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Pollution Control in Municipal Regions

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Traffic Management
Traffic Control
Highway Capacity
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Active control of vibration
Dynamic Behaviour of Stadia Under Human Occupation and Excitation
Earthquake Risk Assessment Attenuation and Vulnerability issues
Lattice Gas and Lattice Boltzmann Simulation of Reactive Flows in Porous Media
Modelling of Walking Forces on footbridges
Robust, Accurate and Efficient Stress Return Algorithms for Advanced
Hardening-Softening Plasticity in Pressure Dependent Materials
Seismic Strengthening using FRP confinement
Soil-structure interaction in masonry arch bridges
The Effects of Crowds on Dynamic Characteristics of Stadia Structures
Vibration serviceability performance of system-built floors

ENVIRONMENTAL ENGINEERING
Environment disasters
Transportation through Mountains
Climatic control measures
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Carbon Abatement Technologies[CATs]
Co-firing with a CO2-neutral biomass
Supercritical and IGCC coal-fired power plant
Saline aquifers
Global Environmental Facility
Environmental impact assessment and mitigation
Water supply and treatment
Wastewater conveyance and treatment
Honey bucket systems
Scrubbers

GEOTECHNICAL ENGINEERING
Behavior of Pile Walls in Liquefying Soil Layers
Analytical and Experimental Studies on Geotextile Reinforced Road Aggregates
Behavior of Reinforced Soil Walls Under Dynamic Loads
Finite Element Analysis of Pile Jetting
Behavior of Reinforced Soil Walls Under Dynamic Loads
Probabilistic Settlement Analysis of Shallow Foundations
Analysis of Beams, Plates, Shells, and their Combinations on Elastic Foundations
Liquefaction Resistance of Soils With Plastic and Non-Plastic Fines

Stochastic Finite Element Method for Reinforced Soil Structures

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Contents

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Kinematics Analysis of the Industrial Robotic Arm Mechanism

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ABSTRACT

Robotic Manipulators are very powerful systems used in almost all industries today to perform different tasks much more precisely and effectively than a human can. One such robotic manipulator is the robotic arm mechanism that is heavily used in all industries, especially the manufacturing industries, due to their greater efficiencies and safer alternatives to humans. For performing the tasks, the most important consideration is getting the gripper of the robotic arm to a required position and orientation. The aim here is to perform the kinematic analysis of the robotic arm mechanism by modeling the forward and inverse kinematics of the arm mechanism. The designing of the movement flow plan and the evaluation of the DH parameter is done for calculating the desired position and orientation of the end effector. Here, the forward kinematics is easy to model, but the inverse kinematics modeling will involve the use of the traditional methods that include the DH notations, transformations, iterations, etc.
Keywords--- Forward Kinematics, Inverse Kinematics, Mechanical Joints and Links, Degree of Freedom

I. INTRODUCTION

The industry is moving towards complete automation, and the need for Manpower is decreasing day by day [9]. We can consider an Automobile Industry, where many changes have taken place in the last 10-20 years. The industry's current situation requires extensive use of the Robotics arm to automate any work to increase productivity and decrease errors ultimately [10]. These changes have introduced us to the two most popular technologies, called industrial robotics arm and exoskeletons. Our work under this article focuses only on the Industrial robotics arm but can be extended to exoskeletons.

A robotics arm is defined as an arm that is the same as a mechanical arm, which is programmed to control specific Motions or behavior to accomplish a given task [19]. They can be imagined as a human arm with certain constraints or freedom, which perform functions along a given path. During programming a robotics arm, the path is fixed. It means that the initial and final point of the gripper is fixed, and it can do any repetitive task until there is a change in the code. The arm consists of different joints that have the flexibility of Motion in different directions. During our coding and all the analysis, we define the Motion of the arm about joints only. The gripper connected to the end of the arm is called end effectors, and its Motion is also controlled by the code written in software. There are other parts of the arm, which have various functions. It consists of a base on which the whole arm stands, the shoulder, the elbow, the wrist, and finally, the end effector, called a gripper arm.

One of the crucial concepts in Robotics is the degree of freedom, which is the constraint of the motion [18]. If we talk about the mechanical context, the degree of freedom is the number of independent variables required to define the Object [2]. Although we have two dimensions or even three dimensions, the degree of freedom can be more than 3. Consider a robotics arm, which is designed to work as a human arm [1]. The shoulder motion can define either the Yaw motion or the pitch motion, which is left

and right or up and down motion, respectively. The wrist can do only pitch or yaw motion, and finally, the elbow can only perform pitch motion. The wrist and shoulder can also make the Rotation motion (Roll). Summing all the motion of different joints gives the value of 5 to 7. Hence, the given robotics arm has a degree of freedom between 5-7. The end effector also has certain degrees of freedom added to the Overall value to define the final degrees of freedom for the complete Industrial Robotics arm. Robotic arms have joints with different motions, characterized based on the type of motion they produce. It can create five types of Mechanical joint motion [3]: Linear joint, Orthogonal joint, Rotational joint, Twisting joint, and revolving joint. We will be explaining each of them one by one in subsequent paragraphs.

II. OBJECTIVE OF ANALYSIS

We are currently in Industry 4.0, and it becomes essential to have a good understanding of Robotics and exoskeleton, especially for Mechanical Engineering. The main objective of the analysis is as follows:
1. Understanding the use of Robotics arm and how the motion is implemented
2. Get familiar with different software that is used for the Kinematic analysis, which includes V-REP and MATLAB and SIMULINK
3. Explore different types of Robotics arm available in the V-REP library and develop the motion

III. KINEMATIC MODEL

Kinematic analysis of Robotics arm requires the Input from the motion of the joint to produce the required motion on the arm, or Input from the motion of the arm to give the needed motion to the Joints [14]. In Mechanics, Kinematics deals with velocity and acceleration of the body and has no relation with the force and torque induced because of the motion. The same is the case for the Robotics arm, where we will be focusing on the motion of joints instead of focusing on the force and torque produced due to the motion (which comes under dynamic analysis).
The definition of a Coordinate system becomes very important as the involvement of velocity and acceleration need to define the coordinate system about which the motion is taking place. Here, we use the Right-Hand coordinate system, which is defined with the configuration of our right hand. For example, we know the direction of the X-axis and Y-axis and want to determine the direction of Z-axis. In that case, we have to use our right hand and the finger so that all the three fingers (defining the three coordinate axes) are perpendicular to each other. We can select any two of them as X-axis and Y-axis, and the third one will be the Z-axis. The defined axes constitute the right-hand coordinate system.
The most fundamental equation used in the kinematic Analysis is the kinematic equation formed by the chain (kinematic chain) that makes the robot. The equation is non-linear and can't be solved directly through analytical methods. We need to use different software(s) to simulate the motion of the robotic arm with the input from the joint angle and joint velocity. Kinematic Analysis is divided into two broad classifications, i.e., Forward kinematics and inverse kinematics. The working of both models is the same, but the input and output differ, along with the governing equation of motion.
The time derivate of the kinematic equation of the robotics arm gives the Jacobian, which establishes a relation between the Joint rate to the angular and linear velocity of the end effector (gripper) [5]. Deriving from the principle ofvirtual work, it can be shown that the Jacobian also establishes the relationship between the Joint torque, its resultant force, and torque by the end effector [16]. We can also identify the singularity (singular configuration) from the Jacobian. Let q be the column matrix that

represents the join velocities, let 'n' is the number of joints. Hence, the size of the matrix is 'n*1' [12], [13]. Let X represents the column matrix for end-effector velocities, let 'm' is a number defined as 6 for spatial robots and 3 for planar robots. Hence the size of the matrix is 'm*1' [11]. Let J defines the Jacobian matrix for the given configuration according to joint velocities and end effector velocities [4], [15].

$$X=J*q \qquad (I)$$

If the order of matrix q is 'n*1' and the order of X is 'm*1', then the order of J is 'm*n [6].
Forward kinematics computes the value of the position of end-effectors from the input value of joint parameters, which includes joint angle and joint velocities [7]. The body Jacobian, which consists of speed Jacobian and rotational velocity Jacobian matrix, gives the relationship between the two [17]. This consists of a non-linear equation and hence, there is no analytical solution available for each type of motion. Inverse kinematics computes the value of Joint parameters, from the input value of end-effectors parameters [8]. In this paper, we will be making a forward kinematic model as well as an Inverse kinematic model to develop the motion of the robotics arm to complete a task. MATLAB and SIMULINK will be used to develop the model from the design data received from either the SOLIDWORKS or the V-REP software [20].

IV. METHODOLOGY

In this paper, the kinematic analysis and simulation of the robotic arm are done using two methodologies. In the first methodology, we use a robotic arm template already present in the V-REP environment for simulation. The first methodology uses the V-REP environment for the simulation and the MATLAB environment for controlling the mechanism and the second methodology uses SOLIDWORKS for designing the CAD model, Simscape Multibody environment for the simulation, and the MATLAB environment for controlling the mechanism.

A. V-REP AND MATLAB SIMULINK INTEGRATION

In this methodology, the KUKA-KR16 robotic arm model template is used that is already present in the V-REP environment. The Virtual Robot Experimentation Platform (V-REP), is an environment that is used for simulating the 3D robotic systems that help you in modeling, editing, programming, and simulating any of the robotic systems. It can help in the modeling and simulation of the sensors, mechanisms, robots, and whole systems in a variety of ways. V-REP can be used for a variety of purposes ranging from remote monitoring, hardware control, fast prototyping and development/parameter verification, adjustment, fast safety algorithm doublechecking, robotics-related education, or factory automation simulations. The three central elements here include: Scene Objects, Calculation Modules, and Control Mechanisms.
Here the control mechanisms consist of the Embedded Scripts, Plugins, and Add-ons that are used for a local interface where we have the same process or hardware; and the Remote API clients and ROS nodes are used as external interfaces where we do not have the same processor hardware. Remote API clients consist of over 100 API functions (Extendable), it has a client program (your program), a server relationship (V-REP plugin), and the programming language that can be used are C/C++, Python, Java, MATLAB, Octave, Lua & Urbi.

In this methodology, MATLAB is used as a Remote API client which is used as an external interface to control the working of the robotic system. In this model, there is a proximity sensor placed near the conveyor belt that will be used to sense whether the block has reached the position, where the robotic arm will be able to lift it from the conveyor belt and place it on the table. As soon as it senses that block has reached that position, the robotic arm will move such that the gripper will be just above the block and will be able to pick it from the belt. The steps involved in controlling the KUKA KR-16 robotic arm include the following:

1. Setting up the simulation environment in V-REP as shown in Figure 1.
2. Making required changes to the LUA scripts of the ROBOTIQ_85 (gripper), the Customizable Table, and the Customizable Conveyor. The changes need to be done in Non-Threaded Child Script for ROBOTIQ_85 in the initialization function, Non-Threaded Child Script for the Customizable Table, and Non-Threaded Child Script for the Customizable Conveyor.
3. The file named remApi.m, remoteApiProto.m, simpleTest.m and remoteApi.dll should be extracted from the: C:\ProgramFiles\VREP3\VREP_PRO_EDU\programming\remoteApiBindings\matlab\matlab. into the folder that contains your simulation files.

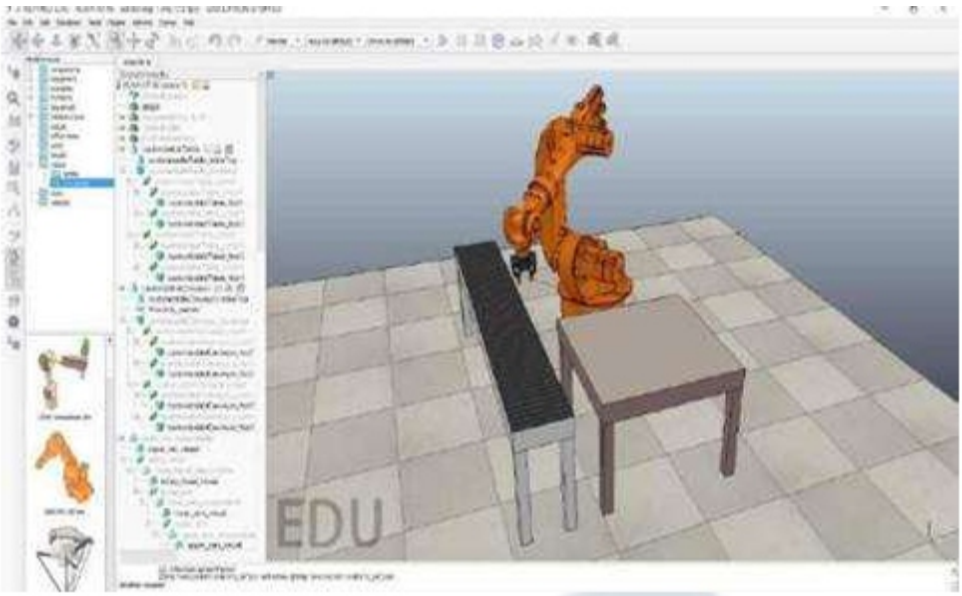


Figure 1: Simulation environment in the V-REP Software

4. Writing the MATLAB function for the picking and placing of the blocks, moving the arm, and gripping the block and the MATLAB code for integrating these functions and getting the task done.
5. Run the V-REP Simulation and the simpleTest MATLAB code to check for any faults.
6. Run the V-REP Simulation and the MATLAB code for carrying out the task.

B. SOLIDWORKS AND MATLAB-SIMULINK INTEGRATION

There will not be templates available for all the robotic arm mechanisms that are being used in the industry because of which there will be a need to design a 3-D model of the robotic arm mechanism using any of the available CAD software and then convert it into a Simulink model using the Simscape

Multibody Link which is used for the kinematic analysis. Here the Simulink acts as the simulation platform and MATLAB acts as the interface used to control the movements of the mechanism. The CAD software used is SOLIDWORKS. Here, both forward and inverse kinematic analysis are performed on the model by developing suitable Simulink model and MATLAB codes. A detailed explanation of the steps is given below:

1. Designing a 3-D model of the robotic arm mechanism using the CAD software as shown in Figure 2.

Figure 2: 3-D Model of the Robotic Arm Mechanism

2. Exporting it as an .xml file from SolidWorks to the Simscape Multibody Link Platform.
3. Using the MATLAB software, importing it from .xml to .slx format to the Simulink platform with the command smimport('Name of the file here').
4. In the Simulink platform, take the revolute joints you need to control and form a subsystem of the rest of the joints that are not required and name it 'Extra System' as in Figure 3.
5. To the revolute joints that are required, add suitable blocks for controlling the joints and getting the desired output from them. Fig. 4(a) and 4(b) shows how a model will be derived for the kinematic analysis

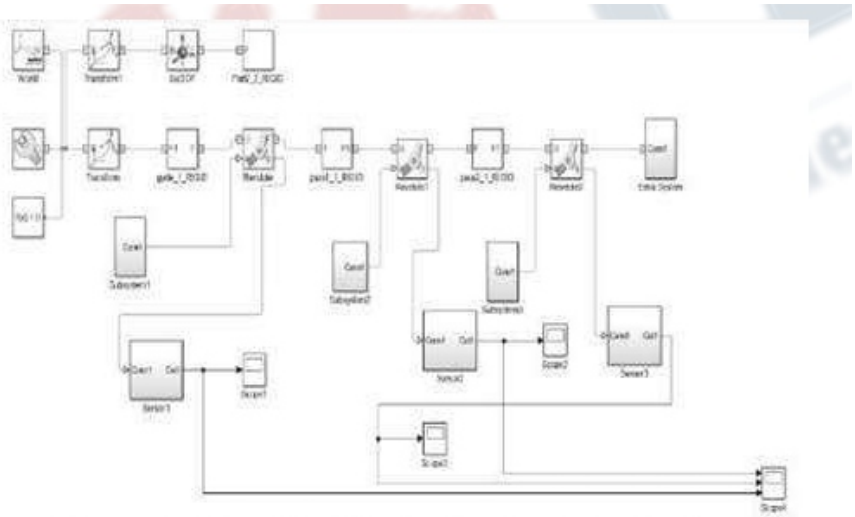
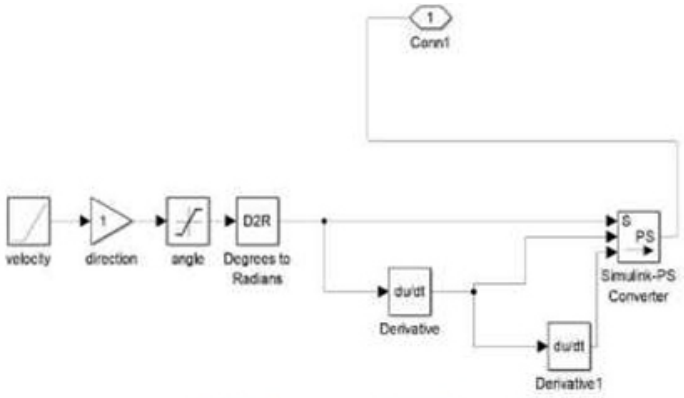
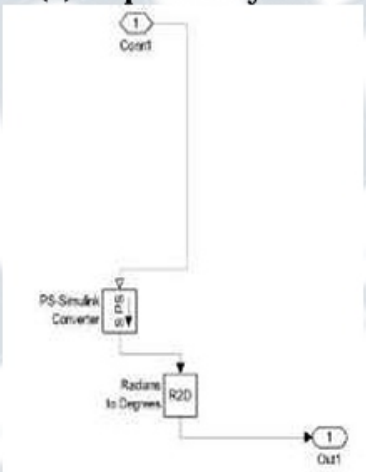


Figure 3: Simulink Model for the Robotic Arm

6. For the Forward Kinematic Model, the MATLAB code is developed that takes the input of the joint angle and the joint velocities and then computes the transformation matrix, and hence the tait-bryan angle is computed using this transformation matrix.
7. For the Inverse Kinematic Model, the MATLAB code is developed that takes the input of the required rotation of the total robotic arm (tait-bryan angle) along the X, Y, Z axes and the joint velocities and computes the rotation matrix which is then used to compute the joint angles. 8. Finally, the simulation of the robotic arm is done by using the velocity and angle of each joint, and the output is viewed in the Simulink Platform.



(a). Input Subsystem



(b). Output Subsystem

Figure 4: Subsystem of Simulink Multibody

C. ALGORITHM DEVELOPED FOR THE ANALYSIS

The forward kinematic model involves taking the joint angles and the joint velocities as user input and computing the tait-bryan angles, the transformation and, the rotation matrix from the obtained data. The following is the algorithm used for developing the MATLAB code that is used for performing the forward kinematic analysis on the arm mechanism:

1. Set both the rotation and the matrices as an identity matrix.
2. Enter the joint angles as a user input
3. Calculate the transformation matrix using the joint angles
4. Enter the joint velocities and the order of rotation of the x, y, and z-axes as a user input

5. Calculate the tait-bryan angle using the transformation matrix
6. Calculate the rotation matrix using the tait-bryan angles and the order of rotation
7. Feed the joint angle and the joint velocity thus obtained into the simulation environments to get the desired movement of the arm.

The inverse kinematic model involves taking the tait-bryan angles and the joint velocities from the user and using these to compute the joint angles, the rotation matrix, and the transformation matrix. The following is the algorithm used for developing the MATLAB code that is used for performing the inverse kinematic analysis on the robotic arm mechanism:

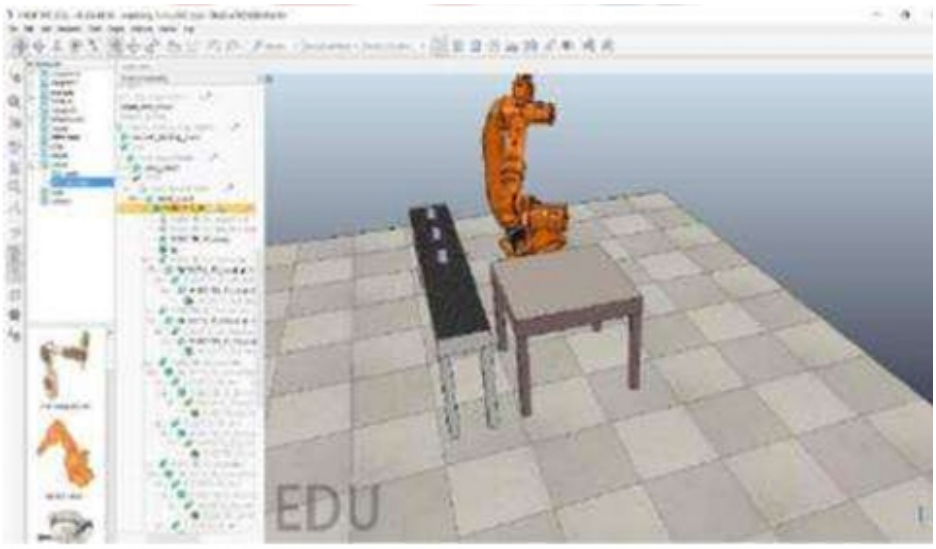
1. Set both the rotation and the matrices as an identity matrix.
2. Enter the joint velocities and the tait-bryan angle as a user input
3. Enter the order of rotation of the co-ordinate axes
4. Calculate the rotation matrix from the data obtained from the user
5. Calculate the joint angles using the rotation matrix obtained
6. Calculate the transformation matrix from the joint angles
7. Feed the data thus obtained into the simulation environments to get the desired movement of the arm.

V. ANALYSIS RESULTS

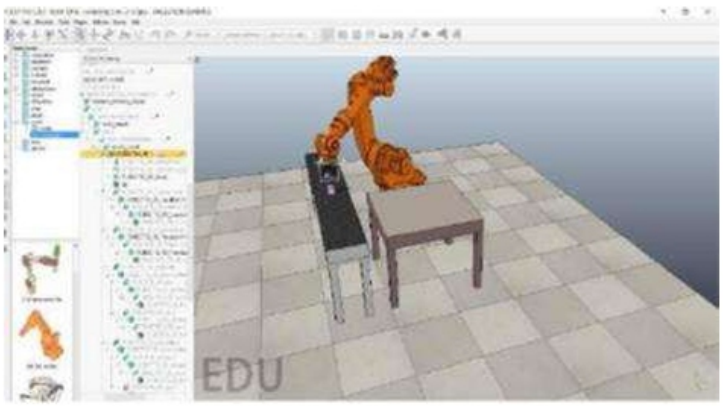
The Analysis carried out in MATLAB and SIMULINK through this methodology results in the simulation of the robotics arm and it performs the motion according to the given input.

A. RESULTS FROM THE FIRST METHODOLOGY

The following is the image of the simulation of the KUKA KR-16 Robotic Arm model on the V-REP environment where the proximity sensor has sensed the block and the gripper is picking up the block.



(a). Initial Position before the Simulation

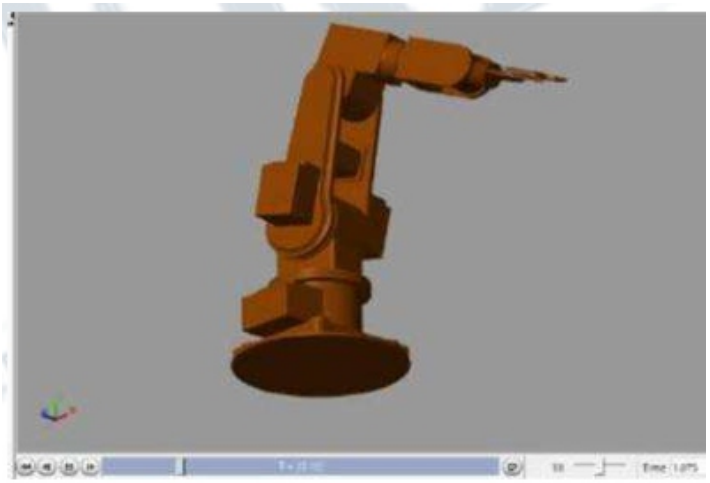


(b). Final Position after the Simulation

Figure 5: Position of the KUKA KR-16 Robotic Arm

B. RESULTS FROM SECOND METHODOLOGY

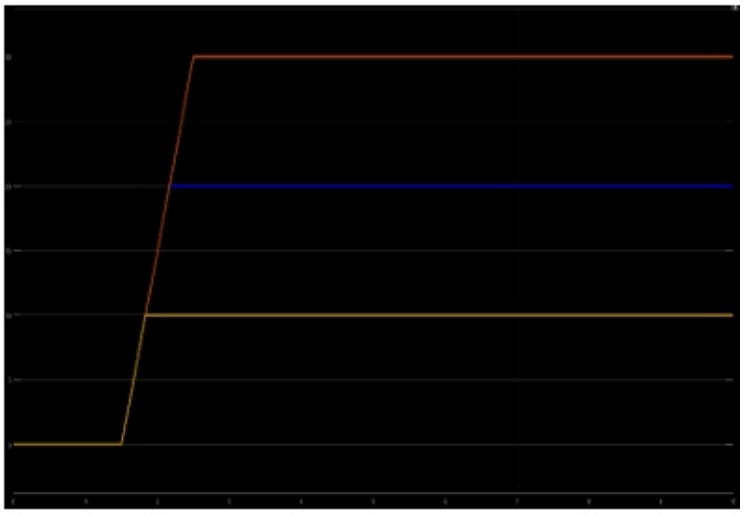
The following is the image of the simulation of the robotic arm mechanism on the SimMechanics window of the MATLAB Simulink platform where the angles and velocities of each joint will be used to simulate the mechanism.



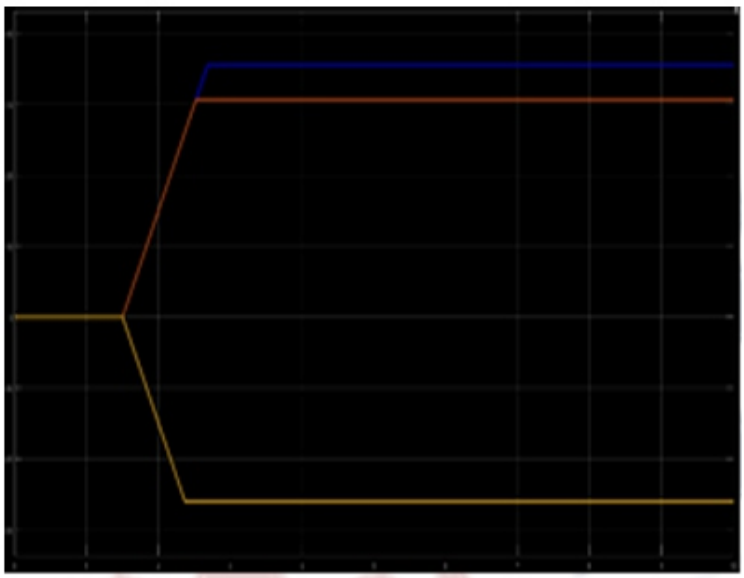
(a). Initial Position before the Simulation

(b). Final Position after the Simulation

Figure 6: Position of the Robotic Arm Mechanism



(a). For the Forward Kinematics



(b). For the Inverse Kinematics

Figure 7: Graphs of the Joint Angle vs Time

C. RESULTS FROM MATLAB CODE

The following are the results obtained from the codes used for the calculations involved in performing the forward and inverse kinematic analysis of the robotic arm mechanism.

```
>> Inverse_Kinematics
Enter the order of rotation
 1. X-Y-Z 2.X-Z-Y
 3.Y-X-Z 4.Y-Z-X
 5.Z-X-Y 6.Z-Y-X
1
Enter the rotation in the x-direction 20
Enter the rotation in the y-direction 30
Enter the rotation in the z-direction 10

rotmatrix =

    0.8529    0.0052    0.5221
    0.1504    0.9551   -0.2552
   -0.5000    0.2962    0.8138


Rotation matrix created!

transmatrix =

    0.8529    0.0052    0.5221
    0.1504    0.9551   -0.2552
   -0.5000    0.2962    0.8138

Enter the joint velocity 1 30
Enter the joint velocity 2 30
Enter the joint velocity 3 30
The joint angles are computed!
The angle of joint 1 is:-2.605239e+01
The angle of joint 2 is:3.553135e+01
The angle of joint 3 is:3.064234e+01
```

(a). Forward Kinematics

```
>> Forward_Kinematics
Enter the joint angle 1 in degrees 10
Enter the joint angle 2 in degrees 20
Enter the joint angle 3 in degrees 30

transmatrix =

    0.7146   -0.6131    0.3368
    0.6337    0.7713    0.0594
   -0.2962    0.1710    0.9397

Enter the joint velocity 1 30
Enter the joint velocity 2 30
Enter the joint velocity 3 30
Enter the order of rotation
 1. X-Y-Z
 2.X-Z-Y
 3.Y-X-Z
 4.Y-Z-X
 5.Z-X-Y
 6.Z-Y-X
1
The Tait-Bryan angles are calculated!
The tait bryan angles thus computed are:
1.031410e+01, 1.722940e+01, 4.156670e+01
```

(b). Inverse Kinematics

Figure 8: Calculations involved in the Kinematic Analysis

VI. CONCLUSION

The robotic kinematics involves the movement of the gripper to a required position through the movement of the links and joints present in the mechanism. Robotic Kinematics can be divided into two types include the forward and the inverse kinematics. Here, the forward and the inverse kinematics are analyzed for a robotic arm mechanism. Forward kinematics is the solving of the forward transformation equation for finding the hand location from the angles and velocities of the joints and Inverse kinematics is the solving of inverse transformation equation for finding the joint angles from the gripper location in 3-D space. For this we have used two methodologies, first involves the V-REP and MATLAB Simulink integration and the second involves the SOLIDWORKS and MATLAB Simulink integration. In the first methodology, then we take the desired user input and perform the calculations as per the kinematic model using MATLAB, an interface is formed between MATLAB and V-REP through which the output is fed to V-REP and the desired motion is obtained by running the simulation. In the second methodology, the CAD model of the robotic arm mechanism is built in SolidWorks and exported to the Simulink platform and a basic model for the mechanism is developed in which we make the required modification for running the forward and inverse kinematic analysis. We take the desired user input and perform the calculations as per the kinematic model using MATLAB. The desired motion of the robotic arm mechanism is obtained by feeding this input to the Simulink block system and running the simulation.

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Stabilization Of Contaminated Dump Yard Soil By Bio-Enzymes

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A B S T R A C T

the occurrence or detection of the construction project is often problematic because of the associated time constraints in correctly determining and classifying the contaminant region and the costs involved with maintaining the safe and effective handling of the contaminated material. The present research work aims to provide a solution to that problem with the help of a newly developed non-conventional stabilizer known as DZ-2x bio enzymes. Contaminated soil from a dump yard is tested with the bio enzymes to determine possible changes in its strength and usability as a construction material. The experiments showed a positive results in terms of its unconfined compression strength, maximum dry density and optimum moisture content with compressive strength increased up to 164% at the end of 28 days.

Index Terms*— soil contamination, stabilization, bio-enzymes,compaction, unconfined compression test*

I. INTRODUCTION

Many a time's engineers are faced with challenge of working with soils which do not possess sufficient engineering properties to support the imposing loads or the building activities on them. For the better performance of the structures built on poor soils, the performance characteristics of such soils must be improved. When a poor quality soil is present at the working site the best way to handle the construction environment is to modify the properties of that soil until it meets the requirements. This need has resulted in variety of soil stabilizing techniques depending upon the types & properties of the soils [1].

Table 1. Trace elements in the samples compared w
Effluent Standards (Ojoawo et. al, 2015)

Elements (ppm)	Obtained	EPA standard
Cu	26.7	3.0
Pb	25.9	1.0
Mg	417.4	-
Cr	0	2.0
Ni	0.9	1.0
Zn	11.6	5.0
Mn	0	2.0
Cd	1856.4	0.03

Soil pollution and land degradation by various human activities involving the xenobiotic elements reduce, alter and change the properties of soils. Soil contamination by hazardous materials is an issue of concern worldwide. Various studies have been undertaken to find the effective way of treating, stabilizing and utilizing this naturally available soil for the construction activities. Table 1 and 2 depicts the chemical properties of the leachate and elements found in the soil of the area under study. It clearly shows the excess of chemical present in the soil. It is impractical to remove and replace the entire soil layer of a building site. Therefore using stabilizing methods to increase the workability and constructability is a better and economical option. The recent advancement in using enzymes as a stabilizing agent has proved to increase the soil stability and other engineering property necessary for a building quality soil. Enzymes are environmental friendly, organic compounds which used in right way can provide a great stabilization of soils which are especially good for the construction of sub grade for highway, road beds [2].

Table 2: Chemical parameters as compared with the Effluent Standards (Ojoawo et. al, 2015)

Properties	Obtained	EPA standard
pH	8.37	6.0
Electrical conductivity (Ms/cm)	76000	-
Chloride (mg/l)	11700	-
COD (mg/l)	44800	160
Sulphate (mg/l)	48.0	-
Nitrate (mg/l)	160.0	50.0
Phenol (mg/l)	1010.0	1.0
Phosphate (mg/l)	85.4	4.0

Combined with rising relocation to urban centers, the growing global population means that vacant land sites are being redeveloped to satisfy demand. Absence of appropriate due diligence to adequately determine the possibility of polluted soil on a site at the early stages of pre-planning and construction can run the risk of significant budget overruns or potentially may have severe safety consequences for all workers and future residents. Open dumping of the city wastes has been extensively practiced in India. The resulting leachate produced from the landfill pose a serious environmental threat to the surrounding area by contaminating the soil and ground water sources [3].

The area under this experimental study is a large open dump site in Mangaluru city. Around 250 MT of solid urban waste is being dumped without shredding and sorting at the dumping yards (Ravi Shankar et al., 2004). The dump yard receives carcasses of animals, chemical, industrial, and bio-medical waste. (Sitaram et al., 2007). Table 3 shows an estimation of growing amount of wastes disposed in the city, thereby prompting a thorough study of soil in the area to mitigate the problems raised due to leachate and

low strength. Scope of the problem

An initial survey of the area reveals an extensive contamination of the soil due to the heavy leakage of the leachate. The ground water sources of the nearby village such as Mandara is found to be polluted. The basic test of the dump yard soil indicates very low geotechnical proprieties suggesting any possible future infrastructure development is impossible without proper ground improvement. The present experimental program is an attempt to come up with solutions to these problems [4].

II. LITERATURE STUDY

Mohd. Yosuf et al., (2016) a laboratory investigation was conducted in this study to analyses TerraZyme's quality on various types of soil. Using 2 % & 5% TerraZyme, laterite and kaolin are treated to assess improvements in the geotechnical properties of the soil. In terms of compaction, unconfined compressive strength and bearing ratio, the results obtained are evaluated and investigated. Modifications in the geotechnical properties of stabilized and unstable soils have been controlled for 0, 7, 15, 21 and 30 days. Laterite with 5% TerraZyme was found to have increased maximum density and decreased optimum moisture content. It is concluded that TerraZyme is not ideal for Kaolin stabilization; to achieve better efficiency, TerraZyme needs soil.

Carvalho et al., (2017) this research aims to show how the use of enzymes in the construction industry could be beneficial. It thus discusses the chemical and biological functioning of enzymes; it examines their advantages and uses in the field of construction and measures the addition of two different types of enzymes in different concentrations to a soil: Alpha soil as well as DZ-2X. In the flexural and compressive tests the soil without treatment and the addition of enzymes are based. The results thus allow the study of the interferences of these enzymes in soil resistance and the comparison of the improvements caused by both substance additions. Finally the results of the study show that adding enzymes to the soil will significantly improve its flexural and compressive behaviour.

Kushwaha et al., (2018) conducted a study on stabilization of red mud with different content of Eko Soil Enzymes (ES). ES variability in the samples was rendered by volume of water 1 to 7 per cent. 7 Samples of varying red mud content of ES were prepared and index and engineering properties tested. The CBR experiments were conducted on unsoaked and soaked samples to understand the role of ES as stabilizing material. Depending on the experimental findings, the application of ES (up to 4%) to red mud improves the average dry density and reduces the optimal content of moisture. The optimal mix was RM+ 4 percent and it improved the soaked CBR by 580.9 percent by 578 percent for 45-day healing period. The properties of permeability and leachate was evaluated for different flow cycles from 1 to 7 days of mixture RM+4 per cent ES [5].

Shankar et al., (2009) Carried out a laboratory investigation to study the properties of laterite soil of Udupi and Dakshina Kannada district with and without blending the soil with sand, in addition to the commercially available enzyme namely Terrazyme. The investigation showed a medium enhancement in the physical properties of soil. Hence the paper suggest that prior experiments with bio-enzymes have to be made before applying it in the field. By using a higher dosage of 200mml per 2m3 of soil, it was possible to get 300% increase in CBR value, 450% rise in unconfined compressive strength. Permeability was reduced by 42% for a curing period of four weeks. The experiment noted that the enzymes are not effective for cohesion less soils [6]

III. METHODOLOGY

The research work is carried out at the NMAM institute of technology, Nitte. During the initial work the

main focus of the study is to understand the geotechnical properties of the heavily contaminated soil of the dump yard. Later part consist of finding an economical solution to improve the soil condition as well as to reduce the percolation of leachate into the soil.[7] Selection of soil from 4 different location of the dump yard as a representative of the contaminated soil and studying their physical and geotechnical properties. Selection of soil in its natural condition from the near by location to study the comparison between the contaminated and non contaminated soil.

Study the basic engineering properties of soil.

Applying a non conventional enzymatic solution to contamiated soil to study any improvements in its geotechnical characteristics.[8]

Table 3 Estimation of waste generation in MCC area (City Corporation, Mangalore)

Year	Population	Waste in tons/day
2001	398745	140
2005	440247	162
2010	486068	189
2015	536658	219

The representative soils were collected from the selected locations at a depth of 1.0-1.2 m. The soil samples were oven dried before conducting the laboratory tests.

Table 4 Nomenclature of the soil samples

Samples	Abbreviation
Natural soil sample	N.S
Contaminated soil sample 1	C.S I
Contaminated soil sample 2	C.S II
Contaminated soil sample 3	C.S III
Contaminated soil sample 4	CS IV

Fig 1 Collection of soil samples DZ-2x

It is a naturally occurring biodegradable substance. It changes and improves physical and chemical of soils through its behavior, resulting in considerably less mechanical effort to achieve higher compaction densities. Soil adsorbs the proteins, which initially allows it to stretch and then contract. The enzymes also help the soil bacteria release hydrogen ions, resulting in pH gradients at the soil particle surfaces, which help break up the soil structure. An enzyme is by definition an organic catalyst that accelerates a chemical reaction, which would otherwise occur at a slower rate, without being a part of the final product. The enzyme interacts with the complex organic molecules to form a reactant intermediate that exchange ions with the surface of the soil, breaking down the lattice and inducing the cover-up reaction, which avoids further water absorption and density loss. The reaction regenerates the enzyme and goes on to react again. The compaction of aggregates by construction machines close to the maximum moisture content provides the desired high densities typical of the shale. The resulting surface has permanent "shale" properties created in a fraction of the time (millions of years) needed by nature.[9]
The enzymes increase the wetting and bonding capacity of the soil particles when applied to a soil. The enzyme makes it possible for soil particles to get moist and densely compacted. It also strengthens the chemical bonding which helps to bind the soil particles together, making a more permanent structure which is more immune to weathering, wear and water penetration. (Dhara Biotech manual)

A. Basic tests

Primary tests were conducted on the soil sample in accordance with the standard code book. The basic tests included specific gravity as per IS 2720: Part III, moisture content as per IS 2720: Part II, Sieve

analysis as per IS 2720: Part IV. Modified proctor test was performed to determine the maximum dry density at optimum moisture content in accordance with IS 2720: Part VIII. Other test like unconfined compression test as per IS 2720: Part X, soaked and unsoaked California bearing ratio as per the code of IS 2720: Part XVI.

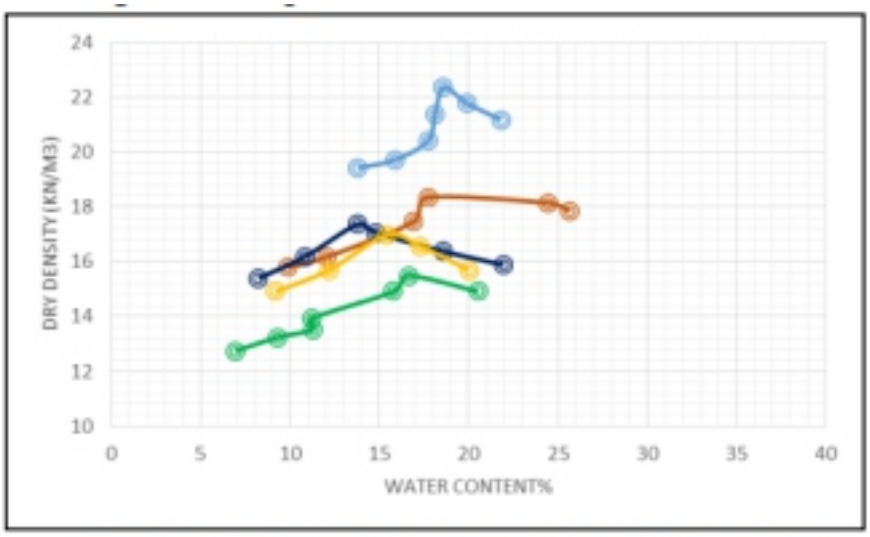

Fig 2 Compaction curves for the samples

The soil samples from the different parts of the dump yard region showed varied properties. The differences indicates the type and amount of the wastes being dumped over the course of the years. The sample CS-I is found be having more clay content in it resulting in more strength compared to the other soil samples.

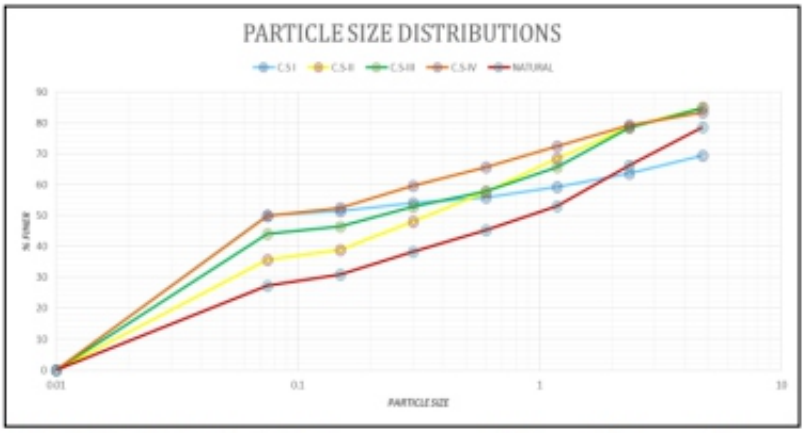

Fig 3 Particle distribution curves of the soil samples

The compaction characteristics of the soil reveal the presence of organic compounds that are accumulated over the course of time in terms of its dry density value which is lower compared to the naturally available soil from the same area. Fig 2 shows the graphical representation of the 5 soil samples and their variation with the moisture content. Table 5 summarizes the index and strength properties of the contaminated soil samples

Table 5: Physical & Geotechnical properties of untreated soil samples

Physical properties	NS	CS I	CS II	CS III	CS IV
Moisture content (%)	12.4	33.82	20.82	17.17	16.35
Specific gravity	2.728	2.394	2.41	2.462	2.321
Atterberg's limits and indices	…. .. …	…. …..	…. …..	… …..	.. … …
Liquid limit	31	52	-	39.29	36.1
Plastic limit	20.38	34.21	-	26.07	20.06
Shrinkage limit	35.76	30.64	-	32.41	33.86
Plasticity index	10.62	17.79	-	13.22	15.5
Liquidity index	1.75	1.02	-	1.67	1.27
Consistency index	0.751	0.021	-	0673	0.274
Particle size distribution	… … ..	… … ..	.. … …	…. …	… ….
Gravel (%)	21.28	30.56	14.96	15.12	16.4
Sand (%)	51.44	19.28	49.28	40.8	33.6
Silt & Clay (%)	27.28	50.16	35.76	44.08	50
C_U	66.29	91.06	34.59	30.16	20.78
C_C	0.345	0.098	0.261	0.154	0.432
Compaction characteristics	…. ….	… …. .	….. …..	…… ……	…… ……
Maximum dry density(kN/m^3)	18.33	22.35	15.49	17.35	16.96
Optimum moisture content (%)	16.63	18.12	21.40	13.79	15.41
IS classification	SC	MI	SM	SC	CI
UCS (MPa)	146.3	157.57	105.7	127.4	133.5
Permeability					
*Constant head (*10^{-3})*	0.583	0.381	2.19	1.764	1.279
*Variable head (*10^{-4})*	3.05	1.595	6.653	4.583	4.016

B. Dosage of DZ-2x stabilizer

It was stated (Tingle et al.) that enzymes remain actively engaged in the soil until no further catalyzing reactions occur. As the enzymes serve as a catalyst in soil inducing reactions, they are necessary for stabilization purposes in very limited dosages. Since no technical requirements have been developed, their applicability is dependent on empirical criteria laid down in previous studies. Because differing dosages of the enzyme have various effects on the same soil, this suggests that inadequate enzymeconcentrations will not produce successful stabilization, whereas higher doses may have detrimental effects on soil. It would also be desirable to arrive at an optimum dose of DZ-2x to improve the effectiveness of enzyme stabilization. The subsequent dosages proposed for this analysis were considered as follows.

Table 6: Dosage of DZ-2x stabilizer used in the study

Dosage (%)	ml/ 1 Lt of water
2	20
4	40
6	60
8	80
10	100

IV. RESULTS AND DISCUSSIONS

Out of the five samples collected from the dump yard the soil sample with least strength and density was chosen to carry out the further experimental investigation with the stabilizer. Only the sample C.S-II was used in all the tests with stabilizer.

C. Compaction characteristics

The compaction properties of the soil samples (B.I.S, 1987) were studied in the laboratory using standard proctor testing. The apparatus used in the test consists of a cylindrical mold with detachable base with an internal diameter of 100 mm and an effective height of 126 mm, with a total volume of 990 ml. The rammer weights 3.5 kilograms, with a 300 mm fall

Table 7 MDD vs OMC of the soil treated with enzymatic solution

Dosage	OMC (%)	MDD (kN/m^3)
0%	21.407	15.54
2%	20.844	15.69
4%	21.889	15.76
6%	19.703	16.17
8%	21.008	15.89
10%	21.27	15.79

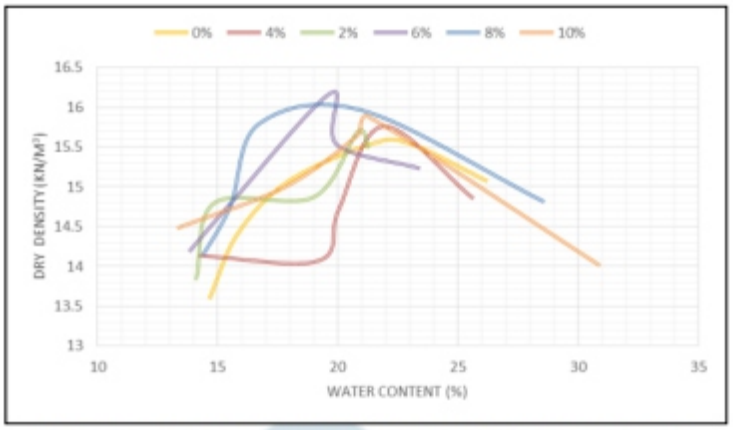

Fig 4 compaction curves for various dosages of stabilizers

The soil samples for the compaction tests were prepared such that the enzymatic solution is added and allowed to mellow for a minimum period of 12 hours as per the manufacturer's instruction in a sealed condition before the compaction procedure. This makes sure the reaction of enzymes with the soil. The result at the end of test yielded a linear increase in the maximum dry density of the soil with every 2%

interval. The optimum solution for the maximum dry density is found to be at 6% of the solution.

D. Unconfined compression strength characteristics

Remolded samples prepared in the laboratory with an optimal moisture content and a maximum dry density using cylindrical molds. The height diameter ratio of each sample was 2:1 and the test was carried out as per IS: 2720 (part 10). Addition of stabilizer shows considerable improvement in the strength. Due to the enzymatic reaction in the soils, there is enhancement in the chemical bonding of the soil particles which helps in packing them closely.

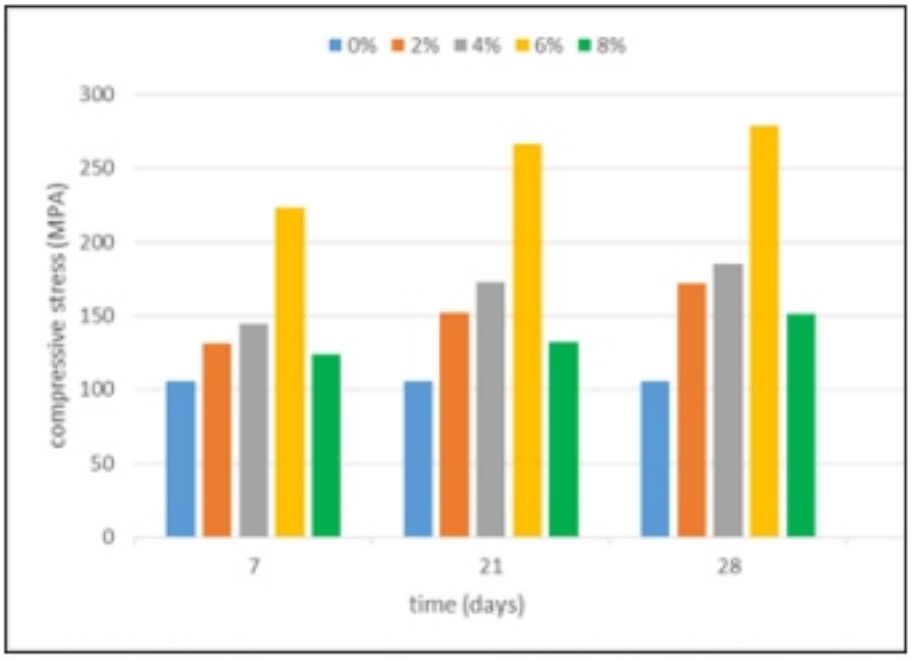

Fig 5 Graphical comparison of effect of stabilizer dosage on soil

The sample tested with 6% of the stabilizer showed almost double the value of the sample with 0% stabilizer. This mirrors the effect of the activities of enzymes in modifying arranging the structure of soil particles as highest at a particular dosage.

Table 8 The unconfined compression strength values

Days/ Dosage	0%	2%	4%	6%	8%
7	105.7	131.62	144.82	223.42	124.14
21	105.7	152.36	173.00	266.78	132.62
28	105.7	171.8	185.33	279.20	150.95

V. CONCLUSTION

This experimental study shows a considerable improvement in the maximum dry density. The contaminated samples have shown little to no negative impacts on the geotechnical properties of the soil in terms of strength. But upon the application of the stabilizer the soil sample has shown a significant improvement in the unconfined compression strength and dry density in comparison. The enzymes have combined with the large organic molecules to form an intermediary that exchange ions with the soil structure and break s down the lattice to produce a tight alignment of soil particles. Maximum dry density improved from 15.49 kN/m3 to 16.17 kN/m3. Compressive strength increased by 164% at the end of 28 days. It's imperative to conduct other tests in order to understand the effect of the enzyme on the contaminated soil before using it on a larger scale.

VI. ACKNOWLEDGEMENT

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Analysis of single and Multi-span Slab Bridges using CSi Bridge Software

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A B S T R A C T

Bridges are authoritative to one and all and which are the most prerequisites of the transportation system but they are likely to fail if its structural insufficiencies are not recognized. And also, Every structure can be analyzed with by static method as well as the dynamic method by Selecting a suitable analysis method whereas this is influenced by a various number of factors. Namely, the purpose of analysis, the importance of the structure, various methods obtainable for analysis, type of the bridge or type of structure and soil conditions as well as soil-structure interaction. To overcome this problem, the paper aims to carry out the analysis of single and multi-span RC Slab Bridge with static and dynamic analysis. CSI bridge software has been used to analyze the Reinforced concrete slab Bridge.

Index Terms— *slab bridges,staticanalysis, dynamic analysis*

I. INTRODUCTION

The ideal purpose of the study search out obtains an correct measure of supposed fundamental response for a likely type of shock. To answer this purpose, a method that is secondhand for study is also concerned significantly. Also, the significance of any form plays a meaningful duty. The static adaptable reasoning is ruined all types of structures. For common forms motionless analysis is acceptable, except for main structures specifically for bridges, the vital study must be carried out. Also, forms mainly have an uneven configuration in addition to a variable subsurface condition that can be resolved by utilizing vital analysis system. Static reasoning maybe carried out manually or through a calculating program. The forms and skills are usually applicable to the bridge design society. Inappropriately, static adaptable study is appropriate for only a limited class of bridges. Dynamic reasoning transfers an correct amount of anticipated fundamental answer for a likely type of earthquake occurrence or order of temblors. If a precise fundamental model maybe settled, the calculated all-encompassing displacements maybe secondhand directly to base seat widths and separations, and local deformations and flexibility necessities can be secondhand straightforwardly to decide the mandatory analyses These models must perform accompanying the appreciative that no level of complicatedness in fundamental displaying can overcome the basic danger in basaltic stowing. The dynamic reasoning maybe used to support an insignificant measure of certain answers, that will ensure the acceptable depiction of the building It is a gravity loading due to the structure which is simply calculated as a product of volume and substantial density of the bridge whereas torsional stiffness of main structural elements was varied[1]-[6].

A. Live Load

Highway Road bridge decks should be created to bear the live loads particularized apiece Indian Road Congress (I.R.C: 6-2010 Section II). In India, artery bridges are created under IRC bridge rule IRC: 6 - 2010 Section II that gives the requirements for the miscellaneous loads and stresses expected deliberate

in bridge plotting. There are three types of standard loadings for that the bridges are planned that is to say, IRC class AA stowing, IRC class A stowing and IRC class B stowing.

B. Seismic Load

If a bridge is situated in an shock-likely field, the upheaval or basaltic forces be entitled to deliberation in fundamental design. Earthquakes cause upright and level forces in the makeup that is to say equivalent to the pressure of the building. Both level and upright elements have to stop living into give reason for the design of bridge constructions. IS: 1893 –1984 concede possibility be refer to for the real design loads [7].

C. Impact Load

For I.R.C. class A loading chart, The impact allowance is Given as a fraction of the applied live load and is Calculated by the following equation,

$$I=4.5/ (6+L)$$

Where, I=impact factor fraction, L= span in meters

II. STATIC AND DYNAMIC ANALYSIS

The structural analysis mainly emphases on the variations taking place in the performance of aphysical structure under surveillance when providedwith a force or in case of structures, load. Now ifthis load is virtual that is very slow, the inertia forcesfound from the basis of newton's first law of motionwould be ignored and therefore the analysis turns out to be static. Whereas the static loads are very slowon the time rate graph after the observations made. Static structure analysis methods are as follows, nonlinear static analysis and linear static analysis. Conflicting to this, if the force or load applied tohave a high rate of change of velocity during theprocess then it gets converted into the dynamicanalysis, the basis and consequenceportion comesin to play here. The system under contemplation isobserved for the expansion going on during asequence of time and then the cause of those changes has been analysed [8].
Dynamic loads are always applied as a function of time or as a function of frequency and the time or frequencyvarying load application brings frequency-varying response that is displacements, velocities, accelerations,forces, and stresses. These time or frequency-varyingphysical characteristics make the dynamic analysis moredifficult as well as more accurate than the static analysis. Dynamic structure analysis method is as follows, Non linear time history analysis, " Non- linear" staticanalysis, Linear elastic time history analysis,Modal- superposition, linear static analysis. All the loads are considered here are dynamic by nature but at some point of time they were inattentive and which also comprises the self- weight of the structure [9].

II. PROBLEM DEFINITION

The bridge analyses are in Table 1 and Cross-section of Bridge proved in Fig 1. The loads and load alliances on the bridge are intentional and the unchanging bridge
posed in CSi Bridge spreadsheet (Fig 2), bridge analyses

BRIDGE DETAILS				
SL NO	DESCRIPTION			
1.	Span of the bridge	4m	4m x 2	4m x 3
2.	Width of the bridge	7m	7m	9m
3.	Number of lanes	2	2	2
4.	Slab thickness	400mm	700mm	1000mm
5.	Type of loading	IRC class AA loading	IRC class AA loading	IRC class AA loading
6.	Compressive strength of concrete	30000kN/m^2	30000kN/m^2	30000kN/m^2
7.	Modulus of elasticity	27386128kN/m^2	27386128kN/m^2	27386128kN/m^2
8.	Poisson's ratio of concrete	0.18	0.18	0.18
9.	Type of analysis	Static and dynamic analysis	Static and dynamic analysis	Static and dynamic analysis

are proved in table 1 and dossier in addition to determinants secondhand for reasoning are proved in Table 2 and subsequently changeless and vital reasoning has existed completed activity to catch the maximum turning importance and active characteristics of the bridge.

TABLE 1: BRIDGE DETAILS

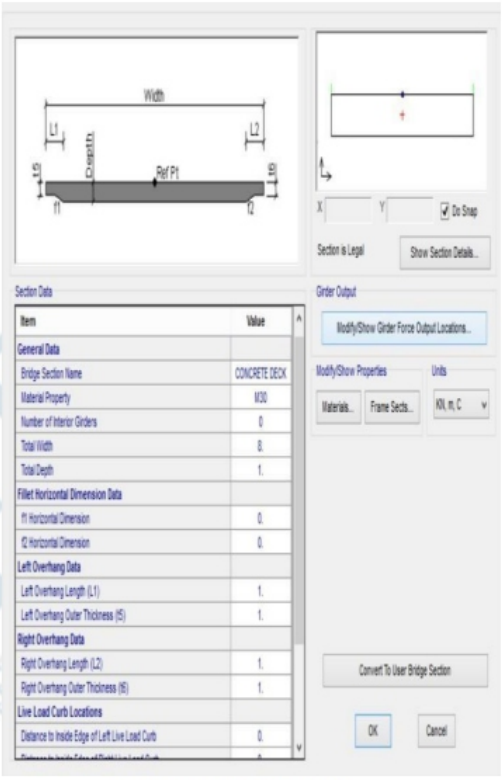


Fig 1 Cross-section details of Bridge

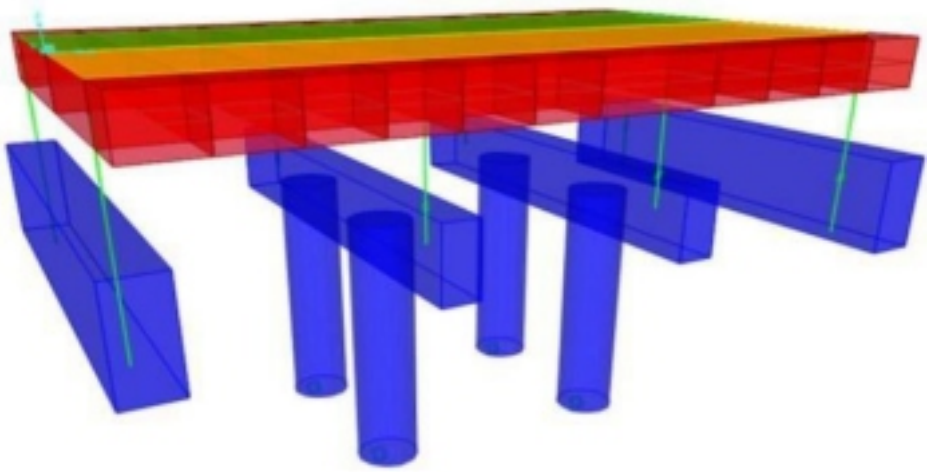


Fig 2 Bridge model in CSi Bridge

Table 2 Input data for analysis

Input data for analysis		
Sl no	Particulars	
1.	Density of reinforced concrete	25kN/m3
2.	Grade of concrete	M-30
3.	Type of live load	IRC class AA wheeled
4.	Impact factor	0.173
5.	Importance factor	1.2
6.	Response reduction factor	3.0
7.	Poisson's ratio of concrete	0.18
8.	Seismic zone	Zone 2
9.	Seismic zone factor	0.16

III. RESULTS AND DISCUSSIONS

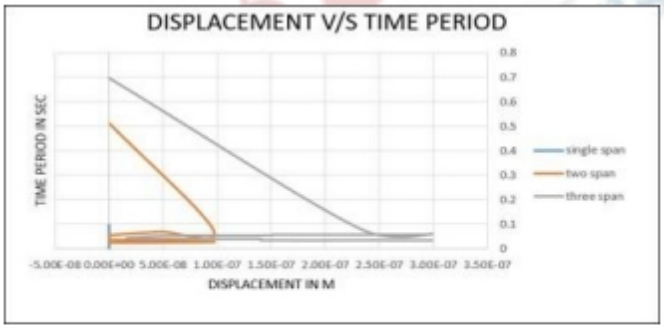
A. Displacement and time period for dead load case

GRAPH 1. DISPLACEMENT VS. TIME PERIOD FOR DEAD LOAD CASE

Graph.1 shows a conspiracy of displacement v/s timeperiod for dead load case. Where displacement valuesare plotted along x-axis and time period values areplotted along the y-axis. From the curves, it is observed that displacement for a single-span bridge is higher when compared to the two- span bridge. In the case of dead load, for a lower time period, the single-span bridge shows comparatively higher displacement when compared to higher span bridges. Which shows thatsinge span bridges are

susceptible to earlier failure than two and three-span bridges. Whereas two and three spanridges are more flexible comparatively [11].

B. Displacement and time period for moving load case.



GRAPH 2. DISPLACEMENT VS. TIME PERIOD FOR MOVING LOAD CASE

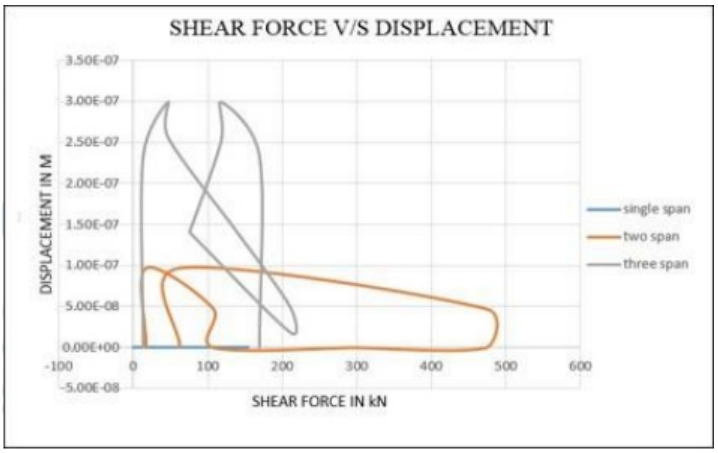
Graph.2 shows a plot of displacement v/s time period for moving load case. Where displacement values are plotted in abscissa and time period inordinate. Forthe moving load case also, we are obtaining the same results as that of dead load. From the obtained results we can observe that more the number of spans higherwill be the displacement and higher time periodshows more flexibility [10].

C. Shear force and displacement for dead load case

GRAPH 3. SHEAR FORCE VS. DISPLACEMENT FOR DEAD LOAD CASE

Graph.3 shows a plot of shear force v/s displacement for dead load case. Where shearforce values are plotted in abscissa and displacement values are plotted inordinate. Theabove curve shows that single-span bridgedisplaces more for lower shear force values whereas two and three-span bridge displacecomparatively more but carries higher shear force. From sheer force carrying capacity point of view short span bridges perform poorly compared to two and three-span bridges.Similarly, two-span will perform better than single span but inferior to the three-span bridge.

D. Shear force and displacement for moving load case.



GRAPH 4. SHEAR FORCE VS. DISPLACEMENT FOR MOVING LOAD CASE

Graph.4 shows a plot of shear force v/s displacement for moving load case. Where shear force values are plotted in abscissa and displacement values areplotted inordinate [13],[14]. From the above curve that is for moving load case, we can observe that twoand three-span bridges show elastic behaviour.Although they show initial displacement and for thesame displacement it takes more load and finallyleads to failure. Whereas single-span bridge showsnegligible elasticity from the observations made.Thereby two-span bridges show higher shear force carrying capacity for lower displacement [12].

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Psychological Influences of Architecture on the Demented in Care Homes of Kerala

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ABSTRACT

The effects of built environment on our health are heightened with age, especially when the process of ageing entails psychological, and physical decline of the human body. Dementia is largely prevalent in Kerala, India, as it comprises of the fastest ageing population in the country. This paper discusses how an architect can create an environment that triggers positive neurological changes in its users by formulating guidelines, which help architects make more informed design decisions. This will improve the quality of life of the fading in Kerala, where there are no set standards for their living environment. The analysis of the experiential responses manifests the efficacious relationship between designed spaces and standard of living ergo guiding the development of design strategies.

Keywords--- *Architectural design, Dementia, Built environment, Inclusive design, Psychology of design, User-centred design*

I. INTRODUCTION

1.1 Background and Context

"While no one can change the outcome of dementia or Alzheimer's, with the right support you can change the journey."- (1)

The concept of care homes has considerable contemporary relevance for persons who are aged with debilitating conditions like dementia. Dementia, a neurodegenerativedisease is one such illness of the old with high morbidity and considerable socioeconomic impact.

Life expectancy the world over has seen a marked improvement in the twentieth century. This is due to improvement in public health and medicine. There are currently an estimated 50 million people diagnosed with dementia worldwide, approximately two thirds of these people are living within LMICs (2). The numbers are expected to rise to over 152 million by 2050. Dementia is the 5th leading cause of death. Much of the burden of the disease will be on developing and highly populated countries such as India, China and countries in Latin America.

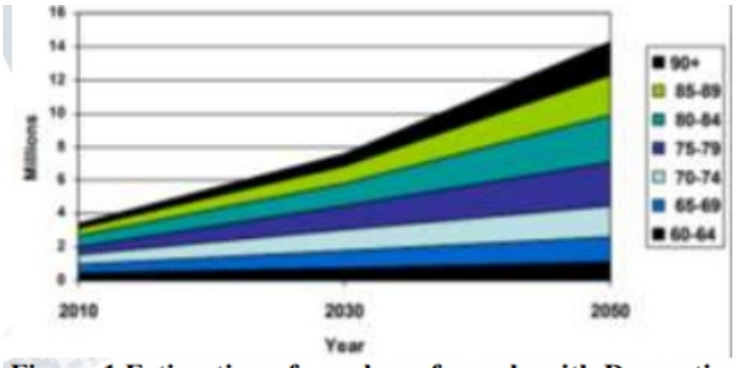

Figure 1 Estimation of number of people with Dementia, India (Source: ARDSI Report, 2010)

In 2010, there are 3.7 million Indians (2.1 million women and 1.5 million men) with dementia which is expected to double by 2030 and triple by 2050.The incidence of dementia doubles every five years from ages 65 to 90 years(2) . In India the growth of people living with Dementia will be 300% more in coming years. Kerala has now ended up with the fastest ageing population in the country. Population above the age of 60 is 13.1% in Kerala against the all-India average of 8.3% in 2015 (3). 2.2 lakh people are suffering from dementia in the state of Kerala (as of 2018) which has surpassed the 1.5 lakh projected prevalence of the disease by the latest Dementia-India (2010) (2) . The Alzheimer's & Related Disorders Society of India (ARDSI) has been integral to dementia awareness in our country and has been taking measures towards its care since 1992.

The creation of spaces for the elderly, euphemistically called as retirement homes at present, has to recognize the special needs of the elderly. This category with specific medical needs requires special features in care homes. Increasingly studies have suggested that design of spaces both indoor and outdoor, along with psychosocial interventions, have a positive impact on the quality of life of the demented (4) (5). Regardless, we still do not have clear or set protocols for the creation of spaces in the Care homes of the elderly with Dementia in India. In view of the contemporary relevance of the subject in the state of Kerala, this dissertation.

1.2 Research Questions

Central Research Question

How does incorporation of architecture in care homes create a positive difference in the lives of the elderly in Kerala coping with dementia?Sub Research Question

What is dementia and how does it affect the human mind and body? What is its incidence in Kerala?

What is the psychological meaning of home and how is it translated into the living environment of care homes?

What is the condition of care homes and dementia care in Kerala?

How is architecture contributing to the psychology of ageing with dementia?

1.3 Aim and objectives

The aim is to develop architectural guidelines that aid in the design of a living environment for the elderly with Dementia so as to make their lives more meaningful.

To understand Dementia, the physical and mental condition associated with it and to notice its incidence in Kerala.

To notice the living environment in care homes for the elderly.

To study the role of architecture in bettering the living environment of persons with dementia.

To develop an architectural protocol that aids in the design of care homes in the context of Kerala.

1.4 Scope & limitations

The topic is significant in terms of its relevance in today's world of increasing ageing population. In a state like Kerala with high social and medical indicators, the population is ageing. This brings with it the category of aged with dementia. The topic is being explored from an architectural perspective without ignoring human sensitivity. It is necessary to explore the key architectural and sensory aspects that improve their mental and physical health.

The study is limited to formulating architectural guidelines and basic scheme for the design of care homes. There is no intent to create a prototype or model for the same. It is also not a medical or sociological or technical study but more of an understanding of the correlation between psychology and architectural. The study will be regardless of the economic and social shortcomings of a patient and will be based only on their physical, mental and psychological needs. This also is not a paper on ideal care homes that already exist.

II. LITERATURE REVIEW

This chapter explores the current theories and literature on Dementia, Care Homes and architecture. It begins with an overall understanding of dementia. Further living environment and sense of home are studied and their relationship with architecture is discussed. Finally, the concept of architecture creating therapeutic environments for dementia and their status in Kerala is investigated.

2.1 Understanding Dementia

Dementia is a syndrome – usually of a chronic or progressive nature – during which there is deterioration in cognitive function (i.e., the capability to process thought) more than what might be expected from regular ageing. The impairment in psychological function is usually accompanied, and sometimes preceded, by deterioration in emotional control, social behaviour, or motivation.

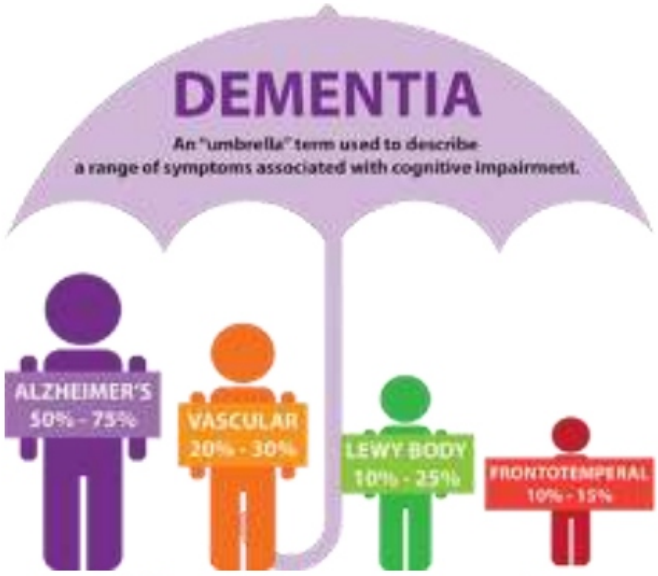

Figure 2 Types of Dementia
(Source: dfwsheridan.org)

Dementia symptoms vary depending on cause but common symptoms include: -

The signs and symptoms linked to dementia can beunderstood in three stages.

Early stage: forgetfulness, losing track of the time, becoming lost in familiar places.

Middle stage: becoming forgetful of recent events and people's names (however remote memory can be left relatively intact. So, they're able to remember public and personal events many decades ago, but

unable to recall what happened earlier that day), becoming lost at home, having increasing issue with communication, undergoing behaviour changes. Blurring of vision and increased vulnerability to glare. Noise disturbance causes distress. Difficulty judging distances.

Late stage: becoming unaware of the time and place, having difficulty recognizing relatives and friends, having an increasing need for assisted self-care, having difficulty walking, experiencing behaviour changes that may escalate and include aggression. (6)

2.2 Principles of built environment for the demented

Environmental Audit Tool (EAT) handbook developed by DPD (Designing for people with dementia, Australia)contains information about key principles of designing for people living with dementia, outlines design considerations for each principle and provides directions for its use. (7)The guide is organised around 10 key design principles.

1. Safety
2. Size
3. Visual access features
4.Stimulus reduction features
5. Highlighting useful stimuli
6. Provision for wandering and access to outside area
7. Familiarity
8. Privacy and community
9. Community links
10. Domestic activity (9)

Six key integrated design principles guide the book 'Design for Dementia' which are similar to the EAT.The principles, when applied with culturally sensitive countries, can identify gaps in knowledge of the design for dementia enabling environments and suggest areas for improvement.

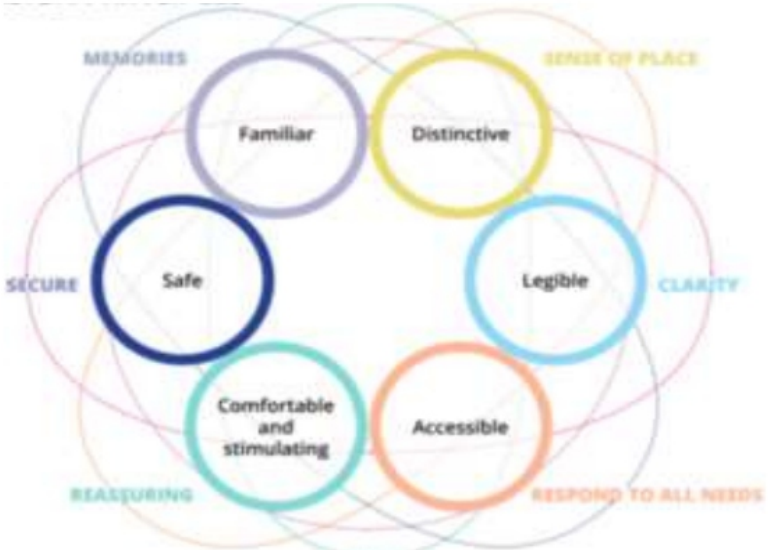

Figure 3 Key Design Principles. Source: (11)

Figure 4 Developing Location specific guidelines. Source: (15)

2.3 Kerala and its status on Dementia Care

The inadequacy of care centres for the aged with higher needs is a harsh reality. Creating awareness for Dementia is possible in an educated society like Kerala which also has a public health legacy. It is also possible to create a pool of care givers. In 2014, for the first time, the State government took notice that dementia care needed a distinct care strategy, separate from prevalent geriatric care. ARDSI now has care homes in Thiruvananthapuram, Ernakulum, Kumbalangi, Kunnamkulam, Tripunithra and Kozhikode. (8)

"Dementia friendly communities" – state wide campaigns, staging plays etc. as part of ADI Conference, Kyoto 2017.

The campaign, distributed messages through pamphlets and displayed notices. (9) However, none of the other components of SIDC — memory clinics in districts, creating a brigade of trained care-givers for dementia patients etc. — have moved forward. A set of architecture solutions would go a long way to make Kerala a Dementia friendly state with improved quality of spaces instead of just provision of structures for the purpose.

2.4 Literature Review Analysis

From multiple reviews (10) (11) (12) (13) (14) it's clear that architecture of care homes is closely linked to the psychology and mental health of the demented. It is difficult to develop or design a complete model of a care home based on the conclusions drawn by the authors. However, the elements that have to go into a good care set out and this gives a key start to the basic requirements. Some limitations, gaps and differences in the previous studies to this study is outlined below:

The background and preferable living conditions of elderly with dementia in Kerala varies greatly from the above studies.

Emphasis on private spaces is not paramount in Indian conditions. Public and quasi-public places are more important in Indian culture.

Living environment relating to memory would require use of traditional construction material which evoke memories so that the aged can relate to it.

Modern equipment for safety and medical purposes has to be judiciously used but a technological overload may disorient the aged in Indian conditions, as he may not have been exposed to such technology earlier and therefore cannot relate to it.

This study attempts to bridge the gap of a lack of a proper study and absence of design principles to suit Indian conditions, especially in the state of Kerala.Nevertheless, there are significant elements of practical and utilitarian value that can be derived from these studies. The research can take a holistic based on the needs of elderly and create guidelines that are context specific as previously done in these articles.

In particular the broader guidelines along which this research shall be based are:

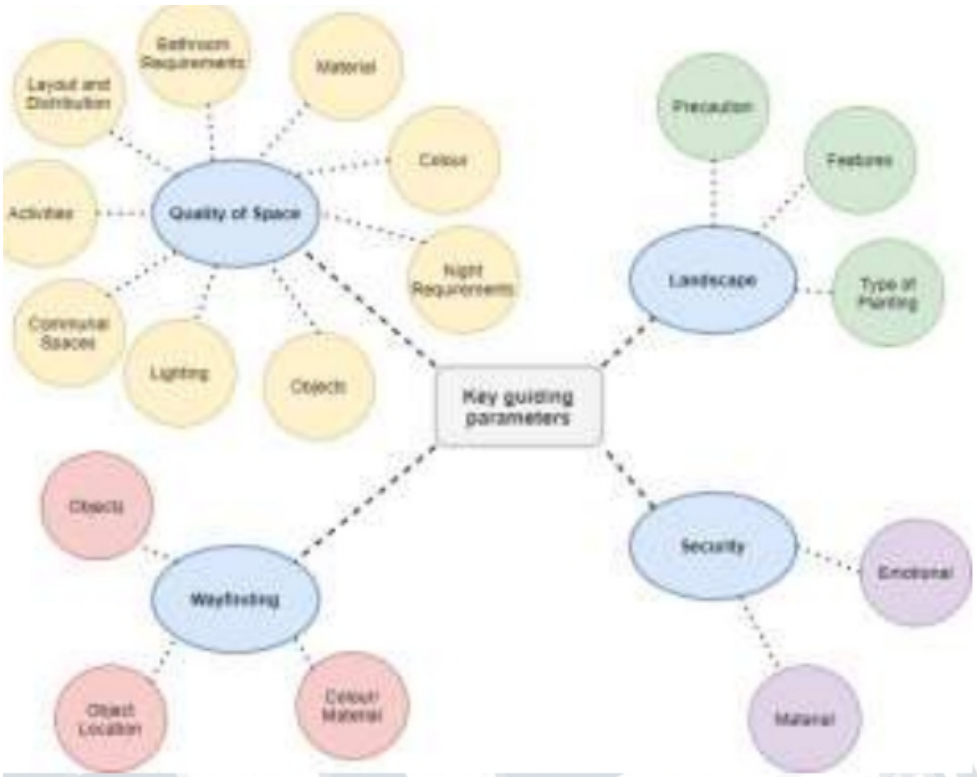

Figure 5 Guiding Principles. Source: (Author, 2020)

This chapter discuses and compares the data collected from the literature case studies adding up to obtain the required suggestions and the conclusions to form the architectural guidelines.

In particular the broader guidelines along which this research shall be based are: -

IV. RESULTS

This chapter discuses and compares the data collected from the literature case studies adding up to obtain the required suggestions and the conclusions to form the architectural guidelines.

3.1 Literature Case Study

Table 1 Comparative study of case studies. Source: (Author,2020)

Factors	De Hogeweyk	The Orchard	Harmony home
No. of demented & staff to demented ratio	180 residents, 1:7	11 clients and day care facilities for up to 25	10 patients, 1:1
Location	Within the city of Weesp,	Within existing 18th century walled garden	lush green village of Kottapady
Designed/Adaptive reuse	Built for the purpose	Built for the purpose	Adaptive Reuse
Quality of	**Space**		
Layout /Distribution	27 houses.6-8 sharing.	Campus-type model.11 Long term care rooms, large respite care spaces, along with Alzheimer's Society Office.	8 Acre plot with porch, backyard Bungalow- 1 ward 3 rooms, no attached bathroom and an outhouse- 1 ward. Dispensary and check-up room.
Light	Maximum light from windows, minimum corridors	Tall windows allow even light. No glare or shadow.	well lit- Multiple windows
View	View of courtyards, gardens, streets with activity.	Views of the gardens.	Calm, lush green view
Colour /Material	Clinker brick facing exterior with colour change. Colour change from room to room, pastel shades, coloured patterned tapestry. Decorated typology wise.	Floor, skirting and walls are different colours, no patterns on floors. Doors are colour coded. No dark corridors. Timber pavilions held within a series of brick walls.	Woodwork, tiled roof, traditional architecture.
Objects	bouquet of flowers, chandelier, plants, classic floor lamps, old cuckoo clock, light curtains, paintings, photo frames	Paintings, photo frames, plants	Basic Req. only
Bathroom Requirement	Handicap friendly. Attached bathrooms to each room.	Handicap friendly. Attached bathrooms to each room.	Shared bathroom.
Communal activities	Daily chores – washing, cooking. Walking club, arts space, classical music room, personal hobbies.	Music singing and dancing, games, gardening, baking, arts, crafts, excursions, flower arranging, personal hobbies.	Prayer, music, Reading, TV, Gardening, Rearing pets, art, games, puzzles.
Therapies	Music, art, walking, cognitive therapy etc. Therapies disguised in the form of daily village activities. Encouraged contact with public.	cognitive stimulation therapy, pet therapy, light exercise	Reminiscence therapy, Aroma therapy, Yoga, Dance, music
Communal spaces	theatre, supermarket, restaurant, pub, courtyards, gardens, hairdresser	Activity room, Contemplation room, Seating room	Semi open Activity Space, Dining Room (capacity 15)
Landscape	Six different 'courtyard' spaces, Formal/informal/symmetrical, a pond, several big trees, curved paths	Terraced gardens, each oriented in a different direction and planted accordingly. Wide walkways, ramps.	Large lush green plot with backyard and land for conducting events. Not designed specifically.
Security	Two access points. No restriction to wandering. A peaceful mind in a safe village with supervision.	Two access points. No restriction to wandering. Maximum indoor outdoor connect.	No restrictions for wandering. Secure home like feeling without grills and locks.
Way finding	Different materials, change in proportions, iconography on the façade, Looping Paths. Encourage walking.	Pathways naturally loop back on themselves. contrast between the labyrinthine walls and the framed gardens	Spaces flow into each and are not ordered- confusing. Signboards present. Large outdoor spaces to wander safely.

I. DISCUSSION

This chapter discusses the observations elaborated in the previous chapters to complete the dissertation objectives. The theories and literature reviews studied to achieve certain objectives are discussed. The primary and secondary data collected are analysed and compared with one another to form the result from this research all of which are discussed below.

4.1 Analysis of Studies

Table 2 Inference from Case Studies. Source: (Author, 2020)

SL NO.	Factors	Inferences
1	**No. of demented sharing their space**	Single sharing to up to 6 sharing in an entire two storeyed cottage/ward. Ideally a maximum of 3 sharing a room.
2	**Location**	Ideally in the outskirts off the city surrounded by lush green calm environment, less commotion along with proximity to hospital.
3	**Quality of Space**	
3.1	Layout/Distribution	Campus or village model with maximum two storey high buildings dispersed around gardens & open spaces to promote walking, wandering & socialising.
3.2	Light	Maximum daylight through large windows, courtyards and balconies. Reduce glare & shadows.
3.3	View	View of gardens, farms, courtyards with activity
3.4	Colour, material	Different pastel colours from buildings, rooms, doors. Colour difference in wall, skirting, floor with no pattern on floors. Purple in therapeutic spaces. Anti-skid flooring Use of roof tile, wood detailing, iconography to evoke sense of home according to context.
3.5	Objects	Paintings, photo frames of family & context. Plants. Personal Belongings. Small curiosities from the past like clocks, lamps.
3.6	Night requirement	24x7 supervision, caretaker sharing a cottage, handrails barricades on walls & beds. Switches for help.
3.7	Bathroom requirement	Attached bathroom, handicap friendly with grab bars & roll in showers.
3.8	Communal Activities	Personal Hobbies, Music, Art, Gardening, Cooking, TV, prayer, games &puzzles.
3.9	Therapies	Music, art, walking, yoga & community meeting. Cognitive, aroma, pet, validation and reminiscence therapy.
3.10	Communal Spaces	Large recreational space. Semi Open or Open like gardens/courtyards. Common practices of life from their past like reading space, eateries, clubs.
4	**Landscape**	Looping paths that lead to the start. Trees and flowering gardens. Multiple courts with different characteristics of design and planting based on orientation.
5	**Security**	No restriction on wandering. Minimum grills and bars to reduce a caged feeling. Maximum indoor outdoor connect. Reduce access points, maximise visibility of caregivers allowing the demented to be carefree without feeling restricted.
6	**Way finding**	Different Materials, iconography, contrasting colours on building exteriors. Signboards. Clear hierarchy of spaces. Looping outdoor paths always leading to start.

Survey was conducted to understand how the built environments and the parameters of design affect the elderly with dementia through experiential responses from doctors/nurses/counsellors who have attended to or nursed 3 or more of this special group of elderly. It is understood specifically in the context of Kerala. The questions are constructed based on the design elements which help create a common basis for analysing both case studies and surveys thereby resulting in the formulation of design guidelines. 17 responses have been recorded. They are combined from both online surveys and personal interviews.

Table 3 Inferences from Survey Source: (Author, 2020)

SL NO.	Factors	Inferences
1	**No. of demented sharing their space**	1-3 sharing -acceptable. 2 Sharing -most preferred. Strongly recommended to allow for similar natured elderly to share
2	**Difficulties in Existing Environment - Kerala**	Need for Dedicated designed facility which is a community/village. Feeling of being caged, lack of space. Lack of opportunity for personalization Lack of communication/empathy
3	**Quality of Space**	
3.1	Time in personal space	They spend majority time in personal space (up to 16 hours). But this may strongly be influenced by their stage of dementia. During early/middle stages it is only used for sleep (8 hours)
3.2	Improvements in personal space of current care facilities	Need for more space, lighting and ventilation. Importance of personalizing space, lack of TPP like color coding.
3.3	Objects in Personal space	Apart from the necessities, memory evoking objects were highly recommended. Personal belongings, old wood furniture, pencil/slate/pen, contextual décor (paddy hanging, paddle boat), murals and pictures of traditional dance forms.
3.4	Lighting	Bright daylight during day and dim night light - indicating time. Maximum light for tasks, dimmer daylight at other times.
3.5	Views from the room, specification of windows	View – greenery, sky, stars or Moving vehicles/ people/children/pets. Windows – large windows with grills and mosquito net, safe opening system. Seating near window with a view.
3.6	Special Night Requirements	Dim light, presence of caretaker, alarm switch, handrail, snacks & water. Sponge bath, music, mild fragrance, comfortable temperature for calming.
3.7	Color, Material	Color – Bright contrasting yet pastel shades of red, blue, green, brown. Contrast in color between room-door- verandah- bathroom and between floor- furniture Material – Contextual & vernacular – wood, roof tiles, clay walls with relief work. Presence of courtyards. Typology of housing / roofing/material according to previous livelihood.
3.8	Special bathroom requirements	Handrails/grab bars, anti-skid mats/floor, Spacious, ventilated & well lit. Easily operable fixtures with clear marking. Positioning of closet- visible at entrance yet private. Floor-toilet seat cover (red, black) contrast.
3.9	Community activities & space	Games/ puzzles, Music – old songs, bhajans, Exercises/yoga, Cooking, Art, Newspaper reading and healthy discussions in a large hall which may be partially divided or form niches for small groups.
3.10	Individual Activities	TV, personal hobbies (stitching, gardening), daily routine, walking
4	**Landscape**	Trees that provide shade, Memory Evoking/Contextual– Banyan tree, Ashoka tree, Coconut Tree, Plantain. Straight pathways-wheelchair friendly, no forks, and loop back to the start. Flowers -different colors and mild smell. Niches, Seating, Gazebos every 20 ft. Shallow, protected water bodies with fishes and waterfalls
5	**Security**	Personal belongings, photos - dedicated space Human Company Ambience of an old home/Nalukettu- old furniture, normal windows, prayer space, old artifacts adapted to facility.
6	**Way finding**	Signage's with colors, pictures, finger indications instead of numbers Picture of youth self on door to room Color coding spaces Object's indicative of room type Single story spacious facility with orderly planning

4.2 Design Guidelines

This research process is fulfilled with the construction of design guidelines, formulated based on the analysis and comparison of the literature studied and the surveys conducted. The guidelines are segmented under four broad parameters with sub elements where necessary. These are developed keeping in mind the culture and context of Kerala.

4.2.1 Quality of Space

This section sets out the guidelines for achieving necessary
quality of built space and personal space inside a care
facility for the aged with dementia. The broad principle of quality of space is divided based on multiple facets of architecture to form guidelines under each as listed below.

4.2.1.1 Layout & Distribution

The care facility should ideally be located near a landmark, in the calmer edges of the city with connectivity to hospitals. Mixed community environment without feeling segregated. Campus/ village model (maximum 2 access points), single storied, spacious living environments interspersed with gardens & courtyards.

Maximize frontage permeability to encourage flow of people. Incorporate visitor's area. Simple design layouts. Active areas to form core of village/building. Scale of private and public spaces to reflect spatial hierarchy.

Living room to be an important node but not the primary node around which everything is planned.

Ideally 2-3 sharing rooms accommodating similar natured elderly

Noise insulation in all spaces using acoustic material, carpets, trees as barriers etc.

Spacious, familiar, well lit and ventilated space with view of the outdoors from all spaces.4.2.1.2 Personal SpaceAccording to Indian culture, most elderly spend only their time of rest in personal space unless they are bedridden

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4.2.1.2 Personal Space

According to Indian culture, most elderly spend only their time of rest in personal space unless they are bedridden.

Freedom to personalize space with few objects and furniture of value. Space to display photos and to enjoy personal hobbies.

Décor of personal space to resonate with their lifestyle from their youth.

Presence of reality orientation techniques-calendar, clock. Provision to play music and radio.

Direct view of the bathroom.

Alarms, list of medicines, emergency contact of family at immediate reach. Board to mark daily routine.

4.2.1.3 Objects

Set of guidelines discussing the type of objects to be present inside the facility to aid the demented.

Object of medical and technical help – wheelchairs, switches/alarms, handrails

Large calendar, large clock with clear marking, flowers and indoor plants in common areas.

Memory evoking objects - Personal belongings (perfume, towel), old wood furniture (easy chair/armchair, teak cot), pencil/slate/pen, kitchen mud pots.

Contextual décor- paddy hanging, classic lamps, old football/frond, nilavilakku, paddle boat, old dolls (wooden elephants), murals of traditional dance forms. Objects to be adapted to facility.

Figure 6 Paddy Hanging. (Source: pinkpepper.in)

Figure 7 Antique Lamp. (Source: amazon.in)

Reversible mirrors with murals/pictures to avoid confusion.
Open shelves/glazed cupboards to reduce anxiety of losing objects.

4.2.1.4 Special Bathroom Requirements

Handicap friendly. Attached bathrooms to each room.
Indirect lighting to avoid glare from shower area.
Handrails/grab bars, anti-skid mats/floor, Locks –operable from outside when in need. Bell at floor and standard height
Avoid all white bathroom. Contrast - Floor brown/ mud colored, toilet seat cover (red, black).
Familiar fixtures which are arthritis friendly with clear HC marking.
Placement of closet- visible at entrance yet positioned to provide privacy. Position of mirror to not cause glare or be confusing.

4.2.1.5 Special Night Requirements

Dim light/sensory lights
24x7 supervision by caretaker from adjacent room, alarm by bedside.
Snacks & water. Temperature controlled to be comfortable.
Sponge bath, music- nature sounds, mild fragrance for calming.

4.2.1.6 Lighting

Bright daylight during day and dim night light -indicating time.
Courtyards, balconies and skylights to allow more daylight in common areas.
Maximum light for tasks– either daylight/task light, dimmer daylight at other times
The elderly with dementia to never be left in the dark. No dark/dim lit corridors.
Windows to provide even light with less to no glare or shadows.

Figure 8 Light from Skylight & Courtyard.
(Source: allegradesigns.in)

4.2.1.7 Colour & Material

Bright contrasting colours to be used to differentiate spaces. Pastel yet vivid varieties of red, green, blue, yellow, brown etc. Warmer hues are clearer. Shades of purple can be therapeutic.

Contrast in color between room-door-verandah bathroom, floor- furniture-cutlery, and wall-skirting. Contrasting handrails and aids.

Matte finishes of paint. Reduce whites/greys to avoid institutional appearance.

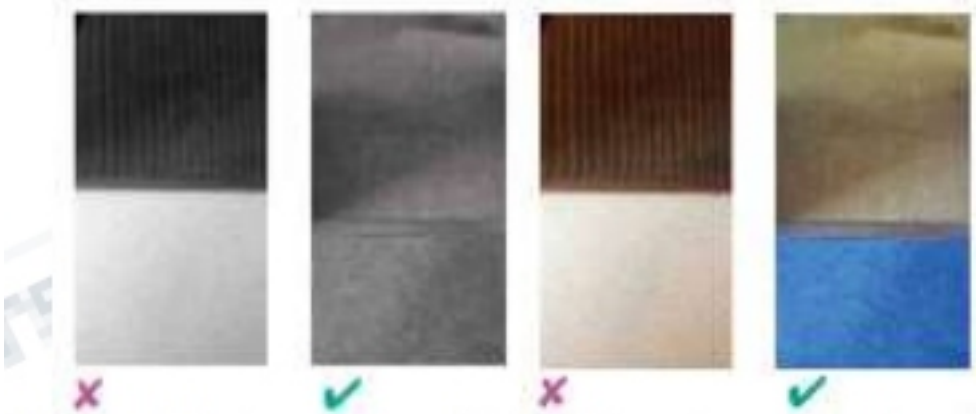

Figure 9 Colour, Material finish at junctions. Source: (11)

Patterns should be avoided in flooring. Subtle patterns with tonal difference can be incorporated in curtains/furniture fabric according to scale of the space.

Change colour or material finishes (Anti-skid material) at level differences, sharp edges, risers &treads. Avoid giving the impression of the same in other areas.

Context specific materials to be integrated – wood, brick, roof tiles, clay walls. Iconography and familiar textures (wood panelling) to evoke sense of Kerala. Typology of cottages/ roofing/material according to previous livelihood.

4.2.1.8 View

Green views of gardens, farms, courtyards or views of playing children/pets.

Unhindered view from all key rooms and seating.

Large windows with grills and mosquito nets. Smaller windows without grill if needed but with size control to discourage escape attempts.

Figure 10 Traditional Windows. (Source: pinterest.com)

Windows/louvers with wooden detailing and familiar traditional appearance.
Easy, familiar opening mechanism – sliding/hinge.

4.2.1.9 Communal Activity & Communal Spaces

Activities - Games/ puzzles, Music (old songs, bhajans), Exercises, Cooking, Art,
Gardening, Daily chores, Excursions, Newspaper reading and healthy discussions

Dedicated decorated rooms and outdoor/indoor clubs like walking club, games club, art space, classical music room, small theatre, market, tea stall/hotel inside village can encourage active living.

Communal spaces stand out by the use of different colours/materials, change in proportions, and iconography on the façade.

Informal spaces and courtyards incorporated to prevent loneliness. Avoid hidden corners. Large hall made to look smaller using furniture or by forming niches.

Therapies disguised in the form of daily activities supported by peaceful calming spaces with dimmed light, reclining chairs and mild infused oil fragrance.

Therapies to also include innovative techniques to keep them motivated and relaxed like pet therapy, Ayurveda massages, community meeting, etc.

4.2.2 Landscape

This section defines a few specifications on landscaping for the outdoor areas of a facility housing the elderly with dementia. These are in accordance with the natural climate and vegetation of Kerala.

Figure 11 Althara. (Source: quora.com)

Memory evoking trees that provide shade with seating under them– Banyan tree, Red bead tree, Mango tree. Trees to be planted without overcrowding.

Sensory attention- flowers of different colors with mild smell (rose, jasmine, champa) which alsoattracts butterflies, bamboo for sound, traditional bird house/bird bath.

Multiple courts with different characteristics/principles of design and planting based on orientation and season. Raised bed for gardening with wider coping as seating.

Gardening tools in a shed visible and positioned near the garden.

Shallow well protected water body with fishes and waterfalls to be visual focus with seating arranged around.

Wide wheelchair friendly paths with defined edges Routes interspersed with activities, social interaction and rest.

Open break out spaces with even ground/gentle gradient for seating in small groups under indirect daylight. Niches, Seating, Gazebos every 20 ft. seating with back and armrest.

Contrast between path, furniture and planting. Terracotta /clay sculptures, planters as decor.

Boundary fence to be concealed by climbers.

4.2.3 Security

This section contains recommendation regarding the security of the residents, focusing more so on the mental security than the physical as there are existing regulations concerning the same.

Acknowledging personal belongings and photos by providing dedicated space. Promoting them to be independent as long as possible.

Human Company, interaction with children and pets to make the elderly feel loved and supported.

Creating a familiar ambience of an old home/Nalukettu with wooden furniture, prayer altar with burning incense, sacred tulsi thara and old familiar artifacts adapted to facility.

Allowing them to wander securely without feeling restricted. Central placement of nurse station.Maximum indoor outdoor connect.

Minimum grills, bars, locked doors to reduce a caged feeling. Concealed technical/medical appliances to not feel alienated or institutionalized.

4.2.4 Way finding

Way Finding is one of the governing criteria's in designing both the built and unbuilt spaces in a facility. The resident forgetting the way and feeling lost can increase anxiety and can indicate poor organization. The following are guidelines to improve way finding in dementia care facilities.

Both graphic and text signage which are well lit and at a lower height than normal (1.2-1.4m). Picture of youth self on door to room. Training with memory cards to understand signage.

Memory object shelves/boxes at entrances indicative of room type.

Figure 12 Colour Coding. Source: (11)

Corridors should be short and wide with seating. No repeating elements. Number of doors and corridors should be kept to a minimum and colour coded.Restricted spaces should have doors matching the colour of the walls.

Single story spacious facility with orderly planning. Visual link between spaces. Less furniture - less obstruction.

Change colour, material and scale of each building. Relief work on façade indicative of functionality.

Exterior paths that loop back to the start without dead ends/forks.

Creating landmarks with sculptures, iconography (lion at gate post), large banyan tree, tulsi thara, prayer alter etc.

V. CONCLUSION

This chapter presents the conclusion of this research and presents its implications and limitations. The guidelines presented here by no means replace existing theories that healthcare professionals' practice today. These guidelines, rather, are designed to help architects, or any caretaker, to make better, more informed design decisions. They are formulated based on experiential responses from around Kerala

and published studies in this topic. As stated earlier, these guidelines address the general population of those with dementia, but may not work with every individual as each person's circumstances and experiences differ. They also focus more on the psychological and nursing aspect of a care facility rather than the cost.

So where do we go from here? The first step in establishing guidelines for designing facilities is to educate the public. Communities, individual residents, and organizations must work together to help create the change. Architects and designers should receive training and need to understand not only that current design methodologies do not always work and may have the opposite effect, but also the reasons why. Next, existing facilities must adopt these guidelines and new facilities must come up in the state as an example for the country. Finally, in order to achieve the goal of establishing these guidelines at the state level, the government must get involved.

The fulfilment of this project, from research to the creation of Kerala's standards for building Dementia Care Facilities, needs to be advocated by the local community first. It is with the help of our communities that this project can truly be realized and become more than a dissertation.

VI. ACKNOWLEDGEMENT

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VII. APPENDICES

Survey questionnaire

1. In your experience with dementia patients, how much time do they spend in their personal space or bedroom?
2. What should be different in present rooms of care facilities to help support dementia patients better? Comment on the following: -
3. Objects in personal space (memory related artifacts, objects specific to Kerala)
4. Lighting (Bright, dim, maximum daylight)
5. Views from the room and specification of windows (sliding window, grills on windows large or small windows)
6. Special Night requirements (for example presence of bystander, dim light)
7. Color and material (preferred generally and specific to Kerala - elements of traditional architecture)
8. Special bathroom requirements other than what is usually present for differently able.
9. Can the demented share a cottage with the other elderly in the Care home? If so how many can share?
10. What kind of community activities keep the aged with dementia active, healthy and at peace? Would a large hall for such activities intimidate them?

11. On which of the following do the aged with dementia spend their personal time most TV/Phone/Books/Routines/Other
12. What features in landscaping the gardens would soothe the aged with dementia? What precautions should be taken while landscaping gardens?
13. What architectural elements can be added to make way finding easier
14. What can be incorporated in living environments to make the aged with dementia feel at home and secure (mentally)?
15. In existing care home environments in Kerala what are the difficulties faced by the elderly with dementia?

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Enhancement of Biogas Yield by Optimizing Key Factors: A Review

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A B S T R A C T

Biogas production through an anaerobic digestion process can solve both the problem of waste disposal and environmental pollution which is prevailing all over the world. But it has certain limitations such as it has low degradation rate, high solid retention time, lower biogas production which makes it unattractive for commercial use. This paper reviews effects of various process parameters such as agitation, ammonia nitrogen concentration, accumulation of volatile fatty acid and buffering capacity, pH, temperature, feedstock characteristics as biogas production optimization. From literature, it has been found that optimizing these process parameters and operating biogas plants at this optimum value results in enhance biogas production.

Keywords--- *Biomass, Agitation, Volatile fatty acids, Buffering capacity*

I. INTRODUCTION

The generation of waste ever increases globally because of population blast and urbanization. Dumping or Burning of such a big volume of waste creates air pollution and groundwater contamination. These problems of both, waste disposal and environmental pollution can be resolved to a certain extent by biogas production via anaerobic digestion. Energy generation through anaerobic digestion is one of the promising technologies for sustainability and pollution mitigation. But anaerobic digestion process has certain limitations such as lower degradation rate, higher retention time, and lower biogas production. In order to resolve these issues and to optimize biogas production, the various researcher investigates the effect of agitation, ammonia nitrogen concentration accumulation of volatile fatty acid and buffering capacity, pH, temperature, substrate characteristics on biogas production. If we operate the biogas digester at its optimum process parameter then we definitely improve anaerobic digester performance.

II. FACTORS AFFECTING BIOGAS PRODUCTION:

2.1 Effects of Agitation

Agitation is necessary for uniform distribution of organic material & microbial population, is to make a close connection between bacteria and biowaste, is to prevent the accumulation of material on the

bottom of the digester and uniform distribution of temperature inside the digester. If agitation is not carried out at regular intervals, there is a scum formation inside the digester. If organic materials are in the scum layer, they are unavailable for microorganisms, thus reducing the degradation rate and hence the biogas production. The agitation can be achieved through a mechanical stirrer, pneumatic stirrer, or with the help of a hydraulic stirrer. The agitation helps in the reduction in particle size and removal of gas from a mixture of slurry. Chen et al. (1990) investigated that higher methane yield was obtained in a non mixing/agitated digester compared to a continuous stirrer digester. They used municipal solid waste and wastewater as feed material in both cases. Stroot et al. (2001) investigated that continuous agitation was not helpful to improve performance of anaerobic digestion and it inhibits biogas production at a higher organic loading rate. They also found that nominal agitation helps in improving biogas generation for organic loading rate ranges from 3.5 to 9.4 g VS/L d at a temperature of 37º C and a hydraulic holding time of 20 days. They observed that reduction in agitation speed also helps in improving the performance of unstable digester.

Kim et al. (2002) investigated that lowest biogas was produced at low and increased organic loading rate in continuous stirred biogas reactor while the intermittent minimally mixed reactor produces maximum biogas at temperatures of 35º C and 55º C. Ong et al. (2002) investigated the effect of Continuously stirring, intermittent stirring (0.5-hour stirring and 5.5hour break) and without stirring on anaerobic digester. They used cow dung as feed material in all three digesters. They found that non-agitated digester produces higher biogas (up to 28.4%) compared to the continuously agitated digester. However, there was no change in biogas quality weather continuously or intermittent stirring was used. Karim et al. (2005) found that agitation did not improve the performance of anaerobic digesters when digester was fed with the manure of total solid concentration of below 5%. However, agitation plays an important role in anaerobic digestion, when digesters were fed with the manure of a total concentration of 10-15%. Deublein et al. (2008) reported that anaerobic bacteria are very reactive to agitation intensity and they may not live in an extreme agitation intensity. Kaparaju et al. (2008) investigated the effects of minimal agitation (10 min before feeding/discharge) and alternate agitation (2hr break before feeding/discharge) using diluted cow dung as a substrate. They observed minimal agitation increases biogas yield by 12.5 % while alternate agitation increases biogas yield by 1.3 %. Kowalczyk et al. (2013) investigated that discontinuous agitation generates additional biogas in the beginning compared to continuous agitation. They used three lab-scale digesters with a capacity of 22 liters. They carried out two experimental studies for the investigations. In the first one, they used corn cob left over and cow dung as substrate. The stirring intensity for fermenter one was two hours which was followed by a one-hour break, digester two was agitated with seven hours stirring and one-hour break while digester three was agitated continuously. For the second experimental study, the researcher uses maize silage and cow dung as input organic material. For the Second experimental study digester, 1 was agitated for 10 minute and 230-minute break. Digester 2 was agitated for 10 minutes and break for 50 minutes. The digester 3 was agitated continuously. In starting days, they found that biogas production increased up to 20 % compared to the continuous stirred digester. Afterward, biogas generation was reduced and altered in a span of ±10% compared to the continuous stirred digester. Aworanti et al. (2017) investigated the impact of stirring intensity on co-digestion of cattle dung, pig dung, and poultry dung (mixed animal dung) with pineapple fruit left out and chicken-gizzard as an inoculum. For this research work, they vary the stirring speed from 30 to 70 rpm in an interval of 10. They found that digester with 30 rpm stirring speed produces the fastest biogas with the highest accumulation yield on 35th day and it remained constant till 70th day which was followed by 40, 50, 60, and 70 rpm speed. They also found that with agitation, biogas generation starts from the first day for all speed while without agitation, biogas generation starts from the fifth day. Without agitation cumulative biogas production was 4.7882 dm3/gm of slurry with

methane percentage of 46 %, while its corresponding value with mixing intensity of 30,40,50,60,70 rpm was 6.2853 6.0028,5.7203, 5.4379 and 5.0443 dm3/gm with a methane content of 58%, 57.1%, 55%, 50%, and 48% respectively. Thus, they concluded that as agitation speed increases from 30 to 70 rpm, biogas production increases from 5.3 to 31.3 %. Bambang et al. (2017) investigated the effects of stirring intensity on the methanogenesis step of two-step anaerobic fermentation of palm oil mill left over. The acidogenesis and methanogenesis stages are physically separated and they used continuously stirred two-stage digester of two-liter capacity in this study. They maintained a pH value of 7 ± 0.2 and a temperature of 55ºC inside the digester. To investigate the effect the researchers of the study vary the speed from 50, 100, 150, 200 rpm and found that the corresponding value of biogas was 52.46 ± 5.52, 58.87 ± 6.27, 57.23 ± 12.06, and 44.29 ±14.56 L/kg-VS respectively. Thus, they concluded that a moderate speed of 100 rpm generates maximum biogas. Karivama, et al. (2018) reported that the efficiency of anaerobic fermentation is not enhanced through continuous stirring and high-intensity stirring mixing. They also foundthat intermittent stirring and low-intensity stirring was beneficial to increase process stability and anaerobic fermentation.

2.2 Effects of Ammonia Nitrogen Concentration:

Ammonia is essential for the growth of bacteria but its excess amount results in failure of the process. The biogas production from the nitrogen-rich substrate like cow manure, Piggery waste, organic fraction of municipal waste, poultry waste, meat processing waste, dairy waste,
etc results in the release of ammonia, causes inhibition of the anaerobic digestion process. The biogas production can be maximized by increasing organic loading. But this practice in the case of protein-rich substrates results in the accumulation of free ammonia nitrogen. Accumulation of ammonia not only results in process instability but also causes environmental pollution. Therefore, the biogas digester operator needs to be monitor ammonia inhibition in order to ensure process stability. Some studies suggest that adjustment C/N ratio was effective to mitigate the effect of ammonia inhibition. McCarty and McKinney (1961) investigated that the threshold limit for free ammonia nitrogen level is 150 mg/L. If the free ammonia nitrogen content exceeds beyond this limit then the anaerobic digestion process may be inhibited. Kayhanian (1999) reported that the effect of ammonia inhibition can be resolved by adjusting C/N proportion and also found that in the case of organic proportion of municipal leftover, carbon to nitrogen proportion of 27-32 is sufficient for its degradation. Ho and Ho (2002) investigated some approaches to alleviate the effect of ammonia accumulation on thermophilic anaerobic fermentation of piggery wastewater. For this purpose, the researcher investigates the effects of pH adjustment and various approaches like organic left over, natural zeolite, and humic acid addition to mitigate the effect of ammonia accumulation. They found that organic left over and humic acid was not effective to mitigate the effect with and without pH adjustment but the mixing of 10-20 g/L of zeolite was most effective without pH adjustment (pH 8.1) than with pH adjustment (pH 6.5). Chen et al. (2008) investigated that ammonia accumulation is reduced to a considerable extent by dilution of feedstock to a solid concentration of 0.5 to 0.3. But the disadvantage of dilution is that it decreases gas production because less organic matter is available for degradation. Kotsopoulos et al. (2008) examined the impact of zeolite concentration of 0,4,8 and 12 g/L on anaerobic digester using pig waste and maintained digester at the thermophilic condition. They observed that zeolites dose of 8 and 12 g/L increased CH4generation significantly. However, they also observed that when zeolite doses were added then total ammonia concentrations decrease slightly. Lin et al. (2009) investigated the effect of microwave radiation to reduce ammonia concentration of cooked plant wastewater at a positive hydrogen ion concentration of 11. For this, they conducted experiments under various pH, radiation time, and with

and without aeration. They found that aeration was not effective to reduce ammonia concentration. They also found that when wastewater was exposed to 750 W radiation at 10 minutes then the ammonia concentration decreases from 5000 mg/L to 350 mg/L at a positive hydrogen ion concentration of 11. But major disadvantages of these methods are microorganisms can be destroyed and the cost of power consumption is high. Zeshan et al. (2012) carried out a simulation study using biodegradable waste material and identifies that C/N of 32 was most effective to minimize the effect of ammonia inhibition. They also found that the C/N ratio of 27 was less effective. Kougias et al. (2013) investigated the effects of different concentration of zeolite such as 5 and 10 g/L on anaerobic digestion of poultry manure. They used swine manure as an inoculum and found that 10 g/L zeolite addition was most effective, increases methane production by 109.75% compared to digester without zeolite addition. They also found that zeolite also reduced volatile fatty acid concentrations in the digester and increases the process stability of the anaerobic digestion process. Cho et al. (2014) investigated the effects of applying ultrasonic waves (frequencies 28 and 40 kHz) on livestock wastes to the decreases ammonia concentration. For, this they conducted an experimental study at varied pH (10-12), temperature (30-72º C), and duration (5-60 minute). A higher ammonia elimination rate was observed at 28 kHz and at pH 11 for about 15 minutes. They concluded that ultrasonic treatment helps in increasing solubilization and ammonia elimination rate was observed at 28 kHz and at pH11 for about 15 minutes. They concluded that ultrasonic treatment helps in increasing solubilization and thereby increasing hydrolysis rate. The ammonia inhibition problem arises because of the large concentration of proteinaceous biowaste, which is present mostly in the form of domestic food left over. Theproteinaceous material when undergoing hydrolysis reaction may result in ammonia inhibition. Depending on the temperature, pH condition maintained inside the digester, a proportion of this total ammonia nitrogen is available as free ammonia nitrogen inside the digester.

Buffering capacity is also known as alkalinity. To enhance digester stability and to control pH value, alkalinity is important. It is achieved by a number of substrates and is obtained by carbonate, bicarbonate, and hydroxide, etc. Neutral pH value is required to carry out anaerobic digestion and for methanogens, bio carbonate is the main source of carbon, therefore bio carbonate alkalinity is of great importance (Altamira, 2008) The anaerobic degradation of amino acids, protein also results in accumulation of alkaline concentration in the digester. In this process, the amino acid is released which will produce ammonia. The produced ammonia will further react with carbon dioxide which will produce ammonium bicarbonate. Hill et al. (1987) found that VFA higher than 2000 mg per liter or a proportion of propionic acid to acetic acid higher than 1.4 results in process failure. Marchaim and Krause (1993) found that the proportion of propionic to acetic acid higher than 1.4 shows an indication of organic overloading. According to Gerardi (2003) alkalinity is prevailing in form of bio carbonate in the digester which is in balance form with the carbon dioxide at a given pH value. According to Gonzales Fernandez and Garcia-Encina (2009) accumulation of volatile fatty acid can be occurred due to organic overloading, changes in the temperature and it inhibit the digestion process due to its toxicosis effect (Mechichi and Sayadi, (2005)) Luo et al. (2015) carried out two experimental study one with biochar and other without biochar using glucose anaerobic digesters. They reported that the first system produces methane 86.6% higher compared to without biochar system. This is because biochar improves buffering capacity of anaerobic digesters. Sunyoto et al. (2016) also found that mixing of biochar in a biowaste material increases hydrogen and methane production by 31.0 % and 10.0 %. Cooney et al. (2016) reported that biochar has acted as a packing material that facilitates the growth and retention of methanogenesis-rich biofilms. This helps in improving the performance of the anaerobic digester.

2.4 Effect of Concentration of Positive Hydrogen Ion

It plays an important and predominant role in the anaerobic digestion process. As reported in the literature,reduction in pH value results in operational problems of biogas reactor. Adjustment of pH value up to optimum leads to an increase in biogas yield and quality. The optimum pH value for acidogenesis bacteria differs from methanogenesis bacteria. During the acidogenesis stage acetic acid, propionic acid, lactic acid is generated. Low pH value may cause inhabitation of acidogenesis. pH value affects the chemical equilibrium of ammonia, hydrogen sulfide, and volatile fatty acid which are responsible for the inhibition of anaerobic digestion. Karki and Dixit (1984) reported that methanogenic bacteria cannot survive at a pH value greater than 8.5 and it creates toxic effects inside the digester. Mosey et al. (1989) reported that the ideal pH for methanogens lies in the span of 6.8-7.6 and observed that growth of methanogenic bacteria was retarded below a pH value of 6.6. Arshad et al. (2011) reported that the optimum pH value for hydrolysis and acidogenesis lies in the range of 5.5 to 6.5. Khalid et al. (2011) reported that the optimal pH value for anaerobic fermentation lies in the span of 6.8 to 7.4. Rajagopal et al. (2013) reported that at higher pH values free ammonia concentration dominates and is responsible for inhibition than ammonium ion (Nh4). Wang et al. (2014) reported that a methanogenic bacteria could not be survived below a pH value of 6.5.

2.5 Effects of Temperature

The degradation takes place faster at higher temperatures. The thermophilic anaerobic digester is much faster and produces more biogas than the mesophilic digester.However, biogas generation remains same in both the cases. Thermophilic fermentation is most effective in terms of organic load and retention time because of the higher temperature involved in it but it is rarely used in actual practice as too much power is required to obtaindesired hotness inside the fermenter. Proper insulation of anaerobic digester helps in maintaining desired temperature and biogas production in the winter. Therefore, in cold climatic conditions or in areas of temperature changes, its effect is minimized by increasing insulation (Kalia, 1988) or by the use of heaters to maintain desired temperatures (Lichtman, 1983). Lund et al. (1996) reported that when the average surrounding temperature is 30º C or less, then the dome temperature of the fermenter remains greater than 4º C above the surrounding temperature. Vindis et al. (2009) reported that thermophilic anaerobic digester (55º C) gives a better result than mesophilic digester (35º C). They used maize as a substrate in their investigation. They also reported that better biogas quality was produced in the thermophilic digester and it was four times faster than thermophilic digester.

2.6 Effect of Carbon Nitrogen Concentration:

Carbon and nitrogen both are essential for the growth and survival of microorganisms. The excess carbon concentration will lead to more carbon dioxide formation and results in decreases in pH value, while the excess of nitrogen will result in the accumulation of ammonia and an increase in pH value which is harmful to microorganisms. A higher or lower C/N ratio will negatively affect anaerobic digester performance. C/N ratio of 30 means that in the organic substrate, there are 30 grams of carbon for each 1 gram of nitrogen. The optimum carbon to nitrogen proportion can be obtained in the digester by adding a high carbon/nitrogen percentage substrate with a low carbon/nitrogen percentage substrate. The optimal value of the C/N ratio varies from substrate to substrate but its optimum values lie in the span of 20-30 [35]. Carbon nitrogen proportion of some frequently used material is given in table-1.0

Table:1.0 Carbon Nitrogen Ratio of Different Substrate [42]

Biowaste	Carbon %	Nitrogen %	C/N Percentage
Chicken waste	45	3.0	15
Pig dung	7.8	0.65	13
Horse dung	10	0.42	24
Cow dung	7.3	0.29	25
Sheep manure	16	0.55	29
Stalks of soy and bean Left over	41	1.3	32
Potato stalks	40	1.2	22
Tree leaves Left over	41	1.0	41
Lucerne	48	2.6	18
Corn cobs	40	0.75	56
Rice straws Left over	42	0.63	67
Barley straws Left over	42	0.75	56
Wheat straws Left over	46	0.53	87
Different herbs	15	0.6	25

2.7 Effects of Feedstock Characteristics:

Different feedstock has different biogas potential and it depends upon proteins, lipids, carbohydrates, lignocellulose content of biomass. The quality of biogas and the rate of biogas production depends upon the types of feedstock that undergo anaerobic degradation. The conversion rate of biogas production is faster with carbohydrates and proteins but it has a lower biogas yield. The biodegradability of lipids is slow so it requires a longer time to degrade but produces the highest biogas. The substrates rich in carbohydrates are food and organic wastes from agricultural-based industries while lipids-rich substrates are food waste, waste coming from dairies, slaughterhouses, or fat refineries. Chen et al. (2008) found that anaerobic fermentation of protein-rich substrate results in a risk of ammonia accumulation inside the digester which would inhibit the digestion process. According to Cuetos et al. (2010) the substrate rich in proteins nitrogen is animal waste and meat processing waste. These wastes have high organic concentration but have low carbon to nitrogen proportion. According to Esposito et al. (2012) animal dung, sewage sludge left over from aerobic wastewater treatment plant, dairy wastes, food left over, agricultural left over, meat and fish industries waste, certain energy crops, municipal

organic solid waste are a very common material used for anaerobic fermentation. Sun et al. (2014) reported that anaerobic digestion of lipidrich substrates may result in a reduction in positive hydrogen iron concentration, hindrance of long-chain fatty acids, and sludge floatation. This may lead to operational problems. Paritosh et al. (2017) reported that anaerobic digestion of carbohydrate-rich substrates could result in unfavorable C/N ratios which may inhibit anaerobic digestion due to rapid acidification and limited nutrients.Percentage Concentration of CH4 from Anaerobic fermentation of different biowaste is listed in table-2.0

Table 2.0 Percentage of CH_4 from Anaerobic Fermentation of Different Substrates [47] [48]

Substrates	Methane Percentage (%)
Cattle dung	50-60
Pig dung	60
Poultry Left over	68
Sheep manure	65
Horse dung	66
Grass	84
Wheat straw Left over	78.5
Dried leaves Left over	58
Barley straw Left over	77
Beet leaves Left over	84.8
Corn silage Left over	54.5

III. 3.0 CONCLUSION:

From the literature review and by studying various research papers it has been concluded that(I) Minimal or intermit agitation has a positive impact on biogas production and reduces the possibility of scum formation in the digester, while continuous stirring reduces the performance of anaerobic digestion. Stirring intensity and duration greatly affect anaerobic digester performance. So, biogas production can be optimized by a selection of intermittent agitation or minimal agitation.

(ii)The threshold limit for free ammonia nitrogen is 150 mg/L. If the free ammonia nitrogen level exceeds beyond this limit then the anaerobic digestion process is inhibited.

(iii)Accumulation of ammonia nitrogen concentration inside the digester inhibits the digestion process and may arise due to the digestion of nitrogen and protein-rich substrates. From literature review and study carried out by different researchers, it is concluded that the problem of accumulation of ammonia

can be resolved and optimized by dilution of substrates, adjusting C/N ratio, mixing zeolite and through different treatment like ultrasonic and microwave.
(iv)Total VFA greater than 2000 mg per liter or a proportion of propionic acid to acetic acid greater than 1.4 results in process inhibition. Accumulation of VFA may occur in the digester due to overloading of organic material and results in a drop in pH value inside the digester. This may even cause process failure. The problem of volatile fatty acid can be resolved and the process can be optimized by maintaining alkalinity inside the digester or avoiding overloading of organic material.
(v) The optimum pH, Carbon to nitrogen proportion lies in the span of 6.8-7.6 and 20- 30 respectively.
(vi)The biogas production in the thermophilic temperature range (50- 60º C) is faster, effective in terms of holding time and biowaste loading rate than the mesophilic temperature range (40-50º C).
(vii)By studying various research papers, it has been found that biogas production depends on the lipid, protein, carbohydrate, and lignocellulose content of biomass.

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