ADDIS ABABA UNIVERSITY
ADDIS ABEBA INSTITUTE OF TECHNOLOGY
School of Civil and Environmental Engineering

Master of Science in Road and Transport Engineering

"Evaluation of Construction Demolition Wastes of Buildings in Addis Ababa to be used as a Sub-base Material: Case study Around Mexico Area"

By
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DECLARATION

I hereby announce that this thesis work entitled **"Evaluation of Construction Demolition Wastes of Buildings in Addis Ababa to be used as a Sub-base Material: Case study Around Mexico Area"** is my best original work. To the best of my knowledge and belief this thesis has not contain other published works elsewhere for assessment and degree or diploma awards.

Yohanes Abebe Fenta

Signature

Place: Addis Ababa Institute of Technology,

Addis Ababa University,

Addis Ababa.

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ABSTRACT

Utilizing recycled materials and wastes like construction wastes and demolition reminders is one of the justifiable solutions in terms of both cost minimizing and environmental concerns of transportation infrastructure constructions.

The main objective of this study is to evaluate the suitability of the usage of Construction Demolition wastes of buildings in Addis Ababa to be fully or partially used as sub-base layer.

The scarcity and difficulty of providing construction materials like sub-base has been a challenge that drags the road construction and the pavement industry not to be continued as expected. On the other hand, in Addis Ababa the extensive production of construction and demolition waste and lack of disposition areas due to the overpopulation of the city have a great contribution on the environmental pollution and it is also becoming a problem.

In this research, Construction Demolition Waste samples were collected from Addis Ababa around Mexico Area. Four samples were collected which are CDW1 (from Previous Goma-Kuteba compound), CDW2 (from left side of Yobek Building), CDW3 (from the back of Wabi-shebele Hotel) and CDW4 (in front of Ministry of Health).

Gradation, Proctor Compaction, CBR, Atterberg Limits as well as LAA tests were conducted on all of the collected samples. However, all the samples pass the gradation requirement but could not pass the CBR requirement for subase material. Their Maximum Dry Densities (MDDs) are also lower than the expected MDD for subase.

Therefore, in order to increase their densities and their bearing strength, it was tried to mix two of the CDWs with Clay material with four proportions (10%, 20%, 30% and 40% by weight of the sample). The MDD and the CBR have shown a big increment when 20% to 30% of Clay material is mixed with both of CDW samples and fulfill the CBR, Liquid Limit and Plasticity index requirements for subase material in accordance to the ERA specification.

However, all the CDW samples have higher LAA value than expected for subase material. Therefore, it was required to reduce the LAA value of the samples and it was tried to mix two of the samples with approved subase material with four proportions (10%, 20%, 30% and 40% by weight of the sample). In doing that, both of the samples fulfill all the ERA specification requirements and the LAA requirement as well.

In addition, it was tried to simulate the compaction during construction on site by proctor compaction and study the gradation curve after compaction. In order to do that, the samples left from pure CDW1 and CDW1 + 20% Subase were taken and compacted by standard proctor compaction procedure and the gradation of pure CDW1 after compaction tends to cross the upper limit allowable for subase material, whereas the CDW1 + 20% subase sample's gradation lies in between. Therefore, CDWs + 20% subase pass all the laboratory test requirements in this research for subase material and 20% subase content is recommended as the optimum proportion of subase which is the minimum requirement. However, using more than 20% subase also fulfil all the requirements specified for subase material.

Key Words: CDW, Clay, Subase, CBR, Gradation, Proctor Compaction, LAA, Liquid Limit and Plasticity Index.

LIST OF ABRIVIATIONS

ERA	Ethiopian road authority
AASHTO	American Association of State Highway and Transportation officials
CBR	California bearing ratio
RCA	Recycled Concrete Aggregate
ASTM	American society for test of material
CCA	Crushed concrete aggregate
DCA	Demolished concrete aggregate
LAA	Los Angeles Abrasion
MDD	Maximum Dry Density
CDW	Construction Demolition Waste
OMC	Optimum moisture content
RDCW	Recycled demolished concrete waste
LL	Liquid Limit
PI	Plasticity Index
NBE	National Bank of Ethiopia
GDP	Gross Domestic Product
BS	British Standard
LS	Linear Shrinkage
RMA	Recycled masonry aggregates
MRA	Mixed recycled aggregates

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CHAPTER ONE
INTRODUCTION

1.1 Background

Transportation is the main constituent of the economic development of a nation and it is considered as one of the most important factors for a country's progress. The transportation industry includes airlines, roads and highways, railroads, shipping, and logistics firms, as well as those that provide transportation infrastructure. Road transportation is the main and widely used type of transportation system in Ethiopia, which makes it to deserve due consideration interns of the quality and cost aspects. It is known that Pavements are the most important and the major costly part of road transportation infrastructures, since their construction and maintenance necessitate huge amounts of capital, resources and materials every year in every country throughout the world.

Utilizing recycled materials and wastes like construction wastes and demolition reminders is one of the justifiable solutions in terms of both cost minimizing concerns and environmental concerns of transportation infrastructure constructions.

The construction industry in Ethiopia has shown rapid growth in recent years. According to the National Bank of Ethiopia (NBE), construction accounts for half of the entire nation’s industry. Moreover, the industry is expanding rapidly. Data from the NBE also suggests that during 2013/14 the building sector grew 37%. Industrial activity accounted for 15% of Ethiopia’s total output [10]. Using these stats it can be seen that construction accounted for 7.5% of Ethiopia’s total GDP during this period. According to African Economic Outlook, this equates to 9.4% of total output at current prices. This would give the construction industry a market value of around $6 billion [11]. This rapid growth of the construction industry is leading to high Construction Demolition Waste (CDW) generation. Most of the wastes that the modern world generates are produced as a result of construction and demolition sectors. CDW materials are normally referred as solid wastes, which are generated by various construction and demolition activities.

CDW materials encompass concrete, brick, steel, timber, plastics, and other building materials and products. Out of these, concrete takes the foremost share of the construction and demolition wastes. These concrete wastes are generally obtained from demolished buildings and any other civil engineering structures and from test conducted on concrete strength [10].

Particularly, in old and large cities like Addis Ababa, replacement of previously constructed building with more modern and high rising building is common and this leads to production of high amount of construction demolition wastes. This leads to have large accumulation of wastes that needed to be disposed. On the other hand, the city is overpopulated and there is no enough space to cart away and damp these CDW materials. Hence, this lack of disposal area results in improper and illegal disposition of these construction demolition waste (CDW), which creates environmental pollution, which in turn can impose glitches on the social health wellbeing of the society.

In this research, it was tried to utilize construction demolition wastes accumulated in Addis Ababa in order to use fully or partially as a sub-base layer aiming to conserve natural stone aggregate and minimize cost of road construction and at the same time removing and recycling the unnecessary accumulation of construction and demolition wastes and preserve the environment from pollution.

1.2 Problem statement

Even though constructing roads in developing countries like Ethiopia can play significant role in sustainable development of the economy, transport of logistics and agricultural products, providing open access for tourism etc., the scarcity of construction materials like sub-base has been a challenge that stops the road construction and the pavement industry to continue as expected. Different researches suggest that using local materials and recycling waste materials and using for road pavements can reduce the cost of the construction materials and manage the construction of roads with less cost and without compromising the quality.

On the other hand, the construction industry in developing countries like Ethiopia is showing fast and tremendous development. Particularly in old cities like the capital Addis Ababa the existence of old building which have low living standard and poor serviceability and place management are becoming the major challenges for the development of the cities. This brings the need for the construction of new infrastructure by removing and demolishing the existing relatively low standard infrastructures for a better quality, aesthetics and service which results in unnecessary production of construction demolition waste deposit of old infrastructures. Therefore, in Addis Ababa the extensive production of construction demolition waste and lack of disposition areas due to the overpopulation of the city have a great contribution on the environmental pollution and it is becoming a serious current problem. Urban population levels in Ethiopia have been growing steadily in recent years. The World Fact book states that, between 2010 and 2015, Ethiopia's urban population has shown an average annual growth rate of 4.89 %. 22 million people could live in urban areas by 2020 [12]. This is likely to result in an increased demand for affordable housing and, if middle to upper income levels increase, more expensive options.

Therefore, in this research, it is tried to utilize Construction Demolition Wastes in Addis Ababa particularly around Mexico in order to use is as a subase material which will reduce the overall cost of construction and also play significant role in tackling environmental pollution issues in this regard.

1.3 Objective of the Study

The main objective of this study is to evaluate the suitability of the usage of Construction Demolition wastes of buildings in Addis Ababa to be fully or partially used as sub-base layer. The specific objectives of the study are:

- ❖ To investigate the properties of the Construction Demolition waste by conducting laboratory tests on itself and by partially replacing with Clay and approved sub-base materials and
- ❖ To compare the test results with the ERA and other specifications for sub-base layer qualification.

1.4 Research questions

The research was undertaken to answer the following main research questions, which are

a) What are the engineering properties of the Construction Demolition waste sample?

b) Can this Construction Demolition waste meet the specification for sub-base and be used as a sub-base by itself or partially substitute the approved sub-base material?

c) Does the Construction Demolition waste need other treatment option in order to meet the specification for sub-base?

1.5 Limitation of the research

The study assesses the effect of the compaction during the construction process and the further compaction applied by traffic throughout the lifetime of the road was not assessed. Therefore, the assessment shall be done in the future and the gradation characteristics after the traffic compaction shall be studied further in order to use the CDWs by partially substituting with subase material.

In this research, the gradation characteristics of CDWs after compaction was studied but there is no indication about the stability of the CDWs. Therefore, the stability of the material shall also be studied in the future in order to use CDWs as a subase material.

Construction demolition wastes obtained from different location might exhibit different properties due to:-

- ✓ The variety of their composition
- ✓ The age of the demolished structure since it might affect the property of the waste.
- ✓ The type of construction materials used for the demolished structure since some might be suitable to be used as a sub-base and some might not.

In this study it was tried to sample the construction and demolition wastes from at least four (4) different places separately and in addition to conducting full property test for each sample. Since the test results does not meet the sub-base specification, it was tried to mix with Clay and approved sub-base material with Two (4) trials, which makes the number of full property tests to be conducted 40. Hence, the number samples and mix proportions are limited since it is difficult to conduct more than 40 full property tests as an individual researcher with limited cost, time and laboratory facility.

1.6 Scope of the research

This study encompasses the laboratory investigation and evaluation of Construction Demolition wastes in Addis Ababa and determining the engineering and index properties of it. Furthermore, comparison of the laboratory test results with the ERA standard specification for sub-base materials and also other specification will be done and since the collected Construction Demolition wastes do not meet the specification, it was tried to mix it with Clay and approved sub-base in different proportion.

The mixing proportion was with 10%, 20%, 30% and 40% by weight of the Construction Demolition waste and the Clay and Sub-base material. Finally, the study tried conclude based on the test results of the Construction Demolition waste by itself by determining if it is suitable to be used as a sub-base material. Since it becomes unsuitable to be used as a subase material by itself it was tried by mixing it with Clay and approved sub-base material with the proportion specified above and the properties of the mix are determined.

Comparison between the engineering and index properties of the mix with ERA standard Technical specification and other Specification was also done.

1.7 Significance of the research

As the study aimed to evaluate the Construction Demolition wastes of buildings in Addis Ababa to be fully or partially used as sub-base layer having completed will provide the numerous significant benefits to the construction industry.

Regarding environmental aspects, utilizing the waste and recycling it to reuse can help in tackling the current environmental pollution problem of the Capital Addis Ababa since the widespread production of construction and demolition waste and shortage of disposing areas due to the overpopulation of the city have a great contribution on protecting the environment from pollution and ensure the wellbeing of the social health.

On the other hand, in relation to cost minimization, utilizing the Construction and Demolition wastes and using it for free by replacing fully or partially in the place of sub-base materials can save a lot of capital in road construction and this can be a significant advantage on the construction industry of developing countries like Ethiopia.

The research can also bring the understanding and culture of taking advantage of recycling and using waste products as a pavement layer instead of using high cost construction materials in order to minimize cost of road construction and to prevent the environment from pollution.

1.8 Conceptual Framework

The overall conceptual analysis of the procedure of this research mainly lies on experimental laboratory testing study and the research activity will be first selection of sampling places for the construction demolition wastes. After selection of the sampling places, sampling was undertaken from each selected places. After that complete laboratory tests was conducted on the samples to determine its index and engineering properties as well as to check if the sample meets the ERA specification for sub-base material.

Sampling of clay material and approved sub-base material from ongoing road projects was also undertaken and then mixing of the construction and demolition wastes with the sub-base material collected was undertaken with different proportion. Then the proportion that best fit with the ERA standard specification requirements as well as requirements of other specifications such as AASHTO and ASTM standard specifications was selected and the After compaction gradation test was conducted.

1.9 Organization of the Thesis

This thesis has five Chapters. The first Chapter contains a general introduction about the study, the objective of the study, the problem statement of the study, scope and limitation of the study as well as the conceptual framework of the study. Whereas chapter two contains a comprehensive literatures review on Construction Demolition Wastes in Addis Ababa and their engineering properties as well in addition to inclusion of general assessment on subase materials and their properties. Chapter three of this study deals about the methodology and the materials used in this thesis.

Chapter four of the study contains results of different laboratory tests indicating the engineering and index properties of the samples tested as well as the detail analysis and discussion of the results. Chapter five of this research includes drawn conclusions based on the objectives of the research and the analysis and discussion of the laboratory test results. Moreover, in this chapter some recommendations based on the conclusions drawn are forwarded.

❖

CHAPTER TWO

2. LITERATURE REVIEW

2.1 General about Sub-base Materials

Sub-base layer is a layer of aggregate materials placed on sub grade of the road on which the base coarse layer is located which is often the main load bearing layer of the pavement [1].

The sub-base layer in flexible pavement road types is an imperative load spreading layer in the completed pavement. The functions of sub-base layer in flexible pavements include:

- ❖ Allowing traffic stresses to be abridged to acceptable levels in the subgrade, protects the subgrade against significant deformation due to traffic loading.
- ❖ Acting as a working platform for the construction of the upper pavement layers
- ❖ Acts as a separation layer between subgrade and base course.
- ❖ Under special circumstances, it may also act as a filter or as a drainage layer and provides an adequate drainage for the infiltration of rain water through the cracks and joints.
- ❖ In addition it is also serve to protect sub grade against frost and environmental damage.

In dry and favorable climatic conditions such as in areas of good drainage and where the road surface remains well sealed, unsaturated moisture conditions prevail the sub-base specifications may be relaxed whereas in wet climatic conditions, the most stringent requirements are dictated by the need to support construction traffic and paving equipment. In these circumstances, the sub-base material needs to be more tightly specified. The selection of sub-base materials will therefore depend on the design function of the layer and the anticipated moisture regime, both in service and at construction [2].

2.2 Construction Materials for Sub-Bases

According to the Ethiopian roads Authority Specification of 2014, the materials used for the construction of sub-base layers shall be derived from the following material sources:

- ❖ Natural Gravel;
- ❖ Scoria (Cinder Gravel)

- Weathered Rock;
- Crushed Gravel;
- Crushed Rock or crushed Boulders;
- Recycled Pavement Material.
- Any other granular material complying with the requirements of this Clause and a combination of any of the above.

2.3 Requirements of Sub-base Materials

The major requirement of for sub base material usually is given in terms of gradation, plastic characteristics, and strength of materials. The ERA specification and Flexible Pavement design manual of 2014 requires the materials used for sub-base shall fulfill certain quality requirements and presented as follows:

A. General

If the nature of the construction material remains deficient in the finer fractions despite every effort made on the material, addition of approved soil fines, crusher fines or sand in controlled quantities not exceeding 15% by mass of the aggregate shall be introduced at the crushing plant.

B. Particle Size Distribution and Shape

The sub-base material shall comply with one of the grading shown in the following Table.

Table 2. 1 PSD Requirement of Sub-base

ISO Sieve Size (mm)	Percentage Passing by Mass		
	Natural Gravel	Crushed Stone	
	A	B (37.5mm)	C (28mm)
63	100		
50		100	
37.5	70-100	95-100	100
26.5			
20	50-100	60-80	70-85

9.5		40-60	50-65
4.75	30-100	25-40	35-55
2.36		15-30	25-40
1	17-75		
0.425	11-56	7-9	12-24
0.075	5-25	5-12	5-12

In addition to the above grading requirement the minimum Grading Modulus shall not be less than 1.5 the flakiness index, determined by testing in accordance with BS812, Part 105 or ASTM D 3398, shall not exceed 35.

C. Plasticity

According to the ERA specification of 2014 Natural gravel sub-base materials shall have a maximum Plasticity Index, when determined in accordance with AASHTO T-90, depending on the climate as shown in the following table. Crushed stone sub-base shall have a Plasticity Index of less than 6 when determined in accordance with AASHTO T-90.

Table 2. 2 Plasticity Limits for Natural Gravel Sub-bases

Moist tropical and Wet tropical	Typical Annual Rainfall (mm)	Liquid Limit (LL)	Plasticity Index (PI)	Linear Shrinkage (LS)
Moist tropical and Wet tropical	> 1000	< 35	< 6	< 3
Seasonally wet tropical	> 500	< 45	< 12	< 6
Arid and semi-arid	< 500	< 55	< 20	< 10

D. Strength

The minimum soaked Californian Bearing Ratio (CBR) shall be 30% when determined in accordance with the requirements of AASHTO T-193. The Californian Bearing Ratio (CBR) shall be determined at a density of 95% of the maximum dry density when determined in accordance with the requirements of AASHTO T-180 method D.

2.4 Construction Demolition Wastes

A latest European survey indicated that 25% of wastes originated from the demolition of engineering structures like buildings and roads. 90% of the produced waste is recyclable, but from this recyclable waste only 30% is recycled and reused for different purposes. According to the study of U.S Environmental Protection Agency (EPA), 215 million tons of municipal solid waste is generated in the United States from C&D waste per year. This made up primarily of concrete, asphalt concrete, wood, gypsum, demolition material and asphalt shingles generated from road construction and high way maintenance, building renovation demolition of building and other structures [3].

According to different literatures it is known that there are three main sets of CDW aggregates: Recycled concrete aggregates (RCA), Recycled masonry aggregates (RMA, sometimes Crushed Clay Masonry-RCM) and Mixed recycled aggregates (MRA–also mixed demolition debris) [4]. Nevertheless, most construction and demolition combinations are blended of these abovementioned three types of CDW aggregates and the percentage of each material can affect different properties of the total mixture. Furthermore, other materials like ceramics can exist in some blends of CDW. The composition of CDW aggregates highly determined by their source and the processing method [5].

The assortment of the construction procedures and methods naturally mean that CDW sourced from construction and demolition activities will change in quality as well as in composition, which will unquestionably yield new construction materials of varying quality. Besides, the method of demolishing a building structure may be effective, and it could be either conventional or selective. The selective demolition approach, along with more control on the quality of the CDW materials obtained, ensures a substantial reduction of the environmental effects specifically caused by climatic change, acidification, summer smog, nitrification and release of heavy metals. These result from the emission of a wide array of compounds and elements, all of which are identified to be major pollutants [6].

2.5 Types of Construction Demolition wastes

According to [7] The European Union divides the construction waste into eight categories: (1) brick, concrete, ceramic, and tile; (2) glass, wood, and plastic; (3) coal and asphalt, (4) metals; (5) soils, including soil excavated from contaminated site, rocks, and soils obtained from dredging; (6) insulation materials and materials containing asbestos, (7) construction materials containing gypsum, and (8) waste from other construction whereas England has ten categories of construction waste: (1) insulation and asbestos materials; (2) concrete, brick, tile, and ceramic; (3) wood, glass, and plastic; (4) asphalt, oil, coal, and bitumen; (5) metals; (6) soil, contaminated soil, stone, and soil from dredging; (7) gypsum; (8) cement, (9) paint and coating materials; and (10) glues and fillings. In other aspect US classification divides waste from construction into 15 groups, including (1) asphalt-related materials, (2) soil related materials, (3) materials related to electrical works, (4) materials related to insulation, (5) materials related to bricks and concrete, (6) material related to steel, (7) materials related to paint work, (8) paper-related materials, (9) materials related to petroleum products, (10) materials related to roofing works, (11) materials related to vinyl, (12) gypsum related materials, (13) wood related materials, (14) materials related to wood containing contaminants, and (15) miscellaneous groups. The following table summarizes the type of CDW according to EU, England and US classification system:

Table 2. 3 CDW classifications

Description	EU	England	US
Asphalt	X	X	X
Soil	X	X	X
Electrical Work	X	X	X
Insulation	X	X	X
Brick and concrete	X	X	X
Steel	X	X	X
Cement		X	X
Paint		X	X
Paper			

Petroleum		X	X
Roof			X
Vinyl			X
Gypsum	X		X
Wood	X	X	X
Contaminated Wood			X
Glues and fillings		X	
Miscellaneous			X

However, according to [8] the major forms of CD wastes are cement-concrete waste.

2.6 Advantages and Benefits of CD wastes

The following table summarizes some of the advantages and benefits of recycling CD waste and using as a substituting material for different construction materials.

Table 2. 4 Advantages and significances of CD waste recycling

Advantages and significances of CD waste recycling [9].	
Benefit	Significance
Protection of earth's natural resources	Fortification of Usual resources for impending generation
Reduction of raw materials requirement	Limited use of natural assets and waste material uses
Exclusion of different wastes	Conservatory gas discharge reduction and Water and Air pollution organized
Reduce waste disposal	Transportation and landfilling cost control
Environment protection	Climate change Prevention

2.7 Reuse of construction demolition waste

It is well known that numerous tons of construction materials are required for road construction. Aggregate which is mostly and commonly used in asphalt pavement especially in developing countries comprises of up to 95% of natural aggregates. The total amount of natural aggregate needed for a project depends on the road's subgrade strength and expected traffic loading and the projects size. From the golden rule of waste management, reduction is first and recycling waste materials is the second, which is very essential in order to minimize the consumption of the natural aggregates and to gain economical merits [10].

Therefore, the reuse of this waste is necessary since improper disposal of CDW creates an ugly site and cause environmental issues [11]. Consequently, it leads to economic losses, and contamination of the groundwater through leaching [12]. In addition, CDW are bulky and not suitable for composting and incineration.

2.8 Engineering properties of CDW

According to [13]'s collection of different laboratory test results obtained by several researchers different properties of CDWs are presented as follows:

1. Particle Size Distribution (PSD)

The particle size distribution (PSD) has a defining role on the mechanical properties of the recycled materials and subsequently, has a major influence on the pavement structural performance. The distribution of particles of CDW products may be different based on the source type and composition, on the procedure of demolition and on the planned application of the material.

2. Flakiness Index of CDW

Flakiness index is an indirect measure of the tendency of particles to break during compaction and under the traffic load of the service period. The shape of a crushed particle depends on the type and condition of the equipment used to carry out the crushing and on the nature of the original rock, as well as on other variables related to the age of the material and its exposure to climate. Different researchers quantified the flakiness index values of CDW materials and some of them are presented in the following ta

Table 2. 5 Flakiness Index values of CDWs

No.	Researcher	Reference	Flakiness Index (%)
1	Barbudo et al, 2012	[14]	15
2	Silva et al, 2019	[15]	8 to 30
3	Vegas et al, 2011	[16]	9 to 40
4	Leite et al, 2011	[17]	26.5
5	Jimenez et al, 2012	[18]	8 to 19
6	Morafa et al, 2017	[19]	12 to 20
7	Nataatmadja et al, 2001	[20]	6 to 14
8	Gomez-Meijide et al, 2014	[21]	4.5
9	Del et al, 2016	[22]	12.8 to 24
10	Herrador et al, 2011	[23]	12

3. Specific Gravity

The specific gravity of natural materials commonly used in geotechnical and paving applications can vary depending on the material type and it ranges between 2.60 and 2.75 or more on average. However, even if the specific gravity of CDWs is lower than the natural materials commonly used in pavement application the average specific gravity of CDWs is relatively higher than that of the other types of recycled aggregates. The Lower specific gravity of CDWs is basically due to the presence of:

- Adhered cement mortar and its porous nature;
- Containing masonry and lightweight materials (in CDW) [37]

Table 2. 6 Specific Gravity values of CDWs

No.	Researchers	References	Specific Gravity (gr/cm3)

1	Barbudo et al, 2012	[14]	2.24
2	Herrador et al, 2011	[24]	2.04
3	Park et al, 2003	[25]	2.533
4	Poon et al, 2006	[26]	2.38
5	Gabr et al, 2012	[27]	2.575
6	Tahmoorian et al, 2017	[28]	2.37
7	Agrela et al 2012	[29]	2.34
8	Tahmoorian et al, 2018	[30]	2.408

4. Compaction Characteristics (MDD and OMC)

Certain engineering properties of soil or other unbound paving materials, such as shear strength, internal friction and water drainage enhanced by plummeting the volumetric ratio between the voids and the particles due to reorganizing and restructuring of grains with mechanical compaction. Numerous types of assessments such as standard Proctor and modified Proctor tests are used to evaluate the compaction characteristics of soils and other construction materials. The main objective here is to determine the optimum moisture content (OMC) at which soils or other construction materials mixes attain the densest condition, demonstrating their Maximum Dry Density (MDD) [37]. The MDD and OMC of CDWs according to laboratory test results of different researchers are presented here under:

Table 2. 7 OMC and MDD values of CDWs

No.	Researchers	References	OMC (%)	MDD (kg/m3)
1	Barbudo et al, 2012	[14]	11.6	1950
2	Arulrajah et al, 2011	[31]	10.7 (brick dominant)	1982
3	Vegas et al, 2011	[16]	6.52	1885
4	Leite et al, 2011	[17]	13.5 (Modified) and 14.6% (Standard)	1820 (Modified) and 1760 (Standard)

5	Jimenez et al, 2012	[18]	12.7	1910
6	Morafa et al, 2017	[19]	12.5	1940
7	Herrador et al, 2011	[23]	9.4	2040
8	Agrela et al 2012	[29]	11.5 - 12.4	1960–1990
9	Arisha et al, 2016	[32]	12.7	1860
10	Jimenez et al, 2012	[18]	12.3	1855
11	Rahman et al, 2015	[33]	12.3	2100
12	Azam et al, 2013	[34]	11.6 - 12.5	1857–1919

5. Strength

California Bearing Ratio (CBR) is extensively used for characterizing the strength of subgrade, sub-base and base materials of pavements. It has been accompanied with road pavement service performance and design methods and it has been at the basis of several airfield pavement design methods. Both soaked and un-soaked CBR laboratory test results of CDWs according to different researchers are presented in the following table:

Table 2. 8 CBR values of CDWs

No.	Researchers	References	Standard Proctor		Modified Proctor	
			Soaked	Un-soaked	Soaked	Unsoaked
1	Barbudo et al, 2012	[14]			74% (mean)	
2	Vegas et al, 2011	[16]			76–197%	
3	Cerni et al, 2012	[35]	90%			
4	Leite et al, 2011	[17]	73%			117%
5	Jimenez et al, 2012	[18]			68%	
6	Morafa et al, 2017	[19]				72–85%
7	Del et al, 2016	[22]				63.7%, 67.3%

8	Poon et al, 2006	[26]	35–62%	35–62%		
9	Gabr et al, 2012	[27]			90–215%	
10	Arisha et al, 2016	[32]			70–153%	
11	Jimenez et al, 2012	[18]			62–94%	
12	Lancieri et al, 2006	[36]	35–113%	71–115%		

2.9 Quantities of Construction Demolition Wastes in Addis Ababa

Waste arising from construction and demolition of construction materials, which are obtained from demolished building and civil engineering infrastructures, constitutes one of the largest waste streams in many developed countries. Of this, a large proportion of potentially useful material disposed of as landfill. The environmental and economic implications of this are no longer considered sustainable and, as a result, the construction industry in the developed countries is experiencing pressure to overcome this practice [47].

There are difficulties to get information on demolition waste generation rates in Addis Ababa. However, the international available data shown in the table below does allow predicting the amount of construction and demolition waste generated yearly in Addis Ababa.

Table 2. 9 CDWs accumulation

No.	Country Name	Construction demolition waste rate per Capita/ year	Reference
1	Brazil	0.5 ton	John et al, 2004
2	Denmark	0.506 ton	Baum and Kats, 2003
3	Sweden	0.66 ton	Baum and Kats, 2003
4	Iceland	0.6 ton	Baum and Kats, 2003
5	Egypt	0.52 ton	Egyptian ministry of environment
6	European Union	0.5 – 1 ton	Lauritzen, 2004
7	United States	1 ton	Lacrossa and Graves, 2002

8	Israel	1 ton	Israel min. of environmental protection

Source: Esayas, 2016

2.10 Overview of Previous Researches

Detailed assessment of literatures was carried out to acquire the essential information concerning the research objectives. A review of literature related to the utilization of construction demolishing wastes in pavement sub base application didn't divulge not more than a few qualitative studies conducted in Ethiopia. However, numerous international studies was conducted aiming to utilize and recycle construction demolition wastes for replacing of natural construction materials in engineering applications such as pavement sub base and other road construction applications. Some of the researches and the results obtained are presented in the following tables:

1. Busari et al, in 2019 conducted a research by reviewing different literatures aiming to check the suitability of CDW for pavement inter layer in order to substitute natural aggregates used in pavements by CDW. The research objective and finding is summarized as follows [46].

Table 2. 10 Previous researches and their results NO. 01

Title of the Research	Objective	Obtained Result
Recycled Aggregate in Pavement Construction: Review of Literatures	To check the suitability of CDW for pavement interlayer and substitute natural aggregate in asphalt mix.	It concluded that a combination of concrete waste (75%), asphalt (20%) and ceramic material (5%), would provide a satisfactory load-bearing capacity similar to what a natural aggregate would provide. And for recycled aggregate to be used in asphalt mixes, the moisture content must be low.

2. Arpan et al, in 2021 conducted a research by reviewing different literatures aiming to check and perform a critical review on the use of CDW in road construction sector regarding various fact and properties of CDW waste material with its effect after using as

an alternative material in road construction. The research objective and finding is summarized as follows [45]:

Table 2. 11 Previous researches and their results NO. 02

Title of the Research	Objective	Obtained Result
Use of CD waste in Road Construction: A critical review	To review the use of CD waste in road sector regarding various fact and properties of CD waste material with its effect after using as an alternative material in road construction.	The research concluded that more attentive research requirements to be conducted in this area for the efficient use of C&D waste as an alternative material for road construction.

3. Francisco et al, in 2012 have undertaken a research in order to investigate about the use of recycled aggregates (cement-preserved) in base and sub-base layers of road construction aggregates. The research objective and finding is summarized as follows [44]:

Table 2. 12 Previous researches and their results NO. 03

Title of the Research	Objective	Obtained Result
Construction of road sections using mixed recycled aggregates treated with cement in Malaga, Spain	To investigate about the use of recycled aggregates (cement-preserved) in base and sub-base layers of roads	The research established that recycled aggregates (cement treated) can be used in sub-base layer construction of road and is a good alternative to usual materials.

4. Arul et al, in 2020 have conducted a research in order to evaluate various properties, characteristics and fatigue life of CDWs with polyethylene terephthalate. The research objective and finding is summarized as follows [43]:

Table 2. 13 Previous researches and their results NO. 04

Title of the Research	Objective	Obtained Result

Stiffness and flexural strength evaluation of cement stabilized PET blends with CDWs	To evaluate various properties, characteristics and fatigue life of stabilized PET blends with CDWs	The research concluded that that 3% cement stabilized 5% polyethylene terephthalate + 95% recycled concrete aggregate and 5% polyethylene terephthalate + 95% crushed brick may be used for pavement bases and sub-bases construction.

5. Tong et al, in 2013 have conducted a research putting a main objective to evaluate construction demolition wastes as road base [42].

Table 2. 14 Previous researches and their results NO. 05

Title	Objective	Obtained Result
Utilization of construction demolition waste as stabilized materials for road base applications.	To evaluate construction demolition wastes as road base.	The research concluded that recycled construction demolition waste from concrete and masonry can be utilized as natural materials for all subgrade, base and sub-base layers of road foundation without cement treated. When using recycled fine aggregate (RFA) for lower base layer of the high performance pavement structures, it should be reinforced with 7.5% cement for RFA from concrete debris and 10.5% cement for RFA from masonry debris. When using RFA for upper layer of the high performance pavement structures and the bituminous pavements, it should be reinforced with 10.5 and 12.5% cement respectively from concrete and masonry.

6. Junhui et al, in 2020 have undertaken a research by mainly aiming to evaluate construction demolition wastes as road base. The research objective and finding is summarized as follows [38]:

Table 2. 15 Previous researches and their results NO. 06

Title of the Research	Objective	Obtained Result

Recycled aggregates from construction and demolition wastes as alternative filling materials for highway subgrades in China.	To evaluate construction demolition wastes as road base.	The research concluded that recycled CD waste aggregates with proper grading and strict Construction technologies perform well and the subgrade filled with recycled C&D waste has a smaller deformation than that of the soil subgrade.

7. Barbudo et al, in 2012 have conducted a study of mechanical behavior of road using different types of recycled materials including CDWs. The research objective and finding is summarized as follows [14]:

Table 2. 16 Previous researches and their results NO. 07

Title of the Research	Objective	Obtained Result
Statistical analysis of recycled aggregates derived from different sources for sub-base applications	Study mechanical behavior of road using different types of recycled materials including CDWs	The research concluded that Concluded that CDW aggregates can be used in road pavement as sub-base layer material.

8. Igor et al, in 2020 have conducted a research aiming to utilizing the CDW-Recycled Aggregate for sub-base by treating with lime and cement [40].

Table 2. 17 Previous researches and their results NO. 08

Title of the Research	Objective	Obtained Result
Application of recycled aggregates from construction demolition wastes with Portland cement and hydrated lime as pavement sub-base in Brazil.	To utilize CDW-Recycled Aggregate for sub-base by treating with lime and cement.	The research concluded that CDW aggregates can be used in road pavement as sub-base layer and according to tested result it is confirmed that the stiffness of CD waste material significantly increases over time it is good sub-base alternative material for heavy traffic loads.

9. Gholamhosein et al, in 2020 have conducted a study in order to utilize CDW generally in road construction [41].

Table 2. 18 Previous researches and their results NO. 09

Title of the Research	Objective	Obtained Result
Evaluating and improving the construction and demolition waste technical properties to use in road construction	To utilize CDW in road construction.	Conducted a series of cyclic plate load tests to evaluate the effectiveness of using geo-cell reinforcement on the bearing capacity of CD waste materials and they showed the bearing capacity of CD waste backfills by 20–40% than that of standard material.

10. Bethelehem et al, in 2018 conducted a research aiming to determine the property of demolished and crushed concrete waste for the use of sub base materials in road construction [46].

Table 2. 19 Previous researches and their results NO. 10

Title of the Research	Objective	Obtained Result
Properties of crushed and demolished concrete waste in pavement sub base applications.	To determine the property of demolished and crushed concrete waste for the use of sub base materials in road construction.	Concluded that the crushed concrete fulfills all the requirement stated on the manuals. The demolished concrete also fulfills all the requirements stated on ERA manual Standard Technical Specification, whereas it fails to satisfy aggregate crushing and impact tests specified by British Standard manual.

CHAPTER THREE

MATERIALS AND METHODS

This chapter includes the materials used in this study which are Construction Demolition Wastes (CDWs), Clay and Approved Sub-base material. It also includes the details of the methodologies followed in order to properly address the objectives of the research. All of the tests that have been conducted on the Construction Demolition Wastes, Clay, Subase material their mixes in different proportions were conducted according to the respective ERA, AASHTO, and ASTM testing standards.

3.1 Study Area

The fast development of the construction industry in Ethiopia, principally in Addis Ababa in the last 11 years headed to produce enormous magnitudes of construction demolition waste materials. In Addis Ababa, these construction demolition waste materials started to be an environmental problem since the foremost amendment plan in the construction sector comprises rehabilitation of the current infrastructures and construction of new civil engineering works, highways, bridges, railway tracks, airports, power plants, water works, and real estate etc.

Therefore, the study area focuses in Addis Ababa which is the capital city of Ethiopia located at the foot of Mount Entoto, at an altitude of 2355 meters above sea level and covers total land area is 1,119,683 square km. since taking many samples that can represent the whole city is difficult as an individual researcher it has been decided to conduct a case study around Mexico Area of the city where there are lots of Construction activities undergoing which makes the construction demolition wastes to be easily accessible.

More specifically the sampling of CD wastes in this research was conducted from around Mexico area, since there is accumulation of demolished wastes and lots of construction activities in the area. Therefore, the CD material was sampled from Waste deposits around Mexico parking areas construction sites, ceased construction places etc.

3.2 Study Methodology Design

Over all the research has tried to collect some indications about how can the construction demolition waste replace the sub-base material from previous studies as well as experimental study or laboratory test findings and comparing the test results with standard specifications like ERA, ASTM and AASHT. Moreover, this portion of the study deals about the data source and collection techniques and data analysis techniques that can best fit with the nature of the study. Some details of the methodology are presented below:

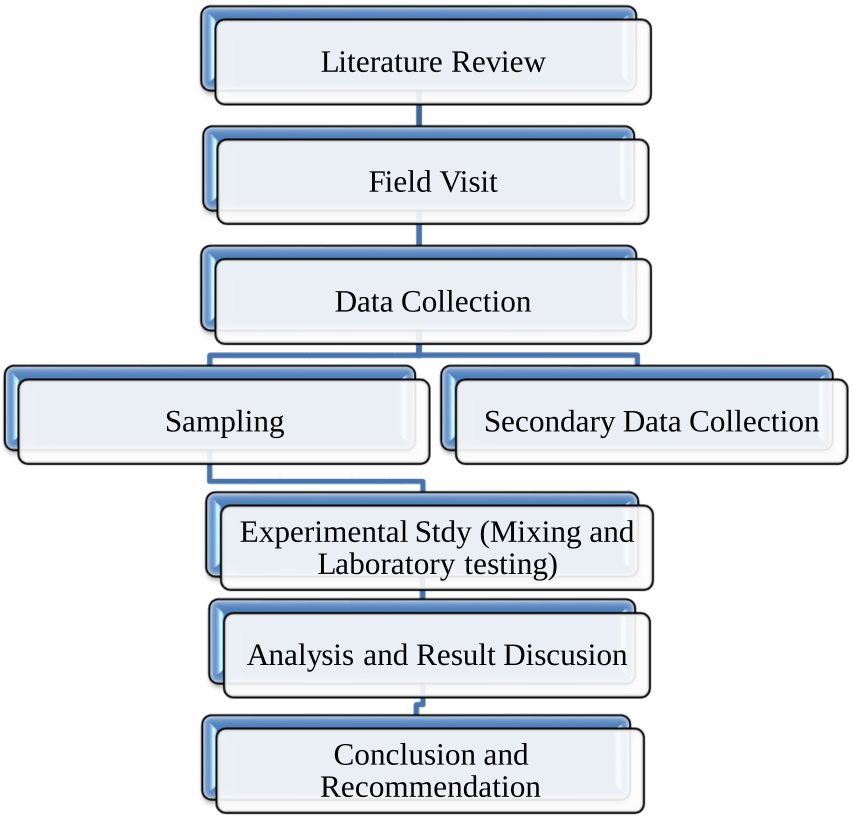

Fig. 3. 1 Methodology of the research

3.3 Field Visit

The field visit was undertaken in order to see the accumulation of the construction and demolition wastes, the extent of environmental pollution due to the wastes, the variety types of demolition wastes available and to select the sampling places for the CDW to be used for the research. Field visit was also conducted to sample approved and tested sub-base material that can meet all the ERA standard specification for sub-base material.

3.4 Sample Collection

After carefully studying where to find the CDWs and how the Construction and Demolition Wastes (CDW) are disposed and where to sample them and also where to find demolished structures during the field visit the next step was sampling CDWs, Clay and approved sub-base material from ongoing road projects in order to use it as a control for the test and to mix it with the CDW by using different proportions if the Construction Demolition Wastes (CDW) by itself couldn't fulfill the requirements of the specifications to be used as a sub-base material.

3.5 Site selection criteria

The sampling site was selected aiming to get the following benefits for the research:

- Availability of adequate Demolition wastes
- Getting permission to sample the wastes from available sites
- Ease for transportations to the laboratory facility

Due to the above and other reasons the sampling place is selected to be around Mexico area on undergoing construction projects and deposit areas of demolishing wastes.

3.6 Sampling Technique

For this research the sample of the demolished and crushed concrete waste from Addis Ababa town around Mexico area was collected in accordance with the ERA sampling procedure by using random sampling technique. The sample of demolished concrete and crushed concrete waste will be collected separately. The obtained result was discussed separately.

This enables the research to be;

- Easy to conduct
- High probability of achieving representative sample
- Meet assumptions of many statistical procedures

Construction Demolition Waste Samples

Four Construction Demolition samples from four different places around mixico area were collected. These are:

- CDW1: the sample was taken from Previous Goma-Kuteba compound which is now under construction
- CDW2: this sample was collected from the left side of Yobek Commercial Building which is now a parking and lots of accumulation of CDW is available
- CDW3: the sample was collected from the back of Wabi-shebele Hotel
- CDW4: the sample was collected from demolition building in front of Ministry of Health

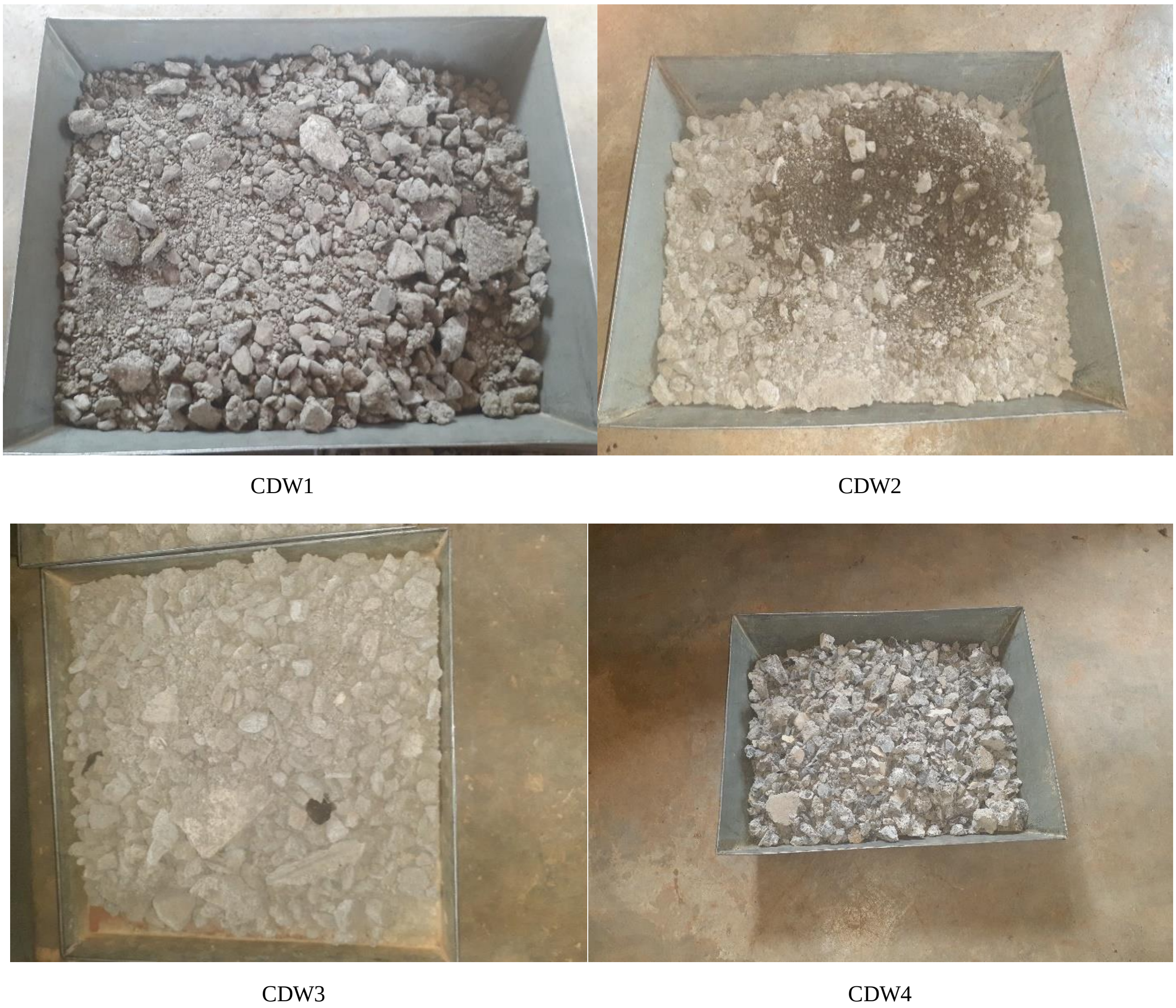

Fig. 3. 2 CDW samples

Material Composition of the Samples

From the brought four samples 20 kg of each of the samples was taken using quartering method of sampling and the material in each of the taken samples was separated and measured for their weights and the composition of materials in each of the samples in percentage is presented in the following table.

Table 3.1 Material Composition of each of CDW samples

Type of Material	Composition in Percentage of CDW1 - CDW4			
	CDW1	CDW2	CDW3	CDW4
Concrete Aggregate	68.70%	71.60%	74.20%	73.60%
Crashhed HCB	18.20%	21.10%	18.90%	19.20%
Brick and Ceramic	2.80%	1.30%	1.40%	2.30%
Pumice	4.70%	3.20%	2.80%	3.10%
Soil and other impurities	5.60%	2.80%	2.70%	1.80%
Total	100.00%	100.00%	100.00%	100.00%

Clay

The clay material was collected in order to mix it with the CDW samples so that it can increase the density of the samples by filling the voids available between the aggregates of CDWs and at the same time to increase the bearing capacity of the samples. It is also targeted to increase the cohesion between the CDW sample aggregates because the all the samples non – plastic as well as cohesion less and the workability of sample wkas under question mark. The Clay material is red in color and was collected from Maji town around which is found in south western part of Ethiopia.

Fig. 3. 3 Clay Sample

The laboratory test results showing the properties of the clay material are summarized in the following table:

Table 3. 1 Properties of the pure Clay sample

Test Performed		Test Method	Test Result	
1	Modified Proctor Compaction	AASHTO T 180 Method D	MDD, gm/cm^3 =	1.46
			OMC, % =	27.0
2	California Bearing Ratio (CBR) soaked	AASHTO T 193	CBR @95% of MDD, % =	6
			Swell @95% of MDD, % =	2
3	Atterberg Limits	AASHTO T 89	LL, % =	64
		AASHTO T 90	PI, % =	22
4	Soil Classification	AASHTO M 145	A-2-7	(0)

Sub-base Material

The Subase material was collected in order to mix it with the CDW samples so that it can increase the LAA results of the CDWs by partially filling the sample with strong subase aggregates. The subase material was sampled from approved source of stock natural gravel material for construction of Omo – Maji road construction project.

The laboratory test results showing the properties of the clay material are summarized in the following table:

Table 3. 2 Properties of the pure Subase material

	Test Performed	Test Method	Test Result	
1	Modified Proctor Compaction	AASHTO T 180 Method D	MDD, gm/cm^3 =	1.94
			OMC, % =	8.2
2	California Bearing Ratio (CBR) soaked	AASHTO T 193	CBR @95% of MDD, % =	52
			Swell @95% of MDD, % =	0.3
3	Atterberg Limits	AASHTO T 89	LL, % =	37
		AASHTO T 90	PL=	29
		AASHTO T 90	PI, % =	8
4	LAA	AASHTO T 96	LAA, % =	19.8

The gradation curve of the pure subase is also attached in the following figure showing the curve lies between the upper and lower limit of the requirements of subase material according to ERA standard specification.

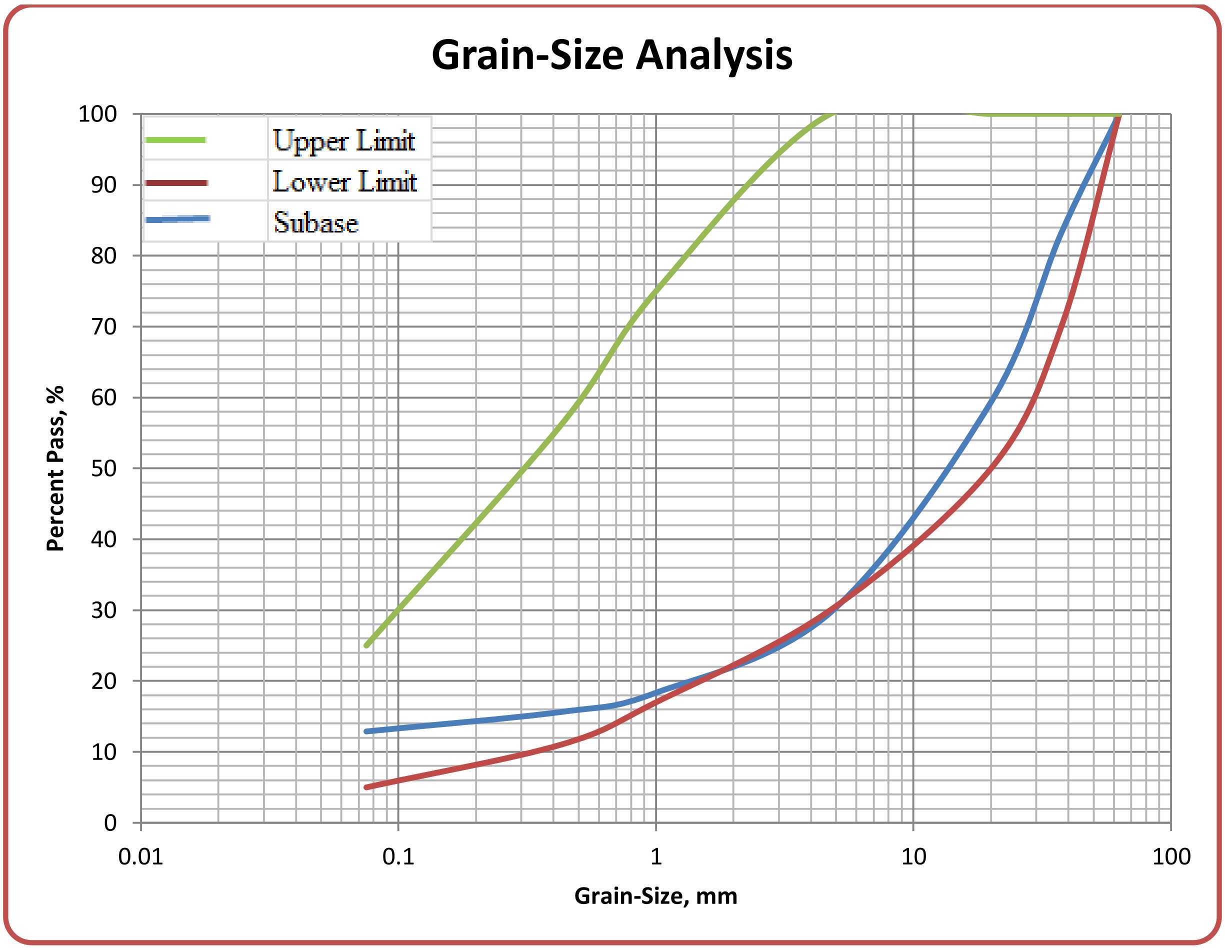

Fig. 3. 4 Grain size distribution of the Subase

3.7 Experimental Study

Experimental study design and laboratory testing was used to accomplish the fundamental objective of the research. After comprehensive reviews on previous related researches and books including different standard specifications on the study area and studying the property of individual material, the full quality tests will be conducted on the samples based on ERA, AACRA, AASHTO and ASTM standards.

3.8 Material Blending Technique

First the Construction Demolition Wastes (CDW) was investigated separately and for the materials which cannot fulfill required qualification for sub-base material mixing with Clay and approved sub-base material using percentage by weight of the CDW material was conducted.

The proportion was selected randomly starting from 10% by weight of the CDW material and was continued by 10% increment. The laboratory tests on both of the mixes with Clay material and approved Subase material conducted with percentage by weight proportion of 10%, 20%, 30% and 40%.

Fig. 3. 5 Mixing CDWs with Clay material

3.9 Laboratory tests

After sampling of the Construction Demolition Wastes as well as the clay and sub-base materials the following laboratory tests were conducted for each sample separately and for the mix with different proportions.

i. Gradation
ii. Atterberg limits
iii. Soil classification for the clay
iv. Proctor Compaction
v. Californian Bearing Ratio (CBR)
vi. Los-Angeles Abrasion

However, the required tests by ERA standard specification might not be sufficient to determine the strength and durability of the aggregates for sub-base materials. Therefore, it was found important to conduct some other tests in order to get some indication on the strength and durability characteristics of the recycled materials. Some of the tests that conducted are:

3.10 Los-Angeles Abrasion

The Los Angeles abrasion test was conducted in addition to other property tests in order to measure the degradation of mineral aggregates of standard grading resulting from the combination of action including abrasion impact and grading in a rotating steel drum containing a specified number of steel spheres. After the prescribed number of revolution the contents are removed from the drum and the aggregate portion is sieved to measure the degradation as a percent loss.

The main objectives of Los Angeles is to use it as indicator the relative quality or competence of the aggregates of CDW sample collected from all the sources. This test was conducted for the pure CDW samples collected as well as for all samples mixed with approved material with all proportions. The test was not conducted on CDW samples mixed with clay material since mixing the material with clay will not bring any improvement on the LAA result of the mixed samples

3.11 After Compaction Characteristics

It is learnt from the above LAA test results of the pure CDW samples that the samples have higher LAA value and as a result of that mineral aggregates in the samples might degrade since the quality of some of the aggregates in the CDW might be poor. In connection with that, in road construction process compaction is very fundamental process in order to improve the material's engineering property such as load bearing capacity, stability, stiffness, volume change characteristics, resistance to settlement and frost damage.

However, while using those CDW materials for subase construction during compaction process of the road construction, the gradation before compaction and after compaction might be different as a result of the load exerted on the CDW material and their after compaction gradation curve might lay out of the specified upper and lower limit specified for subase materials according ERA standard technical specification.

Therefore, in order to investigate the after compaction gradation characteristics of the CDWs and CDW mixed with subase material with the better proportion in fulfilling the subase requirements in each of the above laboratory test results including the LAA test results, it was tried to simulate the compaction at site in to laboratory.

This was done by first compacting the samples by standard proctor compaction method and taking the compacted material out of the mold and conduct the gradation test on the compacted samples. This test was conducted to one pure CDW material and one CDW mixed with approved subase material.

CHAPTER FOUR

ANALYSIS AND RESULT DISCUSSION

This research is conducted in order to evaluate the suitability of the usage of Construction Demolition wastes in Addis Ababa to be fully or partially used as sub-base layer and moreover, to investigate the properties of the Construction and Demolition waste by conducting laboratory tests on itself and by partially replacing on approved sub-base materials and to compare the test results with the ERA and other specifications for sub-base layer qualification. Accordingly, different quality tests were conducted for the pure CDWs, Clay and Subase samples as well as the CDW samples mixed with Clay and Subase materials with different proportions.

Therefore, this chapter incorporates the laboratory test results and discussions of the pure CDWs, Clay and Subase samples as well as the CDW samples mixed with Clay and Subase materials with different proportions. Comparison with the ERA standard technical specification for subase material and other specifications was also incorporated in this chapter.

1. Gradation

It is also called a sieve analysis. Gradation or sieve analysis is type of test method practiced in civil engineering in order to assess the particle size distribution of a granular material by putting the material to be tested on a series of different sized sieves and measuring the percentage passing and retaining mass of the sample in each consecutive sieves. It will tell us the distribution off aggregate particles by size within a given sample. The test method used to conduct this test is AASHTO T 11-91, T 27-93.

The main objective of this test is to determine the particle size distribution after washing the sample materials dry sieving test is performed which is used for coarse and fine aggregate free from particles which cause agglomeration.

The of ERA Standard Technical Specification 2013 provides the ranges in which the percentage passing curve of the materials shall lie on at different particle size distribution (sieve size) in order to be considered as a subase material. The Upper and Lower limit of the percentage passing in each sieve size of the material is indicated below.

Table 4. 1 ERA standard technical specification, gradation requirement for subase

Sieve size	63	37.5	20	4.75	1	0.425	0.075
Lower limit, % Pass	100	70	50	30	17	11	5
Upper limit, % Pass	100	100	100	100	75	56	25

1.1 Gradation of the pure samples

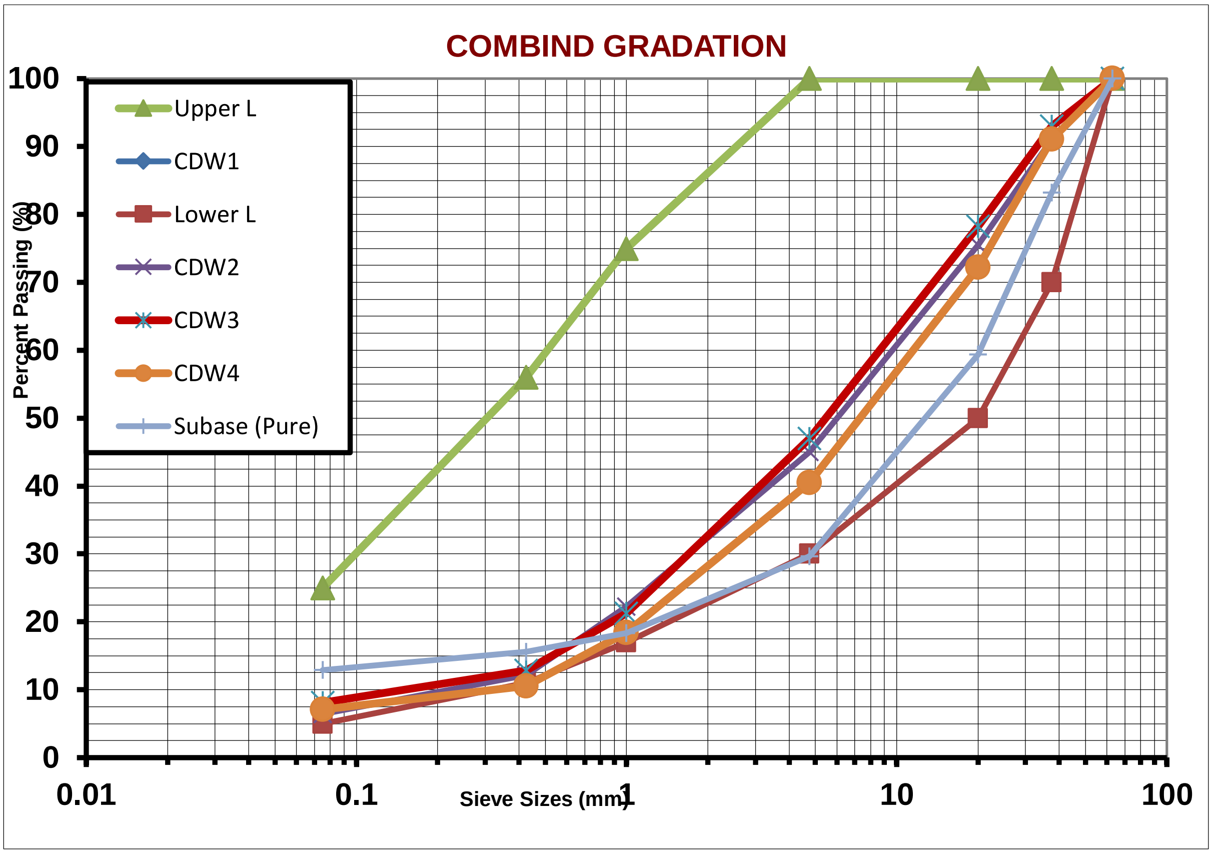

Fig. 4. 1 Gradation curve of the pure samples

Gradation tests on pure CDW samples as well as on the pure Subase sample was conducted in order to investigate if the pure sample's gradation curve lies between the upper and lower limits of the ERA standard technical specification requirement for subase material.

As it can be seen from the above graph, all the tested CDWs have a percent passing in each sieve size between the specified percentages passing amount in each sieve size.

The curve also lies between the upper and lower limits of the ERA standard technical specification requirement for subase material. This indicates that all the CDWs as well as the subase material used to mix the CDWs fulfil the specified gradation criteria in order to be used as a subase material.

However, there were also some boulder materials in the CDWs and they were excluded from the sample to be tasted and some of the boulder materials were sampled and then hand crashed by using hammer in order to prepare the sample for the required tests. Therefore, if we are going to use CDWs as a subase material, in order to exclude boulder materials from CDWs, great care shall be given for the demolishing process so that the CDW materials are suitable for subase construction and one can get the required gradation for subase.

1.2 Gradation of the CDW1 mixed with Subase

Gradation test was also conducted on CDW1 sample mixed with subase material with all proportions in order to investigate the effect of mixing subase material with CDWs on the gradation curve of the sample.

Combining CDW1 with subase material also does not have much change on the gradation of the sample. As it can be seen from the chart below all combining 10%, 20% and 30% subase material with the CDW1 sample still does not affect the sample to fulfil the ERA standard technical specification gradation requirement for subase materials and lie in between the upper and lower limits specified. However, mixing the CDW1 with 40% subase takes the graph below the lower limit specified and does not fulfil the requirement in order to be used as subase material. This may be due to the partial substitution of the relatively smaller size particles of CDWs by bigger size of the subase material.

This indicates that CDW1 can fulfil the gradation requirement by itself or mixing it with subase material with10 – 30% by mass proportion. However, mixing 40% subase with CDWs does not fulfil the gradation requirement and the mixing proportion should be between 10 to 30 percentages by mass of the sample.

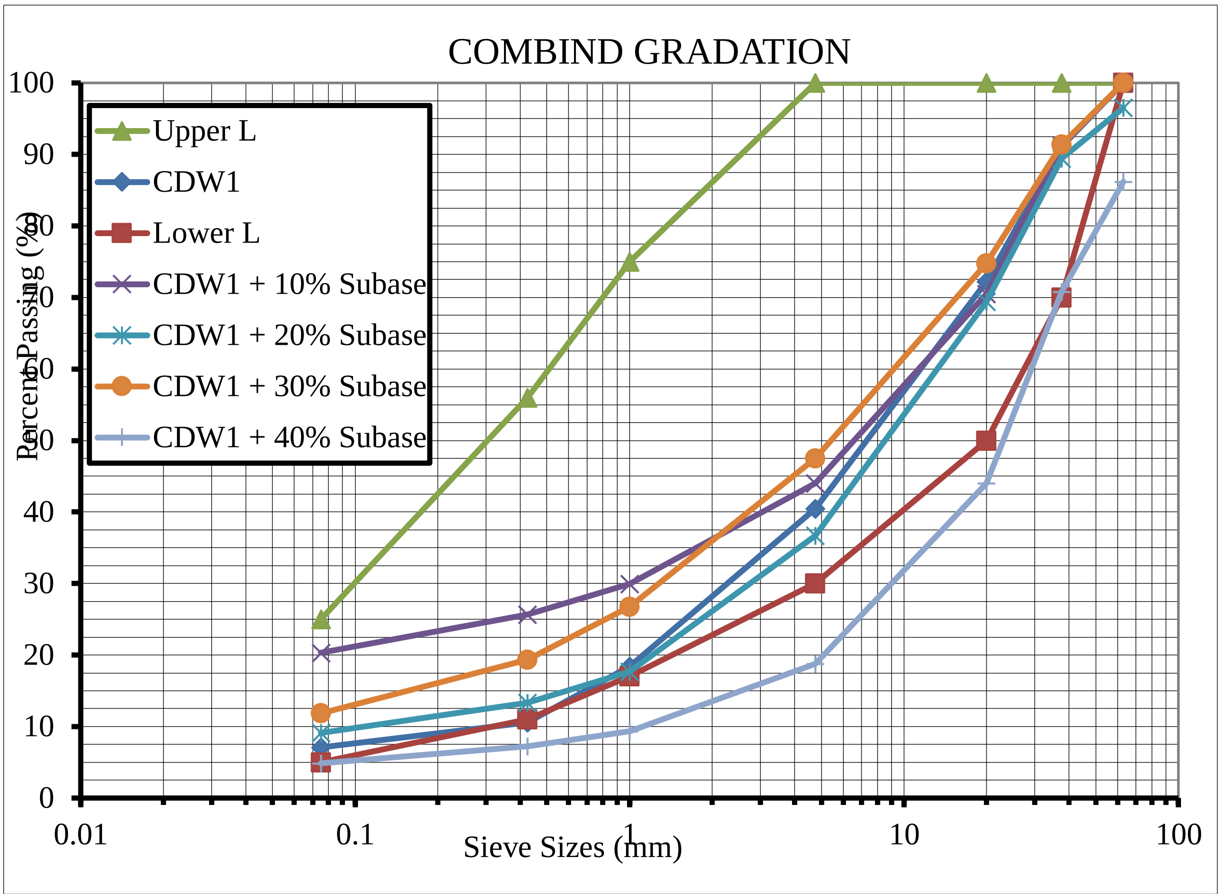

Fig. 4. 2 Gradation curve of the CDW1 mixed with Subase

1.3 Gradation of the CDW2 mixed with Subase

The Gradation test was also conducted on CDW2 sample mixed with subase material with all proportions in order to investigate the effect of mixing subase material with CDWs on the gradation curve of the sample.

Combining CDW2 with subase material also does not have much change on the gradation of the sample. As it can be seen from the chart above all combining 10%, 20%, 30% and 40% subase material with the CDW2 sample still does not affect the sample to fulfil the ERA standard technical specification, gradation requirement for subase materials and lie in between the upper and lower limits specified. In this case, mixing the CDW2 with 40% subase does not affect the sample to fulfil the gradation requirement of ERA standard technical specification unlike the CDW1 sample.

This clearly tells us that CDW2 can fulfil the gradation requirement by itself or mixing it with subase material with 10 – 40 percentage by mass proportion. Therefore, the mixing proportion of CDWs with subase material should be between 10 to 40 percentages by mass of the sample.

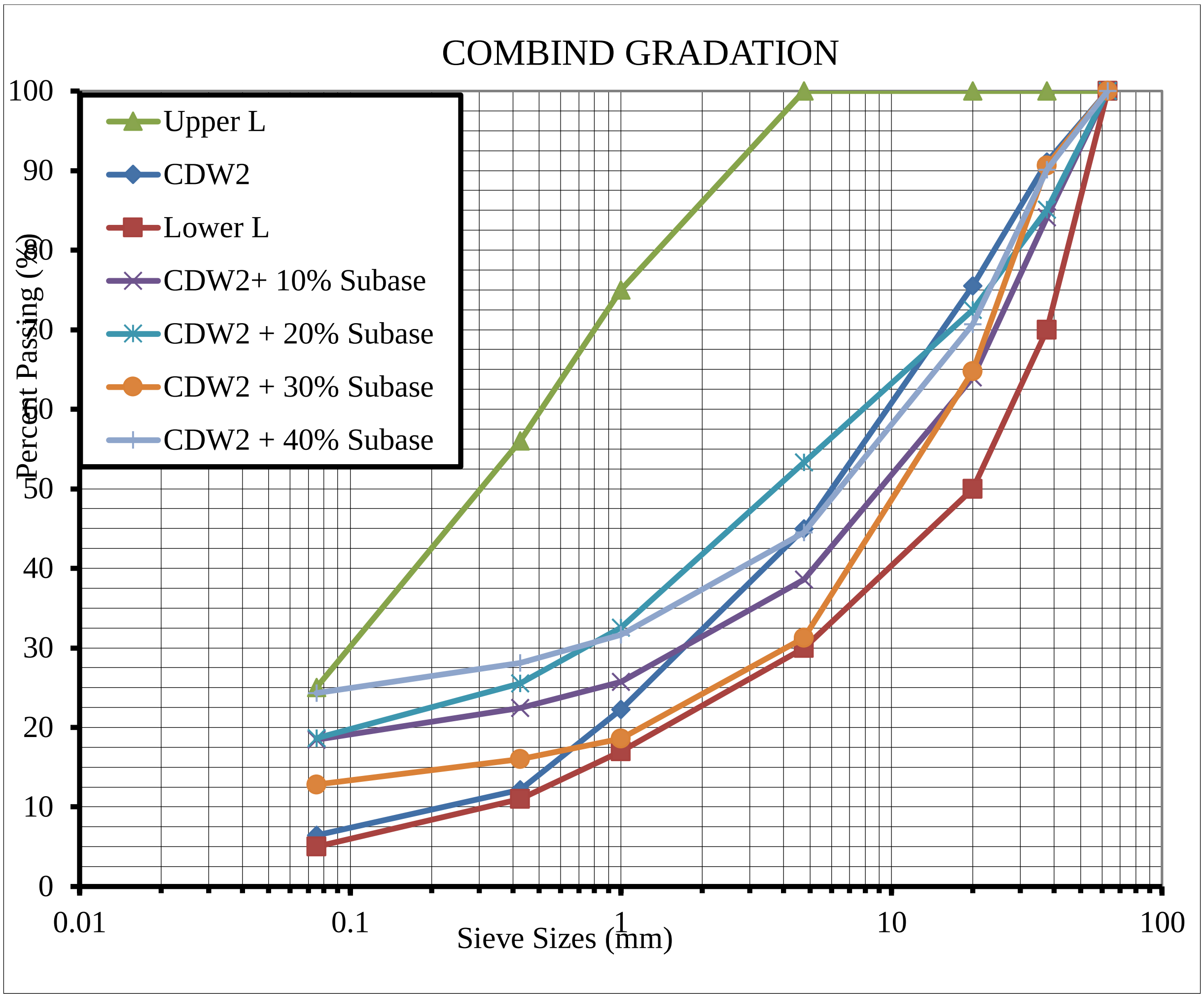

Fig. 4. 3 Gradation curve of the CDW2 mixed with Subase

2. MDD (Maximum Dry Density) and OMC (Optimum Moisture Content)

Proctor Compaction test is a laboratory method of determining the MDD (Maximum Dry Density) and OMC (Optimum Moisture Content) of a given sample or material. It describes the optimal moisture content when the sample is at its most dense state. The test method that have been used to conduct this test is AASTO T-180 method D.

This test has been done to all pure samples of the Construction Demolition Wastes (CDWs) and also on the pure clay and subgrade samples that are used to upgrade the densities of the CDWs by mixing them with different percentile proportion. The results of the tests on the pure samples as well as on the mixed samples are presented and discussed below.

2.1 Results of the pure Clay, Subase and CDWs

This test was conducted on the pure Clay, Subase and CDWs samples of in order to determine the Maximum Dry Densities and Optimum Moisture Contents of each material separately so that it can tell the compaction characteristics of the samples.

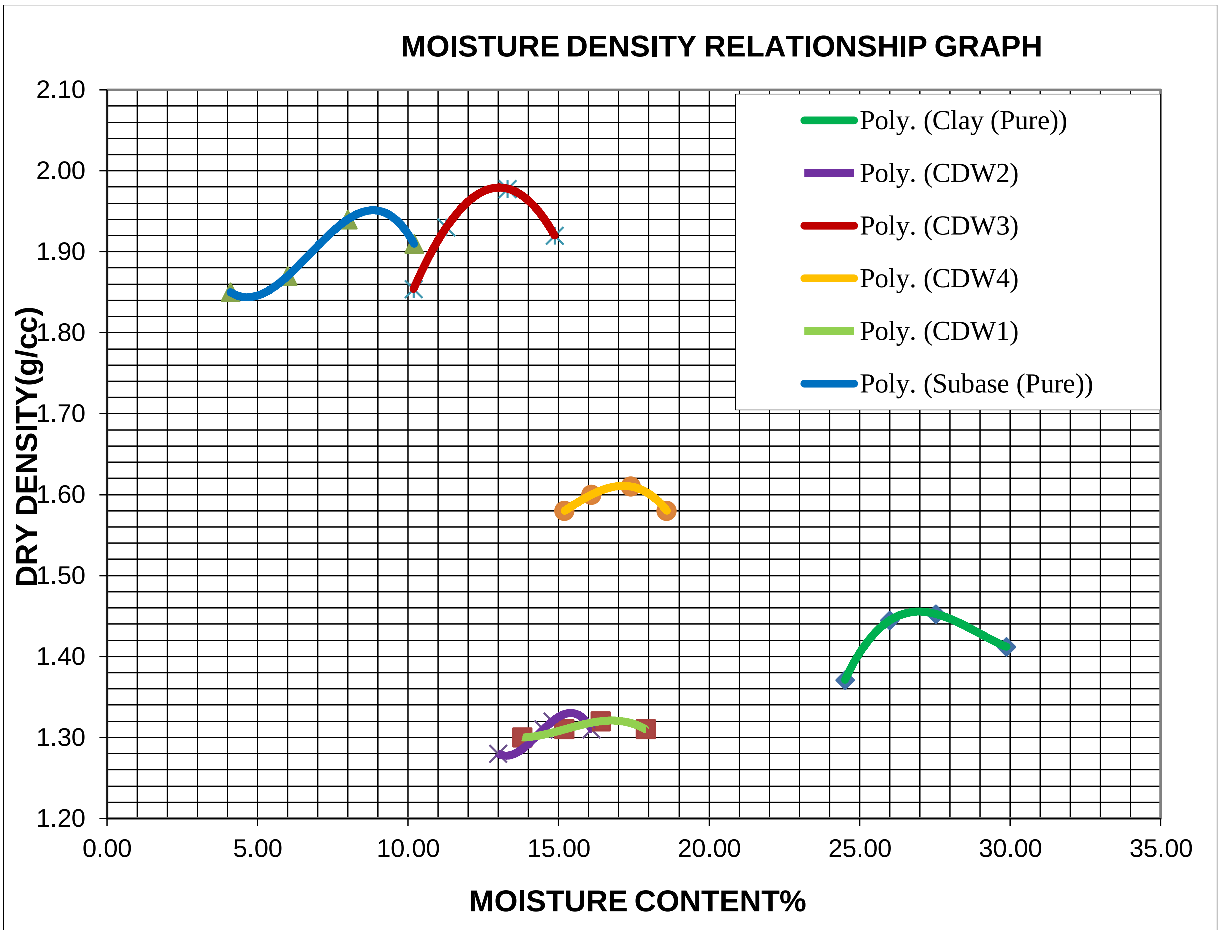

Fig. 4. 4 Moisture Density Relationship Graph of Pure Samples

As it can be seen from the graph above the pure Subase material and the CDW3 have the highest value of MDD from the rest of the samples which is between 1.9 to 2.1 g/cc and the lowest value of OMC which ranges 7 to 14%. However, the rest of CDWs (CDW1, CDW2 and CDW4) and the pure Clay sample have relatively lower MDD value which ranges between 1.6 and 1.3g/cc which is less than the expected MDD value for subase material. In addition, the rest of CDWs (CDW1, CDW2 and CDW4) also have higher OMC value which ranges between 16 to 28% which is also higher than expected OMC value for subase material.

This indicates that, the pure Subase sample and CDW3 are denser at their optimal moisture content and the rest of the CDWs are less dense at their optimal moisture content. From this we can say that CDWs have lesser densities and increment in their densities is necessary in order to use them as a subase material since materials with low densities can have low bearing capacity and results in lower stability and stiffness, volume change characteristics, lower resistance to settlement.

In in this research, in order to increase the Maximum Dry Densities of the CDWs, the CDWs were mixed with Clay and approved Subase materials.

2.2 Results of the CDW1 mixed with Clay

The Proctor test was also conducted on the CDW1 sample mixed with Clay material with different proportions in order to see the effect of the clay material on the MDD and OMC of the CDWs.

Combining the CDW1 sample which have lower MDD and higher OMC when tested by itself with Clay in different proportion resulted a greater increment on the MDD of the sample and decrement on the OMC of the same. As it can be seen from the chart below the maximum value of MDD was obtained when we combine CDW1 with 20 and 30% Clay and the MDD boosted reaches around 2g/cc whereas, the OMC shows decrement and reaches around 12%.

This indicates that, mixing Clay by all proportion with CDWs results on an increment on the maximum dry density and decrement on the optimal moisture content of the sample. However, the maximum increment on the maximum dry density was obtained at 20 and 30 percentage by weight of clay is mixed with the CDW.

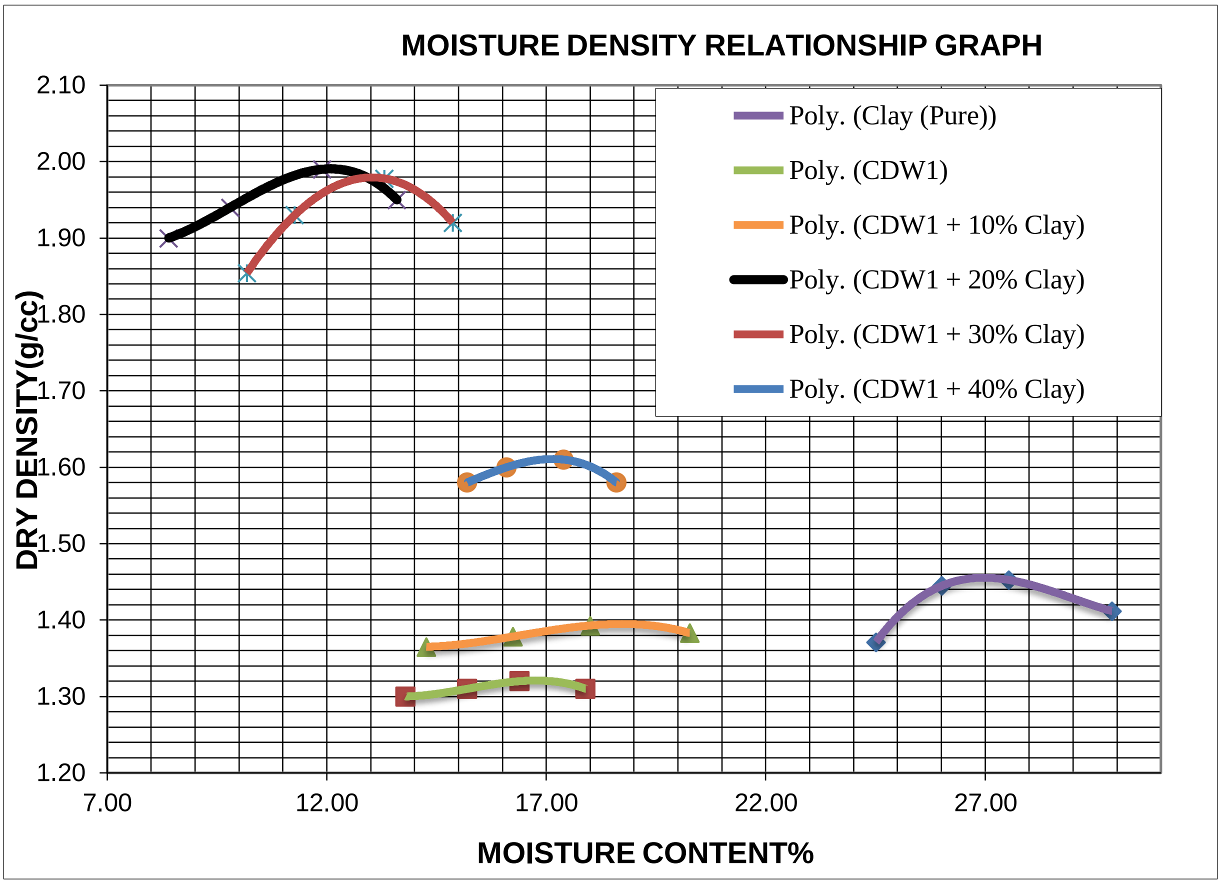

Fig. 4. 5 Moisture Density Relationship Graph for CDW1 mixed with Clay

The obtained increment is due to the introduction of fine particles of the Clay material in to CDWs, which have voids due to their courser materials. When the fine materials fill the voids between the aggregates of the CDWs the density increased by greater amount.

2.3 Results of the CDW2 mixed with Clay

Like wise to CDW1 combining the CDW2 sample which have lower MDD and higher OMC when tested by itself with Clay in different proportion resulted a greater increment on the MDD of the sample and decrement on the OMC of the same. As it can be seen from the chart below, the maximum value of MDD was obtained when we combine CDW2 with 10 and 20% Clay and the MDD boosted reaches greater than 2g/cc whereas the OMC shows decrement and reaches around 10 - 12%.

This also indicates that, mixing Clay by all proportion with CDWs results on an increment on the maximum dry density and decrement on the optimal moisture content of the sample. However, the maximum increment on the maximum dry density will be obtained at 10 and 30 percentage by weight of clay is mixed with the CDW.

The obtained increment here is also due to the introduction of fine particles of the Clay material in to CDWs in which they have between their courser aggregates. When the fine materials fill the voids between the aggregates of the CDWs the density increased by greater amount. In addition, the cohesive nature of the Clay material strengthen the bond between the particles of the mix and this also have contribution on the density increment.

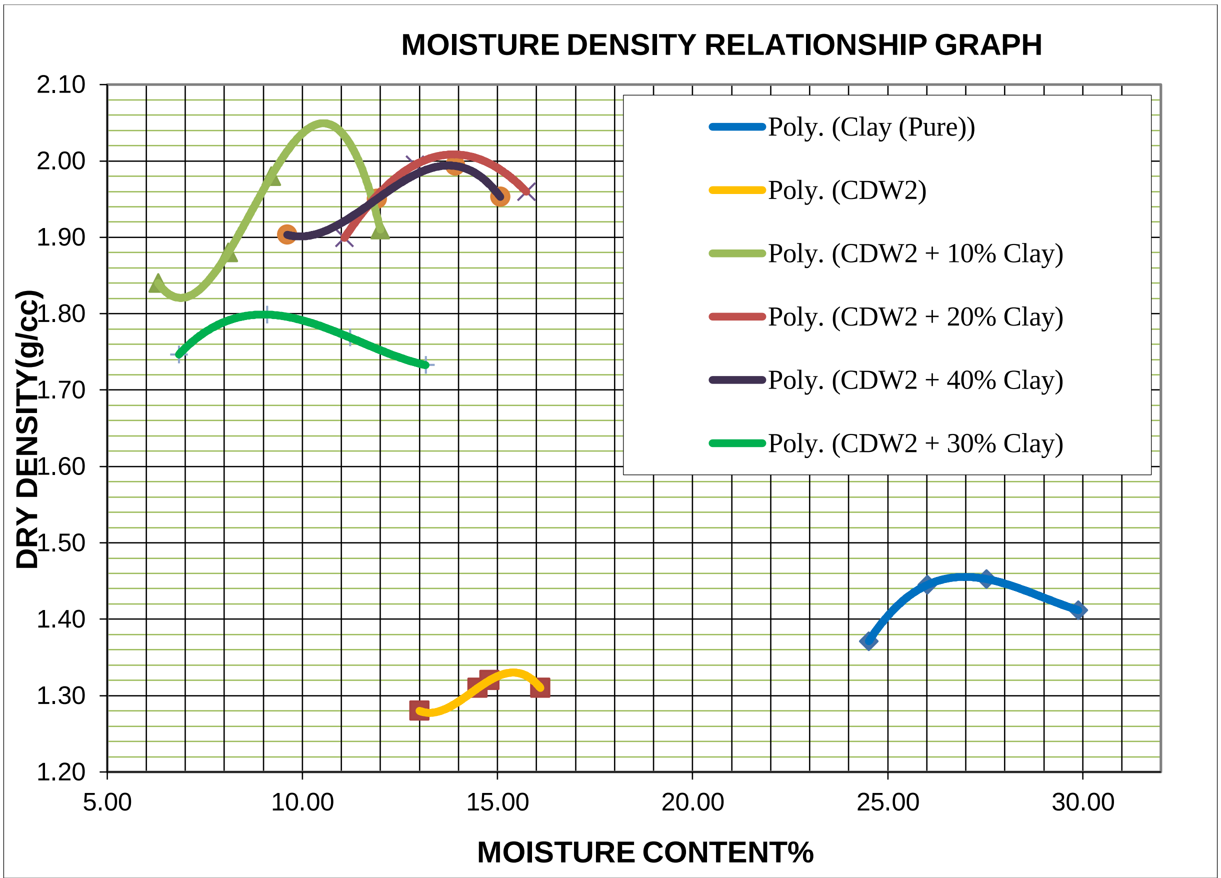

Fig. 4. 6 Moisture Density Relationship Graph for CDW2 mixed with Clay

2.4 Results of the CDW1 mixed with Subase

The Proctor test was also conducted on the CDW1 sample mixed with Subase material with different proportions in order to see the effect of the Subase material on the MDD and OMC of the CDWs.

Mixing the CDW1 sample which have lower MDD and higher OMC when tested by itself with Subase in different proportion also resulted a greater increment on the MDD of the sample and decrement on the OMC of the same.

As one can see from the graph below, the MDD of CDW1 which was around 1.3g/cc increased when mixed in all proportion of subase and reaches greater than 2g/cc whereas the OMC which was around 17% shows decrement and reaches around 8 to 10% when mixed with Subase in all percentile proportion.

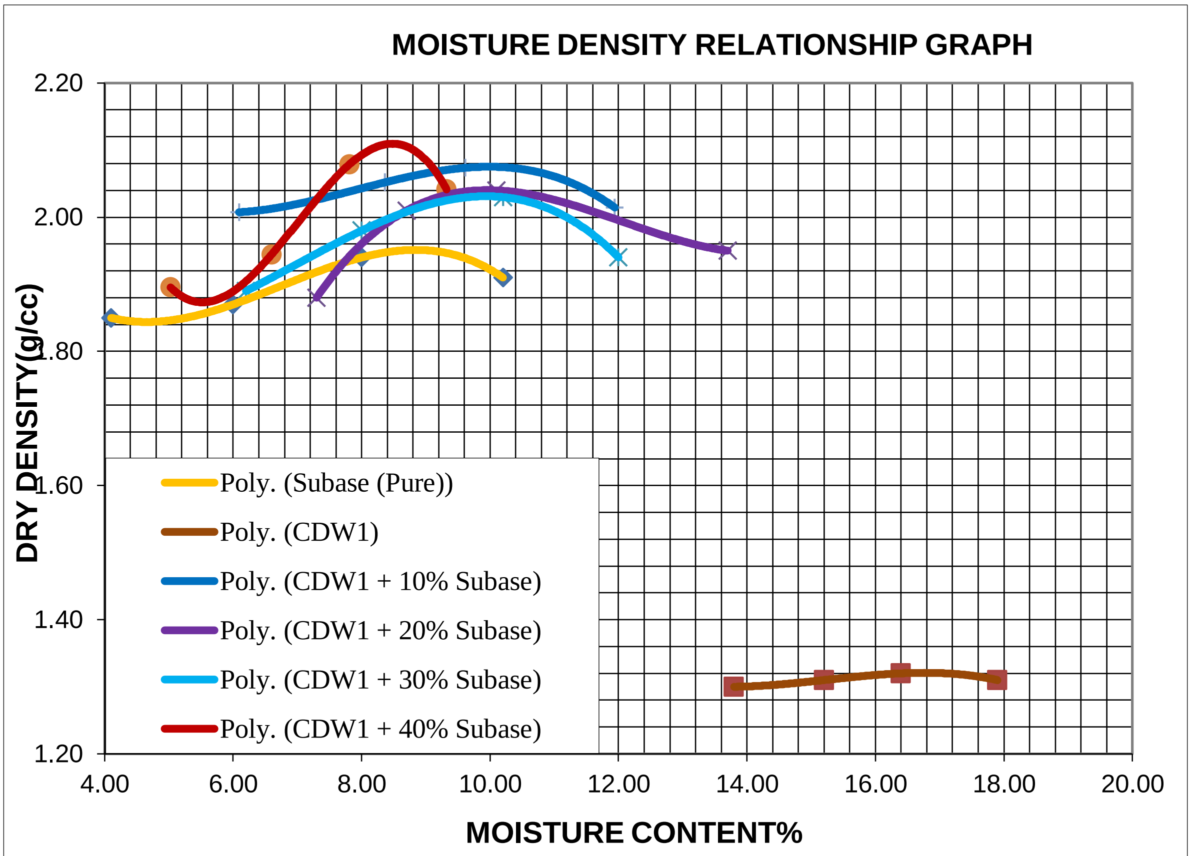

Fig. 4. 7 Moisture Density Relationship Graph for CDW1 mixed with Subase

This indicates that mixing CDWs with subase material can increase the density and decrease the optimal moisture content of the CDWs as well as the subase material itself.

The increment on the densities of the CDWs while mixing with subase material is due to the fine particles of the subase material which have some plasticity and cohesive nature and this increased the cohesion and bond between the aggregates of the mix which resulted in increment of MDD of the CDWs.

2.5 Results of the CDW2 mixed with Subase

Combining the CDW2 sample which have lower MDD and higher OMC when tested by itself with Subase in different proportion also resulted a greater increment on the MDD of the sample and decrement on the OMC of the same.

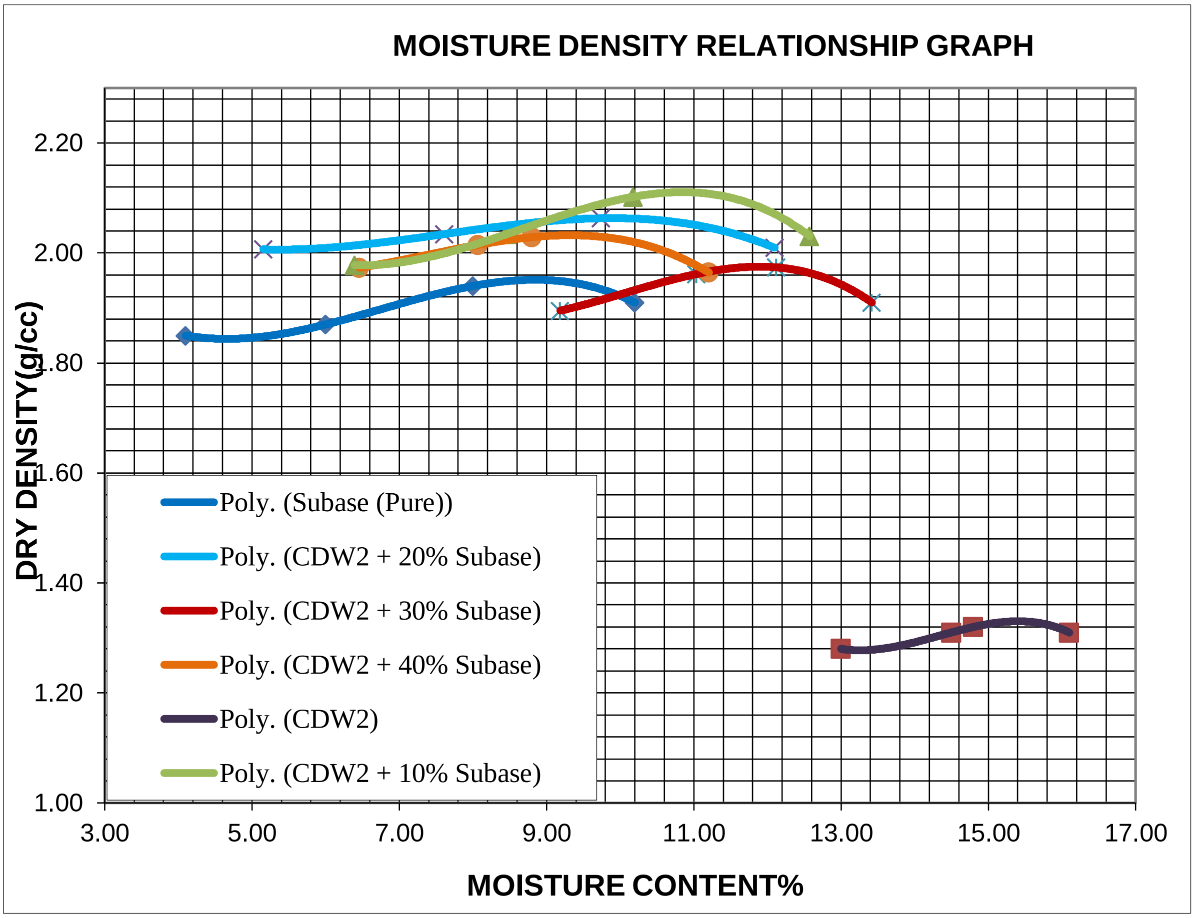

Fig. 4. 8 Moisture Density Relationship Graph for CDW2 mixed with Subase

As it can be seen from the graph above, the MDD of CDW2 which was around 1.35g/cc increased when mixed in all proportion of subase and reaches greater than 2g/cc whereas the OMC which was around 16% shows decrement and reaches around 8 to 11% when mixed with Subase in all percentile proportion.

Fig. 4. 9 Procter Compaction test conducting

This also indicates that, mixing CDWs with subase material can increase the density and decrease the optimal moisture content of the CDWs as well as the subase material itself.

Here also, the augmentation on the densities of the CDWs while mixing with subase material is due to the fine particles of the subase material that have some plasticity and cohesive nature and this increased the cohesion and bond between the aggregates of the mix which resulted in increment of MDD of the CDWs.

3. Californian Bearing Ratio (CBR) test results

Californian Bearing Ratio CBR test can be taken as a measure of any material used in pavement construction. It if performed by measuring the pressure exerted to penetrate the molded sample with a plunger of given standard area. The strength of sub base materials are expressed in terms of their California bearing ratio (CBR) value. This test is used to evaluate the potential strength of CDWs to be used as sub base material by themselves and by mixing them with Clay and Subase material.

The main objective conducting this test is to determine the California bearing ratio by conducting a load penetration test on the pure samples of CDWs and on the mixed samples with Clay and Subase material with different percentage by mass of the sample.

The test method used to conduct this test is AASHTO T 193 – 93. ERA Standard Technical Specification of 2013 suggests that a material shall have a minimum of 30% CBR value in order to be used as a subase material.

2.1 CBR of pure samples

CBR tests on pure CDW samples as well as on the pure Clay and Subase sample was conducted in order to investigate if the pure sample's bearing capacity fulfils the ERA standard technical specification requirement for subase material which is greater than or equal to 30% CBR value.

As it can be seen from the graph below, all the CDWs do not fulfil the ERA Standard Technical Specification of 2013 CBR value requirement since they all have CBR value of a little less than 30%. In addition, the Clay material also cannot fulfill the subase requirement by itself.

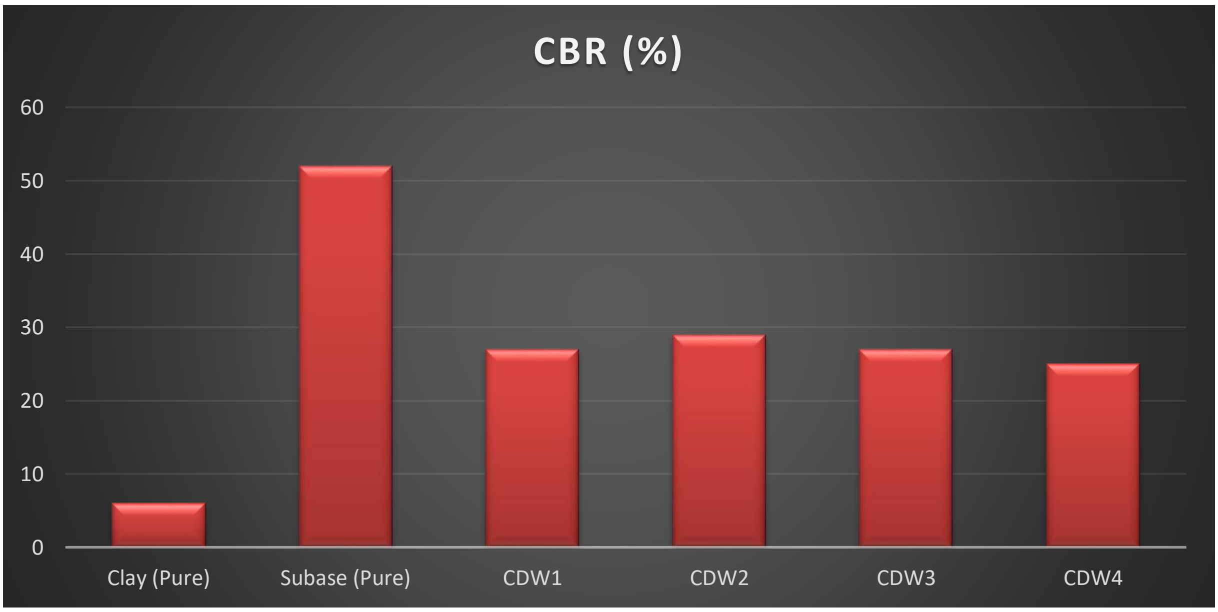

Fig. 4. 10 CBR results of the pure samples

The relatively lower CBR value of the CDWs is due to their aggregates, which can be easily crashed in to pieces when subjected to loads which will lower their load bearing capacity. Moreover, since CDWs have none plastic as well as non-cohesive nature there is no enough cohesion or bondage between the aggregates. This also have contribution in lowering the bearing strength of CDWs.

2.2 CBR of CDW1 mixed with Clay

The CBR test was also conducted on the CDW1 sample mixed with Clay material with different proportions in order to see the effect of the Clay material on the CBR values of the CDWs.

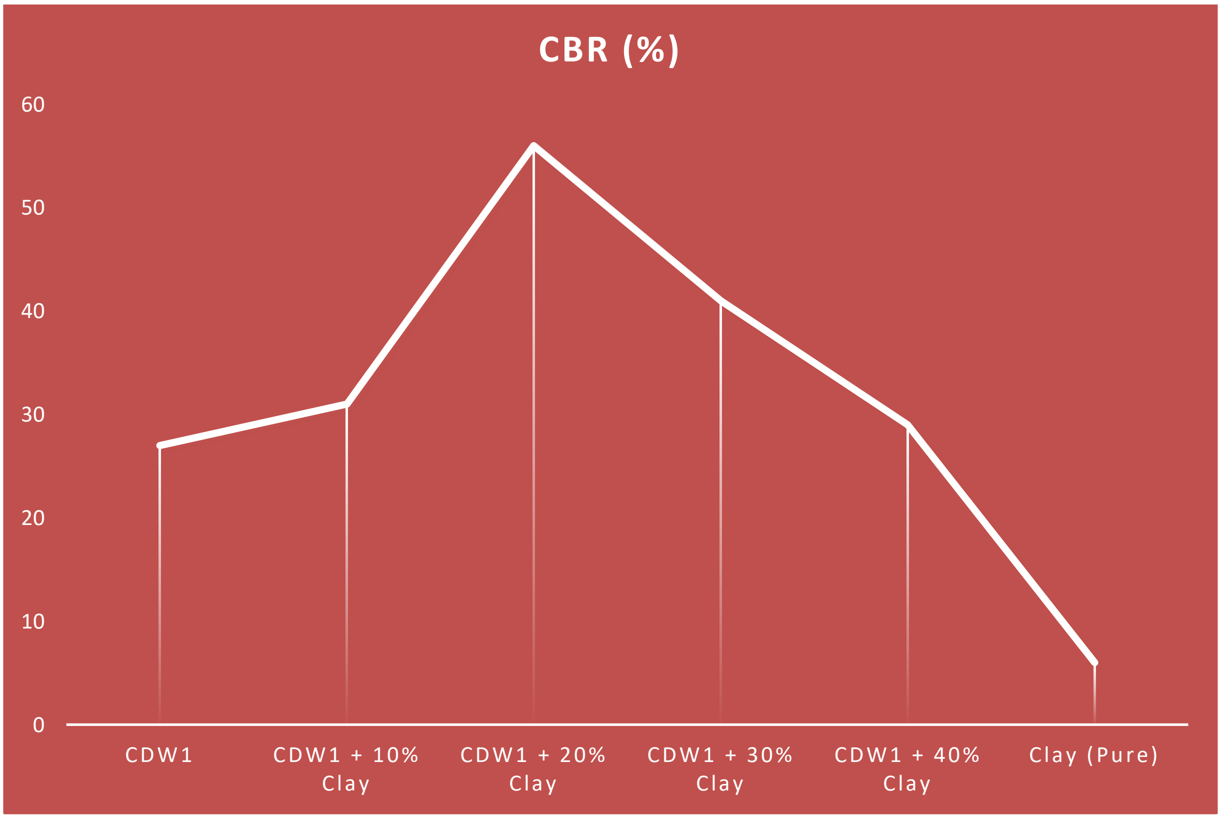

Fig. 4. 11 CBR results of the CDW1with Clay

When CDW1 is mixed with clay material, it shows an increment with increment of the percentage Clay content until it reaches the maximum CBR value at 20% Clay content which becomes 56% CBR value. After that, the CBR value starts to fall down with increment in percentage Clay content and reaches its lowest point at 40% Clay content which makes the CBR value to be 29%.

This indicates that mixing CDW1 with 10 to 30% Clay can increase bearing capacity or bearing strength of the sample and it can make it to fulfil the CBR value criteria in order to be used as a subase material since mixing clay material with 10 – 30% proportion resulted on CBR values greater than the allocated 30% CBR value criteria.

However, the preferable mixing proportion is 20% clay as it results the maximum CBR value, which is 56%.The increment in CBR is due to the introduction of cohesive clay materials in the mix and increased the cohesion between the particles which resulted in increment of the bearing capacity. In addition to that, the voids between the aggregates of the CDWs were filled with the fine materials of the clay and this increased the density of the mix which resulted in increment of the CBR.

2.3 CBR result of CDW2 mixed with Clay

When CDW2 is also mixed with clay material, it shows an increment with increment of the percentage Clay content until it reaches the maximum CBR value at 30% Clay content which becomes 43% CBR value. After that the CBR value starts to fall down with increment in percentage Clay content and reaches its lowest point at 10% and 40% Clay content which makes the CBR value to be 33%.

This indicates mixing CDW2 with all percentage proportions of Clay can increase bearing capacity or bearing strength of the sample and it can make it to fulfil the CBR value criteria in order to be used as a subase material since mixing clay material with 10 – 40% proportion resulted on CBR values greater than the allocated 30% CBR value criteria.

However, the preferable mixing proportion in the case of CDW2 becomes 30% percentage by weight of clay as it resulted the maximum CBR value which is 43%.

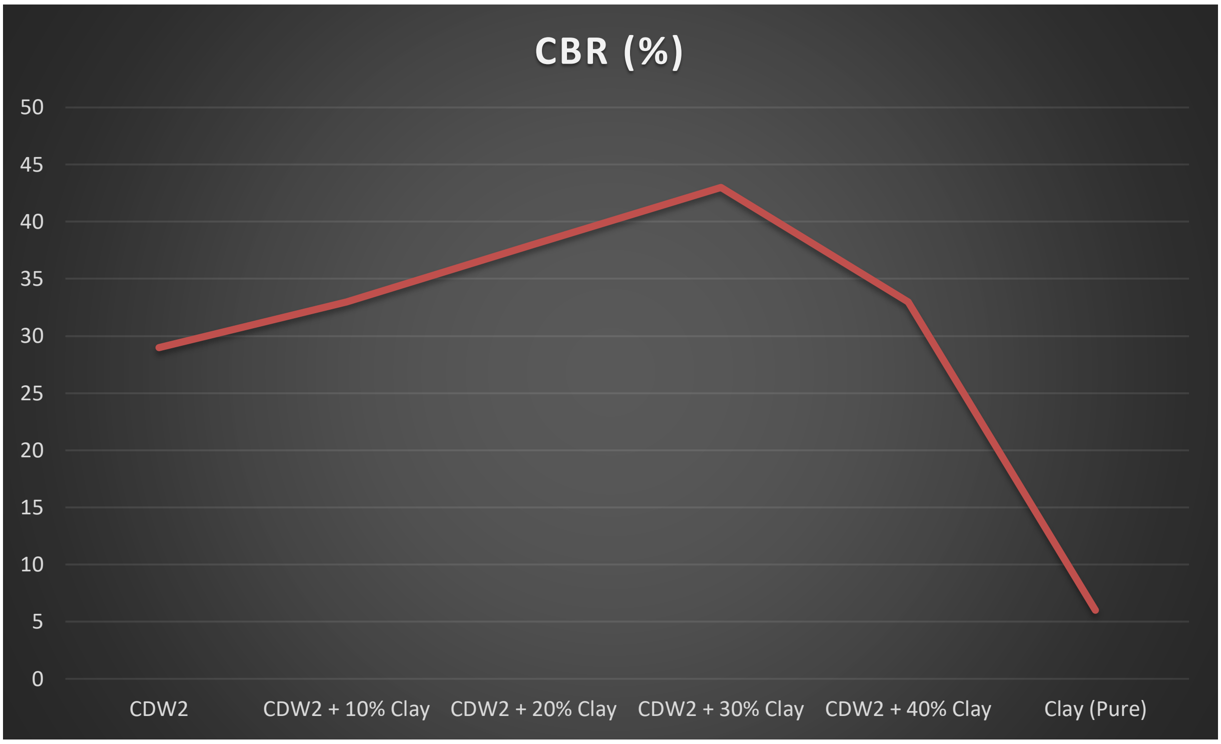

Fig. 4. 12 CBR results of the CDW2 with Clay

Here also the increment in CBR is due to the introduction of cohesive clay materials in the mix and increased the cohesion between the particles which resulted in increment of the bearing capacity. In addition to that, the voids between the aggregates of the CDWs were filled with the fine materials of the clay and this increased the density of the mix which resulted in increment of the CBR.

2.4 CBR of CDW1 mixed with Subase

The CBR test was also conducted on the CDW1 sample mixed with Subase material with different proportions in order to see the effect of the Clay material on the CBR values of the CDWs.

As it can be seen in the graph below, combining CDW1 with Subase material, results a big increment with increment of the percentage subase content until it reaches the maximum CBR value at 40% Clay content which becomes 90% CBR value.

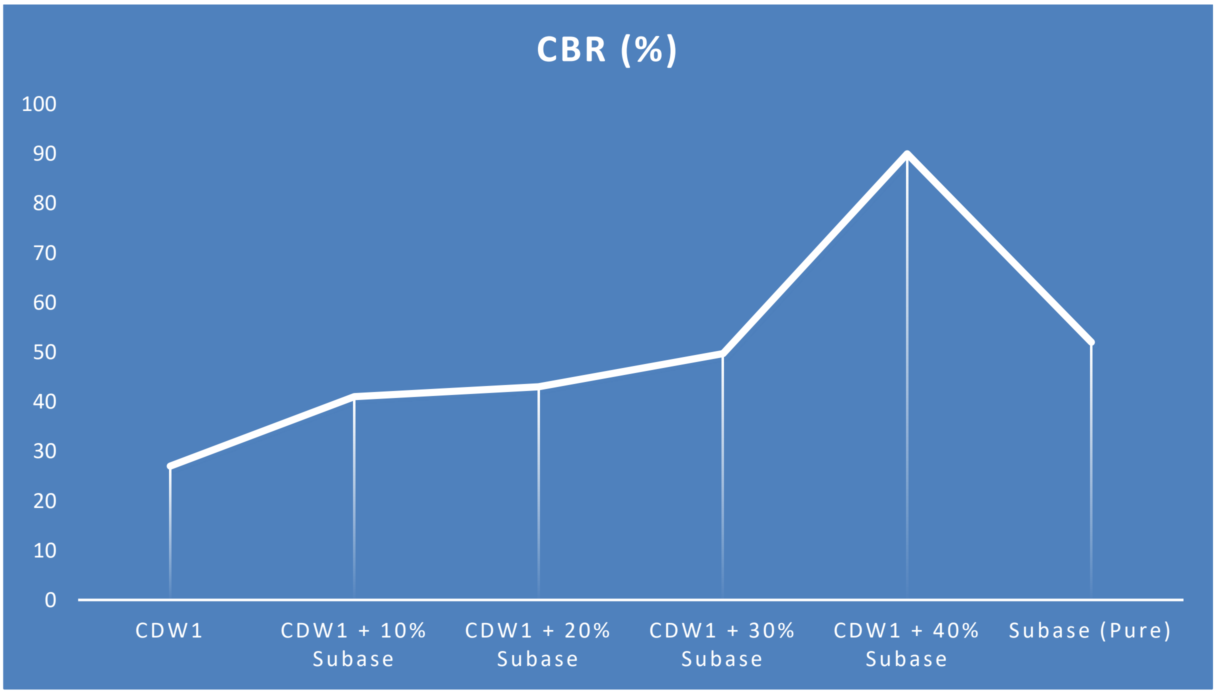

Fig. 4. 13 CBR results of the CDW1 with Subase

This indicates that, mixing CDW1 with all percentages by mass of Subase materials can increase the density as well as the strength of the samples and it can make the samples to fulfil the CBR value criteria in order to be used as a subase material. This is due to the CBR values obtained after mixing the sample with all the mixing proportions are greater than the allocated 30% CBR value criteria. Therefore, according to the graph below, the greater the subase percentage mixed with the CDWs the greater will be the CBR value of the mix.

The increment in CBR is as a result the introduction and partial substitution of strong aggregates of the subase in to relatively weaker aggregates of the CDWs that can easily crashed in to pieces while subjected to loads. The cohesive nature of the finer materials of the subase also increased the bondage between the aggregates of the mix and it contributes on the increment of the bearing capacity of the CDWs.

2.5 CBR of CDW2 mixed with Subase

The graph below clearly shows that combining also CDW2 sample with Subase material, results a big increment with increment of the percentage subase content until it reaches the maximum CBR value at 40% Clay content which becomes 52% CBR value.

This also indicates that mixing CDW2 with all percentages by mass of Subase material can increase the density as well as the strength of the sample and it can make it to fulfil the CBR value criteria in order to be used as a subase material since CBR values obtained after mixing CDW2 with subase by all the mixing proportions are greater than the allocated 30% CBR value criteria.

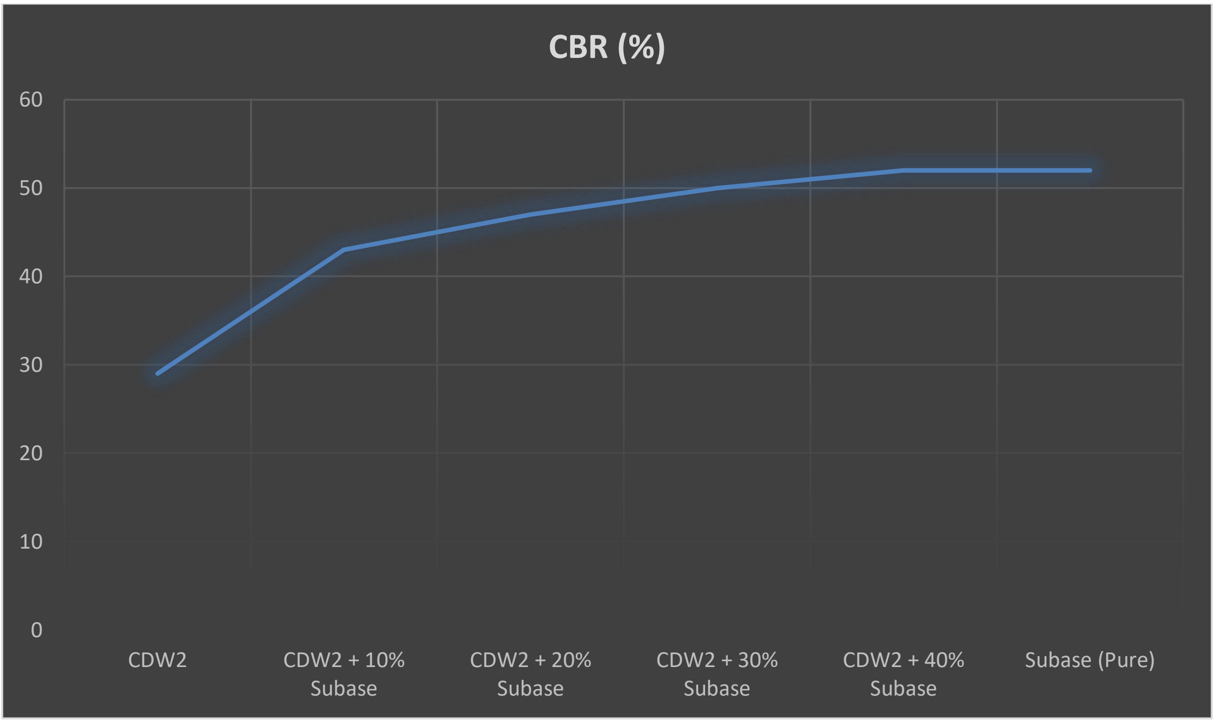

Fig. 4. 14 CBR results of the CDW2 with Subase

Fig. 4. 15 Conducting CBR test

Here also, it can be said that according to the graph above, the greater the subase percentage mixed with the CDWs the greater will be the CBR value of the mix.

The increment in CBR is as a result the introduction and partial substitution of of strong aggregates of the subase in to relatively weaker aggregates of the CDWs that can be easily crashed in pieces while subjected to loads. The cohesive nature of the finer materials of the subase also increased the bondage between the aggregates of the mix and it contributes on the increment of the bearing capacity of the CDWs

4. CBR swell test results

CBR swell means the soil swell resulting from soaking the sample in water. This indicates the expansiveness of the soil or expansion nature of the soil. The test method used to conduct this test is AASHTO T 193 – 93 which is also used to conduct the CBR test. ERA Standard Technical Specification of 2013 suggests that a material shall have a maximum of 1.5% CBR swell value in order to be used as a subase material.

4.1 CBR swell test results of pure samples

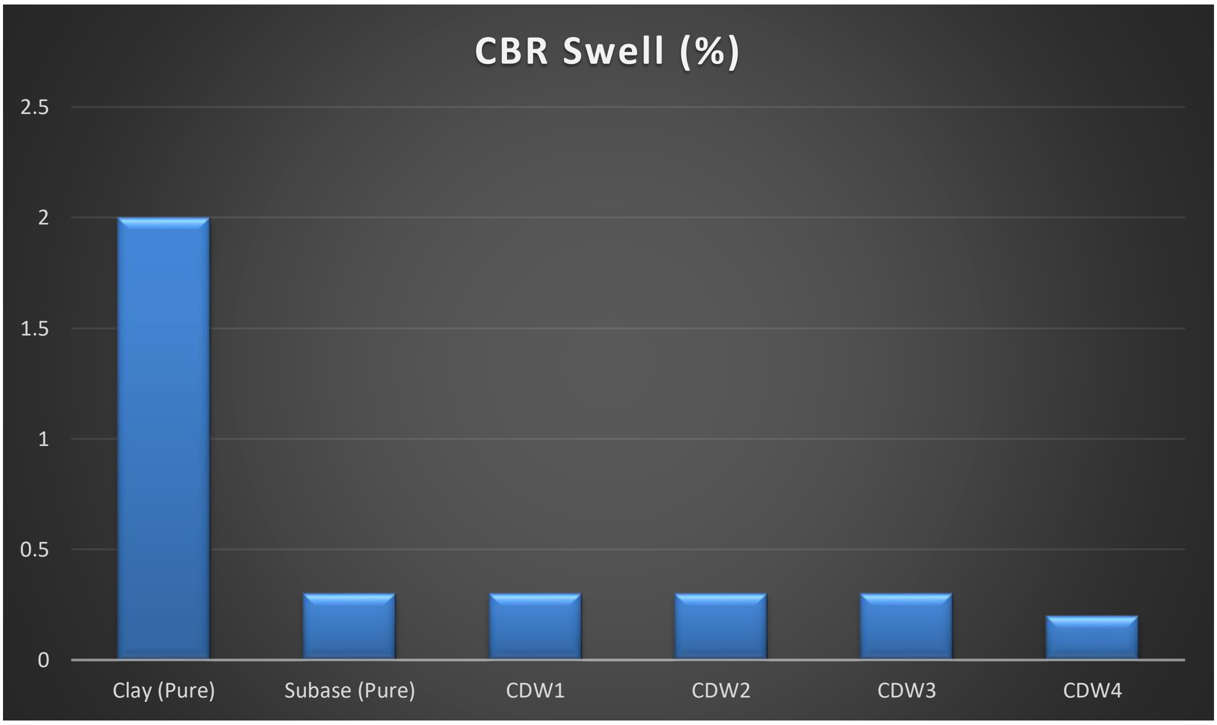

Fig. 4. 16 CBR swell results of pure samples

As it is clearly depicted in the graph babove all the CDW samples as well as the subase material are approximately 0% swell. This indicates that the samples collected have no expansive nature and they fulfil the swell requirement specified under ERA standard technical specification for subase materials.

However, the Clay material used by mixing with CDW samples has a CBR swell of 2% which indicates that it has expansive nature. This makes the clay material not to fulfil the CBR swell criteria of the specification in order to be used as a subase material.

This means that swelling is not a problem on all of the CDWs and there is no expansive nature at all on the particles of the samples.

4.2 CBR swells of CDW1 and CDW2 mixed with Clay

Since the original CDW materials was non plastic and non-swelling materials, mixing the samples with clay give them some plasticity and swelling nature. However, the CBR swell values as it can be seen in the following graphs are below the maximum requirements of the ERA standard technical specification for subase materials which is less than or equal to 1.5% CBR swell value.

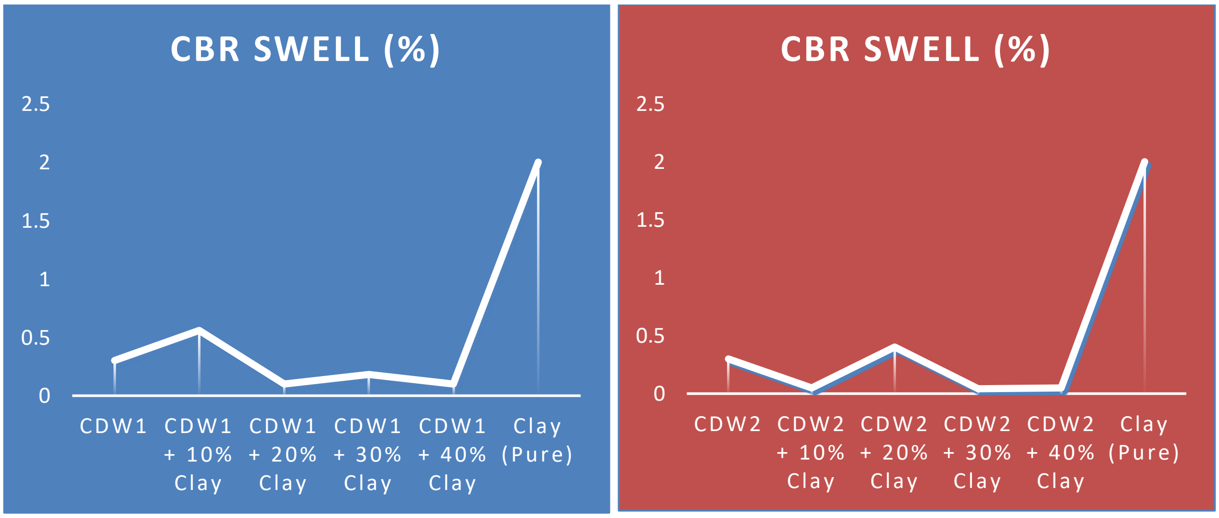

Fig. 4. 17 CBR swell of CDW1 and CDW2 mixed with Clay

The CBR swell values of the CDW1 and CDW2samples mixed with subase materials are not presented in the paper but attached in the appendix since adding subase on the CDWs results almost no difference on the CBR swell value.

5. Liquid Limit test results

The liquid limit is the empirically established moisture content at which the sample passes from the liquid state to the plastic state. The main objective of conducting this test is to determine the plasticity of the pure CDW samples and the CDWS mixed with Clay and Subase in different proportions. The test method used to determine Atterberg limits of the samples is AASHTO T 89 AASHTO T 90. ERA Standard Technical Specification of 2013 suggests that a material shall have a maximum of 45%Liquid Limit value in order to be used as a subase material. Otherwise, it will be highly plastic soil and will not be suitable to be used as a Subase material

5.1 Liquid Limit test results of pure samples

The Liquid Limit test was also conducted on the pure CDWs, clay and Subase samples in order to see the Liquid Limit values of the samples and compare with the requirements specified in the specifications.

As it is clearly described in the graph below, all the CDW samples are non-plastic materials as it is not possible to determine their Liquid Limits. Whereas the Subase material used to be mixed with the CDWs have a Liquid Limit value of 37% which is less than 45% and makes it suitable to be used as a Subase material according to the ERA standard technical specification Liquid Limit requirement which is less than or equal to 45% LL value.

On the other hand the Clay sample has a Liquid Limit of 64% which makes it unsuitable to be used as a Subase material.

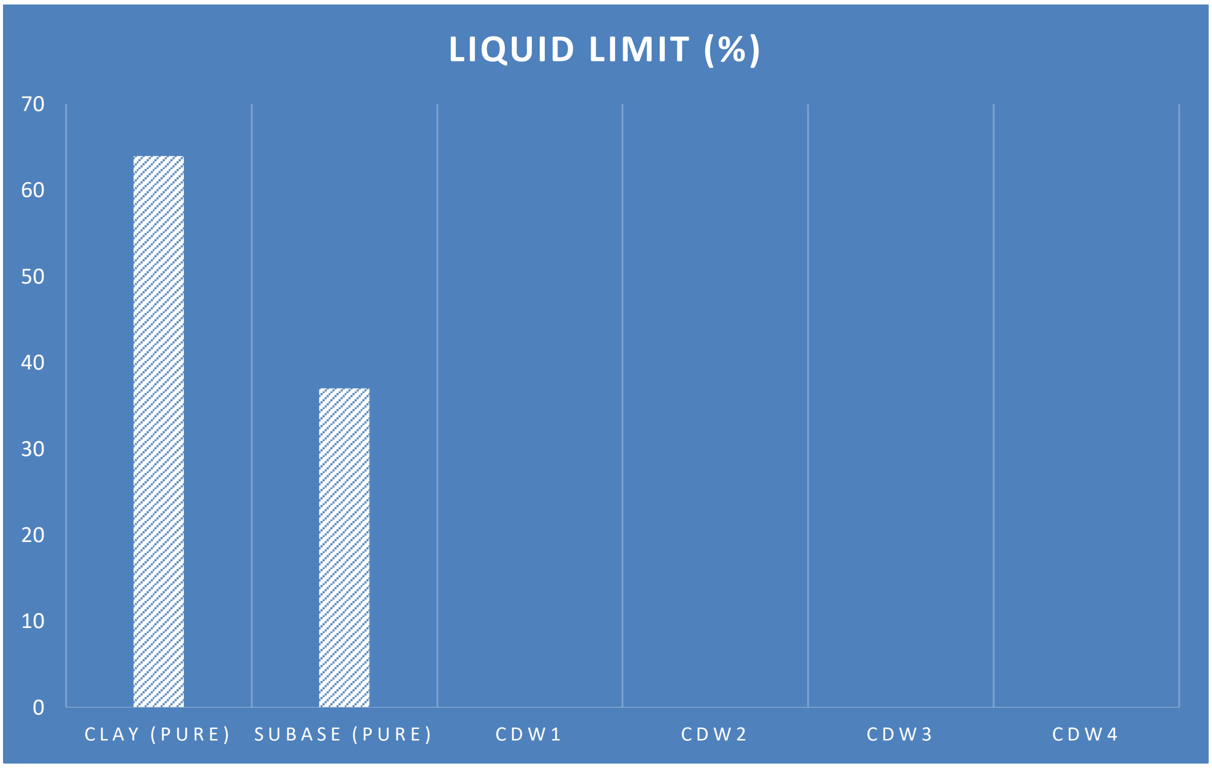

Fig. 4. 18 Liquid Limit results of pure samples

5.2 Liquid Limit test results of CDW1 mixed with Clay

The Liquid Limit test was also conducted on the CDW1 sample mixed with Clay material with different proportions in order to see the effect of the Clay material on the Liquid Limit values of the CDWs.

The graph below clearly shows that combining CDW1 with Clay material, shows an increment with increment of the percentage Clay content until it reaches the maximum at 40% Clay content which becomes 52.6% Liquid Limit value which is greater than 45% and not suitable to be used as a subase material in accordance to the ERA standard technical specification for subase materials.

However, at 10% and 20% clay mixing proportion the Liquid Limit becomes 34% and 37% respectively which is less than 45%. This indicates that mixing CDW1 with 10 – 20% will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles, the density and the bearing capacity of the CDWs since the clay material is highly plastic and it introduces fine materials to the mix.

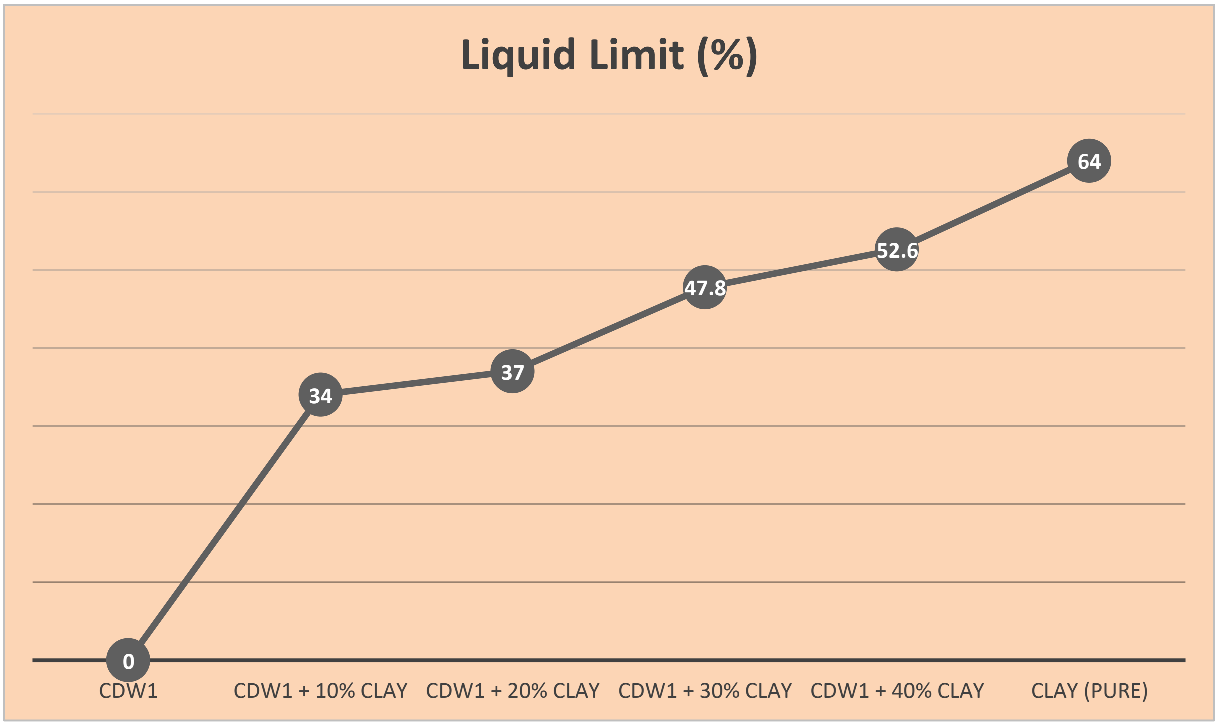

Fig. 4. 19 Liquid Limit results of CDW1 mixed with Clay

The increment in the Liquid Limit of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with highly plastic clay material.

5.3 Liquid Limit test results of CDW2 mixed with Clay

The following graph also clearly shows that combining CDW2 with Clay material, shows an increment with increment of the percentage Clay content until it reaches the maximum at 40% Clay content which becomes 47% Liquid Limit value which is greater than 45% and not suitable to be used as a subase material in accordance to the ERA standard technical specification for subase materials.

However, at 10% and 20% clay mixing proportion the Liquid Limit becomes 37% and 37.3% respectively which is less than 45%. This indicates that mixing CDW2 with 10 – 20% will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles, the density and the bearing capacity of the CDWs since the clay material is highly plastic and it introduces fine materials to the mix.

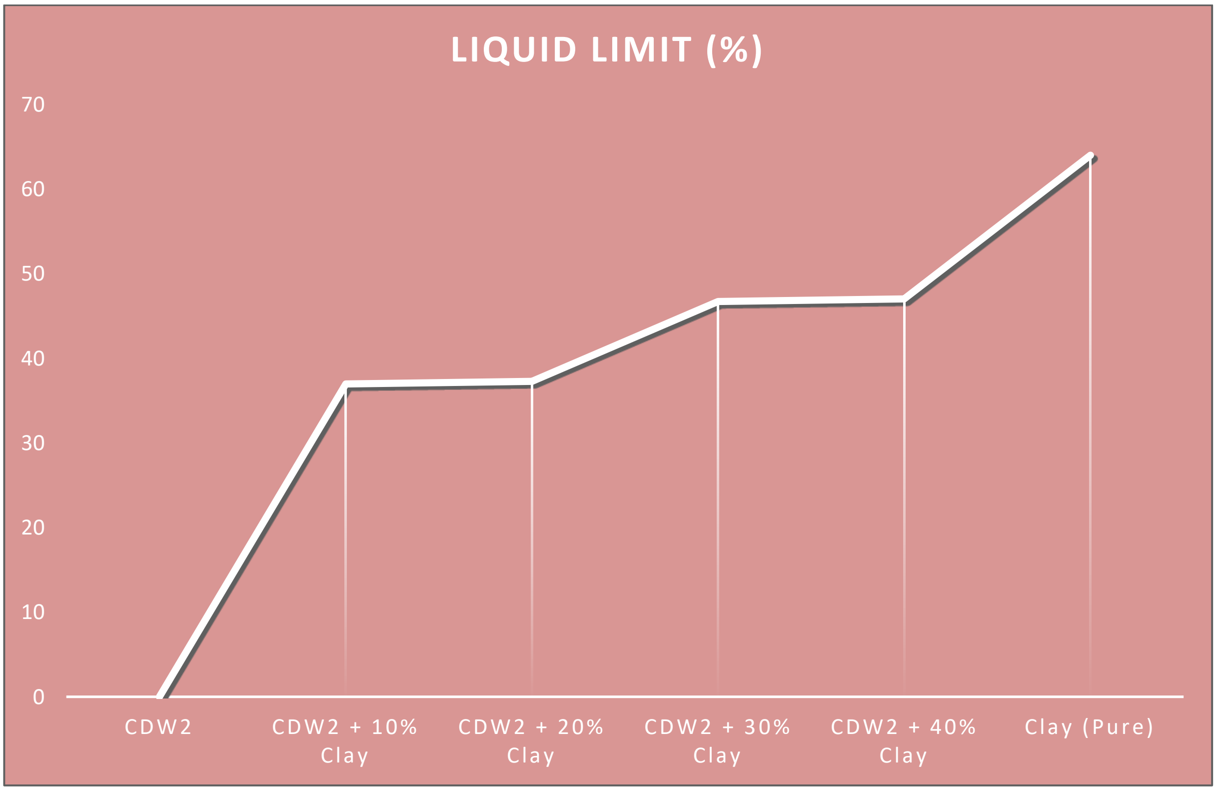

Fig. 4. 20 Liquid Limit results of CDW2 mixed with Clay

Here also, the increment in the Liquid Limit of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with highly plastic clay material which increases the plasticity of the CDWs.

5.4 Liquid Limit test results of CDW1 mixed with Subase

The Liquid Limit test was also conducted on the CDW1 sample mixed with Subase material with different proportions in order to see the effect of the the Subase material on the Liquid Limit values of the CDWs.

As it is tried to clearly indicate in the following graph, combining CDW1 with Subase material, shows an increment with increment of the percentage Clay content until it reaches the maximum at 40% Subase content which becomes 38% Liquid Limit value which is less than 45% and which makes it suitable to be used as a subase material in accordance to the ERA standard technical specification for subase materials.

Therefore, it can be said that mixing subase material in all percentage by mass proportion with CDW1 results a Liquid Limit value of less than 45%.

This indicates that mixing CDWs with all percentage by mass proportion will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles, the density and bearing capacity of the CDWs since the subase material has some plasticity nature and it introduces fine materials to the mix.

The increment in the Liquid Limit of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with plastic subase material which increases the plasticity of the CDWs.

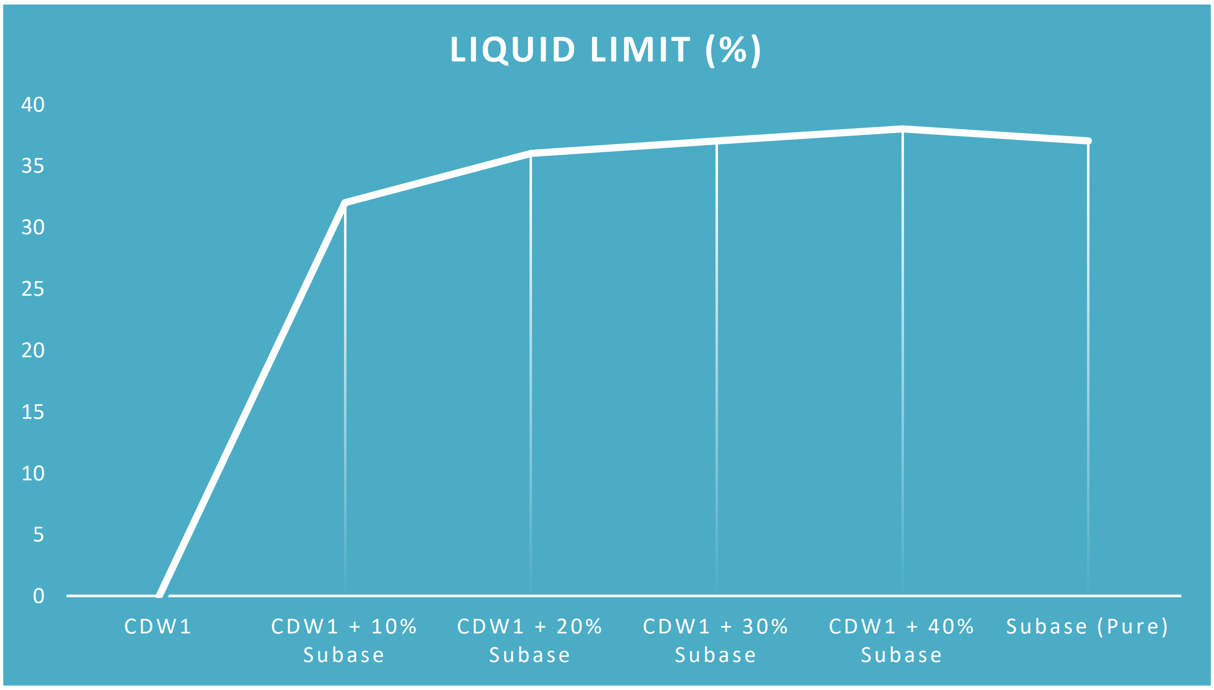

Fig. 4. 21 Liquid Limit results of CDW1 mixed with Subase

5.5 Liquid Limit test results of CDW2 mixed with Subase

The following graph clearly indicates that, combining CDW2 with Subase material, shows an increment with increment of the percentage Clay content until it reaches the maximum at 40%

Subase content which becomes also 38% Liquid Limit value, which is less than 45% and which makes it suitable to be used as a subase material in accordance to the ERA standard technical specification for subase materials.

Therefore, it can be said that mixing subase material in all percentage by mass proportion with CDW2 results a Liquid Limit value of less than 45%. This indicates that mixing CDW2 with all percentage by mass proportion will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles, the density and bearing capacity of the CDWs since the subase material has some plasticity nature and it introduces fine materials to the mix.

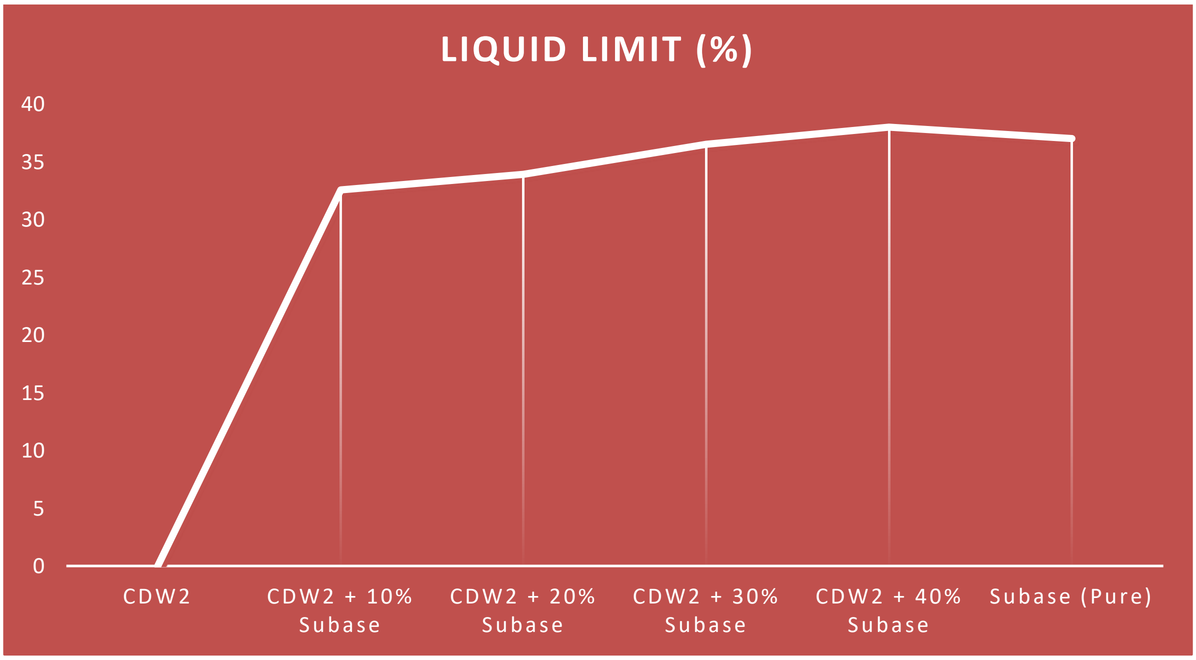

Fig. 4. 22 Liquid Limit results of CDW2 mixed with Subase

The increment in the Liquid Limit of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with plastic subase material which increases the plasticity of the CDWs.

6. Plasticity Index test results

The plasticity index is the range in water content, expressed as a percentage of the mass of the oven dried soil, with in which the material is in a plastic state. It is a numerical difference between the liquid limit and plastic limit of the soil. If the liquid limit or plastic limit is not determined the materials are reported as non-plastic. On the other hand if the plastic limit is equal to or greater than the liquid limit the materials are considered as non-plastic [12]

The main objective of conducting this test is to determine the plasticity of the pure CDW samples and the CDWS mixed with Clay and Subase in different proportions. The test method used to determine atterberg limits of the samples is AASHTO T 89 AASHTO T 90. ERA Standard Technical Specification suggests that, a material shall have a maximum of 12% Plastcity Index value in order to be used as a subase material. Otherwise, it will be highly plastic soil and will not be suitable to be used as a Subase material.

6.1 Plasticity Index test results of pure samples

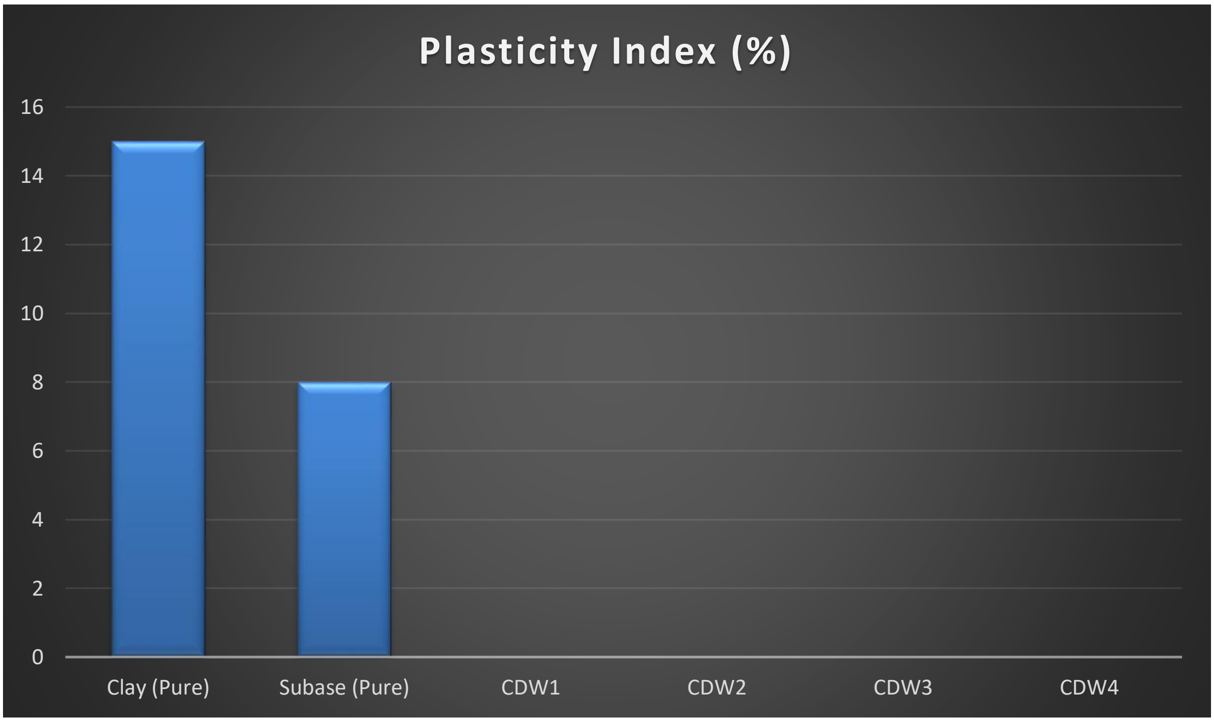

Fig. 4. 23 Plasticity Index results of pure samples

The Plasticity Index was also determined for all pure CDWs, clay and Subase samples in order to see the Plasticity Index values of the samples and compare with the requirements specified in the specifications.

As it is clearly described in the bar chart above all the CDW are non-plastic materials as it is not possible to determine their Plasticity Indices. Whereas the Subase material used have a Plasticity

Index value of 8% which is less than 12% and makes it suitable to be used as a Subase material in accordance with ERA Standard Technical Specification for subase materials. On the other hand the Clay sample has a Plasticity Index of 15% which makes it unsuitable to be used as a Subase material.

6.2 Plasticity Index test results of CDW1 mixed with Clay

The Plasticity Index values were also determined for the CDW1 sample mixed with Clay material with different proportions in order to see the effect of the Clay material on the Plasticity Index values of the CDWs.

The graph below clearly shows that, combining CDW1 with Clay material, shows an increment in Plasticity Index values with increment of the percentage Clay content until it reaches the maximum Plasticity Index value at 40% Clay content which becomes 18%, which is greater than 12% and not suitable to be used as a subase material in accordance with the ERA standard technical specification for subase materials.

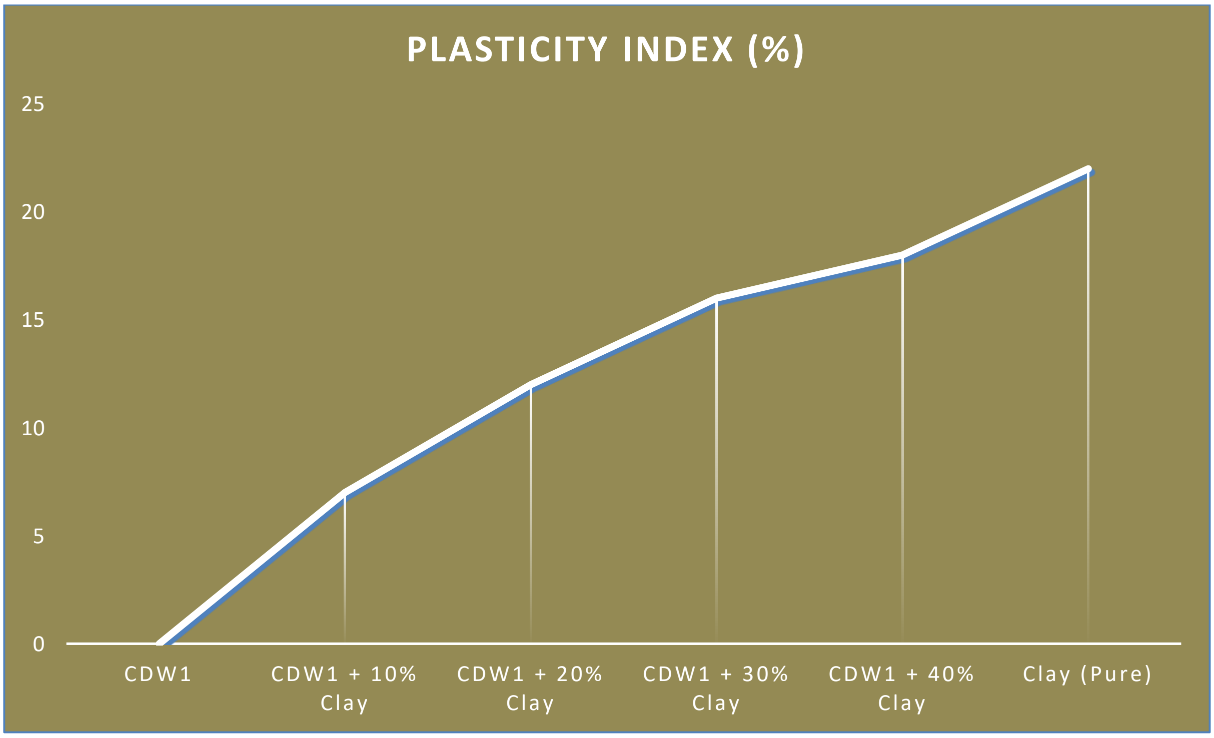

Fig. 4. 24 Plasticity Index results of CDW1 mixed with Clay

However, at 10% and 20% clay mixing proportion the Plasticity Index value becomes 7% and 12% respectively, which is less than or equal to 12%. This indicates that mixing CDW1 with 10 – 20% will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles, the density and bearing capacity of the CDWs since the clay material is highly plastic and it introduces fine materials to the mix.

The increment in the Plasticity Index of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with highly plastic clay material which results increment on the plasticity of the CDWs

6.3 Plasticity Index test results of CDW2 mixed with Clay

The following graph also clearly shows that combining CDW2 with Clay material, shows an increment with increment of the percentage Clay content until it reaches the maximum at 40% Clay content which becomes 17% Plasticity Index which is greater than 12% and not suitable to be used as a subase material in accordance with the ERA standard technical specification for subase materials.

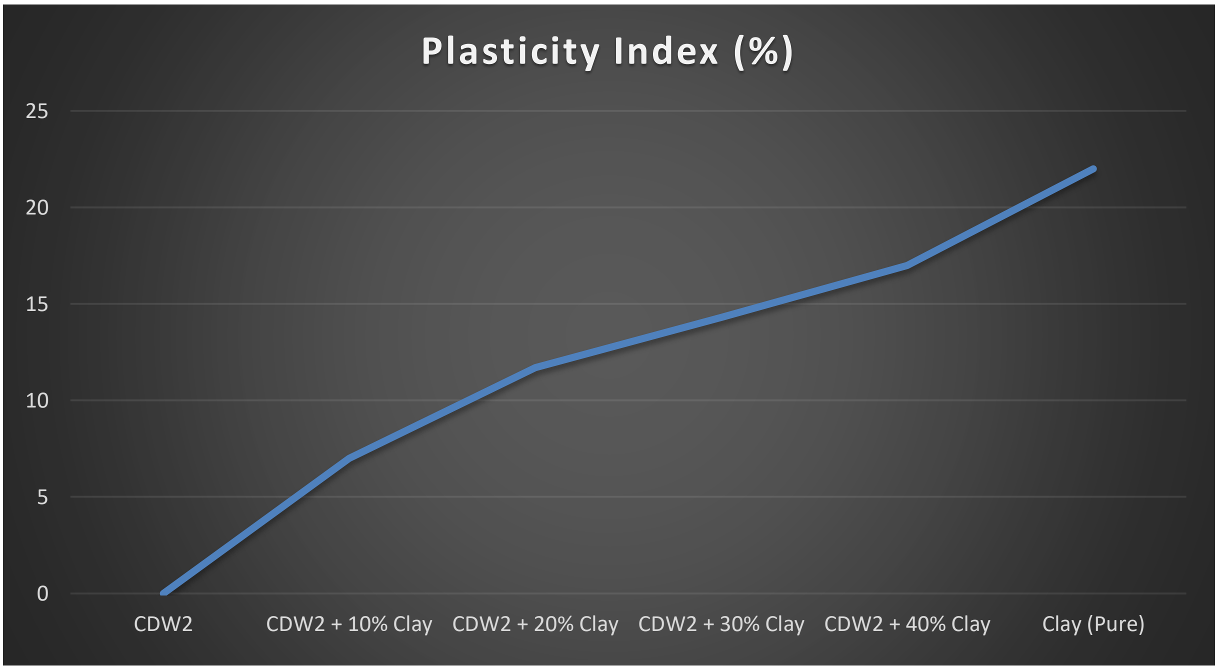

Fig. 4. 25 Plasticity Index results of CDW2 mixed with Clay

However, at 10% and 20% clay mixing proportion the Liquid Limit becomes 7% and 11.7% respectively, which is less than 45%.

This indicates that mixing CDW2 with 10 – 20% will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles of the CDW2 since the clay material is highly plastic and it introduces fine materials to the mix.

Here also, the increment in the Plasticity Index of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with highly plastic clay material, which results increment on the plasticity of the CDWs

6.4 Plasticity Index test results of CDW1 mixed with Subase

In order to investigate the effects of the Subase on the non-plastic CDWs, Plasticity Indexes of the CDW1 mixed with the Subase in different proportion are determined and presented in the following graph.

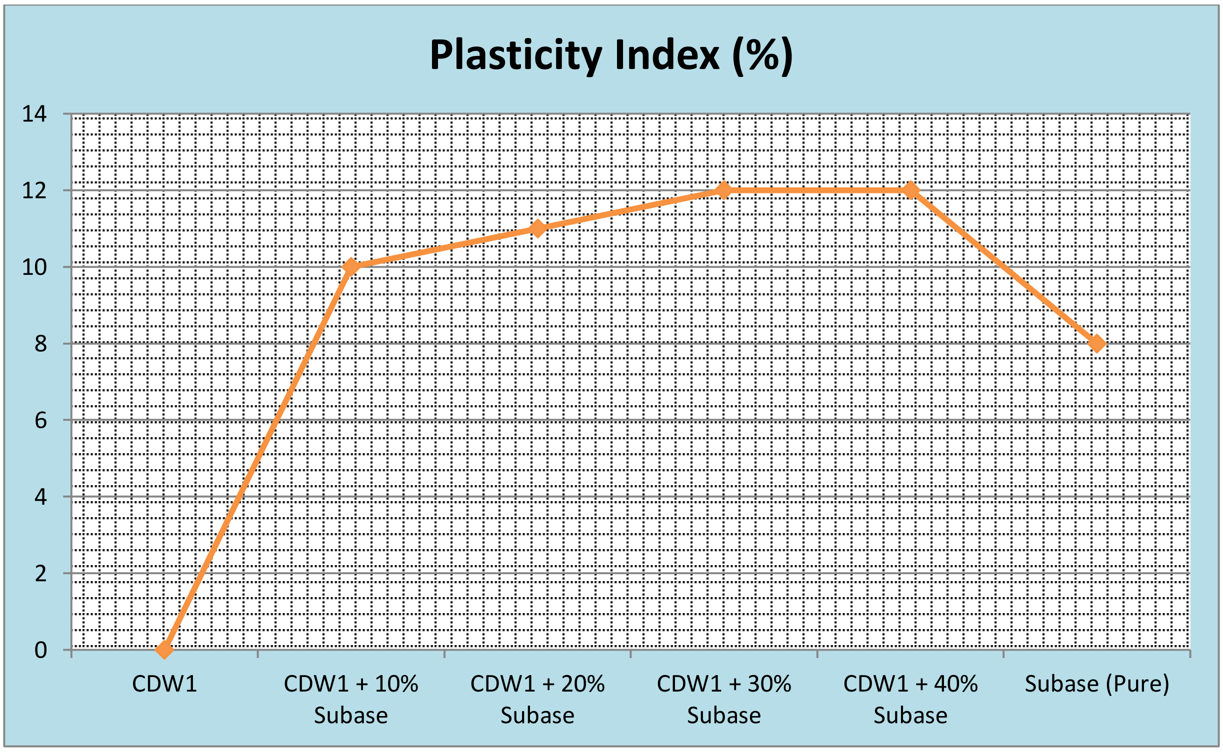

Fig. 4. 26 Plasticity Index results of CDW1 mixed with Subase

As it is tried to clearly indicated in the graph, combining CDW1 with Subase material, shows an increment with increment of the percentage Subase content until it reaches the maximum at 30% and 40% Subase content which becomes 12% Plasticity Index value which is less than or equal to 12% and which makes it suitable to be used as a subase material in accordance with the ERA standard technical specification for subase materials.

Therefore, it can be said that mixing subase material in all percentage by mass proportion with CDW1 results a Plasticity Index value of less than 12%. This indicates that mixing CDW1 with all percentage by mass proportion will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles, the density and bearing strength of the CDWs since the subase material has some plasticity and it introduces fine materials to the mix.

The increment in the Plasticity Index of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with plastic subase material which increases the plasticity of the CDWs.

6.5 Plasticity Index test results of CDW2 mixed with Subase

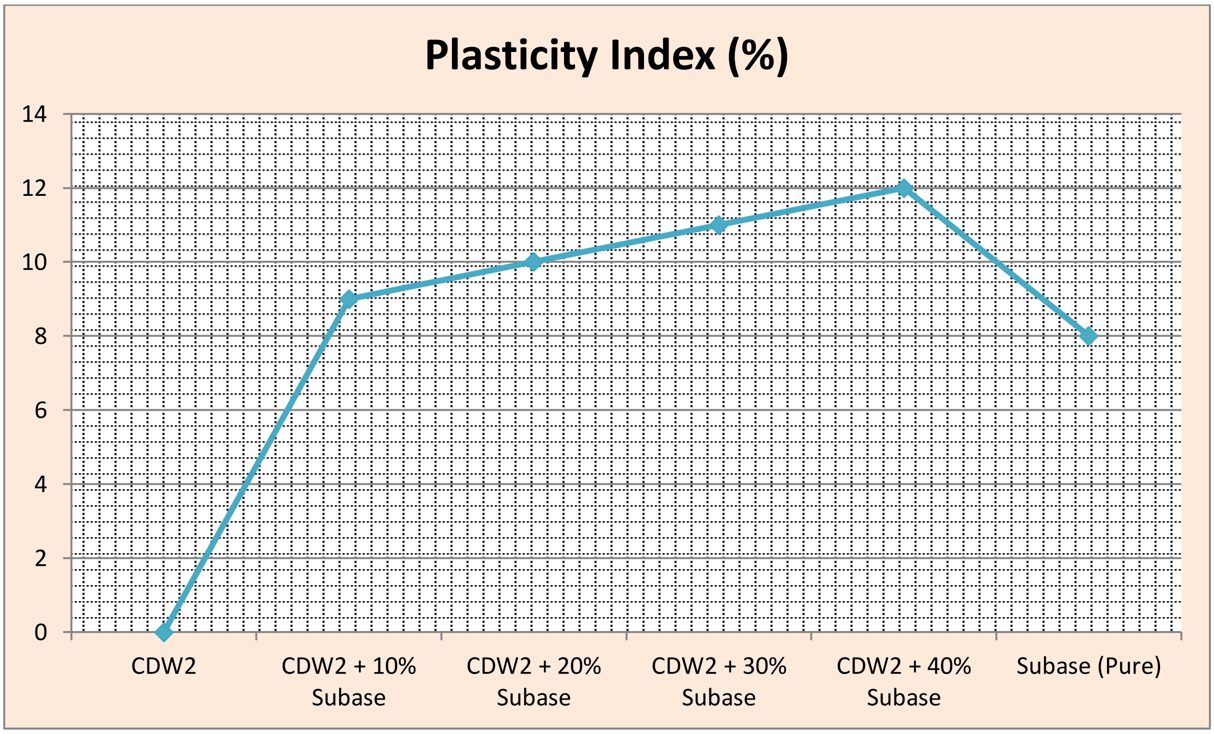

Fig. 4. 27 Plasticity Index results of CDW2 mixed with Subase

The above graph clearly indicates that combining CDW2 with Subase material, shows an increment with increment of the percentage Subase content until it reaches the maximum at 40% Subase content which becomes also 12% Plasticity Index value, which is less than or equal to 12% and which makes it suitable to be used as a subase material in accordance with the ERA standard technical specification for subase materials.

Therefore, it can be said that mixing subase material in all percentage by mass proportion with CDW2 results a Plasticity Index value of less than 12%. This indicates that mixing CDW2 with all percentage by mass proportion will increase its plasticity within the specified requirement allocated for materials to be used as a Subase material. It may also increase the cohesion between the particles, the density and bearing strength of the CDWs since the subase material has some plasticity and it introduces fine materials to the mix.

Here also, the increment in the Plasticity Index of the CDWs is due to the partial substitution of the non-plastic CDW aggregates with plastic subase material which increases the plasticity of the CDWs.

7. Los-Angeles Abrasion (LAA) test results

The Los Angeles abrasion test is measure of degradation of mineral aggregates of standard grading resulting from the combination of action including abrasion impact and grading in a rotating steel drum containing a specified number of steel spheres. After the prescribed number of revolution the contents are removed from the drum and the aggregate portion is sieved to measure the degradation as a percent loss [15]. The main objectives of Los Angeles is to use it as indicator the relative quality or competence of the aggregates of CDW sample collected from all the sources. The test method used to conduct the test is ASTM C 131-03. AASHTO suggests that a material shall have a maximum of 51% LAA value in order to be used as a subase material.

7.1 LAA test results of pure samples

LAA test was conducted on all of the CDW samples and the subase sample used to mix with the CDWs in order to investigate the abrasion resistance of the pure aggregates and check if they can fulfill the AASHTO standard specification.

As it can be seen from the graph below all the CDWs does not fulfill the AASHTO Standard Technical Specification of LAA value requirement since they all have LAA value of a little greater than 51% in accordance with the AASHTO technical specification. However, the subase material used to mix the CDWs fulfills the above requirement since it has LAA value of 19.8%.

The LAA value of the pure CDW samples is higher due to the less quality or abrasion resistance of the aggregates.

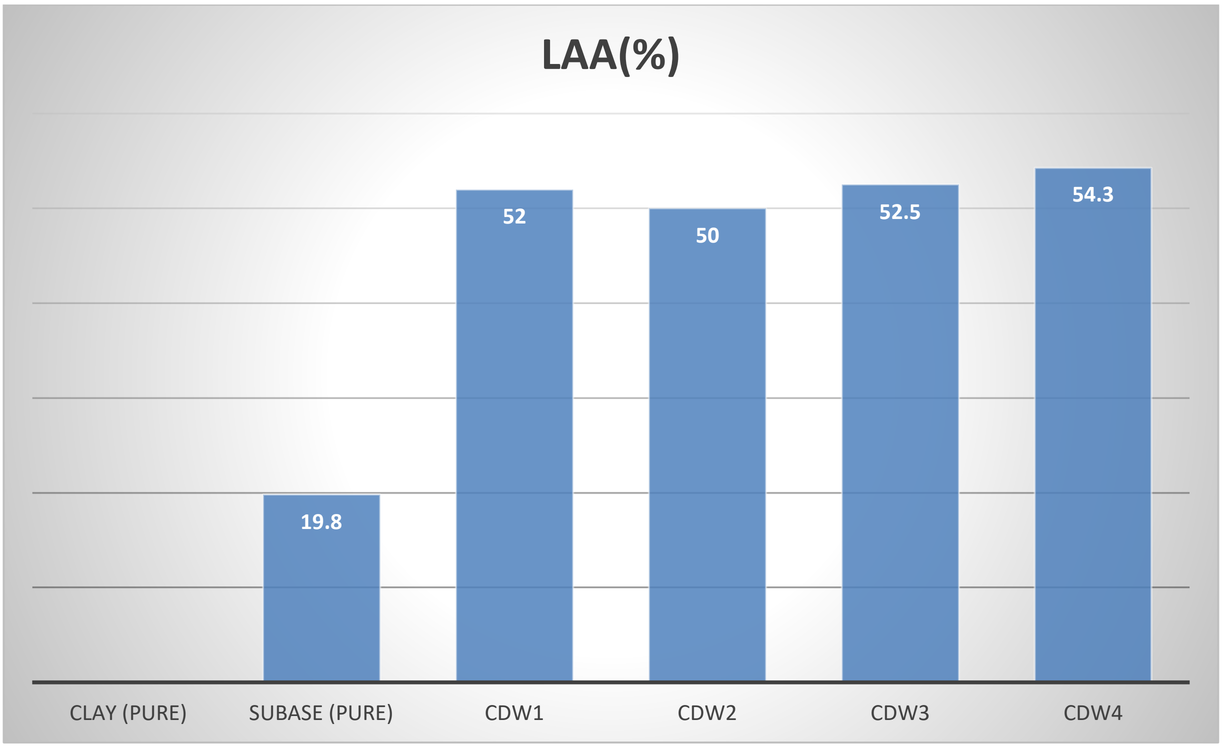

Fig. 4. 28LAA test results of pure samples

7.2 LAA test results of CDW1 mixed with Subase

In order to reduce the LAA values of the CDWs, mixing the samples with the subase material which have a good LAA value was tried in different proportions. After that, the LAA test was conducted on the mixed samples in order to see the effects of the partially substitution of the CDW by subase material.

As it is tried to clearly indicate in the below graph combining CDW1 with Subase material, shows a decrement with increment of the percentage Subase content until it reaches the minimum at 40% Subase content which becomes 39% LAA value which is less than to 51% and which makes it suitable to be used as a subase material.

The graph also indicates that mixing CDW1 with all percentage by mass proportion will decrease its LAA to make it within the specified requirement allocated for materials to be used as a Subase material.

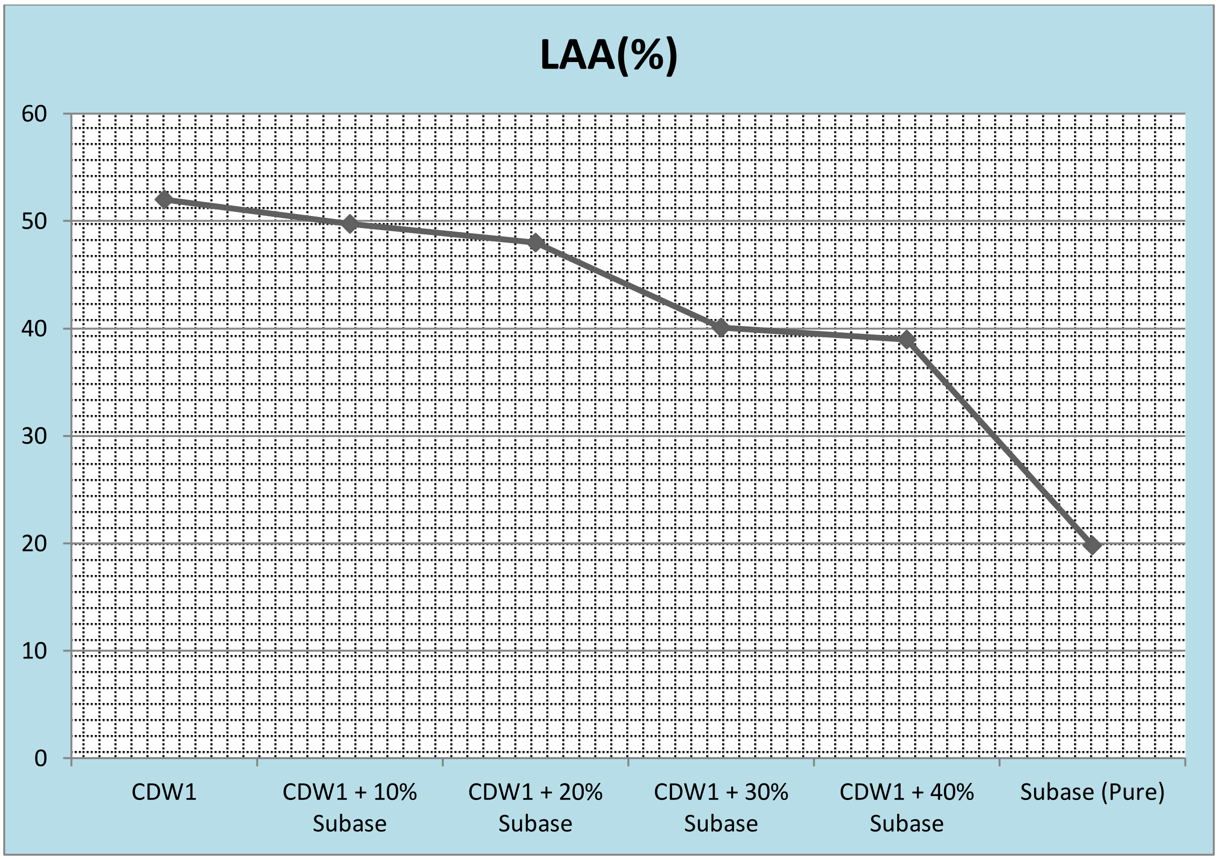

Fig. 4. 29 LAA results of CDW1 mixed with Subase

The decrement in the LAA values of the CDW samples is due to the partial replacement of the CDW aggregates which have less abrasion resistance by the subase material aggregate which have relatively good quality or better abrasion resistance.

7.3 LAA test results of CDW2 mixed with Subase

It is clearly indicated in the following graph that, combining CDW2 with Subase material, shows a decrement with increment of the percentage Subase content until it reaches its minimum at

40% Subase content which becomes 37% LAA value which is less than to 51% and which makes it suitable to be used as a subase material.

The below attached graph also indicates that mixing CDW2 with all percentage by mass proportion will decrease its LAA to make it within the specified requirement allocated for materials to be used as a Subase material.

Here also, the decrement in the LAA values of the CDW samples is due to the partial replacement of the CDW aggregates which have less abrasion resistance by the subase material aggregate which have relatively good quality or better abrasion resistance.

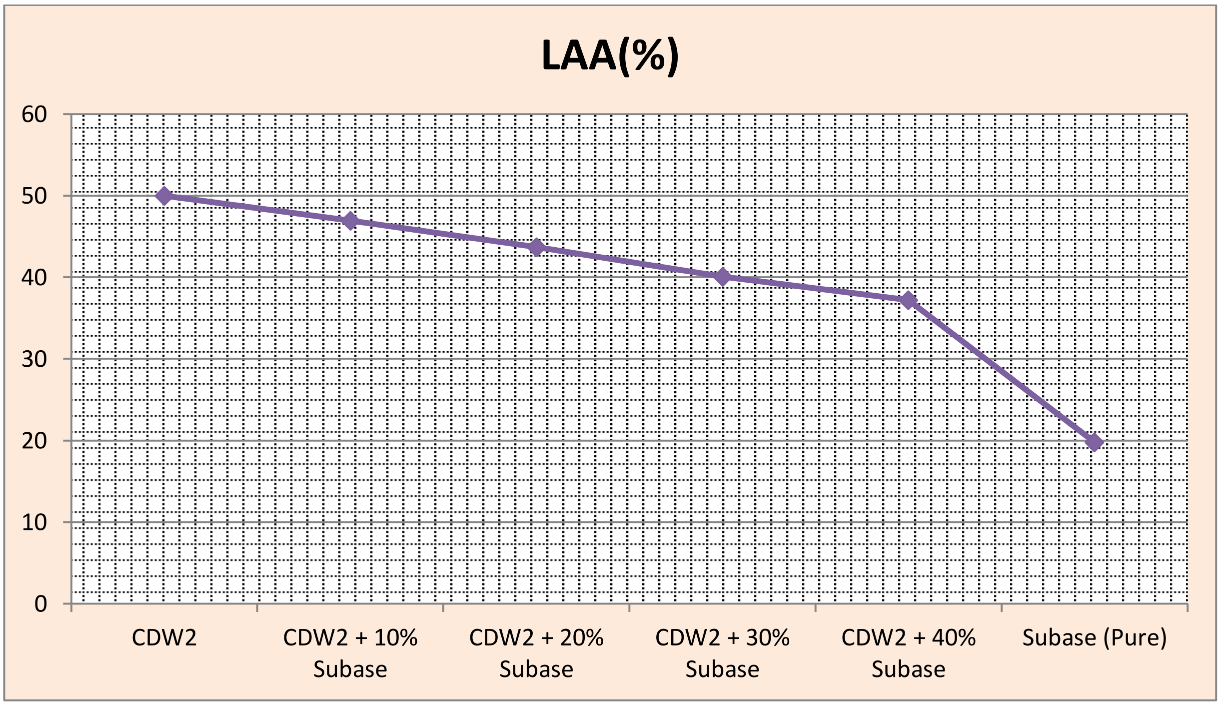

Fig. 4. 30 LAA results of CDW2 mixed with Subase

8. After Compaction Gradation test result

As it was described in chapter three, while using those CDW materials for subase construction, during compaction process of the road construction, the gradation before compaction and after compaction might be different as a result of the load exerted on the CDW material and their higher LAA result. The CDWs after compaction gradation curve might lay out of the upper and lower limit specified for subase materials according ERA standard technical specification.

Hence, in order to examine the after compaction gradation characteristics of the CDWs and CDW mixed with subase material with the better proportion in fulfilling the subase requirements in each of the above disused laboratory test results including the LAA test results, it was tried to simulate the compaction at site in to the laboratory. This was done by first compacting the samples by standard proctor compaction method and taking the compacted material out of the mold and conduct the gradation test on the compacted samples. This test was conducted to one pure CDW material and one CDW mixed with approved subase material.

8.1 After Compaction Gradation test result of CDW1 + and CDW1 + 20% Subase

As it is indicated in the gradation test graph below, part of the graph of the compacted CDW1 sample tends to lie out of the upper and lower limit specified for subase materials according ERA standard technical specification. It touches the upper limit of the curve.

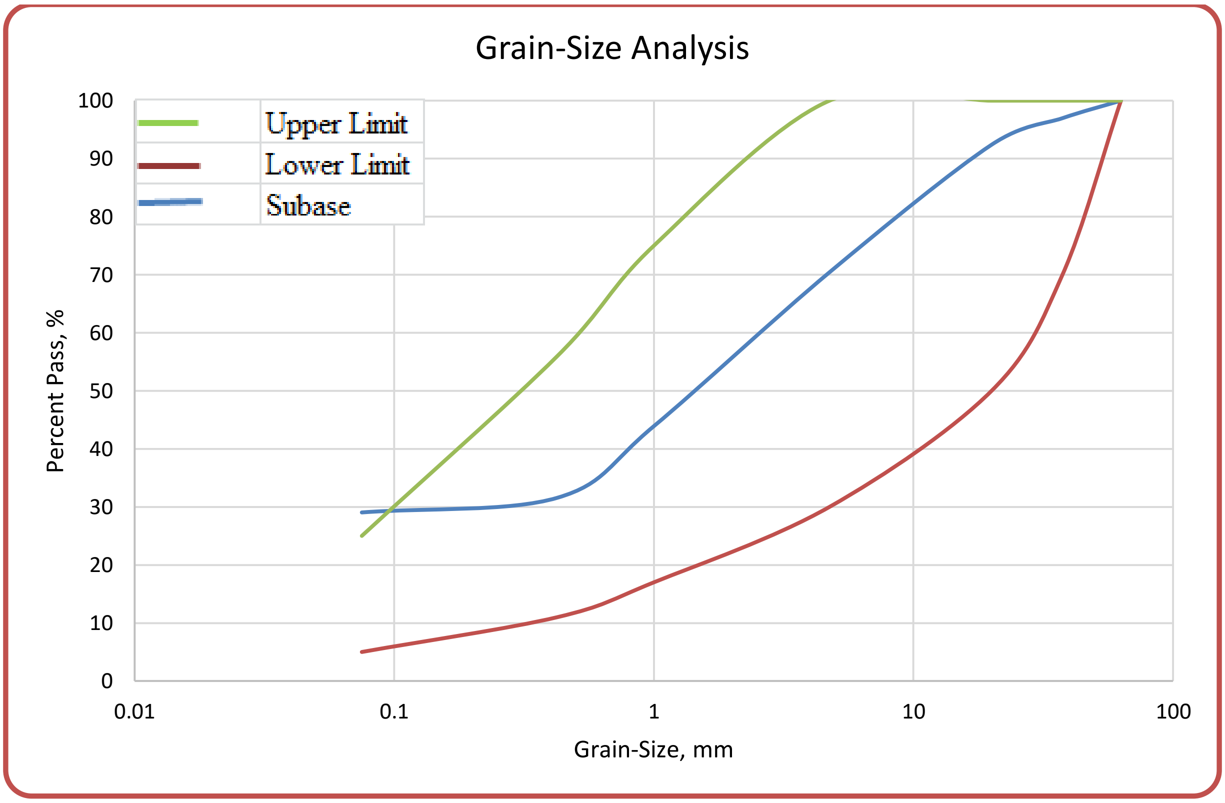

Fig. 4. 31 Gradation of CDW1 after compaction

On the other hand, the gradation test was also conducted for CDW1 material mixed with 20% Subase material. As it is also indicated in the gradation graph below, the tested sample have a percent passing in each sieve size between the specified percentages passing amount in each sieve size.

The curve also lies between the upper and lower limits of the ERA standard technical specification requirement for subase material. This indicates that CDWs mixed with 20% Subase material both before and after compaction fulfil the specified gradation criteria in order to be used as a subase material.

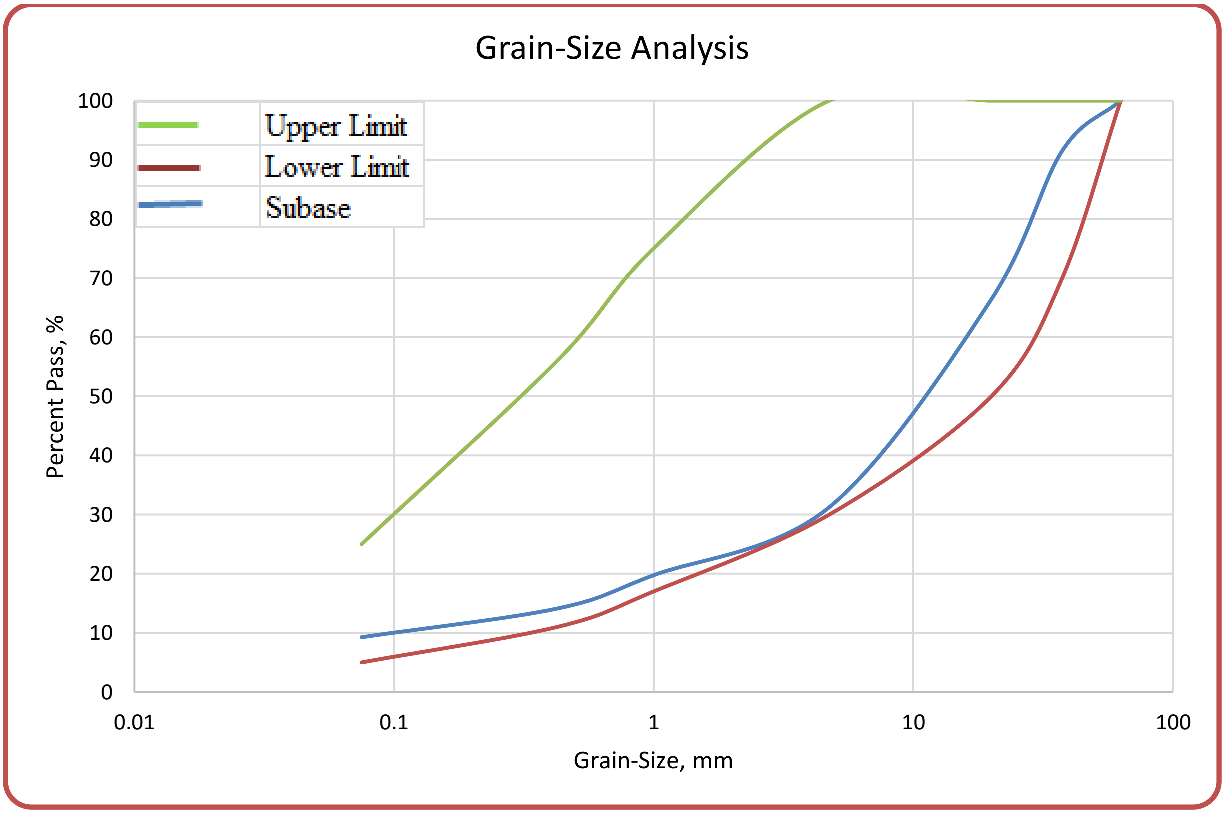

Fig. 4. 32 Gradation of CDW1 + 20% Subase after compaction

This indicates that compacting the CDWs made the aggregates to be crushed in to finer pieces and the percentage passing in the bigger sieve sizes increases and the percentage retained in the smaller sieves increased and the graph tends to cross the upper limit of the gradation at around 0.1mm. this indicates that compaction may alter the gradation of the CDWs. On the other hand, the relatively compaction resistant subase materials mixed with the CDWs help the CDWs by partially substituting the aggregates and also the finer materials of the subase introduced to the CDWs helps the sample to stay in the upper and lower limit of the curve.

This indicates that adding subase materials on CDWs will give a gradation that fulfil the ERA standard technical specification upper and lower limits and even after compaction during the road construction process it is possible to maintain the gradation requirement by mixing the CDWs with 20% and above approved subase materials.

Summary of the test results

From the test results of the pure samples, it is obtained that CDWs have lower MDD value than the expected for subase material. They have also CBR value less than the 30% and do not fulfil the ERA, AACRA and AASHTO specification requirement. In addition, there is no cohesion between the aggregates of the CDWs due to their non-plasticity and lack of fine. Therefore, in order to improve the densities, the CBR and the cohesion between the aggregates, the CDWs were mixed with Clay material in different proportions.

When CDWs mixed with clay material, the densities as well as the CBR of the CDWs were improved with the addition of Clay. Mixing the CDWs with 10 and 20% Clay content improves the CBR, Atterberg Limit and pass the ERA requirements except the LAA is still the same. However, adding Clay more than 20% results on increment of the LL and PI and became greater than 45 and 12 respectively, which makes the sample highly plastic and unsuitable for subase. Nevertheless, it is obvious that the LAA won't change by adding Clay to CDWs. Therefore, in order to improve the LAA the CDWs were mixed with subase material.

When CDWs mixed with subase material, it has been observed that the gradation of CDWs mixed with all proportions of Subase fulfil the ERA and AASHTO requirements.The Maximum Dry Densities and the CBR of CDWs also show big improvement with addition of the Subase in all proportions. The LAA also improved when CDWs mixed with the Subase in all proportions but the AASHTO and ERA specification fulfilled starting from 20% subase.

However, after compaction during the road construction process the durability of the aggregates shall be checked since the CDW aggregates may crash into pieces and the gradation might be out of the specification. This was done by first compacting the samples by standard proctor compaction method and taking the compacted material out of the mold and conduct the gradation test on the compacted samples.

The test was conducted on the pure CDW1 and CDW1 + 20% subase material samples. The test results shows that part of the graph of the compacted CDW1 sample lies out of the upper and lower limit specified for subase materials according ERA standard technical specification because the material becomes finer due to compaction and crashing of the CDWs in to finer pieces.

Whereas the graph of the CDW1 material mixed with 20% lies between the upper and lower limits of the ERA standard technical specification requirement for subase material which indicates that CDWs mixed with 20% subase and above can be used as a subase material for road Construction.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This research was conducted by targeting to evaluate the suitability of the usage of Construction Demolition wastes in Addis Ababa to be fully or partially used as sub-base layer as a main objective. In addition, on trying to maintain the main objective, it was also tried to investigate the properties of the Construction and Demolition waste by conducting laboratory tests on itself and by partially replacing on approved sub-base materials and to compare the test results with the ERA and other specifications for sub-base layer qualification.

Therefore, based on the objectives set at the proposal stage of the research, the literatures collected and reviewed as well as the laboratory test results and the analysis and discussion part of the research the following conclusion are drawn.

- ❖ Construction Demolition Waste material have CBR value less than the requirement specified under ERA standard technical specification, lower MDD and lacks cohesion between the aggregates. The LAA test result of CDWs do not also fulfil the AASHTO requirements for subase materials even though all the collected CDW samples fulfil the subase gradation requirement.
- ❖ CDWs mixed with 10 – 20% clay materials fulfil the CBR requirement, the Liquid Limit, the Plasticity Index as well as the gradation requirements for subase specified under ERA, AASHTO and AACRA standard technical specification. However, the samples do not fulfil the LAA requirement.
- ❖ CDWs mixed with 10 – 40% subase materials fulfil the CBR requirement, the Liquid Limit the Plasticity Index as well as the gradation requirements for subase specified under ERA standard technical specification. They also fulfill the LAA requirement of the ERA and AASHTO standard specification.
- ❖ CDW mixed with 20% subase material is the minimum recommended requirements that fulfil all the requirements for subase material. However, using more than 20% subase also fulfil all the requirements specified for subase material.

- After compaction, pure CDW samples do not completely fulfil the gradation requirement for Subase material whereas after compaction gradation of CDW mixed with 20% subase material fulfils the gradation requirements of the ERA standard technical specification.

5.2 RECOMMENDATIONS

Based on the drawn conclusion in accordance with the objectives of the research and the literature review, the laboratory test results and the result analysis and discussion the following recommendations are forwarded.

- Construction Demolition Wastes cannot be used as a subase material by themselves as all of the CDW samples do not completely fulfil the ERA and ASHTO standard technical specification.
- Using 10 to 20% clay and mixing with CDWs is advisable in order for the samples to meet all the ERA standard technical specification.
- In order to utilize CDWs as a subase materials in road construction, Construction Demolition Wastes mixed with subase materials can be used as a subase material since they fulfil all laboratory test requirements in this research. However, since the research is laboratory investigation based research it is recommended that a more detailed field research by conducting trial section investigation shall be done in the future.
- While demolishing any building, it has to be made sure that the CDWs do not mix with soil and other unsuitable ingredients. Moreover, the place for stoking of the CDW material shall be controlled to avoid mixing with other materials.

5.3 FUTURE RESEARCH DIRECTION

The following future direction were extracted from the limitations of the research in order to have more complete knowledge and understanding about the merits and demerits of utilizing Construction Demolition Wastes to be used as a subase layer in road construction.

- Detail studies on the effect of aging of the aggregates in the CDWs on different engineering and index properties of the mix shall be conducted in the future.

- Detail investigation on the effect of further compaction applied by traffic throughout the lifetime of the road shall be done and the gradation characteristics after the same shall be studied further in order to use the CDWs by partially substituting with subase material.
- Detail studies on the characteristics of different types of Construction Demolition Wastes shall be conducted in the future since the composition of CDWs might be different from place to place.

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APENDIXES

APPENDIX A. Laboratory test results of Construction Demolition Wastes

Appendix A11: Particle size distribution of CDWs

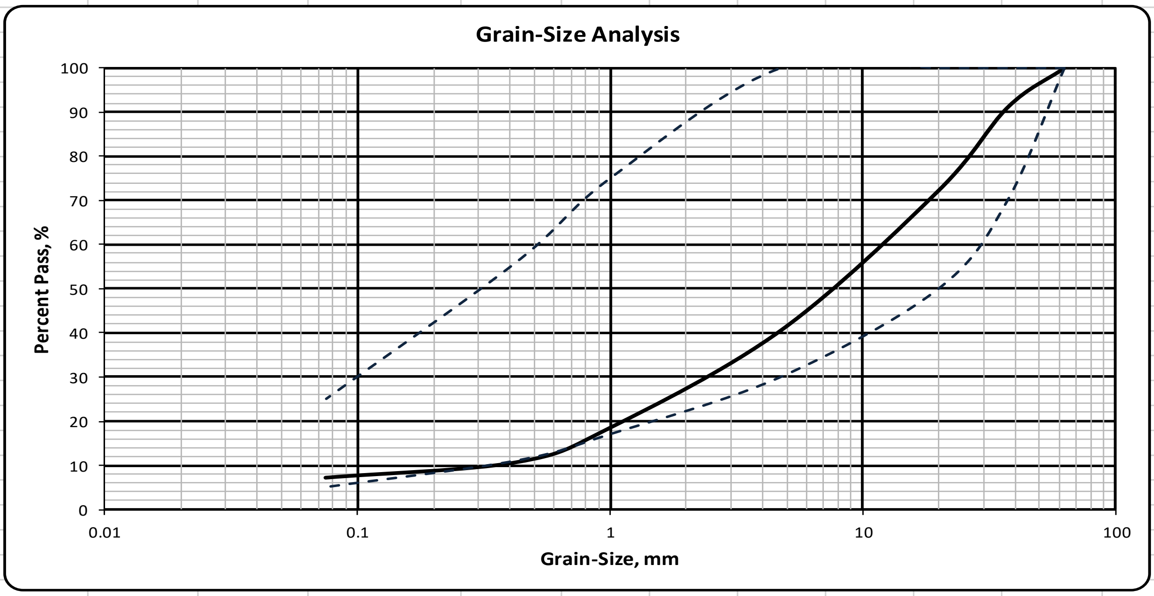
GRADING

Client:	
Sourse of Material	
Description	CDW1
Purpose/intended for:	Subbase construction
Sampled by:	
Tested by:	

TEST METHOD: AASHTO T 11, T27

	Trial-1	Trial-2	Average
Weight of specimen before washing, g	19945	17560	18753

Sieve opening, mm (A)		63	37.5	20	4.75	1	0.425	0.075
Mass Retained, g	T1	0	598	2983	5706	5920	2406	689
	T2	0	2750	4080	6200	2366	529	620
Average Mass retained, g		0	1674	3532	5953	4143	1468	655
% Mass retained		0	9	19	32	22	8	3
% Mass passing		100	91	72	40	18	11	7
Lower limit, %		100	70	50	30	17	11	5
Upper limit, %		100	100	100	100	75	56	25



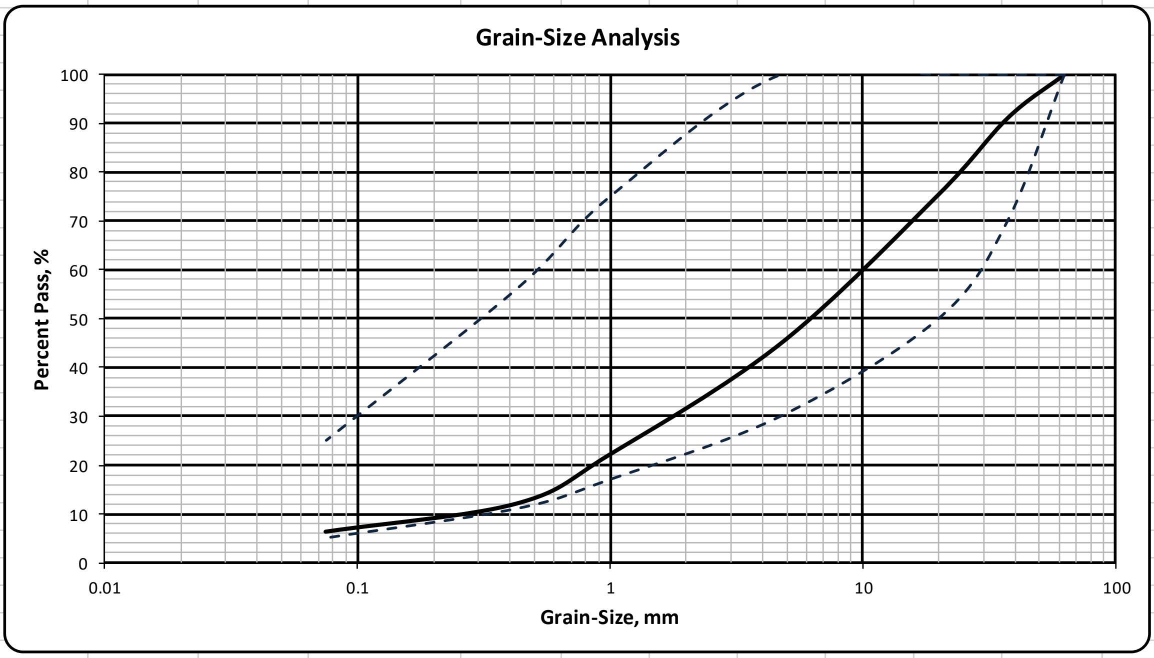
GRADING

Client:
Sourse of Material
Description CDW2
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 11, T27

	Trial-1	Trial-2	Average
Weight of specimen before washing, g	18950	18010	18480

Sieve opening, mm (A)		63	37.5	20	4.75	1	0.425	0.075
Mass Retained, g	T1	0	712	2547	5290	5920	2610	1120
	T2	0	2580	3225	5980	2480	1120	998
Average Mass retained, g		0	1646	2886	5635	4200	1865	1059
% Mass retained		0	9	16	30	23	10	6
% Mass passing		100	91	75	45	22	12	6
Lower limit, %		100	70	50	30	17	11	5
Upper limit, %		100	100	100	100	75	56	25



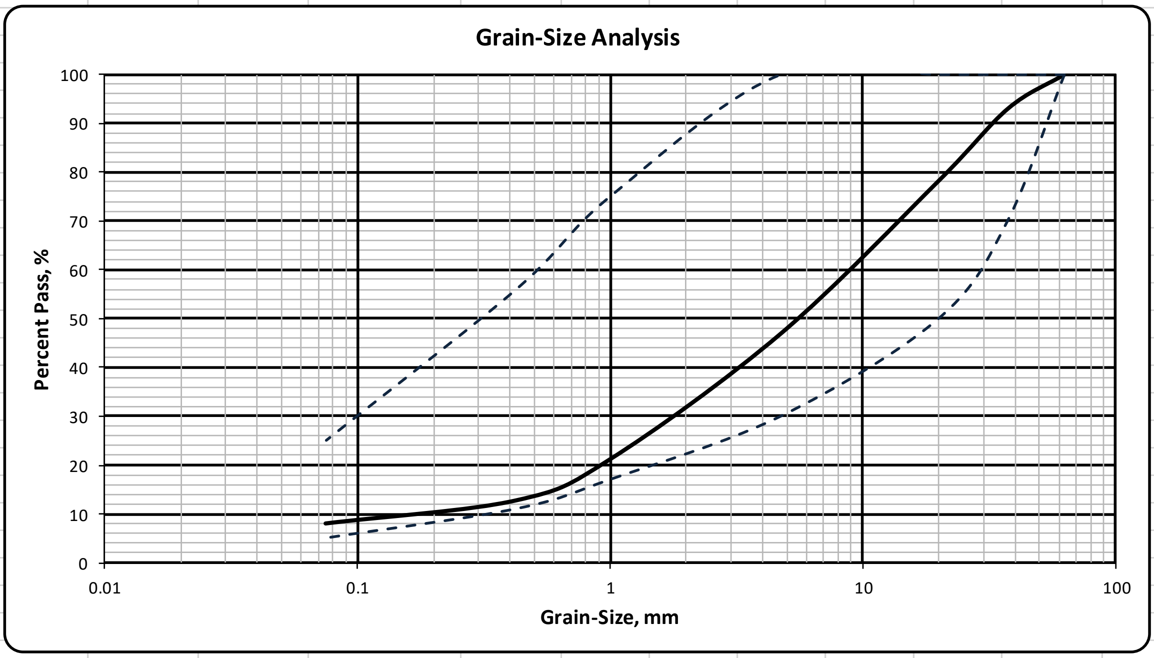
Title	Page No.
GRADING	Page 1 of 1

Client:
Sourse of Material
Description CDW3
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 11, T27

	Trial-1	Trial-2	Average
Weight of specimen before washing, g	17974	18598	18286

Sieve opening, mm (A)		63	37.5	20	4.75	1	0.425	0.075
Mass Retained, g	T1	0	602	2421	5314	5260	2122	825
	T2	0	1970	2960	6120	4160	954	902
Average Mass retained, g		0	1286	2691	5717	4710	1538	864
% Mass retained		0	7	15	31	26	8	5
% Mass passing		100	93	78	47	21	13	8
Lower limit, %		100	70	50	30	17	11	5
Upper limit, %		100	100	100	100	75	56	25



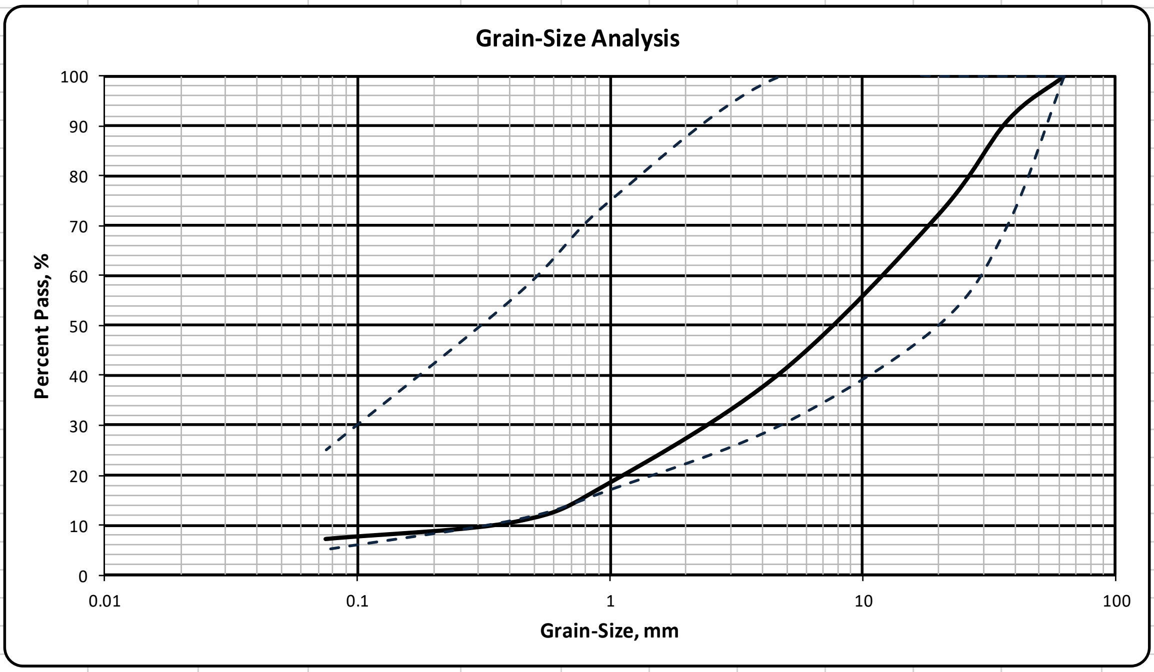
GRADING

Client:
Sourse of Material
Description CDW4
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 11, T27

	Trial-1	Trial-2	Average
Weight of specimen before washing, g	19945	17560	18753

Sieve opening, mm (A)		63	37.5	20	4.75	1	0.425	0.075
Mass Retained, g	T1	0	598	2983	5706	5920	2406	689
	T2	0	2750	4080	6200	2366	529	620
Average Mass retained, g		0	1674	3532	5953	4143	1468	655
% Mass retained		0	9	19	32	22	8	3
% Mass passing		100	91	72	40	18	11	7
Lower limit, %		100	70	50	30	17	11	5
Upper limit, %		100	100	100	100	75	56	25



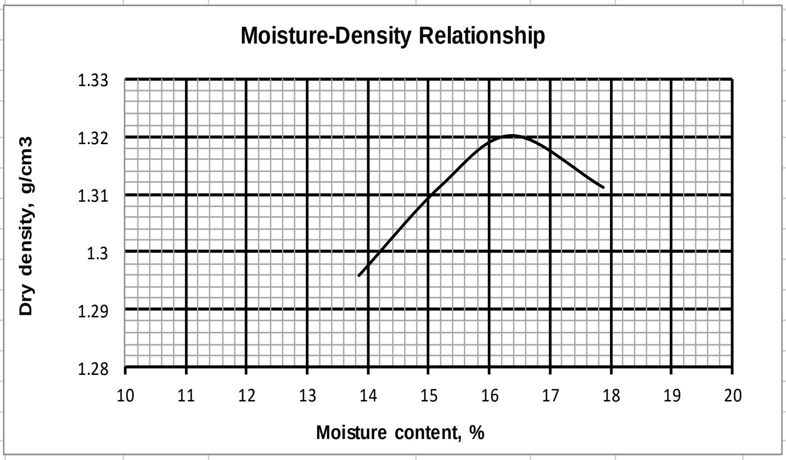
Appendix A12: Proctor Compaction test results of CDWs

MOISTURE-DENSITY RELATIONS OF SOILS TEST

Client:
Matarial sourse
Description CDW1
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			10%	12%	14%	16%			
Bulk Density	Mass of Mould + Soil	g	8645.0	8720.0	8775.0	8795.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	3150.0	3225.0	3280.0	3300.0			
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.475	1.511	1.536	1.546			NMC
Moisture Content	Container No.		44	8	C	16			110
	Mass of Container + Wet Soil	g	980.0	815.0	800.0	850.0			1135
	Mass of Container + Dry Soil	g	876.0	724.0	705.0	740.0			1114
	Mass of Container	g	125.0	125.0	125.0	125.0			370
	Moisture Content	%	13.8	15.2	16.4	17.9			2.8
	Dry Density	g/cm^3	1.30	1.31	1.32	1.31			



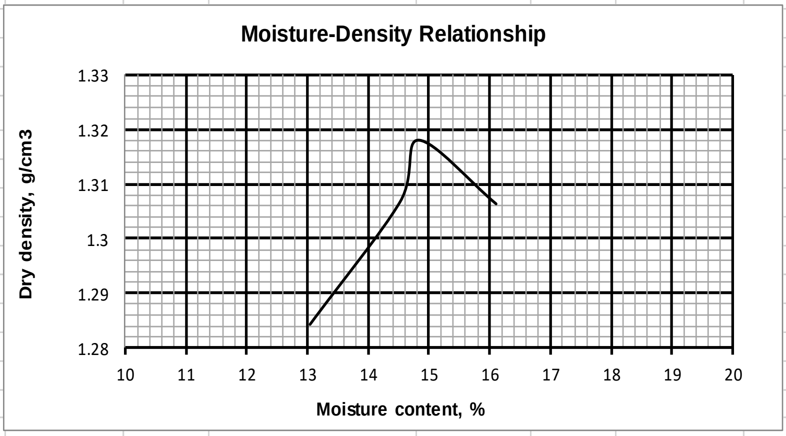
Maximum Dry Density= ***1.32***
Optimum Moisture Content= ***16.4***

MOISTURE-DENSITY RELATIONS OF SOILS TEST

Client:	
Matarial sourse	
Description	CDW2
Purpose/intended for:	Subbase construction
Sampled by:	
Tested by:	

TEST METHOD:AASHTO T 180

			10%	12%	14%	16%			
Bulk Density	Mass of Mould + Soil	g	8595.0	8690.0	8726.0	8733.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	3100.0	3195.0	3231.0	3238.0			
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.452	1.496	1.513	1.517			NMC
Moisture Content	Container No.		44	8	C	16			110
	Mass of Container + Wet Soil	g	974.0	811.0	791.0	839.0			1142
	Mass of Container + Dry Soil	g	876.0	724.0	705.0	740.0			1123
	Mass of Container	g	125.0	125.0	125.0	125.0			370
	Moisture Content	%	13.0	14.5	14.8	16.1			2.5
	Dry Density	g/cm^3	1.28	1.31	1.32	1.31			



Maximum Dry Density= ***1.32***

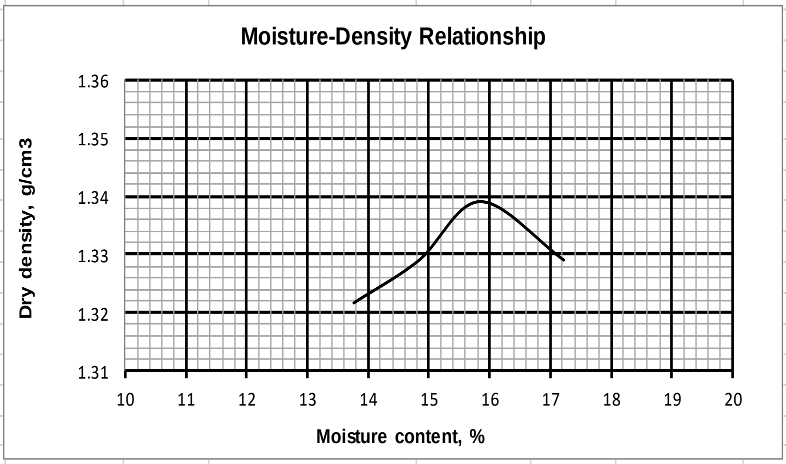
Optimum Moisture Content= ***14.8***

Title	Page No.
MOISTURE-DENSITY RELATIONS OF SOILS TEST	Page 1 of 1

Client:	
Matarial sourse	
Description	CDW3
Purpose/intended for:	Subbase construction
Sampled by:	
Tested by:	

TEST METHOD:AASHTO T 180

			10%	12%	14%	16%			
Bulk Density	Mass of Mould + Soil	g	8705.0	8753.0	8807.0	8821.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	3210.0	3258.0	3312.0	3326.0			
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.504	1.526	1.551	1.558			NMC
Moisture Content	Container No.		44	8	C	16			110
	Mass of Container + Wet Soil	g	869.0	853.0	827.0	874.0			1121
	Mass of Container + Dry Soil	g	779.0	759.0	731.0	764.0			1103
	Mass of Container	g	125.0	125.0	125.0	125.0			370
	Moisture Content	%	13.8	14.8	15.8	17.2			2.5
	Dry Density	g/cm^3	1.32	1.33	1.34	1.33			



Maximum Dry Density= ***1.34***

Optimum Moisture Content= ***15.8***

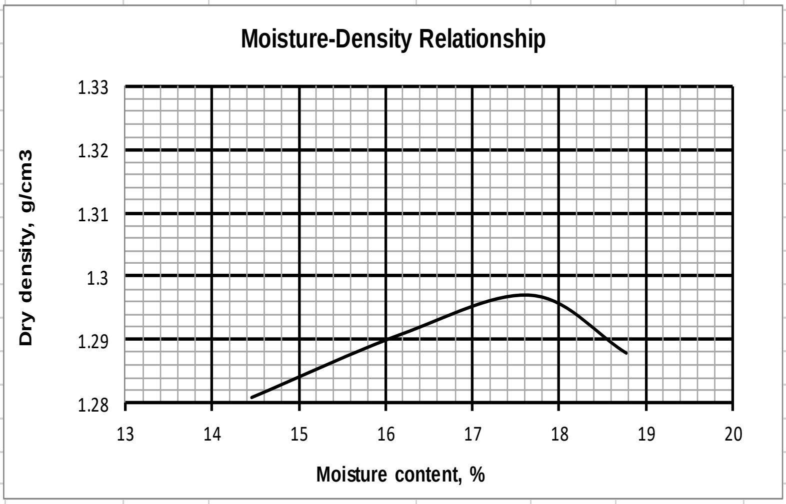
Title

MOISTURE-DENSITY RELATIONS OF SOILS TEST

Client:
Matarial sourse
Description CDW4
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			10%	12%	14%	16%			
Bulk Density	Mass of Mould + Soil	g	8625.0	8697.0	8754.0	8761.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	3130.0	3202.0	3259.0	3266.0			
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.466	1.500	1.526	1.530			NMC
Moisture Content	Container No.		33	6	B	14			100
	Mass of Container + Wet Soil	g	964.0	807.0	797.0	846.0			1242
	Mass of Container + Dry Soil	g	858.0	712.0	696.0	732.0			1216
	Mass of Container	g	125.0	125.0	125.0	125.0			374
	Moisture Content	%	14.5	16.2	17.7	18.8			3.1
	Dry Density	g/cm^3	1.28	1.29	1.30	1.29			



Maximum Dry Density= ***1.30***
Optimum Moisture Content= ***17.7***

Appendix A13: California Bearing Ration (CBR) test results of CDWs

Page 1 of 2

CALIFORNIA BEARING RATIO TEST

Client:	
Sourse of Material	
Description	CDW1
Purpose/intended for:	Subbase construction
Sampled by:	
Tested by:	

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		B-10		B-30		B-65	
Mass of Mould	g	6445		6430		6445	
Mass of Mould Plus Soil	g	9315	9729	9510	9883	9730	10051
Mass of Soil	g	2870	3284	3080	3453	3285	3606
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	1.35	1.55	1.45	1.63	1.55	1.70
Dry Density	g/cm^3	1.15	1.55	1.24	1.63	1.32	1.70

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		44		138		66	
Mass of Container	g	125		125		125	
Mass of Container Plus Wet Soil	g	1035		960		1160	
Mass of Container Plus Dry Soil	g	900		838		1008	
Moisture Content	%	17.4		17.1		17.2	

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.34
Load @5.08	20

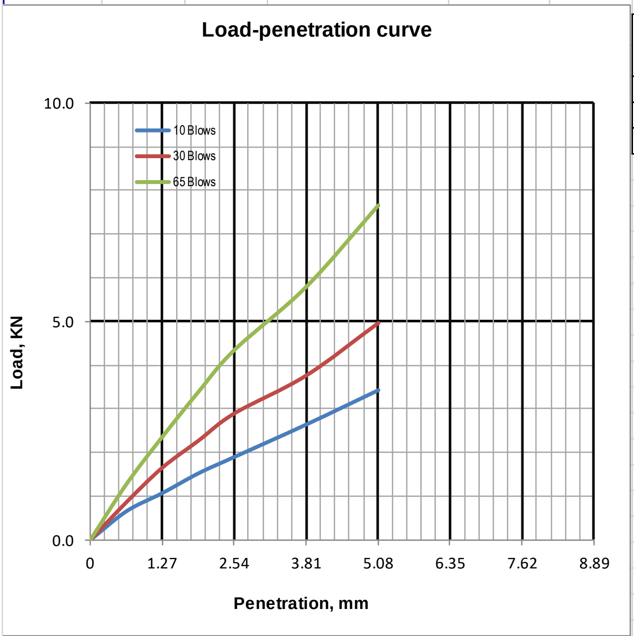
PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	16.0	0.7			21.0	0.9			31.0	1.3		
1.27	26.0	1.1			40.0	1.7			57.0	2.4		
1.91	37.0	1.5			55.0	2.3			82.0	3.4		
2.54	46.0	1.90	1.90	14.3	70.0	2.89	2.89	21.7	105.0	4.34	4.34	32.5
3.81	64.0	2.6			91.0	3.8			140.0	5.8		
5.08	83.0	3.43	3.43	17.2	120.0	4.96	4.96	24.8	185.0	7.65	7.65	38.2
7.62	0.0	0.0			0.0	0.0	0.0	0	0.0	0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	3.09	2.71	2.57
Reading After Soaking, mm	3.11	3	3.43
Percent Swell	0.02	0.25	0.74

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

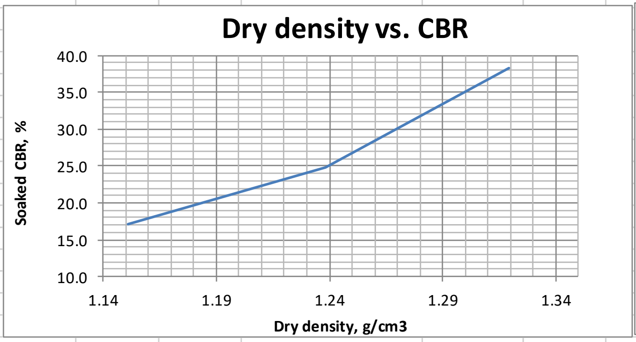
TEST METHOD: AASHTO T 193

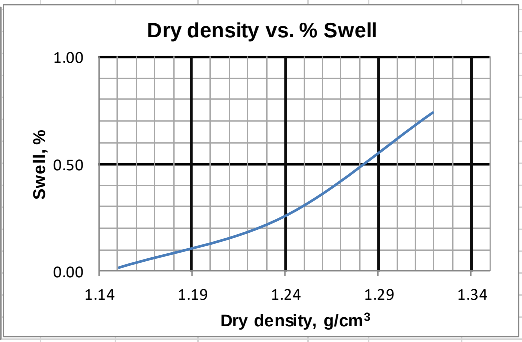


Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.15	1.90	3.43	14.3	17.2	0.02
30	1.24	2.89	4.96	21.7	24.8	0.25
65	1.32	4.34	7.65	32.5	38.2	0.74

Max. Dry Density (MDD)= 1.32 g/cm^3
95 of MDD= 1.25 g/cm^3

CBR at 95% of MDD= 27 %
Swell at 95% of MDD= 0.3





CALIFORNIA BEARING RATIO TEST

Client:	
Sourse of Material	
Description	CDW2
Purpose/intended for:	Subbase construction
Sampled by:	
Tested by:	

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		B-10		B-30		B-65	
Mass of Mould	g	6445		6430		6445	
Mass of Mould Plus Soil	g	9285	9694	9473	9851	9691	10007
Mass of Soil	g	2840	3249	3043	3421	3246	3562
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	1.34	1.53	1.43	1.61	1.53	1.68
Dry Density	g/cm^3	1.14	1.53	1.22	1.61	1.30	1.68

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		44		138		66	
Mass of Container	g	125		125		125	
Mass of Container Plus Wet Soil	g	1014		939		1137	
Mass of Container Plus Dry Soil	g	881		817		986	
Moisture Content	%	17.6		17.6		17.5	

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.34
Load @5.08	20

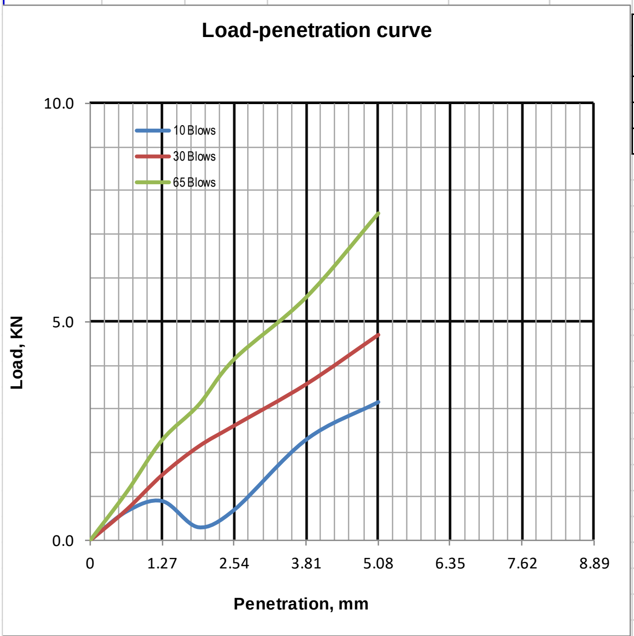
PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	16.0	0.7			21.0	0.7			31.0	1.1		
1.27	26.0	0.9			40.0	1.5			57.0	2.3		
1.91	37.0	0.3			55.0	2.2			82.0	3.1		
2.54	46.0	0.70	0.70	5.2	70.0	2.63	2.63	19.7	105.0	4.15	4.15	31.1
3.81	64.0	2.3			91.0	3.6			140.0	5.6		
5.08	83.0	3.17	3.17	15.9	120.0	4.71	4.71	23.6	185.0	7.49	7.49	37.5
7.62	0.0	0.0			0.0	0.0	0.0	0	0.0	0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	3.02	2.63	2.67
Reading After Soaking, mm	3.21	2.87	3.13
Percent Swell	0.16	0.21	0.40

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

TEST METHOD: AASHTO T 193



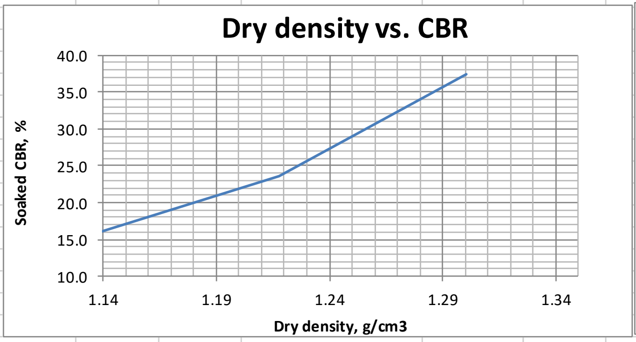
Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.14	0.70	3.17	5.2	15.9	0.16
30	1.22	2.63	4.71	19.7	23.6	0.21
65	1.30	4.15	7.49	31.1	37.5	0.40

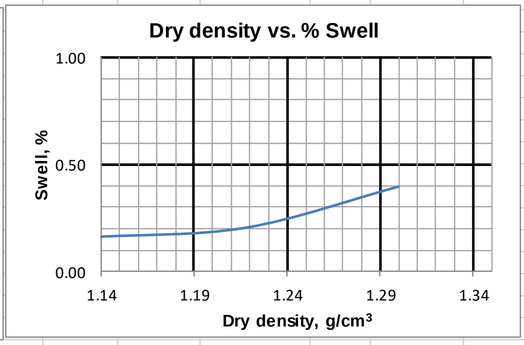
Max. Dry Density (MDD)= 1.32 g/cm^3

95 of MDD= 1.25 g/cm^3

CBR at 95% of MDD= 29 %

Swell at 95% of MDD= 0.3





CALIFORNIA BEARING RATIO TEST

Client:
Sourse of Material
Description CDW3
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		B-10		B-30		B-65	
Mass of Mould	g	6445		6430		6445	
Mass of Mould Plus Soil	g	9315	9729	9510	9883	9730	10051
Mass of Soil	g	2870	3284	3080	3453	3285	3606
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	1.35	1.55	1.45	1.63	1.55	1.70
Dry Density	g/cm^3	1.15	1.55	1.24	1.63	1.32	1.70
MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		44		138		66	
Mass of Container	g	125		125		125	
Mass of Container Plus Wet Soil	g	1035		960		1160	
Mass of Container Plus Dry Soil	g	900		838		1008	
Moisture Content	%	17.4		17.1		17.2	

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.34
Load @5.08	20

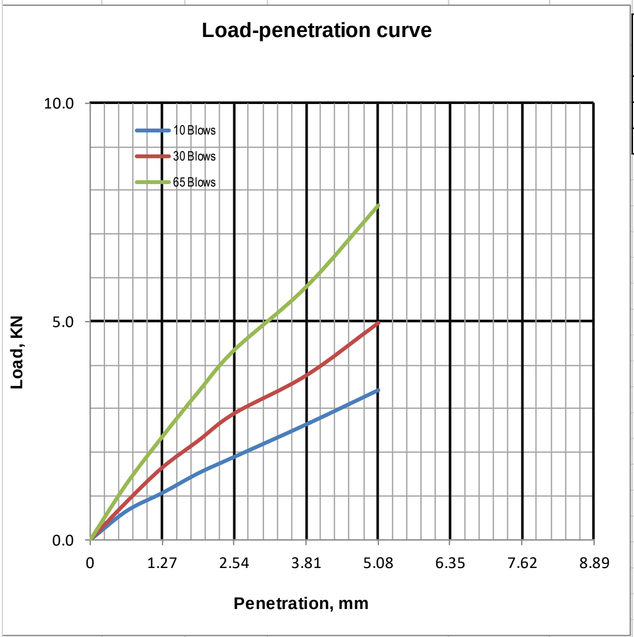
PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	16.0	0.7			21.0	0.9			31.0	1.3		
1.27	26.0	1.1			40.0	1.7			57.0	2.4		
1.91	37.0	1.5			55.0	2.3			82.0	3.4		
2.54	46.0	1.90	1.90	14.3	70.0	2.89	2.89	21.7	105.0	4.34	4.34	32.5
3.81	64.0	2.6			91.0	3.8			140.0	5.8		
5.08	83.0	3.43	3.43	17.2	120.0	4.96	4.96	24.8	185.0	7.65	7.65	38.2
7.62	0.0	0.0			0.0	0.0	0.0	0	0.0	0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	3.09	2.71	2.57
Reading After Soaking, mm	3.11	3	3.43
Percent Swell	0.02	0.25	0.74

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

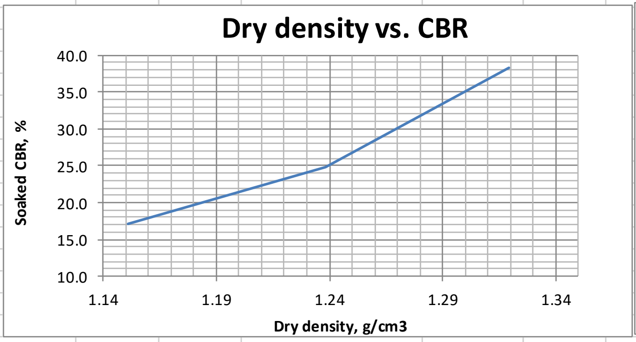
TEST METHOD: AASHTO T 193

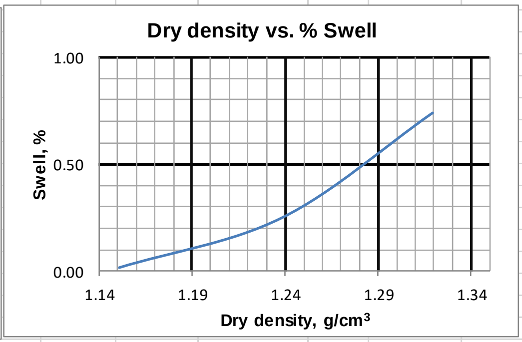


Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.15	1.90	3.43	14.3	17.2	0.02
30	1.24	2.89	4.96	21.7	24.8	0.25
65	1.32	4.34	7.65	32.5	38.2	0.74

Max. Dry Density (MDD)= 1.34 g/cm^3
95 of MDD= 1.27 g/cm^3

CBR at 95% of MDD= 27 %
Swell at 95% of MDD= 0.3





CALIFORNIA BEARING RATIO TEST

Client:
Sourse of Material
Description CDW4
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		A-10		A-30		A-65	
Mass of Mould	g	6440		6425		6440	
Mass of Mould Plus Soil	g	9324	9738	9514	9901	9742	10068
Mass of Soil	g	2884	3298	3089	3476	3302	3628
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	1.36	1.55	1.45	1.64	1.55	1.71
Dry Density	g/cm^3	1.15	1.55	1.24	1.64	1.32	1.71

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		44		138		66	
Mass of Container	g	125		125		125	
Mass of Container Plus Wet Soil	g	1114		1003		1186	
Mass of Container Plus Dry Soil	g	966		872		1028	
Moisture Content	%	17.6		17.5		17.5	

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.34
Load @5.08	20

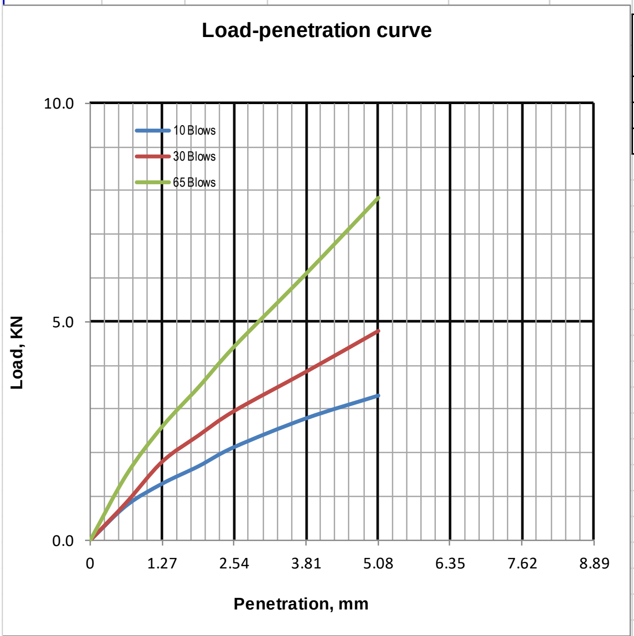
PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	16.0	0.8			21.0	0.9			31.0	1.5		
1.27	26.0	1.3			40.0	1.8			57.0	2.6		
1.91	37.0	1.7			55.0	2.4			82.0	3.5		
2.54	46.0	2.14	2.14	16.0	70.0	2.96	2.96	22.2	105.0	4.43	4.43	33.2
3.81	64.0	2.8			91.0	3.9			140.0	6.1		
5.08	83.0	3.32	3.32	16.6	120.0	4.79	4.79	24.0	185.0	7.83	7.83	39.2
7.62	0.0	0.0			0.0	0.0	0.0	0	0.0	0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	3.12	2.9	2.87
Reading After Soaking, mm	3.14	3.15	3.15
Percent Swell	0.02	0.21	0.24

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

TEST METHOD: AASHTO T 193



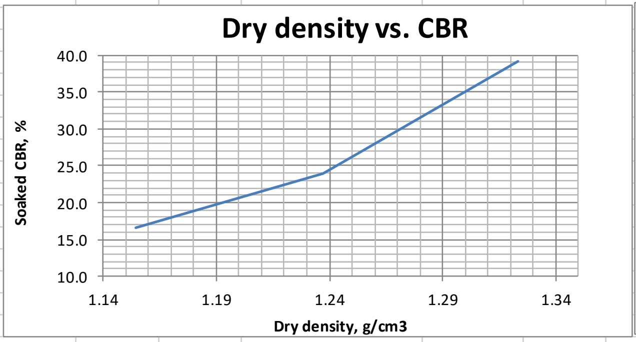
Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.15	2.14	3.32	16.0	16.6	0.02
30	1.24	2.96	4.79	22.2	24.0	0.21
65	1.32	4.43	7.83	33.2	39.2	0.24

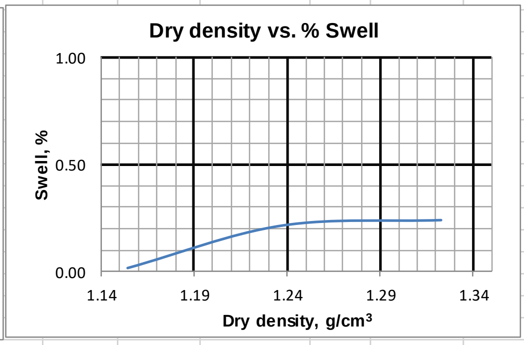
Max. Dry Density (MDD)= 1.30 g/cm³

95 of MDD= 1.24 g/cm³

CBR at 95% of MDD= 25 %

Swell at 95% of MDD= 0.2





Appendix A14: Los-Angeles Abrasion test results of CDWs

LOS ANGELES ABRASION TEST (LAA) FOR Sub Base
Test Method ASTM Designation: C 131 - 03

Date Sampled	
Description	CDW1
Location	
Material Type	Sub Base

Specification Limits : Maximum = 51% For Natural Sub Base

Sieve Size (SquareOpenings)		Mass of Indicated Size, (g) Grading				t. of sample to be test	
Passing	Retained on	A	B	C	D	Trial 1	Trial 2
37.5 mm	25.0 mm	1250 ± 25	---	---	---	1250	1250
25.0 mm	19.0 mm	1250 ± 25	---	---	---	1250	1250
19.0 mm	12.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
12.5 mm	9.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
9.5 mm	6.3 mm	---	---	2500 ± 10	---		
6.3 mm	4.75 mm	---	---	2500 ± 10	---		
4.75 mm	2.36 mm	---	---	---	5000 ± 10		
Total		5000 ± 10	5000 ± 10	5000 ± 10	5000 ± 10	5000	5000
Number of Spheres (Balls) used		12	11	8	6		

Test Result Analysis

Grading Type Used	A	B	C	D

Trial		$Trial_1$	$Trial_2$
Number of Revolution		500	500
Total Wt. of Sample Tested	(W)	5000	5000
Wt. of Tested Sample Retained On 1.70 mm Sieve	(X)	2410	2390
Loss in grams	Y = (W - X)	2590	2610
Percent Loss	Z = (Y / W)*100	51.80	52.20
Average Percent Loss ($Trial_1 + Trial_2$)/2		**52.00**	

							Page No.
RESISTANCE TO DEGRADATION IN LOS ANGELES MACHINE							Page 1 of 1
Client:							
Sample of:							
Station:							
Description			CDW2				
Purpose/intended for:			Subbase Construction				
Sampled by:							
Tested by:							

TEST METHOD: AASHTO T 96

Table: Standard Grading of Test Samples

Sieve Size			Mass of Indicated Sizes, g			
			Grading			
Passing	Retained on		A	B	C	D
37.5mm(1 1/2in.)	25.0mm(1in.)		1250±25			
25.0mm(1in.)	19.0mm(3/4in.)		1250±25			
19.0mm(3/4in.)	12.5mm(1/2in.)		1250±10	2500±10		
12.5mm(1/2in.)	9.5mm (3/8in.)		1250±10	2500±10		
9.5mm (3/8in.)	6.3mm (1/4in.)				2500±10	
6.3mm (1/4in.)	4.75mm (No.4)				2500±10	
4.75mm (No.4)	2.36mm(No.8)					5000±10
Total			5000±10	5000±10	5000±10	5000±10
Number of Charges			12	11	8	6

Grading Used		**A**	B		
Mass of Sample Before Test	g	5000	5000		
Mass of Sample Retained on 1.7mm (No.12) Sieve	g	2448	2558		
Mass of Sample Passed on 1.7mm (No.12) Sieve	g	2552	2442		
LAA Value	%	51.0	48.8		
Avg.		50			

Test Method ASTM Designation: C 131 - 03

Sampling Station :	
Description :	CDW3
Purpose :	sub-base

Specification Limits : For ---------- = 51 Max

Sieve Size (SquareOpenings)		Mass of Indicated Size, (g) Grading				Wt. of sample to be tested	
Passing	Retained on	A	B	C	D	Trial $_1$	Trial $_2$
37.5	25					1252	1260
25	20					1252	1256
20	12.5					1250	1250
12.5	9.5					1250	1250
Total							
Number of Spheres (Balls) used		12	11	8	6		

Test Result Analysis

Grading Type Used	**A**	**B**	**C**	**D**

Trial	$Trial_1$	$Trial_2$
Number of Revolution	500	500
Total Wt of Sample Tested(W)	5004	5016
Wt. of Tested Sample Retained On 1.70 mm Sieve(X)	2290	2470
Loss in grams Y=(W-X)	2714	2546
Percent Loss Z=(Y/M)*100	54.24	50.76
Average Percent Loss = $Trial_1$ + $Trial_2$) /	52.50	

LOS ANGELES ABRASION TEST (LAA) FOR Sub Base

Test Method ASTM Designation: C 131 - 03

Date Sampled			
Description	CDW4	Tested By	
Location		RFI.No	
Material Type	Sub Base		

Specification Limits : Maximum = 51% For Natural Sub Base

Sieve Size (SquareOpenings)		Mass of Indicated Size, (g) Grading				Wt. of sample to be tested	
Passing	Retained on	A	B	C	D	Trial $_1$	Trial $_2$
37.5 mm	25.0 mm	1250 ± 25	---	---	---	1250	1250
25.0 mm	19.0 mm	1250 ± 25	---	---	---	1250	1250
19.0 mm	12.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
12.5 mm	9.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
9.5 mm	6.3 mm	---	---	2500 ± 10	---		
6.3 mm	4.75 mm	---	---	2500 ± 10	---		
4.75 mm	2.36 mm	---	---	---	5000 ± 10		
Total		5000 ± 10	5000 ± 10	5000 ± 10	5000 ± 10	5000	5000
Number of Spheres (Balls) used		12	11	8	6		

Test Result Analysis

Grading Type Used	A	B	C	D

Trial		Trial$_1$	Trial$_2$
Number of Revolution		500	500
Total Wt. of Sample Tested	(W)	5000	5000
Wt. of Tested Sample Retained On 1.70 mm Sieve	(X)	2276	2294
Loss in grams	Y = (W - X)	2724	2706
Percent Loss	Z = (Y / W)*100	54.48	54.12
Average Percent Loss (Trial$_1$ + Trial$_2$)/2		**54.30**	

Appendix A2: Laboratory test results of Pure Clay

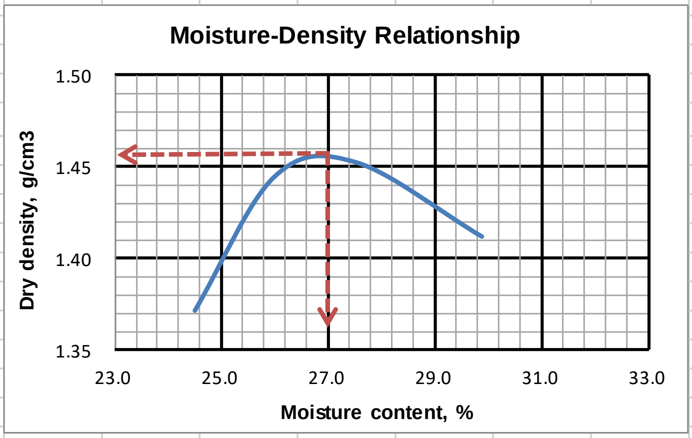
Appendix A21: Proctor Compaction test result of Pure Clay

MOISTURE-DENSITY RELATIONS OF SOILS TEST

Client:
Sample of: Red Clay
Description For mixing with CDWs
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			6%	8%	10%	16%			
Bulk Density	Mass of Mould + Soil	g	9140.0	9382.0	9450.0	9410.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	3645.0	3887.0	3955.0	3915.0	0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.707	1.821	1.852	1.834	#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		T	Y	16	1			20
	Mass of Container + Wet Soil	g	1150.0	1122.0	1018.0	1028.0			1630
	Mass of Container + Dry Soil	g	948.0	916.0	825.0	820.0			1432
	Mass of Container	g	124.0	124.0	124.0	124.0			372
	Moisture Content	%	24.5	26.0	27.5	29.9	#DIV/0!	#DIV/0!	18.7
	Dry Density	g/cm^3	1.37	1.44	1.45	1.41	#DIV/0!	#DIV/0!	



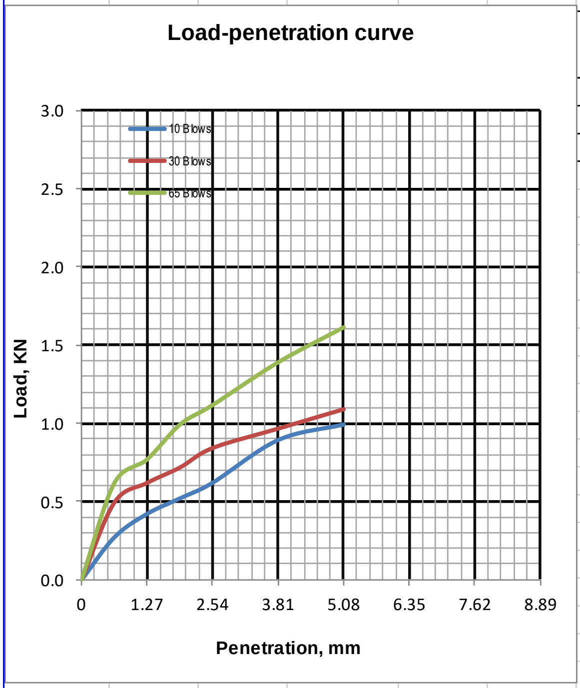
Maximum Dry Density= 1.46 g/cm^3
Optimum Moisture Content= 27.0 %

Appendix A22: Californian Bearing Ratio (CBR) test result of Pure Clay

CALIFORNIA BEARING RATIO TEST

Client:
Sample of: Red Clay
Description For mix with CDWs
Sampled by:
Tested by:

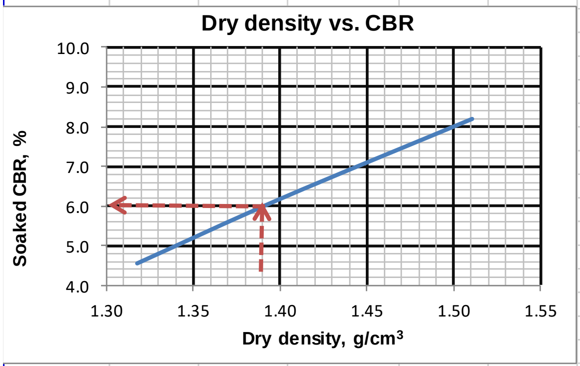
TEST METHOD: AASHTO T 193

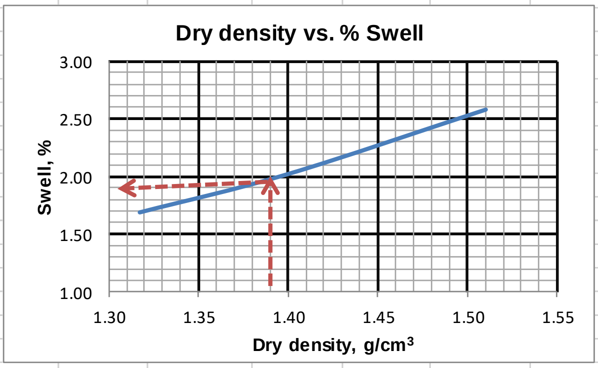


Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.32	0.62	0.99	4.6	4.9	1.68
30	1.40	0.84	1.09	6.2	5.4	2.02
65	1.51	1.12	1.61	8.2	7.9	2.58

Max. Dry Density (MDD)= 1.46 g/cm^3
95 % of MDD= 1.39 g/cm^3

CBR at 95% of MDD= 6 %
Swell at 95% of MDD= 2 %





Appendix A23: Atterber Limit test result of Pure Clay

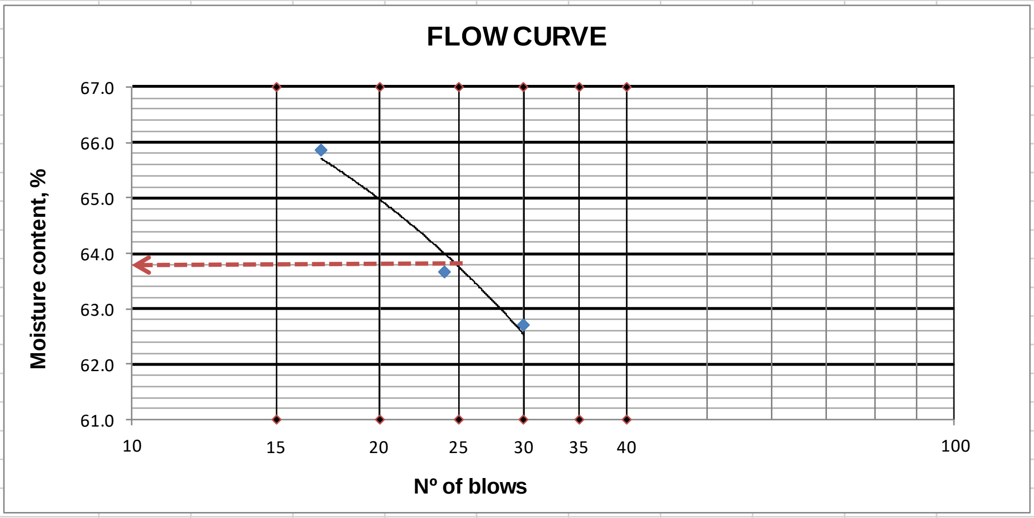
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST

Page 1 of 1

Client:
Sample of: Red Clay
Description For mix with CDWs
Sampled by:
Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		30	24	17				
Container No.		D	10	s			31	161
Mass of Container	g	45.35	45.54	45.29			45.56	45.54
Mass of Wet Soil + Container	g	60.14	61.22	59.72			48.37	48.46
Mass of Dry Soil + Container	g	54.44	55.12	53.99			47.55	47.59
Mass of Water in Specimen	g	5.70	6.10	5.73	0.00	0.00	0.82	0.87
Mass of Dry Soil	g	9.09	9.58	8.70	0.00	0.00	1.99	2.05
Moisture Content	%	62.7	63.7	65.9	#DIV/0!	#DIV/0!	41.2	42.4
						Average PL, %		41.8



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10	44	4	96	63.6	21.8	A-2-7 (0)	1.18
№ 40	444	41.6	54				
№ 200	240	22.5	32				
Initial Mass	1068						

Appendix A3: Laboratory test results of Pure Subase

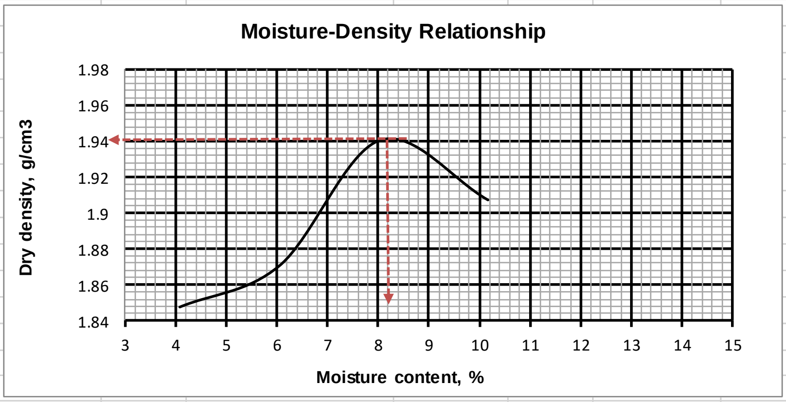
Appendix A31: Proctor Compaction test result of Pure Subase

Title	Page No.
MOISTURE-DENSITY RELATIONS OF SOILS TEST	Page 1 of 1

Client:
Matarial sourse Subase Pure
Description Dark Gray Silty Gravel sand material
Purpose/intended for: For mix with CDWs
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			2%	4%	6%	8%			
Bulk Density	Mass of Mould + Soil	g	9600.0	9730.0	9970.0	9980.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4105.0	4235.0	4475.0	4485.0			
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.923	1.984	2.096	2.101			NMC
Moisture Content	Container No.		66	A	Y	14			80
	Mass of Container + Wet Soil	g	1300.0	1300.0	1295.0	1155.0			1370
	Mass of Container + Dry Soil	g	1254.0	1233.0	1208.0	1060.0			1350
	Mass of Container	g	125.0	125.0	125.0	125.0			370
	Moisture Content	%	4.1	6.0	8.0	10.2			2.0
	Dry Density	g/cm^3	1.85	1.87	1.94	1.91			



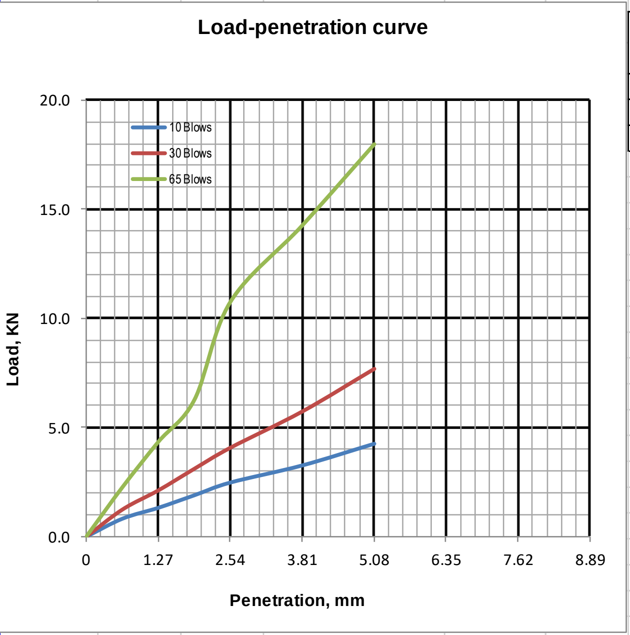
Maximum Dry Density= ***1.94***
Optimum Moisture Content= ***8.2***

Appendix A32: Californian Bearing Ratio (CBR) test result of Pure Subase

CALIFORNIA BEARING RATIO TEST Page 2 of 2

Client:	
Sourse of Material	Subase Pure
Description	Dark Gray Silty Gravel sand material
Purpose/intended for:	For mix with CDWS
Sampled by:	
Tested by:	

TEST METHOD: AASHTO T 193



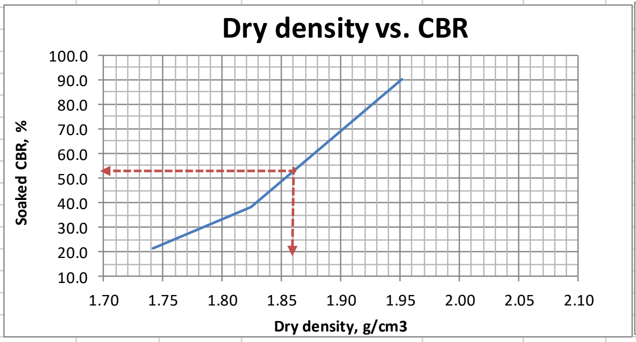
Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.74	2.48	4.26	18.6	21.3	0.21
30	1.82	4.05	7.65	30.4	38.2	0.24
65	1.95	10.75	17.98	80.6	89.9	0.33

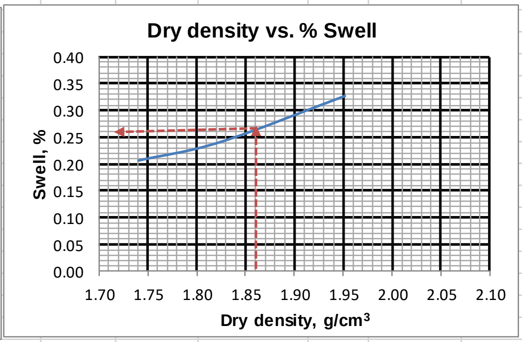
Max. Dry Density (MDD)= 1.94 g/cm^3

95 of MDD= 1.86 g/cm^3

CBR at 95% of MDD= 52 %

Swell at 95% of MDD= 0.3





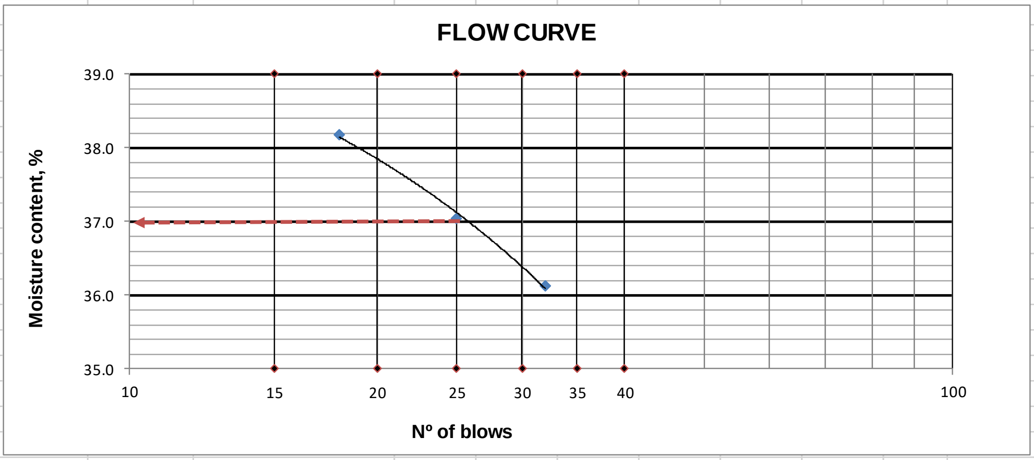
Appendix A33: Atterberg Limit test result of Pure Subase

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Client:	
Matarial sourse	Subase Pure
Description	Dark Gray Silty Gravel sand material
Purpose/intended for:	For mix with CDWS
Sampled by:	
Tested by:	

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		32	25	18				
Container No.		64	N	88		11	15	
Mass of Container	g	45.1	45.63	45.47		45.47	45.49	
Mass of Wet Soil + Container	g	76.56	76.74	76.74		50.14	49.86	
Mass of Dry Soil + Container	g	68.21	68.33	68.10		49.10	48.89	
Mass of Water in Specimen	g	8.35	8.41	8.64	0.00	1.04	0.97	
Mass of Dry Soil	g	23.11	22.70	22.63	0.00	3.63	3.40	
Moisture Content	%	36.1	37.0	38.2	0.0	28.7	28.5	
						Average PL, %		**29**



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI
№ 10				37	8
№ 40					
№ 200					
Initial mass					

Appendix A34: Los-Angeles test result of Pure Subase

Title

RESISTANCE TO DEGRADATION IN LOS ANGELES MACHINE

Page No. Page 1 of 1

Client:
Sample of: Subase Pure
Description Dark Gray Silty Gravel sand material
Purpose/intended for: For mix with CDWS
Sampled by:
Tested by:

TEST METHOD: AASHTO T 96

Table: Standard Grading of Test Samples

Sieve Size		Mass of Indicated Sizes, g			
		Grading			
Passing	Retained on	A	B	C	D
37.5mm(1 1/2in.)	25.0mm(1in.)	1250±25			
25.0mm(1in.)	19.0mm(3/4in.)	1250±25			
19.0mm(3/4in.)	12.5mm(1/2in.)	1250±10	2500±10		
12.5mm(1/2in.)	9.5mm (3/8in.)	1250±10	2500±10		
9.5mm (3/8in.)	6.3mm (1/4in.)			2500±10	
6.3mm (1/4in.)	4.75mm (No.4)			2500±10	
4.75mm (No.4)	2.36mm(No.8)				5000±10
Total		5000±10	5000±10	5000±10	5000±10
Number of Charges		12	11	8	6

Grading Used			B
Mass of Sample Before Test	g	5005	
Mass of Sample Retained on 1.7mm (No.12) Sieve	g	4015	
Mass of Sample Passed on 1.7mm (No.12) Sieve	g	990	
LAA Value	%	19.8	

Appendix A4: Laboratory test results of CDW1 mixed with Clay

Appendix A41: Proctor Compaction test result

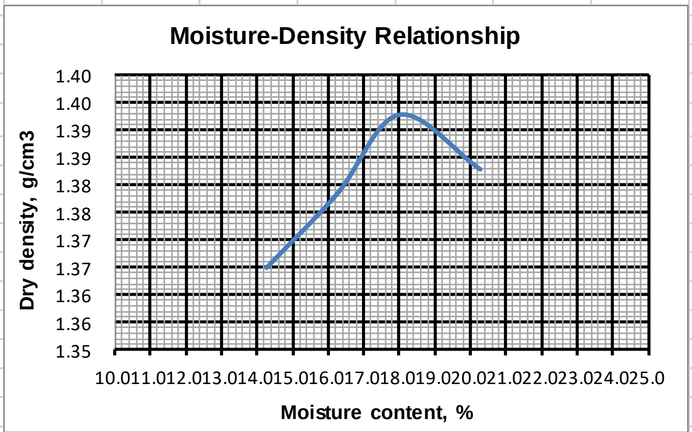
Title: **MOISTURE-DENSITY RELATIONS OF SOILS TEST**

Page No.: Page 1 of 1

Client:
Sample of: CDW1 + 10% Clay
Description
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			8%	10%	12%	14%	5	6	
Bulk Density	Mass of Mould + Soil	g	8825.0	8916.0	9004.0	9046.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	3330.0	3421.0	3509.0	3551.0	0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.560	1.602	1.644	1.663	#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		88	1	2	20			60
	Mass of Container + Wet Soil	g	965.0	904.0	878.0	931.0			1500
	Mass of Container + Dry Soil	g	860.0	795.0	763.0	795.0			1436
	Mass of Container	g	124.0	124.0	124.0	124.0			372
	Moisture Content	%	14.3	16.2	18.0	20.3	#DIV/0!	#DIV/0!	6.0
	Dry Density	g/cm^3	1.36	1.38	1.39	1.38	#DIV/0!	#DIV/0!	



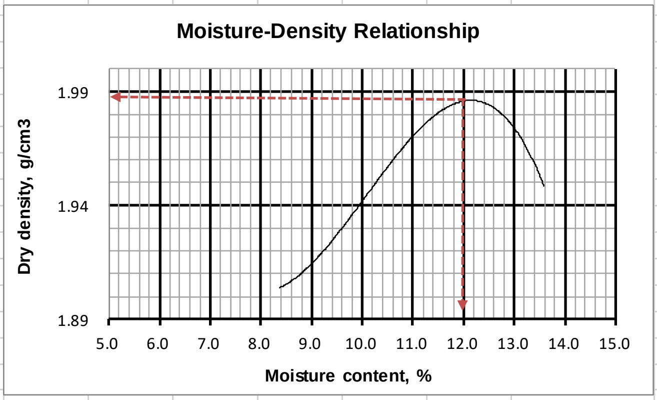
Maximum Dry Density= 1.39 g/cm^3
Optimum Moisture Content= 18.0 %

Title	Page No.
MOISTURE-DENSITY RELATIONS OF SOILS TEST	Page 1 of 1

Client:
Sample of: CDW1 + 20% Clay
Description
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			6%	8%	10%	12%	5	6	
Bulk Density	Mass of Mould + Soil	g	9900.0	10038.0	10238.0	10220.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4405.0	4543.0	4743.0	4725.0	0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	2.063	2.128	2.222	2.213	#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		16	20	3	180			100
	Mass of Container + Wet Soil	g	1393.0	1251.0	1619.0	1528.0			1365
	Mass of Container + Dry Soil	g	1295.0	1150.0	1460.0	1360.0			1345
	Mass of Container	g	124.0	124.0	124.0	124.0			365
	Moisture Content	%	8.4	9.8	11.9	13.6	#DIV/0!	#DIV/0!	2.0
	Dry Density	g/cm^3	1.90	1.94	1.99	1.95	#DIV/0!	#DIV/0!	



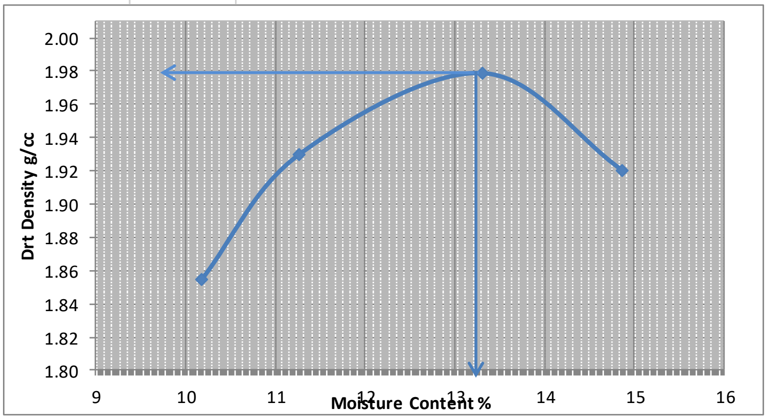
Maximum Dry Density= 1.99 g/cm^3
Optimum Moisture Content= 12 %

TEST METHOD : AASHTO T-180 METHOD D								
SOURSE LOCATION								
REPRESENTING SECTION								
MATERIAL DESCRIBTION	CDW1 + 30% Clay							
PURPOSE	For sub base							
OFF SET FROM CL	—							

DENSITY	TRIAL NUMBER	D1	D1	D1				
	WEIGHT OF SAMPLE (g)	6000	6000	6000	6000			
	WATER ADDED (%)	2.0	4.0	6.0	8.0			
	WEIGHT OF SOIL + MOLD (g)	9876	10098	10300	10223			
	WEIGHT OF MOLD (g)	5514	5514	5514	5514			
	WEIGHT OF SOIL (g)	4362	4584	4786	4709			
	VOLUME OF MOLD (cc)	2135	2135	2135	2135			
	Wet DENSITY OF SOIL (g/cc)	2.043	2.147	2.242	2.206			NMC
MOISTURE	CONTAINER NUMBER	n	g	r	e			130
	WET SOIL + CONTAINER (g)	345.0	348.0	333.0	348.0			1700.0
	DRY SOIL + CONTAINER (g)	316.0	316.0	298.0	308.0			1609.0
	WEIGHT OF WATER (g)	29.0	32.0	35.0	40.0			91.0
	WEIGHT OF CONTAINER (g)	31.0	32.0	35.0	39.0			375.0
	WEIGHT OF DRY SOIL (g)	285.0	284.0	263.0	269.0			1234.0
	MOISTURE CONTENT (%)	10.18	11.27	13.31	14.87			7.37
	DRY DENSITY OF SOIL (g/cc)	1.854	1.930	1.978	1.920			

MDD (gm/cc) :	1.69
OMC (%) :	17.5

REMARK:



Moisture-Density Relations of Sub Base: AASHTO T 180

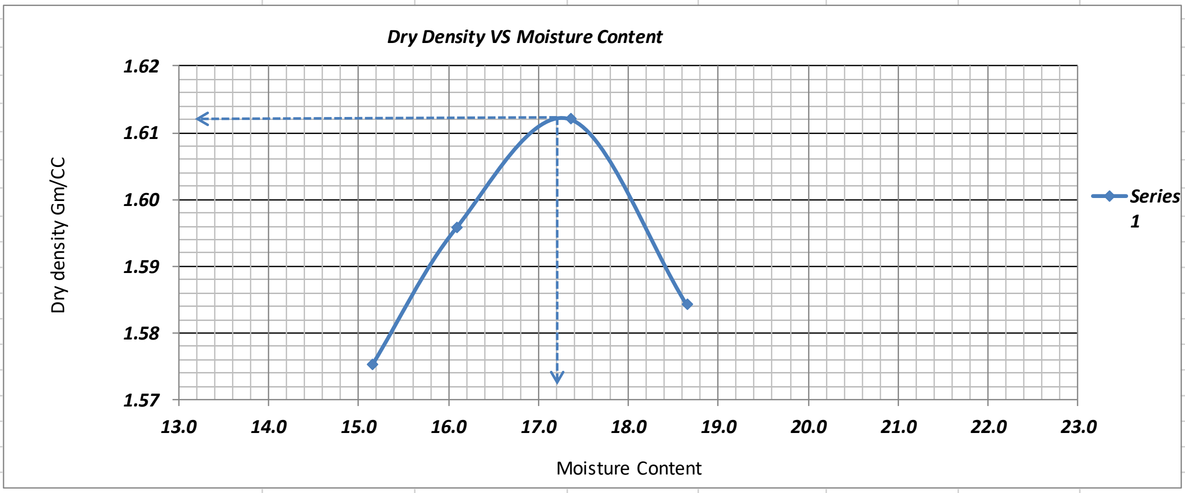
Type of Material	CDW1 + 40% Clay		
Description of Source Material			
Location			

(A) Density Determination

Trial No.		6%	8%	10%	12%		
Mass of Wet Sample + Mould, (gm)	A	9368	9450	9534	9508		
Mass of Mould, (gm)	B	5495	5495	5495	5495		
Mass of Wet Sample, (gm)	C=A-B	3873	3955	4039	4013		
Volume of Mould, (cm3)	V	2135	2135	2135	2135		
Bulk Density, (g/cm3)	W=C/V	1.81	1.85	1.89	1.88		

(B) Moisture Determination

Container No.		16	3	180	10		10
Mass of Container + Wet Soil	E	1294	1190	1152	932		1370
Mass of Container + Dry Soil	F	1140	1042	1000	805		1302
Mass of Container	G	124	122	124	124		370
Mass of Dry Sample	H=F-G	1016	920	876	681		932
Mass of Moisture	I=E-F	154	148	152	127		68
Moisture Content	J=(I/H)*100	15.2	16.1	17.4	18.6		7.3
Dry Density	D=W/(100+J)*100	1.58	1.60	1.61	1.58		0.00



Maximum Dry Density (gm/cm3) =	1.61
Optimum Moisture Content (%) =	17.2
Remark:	

Appendix A42: Californian Bearing Ratio (CBR) test result

Title	Page No.
CALIFORNIA BEARING RATIO TEST	Page 1 of 2

Client:	
Sample of:	CDW1 + 10% Clay
Description	
Purpose/intended for:	Subase Construction
Sampled by:	
Tested by:	

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		E-10		E-30		E-65	
Mass of Mould	g	6414		6440		6432	
Mass of Mould Plus Soil	g	9520	10045	9658	10121	9980	10182
Mass of Soil	g	3106	3631	3218	3681	3548	3750
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	1.46	1.71	1.52	1.73	1.67	1.77
Dry Density	g/cm^3	1.23	1.71	1.26	1.73	1.40	1.77

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before		Before	After	Before	After
Container Number		5		10		3	
Mass of Container	g	124		124		124	
Mass of Container Plus Wet Soil	g	864		904		934	
Mass of Container Plus Dry Soil	g	745		775		805	
Moisture Content	%	19.2		19.8		18.9	

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.6
Load @5.08	20.3

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	10.0	0.4			30.0	1.2			35.0	1.4		
1.27	16.0	0.7			48.0	2.0			70.0	2.9		
1.91	20.0	0.8			66.0	2.7			101.0	4.2		
2.54	28.0	1.16	1.16	8.5	80.0	3.31	3.31	24.3	138.0	5.70	5.70	41.9
3.81	38.0	1.6			115.0	4.8			175.0	7.2		
5.08	44.0	1.82	1.82	9.0	145.0	5.99	5.99	29.5	210.0	8.68	8.68	42.8
7.62		0.0				0.0				0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	4.85	5.05	3.03
Reading After Soaking, mm	5.33	5.6	3.85
Percent Swell	0.41	0.47	0.70

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

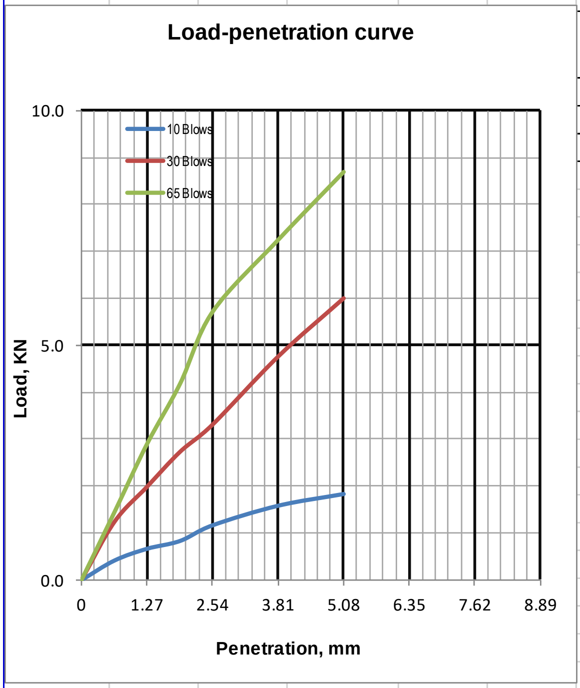
Title

CALIFORNIA BEARING RATIO TEST

Page No.
Page 2 of 2

Client:
Sample of: CDW1 + 10% Clay
Description
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

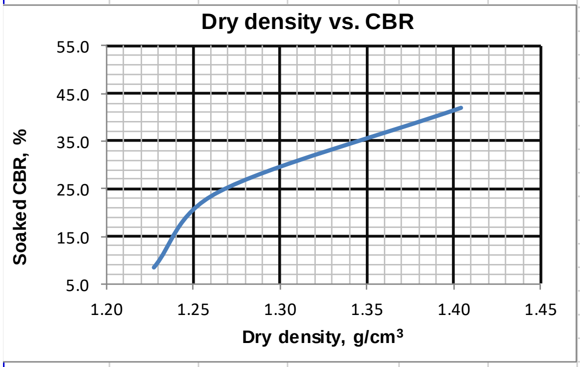
TEST METHOD: AASHTO T 193

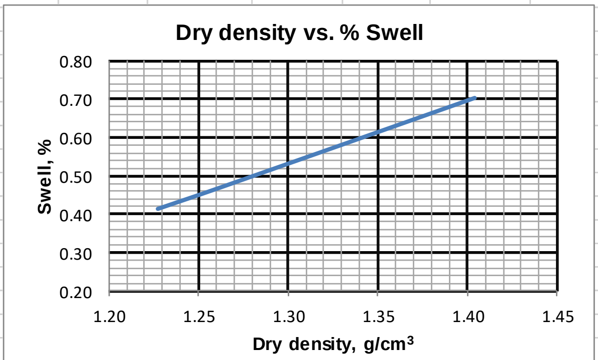


Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.23	1.16	1.82	8.5	9.0	0.41
30	1.26	3.31	5.99	24.3	29.5	0.47
65	1.40	5.70	8.68	41.9	42.8	0.70

Max. Dry Density (MDD)= 1.39 g/cm³
95 % of MDD= 1.32 g/cm³

CBR at 95% of MDD= 31.0 %
Swell at 95% of MDD= 0.6 %





Title	Page No.
CALIFORNIA BEARING RATIO TEST	Page 1 of 2

Client:
Sample of: CDW1 + 20% Clay
Description
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		F-10		F-30		F-65	
Mass of Mould	g	6460		6495		6415	
Mass of Mould Plus Soil	g	10715	10747	11065	11101	11235	11248
Mass of Soil	g	4255	4287	4570	4606	4820	4833
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.00	2.02	2.15	2.17	2.27	2.28
Dry Density	g/cm^3	1.79	2.02	1.92	2.17	2.03	2.28

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		44		D		C	
Mass of Container	g	125		125		125	
Mass of Container Plus Wet Soil	g	1295		1095		1475	
Mass of Container Plus Dry Soil	g	1170		991		1330	
Moisture Content	%	12.0		12.0		12.0	

CALIBRATION/STANDARD DATA	
Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.34
Load @5.08	20

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	35.0	1.4			45.0	1.9			50.0	2.1		
1.27	60.0	2.5			80.0	3.3			95.0	3.9		
1.91	85.0	3.5			115.0	4.8			149.0	6.2		
2.54	100.0	4.13	4.13	31.0	150.0	6.20	6.20	46.5	197.0	8.14	8.14	61.0
3.81	130.0	5.4			210.0	8.7			273.0	11.3		
5.08	160.0	6.61	6.61	33.1	270.0	11.16	11.16	55.8	360.0	14.88	14.88	74.4
7.62	0.0	0.0				0.0				0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	5	5.27	2.45
Reading After Soaking, mm	5.06	5.37	2.6
Percent Swell	0.05	0.09	0.13

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

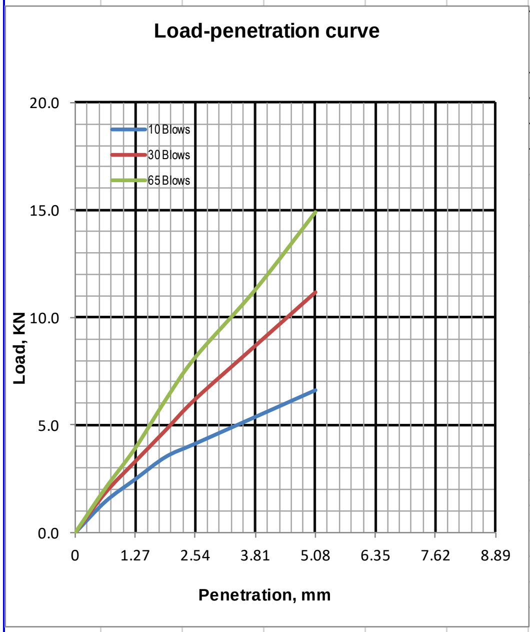
Title

CALIFORNIA BEARING RATIO TEST

Page No.
Page 2 of 2

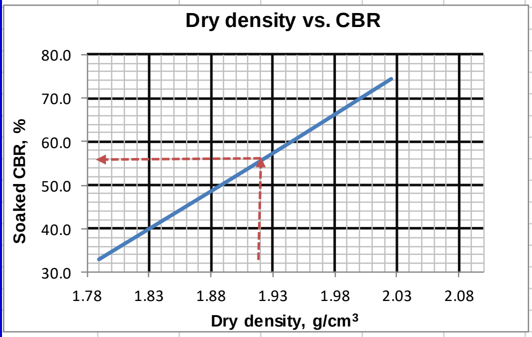
Client:
Sample of: CDW1 +20% Clay
Description
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

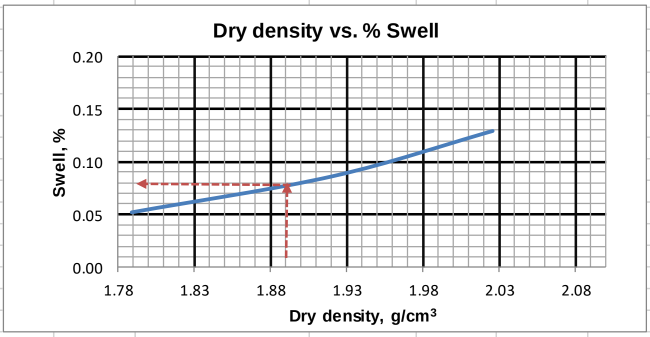
TEST METHOD: AASHTO T 193



Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.79	4.13	6.61	31.0	33.1	0.05
30	1.92	6.20	11.16	46.5	55.8	0.09
65	2.03	8.14	14.88	61.0	74.4	0.13

Max. Dry Density (MDD)=	1.99	g/cm^3
95 % of MDD=	1.89	g/cm^3
CBR at 95% of MDD=	56	%
Swell at 95% of MDD=	0.1	%





CALIFORNIA BEARING RATIO TEST

TEST MATHOD : AASHTO T-193

SOURCE STATION	
REPRESENTED SECTION	
MATERIAL DESCRIPTION	CDW1 + 30% Clay
PUROPSE	For sub base
DEPTH	

DENSITY DETERMINATION

SOAKING CONDITION			10 Blows		30 Blows		65 Blows	
			BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
MOLD NUMBER			G-10		G-30		G-65	
WEIGHT OF SOIL + MOLD	(g)	W_1	12607	12985	11597	11874	13160	13342
WEIGHT OF MOLD	(g)	W_2	8987	8987	7633	7633	9044	9044
VOLUME OF MOLD	(Cm^3)	V	2124	2124	2124	2124	2124	2124
WEIGHT OF WET SOIL	(g)	$W_3 = W_1 - W_2$	3620	3998	3964	4241	4116	4298
WET DENSITY OF SOIL	(g/cm3)	$W_d = (W_3/V)$	1.70	1.88	1.87	2.00	1.94	2.02
DRY DENSITY OF SOIL	(g/cm3)	$D_d = W_d/(100+m)*100$	1.45	1.49	1.57	1.64	1.64	1.67

MOISTURE DETERMINATION

SOAKING CONDITION			10 Blows			30 Blows			65 Blows		
			BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER	
				TOP 1 in.	AVG.		TOP 1 in.	AVG.		TOP 1 in.	AVG.
CONTAINER NUMBER			P	K		H	M		G	P	
WET SOIL + CONTAINER	(g)	a	419	433		403	342.0		395.0	395	
DRY SOIL + CONTAINER	(g)	b	361.0	352.0		345.0	287.0		340.0	332.0	
WEIGHT OF CONTAINER	(g)	c	32	43		38.0	36.0		32.0	32.0	
WEIGHT OF WATER	(g)	d = a - b	58.0	81.0		58.0	55.0		55.0	63.0	
WEIGHT OF DRY SOIL	(g)	e = b - c	329	309		307	251.0		308	300	
MOISTURE CONTENT	(%)	m =(d/e)*100	17.63	26.21		18.89	21.91		17.86	21.00	
AVG. MOIST. CONTENT (%)											

PENETRATION TEST DATA

PENETRATION (mm)	10 Blows				30 Blows				65 Blows			
	DIAL RDG	LOAD (kn)	COR. LOAD (kn)	CBR %	DIAL RDG	LOAD (kn)	COR. LOAD (kn))	CBR %	DIAL RDG	LOAD (kn)	COR LOAD (kn))	CBR %
0	0.0	0			0.0	0			0.0	0		
0.64	33.0	0.8382			37.0	0.9398			75.0	1.9050		
1.27	51.0	1.2954			77.0	1.9558			151.0	3.8354		
1.96	64.0	1.6256			134.0	3.4036			202.0	5.1308		
2.54	75.0	1.9050		14.3	196.0	4.9784		37.3	236.0	5.9944		44.9
3.18	84.0	2.1336			248.0	6.2992			265.0	6.7310		
3.81	93.0	2.3622			288.0	7.3152			295.0	7.4930		
4.45	102.0	2.5908			310.0	7.8740			320.0	8.1280		
5.08	108.0	2.7432		13.7	330.0	8.3820		41.9	345.0	8.7630		43.8

SWELL

Height of Specimen(mm)	116.43		
No. OF BLOWS	**10**	**30**	**65**
RDG (BEFORE SOAKING)	2.27	1.42	1.43
RDG (AFTER) SOAKING)	2.58	1.60	1.58
PERCENT SWELL	0.27	0.15	0.13
AVERAGE PERCENT SWELL :	0.18		

RING FACTOR

25.4 N/Divis.

MDD (gm/cc)	1.69
OMC %	17.5
95% of MDD	1.61

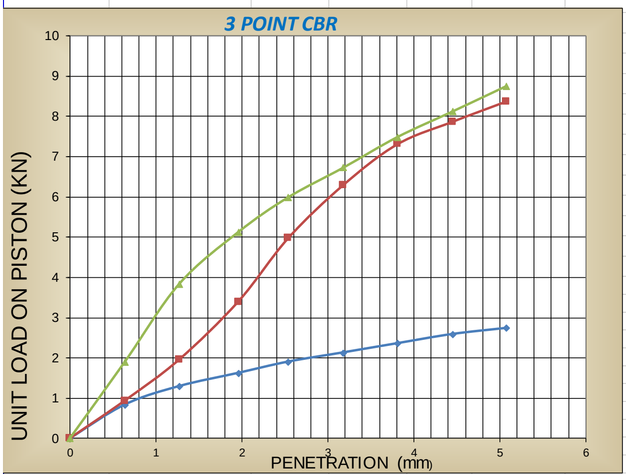
CALIFORNIA BEARING RATIO TEST
TEST MATHOD : AASHTO T-193

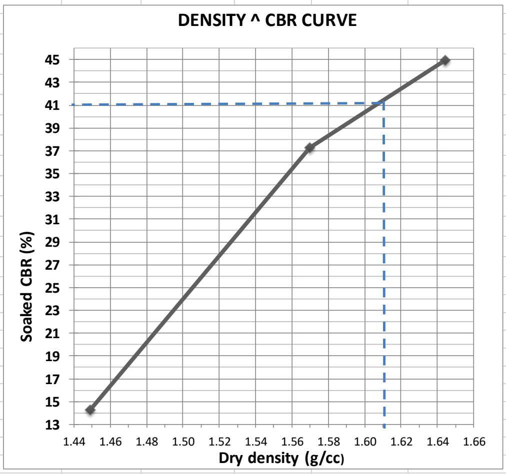
SOURCE STATION	
REPRESENTED SECTION	
MATERIAL DESCRIPTION	CDW1 + 30% Clay
PUROPSE	For sub base
DEPTH	

BLOWS	LOAD (KN)		CBR(%)		SWELL %
	2.54mm	5.08mm	2.54mm	5.08mm	
10	1.91	2.74	14.3	13.7	0.27
30	4.98	8.38	37.3	41.9	0.15
65	5.99	8.76	44.9	43.8	0.13

DRY DENSITY Vs SOCKED C.B.R.

No # OF BLOWS	10	30	65
DRY DENSITY	1.45	1.57	1.64
SOCKED C.B.R.	14.3	37.3	44.9





MODIFIED PROCTOR : T 180	
MDD (g/cc) :	1.69
OMC (%) :	17.5
95% of MDD(g/cc)	1.61
CBR@ 95% of MDD(%)	41.0

California Bearing Ratio (CBR) of Sub Base: Standard Method of Test: AASHTO T 193

Type of Material	*CDW1 + 40% Clay*
Description of Source Material	

(A) Compaction Determination

Compaction Data		10 Blows		30 Blows		65 Blows	
		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Mould No.		A-10		A-30		A-65	
Mass of Soil + Mould	gm	10194	10474	10458	10678	10494	10627
Massof Mould	gm	6420	6420	6474	6474	6456	6456
Mass of Soil	gm	3774	4054	3984	4204	4038	4171
Volume of Mould	cm3	2124	2124	2124	2124	2124	2124
Wet Density of Soil	gm/cm3	1.78	1.91	1.88	1.98	1.90	1.96
Dry Density of Soil	**gm/cm3**	**1.52**	**1.49**	**1.60**	**1.58**	**1.62**	**1.55**

(B) Moisture Determination

Moisture Content Data		10 Blows		30 Blows		65 Blows	
		Before Soaking	After Soaking	Before Soaking	After Soakin	Before Soaking	After Soaking
Container No.		7	13	C	X	2	D
Mass of Wet Soil + Container	gm	1102	1044	990	1110	860	1080
Mass of Dry Soil + Container	gm	959	840	862	910.0	751	880.0
Mass of Container	gm	124	124	124	124.0	124	124.0
Mass of Water	gm	143	204	128	200	109	200
Mass of Dry Soil	gm	835.00	716.00	738.00	786.00	627.00	756.00
Moisture Content Data	**%**	**17.1**	**28.5**	**17.3**	**25.4**	**17.4**	**26.5**

(C) CBR Penetration Data

Penetration After 96 hrs Soaking Period **Surcharge Weight = 4.55 KG** **Ring Calibration Factor (KN/Div.) = 0.04136**

Penetration, mm	10 Blows				30 Blows				65 Blows			
	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %
0.00	0.0	0.00			0.0	0.00			0	0.00		
0.64	30.0	1.24			38.0	1.57			41.0	1.70		
1.27	50.0	2.07			62.0	2.56			73.0	3.02		
1.91	68.0	2.81			92.0	3.81			100.0	4.14		
2.54	84.0	3.47	3.47	17.4	115.0	4.76	4.76	35.7	172.0	7.11	7.11	53.3
3.18	100.0	4.14			142.0	5.87			195.0	8.07		
3.81	110.0	4.55			162.0	6.70			215.0	8.89		
4.45	122.0	5.05			185.0	7.65			240.0	9.93		
5.08	132.0	5.46	5.46	27.3	206.0	8.52	8.52	42.6	258.0	10.67	10.67	53.4
7.62	145.0	6.00			215.0	8.89			275.0	11.37		

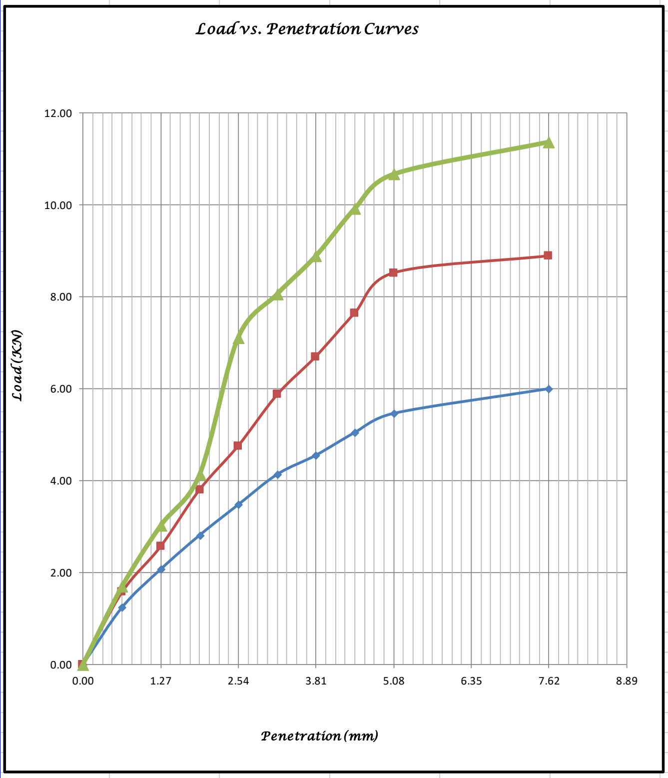
Modified Max. Dry Density, g/cc =	**1.61**	**Plunger Cross-section Area, mm2 =**	**1935**	**Standard Load, KN**	**at 2.54mm**	**=**	**13.34**
Opt. Moisture Content, % =	**17.2**				**at 5.08mm**	**=**	**20**

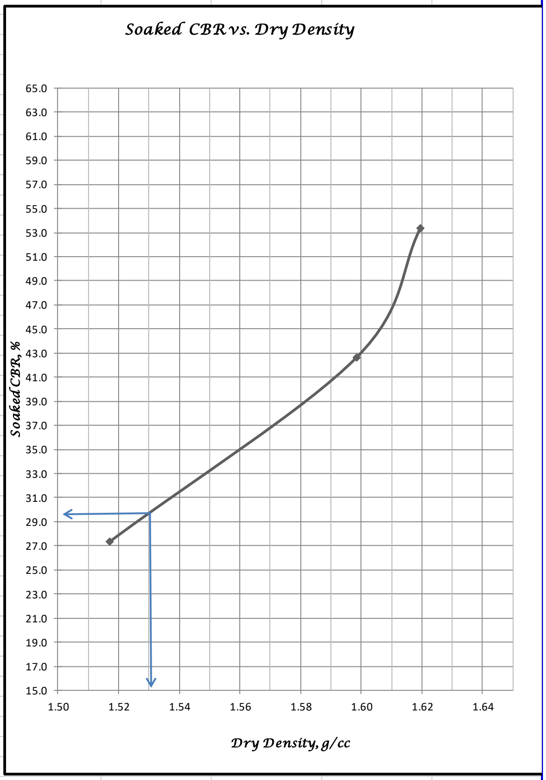
(D) Swell Determination

No. of Blows	10	30	65
Readiing Before Soaking, div	2.7	5.0	5.1
Reading After Soaking, div	2.8	5.1	5.4
Dial Gauge Factor, mm/div	0.1	0.1	0.3
Height of the specimen	116.4	116.4	116.4
Swell %	0.09	0.09	0.26
Average Swell, %	0.15		

Remark:

Type of Material	CDW1 + 40% Clay
Description	
Location	

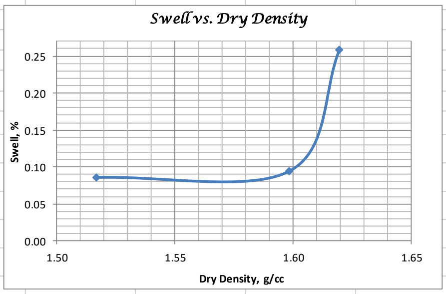




Blows	Pen. mm	Load, KN	Corr. Load, KN	CBR, %	Swell, %
10	2.54	3.47	3.47	17.4	0.09
	5.08	5.46	5.46	27.3	
30	2.54	4.76	4.76	35.7	0.09
	5.08	8.52	8.52	42.6	
65	2.54	7.11	7.11	53.3	0.26
	5.08	10.67	10.67	53.4	

No. of Blows	MCBS, %	DDBS, g/cc	Corr. CBR, %	% of Compaction
10	17.1	1.52	27.3	94%
30	17.3	1.60	42.6	99%
65	17.4	1.62	53.4	101%
95% of MDD =				1.53
Maximum Dry Density =				**1.61**

No. of blows	Dry Density	Swell
10	1.52 g/cc	0.09 %
30	1.60 g/cc	0.09
65	1.62 g/cc	0.26 %



Summary	
MDD, gm/cc	**1.61**
OMC, %	**17.2**
95 % 0f MDD	**1.53**
CBR at 95% of MDD, %	**29**
Swell at 95% of MDD, %	**0.1**

Remark:

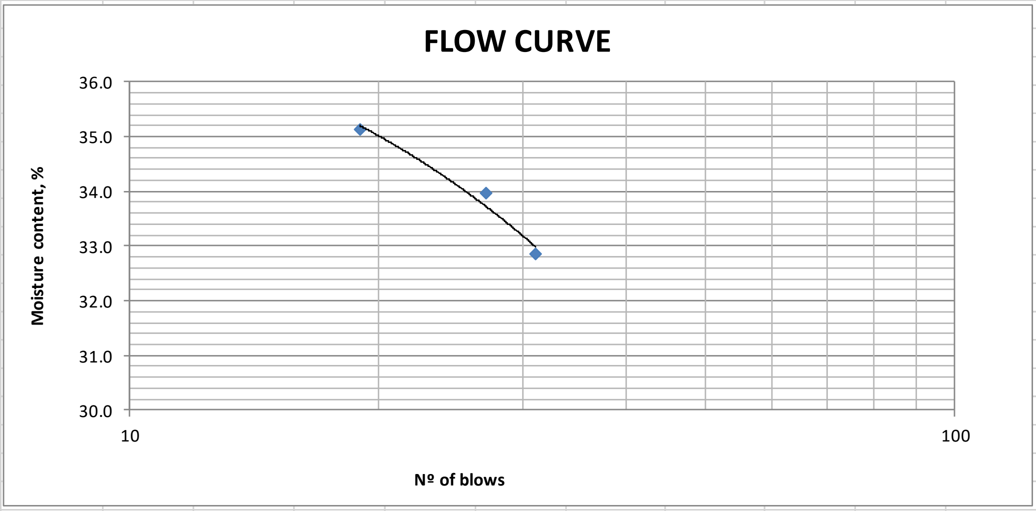
Appendix A43: Atterberg Limit test results

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Client:	
Sample of:	CDW1 + 10% Clay
Station:	
Description	
Purpose/intended for:	Subase Construction
Sampled by:	
Tested by:	

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		31	27	19				
Container No.		D	64	20		6	E	
Mass of Container	g	45.27	45.1	45.47		45.78	45.81	
Mass of Wet Soil + Container	g	65.25	65.22	65.78		49.88	49.99	
Mass of Dry Soil + Container	g	60.31	60.12	60.50		48.95	49.15	
Mass of Water in Specimen	g	4.94	5.10	5.28	0.00	0.93	0.84	0.00
Mass of Dry Soil	g	15.04	15.02	15.03	0.00	3.17	3.34	0.00
Moisture Content	%	32.8	34.0	35.1	#DIV/0!	29.3	25.1	#DIV/0!
						Average PL, %		**27.2**



Sieve No.	Mass Ret.	% Retain.	% Pass.
№ 10			
№ 40			
№ 200			
Initial Mass			

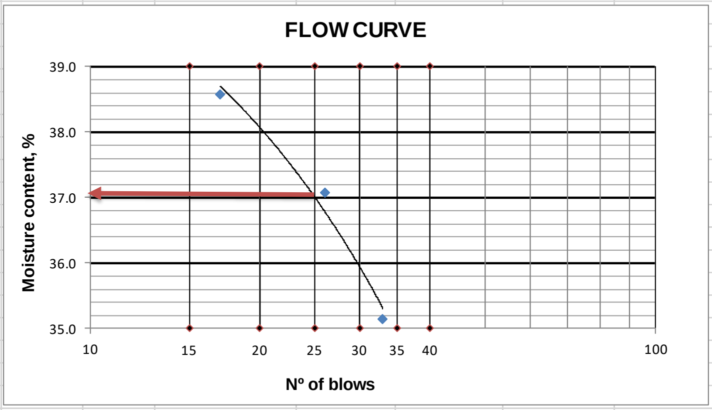
LL	PI	AASHTO Classification	Grading Modulus
34	7		

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Client:
Sample of: CDW1 + 20% Clay
Description
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		33	26	17				
Container No.		A	20	11		K	E	
Mass of Container	g	45.2	45.47	45.84		45.56	45.69	
Mass of Wet Soil + Container	g	65.58	65.95	64.88		48.87	49.03	
Mass of Dry Soil + Container	g	60.28	60.41	59.58		48.17	48.42	
Mass of Water in Specimen	g	5.30	5.54	5.30	0.00	0.70	0.61	
Mass of Dry Soil	g	15.08	14.94	13.74	0.00	2.61	2.73	
Moisture Content	%	35.1	37.1	38.6	#DIV/0!	26.8	22.3	
			36.93368552			**Average PL, %**		25



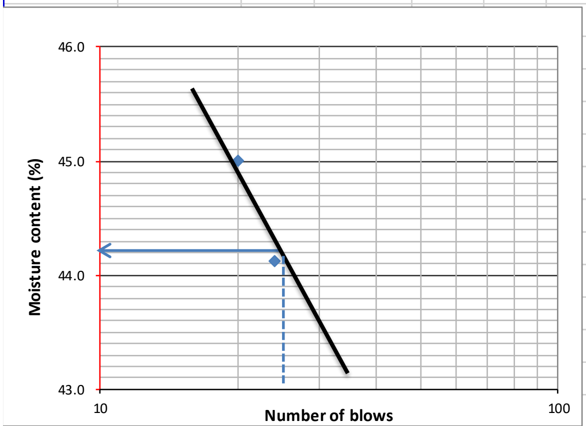
Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10				37	12		
№ 40							
№ 200							
Initial Mass							

DETERMINATION OF LIQUID LIMIT & PLASTIC LIMIT OF SOIL

TEST METHOD : AASHTO T89

SAMPLING STATION	
INTENDED PURPOSE	Subase Construction
MATERIAL DESCRIPTION	CDW1 + 30% Clay
DEPTH	

Determination		*Liquid Limit*				***Plastic Limit***		
Number of blows		*30*	*24*	*20*				
Test	No						1	2
Container	No	36	32	7			33	15
Wt. of container + wet soil,	(g)	36.76	34.49	36.07			18.01	18.11
Wt. of container + dry soil,	(g)	29.374	28.773	29.726			17.415	17.540
Wt. of container,	(g)	15.72	15.82	15.62			15.66	15.65
Wt. of water,	(g)	7.39	5.72	6.35			0.59	0.57
Wt. of dry soil,	(g)	13.65	12.95	14.10			1.76	1.89
Moisture container,	(%)	*54.13*	*44.13*	*45.00*			*33.60*	*30.19*
Average	(%)	47.8				31.9		



Linear shrinkage

Initial length of specimen (L_1)______

Length of dried specimen (L_2)_______

Linear shrinkage = $\left(\frac{(L_1 - L_2)x100}{L_1}\right)$

If LL or PL cannot bedetermined

use PI = 2.13 x LS =

Remark

Determination of (PI)	***(LL - PL)***			**Grading**			
	-	LL	47.8	ASTM SIEVE NO			
	-	PL	31.9	Dim. mm			
	PI	16		% passing			
				AASHTO Soil Classification			

Determination of Liquid Limit and Plasticity Index of Sub Base: AASHTO T 89 & T 90

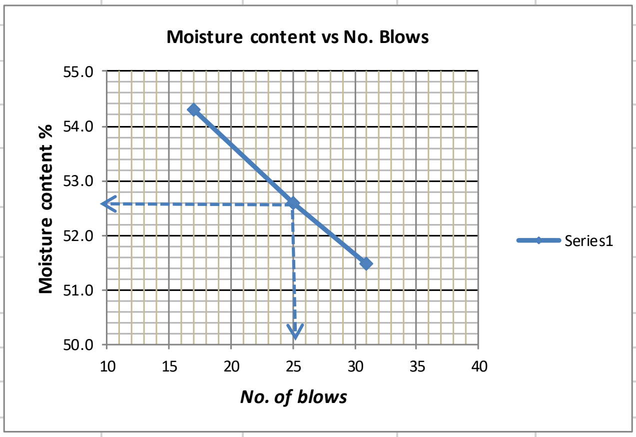
Type of Material	*CDW1 + 40% Clay*		
Description of Sourse Material			
Location			

Test Data			***Liquid Limit***			***Plastic Limit***	
Test No.			***1***	***2***	***3***	***1***	***2***
No. of Blows			31	25	17		
Container No.			C	M	6	140	144
Mass of Wet Soil + Container	*(gm)*	*A*	63.14	63.5	63.99	47.63	47.73
Mass of Dry Soil + Container	*(gm)*	*B*	57.05	57.29	57.53	47.01	47.19
Mass of Container	*(gm)*	*C*	45.22	45.48	45.63	45.24	45.65
Mass of Water	*(gm)*	*D=A-B*	6.09	6.21	6.46	0.62	0.54
Mass of Dry Soil	*(gm)*	*E=B-C*	11.83	11.81	11.9	1.77	1.54
Moisture Content	*(%)*	*F=D/E*100*	51.5	52.6	54.3	35.0	35.1
Liquid Limit			**52.8**		**Plastic Limit**		**35.0**

Linear shrinkage: BS 1377-2

Initial length of specimen	**(L1)**	
Length of dried specimen	**(L2)**	
Linear shrinkage (%)	**(L1-L2)*100/L1**	

Note: If LL or PL cannot be determined use PI = 2.13 x LS



Summary

Liquid Limit (%)	*52.6*
Plastic Limit (%)	*35.0*
Plasticity Index (%)	*17.6*

Remark:

Appendix A5: Laboratory test results of CDW2 mixed with Clay

Appendix A51: Proctor Compaction test result

Title

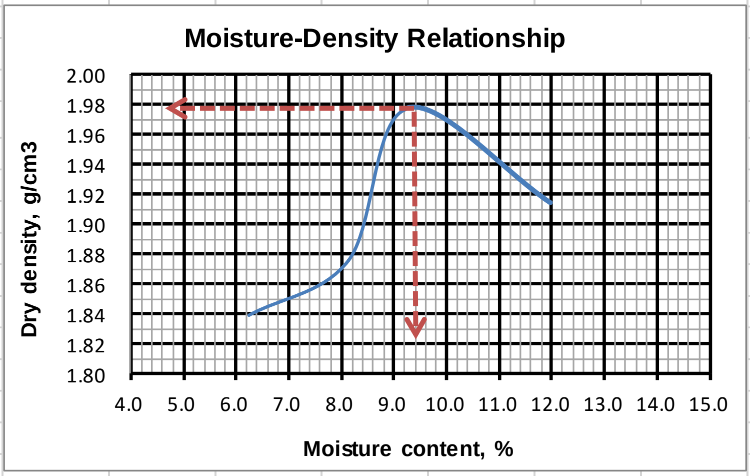
MOISTURE-DENSITY RELATIONS OF SOILS TEST

Page No. Page 1 of 1

Client:
Sample of: CDW2 + 10%
Description
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			4%	6%	8%	10%		
Bulk Density	Mass of Mould + Soil	g	9667.0	9827.0	10107.0	10071.0		
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0		
	Mass of Wet Soil	g	4172.0	4332.0	4612.0	4576.0		
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0		
	Bulk Density	g/cm^3	1.954	2.029	2.160	2.143		NMC
Moisture Content	Container No.		138	1	44	2		11
	Mass of Container + Wet Soil	g	1076.0	1161.0	917.0	1099.0		1313
	Mass of Container + Dry Soil	g	1020.0	1083.0	850.0	995.0		1300
	Mass of Container	g	125.0	125.0	125.0	125.0		313
	Moisture Content	%	6.3	8.1	9.2	12.0		1.3
	Dry Density	g/cm^3	1.84	1.88	1.98	1.91		



1.98 g/cm^3
9.4 %

Title

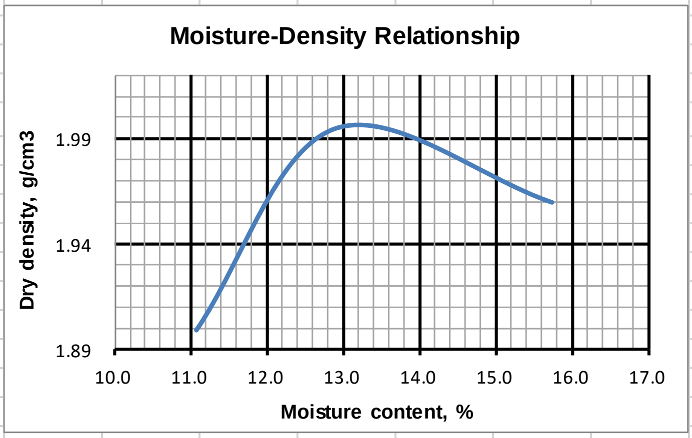
MOISTURE-DENSITY RELATIONS OF SOILS TEST

Page No.
Page 1 of 1

Material type CDW2 + 20% Clay
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			0%	2%	4%				
Bulk Density	Mass of Mould + Soil	g	9999.0	10303.0	10338.0				
	Mass of Mould	g	5495.0	5495.0	5495.0				
	Mass of Wet Soil	g	4504.0	4808.0	4843.0		0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0				
	Bulk Density	g/cm^3	2.110	2.252	2.268		#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		B	P	5				100
	Mass of Container + Wet Soil	g	1297.0	1070.0	1058.0				1365
	Mass of Container + Dry Soil	g	1180.0	962.0	931.0				1266
	Mass of Container	g	124.0	124.0	124.0				365
	Moisture Content	%	11.1	12.9	15.7		#DIV/0!	#DIV/0!	11.0
	Dry Density	g/cm^3	1.90	1.99	1.96		#DIV/0!	#DIV/0!	



Maximum Dry Density= 1.99 g/cm^3
Optimum Moisture Content= 13.2 %

Moisture-Density Relations of Road-Bed: AASHTO T 180

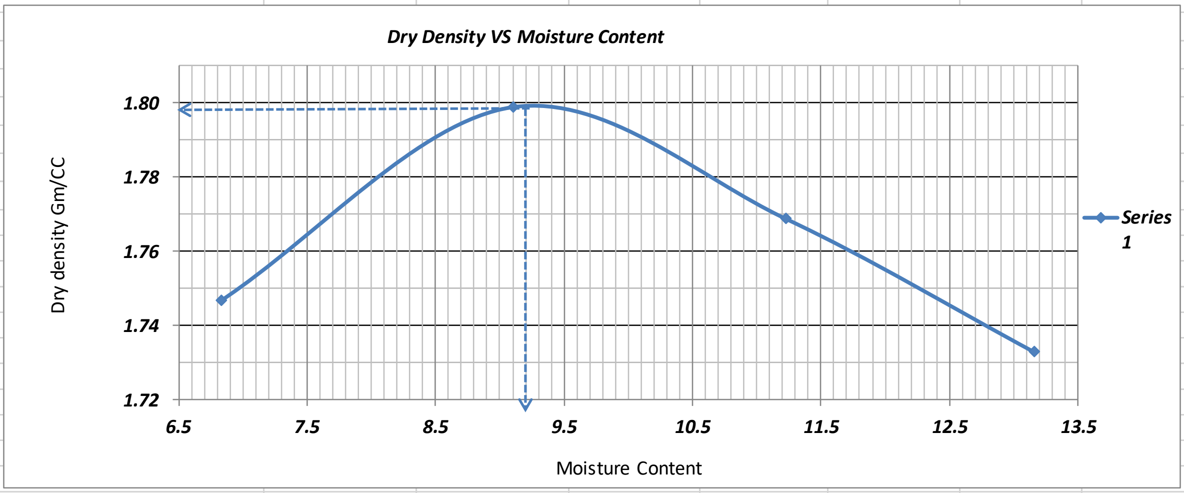
Type of Material	sub base
Description of Source Material	CDW2 + 30% Clay
Location	

(A) Density Determination

Trial No.		4%	6%	8%	10%		
Mass of Wet Sample + Mould, (gm)	A	9498	9704	9714	9700		
Mass of Mould, (gm)	B	5514	5514	5514	5514		
Mass of Wet Sample, (gm)	C=A-B	3984	4190	4200	4186		
Volume of Mould, (cm3)	V	2135	2135	2135	2135		
Bulk Density, (g/cm3)	W=C/V	1.87	1.96	1.97	1.96		

(B) Moisture Determination

Container No.		1	2	3	6		100
Mass of Container + Wet Soil	E	1344	1132	1096	1156		1280
Mass of Container + Dry Soil	F	1266	1048	998	1036		1150
Mass of Container	G	125	125	125	124		280
Mass of Dry Sample	H=F-G	1141	923	873	912		870
Mass of Moisture	I=E-F	78	84	98	120		130
Moisture Content	J=(I/H)*100	6.8	9.1	11.2	13.2		14.9
Dry Density	D=W/(100+J)*100	1.75	1.80	1.77	1.73		0.00



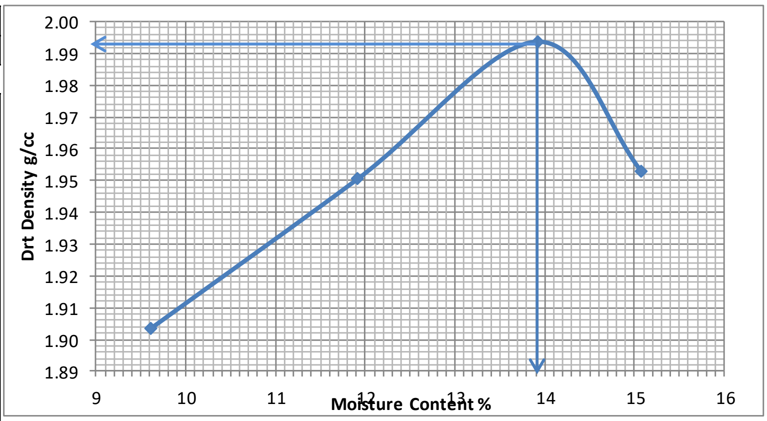
Maximum Dry Density (gm/cm3) =	1.80
Optimum Moisture Content (%) =	9.2
Remark:	

MOISTURE DENSITY RELATIONSHIP OF SOIL			
TEST METHOD : AASHTO T-180 METHOD D			
SOURSE LOCATION			
REPRESENTING SECTION			
MATERIAL DESCRIBTION	CDW2 + 40% Clay		
PURPOSE	For Subase		
OFF SET FROM CL			

DENSITY	TRIAL NUMBER	D1	D1	D1	D1			
	WEIGHT OF SAMPLE (g)	6000	6000	6000	6000			
	WATER ADDED (%)	4.0	6.0	8.0	10.0			
	WEIGHT OF SOIL + MOLD (g)	10255	10458	10643	10593			
	WEIGHT OF MOLD (g)	5874	5874	5874	5874			
	WEIGHT OF SOIL (g)	4381	4584	4769	4719			
	VOLUME OF MOLD (cc)	2100	2100	2100	2100			
	Wet DENSITY OF SOIL (g/cc)	2.086	2.183	2.271	2.247			NMC
MOISTURE	CONTAINER NUMBER	X	T	Y	W			10
	WET SOIL + CONTAINER (g)	458.0	423.0	478.0	518.0			2412.0
	DRY SOIL + CONTAINER (g)	421.0	382.0	424.0	455.0			2320.0
	WEIGHT OF WATER (g)	37.0	41.0	54.0	63.0			92.0
	WEIGHT OF CONTAINER (g)	36.0	38.0	36.0	37.0			373.0
	WEIGHT OF DRY SOIL (g)	385.0	344.0	388.0	418.0			1947.0
	MOISTURE CONTENT (%)	9.61	11.92	13.92	15.07			4.73
	DRY DENSITY OF SOIL (g/cc)	1.90	1.95	1.99	1.95			

MDD (gm/cc) :	1.99
OMC (%) :	13.9

REMARK:



Appendix A52: Californian Bearing Ratio (CBR) test result

CALIFORNIA BEARING RATIO TEST

Page 1 of 2

Client:
Sample of: CDW2 + 10% Clay
Description
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		E-10		E-30		E-65	
Mass of Mould	g	6426		6453		6428	
Mass of Mould Plus Soil	g	10667	10767	10780	10780	11100	11105
Mass of Soil	g	4241	4341	4327	4327	4672	4677
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.00	2.04	2.04	2.04	2.20	2.20
Dry Density	g/cm^3	1.82	2.04	1.87	2.04	2.01	2.20

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		Y		B		A	
Mass of Container	g	124		124		124	
Mass of Container Plus Wet Soil	g	860		817		526	
Mass of Container Plus Dry Soil	g	795		760		492	
Moisture Content	%	9.7		9.0		9.2	

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.34
Load @5.08	20

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	18.0	0.7			19.0	0.8			30.0	1.2		
1.27	34.0	1.4			35.0	1.4			53.0	2.2		
1.91	53.0	2.2			55.0	2.3			78.0	3.2		
2.54	75.0	3.10	3.10	23.2	76.0	3.14	3.14	23.6	97.0	4.01	4.01	30.1
3.81	98.0	4.1			114.0	4.7			139.0	5.7		
5.08	129.0	5.33	5.33	26.7	154.0	6.37	6.37	31.8	182.0	7.52	7.52	37.6
7.62		0.0				0.0				0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	5.36	6.7	2.44
Reading After Soaking, mm	5.4	6.75	2.54
Percent Swell	0.03	0.04	0.09

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

Title	Page No.
CALIFORNIA BEARING RATIO TEST	Page 1 of 2

Material type CDW2 + 20% Clay
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows Before	10 Blows After	30 Blows Before	30 Blows After	65 Blows Before	65 Blows After
Mould Number		E-10		E-30		E-65	
Mass of Mould	g	6431		6448		6436	
Mass of Mould Plus Soil	g	10716	10565	11059	10900	11307	11120
Mass of Soil	g	4285	4134	4611	4452	4871	4684
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.02	1.95	2.17	2.10	2.29	2.21
Dry Density	g/cm^3	1.79	1.95	1.92	2.10	2.03	2.21

MOISTURE CONTENT DETERMINATION		10 Blows Before	10 Blows After	30 Blows Before	30 Blows After	65 Blows Before	65 Blows After
Container Number		5		2		8	
Mass of Container	g	124		124		124	
Mass of Container Plus Wet Soil	g	916		712		712	
Mass of Container Plus Dry Soil	g	825		644		644	
Moisture Content	%	13.0		13.1		13.1	

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.34
Load @5.08	20

PENETRATION TEST DATA

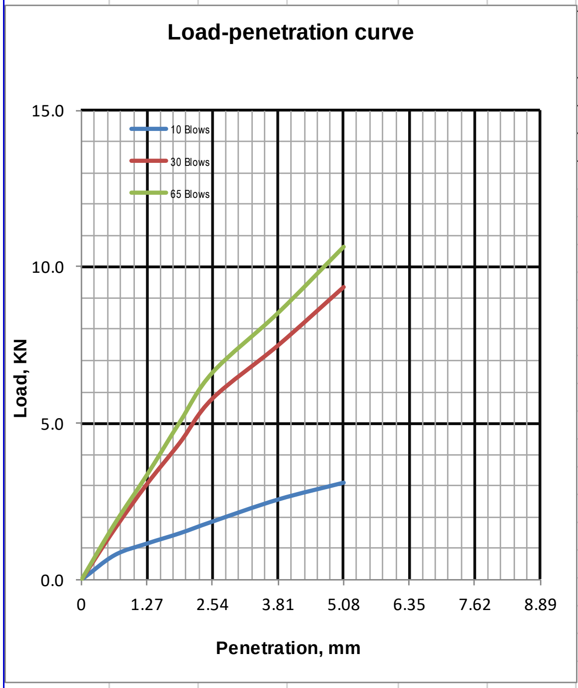
Penetration	10 Blows Dial Read.	10 Blows Load	10 Blows Corr. Load	10 Blows CBR	30 Blows Dial Read.	30 Blows Load	30 Blows Corr. Load	30 Blows CBR	65 Blows Dial Read.	65 Blows Load	65 Blows Corr. Load	65 Blows CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	19.0	0.8			39.0	1.6			43.0	1.8		
1.27	28.0	1.2			74.0	3.1			81.0	3.3		
1.91	36.0	1.5			106.0	4.4			122.0	5.0		
2.54	45.0	1.86	1.86	13.9	140.0	5.79	5.79	43.4	160.0	6.61	6.61	49.6
3.81	62.0	2.6			181.0	7.5			206.0	8.5		
5.08	75.0	3.10	3.10	15.5	226.0	9.34	9.34	46.7	257.0	10.62	10.62	53.1
7.62		0.0				0.0				0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	5.34	3.21	3.21
Reading After Soaking, mm	5.37	3.26	3.27
Percent Swell	0.03	0.04	0.05

SOAKING CONDITION	
Unsoaked	
Soaked	√
Surcharge Load	**4.54** Kg
Days Soaked	**4**

Client:
Sample of: CDW2 + 10% Clay
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

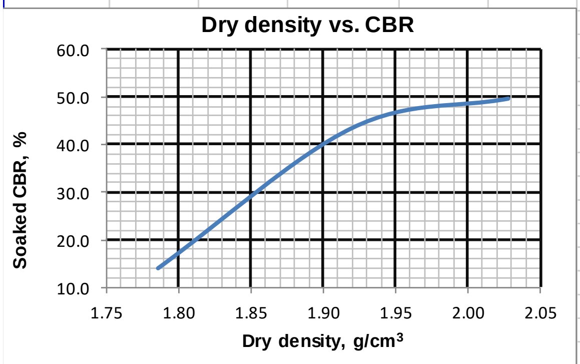
TEST METHOD: AASHTO T 193

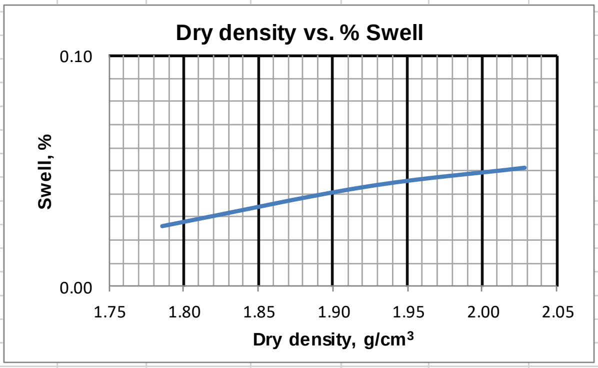


Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.79	1.86	3.10	13.9	15.5	0.03
30	1.92	5.79	9.34	43.4	46.7	0.04
65	2.03	6.61	10.62	49.6	53.1	0.05

Max. Dry Density (MDD)= 1.99 g/cm^3
95 % of MDD= 1.89 g/cm^3

CBR at 95% of MDD= 38 %
Swell at 95% of MDD= 0.4 %





California Bearing Ratio (CBR) of Road-Bed: Standard Method of Test: AASHTO T 193

Type of Material	*CDW2 + 30% Clay*
Intended Purpose	*For subase Material*

(A) Compaction Determination

Compaction Data		10 Blows Before Soaking	10 Blows After Soaking	30 Blows Before Soaking	30 Blows After Soaking	65 Blows Before Soaking	65 Blows After Soaking
Mould No.		G-10		G-30		G-65	
Mass of Soil + Mould	gm	10840	11014	11136	11720	11338	11445
Massof Mould	gm	6452	6452	6452	6452	6444	6444
Mass of Soil	gm	4388	4562	4684	5268	4894	5001
Volume of Mould	cm3	2124	2124	2124	2124	2124	2124
Wet Density of Soil	gm/cm3	2.07	2.15	2.21	2.48	2.30	2.35
Dry Density of Soil	**gm/cm3**	**1.88**	**1.95**	**2.01**	**2.25**	**2.10**	**2.13**

(B) Moisture Determination

Moisture Content Data		10 Blows Before Soaking	10 Blows After Soaking	30 Blows Before Soaking	30 Blows After Soakin	65 Blows Before Soaking	65 Blows After Soaking
Container No.		2	16	3	**20**	6	P
Mass of Wet Soil + Container	gm	1304	1360	1280	1362	1326	1316
Mass of Dry Soil + Container	gm	1198	1245	1180	1246.0	1218	1204.0
Mass of Container	gm	124	124	122	124.0	124	124.0
Mass of Water	gm	106	115	100	116	108	112
Mass of Dry Soil	gm	1074.00	1121.00	1058.00	1122.00	1094.00	1080.00
Moisture Content Data	**%**	**9.9**	**10.3**	**9.5**	**10.3**	**9.9**	**10.4**

(C) CBR Penetration Data

Penetration After 96 hrs Soaking Period **Surcharge Weight = 4.55 KG** **Ring Calibration Factor (KN/Div.) = 0.04131**

Penetration, mm	10 Blows Dial Gauge Reading	10 Blows Load, KN	10 Blows Corr. Load, KN	10 Blows CBR, %	30 Blows Dial Gauge Reading	30 Blows Load, KN	30 Blows Corr. Load, KN	30 Blows CBR, %	65 Blows Dial Gauge Reading	65 Blows Load, KN	65 Blows Corr. Load, KN	65 Blows CBR, %
0.00	0.0	0.00			0.0	0.00			0	0.00		
0.64	32.0	1.32			45.0	1.86			50.0	2.07		
1.27	56.0	2.31			80.0	3.30			95.0	3.92		
1.91	74.0	3.06			118.0	4.87			144.0	5.95		
2.54	91.0	3.76	3.76	18.8	136.0	5.62	5.62	42.1	191.0	7.89	7.89	59.1
3.18	104.0	4.30			178.0	7.35			230.0	9.50		
3.81	112.0	4.63			210.0	8.68			261.0	10.78		
4.45	119.0	4.92			240.0	9.91			294.0	12.15		
5.08	125.0	5.16	5.16	25.8	263.0	10.86	10.86	54.3	327.0	13.51	13.51	67.5
7.62	133.0	5.49			280.0	11.57			355.0	14.67		

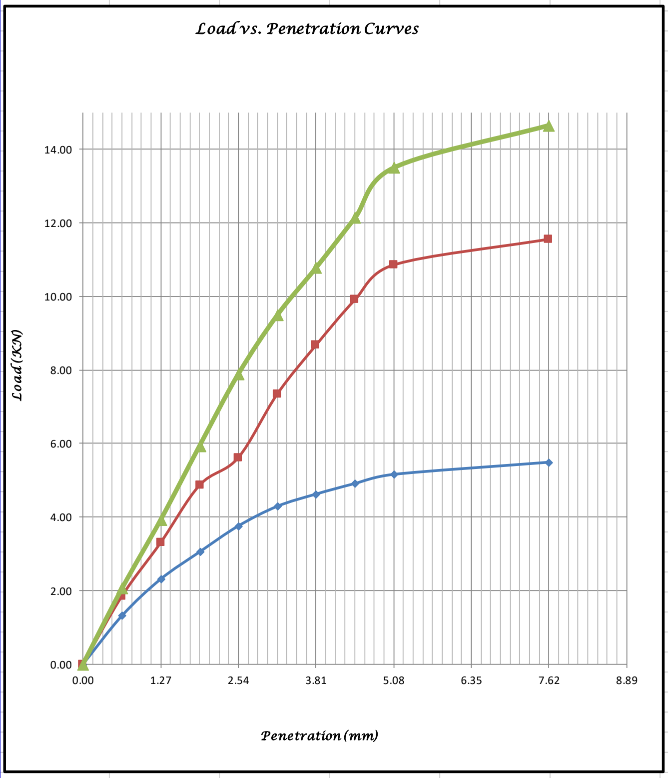
Modified Max. Dry Density, g/cc =	**2.06**	**Plunger Cross-section Area, mm2 =**	1935	Standard Load, KN	at 2.54mm	=	13.34
Opt. Moisture Content, % =	11.3				at 5.08mm	=	20

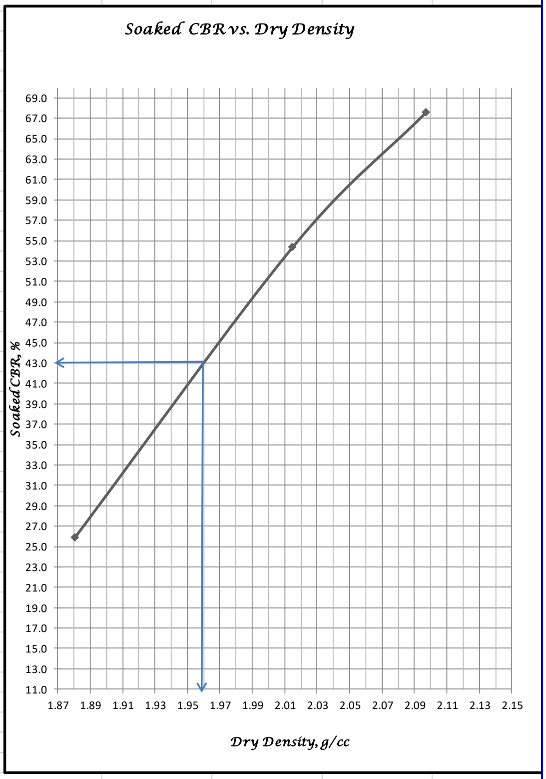
(D) Swell Determination

No. of Blows	10	30	65
Readiing Before Soaking, div	2.0	3.1	5.1
Reading After Soaking, div	2.1	3.1	5.1
Dial Gauge Factor, mm/div	0.01	0.01	0.01
Height of the specimen	116.4	116.4	116.4
Swell %	0.04	0.04	0.04
Average Swell, %	0.04		

Remark:

Type of Material	CDW3 + 30% Clay
Intended	For Subase
Location	

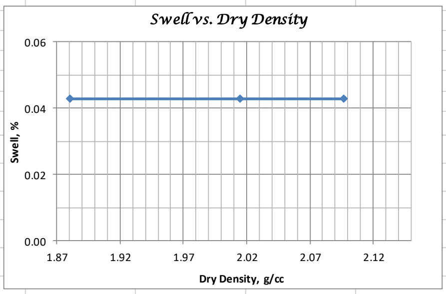




Blows	Pen. mm	Load, KN	Corr. Load, KN	CBR, %	Swell, %
10	2.54	3.76	3.76	18.8	0.04
	5.08	5.16	5.16	25.8	
30	2.54	5.62	5.62	42.1	0.04
	5.08	10.86	10.86	54.3	
65	2.54	7.89	7.89	59.1	0.04
	5.08	13.51	13.51	67.5	

No. of blows	Dry Density	Swell
10	1.88 g/cc	0.04 %
30	2.01 g/cc	0.04
65	2.10 g/cc	0.04 %

No. of Blows	MCBS, %	DDBS, g/cc	Corr. CBR, %	% of Compaction
10	9.9	1.88	25.8	91%
30	9.5	2.01	54.3	98%
65	9.9	2.10	67.5	102%
95% of MDD =				1.96
Maximum Dry Density =				**2.06**



Summary

MDD, gm/cc	**2.06**
OMC, %	**9.2**
95 % 0f MDD	**1.960**
CBR at 95% of MDD, %	**43**
Swell at 95% of MDD, %	**0.042**

Remark:

CALIFORNIA BEARING RATIO TEST

TEST MATHOD : AASHTO T-193

SOURCE STATION			
MATERIAL DESCRIPTION	CDW3 + 40% Clay		
PUROPSE	For Capping		
DEPTH			

DENSITY DETERMINATION

SOAKING CONDITION		10 Blows		30 Blows		65 Blows	
		BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
MOLD NUMBER		A3		A4		A1	
WEIGHT OF SOIL + MOLD (g)	W_1	13301	13565	13456	13792	13198	13343
WEIGHT OF MOLD (g)	W_2	8937	8937	8990	8990	8315	8315
VOLUME OF MOLD (Cm^3)	V	2124	2124	2124	2124	2124	2124
WEIGHT OF WET SOIL (g)	$W_3 = W_1 - W_2$	4364	4628	4466	4802	4883	5028
WET DENSITY OF SOIL (g/cm3)	$W_d = (W_3/V)$	2.05	2.18	2.10	2.26	2.30	2.37
DRY DENSITY OF SOIL (g/cm3)	$D_d = W_d/(100+m)*100$	1.79	1.87	1.84	1.95	2.01	2.06

MOISTURE DETERMINATION

SOAKING CONDITION		10 Blows			30 Blows			65 Blows		
		BEFORE	AFTER TOP 1 in.	AFTER AVG.	BEFORE	AFTER TOP 1 in.	AFTER AVG.	BEFORE	AFTER TOP 1 in.	AFTER AVG.
CONTAINER NUMBER		Y	N		W	R		T	L	
WET SOIL + CONTAINER (g)	a	433	406		416	390.0		418.0	388	
DRY SOIL + CONTAINER (g)	b	382.0	352.0		368.0	341.0		371.0	341.0	
WEIGHT OF CONTAINER (g)	c	36	31		37.0	34.0		38.0	32.0	
WEIGHT OF WATER (g)	d = a - b	51.0	54.0		48.0	49.0		47.0	47.0	
WEIGHT OF DRY SOIL (g)	e = b - c	346	321		331	307		333	309	
MOISTURE CONTENT (%)	m =(d /e)*100	14.74	16.82		14.50	15.96		14.11	15.21	
AVG. MOIST. CONTENT (%)										

PENETRATION TEST DATA

PENETRATION mm	10 Blows DIAL RDG	10 Blows LOAD (kn)	10 Blows COR. LOAD (kn)	10 Blows CBR %	30 Blows DIAL RDG	30 Blows LOAD (kn)	30 Blows COR. LOAD (kn)	30 Blows CBR %	65 Blows DIAL RDG	65 Blows LOAD (kn)	65 Blows COR LOAD (kn)	65 Blows CBR %
0	0	0			0	0			0	0		
0.64	38	0.9652			41	1.0414			44	1.1176		
1.27	74	1.8796			83	2.1082			92	2.3368		
1.96	111	2.8194			125	3.1750			137	3.4798		
2.54	146	3.7084		27.8	169	4.2926		32.2	185	4.6990		35.2
3.18	176	4.4704			201	5.1054			227	5.7658		
3.81	205	5.2070			236	5.9944			268	6.8072		
4.45	228	5.7912			268	6.8072			309	7.8486		
5.08	247	6.2738		31.4	290	7.3660		36.8	345	8.7630		43.8

SWELL

Height of Specimen(mm)		116.43	
No. OF BLOWS	10	30	65
RDG (BEFORE SOAKING)	1.30	1.04	0.60
RDG (AFTER) SOAKING)	1.36	1.10	0.65
PERCENT SWELL	0.05	0.05	0.04
AVERAGE PERCENT SWELL :		0.05	

RING FACTOR: 25.4 N/Divis.

MDD (gm/cc)	1.99
OMC %	13.9
95% of MDD	1.89

REMARK:

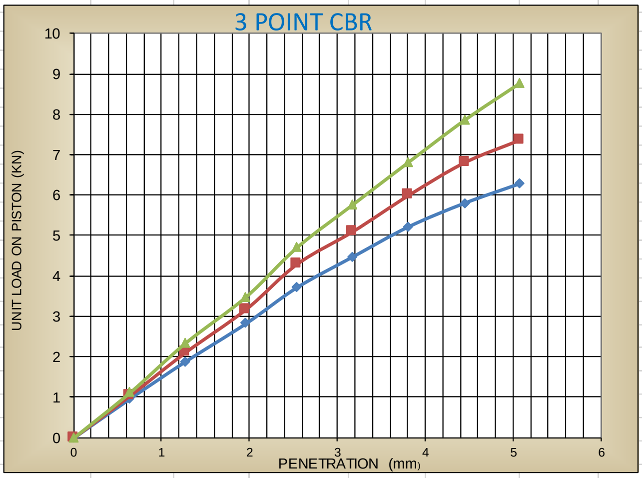
CALIFORNIA BEARING RATIO TEST
TEST MATHOD : AASHTO T-193

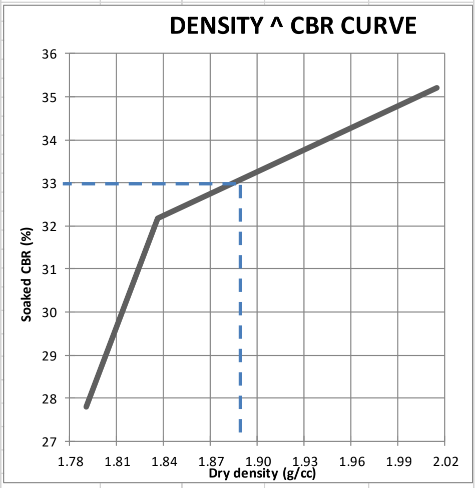
SOURCE STATION	
MATERIAL DESCRIPTION	CDW3 + 40% Clay
PUROPSE	Subase
DEPTH	

BLOWS	LOAD (KN)		CBR(%)		SWELL %
	2.54mm	5.08mm	2.54mm	5.08mm	
10	3.71	6.27	27.8	31.4	0.05
30	4.29	7.37	32.2	36.8	0.05
65	4.70	8.76	35.2	43.8	0.04

DRY DENSITY Vs SOCKED C.B.R.

No # OF BLOWS	10	30	65
DRY DENSITY	1.79	1.84	2.01
SOCKED C.B.R.	27.8	32.2	35.2





MODIFIED PROCTOR : T 180	
MDD (g/cc) :	1.99
OMC (%) :	13.9
95% of MDD(g/cc)	1.89
CBR@ 95% of MDD(%)	33.0

REMARKS:

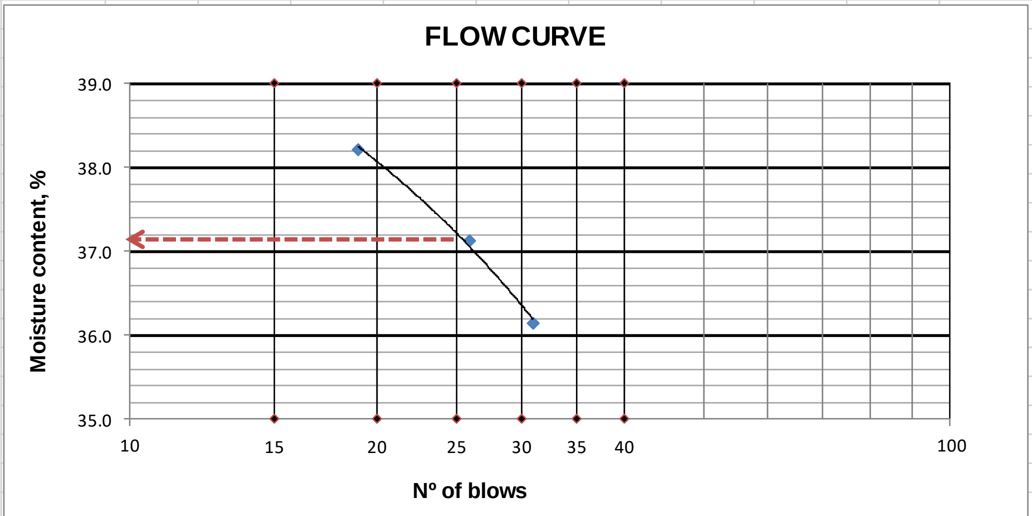
Appendix A53: Atterberg Limit test results

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Sample of:	CDW2 + 10% Clay
Description	
Purpose/intended for:	Subbase Construction
Sampled by:	
Tested by:	

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		31	26	19				
Container No.		144	26	11		6	20	
Mass of Container	g	45.65	45.38	45.44		45.6	45.41	
Mass of Wet Soil + Container	g	70.17	70.27	70.18		49.75	49.5	
Mass of Dry Soil + Container	g	63.66	63.53	63.34		48.80	48.53	
Mass of Water in Specimen	g	6.51	6.74	6.84	0.00	0.95	0.97	0.00
Mass of Dry Soil	g	18.01	18.15	17.90	0.00	3.20	3.12	0.00
Moisture Content	%	36.1	37.1	38.2	#DIV/0!	29.7	31.1	#DIV/0!
						Average PL, %		**30.4**



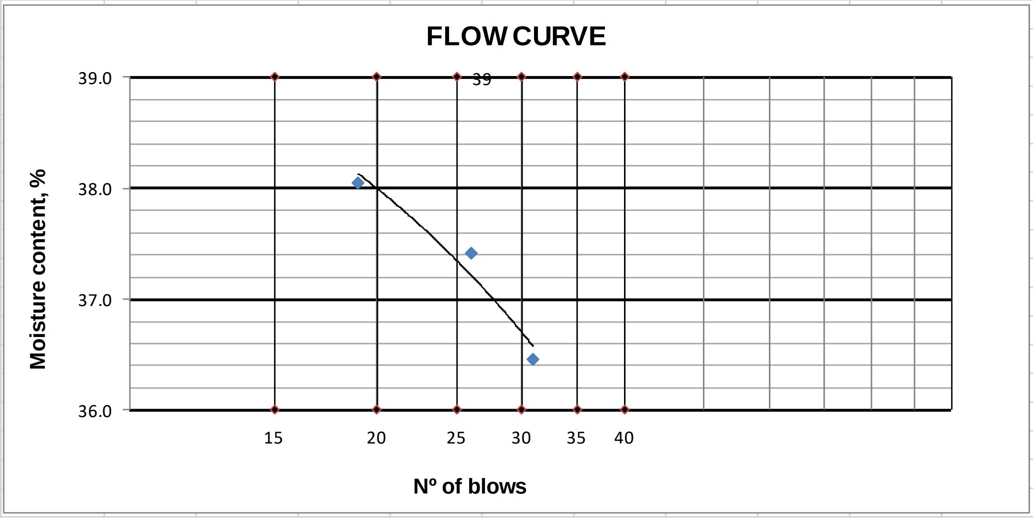
Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10				37.2	7		
№ 40							
№ 200							
Initial Mass							

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Material type CDW2 + 20% Clay
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		31	26	19				
Container No.		11	64	9		A	K	
Mass of Container	g	45.59	45.07	45.3		45.21	45.51	
Mass of Wet Soil + Container	g	70.78	70.74	70.59		49.07	49.16	
Mass of Dry Soil + Container	g	64.05	63.75	63.62		48.26	48.44	
Mass of Water in Specimen	g	6.73	6.99	6.97	0.00	0.81	0.72	0.00
Mass of Dry Soil	g	18.46	18.68	18.32	0.00	3.05	2.93	0.00
Moisture Content	%	36.5	37.4	38.0	#DIV/0!	26.6	24.6	#DIV/0!
						Average PL, %		**25.6**



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10				37.3	12		
№ 40							
№ 200							
Initial Mass	1877						

Determination of Liquid Limit and Plasticity Index of Sub Base: AASHTO T 89 & T 90

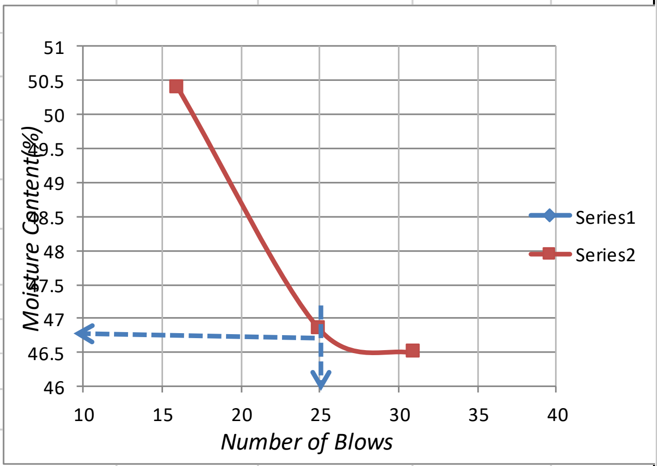
Type of Material	*CDW3 + 30% Clay*		
Intended Perpose	*Subase*		
Location			

Test Data			***Liquid Limit***			***Plastic Limit***	
Test No.			***1***	***2***	***3***	***1***	***2***
No. of Blows			31	25	16		
Container No.			X	26	Z	10	14
Mass of Wet Soil + Container	*(gm)*	*A*	67.89	67.29	65.18	56.95	56.46
Mass of Dry Soil + Container	*(gm)*	*B*	60.79	60.31	58.62	53.97	53.94
Mass of Container	*(gm)*	*C*	45.52	45.41	45.6	45.6	45.31
Mass of Water	*(gm)*	*D=A-B*	7.1	6.98	6.56	2.98	2.52
Mass of Dry Soil	*(gm)*	*E=B-C*	15.27	14.9	13.02	8.37	8.63
Moisture Content	*(%)*	*F=D/E*100*	46.5	46.8	50.4	35.6	29.2
Liquid Limit			**47.9**		**Plastic Limit**		**32.4**

Linear shrinkage: BS 1377-2

Initial length of specimen	**(L1)**	
Length of dried specimen	**(L2)**	
Linear shrinkage (%)	**(L1-L2)*100/L1**	

Note: If LL or PL cannot be determined use PI = 2.13 x LS



Summary

Liquid Limit (%)	*46.7*
Plastic Limit (%)	*32.4*
Plasticity Index (%)	*14.3*

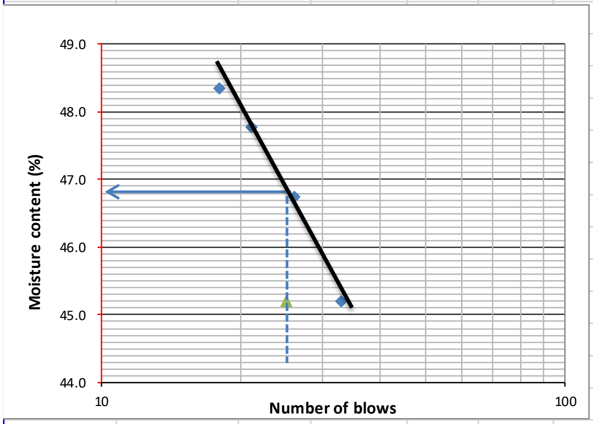
Remark:

DETERMINATION OF LIQUID LIMIT & PLASTIC LIMIT OF SOIL

TEST METHOD : AASHTO T89

SAMPLING STATION			
INTENDED Purpose			
MATERIAL DESCRIPTION	CDW2 + 40% Clay		
DEPTH			

Determination		***Liquid Limit***				***Plastic Limit***		
Number of blows		*33*	*26*	*21*	*18*			
Test	No						1	2
Container	No	B1	B5	C	O		X	Y
Wt. of container + wet soil,	(g)	43.76	43.23	48.55	40.95		20.17	20.49
Wt. of container + dry soil,	(g)	35.03	34.52	38.01	32.71		19.16	19.42
Wt. of container,	(g)	15.72	15.89	15.96	15.65		15.77	15.81
Wt. of water,	(g)	8.73	8.71	10.54	8.25		1.00	1.07
Wt. of dry soil,	(g)	19.31	18.63	22.05	17.06		3.40	3.61
Moisture container,	(%)	*45.21*	*46.75*	*47.79*	*48.36*		*29.53*	*29.70*
Average	(%)	47.0				29.6		



Linear shrinkage

Initial length of specimen (L_1)______

Length of dried specimen (L_2)_______

Linear shrinkage = $\left(\frac{(L_1 - L_2)x100}{L_1}\right)$

If LL or PL cannot bedetermined

use PI = 2.13 x LS =

Remark

Determination of (PI)	***(LL - PL)***		
-	LL	46.8	
-	PL	29.6	
PI	17		

Grading			
ASTM SIEVE NO			
Dim. mm			
% passing			
AASHTO Soil Classification			

Appendix A6: Laboratory test results of CDW1 mixed with Subase

Appendix A61: Proctor Compaction test result

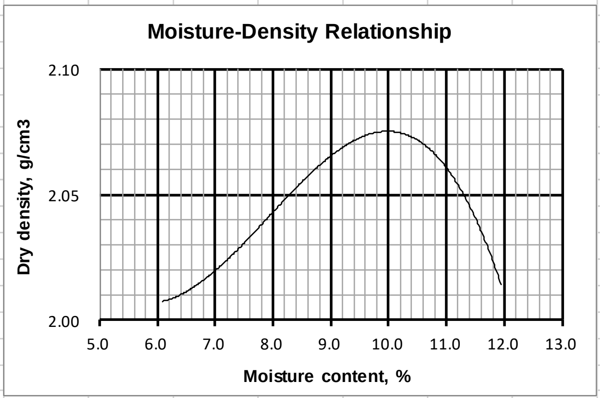
Title | Page No.

MOISTURE-DENSITY RELATIONS OF SOILS TEST | Page 1 of 1

Client:
Sample of: CDW1 + 10% Subase
Description
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			2%	4%	6%	8%	5	6	
Bulk Density	Mass of Mould + Soil	g	10042.0	10242.0	10348.0	10309.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4547.0	4747.0	4853.0	4814.0	0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	2.130	2.223	2.273	2.255	#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		M	X	A	6			F
	Mass of Container + Wet Soil	g	1291.0	1083.0	1036.0	903.0			1372
	Mass of Container + Dry Soil	g	1224.0	1009.0	956.0	820.0			1336
	Mass of Container	g	124.0	124.0	124.0	125.0			372
	Moisture Content	%	6.1	8.4	9.6	11.9	#DIV/0!	#DIV/0!	3.7
	Dry Density	g/cm^3	2.01	2.05	2.07	2.01	#DIV/0!	#DIV/0!	



Maximum Dry Density= 2.07 g/cm^3
Optimum Moisture Content= 10 %

Moisture-Density Relations of Road-Bed: AASHTO T 180

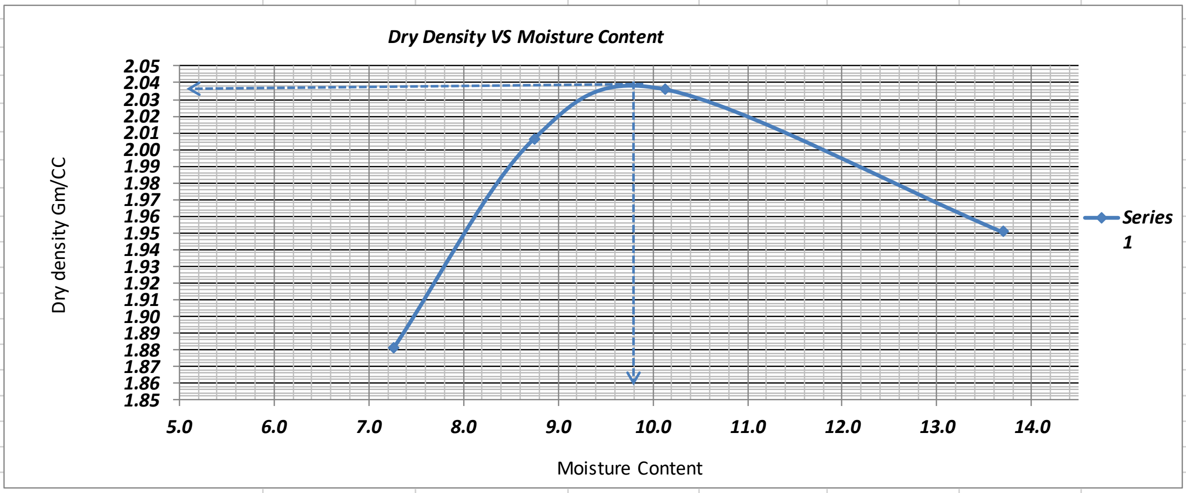
Type of Material	CDW + 20% Subase	
Intended Purpose	Subase	
Location		

(A) Density Determination

Trial No.		2%	4%	6%	8%		
Mass of Wet Sample + Mould, (gm)	A	9821	10171	10301	10248		
Mass of Mould, (gm)	B	5514	5514	5514	5514		
Mass of Wet Sample, (gm)	C=A-B	4307	4657	4787	4734		
Volume of Mould, (cm3)	V	2135	2135	2135	2135		
Bulk Density, (g/cm3)	W=C/V	2.02	2.18	2.24	2.22		

(B) Moisture Determination

Container No.		A	3	20	8		130
Mass of Container + Wet Soil	E	1512	1255	1221	1086		1374
Mass of Container + Dry Soil	F	1418	1164	1120	970		1320
Mass of Container	G	124	123	123	123		375
Mass of Dry Sample	H=F-G	1294	1041	997	847		945
Mass of Moisture	I=E-F	94	91	101	116		54
Moisture Content	J=(I/H)*100	7.3	8.7	10.1	13.7		5.7
Dry Density	D=W/(100+J)*100	1.88	2.01	2.04	1.95		0.00



Maximum Dry Density (gm/cm3) =	2.06
Optimum Moisture Content (%) =	11.2
Remark:	

Moisture-Density Relations of Road-Bed: AASHTO T 180

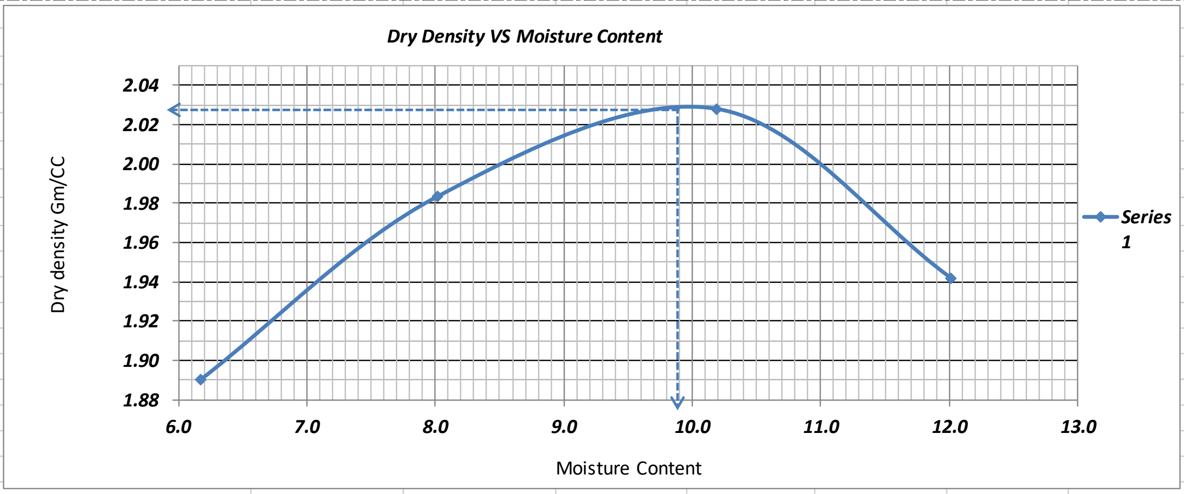
Type of Material	CDW1 + 30% Subase
Intended Purpose	Subase
Location	

(A) Density Determination

Trial No.		4%	6%	8%	10%		
Mass of Wet Sample + Mould, (gm)	A	9798	10088	10285	10158		
Mass of Mould, (gm)	B	5514	5514	5514	5514		
Mass of Wet Sample, (gm)	C=A-B	4284	4574	4771	4644		
Volume of Mould, (cm3)	V	2135	2135	2135	2135		
Bulk Density, (g/cm3)	W=C/V	2.01	2.14	2.23	2.18		

(B) Moisture Determination

Container No.		44	Y	7	5		110
Mass of Container + Wet Soil	E	1604	1512	1433	1392		1350
Mass of Container + Dry Soil	F	1518	1409	1312	1256		1322
Mass of Container	G	124	124	124	124		350
Mass of Dry Sample	H=F-G	1394	1285	1188	1132		972
Mass of Moisture	I=E-F	86	103	121	136		28
Moisture Content	J=(I/H)*100	6.2	8.0	10.2	12.0		2.9
Dry Density	D=W/(100+J)*100	1.89	1.98	2.03	1.94		0.00



Maximum Dry Density (gm/cm3) =	2.03
Optimum Moisture Content (%) =	9.9
Remark:	

Title

Page No.

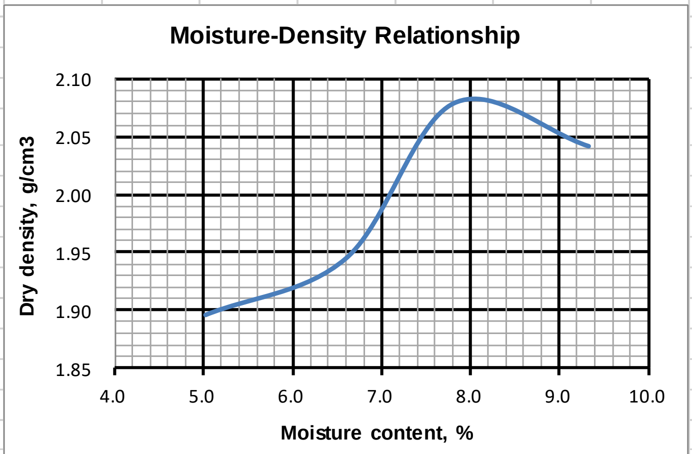
MOISTURE-DENSITY RELATIONS OF SOILS TEST

Page 1 of 1

Client:
Sample of: CDW1 +40% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			2%	4%	6%	8%	5	6	
Bulk Density	Mass of Mould + Soil	g	9745.0	9920.0	10280.0	10260.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4250.0	4425.0	4785.0	4765.0	0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	1.991	2.073	2.241	2.232	#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		180	b	138	8			20
	Mass of Container + Wet Soil	g	1170.0	1175.0	1160.0	1415.0			1375
	Mass of Container + Dry Soil	g	1120.0	1110.0	1085.0	1305.0			1355
	Mass of Container	g	125.0	125.0	125.0	125.0			375
	Moisture Content	%	5.0	6.6	7.8	9.3	#DIV/0!	#DIV/0!	2.0
	Dry Density	g/cm^3	1.90	1.94	2.08	2.04	#DIV/0!	#DIV/0!	



Maximum Dry Density= 2.08 g/cm^3

Optimum Moisture Content= 8 %

Appendix A62: Californian Bearing Ratio (CBR) test results

Title | Page No.

CALIFORNIA BEARING RATIO TEST

Page 1 of 2

Client:
Sample of: CDW1 + 10% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		D-10		D-30		D-65	
Mass of Mould	g	6430		6435		6520	
Mass of Mould Plus Soil	g	10975	10927	11185	11182	11380	11319
Mass of Soil	g	4545	4497	4750	4747	4860	4799
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.14	2.12	2.24	2.23	2.29	2.26
Dry Density	g/cm^3	1.94	1.83	2.03	1.94	2.08	1.94

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		5	66	2	44	10	5
Mass of Container	g	125	122	125	124	125	124
Mass of Container Plus Wet Soil	g	940	1496	975	1250	950	1345
Mass of Container Plus Dry Soil	g	865	1310	895	1100	875	1175
Moisture Content	%	10.1	15.7	10.4	15.4	10.0	16.2

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.6
Load @5.08	20.3

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	30.0	1.2			52.0	2.1			71.0	2.9		
1.27	40.0	1.7			97.0	4.0			113.0	4.7		
1.91	85.0	3.5			154.0	6.4			169.0	7.0		
2.54	109.0	4.51	4.51	33.1	166.0	6.86	6.86	50.5	199.0	8.23	8.23	60.5
3.81	135.0	5.6			225.0	9.3			240.0	9.9		
5.08	185.0	7.65	7.65	37.7	243.0	10.05	10.05	49.5	337.0	13.93	13.93	68.6
7.62	0.0	0.0				0.0				0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	4.93	2.3	3.3
Reading After Soaking, mm	4.96	2.36	3.46
Percent Swell	0.03	0.05	0.14

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

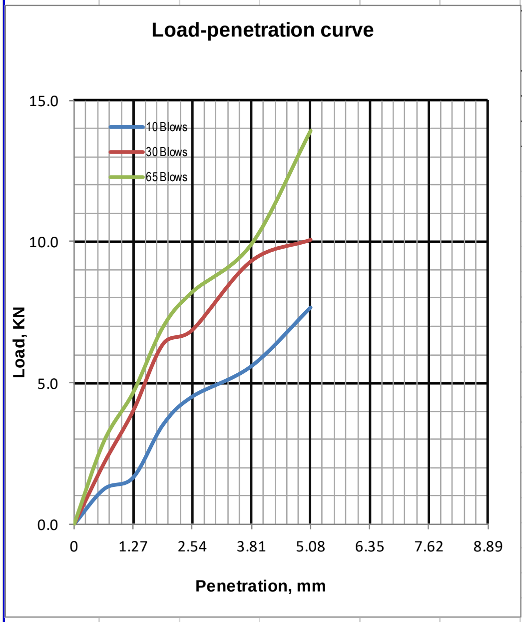
Title

CALIFORNIA BEARING RATIO TEST

Page No. Page 2 of 2

Client:
Sample of: CDW1 + 10% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

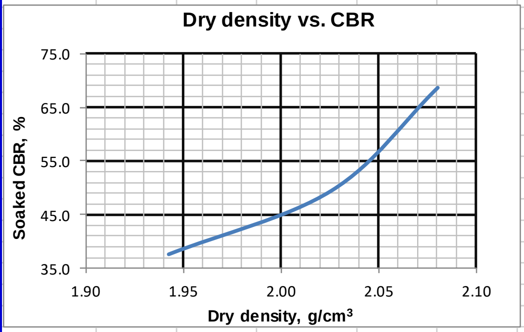
TEST METHOD: AASHTO T 193

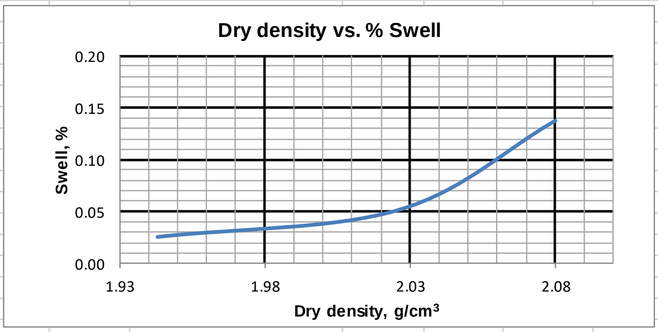


Blows	Dry Density, g/cc	Load (KN) at 2.54mm	Load (KN) at 5.08mm	CBR(%) at 2.54mm	CBR(%) at 5.08mm	Swell %
10	1.94	4.51	7.65	33.1	37.7	0.03
30	2.03	6.86	10.05	50.5	49.5	0.05
65	2.08	8.23	13.93	60.5	68.6	0.14

Max. Dry Density (MDD)= 2.07 g/cm^3
95 % of MDD= 1.97 g/cm^3

CBR at 95% of MDD= 41 %
Swell at 95% of MDD= 0.0 %





California Bearing Ratio (CBR) of Road-Bed: Standard Method of Test: AASHTO T 193

Type of Material	CDW1 + 20% Subase
Intended Purpose	Subase

(A) Compaction Determination

Compaction Data		10 Blows		30 Blows		65 Blows	
		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Mould No.		G-10		G-30		G-65	
Mass of Soil + Mould	gm	10840	11014	11136	11720	11338	11445
Massof Mould	gm	6452	6452	6452	6452	6444	6444
Mass of Soil	gm	4388	4562	4684	5268	4894	5001
Volume of Mould	cm3	2124	2124	2124	2124	2124	2124
Wet Density of Soil	gm/cm3	2.07	2.15	2.21	2.48	2.30	2.35
Dry Density of Soil	**gm/cm3**	**1.88**	**1.95**	**2.01**	**2.25**	**2.10**	**2.13**

(B) Moisture Determination

Moisture Content Data		10 Blows		30 Blows		65 Blows	
		Before Soaking	After Soaking	Before Soaking	After Soakin	Before Soaking	After Soaking
Container No.		2	16	3	20	6	P
Mass of Wet Soil + Container	gm	1304	1360	1280	1362	1326	1316
Mass of Dry Soil + Container	gm	1198	1245	1180	1246.0	1218	1204.0
Mass of Container	gm	124	124	122	124.0	124	124.0
Mass of Water	gm	106	115	100	116	108	112
Mass of Dry Soil	gm	1074.00	1121.00	1058.00	1122.00	1094.00	1080.00
Moisture Content Data	**%**	**9.9**	**10.3**	**9.5**	**10.3**	**9.9**	**10.4**

(C) CBR Penetration Data

Penetration After 96 hrs Soaking Period   **Surcharge Weight = 4.55 KG**   **Ring Calibration Factor (KN/Div.) = 0.04131**

Penetration, mm	10 Blows				30 Blows				65 Blows			
	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %
0.00	0.0	0.00			0.0	0.00			0	0.00		
0.64	32.0	1.32			45.0	1.86			50.0	2.07		
1.27	56.0	2.31			80.0	3.30			95.0	3.92		
1.91	74.0	3.06			118.0	4.87			144.0	5.95		
2.54	91.0	3.76	3.76	18.8	136.0	5.62	5.62	42.1	191.0	7.89	7.89	59.1
3.18	104.0	4.30			178.0	7.35			230.0	9.50		
3.81	112.0	4.63			210.0	8.68			261.0	10.78		
4.45	119.0	4.92			240.0	9.91			294.0	12.15		
5.08	125.0	5.16	5.16	25.8	263.0	10.86	10.86	54.3	327.0	13.51	13.51	67.5
7.62	133.0	5.49			280.0	11.57			355.0	14.67		

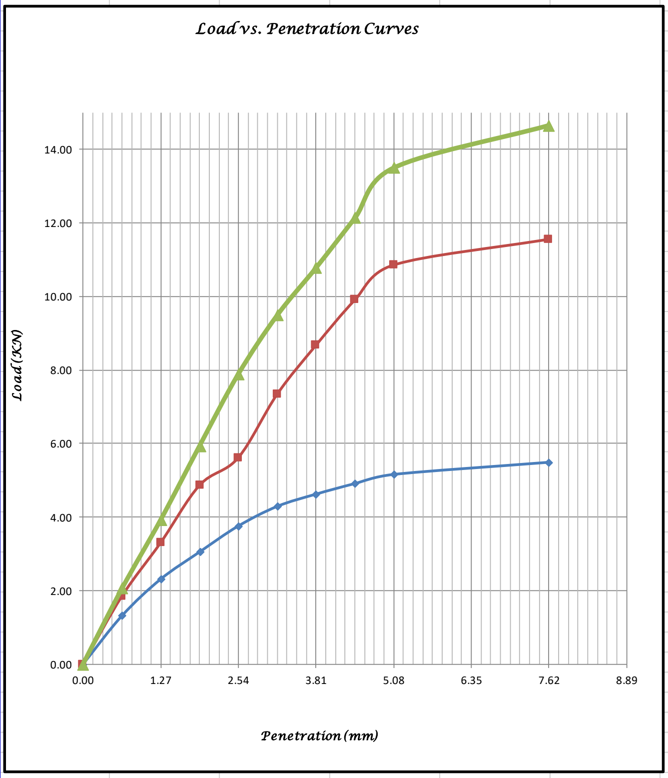
Modified Max. Dry Density, g/cc =	**2.06**	**Plunger Cross-section Area, mm2 =**	**1935**	**Standard Load, KN**	**at 2.54mm**	**=**	**13.34**
Opt. Moisture Content, % =	**11.3**				**at 5.08mm**	**=**	**20**

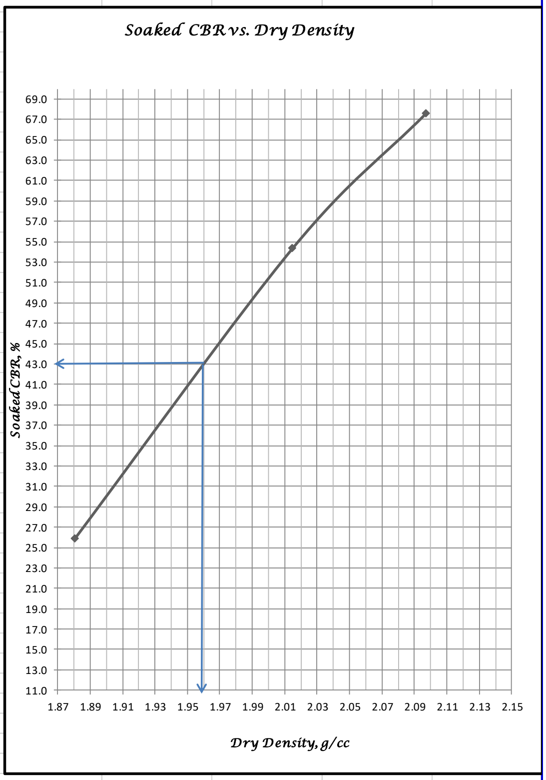
(D) Swell Determination

No. of Blows	10	30	65
Readiing Before Soaking, div	2.0	3.1	5.1
Reading After Soaking, div	2.1	3.1	5.1
Dial Gauge Factor, mm/div	0.01	0.01	0.01
Height of the specimen	116.4	116.4	116.4
Swell %	0.04	0.04	0.04
Average Swell, %	0.04		

Remark:

Type of Material	CDW1 + 10% Subase
Intended purpose	Subase

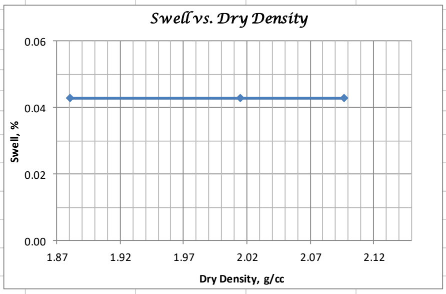




Blows	Pen. mm	Load, KN	Corr. Load, KN	CBR, %	Swell, %
10	2.54	3.76	3.76	18.8	0.04
	5.08	5.16	5.16	25.8	
30	2.54	5.62	5.62	42.1	0.04
	5.08	10.86	10.86	54.3	
65	2.54	7.89	7.89	59.1	0.04
	5.08	13.51	13.51	67.5	

No. of blows	Dry Density	Swell
10	1.88 g/cc	0.04 %
30	2.01 g/cc	0.04
65	2.10 g/cc	0.04 %

No. of Blows	MCBS, %	DDBS, g/cc	Corr. CBR, %	% of Compaction
10	9.9	1.88	25.8	91%
30	9.5	2.01	54.3	98%
65	9.9	2.10	67.5	102%
95% of MDD =				1.96
Maximum Dry Density =				**2.06**



Summary

MDD, gm/cc	**2.06**
OMC, %	**11.2**
95 % 0f MDD	**1.960**
CBR at 95% of MDD, %	**43**
Swell at 95% of MDD, %	**0.042**

Remark:

California Bearing Ratio (CBR) of Road-Bed: Standard Method of Test: AASHTO T 193

Type of Material	*CDW1 + 30% Subase*
Intended purpose	*Subase*

(A) Compaction Determination

Compaction Data		10 Blows		30 Blows		65 Blows	
		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Mould No.		E-10		E-30		E-65	
Mass of Soil + Mould	gm	10695	10985	10870	11200	11068	11450
Massof Mould	gm	6436	6436	6436	6436	6440	6440
Mass of Soil	gm	4259	4549	4434	4764	4628	5010
Volume of Mould	cm3	2124	2124	2124	2124	2124	2124
Wet Density of Soil	gm/cm3	2.01	2.14	2.09	2.24	2.18	2.36
Dry Density of Soil	**gm/cm3**	**1.84**	**1.84**	**1.92**	**1.93**	**2.01**	**2.02**

(B) Moisture Determination

Moisture Content Data		10 Blows		30 Blows		65 Blows	
		Before Soaking	After Soaking	Before Soaking	After Soakin	Before Soaking	After Soaking
Container No.		20	D	136	**16**	m	m-2
Mass of Wet Soil + Container	gm	1152	1310	1050	1286	1088	1184
Mass of Dry Soil + Container	gm	1066	1142	975	1125.0	1012	1032.0
Mass of Container	gm	124	124	124	124.0	124	124.0
Mass of Water	gm	86	168	75	161	76	152
Mass of Dry Soil	gm	942.00	1018.00	851.00	1001.00	888.00	908.00
Moisture Content Data	**%**	**9.1**	**16.5**	**8.8**	**16.1**	**8.6**	**16.7**

(C) CBR Penetration Data

Penetration After 96 hrs Soaking Period — **Surcharge Weight = 4.55 KG** — **Ring Calibration Factor (KN/Div.) = 0.04134**

Penetration, mm	10 Blows				30 Blows				65 Blows			
	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %	Dial Gauge Reading	Load, KN	Corr. Load, KN	CBR, %
0.00	0.0	0.00			0.0	0.00			0	0.00		
0.64	27.0	1.12			38.0	1.57			46.0	1.90		
1.27	47.0	1.94			62.0	2.56			76.0	3.14		
1.91	58.0	2.40			82.0	3.39			108.0	4.46		
2.54	70.0	2.89	2.89	14.5	115.0	4.75	4.75	35.6	150.0	6.20	6.20	46.5
3.18	84.0	3.47			145.0	5.99			190.0	7.85		
3.81	100.0	4.13			170.0	7.03			222.0	9.18		
4.45	109.0	4.51			200.0	8.27			295.0	12.20		
5.08	122.0	5.04	5.04	25.2	225.0	9.30	9.30	46.5	341.0	14.10	14.10	70.5
7.62	130.0	5.37			240.0	9.92			353.0	14.59		

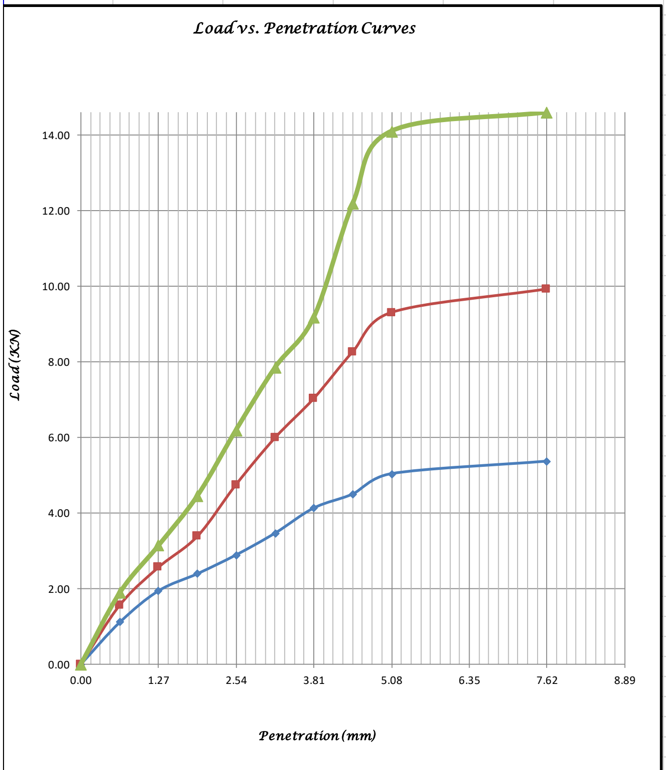
Modified Max. Dry Density, g/cc =	**2.03**	**Plunger Cross-section Area, mm2 =**	**1935**	**Standard Load, KN**	**at 2.54mm**	**=**	**13.34**
Opt. Moisture Content, % =	**9.9**				**at 5.08mm**	**=**	**20**

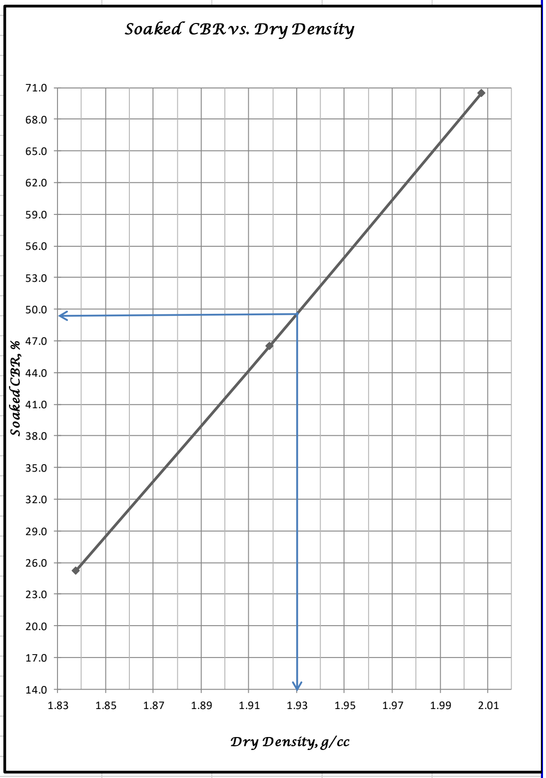
(D) Swell Determination

No. of Blows	10	30	65
Readiing Before Soaking, div	10.0	16.0	16.0
Reading After Soaking, div	10.2	16.1	16.9
Dial Gauge Factor, mm/div	0.01	0.01	0.01
Height of the specimen	116.4	116.4	116.4
Swell %	0.10	0.06	0.77
Average Swell, %	0.31		

Remark:

Type of Material	*CDW1 + 30% Subase*
Intended purpose	*Subase*

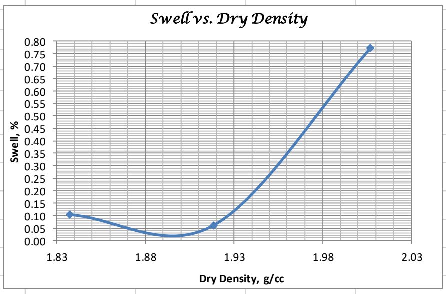




Blows	Pen. mm	Load, KN	Corr. Load, KN	CBR, %	Swell, %
10	2.54	2.89	2.89	14.5	0.10
	5.08	5.04	5.04	25.2	
30	2.54	4.75	4.75	35.6	0.06
	5.08	9.30	9.30	46.5	
65	2.54	6.20	6.20	46.5	0.77
	5.08	14.10	14.10	70.5	

No. of Blows	MCBS, %	DDBS, g/cc	Corr. CBR, %	% of Compaction
10	9.1	1.84	25.2	89%
30	8.8	1.92	46.5	93%
65	8.6	2.01	70.5	97%
95% of MDD =				1.96
Maximum Dry Density =				**2.06**

No. of blows	Dry Density	Swell
10	1.84 g/cc	0.10 %
30	1.92 g/cc	0.06
65	2.01 g/cc	0.77 %



Summary

MDD, gm/cc	**2.03**
OMC, %	**9.9**
95 % 0f MDD	**1.93**
CBR at 95% of MDD, %	**49.5**
Swell at 95% of MDD, %	**0.1**

Remark:

Title	Page No.
CALIFORNIA BEARING RATIO TEST	Page 1 of 2

Client:
Sample of: CDW1 + 40% Subase
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		A-10		A-30		A-65	
Mass of Mould	g	6459		6480		6415	
Mass of Mould Plus Soil	g	10743	10841	11076	11160	11205	11195
Mass of Soil	g	4284	4382	4596	4680	4790	4780
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.02	2.06	2.16	2.20	2.26	2.25
Dry Density	g/cm^3	1.87	1.87	2.00	1.98	2.08	1.99

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		4	66	1	44	10	5
Mass of Container	g	124	122	124	124	124	124
Mass of Container Plus Wet Soil	g	982	1496	1057	1250	867	1345
Mass of Container Plus Dry Soil	g	918	1365	988	1135	810	1205
Moisture Content	%	8.1	10.5	8.0	11.4	8.3	13.0

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04134 KN/div
Load @2.54	13.6
Load @5.08	20.3

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	40.0	1.7			55.0	2.3			96.0	4.0		
1.27	70.0	2.9			105.0	4.3			170.0	7.0		
1.91	100.0	4.1			165.0	6.8			260.0	10.7		
2.54	180.0	7.44	7.44	54.7	290.0	11.99	11.99	88.2	370.0	15.30	15.30	112.5
3.81	290.0	12.0			340.0	14.1			500.0	20.7		
5.08	350.0	14.47	14.47	71.3	470.0	19.43	19.43	95.7	600.0	24.80	24.80	122.2
7.62		0.0				0.0				0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	4.93	2.3	3.38
Reading After Soaking, mm	4.96	2.36	3.45
Percent Swell	0.03	0.05	0.06

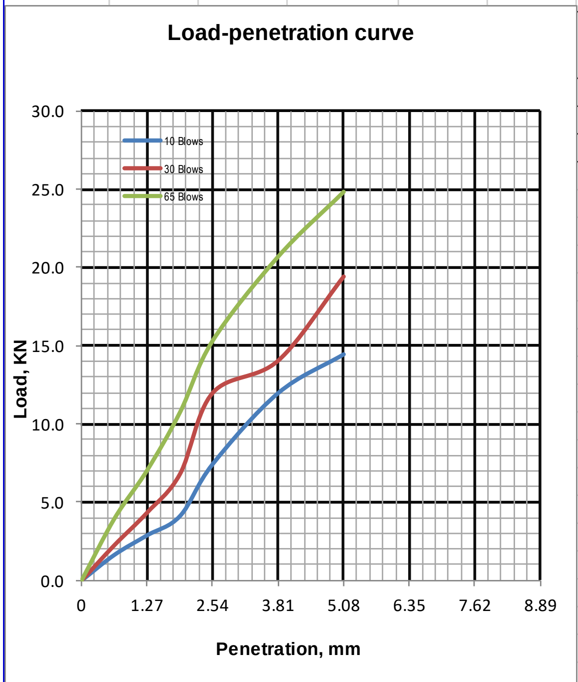
SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

Page No.
Page 2 of 2

CALIFORNIA BEARING RATIO TEST

Client:
Sample of: CDW1 + 40% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

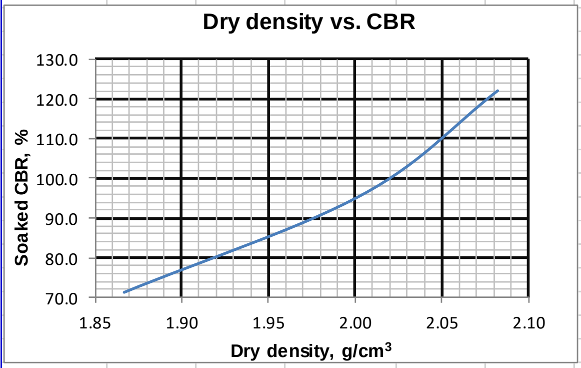
TEST METHOD: AASHTO T 193

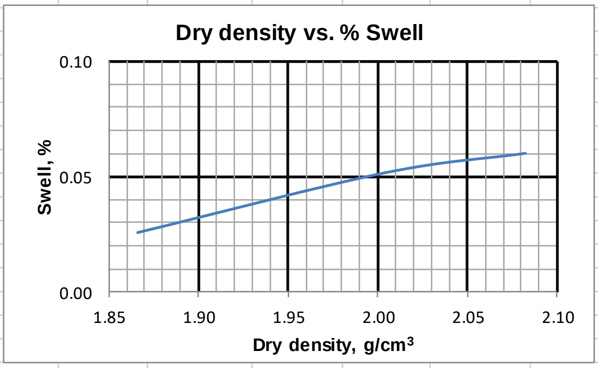


Blows	Dry Density, g/cc	Load (KN) at 2.54mm	Load (KN) at 5.08mm	CBR(%) at 2.54mm	CBR(%) at 5.08mm	Swell %
10	1.87	7.44	14.47	54.7	71.3	0.03
30	2.00	11.99	19.43	88.2	95.7	0.05
65	2.08	15.30	24.80	112.5	122.2	0.06

Max. Dry Density (MDD)= 2.08 g/cm³
95% of MDD= 1.98 g/cm³

CBR at 95% of MDD= 90 %
Swell at 95% of MDD= 0.1 %





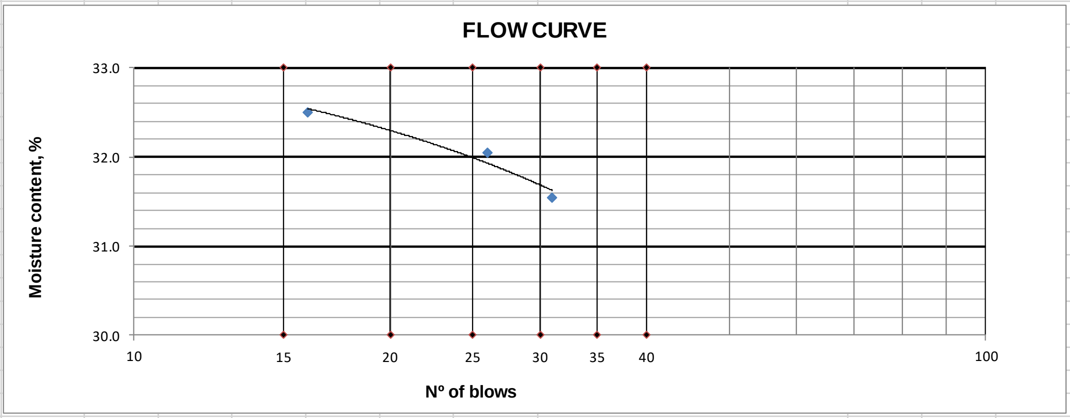
Appendix A63: Atterberg Limit test results

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Client:
Sample of: CDW1 + 10% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		31	26	16				
Container No.		K	10	G		A	11	
Mass of Container	g	45.52	45.59	45.31		45.2	45.6	
Mass of Wet Soil + Container	g	70.83	70.19	70.34		49.13	49.44	
Mass of Dry Soil + Container	g	64.76	64.22	64.20		48.40	48.77	
Mass of Water in Specimen	g	6.07	5.97	6.14	0.00	0.73	0.67	0.00
Mass of Dry Soil	g	19.24	18.63	18.89	0.00	3.20	3.17	0.00
Moisture Content	%	31.5	32.0	32.5	#DIV/0!	22.8	21.1	#DIV/0!
						Average PL, %		**22.0**



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10				32	10	A-2-4	
№ 40							
№ 200							
Initial Mass							

)etermA+A6:H356:H35ination of Liquid Limit and Plasticity Index of Sub Base: AASHTO T 89 & T 9

Type of Material	CDW1+ 20% Subase
Purpose	Subase
Location	

Test Data			Liquid Limit			Plastic Limit	
Test No.			*1*	*2*	*3*	*1*	*2*
No. of Blows			33	28	17		
Container No.			66	6	3	7	43
Mass of Wet Soil + Container	*(gm)*	*A*	74.98	72.11	74.84	53.83	53.59
Mass of Dry Soil + Container	*(gm)*	*B*	67.18	65.05	66.79	52.18	51.80
Mass of Container	*(gm)*	*C*	45.24	45.62	45.23	45.22	45.31
Mass of Water	*(gm)*	*D=A-B*	7.8	7.06	8.05	1.65	1.79
Mass of Dry Soil	*(gm)*	*E=B-C*	21.94	19.43	21.56	6.96	6.49
Moisture Content	*(%)*	*F=D/E*100*	35.6	36.3	37.3	23.7	27.6
Liquid Limit			**36.4**		**Plastic Limit**		**25.6**

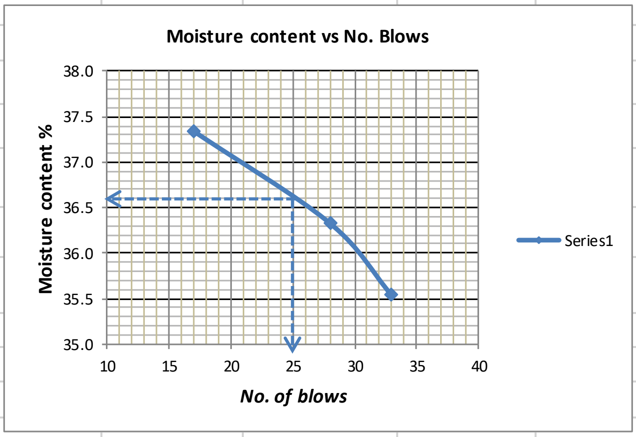
Linear shrinkage: BS 1377-2

Initial length of specimen	**(L1)**	
Length of dried specimen	**(L2)**	
Linear shrinkage (%)	**(L1-L2)*100/L1**	

Note: If LL or PL cannot be determined use PI = 2.13 x LS

Summary

Liquid Limit (%)	*36.4*
Plastic Limit (%)	*25.6*
Plasticity Index (%)	*10.8*



Remark:

Determination of Liquid Limit and Plasticity Index of Sub Base: AASHTO T 89 & T 90

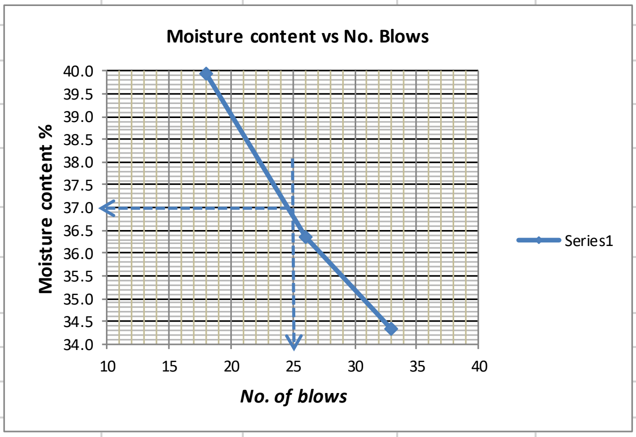
Type of Material	CDW1 +30% Subase
Intended Purpose	Subase Construction
Location	

Test Data			Liquid Limit			Plastic Limit	
Test No.			*1*	*2*	*3*	*1*	*2*
No. of Blows			33	26	18		
Container No.			66	7	6	14	M
Mass of Wet Soil + Container	*(gm)*	*A*	65.35	64.58	66.27	54.74	54.54
Mass of Dry Soil + Container	*(gm)*	*B*	60.21	59.42	60.38	52.92	52.59
Mass of Container	*(gm)*	*C*	45.24	45.22	45.63	45.35	45.26
Mass of Water	*(gm)*	*D=A-B*	5.14	5.16	5.89	1.82	1.95
Mass of Dry Soil	*(gm)*	*E=B-C*	14.97	14.2	14.75	7.57	7.33
Moisture Content	*(%)*	*F=D/E*100*	34.3	36.3	39.9	24.0	26.6
Liquid Limit			**36.9**		**Plastic Limit**		**25.3**

Linear shrinkage: BS 1377-2

Initial length of specimen	**(L1)**	
Length of dried specimen	**(L2)**	
Linear shrinkage (%)	**(L1-L2)*100/L1**	

Note: If LL or PL cannot be determined use PI = 2.13 x LS



Summary

Liquid Limit (%)	*36.9*
Plastic Limit (%)	*25.3*
Plasticity Index (%)	*11.5*

Remark:

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Client:

Sample of: CDW1 + 40% Subase

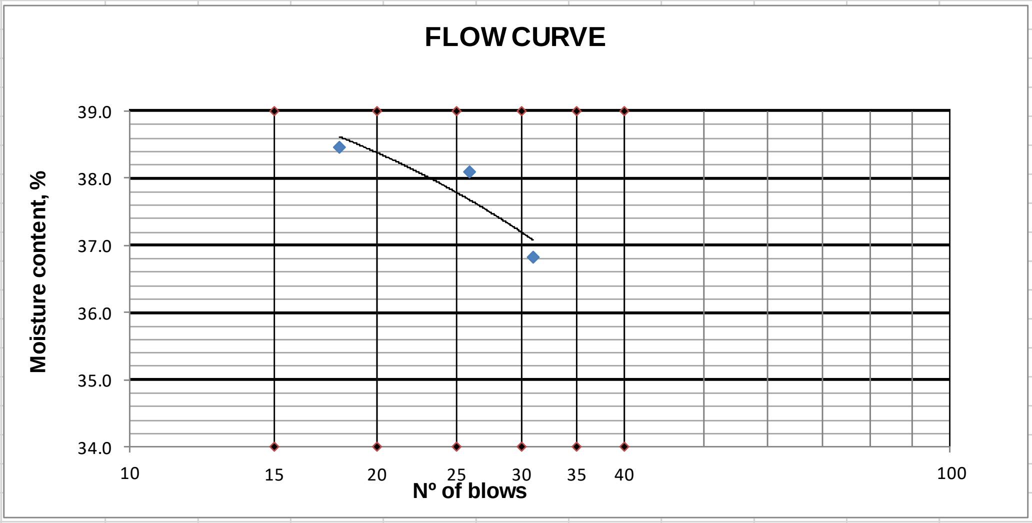
Purpose/intended for: Subbase Construction

Sampled by:

Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		31	26	18				
Container No.		5	6	10		F	144	
Mass of Container	g	45.29	45.62	45.44		45.28	45.65	
Mass of Wet Soil + Container	g	65.84	66.28	65.89		49.23	49.54	
Mass of Dry Soil + Container	g	60.31	60.58	60.21		48.38	48.80	
Mass of Water in Specimen	g	5.53	5.70	5.68	0.00	0.85	0.74	0.00
Mass of Dry Soil	g	15.02	14.96	14.77	0.00	3.10	3.15	0.00
Moisture Content	%	36.8	38.1	38.5	#DIV/0!	27.4	23.5	#DIV/0!
						Average PL, %		**25.5**



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10				37.7	12		
№ 40							
№ 200							
Initial Mass							

Appendix A63: Lo-Angeles Abrasion test results

Title	Page No.
RESISTANCE TO DEGRADATION IN LOS ANGELES MACHINE	Page 1 of 1

Client:
Sample of: CDW1 + 10% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 96

Table: Standard Grading of Test Samples

Sieve Size		**Mass of Indicated Sizes, g**			
		Grading			
Passing	**Retained on**	**A**	**B**	**C**	**D**
37.5mm(1 1/2in.)	25.0mm(1in.)	1250±25			
25.0mm(1in.)	19.0mm(3/4in.)	1250±25			
19.0mm(3/4in.)	12.5mm(1/2in.)	1250±10	2500±10		
12.5mm(1/2in.)	9.5mm (3/8in.)	1250±10	2500±10		
9.5mm (3/8in.)	6.3mm (1/4in.)			2500±10	
6.3mm (1/4in.)	4.75mm (No.4)			2500±10	
4.75mm (No.4)	2.36mm(No.8)				5000±10
Total		5000±10	5000±10	5000±10	5000±10
Number of Charges		12	11	8	6

Grading Used		**A**	B		
Mass of Sample Before Test	g	5000	5000		
Mass of Sample Retained on 1.7mm (No.12) Sieve	g	2442	2434		
Mass of Sample Passed on 1.7mm (No.12) Sieve	g	2558	2566		
LAA Value	%	51.2	51.3		
Avg.		51.24			

LOS ANGELES ABRASION TEST (LAA) FOR Sub Base
Test Method ASTM Designation: C 131 - 03

Intended Purpose	Sub Base
Material Type	CDW1 +20% Subase

Specification Limits : Maximum = 51% For Natural Sub Base

Sieve Size (SquareOpenings)		Mass of Indicated Size, (g) Grading				Wt. of sample to be tested	
Passing	Retained on	A	B	C	D	Trial 1	Trial 2
37.5 mm	25.0 mm	1250 ± 25	---	---	---	1250	1250
25.0 mm	19.0 mm	1250 ± 25	---	---	---	1250	1250
19.0 mm	12.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
12.5 mm	9.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
9.5 mm	6.3 mm	---	---	2500 ± 10	---		
6.3 mm	4.75 mm	---	---	2500 ± 10	---		
4.75 mm	2.36 mm	---	---	---	5000 ± 10		
Total		5000 ± 10	5000 ± 10	5000 ± 10	5000 ± 10	5000	5000
Number of Spheres (Balls) used		12	11	8	6		

Test Result Analysis

Grading Type Used A ☒ B ☐ C ☐ D ☐

Trial	Trial$_1$	Trial$_2$
Number of Revolution	500	500
Total Wt. of Sample Tested (W)	5000	5000
Wt. of Tested Sample Retained On 1.70 mm Sieve (X)	2612	2588
Loss in grams Y = (W - X)	2388	2412
Percent Loss Z = (Y / W)*100	47.76	48.24
Average Percent Loss (Trial$_1$ + Trial$_2$)/2	**48.00**	

Remark

LOS ANGELES ABRASION TEST (LAA) FOR Sub Base

Test Method ASTM Designation: C 131 - 03

Intended Purpose	Sub Base
Material Type	CDW1 +30% Subase

Specification Limits : Maximum = 51% For Natural Sub Base

Sieve Size (SquareOpenings)		Mass of Indicated Size, (g) Grading				Wt. of sample to be tested	
Passing	Retained on	A	B	C	D	Trial 1	Trial 2
37.5 mm	25.0 mm	1250 ± 25	---	---	---	1250	1250
25.0 mm	19.0 mm	1250 ± 25	---	---	---	1250	1250
19.0 mm	12.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
12.5 mm	9.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
9.5 mm	6.3 mm	---	---	2500 ± 10	---		
6.3 mm	4.75 mm	---	---	2500 ± 10	---		
4.75 mm	2.36 mm	---	---	---	5000 ± 10		
Total		5000 ± 10	5000 ± 10	5000 ± 10	5000 ± 10	5000	5000
Number of Spheres (Balls) used		12	11	8	6		

Test Result Analysis

Grading Type Used: A ☒ B ☐ C ☐ D ☐

Trial	Trial$_1$	Trial$_2$
Number of Revolution	500	500
Total Wt. of Sample Tested (W)	5000	5000
Wt. of Tested Sample Retained On 1.70 mm Sieve (X)	2787	2798
Loss in grams Y = (W - X)	2213	2202
Percent Loss Z = (Y / W)*100	44.26	44.04
Average Percent Loss (Trial$_1$ + Trial$_2$)/2	**44.15**	

Remark

Title

RESISTANCE TO DEGRADATION IN LOS ANGELES MACHINE

Page No. Page 1 of 1

Client:
Sample of: CDW1 + 40% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 96

Table: Standard Grading of Test Samples

Sieve Size		Mass of Indicated Sizes, g			
		Grading			
Passing	**Retained on**	**A**	**B**	**C**	**D**
37.5mm(1 1/2in.)	25.0mm(1in.)	1250±25			
25.0mm(1in.)	19.0mm(3/4in.)	1250±25			
19.0mm(3/4in.)	12.5mm(1/2in.)	1250±10	2500±10		
12.5mm(1/2in.)	9.5mm (3/8in.)	1250±10	2500±10		
9.5mm (3/8in.)	6.3mm (1/4in.)			2500±10	
6.3mm (1/4in.)	4.75mm (No.4)			2500±10	
4.75mm (No.4)	2.36mm(No.8)				5000±10
Total		5000±10	5000±10	5000±10	5000±10
Number of Charges		12	11	8	6

Grading Used		**A**	B
Mass of Sample Before Test	g	5000	5000
Mass of Sample Retained on 1.7mm (No.12) Sieve	g	3036	3068
Mass of Sample Passed on 1.7mm (No.12) Sieve	g	1964	1932
LAA Value	%	39.3	38.6
Avg.		38.96	

Appendix A7: Laboratory test results of CDW2 mixed with Subase

Appendix A71: Proctor Compaction test result

Title

MOISTURE-DENSITY RELATIONS OF SOILS TEST

Page No. Page 1 of 1

Client:

Matarial sourse CDW2 + 10% Subase

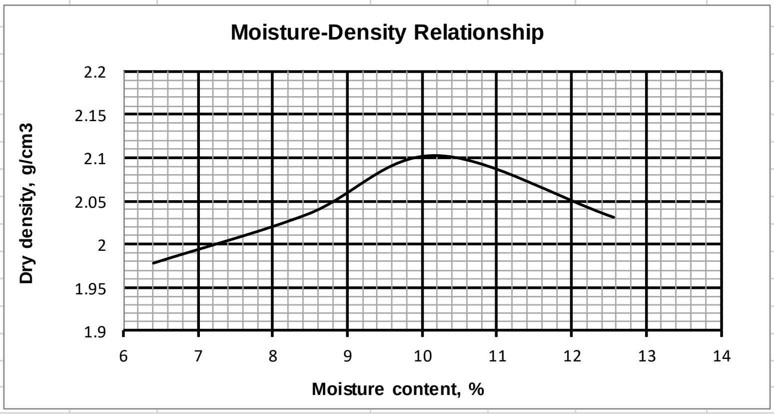
Purpose/intended for: Subbase construction

Sampled by:

Tested by:

TEST METHOD:AASHTO T 180

			2%	4%	6%	8%			
Bulk Density	Mass of Mould + Soil	g	9988.0	10206.0	10440.0	10376.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4493.0	4711.0	4945.0	4881.0			
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	2.104	2.207	2.316	2.286			NMC
Moisture Content	Container No.		Y	66	6	1			20
	Mass of Container + Wet Soil	g	1322.0	1252.0	1228.0	1306.0			1372
	Mass of Container + Dry Soil	g	1250.0	1164.0	1126.0	1174.0			1328
	Mass of Container	g	124.0	124.0	124.0	124.0			372
	Moisture Content	%	6.4	8.5	10.2	12.6			4.6
	Dry Density	g/cm^3	1.98	2.03	2.10	2.03			



Maximum Dry Density= ***2.1g/cm***

Optimum Moisture Content= ***10.2***

Title

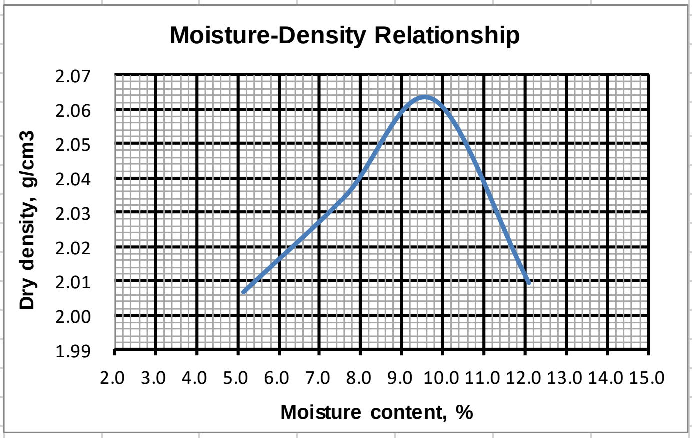
MOISTURE-DENSITY RELATIONS OF SOILS TEST

Page No. Page 1 of 1

Client:
Matarial sourse CDW2 + 20% Subase
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			2%	4%	6%	8%	5	6	
Bulk Density	Mass of Mould + Soil	g	10000.0	10169.0	10329.0	10304.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4505.0	4674.0	4834.0	4809.0	0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	2.110	2.189	2.264	2.252	#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		1	6	20	14			40
	Mass of Container + Wet Soil	g	736.0	1142.0	934.0	754.0			1372
	Mass of Container + Dry Soil	g	706.0	1070.0	862.0	686.0			1338
	Mass of Container	g	124.0	124.0	123.0	124.0			372
	Moisture Content	%	5.2	7.6	9.7	12.1	#DIV/0!	#DIV/0!	3.5
	Dry Density	g/cm^3	2.01	2.03	2.06	2.01	#DIV/0!	#DIV/0!	



Maximum Dry Density= 2.06 g/cm^3
Optimum Moisture Content= 9.6 %

Title

Page No.

MOISTURE-DENSITY RELATIONS OF SOILS TEST

Page 1 of 1

Client:

Matarial sourse CDW2 + 30% Subase

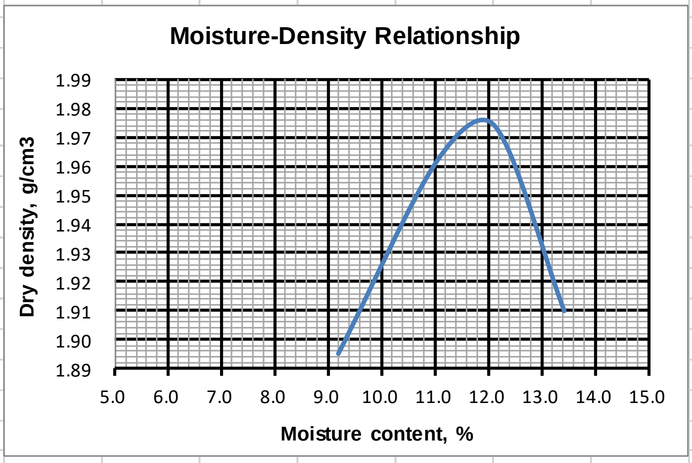
Purpose/intended for: Subbase construction

Sampled by:

Tested by:

TEST METHOD:AASHTO T 180

		Unit	4%	6%	8%	10%	5	6	
Bulk Density	Mass of Mould + Soil	g	9913.0	10146.0	10220.0	10120.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4418.0	4651.0	4725.0	4625.0	0.0	0.0	
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	2.069	2.178	2.213	2.166	#DIV/0!	#DIV/0!	NMC
Moisture Content	Container No.		88	138	12	b-3			30
	Mass of Container + Wet Soil	g	1146.0	1150.0	1123.0	1265.0			1363
	Mass of Container + Dry Soil	g	1060.0	1048.0	1015.0	1130.0			1321
	Mass of Container	g	124.0	124.0	124.0	124.0			363
	Moisture Content	%	9.2	11.0	12.1	13.4	#DIV/0!	#DIV/0!	4.4
	Dry Density	g/cm^3	1.90	1.96	1.97	1.91	#DIV/0!	#DIV/0!	



Maximum Dry Density= 1.97 g/cm^3

Optimum Moisture Content= 12 %

Title | Page No.

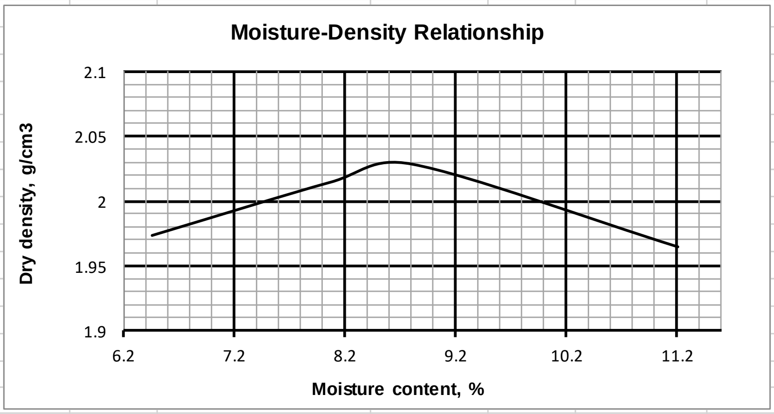
MOISTURE-DENSITY RELATIONS OF SOILS TEST

Page 1 of 1

Client:
Matarial sourse CDW2 + 40% Subase
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD:AASHTO T 180

			4%	6%	8%	10%			
Bulk Density	Mass of Mould + Soil	g	9980.0	10144.0	10208.0	10159.0			
	Mass of Mould	g	5495.0	5495.0	5495.0	5495.0			
	Mass of Wet Soil	g	4485.0	4649.0	4713.0	4664.0			
	Volume of Mould	cm^3	2135.0	2135.0	2135.0	2135.0			
	Bulk Density	g/cm^3	2.101	2.178	2.207	2.185			NMC
Moisture Content	Container No.		2	3	14	1			11
	Mass of Container + Wet Soil	g	1113.0	887.0	1062.0	1156.0			1311
	Mass of Container + Dry Soil	g	1053.0	830.0	986.0	1052.0			1289
	Mass of Container	g	124.0	124.0	123.0	124.0			311
	Moisture Content	%	6.5	8.1	8.8	11.2			2.2
	Dry Density	g/cm^3	1.97	2.01	2.03	1.96			



Maximum Dry Density= ***2.03 g/cm3***
Optimum Moisture Content= ***8.8***

Appendix A72: Californian Bearing Ratio (CBR) test results

Title	Page No.
CALIFORNIA BEARING RATIO TEST	Page 1 of 2

Client:	
Material	CDW2 + 10% Subase
Purpose/intended for:	Subbase construction
Sampled by:	
Tested by:	

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		K-10		K-30		K-65	
Mass of Mould	g	6460	6450	6509		6452	
Mass of Mould Plus Soil	g	10988	11105	11250	11358	11420	11456
Mass of Soil	g	4528	4645	4741	4849	4968	5004
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.13	2.19	2.23	2.28	2.34	2.36
Dry Density	g/cm^3	1.95	2.00	1.99	2.09	2.12	2.14

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		5	66	88	44	5	K
Mass of Container	g	124	122	124	124	124	124
Mass of Container Plus Wet Soil	g	928	1120	1138	1050	615	1210
Mass of Container Plus Dry Soil	g	858	1035	1030	973	570	1112
Moisture Content	%	9.5	9.3	11.9	9.1	10.1	9.9

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04170 KN/div
Load @2.54	13.6
Load @5.08	20.3

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	20.0	0.8			35.0	1.5			40.0	1.7		
1.27	35.0	1.5			70.0	2.9			90.0	3.8		
1.91	50.0	2.1			100.0	4.2			120.0	5.0		
2.54	65.0	2.71	2.71	19.9	127.0	5.30	5.30	38.9	140.0	5.84	5.84	42.9
3.81	90.0	3.8			160.0	6.7			172.0	7.2		
5.08	113.0	4.71	4.71	23.2	205.0	8.55	8.55	42.1	230.0	9.59	9.59	47.2
7.62	120.0	5.0			220.0	9.2	9.2	45	250.0	10.4		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	5.12	5.32	3.76
Reading After Soaking, mm	5.15	5.42	3.8
Percent Swell	0.03	0.09	0.03

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

Title

CALIFORNIA BEARING RATIO TEST

Page No.

Page 2 of 2

Client:

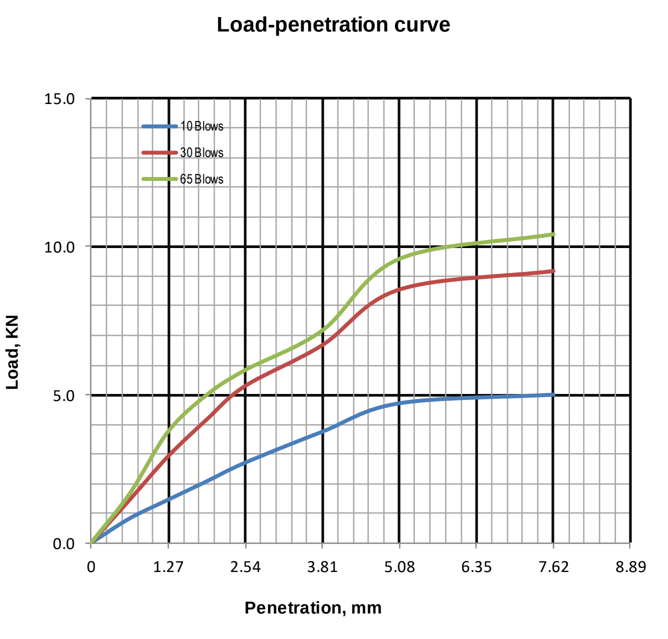
Sourse of Material CDW2 + 10% Subase

Purpose/intended for: Subbase construction

Sampled by:

Tested by:

TEST METHOD: AASHTO T 193



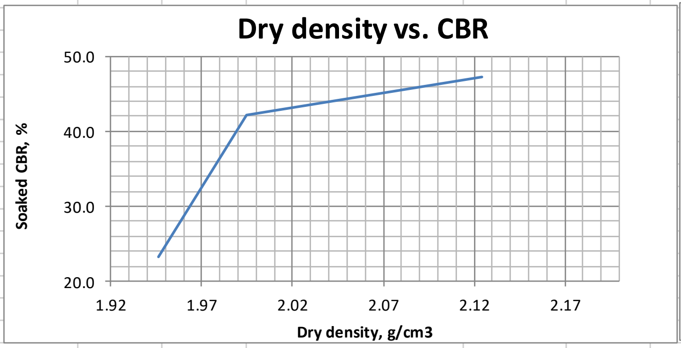
Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.95	2.71	4.71	19.9	23.2	0.03
30	1.99	5.30	8.55	38.9	42.1	0.09
65	2.12	5.84	9.59	42.9	47.2	0.03

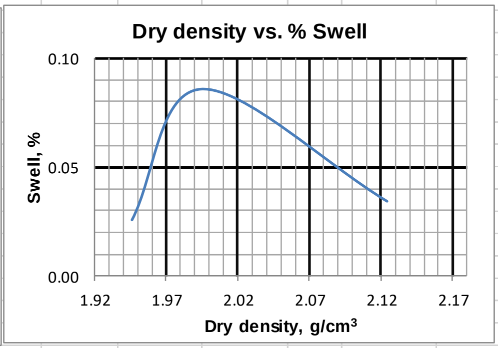
Max. Dry Density (MDD)= 2.10 g/cm^3

95 of MDD= 2.00 g/cm^3

CBR at 95% of MDD= 43 %

Swell at 95% of MDD= 0.1





CALIFORNIA BEARING RATIO TEST

Page 1 of 2

Client:
Sample of: CDW2 + 20% Subase
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		K-10		K-30		K-65	
Mass of Mould	g	6429		6447		6389	
Mass of Mould Plus Soil	g	10720	10830	11024	11122	11260	11360
Mass of Soil	g	4291	4401	4577	4675	4871	4971
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.02	2.07	2.15	2.20	2.29	2.34
Dry Density	g/cm^3	1.84	1.81	1.97	1.95	2.09	2.08

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		1	66	16	44	138	5
Mass of Container	g	124	122	124	124	124	124
Mass of Container Plus Wet Soil	g	657	1496	682	1250	600	1345
Mass of Container Plus Dry Soil	g	610	1325	633	1120	558	1210
Moisture Content	%	9.7	14.2	9.6	13.1	9.7	12.4

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04170 KN/div
Load @2.54	13.6
Load @5.08	20.3

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	30.0	1.3			50.0	2.1			68.0	2.8		
1.27	40.0	1.7			95.0	4.0			115.0	4.8		
1.91	80.0	3.3			150.0	6.3			165.0	6.9		
2.54	110.0	4.59	4.59	33.7	160.0	6.67	6.67	49.1	195.0	8.13	8.13	59.8
3.81	135.0	5.6			200.0	8.3			248.0	10.3		
5.08	180.0	7.51	7.51	37.0	245.0	10.22	10.22	50.3	335.0	13.97	13.97	68.8
7.62	240.0	10.0			330.0	13.8			425.0	17.7		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	2.82	4.3	5.1
Reading After Soaking, mm	2.88	4.39	5.24
Percent Swell	0.05	0.08	0.12

SOAKING CONDITION	
Unsoaked	
Soaked	√
Surcharge Load	**4.54** Kg
Days Soaked	**4**

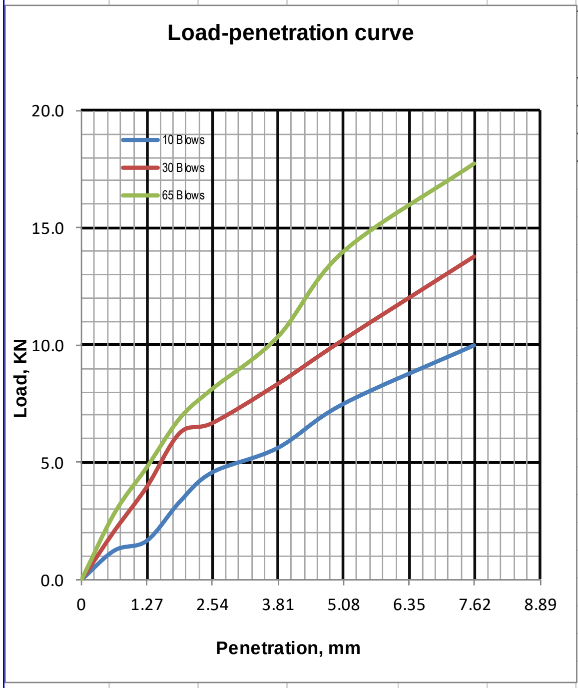
Title

CALIFORNIA BEARING RATIO TEST

Page No.
Page 2 of 2

Client:
Sample of: CDW2 + 20% Subase
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

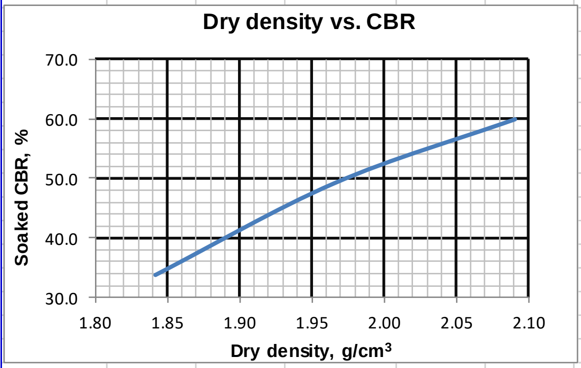
TEST METHOD: AASHTO T 193

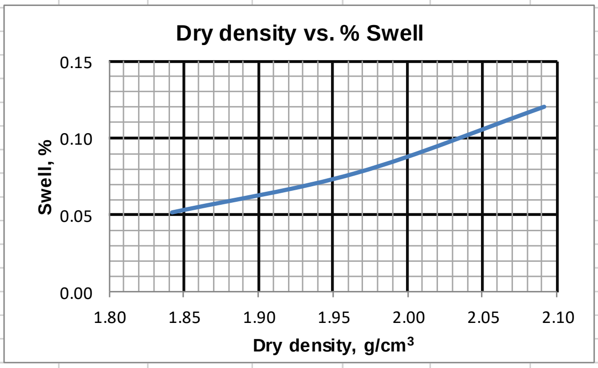


Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.84	4.59	7.51	33.7	37.0	0.05
30	1.97	6.67	10.22	49.1	50.3	0.08
65	2.09	8.13	13.97	59.8	68.8	0.12

Max. Dry Density (MDD)= 2.06 g/cm^3
95 % of MDD= 1.96 g/cm^3

CBR at 95% of MDD= 47 %
Swell at 95% of MDD= 0.1 %





Title	Page No.
CALIFORNIA BEARING RATIO TEST	Page 1 of 2

Client:
Sample of: CDW2 + 30% Subase
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		A-10		A-30		A-65	
Mass of Mould	g	6411		6482		6439	
Mass of Mould Plus Soil	g	10764	10845	10957	11055	11195	11305
Mass of Soil	g	4353	4434	4475	4573	4756	4866
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.05	2.09	2.11	2.15	2.24	2.29
Dry Density	g/cm^3	1.83	1.80	1.88	1.87	2.00	1.99

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		12	66	3	44	139	5
Mass of Container	g	124	122	124	124	124	124
Mass of Container Plus Wet Soil	g	883	1496	581	1250	804	1345
Mass of Container Plus Dry Soil	g	800	1305	532	1100	730	1185
Moisture Content	%	12.3	16.1	12.0	15.4	12.2	15.1

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04170 KN/div
Load @2.54	13.6
Load @5.08	20.3

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	33.0	1.4			37.0	1.5			42.0	1.8		
1.27	58.0	2.4			80.0	3.3			89.0	3.7		
1.91	89.0	3.7			129.0	5.4			143.0	6.0		
2.54	102.0	4.25	4.25	31.3	168.0	7.01	7.01	51.5	193.0	8.05	8.05	59.2
3.81	128.0	5.3			202.0	8.4			289.0	12.1		
5.08	159.0	6.63	6.63	32.7	252.0	10.51	10.51	51.8	375.0	15.64	15.64	77.0
7.62		0.0				0.0				0.0		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	5.25	3.15	2.82
Reading After Soaking, mm	5.33	3.29	2.98
Percent Swell	0.07	0.12	0.14

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

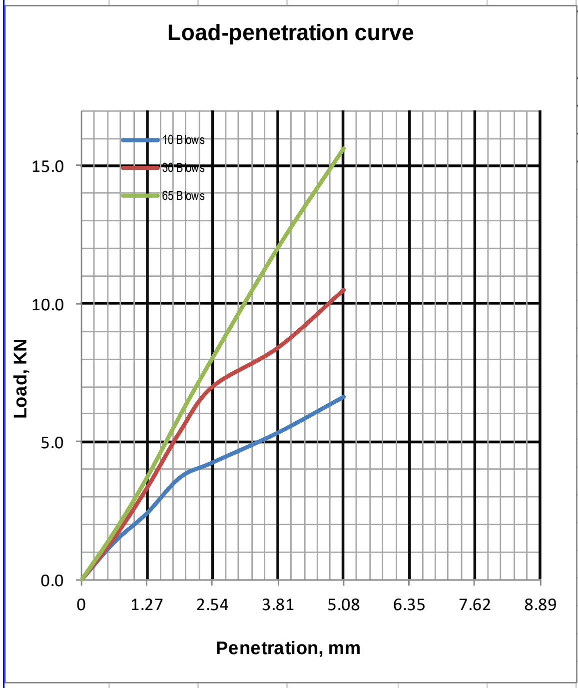
Title

CALIFORNIA BEARING RATIO TEST

Page No.
Page 2 of 2

Client:
Sample of: CDW2 + 30% Subase
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

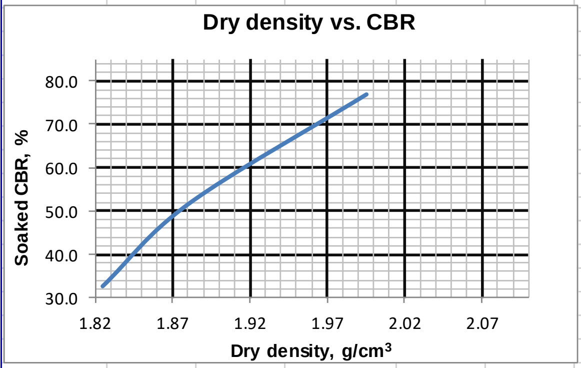
TEST METHOD: AASHTO T 193

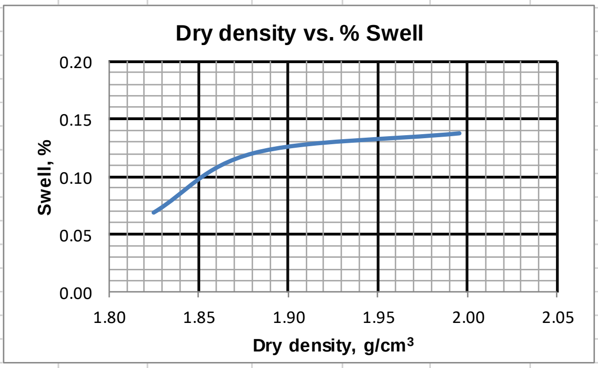


Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.83	4.25	6.63	31.3	32.7	0.07
30	1.88	7.01	10.51	51.5	51.8	0.12
65	2.00	8.05	15.64	59.2	77.0	0.14

Max. Dry Density (MDD)= 1.97 g/cm^3
95 % of MDD= 1.87 g/cm^3

CBR at 95% of MDD= 50 %
Swell at 95% of MDD= 0.1 %





Title	Page No.
CALIFORNIA BEARING RATIO TEST	Page 1 of 2

Client:

Material CDW2 + 40% Subase

Purpose/intended for: Subase

Sampled by:

Tested by:

TEST METHOD: AASHTO T 193

DENSITY DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Mould Number		D-10		D-30		D-65	
Mass of Mould	g	6450	6450	6424		6540	
Mass of Mould Plus Soil	g	10919	11046	11042	11159	11284	11358
Mass of Soil	g	4469	4596	4618	4735	4744	4818
Volume of Mould	cm^3	2124	2124	2124	2124	2124	2124
Wet Density	g/cm^3	2.10	2.16	2.17	2.23	2.23	2.27
Dry Density	g/cm^3	1.92	1.98	1.96	2.04	2.05	2.06

MOISTURE CONTENT DETERMINATION		10 Blows		30 Blows		65 Blows	
		Before	After	Before	After	Before	After
Container Number		B3	66	5	44	C	5
Mass of Container	g	124	122	124	124	124	124
Mass of Container Plus Wet Soil	g	722	1120	742	1050	609	1210
Mass of Container Plus Dry Soil	g	671	1035	682	973	570	1112
Moisture Content	%	9.3	9.3	10.8	9.1	8.7	9.9

CALIBRATION/STANDARD DATA

Rammer	4.54 KN
Layer	5
Volume,cm^3	**2124**
Height,mm	**116.43**
Ring No.	50KN
Ring Factor	0.04170 KN/div
Load @2.54	13.6
Load @5.08	20.3

PENETRATION TEST DATA

Penetration	10 Blows				30 Blows				65 Blows			
	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR	Dial Read.	Load	Corr. Load	CBR
mm	div	KN	KN	%	div	KN	KN	%	div	KN	KN	%
0	0.0	0.0			0.0	0.0			0.0	0.0		
0.64	33.0	1.4			35.0	1.5			40.0	1.7		
1.27	64.0	2.7			67.0	2.8			90.0	3.8		
1.91	97.0	4.0			100.0	4.2			142.0	5.9		
2.54	133.0	5.55	5.55	40.8	147.0	6.13	6.13	45.1	186.0	7.76	7.76	57.0
3.81	188.0	7.8			210.0	8.8			285.0	11.9		
5.08	246.0	10.26	10.26	50.5	295.0	12.30	12.30	60.6	380.0	15.85	15.85	78.1
7.62	369.0	15.4			408.0	17.0	17.0	84	562.0	23.4		
10.16		0.0				0.0				0.0		
12.7		0.0				0.0				0.0		

SWELL, %			
Number of Blows	10	30	65
Reading Before Soaking, mm	5.06	5.41	3.88
Reading After Soaking, mm	5.11	5.49	3.88
Percent Swell	0.04	0.07	0.00

SOAKING CONDITION		
Unsoaked		
Soaked	√	
Surcharge Load	**4.54**	Kg
Days Soaked	**4**	

Title

CALIFORNIA BEARING RATIO TEST

Page No. Page 2 of 2

Client:

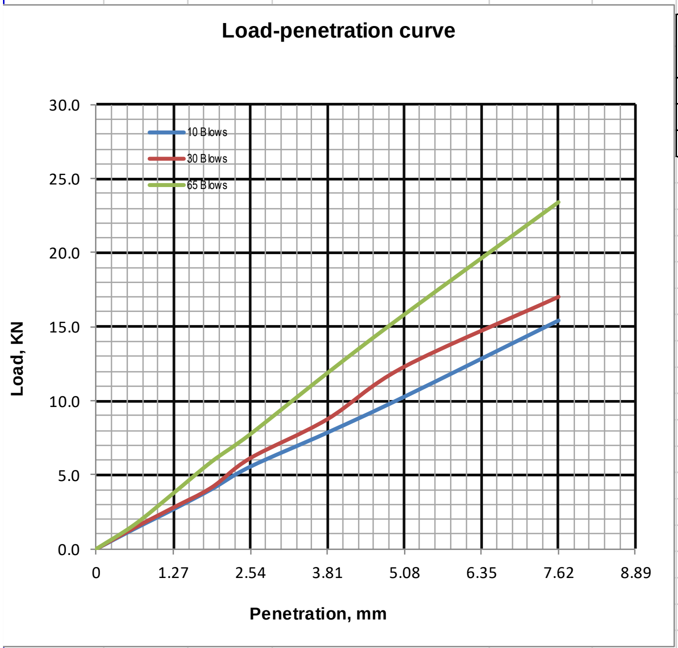
Material CDW2 + 40% Subase

Purpose/intended for: Subbase construction

Sampled by:

Tested by:

TEST METHOD: AASHTO T 193



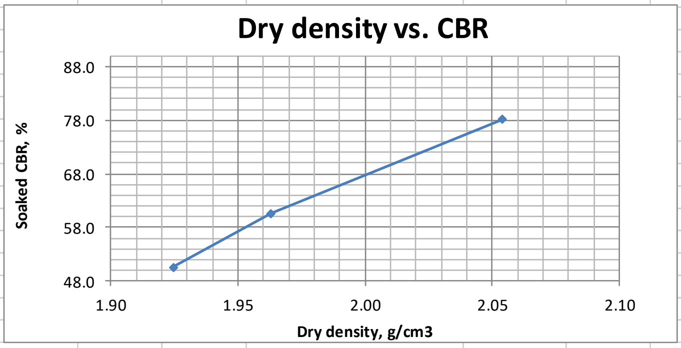
Blows	Dry Density, g/cc	Load (KN) at		CBR(%) at		Swell
		2.54mm	5.08mm	2.54mm	5.08mm	%
10	1.92	5.55	10.26	40.8	50.5	0.04
30	1.96	6.13	12.30	45.1	60.6	0.07
65	2.05	7.76	15.85	57.0	78.1	0.00

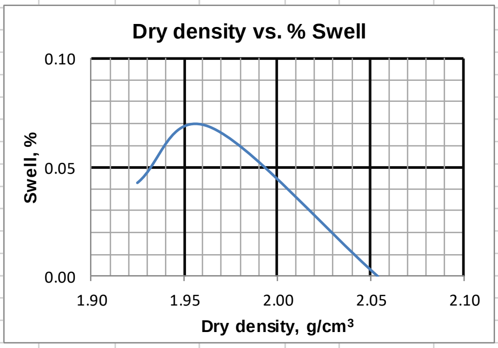
Max. Dry Density (MDD)= 2.03 g/cm^3

95 of MDD= 1.93 g/cm^3

CBR at 95% of MDD= 52 %

Swell at 95% of MDD= 0.0





Appendix A73: Atterberg Limit test results

Title

ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST

Page No. Page 1 of 1

Client:

Matarial s CDW2 + 10% Subase

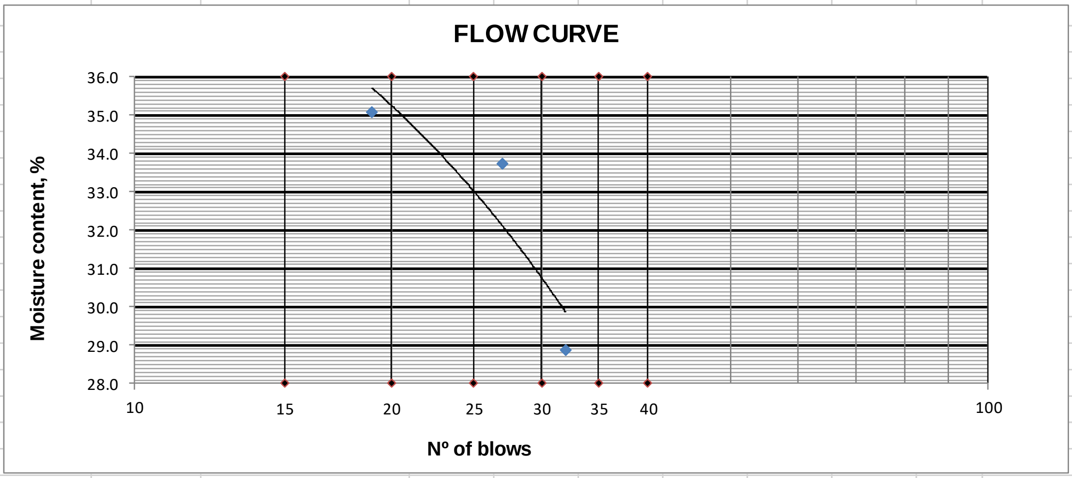
Purpose/intended for: Subbase construction

Sampled by:

Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		32	27	19				
Container No.		10	20	D		E	144	
Mass of Container	g	45.44	45.46	45.3		45.69	45.64	
Mass of Wet Soil + Container	g	68.52	68.70	68.75		49.39	49.34	
Mass of Dry Soil + Container	g	63.35	65.79	62.66		48.66	48.68	
Mass of Water in Specimen	g	5.17	6.86	6.09	0.00	0.73	0.66	
Mass of Dry Soil	g	17.91	20.33	17.36	0.00	2.97	3.04	
Moisture Content	%	28.9	33.7	35.1	0.0	24.6	21.7	
			32.563479			**Average PL, %**		**23**



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI
№ 10				33	9
№ 40					
№ 200					
Initial mass					

Title+A11:M56D16A1A11:M61

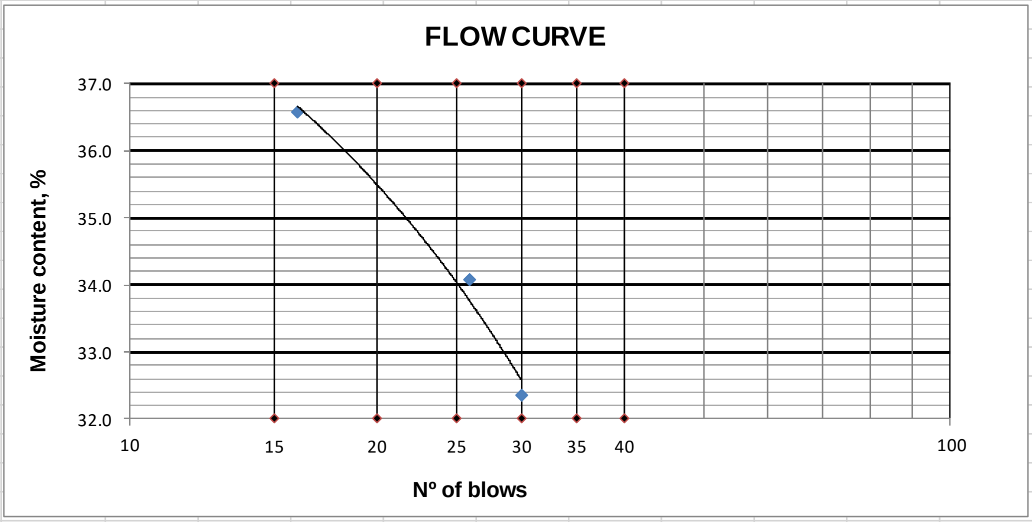
Page No. Page 1 of 1

ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST

Client:
Sample of: CDW2 + 20% Subase
Purpose/intended for: Subase
Sampled by:
Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		30	26	16				
Container No.		140	88	48		10	65	
Mass of Container	g	45.65	45.03	45.18		45.26	45.45	
Mass of Wet Soil + Container	g	70.40	66.2	62.58		49.10	49.39	
Mass of Dry Soil + Container	g	64.35	60.82	57.92		48.35	48.64	
Mass of Water in Specimen	g	6.05	5.38	4.66	0.00	0.75	0.75	0.00
Mass of Dry Soil	g	18.70	15.79	12.74	0.00	3.09	3.19	0.00
Moisture Content	%	32.4	34.1	36.6	#DIV/0!	24.3	23.5	#DIV/0!
						Average PL, %		**23.9**



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10				33.9	10	A-2-7	
№ 40							
№ 200							
Initial Mass							

Title

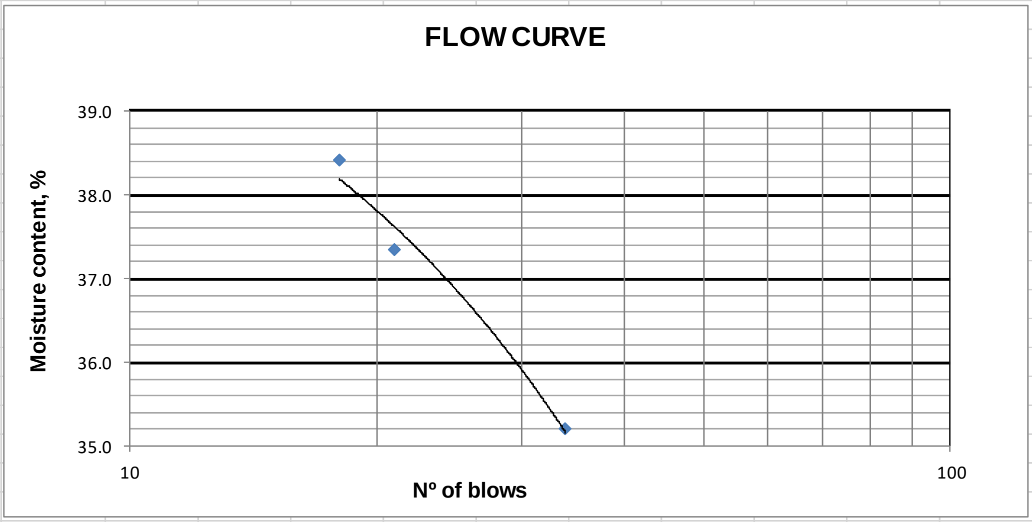
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST

Page No.
Page 1 of 1

Client:
Sample of: CDW2 + 30% Subase
Purpose/intended for: Subbase Construction
Sampled by: Jointly
Tested by: Jointly

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		34	21	18				
Container No.		77	31	43		120	88	
Mass of Container	g	45.38	45.56	45.3		45.52	45.42	
Mass of Wet Soil + Container	g	64.31	65.16	66.92		48.69	48.31	
Mass of Dry Soil + Container	g	59.38	59.83	60.92		48.08	47.7	
Mass of Water in Specimen	g	4.93	5.33	6.00	0.00	0.61	0.61	0.00
Mass of Dry Soil	g	14.00	14.27	15.62	0.00	2.56	2.28	0.00
Moisture Content	%	35.2	37.4	38.4	#DIV/0!	23.8	26.8	#DIV/0!
						Average PL, %		**25.3**



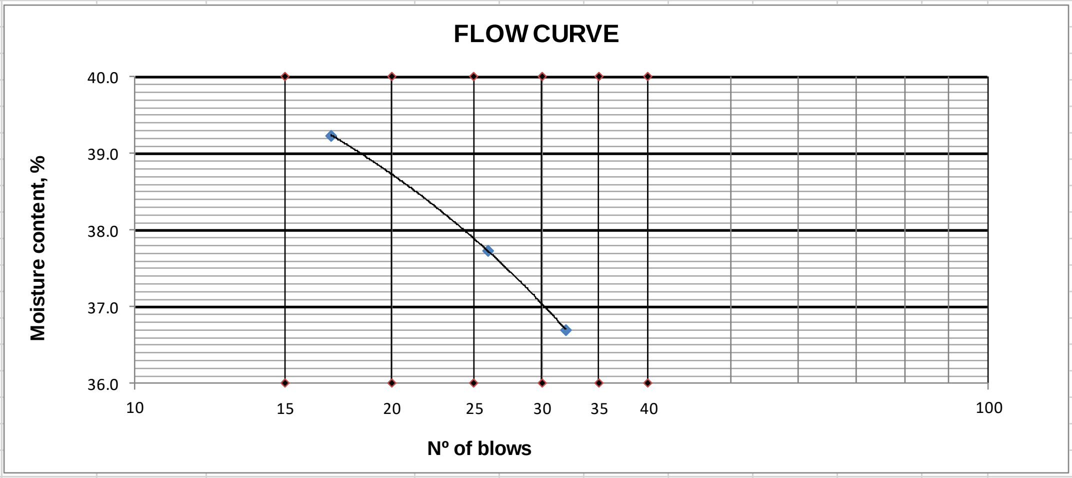
Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI	AASHTO Classification	Grading Modulus
№ 10				36.5	11		
№ 40							
№ 200							
Initial Mass							

Title	Page No.
ATTERBERG LIMITS AND SOIL CLASSIFICATION TEST	Page 1 of 1

Client:
Matarial CDW2 + 40%
Purpose/intended for: Subbase construction
Sampled by:
Tested by:

TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)				Plastic Limit (PL)		
No. of blows		32	26	17				
Container No.		F	26	9		88	20	
Mass of Container	g	45.26	45.39	45.3		45.46	45.27	
Mass of Wet Soil + Container	g	74.65	74.81	74.01		49.10	49.34	
Mass of Dry Soil + Container	g	66.76	66.75	65.92		48.37	48.49	
Mass of Water in Specimen	g	7.89	8.06	8.09	0.00	0.73	0.85	
Mass of Dry Soil	g	21.50	21.36	20.62	0.00	2.91	3.22	
Moisture Content	%	36.7	37.7	39.2	0.0	25.1	26.4	
						Average PL, %		**26**



Sieve No.	Mass Ret.	% Retain.	% Pass.	LL	PI
№ 10	0	0.0	0	38	12
№ 40	0	0.0	0		
№ 200	0	0.0	0		
Initial mass	0				

Appendix A74: Los-Angeles Abrasion test results

LOS ANGELES ABRASION TEST (LAA) FOR Sub Base
Test Method ASTM Designation: C 131 - 03

Intended Purpose	Subase
Material	CDW2 + 10% Subase

Specification Limits : Maximum = 51% For Natural Sub Base

Sieve Size (SquareOpenings)		Mass of Indicated Size, (g) Grading				Wt. of sample to be tested	
Passing	Retained on	A	B	C	D	Trial 1	Trial 2
37.5 mm	25.0 mm	1250 ± 25	---	---	---	1250	1250
25.0 mm	19.0 mm	1250 ± 25	---	---	---	1250	1250
19.0 mm	12.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
12.5 mm	9.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
9.5 mm	6.3 mm	---	---	2500 ± 10	---		
6.3 mm	4.75 mm	---	---	2500 ± 10	---		
4.75 mm	2.36 mm	---	---	---	5000 ± 10		
Total		5000 ± 10	5000 ± 10	5000 ± 10	5000 ± 10	5000	5000
Number of Spheres (Balls) used		12	11	8	6		

Test Result Analysis

Grading Type Used	A	B	C	D

Trial	$Trial_1$	$Trial_2$
Number of Revolution	500	500
Total Wt. of Sample Tested (W)	5000	5000
Wt. of Tested Sample Retained On 1.70 mm Sieve (X)	2675	2628
Loss in grams Y = (W - X)	2325	2372
Percent Loss Z = (Y / W)*100	46.50	47.44
Average Percent Loss ($Trial_1$ + $Trial_2$)/2	**46.97**	

Remark

Title

RESISTANCE TO DEGRADATION IN LOS ANGELES MACHINE

Page No. Page 1 of 1

Client:
Sample of: CDW2 + 20% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 96

Table: Standard Grading of Test Samples

Sieve Size			Mass of Indicated Sizes, g			
			Grading			
Passing	**Retained on**		**A**	**B**	**C**	**D**
37.5mm(1 1/2in.)	25.0mm(1in.)		1250±25			
25.0mm(1in.)	19.0mm(3/4in.)		1250±25			
19.0mm(3/4in.)	12.5mm(1/2in.)		1250±10	2500±10		
12.5mm(1/2in.)	9.5mm (3/8in.)		1250±10	2500±10		
9.5mm (3/8in.)	6.3mm (1/4in.)				2500±10	
6.3mm (1/4in.)	4.75mm (No.4)				2500±10	
4.75mm (No.4)	2.36mm(No.8)					5000±10
Total			5000±10	5000±10	5000±10	5000±10
Number of Charges			12	11	8	6

Grading Used		B
Mass of Sample Before Test	g	5005
Mass of Sample Retained on 1.7mm (No.12) Sieve	g	2816
Mass of Sample Passed on 1.7mm (No.12) Sieve	g	2189
LAA Value	%	43.7

Title	Page No.
RESISTANCE TO DEGRADATION IN LOS ANGELES MACHINE	Page 1 of 1

Client:
Sample of: CDW2 + 30% Subase
Purpose/intended for: Subbase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 96

Table: Standard Grading of Test Samples

Sieve Size			**Mass of Indicated Sizes, g**			
			Grading			
Passing	**Retained on**		**A**	**B**	**C**	**D**
37.5mm(1 1/2in.)	25.0mm(1in.)		1250±25			
25.0mm(1in.)	19.0mm(3/4in.)		1250±25			
19.0mm(3/4in.)	12.5mm(1/2in.)		1250±10	2500±10		
12.5mm(1/2in.)	9.5mm (3/8in.)		1250±10	2500±10		
9.5mm (3/8in.)	6.3mm (1/4in.)				2500±10	
6.3mm (1/4in.)	4.75mm (No.4)				2500±10	
4.75mm (No.4)	2.36mm(No.8)					5000±10
Total			5000±10	5000±10	5000±10	5000±10
Number of Charges			12	11	8	6

Grading Used		**A**	B	
Mass of Sample Before Test	g	5000	5000	
Mass of Sample Retained on 1.7mm (No.12) Sieve	g	2974	3019	
Mass of Sample Passed on 1.7mm (No.12) Sieve	g	2026	1981	
LAA Value	%	40.5	39.6	
Avg.		40.07		

LOS ANGELES ABRASION TEST (LAA) FOR Sub Base
Test Method ASTM Designation: C 131 - 03

Intended Purose	Subase
Material	CDW2 + 40% Subase

Specification Limits : Maximum = 51% For Natural Sub Base

Sieve Size (SquareOpenings)		Mass of Indicated Size, (g) Grading				Wt. of sample to be tested	
Passing	Retained on	A		C	D	Trial 1	Trial 2
37.5 mm	25.0 mm	1250 ± 25	---	---	---	1250	1250
25.0 mm	19.0 mm	1250 ± 25	---	---	---	1250	1250
19.0 mm	12.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
12.5 mm	9.5 mm	1250 ± 10	2500 ± 10	---	---	1250	1250
9.5 mm	6.3 mm	---	---	2500 ± 10	---		
6.3 mm	4.75 mm	---	---	2500 ± 10	---		
4.75 mm	2.36 mm	---	---	---	5000 ± 10		
Total		5000 ± 10	5000 ± 10	5000 ± 10	5000 ± 10	5000	5000
Number of Spheres (Balls) used		12	11	8	6		

Test Result Analysis

Grading Type Used	A	B	C	D

Trial		$Trial_1$	$Trial_2$
Number of Revolution		500	500
Total Wt. of Sample Tested	(W)	5000	5000
Wt. of Tested Sample Retained On 1.70 mm Sieve	(X)	3128	3149
Loss in grams	Y = (W - X)	1872	1851
Percent Loss	Z = (Y / W)*100	37.44	37.02
Average Percent Loss ($Trial_1$ + $Trial_2$)/2		**37.23**	

Remark

Appendix A8: Gradation test result for CDW1 after compaction

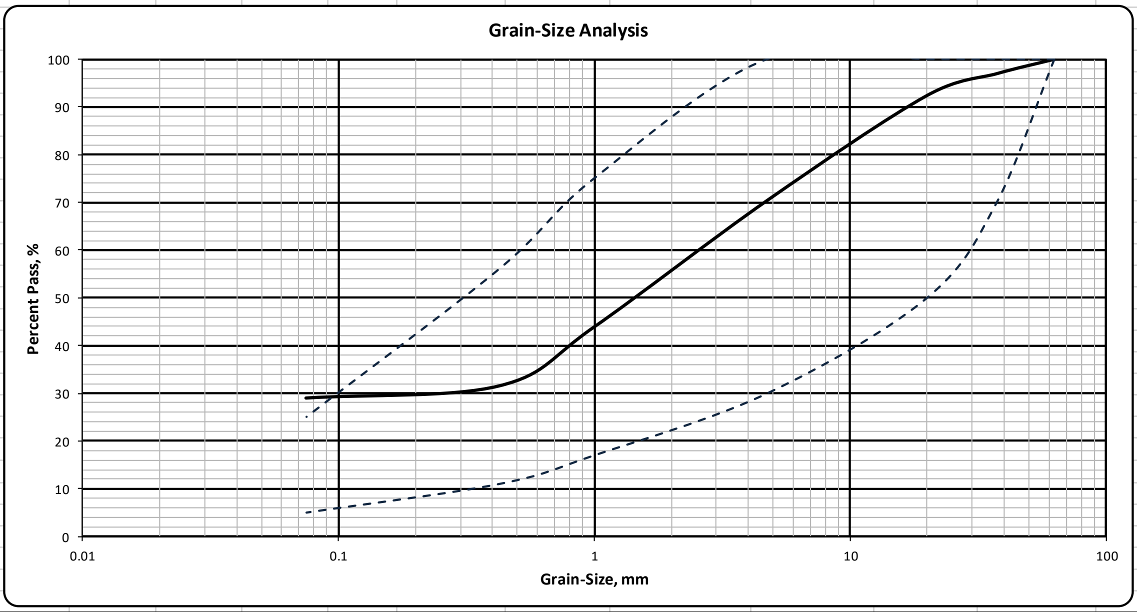
GRADING

Client:	
Sample of:	
Description	After Compaction Gradation of CDW1
Purpose/intended for:	Subase Construction
Sampled by:	
Tested by:	

TEST METHOD: AASHTO T 11, T27

	Trial-1	Trial-2	Average
Weight of specimen before washing, g	18554	17993	18274

Sieve opening, mm (A)		63	37.5	20	4.75	1	0.425	0.075
Mass Retained, g	T1	0	462	785	4140	5141	2164	4144
	T2	0	642	887	3892	5668	2344	4268
Average Mass retained, g		0	552	836	4016	4846	2254	462
% Mass retained		0	3	5	22	27	12	3
% Mass passing		100	97	92	70	44	32	29
Lower limit, %		100	70	50	30	17	11	5
Upper limit, %		100	100	100	100	75	56	25



Appendix A9: Gradation result for CDW1 + 20% Subase after compaction

GRADING

Client:
Description After Compactiongradation CDW1 + 20% Subase
Purpose/intended for: Subase Construction
Sampled by:
Tested by:

TEST METHOD: AASHTO T 11, T27

Weight of specimen before washing, g	Trial-1	Trial-2	Average
	19566	18773	19170

Sieve opening, mm (A)		63	37.5	20	4.75	1	0.425	0.075
Mass Retained, g	T1	0	1575	4987	6738	2148	1221	971
	T2	0	1678	4638	6742	2261	941	887
Average Mass retained, g		0	1627	4813	6740	2205	1081	929
% Mass retained		0	8	25	35	12	6	5
% Mass passing		100	92	66	31	20	14	9
Lower limit, %		100	70	50	30	17	11	5
Upper limit, %		100	100	100	100	75	56	25