The gradation of the coarse and fine aggregates
(4) The mineral composition of the particles
(5) The particle shape
(6) Soundness abrasion resistance
(7) Water absorption

3.5 AASHTO STANDARDS

For road construction standards are proposed by AASHTO which are shown in Table 3.1

Table 3.1.AASHTO specification standards for each layer of roads construction.American Society of Testing and Materials (ASTM)

S.NO	Layers		Material required per AASHTO Standard	FDT (Maximum required compaction value)	Gradation (Sieve analysis) Sieve No. 200 (Passing material)	Plastic Index (PI)
1	Asphalts	Wearing coarse Base coarse	---------------	93 – 97% 3 – 4 air voids required	---------------	---------------
2	Aggregates/Water bound		---------------	100%	---------------	---------------
3	Sub base		A1-a, A1-b	98%	15 Max, 25 Max	6 Max, 6 Max
4	Sub base		A-4, A-5, A-6	95%	36 Min, 36 Min, 36 Min	10Max 10Max 11Min
5	Embankment	Zone A	A-3 (used in floody areas)	95%	10 Max	N.P
		Zone B	A-1, A-2, A-3, A-4, A-4	93%	15 Max, 35 Max.	10 Max
		Zone C		90%	10 Max, 36 Min	10 Max
6	NGC (Natural Ground Compaction)		---------------	90%	---------------	---------------

Table 3.2.Gradation of fine aggregates.(General specification standards (1998) Available at: http://downloads.nha.gov.pk/nhadocs/nha-general-specification-e-35-volum-ii.pdf).

Gradation of fine aggregates	
Sieve designation	Percentage passing by weight
No. 3/8	100
No. 4	95-100
No. 16	45-85
No. 50	10-30
No. 100	2-10
No. 200	0-3

Table 3.3.AASHTO soil classification American Society of Testing and Materials (ASTM) D590, reapproved 1998

General Classification	Granular material (35% passing or less total sample passing sieve No. 200)										
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1a, A-1b			A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6
Sieve Analysis											
Sieve No. 10	Max 50	......	......	......	......	......	......	......	......	......	......
Sieve No. 40	30 Max	50 Max	51 Max	......	......	......	......	......	......	......	......
Sieve No.200	15 Max	25 Max	10 Max	35 Max	35 Max	35 Max	35 Max	36 Min	36 Min	36 Min	36 Min
Characteristic fraction passing #40											
Liquid Limit	......	......	......	40 Max	41 Max	40 Max	41 Max	40 Max	41 Max	40 Max	41Max
Plastic Limit	6 Max	6 Max	N.p	10 Max	10 Max	11 Min	11 Min	10 Max	10 Max	11 Min	11 Min
Group Index	0	0	0	0		4 Max		8 Max	12 Max	16 Max	20 Max

Table3.4.AASHTO specification table for sieve analysis. (General specification standards (1998)

Sieve Designation		Mass Percentage Passing Grading	
Mm	Inch	A	B
50.0	2	100	100
25.0	1	70-95	95-65
9.5	3/8	30-65	40-75
4.75	No. 4	25-55	30-60
2.00	No. 10	15-40	20-50
0.425	No. 40	8-20	12-25
0.075	No. 200	2-8	5-10

CHAPTER 4

ENGINEERING PROPERTIES OF PROJECT SITE

4.1 Gradation (Sieve Analysis)(ASTM: C 136M)

4.1.1 Purpose

The gradation is primarily used to determine the grading of material proposed being used as aggregate and for the classification of aggregates .This test determines the particle size distribution of course and fine aggregates with the help of sieves. The outcome are utilized to decide compliance of the particle size distribution with applicable requirements and to give necessary data for control of the production of various aggregate products and blends containing aggregates. This data may likewise be valuable in creating connections containing porosity and packing. This test is normally used for all layers i.e. sub grade, sub base, embankment, water bound and asphalt on road construction.

4.1.2 Apparatus

(1) Oven for drying sample

(2) Balance

(3) Sieves

(4) Sieve shaker

Figure 4.1.Sieves and sample for gradation.

4.1.3 Procedure

Mix the sample of aggregate thoroughly. Quarter the sample by quartering machine and reduce it to desired suitable amount required for test as shown in figure 4.1. Take minimum 13119gm sample for aggregate base course as given below. Wash the sample for the determination of the percent mass of particles finer than #200 sieve. Weight and record the mass of sample coarser than #200 sieve after drying in oven at a constant temperature of 110 ± 5 C°. Select sieves with suitable openings to furnish the information required by the specifications covering the material to be tested. Sieves are arranged in the descending order of their sizes with a pan at bottom. The sieving operation shall be conducted by lateral and vertical motion of the sieves so as to keep the sample moving continuously over the sieve surface. The soil particles shall not be turned or manipulated through the sieves by hand. Sieving shall be continued until not more than one percent by mass of the residue passes any sieve during 60-seconds. Remove the sieves from the sieve shaker and record the mass of the soil retained on each sieve. Remove the particles sticking to the sieve mesh and should be included to the mass retained. Tabulate the data and calculate the percentage passing as shown in the following table. Gradation of 4.no sieve pass and retain materials conduct separately and in final compile the result with respect to the total material

4.2 CBR (California bearing ratio)(ASTM: D1883-05)

4.2.1 Purpose

CBR (California bearing ratio) was developed by California state highway department of USA in around 1930. It is the penetration test for the evaluation and test of the aggregate base coarse grade strength of highway and pavement. This test tells us about the thickness of pavement and its components layers. It is usually used with the empirical curves for the determination of the results. It also tells us about the load bearing capacity of the road. California bearing ratio is defined as the ratio of the force per unit area required to penetrate the soil mass with a standard circular piston of specific rate to that required for the corresponding of the standard material. CBR value is usually defined and determined at 2.5 mm and 5 mm penetration.

4.2.2 Apparatus

(1) Moulds (diameter of 150 mm and height of 175 mm)

(2) Detachable base plate

(3) Detachable collar

(4) CBR machine (load capacity of 5000 kg and capable of traveling at the rate of 2.5mm)

(5) Spacer disk (148mm diameter and height of 47.7mm)

(6) Metal rammer (2.5 kg)

(7) Slotted weight (2.5 kg each having center hole of 50mm)

(8) Graduated cylinder Sampling tray, Scoop

(9) Straight edge

(10) Balance

(11) Soaking tank, filter paper, gloves

(12) Sieves ¾ In, 4mm

Figure 4.2.CBR mould for sample preparation.

4.2.3 Procedure

CBR usually perform after the proctor test. First we take a sample from the site. For the preparation of the mould we first use sieve ¾ and sieve no. 4 in such a way the passing of sieve no. ¾ and retain and pass of sieve no. 4. Retain of the sieve no. 4 is coarse material and pass of that is fine material. We usually required a sample of 8 kg for a mould so we classify our sample we use 60 % coarse material and 40% fine material in the mould. We than add optimum moisture content to the sample which we already calculated from proctor test as for our test concern we have 6 percent optimum moisture content. We add 6 % water and mix the sample well enough. We divide the sample into five layers in a large tray. Place the filter beneath the mould and above the base plate. We put first layer into the mould A and give 10 blows and we repeat that process for all the 5 layers as shown in figure 4.2. We then remove the collar and use the straight edge to level the surface of the mould. We detached the mould from the base plate and weight it. We remove the filter paper from the base plate and place the mould in such a way that straight edge surface is place at the bottom and filter paper side is now facing the top. After that place filter paper and two slotted weights of 2.5 kg each above the mould. These apply pressure on the surface of sample. As for the mould B we prepare another 8 kg sample of 60% coarse and 40% fine material. We repeat the same procedure for the mould B but a little change of blows. We now give 30 blows to each layer. Same procedure is used for the mould C but now we give 65 blows each of the five layers. After the moulds are prepared we placed them in a soaked tank for 96 hours. After 96 hours take out the moulds and remove the slotted weight and place those on the CBR machine note the reading on different penetration.

4.3 Proctor Test (ASTM: D698)

4.3.1 Purpose

Proctor test or compaction test is a method used in laboratory to find the optimum moisture content at which maximum dry density can be achieve. The compaction is used to reduce the air voids by using metal rammer. Every aggregate material has its own specific compaction value.

4.3.2 Apparatus

(1) Compaction mould
(2) Detachable base plate
(3) The Rammer (2.6 kg)
(4) Collar
(5) Sieves No. ¾, ½, 3/8, 4
(6) Straight edge
(7) Weight balance
(8) Mixing tools (Pan, Spoon, Towel, Spatula)

(9) Graduated cylinder, Containers

(10) Desiccators and Oven

4.3.3 Procedure

We take a sample of 7000 g from the field. We used four sieves and place them on each other. The first we place sieve ¾ below which the sieve no. ½, 3/8, and No. 4 lays respectively. Calculate the weight of aggregate whichpass from sieve no. ¾ and retained on the sieve no. ½, 3/8 and 4. Also calculate the weight of material passing from sieve no.4 (fine material). The retained weight on the sieves is 4095 g and passing through sieve no. 4 is 2095 g. After that mix the material in the large tray and dry the sample in oven. After complete dry we pour water of about 2% which is 140 ml using graduated cylinder. Mix the material. Weight the mould and make the 5 layer for the mould. Put each layer in the mouldand gave 56 blows to each layer with the help of Rammer. After first mould is ready remove the collar and level the mould with the help of straight edge and give light blows with the rubber hammer if it is required to level the surface. Total weight of the mould is 8855 g. The weight of mould is 4388 g and weight of material 4467 g. Calculate the Wet density which is equal to weight of compacted sample divided by volume of mould. After this we calculate dry density. We take small container and weight it 43 g. Then we take sample from material of about 237 g (container + sample). Oven dries the sample for 24 hrs. Calculate the water content which is 5 g. We then calculate dry density. We take another mould and repeat the whole process but by first adding 1.5 % extra water to the previous sample. Give 56 blows to the 5 layers .Take a sample of 236 g in a container and oven dies it. Calculate the water content for container B which is 6 g. After that we add 1.5% extra water to the sample and repeat the whole process for containers C,D and E. After the complete process we calculate dry density and water content for each of the container. We draw graph between dry density and water content such that the water content is in the horizontal axis and dry density on vertical axis. Plot all the points on the graph and joint them smoothly. This gives a relationship between dry density and water content for aggregate. From the curve maximum elevation of the graph is maximum dry density on vertical axis and Optimum moisture content on the horizontal axis.

4.4 Specific gravity and absorption (ASTM D6473-15)

4.4.1 Purpose

Aggregate which are sometime buttes as an inert ingredient occupy nearly seventy to seventy five percent volume of concrete however it is well recognized that physical, chemical and thermal properties of aggregate greatly influenced the properties and performance of concrete. One of the important properties of coarse aggregate is the determination of its specific gravity and water absorption.

4.4.2 Apparatus

To carry out this experiment the apparatus required includes:

(1) Weight balance

(2) Oven

(3) Glass vessel

(4) Air tight container

(5) Scoop

(6) Sieve ¾

(7) Coarse aggregate sample

(8) Observation sheet

(9) Wire mesh container

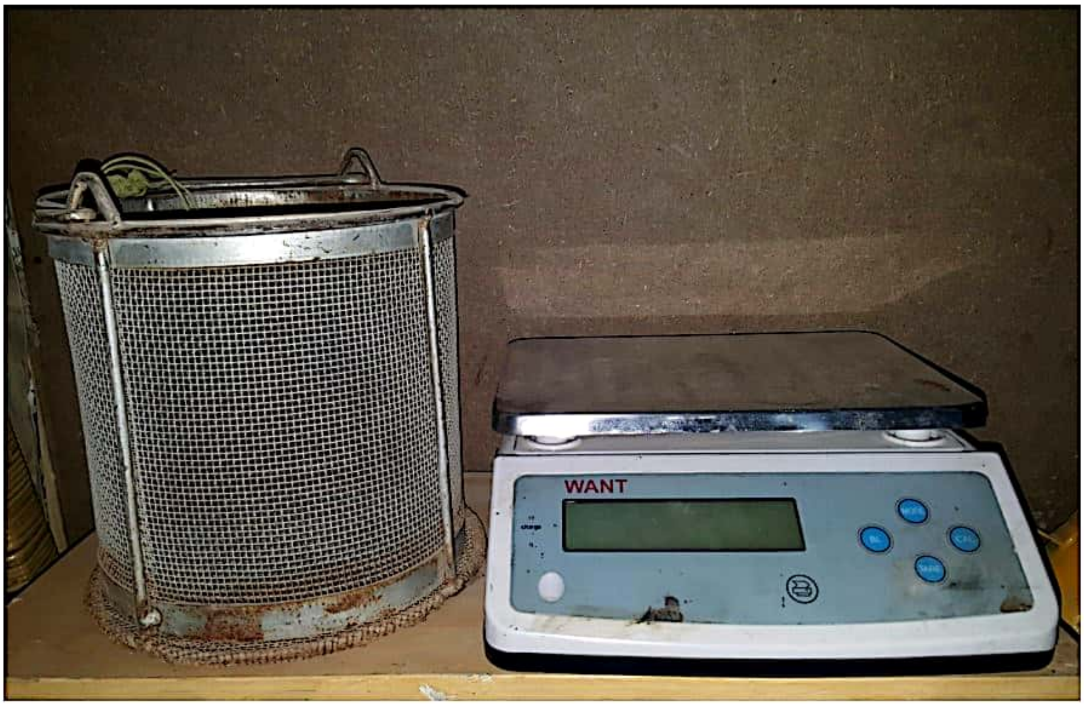

Figure 4.3.Wire mesh used for specific gravity and water absorption test.

4.4.3 Procedure

To start the experiment we take 4900 g sample weight of coarse aggregate. The quantity of sample depends upon the size of aggregate. Record the reading on the observation sheet. Use the Sieve ¾ to remove the fine particles from the sample. Place the sample in the glass vessel. After that put water in the sample of vessel glass and keep that for 24 hrs. After that we used towel to saturate surface dry the sample. We weight again the sample and note it that weight is SSD weight which is equal to 4779 g. Now we put the sample in the wire mesh container as shown in figure 4.3 and take water in a separate container place the sample in the water container and weight the sample such that it cannot touch the side and bottom of the container. The weight of sample in water is 2927 g then oven dry the sample for 24 hrs. After 24 hours weight the sample which is equal to 4746 g. Calculate the following Bulk specific gravity for oven dry sample, Bulk specific gravity of SSD, Apparent specific gravity and Water absorption percentage.

4.5 Los angeles (ASTM: C131)

4.5.1 Purpose

Aggregates used in the aggregates base coarse layer of roads are subjected to wear due to vehicles moving over it.Thefraction between the moving tires and the road surface result in abrasion of aggregates. This effect further enhanced due to presence of dust particles on road surface. Therefore the aggregates should bear enough resistance against abrasion. This property is evaluated by abrasion value test. Various types of test can be used for determining abrasion value. These are

(1) Los angeles abrasion value test

(2) Deval abrasion test

(3) Dorry abrasion test

4.5.2 Apparatus

(1) Los Angeles abrasion machine

It has a hollow steel cylinder having an internal diameter 17cms and length 50cms.The machine can rotate about the horizontal axis. The shelf within the cylinder is placed at a distance of minimum 125 cm from the opening in the direction of rotation.

(2) Abrasive charge

It comprised of steel balls of diameter 48mm and weight between 390 to 445gm. 12 balls are available for such test ,there number depends upon the type of grading used.

(3) Weighing matching

(4) Sieves:

1", 3/4", 1/2", 3/8"

The aggregates used for test comprised of grading. The selection of grading is dependent on designated use, e.g. for WBM we will select grading E,for SDBC Grading B,C or D are selected. We performed the test for Grade A aggregates in which we used the required sieves of 1",3/4", ½" and 3/8".A total of 2.5 kg of materials passing 1" sieve and retain on ¾" sieve is taken and also 2.5 kg of material passing ½' sieve and retain on 3/8" is taken.

Figure 4.4.Los angeles machine.

4.5.3 Procedure

First of all 5 kg of materials is taken and dry an oven under 110 for 24 hours. Took the material out and allow it to cool at room temperature. Measure the exact weight of the sample after drying. Corresponding to the selective grading we used abrasive charge, for grading A we need 12 steel balls. Before starting the test it is necessary to ensure that the cylinder is clean from inside. After that sample along with the abrasive charge placed in the cylinder fixed the cover firmly in position as shown in figure 4.4. Check that the counter has reading zero. Now switch ON the machine and allow the machine to run at the speed of 30 to 33 revolutions per minute. Give 500 revolutions for Grading A, B, C, and D, and 1000 revolutions for Grading E, F and G. Since we used the grading A we subjected the sample to 500 revolutions. During the movement the aggregates are subjected to abrasion by the steel balls, they also rub against each other which is known as attrition. Thus both the abrasion and the impact occur during this test. There this test simulates field condition better as compared to any other such test. After the test is completed removed the material from the cylinder and used a 12mm sieve. Measured the passing and retained weight of the sample.

4.6 Sand equivalent test (ASTM: D2419)

4.6.1 Purpose

Sand equivalent test is used to show the relative proportion of dust and clay material in fine aggregate. Higher the values of sand equivalent less will the presence of clay material. Before using material in construction it is necessary to know that how much clay content is present in material.

4.6.2 Apparatus

(1) Graduate cylinder
(2) Scoop
(3) Rubber stopper a flexible siphon hose
(4) Timer
(5) Funnel
(6) Sand equivalent cup (120g)
(7) Stock solution (4 % glycerin plus formaldehyde, 96 % water or 1 % Nacl solution)
(8) Assembly, cans
(9) Sieve (4mm)

Figure4.5.Apparatus for sand equivalent.

4.6.3 Procedure

The sample is collected from the field site that is used in concrete. Take a sample of about 500 gm passing of sieve 4mm as shown in figure 4.5. First of all mix the sample well and divide the sample into 4 equal parts. Fill the can with the sample and weight it 146 gm (can + material). Pour the 4 inch stock solution into the graduate cylinder. Using cone pour the sample of can into the graduated cylinder. Keep it for 10 minutes. After 10 minutes shake the cylinder such that 90 times shaking in 30 seconds with a distance should be 6 inch. Repeat the experiment for second and third can both the samples are of 146 gm each. The interval between cylinders is 2-3 minutes each. After shaking leave the graduated cylinder for 20 minutes undisturbed. After that stock solution is added and placed it more 10 min undisturbed. Note the reading of clay and sand in the graduated cylinder tube and it is done by putting assembly down in the tube.

4.7 Atterberg limit (ASTM: D4318)

4.7.1 Purpose

In this test we determined the liquid and plastic limit of aggregate base course. The atterberg limit is a basic measure of the critical water contents of a fine-grained soil: its shrinkage limit, plastic limit, and liquid limit. As a dry, clayey soil takes on increasing amounts of water, it undergoes distinct changes in behavior and consistency.

4.7.2 Apparatus

(1) Mechanical liquid limit device
(2) Casagrande type tool& ASTM type tool
(3) Porcelain evaporating dish
(4) Spatula
(5) Balance
(6) Thermostatically controlled oven
(7) Wash bottle containing distilled water
(8) Sample containers
(9) 40 mm sieve

Figure4.6. Apparatus for atterberg limit.

4.7.3 Procedure

To start with the liquid limit first inspects the liquid limit device, to ensure that it is clean, dry and working order as shown in figure 4.6. From a prepared sample passing through 40mm sieve take about 200 g samples in a evaporating dish. Add distilled water to the soil sample. Mix it thoroughly to form uniform paste of a spatula. If the soil is clayey leave it for 24 hours to ensure uniform moisture distribution. Now place a portion of a paste in the cup of liquid limit device. Squeeze down and spread the paste in the cup with the spatula. Clean the soil at the top so that the maximum depth of soil in the cup is 1 cm. If the soil is clayey used the casagrande grooving tool to divide the paste in the cup into 2 half in a direction perpendicular to the direction of rotation of handle. As the soil is sandy used the ASTM grooving tool .Now lift and drop the cup by rotating the handle at the rate of two revolutions per second till two half of the soil paste come in contact by flowing and not by sliding with the bottom of the groove along a distance of about 12mm. count the number of blows required and record the readings in the performer. Ensure that the number of blows range between 15 to 35.From a float portion take a representative sample using a spatula in a sample container of known weight. Determine the moisture content of sample as per standard procedure.

4.7.4 Plastic limit

Plastic limit of a soil is the water content at which a soil just begins to crumble when rolled in to the thread approximately 3mm diameter. But the test sample was non plastic in nature, because the sample was unable to form a ball or to roll in to thread. The sample mostly consists of sandy soil and non-plastic in nature which belongs to grade A-3.

4.8 Field density test (ASTM: D1556-00)

4.8.1 Purpose

The field density test also known as sand cone method test used to determine the moisture content of compacted soil and amount of compaction achieve in the field. Compaction is very important for the sub base grade layer and in construction of roads or embankment in order to increased stability. Field density is determined through several methods such as core cutter method, sand replacement method and heavy oil method etc. Among them the most common is sand replacement method which is used for coarse grain. The core cutter method has certain limitations for coarse grain soil. The basic principle of test is to measure the volume of the in-situ hole from we excavate the material and filled it with sand of known weight. The in-situ density of the material is given by the weight of the excavated material divided by the in-situ material.

4.8.2 Apparatus

(1) Sand pouring cylinder(cone)

(2) Cylinder calibrating container

(3) Metal tray with hole (for excavation)

(4) Excavation tool

(5) Weight balance

(6) Metal tray

(7) Sand (passing 1mm and retained on 600 micron through sieve)

(8) Water determination apparatus

(9) Glass plate

4.8.3 Procedure

The test conducted in two steps calibration of apparatus and measurement of field density.

4.8.3.1 Calibration of apparatus

Calibration of tool includes determination of the density of sand used in the experiment and also determination of the weight of sand occupying the space of sand pouring cylinder. We used clean and dry sand for sieve and take a sample (pass on 1 mm and retained on 600 micron) of 9000 gm. The top cap of the cylinder is removed and shutter is closed. Pouring cylinder is filled with the dry sand up to about 10mm from the top. Weight the pouring cylinder that is 1799 gm. The weight of the cylinder with the sand is w1.In all test i.e. calibration test and field density test the initial weight for sand is w1. Keep the Sand pouring cylinder on the cylinder calibrating container and open the shutter till the calibrating cylinder (cone) is filled and then closed the shutter. Now place the pouring cylinder on the glass plate and open the shutter and allow the sand to run out until no further visible movement of the sand is seen. Now closed the shutter and remove the sand pouring cylinder and carefully collect the sample which is left on the glass plate. Weight the sample in another container and now pouring cylinder is again refilled with the sand to its initial weight w1. Now place the cylinder on the central top of the calibration cylinder and open the shutter so the sand run out and when the sand fill the calibration container then closed the shutter and weight them both and repeat the experiment 2 to 3 times to find the mean values for w2 and w3 which is 7210 gm (wt of sand in hole and cone). Weight of cylinder in cone is 3266 gm. The unit weight of sand is 1.398gm/cc. The volume of the calibrating cylinder is determined by measuring the internal diameter. From the weight of sand and its volume we measure density of sand.

4.8.3.2 Measurement of field density

In the field where the field density test is to be conducted the area of about 450mm sq is cleaned and leveled by using scraper. Keep the metal tray with the central hole on the surface which is cleaned and prepared. Excavate the material from the hole using excavation tool. The excavation depth is up to 15 cm. Remove the excavated material and collect that material in metal container and weight it 3935gm. The sand pouring cylinder is refilled again with the sand such that its weight becomes w1. Place the pouring cylinder on the metal tray vertically and centrally on the hole after that open the shutter and allow the sand to run out from the cone until no further movement is seen. The shutter is closed and weights the cone which is 1799 gm. Take some specimen sample for the determination of moisture content which is 5.0 % by using speedy moisture apparatus.

4.9 Calculations and results

4.9.1 Gradation (ASTM: C 136M)

Table 4.1.Retained percentage of each sieve for gradation

Maximum sieve size (in/mm)	Minimum mass of sample (g)
2″	NIL
1″	3535
1/2″	7227
3/8″	8359
4 mm	10152
10 mm	259
40 mm	459
200 mm	576

Table 4.2.Calculation of aggregate base course gradation

Sieve analysis							
				Weight of dry sample + container (g)			
Description : 1 ½" Aggregate				Weight of container : (g)			
				Weight of dry sample :			
ASTM Sieve	Size(mm)	Wt. Retained (g)	Cum Weight Retained (g)	Cum Retained %	Passing observation Report		Specification %
3"	75						
2"	50		Nil	Nil	100		100
1 ½"	38						
1"	25		3535	26.9	73.1		70-95
¾"	19						
½"	12.5		7227	55.1	44.9		-----
3/8"	9.5		8359	63.7	36.3		30-65
#4	4.75		10152	77.4	22.6		25-55
Total weight = 757g							
					pass %	Actual pass%	
#10	2		259	34.2	65.8	15	15-40
#16	1.18						
#30	0.6						
#40	0.425		459	60.6	40	9	8-20
#50	0.3						
#80	0.18						
#100	0.15						
#200	0.075		576	75.8	24.2	5.5	2-8
Pan	-0.075						
Fineness modulus = (1.2 ratio of sieves, addition cum retained % from (+)							
Dry constant weight of sample after washing + #200 sieve: (g)							
Lost percentage of sample during test (ii-pan)/1*100 (%)							
Percentage of material finer than No. 200 sieve by washing, [(i)-(ii)]/(i)*100 : %							

Mass% passing #200 sieve = [(mass of sample before washing – mass of Sample after washing)/mass of sample before washing] x100.

Retained mass % = (retained mass / total sample mass) X 100

Cumulative retain mass% = retain mass of first + retain mass of second

Passing % = 100 – cumulative retain mass %

Recommend value

According to AASHTO standards the results of this test shows that it belongs to A grade material. This grade A type material is suitable for all types of construction.

4.9.2 CBR (California bearing ratio) (ASTM: D1883-05)

Table 4.3.Calculation of California bearing ratio for aggregate base course.

California bearing ratio								
Molding moisture content					**Density determination**			
Test no.		1	2	3	Mold No.	1	2	3
Can no.		X	Y	Z	Mold + wet soil (g)	10442	10746	10974
A	Wt. of wet soil + Can(g)	395.5	380.2	388.2	Wt. of mold (g)	5740	5775	5636
B	Wt. of dry soil + Can(g)	378.7	365	372.8	Wt. of wet soil (g)	4701	4971	5338
C	Wt. of water (g)	16.8	15.2	15.4	Mold volume (cc)	2124	2124	2124
D	Wt. of can (g)	110	120	114	Wet density (g/cc)	2.214	2.340	2.513
E	Wt. of dry soil(g)	268.7	245	258.8	Moisture content (%)	6.3	6.2	6.0
F	Moisture content C//E*100 (%)	6.3	6.2	6.0	Dry density (g/cc)	2.083	2.204	2.372

Test No.		Standard Load Stresses Kg/cm²	**1**				**2**				**3**			
Blows Per Lift			**10**				**30**				**65**			
Penetration			Molded		Tested		Molded		Tested		Molded		Tested	
Time Min.	Pent min.		Dial Reading	Load Kg	Unit Load Kg/ Cm²	CBR h%	Dial Reading	Load Kg	Unit Load Kg/ Cm²	CBR %	Dial Reading	Load Kg	Unit Load Kg/ Cm²	CBR %
½	0.64		9	183.5	9.5		12	244.7	12.6		24	489.4	25.3	
1	1.27		14	285.5	14.8		24	489.4	25.3		40	815.6	42.1	
1½	1.90		18	367	19		34	693	35.8		54	1101	56.9	
2	2.54	70.3	22	448.6	23.2	33	45	917.6	47.4	67.4	69	1406.9	72.7	103.4
3	3.81		31	632.1	32.7		59	1203	62.2		87	1773.9	91.7	
4	5.08	#	39	795.2	41.1	38.9	73	1488.5	76.9	72.9	101	2059.4	106.4	100.9
6	7.62		50	1019.5	52.7		92	1875.9	96.9		124	2528.4	130.7	

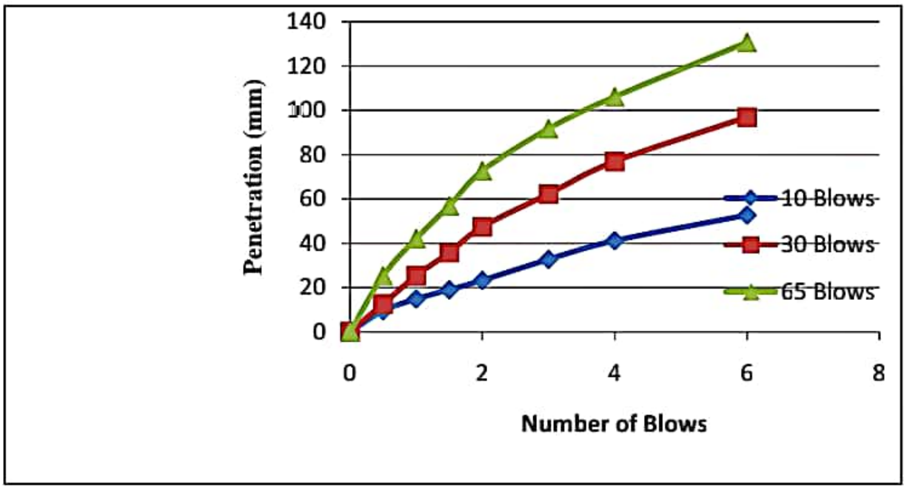

Figure 4.7.Relationship between number of blows and penetration (millimeters)

Table 4.4.Calculation of soaked C.B.R. for aggregate base course

No. of blows per layer	Dry density (g/cm²)	Soaked C.B.R.	Remarks
10	2.083	33	△
30	2.204	67.4	○
65	2.372	103.4	□

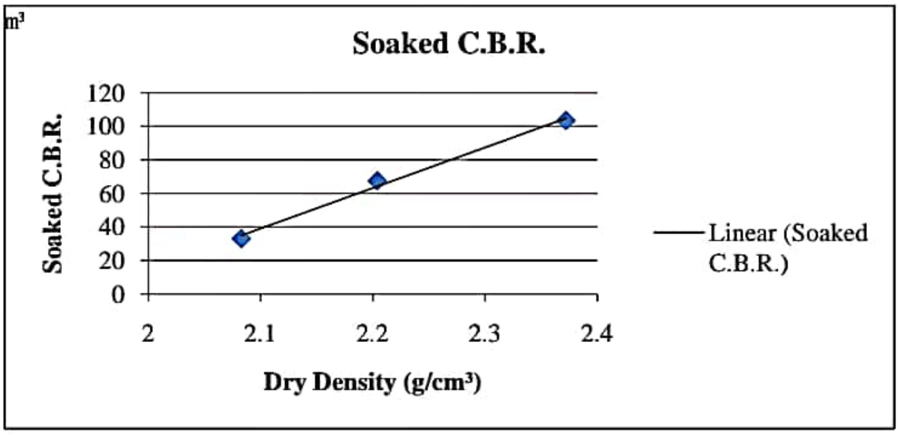

Figure 4.8 Relationship between soaked C.B.R and dry density (g/cm³).

Table 4.5California bearing ratio values calculated from proctor density.

Proctor	**Max dry density**		2.320	g/cm³
Modified	**Optimum moisture content**		5.92	%
Blows per lift no.		10	30	65
Dry density g/cm²		2.083	2.204	2.372
Soaked C.B.R %		33	67.4	103.4
100% of max. dry density		2.320g/cm³		
C.B.R at 100% of max. dry density		94.0%		

Recommend value

The test result is 94% which is according to AASHTO standards. It is penetration test for evaluation of mechanical strength of road base courses.

4.9.3 Proctor Test (ASTM: D698)

Table 4.6 Calculation of moisture density relation test for aggregate base course.

Moisture density relation					
Weight of mould = 4388		Volume of mould = 2116			
Trail no.	I	II	III	IV	V
Weight of wet soil + mould (g)	8855	9139	9509	9588	9480
Weight of wet soil (g/cc)	4467	4781	5121	5200	5092
Wet density (g)	2.111	2.245	2.42	2.457	2.406
Container No.	01	2	3	4	5
Weight of wet soil + container (g)	237	236	228	251	220
Weight of dry soil + container (g)	232	230	219	239.5	205
Weight of water (g)	05	06	9	12.5	15
Weight of container (g)	43	26	27	28	43
Weight of dry Soil (g)	189	204	192	211	162
Water content (%)	2.64	2.94	4.68	5.92	9.2
Dry density (g)	2.056	2.180	2.316	2.324	2.203

DRY density = Wet density / Water content + 100 * 100

Wet density = Weight of compacted material / volume of mould Water content = Weight of container (container A,B,C,D,E) + Sample – Dry sample weight.

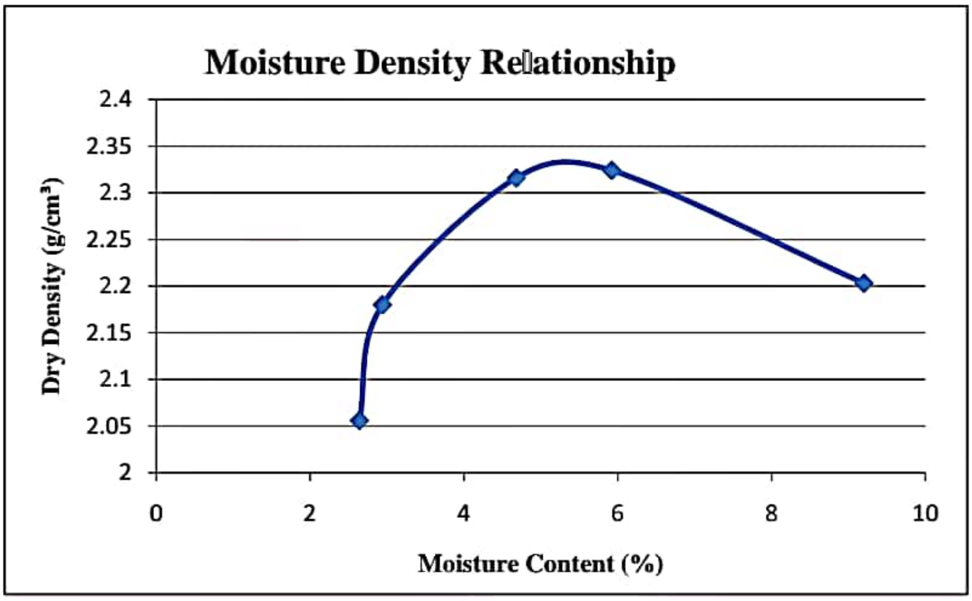

Figure 4.9. Relationship between moisture content (%) and dry density (g/cm³).

Recommend value

The acquired result of the maximum dry density is 2.32 and the optimum moisture content is 5.92 using heavy compaction. These results are applied directly during field compaction tests to express the percent compaction and determine if project design requirements are being met. The compaction is 100% which is according to AASHTO standards.

4.9.4 Specific gravity and absorption (ASTM D6473-15)

Table 4.7 Calculation of specific gravity and absorption test for aggregate base course.

Coarse aggregate					
Description of Sample			1	2	Total
1	Wt. of oven dry sample in air	(g)	2555	2191	4746
2	Wt. of saturated surface dry sample in air	(g)	2574	2205	4779
3	Wt. of saturated surface dry sample in water	(g)	1590	1337	2927
4	Oven dry bulk specific gravity = (1)/(2-3)	(g/cc)	------	-------	2.56
5	SSD Bulk specific gravity = (2)/(2-3)	(g/cc)	------	-------	2.58
6	Apparent specific gravity = (1)/(1-3)	(g/cc)	-------	-------	2.60
7	Absorption % =[(2-1)/1]*100	(%)	-------	--------	0.7

Bulk specific gravity of oven dry sample = oven dry weight / SSD weight – weight in water

Bulk specific gravity of SSD = SSD weight / SSD weight – weight in water

Apparent specific gravity = oven dry weight / oven dry weight – weight in water

Water absorption % = SSD weight / SSD weight * 100

Recommend value

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0. Though high specific gravity is considered as an indication of high strength, So water absorption shall not be more than 0.7 per unit by weight.

4.9.5 Los angeles (ASTM: C131)

Table 4.8 Calculation of los angeles abrasion test for aggregate base course.

Los angeles abrasion test							
Description							
Sieve size				Mass of Indicated Size (grams)			
Passing		Retained		A	B	C	D
(mm)	(inch)	(mm)	(inch)				
38.1	1-1/2"	38.1	1-1/2"				
25.4	1"	25.4	1"	1250			
19	¾"	19	¾"	1250			
12.7	½"	12.7	½"	1250			
9.5	3/8"	9.5	3/8"	1250			
6.4	¼"	6.4	¼"				
4.75	#4	4.75	#4				
Total				5000			

Total weight of sample = 5000g

Weight of fraction retained on 12mm sieve = 3968g

Los angeles = initial weight of sample (w1) – weight (w2) of 12mm sieve / total weight of sample * 100

Los angeles = 5000 – 3968g * 100 / 5000g

Los angeles = 20.6 %(fine)

Coarse = 100 – 20.6 = 79.4%

Recommend value

The acquired result is 20.6% which is best suitable for project. According to AASHTO standard it should not be greater than 40% for road base course.

4.9.6 Sand equivalent (ASTM: D2419)

Table 4.9 Calculation of sand equivalent for aggregate base course.

Sand equivalent
Description
Calculation A. Sand reading =3.1 B. Clay reading = 4.1 C. Sand equivalent = Sand reading/clay reading*100 Sand Equivalent =75%

Sand equivalent %= actual sand reading / clay reading * 100

Sand equivalent= 3.1/ 4.2*100= 74% aggregate base course

Sand equivalent= 3.1 / 4.1 *100= 76% aggregate base course

Mean value = 75%

Recommend value

The test result is 75%. According to AASHTO standard the sand values ranges from 75 to 80%.

4.9.7 Atterberg limit (ASTM: D4318)

Table 4.10 Calculation of plasticity index of aggregate base course.

Type of test	Liquid limits			Plastic limits	
No. of blows	17	25	33	NP	
Container no.	A	B	C	D	E
Container + wet soil A	35	36.6	39.1		
Container + dry soil B	30.4	31.89	34.1		
Weight of water	4.6	4.71	5		
Container C	10.2	10.9	11.1		
Weight of dry soil	22.2	20.99	23		
Moisture contents	22.8	22.4	21.73		
Limits	Liquid (LL) % =18.32			Non plastic	
Plastic Index	Non plastic				

Moisture content % = weight of water / weight of dry soil *100

Weight of water = wet weight – dry weight

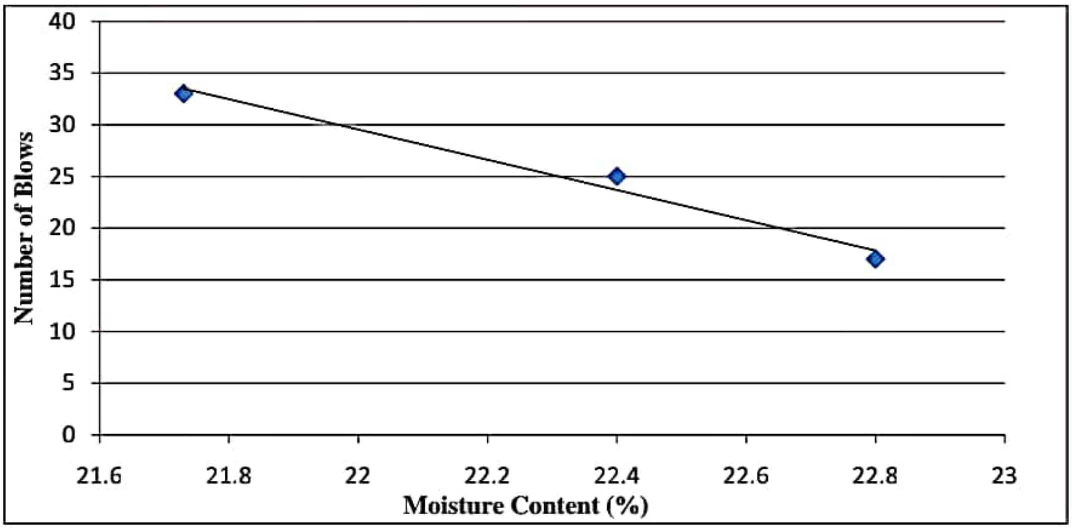

Figure 4.10.Relationship between no. of blows and Moisture content

Recommend value

The material we used was non plastic in nature. According to AASHTO standard plasticity index should not be greater than 6% for road base courses, if it is plastic.

4.9.8 Field density test (ASTM: D1556-00)

Table 4.11 Calculation of field density test

Field density test (FDT)		
1	Wt. of material excavated from hole (gm)	7130
2	Wt. of sand before pouring (gm)	9000
3	Wt. of sand after pouring (gm)	1799
4	Wt. of sand in hole & cone (gm)	7201
5	Wt. of sand to fill cone (gm)	3266
6	Wt. of sand to fill hole (gm)	3935
7	Unit wt. of sand (gm/cc)	1.398
8	Gross volume of hole (cc)	2815
9	Wt. Ret. ¾ from hole (gm)	1426
10	% age of Ret. ¾ from hole (%)	20
11	Wet density of soil (gm/cc)	2.533
12	Dry density of soil (gm/cc)	2.391
13	Max. dry density (gm/cc)	2.320
14	Opt. M.C. (%)	5.92
15	Adjusted proctor (gm/cc)	2.384
16	Compaction obtained (%)	100
17	Required compaction (%)	100

Bulk wet density of excavated soil = weight wet/volume of mold

Dry density = Wet density/ Water content + 100

Opt moisture content= 5.92% (proctor method)

Compaction= dry density*100%/ max dry density=2.391*100% / 2.32=101.2

Recommend value

Knowing the field density and field moisture content the compaction is calculated. According to AASHTO standards Compaction should be 100% for road base course. The FDT is importance as a field control test for the compaction of any pavement layer.

Table 4.12 Comparison between calculated values and AASHTO Standards.

Test no.	Name of test	Result value	AASTO standard
1.	Gradation	A	A,B,C
2.	Loss Angels	20.6	Max 40 %
3.	California bearing ratio	94 %	80 - 100%
4.	Field density test	100 % compaction	100% compaction
5.	Plasticity index	Non plastic	If plastic max 6 %
6.	Specific gravity	2.6 gm/cm3	2.6-2.8 gm/cm3
7	Sand equivalent	75%	75-80%

CONCLUSIONS

(1) Various tests were conducted to determine the Geotechnical behavior of the materials used in the aggregate base course i.e,Sieve analysis, Liquid limit and plastic limit determination test, Field density test, California bearing Ratio test (CBR), Sand equivalent test, Los Angeles Abrasion test, Specific gravity and water absorption test and proctor test. The results of these tests are Grade A, Non plastic, 100% compaction, 94%, 75%, 20.6% and 2.6g/cm3 respectively.

(2) Test results were compared with the international AASHTO standards for Aggregate base course which are, Grade (A,B,C) ,if plastic P.I(max 6) ,100% compaction for the aggregate base course, CBR (80-100%), Sand equivalent (75-80%), Loss Angeles (max 40%), Specific gravity (2.5-3.0 g/cm3).

(3) According to AASHTO standards the following results were reliable and the material is best suitable for the aggregate base course. The type of material selected for the project was Margalla hills limestone. The Margalla limestone is most preferably used as a crushed material, as compared to Lockhart and Samanasuk formation. According to Los Angles test it has lowest clayey fraction. The derived material for the project was fresh in nature and do not have enough fractures. So it would not support the water infiltration in rainy seasons. According to AASHTO classification the grading of material is A. The A grade material has lowest fine material fraction, so there will be minor chances of swelling factor which subsequently leads to the minor fractures in road surface. According to FDT test the compaction of the required layer was 100%. The maximum compaction brings the grains into to contact and reduced the pore spaces as much as possible. The compaction factor will not allow the water to infiltrate downward. So there will be no chances of liquefaction effect. There was also lane of concrete slab over the aggregate base which will reduce the effect of distortion for the heavier traffic.

RECOMMENDATIONS

(1) The project for the construction of 25 kilometer road from Zero Point to Rawat connects Islamabad and Rawalpindi to all over Punjab and heavy traffic uses this Road for travelling.

(2) Therefore it is necessary to use material grade type A for construction.

(3) It is recommended that CBR (California Bearing Ratio) should be conducted during the compaction to know each layer bearing strength .The standard of CBR conducted for every hundred meter lengthwise.

(4) Along with these tests other qualitative tests regarding geochemical and geotechnical should be conducted for better and effective results.

(5) Compaction is an important factor in the field. Therefore the specific absorption and capacity of the soil should be predetermined.

(6) The other factors like surface water and ground water level must take under observation.

(7) The climate condition of the area should be kept in mind.

(8) The thickness and the embankment should be achieved in a closed fashion to the specification.

(9) The retaining wall is also used in the elevated areas to avoid any unnecessary disturbance.

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2.1.2 Northern Deformed Fold and Thrust Belt

It comprised of heavily deformed sedimentary, meta-sedimentary and igneous rocks, the Northern Deformed Fold and Thrust Belt (NDFTB) is bordered by MMT in the North and MBT in the south distinguishing it from the south lying Southern Deformed Fold and Thrust belt. The NDFTB is stretched from Kurram region near Afghan border in the west up to the Kashmir basin in the east (Khan, 2011).The Main Boundary Thrust (MBT) and the Salt Range Thrust (SRT) are the major members of this fault system .

2.1.3 Main Boundary Thrust

The Main Boundary Thrust (MBT) is extended along the front of the Northern Fold and Thrust Belt around Hazara-Kashmir Syntaxes from northeast to southwest, representing the southward migration of Himalayan deformation from the site of MMT in the north. The hanging wall of the MBT carries the pre-collisional Paleozoic and Mesozoic sedimentary rocks of the Northern Deformed Fold and Thrust Belt and post collisional folded Miocene foreland basin deposits in its footwall (Khan, 2011). The MBT is connected to the Hazara and Murree faults that bound the northern margins of Hazara and Kalachitta range.

2.1.4 Southern Deformed Fold and Thrust Belt

The Southern Deformed Fold and Thrust Belt (SDFTB) rim the Himalayan mountain belt from Ganges delta in India up to the South Waziristan Agency in Pakistan. It is oriented east west and is underlain by a thick pile of sediments. The Southern Deformed Fold and Thrust Belt is further divided into Kohat plateau in the west and Potwar plateau in the east of Indus river. Potwar plateau comprise internally less deformed fold and thrust belt with approximate width of 150 km in north south direction (Kazmi and Jan, 1982). Salt Range Thrust (SRT) and Trans Indus Range lies in the south of the SDFTB separating it from Punjab Foredeep Deformation is mostly restricted to the Northern Potwar Deformed Zone (NPDZ), which is located in the north of the plateau. The SRT and TIRT represent an active deformational front along which Cambrian to Paleocene rocks are thrust onto the Punjab Foredeep in the south (Ahmad, 2003). Kohat plateau is located in the extreme west of the Southern Deformed Fold and Thrust belt (Khan, 2010). The successive southward deformation took place in the late Miocene in the plateau.