

STUDY ON EFFECT OF COASTAL DIVERSITY ON EXITING PAVAMENT

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering Degree in Civil Engineering

by

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DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF BUILDING AND ENVIRONMENT

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonfire work of **KOWSHIKA K** (Reg. No. 37200033) and **MENAKASWAMY M** (Reg. No.37200041) who carried out the project entitled “STUDY ON EFFECT OF COASTAL DIVERSITY ON EXISTING PAVEMENT” under our supervision from DECEMBER 2020 to MARCH 2021.

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Submitted for Viva Voce Examination held on _____

Internal Examiner

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DECLARATION

We, **KOWSHIKA K** (Reg. No. 37200033) and **MENAKASWAMY M** (Reg. No.37200041) hereby declare that the project entitled “**STUDY ON EFFECT OF COASTAL DIVERSITY ON EXISTING PAVEMENT**” done by us under the guidance of **Mrs M. PRABA** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

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ABSTRACT

Pavements are the vital source for every human being for travelling from one place to another place for various reasons. Nowadays due to rapid urbanization all over the country, the coastal regions are also used to connect big cities with the help of pavements. The coastal region vastly differs in the geographical arrangement when compared with the usual region. Those geographical parameters will affect the coastal pavement in a wider range. The major factors which influence the pavement to fail are constant groundwater table increase, soil type and improper mix design. The coastal regions are prone to Sea – Level Rise which will increase the groundwater level persistently in the following years. When the groundwater is raised by the sea increase the pavement will lose its stability since the coastal soil is subjected to bulking when reacted with water. This will consequently decrease the bearing strength of the subgrade which in turn deteriorates the pavement stability. The study carried out in the coastal rigid pavement identified the factors which affect the pavement quality in a seashore region. The study concluded that there should be a separate IS standards for designing a pavement in a coastal region for a durable pavement.

Keywords: Rigid Pavement, Sea-Level Rise, Groundwater level, Subgrade, Concrete quality.

CONTENTS

CHAPTER No.	TITLE	PAGE No.
	ABSTRACT	V
	LIST OF TABLES	VIII
	LIST OF FIGURES	IX
	LIST OF SYMBLOS AND ABBERVATIONS	X
1	INTRODUCTION	
	1.1 General	1
	1.1.1 Rigid pavement	1
2	LITERATURE SURVEY AND METHODOLOGY	
	2.1 Literature Survey	2
	2.2 Methodology	5
3	AIM AND SCOPE OF THE STUDY	
	3.1 Aim	6
	3.2 Objective	6
	3.3 Scope of the study	6
4	STUDY AREA AND EXPERIMENTAL ANALYSIS	
	1 Study Area	7
	4.1.1 Failures observed in coastal rigid pavement	8
	4.1.2 Relationship between SLR and groundwater level	10
	4.1.2.1 Findings from the above analysis	12

4.2	Experimental analysis of study area soil property	13
4.1.3	Soil testing and analysis	13
4.1.3.1	Sieve analysis	14
4.1.3.2	Standard proctor density	15
4.1.3.3	Specific gravity	18
4.1.3.4	Atterberg limits	18
4.1.3.5	California Bearing Ratio (CBR) test	19
4.1.4	Experimental analysis of study area groundwater characteristics	22
4.1.4.1	Electrical Conductivity test	22
4.1.4.2	Parameter limit	24
4.1.5	Non–Destructive tests conducted on study area rigid pavement	26
4.1.5.1	Rebound Hammer test	26
4.1.5.2	Ultrasonic pulse velocity test	29
5	RESULTS AND DISCUSSION, PERFORMANCE ANALYSIS	33
6	CONCLUSION AND RECOMMENDATIONS	34
	REFERENCE	36
	APPENDIX A	37
	APPENDIX B	38
	APPENDIX C	39
	APPENDIX D	40
	APPENDIX E	41

LIST OF TABLES

TABLE No.	TITLE	PAGE No.
4.1	Description of Study Area.	6
4.2	Groundwater level data for the average of 10 years in metre.	10
4.3	Result of sieve analysis.	14
4.4	Tabulation of proctor density test.	16
4.5	Specific gravity test results.	17
4.6	California Bearing Ratio test results	20
4.7	Other parameters of water sample.	23
4.8	pH limit for water.	24
4.9	TDS limits for water.	24
4.10	Limits for hardness determination of water.	24
4.11	Limits for Sulphate content in water.	25
4.12	Limits for Ammonia content in water.	25
4.13	Salinity range.	25
4.14	Rebound Hammer Test Reading.	28
4.15	Test results of UPV	31

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
4.1	Study Area	7
4.2	Scaling of Cement Concrete	8
4.3	Joint Spalling in Rigid Pavement	8
4.4	Segregation of aggregates	9
4.5	Edge Breaking	9
4.6	Mean Sea Level (MSL) – Source: PSMSL	11
4.7	Graphical Representation of Groundwater level fluctuation	12
4.8	Soil sample collection	13
4.9	15 kg of sample	13
4.10	Mechanical shaker	14
4.11	Weighing machine	14
4.12	Texture triangle	15
4.13	Proctor standard density testing apparatus	16
4.14	Graphical representation of proctor density test.	19
4.15	California Bearing Ratio testing apparatus	18
4.16	Graphical representation of CBR test results	21
4.17	Water Sampling	22
4.18	Diagrammatic representation of rebound hammer	26

4.19	Performing Rebound Hammer Test	27
4.20	Impact Energy of Rebound Hammers	27
4.21	Graphical representation of Rebound Hammer test results	28
4.22	Diagrammatic representation of UPV test setup	29
4.23	Working of UPV test by Indirect method	29
4.24	Working of UPV test by Indirect method	29
4.25	Performing UPV test in study area	30
4.26	Calibration checking	30
4.27	Graphical representation of UPV test result	31
4.28	Velocity criterion for UPV as per IS: 516 (Part 5)	32

LIST OF SYMBOLS AND ABBREVIATIONS

NDT	Non-Destructive Test
JPCD	Jointed Plain Concrete Pavement
AASTHO	American Association of State Highway and Transportation Officials
ASTM	American Society Testing Material
JRCP	Jointed Reinforced Concrete Pavement
CRCP	Continuous Reinforced Concrete Pavement
PCP	Pre-Stressed Concrete Pavement
NCCR	National contra for Coastal Research
CBR	California Bearing Ratio
OMC	Optimum Moisture Content
MDD	Maximum Dry Density
SGSWRDC	State Ground and Surface Water Resource Data Centre
pH	Potential of hydrogen (or) Power of Hydrogen
TDS	Total dissolved solids
EC	Electrical conductivity
APHA	American public health association

UPV	Ultrasonic pulse velocity
m	Metre
mm	Millimetre
cm	Centimetre
l	Litre
KN	Kilonewton
N	Newton
G	Gram
Kg	Kilogram
mg	Milligram

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Pavements are generally designed for primary use by vehicular and pedestrian traffic. There are various factors which affects the pavement performance. Among those the subgrade strength is the important factor. Different types of subgrade soil possess different strength characteristics. A subgrade is expected to withstand the loads transmitted from the pavement. This load bearing capacity is often affected by degree of compaction, moisture content and soil type. A subgrade that can support a high amount of loading without excessive deformation is considered good.

In this regard, the coastal region differs in the major pavement strength factors when compared with the normal land. The main challenges of coastal pavements other than subgrade is water logging and varying ground water table level due to sea level fluctuations and comparatively higher precipitation rate.

1.1.1 RIGID PAVEMENT

Rigid pavement is a concrete pavement which is made up of Portland cement, fine aggregate, coarse aggregate. Sometimes the rigid pavements are reinforced with steel rod or mesh to add additional load carrying capacity to the pavement structure. Normally rigid pavements are ready to traffic after 14days of curing process. Rigid pavement exhibits high flexural strength when the load acts in it. The maintenance cost of rigid pavement is comparatively lower than flexible pavement. Rigid pavements are classified based on the reinforcement provided in it. They are listed below:

1. Jointed Plain concrete Pavement (JPCP),
2. Jointed Reinforced Concrete Pavement (JRCP),
3. Continuous Reinforced Concrete Pavement (CRCP), and
4. Pre-Stressed Concrete Pavement.

CHAPTER 2

LITERATURE SURVEY AND METHODOLOGY

2.1 LITERATURE SURVEY

Jayne F. Knott, et.al (2017)

This study states that the coastal roads are affected by the sea level rise caused by the climate change. This research is carried out based on a case study of New Hampshire city which is near the coast. The study states that the groundwater rise due to the sea level rise will affect the unbound layers of coastal pavement resulting in the reduced service life of pavement. The USGS MODFLOW-2005 model was used to locate the groundwater level rise caused due to the sea level increase. The results of this study show how the pavements get affected due to the groundwater table increase and provides a framework to identify the effect in different layers of pavements.

Dale Harrington, et.al (2018)

The authors prepared a guide for identifying concrete pavement distress, causes and prevention of distress. It gives clear vision about the types of concrete pavements and their components. In this they stated all the possible reasons for a pavement distress. This publication also describes the various tests that are carried out for materials used in pavement and also for the pavement related tests like NDT tests. This guide also provides more information regarding the overlay types in pavements and their application. The tests and the interpretation of results are tabulated as per AASTHO and ASTM specifications.

Janaga.Vijay, Potlapelli.Avinash (2016)

The subgrade properties of different type of soils are discussed and their characteristics are identified. To identify the subgrade property the lab tests are conducted. The lab tests include moisture content test, specific gravity test, atterberg limit and compaction test. The comparison did in this study is between red soil, silt soil and clay soil . The desired properties of soil are obtained from the results of the test and analysed for stability of pavement construction.

S. Muthu Lakshmi, et.al (2015)

This study was carried out to evaluate the values obtained from soaked and unsoaked CBR tests. The journal also highlights the difference between the soaked and unsoaked CBR values which determines strength property of the soil. They also conducted standard proctor density test of the soil to identify the Optimum Moisture Content and Maximum Dry Density of soil at different number of blows. They conducted the test for different trials with 10, 25, 35, 45, 55 number of blows. The OMC and MDD identified from the test are used to compact the soil for CBR testing. They observed that the CBR values tends to increase with a decreasing OMC. They also used regression models to obtain the CBR values with the help of MDD obtained. This study is a comparison and analysing the resulted in a comparatively lower value for soaked CBR tests.

Farhad Salour and Sigurdur Erlingsson (2013)

The authors studied the effect of groundwater table in the existing flexible pavement with the help of Falling Weight Deflectometer. With the help of FWD the critical strains of pavement layers are identified by back calculating it. The influence of the GWT on the service of pavement was analysed. The test results states that higher GWT results in reduced stiffness of the subgrade and the pavement layers.

Henraj .R. Kumavet, et.al (2020)

The Schmidt Rebound Hammer test is performed and the parameters which influences the rebound number value are identified and analysed. The parameters identified by the researchers are influence of carbonation, influence of moisture content in the surface of contact, Influence of surface roughness, influence of elevated temperature, influence of exposed fire and other miscellaneous factors. The conclusion part of this research paper states that the average rebound index and compressive strength of concrete are time dependent properties of the concrete structures. They also concluded that estimating strength of a structure with the help of rebound hammer may show higher strength values so that it should be always taken as a approximate compression strength value.

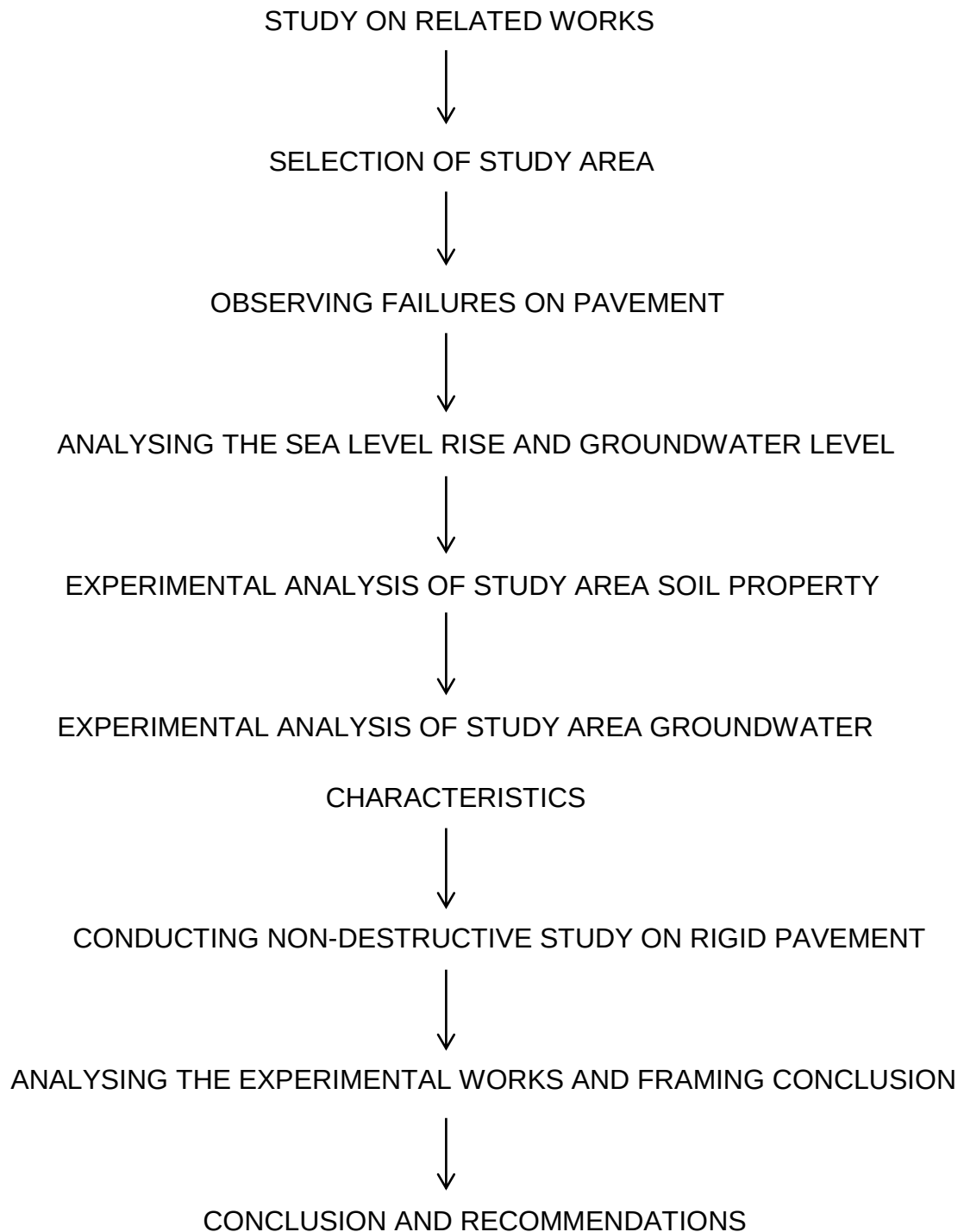
Samuele Biondi, et.al (2014)

In this study the researchers conducted UPV in in-situ concrete to determine the dynamic elastic modulus of concrete cores. They conducted the UPV by immersing the specimen in water to obtain the result in full wet condition. Masses of different specimens are weighed and then tested for concrete quality with the help of UPV. The study highlights the indirect UPV test conducted in concrete is more reliable with the values obtained from the direct method. The study suggested that the UPV test can be carried out in three conditions. They are dry, full wet and intermediate conditions. They concluded that there should be an assumption of linear model to find out the velocity dependence of direct and indirect method.

Mani Murali (2014)

The study is about coastal vulnerability due to the sea level rise along the Central Orissa coast, India. The study was carried out by taking a reference of 1m sea level rise and analysed the results. Areas which come under low lying areas are more vulnerable to sea level rise. The study analysed different properties of study area with the help of geo – spatial technology. The study stated that this sea level rise will remain hazardous for living in the coastal areas for the following areas and the vegetation will be tremendously affected due to this.

2.2 METHODOLOGY



CHAPTER 3

AIM AND SCOPE OF THE STUDY

3.1 AIM:

To study the influence of coastal diversity on already existing pavement.

3.2 OBJECTIVE:

The objective of our study is to analyse the sea-shore pavement by examining the pavement strength factors like subgrade, groundwater level and concrete quality in order to predict the service life of pavement. To obtain these parameters the experimental works are to be carried out.

1. To understand the impact of sea-level rise on ground water level.
2. To investigate the effect of subgrade properties on pavement.
3. To evaluate the strength properties of concrete laid in the existing pavement.
4. To identify the properties which affected the pavement strength .

3.3 SCOPE OF THE STUDY:

1. Framing separate design procedures for coastal pavements considering the marine environmental factors.
2. Understanding the pavement characteristics under sea-shore environment.

CHAPTER 4

STUDY AREA AND EXPERIMENTAL ANALYSIS

1.1 STUDY AREA

The study area was selected near the coastal region in order to forecast the challenges which the coastal pavements undergo. India has a coastline of about 7500kms. The coastline of Tamil Nadu has a length of 1076 kms constitutes about 15% of the total coastal length of India. This study on coastal road was carried out in a village road which is located in Muttukadu, Kanchipuram district, Tamil Nadu 603112, India.

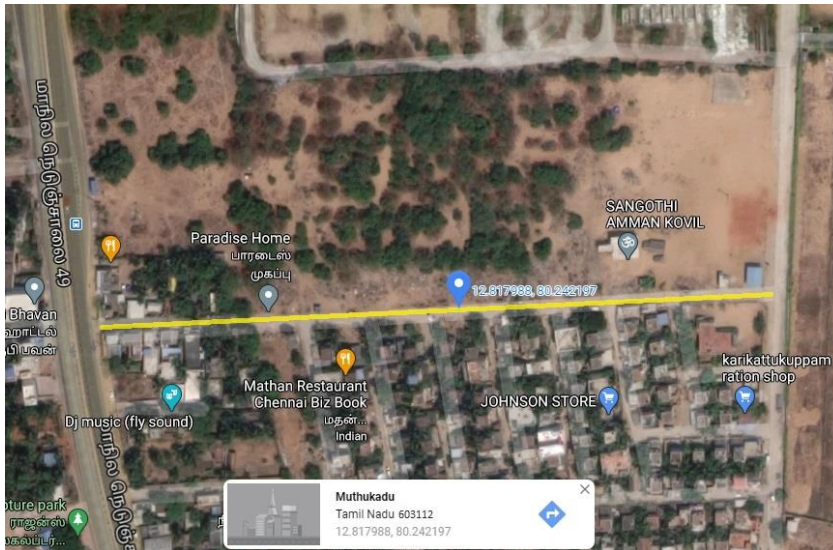


Fig:4.1 :Study Area

Table 4.1 : Description of Study Area

SI.No	PARAMETER	RANGE
1	Length of the pavement	315 m
2	Width of the pavement	4 m
3	Type of pavement	Rigid Pavement - Jointed Plain Concrete Pavement (JPCP)
4	Traffic Volume	Medium volume heterogeneous traffic
5	Type of Area	Residential area

1.1.1 FAILURES OBSERVED IN COASTAL RIGID PAVEMENT



Fig:4.2 :Scaling of Cement Concrete.

The magnitude of this distress is measured with the help of measuring tape. The magnitude is measured as 3175mm in length and 57.15mm in width. The most possible cause of this type of failure is higher ground water table near the pavement or due to improper mix design. This type of distress can also categorized under material related issues.



Fig:4.3 :Joint Spalling in Rigid Pavement.

The magnitude is measured as 1,676.4mm in length and 150mm in width. The joint spalling is joint deterioration, refers to cracking of the concrete slab near the joints. The deterioration also increases due to the environmental factors in the specified region. If left untreated it may also invade to the full depth of the pavement thickness. Weak concrete at the joint is another cause for joint spalling.

This joint spalling may also leads to further cracking distresses in the pavement which will in turn causes roughness in the pavement surface.

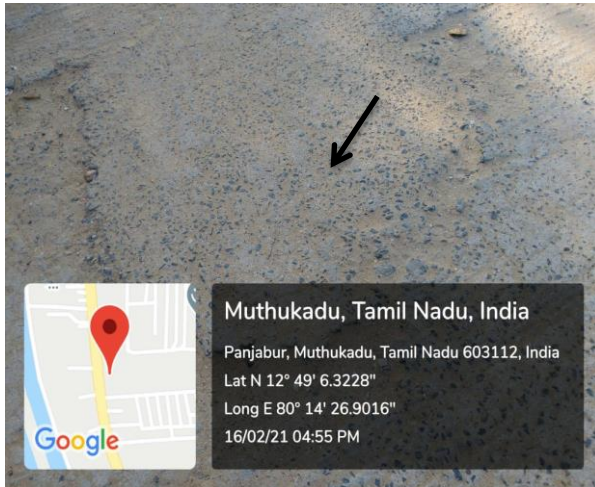


Fig:4.4 : Segregation of aggregates

Segregation of aggregates in rigid pavement is observed in the full stretch of the study area. This may be due to improper mixing and placement or because of adverse weather conditions occurring in the coastal region. It may also lead to further shrinkage cracks. This distress causes roughness in the road surface which will create discomfort to the vehicle drivers.



Fig:4.5 : Edge Breaking

The magnitude of distress is measured as 1,676.4mm in length and 150mm in width. Due to wheel loading in the edges of the road, the pavement edges tend to fail forming edge cracks. This is also due to deficient material property used in

the shoulder and base layer of rigid pavement. It may also leads to joint spalling when occurred near the joints.

4.1.2 RELATIONSHIP BETWEEN SEA-LEVEL RISE AND GROUNDWATER LEVEL

A high groundwater table exerts severe effects on the roadway base and the whole pavement. A pavement should be designed in such a way that water is prevented from entering the pavement in order to reduce its effects. As per codal provision the depth of groundwater level should be at below 2ft from the pavement subgrade. Whereas in coastal regions due to sea level fluctuations the ground water level tend to fluctuate accordingly. To study the relationship, the annual groundwater level data for the average of 10 years is obtained from Tamil Nadu, State Ground and Surface Water Resources data Centre and analysed. The data is collected from the nearby station and utilised for obtaining the groundwater level fluctuations. The ground water fluctuations may also happen due to precipitation rate and the seasonal factors in the specific area. Since the groundwater level is related with the pavement stability this factor was taken into account for this study.

A study was conducted by National Centre for Coastal Research (NCCR) which stated that the sea level in Chennai will increase by 7cm by 2025 which will inundate nearly 100m of seashore area. The sea level rise is normally due to melting of ice-glaciers and also due to thermal expansion of water. The sea level is not always rising, it actually fluctuates with respect to the climate changes. Nowadays global warming has become one of the main reasons for melting of ice glaciers in a higher rate. The study area is 140m away from the sea and the elevation of the study area is 32 m from the mean sea level. The study area is comparatively having lower slope in which the pavement will be easily affected by groundwater level increase. The groundwater level rise due to sea level fluctuation is analysed using the data obtained from past 10 years. Even though the soil stabilisation techniques are used to increase the stability of the pavement, the groundwater rise will affect the soil strength which is the natural bed for a pavement since the effect will be severe in this case.

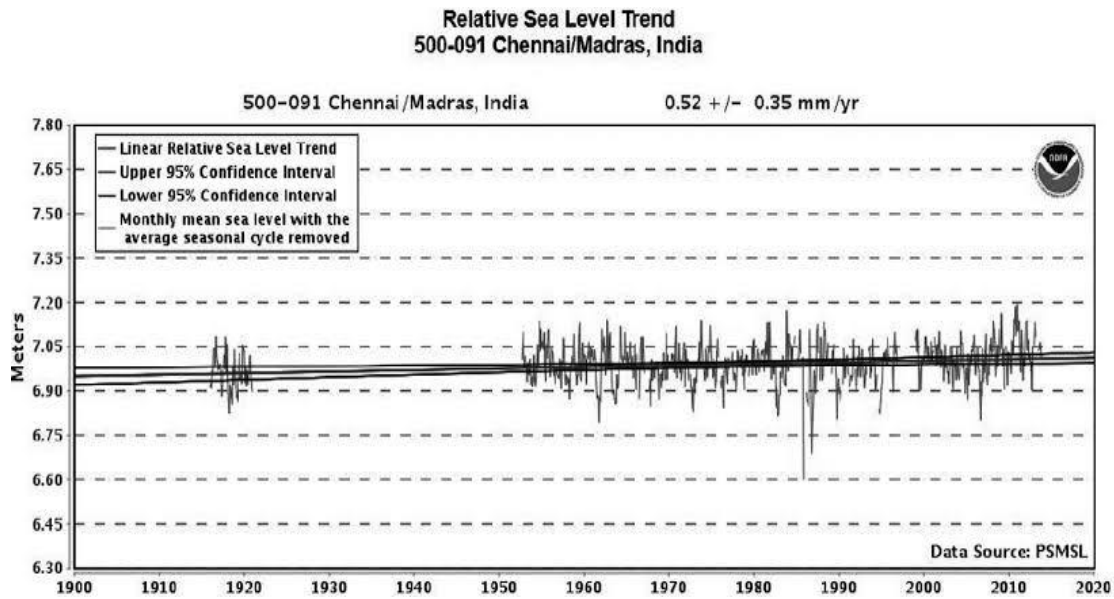


Fig:4.6 : Mean Sea Level (MSL) – Source: PSMSL

Table:4.2 :Groundwater level data for the average of 10 years in metre.
(Source: SG&SWRDC)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Month										
Jan	3.99	4.08	6.55	6.85	6.05	3.62	5.55	4.56	6.71	7.05
Feb	4.47	4.81	6.25	6.65	6.45	3.86	5.72	5.29	6.80	7.87
Mar	4.54	5.49	5.81	7.11	6.77	4.17	5.93	5.34	6.91	7.74
April	5.25	5.50	6.00	6.95	7.11	4.47	6.25	5.73	7.26	7.75
May	5.67	5.65	6.25	Dry	6.55	5.14	6.37	6.05	7.77	7.53
Jun	6.22	5.67	6.45	Dry	6.81	5.10	6.80	6.70	7.43	Dry
Jul	5.71	6.17	7.15	Dry	8.35	5.14	6.83	6.41	7.69	Dry
Aug	5.60	6.38	6.65	Dry	8.30	5.25	6.96	6.53	7.33	Dry
Sep	5.70	6.35	6.85	Dry	8.25	5.50	6.74	6.53	Dry	Dry
Oct	5.30	6.05	6.55	Dry	7.15	5.34	6.51	6.64	7.67	Dry
Nov	5.19	5.55	6.55	6.75	7.55	5.69	5.00	6.70	7.35	7.11
Dec	3.72	5.72	6.34	6.43	3.05	5.80	4.25	6.61	7.22	5.65

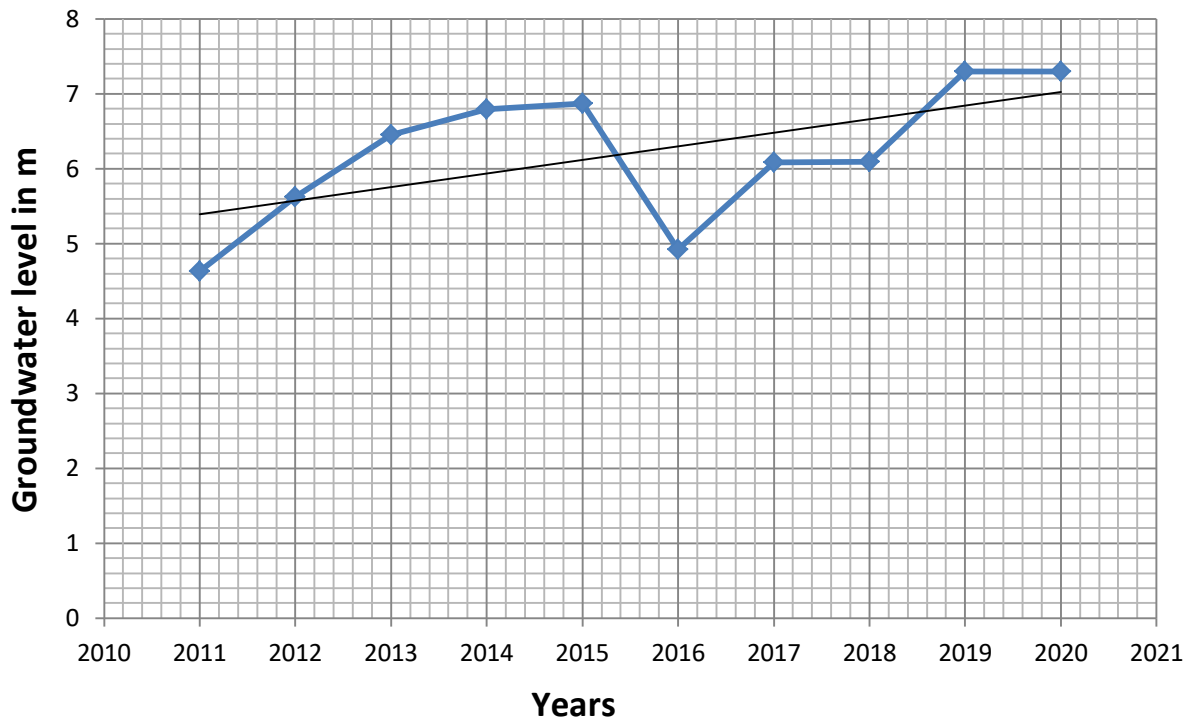


Fig:4.7 : Graphical Representation of Groundwater level fluctuation.

4.1.2.1 FINDINGS FROM THE ABOVE ANALYSIS

1. The groundwater level near seashore regions tends to fluctuate more when compared with the normal landscapes due to the sea level fluctuations.
2. Also due to the humid climate frequent rains are also possible in the seashore region which will in turn increase the groundwater level.
3. The past ten year groundwater level data of the seashore area clearly states that there is a constant increase in the groundwater level.
4. During the year 2011, the groundwater level has been recorded as 4.63m and it gradually increased till 2015. A decline in the sea level is recorded during the year 2016 consequently the groundwater level also decreased. This groundwater level decline may also caused due to some other environmental factors.
5. And then the groundwater level started to gradually increase in the further years, the recorded rate of groundwater level for the year 2020 is 7.24m which is nearly 2.5 times greater than the rate of 2011.
6. As researchers strongly states that the mean sea level will rise tremendously for the upcoming years, there is a chance of further increase in the groundwater level in the seashore regions.

7. In low lying areas, the seawater will freely inundate as the natural groundwater level becomes very low making path to the sea water intrusion.

4.2 EXPERIMENTAL ANALYSIS

4.1.3 SOIL TESTING AND ANALYSIS

In evaluating the pavement, the subgrade properties of the pavement plays a vital role. For analysing the coastal pavement, the subgrade properties and the strength characteristics are found out using experimental analysis. The important subgrade properties are stability, incompressibility, permanency of strength, less volume changing capacity and stability under extreme weather conditions and high groundwater level. Different types of soil acquire different physical properties. In this study we analysed the coastal area soil properties. Those properties are soil type, specific gravity, liquid limit, plastic limit, optimum moisture content, maximum dry density.

COLLECTION OF SOIL SAMPLE

15 Kg of coastal area soil sample is collected from the nearby study area for experimental analysis. The soil sample is collected by digging the ground for 2 ft. The soil is used for conducting various tests on soil to study the site specific property of soil which affects the pavement stability. The sample is collected within 2m from the pavement where the natural ground surface exists.



Fig: 4.8 :Soil sample collection



Fig:4.9 :15 kg of sample

4.1.3.1 SIEVE ANALYSIS

Sieve analysis is done for identifying the particle size distribution of soil. The gradation curve gives us the type of soil exists in the study area. The sieve analysis is carried out as per **IS: 2720 (part-4)**. 100g of oven dried sample is analysed using the standard sieve sizes. The sample is dried at 110 degree Celsius. The standard sieves used to identify particle size distribution of soil are 4.75mm, 236mm, 1.18mm, 425microns, 212microns, 125microns and 75microns. The soil type is identified using the percentage of soil particles retained in the sieves.



Fig:4.10 :Mechanical shaker



Fig:4.11 :Weighing machine

PROCEDURE

1. 100g of oven dried sample is taken for analysis
2. Mechanical shaker is used to sieve the soil particles accurately.
3. The amount of soil particles retained in every sieve is weighed with the help of weighing machine.
4. The percentage retained is calculated and particle size distribution is examined.

Formula used for percentage retained calculation:

$$\text{Percentage retained} = \frac{\text{Weight of soil retained}}{\text{Total amount of soil taken}} \times 100$$

Table:4.3 :Results of sieve analysis

SIEVE SIZE (mm)	SOIL RETAINED (g)	PERCENTAGE RETAINED	CUMMULATIVE % RETAINED	PERCENTAGE FINER
4.75	0	0	0	0
2.36	0	0	0	0
1.18	0	0	0	0
0.425	1.40	1.4	1.4	98.6
0.212	73.2	73.2	74.6	25.4
0.125	23.2	23.2	97.8	2.2
0.75	2.20	2.20	100	0
pan	0	0	0	0

SOIL TYPE IDENTIFICATION – TEXTURE TRIANGULAR CLASSIFICATION

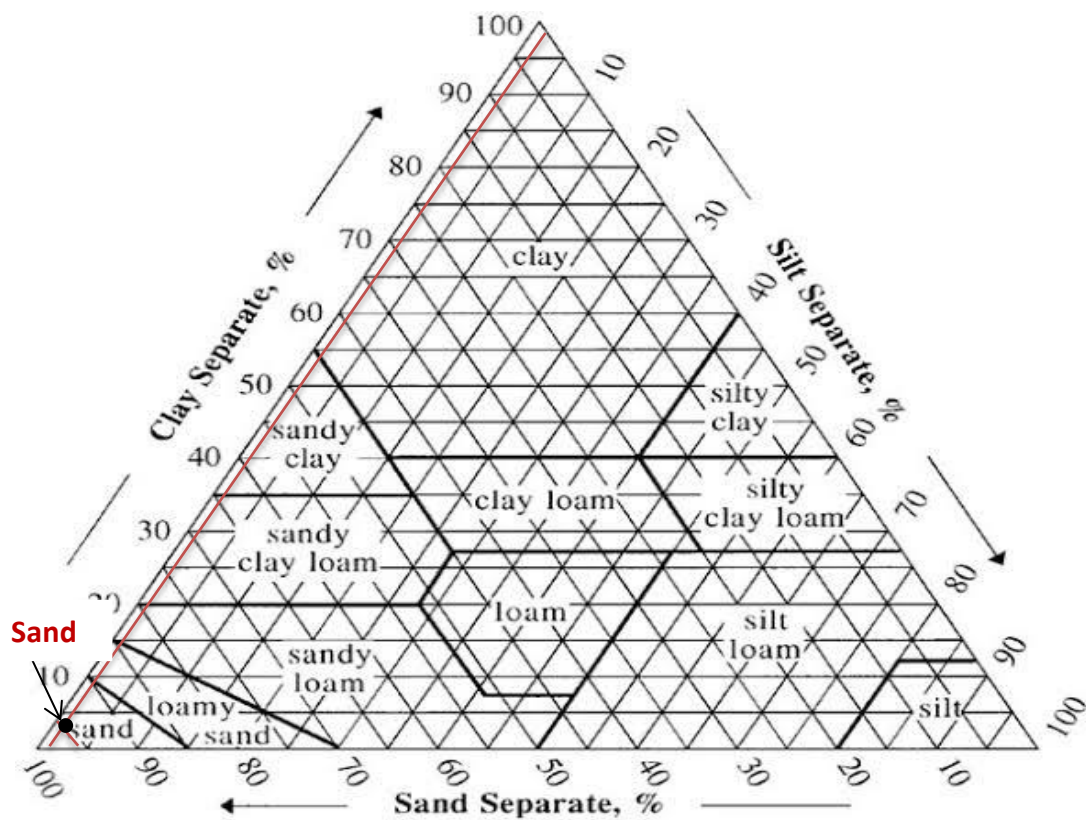


Fig:4.12 :Texture triangle

4.1.3.2 STANDARD PROCTOR DENSITY

Standard proctor density is carried out to determine the optimum moisture content and maximum dry density which is needed to compact the soil. The test is carried out as per IS: 2720 (part 7). 3 kg of soil sample is taken to analyse the OMC and MDD. The value of optimum moisture content is obtained from the corresponding value of maximum dry density attained. Light compaction method is used to analyse the soil sample as per codal guidelines.



Fig:4.13 :Proctor standard density testing apparatus

The apparatus consists of:

1. Cylindrical metal mould , having internal diameter(10.16cm) and internal effective height(11.7cm)
2. Rammer, weighing 2.6kg and 310mm in height.
3. Weighing balance.
4. Thermostatically controlled oven to dry the sample.
5. IS sieves

PROCEDURE

1. 3kg of oven dried soil sample passing 4.75 mm sieve is taken.
2. The cylindrical mould without collar is weighed in the weighing machine.
3. Initially 4% of water is added to the soil sample.
4. The soil sample is compacted in three layers, each layer is compacted for 25 blows using metal rammer.
5. The water content is increased for each trial for about 2%.

6. The weight of soil is measured using weighing balance after adding water.
7. The OMC and MDD is obtained when the weight of the sample starts decreasing after several trials.

Table:4.4 :Tabulation of proctor density test.

WEIGHT OF CYLINDRICAL MOULD (Kg)	WATER CONTENT (%)	WEIGHT OF WET SOIL (Kg)
3.886	4%	5.515
3.886	6%	5.554
3.886	8%	5.6
3.886	10%	5.617
3.886	12%	5.604

Maximum dry density = $\frac{\text{Weight of wet soil}}{1 + \text{moisture content}}$

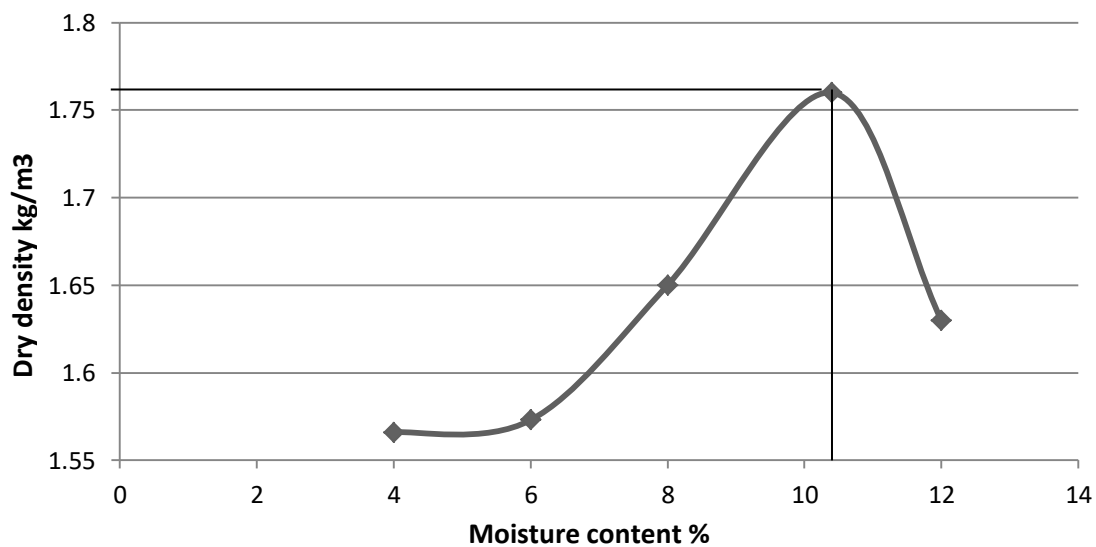


Fig:4.14 :Graphical representation of proctor density test.

Maximum Dry Density of the soil sample: **1.760 kg/m³**

Optimum Moisture Content of the soil sample: **10.40%**

The optimum moisture content obtained from the standard proctor is used to compact the soil during pavement construction. The maximum dry density should be reached by adding the adequate amount water found from the standard proctor while preparing soil bed to construct the pavement.

4.1.3.3: SPECIFIC GRAVITY

Table:4.5 :Specific gravity test results

DETERMINATION	TRIAL:1	TRIAL:2
Weight of pycnometer(W1) gm	670.5	670.5
Weight of pycnometer + soil (W2) gm	1185.48	1190
Weight of pycnometer + soil +Water (W3)gm	1765.14	1773.93
Weight of pycnometer + water(W4)gm	1449	1449

$$\text{Specific gravity} = \frac{(W2-W1)}{(W2-W1) - (W3-W4)}$$

Specific gravity of study area soil is **2.63**

4.1.3.4: Atterberg limits

1. Atterberg limits test are restricted to cohesive soils.
2. Since the coastal soil is non – cohesive in nature, the Atterberg limits are not obtained.
3. Liquid limit: Nil
4. Plastic limit: Nil
5. Plasticity Index: Non – plastic

4.1.3.5: California Bearing Ratio (CBR) test

California Bearing Ratio test is the penetration test which is used to evaluate the pavement subgrade strength. Thickness of pavement layers is found out using the results obtained from CBR test. This test is conducted as per **IS: 2720(Part 16)**. Optimum moisture content obtained from the Standard proctor test is used for static compaction of soil for conducting CBR test. The CBR value obtained is compared with the CBR value of 100% which is obtained from the crushed rocks.

SOAKED CONDITION

The CBR test for this soil sample is carried out in soaked condition to obtain the adverse effects of the study area subgrade soil when subjected to heavy rainfall and floods. For this the soil sample is soaked in water for 96 hours (4 days).



Fig:4.15 :California Bearing Ratio testing apparatus

APPARATUS

1. Mould with internal diameter 150mm and a height of 175mm,
2. Detachable collar,
3. Detachable base plate with perforations at the bottom,
4. Spacer disc with 148mm diameter and a height of 47.7mm,
5. Surcharge weights of mass 2.5kg and an internal hole of 53mm diameter,

6. Slotted weight of 2.5 kg,
7. Penetration plunger of height 100mm and diameter 50mm,
8. Loading machine of capacity 5000 kg,
9. Penetration capacity – 1.25mm/minute,
10. Proving ring,
11. Dial gauges,
12. Weighing balance,
13. Compaction Rammer,
14. Filter paper,
15. Soil mixing tools,
16. Measuring cylinder.

PROCEDURE

Preparation of test specimen:

1. Take 5 kg of soil sample passing 20mm sieve and mix it with 312ml of water which is the pre-determined value of optimum moisture content from the Standard Proctor Density test conducted for the same soil sample.
2. Uniformly mixed soil is allowed to compact with the help of rammer by giving 56 blows for each of the 5 layers.
3. After compacting the soil, collar is removed and specimen is weighed.

Testing of test specimen:

1. Place the angular weight of mass 2.5kg on the specimen.
2. Place the assembly on pedestal of loading frame and set the proving ring and dial gauge in position.
3. Fix the plunger and bring it to contact with the soil surface.
4. Apply the load with the help of loading frame.
5. The readings in the proving ring are noted and the corresponding penetration values are taken.

The values obtained from the Standard Proctor density are used for the CBR testing.

Optimum Moisture Content: 10.40%

Maximum dry density: 1.760kg/m³

Table:4.6 : California Bearing Ratio test results:

Sl.No	PENETRATION (mm)	PROVING RING DIAL READING (DIVISIONS)	PISTON LOAD (Kg/cm ²)
1	0	0	0
2	0.5	20	112
3	1.0	36	201.6
4	1.5	52	291.2
5	2.0	68	380.8
6	2.5	80	448
7	4.0	98	548.8
8	5.0	99	554.4
9	7.5	87	487.2
10	10.0	73	408.8

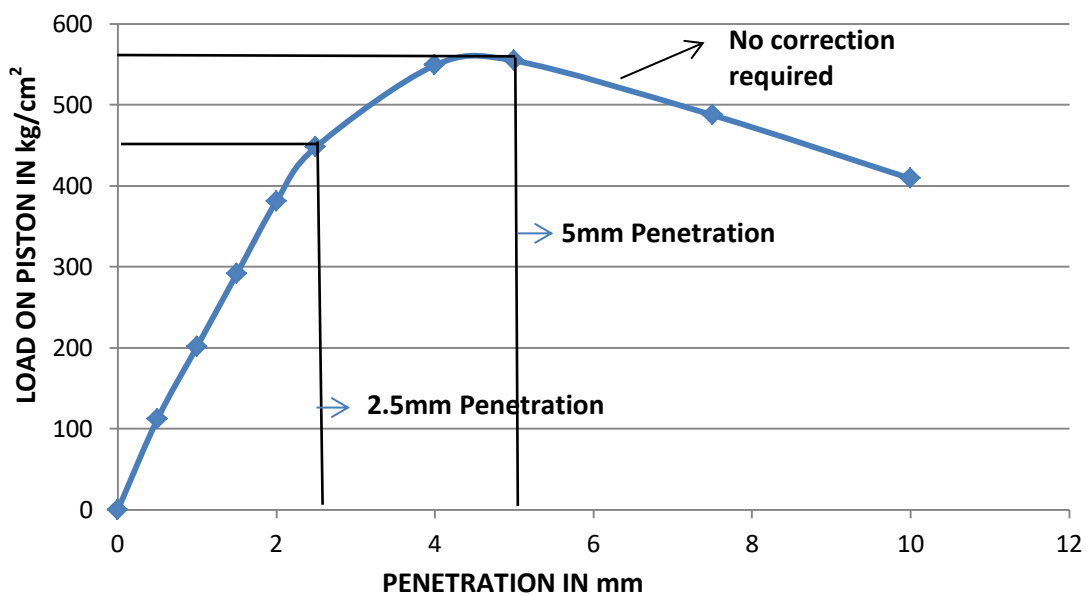


Fig:4.16 :Graphical representation of CBR test results

$$\text{CBR}\% = \frac{\text{Unit load carried by specimen at standard penetration}}{\text{Unit load carried by standard crushed stone at standard penetration}} \times 100$$

CBR% of the study area soil is found out as **32.70%**.

4.1.4: EXPERIMENTAL ANALYSIS OF STUDY AREA GROUNDWATER

CHARACTERISTICS

COLLECTION OF WATER SAMPLE

2 litres of water sample is collected through a bore well from the study area to study the groundwater properties. The water sample is then tested for the parameters which includes pH, TDS level, Total hardness, Electrical conductivity, Sulphate, Ammonia and salinity.



Fig:4.17 :Water Sampling

4.1.4.1 Electrical Conductivity test

Electrical Conductivity is carried out as per Clause 3.1.1 of IS 3025. EC is the test which determines the property of water by passing current with the help of electrodes. It is measured in Micromho/cm or $\mu\text{mho/cm}$ and Millimho/cm.

APPARATUS

1. EC meter
2. Probe
3. 40ml beaker
4. Electrodes
5. Conductivity cell
6. Water sample

PROCEDURE

1. Connect the conductivity cell to the instrument.
2. Note the value of cell constant.
3. Ensure the instrument is in calibration mode.
4. Measure the conductivity of standard solution.
5. Standard solution is prepared by dissolving 0.5232g of potassium chloride in 1 litre of de – ionized water.
6. Take 40ml of sample water in a beaker.
7. Insert the conductivity cell in the sample and measure the conductivity value.

Electrical Conductivity of study area water sample @ 25°C is found out as 1724 μ S/cm.

Table:4.7 :Other parameters of water sample.

SI.No	TEST PROCEDURE	UNIT	METHOD OF REFERENCE	RESULTS
1	pH @ 25°C	---	IS 3025 Part 11 (Reaffirmed 2012)	6.61
2	Total Dissolved Solids	mg/L	IS 3025 Part 16 (Reaffirmed 2002)	1069
3	Total hardness	mg/L	IS 3025–(Part21):2009 (Reaffirmed 2014)	400
4	Sulphate as SO ₄	mg/L	APHA 22 nd Edn.4500 SO ₄	163
5	Ammonia as NH ₃	mg/L	IS:3025 (Part-34):1998(Reaffirmed)	0.29
6	Salinity	g/L	IS:3025 (Part-14):2013(Reaffirmed 2019)	0.80

4.1.4.2 Parameter limits

The following limits are tabulated as per IS 10500 : 2012.

Table:4.8 :pH limit for water.

pH level	Nature
0 to 6	Acidic
7	Neutral
8 to 14	Alkaline

The pH limit for the study area water sample is **6.61** which is acidic in nature.

Table:4.9 :TDS limits for water.

TDS Level in parts per million.	Limit (mg/L)
Desired limit	500
Permissible limit	2000

TDS level of study area water sample is **1069 mg/L** which is higher than the expected standard limits.

Table:4.10 :Limits for hardness determination of water.

Hardness range	Limit (mg/L)
Desired range	200
Permissible range	600

Hardness of study area water sample is **400 mg/L**.

Table:4.11 :Limits for Sulphate content in water.

Sulphate Content	Limit (mg/L)
Desired range	200
Permissible range	400

Sulphate content of study area groundwater is **163mg/l**.

Table:4.12 :Limits for Ammonia content in water.

Ammonia Content	Limit (mg/L)
Desired range	0.5
Permissible limit	No relaxation

Ammonia content of study area groundwater is **0.29mg/L**.

Table:4.13 :Salinity range.

Salinity Range	Limit (g/L)
Permissible limit	0.5

Salinity range of study area groundwater is found out as **0.8 g/L**.

4.1.5: NON – DESTRUCTIVE TESTS CONDUCTED ON STUDY AREA RIGID PAVEMENT

The non – destructive tests are carried out in the rigid pavement to obtain the compressive strength and other properties of concrete to evaluate their strength characters. In order to acquire the concrete properties of the existing seashore pavements NDT's was conducted as per IS standards. As the name indicates it is a non-destructive test which does not disturb the existing structure. The two tests conducted in the existing pavement are Rebound Hammer test to find out the compressive strength of concrete and Ultrasonic Pulse Velocity (UPV) test to find out the concrete quality.

4.1.5.1: *Rebound Hammer test*

This test is carried out to determine the compressive strength of concrete in the existing pavement. The test was carried out as per BIS: **IS: 13311 (part 2) – 1992 (RA: 2004)**. The strength of the concrete tends to decrease with their age. 12 different locations are selected to test the compressive strength of pavement in the study area to obtain the variations of compressive strength at different location and an average rate of deterioration of that pavement. It is a hardness test which states that the rebound of an elastic mass is influenced by the hardness of the surface against which the mass impinges.

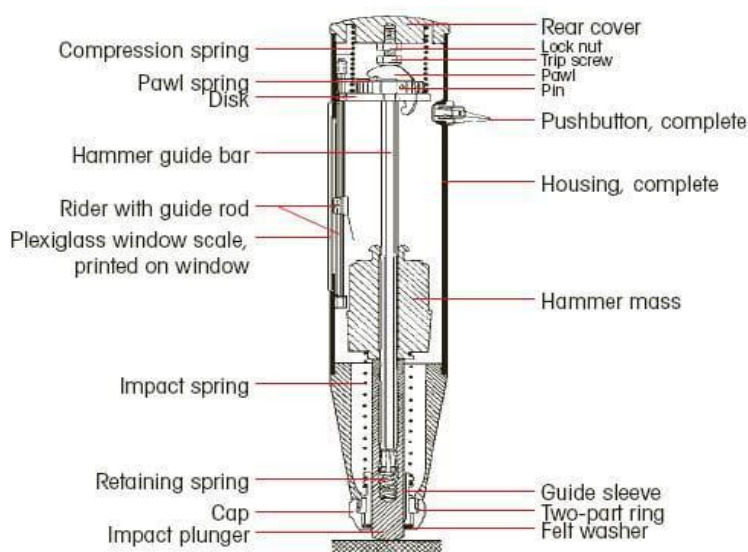


Fig:4.18 : Diagrammatic representation of Rebound Hammer



Fig:4.19 : Performing Rebound Hammer test

INSTRUMENT DESCRIPTION

1. Instrument Type: Digital Silver Schmidt Rebound Hammer
2. Spring Extension: 75mm (2.95")
3. Plunger Radius: 25mm (0.98")
4. Operating temperature: 0 to 50°C
5. Impact energy : 30Nm

**Table 1 Impact Energy for Rebound Hammers
for Different Applications
(Clause 4.1)**

Sl No.	Application	Approximate Impact Energy Required for the Rebound Hammers (Nm)
i)	For testing normal weight concrete	2'25
ii)	For light-weight concrete or small and impact sensitive parts of concrete	0'75
iii)	For testing mass concrete, for example in roads, air-fields pavements and hydraulic structures	30'00

Fig:4.20 : Impact Energy for Rebound Hammers.

PROCEDURE

1. The concrete pavement surface located in the study area is smoothened with the help of stone and then tested.
2. The hammer is pressed against the concrete pavement orthogonally, exactly at 90° to the pavement surface.
3. When the hammer is pressed, the plunger come into contact with the surface which is pushed with an impact energy of 30Nm as mentioned in **IS: 13311**.
4. The Rebound number is noted from the display and the compressive strength of the concrete is calculated for different positions.

Table: 4.14 :Rebound Hammer test results.

No.of.locations	1	2	3	4	5	6	Range	Result
Concrete pavement	36.5	36.0	35.0	30.5	37.5	37.5	Max	44.50
							Min	28.00
	32.0	36.0	44.5	36.5	28.0	42.0	Avg	35.96
							fck (N/mm²)	38.83

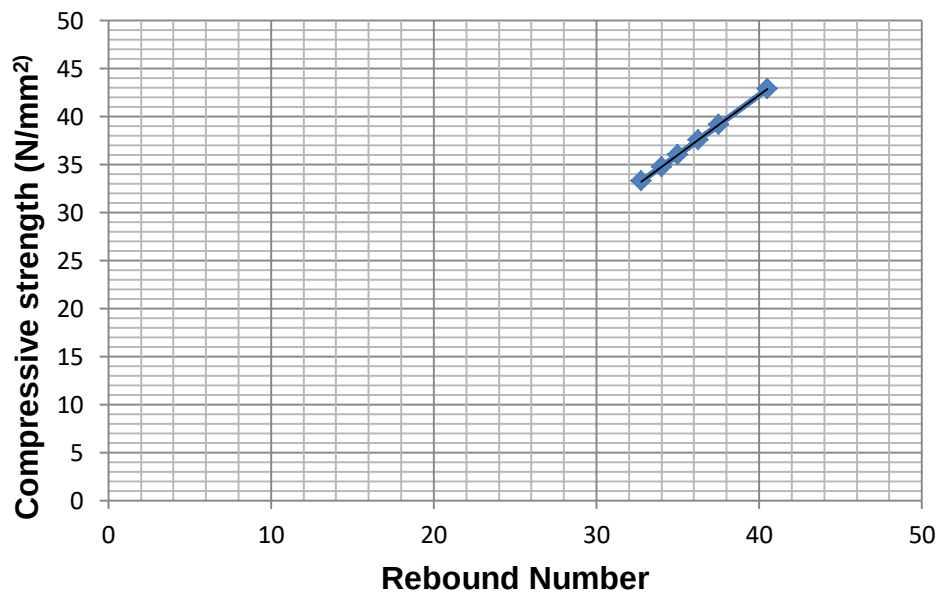


Fig:4.21 : Graphical Representation Rebound Hammer results.

$$fck = 1.2585 \times A - 6.4089$$

4.1.5.2 Ultrasonic Pulse Velocity (UPV) test.

ASSESSMENT OF INTEGRITY OF CONCRETE CONDUCTED BY UPV

UPV test is carried out to find the homogeneity of concrete surface with help of ultrasonic waves. The test is carried out as per **IS: 13311 (PART 1)**. The UPV test is used to determine the amount of voids present in the concrete surface, de – lamination zones of concrete pavement and cavities present in it. Depending upon the values obtained from the UPV test the concrete quality is graded as doubtful, medium, good and excellent.

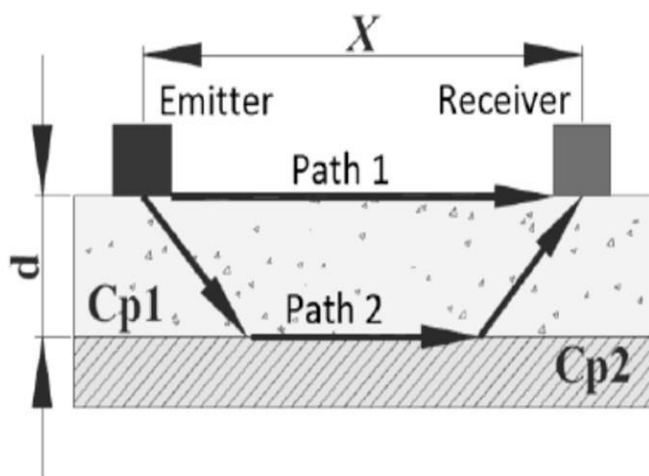


Fig:4.22 :Diagrammatic representation UPV test setup

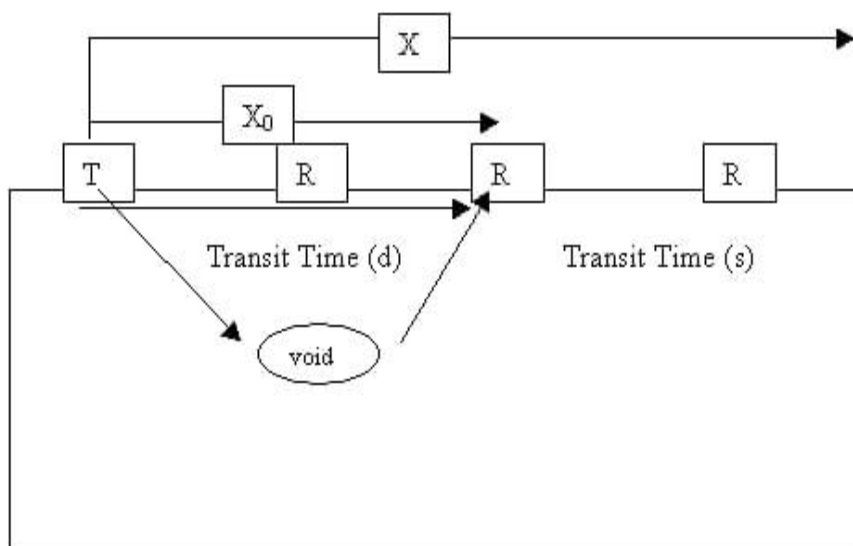


Fig:4.23 :Working of UPV test by Indirect method



Fig:4.24 :Performing UPV test in study area



Fig:4.25 :Calibration checking

INSTRUMENT DESCRIPTION

1. Instrument type: PROCEQ ULTRA SONIC TESTING EQUIPMENT
2. Transmit time : 0.1 to 1999.9 μ s
3. Resolution : 0.1 μ s
4. Type of test conducted : Indirect method

PROCEDURE

1. The test surface is smoothened by rubbing it with stone and then grease is applied to obtain test result without any deviation.
2. The transmitter and the receiver are placed after marking the contact point in the pavement with a distance of 15cm which is known as grid marking.
3. Current supply is given to the setup and the ultrasonic pulse is allowed to pass through the transmitter.
4. The velocity readings are noted from the instrument and the concrete quality is identified.

Table: 4.15: Test results of UPV

Location	1	2	3	4	5	6	Range	Pulse velocity
Concrete pavement	4.44	2.31	2.64	2.78	3.49	3.48	Max	4.44
	2.79	3.32	3.56	3.29	2.54	3.27	Min	2.31
							Average	3.15

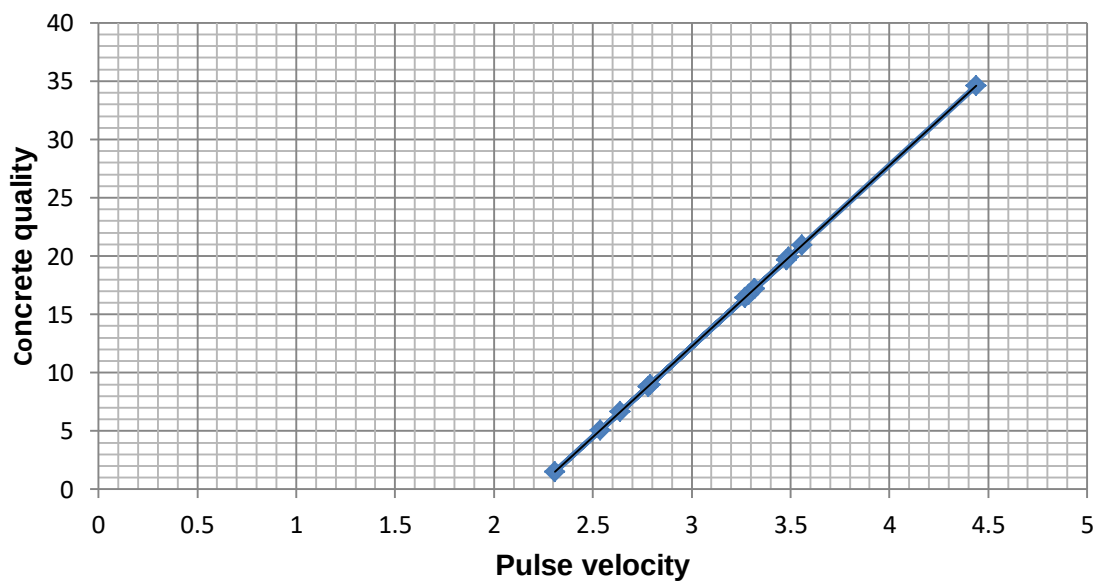


Fig:4.26 :Graphical representation of UPV test result

**Table 1 Velocity Criterion for Concrete
Quality Grading**
(Clause 2.5.2)

Sl No.	Average Value of Pulse Velocity by Cross Probing km/s	Concrete Quality Grading
(1)	(2)	(3)
i)	Above 4.40	Excellent
ii)	3.75 to 4.40	Good
iii)	3.00 to 3.75	Doubtful ¹⁾
iv)	Below 3.00	Poor

Fig:4.27 :Velocity Criterion for UPV as per IS: 516 (Part 5, Section 1).

CHAPTER 5

RESULTS AND DISCUSSION, PERFORMANCE ANALYSIS

Experimental analysis on subgrade property, groundwater quality are carried out and the results are shown in the above chapter. The identified failures showed a severity in magnitude in the study area.

Soil Property: As the CBR value of every subgrade is determined before the construction of pavement, the study area's CBR is checked by conducting California Bearing Ratio test. CBR value is obtained as 32.7% which indicates that the bearing capacity of soil is very high which can easily withstand the load as per codal provisions. Even though the subgrade strength is high, the pavement was subjected to higher magnitude of failure. In this case of coastal region, the soil type is identified as sandy soil. These soil is generally having the tendency to bulk when added with water. As the coastal region is more vulnerable to high groundwater table, it is concluded that the distresses may caused due to bulking of sand as the soil have low water absorption capacity. This type of soil is more suitable for drainage of water during precipitation but when the rainfall rate is high then it starts to fail in providing strength to the pavement.

Groundwater Analysis: As it is well known that the drinking water is more suitable for concrete constructions, the rigid pavement will also exhibit the same property. In order to evaluate the groundwater quality, the water is checked for some important parameters which are tabulated and checked for the limits framed by Indian Standards in the previous chapter. The results obtained from the water quality analysis satisfied the limits framed by the Indian Standards for drinking water. As the water quality is suitable for drinking purposes, it won't affect the pavement stability when reacted with the soil or concrete when the groundwater table increased. The Study was carried out after a monsoon season which may be the reason for low salinity range of the groundwater table.

Concrete quality: Concrete quality of the pavement is determined with the help of UPV test on concrete. The pulse velocity is obtained as 3.15, which is categorized under doubtful quality of concrete as per IS:516 (Part 5) which is expected to deteriorate in the upcoming years.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Pavements are generally designed for light to heavy traffic depending on their types. These pavements are influenced by the major pavement strength factors which include subgrade strength, concrete quality and groundwater table level. The study area comprises of rigid pavement situated in coastal area which is designed for medium – volume heterogeneous traffic. To analyse the pavement, type of distresses are identified in the pavement with the severity range. They are scaling of cement concrete with a severity range of 3175mm in length and 57.15mm in width, joint spalling with a severity range of 1,676.4mm in length and 150mm in width, segregation of aggregate and edge breaking with a severity range of 1,676.4mm in length and 150mm in width. As the severity range of these distresses are high, the study is carried out to identify the factors which affected the pavement quality in the study area. To analyse that, testing on soil, water and existing pavement surface are carried out.

The soil type is identified as sandy soil from the test result. As per Highway Research Board (HRB) classification of soil and soil aggregate mixture, the test soil is categorized under A-3 group classification which is non – plastic in nature. CBR value of the subgrade is comparatively higher than the nominal range which is obtained as 32.70%. However the bearing capacity of the sample soil is high, there may be bulking of sand, since the soil doesn't absorb moisture. As the study area is chosen near the coastal region, the sea level rise will predominantly increase the groundwater table, with that the other factors like precipitation, floods will also increase the groundwater table level. As per codal provisions, the GWT should be situated at 3m below the pavement layer. In this case the groundwater table is not expected to stay stable as the sea – level fluctuates. The concrete quality of the pavement is found out as medium quality as the pulse velocity is obtained as 3.15km/s from the NDT test conducted on the study area. Since it is identified as medium quality the concrete pavement surface may deteriorate in the following years before the completion of its service life.

The coastal region exhibits adverse climatic variations when compared with normal land. The suggestions made by IS – codal provision for pavement thickness and material gradations suits only for the normal pavements. The coastal region is supposed to affect due to the bulking property of coastal soil and varying groundwater level which is expected to increase at a higher rate due to sea – level rise in the upcoming years. The above analysis states that the standard IS – codal provision for pavement is not suitable for constructing a pavement at a coastal region. Since the pavement has undergone a high rate of failure within its service life.

6.2 RECOMMENDATIONS

1. Effective soil stabilization methods should be implemented while constructing a pavement in the coastal region.
2. Separate codal specifications should be framed to construct a pavement near the coastal region, since the pavement which was constructed using the available standard codes, exhibited severe deterioration before their service life completion.
3. Saltwater intrusion, Groundwater level increase, Bulking property of the coastal sand should be considered as the main design parameters in the coastal region pavement construction.
4. More researches must be carried out in these coastal pavements to identify the actual impacts and the factors affecting it.

REFERENCE

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3. Elad Levanon, et.al, “The Dynamics of Sea Tide Induced Fluctuations of Groundwater level and Freshwater – Saltwater Interface in Coastal Aquifers: Laboratory experiments and numerical modelling” August 2019 – Pg:15-28.
4. Janaga Vijay, Pottapelli Avinash, “Properties of Subgrade Soil for Pavement Construction” October 2016 – Pg: 7-9.
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6. Hemraj R, Kumaret, et.al, “Factors Influencing the Performance of Rebound Hammer used for Non – Destructive testing of Concrete Members: A Review” July 2020 – Pg:5-12.
7. Samuele Biondi, et.al, “Concrete Strength Evaluation through Indirect UPV” August 2019-Pg: 3-9.
8. Mani Murali, “Application of Geo-Spatial Technologies in Coastal Vulnerability Studies due to Sea – Level Rise (SLR) along the Central Orissa Coast, India” 2014 – Pg:21-31.
9. Dr.B.C.Punmia,et.al, “Soil Mechanics and Foundations”, 16th Edition-Pg:111-114.

Appendix – A – Experimental test report on Soil property

ISO / IEC 17025
NABL ACCREDITED LABORATORY


FALCON
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TEST REPORT

SOIL SAMPLE TEST RESULTS

Test Report No: TR2102046	Reporting Date: 20.02.2021	Page 1 of 1
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Student Name : Miss.K.Kowshika ,Miss M.Menakaswamy
College Name : SATHYABAMA INSITITUTE OF SCIENCE TECH
Project Name : Study on Effect of Coastal Diversity on Existing Pavement
Customer's Reference : Letter dtd: 09.02.2021

Sample Details:-

- **Description** : Soil Sample
- **Sample received on** : 09.02.2021
- **Quantity** : 15 kg
- Period of Test** : 09.02.2021 to 20.02.2021
- Standard Ref** : IS 2720 (P, 2, 4, 5, 8, 16) – 1985 (RA - 2010); IS 1498 – 1970 (RA: 2007)

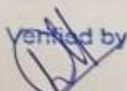
Sl No	Description	Results
1	Sieve Analysis	
	i)Coarse Sand (4.75 to 2.00mm)	0.00
	ii)Medium Sand (2.00mm to 425µ)	1.40
	iii)Fine Sand (425µ to 75µ)	96.40
	iv)Silt(<75µ)	2.20
2	Atterberg Limts(%)	
	i)Liquid Limit(%)	Nil
	ii)Plastic Limit(%)	Nil
	iii)Plasticity Index(%)	Non Plastic
3	Proctor Density	
	Maximum Dry Density(gm/cc)	1.760
	Optimum Moisture content	10.40
4	Specific Gravity	2.63
5	CBR (Unsoaked)	Penetration Depth
		2.50mm Penetration (%) 5.00mm Penetration (%)
		32.70 26.98

*Sample Details are Furnished by the customer



*** End of Test report***

Verified by



J. Dharmodharan
Lab Incharge

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 lab@fitpl.in

Terms and Conditions :

- ❖ The test results relate to the items tested
- ❖ The report is generated for the sole use and specific purpose of the customer and based on items/sample submitted by the customer.
- ❖ The report shall not be considered to be the representative of similar or equivalent items.
- ❖ Any correction makes this report invalid.

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Appendix – B – Experimental test report on groundwater quality.

ISO / IEC 17025
NABL ACCREDITED LABORATORY



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Building Materials & Soil Testing
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LABORATORY PVT LTD.

TEST REPORT

Test Report No: TR2102046	Reporting Date: 16.02.2021	Page 1 of 1
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CUSTOMER DETAILS	
Name of the Student	: Miss.K.Kowshika Miss M.Menakaswamy
Name of the college	: SATHYABAMA INSITITUTE OF SCIENCE TECH
Project name	: Study on Effect of Coastal Diversity on Existing Pavement
Customer Reference	: Test Request Form dated on 09.02.2021

SAMPLE DETAILS	
Sample Name	: WATER
Sample Description	: WATER
Test Started on	: 09.02.2021
Sampled by	: Customer
Quantity	: 1 Liter
Test Completed on	: 16.02.2021

Sl. No.	Test Parameter	Unit	Method of Reference	Results
1	pH @ 25°C	--	IS 3025 Part 11 (Reaff 2012)	6.61
2	Total Dissolved Solids	mg/L	IS 3025 Part 18(Reaff 2002)	1069
3	Total Hardness as CaCo3	mg/L	IS 3025-(Part 21) :2009 (Reaffirmed 2014)	400
4	Electrical Conductivity @ 25°C	µS/cm	IS:3025 (Part-14):2013(Reaffirmed 2019)	1724
5	Sulphate as SO ₄	mg/L	APHA 22 nd Edn. 4500 SO ₄ E	163
6	Ammonia as NH ₃	mg/L	IS:3025 (Part-34):1988 (Reaffirmed 2019)	0.29
7	Salinity	g/L	IS:3025 (Part-14):2013(Reaffirmed 2019)	0.80

*Sample Details are furnished by the customer



End of Report

Verified by



J. Dhamodharan
Lab Incharge

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- ❖ The report shall not be considered to be the representative of similar or equivalent items.
- ❖ Any correction makes this report invalid.

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Appendix – C – Test report on Rebound Hammer

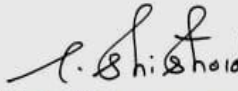
Test report No:TR2102151	Reporting Date : 02.03.2021	Page No: 08 of 08
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Table 1 Rebound Hammer Test Reading								
Grade of Concrete	Nil							
Location of Structure	Concrete Pavement							
Date of Casting	Nil							
Date of Testing(R.H)	28.02.2021							
Sl.No/ Location	1	2	3	4	5	6	N	12
Concrete Pavement	36.5	36.0	35.0	30.5	37.5	37.5	Max	44.50
							Min	28.00
							Average	35.96
	32.0	36.0	44.5	36.0	28.0	42.0	Est.Comp Str (N/mm ²)	38.83

Requirements:

The Probable accuracy of 25% (+,-) is allowable for existing strength of the structure is considered for comparing the compressive strength of concrete as per code provisions of IS 13311 (P2) -- 1992 (RA:2008).

*Sample details are furnished by the customer


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 OMR, Perungudi, Chennai - 600 096.

Appendix – D – Experimental report on UPV test.



Test report No: TR2102151	Reporting Date : 02.03.2021	Page No: 07 of 07
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1-FORMULA: Velocity=Probe Distance /Time taken of wave (Km/sec)									
Sl.No	Location	1	2	3	4	5	6	N	12
1	Concrete Pavement	4.44	2.31	2.64	2.78	3.49	3.48	Max	4.44
2		2.79	3.32	3.56	3.29	2.54	3.27	Min	2.31
								Average	3.15

Table A

Table No	Description	Ultrasonic Pulse Velocity (km/s)	Concrete Quality Grading
1	North East Column	3.15	Medium

7. Table B

Instrument : **PROCEQ ULTRA SONIC TESTING EQUIPMENT**
Concrete quality grading for different velocity criterion from
Table-2 of IS: 516 (Part 5/Sec 1) : 2018

Pulse Velocity (Km/Sec)	Concrete Quality Grading
Below 3.0	Doubtful
3.0 to 3.5	Medium
3.5 to 4.5	Good
Above 4.5	Excellent

Note: In case of "Doubtful quality", it may be necessary to carry out further test

S. Sherin Prem Nishold
Dr. S. Sherin Prem Nishold, M.E., (GeoTech), Ph.D., (IT Madras)
Technical Manager
Falcon Industrial Testing Laboratory Pvt. Ltd.
Plot No.181, Estate 2nd Main Road, Burma Colony,
OMR, Perungudi, Chennai - 600 096.



Appendix – E – Certificate



05/03/2021

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Miss.K.Kowshika (Reg No:37200033) & Miss.Menakaswamy.M (Reg No:37200041) , a student of BE (Civil Engineering) SATHYABAMA INSITITUTE OF SCIENCE TECH, had tested the Soil Sample, Water & NDT Test on Concrete Pavement from the Period of 09.02.2021 to 28.02.2021.

Soil Sample:

1. Sieve Analysis
2. Atterberg's limit
3. Proctor Density
4. Specific Gravity
5. CBR(Soaked)

Non Destructive Tests:

1. Rebound Hammer Test
2. Ultrasonic Pulse Velocity

During this testing they gained Knowledge about this testing under the Supervision of Our Technical Team.

For Falcon Industrial Testing Laboratory Pvt Ltd



**FALCON INDUSTRIAL TESTING
LABORATORY PVT. LTD.,**

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