Sustainable Construction and a Community-based Dry Toilet

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ABSTRACT

In the spring of 2006 the Beacon Hill Allotment and Leisure Gardeners Society in Cleethorpes, Lincolnshire, United Kingdom initiated a process of revitalisation and community-development. A flagship project has been the design and construction of a dry toilet facility.

The community dry toilet embodies both ecological and social sustainability. The allotment society contracted Hill Holt Wood, an award winning social enterprise committed to sustainability, to manage the design and construction processes. As well as being an ecological designer and builder, Hill Holt Wood provides vocational training to 'disengaged' youth.

From a sustainable construction perspective, the building structure used several techniques: straw bales, green oak timber framing, lime-cement render and plaster and various recycled materials such as reused sinks and car tyres manufactured into 'slate' tiles for the roof.

The ecological impact of the building was also considered from the standpoint of what the structure will provide: nesting spaces were integrated into the building to provide rare songbird habitat while the 'compost' produced in the toilet will fertilise fruit trees growing adjacent to it.

The Beacon Hill Allotment dry toilet project approaches sustainability from both ecological and social points of view, it is not just a matter of 'what' is built but 'how'. The dry toilet was a key part of a revitalisation program at the gardens. Not only was the structure made using very low impact construction techniques but the building design and construction contributed to a sense of ownership in the gardens and

increased participation of women in the allotment society. The architectural plans and construction process results will be presented in detail, as well as best practise recommendations for future projects.

When necessary the youth were billeted in the homes of allotment members during construction, simultaneously building local community connections and the dry toilet.

The ecological footprint of the materials and energy saved from primary sourcing during construction was calculated and will be presented.

INTRODUCTION

Dry toilets represent a significant technology in the design and construction of a sustainable built environment. While there use remains commonplace in many parts of the world, their presence has become virtually extinct in the North America and the United Kingdom. The advent of the ‘water closet’ and indoor plumbing in the nineteenth century, followed by the suburbanisation of cities after the Second World War, coupled with Victorian-era social values that labelled human waste as taboo, resulted in the dry toilet technology being almost extinguished.

The ‘west’ embodied by North America and the United Kingdom can no longer afford to ignore dry toilet techniques. The global environmental crisis is seen as reaching dire proportions in the next century. Climate change coupled with numerous other vectors of environmental degradation are seriously affecting more communities and regions. The continued exportation of large-scale sewerage system methods is no longer practicable in the context of sustainability.

Large-scale sewerage infrastructure requires huge capital investments, massive amounts of fresh potable water, creates very serious water pollution along rivers and coastlines and finally, represents an enormous loss of resources in the form of nutrients that could be recycled into fertilisers on fields contributing to the food production cycle. However at present the United Nations continues to drive a program to halve the number of people in the world who lack clean drinking water and modern sanitation by 2015. Taking into account population growth, this goal means connecting to sewerage infrastructure, 400, 000 people every day for the next 9 years [1].

Given the enormous financial cost of these projects who are generally awarded to water industrialists, and the ecological costs including the abstraction of freshwater, it is fast becoming not a choice but a necessity for governments and planners to consider ways that water can be conserved and the use of multiple strategies to deal with potable and domestic water and sewerage demands. There is considerable evidence that clean water will be the ‘blue gold’ of the 21st century, being the resource whose scarcity will lead to conflicts between nations for control of supply. The commodification of water is a process that has definitely been initiated over the past decade and this is only likely to continue. Finally, the previously mentioned vagaries of climate change indicate that historical water patterns are changing and droughts may happen with increasing frequency and ferocity, at the very least it is prudent to begin designing and building our communities to decrease their freshwater demands and to recycle locally available nutrients.

Within the abovementioned context are related questions of the built environment. The majority share of energy and materials used in the United Kingdom are used for the construction and maintenance of the built environment, particularly buildings. The creation of sustainable communities also means that considerable effort and thought are required to develop low-impact methods and materials of construction for buildings with best practise design for low energy operation.

This paper examines a very small scale project that combines both of the issues identified, a dry toilet built using sustainable construction design and techniques, and attempts to quantify the ecological footprint of the materials and processes used. The paper also incorporates questions of social sustainability in terms of educating people and working with youth in these methods and techniques.

The project was located in a large garden allotment in the East of England.

METHODS

This study involved both quantitative and qualitative values. The qualitative aspect of the study concerned the people involved with the project and how the construction of a dry toilet within a sustainably constructed building affected them.

Qualitative methods

An Eco-loo also speaks to the values embodied by the Allotment Associate, that of a community's connection to the land and growing one's food while meeting with one's neighbours. During the design process the Beacon Hill Allotment and Leisure Gardeners Society agreed that the following statements were the foundations of the building's design and purpose:

- Sewerage: As the Beacon Hill Allotment has no sewerage services and the cost of installation for a single loo is prohibitive, a compost loo provides a hygienic and cost-effective solution

- Functionality: the primary purpose of the building is utilitarian there were no lavatory facilities available on the allotment. A basic facility such as this was an obvious requirement so that allotment members can comfortably stay on site for longer periods of time without discomfort. Furthermore, there is an increasing number of women allotment holders for whom 'visiting the bushes' is not an option.

- Demonstrative: This proposal goes beyond being just a 'compost loo' to becoming an eco-loo by virtue of its holistic design using low-impact construction techniques

- Educational: The building is intended to be a 'classroom' about compost toilets. There will explanatory signs describing compost toilets, rainwater harvesting, sustainable construction technology. Ultimately the intent of the building is to also facilitate education and encourage discussion.

- Community Building: This proposed structure will be the first 'community service' for the allotment society. As such, it is hoped that by providing sewerage on-site the allotment community will attract new users from previously underrepresented social groups. The building will help to create a sense of 'community' at Beacon Hill via the social goodwill represented by the Society to provide such a facility.

- Artistic: While many of the materials used in this building are unfamiliar to people today, they are all vernacular materials that have been used for generations. The external walls, finished with lime render and recycled paint will also permit a level of creativity.

Quantitative methods

Quantitative analysis was used in the design process of the toilet to ensure that the vault chamber size would of a sufficient volume and to estimate the quantity of rainwater that would be captured and made available.

The rainwater will be captured from the roof by reused plastic guttering along the sides and bottom of the roof. The guttering pipes will transport the water to a plastic catchment tank on the lower level of the composting toilet.

Rainwater Harvesting: Using averaged weather data from the UK Meteorological Office, the following prediction was made regarding the probable amount of rainwater that could be theoretically harvested (with a Coefficient of Performance of 0.7 or 70% system efficiency) from a 27.5m^2 roof at this location.

Table 1. Annual Rainwater Volume - Cleethorpes, Lincolnshire, for a 27.5m^2 area roof [4]

Month	m^3 / month
January	0.92
February	0.76
March	0.92
April	0.85
May	0.89
June	0.90
July	0.79
August	1.00
September	0.95
October	0.84
November	1.16
December	0.93
Total	**10.91**

Chamber Size: The two compost storage chambers are sized, at approximately 1.0m^3 each, according to the following calculation of use over a year period. The used average weight of faeces per person per day was 300g [2]:

Table 2. Calculated user regime and equivalent waste weight generated for the Beacon Hill dry toilet.

User Regime			
Months	**Number of Uses/day**	**Total Weight (kg)/day**	**Total Weight (kg)/yr**
March - October	3	0.9	328.5
November - February	1	0.3	109.5
Total			438

The density of faeces is given as 1.0kg/dm^3. Therefore the total volume by weight produced per year is 0.438m^3. The two compost storage chambers are sized at approximately 1.0m^3 each.

This project aimed to provide an ecological construction within the commercial limitations of a commercial build. There were materials used, such as concrete blocks, that have ecological alternatives but due to cost considerations were not specified. It is challenging to calculate the full Life Cycle Analysis of any project because it is difficult to define where to start and stop considering an energy flow as a part of a building. The concept of embodied energy illustrates that true energy cost accounting must follow the full life of a material and its processes. While this concept is straightforward in theory, it is very difficult to apply. This method simply accounts for the energy saved in the use of locally-produced, reused and recycled materials in this build.

Figure 1. Locally source green oak frame and strawbales.

Table 3. Schedule of sustainably sourced materials used for Cleethorpes dry toilet

Material	Quantity	Source
Strawbales	45 bales	Local
Timber: Oak	$0.54m^3$	Local
Guttering Downpipe + fittings	4m 3m	Reused
Urinal	1 - Plastic	Reused
Sink	1	Reused
Door	1 (1m wide min)	Reused
Windows	1 – 750mm x 300mm 4 – 700mm x 600mm	Reused
Paint	$80m^2$	Upcycled
Ardesia Tiles (recycled car tyres)	$20m^2$	Merchants
Toilet Seat	2	Merchants – Foresty Stewardship Council

RESULTS

It is very difficult to precisely quantify the primary and embodied energy saved by the use of local, recycled, reused and sustainably produced materials in this structure. Much like dry toilets themselves, it can absolutely be stated that there use does save materials and energy and that they contribute to the development of a sustainable society. This relationship can be conclusively demonstrated via comparisons of the embodied energy of the wood used in the structure.

Table 4. Energy requirement for manufacturing and producing local hardwoods versus imported softwoods [5].

Material	kWh/ m^3	kWh in structure
Timber-local green oak	220	88.8
Timber-imported softwood	754	905

Therefore, while the green oak formed the main structure of the building, in was the finishing elements that required a far larger energy input in their manufacture. The use of the local hardwoods resulted in 407KWh of embodied energy being saved in the structure.

Figure 2. Front and side elevation of dry toilet; combination of local hardwoods and treated softwoods signify large differences in embodied energy.

DISCUSSION AND CONCLUSIONS

This project was innovative and provided a structure that serves an ecological purpose while also exemplifying the growing field of ecological construction.

From a qualitative perspective the results of the project are that the allotment holders have a building that is interesting both in its purpose and its construction. The dry toilet makes the site more accessible to women, disabled and the elderly and it has encouraged the uptake of allotments on the site. The dry toilet also serves to normalise the use of dry toilet technology and understand its purpose to the allotment holders while also educating other people who come to the site. The company involved in the actual construction learned valuable lessons in ecological design and construction while providing important vocational training for disadvantaged youth.

The quantitative results indicate that ecological construction is difficult to achieve and that like any process of social change small steps will be required. While the main body of the building – the wooden frame and strawbale walls are locally sourced, there is still considerable embodied energy in the mechanical farming of land with fuel and fertiliser inputs, there are also fuel costs associated with working the wood. There were approximately 700 miles driven to and from the site during the course of construction. As well, there were: 3 tonnes of sharp sand, 1 tonne of gravel aggregate, 300kg of portland cement, 150kg of lime powder, 1.2 m^3 treated softwood, 34m of plastic piping and guttering and a water butt used in the construction of this building that were simply purchased from the local builders merchants. There are no controls or certifications for these materials and while the sand and aggregate are likely to be locally sourced, the process of extraction has ecological impacts and the softwoods employed are certainly very unsustainably sourced with significant ecological costs and pollution in their treatment, finally the embodied energy of plastics production is extremely high. The combined impact of all these materials and the transportation results in a significant ecological impact from the construction process of the building. However this impact was reduced by the design and materials specification. Furthermore, there is a social impact from the construction that cannot be quantified, in terms of consciousness raising and the learning from having undertaken the project.

Figure 3. Allotment community open dry toilet

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