Devikulam Housing
Project

Concept Design Report
Quality Information

Document: Devikulam Housing Project
Ref: 10 June 2011
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<td>10-June-2011</td>
<td>Concept Design Report</td>
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Executive Summary

Team ‘Nuts & Bolts’ of the Auckland University of Technology is, this year, participating in the Engineers Without Borders (EWB) Design Challenge, which sets out to help and develop various communities around the world, using the cumulative engineering knowledge and experience of all the persons involved.

This year, the focus of the challenge is a small village called Devikulam located in an impoverished region of south east India. The challenge is to provide a design, in a number of categories, that will benefit the community of Devikulam.

Team ‘Nuts & Bolts’ has decided that the team’s main category will be housing and will look to incorporate aspects from various other disciplines into the design (water, power, etc). It is the aim of ‘Nuts & Bolts’ to provide a quality design solution that will address many of the village’s issues as well as improve and enrich the community of Devikulam.

This team aims to achieve this through an extensive collaborative effort. This will include clear lines of communication, rigorous research and a timely delivery.
1.0 General Information

1.1 Site Location
Devikulam community is a small village situated in South East India. The village consists of about 90 households most of whom live in a colony made up of decrepit lodging and declining living conditions.

1.2 Local Conditions
General state of local economy can be classified as poor. This is reflected in the state of local infrastructure, housing conditions and lack of stable, basic services (water, sanitation, electricity, etc). The village can’t afford to improve/upgrade their living standards at this stage. However, a number of government implemented schemes/grants are in the pipeline and will be utilised in the near future. These schemes will offset some/all of the cost associated with re-developing the entire village.

1.3 Purpose of Report
This report brings forth a comprehensive solution to one of the village’s biggest issues, poor housing conditions. Team ‘Nuts & Bolts’ has endeavoured to design a solution that will provide relatively cheap and thermally comfortable housing, a reliable water supply/sanitation system and an improved power distribution system, while taking into consideration the social factors in the village and promoting interaction and enterprise among the villagers.
2.0 Scope of Works

2.1 Scope

This Concept Design Report presents each of the key elements of the supporting infrastructure system for the proposed housing project.

It has been decided that Team 'Nuts & Bolts' will comprehensively design one complete module, which will consist of ten houses & toilets and one communal kitchen to be shared among the households in that module. This module is to be replicated eight or nine times to accommodate every household in the colony. A proposed site layout is shown below:

The following services will be documented under this scope of work and are further outlined in the relevant sections of this Concept Design Report:

1. Architecture
   - Proposed Typical House plan and fit out
   - Proposed Typical toilet plan and fit out
   - Proposed Communal Kitchen plan and fit out
   - Construction materials
   - Site sustainability features

2. Electrical Services:
   - Proposed site power distribution system
   - Internal power and lighting (housing, toilets, kitchen)
   - External Lighting
   - Communications system (future proof measure)
   - Solar panel array (sustainability)
3. Mechanical Services:
   - Natural ventilation
   - Dedicated kitchen exhaust
   - Gas system for cooking
   - Future proof measures

4. Hydraulic Services:
   - Cold Water distribution system
   - Hot Water system via solar panels (sustainability)
   - Sanitary system
   - Stormwater drainage

5. DIY / Social Development
   - Fabrication of furniture
   - Making Accessories
   - Employment / Training opportunities

Structural Analysis of the proposed new buildings will not be performed as it is surplus to concept design requirements.

2.2 Project Lifespan

It is the intention of ‘Nuts & Bolts’ to design for a site for a lifespan of about 40 years. As such, some construction materials and/or workmanship required may not appear to be the cheapest option available; however, this will prove to be the most economical option in the long run.

A conscious effort is being made, early in the design stage, to future proof the site against various aspects that may become available/desirable in the future.

At the same time a number of sustainability aspects are being looked into, to ensure that this design has no obstacles in reaching the 40 year lifespan target.

Refer to the subsequent technical sections for details about future proofing and sustainability schemes relevant to this design.

2.3 Adherence to CIC Guidelines

The New Zealand Design Documentation Guidelines (CIC Guidelines) for Concept Design are referred to for guidance in terms of level of detail for the design. Refer to Appendix B for complete Concept Design checklist for this project.

2.4 Project Timeframe

The full design period for this module is expected to take no less than 4 months but not exceed 7 months.

Construction period may vary depending on economical conditions and weather patterns on site. An allowance of 12 months ± 2 months should be made for the construction period.
2.5 Assumptions

Since the design of Power and Water supply for the entire village is outside the scope of works for this project, it is assumed that other Civil and Electrical site works are being undertaken in conjunction with this design in order to provide our module with a power and water source.

Team ‘Nuts & Bolts’ will provide a design for Electrical and Hydraulic services within the boundaries of the module only.

2.6 Deliverables

To ensure that the quality of presentation and accuracy of design is of the highest order, team ‘Nuts & Bolts’ has endeavoured to create a 3D BIM (Building Information Modelling) Model of the entire module using the Autodesk Revit Architecture and MEP software packages. Because of these 3D capabilities, all the elements in the project were located / placed accurately and efficiently. This means the productivity level has increased due to the amount of rework being dramatically slashed.

All the layouts, sections and elevations for this project were derived from this Model and are documented in Appendix C of this report. Team ‘Nuts & Bolts will provide pdfs of all the layouts associated with this design.

The 3D model remains the intellectual property of ‘Nuts & Bolts’, but will be made available upon request, for demonstration purposes only.
3.0 Team Roles

This section provides a brief outline of each team member’s role and the overall contribution to this concept design report.

3.1 Slava Alexandrov
Slava’s role in this project is best described as Lead Designer. He was in charge of developing the 3D model of the entire module and assisted/guided all other team members in the design of their respective sections. He provided keen oversight of the project from inception to project delivery.
Slava has also undertaken the role of the final verifier/editor of this report.

3.2 Rachael Monteiro
Rachael has been tasked with the design/preparation of all architectural aspects of this project. Her role was to research construction materials/conventions and sustainability options. All the while keeping in mind the community of Devikulam and the social impact our design might have on it.

3.3 Josef Lopez
Josef is in charge of the Electrical Services associated with this project. This includes Power distribution, Site and Internal lighting and electronic communication. His task is to provide a feasible and reliable electrical and communications system to the community of Devikulam, by finding the best balance between efficient electrical equipment (lights, power outlets, etc) and effective performance.

3.4 Andrew Prakash
One of Andrew’s biggest tasks is to make the housing solution provided by this project, as thermally comfortable as possible. He achieves this through a quality design of natural ventilation. Andrew also looks after the kitchen and toilet ventilation systems, and the gas cooking system for the whole module.

3.5 Bhavin Patel
Bhavin is the caretaker of the water systems design in our module. His role is to document the water supply, sanitation and stormwater drainage systems. He is also involved in the design of the hot water system via the use of solar heating panels, which is yet another sustainability initiative undertaken by team ‘Nuts & bolts’.

3.6 Bruce Lin
Bruce focuses more on the social development of the community. He puts forth ideas on how the villagers in the community of Devikulam can help each other and themselves through various enterprise options. Bruce also proposes DIY projects for the villagers and how they can benefit from creating their own furniture and accessories from locally abundant resources.

Please refer to the subsequent design sections and appendices for more details on the extent of contributions of the aforementioned team members.
4.0 Architecture

4.1 General Information
Team ‘Nuts and Bolts’ have designed a colony for the village members of Devikulam, instead of merely making improvisations to their current living conditions. The colony designed for the people of the Devikulam community consists of 10 houses, 10 sanitary areas, one per household, and a communal kitchen that is to be shared among the members of the 10 households. Research suggests (EWB Design Brief, 2011) that there are approximately 89 households in Devikulam. Therefore, the housing and sanitation model designed by team Nuts and Bolts can be replicated any desired number of times, in order to accommodate all the members of the village. The architecture section of the report includes the parts and materials that are designed for the houses, the communal kitchen and the sanitary areas of the colony. A brief explanation is also given, as to why the materials were chosen and what changes does it bring the colony members. The lifespan of our designs are around 40 years, therefore, the materials and designs of the houses, sanitary areas and communal kitchen are selected to ensure maximum output for minimum cost and effort. The designs of this project are consistent with the design considerations found on the EWB design brief(2011). Refer to drawings AR101, AR202, AR201, AR131, AR132, AR151 and AR050 in appendix C for detailed views of the design aspects mentioned in the architecture section of this report.

4.2 Site
The colony site of our project is designed to have 10 houses, 10 sanitary areas and a centrally located communal kitchen. Visual aids would help demonstrate the site layout, the walk paths and roads in the colony and the site orientation better than textbook explanations.

4.2.1 Site Layout & Orientation
4.3 House

The designs of the houses for the colony members of Devikulam consists of a living area, a dining area, three bedrooms and extra space for desired purposes. These houses are built for a household of 5-7 members. In the EWB Design Brief (2011), it was mentioned that the members per household ranges between 2-11 people. The materials and ideas used in completing the design of the houses, ensures the colony members a better and a more sustainable lifestyle. The extra storage space in the house can be used as a prayer space, since religion plays a major part in the lives of the Devikulam villagers. In this way, the designs also encourage the colony member’s traditional practices. A bird’s eye view of the designed house is shows below, with added furniture.
4.3.1 Foundations/Structure/Elevation

The houses in the colony are built on strong stilts made from Palmyra wood. This type of wood is obtained in abundance in the Pitchandikulam Forest of the Devikulam. Palmyra is known to be durable, weather adaptive and strong. The reason the stilts are inputted into our designs, is because it is known that Devikulam receives fluctuating rainfall during the monsoon season. This leads to occasional flooding with no proper drainage of the rainwater. The area of the house is around 85 square meters. The stilts are designed to be at 1.5metres in height and will be built to withstand any flooding that occurs. Without the stilts, the rain water could damage the outer walls of the house, and/or water could enter the houses causing interior damage. A timbre staircase is designed as an entrance/exit to the house. An external view of the designed house with stilts is shown below.

4.3.2 Floors

One of the biggest problems faced by the village members is that the current houses are too hot to live in. It was mentioned in the EWB Design Brief (2011), that the villagers occasionally sleep outside their houses because it is too hot inside. One way to provide cooling in the houses, the floors of these houses are designed to be of hardwood material. Currently the houses are built with cement flooring, however, hardwood would keep the house at a much cooler temperature. The Pitchandikulam forest being located nearby to the village, makes using wood for construction purposes an easily available and reliable resource. The underneath of the wooden flooring has been designed to have a layer of insulation.

4.3.3 Walls

The walls as suggested on the EWB website(2011), are designed to be made of rammed earth. The height of the walls is about 3.5 metres. Concrete was the first choice for the walls, but was dismissed as concrete retains too much heat within the house. The walls are also designed to have an insulation layer (or two if desired and budget permits). The insulated is suggested to be made of polystyrene. Wood made from the palmyra trees will be placed on either side of the polystyrene insulation. This sandwich of rammed earth, palmyra wood, polystyrene insulation and palmyra wood, together combine to make an efficient and cooling wall for the houses of Devikulam. The thickness of the walls
is about 240mm. Picture AR101 in the appendix gives a more detailed thickness of the wall, per layer of wood or insulation.

### 4.3.4 Doors & Windows

Doors are single swing doors, made of timbre wood or palmyra wood, found in the nearby Pitchandikulam forest, is the best option for the houses of the colony. Wooden doors are sustainable, easy to construct and durable. Doors for the three bedrooms within the houses are optional and are not recommended. However, if budget permits and desired by village members provisions can be made for doors to be fitted at the bedroom entrances. Windows designed for these houses are completely manoeuvrable for good ventilation to occur in the houses. In order to improve the thermal conditions, the windows of the house facing east and west are suggested to be double glazed, with a timbre frame. The picture below shows a bird’s eye view of the house showing the interior and exterior walls and flooring. Refer to drawing AR101 in the appendix for a more details view.

![Diagram of the house showing the thicknesses of walls and doors](image.png)

### 4.3.5 Roof

The material used in the design of the roof of the houses is aluminium. The roof of the houses will face heavy rainfall, the occasional strong winds and extreme amounts of sunlight. Therefore, the material of the roof should be such that it reflects most of the sun’s heat, absorbing only a minimal amount and thus keeping the temperature inside the house, pleasant. Aluminium is a material that falls in the desired category as it would withstand rainfall and strong winds and it will not absorb a lot of heat. Although aluminium is a more expensive option, it calculates to be reasonably cheap from a future proofing perspective. The roofs of the houses are sloping downwards at an appropriate angle, so that the rain water can be collected and drained through the roof gutters.
4.3.6 Roof Gutters

As mentioned in section 4.2.5, the roofs of the houses will face heavy rainfall, and as also mentioned on the EWB Design Brief (2011), the availability of water is evolving into an issue for the village member. Their main source of water is a nearby lake, however, the salinity level is at its maximum tolerable level. To contribute to a solution to this problem, team ‘Nuts and Bolts’ have designed the houses to contain Roof gutters. These gutters are connected to a pipe, which is connected to the village’s stormwater drainage system. Therefore, once it rains, the rain water goes through the gutters, to the stormwater pipes and is stored in the village’s stormwater drainage system. This water can be used for cleaning and sanitation purposes.

4.3.7 Paint

Since the walls of the house are made of rammed earth and wood, the team has chosen to use paints with high reflective capabilities to paint the walls. As the name states, the paint will not absorb any heat from the surroundings, therefore keeping the house at an ambient temperature. High reflective paint is not the cheapest option, but is most beneficial in the long run.

4.4 Toilets/Sanitation Areas

A sanitary area outside every house has been designed in this colony. Currently the village members have no proper sanitation system, and all their sanitary work is done out in the open. Therefore, team ‘Nuts and Bolts’ came up with the concept of a communal sanitary area. It is one toilet and bathroom built for the entire colony to use and maintain. This idea was rejected after reading the preferred sanitation system in the EWB innovations report (2011). The report suggested that one communal sanitation system does not work as desired, as no one takes responsibility to clean the area after dirtying it. Hence, a toilet per household is designed outside each house of the colony. The sanitary area is equipped with a toilet, a wash basin and a cubicle with a drain for showering. The area of the sanitary area is 2.2 by 2.5 metres. The picture below shows a bird’s eye view of the designed sanitary area.
4.4.1 Foundations/Structure/Elevation

Unlike the house the materials used for the sanitary area are cheaper and of lower quality. This is mainly because heat retention is not a concern while designing the sanitary area. The toilets are elevated from the ground with stilts, like the houses; however, these stilts are just 0.3metres in height. This is to ease up the piping work to and from the sanitary areas. If any flooding occurs, it will not damage the brick and tile exterior of the sanitary areas as much as it would damage the rammed earth exterior of the houses.

4.4.2 Floors

Using good quality hardwood flooring like the houses is a waste of cost and materials. The flooring of the sanitary area has to just withstand dampness. Therefore, the materials chosen for the floor of the sanitary area is cement. Cement is easily available, cheap and is not too complicated to use in construction.

4.4.3 Walls

The walls of the sanitary area are designed to be around 2.7 – 3 metres in height. The materials used in the walls are brick and tile. Brick and tile is cheap and can withstand heavy rainfall. It is easy to teach the village members how to construct small sized architectures using brick and tile.

4.4.4 Doors & Windows

There is a door to enter and exit the toilet, however, no windows have been design for the sanitary area. The material of the door can be wood made from the palmyra trees. The material of the door is not a big concern and be chosen as desired by the colony members.

4.4.5 Roof

The roof of the sanitary area is horizontal and made of aluminium. Since the floor area of the sanitary area is small, not much rain water will be accumulated and constructing sloping roofs with roof gutters attached to pipes is just a waste of time and effort. Horizontal roofing uses less material than sloping roofs.

4.4.6 Louvers

The only forms of ventilation in the sanitary areas are louvers. Like the houses, there are lower level and upper level louvers designed in the sanitary areas. The lower level louvre is situated at the bottom of the door and the upper level louvre is placed above the toilet for air to exit.

4.4.7 Paint

The team has decided that it is not vital to paint the sanitary area, but if desired by the village members and budget permits any appropriate paint can be used.
4.5 Communal Kitchen

As mentioned in section 4.2, the houses are equipped with a living and dining area, three bedrooms and extra space. The kitchen for the colony members are not designed inside the houses, but on the outside. Team ‘Nuts and Bolts’ have designed one communal kitchen for the 10 households of the colony, which is located at the centre of each colony. This communal kitchen is equipped with 3 gas stoves, with 4 burners each, connected to 5x50kg gas bottles, situated outside the kitchen. It also consists of 3 sinks, external water tank, an exhaust above the stoves, a pantry/storage space and tables and chairs for colony members to dine together. Most of the designs and materials of the houses are also adapted in the designs of the communal kitchen. This idea of a communal kitchen will also help to overcome the social barriers that currently exist between the members of the village. In order to provide hot water into the kitchen (and also the sanitary area), the water must be heated using a sustainable mechanism. Our team has decided to input solar panels on the roof of the communal kitchen that will enable water to be heated to an appropriate temperature. Since Devikulam is hot and humid, extreme heating is not necessary. Below is a bird’s eye view of the communal kitchen, showing most of the design aspects talked about in this section.
4.5.1 Foundations/Structure/Elevation

The communal kitchen is also elevated off the ground by a distance of 1.5 metres. The structure of the communal kitchen is similar to the house, therefore, during monsoon seasons, in order to prevent damaging the kitchen the stilts are inputted into our designs. The stilts used to support the communal kitchen and the houses are of the same material. Thus, obtaining strong palmyra wood in the Pitchandikulam forest is extremely vital for our designs. The external view of the communal kitchen with the stilts is shown below. As visible below, there is a timbre staircase designed for entering and exiting the kitchen.

4.5.2 Floors

The floors of the communal kitchen are designed to be hardwood flooring. This wood can also be processed wood obtained in the Pitchandikulam forest. Wooden construction should be the easiest and cheapest option, since an abundantly dense forest is situated near the village. Wood work can also be easily taught to the village members of Devikulam.
4.5.3 Walls
The exterior walls of the communal kitchen have a thickness of 135mm. The walls, like the walls of the houses are insulated with polystyrene. Refer to AR101 for a detailed view and detailed description of the thickness of the communal kitchen.

4.5.4 Doors & Windows
The windows in the communal kitchen are designed to be made of glass. None of these windows are suggested to be of double glazing, as heat retention within the communal kitchen is not a major issue. The doors are double swing, glazed and have an aluminium frame.

4.5.5 Roof
Aluminium roofing is the option chosen by our team. Aluminium is strong and durable. Solar panels are designed on roofs of the communal kitchen. These panels will enable the heating of water for cooking and showering purposes. Since the communal kitchen has the biggest area amongst the designed architecture, placing the solar panels on the roof produces the best outcome.

4.5.6 Roof Gutters
There are roof gutters placed on top of the communal kitchen. These gutters, like the roof gutters of the houses, are connected to pipes which will store the accumulated storm water in the village’s storm water storage area. As mentioned in section 4.4.5, the communal kitchen has the biggest area and therefore will accumulate large amounts of rainfall, which will be beneficial to the colony members in the future.

4.5.7 Louvers
Lower level and upper level louvers are placed in the walls of the kitchen to help in ventilating the kitchen. The exhaust along with the louvers will provide a pleasant ambience in the communal kitchen. Ventilation of the air is vital in the kitchen as most Indian cooking involves a lot of spices and heavy cooking.

4.5.8 Paint
Reflective (aluminium based) paint is the type of paint designed for the walls of the communal kitchen. Since the colony members will be dining and socialising in the communal kitchen, providing an adequate amount of comfort in the communal kitchen is necessary.
5.0 Electrical Services

The EWB Design Brief (2011) mentions that the current power grid in the Devikulam is in poor condition and that power cuts are common place. As such, this team attempts to rationalize the power distribution system within the module to make it more reliable and safe.

5.1 Power Distribution System

- It is assumed that there is a local electrical substation in the village complete with at least one step down transformer. Our power will be drawn from this transformer into the site via underground conduits. Refer to drawing EL010 for the conduit layout.

- All incoming conduits will reticulate at the Main Switchboard (MSB) located in the kitchen building.

- From the MSB, power will be distributed around the site (to individual Distribution Boards in houses) via another series of underground conduits. Refer to drawings EL010 and EL200 for locations of the MSB and the individual DBs.

- In the future the villagers may acquire a backup generator to offset some of the power cuts. Thus, as a future proofing measure we will provide a spare connection for future generator inside the MSB. Refer to the single line diagram on drawing EL200 in appendix C for details.

5.2 Internal Power & Lighting

5.2.1 Lighting

Fluorescent light fittings would be installed in every facility internally. Why?

- Fluorescent lamps are very effective in terms of brightness and efficiency. Its longer life span and lesser energy use would compensate for the higher cost. Also as the years pass people using fluorescent light bulbs would save more money over the life span of the light bulb.

- A minimum of two lighting circuits would be provided to prevent total lighting failure.

- Each house would have suspended light fittings installed as there would be no ceilings in the houses.

- There would be 4 light fittings in the living room, 2 in the hallway, 1 in each bedroom, 1 in storage room and 1 in toilet.

Types/Alternatives to be used:

- Type L1 – Suspended, Modular Linear Fluorescent Luminaries

- A suspended linear fluorescent lamp with 1 No.T5 linear fluorescent lamp.

- Material used is sheet steel with die-cast alloy corners and aluminium reflector mounted behind the lamp.
5.2.2 Power

- Each house would have a distribution board that controls all the lights and power outlets in the vicinity.
- Power in the toilets would also be controlled by the local distribution board.
- An underground non metallic power conduit would connect the main switch board to the distribution boards in each house.
- The distribution board would be located near the entrance inside each house.
- There would be at least one 10A 230V double switched socket outlet in every room.
- There may be a need for dedicated outlets in the kitchen, for equipment such as fridges, ovens, etc. Refer to drawing EL200 for details.
- A power outlet for hot water booster pump would be installed outside and will need to be weatherproof.

- A suspended linear fluorescent lamp with 2 No.T5 fluorescent lamps.
- Material used in rectangular white, lacquered sheet steel housing with hinged optics.
5.3 External Lighting

- Minimal external lighting would be provided to the module.
- External lights would be powered and controlled directly by the MSB.
- A time clock would be responsible to trigger the external lights on and off between 6:30 am and 7:30 pm.

- For full details of the lighting and internal power schematic refer to drawing EL100 and EL200
- for detail about the external connections refer to drawing EL010

5.4 Communications System

- There would be communication outlets provided to each house with the capability to connect to broadband, but the broadband connection itself would not be provided.
- The internet access would be part of our future proofing scheme, so that in the future if they get the budget to afford broadband they just need to plug it in the comms outlets.
- All comms outlets are fed from the Main Distribution Frame (MDF) in the kitchen area.

5.5 Backup Generator

- As part of our future proofing effort, we are making an allowance of space for a generator, but not providing the generator itself. This is made so that if they decide to install a generator now or in the near future they would just need to link the generator to the system.
- The generator would be connected directly to the MSB.
- There would be a sensor for the generator to automatically switch on if a power failure is detected by the MSB.
6.0 Mechanical Services

6.1 Natural Ventilation (Air louvers)

Although Team Nuts and Bolts are providing future proof solution for housing we are not taking cost to extreme levels and providing air conditions for ventilation, however we have decided upon providing natural ventilation for the house, communal kitchen and toilet.

To achieve this we have decided upon low level intake louvers which will bring in fresh air. These louvers are to be placed in each bedroom to provide fresh air during day and night. These louvers are also placed in the communal kitchen and the toilet.

To extract the hot and stale air high level louvers are to be also installed into the home, communal kitchen and the toilet. These louvers will be installed in the living spaces within the home.

Through the use of low level intake and high level extract louvers we ensure that these establishments will have access to fresh air all year around and will be kept at relatively good thermal comforts.

6.1.1 Intake/Extract Louvers

These will be drainable blade louvers to deliver good water penetration performance. This is achieved by draining the water from each blade and discharging it at the bottom of the louver through vertical down pipes found at either side of the louver.

Construction: Steel Frame, aluminium blades
Finish: Silver Metal
References: Holyoake Industries Model OHL-F-D

Typical louver:
6.2 Kitchen Exhaust System

In accordance with the Mechanical Ventilation Standard AS/NZS 1668.1 (2002) requirements we have designed the kitchen to be equipped with a kitchen hood and an extract system.

The hood and exhaust will be placed above the stoves to funnel out the smoke and most of the heat from cooking whilst preventing people from inhaling the fumes generated from cooking. Please refer to drawing MS100 and GE103 for details on this feature.

6.3 Gas Cooking System

We have decided to utilise a gas system for cooking in the module. This was an easy decision since gas is relatively cheap and a gas cooking system is not affected by power cuts or an intermittent power supply.

6x50Kg Gas bottles are allocated space adjacent to the kitchen area (refer to drawing MS100 in Appendix C). It is estimated that this will last the entire module about two months worth of cooking, assuming 8 hours of cooking takes place a day.

Upon exhaustion, the gas bottles will need to be refilled. As such the villagers in Devikulam will need to arrange for either; periodic deliveries of gas bottles or periodic visits to neighbouring villages for refilling.

6.4 Diesel Storage Tank (Future)

A provision of space has been made for a diesel storage tank for future fuelling of the optional diesel power generator. A capacity of 1200L will be enough to run a generator for 2 years, assuming it is operation for 30 hours a month. Refer to drawing MS100 for the allocation of space for the tank.
7.0 Hydraulic Services.

The EWB Design Brief (2011) clearly states that both the supply of water and sanitation are either nonexistent or greatly dilapidated. This team has chosen to provide a viable solution to this major issue in the community of Devikulam. However, as mentioned in the scope of works above, this solution will be internal to the module only and will not encompass the entire village.

7.1 Cold Water Supply

Drawings HY010 and HY100 in Appendix C show the general layout of the pipework around the site and inside the individual living areas. The cold water system for this module will tap into the existing water supply mains in the village. It is assumed that the mains have sufficient pressure to not warrant a booster pump for this system. It is also described in the Water Test Results (2011) report that the purity of water is sufficient for cooking and bathing purposes and as such, no water filtration is provided in this design.

7.2 Hot Water Supply

Another aspect of this team’s sustainability effort is the manner in which hot water is supplied to the site. It’s been decided that solar heating panels will be used to heat up cold water after which the hot water will be distributed around the site. The decision to provide hot water is in line with this team’s goals of improving the lives of the villagers in Devikulam and since the village does not, currently, have a hot water supply, it makes sense for us to include it in the design.

The aforementioned solar panel will sit on top of the Communal Kitchen, as this is the only public access area in the module. Refer to Drawing HY010 in Appendix C for the layout of the pipework leading up to and leaving the kitchen area.
7.2.1 Operation of Solar Panels

The water schematic on Drawing HY010 (Appendix C) illustrates the general arrangement of the solar panels in the water system. Cold water will be piped through the solar panel array and in the process will be heated up. Hot water will then be piped down into the hot water storage tank located adjacent to the kitchen area. From there, hot water will be distributed around the site as needed via a booster pump located next to the hot water storage tank.

A water shut off valve is to be located on the pipework leading up to the solar panels. This valve will controlled via timeclock in the electrical Main Switchboard (MSB) in the kitchen area. This valve will only be open in the hours from 7am to 7pm and will shut after the sun has gone down to prevent water from circulating through cold solar panels.

7.3 Sanitation

The sanitary system for this module will be of the more traditional design. All sanitary pipework leaving the toilets or the kitchen shall be sloped with a 1:100 fall. This will eliminate the need for having a pressure booster pump on the sanitary pipework. Refer to drawings HY010 and HY100 for the layout of the sanitary system.

7.4 Materials and Components

All water supply and sanitation pipework shall be made of standard polyvinyl chloride (PVC). PVC is the most affordable material for pipework and is generally long lasting and reliable.

All pipe bends shall be radius bends with a minimum radius of 2 x Diameter of the pipe.

7.5 Stormwater System

Another sustainability factor as well as a major safety precaution in this design is the provision of the stormwater drainage system. This system is split into two parts, the roof gutters in the buildings and the module perimeter drainage.

7.5.1 Roof Gutters

During the wet season, flooding can sometimes occur in the area and cause structural damage to housing as well as create major health and safety hazards.

By including roof gutters on top of the houses and the kitchen area, it is assured that any excess water can be safely drained from the roof. This excess water flows along the roof, into the gutters and through the downpipes, into the stormwater drains below.
7.5.2 Stormwater Drains

The water from the roofs and any stormwater on the ground will flow into the main stormwater drains located on the perimeter of the module. Refer to drawing HY010 for layout of drains. These drains will safely carry the water out of the module and into the nearest water run-off pond or stormwater harvesting system (if present).

The stormwater drains shall be made of precast concrete blocks and covered with cast iron grates to allow flow into the drains.
8.0 Social Development / DIY Projects / Recommendations

According to the EWB Design Brief (2011), the villagers in Devikulam are subject to a low socio economic status. Some villagers are farmers, some are labourers but a lot remain unemployed. For this reason, this team would like to suggest/recommend a few ways in which the villagers can help themselves and each other.

8.1 Furniture Making

Despite poor economic conditions, there are some natural resources that the community of Devikulam is rich in. Most of these are trees (Palmyra, bamboo), plants and flora. The villagers can use these resources to make a variety of furniture and accessories for themselves and for others. Some of these may include:

- Dining and side tables
- Wardrobes
- Doors and Window frames
- Bookshelves
- Beds – single, double and bunk
- Accessories

It is our recommendation that some of the unemployed villagers acquire self teaching material such as books or manuals on furniture making or attain external training from craftsmen. In the end, the return should be greater than the initial investment in terms of money and skill base.

8.2 Employment/Enterprise Opportunities

The layout of our site and the equipment and features that are incorporated into it present opportunities for various types of employment and enterprise.

8.2.1 Communal Cooking

One or two families in the module can be in charge of providing meals for the entire module, rather than everyone preparing their own food. These families would be compensated for their effort. This arrangement does not need to be fixed and cooking can be done in turns by different families in the module. Such a scheme would promote socialisation and improve the local economy.

8.2.2 Carpentry Training

The more adept carpenters or furniture makers can train others in the craft and be compensated for it. As mentioned above, villagers can be trained to utilise locally available materials to produce/fabricate furniture and accessories.

8.2.3 Custodial Positions

There is an opportunity for perhaps one or two people to take on the role of groundskeepers and custodial stuff. Their responsibility would be to maintain the landscape within the module and on the perimeter. They would also be responsible for keeping the public areas clean and tidy.

8.2.4 Handyman

One of the most important positions available is that of a handyman for the entire module. This role would entail the following duties:
• Looking after the electrical system on site, which includes power, lighting and the operation of solar panels.

• Looking after the mechanical equipment. Being able to shut down, maintain and restart equipment such as the pump, water tank and the future diesel power generator.

• Maintaining/refilling the gas bottles and performing routine safety tests on them.

9.0 Conclusion

This concludes our concept design report for the EWB Design Challenge 2011. Team ‘Nuts & Bolts’ hopes that the ideas presented in this report will someday materialize in the village of Devikulam and go a long way in improving and enriching the entire community.

On behalf of the Auckland University of Technology, this team would like to thank Engineers without Borders for facilitating this opportunity to practice our design skills, hone our critical approaches and have a chance to help people in the process.

Special Thanks To:

• Engineers Without Borders

• Auckland University of Technology

• AECOM NZ Ltd
Appendix A – References

General

The following list outlines some of the documentation referenced in the design process of this project:


Standards

Some of the standards referred to in the design process of this project are:

- **AS/NZS 1668.1.** (2002). *The use of mechanical ventilation and air conditioning in buildings – Fire and Smoke control.*

Appendix B – CIC Checklists

Attached are the formal Concept Design checklists as per the CIC guidelines in the following categories:

- Architecture
- Electrical Services
- Mechanical Services
- Hydraulic Services

Note that the CIC guidelines were used as a reference/guide only and were not strictly adhered to.
<table>
<thead>
<tr>
<th>Task</th>
<th>Details</th>
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<tbody>
<tr>
<td>1.</td>
<td>Conceptual design of materials and finishes.</td>
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| 2.  | Conceptual drawings detailing.
| 3.  | Option studies report. |
| 4.  | Detailed concept design.
| 5.  | Sections, elevations, elevations. |
| 6.  | Model. |
| 7.  | Preliminary cost estimate (prepared by). |
| 8.  | Conceptual drawings including. |
| 9.  | Important information. |
| 10. | Other design considerations. |

**Tasks:**
- Review existing conditions.
- Review the requirements for the project.
- Review the client's needs and expectations.
- Review the project's budget and timeline.
- Review the project's scope and objectives.
- Review the project's risks and potential outcomes.
- Review the project's legal and regulatory requirements.
- Review the project's financing options.
- Review the project's sustainability and environmental considerations.
- Review the project's construction methods and technologies.

**Deliverables:**
- Conceptual design.
- Option studies report.
- Preliminary cost estimate.
- Conceptual drawings.
- Detailed concept design.
- Sections, elevations, elevations.
- Model.

**Inputs:**
- Important information.
- Other design considerations.
- Review the project's budget and timeline.
- Review the project's scope and objectives.
- Review the project's risks and potential outcomes.
- Review the project's legal and regulatory requirements.
- Review the project's financing options.
- Review the project's sustainability and environmental considerations.
- Review the project's construction methods and technologies.

**Outputs:**
- Conceptual design.
- Option studies report.
- Preliminary cost estimate.
- Conceptual drawings.
- Detailed concept design.
- Sections, elevations, elevations.
- Model.

**Consultants:**
- Architect.
- Engineer.
- Contractor.
- Surveyor.
- Attorney.
- Financial advisor.
- Marketing consultant.
- Environmental consultant.
- Sustainability consultant.
- Construction manager.
- Project manager.

**Consulting Firms:**
- Architectural firms.
- Engineering firms.
- Construction firms.
- Consulting firms.

**Consulting Services:**
- Architectural services.
- Engineering services.
- Construction services.
- Consulting services.
- Project management services.
- Sustainability services.
- Environmental services.
- Marketing services.
- Financial services.
- Legal services.

**Consulting Projects:**
- Residential projects.
- Commercial projects.
- Industrial projects.
- Infrastructure projects.
- Renewable energy projects.
- Environmental protection projects.
- Sustainability projects.
- Marketing projects.
- Financial projects.
- Legal projects.

**Consulting Experiences:**
- Experience in residential projects.
- Experience in commercial projects.
- Experience in industrial projects.
- Experience in infrastructure projects.
- Experience in renewable energy projects.
- Experience in environmental protection projects.
- Experience in sustainability projects.
- Experience in marketing projects.
- Experience in financial projects.
- Experience in legal projects.

**Consulting Skills:**
- Architectural skills.
- Engineering skills.
- Construction skills.
- Consulting skills.
- Project management skills.
- Sustainability skills.
- Environmental skills.
- Marketing skills.
- Financial skills.
- Legal skills.

**Consulting Areas of Expertise:**
- Residential design.
- Commercial design.
- Industrial design.
- Infrastructure design.
- Renewable energy design.
- Environmental protection design.
- Sustainability design.
- Marketing design.
- Financial design.
- Legal design.

**Consulting Fees:**
- Hourly rates.
- Project rates.
- Retainer rates.
- Consulting rates.

**Consulting Awards:**
- Awards for residential design.
- Awards for commercial design.
- Awards for industrial design.
- Awards for infrastructure design.
- Awards for renewable energy design.
- Awards for environmental protection design.
- Awards for sustainability design.
- Awards for marketing design.
- Awards for financial design.
- Awards for legal design.

**Consulting Resources:**
- Architectural resources.
- Engineering resources.
- Construction resources.
- Consulting resources.
- Project management resources.
- Sustainability resources.
- Environmental resources.
- Marketing resources.
- Financial resources.
- Legal resources.

**Consulting Referrals:**
- Referrals for residential design.
- Referrals for commercial design.
- Referrals for industrial design.
- Referrals for infrastructure design.
- Referrals for renewable energy design.
- Referrals for environmental protection design.
- Referrals for sustainability design.
- Referrals for marketing design.
- Referrals for financial design.
- Referrals for legal design.

**Consulting References:**
- References for residential design.
- References for commercial design.
- References for industrial design.
- References for infrastructure design.
- References for renewable energy design.
- References for environmental protection design.
- References for sustainability design.
- References for marketing design.
- References for financial design.
- References for legal design.
### Commentary

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<th>Design Standards to be used</th>
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<tr>
<td>Definition of system requirements and key assumptions</td>
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<tr>
<td>Analytical options and requirements and system concepts and design report generating standards and services for electrical services</td>
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6. Costing only on per m² basis
5. No coordination completed at this stage
4. Learning at this stage unlikely to result in a like-for-like comparison on similar projects
3. Concept and preliminary design phases are often subjective options
2. Agreement between client and engineer/consultant
1. To achieve clean brief and to review/consider

### Deliverables

- Reports:
  - 600x900mm drawings
  - NZ industry guidelines
  - NZ industry guidelines

- Specification:
  - Plant room requirements and services for electrical services
  - Electrical drawings (may comprise marked-up)

- Drawings:
  - 600x900mm drawings
  - NZ industry guidelines

### Design Process

- Concept Design/Phases
  - Project delivery methodology
  - Site and environmental condition assessments
  - Survey information
  - Environmental site reports
  - Project team schedule
  - Architectural Sextis owner's
  - Clean brief and budget

### Electrical Services

- NZ Industry Council (CIC)
<table>
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<th>Concept Design Phase</th>
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<td>Documents:</td>
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<td>Site visit</td>
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<tr>
<td>Definition of system descriptions and applicable codes and standards</td>
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<td>Site and environmental conditions</td>
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<tr>
<td>Concept service brief to establish applicable applicable options and recommendations and system concepts and broad range of viewing</td>
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<td>Pre-award procedure report</td>
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<tr>
<td>2. Acquire roles and responsibilities</td>
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<td>3. Conceptual and preliminary design phases are often</td>
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<td>4. Finalising at this stage unlikely to result in the final</td>
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<td>5. The concept phase component at this stage</td>
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<td>6. Costing only on per m² basis</td>
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Design HVAC Services

Industry Council CIC
NZ Construction
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<tr>
<td><strong>Design Documentation Guidelines</strong></td>
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</table>

- Review concepts for significant and unusual health and safety risks inherent to the design.
- Establish criteria to support the design.
- Establish design criteria for hydraulic services.
- Establish design criteria for the project.
- Review of client requirements.
Appendix C – Concept Design Drawings

Drawing List:

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<th>Drg No.</th>
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<td>AR101</td>
<td>Proposed Housing, Toilet and Kitchen Plan</td>
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<tr>
<td>AR131</td>
<td>Housing and Toilet Elevations</td>
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<td>AR131</td>
<td>Kitchen Elevations</td>
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<td>AR151</td>
<td>Housing, Toilet &amp; Kitchen Roof Plans</td>
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<td>AR201</td>
<td>Housing &amp; Toilet - Proposed Fitout Plan and Sections</td>
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<td>Kitchen Area - Proposed Fitout Plan and Sections</td>
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<td>EL010</td>
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<td>EL100</td>
<td>Lighting Layouts</td>
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<td>EL200</td>
<td>Power &amp; Coms Layouts</td>
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<td>HY010</td>
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<td>HY100</td>
<td>Kitchen &amp; Toilet - Water &amp; Sanitary Layouts</td>
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**Floor Schedule**

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<tr>
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<td>02</td>
<td>SOLID CONCRETE FLOOR WITH OPTIONAL TILED FINISH</td>
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<td>03</td>
<td>EXTERNAL PINE SLAB PANEL FLOOR</td>
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**Wall Schedule**

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<tr>
<td>01</td>
<td>120mm EXTERNAL WALL: 15mm EXTERNAL PLYWOOD FINISH - 65mm RAMMED EARTH CORE - 20mm FOAM OR POLYSTYRENE INSULATION - 15mm INTERNAL PLYWOOD FINISH</td>
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<td>02</td>
<td>75mm RIGID INTERNAL PARTITION: 15mm PLYWOOD FINISH - 45mm RAMMED EARTH CORE - 15mm PLYWOOD FINISH</td>
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<td>03</td>
<td>75mm SOLID BRICK WALL WITH OPTIONAL 10mm TILED INTERNAL FINISH</td>
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**Window Schedule**

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<td>W2</td>
<td>DOUBLE GLAZED, DOUBLE PANE WINDOW WITH TIMBER FRAMING</td>
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<tr>
<td>W4</td>
<td>SINGLE GLAZED, TRIPLE PANE WINDOW WITH TIMBER FRAME</td>
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**Door Schedule**

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<td>D2</td>
<td>710mm INTERNAL WOODEN DOOR - SINGLE SWING</td>
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<tr>
<td>D4</td>
<td>1420mm EXTERNAL GLAZED DOOR WITH ALUMINIUM FRAME - DOUBLE SWING</td>
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**Proposed Housing, Toilet, and Kitchen Plan**

- **Floor Type 1**: Used in certain rooms for flooring.
- **Floor Type 2**: Specific type used for certain areas.
- **Floor Type 3**: Another type with unique specifications.

**Communal Kitchen**

- Includes wooden patio for evening dining.

**Generator Enclosure**

- (FUTURE) - Indicates a feature that is planned but not yet implemented.

**Team 'NUTS & BOLTS'**

- Concept Design: SA, RM
- Date: 10.06.2011

**EWB Design Challenge 2011**

- **Devikulam Housing Project**
- Proposed housing, toilet, and kitchen plan.
House floor to be elevated to 1500mm above ground, to prevent flood water damage during wet season.

Timber staircase and hand rails

Roof gutter for stormwater management

Ø50mm downpipe connected to roof gutter. Stormwater to drain off into nearest drain.

Air extract louvers @ high level

Air intake louvers @ low level

Toilet floor elevated to be elevated at 300mm above ground level, to minimize risk of flood damage during wet season.
Communal Kitchen

10 ISLAND/BENCH Ø50mm DOWNPIPE FROM ROOF GUTTER. TO RUN OFF INTO NEAREST STORMWATER DRAIN.

DINING TABLE

KITCHEN SINKS/BENCH

KITCHEN STOVES FRIDGES

MICROWAVE

OVERHEAD CUPBOARDS

OVERHEAD CUPBOARD

BENCH

PANTRY SHELVES

GAS BOTTLES

WATER TANK

HOT/WARM WATER PUMP

ROOF ACCESS LADDER

CHAINLINK FENCE

COMPOUNDING GAS BOTTLES AND WATER TANK

PATIO FOR ADDITIONAL SEATING / EVENING DINING

Model Ref: DESIGNED DRAWN APPROVED

SCALES: 1 : 50 @ A1

1 : 100 @ A3

TEAM 'NUTS & BOLTS' AUT

EWB DESIGN CHALLENGE 2011 DEVIKULAM, INDIA

DEVIKULAM HOUSING PROJECT

KITCHEN AREA - PROPOSED FITOUT PLAN AND SECTIONS

TEAM 'NUTS & BOLTS' AUT

EWB DESIGN CHALLENGE 2011 DEVIKULAM, INDIA

CONCEPT

DEVIKULAM HOUSING PROJECT

KITCHEN AREA - PROPOSED FITOUT PLAN AND SECTIONS

TEAM 'NUTS & BOLTS' AUT

EWB DESIGN CHALLENGE 2011 DEVIKULAM, INDIA

CONCEPT

DEVIKULAM HOUSING PROJECT

KITCHEN AREA - PROPOSED FITOUT PLAN AND SECTIONS

TEAM 'NUTS & BOLTS' AUT

EWB DESIGN CHALLENGE 2011 DEVIKULAM, INDIA

CONCEPT

DEVIKULAM HOUSING PROJECT

KITCHEN AREA - PROPOSED FITOUT PLAN AND SECTIONS

TEAM 'NUTS & BOLTS' AUT

EWB DESIGN CHALLENGE 2011 DEVIKULAM, INDIA

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NOTES:
1. All external light fittings are fed directly from the MSB and controlled via time clock inside the MSB.
2. Refer to the design report for luminaire schedule.

CONCEPT DESIGN

SA, JL 10.06.2011

TEAM 'NUTS & BOLTS'
AUT

EBW DESIGN CHALLENGE 2011
DEVIKULAM, INDIA

ELECTRICAL SERVICES
SITE POWER DISTRIBUTION
AND EXTERNAL LIGHTING
NOTES:
1. All light fittings in the house and toilet areas are fed from the local DB. A minimum of two circuits to be used for lighting to prevent total lighting failure.
2. All light fittings in the kitchen area are fed directly from the MSB.
3. Refer to the design report for luminaire schedule.

1. HOUSING & TOILET - LIGHTING LAYOUT
   Scale 1:50 @ A1, 1:100 @ A3

2. KITCHEN AREA - LIGHTING LAYOUT
   Scale 1:50 @ A1, 1:100 @ A3

NOTES:
1. All light fittings in the house and toilet areas are fed from the local DB. A minimum of two circuits to be used for lighting to prevent total lighting failure.
2. All light fittings in the kitchen area are fed directly from the MSB.
3. Refer to the design report for luminaire schedule.
NOTES:
1. ALL HOUSING AND TOILET POWER OUTLETS TO BE FED FROM THE LOCAL DB.
2. ALL KITCHEN POWER OUTLETS ARE FED DIRECTLY FROM THE MSB.
3. ELECTRICAL CONTRACTOR SHALL PROVIDE ADEQUATE CIRCUITING OF THE POWER OUTLETS. NO MORE THAN 6 DOUBLE OUTLETS (SINGLE PHASE) SHALL SIT ON ONE CIRCUIT. ANY / ALL THREE PHASE OUTLETS WILL HAVE A DEDICATED CIRCUIT.
4. ALL COMMS OUTLETS ARE SUPPLIED FROM THE MAIN DISTRIBUTION FRAME IN THE KITCHEN AREA.
This drawing is confidential and shall only be used for the purposes of this project.

DATE
No. DESCRIPTION APPD

A1

DEVIKULAM HOUSING PROJECT

TEAM 'NUTS & BOLTS' AUT

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DATE BY No. DESCRIPTION APPD REVISIONS CHECKED CHECKED DATE

CONCEPT DESIGN

TOILET - PERSPECTIVE VIEWS

TOILET FRONT VIEW

TOILET BACK VIEW

TOILET INTERIOR VIEW

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