THE REPUBLIC OF SOUTH SUDAN

WESTERN EQUATORIA STATE

Maridi – Mudubai and Maridi – Emba Access Roads

Design Report

EMPLOYER:

ACTED South Sudan, Western Equatoria State

CONSULTANT:

Tel: +211920105359

Email: ladderedi@gmail.com

Juba, The Republic of South Sudan

FEBRUARY, 2023

Contents

1. INTRODUCTION

1.1 GENERAL

Ladder Consultancy and General Trading was invited by the ACTED South Sudan, Western Equatoria State to submit a technical and financial proposals for the infrastructure services of Maridi Mudubai and Maridi – Emba access road within Western Equatoria State.

A detailed survey was conducted and a design prepared for the above-mentioned access roads.

This report therefore, highlights, the General Description of the Area, the Geology, Existing Situation, Traffic, the Proposed Alignment, Hydrological and Hydraulic Studies and Drainage Structures, Soils and Materials, Design Standards, Pavement Designs, Safety and Comfort, Economic Studies and Designs etc.

1.2 Terms of Reference

The survey and design of the road is in line with the terms of reference provided by the Employer.

1.2.1 Introduction

ACTED South Sudan, Western Equatoria State has entrusted Ladder Consultancy and General Trading with carrying out the services outlined in these terms of reference (TOR).

1.2.2 Objectives

The objectives of the consulting service are preparation of Earth Road, Storm Water Drainage design and road crossings. The designer has to select the most appropriate route connecting the places as shown in the drawing. The route selected should be the most economical (with emphasis on the existing), but the designer is free to make changes, if another route has advantage over the existing. The Road design shall consist of both geometric design, recommendations and design for sub-grade construction or preparation for making the road surfaces.

1.2.3 Scope of the Services

The services to be provided by the Consultant shall include, but not limited to the following:

1.2.3.1 Road Profile Survey and Design

Preliminary Design

i) Consultation, investigations and ascertainment of available data and information relating to the scheme with the Employer.
ii) The Collaboration with the Employer with respect to the programme and preparation of scheme for the approval of the Employer.
iii) Route map of the proposed road.
iv) Preparation of preliminary road designs, drainage plans and Storm Drainage Design with proposals for any necessary drainage structures and other necessary detail drawings. The designs shall comply to well established Codes of Practices.

v) The preparation of provisional cost estimate
vi) Preparation of outline specifications
vii) Preparation and presentation of preliminary renovation/design report.

Final Design

i) Preparation of Drawings.
ii) Drainage Plan should be made in such a way that no stagnation of water occurs throughout the year, especially rainy season.
iii) Cross-sections corresponding with the original road survey results.
iv) Road profiles with plans depicting existing and design road levels, curve details and others relevant details.
iv) Drainage structures details.
v) Site soil material investigation, laboratory tests and other necessary assessments with complete sub-grade design (according to South Sudan Standards and according to well accepted international code of practice, AASHTO is recommended).
vi) Preparation of Bill of Quantities by items and categories of the work based on the Employers specification.
vii) Preparation of detailed cost estimates based on the prepared bill of quantities.
ix) Presentation of final design.
x) Incorporation of all corrections and amendments agreed upon in the presentation of comments by the Employer.

1.2.4 Obligations of the Employer

Data to be furnished to the Consultant:

2.4.1 The Employer shall furnish tall pertinent available data and information and give such assistance as shall be reasonably required by the Consultant in carrying out provisions of this Agreement.

2.4.2 The Employer shall give his decision on all sketches, drawings, reports, recommendations and other matters referred to him for decision by the Consultant in such reasonable time as not to delay or disrupt the performance by the Consultant of his services under this Agreement.

2. GENERAL DESCRIPTION OF THE AREA TOPOGRAPHY AND CLIMATE

2.1 General Description

The proposed Access Roads are located within the Western Equatoria State, starting from Maridi on the Munduri - Yambio Road, where Maridi – Mudubai is about 10Km while the other road of Maridi - Emba is about 20Km.

2.2 Topography

The area of the proposed road consists of almost flat terrain, bisected by small streams. In general, the altitude of the project area varies from 650 to 777m above sea level.

2.3 Vegetation and Cultivation

The area is highly vegetative and is almost covered with grass and trees.

Almost all the area is suitable for agriculture.

2.4 Climate

Similar to other areas within Western Equatoria, the project area experiences the two distinctive seasons, the rainy season lasting from April to October (7 months) and the dry season extending over the remaining months of the year (5 months).

The mean month rainfall for April / October is approximately about 1000 mm.

3. GEOLOGY

5.1 Introduction

The geological map of South Sudan indicates the general geological setting. Inspection of cuttings existing borrow pits indicate substantially suitable of the local material for construction purposes of the Roads. Soil samples have been collected and the test result is attached where there is sufficient and suitable material for selected material fill.

The purpose of this geological study is to know the geology of the area, determine the route soil and required source of construction materials.

5.1 Road Construction Material

In order to minimize construction costs, local materials should be used as much as possible before considering importation of materials from some distance. It is therefore, of prime importance to make a complete inventory of all available road making materials. Basically, materials required for the construction of the road were found in the area and include:

a. Embankment material
b. Laterite (murram) for sub base
c. Water (there are rivers and streams)

All the materials comply with the requirement of the technical specification.

3.5.1 Earthworks and Sub-Grade

The sub grade classification is determined as a function of the bearing capacity under favourable density and moisture conditions to which the sub grade is subjected in the design period.

As a result, suitable materials are sampled at frequent intervals around and are found acceptable.

3.5.2 Sub-Base Material

Quarries around Maridi are found suitable for sub base as identified with sources:

Graded granular laterite material shall be used as sub-base course and to avoid segregation, the materials should always be kept wet during handling and laying. It should normally be located to the site in ready mixed condition and spread by means of a grader.

4. TRAFFIC

5.1 Existing Traffic

The existing traffic of the area is very small.

5.1 Future Traffic

Future traffic shall definitely be generated and developed. The construction of the road shall open up the area for agricultural, commercial, industrial and residential developments as well as encourage other infrastructural services.

5. PROPOSED ALIGNMENT

5.1 General

In general, the beneficiaries of this road are Mudubai and Embe. The alignment for this road is following the existing trial, which is the most economical route to connect. The alignment is passing low side slopes. The alignment has streams crossing which have discharge points on both sides.

6. HYDROLOGICAL AND HYDRAULIC STUDIES

6.1 General

The subject road project is vegetated area and the road will be upgraded by gravel surfaced road. This will help the drainage of water in a proper way with the given cross fall.

6.1 Hydrologic Analysis

6.1.1 General

Based on the available data obtained from Juba, it was used for the Project area as well.

6.1.2 Rainfall Data

Available rainfall records for Juba on which it is assumed to be representative for the project site are obtained.

6.1.3 Analysis of Yearly Rainfalls

The yearly rainfalls have been classified by decreasing intensities, the return time has been calculated according to the formula.

$$T = \frac{n + 1}{m}$$

where : T return times
m rank
n total number data

this gives following results

Y average : 527.865 mm/year
$\sum Y$: 26921.1mm
$\sum Y^2$: 15610489.65
Sy : 167.32
σ_x : 165.671
n : 51

7. HYDRAULIC DESIGN

7.1 General

After identifying the crossings, hydraulic design has been made. The principal goal of this study is to determine the size of the hydraulic structures. To accomplish this goal, peak discharge is observed for each crossing with catchment area less than 5km2 so as to determine the required size of each crossing to allow safe circulation of the flow.

In this project, three types of hydraulic structures have been utilised namely corrugated pipe culvert, slab culvert, and longitudinal ditch.

7.2 Longitudinal Ditch

The ditches collect all the run off from the road, whether from the adjacent impluvium, or from the road surface and the side slopes. The common return period for this type of drainage structure is two years. This means that, on average, once every two years, the ditches will have either overflowed or supported a flow velocity speed faster than allowed. In all cases, a minimum of maintenance shall have to be carried out both to remove debris fallen in the ditch and to repair any formed erosion channels. The longitudinal slope of side ditches is determined by the longitudinal profile of the road.

7.3 Culverts

Run-off from minor streams, watercourses and surrounding terrain shall be controlled and prevented from affecting the road structure by the provision of gently sloping intercepting channels. This will be co-ordinated by providing culverts to carry such discharges across the proposed road to lower terrains.

The effects of sub-soil water on the road structure shall be controlled by raising the formation levels, appropriately, using channels with invert levels suitably kept below the margin at edges and providing culverts to avoid any surcharge of head water.

7.4 Culvert Size

Culvert sizes have been determined on the basis of the hydrological information and observations on site. In sizing pipe culverts, a velocity of 3.5 m/s is kept as a maximum limit to keep the erosive effect on the base of the structure. The culverts should have at least 1% longitudinal slope and minimum velocity of 0.61 m/s to limit the risk of siltation. Corrugated steel twin 600mm pipes have been used in most of the areas, larger culverts shall be of reinforced box units.

8. DESIGN STANDARD

8.1 Topography

The topography through which the existing roads and new alignments is passing is flat ground.

8.2 Geometric Standards

The road design is carried out according to AASHTO standards and South Sudan Standards assuming that the road is going to serve as an access road. The standards followed are outlined below:

Design Speed*:* - The design speed for different class of road is listed below as per AASHTO (rep. 5,6)

Classification Roads	Speeds is K.P.H.
Arterial	80
Sub arterial	60
Collector roads	50
Local roads	30

The design speed table is for Asphalt conditions, a reduction of 20% has been done in the maximum specified design speed to suit it to surface conditions of earth roads. Therefore, a maximum design speed of 60 to 50 km/hour has been adopted for the design of road. But, a minimum design speed of 30 to 40km per has been maintained at certain sharp curve in villages.

Super-elevation:- For the design speed and camber adopted the super elevation is calculated using the formula mentioned below,

Total Super elevation = e

$$e = \frac{V^2}{127R}$$

where e = Super elevation
V = Design Speed
R = Radius of the curve

Value of m co–efficient of friction has been taken as per AASHTO.
Co –efficient of lateral faction as recommended by AASHTO (source: ref.3)

Design speed	50	65	80	100	120	130
Maximum lateral tractions values	0.16	0.15	0.14	0.13	0.12	0.11

Maximum Super Elevation*:* - As per AASHTO Practice maximum limit of super elevation is 0.12% but, in the design, a maximum limit of 0.07% has been considered sufficient. All super elevation where necessary are specified on respective curves on drawings.

Method of attainment of super elevation: -

In this design report all super-elevation is supposed to be attained by revolving about the centre line.

Vertical alignment: -

Vertical Curves*:* - The vertical curves are provided to: -

Serve as a gradual transition from one gradient to another without discomfort to riders.
Eliminate sudden lumps and troughs.
To provide adequate visibility for stopping and overtaking.
To achieve the above-mentioned goals the vertical curves are designed on (length of vertical base)
Length of all summit curves has been calculated for:
Safe stopping sight distance:-

When the right distance 'S' is less than the length of curve 'L'

$$L = \frac{NS^2}{9.6}$$

When the right distance (S) is greater than the length of the curve 'L'

$$L = 2S - \frac{9.6}{N}$$

Where, N = Difference of in slopes
S = sight distance in meters
L = Length of vertical curve, in meters Height

All vertical curves have been designed by assuming the driver eye height 1.2m. above roadway surface and for an obstacle of height 0.15metre above roadway surface.
But the minimum length of vertical curves is maintained as per table given below:

Minimum length of vertical curve
(Ref. 2)

Design speed	Maximum grade change (percent) not requiring a vertical curve	Minimum length of vertical curve
Up to 35	1.5	15
40	1.2	20
50	1.0	30
65	0.8	40
80	0.6	50
100	0.5	60

All vertical curves are designed as parabolas

Sag Curves (Valley curve):- The following criteria has been used to determine the length of vertical sag curves
Rider comfort
Vehicle headlight right distance
Drainage control and general appearance.
The length of curves is determined: -
Case (I) When the length of the curve exceeds the required sight distance i.e. L>S

$$L = \frac{NS^2}{1.5+0.0355}$$

Case (II) When L>S

$$L = 25 - \frac{1.50 +0.0355}{N}$$

Where L, N and S stands for their usual notation as mentioned earlier.

Sight Distance: - For the safe operation of traffic an roads the sight distance has been given due consideration and the safe stopping distance has been maintained as per table given below:
Stopping sight distance as per AASHO
(Ref. 3)

Design Speed	Safe stopping sight distance (meters)
20	20
30	30
40	45
50	60

For calculating sight distance and stopping distance the perception and broke reaction time of 2.5 second has been considered as reasonable.

For the design of profile eagle point software has been used and results are printed on plan and profile drawings a sample sheet is attached here (see drawing package)

Road Junctions: - A clear sight distance has been maintained as per tables above on all road junctions.

X – Section Element: - For all earth roads the minimum thickness of sub base has been designed for a CBR of 15% saturated, assuming the pavement as flexible pavement; and thickness of sub base is counter checked by using asphalt institute method the x-sectional elements are as follows:

Carriageway Width: - The carriage width is kept 5.0m plus clear as required by the Employer.

Shoulders: - 1.0m wide shoulders are provided on either side of the carriage way. The shoulders are sloping 5% outward.

Side Ditches: - side ditches are provided on either side of road to drain out water from road surface as well as from surrounding area. The size of drain has been selected according to hydrological calculations.

Earth Works: - All earth work has been calculated by using eagle point software 2001 and results are collected to prepare the estimate.

Appendices

Juba Rainfall Data

YEAR	JUBA JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	13.3	8.3	44.4	49.9	143.7	50.4	116	118.7	107.1	193.1	87	0.3
1962	0	0	86.3	82.3	302.4	90.3	106.7	116.9	260.2	192.3	59.6	4
1963	3.4	13.4	67.6	128.5	178.1	142.4	91.2	140.7	99.8	86.9	47.5	7.1
1964	0.1	3.9	15.5	73	228.1	95	100.6	169.1	161.5	67.6	33.3	12.2
1965	0	0	19.3	100.1	120.4	84.7	34	122.7	86.6	211.5	40.6	0.2
1966	1.8	6.3	85.6	116.2	129.1	111.8	194.1	124.9	85	104.5	23.8	0
1967	0	1.9	58.2	47	127	220.4	210.4	190.9	220.7	134.8	80.9	1.6
1968	0	32.7	13.6	70.4	178.5	76.5	149	177.1	31.6	96.4	24.8	39.9
1969	36.2	57.8	107.7	57.4	145.7	126.4	92.8	161.9	75.3	116.7	26.8	4.3
1970	3	2.8	53.3	167.8	113.9	198.3	54.6	139.7	154.9	186	10.2	0
1971	0	0	12.8	87.6	178.4	116	211.2	170.4	150.2	23.8	50.2	1.2
1972	2.5	7.6	14.9	110.6	118.1	128.1	54.6	146.3	125.1	93.5	24.2	9.9
1973	0	14.6	13.3	156.3	117.2	185	216.9	190.4	109	48.6	8	0
1974	3.9	0	32.3	88.8	85.1	43.7	237.2	92.4	131.1	54	21.9	0
1975	0	5.3	24	65.6	142	116.1	88.4	274.4	112.9	74.2	34.4	2.3
1976	0	4.4	58.9	132.4	141.2	146	176.6	102.1	117	54.8	44	13.2
1977	8.3	4.8	83.8	70.2	66.2	96.3	94.2	143.6	21.2	101.5	27.9	11.4
1978	0	14.5	49.2	122.7	54	34.8	109.5	129.3	41.6	153.5	30.5	18.1
1979	4.9	40.9	18.6	153.6	168.2	184.3	127.1	170.3	47	65.3	70.8	0
1980	2.1	31.9	22	52.4	202.3	103.5	164.5	204	102.7	89.8	102.8	0
1981	0	14.6	73.7	49.2	96.1	91.3	102.5	120.2	173.6	18.2	73.4	1.8
1982	14.8	0	18.3	110.8	244.3	213.1	76.1	115.9	64.4	171.1	3.4	0.5
1983	0	0	9.1	55.1	89.7	165	111.4	132.5	118	154.7	51.3	3.5
1984	0	0	1.9	106.7	125.6	85	272.1	67.5	96.8	24.8	49.3	2.5
1985	5.9	0.5	116.2	156.2	205.2	140.3	75.6	74.8	143.2	85.4	51.1	9.5
1986	2.7	38.9	42.2	100	94.6	200.7	151.4	89	99.7	112.5	27.7	1.9
1987	0	5.5	24.3	78.4	245.7	46.3	20.6	40.4	86.7	66.8	60.8	3.3
1988	3.9	10.1	20.5	80.3	184.6	133.9	231.9	162.7	247.2	91.4	35.7	36.7
1989	0	0.5	102.4	73.9	114	151.9	157.7	93.5	128.9	53.3	107.2	4.9
1990	2.5	27.1	55.8	49.7	106.8	13.9	142.5	213.4	98.3	127.5	48	21.1
1991	3	35.1	19.4	172.1	144.6	57.9	154.4	173.4	95.6	128.2	16.2	2
1992	44.5	0	18.5	69.2	106.8	88.9	136.7	113.6	65.8	263.9	18.9	15.2
1993	11.4	3.1	39.4	153.8	189.4	127.8	266.8	41.4	48.9	78.2	27.3	53.5
1994	2.5	0	4.5	128.1	105.9	108.2	250.3	179.1	100.4	102.5	68.7	0.5
1995	0	9	45.1	57.2	136.5	39.7	100.3	65.9	113.7	109.7	4	0.7
1996	19.9	59	102.3	170.9	115.3	133.4	98.6	136.7	134.2	148.1	0	0.2
1997	1.5	0	20.4	180.2	79.9	55.9	81.7	101.1	61.7	244.3	106.7	31.9
1998	17.2	3	21.3	138.7	77.1	183.2	187.6	63.4	42.7	294.2	70.7	0
1999	0	0.5	32.2	320.3	100.7	188	106.8	149.3	142.4	205.3	29.2	0
2000	0	0	4.8	52.7	62.5	154.9	136.9	68.5	90.9	175.3	25.8	1.1
2001	0	7.4	16.7	107.6	150.4	177.7	108.9	78.4	80.6	151.1	42.8	1

2002	0	1.5	91.5	87.6	43.2	206.7	148.6	127.5	175.6	209.9	48	34.2
2003	4.6	30	66.1	71	218	91.2	148.9	197.4	147.6	50.1	208.7	12.2
2004	14	1.2	36.5	170.4	74.1	153.5	115.1	305.2	56.5	92.8	96.7	0
2005	0	0	22.8	103.7	173	129.8	188.6	29.5	67.9	90.6	15.2	0
2006	0	5.5	129.8	88.3	188.2	82.1	60.5	265	144.5	80	35.5	21.5
2007	0	1	11.8	117.4	178.8	129.8	194	125.5	172	74.5	56.5	0
2008	19	0	17.6	173.5	173	134.7	205.8	191.1	471.9	357.2	109.5	0
2009	78	270.5	12.2	438.2	87.6	65.6	162.2	338.5	280.6	123.7	62.5	14
2010	0	26.5	31	101.5	122.6	145	194.6	60.5	93	110.5	28	15
2011	0	0	22	88.4	202	106.1	134.3	134.6	148.6	162.3	36.5	0.1
2012	0.1	0	26.4	297.1	155.6	121.9	177.4	87.5	77.5	133.6	90	14
2013	6.6	5.4	27.9	85.9	71.5	123	121	35.5	85.4	134.4	91.3	0
2014	0	0	154.5	76.6	181.7	132.2	134.1	137	191.7	69.4	41	0
2015	14.5	4	23.3	88.3	108	299	91.6	74.9	17.1	180.8	61.7	0.2
2016	0.1	73	2.2	84.4	59.1	119.7	107.1	36.5				
2017	0	13.5	23.8	100.4								
LTM										126.4	50.9	7.9

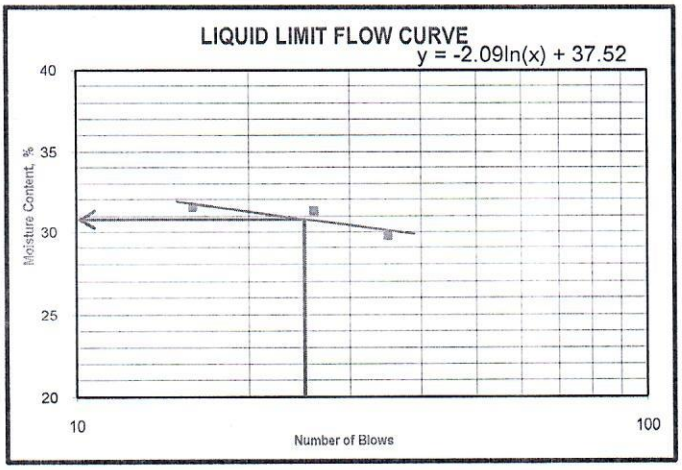
Soil Test Data

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS BRIDGES
REPUBLC OF SOUTH SUDAN

PROJECT	Prefissibility Study & Thechinical Survey for Road Construction	SAMPLE N0	TP-2 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	DATE OF TEST	14-Feb-23
MATERIAL	Brown Gravel Soil	SOURCE	Borrow Pit
CONSULTANT	Ladder Engineering & General Trading	CLIENT	ACTED South Sudan

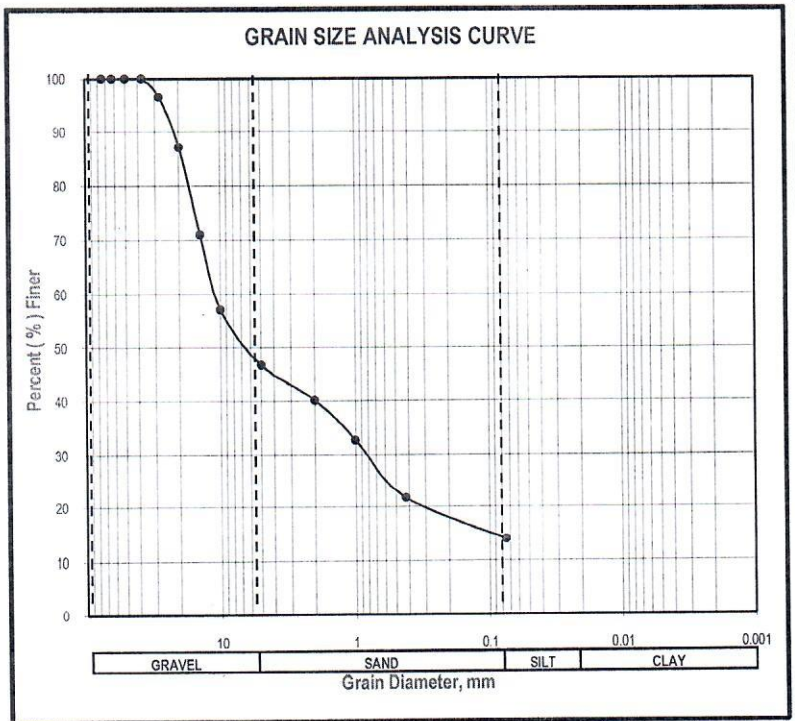
TEST REPORT ON NATURAL MOISTURE CONTENT
ATTERBERG LIMIT, AND GRAIN SIZE ANALYSIS OF SOILS

TYPE OF TEST		NMC	Liquid Limit			Plastic Limit		
			1	2	3	1	2	4
Can Number			U12	CE	TD	U2		X5
Weight of Can + Wet Soil (gm)	A		32.8	33	32.6	22.6		22.5
Weight of Can + Dry Soil (gm)	B		28.2	28.4	28.2	21.4		21.3
Weight of Water (gm)	(A-B)		5	5	4	1		1
Weight of Can (gm)	C		14.6	14.7	14.8	14.9		14.8
Weight of Dry Soil (gm)	(B-C)		14	14	13	6.5		6.5
Moisture Content (%)	(A-B)/(B-C)*100		32	31	30	18		18
Number of Blows			16	26	35		18	



Wt. of O.D. Spl (gm)	1943.00	Can No.	

Sieve Size	Weight Retained gm.	Cum. Wt. Retained gm.	Cum. % Retained	Percent Passing
75.000	0.00	1943	0.0	100
63.000	0	1943	0.0	100
50.000	0	1943	0.0	100
37.500	0	1943	0.0	100
28.000	68	1943	3.5	97
20.000	181	1943	9.3	87
14.000	316	1943	16.3	71
10.000	269	1943	13.8	57
5.000	202	1943	10.4	47
2.000	127	1943	6.5	40
1.000	145	1943	7.5	33
0.425	212	1943	10.9	22
0.075	151	1943	7.8	14
Pass 75	272	1943	14	0



LL (%) 31 PI (%) 12

Final Soil Classification:
Silty/Clay - Sandy - GRAVEL

Reference Procedure:
AASHTO T27-99/BS 1377 Part2:1990:4.5/4.6

Remarks/Recommendation:
53% Gravel
33% Sand
14% Silt Clay

Tested by:
J.Deng
Laboratory Technician
Date: 14-Feb-23

Prepared/Checked by:
Daniel Vinansio
Sr. Lab Technician
Date: 14-Feb-23

Approved by:
Eng. Anthony Lodongi
14-Feb-23

MINISTRY OF ROADS & BRIDGES
CENTRAL MATERIALS LABORATORY
17 FEB 2023

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS AND BRIDGES
REPUBLIC OF SOUTH SUDAN

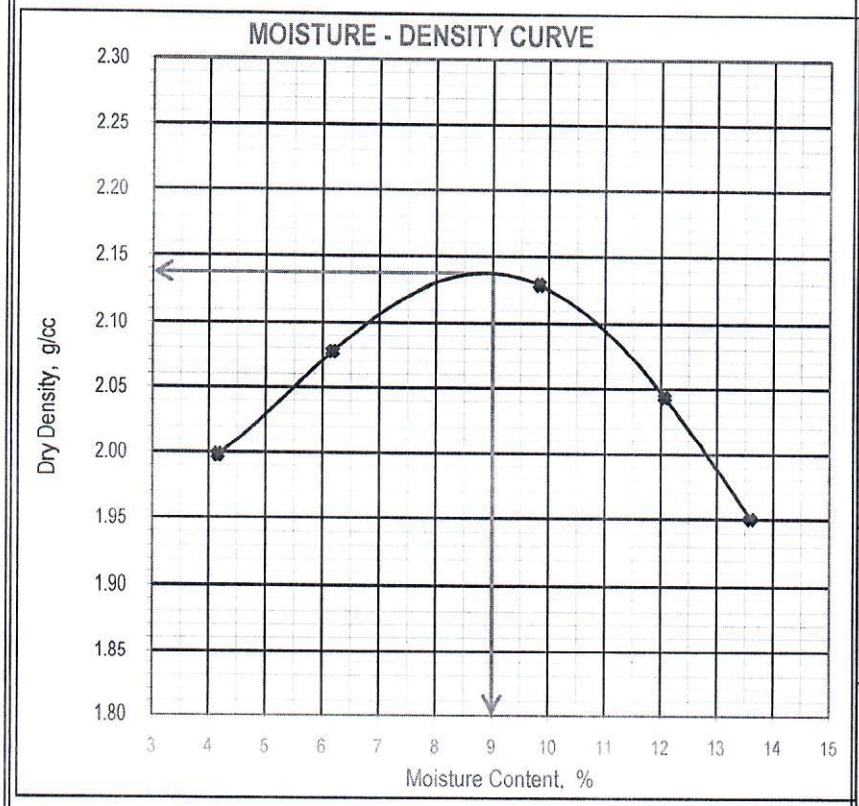
PROJECT	Prefissibility Study & Thechinical Survey for Road Cons	Lab N0.	TP-2 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	SOURCE	Borrow Pit
MATERIAL	Brown Gravel Soil	DATE OF TEST	13-Feb-23
CONSULTANT	Ladder Engineering & General Trading	CLIENT	ACTED South Sudan

DENSITY DETERMINATION

Mold Number	1	2	3	4	5	
Wt. of Mold + Wet Soil (gm)	9276	9538	9818	9716	9560	
Wt. of Mold (gm)	4898	4898	4898	4898	4898	
Wt. Of Wet Soil (gm)	4378	4640	4920	4818	4662	
Wet Density of Soil (gm/cc)	2.081	2.205	2.339	2.290	2.216	
Dry Density of Soil (gm/cc)	**1.998**	**2.077**	**2.129**	**2.043**	**1.951**	

MOISTURE DETERMINATION

Can Number	RT	M2	DX	BL	FS	
Wt. of Can and Wet Soil (gm)	175.50	176.80	163.80	177.90	167.70	
Wt. of Can and Dry Soil (gm)	169.60	168.30	150.90	162.00	150.00	
Wt. of Water (gm)	5.90	8.50	12.90	15.90	17.70	
Wt. of Can (gm)	27.70	30.60	19.80	30.30	19.90	
Wt. of Dry Soil (gm)	141.90	137.70	131.10	131.70	130.10	
Moisture Content (%)	**4.16**	**6.17**	**9.84**	**12.07**	**13.60**	



Diameter of Mold (cm)	15.20
Height of Mold (cm)	11.60
Volume of Mold (cc)	2104
Mass of Rammer (kg)	4.50
Height of Fall (cm)	457
No. of Layers	5
Blows / Layer	56
Reference Procedure	AASHTO T180
Method Used	D
Maximum Dry Density (g/cc)	**2.138**
Optimum Moisture Content (%)	**9.00**

Tested by:

Lab Team
Laboratory Technician
Date: 13-Feb-23

Prepared/Checked by:

Daniel Vinansio
Sr. Laboratory Technician
Date: 13-Feb-23

Approved by:

Eng. Anthony Lodongi
13-Feb-23

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS BRIDGES
REPUBLIC OF SOUTH SUDAN

California Bearing Ratio (CBR) AASHTO T193

PROJECT	Prefissibility Study & Thechinical Survey for Road Construction	SAMPLE NO.	TP-2 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	DATE OF PENETRATION TEST	17-Feb-23
MATERIAL	Brown Gravel Soil	SOURCE	Borrow Pit
CONSULTANT	Ladder Engineering & General Trading	CLIENT	ACTED South Sudan

CBR MOISTURE CONTENT

		Before Soaking		After Soaking		
		B7	O2	10 Blows	25 Blows	56 Blows
Tin No.	gm	176.1	174.7	170.5	157.9	169.8
Tin + wet soil	gm	164.5	163.3	157.8	146.4	157.6
Tin + dry soil	gm	30.50	30.80	27.80	27.60	27.60
Tin weight	gm	11.6	11.4	12.7	11.5	12.2
Water	gm	134.0	132.5	130.0	118.8	130.0
Dry Soil	%	8.7	8.6	9.8	9.7	9.4
M.C	%	8.6		9.6		
Average M.C						

Ring Factor 11.587

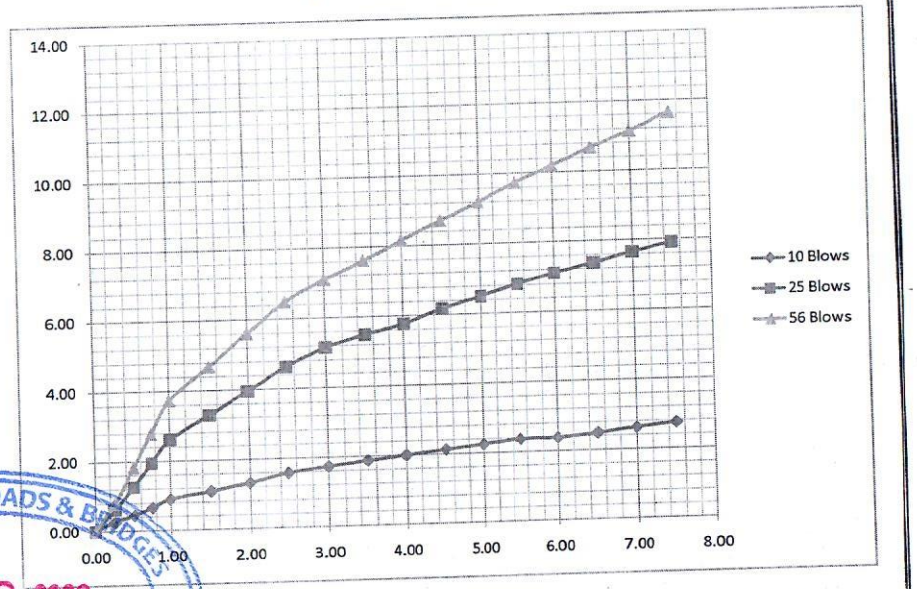
CBR COMPACTION DATA

		Before Soaking			After Soaking		
No. of Blows		10	25	56	10	25	56
Mould No.		CL	B10	AB	CL	B10	AB
Mould + Wet Soil	gm	10739	10963	11107	10809	11042	11155
Mould Weight	gm	6411	6312	6278	6411	6312	6278
Wet soil weight	gm	4328	4651	4829	4398	4730	4877
Compaction MC	%		8.6			9.6	
Dry Density	kg/m^3	1.893	2.034	2.112	1.906	2.050	2.114
compaction	%	89	95	99	89	96	99
VOLUME OF MOULD			2.105				
MDD/OMC			2.138	9.0			

STANDARD LOAD
AT 2.5 mm penetration = 13.24 kn
At 5.0 mm penetration =19.96 kn

10 Blows			25 Blows			56 Blows		
PEN(mm)	GAUGE	LOAD(Kn)	PEN(mm)	GAUGE	LOAD(Kn)	PEN(mm)	GAUGE	LOAD(Kn)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.023	0.27	0.25	0.054	0.63	0.25	0.068	0.79
0.50	0.039	0.45	0.50	0.109	1.26	0.50	0.158	1.83
0.75	0.057	0.66	0.75	0.168	1.95	0.75	0.241	2.79
1.00	0.078	0.90	1.00	0.225	2.61	1.00	0.322	3.73
1.50	0.095	1.10	1.50	0.285	3.30	1.50	0.404	4.68
2.00	0.114	1.32	2.00	0.342	3.96	2.00	0.483	5.60
2.50	0.136	1.58	2.50	0.4	4.63	2.50	0.56	6.49
3.00	0.149	1.73	3.00	0.445	5.16	3.00	0.612	7.09
3.50	0.161	1.87	3.50	0.474	5.49	3.50	0.657	7.61
4.00	0.172	1.99	4.00	0.498	5.77	4.00	0.705	8.17
4.50	0.183	2.12	4.50	0.533	6.18	4.50	0.75	8.69
5.00	0.194	2.25	5.00	0.561	6.50	5.00	0.794	9.20
5.50	0.204	2.36	5.50	0.589	6.82	5.50	0.84	9.73
6.00	0.205	2.38	6.00	0.613	7.10	6.00	0.879	10.18
6.50	0.214	2.48	6.50	0.636	7.37	6.50	0.922	10.68
7.00	0.226	2.62	7.00	0.661	7.66	7.00	0.961	11.14
7.50	0.236	2.73	7.50	0.683	7.91	7.50	1.005	11.64

LOAD 2.5	11.9		35.0		49.0
LOAD 5.0	11.3		32.6		46.1
	11.9		35.0		49.0
Initial	0.00		0.00		0.00
Final	1.00		0.00		0.00
% swell	0.01		0.00		0.00



CLIENT

MINISTRY OF ROADS & BRIDGES
CENTRAL MATERIALS LABORATORY
17 FEB 2023
MoR&B LAB

FOR CONTRACTOR

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS BRIDGES
REPUBLIC OF SOUTH SUDAN

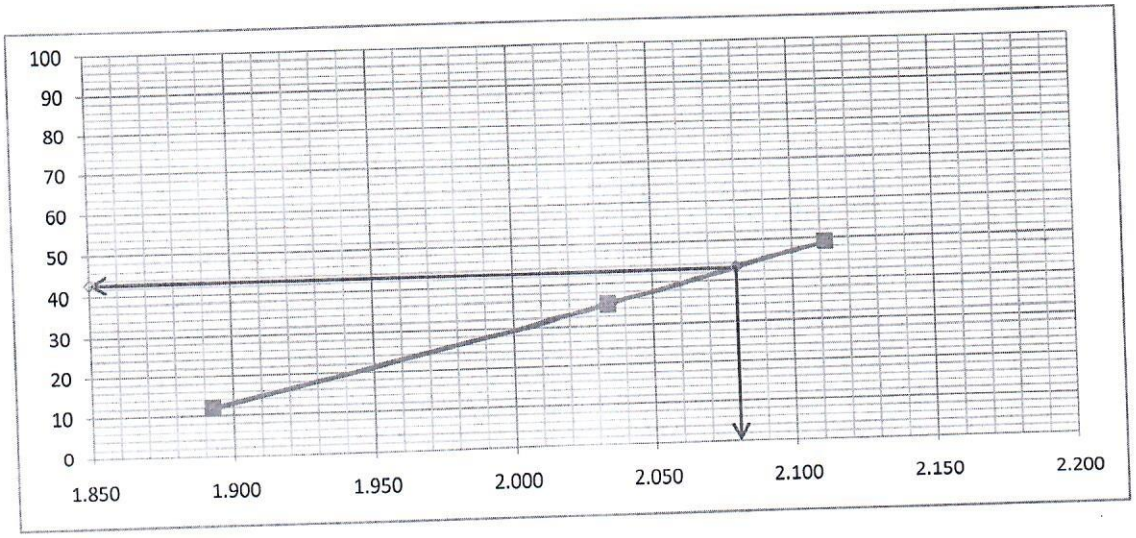
3 POINT CBR
(AASHTO T 193)

PROJECT	Prefissibility Study& Thechinical Survy for Road Construction	SAMPLE N0.	TP-2 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	DATE OF TEST	17-Feb-23
MATERIAL	Brown Gravel Soil	SOURCE	Borrow Pit
CONSULTANT	Ladder Engineering & General Trading	CLIENT	ACTED South Sudan

STANDARD MODIFIED PROCTOR TEST DATA			
MDD(gm/m^3)	**2.138**	OMC %	**9.0**

DRY DENSITY Vs C.B.R

BLOWS	DRY DENSITY	M.C	CBR(2.5mm)	CBR(5.0mm)	REPORTED CBR
10	1.893	8.6	12	11	**12**
25	2.034	8.6	35	33	**35**
56	2.112	8.6	49	46	**49**



Compaction at	CBR %	Density,gm/cm^3
100% of MDD		2.112
98% of MDD		2.070
95% of MDD	**43**	2.006

REMARKS: ----------

CLIENT

MoR&B LAB

MINISTRY OF ROADS & BRIDGES
CENTRAL MATERIALS LABORATORY
17 FEB 2023

FOR CONTRACTOR

Ministry of Roads and Bridges
Republic of South Sudan
Central Materials Testing Laboratory

Determination of Linear Shrinkage Factors

BS 1377: Part 2: 1990: 6.5

Project	Prefissibility Study & Thechinical Survey for Road Constru	**Lab No.**	Trial Pit No.(2)
Location	Maridi (Western Equaterial State)	**Date Testing**	14/2/2023
Material Type	Brown Gravel-Soil	**Depth (M)**	(1.0 M)
CONSULTANT	Ladder Engineering & General Trading	**CLIENT**	ACTED South Sudan

Location(KM) Trial Pit No.2	**2**	**2**		
Test Mould No.	XK	UD		
Initial Length (L - O) mm	140	140		
Oven Dried Length (L - D)	133	134		
Linear Shrinkage (L-O - L-D)/ L - O X 100	5.0	4.3		
Linear Shrinkage %	**5.0**	**4.3**		
Average Linear Shrinkage %	**4.6**			
Remarks				

MRB: Sr. LabTech	**Daniel Vinansio**	MRB Material Engineer	**Eng. Anthony Lodongi**
Date	14/2/2023	Date	14/2/2023

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

Central Materials Testing Laboratory
Ministry of Roads and Bridges / RSS
Republic of South Sudan -Juba

Determination of Natural Moisture Content (NMC).
ASTM D2216

Specimen Reference No.	**1**	**2**		
Depth (m)	***(1.0 M)***			
Container number	FB	HX		
Weight of wet soil + Container,g	172.9	175.5		
Weight of dry soil+ Container, g	168.1	171		
Weight of Container g	30.6	30.4		
Weight of Moisture g	4.8	4.5		
Weight of dry soil g	137.5	140.6		
	3	3		
Natural Moisture Content , %	**3**			

Project: Prefissibility Study & Thechinical Survey for Road Co
Location: Maridi (Western Equaterial State)
Consultant Ladder Engineering & General Trading
Client ACTED South Sudan

Lab. No: Trial Pit No.2
Depth (M) (1.0 m)
Material: **Brown Gravel,Soil**
Date Tested: **13/2/2023**

Consultant: .....

Contractor:.....

REMARK

Reported & Checked by:
MRB: Sr.Lab Technician:
Daniel Vinansio.T

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

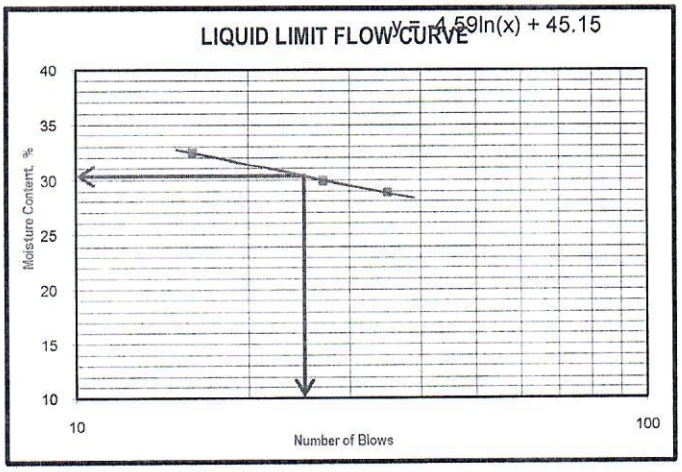
Approved by Lab Manager
MRB Eng. Anthony Lodongi

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS BRIDGES
REPPUBLIC OF SOUTH SUDAN

PROJECT	Prefissibility Study & Thechinical Survey for Road Construction	SAMPLE N0	TP-1 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	DATE OF TEST	14-Feb-23
MATERIAL	Brown Gravel Soil	SOURCE	Borrow Pit
CONSULTANT	Ladder Engineering & General Trading	CLIENT	ACTED South Sudan

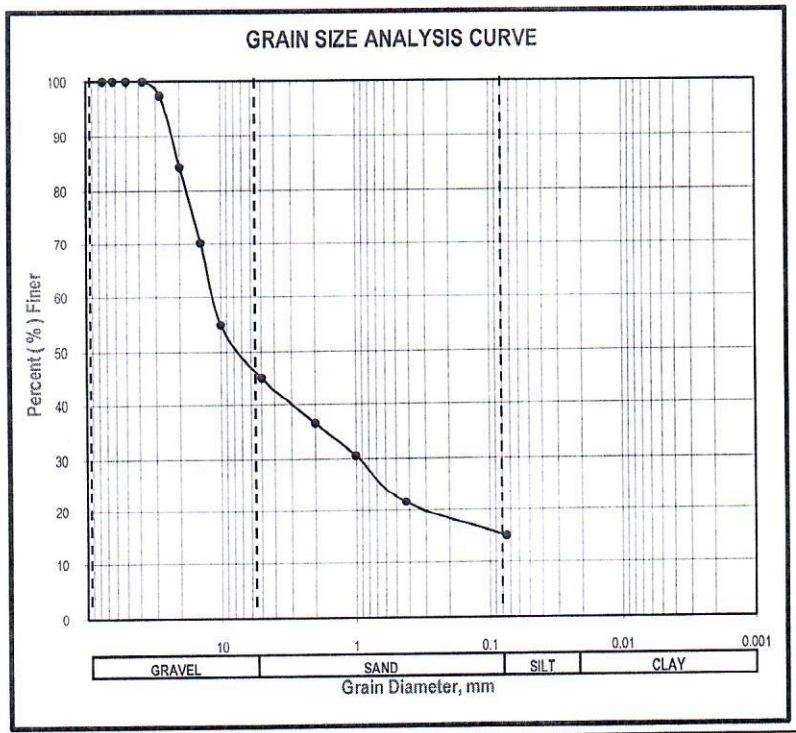
TEST REPORT ON NATURAL MOISTURE CONTENT ATTERBERG LIMIT, AND GRAIN SIZE ANALYSIS OF SOILS

TYPE OF TEST		NMC	Liquid Limit			Plastic Limit		
			1	2	3	1	2	4
Can Number			U1	X5	D2	U8		X3
Weight of Can + Wet Soil (gm)	A		33.3	35.1	34.6	22.5		23.0
Weight of Can + Dry Soil (gm)	B		28.5	30.7	30.3	21.2		21.7
Weight of Water (gm)	(A-B)		5	4	4	1		1
Weight of Can (gm)	C		14.8	14.7	14.9	14.8		14.7
Weight of Dry Soil (gm)	(B-C)		14	16	15	6.4		7.0
Moisture Content (%)	(A-B)/(B-C)*100		32	30	29	20		19
Number of Blows			16	27	35		19	



Wt. of O.D. Spl (gm)	2022.00	Can No.	

Sieve Size	Weight Retained gm.	Cum. Wt. Retained gm.	Cum. % Retained	Percent Passing
75.000	0.00	2022	0.0	100
63.000	0	2022	0.0	100
50.000	0	2022	0.0	100
37.500	0	2022	0.0	100
28.000	49	2022	2.4	98
20.000	267	2022	13.2	84
14.000	288	2022	14.2	70
10.000	308	2022	15.2	55
5.000	201	2022	9.9	45
2.000	168	2022	8.3	37
1.000	122	2022	6.0	31
0.425	185	2022	9.1	21
0.075	128	2022	6.3	15
Pass 75	306	2022	15	0



LL (%) 30 PI (%) 11

Final Soil Classification:
Silty/Clay - Sandy - GRAVEL

Reference Procedure:
AASHTO T27-99/BS 1377 Part2:1990:4.5/4.6

Remarks/Recommendation:
55% Gravel
30% Sand
15% Silt Clay

Tested by:
J.Deng
Laboratory Technician
Date: 14-Feb-23

Prepared/Checked by:
Daniel Vinansio
Sr. Lab Technician
Date: 14-Feb-23

Approved by:
Eng. Anthony Lodongi
14-Feb-23

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS AND BRIDGES
REPUBLIC OF SOUTH SUDAN

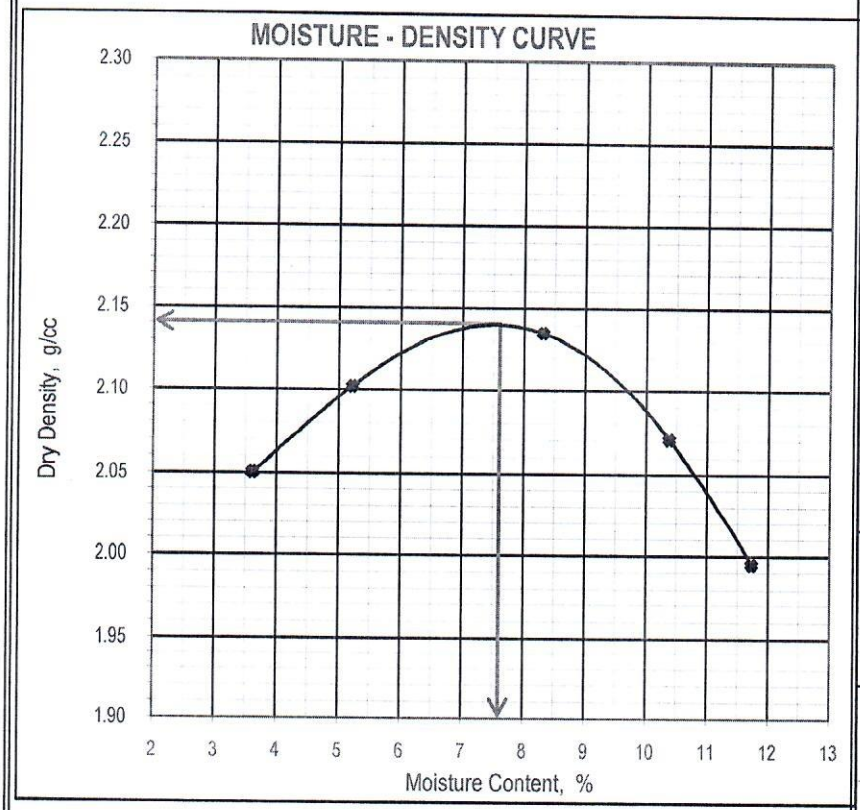
PROJECT	Prefissibility Study & Thechinical Survey for Road Cons	Lab N0.	TP-1 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	SOURCE	Borrow Pit
MATERIAL	Brown Gravel Soil	DATE OF TEST	13-Feb-23
CLIENT	Ladder Engineering & General Trading	Client	ACTED South Sudan

DENSITY DETERMINATION

Mold Number	1	2	3	4	5	
Wt. of Mold + Wet Soil (gm)	9372	9556	9768	9712	9593	
Wt. of Mold (gm)	4903	4903	4903	4903	4903	
Wt. Of Wet Soil (gm)	4469	4653	4865	4809	4690	
Wet Density of Soil (gm/cc)	2.124	2.212	2.312	2.286	2.229	
Dry Density of Soil (gm/cc)	**2.050**	**2.102**	**2.135**	**2.071**	**1.995**	

MOISTURE DETERMINATION

Can Number	P3	M2	DL	CD	O2	
Wt. of Can and Wet Soil (gm)	171.20	169.60	173.60	169.90	166.80	
Wt. of Can and Dry Soil (gm)	166.30	162.70	162.60	156.10	152.20	
Wt. of Water (gm)	4.90	6.90	11.00	13.80	14.60	
Wt. of Can (gm)	30.60	30.40	30.20	23.20	27.80	
Wt. of Dry Soil (gm)	135.70	132.30	132.40	132.90	124.40	
Moisture Content (%)	**3.61**	**5.22**	**8.31**	**10.38**	**11.74**	



Diameter of Mold (cm)	15.20
Height of Mold (cm)	11.60
Volume of Mold (cc)	2104
Mass of Rammer (kg)	4.50
Height of Fall (cm)	457
No. of Layers	5
Blows / Layer	56
Reference Procedure	AASHTO T180
Method Used	D
Maximum Dry Density (g/cc)	**2.141**
Optimum Moisture Content (%)	7.60

Tested by:

Lab Team
Laboratory Technician
Date: 13-Feb-23

Prepared/Checked by:

Daniel Vinansio
Sr. Laboratory Technician
Date: 13-Feb-23

Approved by:

MINISTRY OF ROADS & BRIDGES
CENTRAL MATERIALS LABORATORY

Eng.Anthony Lodongi
13-Feb-23
17 FEB 2023

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS BRIDGES
REPUBLIC OF SOUTH SUDAN

California Bearing Ratio (CBR) AASHTO T193

PROJECT	Prefissibility Study & Thechinical Survey for Road Construction	SAMPLE N0.	TP-1 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	DATE OF PENETRATION TEST	17-Feb-23
MATERIAL	Brown Gravel Soil	SOURCE	Borrow Pit
CONSULTANT	Ladder Engineering & General Trading	CLIENT	ACTED South Sudan

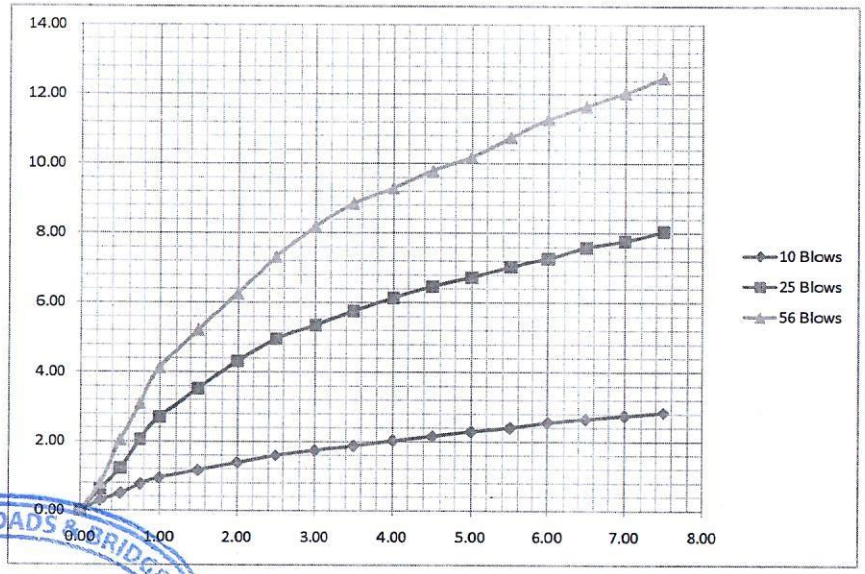
CBR MOISTURE CONTENT								
				Before Soaking		After Soaking		
Tin No.	gm			B2	14D	10 Blows	25 Blows	56 Blows
Tin + wet soil	gm			164.5	167.3	159.9	168.4	162.5
Tin + dry soil	gm			155.1	158.2	149.3	157.7	152.7
Tin weight	gm			22.90	23.20	19.80	19.90	19.80
Water	gm			9.4	9.1	10.6	10.7	9.8
Dry Soil	%			132.2	135.0	129.5	137.8	132.9
M.C	%			7.1	6.7	8.2	7.8	7.4
Average M.C				6.9		7.8		
Ring Factor	11.587							

CBR COMPACTION DATA							
		Before Soaking			After Soaking		
No. of Blows		10	25	56	10	25	56
Mould No.		D6	EO	C8	D6	EO	C8
Mould + Wet Soil	gm	10631	11018	11253	10723	11128	11300
Mould Weight	gm	6333	6430	6436	6333	6430	6436
Wet soil weight	gm	4298	4588	4817	4390	4698	4864
Compaction MC	%		6.9			7.8	
Dry Density	kg/m^3	1.910	2.038	2.140	1.935	2.071	2.144
compaction	%	89	95	100	90	97	100
VOLUME OF MOULD			2.105				
MDD/OMC			2.141	7.6			

10 Blows			25 Blows			56 Blows		
PEN(mm)	GAUGE	LOAD(Kn)	PEN(mm)	GAUGE	LOAD(Kn)	PEN(mm)	GAUGE	LOAD(Kn)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.025	0.29	0.25	0.054	0.63	0.25	0.069	0.80
0.50	0.043	0.50	0.50	0.106	1.23	0.50	0.176	2.04
0.75	0.066	0.76	0.75	0.178	2.06	0.75	0.268	3.11
1.00	0.082	0.95	1.00	0.234	2.71	1.00	0.357	4.14
1.50	0.101	1.17	1.50	0.305	3.53	1.50	0.45	5.21
2.00	0.12	1.39	2.00	0.373	4.32	2.00	0.541	6.27
2.50	0.138	1.60	2.50	0.428	4.96	2.50	0.632	7.32
3.00	0.151	1.75	3.00	0.462	5.35	3.00	0.707	8.19
3.50	0.162	1.88	3.50	0.497	5.76	3.50	0.764	8.85
4.00	0.175	2.03	4.00	0.53	6.14	4.00	0.802	9.29
4.50	0.186	2.16	4.50	0.558	6.47	4.50	0.845	9.79
5.00	0.198	2.29	5.00	0.581	6.73	5.00	0.879	10.18
5.50	0.208	2.41	5.50	0.607	7.03	5.50	0.928	10.75
6.00	0.22	2.55	6.00	0.628	7.28	6.00	0.973	11.27
6.50	0.229	2.65	6.50	0.655	7.59	6.50	1.006	11.66
7.00	0.237	2.75	7.00	0.671	7.77	7.00	1.039	12.04
7.50	0.245	2.84	7.50	0.695	8.05	7.50	1.077	12.48

LOAD 2.5	12.1		37.5		55.3
LOAD 5.0	11.5		33.7		51.0
	12.1		**37.5**		**55.3**
Initial	0.00		0.00		0.00
Final	1.00		0.00		0.00
% swell	0.01		0.00		0.00

STANDARD LOAD
AT 2.5 mm penetration = 13.24 kn
At 5.0 mm penetration =19.96 kn



CLIENT

MoR&B LAB

FOR CONTRACTOR

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

CENTRAL MATERIALS LABORATORY
MINISTRY OF ROADS BRIDGES
REPUBLIC OF SOUTH SUDAN

3 POINT CBR
(AASHTO T 193)

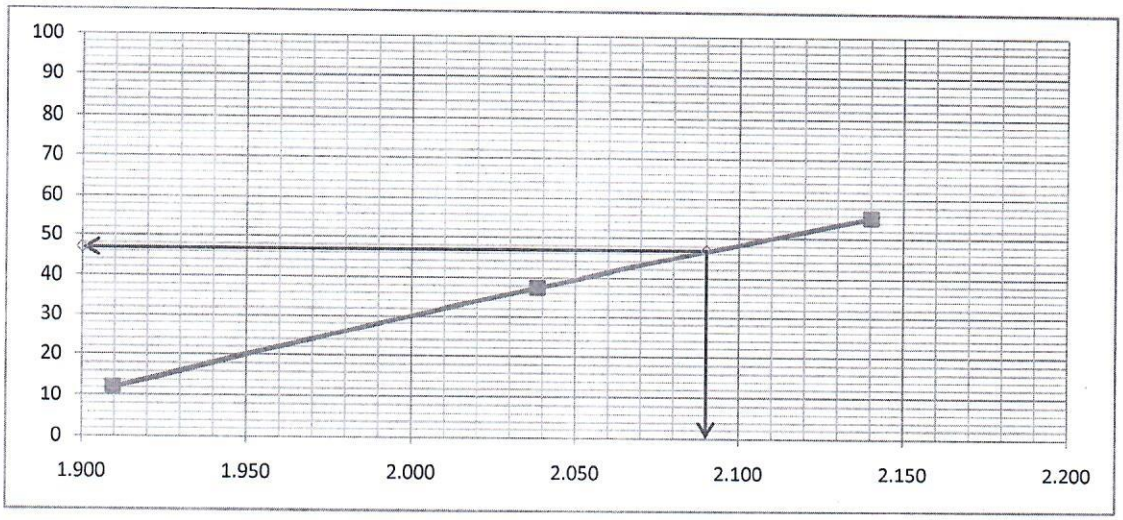
PROJECT	Prefissibility Study & Thechinical Survey for Road Construction	SAMPLE N0.	TP-1 (DEPTH: 1.0 M)
LOCATION	Maridi (Western Equaterial State)	DATE OF TEST	17-Feb-23
MATERIAL	Brown Gravel Soil	SOURCE	Borrow Pit
CONSULTANT	Ladder Engineering & General Trading	CLIENT	ACTED South Sudan

STANDARD MODIFIED PROCTOR TEST DATA

MDD(gm/m^3)	**2.141**	OMC %	**7.6**

DRY DENSITY Vs C.B.R

BLOWS	DRY DENSITY	M.C	CBR(2.5mm)	CBR(5.0mm)	REPORTED CBR
10	1.910	6.9	12	11	**12**
25	2.038	6.9	37	34	**37**
56	2.140	6.9	55	51	**55**



Compaction at	CBR %	Density,gm/cm^3
100% of MDD		2.140
98% of MDD		2.097
95% of MDD	**47**	2.033

REMARKS: ----------

CLIENT | MoR&B LAB | FOR CONTRACTOR

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

Ministry of Roads and Bridges
Republic of South Sudan
Central Materials Testing Laboratory

Determination of Linear Shrinkage Factors

BS 1377: Part 2: 1990: 6.5

Project	Prefissibility Study & Thechinical Survey for Road Constru	**Lab No.**	Trial Pit No.(1)
Location	Maridi (Western Equaterial State)	**Date Testing**	14/2/2023
Material Type	Brown Gravel-Soil	**Depth (M)**	(1.0 M)
CONSULTANT	Ladder Engineering & General Trading	**CLIENT**	ACTED South Sudan

Location(KM) Trial Pit No.1	**1**	**1**		
Test Mould No.	H	W		
Initial Length (L - O) mm	140	140		
Oven Dried Length (L - D)	135	134		
Linear Shrinkage (L-O - L-D)/ L - O X 100	3.6	4.3		
Linear Shrinkage %	**3.6**	**4.3**		
Average Linear Shrinkage %	**3.9**			
Remarks				

MRB: Sr. LabTech	**Daniel Vinansio**	MRB Material Engineer	**Eng. Anthony Lodongi**
Date	14/2/2023	Date	14/2/2023

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

Central Materials Testing Laboratory
Ministry of Roads and Bridges / RSS
Republic of South Sudan -Juba

Determination of Natural Moisture Content (NMC).
ASTM D2216

Specimen Reference No.	**1**	**2**		
Depth (m)	***(1.0 M)***			
Container number	DC	O2		
Weight of wet soil + Container,g	175.4	177.1		
Weight of dry soil+ Container, g	170.3	171.2		
Weight of Container g	30.2	30.5		
Weight of Moisture g	5.1	5.9		
Weight of dry soil g	140.1	140.7		
	4	4		
Natural Moisture Content , %	**4**			

Project: Prefissibility Study & Thechinical Survey for Road Co
Location: Maridi (Western Equaterial State)
Consultant Ladder Engineering & General Trading
Client ACTED South Sudan

Lab. No: Trial Pit No.1
Depth (M) (1.0 m)
Material: **Brown Gravel,Soil**
Date Tested: **13/2/2023**

Consultant: .....

Contractor:.....

REMARK

Reported & Checked by:
MRB: Sr.Lab Technician:
Daniel Vinansio.T

MINISTRY OF ROADS & BRIDGES
17 FEB 2023
CENTRAL MATERIALS LABORATORY

Approved by Lab Manager
MRB Eng. Anthony Lodongi