EXPERIMENTAL INVESTIGATION ON SOIL SUITABILITY OF THE EARTHEN DAM

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ABSTRACT

A dam is an engineering structure constructed on a river or stream to divert, or store water for the purpose of water supply energy generation, irrigation, flood control, ground water recharge, conservation, storage and recreation among others. Concrete and Embankment are two generic types of dams, amongst which embankment dams being the first choice for technical as well as economical reasons. Rock fill and Earthen dam being the principal variants of embankment dams, the present work focuses on suggesting soil suitability and slope stability analysis using software for a proposed earth dam construction "Earthen Dams or Earth dams are the dams which are built of compacted soil or rock fragments". Dam failure constitutes a potential hazard to downstream life and property and can result in unacceptable fatalities and economic damage. A failure of earth dam is basically involves a seepage failure or a structural failure. Thus the design and construction of an earthen dam is one of the key challenges in the field of geotechnical engineering.The proposed earth dam considered herein is a zoned dam that is composed of the central impermeable core and flanked by more pervious shells. This project thus briefs about a theoretical background of earthen dam, its components, classification, modes of failures, and principles adopted for governing safety of dam pre and post construction. The project work is comprised of thorough experimental investigation as per IS codes to suggest suitability amongst 6 soil samples viz; 4 core samples and 2 casing samples Based on detailed laboratory investigation out of 4 core samples only 2 with classification as SC and SM, are recommended to be fairly suitable, however, laboratory investigation suggests unsuitability of the 2 casing samples received. Thus a thorough laboratory investigation facilitated a reliable and stability of proposed earthen dam.

Keywords: Earthen dam , Stability, Suitability, Failure, Strength

I. INTRODUCTION

The construction of a dam ranks 1st with the earliest and most fundamental of civil engineering activities. All great civilizations have been identified with the construction of storage reservoirs appropriate to their needs, in the earliest instances to satisfy

irrigation demands arising through the development and expansion of organized agriculture. Operating within constraints imposed by local circumstances, notably severe climate and terrain, the economic power of successive civilizations were related to proficiency in water engineering. Prosperity, health and material progress became increasingly linked to the ability to store and direct water.The primary purpose of a dam may be defined as to provide for the safe retention and storage of water. As a corollary to this every dam must represent a design solution specific to its site circumstances. The design therefore also represents an optimum balance of local technical and economic considerations at the time of construction. The entire body of an earthen dam is made up of various types of earth such as clay, silt, gravel. Earthen dams are commonly used in many countries because of their simplicity in construction and maintenance. Also, earthen dams can be built on virtually any type of ground base (except strongly liquescent muddy soil). Amongst various types of earth structures like earth fills, earth embankments, earthen dam is the most complex. It is to be noted that, dams of height less than 15 m are called small dams and height more than 15 m are called large dams. Dam failures are comparatively rare, but can cause immense damage and loss of life when they occur. Dams are considered as 'installations containing dangerous forces' under International Humanitarian Law due to massive impact of possible destruction on the civilian population and environment. The most significant issue associated with dam failure involves the properties and populations in the inundation zones. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failure. These events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard. There are numerous causes of failure of earthen dam broadly categorized as; Hydraulic failure, Seepage failure and Structural failure

Percentage of dam failure in past due to respective causes of failure

Cause of failure	Percentage of dam failure in the pas (%)
Overtopping	30%
Erosion of upstream slope by waves	5%
Piping	23%
Conduit leakage	13%
Sloughing	2%
Sliding of upstream and downstream slopes	15%
Liquefaction slides	3%
Other	9%

Objectives:

1) Detailed experimental investigation on four core and two casing samples received from dam site to ensure suitable and unsuitability of soil samples for core and casing.Thorough experimental investigation of locally available soil samples include determination of Index Properties namely; specific gravity, wet sieve analysis, consistency limits and classify soil accordingly. Engineering properties such as maximum dry density and optimum moisture content using light compaction test (Standard Proctor Test), direct shear test to measure shear strength properties and triaxial shear test to measure mechanical properties of deformable soil has also been carried out. Furthermore, consolidation test to determine settlement of soil due to primary consolidation has also been performed

II. EXPERIMENTAL WORK

The experimental work consists of the following steps:

1 Classification of soil as per indian standard classification system
2 Determination of soil index properties (Atterberg Limits)
i) i)Liquid limit by Casagrande's apparatus
ii) ii)Plastic limit
3 Determination of specific gravity of soil
4 Determination of shear strength by:
i) i) Direct shear test (DST)
ii) ii)Triaxial test (TST)
5 Determination of coefficient of consolidation
6 Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test

III. RESULTS AND DISCUSSION

Samples from two locations/ quarries (Q1 and Q2) were received and details are given

Details of soil samples from proposed dam site

Sr. No	Field Identification	Sample No	Weight of sample Received (kg)	Sample testi as
1	Q1 - ¼	1(13806)	16.30	Core
2	Q1 - 2/4	2(13807)	18.25	Core
3	Q1 - ¾	3(13808)	16.45	Casing
4	Q1 - 4/4	4(13809)	14.85	Core
5	Q2 - ½	5(13810)	19.20	Casing

6	Q2 - 2/2	6(13811)	21.50	Core

Results of Soil Classification

Particle size / Sample no.	1 13806	2 13807	3 13808	4 13809	5 13810	6 13811
Gravel	0	0	0	0	0	0
Sand	17.06	24.62	51.75	7.5	53	36.965
Silt	81.96	73.3	38.69	88.98	45.69	63.04
Clay	0.98	2.08	9.56	3.52	1.3	0
Classification	MH	MH	SC	MH	SM	ML

Suitability of Soils for Construction of Earthen Dams (IS 8826:1978):

Relative suitability	Homogeneou dykes	Zoned earth dam		Impervious blanket
		Impervious co	Pervious casing	
Very suitable	GC	GC	SW, GW	GC
Suitable	CL, CI	CL, CI	GM	CL, CI
Fairly suitable	SP, SM, CH	GM, GC, SM SC, CH	SP, GP	CH, CM, SC, GC
Poor	-	ML, MI, MH	-	-
Not suitable	-	OL, OI, OH	-	-

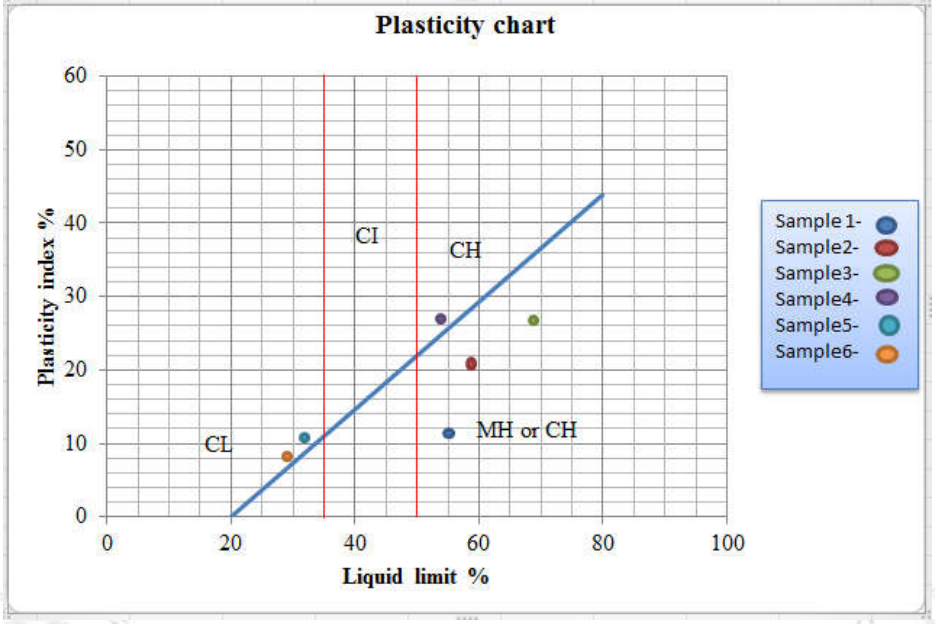
Results of Specific Gravity

Sample no	1 (13806)	2 (13807)	3 (13808)	4 (13809)	5 (13810)	6 (13811)
Specific gravity	2.52	2.48	2.52	2.41	2.27	2.37
Type of so	Organic so	Organic so	Organic so	Organic so	Organic so	Organic so

Soil Classification Based on Specific Gravity

Type of soil	Specific gravity range
Gravel and Sand	2.65-2.68
Silty sand and Silts	2.66-2.70

Inorganic clay	2.70-2.80
Organic soils	Variable, may be below 2
Soil with high mica, iro	2.75-2.85



Plasticity chart

Result for Liquid limit and Plastic Limit

Serial Numbe	Sampl Numbe	Liquid Limi (%)	Plastic Limit (%)	Plasticity Index
1.	1-(1380	60	43.75	11.25
2.	2-(1380	59.4	37.08	21.32
3.	3-(1380	72	41.6	26.9
4.	4-(1380	56	27.08	27.12
5.	5-(1381	33	19.8	11
6.	6-(1381	31	29.57	8.59

Soil Classification

Silts and Clay (Liquid limit 50% o less)			Silts and clay (Liquid limit > 50%		
ML	CL	OL	MH	CH	OH
M= Silts	C= Clay	O= Organi	M= Silts	C= Clay	O= Organi
Inorganic	Inorganic	Organic	Inorganic	Inorganic	Organic

silts verifying sand or clayey fine sand.	clays, Gravelly clays, silty clays and sandy clays.	silts and organic silty clays of low plasticity.	silts, elastic silts.	clay of high plasticity.	clays of medium to high Plasticity.

Results of OMC and MDD

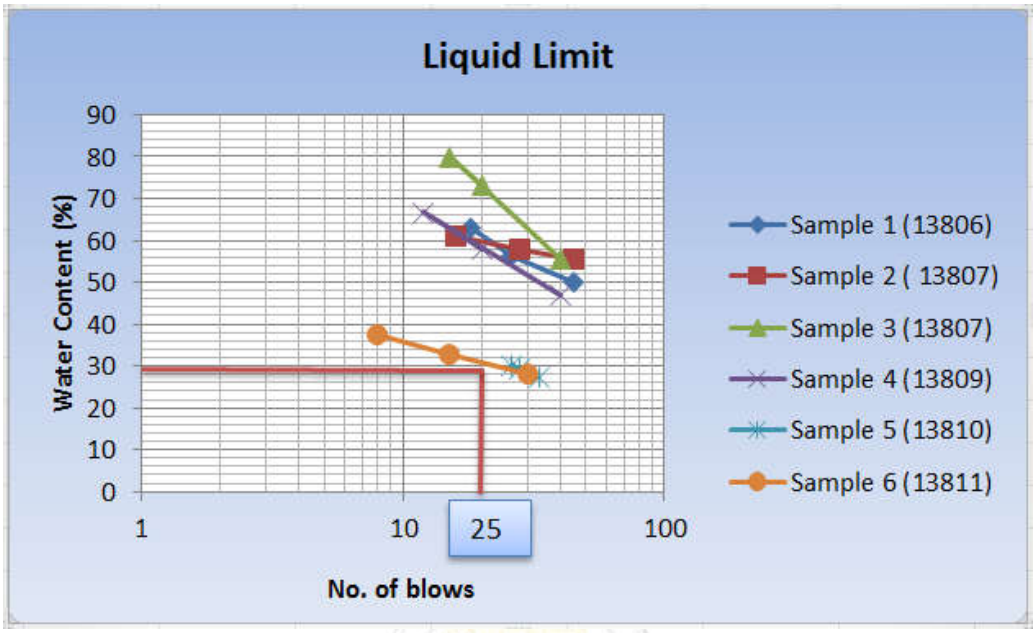
Sample no	1 (13806)	2 (13807)	3 (13808)	4 (13809)	5 (13810)	6 (13811)
Optimum moisture content (%)	25.03	27.20	25.50	27.90	14.1	18.35
Maximum dry density (gm/cc)	1.5507	1.4724	1.4724	1.451	1.8387	1.8681

Results of Triaxial Shear Tests- CU TEST

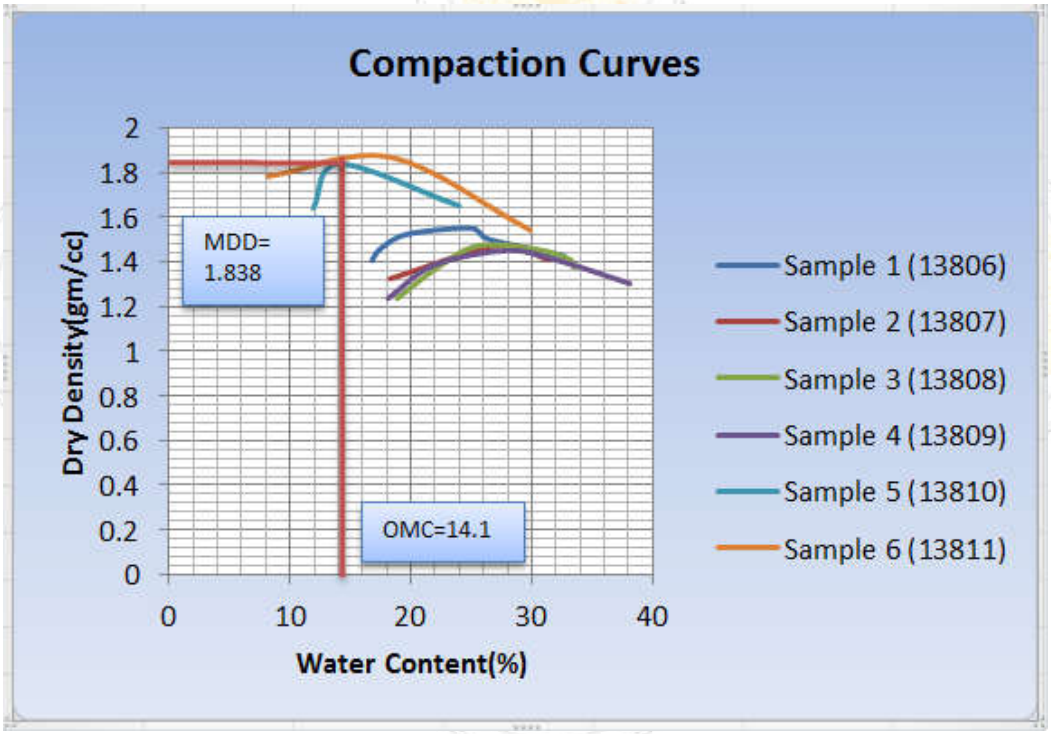
Sample no.	1 13806	2 13807	3 13808	4 13809	5 13810	6 13811
Total Cohesion (kg/cm^2)C	0.0725		1.005		0.4243	0.764
Total Friction Angle (deg.)	15.3075		7.2962		30.9306	25.5945

Result of Consolidation Test

Sample No.	1 (13806)	2 (13807)	3 (13808)	4 (13809)	5 (13810)	6 (13811)
Coefficient Consolidation (c cm^2/min	0.042	0.0	0.024	0.0116	0.023	0.093
Compression Index (cc)	0.05	0.0	0.12	0.055	0.016	0.043



Liquid Limit



Compaction Curve

IV. CONCLUSION

This project work resulted in providing a reliable and economical solution by recommending soil suitability as core and casing material for a proposed earthen dam. Based on experimental investigation carried out as per IS 8826:1978 the following

recommendations are made:

a. Sample No. 13808 (sample 3) (SC) and Sample No. 13810 (sample 5) (SM) are fairly suitable to be used as impervious core for zoned earthen dam

b. Sample No.13806 (1) MH, Sample No.13807 (2) MH, Sample No.13809 (4) MH, Sample No.13811 (6) ML are poorly suitable to be used as impervious core of zoned earthen dam

c. Sample no 13808(3), 13810(5) are found unsuitable for use as casing material of zoned earthen dam.

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