Project Malachi: Adapting Shipping Containers for Temporary Housing Solutions

CEGEG015/CEGEM009/CEGEG139: Collaborative Project
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Introduction

In the UK, it is estimated that there are 307,000 people living without shelter or adequate housing is (Butler, 2017). One of the main reasons for this is housing supply and availability (JR Foundation, 2003). When the Salvation Army (SA) received a £5 gift from five year old Malachi Justin, who requested his gift from the tooth fairy be given to the homeless, they established Project Malachi. This project aims to provide temporary housing solution for rough sleepers seeking who need support integrating into formal systems which require permanent address. Having acquired a plot of land in Ilford, London for a 5 year period, the SA plan to build housing units made of shipping containers.

This study aims to advise how Project Malachi can be a more sustainable project that can educate the local community and also modify the existing steel containers so that they are habitable.

Site & Architectural Plans

As can be seen in Figure 1, the building area highlighted in red is located in Ilford, a town in east London. It is near the Chadwick Road and Postway Mews with a nearby large-sized car park, and it is surrounded by several residential buildings.

The residence for the homeless will be built as a four-storey building made up by standard 20ft shipping containers as illustrated in Figure 2. In the design scheme given by the SA, there are 44 rooms, including rooms for those who may be mobility impaired and a large cycle centre which is used for skill training and recycled bike storage as shown in Figure 3. A laundry and an office (reception) are also included. The typical arrangement of the rooms is shown in Figure 4. The typical room is 12 m² and includes a kitchen and bathroom. The roof is planar which can be used to install solar panel, wind turbine or for roof garden.

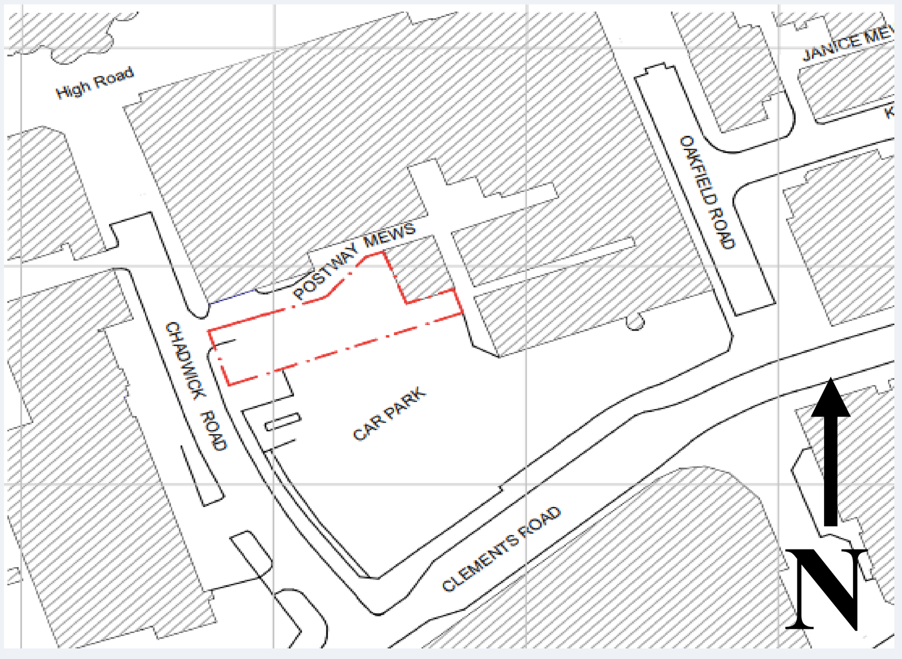

Figure 1: Proposed site for Project Malachi

Figure 2: North Elevation of proposed building

Figure 3: Ground floor layout & landscape

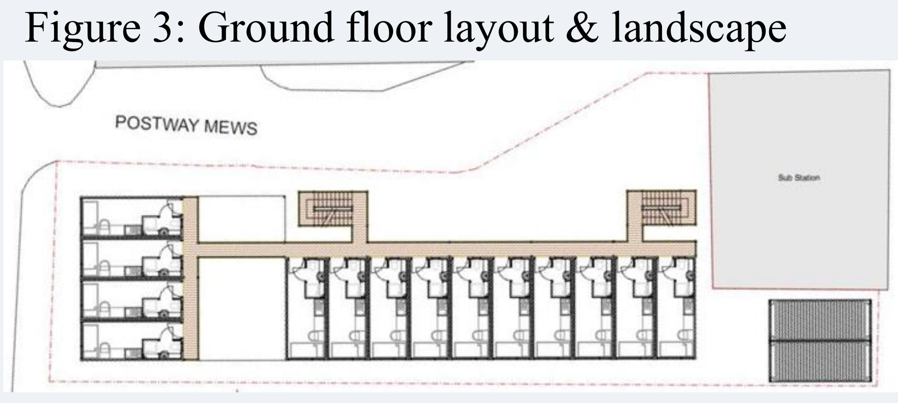

Figure 4: Typical room layout

Building Services & Heating System

In the UK, new residential buildings must meet Building Regulations Part L1A & F (HMG, 2013). These cover the Conservation of fuel and power in new dwellings and Means of ventilation respectively and define the necessary conditions to be suitable for occupation and efficient. SAP 2012 software was used to demonstrate compliance with only 740 kg of CO2 emitted per annum.

Initially, a detailed investigation was done on the various types of heating systems available on the market. This covered systems using fossil fuel, solar and wind as energy sources as well as connection to the grid for electricity. It was found that using gas as the main heating source, the energy costs would be the cheapest. A gas boiler was then sized on the assumed heat loss from the steel shipping container and was found to require a 7.8 kW boiler for each room. It was identified that the high heating requirement was above that recommended by CIBSE Guide F for residential buildings, and methods should be investigated for minimising heat loss.

The following insulating fabric parameters were then recommended:Walls, 0.14 W/m²k; Floor & Roof, 0.1 W/m²k; Windows, 1.4 W/m²k and Door, 1.5 W/m²k. To comply with Part F and stay within TM59 overheating limits as modelled in IES VE 2017, background Mechanical Ventilation with Heat Recovery (MVHR) is recommended.

Outdoor Air Quality

Good air quality is very important to human health. Based on the outdoor air quality evaluations, it can be concluded that the outdoor air quality in the area where the units will be set up is good. This can be seen in Figure 5 which shows an outdoor air quality model of the annual mean NO_2 from 2013., the marker indicates the proposed site. Hence, it is very possible that indoor air quality will also be good. It is not possible to improve the outdoor air quality, but indoor air quality can be enhanced by applying various systems, such as source control, HVAC system and filtration.

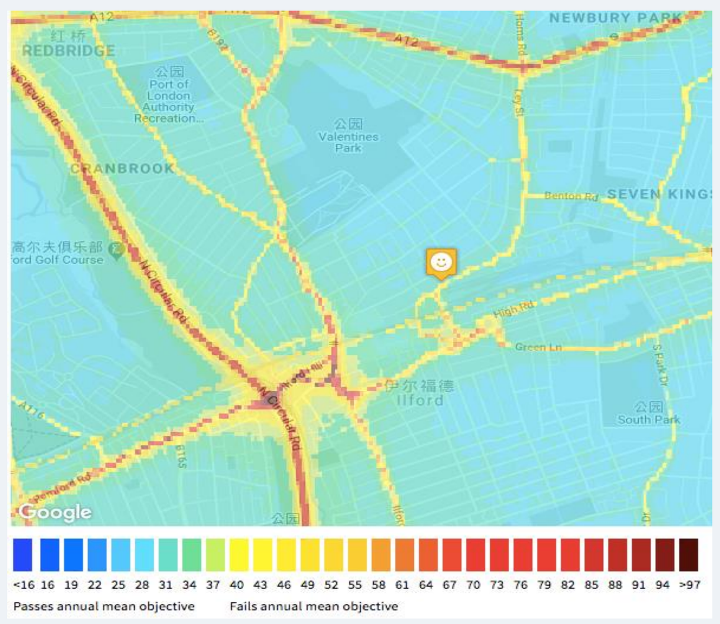

Figure 5: Annual mean NO_2 Accessed from: londonair.org.uk

Wind Energy

It was found that single small turbines, especially roof mounted ones are one of the fastest growing sources of energy globally. Moreover, the roof mounted turbines designated for project Malachi fall within the parameters of specification. The recommended unit for this application was the SWIFT 1.5. This wind turbine will cost £1,500 with a payback period of just under 8 years. Therefore this will be just outside the tenure of the land, but if the plans to transport the scheme to multiple locations remain then the benefits will outweigh the costs as well as providing a low carbon source of energy.

Solar Energy

A solar photovoltaic system normally consists of 14 to 18 panels and provide roughly 3400kWh of power in London, UK (Louwen et al., 2016). A total number of 6 systems can be installed based on the roof top area of the shelter campsite, above the aquaponics roof system. The proposed system can not only provide enough energy for 40 containers and the energy needed for the site, there is also excess energy produced to power other application suggested by my colleague. It was found that £27,700 would be saved from electricity connection including FIT government subsidies over the solar panels lifetime.

Grey Water Collection and Treatment

Grey water which makes up about 55-60 % of waste water, could be recycled in project Malachi. It is estimated to be able to reduce the water usage by about 40% in this project. The bio-mechanical treatment system, which is considered to be the most efficient system was chosen in this project to avoid the odour and noise issues during treatment. The estimated cost of the treatment system is about £3000 in total and the payback period is estimated to be under 5 years.

To treat the water collected, both UV disinfection and reverse osmosis systems would ensure drinking water quality is at the national standard. The devices would be installed near the greywater system which is situated at the back of the shipping container building shown in Figure 6 at a total cost of roughly £2000. The maintenance cost of the whole system is about £120 per year, and would need maintenance every two to five years.

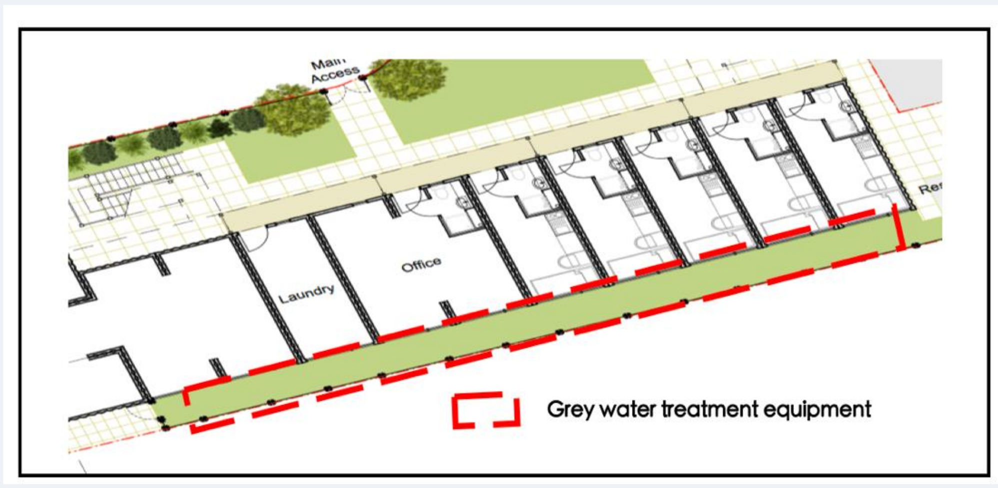

Figure 6: Grey Water Collection & Treatment Point

Rainwater Harvesting System (RWHS)

Another option to sustainably manage water is the implementation of a RWHS. Using the total roof area of 270 m² and the average rainfall of 755.5 mm per year, a tank of 7,500 L was chosen to meet needs which could be located underground. The cost of the tank would be £3,800 and a payback time of 4.8 year was calculated.

Aquaponics System

For Project Malachi, it is suggested that the aquaponics system functions not only as a sustainable roof garden, but also as a food source (vegetable production), a leisure platform (fish farming) and a working platform for the residents. The system is established in a hope to provide social and technical skills.

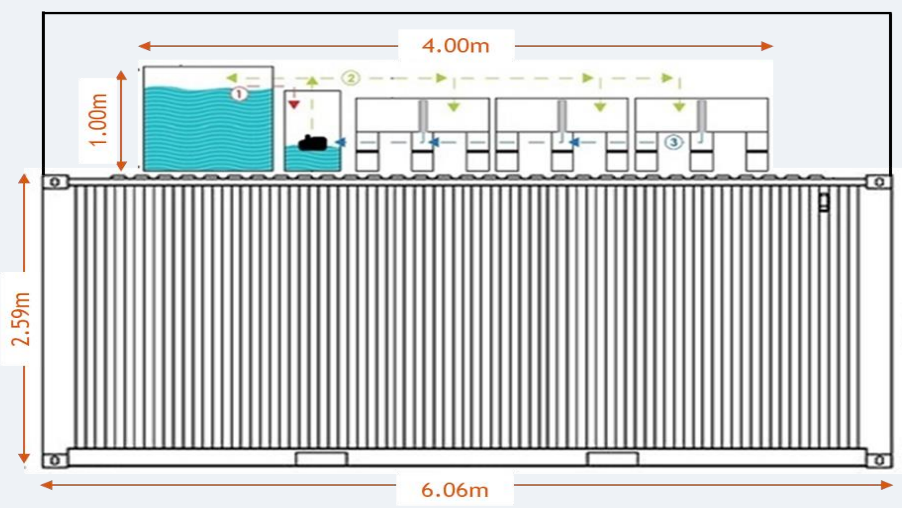

Figure 7: Aquaponics system shown on container

The total cost of running the system is approximated to value at £4590 per year with an initial construction cost of £2010. Running costs can be further reduced with the utilization of renewable energy to support the electricity consumption and heating system. Due to the limited land area on site, the system is suggested to be installed on top of the highest stackable containers, the size of the system is shown in Figure 7.

Collaborators logos

THE SALVATION ARMY

The Engineering Exchange