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Design and Fabrication of an Automated Chicken Coop

Final Report

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Declaration

We hereby declare that the work contained in this report is original; researched and documented by the undersigned students. It has not been used or presented elsewhere in any form for award of any academic qualification or otherwise. Any material obtained from other parties have been duly acknowledged. We have ensured that no violation of copyright or intellectual property rights have been committed.

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Abstract

Agriculture contributes 25 per cent of Kenya's gross domestic product. Poultry farming represents 30 percent of this contribution. Small and medium scale poultry farmers contribute the most to the sector and one of the challenges they face is inaccessibility of proper equipment which will reduce the amount of labor and time used to rear poultry animals. These farmers are disadvantaged as they cannot compete with large corporations that have the means of accessing top notch equipment and consequently, they are usually forced out of the market. This therefore creates the need to come up with a affordable system that will effectively reduce the amount of time and labor required to maintain chickens and create a comfortable and conducive environment for the chicken.

The solution explored was an integration of mechanical, electrical and control systems with the aim of automating the integral units which included the feeding and watering, waste management and egg collection systems and enabling the remote access of the various automated systems so as to eliminate or extensively reduce the human input needed. The design integrated all the above systems to come up with one automated chicken coop.

The automation of the chicken coop resulted in reduced time spent in performing the upkeep duties and the required labor. The level of automation achieved by the design subsequently lead to efficient production of good quality eggs. This was accomplished by maintaining feed and water efficiency, proper handling of wastes, and improved physiological state of the chicken.

Acknowledgment

We hereby take this opportunity to express our infinite gratitude to all the parties involved in assisting us to come up with this project .We specifically want to appreciate our lecturer Mr. Muchiri, our supervisors Dr. Murimi and Ms Maureen Andanje and our technician Mr. Mumu for their guidance and consult from the start. The knowledge and experience departed unto us was of immense aid for this project and future endeavors.

Nomenclature

PVC - Polyvinyl Chloride

STL - Standard text language

RPM - Revolutions per minute

PLA - Polylactic acid

GSM - Global system for mobile communications

PCB - Printed circuit board

Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

Poultry farming is a major contributor to the economy of Kenya. According to the Kenya Poultry Farmers Association Baseline Survey in 2008, about 3.8 million farmers in Kenya practice poultry farming both for commercial and subsistence purpose. The annual estimates given by the Kenyan Ministry of Livestock Development in 2008 shows that about 18,600 tonnes of poultry meat valued at Kshs 3.5 billion is produced per annum while 1.2 billion eggs valued at Kshs 9.7 billion are produced per annum [1]. There is room for improvement but this growth is stifled by the fact that most small scale or medium scale farmers, who constitute the larger percentage of poultry farmers in Kenya, lack both reliable and cost efficient inputs. Lack of easy access to credit to run their businesses is also another challenge faced by these farmers. These challenges force them to miss out on the advantages enjoyed by large scale poultry farmers, who, due to the benefits of economies of scale, are able to access top notch equipment for their farms. These small and medium scale farmers therefore have to sacrifice more time and effort in terms of labour to ensure the success of their poultry farms.

It is true to state that though poultry farming is an easier task when compared to other animal farming ventures (e.g. dairy farming), it still requires a fair amount of attention so as to make it successful. For maximum efficiency of ones poultry farm, one needs to consider factors such as feeding of the poultry, egg collection, sanitation of chicken coop, manure management, egg production management among many other factors briefly outlined below:

1. Poultry breeds require high quality feeds and a sufficient amount of fresh and clean supply of water daily. Their meals should have high amounts of vitamins, protein and minerals.

2. A chicken lays an average of six eggs per week. The eggs should be collected every day, in some cases, depending with the number of eggs laid, twice a day.

3. To ensure proper sanitation, the chicken coop together with its pen should be cleaned at least once a week. This is because the accumulation of chicken droppings leads to issues with the humidity (given that 85% of the droppings is water) and bad odour. The feeders and the waterers should also be cleaned and disinfected regularly to minimize the chances of the poultry getting infected.

4. Chickens require twelve to fourteen hours of light daily to continue laying eggs. This requires switching on of a light bulb when there is minimum amount of light.

1.2 Problem Statement

Poultry farming is an integral sector within Kenya's agricultural industry,representing 30 percent of agriculture's contribution to the Kenyan GDP. This success within the poultry sector is mainly driven by small and medium scale farmers who make up the larger percentage of poultry farmers in Kenya. However, most of these farmers have to sacrifice a lot of time and labour to successfully maintain their poultry farms which is more expensive since they have to hire extra personnel to help out. They also do not have access to the proper equipment for efficient and autonomous running of the farms due to insufficient funds. There is therefore a need to come up with a cost-effective automated system that will make rearing of poultry easier and cheaper for these farmers.

1.3 Objectives

1.3.1 Main Objective

To come up with an automated chicken coop system that provides an automated feeding and watering system, an automated waste management system, an automated egg counting system and allows for remote access of the chicken coop.

1.3.2 Specific Objectives

- To design a system that monitors the amount of feed and water available for the chickens.
- To design a system that counts the eggs laid and collects them at some point,.
- To design a system that allows for remote access of the chicken coop.
- To design a system that manages waste removal from the chicken coop.

1.4 Justification

The main intention of the project was to create a conducive and comfortable environment for hens to lay eggs and significantly reduce the amount of time and labour that is input into the maintenance of the chicken coop. In a country where manual methods of rearing poultry birds are mainly employed, automating the processes involved in rearing of hens has definitely led to a reduction in the amount of time and labour required to rear chickens while at the same time increase the efficiency within the poultry farm by greatly reducing human errors as there will be minimum involvement of human labourers. With the automated systems working to clean the coop, ensure favourable conditions for egg laying and the overall enhancement of the poultry well-being, it is inevitable that the chicken rearing process has become more productive. The proper sanitation and waste management methods are also in tandem with our country's green policy which protects the environment.

2 Literature Review

As the human population increases, the poultry industry continues to grow to meet the demand for poultry products in world markets. The importance of poultry farms lies in the quality of products that are provided to humans. Poultry farms are fast-paced operations that can fulfil the demand for meat and eggs, and can be expanded easily to meet the ever-growing demand [1]. Poultry coops can be built in almost every possible shape and size. In the past they employed the use of traditional methods but with time technology and inventions in the agricultural sector have led to certain developments in poultry farming [2]. Discussed below are the different types of poultry coops available in the market today. Traditional systems will not be considered in this study as they fall outside the scope of this project.

2.1 Modern Coops

There exists two types of modern coops:

2.1.1 Mechanical Coops

These are organized and structured houses which are not automated. They are referred to as coops. There exist many variations of this type of coops but they can all be classified into two groups, portable and permanent coops. Portable coops do not fall under the scope of this project and therefore will not be discussed any further.

Permanent Free-Range Coops

A permanent coop is ideal if the space available is limited or if the poultry farm operation is large. Benefits of building a fixed house are mainly due to the versatility in choosing building materials that are sturdier. A larger house can be built to accommodate harsh

[1] www.utm.edu/msanr/pdfs

weather conditions, more chickens, and ensure ease of chores. The size of the house can be increased and added amenities like electricity can be supplied. Permanent coops can either be free-range or caged coops. This project however concentrates on caged coops as they are more common nowadays.

Caged coops

These coops house the birds in cages.

1. **Battery Cages**

   According to the United Poultry Concerns [2] ,battery cages are defined as wire cages usually used for egg-laying hens. The size of the cages is usually approximately 460 mm $\times$ 510 mm. Each of these cages can house about 11 birds. The cages are identical and are usually arranged in rows and columns connected together to form a single unit. The floors of the cages are usually sloped so as to allow for the rolling of eggs out of the cages once they have been laid. Food is usually supplied to the chickens in gutters fixed outside the cages and water supplied through pipes which have been fitted with drinking nipples. Chicken droppings usually fall on a platform below the cages where they are usually manually scrapped off. Figure 2.1 shows an image of an A type battery caged coop [3].

2. **Furnished Cages**

   They are also referred to as *enriched* or *modified* cages. Essentially, they are a modification of the battery cages and were designed so as to overcome some of the welfare concerns of battery cages. They are mainly used with layer hens. By incorporating the features outlined in referencing [3], the social welfare of the birds is improved, leading to better quality eggs as compared to those produced by layer hens in battery cages. Figure 2.2 shows an image of a furnished caged system [4].

[2] https://www.thoughtco.com/what-is-a-battery-cage-127710

[3] www.myclassifieds.co.zw/zimbabwe-business-directory/farming/160bird-chicken-cage-layer-cage-poultry-cage-battery-cage-poultry-equipment-i60253

[4] $https : //www.researchgate.net/profile/Xiang_Li224/publication/308092360/figure/fig1/AS :$

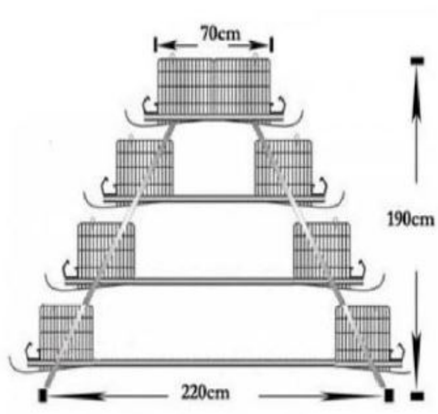


Figure 2.1: A type Battery Cage

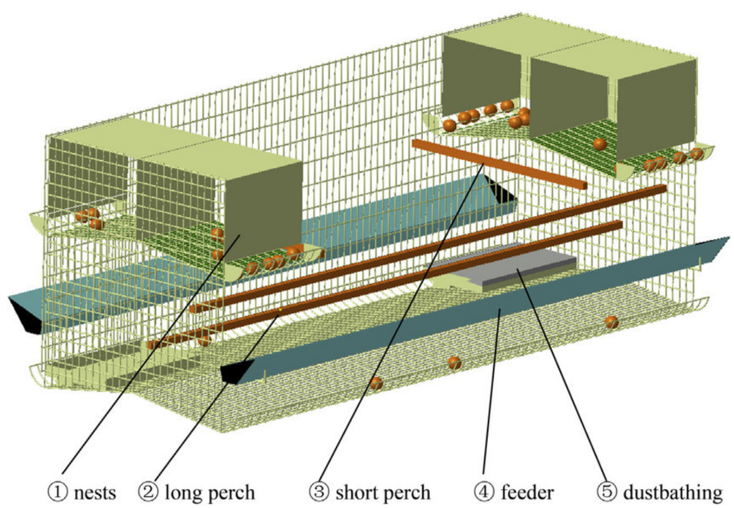


Figure 2.2: A furnished caged system

2.1.2 Automated Systems

These systems are a modification of the mechanical systems, where the processes involved in poultry farming have been automated so as to improve efficiency and reduce the amount of labour and time required to rear poultry birds. Discussed below are how the different

614260333895680@1523462484705/*The − detailed − design − of − LFC − LFC − large − furnished − cage.jpg* types of mechanical coops have been automated. Traditionally, the poultry farmer is required to open the coop door early in the morning so as to let the chickens out of the coop and close it at night so as to ensure that the birds are protected from predators. To make poultry farming easier, companies such as Automatic Chicken Coop Doors and NOPEC Corporation make and sell timer based automatic/motorized chicken coop doors[4]. This removes the burden that is usually on the farmer to wake up early or be at the farm before sunset so as to open or close the chicken coop door.

Layer hens require 12 to 14 hours of light daily for maximum egg production [5]. Most poultry farmers depend on the sun to provide this light but given the variations in weather, this might prove to be unreliable. Therefore, poultry farmers usually install electric lamps in their coops to provide light on gloomy days. Initially, a farmer would turn the lights on and off using an electric switch but with the advent of light sensors, automatic switching of the lamps has been enabled. This system has also been applied in deep litter coop and caged systems.

There exists different types of automatic feeders used commercially today. A travelling hopper consists of a silo or a central hopper used to store the feed [6]. The feed is stored in a silo or central hopper. This feed is then deposited in a movable system of hoppers that is automatically actuated by a motor. The movable hopper system moves along the feeding trough continuously, supplying feed to the chickens. Figure 2.3 shows an image of a traveling hopper [7].

Another automated caged feeding system consists of a continuous chain conveyor running in the bottom of the feeding trough to deliver the chicken feed(granular or powdered) from the silo [5]. Time switches, where the time is usually set by the farmer, are used to run the system for a set period of time at regular intervals. Figure 2.4 shows an image of a chain feeder system [8].

Another automation in caged systems has been in egg collection. The technologies used

[5] www.backyardchickens.com

[6] https://www.china-chickencage.com/automatic-feeding-machine-system/

[7] https://www.china-chickencage.com/automatic-feeding-machine-system/

[8] Youtube-A type layer chicken poultry cage with chain feeding system

Figure 2.3: A Travelling Hopper

Figure 2.4: A Chain Feeder System

included elevator lift or conveyor systems [9].

A propylene belt conveyor placed below the cages collects the chicken droppings. A scraper made of wear resistant material is then used to clean the belt.The conveyor can be actuated by a motor while the scraper is fixed at one end of the conveyor. The droppings are then collected in a bin. The scraper can be actuated by the use of a lead screw coupled with a motor while the propylene belt remains stationary. In this case,

[9] texha.com

the belt will just be a flat surface beneath the cages.Such a system was developed by the china chickencage company.
An automatic feeding system was developed by Hebei baiyu technology [10] consisted of an Auger elevator can transfer the feeding food to the silo, and then transfer the feeding food to the hopper of the automatic feeding machine, then the automatic feeding machine will spread feeding food into the feeding through as shown in figure 2.5. The system also consisted of an egg collection and transfer system, manure cleaning system as well as environment control to keep temperature and humidity of the chicken house as required.

Figure 2.5: Automatic feeding system

2.2 Gap Analysis

The mechanical coops are easy to implement and relatively cheap as compared to the automated system. They however require a lot of labour. This is because tasks such as the feeding of the birds, collection of the eggs and cleaning of the coop are all done manually. Therefore, more attention is required when rearing birds housed in these coops. This consumes a lot of time and may lead to inefficiencies in the poultry farm due to human errors.

The automated systems solve the problem present in the mechanical coop as automation has been extensively achieved in these systems with little room for improvement. However,

[10]http://www.chinachickenfarm.com/chicken-cage/automatic-system-204.html

currently, other than the large scale poultry farmers, few farmers in Kenya have been able to employ these systems in their farms mainly due to their high prices. Therefore, there exists a gap that can be filled by coming up with cost effective automated chicken coop systems.

3 Methodology

The main objective was to come up with an automated chicken coop that would help create a comfortable and conducive environment for the chicken for maximum egg production. The project focused on the following areas:

- The provision of food and water to the chicken.
- Egg counting.
- Remote access of the chicken coop.
- Waste management system.

By introducing automation to these areas, the amount of attention required by the chicken coop would significantly reduce and the efficiency of the coop would improve. With this in mind, the following questions arose:

1. How would the feeding and watering system be automated?
2. How would the egg collection system be simplified?
3. How would the chicken coop be remotely accessed?
4. How would there be proper management of waste in the coop?

The design in this project was an implementation of these already existing systems but on a smaller scale. The final design was then compared to the already existing coops, with the point of interest being the simplicity of rearing chicken when using the project design.

The project design is made up of the following subsystems:

- Caging Structure.

- Feeding and Watering System.
- Waste Management System.
- Egg Collection System.
- Remote Access System.
- Control System.

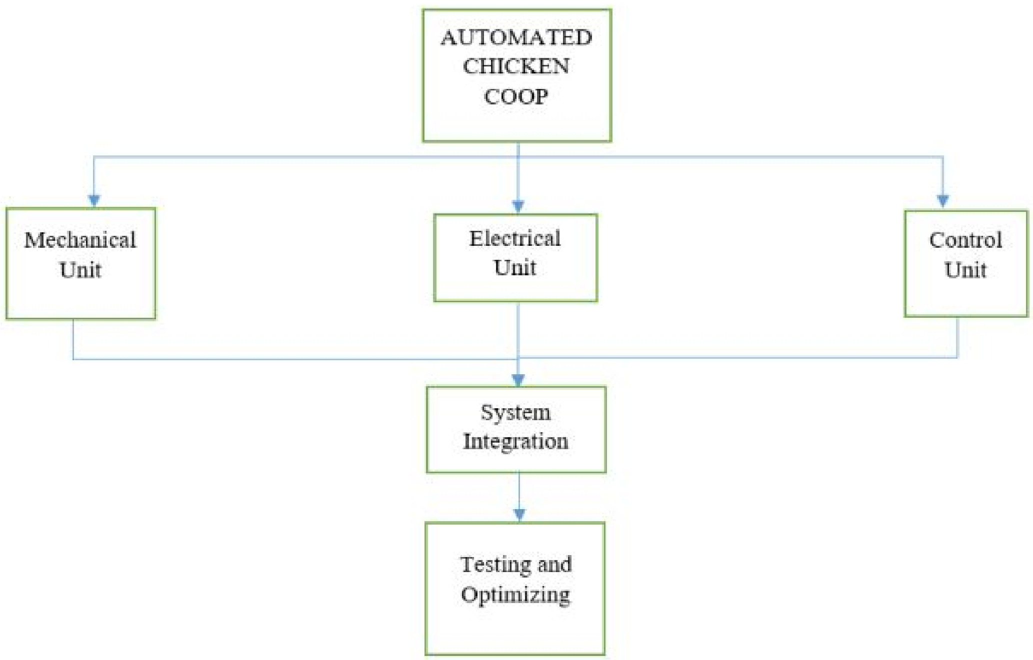
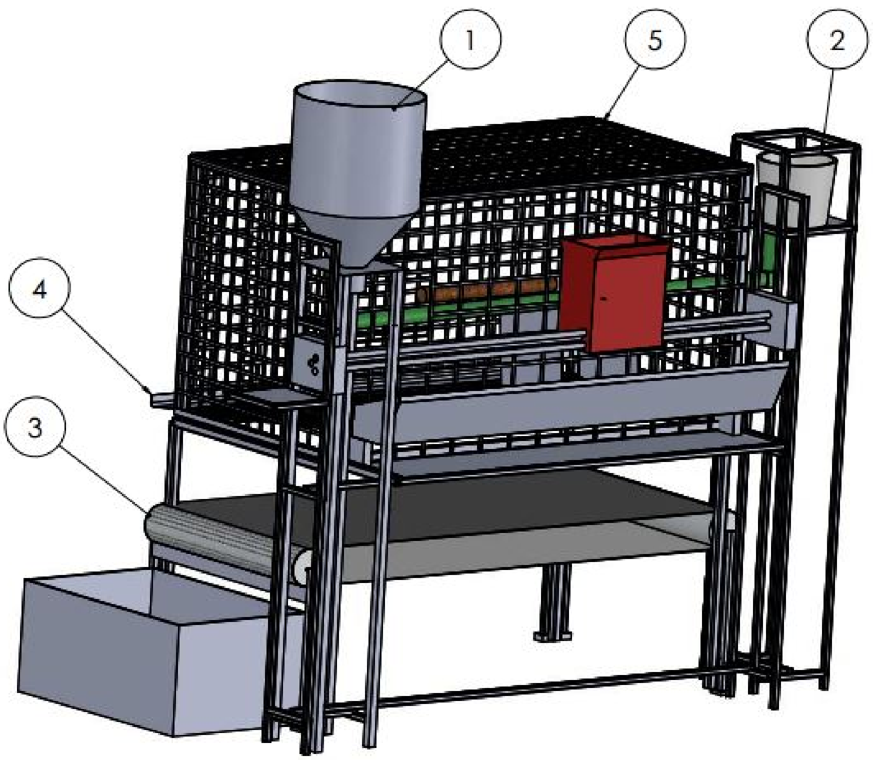


Figure 3.1: Procedure pathway

Figure 3.1 shows the procedure pathway followed in the design of the each of the subsystems mentioned above.

3.1 Mechanical System

The mechanical system is made up of the following parts as shown in figure 3.2.



PART NUMBER	PART DESCRIPTION
1	FEEDING SUBSYSTEM
2	WATERING SUBSYSTEM
3	WASTE MANAGEMENT SUBSYSTEM
4	EGG COLLECTION SUBSYSTEM
5	CAGING SUBSYSTEM

Figure 3.2: Automated chicken coop design

3.1.1 Caging Structure

The parts in the caging structure are shown in figure 3.3.

The following are the design considerations that guided the design of the caging structure:

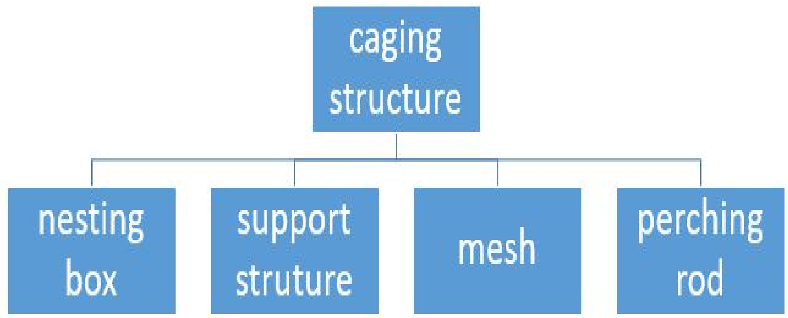


Figure 3.3: Caging structure parts

- It should be well spacious
- It should be well ventilated
- It should be well lit
- It should be aesthetically pleasing
- It should be able to support weight of the chicken

Implementation of the design considerations

When deciding on the type of chicken coop to use, the main types of coops being used were considered and analysed as shown in table 3.1.

Cage-Free vs Battery-Cage

The project design implemented a blend of the two types of systems so as to enjoy the benefits of each system.

Design of the Improvised Caged Coop

- The recommended 120000 mm^2 of floor space for each chicken in a coop was used. The design for this project was for three hens.

Table 3.1: Comparison of the existing caged with the Design's cage

Cage Free	**Battery Cage**	**Improvised Project Design**
More chicken kept	More chicken kept	Adequate number kept
Plenty of space for nesting, perching	No space for nesting, perching	Space for nesting, perching
Easy spread of diseases	Diseases dont spread easily	Diseases dont spread easily
More natural feel for chicken	Generally poor psychological health for chicken	Better psychological health for chicken

- 1 nesting box was provided for every 3 chickens [11].
- At least 900mm off the ground for adequate air space was provided.
- 150mm of rounded roosting length per chicken was provided [12].
- The floor of the cage (including the floor of the nest box) was slanted at an angle of 7° so as to enable the egg to roll smoothly without cracking upon reaching the collection point [13].

Based on the recommended dimensions for the coop structure, then the coop structure in this project was taken to have a length , width and height of 750 mm, 375 mm and 400 mm respectively.

Various materials that can be used to make the coop structure were analysed as shown in table 3.2.

[11] https://www.backyardchickens.com/threads/number-of-chickens-and-coop-size.532080/
[12] https://hencam.com/henblog/2013/03/chicken-coop-dimensions-and-design-criteria/
[13]http://academic.coup.com/article/91/7/1522/1521906

Table 3.2: Comparison of the different Coop Structure materials

Parameters	**Framing lumber**	**Mild steel**	**Aluminium**
Service life	Rots after a while	Long life	Long life
Cost	Cheap	Relatively Cheap	Expensive
Availability	Locally available	Locally available	Locally available
Reaction to water	Wets	Does not rust	Does not rust
Strength	Fairly strong	Very strong	Very strong

Mild steel was chosen since it is cheaper, strong and easily available.

Mesh to Use

Mesh is needed to protect the chicken from predators, have spacing for the chicken to access feed from and for their droppings to fall and pass through. The following types of mesh were analysed in table 3.3

3×3 welded low carbon steel mesh was chosen since it would allow the droppings from

Table 3.3: Comparison of the different types of wire mesh

Parameters	**Galvanized before weld**	**Galvanized after weld**	**Durable twisted woven mesh**	**Low Carbon steel**
Cost	Inexpensive	More expensive	Inexpensive	Inexpensive
Durability	Prone to rust and corrosion	Protected from rust and corrosion	High strength and durability	High strength and durability
Lifetime	Limited lifetime	Extended lifetime	Extended lifetime	Extended lifetime
Availability	Easily available	Not easily available	Easily available	Easily available
Appearance	Utilitarian	Utilitarian	Aesthetically pleasing	Utilitarian
Weld-ability	Not easy	Easy to weld	Not easy	Easy to weld

the chicken to fall through as well as enable to chicken to walk on top of it without slipping through. It is also cheap and easily welded. The mesh was be used to build the walls, floor and roof of the chicken coop.

The dimensions of the coop are shown in figure 3.4.

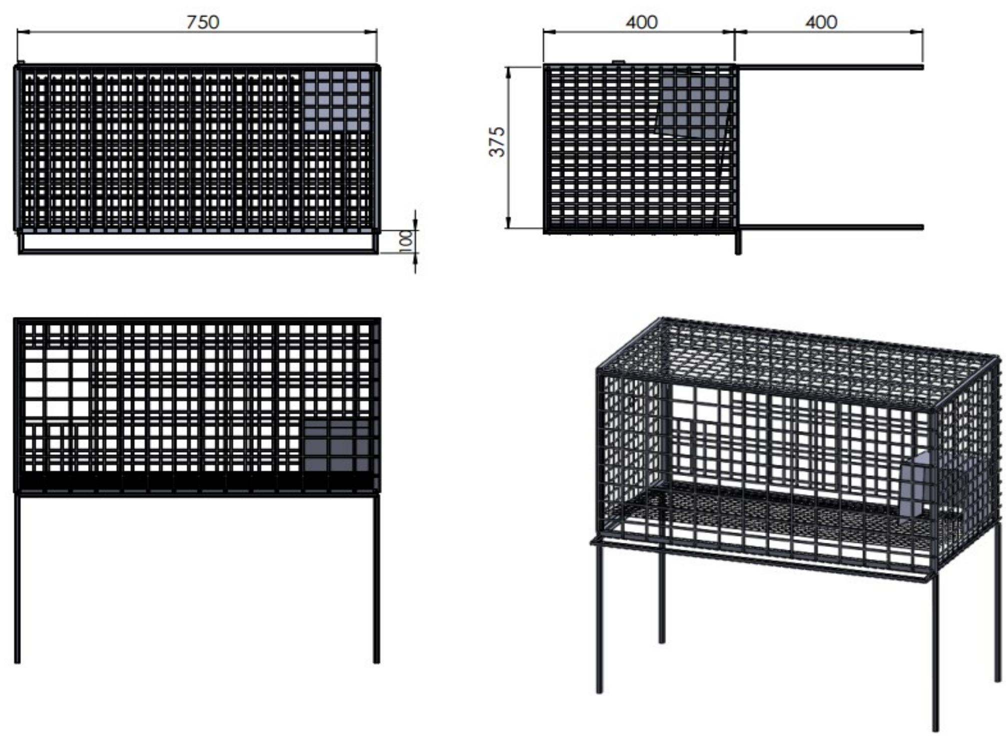


Figure 3.4: Coop structure 2D drawing

The Caging structure encompassed the following systems on the floor space:

- Roosting area
- Feeding area
- Watering area
- Nesting area

Perching Area

The perching area is the rod on which the chicken sleeps at night. The rod was designed based on the following considerations:

- It would provide at least 150 mm per chicken. For 3 chickens, it was to be at least 450 mm long.
- It was to be rounded since chicken have special ligaments in their legs that lock in place when they sleep [14].
- It had to be higher than the nesting area so as to ensure that the chicken would not roost on the nesting area.

The dimensions of the rod had a diameter of 20 mm and length of 750 mm.

For the material to be used, wood was preferred over metal as it was found to be easier to grab and metal would be too cold for the hens as it conducts away heat.
The 2D drawing for the perching area is as shown in figure 3.5.

Nesting Box

Nest boxes are the areas you provide for your hens to lay their eggs. Nest boxes should be roughly one cubic foot (28316800 mm^3) each. Hens naturally seek out a small dark area to hide their eggs. The nest boxes should also have roofs (preferably angled) so that the chickens dont perch on top and leave their manure [15] . The following are the considerations that guided the design of the nest box:

- Should be 100 mm above the ground so chicken dont peck at eggs.
- At least 1 nesting box was to be provided per 3 chickens.
- It was to be roofed so chicken do not roost on top of it and poop in it.

[14] https://hencam.com/henblog/2013/03/chicken-coop-dimensions-and-design-criteria/
[15] http://abundantpermaculture.com/chicken-housing-that-works-5-brilliant-ways/

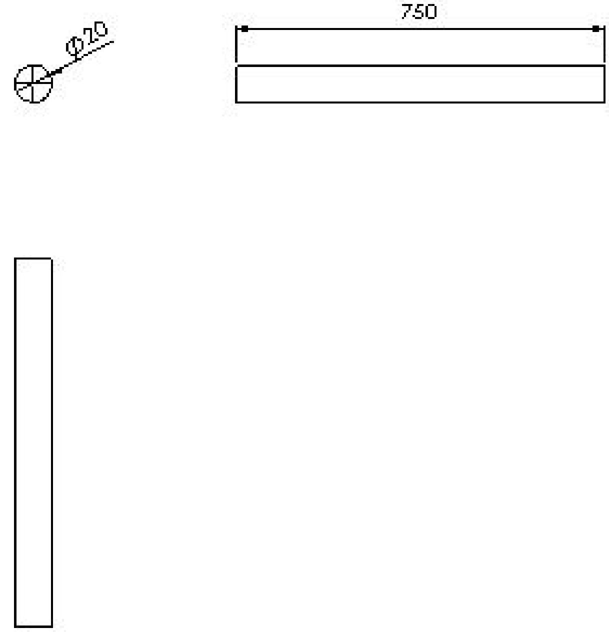


Figure 3.5: Perching Rod Drawing

Which, when applied led to the design of a **150mm** × **150mm** × **150mm.**

The 2D drawing of the nest box is shown in figure 3.6:

3.1.2 Feeding System

The feeding system constituted the trough, conveying system and the silo and hopper system.

Trough

Designing of the trough involved calculation of the trough dimensions and selection of the troughs material.

Trough dimensions and its structural appearance

Basing our calculation on the standards provided by NAFIS [16], the trough had the following dimensions:

[16]www.nafis.go.ke/livestock/poultry-chicken/general-information/feeds-and-feeding

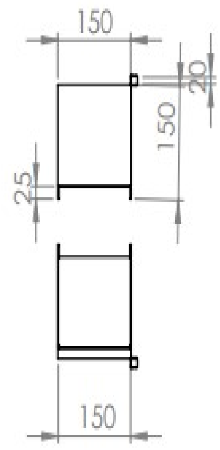


Figure 3.6: Nesting box 2D drawing

The length of the trough was obtained as **750 mm** so as to cover the full length of the coop. The width of the trough was obtained as **75 mm** so as to hold enough feed. The height of the *outer side* was obtained as **110 mm** to ensure that the feed did not spill and reduce wastage. Given the restrictions faced by the birds, the height of the *inner side* was reduced to **50 mm** so as to allow the hens more space for accessing the feed in the trough. For symmetry, the troughs slant angle(β) was set to the same value as that of the cabin floor (α) 3.1.2 . The drawing of the trough is shown in figure 3.7

Selection of the trough material.

The materials that were considered to viable for the fabrication of the trough were Poly Vinyl Chloride (PVC), galvanised plain steel, stainless steel and aluminium. The table 3.4 shows their different properties based on the following design considerations:

Based on the following considerations, the material chosen for the troughs design was **galvanised plain steel**. This is because galvanized plain steel was found to be cost effective and easy to machine.

Conveying System

For this design, three types of conveying systems were compared so as to determine the most suitable conveying system conveying system; conveying belt system, cabin driven

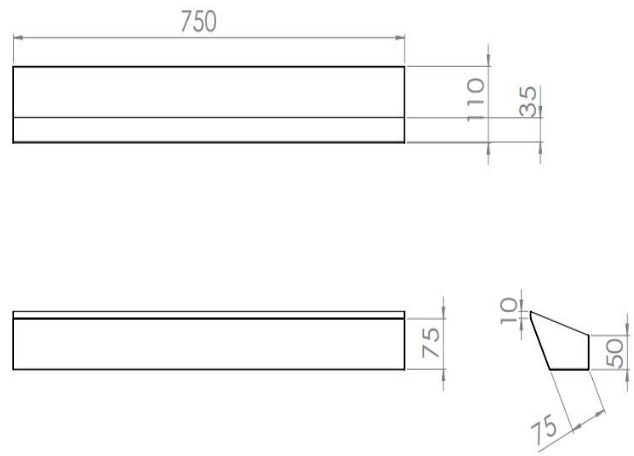


Figure 3.7: Trough 2D drawing

Table 3.4: Comparison of the different materials considered for the trough's design

	Plastic	**Galvanized plain sheet**	**Stainless steel**	**Aluminium alloys**
Cost	Cost effective.	Cheap.	Relatively cheap.	Expensive.
Formability	Easy to machine	Easy to machine	Good formability properties	Good workability
Resistance to corrosion	High	High	High	High

by a lead screw and pulley and belt driven cabin system. The following were compared to determine the most viable type. The comparison is shown in the table 3.5:

The system chosen was the Cabin Driven By a Lead Screw Design since it was cheaper and easier to design.

<u>Cabin Driven By A Lead Screw.</u>

This system is made up of the cabin and lead screw. In designing the cabin, the type of material used, dimensions and structural shape were considered.

The material chosen for the cabin was compared in table 3.4 and PLA was selected. PLA

Table 3.5: Types of conveying systems and their characteristics

	Conveyor system	**Cabin driven by a lead screw**	**Cabin driven by a pulley system**
Cost	Relatively expensive	Inexpensive	Inexpensive
Maintenance	Difficult to maintain	Relatively easier to maintain	Difficult to maintain
Continuity with regard to flow	Discontinuous	Continuous	Continuous
Machinability	more difficult	Easy to design	easy to design

was used since it enabled the cabin to be 3D printed to enable the machining of some of the finer features of the cabin with ease.

Cabin design had a trapezoidal front face which had height of **100 mm** with its longer length being **130 mm** and its shorter length being **55 mm**. The floor's slant angle was therefore obtained as **63.4°** .The cabin was also designed to have an opening from which feed would flow into the trough. The height of this opening was obtained as **10 mm**. The entire length of the cabin was obtained **165mm**. Its shape also included a funnel top to ensure that the feed does not spill when it pours from the silo into the cabin. Furthermore, the nut hole spacing, where the lead screw nut was to be fitted into, was included, it taking the shape of the M10 nut to ensure a perfect fit is achieved. To prevent swaying of the cabin, two holes for the support rods were also added to the design. The holes were positioned symmetrically using the centre point of the nut spacing as a point of reference. The smooth rods had a diameter of **10mm**, similar to the outer diameter of the lead screw. The 2D drawing of the cabin is shown in figure 3.8.

There are four commonly used types of threads used in the making of the lead screw:

- V threads.

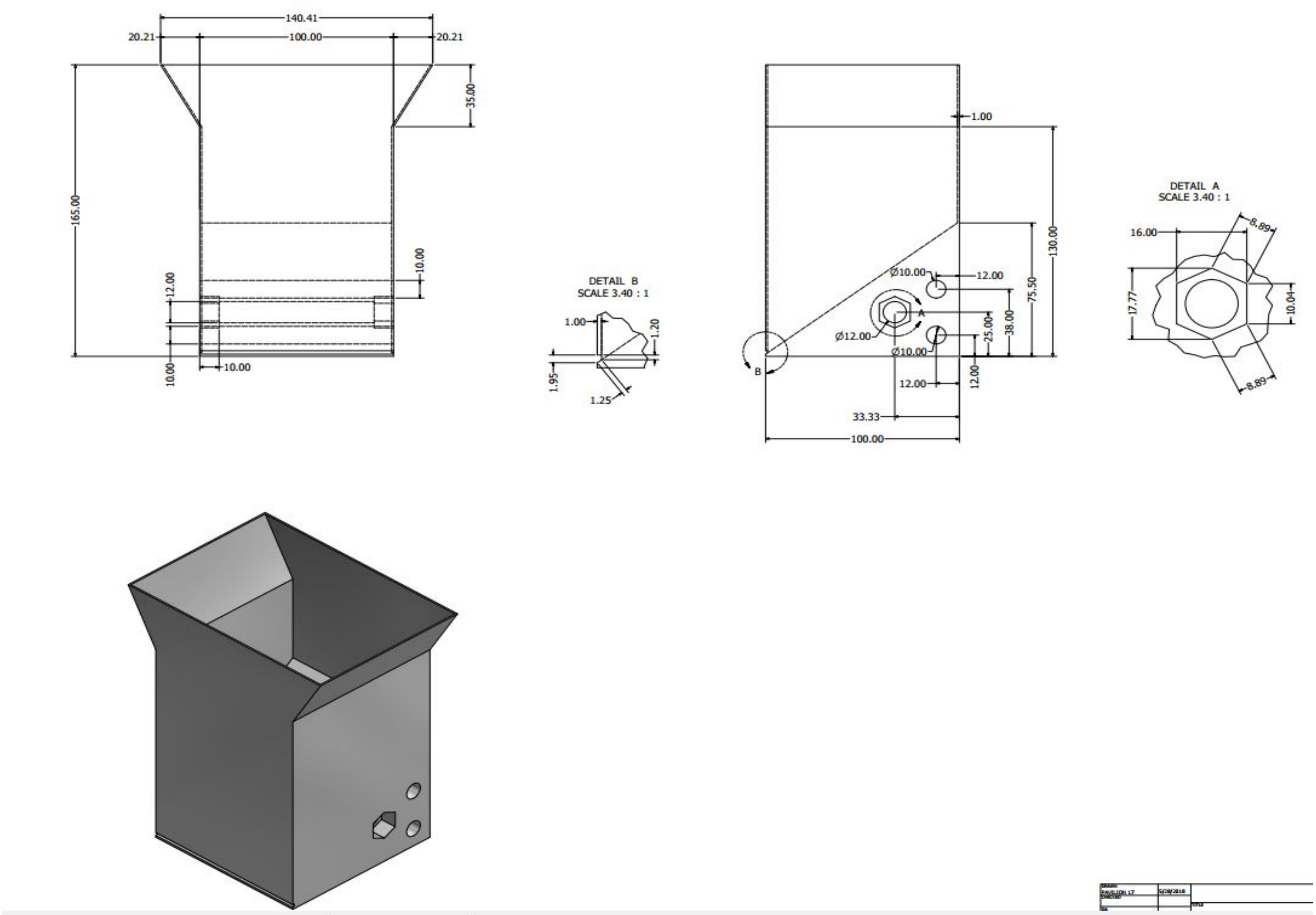


Figure 3.8: Cabin 2D drawing

- Square threads.
- Acme threads. A
- Buttress threads.

The threads were compared in table 3.6.

Taking these considerations into account, the lead screw was designed having a major diameter of **10mm**, a minor diameter of **6.5mm** and a length of **1000mm**. The lead screw settled on was the V thread since it was cheapest and most easily available.

Table 3.6: Comparison of the different types of threads

V THREADS	**SQUARE THREADS**	**ACME THREADS**	**BUTTRESS THREADS**
Less suitable as they have more friction between their threads	Most efficient as they have the least friction	Increased friction angle as compared to the square thread due to thread angle	They are as efficient as square threads
Difficult to machine	Most difficult to machine	Easier to machine than square threads	Easier to manufacture than square threads
Cheap	Most expensive	Cheaper than square	Relatively expensive
Carry light loads	Carry relatively light loads	Can handle more load than square thread	They are used where the load force on the screw is only applied in one direction.

Pillow blocks were needed to support the lead screw and the smooth rods. The dimensions of the pillow blocks were determined by the outer diameter of the bearings, which was **26mm**, the thickness of the bearings, which was **8mm** (the 6000 metric bearing [17] were used, given that the threaded rod had an outer diameter of 10mm), the diameter of the smooth rods and the position of the holes through which the smooth rods would run in the cabin. These consideration factored in during the design of the pillow blocks, resulting in the 2D drawing shown in figure 3.9. Different materials were compared as shown in table 3.2. Aluminium blocks were readily available in the foundry workshop. Research [6] also showed that the metal has a high mechanical strength and high resistance to corrosion. Given these properties, it was decided that the aluminium blocks would be used for the fabrication of the pillow blocks.

[17] www.microbluebearings.com/bearing-size-charts/

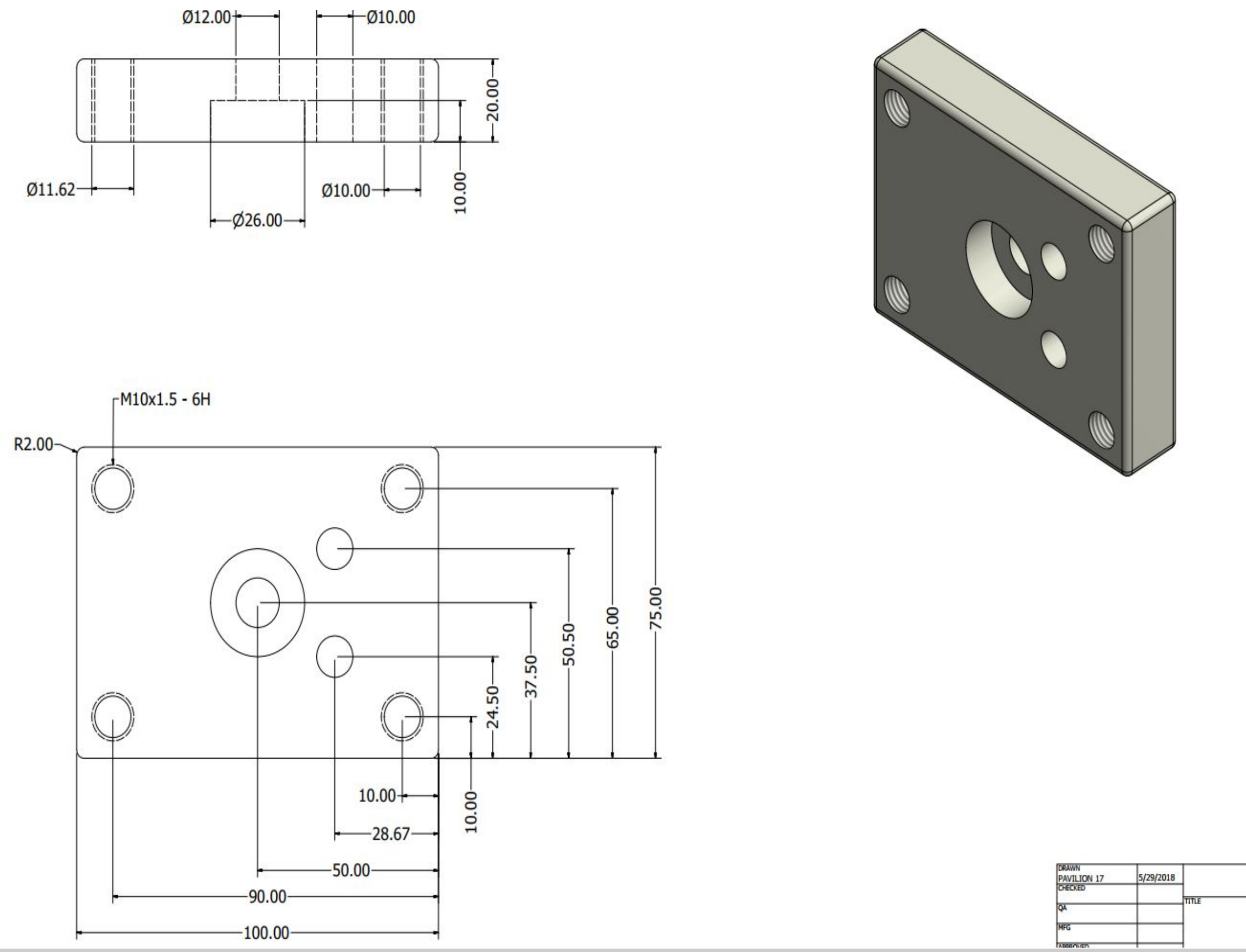


Figure 3.9: 2D drawing of the pillow block

The Lead Screw Support Structure

The following design considerations were factored :

- The length of the support structure was dependent on the length of the trough(L_{tr}), the offset distance between the trough and the silo(L_{off}), which was set as 40mm, the length of the cabin(L_c) and the length of the motor support(L_m), which was set as 100mm.
- Its height was dependent on the height of the trough(h_{tr}) and its distance from the ground(h_d), the clearance space between the trough and the cabin(h_{cs}, which was

set as 70mm), and the cabin's height(h_c. This was the height of the cabin less the height of its funnel).

- Its width was dependent on the length of the pillow blocks.
- The material to be used had to be readily available, cheap and mechanically strong.

For the material, the most readily available and cost effective materials were the square steel tubes as shown in table 3.2. The total length(L_t) was obtained from equation 3.1.

$$L_t = L_{tr} + L_{off} + L_c + L_m \tag{3.1}$$

Replacing L_{tr}, L_{off}, L_c and L_m, with their actual values, L_t was obtained as 990mm. The total height of the structure(h_t) was obtained from equation **??**.

$$h_t = h_{tr} + h_d + h_{cs} + h_c \tag{3.2}$$

Replacing the known variables in equation 3.2 with their actual values, h_t was obtained as 720mm. The width of the support structure was set at 100mm, which was also the value of the pillow block's length. The resulting 2D diagram is shown in figure 3.10.

Silo and hopper system

Design of the hopper system involved considering the amount of feed that was to be stored, the rate at which feed would be dispensed into the cabin and the material to be used. When all these factors were considered and using the procedure provided in reference [7], a silo was designed having the following dimensions: A cylindrical height of **350mm**, An outer diameter of **160mm**, An outlet diameter of **80mm** and A slant angle of **15°**

The 2D drawing of the silo is shown in figure 3.11.

The Silo support structure

A silo support structure was designed based on the following considerations:

- Its height was dependent on the height of the trough(h_{tr}) and its distance from the ground(h_d), the clearance space between the trough and the cabin(h_{cs}), the cabin's

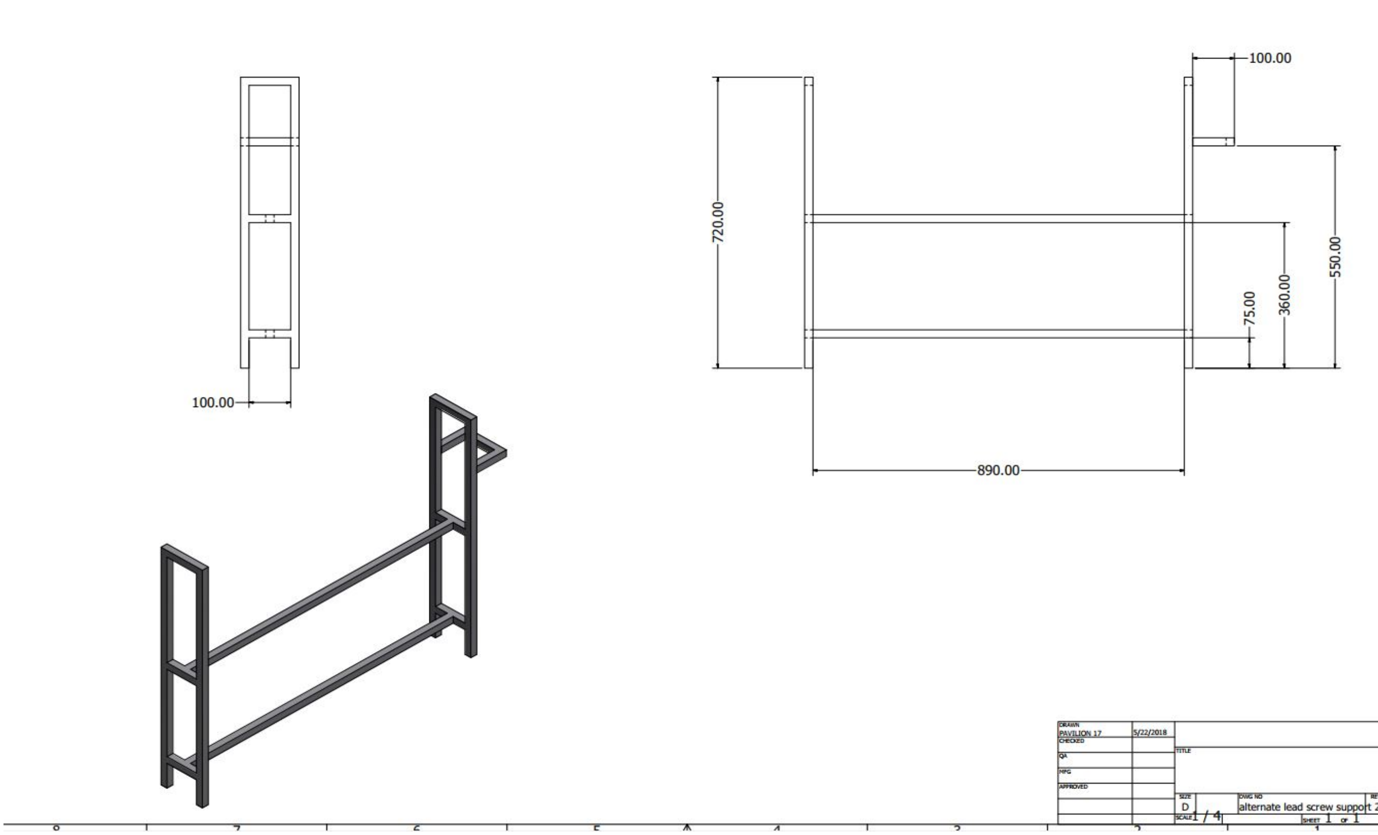


Figure 3.10: Lead screw support structure 2D diagram

height($h_c a$), the clearance between the cabin and the silo's mouth(h_{cds}. This was set as 30mm) and the vertical distance between the silo's mouth and the bottom of the cylindrical part of the silo(h_{smc}).

- The width and length of the structure were dependent on the value of the diameter of the cylindrical part of the silo.

The structure would be made from square steel tubes for the same reasons as those cited for the lead screw support structure 3.1.2. Its height(h_s) was obtained from equation 3.3.

$$h_s = h_{tr} + h_d + h_{cs} + h_{ca} + h_{cds} + h_{smc} \tag{3.3}$$

Replacing the known variables in equation 3.3 with their known values, h_s was obtained as 935mm. The width and length of the structure were set as 200mm, the value of the

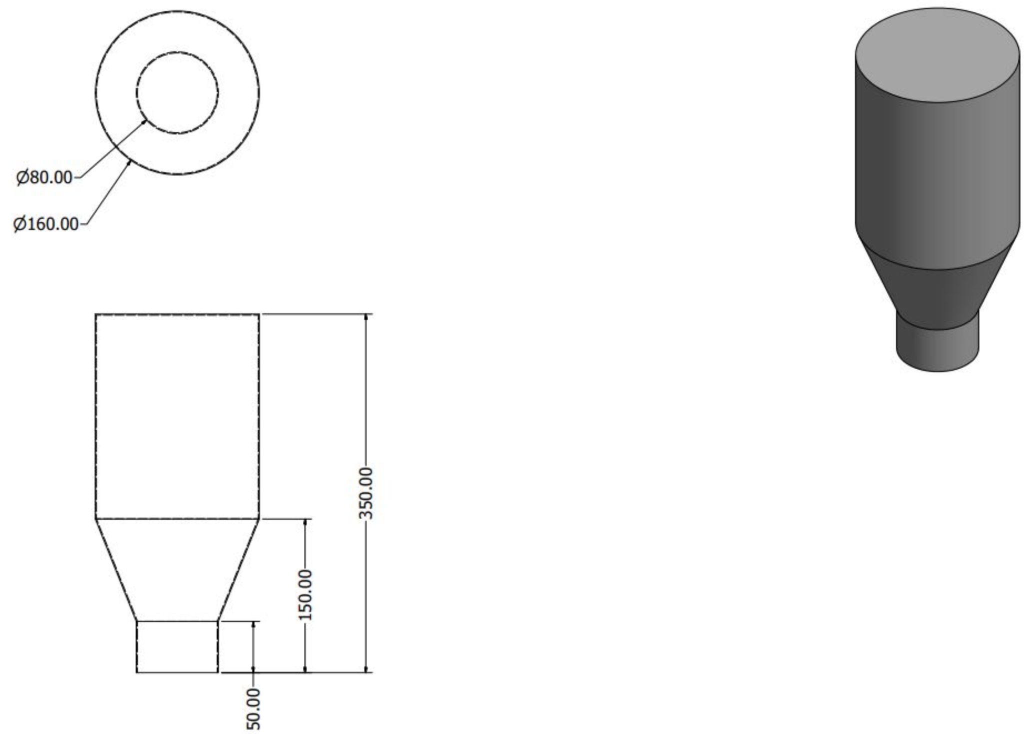


Figure 3.11: Silo 2D drawing

diameter of the cylindrical part of the silo.The resulting design is that shown in figure 3.12.

3.1.3 Watering System

The design considerations for the watering system:

- avoid stagnant water and introducing too much moisture in the coop.
- easily accessible
- hold enough water.
- not rust or corrode.

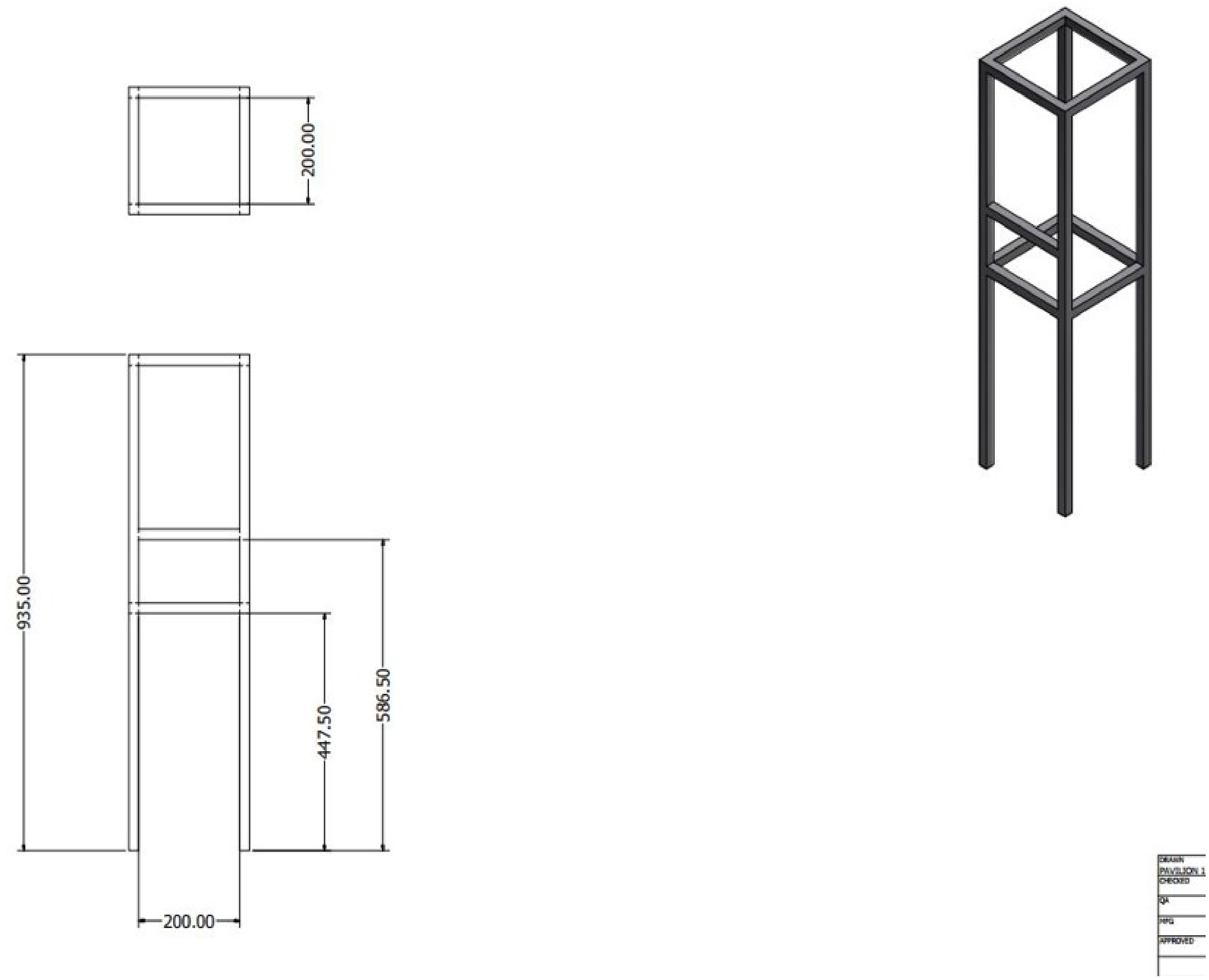


Figure 3.12: 2D drawing of the silo support structure

- Light in weight
- Avoids water spillages

Water consumption rates for chickens

Table 3.7 shows the intake of layer hens at different age(in weeks) /rate of production [18] Since the coop is meant for adult layers, they consume about **0.3 litres** of water on a temperate day. Three chickens would consume 0.9 litres for the same day which is

[18] http://www.poultryhub.org/nutrition/nutrient-requirements/water-consumption-rates-for-chickens/

Table 3.7: Water intake of layers at different stages of Maturity

Production Stage	**Age/Rate of Production**	**Litres of water per 1000 birds at 21^oC in a day**
Layer pullet	4 weeks	100
Layer pullet	12 weeks	160
Layer pullet	18 weeks	200
Laying hens	50 per cent production	220
Laying hens	90 per cent production	270

approximately **1 litre** of water a day. The tank which is the reservoir of the water should be able to hold enough water for at least **10 days**. So it was designed to have a capacity of **10 litres** of water.

Watering mechanisms

Analysis of various watering systems was done to pick the best one as shown in the table 3.8. The water nipple system was preferred since it avoids stagnant water and easy spread

Table 3.8: Various watering systems

	NIPPLE SYSTEM	WATER TROUGH
avoids stagnant water	yes	no
easily accessible	yes	yes
holds enough water	yes	yes
light in weight	yes	yes
avoids spread of diseases	yes	no
avoids water spillages	yes	no

of diseases.

Types of pipes

Then various types of pipes used to transport the water to the chicken in the coop are shown in the table 3.9. The PVC pipe was chosen as the best one to use for the watering

Table 3.9: Various watering systems

	PVC	STEEL PIPES	COPPER PIPES
cheap	yes	no	no
resistant to corrosion	yes	yes	yes
durable	yes	no	yes
light in weight	yes	yes	yes
strong	yes	yes	yes
easily to machine	yes	no	yes

system because it was light and cost effective.

The tank was to be purchased since this was cheaper than machining one ourselves. A tank that can hold about **10l** of water which is enough water for 2 weeks.

The tank needed a support structure to hold the total weight of the tank and water and it had to be elevated higher than the caging structure to enable the water to flow into the pipes by gravity. With these considerations the tank support structure design is shown in figure 3.13 . This design was preferred to be different from the caging structure so as to enable easier mobility of the system. Material used for design was mild steel square tube since it was cheap and easily available as shown in table 3.2

Design of the piping system

The pipe was designed to have 2 holes drilled where the nipples would be inserted so as to provide each hen with their own nipple. In the design, the pipe ran across the length of the coop. The length of the pipe is **810mm**. It was then connected to a joint where another pipe was then connected to the tank. The length of the pipe was set at **270mm** so as to ensure it reached the tank which was outside the coop. The pipe design was a

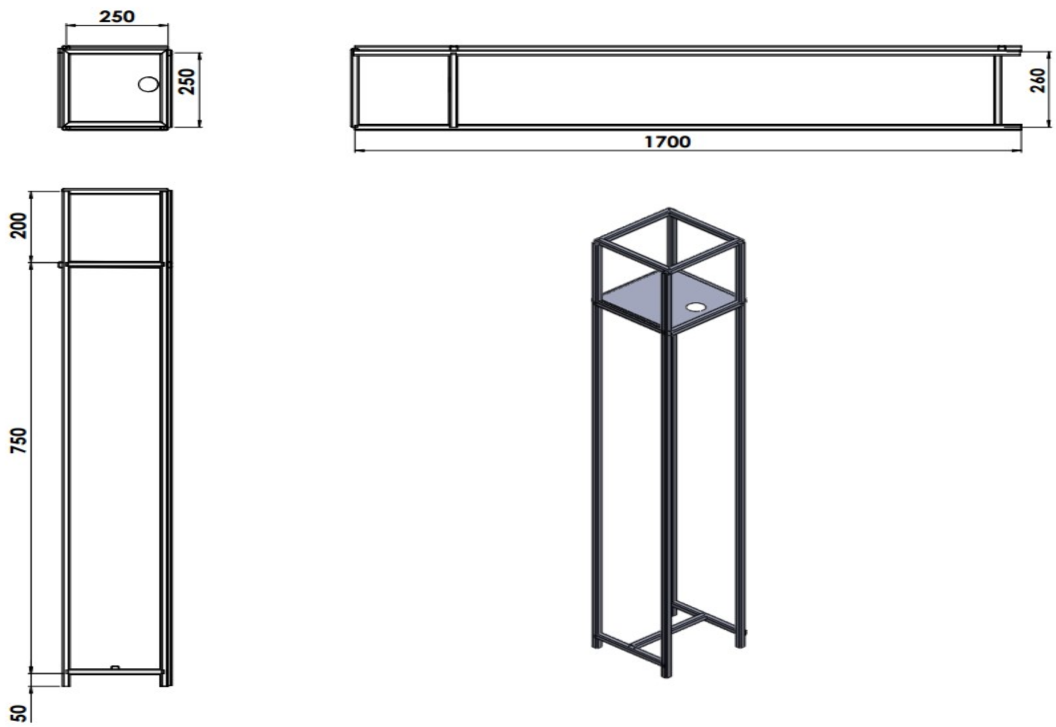


Figure 3.13: Tank support 2D drawing

0.5 inch(19.04 mm) pipe. The design of the piping system is shown in figure 3.14.

3.1.4 Waste Management System

For the waste management system the following was considered while designing:

- The system should be simple but effective.
- The system should be as cost friendly as possible.
- The system should be fully automated.
- The system should strive to be independent from the structure of the chicken coop

Establishing this, various systems were evaluated to come up with the most viable system. Table 3.10 shows the evaluation process undertaken.

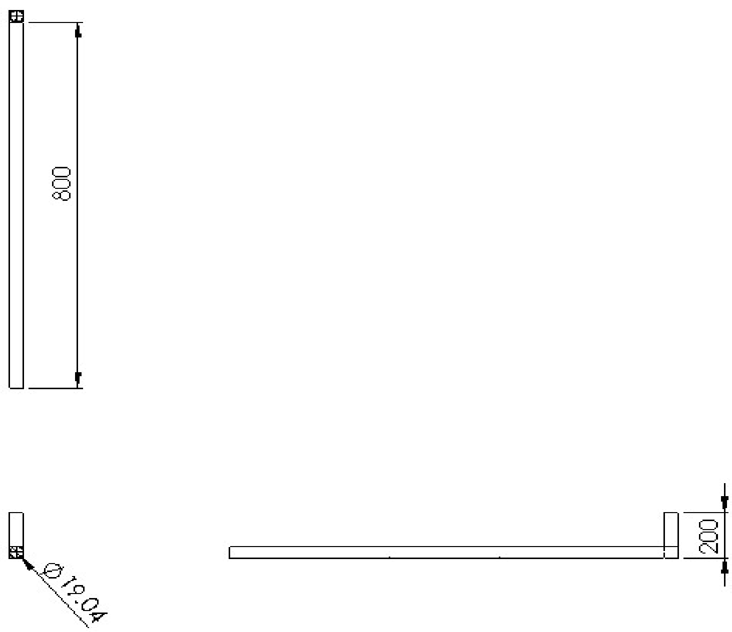


Figure 3.14: Pipe 2D drawing

Table 3.10: Comparison of the different types of cleaning mechanisms

	Removable Platform	**Water Removal**	**Movable Squeegee**	**Scraper Type**
Environmentally friendly	Yes	No	Yes	Yes
Complexity	Low	High	Medium	Medium
Effect on the chicken coop	Low	High	High	Low
Effectiveness	Yes	No	Yes	Yes
Cost	Very Low	High	High	Relatively low
Automation	Not automated	It involves automation	It involves automation	It involves automation

The most representative and economically practical was the scraper type manure removal machine. Upon deciding on the scraper type manure removal system, it was broken down and analysed further so as to be able to actualize it efficiently. The general design considerations were;

- Type of motion-The conveyor needs to move slowly and continuously so as to allow for effective scraping of the droppings
- The dimensions/size of the system- The width should be a little bit smaller than the width of the structure but the length should have some tolerance.
- The weight - The conveying system should be able to handle the total weight of the droppings from the chicken and the revolving platform.
- The system should be cost effective.

Materials

The material to be used to make the conveying platform was further evaluated in table 3.11.

Table 3.11: Comparison of materials used for the waste management system

	Aluminium	**Canvas**	**Polypropene**
Cost	expensive	cheap	cheap
Resistance to corrosion	good	good	good
Fatigue resistant	poor	good	good
Resistant to rust	good	good	good
Rigidity	good	poor	good
Weight	it is the heaviest of the three	it is the lightest	light
Ease of Fusion	difficult	easy	easy

Canvas was found to be the most viable material to use since it is light and easily available.

The waste management was designed with the following components:

Conveyor

The conveyor was 1600mm long and 330mm wide. The width is less than that of the structure so as to be able to fit beneath the cage. It is also a little bit longer to ensure that all the waste will effectively deposited in the manure collector at the end. Figure of the conveyor is shown in figure 3.15.

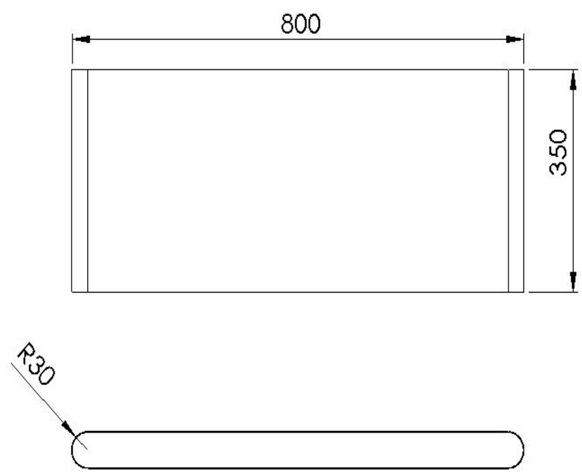


Figure 3.15: Conveyor 2D drawing

Rollers

The rollers was designed using material made of nylon plastic so as to increase the friction between the rollers and the canvas sheet. They are made of nylon plastic since it is lighter and will reduce the load ratings of our system as shown in table 3.4. The drawing of the roller is shown in figure 3.16.

Container

The manure collector was 330mm long , 230mm wide and 200mm high. It was designed using aluminium alloy which is corrosive resistant and will not be affected by the uric acid present in the chicken droppings as shown in table 3.4. The drawing of the container is shown in figure 3.17.

Scrapper

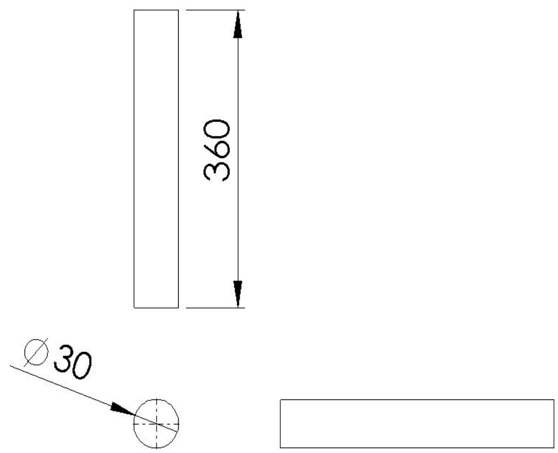


Figure 3.16: Roller 2D drawing

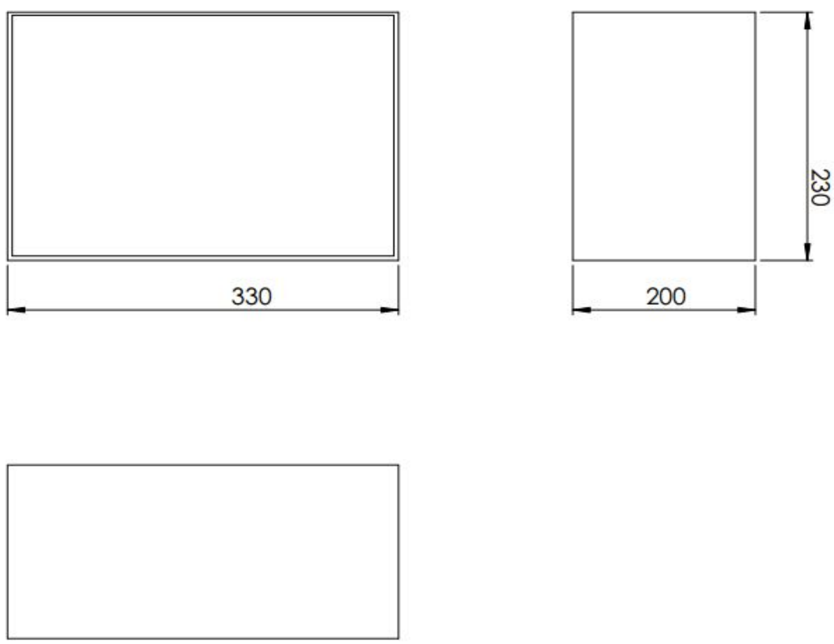


Figure 3.17: Container 2D drawing

The scrappers function was to remove the chicken dropping from the canvas into the container. The chicken droppings are semi-solid in nature and may tend to stick on the canvas, the scraper thus ensures that the droppings fall in to the container keeping the conveyor clean. It was designed using galvanized plain sheet just as trough due to the materials machinability and availability as shown in table 3.4.

3.1.5 Egg Collection System

This system was made up of the nest box and the egg counting system. The design of the nest box has already been discussed in section 3.1.1.

The egg collection tray

As stated earlier(in section 3.1.1), a nest was provided for the hens so that they may lay their eggs peacefully. The floor of this nest box was slanted at an angle of 7° to enable the eggs to roll to the egg tray. When designing the tray, some of the considerations taken into account were:

- The tray was supposed to cover the entire length of the coop.
- The tray should hold the entire egg, without part of it, the egg, lying in the coop.
- The material used should be mechanically strong to hold all the eggs laid by the three hens after a period of time.
- It should have a cushion to prevent breakage of the eggs on impact with its walls.

Based on the following considerations, the egg tray shown in figure 3.18, was designed. Carton was used as a cushion for the eggs. The material used was same to that of the feeding trough, galvanized plain sheet 3.1.2.

The complete design of the egg collection system is shown 3.19.

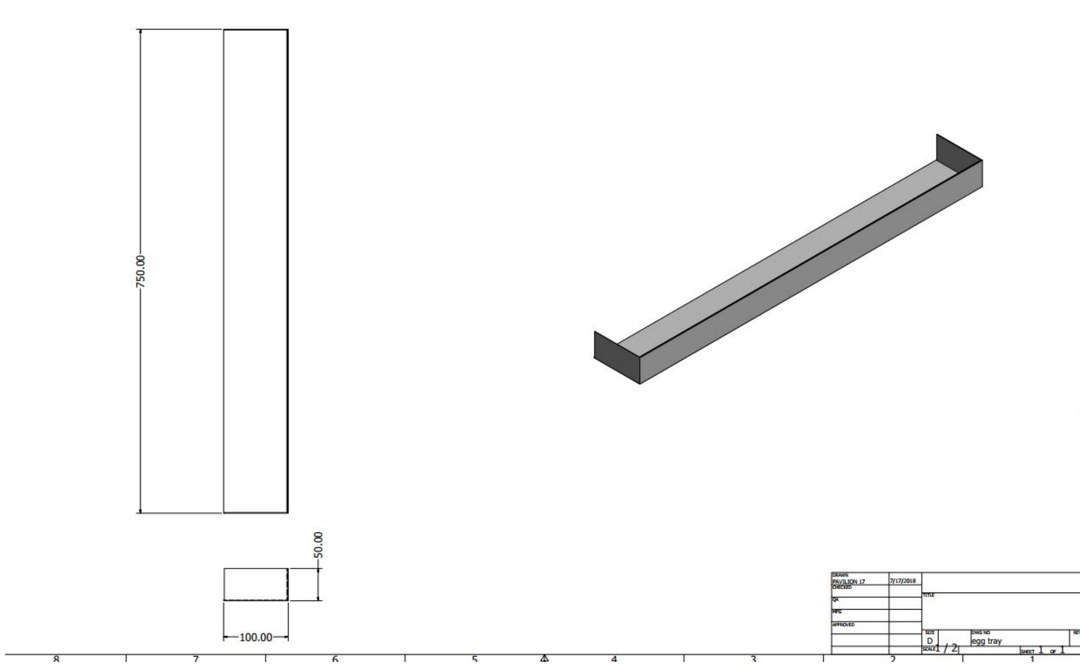


Figure 3.18: 2D diagram of the Egg Tray

PART NO	PART NAME	QUANTITY
A	PERCHING ROD	1
B	EGG COLLECTOR	1

Figure 3.19: Complete egg collection system

3.2 Electrical System

3.2.1 Lighting

Table 3.12: Comparison of different electrical bulbs

	Compact fluorescent	**High Intensity Discharge (HID)**	**Light Emitting Diode (LEDs)**	**Incandescent tungsten filament bulb**
Cost	100 ksh	1200 ksh	150 ksh	100 ksh
Energy consumption	9W	35W	6W	40W
Lifespan	10000 hours	3000 hours	30000 hours	1000 hours
Availability	readily available	readily available	readily available	readily available

Chicken need up to 14 hours of sunlight everyday to increase productivity of eggs [8]. The cage was therefore designed to have an electrical bulb which would provide light for the chicken when it became too dark during the daytime. This project employed a 8V LED bulb as it was readily available, had the best lifespan and had the best energy consumption as shown in table 3.12. For better distribution of light, an LED strip was chosen.

The current drawn by the bulb can be calculated as shown in equation 3.4.

$$I = \frac{P}{V} \tag{3.4}$$

where I represents current, P represents power and V represents voltage. From the specifications [19], the bulb could draw 0.66 A.

A light dependent resistive (LDR) was used to detect the light intensity. Whenever the light falls below the set threshold before the chicken have had ther 14 hours of sunlight, then the LDR detected this and the bulb was turned on to supply the chicken with

[19]https://m.aliexpress.com/item/32742755890.html

light. The LDR was supplied with a potential difference of 5V as per its specifications [20]. Referring to equation 3.4, the maximum current drawn by the LDR was obtained as 2mA.

3.2.2 Motors

Motors were required to provide motion in the feeding system and waste management system.

Feeding System

Given that the pitch of the lead screw (p) was 3 mm with a major diameter (do) of 10 mm, equation 3.5 was used to calculate the smaller diameter (d).

$$d = do - \frac{p}{2} \tag{3.5}$$

Therefore, the smaller diameter was obtained as 8.5 mm.

The force, P, required to overcome lead screw's friction was calculated using equation 3.6.

$$P = W[\frac{\tan\alpha + \tan\phi}{1 - \tan\alpha \times \tan\phi}] \tag{3.6}$$

Where W was the weight of the load acting on the lead screw amounting to 30N. Furthermore, equation 3.7

$$\tan\alpha = \frac{p}{\pi \times d} \tag{3.7}$$

and equation 3.8

$$\tan\phi = \frac{\mu}{\cos\beta} \tag{3.8}$$

where μ was the coefficient of friction of the lead screw taken as 0.25, α was the lead/helix angle, β was the semi angle of the acme thread which was 14.5° and ϕ was the virtual friction angle. Tan α was obtained as 0.1123 using equation 3.7 and tan ϕ was obtained as 0.2583 using equation 3.8 . Therefore, the force required was obtained as 11.45 N. The

[20] www.ktechnics.com

torque required to overcome the force on the lead screw was calculated using equation 3.9.

$$T = P \times \frac{d}{2} \tag{3.9}$$

Having obtained the internal diameter (d) as 8.5 mm and the force (P) as 11.45 N, torque (T) was obtained as 48.66 N-mm.

This value was multiplied by a factor of safety of 2 to get **97.325N-mm**.
Taking D_t, length of trough, which was 750mm and T_t, the expected time for cabin to travel across D_t, which was 6.25s. V_{cabin} was obtained as 0.12m/s using equation 3.10.

$$V_{cabin} = \frac{D_t}{T_t} \tag{3.10}$$

Equation 3.11 was used to obtain the lead screw rotational speed (θ) which was 251.42 rpm.

$$V_{cabin} = \frac{d}{2} \times tan\alpha \times \theta \tag{3.11}$$

Various motors were compared as shown in table 3.13. The NEMA 17 unipolar stepper motor, which provided a torque of 0.48Nm [21]. The stepper motor was selected since it provided the necessary torque and was cheap and easily available.

Table 3.13: Comparison of motors

	STEPPER MOTOR	SERVO MOTOR	DC MOTOR
motion	slow	rapid rotational	fast
torque	0.63N-m	0.094N-m	0.39 N-m
current rating	2A	1.2 A	2.1A
voltage rating	12v	8v	12v
Cost	cheap	cheap	cheap
Availability	readily available	readily available	readily available

[21] http://www.pbclinear.com/Pages/Data-Sheets

Design for the silo off-loading system.

The silo stored the feed for the chicken which was to be transferred into the travelling cabin that would then dispose the feed into the feeding trough. Various motors were analysed in table 3.13. The type of actuator selected for the silo's opening system was the MG996 Metal Gear High Torque Servo Motor due to its controllability, high speed and cost effectiveness.

Waste Management System

The DC geared motor was found as a suitable actuator for the waste management system as it provides a wide range of torque requirements, easy to control and affordable as shown in table 3.13.

The motor will be coupled to a roller to provide the torque and speed needed to move the conveyor. The motor motion required is be unidirectional because the scraper is mounted to scrape off the droppings in to a container located at a specific end of the conveyor.

DC motors were considered since speed variation can be achieved by varying the voltage supplied to the motors. This will ensure that the speed can be controlled to avoid a high speed which will haul the droppings off the conveyor. In order to determine the motor ratings, the following parameters were used:

1. Total Mass Maximum possible mass of chicken droppings on the conveyor at single instance. It also includes the maximum possible mass of chicken droppings on the conveyor at single instance which is 40 grams, two Nylon rollers at 0.935kg and conveyor belt at 200grams. The total Mass is 1.175kg.

2. Desired maximum speed of the conveyor To determine the speed required for the conveyor, the following equation was used

$$v = \frac{d}{t} \tag{3.12}$$

   Where v is speed, d is distance and t=time. Length of the conveyor was 0.75m. Time required for one revolution was 5s. Using equation 3.12 the speed was found to be 0.15 m/s.

3. Desired acceleration of the conveyor:

   To determine the acceleration required for the conveyor, the following equation was used

$$v = u + at \tag{3.13}$$

   Taking the initial velocity, u was 0, an acceleration of 0.15 m/s^2 was required over a period t of 1s, then the final velocity v of 0.15 m/s would be achieved.

4. Roller diameter: 0.03m (radius - 0.015 m)

5. Angle of Inclination of the conveyor: 0 degrees

6. The rolling friction and air drag are negligible The motor speed ratings can be determined by the following:

$$n_w = v\frac{w}{c} \tag{3.14}$$

$$n_w = \frac{v_{max}}{2\pi R_w} \tag{3.15}$$

   Where n_w is revolution of the wheel, v is Velocity, w_c is wheel circumference and R_w- wheel radius.

   The no-load speed rating of the motor should therefore be greater than 95.5 rpm; got from equation 3.15, in order to compensate for loss of speed due to the weight of the conveyor and any friction incurred.

$$mg_x = m \times g \times sin(\theta) \tag{3.16}$$

$$\sum F_x = 0 \tag{3.17}$$

$$Therefore : M_a = f - (m \times g \times sin(\theta)) \tag{3.18}$$

$$f = M(a + g \times sin\theta) \tag{3.19}$$

$$T = f \times R \tag{3.20}$$

$$T = MR(a + g \times sin\theta) \tag{3.21}$$

$$T = \frac{MR(a + g \times sin\theta)}{N} \tag{3.22}$$

where M is Total mass of the conveyor contents, a is acceleration of the conveyor, N of Number of motors to be used on the conveyor, M_{gy} is balanced by the normal force the surface exerts on the wheel. The torque using equation 3.22 was found to be 0.0264375Nm.

Taking the required efficiency of the motor used to be 80 percent, the total torque required to be supplied to each motor is calculated as follows:

$$T_t = T \times 100/80 \tag{3.23}$$

The new torque was found to be 0.033044(Nm), using equation 3.23. From the above analysis, a geared motor with the following minimum specifications was used: Torque is 0.033Nm and Speed is 95.492rpm

3.2.3 Motor Drives

A motor drive was needed to control the direction and speed of the stepper motor the dc motor. A comparison of various motor drives was done as shown below in table 3.14, to determine the most appropriate motor drive for the motors. Given that the rated current of the stepper motor was 2A and the dc motor was 2.1A, the drive chosen was the l298 motor drive since it could handle these currents. It was also cost effective and readily available. The stepper motor did not need a motor since its control was simpler. A diagram of the l298 motor drive is shown in figure 3.20.

Table 3.14: Comparison of motor drives

	L298N	**TIB6612FNG**	**LV8406T**
operating voltage	4.5V-46V	4.5V-15V	-05.5V-15V
peak current	3A	3.2A	2.5A
single channel current	2A	1.2 A	1.4A
Cost	cheap	cheap	relatively expensive
Availability	readily available	readily available	not easily available

Figure 3.20: L298 Motor Drive

3.2.4 Remote Access Control

A GSM module was used to send the values of:

- The level of feed in the silo. The value informed the farmer when they needed to refill the silo.
- The number of eggs laid by the hens. This helped the farmer monitor the well being of the hens with respect to the number of eggs the lay.

SIM 800 and SIM 900 are the two GSM modules considered in this project The two types were compared so as to determine the most viable in table 3.15.

Table 3.15: Comparison of the SIM800 and SIM900 Modules

SIM800	SIM900
Cheaper.	More expensive than SIM800.
Provide Bluetooth services	Does not provide Bluetooth services
Its operating voltage ranges between 3.4-4.4V.	Its operating voltage is between 3.2-4.8V
It is harder to integrate to the arduino.	It is easier to integrate to the arduino.

The SIM900 module was used for our system since it was easily integrated into the arduino.

3.2.5 Sensors

The Timer System

A timer was used to control the times of the day when the hens were to be fed. There were two ways which could have been employed to achieve this timing operation. The first method involved using the internal clock of the arduino board as a timer. The second method involved using an external timer. The former method was found to be cheaper as it did not require an external clock. It was however inefficient as the time as indicated by the arduino would require reprogramming every time the arduino was turned on. The latter method required an external clock. It is worth noting that these clocks are relatively cheap. The use of an external clock also allowed for a one time programming of the time as the clock had a battery that allowed it to function even when the arduino system was off. This project therefore implemented the second method for its timing operations. The type of external clock selected for use in this project was the DS3231 as it had the following advantages [22]:

[22] https://datasheets.maximintegrated.com>5

- It was highly accurate and completely manages all timekeeping functions.
- It had a simple serial interface that connected to the micro-controller.
- It had a battery-backup input for continuous timekeeping.
- It had a low power operation extending the battery-backup run time.

Figure 3.21 shows an image of the DS3231 timer used for the timing operations of the feeding sub system.

Figure 3.21: A DS3231 Timer

Level sensing

Level sensing was required for the silo and watering system to monitor the amount of feed or water in respective areas. It would obtain information about the amount of feed in the silo and water in tank and relay the information back to the micro controller. The minimum amount of feed that should be in the silo depends on the preferences of the farmer. Several sensors were compared in table 3.16. The Infrared IR Proximity Sensor-Sharp GP2Y0A21YK 100mm to 800mm shown in figure 3.22 was selected for both feed and water level sensing because it is cheap, easily available and effective range is suitable. [23]. The parameters of this sensor are discussed below [24]:

[23]https://ktechnics.com

[24]https://sparkfun.com>Components

Table 3.16: Comparison of the different types of sensors

	Pyoelectric Infrared sensor	**Passive Infrared sensor**	**Reflectance sensor**	**Proximity sharp Infrared Sensor**
Accuracy	Low	Low	High	High
Complexity	High	High	Low	Low
Range	Small	Small	Relatively large	Large
Effectiveness	Low	Low	High	High
Cost	High	High	Low	Relatively Low

- Operating Voltage: 4.5V to 5.5V-DC
- Operating Current: 30 mA
- Range :100-800 mm

A diagram of the IR sensor is shown in figure 3.22.

Figure 3.22: An Infrared IR Proximity Sensor-Sharp GP2Y0A41SK0F

Egg Counting system

The egg collection system should be able to count the eggs from the nesting box and the cage automatically and relay the information to the microprocessor which in turn

transmits the value to the farmer's phone. A counter was required for the counting of the eggs. To find the most viable counter for the project design, the evaluation as shown in table 3.16 was done.
The Infrared IR Proximity Sensor-Sharp GP2Y0A21YK sensor chosen above was also found suitable for egg counting.

3.2.6 Power Supply

Most of the outlets available provide 240V 50Hz AC signal. The systems in this project were designed to run on direct current (DC). This therefore led to the need to come up with a power supply system that would ensure that the components of this project received the required power ratings. The first step was to determine the power requirements of the components. The voltage and current requirements are listed below.

1. **Voltage**

   (a) The lead screw and waste management motors required a 12V input,

   (b) The micro controller required a 9V input.

   (c) The GSM module required 3.8V.

   (d) All of the sensors required a 5 V input.

2. **Current**

   For this analysis, the components were analysed in categories based on their voltage requirements. Listed below is each component in their voltage category and their corresponding current requirements.

   (a) <u>12V-DC components</u>

   - LED bulb = 0.66A.
   - Feeding system's motor = 0.7A.
   - Waste management system's motor = 1.1A

The total current required for the 12 V-DC components was therefore obtained as **2.46A**.

(b) 5V-DC components

- L.D.R = 0.002A.
- Feeding system level sensor = 0.03A.
- Feeding system's servo motor = 1.2A.
- Watering system's level sensor = 0.03A.
- L298 Motor drive = 0.036A.
- Egg counting sensor = 0.1A.

The total current required for the 5 V-DC components was therefore obtained as **1.398A**.

(c) 3.8V-DC components

- GSM module = 2A.

Having defined the needed requirements, the power supply system was developed. Power is to be tapped from the grid. The voltage ratings of the grid power were too high and therefore had to be stepped down to 15-17V. The voltage was still alternating. It therefore needed to be rectified. The full wave bridge was used to achieve this rectification. The output voltage still had some ripples and therefore a capacitor was used to stabilize the voltage signal. The capacitance needed to be of high capacitance for effective reduction in the ripples. A buck converter then used to further reduce the voltage level to the required levels of 12V, 9V and 5V respectively. As stated above, the amount of current required for the 12V components is to be 2.46A and that required for the 5V components is to be 1.398A. The buck converter supplied a peak current of 3.2A which is more than sufficient for the various components mentioned above for the project.

3.3 Control System

It comprised of a micro controller which oversaw the entire operations of the chicken coops. The control of each of the subsystems is explained below.

1. Feeding System

   Here, the micro controller monitored the level of feed in the silo through a sensor. In the case that the amount of feed is below the set threshold value, the micro controller sent a message to the farmer informing him/her that they need to refill the tank. It also controlled the actuation of the motor driven lead screw. Based on times defined in its program, the micro controller determined when feed is availed to the hens.

2. Watering System.

   The micro controller monitored the amount of water in the tank and notified the farmer to refill tank when it fell below the minimum level.

3. Waste management System. Using a timer, the micro controller controlled the time when the motor driven conveyor system would be actuated, based on times defined in its code.

4. Egg collection system.

   The micro controller monitored the number of eggs laid by the hens through a counter. It then relayed this information back to the farmer.

5. Lighting system

   The micro controller controlled the amount of light in the cage by monitoring it through a Light Dependent Resistor. If the light levels a low, it turned led bulbs to light up the cage.

To determine the micro controller to use, several were compared as shown in table 3.17. The micro controller chosen was the ATmega 2560 mounted on an Arduino board, shown

Table 3.17: Comparison of micro controllers

	PIC18F4550	**Atmega2560**	**Atmega328P**
operating voltage	5V	5V	5V
input voltage	7-12V	7-12V	7-12V
digital input pins	14	54	14
analog input pins	6	16	6
PWM output pins	2	14	6

in figure 3.23. This was because it provides a platform that makes it easy to write code and develop programs, readily available, cost efficient and provides more pins for connections.

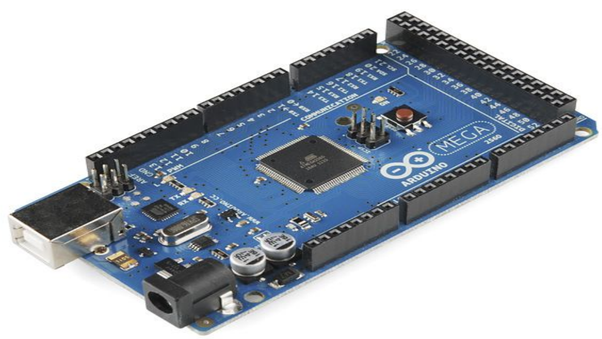


Figure 3.23: Arduino Mega

Design of the control box

A control box was needed to house the arduino mega, GSM and the PCB. The material used in the design was aluminium alloy because it light, had good machinability and was readily available in the school workshop as shown in table 3.4. The dimensions of the control box had to be large enough to accommodate the arduino mega, GSM and the PCB. The lid of the control box was made clear so the electrical components could be seen clearly and also to enhance its aesthetic value. Perspex was used since it is clear, light, cost effective and could be engraved easily.

The flowchart for the control system is shown in appendix B.

3.4 Fabrication

The production plan the was followed in the fabrication of the system is found in the link [25].

3.4.1 Fabrication of the Mechanical module

Figure 3.24 shows the sequence of operations that was followed in the fabrication of the feeding system.

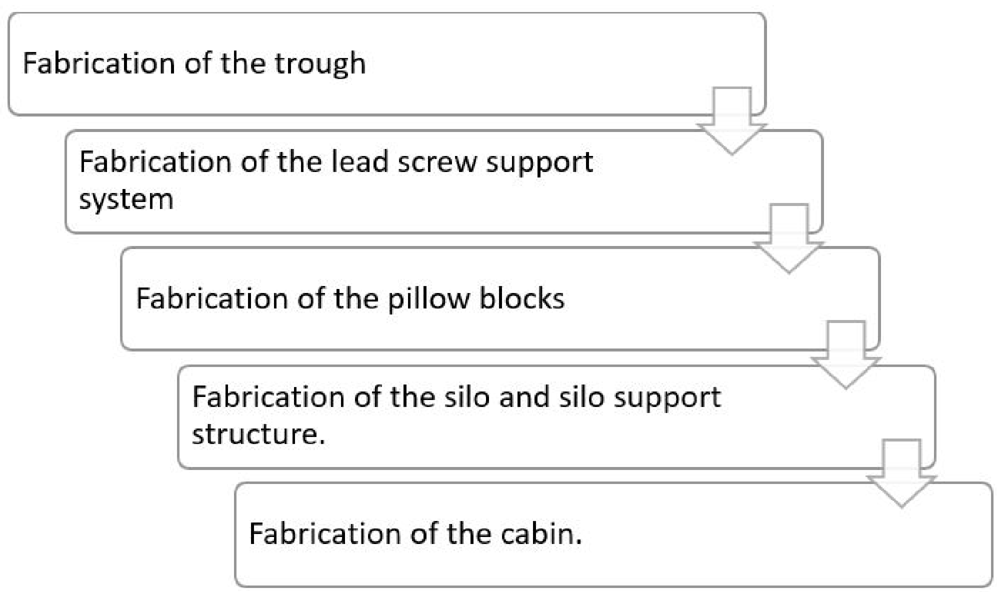


Figure 3.24: Production Plan of the Feeding System

Galvanized plain steel was cut up to the required size and then bent to shape using the bending machine to make the trough. Sides were riveted together to form final shape.

[25] https://drive.google.com/open?id=1c2gau2Z_f5o_CuJ−A_AlmuFgMfbMojko

5.5m of square steel tube was to make the lead screw support. It was cut into the required lengths and was welded together as per the design using the arc welding machine. The threaded rod and the smooth rods were purchased. Aluminium blocks using to make the pillow blocks were cut to desired dimensions using a milling machine. The hole of 26mm diameter that was to house the bearing was drilled. The two holes through which the smooth rods were to go through were then drilled using a 10mm drill bit. The bearings were purchased. Mild steel sheet was used to make the silo was cut to required dimensions. The pieces were rolled into the shape of the cylinders using the rolling machine. The parts were then welded together using the arc welding machine. 5.6m of square steel tube was used to make the silo support structure. It was cut into required dimensions and the welded together. The cabin was 3D printed. The trough was mounted into the coop frame. The bearings were fitted into the pillow blocks. The two pillow blocks were then mounted to the lead screw support structure using M6 bolts and nuts. 2 M10 nuts from the lead screw were fixed into the space allocated for them in the cabin. The cabin was then fitted to the threaded rod and the smooth rods. The threaded rod was then fitted into the bearings on both ends. The smooth rods were also fitted into the pillow blocks on both ends through the holes allocated for them in the pillow blocks. The silo was welded onto its support structure.

For the watering system, pipes used was 19.04mm (0.5 inch) PVC. It was cut into the required dimensions. Holes of 4mm diameter were drilled into the pipe and water nipples were then force-fit into those holes. Pipe welding machine was used to join the pipes at right angles. Material used to make the tank support structure was square tubes of 0.5 mm thickness. It was cut up into the required dimensions and then welded together to form the structure. The 10l tank used was purchased. Using the 30mm-32mm pipe welding machine it was bored to allow for the threaded end of the connector to pass through. The pipe was then mounted into the tank. The tank and pipe was then supported on the tank support structure.

Material used to make the coop structure was square tube of 0.5 mm thickness. The tube was cut into the dimensions and welded together to form the structure. The mesh was cut up into the required sizes and then welded onto the coop structure. A hinge was bolted in 4mm holes on the anterior side of the welded mesh and a Perspex board of 200 by 250 mm was also bolted onto the other side of the hinge. This was the door for the coop. The nesting box was built using mild steel. The mild steel was cut up into the required dimensions and bent using the form press to form the desired shape. The nesting box was then welded onto the coop structure. The material used to make the perching rod was cypress of 40 mm diameter. Two rectangular mild steel plates of 50 mm $\times$ 375 mm were welded at the centre of the coop on opposite sides. The rod was then nailed across the length of the coop at the middle of the steel support plate.

In the waste management system, the rollers were made of nylon plastic. The nylon plastic was first faced and turned using a lathe machine to achieve the desired length and width. A 25.5 mm drill bit was used to drill the slot where the bearing for the driven roller would be placed. The rollers were knurled to obtain the roughness required to grip the conveyor belt. The bearings were force-fitted. The rollers were held in place by stands which are attached to the frame of the chicken coop. The stands were square mild steel sheets of 100mm which had been drilled by the 10mm drill bit at the centre to allow for the shaft in the case of the driver pulley and to allow for the M10 bolts in the case of the driven to pass. Galvanized steel was used to make the scrapper. It was cut to required dimensions. The strips were then folded at the ends to enable them to be attached on the roller support system. They were then drilled with the 3.2 drill bit to enable fastening. The rubber was purchased and cut into a strip 330mm long and 25mm wide. The strip was then attached onto the galvanized steel using acrylic adhesive so as to act as the point of between the canvas and the scraper. The conveyor belt was made of canvas material. It was cut into the required dimensions and sawn together. A sheet of mild steel, used to make the waste container, was cut into the required dimensions and folded using the bending machine. The sides were fastened on using 4mm rivets by use of the rivet gun.

For the egg collection system, the net shape of the tray was drawn on the plain steel, cut into the required dimensions using a bench shear machine. The cut profile was then bent into shape using the bending machine and its sides were spot welded to form the desired shape. Two M6 bolts and nuts were used to mount the tray to the coop on two pieces of square steel tubes with a length of 100mm which were arc welded on each end of the coop along its length.

3.4.2 Fabrication of electrical system

The PCB was fabricated on a 1500mm by 1500mm copper board. The circuit was printed on a glossy paper as per the design shown in figure 4.11. The circuit was then transferred to the board by applying heat and pressure. The board was then inserted in etchant to produce the desired circuit lines. Holes of 0.5 mm were drilled on the board and components mentioned in the design were soldered onto the board.

3.4.3 Fabrication of control box

Galvanized aluminium alloy was used. The metal was cut up into the required dimensions and then bent at the corners using the bending machine. The corners were joined together using rivets. Two 10mm holes were drilled on the sides for wires from various electrical devices controlled by the micro-controller to be able to enter the control box. Engraving of the perspex was done using a laser cutter. Three 6mm holes were also drilled on its bottom surface where it was bolted onto the caging structure using M6 bolts and nuts.

4 Results and Discussion

The design solution was expected to perform the following functions:

- Automate the feeding, watering and lighting systems.
- Enable remote access of the coop.
- Count the eggs laid and collect them in one area.
- Ensure the coop remain in clean hygienic conditions.

4.1 Mechanical module

The mechanical structure with all the various subsystems is shown in figure 4.1

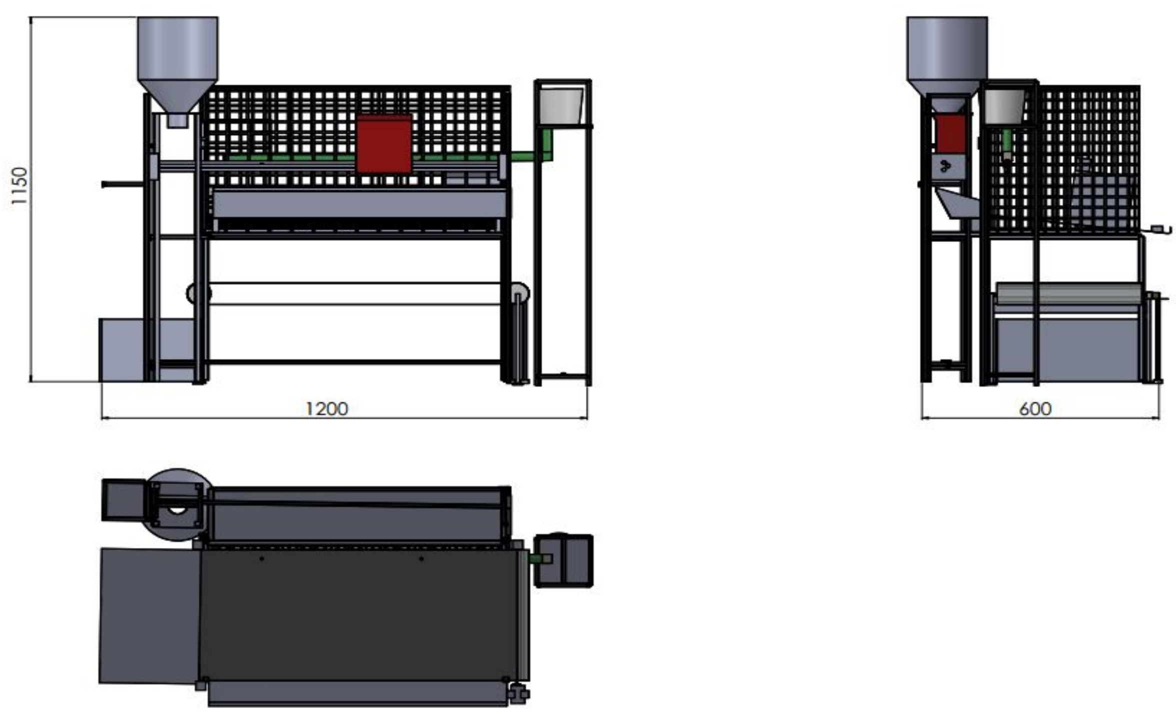


Figure 4.1: Automated chicken coop 2D drawing

4.1.1 Caging structure

The final design of the caging structure is shown in figure 4.2. The fabricated coop struc-

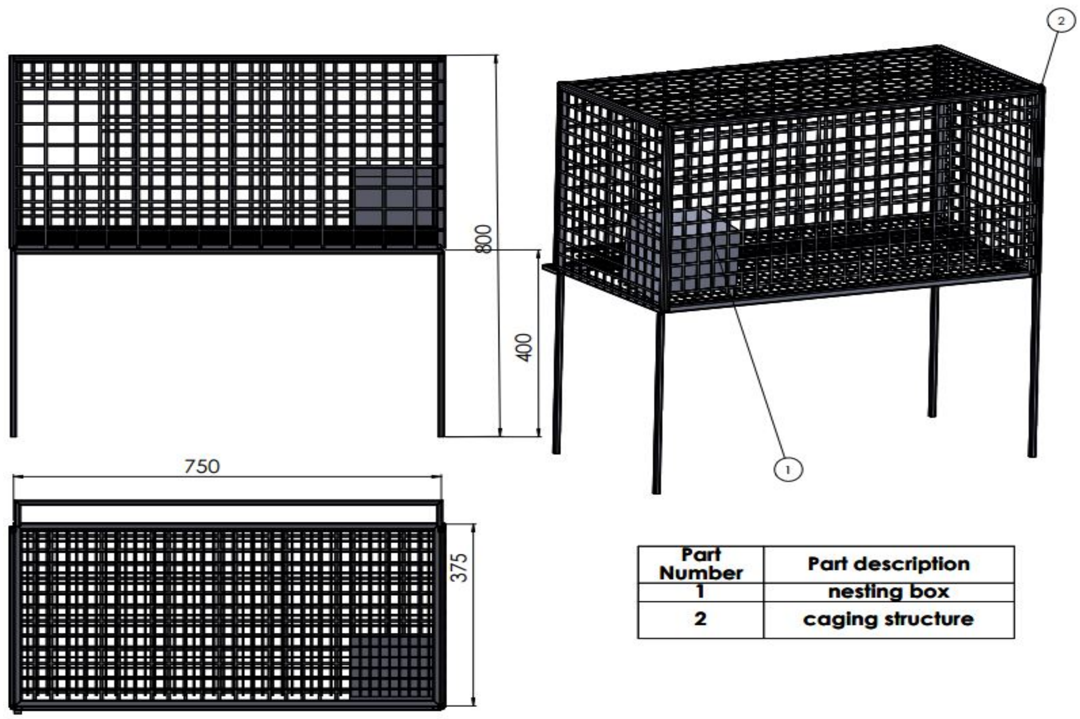


Figure 4.2: Final design of the caging structure

ture is shown in figure 4.3.

The caging structure was stable and within the dimensions of the design.

4.1.2 Feeding system

The final design of the feeding system is shown in figure 4.4.

The fabricated and assembled feeding system is shown in figure 4.5.

The silo was not able to dispense the feed as smoothly as expected. Upon investigation it was discovered that the feed used had absorbed moisture and was thus sticking to the

Figure 4.3: Fabricated coop structure

walls of the silo. This was remedied by agitating the trap door by using vibration motors. This stickiness of the feed also slowed the rate of flow of feed from the cabin to the trough. The slip of the cabin had to be expanded to allow for more feed to fall out.

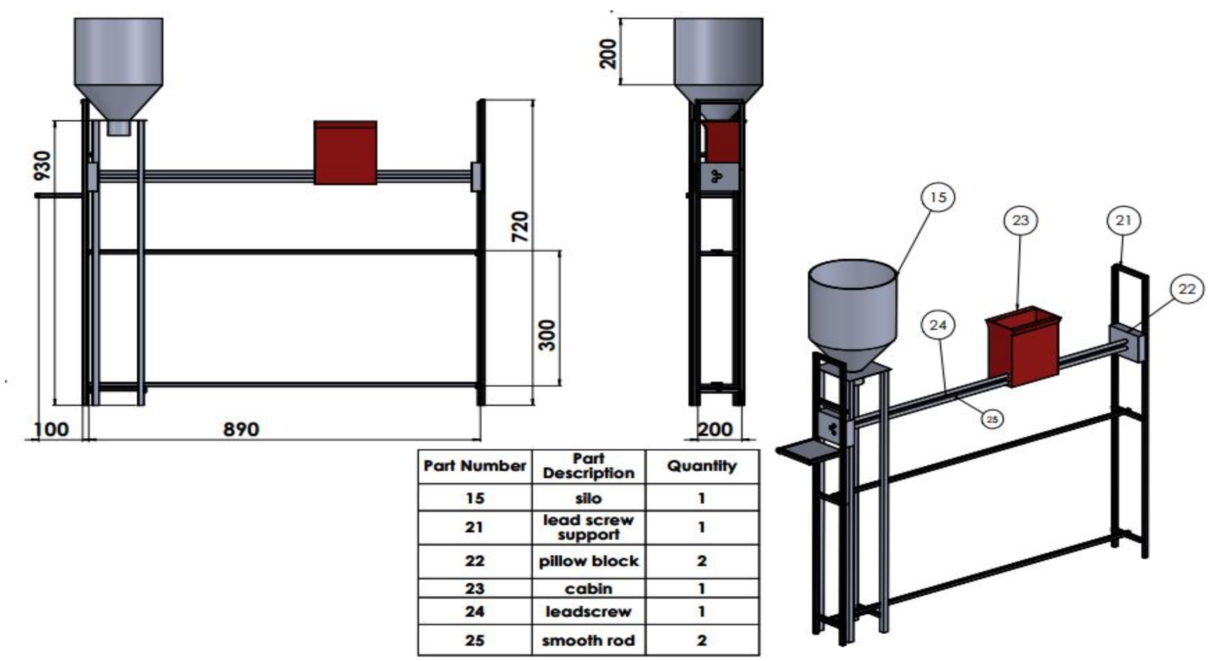
4.1.3 Watering system

The final design of the watering system is shown in figure 4.6. The complete watering system fabrication and assembly is shown in figure 4.7.

The watering system worked as expected, though a few leakages were experienced but sealant was added to stop them.

4.1.4 Waste management system

The final design of the waste management system is shown in figure 4.8.



Part Number	Part Description	Quantity
15	silo	1
21	lead screw support	1
22	pillow block	2
23	cabin	1
24	leadscrew	1
25	smooth rod	2

Figure 4.4: Final design of the feeding system

The fabricated waste management system and its assembly is shown in 4.9.

One of the shafts of the driving roller broke after fabrication. After reattaching it with some glue, it was too weak so the tension in the conveyor had to be loosened to prevent it from breaking again. This led to the conveyor sagging.

4.1.5 Egg collection system

The design for the egg collection system is shown in figure. The fabricated egg collection tray is shown in figure 4.10.

The egg collection tray was fabricated to the correct dimensions. Padding had to be added to prevent the egg from breaking when it rolls into the tray.

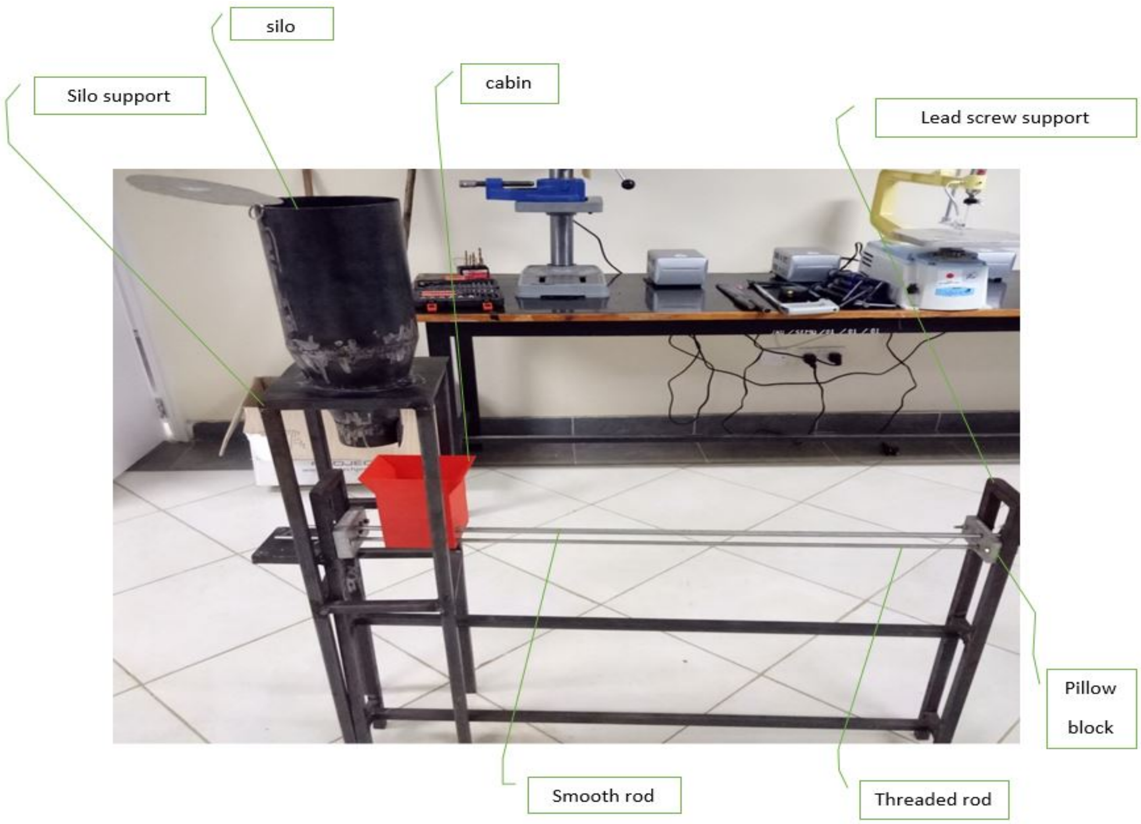
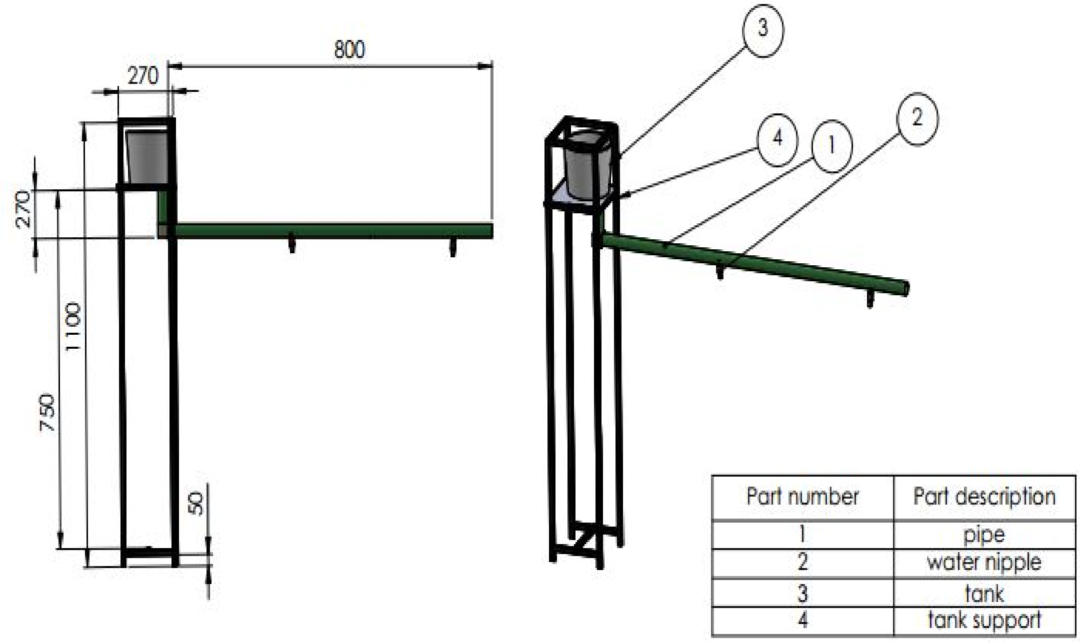


Figure 4.5: Assembled feeding system

4.2 Electrical module

Appendix C shows the power supply circuit used to power all the electrical and control components of the model.
A printed circuit board (PCB) mechanically supports and electrically connects electronic or electrical components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and or between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it. using header pins. Input/output devices were connected to the PCB board via terminal blocks. This ensured that the wires were secured safely on the board to avoid any loose connections. The terminal blocks were for the 5V, 12V and ground supply. The other terminal blocks are for connecting



Part number	Part description
1	pipe
2	water nipple
3	tank
4	tank support

Figure 4.6: Final design of the watering system

the motor drivers, motors, IR sensors, buck converter, real time clock and LED strip to the controller . Factoring all the above components in the circuit and the various power lines from the power conversion circuit resulted in the design shown in figure 4.11.

For the feeding system, A high speed-high torque motor had been designed to move the cabin along the length of the lead screw. However, such a motor was not available in school and in the local market. Eventually, a low speed-high torque motor that was available in school was used. The motor had a speed of 75 rpm against the designed 251 rpm but had the required torque. The dc motor used was thus too slow to drive the cabin at the required speed. The stickiness off the feed also made it unable to pour out of the the cabin and silo smoothly. To agitate it, vibration motors were mounted to loosen up the feed particles and this enabled the feed to flow more smoothly.
In order to achieve negative feedback of the motion of the cabin, limit switches were introduced to detect when the cabin has travelled to the correct position. The need to include the limit switches was due to the inconsistencies in the open loop control system

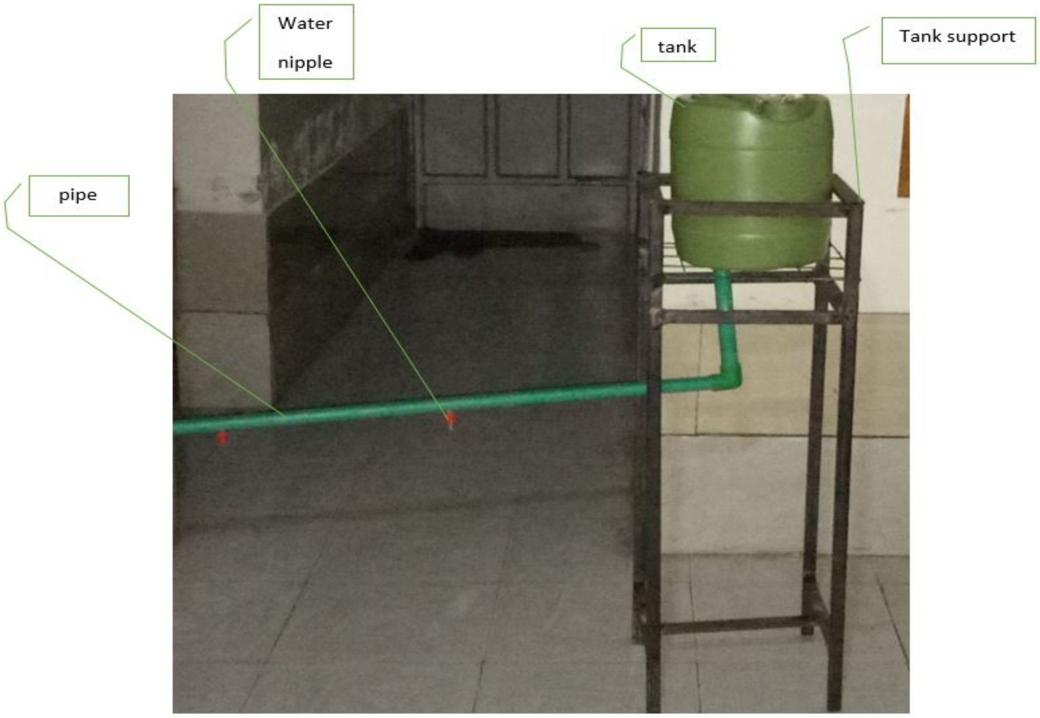


Figure 4.7: Watering system assembly

which did not move the cabin to the correct position accurately. The two limit switches were mounted on the two pillow blocks.

The servo motor meant to control the feed was able to open and close the trap door effectively as designed. However there were some alignment issues which made the trap door not be completely flash with the mouth of the silo. This made it unable to effectively block the feed from spilling out. To remedy this, rubber was added to fill the gap between the trap door and the mouth of the silo.

All the IR sensors used to measure the feed and water level were able to work as expected. In case the level feed or water was below the lower limit, the sensors sent a signal to the micro-controller which then sent a signal to the GSM module. The GSM then sent a message to inform the user that the feed or water level was low and needed to be refilled. The IR sensor for counting the eggs collected also achieved its function of counting eggs. However, the egg collection sensor was too sensitive and thus generated errors when tested.

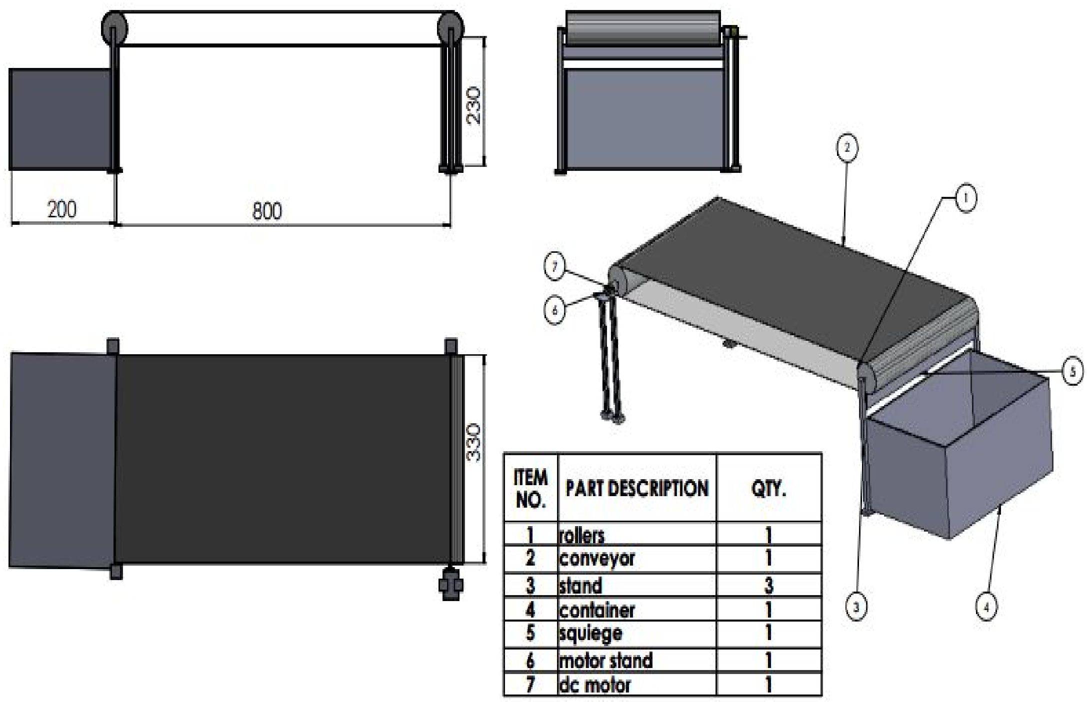


Figure 4.8: Final design of the waste management system

It produced false positive readings. In order to solve this, the walls of the collection tray were folded inwards to reduced the distance and also removed any barriers on its path so as to eliminate the errors.

The waste management system motor worked as expected. The motor used was powerful enough to drive the conveyor and the scrapper removed the waste as designed and at the expected speed.

The LED strip was able to light up whenever the LDR detected a light level below the set threshold as expected.

The PCB worked as desired. Some of the conduits were incomplete upon etching but this was fixed by adding solder material to finish the circuit. The fabricated PCB is shown in figure 4.12.

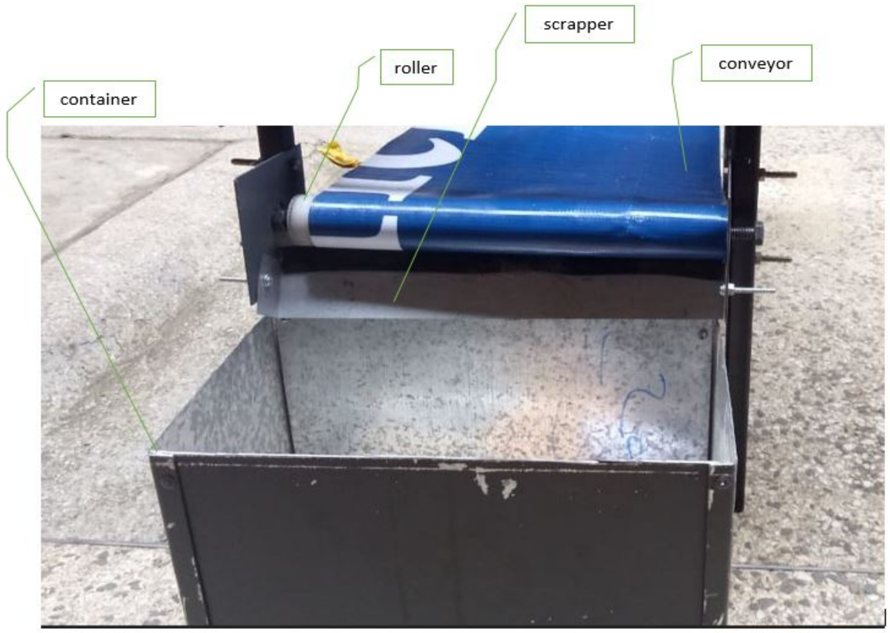


Figure 4.9: Fabricated waste management system

Figure 4.10: Fabricated egg collection tray

4.3 Control module

The control of the entire system worked as expected. The micro controller was able to receive signals from the sensors and actuate the required actuator accordingly. The

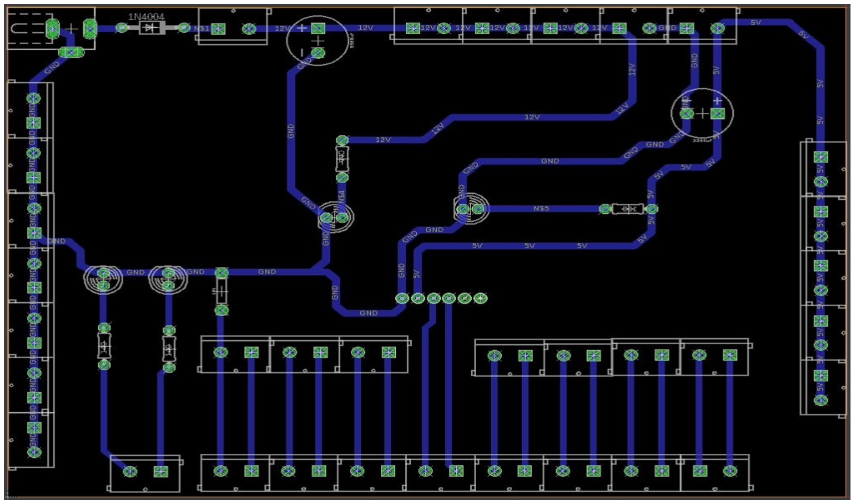


Figure 4.11: PCB design

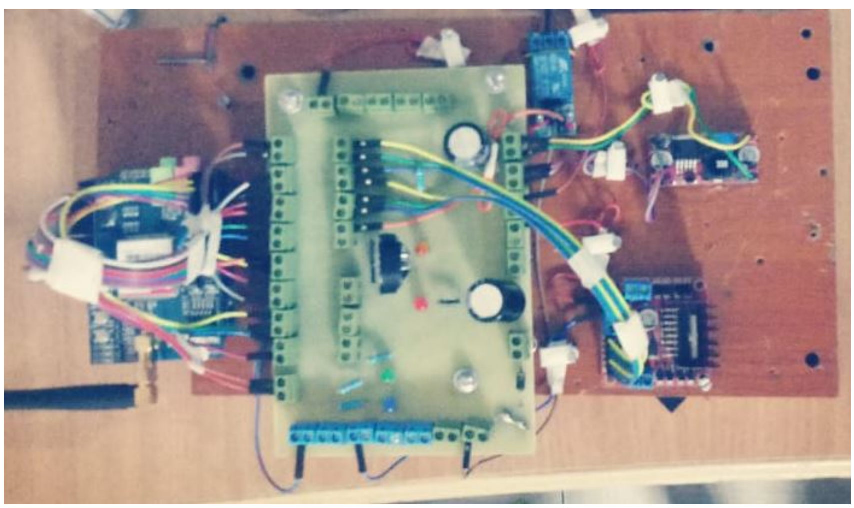


Figure 4.12: Fabricated PCB

control box was also built to within the dimensions specified in the design. The elecrical circuit of the system mainly comprised of the fabricated printed circuit board, the real time clock, the arduino mega, the GSM module, the motor drives, the buck converter and the signal and power cables from the individual components all fit into the control box as desired. The complete code for the system is shown in link [26].

[26] https://drive.google.com/open?id=1HIYbHTLtRjQNKbAIw0S5vkDX0RIWOQZy

4.4 Testing the model

The fabricated and assembled chicken coop is shown in figures 4.13 and 4.14.

Figure 4.13: Final fabricated chicken coop

The assembled automated chicken was able to function as expected in most of the areas. Specifically the waste management system, egg collection system, watering system and remote access system were all tested and worked optimally as per the design.

The feeding system did work but with some slight variations from the expected outcome. The motor used was of a lesser speed than the designed one and when tested it was able to transverse the cabin along the length of the lead screw. However due to the small pitch

Figure 4.14: Side view of final fabricated chicken coop

of 3mm of the lead screw, the movement was slightly slower than desired, but still enough to show proof of concept and delivered the feed from the silo to the cabin and finally to the trough.

The project was slightly over budget as shown in table 4.1. This was due to the fact that we had to source external 3D printing services since the school printer broke down. Since this cost was not in the original budget, it forced the project to exceed the budget.

Table 4.1: Budget

part	**description**	**quantity**	**Total price**	**availability**
IR Sensor	Infrared IR SHARP Sensor Switch 3-80cm	3	3000	ktechnics
Servo Motor	MG996 Metal Gear High Torque	1	1200	ktechnics
DC Motor	12v DC 120 RPM High Torque Gear Box Motor	1	1500	ktechnics
DC Motor	12V DC geared motor	1	1300	ktechnics
Motor drive	l298d	2	800	ktechnics
Mild steel	Sheet 2mm thick	$15000cm^2$	2000	workshop
mesh	3×3 low carbon steel	$60000cm^2$	4000	Wanjon hardware
timber	Pine	5cm diameter, 75cm long	200	workshop
Water nipple	-	3	450	Savannah agro vet, Githurai
tank	polyethene	10 litres	700	Happy supermarket
arduino mega	-	1	1600	Nerokas
capacitor	-	6	180	Nerokas
resistor pack	-	1	200	Nerokas
voltage regulators	3v, 5v, 9v, 12v	4	200	Nerokas

perspex	50cm2	1	600	Thika central hardware
bearings	M10	6	3000	Thika central hardware
rollers	nylon plastic	2	2200	Thika central hardware
conveyor belt	canvas	$1.2m^2$	1200	workshop
LED bulb	3W, white	1	350	DM electronics
Aluminuim	sheet metal	$300cm^2$	1000	Thika central hardware
GSM module	SIM800	1	4500	ktechnics
PVC pipe and fittings	5 inch diameter	300cm	400	zenith plumbing solutions
PVC pipe and fittings	8cm diameter	200cm	600	zenith plumbing solutions
copper board	150cm × 150cm	-	500	Nerokas
cabin	3D printing	-	2700	Cubic 3D
TOTAL	-	-	**31380 Ksh**	-

5 Conclusion

The main objective of the project was to come up with a feasible automated chicken coop. This was aided by the specific objectives that included the creation of poultry feeding and water dispensing systems, an efficient egg collection mechanism, a practical waste management system and remote access of the chicken coop. By the integration of all of the above designs, the solution that was created had a conducive environment that ensured the hens were in a good psychological state of mind and reduced the amount of work done by humans and the effect of human errors leading to an increase in egg production within a poultry farm. The design and fabrication of the automated chicken coop was successfully completed and it was able to achieve all the objectives set out for it.

5.1 Challenges

During the course of the design an fabrication of the automated chicken coop, some challenges were experienced. These challenges are listed bellow:

1. Pillow blocks were not available locally. The fabricated pillow blocks were not perfectly aligned so they induced vibrations in the moving cabin and also bent the lead screw slightly which increased the torque needed to move it.

2. The 3D printer at the school was not available for use, so this necessitated the use of external printing services for 3D printing of the cabin, that forced our project to be slightly over budget shown in table 4.4.

3. Welding of the mesh ot the floor of the cage was not perfectly flat which made some parts of that floor to be bumpy and thus inhibited the smooth roll of the egg.

Factoring the challenges faced during the actualization of this project, the following recommendations were made:

1. It is extremely difficult to fabricate perfectly aligned pillow blocks. The best alternative is to purchase pillow blocks of the same diameter size as the lead screw as these will function much better since they will have no slip or induce any bending in the lead screw.

2. Bench pressing the mesh before welding it onto the floor of the coop to ensure it is completely flat and ensure the eggs can roll smoothly onto the egg tray.

3. Using a lead screw of a large pitch is advisable as this will reduce the number of revolutions needed to translate the cabin. This will increase the speed of the cabin.

4. Polishing the inner lining of the silo walls to reduce the friction between the walls and the feed and thus enabling the feed to fall of the silo more smoothly.

5. The sharp IR sensor used to count the eggs generated false positive readings. The sensor is not recommended for the function of counting eggs. A break beam IR sensor was thought as a possible replacement for it.

Comparing this chicken coop system with others existing the market as shown in section 2, it was noted that this systems holds far less chicken in the same space as the latter. This automated chicken coop has some advantages over the existing systems such as:

1. By storing less chicken in the coop, it minimizes the risk of spread of diseases and also gives the chicken more room to move about which improves their psychological state, which will conversely lead to better egg production.

2. This system enables remote access of the chicken coop across a large distance by use of text messages sent via GSM.

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A Timeplan

Time-plan used in the deign an fabrication of the project is shown in appendix A .

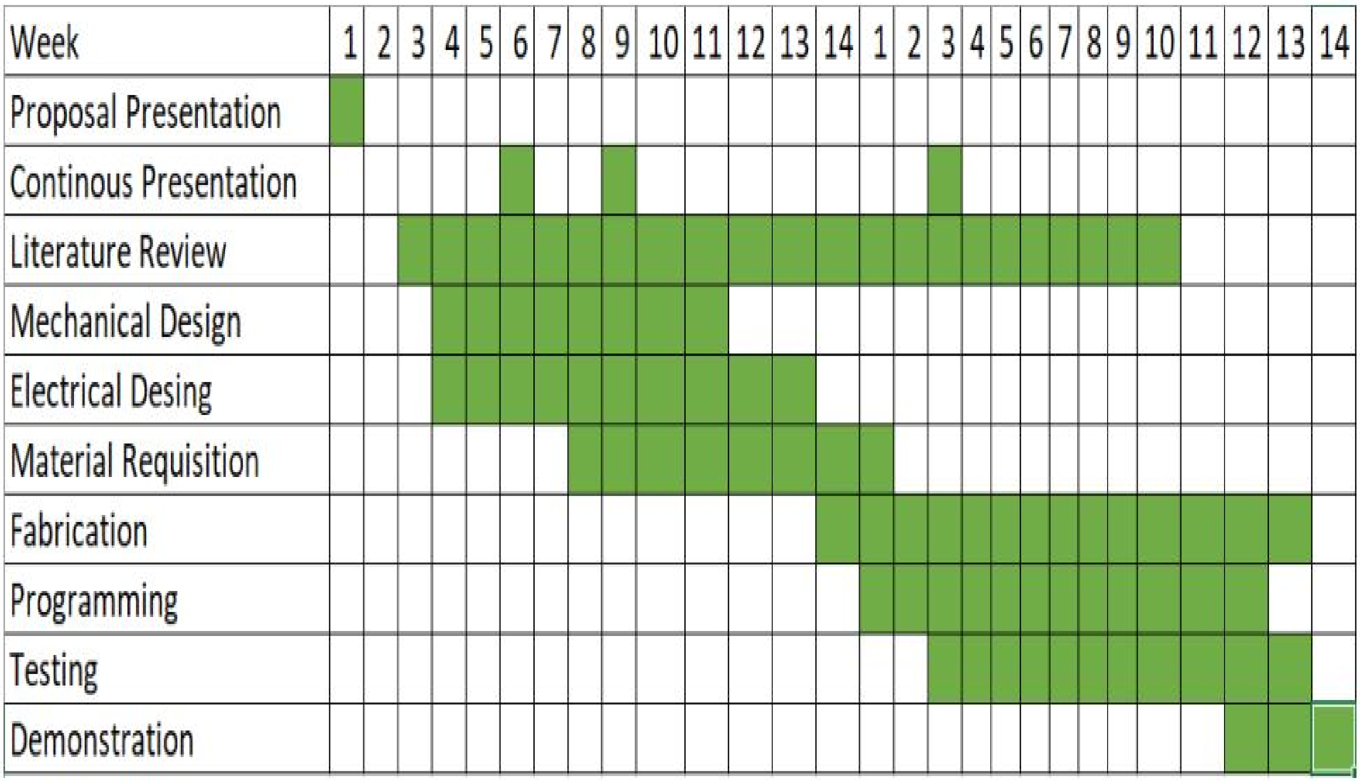

Figure A.1: Time-plan

B Flowchart

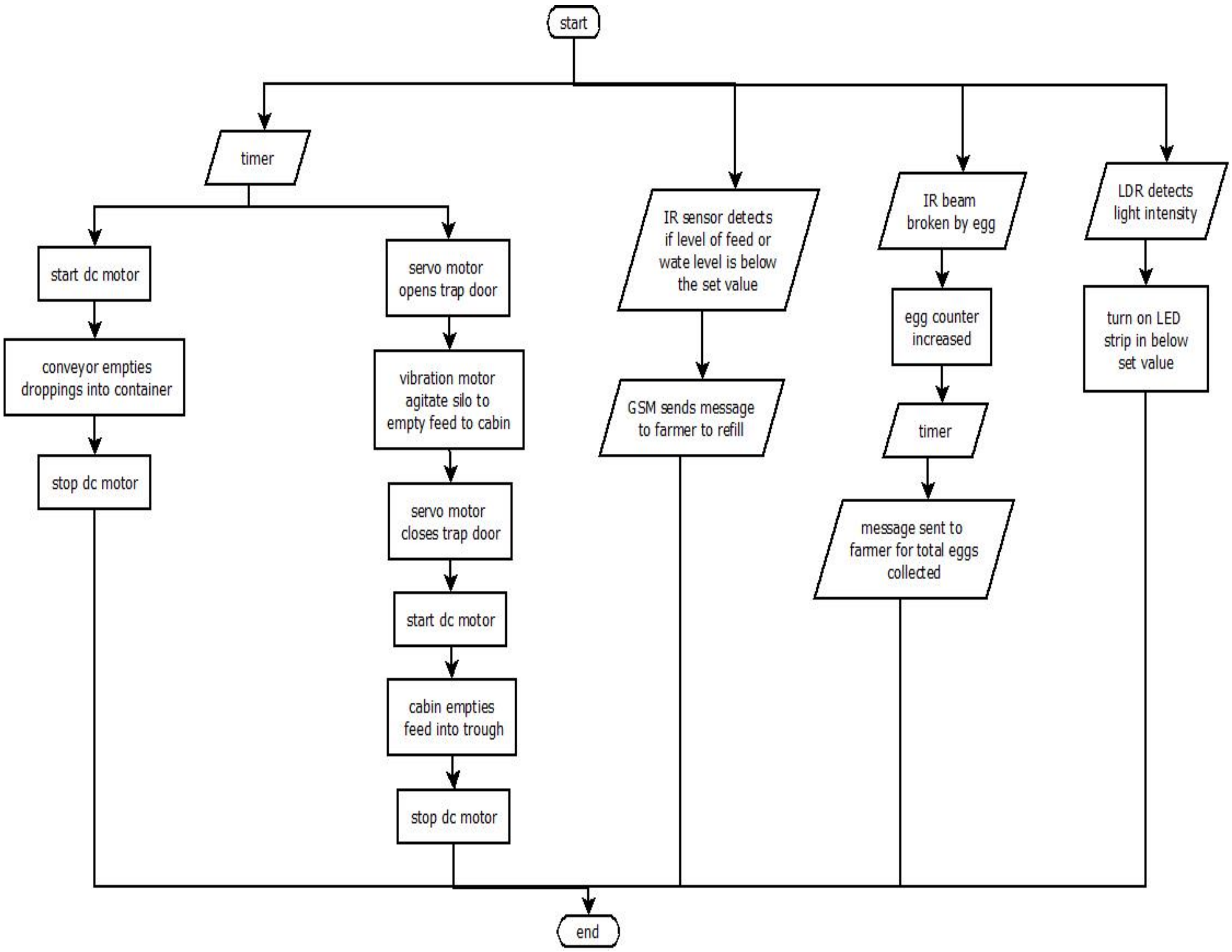

Figure B.1: Flowchart

C Power supply circuit

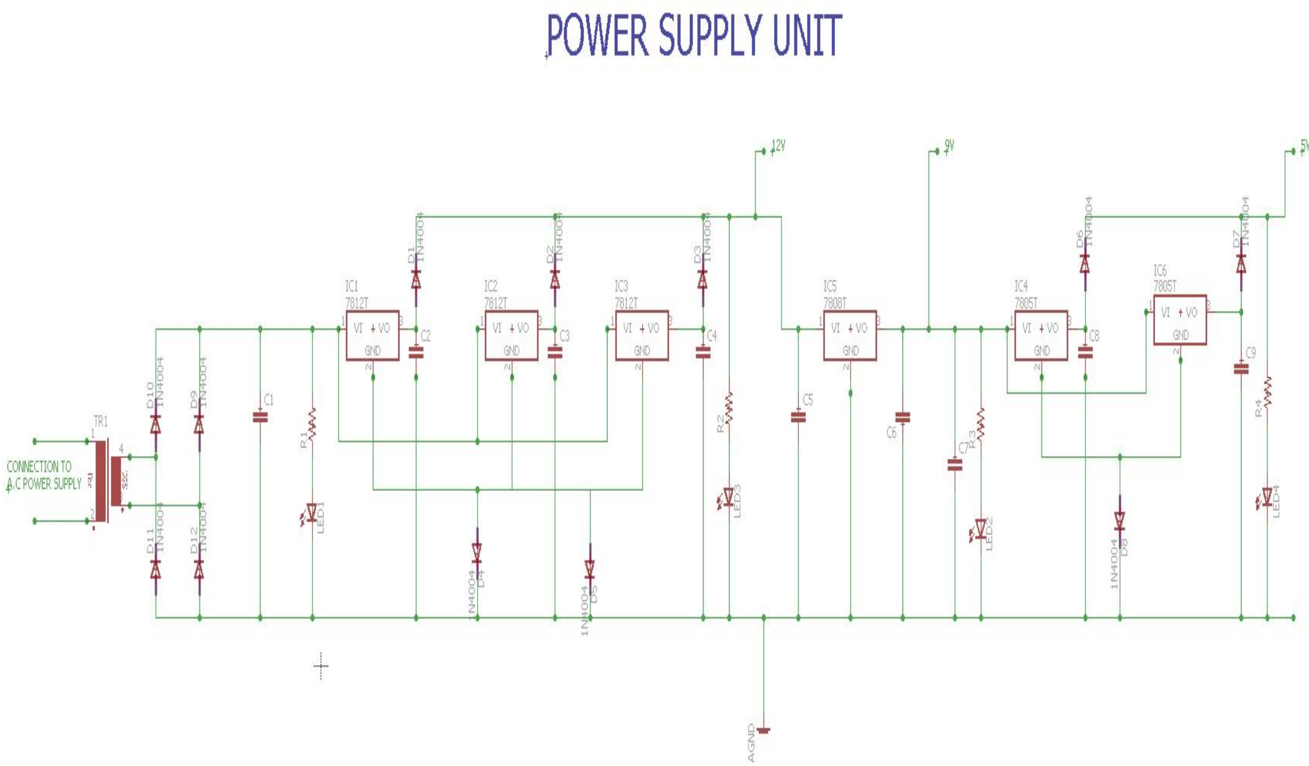

Figure C.1: Power supply circuit