Demonstrations of Sustainability in Construction

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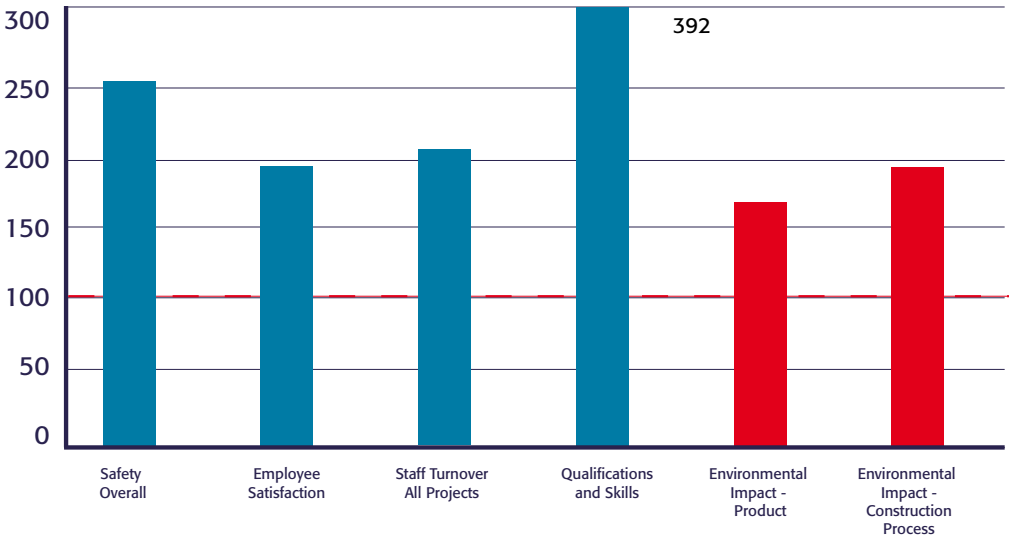
Introduction

Jon de Souza
Director of Member Services

I am absolutely delighted to be able to present this new publication from Constructing Excellence. The case studies found within this document are part of a growing evidence base that indicates how construction businesses can best engage with the sustainability agenda. Much of that evidence base sits within the Constructing Excellence Demonstration programme. That programme has been operating since 1998 and, from the outset, we have seen a commitment to sustainability from across a wide range of projects as evidenced in our earlier publication Demonstrations of Sustainability (2005). Over the last three or four years the number of Demonstration projects that have addressed sustainability, especially environmental issues, has grown exponentially. The nine projects within this document are a selection of the non-residential building and infrastructure projects with which Constructing Excellence has worked over the last twelve months.

What has been notable over the life of the programme is that the Demonstrations have clearly outperformed the rest of the sector across the suite of industry Key Performance Indicators. However, the greatest differentiators between the Demonstrations and the rest of industry have been in what have traditionally been considered as softer issues for the sector; this is evidenced by the performance gap on the respect for people and environmental indicators. The data published in June 2008 showed that the Demonstrations achieved:

- 2.5 times better performance than the industry average for health and safety
- 4 times better performance than the industry average in qualifications and skills
- 2 times better performance than the industry average in environmental impact



Demonstration v Industry 2008

CE 2008 Industry 2008 = 100

People and Environment KPIs

Demonstrations outperform industry by an average of 64%

So, why did the Demonstrations achieve this admirable level of performance? From the knowledge that Constructing Excellence has collected over the ten years of the Demonstration programme, we are able to draw some strong conclusions as to the processes and practices that impact positively on environmental performance. The overarching message from the Demonstrations is one of integration, integration, integration. It is clear from the evidence contained within this document and from elsewhere in the Demonstration portfolio that it is only where there is early involvement of relevant supply chain partners; selection by value rather than lowest cost and an ethos of collaboration, trust and team-working that environmental performance can be maximised.

The second common thread running through the Demonstrations is that of client leadership. In all cases within this document, environmental performance was a key client driver from the outset of the project. This client leadership has enabled an investment to be made (where necessary) in measures to improve sustainability performance. These enlightened clients have understood the causal relationship between sustainability and whole life costs and have embraced the notion that making an increased capital cost investment can bring about significant savings over the life of any building / facility.

The final common thread running through a number of these projects is that there is a demonstrable commitment to the value agenda – the idea that a well designed and constructed facility can bring about significant benefits for those that use it, be that the school that brings about better student attainment or a reduction in truancy, the hospital that sees faster patient recovery times or the office development that causes improvements in workers' productivity. Research across the sector, including Constructing Excellence's seminal publication Be Valuable (2005) has demonstrated that there is a relationship between the quality of the built environment and its users and we are delighted to see that clients and their project teams are embedding this thinking in the way that they procure and deliver construction.

In the financial climate in which we find ourselves in early 2009, there is a real risk that sustainability will be the first thing to be cut in any value engineering exercise. I would urge anyone considering this course of action to think again. There are a plethora of measures that can be taken to improve sustainability performance at low or no cost and some examples of these can be found within this document.

The purpose of the Demonstration programme is to use the learning from forward-thinking projects to help influence industry change. As such I very much hope that you find this document useful and can take some lessons from it to help impact on the performance of your own organisation and its construction projects.

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demonstration project

Earthship Brighton from the West

Earthship Brighton

Client:	Low Carbon Trust
Case Study Ref:	330
Project Number:	3061
Publication Date:	October 2008
Region:	South East
Sector:	Sustainable Buildings
Contract Value:	£330,000
Project Timescales:	April 2003 - December 2006
Themes:	Sustainability

Domestic buildings account for 29% of the UK's total carbon footprint. The Low Carbon Trust was formed in 2001 to highlight the connection between buildings, the carbon emissions they produce and climate change it causes, through innovative construction projects and communications work.

Earthship Brighton was the Low Carbon Trust's first project and the first Earthship to be built in England. The project was designed to be a sustainable community centre for Stanmer Organics and sited within 17 acres of a country park near Brighton, East Sussex.

"Earthship" construction is a pioneering design and construction technique developed by Mike Reynolds of Earthship Biotecture and the residents of three Earthship communities in New Mexico, USA. Earthships are designed to be entirely self sustaining and "off grid". Solar panels and a wind turbine provide all the energy required by the development and rainwater and grey water are treated for reuse onsite using plants and filters. Energy and water conservation are also central to the technique and extensive energy efficiency and water conservation features are included throughout the building. Earthships are timber framed and earth sheltered to provide extra insulation. The walls are constructed using old car tyres, other waste materials and rammed earth.

The original Earthship model was designed to be a residential development and was adapted for the community centre. The project was funded by a combination of individual donations, public grants and corporate sponsorship.

Drivers for Change

The key drivers for this unique project were:

- To deliver a sustainable community centre in response to a genuine local need
- To change values in the construction industry
- To inspire positive action in individuals to generate environmental change through modifying people's behaviour to less carbon intensive lifestyles

The project was designed to demonstrate the possibilities created by an integrated approach to passive solar design, renewable energy, rainwater harvesting and on-site waste-water treatment. The project also aimed to inspire people to adopt less carbon intensive lifestyles.

Targets

The following targets were set for the project:

- To deliver the first Earthship in England
- To adapt an established design for a cutting edge eco-build to UK building regulations
- To pave the way for the use of whole car tyres in construction
- To successfully harvest and supply rainwater as potable water in a public building

Earthship Brighton during construction

Project Successes

Integrated Teams

To minimize costs the project team approached corporate partners, many of whom were suppliers of sustainable building materials. The corporate partners were essential to the success of the project as many donated free materials and services. By donating materials and services they were able to showcase their product in situ and were offered the chance to display their logo on the project website. The project team were able to obtain free glazing, roof materials, sun pipes, rainwater tanks and insulation amongst other things. The suppliers then benefitted from the high level of public interest and publicity in the project.

Raising Awareness

At least 8,000 people have been given tours of the project so far including 600 children, 160 people from the public sector, over 180 people from the construction industry and the former Secretary of State for the Environment, Rt Hon David Milliband MP and Sir Menzies Campbell MP. The tours included explanations of how the building was designed and constructed and the benefits of onsite water treatment and renewable energy generation. The project has also recently taken part in the "Eco Open Houses in Brighton and Hove" event which invited members of the public to tour and learn about low carbon developments across the area. As well as this, the team have disseminated the learning from the project by delivering CPD seminars to the Royal Institute of Chartered Surveyors and the Royal Institute of British Architects.

The unusual design and construction of the project has attracted extensive media attention. It has featured in over 140 mainstream articles including the front page of the Guardian and has appeared on television on programmes such as "Grand Designs". The project website www.lowcarbon.co.uk generates around 150,000 hits per month.

Training

The Earthship has served as an educational facility as well as a community centre for Stanmer Organics. Two and four day training courses on Earthship construction techniques were delivered to 124 people over the duration of the project. The construction phase of the project also provided volunteering opportunities for those interested in learning more about construction and sustainable development. The team intend to revive the training courses in the near future.

Post-Occupancy Review

The team are keen to monitor the success of the design features and renewable energy technology during the operational phase of the building. To this ends, the University of Brighton are currently undertaking a three year thermographic study to monitor the performance of the building. In addition, in future, the team would like to undertake a study to monitor the quality of the rain water capturing system.

Lessons Learnt

Design

The Earthship design originated in New Mexico and is best suited to an extreme climate. The design relies on inter seasonal thermal storage which captures the heat in summer and stores it for release in the winter. England has a more temperate climate which meant that the temperature in Earthship Brighton could be low in winter. The team felt that further insulating features such as under floor insulation, extension of the south facing sun space, further sun pipes and sky lights would have been beneficial and would also have increased the amount of natural light in the building.

Materials

Challenges associated with sourcing recycled materials and the costs of processing the materials meant that, in some cases, anticipated cost savings were not made and the final expenditure was comparable to the cost of virgin materials.

Carbon Reduction

A carbon footprinting exercise was conducted to assess the impact of the first phase of the project. It found that around 80% of the carbon impact of the build at that stage was attributable to the air travel of the American crew that trained the workforce in the Earthship building method. Now the project team have developed their own expertise, training will not be necessary for future projects. Another area of concern for the team was the use of cement which has high embodied carbon content. In their next project the team would like to investigate alternative products to replace the cement used to pack out the tyres. The specific design requirements of the project would make it unsuitable for use on a largescale residential development as specific site criteria must be met for the building to have sufficient energy generation and thermal properties.

Conclusions

Some of the team had no previous construction experience and the project presented an extremely steep learning curve. The method of building had not been used before in England and financial difficulties complicated matters further. In future, the team felt that time and money could have been saved by more detailed and informed budgeting upfront.

The successful completion of the project was dependent upon the exceptional commitment of the dedicated core team. Labour was provided on a voluntary basis and many of the project team supported the project financially. The project also enjoyed support from Brighton and Hove City Council who provided funding and assistance at the planning stage. Corporate partners were essential to the successful completion of the project as they provided materials and services at no cost. The exceptional media interest proved a useful tool for accessing further support and the team feel that they have been able to raise awareness of the project and of climate change issues far beyond expectations.

Awards

- The Low Carbon Network won an innovation award in the South East renewable Energy Awards 2005.
- Water Efficiency Awards 2007 – Inspiring Change - Finalist
- Water Efficiency Awards 2007 – Construction & Renovation - Commended
- Constructing Excellence Awards - Highly commended
- Green Apple Awards 2007 for Business - National Gold Winner
- South East Low Carbon Awards 2007 – Low Carbon Development of the Year Highly commended
- National Energy Efficiency Awards 2007 – Construction & Renovation Highly commended
- Earthship Brighton was the national Gold Winner of the "Green Apple Award" for the built environment and architectural heritage in the new build tourism category in 2007.
- RICS South East Awards 2008 – Sustainability category – highly commended

Further information about the project and the "Earthship" build techniques can be found at www.lowcarbon.co.uk and in the book "Earthships: Building A Low Carbon Future for Homes" by Mischa Hewitt and Kevin Telfer. Available at http://www.lowcarbon.co.uk/publications.

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Constructing Excellence
in the Built Environment
Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

Mischa Hewitt, Project Manager, Low Carbon Trust
T 07974 122 770 **E** info@lowcarbon.co.uk

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demonstration project

New Coastal Defence Revetment Works: Placement and Bedding of curved Precast Stepped Revetment Units to prepared Revetment Substructure

Cleveleys Coastal Defence Improvement and Promenade Enhancement Scheme

Contractor:	Birse Coastal
Client:	Wyre Borough Council
Funders:	Wyre Borough Council, Defra, Environment Agency, European Regional Development Fund
Case Study Ref:	329
Project Number:	2800
Publication Date:	October 2008
Region:	North West
Sector:	Civil Engineering
Contract Value:	£20m
Project Timescales:	October 2005 to March 2008
Themes:	Sustainability, Integrated Teams

Cleveleys is a small coastal town within Wyre Borough on the Fylde coast of Lancashire, four miles north of Blackpool. A partnership between Wyre Borough Council, Birse Coastal and other strategic partners was formed in March 2004 following an extensive, quality-based tender to improve flood protection to 8700 properties in the Cleveleys area and to upgrade Cleveleys' promenade. The project is Wyre Borough Council's largest ever civil engineering project and the first partnering contract it has let.

In addition the scheme was felt to be important because it was recognised as one of the highest priorities in England for flood risk. Analysis undertaken by Halcrow Group consulting Engineers in partnership with the Authorities own engineers of coastal structures, identified the defences at Cleveleys as needing major reconstruction. The scheme was fully supported by Defra and the Environment Agency.

The project was identified in the Council's Corporate Plan, in which a key target was to reduce the potential for coastal flooding to occur due to a breach of the Cleveleys sea defences from 20% to 2% by 2009. The council also incorporated targets of:

- Increasing satisfaction with public open spaces from 51% to 65% by 2008
- Redeveloping Cleveleys Promenade, completing phase 2 by 2007, and phase 3 by 2009.

The project team set targets above the industry average and 8 Key Performance Indicators which were monitored on a quarterly basis. Sustainability and environmental performance were measured as a key contract performance indicator (given extra relevance due to the pain/gain share in operation on the project). Birse also worked with all key partners to ensure that waste minimisation was also one of their key priorities.

Integrated Teams

The client recognised that early contractor involvement and integrated working were essential in delivering a successful scheme. Partners were incentivised by a pain/gain share arrangement and used an open-book, live cost monitoring system which could be reviewed and observed at any time. The success of the Cleveleys partnership was built on trust, understanding and shared objectives, and used a number of techniques such as team building exercises, joint steering group meetings, a project intranet and co-location of project staff. The team wanted to use an entirely non adversarial approach and found that early involvement was essential to this. They were brought together as much as a year prior to work beginning on site and the contractors were given the opportunity to input into the design stage of the project.

Use of Modern Methods of Construction

Concrete was used to create high quality, stylish public realm works to architecturally enhance the seafront and associated infrastructure works. Decorative techniques involving pigments, acid etching and exposed aggregate were used to create a high quality finish.

Birse Coastal was actively involved throughout the design period which allowed for innovative approaches such as the use of concrete precasting on high risk items such as revetments. The team wanted to prove that the project could be delivered using precast concrete units as a safe, cost effective, higher quality and more sustainable alternative to traditional solutions such as rock armour or in-situ concrete.

Precast units were manufactured using a high strength concrete (Tarmac Toproc C75) in a purpose-built facility, just 5 miles away from site, which allowed the team to take advantage of traditional manufacturing techniques such as just-in-time demand management and lean construction, this resulted in less waste and higher efficiency. It also allowed the team to maximise health, safety, quality and environmental benefits associated with off-site construction, whilst the close location of the facility significantly reduced haulage costs of the completed units to site.

An additional benefit of the precise solution was that no pollution occurred in the sensitive coastal environment. As concrete is precast off-site, there was no risk of washout from unset concrete and a greatly reduced number of vehicles required on-site. Where vehicles were needed on-site, strict procedures help protect the environment:

- No refuelling near the beach
- All equipment is regularly maintained to avoid oil spillage
- Extensive emergency procedures are incorporated into the site environmental management system.
- Beach regularly inspected and cleaned

Environmental Sustainability

An environmental toolbox talk was made mandatory for all site operatives as a follow up to their site induction. Areas covered included "being a good neighbour", "housekeeping" and "how to deal with spillages".

Minimising Waste

The Precast units were designed so that one 6m3 wagon filled one revetment mould or three 8m3 wagons filled 4 revetment moulds, which kept waste to a minimum. The controlled factory environment resulted in no waste due to weather or temperature.

An on-site crusher was used to process all demolition arisings for re-use within the works. In the early stages of the project, the team cleared significant volumes of debris in the form of concrete that had broken off the existing sea wall, steps and walkways along a several mile stretch along the beach. Surfacing from the old promenade was skimmed off, separated, crushed and reused as sub-base and capping material. As well as this, the concrete mix used for the precast units contained a high percentage of recycled material.

Once all opportunities for reuse had been exhausted, the remaining waste was segregated and sent off-site for recycling. No demolition waste was sent to landfill.

New Coastal Defence Revetment Works: Use of 135T Crawler Crane and Specialist Vacuum Lifting Unit to install 15.5T Precast Stepped Revetment Units during limited tidal working period

Vehicle Movements

The team attempted to source as much in the way of local materials and suppliers as possible. This included setting up a joint precast facility adjacent to a concrete supplier within Wyre Borough.

Tarmac suppliers also set up plants close to the site which helped to reduce the amount of vehicle movements used in the project. The Birse team carried out extensive monitoring of the vehicle movements delivering the off-site components to site. This data was then compared to existing data collected by Birse on traditional techniques.

Green Infrastructure and Biodiversity

One of Wyre Borough Council's key drivers is to maximise the use of open spaces. The Cleveleys coastal project helped achieve this through the creation of a new public amenity area known as Jubilee Gardens which included new play and games facilities.

Biodiversity issues were taken into account when planning works. For instance work initially started at the north end of the project to ensure that the migratory flight paths of local bird life were not disturbed. The project team also strived to raise public awareness of local wildlife and held a public awareness event in the new parkland.

Peat onsite caused unstable ground conditions which had not been identified by the original site survey. This could have caused major and expensive problems for the project team however Birse were able to identify a cost effective and sustainable solution to stabilize the ground. This saved the project up to £1m and was absorbed into the main programme so did not cause a time delay.

Low Energy and Renewable Technologies

Various low energy and renewable technologies were used on site:

- Wind turbines were installed to provide power back the national grid.
- Solar panels were installed to provide power for heating and lighting in the shelter areas.
- LED luminaires were used to provide energy efficient lighting.

Social Sustainability

The project participated in the Considerate Constructors scheme which involved regular review and assessment of key areas including environment, cleanliness, good neighbour and safety. Each assessment saw a consistently improved score and the team eventually achieved 38.5 out of a potential 40 points.

Community Consultation and Engagement

The team used a variety of communication methods to keep an open and informative dialogue with the public, for instance:

- The wider public consultation included public involvement in the selection of the winner of the architectural competition for the details of the promenade behind the new defences.
- A public liaison hut, which was accessible to wheelchair users, was established on-site to provide information to the public. It featured a "window on the works" so members of the public could view work as it progressed. Activities and competitions were provided for children.
- Display panels showed the history of the promenade, the design of the new scheme and progress of the works. An accompanying website showed photos of the progress made by the team and weekly written updates.
- A visitor's opinion book was made available for visitors to record their comments. Thousands of comments both positive and negative were assessed and a proactive implementation plan was put into place to actively respond to the public's detailed concern/praise.
- The local press and radio were also engaged to update the public on the progress and aims of the scheme.

The team also engaged with the local community by providing a quad bike and appropriate training for members of the beach patrol team. In addition, local opportunities for reuse of waste materials were identified, for instance, the original benches from the promenade were refurbished and donated to the local bowls club rather than being sent to landfill.

Skills and Local Labour

Local people were employed where possible in areas such as administration, security and skilled labour. Local labourers were taken on as trainees in trades on site. As well as this, three students were employed on the project to give them an opportunity to increase their skills. In total 75% of staff on the scheme lived within approximately 35 miles of the site. Birse also endeavoured to employ local suppliers. 76% of suppliers were located within a 25 mile radius.

Health and Safety

Coastal Defence projects are generally on exposed and unstable sites and carry a higher risk to health and safety of the public and site workers. Strict zero tolerance targets were set to provide safe working conditions in what could have been an extremely challenging and potentially hazardous working environment. Weekly safety meetings meant that any potential health and safety issues could be identified and thus prevented at an early stage and responsibility for project monitoring and continuing safety of workers and public was give to every member of the team. This resulted in there being no reportable incidents onsite.

Economic Sustainability

A customer quality plan of works combined with a Live Quality Alert System contributed to the high quality of the finished project. The time and cost savings made on the project were reinvested in improving the quality of the finishes and higher quality of material used on the promenade.

An innovative Efficient Method of Working was employed to minimise the risk to timescale and budget posed by tidal working. Tidal working section activities were combined with non tidal working activities to maximise production resource efficiency.

Topic	Target Score	Final Score
Health and Safety	81%	90%
Environmental Performance	67%	95%
Conformance to Programme	100%	100%
Quality of Work Target	78%	94%
Best Value for Money	77%	87%
Project Team Culture	70%	87%
Public Satisfaction	70%	93%
Innovation and Continuous Improvement	70%	92%

Key Success Factor

Early integration of the project team was identified as the key success factor in the project as it created an atmosphere of collaboration and trust. Monthly steering group meetings between client and contractor ensured open lines of communication and the open book approach meant that the whole team were working towards a successful outcome. From early inception the client and contractor worked as one team.

The new promenade has been developed for full accessibility, providing a high quality, safe environment for the user. Visitor orientation was a prime consideration in the design concept which incorporates features to entice the visitor along the length of the redeveloped promenade, providing focal points of interest, information, outlook and experience of the highest quality. The scheme has made a significant contribution towards increasing public satisfaction with open spaces, a key target of the Wyre Borough Council Corporate Plan. It has enjoyed a high level of public support, as evidenced by feedback from public consultation and the formation of the Cleveleys Seafront Partnership (an independent body comprising residents and local businesses to promote the seafront area).

The collaborative approach has proved so successful that Birse intend to use it on future projects. They have found that it creates a win win situation where both client and contractor are able to add value to the project.

Key Lessons

- Early contractor involvement and integrated working are essential for a successful outcome.
- Use of MMC can reduce the risk of environmental incidents on sensitive sites.
- Biodiversity issues should be addressed at the project planning stage to minimise disruption to local wildlife.
- Creative and open approaches to community consultation can improve the relationship between the project and the local community.
- Regular project meetings identify health and safety hazards early and so reduce the risk of incidents.

Awards

- Silver Award from the Considerate Constructors scheme which placed it in the top 2% of schemes in the country in terms of reducing the impact of the work on the environment, providing good facilities for employees and doing all possible to reduce the negative impact on the general public
- International Safety Award from British Safety Council for showing commitment to health and safety from the boardroom to the shop floor.
- British Construction Industry Environmental Award - October 2008

"A true team effort between client, funding agencies, contractor, designers, suppliers and the local people"
Richard Trevitt- Considerate Constructors Scheme

"Birse have produced a truly wonderful scheme of which all residents of Wyre can be very proud."
His Worshipful the Mayor of Wyre, Councillor Peter Hawley

"What a wonderful surprise we had today to see such a vast improvement here to Cleveleys Beach. Well done it is amazing in every way."
Eve and Dennis Hession,
comment written in public comments book.

Key Achievements

- The project was completed 61 weeks ahead of schedule. This phenomenal time saving was calculated from the original target completion in the scoping study by Halcrow and based on experience from previous schemes.
- The project team identified three key aspects that contributed to the time savings:
  - The use of precast high risk elements (including the revetments)
  - Improved understanding of project through early contractor involvement
  - Phased working through the winter and summer - only made possible with agreement through planning and consultation
- The project team were also able to achieve a saving of £1.417 million on whole life costs. The savings were derived from the independent auditors report, which indicated that the offer provided by Birse was 5% lower than other schemes. Evolving value engineering and design development continued throughout the scheme. For instance, the project included an "intermediate wave wall" which allowed the size of the walls to be reduced by 30% thus saving time and money. Standardisation of design principles for precast concrete unit design enabled excellent cost savings to be made without sacrificing quality. Savings were reinvested into the scheme which generated design enhancements.

Project Site Team captured following success of reaching 250,000 safe man hours worked mile stone. Team went on to achieve 390,000 + safe man working hours during the scheme

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CONSTRUCTING EXCELLENCE
in the built environment

Constructing Excellence
in the Built Environment
Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

Birse Coasta

Wyre Borough Council
LIVE WYRE LOVE WYRE

Caroline Mottram, Business Development Director, Birse Coastal
T 01257 261723 **E** Caroline.Mottram@birse.co.uk

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demonstration project

Barts site March 2008

Contractor Offers Financial Incentives for Waste Minimization

Contractor:	Skanska
Client:	Barts and The London NHS Trust
Case Study Ref:	333
Project Number:	1379
Publication Date:	October 2008
Region:	London
Sector:	Health
Contract Value:	£1bn
Start Date:	April 2006
Themes:	Sustainability, waste management, value

St Bartholomew's in Smithfield and The Royal London in Whitechapel are two of the oldest and best known hospitals in the UK. The work being undertaken at both sites is Britain's largest new hospital's programme, with a total value of £1 billion. Once complete, Barts will become a Cancer and Cardiac Centre of Excellence with the majority of care provided in a new eight-storey, state-of-the-art facility.

Most of the services currently provided at The London Chest Hospital in Bethnal Green will also move to Barts. Clinical services at The Royal London, including London's leading trauma centre, the capital's second biggest children's hospital and one of Europe's largest renal units, will be brought together in a new landmark 17-storey building. The new hospital project is integral to wider plans for modernising health services across London, supported by state of the art technology and facilities.

Working with Suppliers to Reduce Waste

The cost of sending waste to landfill has increased and responsible disposal of waste has become a financial, as well as moral imperative. Opportunities for the biggest cost savings can be made at the design stage. Careful planning and designing standard product sizes can lead to fewer off-cuts and a reduction of waste. Over ordering is common practice in the wider industry which results in virgin material being sent to landfill. To reduce the need for over ordering Skanska used an innovative 3D modelling system to identify the exact quantities of each material needed. The use of 3D modelling also allowed the team to check for safe access during operation and maintenance. In addition, detailed modelling was used to confirm opportunities for installation of large pieces of medical equipment as well as more detailed monitoring of the plan and construction process. Using the 3D modelling system Skanska were able to estimate the amount of waste that would be produced both in terms of packaging and excess materials. Once these quantities had been established contractors were invited to tender and detail exactly how they intended to minimize waste. For example one plasterboard supplier stated that they intended to use reusable stillages, bearers and pallets where possible and order larger unit sizes where possible to minimize bagged waste. As well as this, contractors were required to identify their anticipated waste streams and list both their predicted tonnages of materials and predicted tonnages of waste. Skanska then worked with the tenderers to negotiate the level of waste down to a level which was both achievable and acceptable to client and contractor. For example one contractor submitted an estimated 1371 tonnes of plasterboard waste, Skanska were able to work with them to revise this figure down to 624 tonnes. Once an anticipated level of waste had been established the contract was awarded.

Skanska were also keen to reduce the amount of hazardous waste on site. They worked collaboratively with contractors to identify hazardous waste streams and opportunities for

Flat-pack storage

alternatives. This resulted in a number of contractors turning to water based, non-hazardous products.

Once the contract was in place and work had begun contractors were committed to reducing their waste. For every tonne of waste they produced over and above the amount agreed at the tender stage the contractor was charged, and for every tonne that was eliminated from the amount agreed, those contractors working on the Barts site received a financial reward.

Skanska worked with contractors to identify and develop innovative methods to reduce the amount of packaging waste. Some of these have led to real financial benefits. For instance, mechanical and electrical products were packaged in reusable, flat packed containers. Once emptied the containers were returned to the consolidation centre. This approach saved the contractors at least £10,000.

Even suppliers of fragile products were encouraged to reduce packaging where possible. The main cladding contractors, Sheldebouw, were challenged to reduce their packaging waste. Every cladding panel was delivered on a reusable, metal cradle and wooden supports were used to protect the glass. Both the supports and the cradle were then returned to the suppliers for reuse.

Skanska also used prefabrication, where appropriate, to reduce waste. All major pipe-work at the London site was prefabricated in one block for installation in the hospital corridors. The blocks comprised of nine services in total including duct work, oxygen, nitrogen, water, fire suppressions and electrical supplies.
The main benefits of this approach were:

- Quality - assembly took place in a controlled environment which allowed tight quality control
- Time saving - logistical problems involved in employing a variety of different trades to work onsite could be avoided as assembly took place offsite.
- Waste - Assembly in a factory environment meant less packaging and weatherproofing were needed and excellent recycling facilities were provided.

As a result of the minimal amount of waste generated despite the large scale of the project, Skanska has only employed four logistics personnel.

Recycling

Skanska routinely used colour coded bins to collect different waste streams for recycling or disposal. At least six streams of waste are separated out and collected: hardcore, timber, metals, plasterboard, plastic, cardboard, hazardous waste and general waste. The picture on the facing page illustrates the difference in cost for disposal or recycling of different waste streams. This picture illustrates the clear financial imperative to segregate and recycle waste.

Every bin is bar coded and issued specifically to an individual trade contractor. When the bins are returned they are scanned, instantly identifying who the bin was issued to, and then the waste type and weight recorded. Using this system Skanska have an instant, rolling picture of how each trade contractor is performing against their allotted waste allowance. The real-time data allows Skanska and trade contractors alike to target poorly performing areas. Looking forward the data will also provide invaluable input into future Site Waste Management Plans on other contracts.

Local recycling facilities were chosen to process the waste from the two sites. The recycling plant was located just two miles from the development and was the most cost effective. Further benefits of a local plant included fewer vehicle movements and therefore fewer carbon emissions. Using local facilities also supported local employment in the area.

Skanska were anxious to ensure that COSHH (Control of Substances Hazardous to Health) waste was effectively and responsible disposed of. To make disposal easy and convenient COSHH bins were placed at exits. This meant that site operatives always knew where to find the bin and were able to dispose of the waste quickly, easily and safely.

Environmental Training

Skanska recognised that it was essential that site supervisors were bought into the new approaches and could answer queries on site. To ensure that all supervisors were aware of environmental and health and safety procedures they undertook two hours of environmental, health and safety training. This is in additional to the standard site induction. The supervisors were also encouraged to make suggestions to improve the site. One such suggestion resulted in the provision of a can crusher near the catering facilities to allow for all drinks cans to be recycled.

Skanska also worked to ensure that all site staff recognised the importance of a tidy site and introduced a system of "tidy Fridays". Every Friday each trade contractor supplied one person for two hours to tidy the site up. All those that took part were then rewarded with a lunch voucher. Small scale initiatives like these have helped the site team to take responsibility for the tidiness of the site and feel more engaged in the project.

Communications

Due to the scale of the development many stakeholders were engaged and informed of the progress of the project. Many tiers of stakeholders were communicated with from the NHS Trust, Local Authority and Government to the media and trade organisations. To ensure that messages were consistent and all stakeholders remained on board Skanska implemented a detailed and structured communications plan which included a matrix outlining who to talk to, how and the person responsible for this communication.

Key Achievements:

Winner of Quality in Construction Award for Corporate Social Responsibility March 2008.

Measurable benefits

Skanska have now put together an environmental strategy containing challenging targets and measurements to be rolled out to all sites.

It is too early to assess the full financial and environmental benefits, however Skanska will be monitoring them closely ready to report in the future.

Lessons Learnt:

- Early consideration of waste and collaborative involvement of contractors at an early stage can lead to a reduction in waste and financial benefits.
- Environmental training is essential to ensure all site staff are aware and engaged with environmental initiatives.
- Communication with a large amount of stakeholders requires a clear and consistent strategy.

Cost implications of different waste streams

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Constructing Excellence
in the Built Environment
Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

SKANSKA

James Macmillan, Environment and Communications Manager, Skanska
T 07977 990721

Construction Clients' Group
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demonstration project

SBC completed in April 2008

Wolseley Sustainable Building Center - A client driven sustainability showcase

Client:	Wolseley UK Ltd
Contractor:	Sol Construction Ltd
Case Study Ref:	332
Project Number:	2942
Publication Date:	November 2008
Region:	West Midlands
Sector:	Commercial
Contract Value:	£3,277,123
Project Timescales:	June 2006 - April 2008
Themes:	Sustainability, Client-led, Value

The project to deliver the Sustainable Building Center saw Wolseley fulfil dual roles of both client and supplier and is an excellent example of how a client can drive sustainability on a project whilst ensuring that the resulting building is fit for purpose and helps to improve that client's business.

Sustainable construction products are going to become increasingly crucial to the industry as it strives to address government targets. Market research, conducted by Wolseley, found that their customers did not understand which sustainable construction products were available and where they might find them. Customers were also unsure of what might be achieved through sustainable building techniques and what standards existed. To address this need, Wolseley commissioned the Sustainable Building Center to be a living, interactive showcase featuring renewable and sustainable materials for building and water conservation products. Inside the building is a 40 seat lecture theatre, 20 seat café and a large open space upstairs gallery capable of seating 20. The Center shows products in situ with cut away sections displaying the technologies embedded in the structure of the building, and touch screens providing information about the products displayed.

There has been great interest in the project from customers and staff throughout both the construction phase and the operational phase. Since the Center opened in April 2008 it has had around 240 bookings from a huge range of organisations, from housebuilders, developers and government departments to Housing Associations and small scale builders.

Key drivers

The strategy for addressing the anticipated increase in demand for sustainable building products involved several key strands:

- The establishment of robust supply chain links
- Securing the necessary products
- The establishment of a team with the necessary skills, knowledge and experience to provide a successful implementation.

The project received a large amount of support from the Wolseley leadership team and this combined with practical and economic support from suppliers proved vital in driving the project forward.

Strategic Partnering

This project is unique as Wolseley are both client and supplier. They were challenged to find a suitable architect which had the appropriate experience and expertise to realise the vision within a commercial environment. As well as this, the company had to audit the entire product portfolio to identify both suppliers and products that could deliver more sustainable outcomes. Woseley employed a team to not only drive forward the building project to a successful conclusion, but also to establish the sustainable product range. The roles of the team then changed to address the exploitation of commercial opportunities and the day to day running of the facility. They first looked at sustainable construction products in 2003 and this programme has allowed them to deepen their understanding of the products. Rarely did they see them being used, their involvement ending when they left the branch, so it has been good for Wolseley to see products in use and to understand the supply chain experience at first hand. The effects of products performing well (or less well) have been seen.

Eastern elevation showing ground source heatpump compact collectors

Structural engineered timber

Partnering was largely between the design team, the main contractor, the sub-contractors and Wolseley. The complex and unique nature of the project enhanced the communication between team members as they worked together to learn about the products and overcome any difficulties. Communication was conducted largely through monthly project meetings between the client, design team and main contractor with occasional interim meetings. The build was located very near to the Wolseley head office which meant that the client was able to visit the site every day and maintain a close relationship and good rapport with site staff. As this was a showcase project the team appreciated the opportunity to work on it and a "can do" attitude prevailed.

"A real joy has been informal engagement driven by necessity due to the complex nature of the building but also by all parties' willingness to deliver an outstanding result. We saw members of the design team walking about the site, becoming actively involved in delivery, to an extent above that which would normally be expected."

Tim Pollard, Head of Sustainability, Wolseley UK Ltd

Wolseley can supply, all materials for a client and often have a dedicated person to act as an interface, obviating the learning curve every time the two sides need to communicate. However, since in this instance Wolseley are their own supply chain, they had a central ordering facility and preselected branches responsible for delivering product to site. This was then back integrated into the main contractor, who had a central ordering section.

Sustainable Products

The 6,800 sq ft. building featured two wings with a linking street. The northern wing is a lightweight timber frame structure and the southern wing featured pre-formed concrete elements in the heavyweight structure. The center was designed to achieve excellence in areas such as heating and ventilation, envelope efficiency, glazing, waster consumption/drainage, renewables and micro generation and lighting. During the initial phase of the building, a consultation exercise highlighted the opportunities in the design of the building for cut away panels to display products normally hidden in the fabric of the building and touch screen panels to allow stakeholders to access product information. The building has been designed to be flexible so in future if necessary, it can easily be converted into office space.

170 types of products feature in the center including:

- Photovoltaics
- Micro wind
- A sedum roof
- E-glazing
- Natural lighting
- Natural insulation
- Green floor coverings
- Rainwater harvesting
- Biomass boiler
- A ground source heat pump

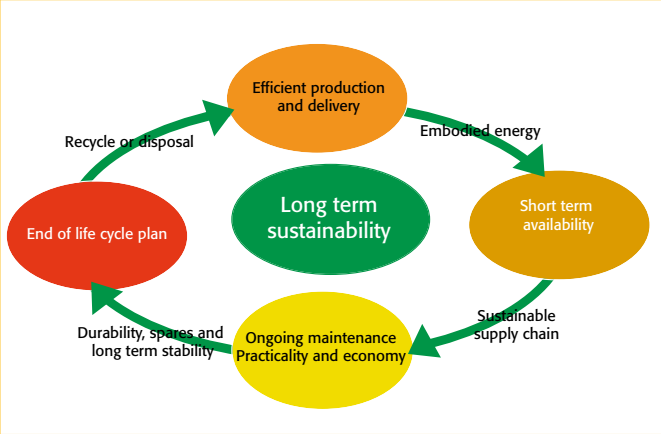
Installation of the rainwater harvesting tank

- Engineered timber
- Low energy lighting
- Water saving devices
- Solar thermal
- Sustainable drainage.

The key criteria for product selection were:

- The product had to be available in commercial quantities
- The product had to be supplied to commercial timescales
- The product had to be competitively priced (according to whole life cycle costing principles).

A model was developed to define the process to help both internal staff and supply partners to understand the requirements:



The center was not designed to feature development products but current, practical products that were already in production that customers could buy off the shelf. Woseley wanted to be able to define why the product was chosen, its features and benefits and the circumstances and projects which would be most appropriate. To ensure a high level of transparency, the Wolseley team has worked hard to verify the claims of manufacturers, researching and challenging claims and collating research data.

The center was designed to maximise natural light and used a passive ventilation system. To demonstrate the variety of renewable energy generation technologies available, a selection were installed including a ground source heat pump, a biomass boiler, solar thermal and a condensing boiler. Heat is provided primarily by the ground source heat pump but this can be transferred manually to the biomass boiler, to demonstrate its use. Monitors provide a visual picture in real time of how each technology is performing.

As well as energy generation, the building also showcases water saving technology. A rain water harvesting system provides water for toilet flushing and a sedum roof helps prevent water run off from the roof. To reduce the amount of water flowing off the site into storm drains, a sustainable urban drainage system has been designed in, featuring porous paving and an attenuation system.

Water returning to storm drains has been monitored and, despite recent heavy rain, the system has performed well.

As it is expected that technologies will continue to be developed and new products will come on to the market, the building has been designed to allow for the inclusion of non-structural elements and plant.

"I found it refreshing to be able to actually see the products in use and to be able to envisage how they could be incorporated into our schemes."

Ralph Middlemore
Managing Director, South Staffordshire Property Care,
Central Borders Housing Group.

Training Opportunities

One of the key objectives of the build was to demonstrate the ease with which many of the sustainable technologies could be installed. Wolseley deliberately chose a non specialist contractor to install much of the technology and many personnel involved in the project had little previous experience of sustainable technologies. Each stage of the build process was photographed and some stages were filmed so that the learning from the installation of the technologies and systems was not lost.

In addition, the project has partnered with local schools and the team have developed a solar thermal training course with a local college. Online training modules have also been developed for Wolseley staff to help disseminate the learning from the project.

Now it is complete, the building is a key training establishment, and is used to train Wolseley's colleagues regarding the availability and purpose of sustainable building products. It also serves as an exemplar to customers such as Premier Travel Inns, the Ministry of Defence, house builders and architects.

Worcester Ground source heatpump

South facing roof featuring both solar thermal and photovoltaic installations

Potential Barriers

Before the project began on site it was found that certain parts of the project needed re-engineering. This required the project to go through the process of retendering. Another slight delay was caused by the discovery of a high voltage cable which needed to be diverted. These problems were overcome and any major impact on the project timetable was avoided.

As the building is a showcase, many materials and products were used in combination which would usually be installed separately. This presented a challenge for all partners. In particular, issues of interfaces between materials arose as in some cases, no off-the-shelf connectors were available. To overcome this, the team developed bespoke connectors especially for this project.

Waste Minimisation

The site team bought into the concept of waste minimisation and responsible waste management from a very early stage. A competitive spirit between the trades helped drive it forward and operatives actively looked for opportunities to minimize offcuts. Any site waste was segregated into clearly identifiable skips which were removed for recycling regularly.

Conclusions

The project was completed on budget and on time. The building is a stylish and contemporary building and shows the practical opportunities given by sustainable construction.

Lessons Learnt

As Wolseley usually acts as supplier rather than client, at times, the experience was quite daunting. However, being a one off client meant that they could take a fresh approach. It also gave the team first hand experience of working with the products so once the building was up and running the sales team were more informed.

The team identified one of the most successful parts of the building as the passive stack ventilation system which has exceeded expectations in providing a comfortable environment in areas with extensive fenestration even with intense sunlight. The sustainable urban drainage system has also proved successful and the site now returns less water to the water table than the original brownfield site.

"It was a bold move to invest in the Center and from our discussion it is evident that it is provoking interest amongst some of the market leaders in development and construction."

Patrick Churchard CEng. MCIBSE
Director, ACDP (Integrated Building Services) Ltd.

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Constructing Excellence
in the Built Environment
Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

WOLSELEY

Tim Pollard, Head of Sustainability, Wolseley UK Ltd
T 01926 705 569 **E** tim.pollard@wolseley.co.uk

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View from Year 7 & 8 courtyard

The Academy of St Francis of Assisi

Contractor:	Birse Build
Client:	Kensington Academy Trust
Architect:	Capita Architecture
Case Study Ref. No.:	318
Project Number:	2845
Publication date:	December 2008
Region:	North West
Sector:	Education
Contract value:	£17.5 million
Project timescales:	May 2004 - Sept 2005
Themes:	Sustainability, Value

The Academy of St Francis of Assisi is a 900 place Academy for 11-16 year old students in the Kensington area of Liverpool. One of the Government's new flagship academies, it was co-sponsored by the Roman Catholic Church and Church of England, with the DCSF.

The Academy was designed as a landmark building, with a specific focus on the environment. The client had very clear ideas for what the project had to achieve: community regeneration, significant improvement in the achievements of the school-children, and demonstrable environmental responsibility. Constructed with high levels of environmental performance built in, the building also uses these technologies to support specific learning outcomes for the children who attend, so the Academy provides not only a great place to learn about environmental issues, but also acts as a learning resource in its own right. In addition, this project was designed to connect with the wider urban regeneration of the area, which was supported by the New Deal for Communities.

Kensington is a highly deprived area in Liverpool and the brownfield site was particularly challenging, experiencing problems with anti-social behaviour, contamination issues from its former use as a council tip depot, a constrained site, and a very sensitive local context on the edge of a historic park with Victorian housing adjacent. The design solution had to provide an educational environment which reflected the aspirations of the curriculum, whilst having a form which handled the site responsively. Further to this was the desire to create environmentally responsible architecture, and the client brief stressed the need for the building to facilitate environmental education, to model good environmental design practice and to offer itself as an educational resource, so that wherever possible, its environmental strategies were clearly evident to the building users. To this end, throughout the Academy features which clearly demonstrate "green thinking" are on show.

Key Practice and Policy Drivers

There were two key drivers for the development of the Academy. The first was the environmental performance of the building, which achieved the BREEAM "Excellent" rating. This was driven by a large number of individual process and performance aspects of the building, which gained it both regional and national recognition as a green school. The achievements to date have included a "Green Champion" award 2006, which is the top prize in the Building and Construction Category of the National Green Apple Environmental Awards. These awards are organised by the Green Organisation and supported by the Environment Agency, the Chartered Institution of Waste Management, the Chartered Institute of Environmental Health, Municipal Journal and a number of other bodies.

The second policy issue is using education as a driver for regeneration. Successful schools are the basis for much

community interaction, and by developing a landmark building for the education of local children, the Archdiocese engaged and involved the community in the wider regeneration of the area. The opening of the Academy has had a considerable positive impact, both on the students and wider community. In relation to educational performance, the Commission for Architecture and the Built Environment (CABE) note that well-designed schools are one of the major contributors to success and this is backed up in the Constructing Excellence publication Be Valuable. As testament to this, the school has recently come top of a new UK league table showing pupil's educational attainment, and this is seen to be largely attributable to the positive impact that the building has had on students' studies.

Value

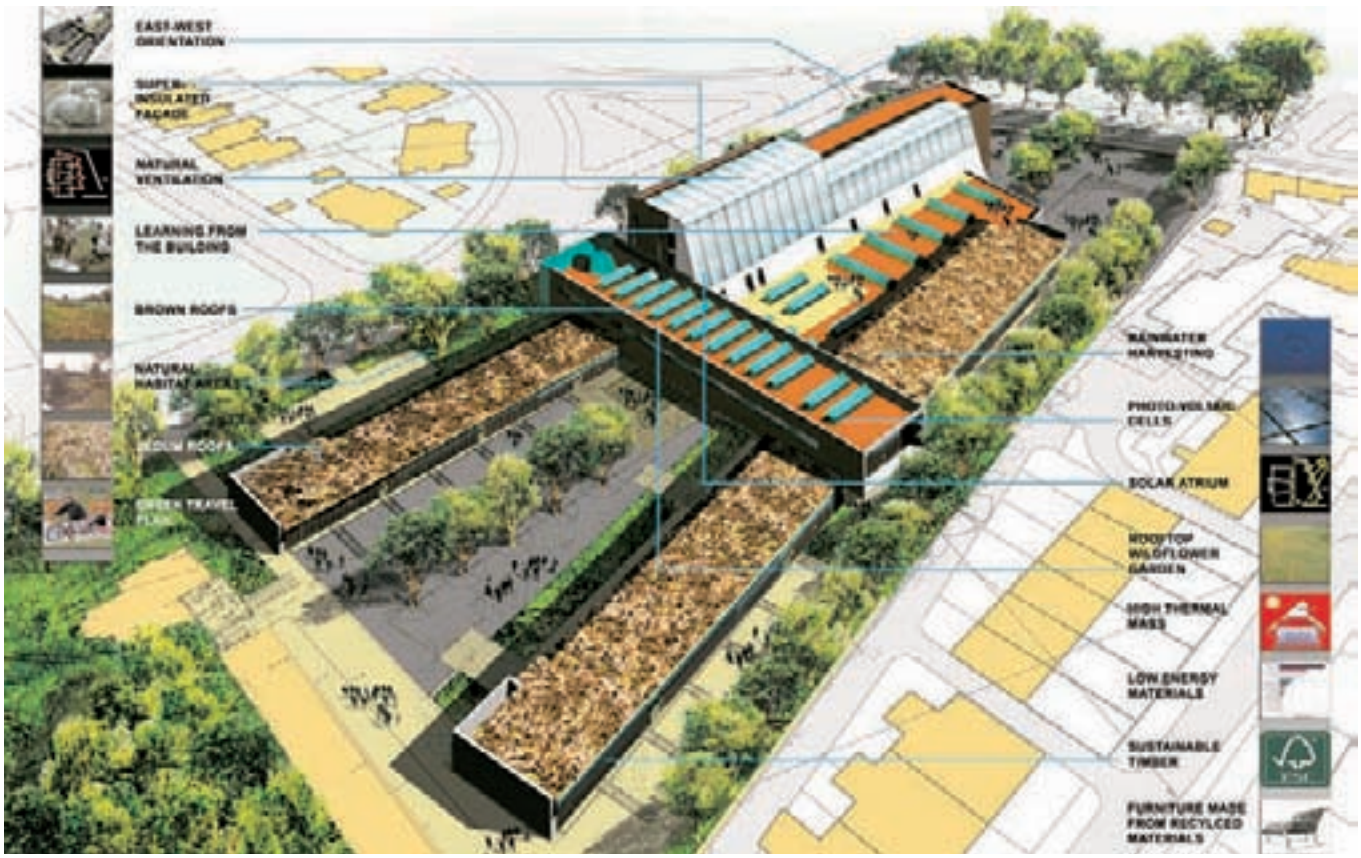
For the client, the value from this project was realised in a number of ways. Primarily, the educational impact the finished building has had on pupils' achievement has been a key success of the project. In a recent announcement of the "value-added" league tables the Academy was the top school in the UK. The Academy's Principal has commented:

"The excellent GCSE results and the fact that our students finished top of the national league tables for progress can rightly be attributed to the impact the building had on their studies." Jim Burke, Principal

The latest Ofsted report from July 2008 shows that the Academy has had a really positive impact on the students' personal development and academic achievement. Students enjoy coming to the Academy which has resulted in a marked improvement in attendance, and the level of exclusion has fallen dramatically. This in turn has led to a huge improvement in standards over the last two years. The academy met most of its targets in 2007 when 44% of the Year 11 students gained five or more A* to C passes at GCSE, and in 2008 this figure rose to 57%.

Description of Works

Works comprised demolition of existing buildings and construction of an educational building incorporating reinforced concrete basements, walls & frame, which ranges from one to four storeys. Roof coverings are comprised of green and brown surfacing on waterproof barriers with slotted and spherical roof lights. The green roofs are a variety of sedum species, whilst the brown roofs predominantly comprise crushed excavated sandstone seeded with an indigenous wildflower seed mix. External walls are a combination of facing bricks, copper and timber cladding and ETFE cushions. External windows are a composite aluminium and timber combination. Internal walls are mainly FF concrete and metal stud. External works comprise a multi-use games area (MUGA) pitch and playground decking, car parking, landscaping, drainage and refurbishment of an existing lodge building.



Each Academy has an identified specialism. The Kensington Academy's specialism is the environment and sustainability and this is achieved through the following features which support the environmental vision:-

Solar Atrium - Brings warmth and natural lighting into the building in winter whilst solar shading prevents overheating in summer conditions. This will also reduce heating bills

Rainwater Harvesting - Collects rainwater for re-use to minimise water consumption

PhotoVoltaic Cells - Converting energy from the sun into electricity. The Academy incorporates possibly the largest quantity of photo-voltaic cells on any school building in the country, providing over 10% of the student controlled energy requirements of the Academy

East - West Orientation - To maximise solar benefits

Natural Ventilation - Large glazed louvres, with simple occupant controls allow all habitable spaces to enjoy natural ventilation

Super Insulated Façade - All walls and the roof are insulated to standards far in excess of current Building Regulation requirements

Learning from the Building – The building is designed to encourage opportunities for the students to learn lessons about the environment

Green Travel Plan – A plan has been developed to encourage pedestrian traffic, bicycles and public transport usage

Rooftop Wildflower Garden – The roof over the basement halls provides a protected outdoor classroom and a wildflower garden

Sedum Roofs – The single storey wings have roofs planted with sedum - already providing a habitat enjoyed by a variety of bird species

Brown Roofs - Other roofs are topped with sandstone salvaged from site excavations increasing biodiversity in the urban environment

High Thermal Mass - The concrete structure is deliberately left exposed in many areas to provide free cooling in summer and heat retention in winter

Sustainable Timber - All timber used has been specified to be accredited by the Forestry Stewardship Council

Low Energy Materials - All materials have been carefully selected to minimise embodied energy, and to maximise design life

Furniture made from Recycled Materials – Selection extends to the choice of internal furniture, and includes recycled materials

Natural Habitat Areas – Dedicated areas established to increase the variety and bio diversity of the urban environment

Above: Night view of internal street and solar atrium
Below: Exterior view of the solar atrium from brown roof garden

Performance Measurement

The Academy is dedicated to improving young people's understanding of the environment, and it is this approach that has singled it out as a unique school. Pupils' awareness that they are entering a different kind of school comes before they even enter the classroom. The year 7 and 8 classes are covered with sedum roofs and resemble mossy banks rather than a traditional classroom block. Solar panels harness the sun and provide up to 3 per cent of the school's electricity.

From day one, the pupils get an education concentrating on "green issues". An example of this is that all year seven classes have a garden attached and each class is given £1,000 to design and cultivate theirs with the help of the Groundwork Trust, an environmental charity.

The project also shows how environmental studies can be taught through the school curriculum. Maths lessons, for instance, can cover the financial transactions needed to buy materials for the garden. In geography, pupils can study the soil and decide what would be most likely to flourish in it. In addition to encouraging all children to take environmental sciences at GCSE level, the pupils will also be able to work on the land. The school backs on to Newsham Park, one of Liverpool's most underused amenities, which is undergoing improvements as part of the wider regeneration agenda. The park rangers are set to be based in the school, with pupils shadowing them and doing regeneration work. The building is also available for community use.

Classroom block / North façade

Lessons learned

- Early consultation between all parties was key to the success of the project
- The design solution provides an educational environment which reflects the aspirations of the curriculum, whilst handling the site responsively
- A sustainable approach can have both social and economic benefits
- Well-designed schools are one of the major contributors to successful educational performance

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Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

Birse Group
CAPITA ARCHITECTURE

Richard Woods, Senior Associate Director, Capita Architecture
T 029 2022 4334

demonstration project

The PV array is mounted on 100 steel frames which sit across the top of the building (as seen here)

Photovoltaic cells at The Alan Turing Building, University of Manchester

Contractor:	BAM Construction
Client:	University of Manchester
Architect:	Sheppard Robson
Specialist Consultant:	Solar Technologies
Case Study Ref:	291
Project Number:	2760
Publication date:	January 2009
Region:	North West
Sector:	Education
Contract value:	£24m
Themes:	Sustainability

The Alan Turing Building, University of Manchester has been developed with environmental sustainability as a core project objective. The project has been designed with a view towards achieving BREEAM Excellent and has integrated photovoltaic cells (PVs) into the design of the building, offering an exemplar for the application of renewable energy in the North West.

The approach taken was to avoid the "bolt-on" approach that can sometimes be adopted with environmental technologies. Although the PVs were included as a late variation due to funding constraints, the design and construction delivery teams managed the process with two design options, one with the PVs and one without. This enabled the team to maximise the value from their adoption rather than finding ways of integrating the PVs into a design which had not considered their implementation from the outset.

The team also looked at ways to maximise the benefit of the implementation of the PVs, using the energy generated after commissioning to run site facilities. This approach has been the first use of renewable energy in this way in the country.

Key Practice and Policy Drivers

Energy is currently a key issue at both the national and regional level. The Department for Business Enterprise & Regulatory Reform (BERR) highlighted the importance of renewables in the energy strategy *Our Energy Future* (2003). This has been reiterated at the regional level by the NWDA, through their Climate Change Strategy, and through other regional documentation such as the Planning Policy Statements from the Department of Local Government and Communities.

The built environment is responsible for some 46% of total energy use and is therefore a key target where gains can be made in the construction, operation and demolition of buildings. There are a number of strategies that may be adopted in achieving carbon reduction which have been identified and applied in Project Unity (the merger of The Victoria University of Manchester and the University of Manchester Institute of Science and Technology (UMIST) to create a new world-class university - The University of Manchester).

One of the key strategies is the micro generation of renewable energy at the site or development level. This has been identified through energy policy at the regional level, through the NWDA Climate Change Strategy, and Planning Policy Statement 22: Renewables. The implementation of a defined percentage of energy being generated through renewables has become an increasingly common requirement for developments with local authorities and regional development agencies identifying specific levels of renewables for specific developments.

Renewables may be generated in a number of different ways;

- Hydro Power – water turbines
- Ground Heat – heat exchange pumps
- Wind Power – wind turbines
- Solar Power – photovoltaic cells

Each of the opportunities that may be taken are often site specific, depending on a number of different geographical and topological factors.

Demonstration Implementation

The Alan Turing Building provides teaching, laboratory and office space for the related sciences of mathematics, physics, photon science and astronomy. The building is conceived as three fingers – two linked by full height, three storey atrium and the third by an enclosed bridge over the newly created pedestrian walkway, Wilton Street. The street links to the newly created University Place, a critical issue in the Unity masterplan.

The PVs have been mounted on a roof rack, which was integral to the design. The roof rack was determined as a design element to provide solar shading for the glass atrium in order to reduce the need for mechanical cooling. The inclusion of solar panels or photovoltaic cells has been considered from the start of the project.

The panels have been paid for through a mixture of funding with the main proportion of the funds coming from the Department for Business Enterprise & Regulatory Reform (BERR) and then matched by the University of Manchester. The team had to undergo a number of funding applications before the successful outcome. While it was always the intention of the project team to implement the PVs, funding uncertainty meant that the project was designed with two options, one with and one without the proposed PVs array. The delay in funding meant that the PVs were implemented at a later stage than planned, however due to the preplanning and communication across the project delivery team, they were well prepared to deliver this change.

Design Review

A methodology promoted by the Commission for Architecture and the Built Environment (CABE) to assess the design of a building within its context, addressing issues such as linkages with other spaces and buildings and design impact.

The consultant that designed the solar array was Solar Technologies who were also involved in the bidding process to the Department for Business Enterprise & Regulatory Reform (BERR). The consultant worked with the design team to ensure that issues such as the angle of inclination of the array and the support systems delivered the maximum possible value for the project.

Internal view of the Alan Turing Building

The enclosed bridge over the newly created pedestrian walkway

They also relied on strategic supply chains developed by Solar Technologies. This is a particularly significant issue given that there has been a shortage of the silicon that forms the basis of PVs, making the issue of supply a key risk factor.

The PV array is mounted on 100 steel frames with 1100 cells in total. Due to the design requirement of the PV array to provide solar shading, the option for the PV was to use thin film technology to diffuse the light passing through the array. Solar Technologies were keen to support the array fixing systems identified by the contractor. The consultant stated that they were conscious of the fact that PVs were often viewed as an additional risk factor by constructor teams and, therefore, looked to integrate as closely as possible with solutions identified by the contractor. This is the first example of semi-transparent film being used within an integrated design in the UK. Estimates identify that the array will produce 40898 kWh/year, which is equivalent to approximately 10-12 domestic three bedroom houses.

There were a number of issues that had to be addressed with the assembly and installation of the array. Given the fragility of the array, with the semi-transparent film being mounted on glass, off-site manufacturing was regarded as carrying too much risk of damage, which meant that the array would have to be assembled on-site. This was further complicated by the fact that the site had a very limited footprint, so as far as possible the steel was fabricated off-site and delivered with the glass panels in place. A completed floor within the building was then used as an assembly factory to complete the arrays, which were then lifted using a specially designed hoist to fix the panels onto the installed frame. Further to this, the time available within the contractors programme to complete this installation was tight, and this meant that an innovative mix of on-site and off-site manufacturing had to be adopted bearing in mind the risks in terms of both damage to the array and the potential for slippage in the programme.

The next phase for consideration was the commissioning of the PV array. The Department for Business Enterprise & Regulatory Reform (BERR) has stipulated that the array be connected to the grid six to eight months prior to the actual occupation of the building. The team identified that rather than allowing energy to be generated for no reason, the site team could make use of the energy and so the site cabins will be powered by the PVs on the Alan Turing Building, University of Manchester until the end of the project. It is the first time that a renewable energy solution has been used in this way.

PVs as a solution are often criticised in terms of their economic viability, however, in respect of the Alan Turing Building, the pay back will be achieved over a long timescale. Furthermore, there are additional economic benefits to the structure above and beyond the traditional approach of generation of energy.

- The reduction of carbon should be considered as an economic benefit which needs to be factored in.
- The structure functions as a solar shade which has greatly reduced the need for mechanical cooling within the building.

However, it should be noted that the pure economic argument is not the sole issue. There are a number of "soft" issues which could be seen to have a perceived benefit.

- Research into green buildings, such as the RICS Green Value Report, has shown them to drive improvements in productivity and improve the health of those working in them.
- Using an emergent technology supports further development into PVs as a solution into the longer term. Exemplar projects of this type are needed to further support the development of PVs as a renewable technology which can be introduced as a more mainstream technology over time.
- The development of the Alan Turing Building, University of Manchester as a sustainable building has a public relations benefit for the University. It may be used as a marketing point and, potentially attract researchers to work in the building.
- At a contract level, the use of PVs generated "excitement" among the project team.

Using a traditional cost model, PVs could be seen to be unsuccessful. However, if one considers the wider implications of the approach we can see that there are a wide range of benefits which may not be considered from a traditional commercial perspective.

It could be seen that the University has embraced its role as a deliverer of exemplar projects which consider the wider implications of design and construction decisions rather than pure capital cost.

Project Unity sets out its objectives to create a world class research intensive university. The objective applies not only to the work carried out, but also the built environment in which that activity will take place. The client and their team have committed to the application of a new technology to see how they could push the envelope of the application of PVs and what lessons could be learned for future projects. With renewable energy being an increasingly important solution to the delivery of a low carbon society, developing an understanding of how technologies are implemented can be seen as an end in itself.

The roof rack design of the PV array provides solar shading for the glass atrium, reducing the need for mechanical cooling

The attainment of BREEAM Excellent has been driven by a commitment from the client. The PVs solution was one of a number of approaches that were adopted in order to address sustainability issues for the Alan Turing Building, University of Manchester Building. The client showed their drive to achieve these goals from an early stage, in terms of both the generation of ideas and their willingness to provide additional funds to implement the ideas of the whole team.

Key Lessons Learned

There are a number of key lessons which can be considered when considering the application of PVs in this way:

- Sustainability and renewables are still developing. They represent a risk in both the construction and management of a building. It requires a strong knowledgeable team to effectively manage those risks.
- Sustainability must be an issue that is considered from the start of the development. It should not be a "bolt-on" or afterthought if it is to be used and understood in the most effective way. In the example shown the PVs were integral parts of the design looking to take advantage of their installation in terms of both environmental and aesthetic performance. Much of this has to be driven by the commitment of the client.
- A broader understanding of the wide benefits of renewable technologies must be developed. A simple cost accounting approach does not always take into account the wider performance benefits that can be generated by engaging in a project of this type, in terms of building performance and benefit to the wider community.

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Constructing Excellence
in the Built Environment
Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

James Jones, Architect, Sheppard Robson
T 0161 233 8950

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Aerial view of Woodbridge Airfield

Woodbridge Airfield - a sustainability exemplar

Contractor:	Skanska
Client:	Ministry of Defence
Case Study Ref:	334
Project Number:	1260
Publication Date:	November 2008
Region:	East of England
Sector:	Infrastructure, Buildings and Estates
Contract Value:	£82 million
Project Timescales:	May 2004 - May 2006
Themes:	Health and Safety, Sustainability

In 2004 Skanska commenced the £82million redevelopment of Woodbridge Airfield into a modern 21st century barracks to accommodate training, service and operation of 23 Engineer Regiment (Air Assault), part of a fast reaction task force supporting Britain's defence commitments.

Construction work consisted of demolition of 92 structures and refurbishment of four hangers; provision of 18 new buildings for accommodation, training, medical, sport, leisure, vehicle maintenance facilities, storage and ancillary structures including an outdoor barrack range, assault course, playing fields, refuelling facilities and vehicle wash facilities.

The 69-hectare site was extremely environmentally sensitive. It was surrounded by a Site of Special Scientific Interest (SSSI) and located within the Suffolk Coast and Heaths Area of Outstanding Natural Beauty (AONB), Special Protection Area (SPA) and Country Wildlife Site (CWS). The challenges posed by the site meant that environmental sustainability had to be a priority. Another key focus was health and safety and stringent standards were set to ensure that accidents were avoided.

Environmental Sustainability

Reuse and recycling

Decisions were taken at the design stage to reduce waste arising on site. Prefabricated bathroom pods were used as all the waste produced in their manufacture is contained within the factory. The pods had other advantages as their high thermal mass reduced heating costs and fabrication off site reduced the health and safety risk, as hazardous materials were contained in the factory area.

The team reused demolition materials on site wherever possible. Crushed brick, concrete and tarmac were used to create roadways, hard standing and concrete. In total approximately 70,000 tonnes of materials were crushed and re-used on site. As well as reducing waste, this had other advantages as it avoided the need for imported material and disposal offsite, also reducing vehicle movements. It is estimated that this approach saved the project 10,000 vehicle movements thus reducing carbon emissions and minimizing local congestion; it also saved the project £120,000.

A target of 65% of all waste was established at the start of the project. Waste was segregated into six colour coded bins and these waste stations were controlled by full time waste marshals. Overall, the approach was extremely successful and resulted in the recycling of 72% of construction waste and 98% of demolition waste.

Some children from the local primary school were given a tour of the site

Measurement

In most construction projects total recycling figures include an estimate of general waste, that it is assumed is automatically recycled by the waste contractor. However, on this project, only material that was sent directly to recycling was included in the final recycling total. As a result of this project, all future Skanska projects only include waste that has gone directly to recycling in their recycling totals. The assumption is then made that any waste disposed of as "general waste" is sent to landfill.

Key Achievements in Sustainability

- Focus on community engagement led to no complaints from surrounding residents.
- High level of reuse of materials onsite led to reduced vehicle movements.
- High recycling target exceeded.
- Successful preservation and enhancement of habitats for local wildlife.

Waste was segregated into colour coded bins

Biodiversity

The Woodbridge site was extremely rich in biodiversity. Parts of the site had remained unused for some time and had become habitats for local wildlife. The heather surrounding the air field was found to support 10% of the UK population of nightjar and woodlark which are on the International Conservation Union red list. To protect this valuable population, an area of heather the size of a football pitch was translocated to a quieter area of the site. This operation was performed in close consultation with English Nature, Suffolk Wildlife Trust, RSPB and the local County Council.

As well as this invertebrates and amphibians were translocated to a wildlife pond that is recharged from buildings roof run off and the area was made more attractive to wildlife by the installation of 40 bat boxes.

"Skanska's dedication to environmental protection is outstanding"

Alan Smith, Defence Estates Project Manager

Social Sustainability

Health and Safety

A rigorous approach to health and safety was driven from the top down. The Project Director was passionate about health and safety and ensured that the site was as safe as possible. He insisted that site operatives wore full Personal Protective Equipment (PPE) including gloves, hard hats, high visibility jackets, glasses and steel toe capped boots at all times. Every site operative was also required to have a Construction Skills Certification Scheme (CSCS) card. In addition, Skanska operated a system of "start cards" which meant that every day operatives were briefed on the risks and challenges

posed by their working environment and these challenges were recorded on the cards. "Near miss" cards were also used to record any incidents which could have resulted in injury. To ensure that the site remained safe, all Skanska staff spent an hour every Friday, walking around the site to identify and address any potential health and safety hazards and environmental issues.

Staff health and wellbeing was also seen as a priority and a canteen was provided for site workers. The canteen served healthy options such as salads and baked potatoes and all food was prepared freshly on site.

The end result was an extremely safe site with almost no reportable incidents. The time spent on training and ensuring the highest Health and Safety standards put some pressure on the programme timescales and if the same approach was undertaken in future this would have been programmed in at the project planning stage.

Key Achievements in Health and Safety

- "Near miss" cards and "start" cards
- A fully trained workforce with CSCS cards
- Tool Box talks twice weekly
- No stepladders on site
- Full PPE for all persons on site
- Highest standards of welfare/canteen facilities
- Nutritious/healthy food

Community Engagement

Skanska strived to become part of the local community, for instance when an accident on site cut off local water supplies,

Translocation of an area of heather which was found to support 10% of the UK population of Nightjar and Woodlark

letters of apology and chocolates were given out as well as complementary bottled water. To engage the community further, over one hundred children from the local primary school were invited onto site. They were given a tour of the site and their own mini hard hats and high visibility jackets to keep. As a result of these measures there were no complaints from local residents.

Lessons Learnt

- Decisions taken at the design stage helped to reduce waste arising on site
- Reusing demolition materials on site wherever possible helped to reduce vehicle movements and also saved money on the project
- Strong leadership was vital in driving the project forward
- The team held a two day workshop to ensure none of the learning from this project was lost

Segregated crush material

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Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

SKANSKA

James Macmillan, Environment and Communications Manager, Skanska
T 07977 990721

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The pond has attracted a large amount of fauna and accompanying biodiversity

Project Genesis

Client:	South West Regional Development Agency (SWRDA), the Learning and Skills Council
Case Study Ref:	342
Project Ref:	1201
Publication Date:	February 2009
Region:	South West
Sector:	Education
Project Timescales:	October 2004 – May 2006
Contract Value:	£2.5million
Themes:	Sustainability

The Genesis Centre is an educational facility in Taunton which demonstrates a variety of sustainable building techniques. The £2.5 million, innovative development integrates cutting edge and contrasting sustainable building techniques with mainstream methods. The centre is self funding and acts as a showcase to promote sustainable construction techniques and materials to the public and the construction industry.

It aims to provide a one stop shop for the industry to learn about sustainable construction techniques, receive CPD training and provide advice. The centre is a powerful learning tool for Somerset College of Arts and Technology students and also provides learning resources and materials for training and education partners in the region. The college was the first in the country to offer a foundation degree in sustainable construction.

Background

Whilst sustainable building systems and technology are advancing rapidly, take-up of new materials and techniques in the construction industry remains slow. Through organisations such as Constructing Excellence South West, Sustainability South West, Ecos Trust (formerly Somerset Trust for Sustainable Development) and the Cornwall Sustainable Building Trust the region has developed a large number of exemplar construction projects. The partners felt there was a need for a focal point for showcasing the viability of sustainable construction both to the industry itself, to the public and to local government planning authorities.

Overall Project Aims

The main medium to long term aims of the project were to embed Sustainable principles through:

- Having an impact on the design of future housing and refurbished buildings
- Training the crafts and professionals, both new to the construction industry and already employed within the industry to build using sustainable principals and local sustainable materials
- Impacting energy use in the South West
- Increasing recycling
- Creating more local businesses and jobs in the industry
- Changing lifestyles to embrace sustainability
- Creating new businesses providing sustainable materials, resources and services for sustainable construction
- Contributing to the reduction in traffic congestion in towns and cities through promoting and educating on sustainable transport

The team were also keen for any lessons learnt through the construction of the centre to be shared and disseminated throughout the industry and through the wider community.

The building is designed around a central forum space with a series of intersecting pavilions

The Approach

The Genesis Project began as a student assignment carried out by the HNC construction students to provide a new resource for the construction industry to promote and exchange new ideas on sustainable construction. Some excellent designs were developed by the students and, with the help of the Construction Industry Training Board (CITB), a South West Regional Development Agency Grant was eventually won to turn the student project into a reality.

The Genesis project was officially launched in February 2004 at Homes for Good, the South West's first major green building fair. A scale model of the design was unveiled at the fair by Grand Designs TV presenter, Kevin McCloud.

Partnering

Initial project meetings included the Client, Finance Director and Deputy Principal of the college, architect, mechanical and engineering consultants, structural engineers, Ecos Trust and the project managers. As well as this, local experts were brought in to advise on and debate the advantages of the different build materials and techniques. The contractors and facilities management team did not become involved until the designs were quite well developed. It was subsequently felt that earlier involvement of the Facilities Management team could have avoided difficulties encountered during the operational phase of the project.

Design

Building Materials

The building is designed around a central forum space with a series of intersecting pavilions. The externally protruding portion of each of the pavilions is fully finished and weather tight, whilst the internally protruding sections inside the main forum space have their fabric stripped away to reveal and demonstrate the construction. The four building types used in the pavilions consisted of: timber frame insulated with recycled newspaper and clad in green western red cedar; straw bale construction finished with a lime render externally and lime plaster internally; earth construction, including rammed earth and cob techniques; single fired clay block; and steel and glass. The roofs were insulated with recycled cotton denim quilt and roof finishes included EDPM single ply rubber membrane on the main forum building and a variety of green roofs on the pavilions. The use of concrete and its cement content were minimised. The selection of materials was not designed to demonstrate the definitive solution to sustainable building but demonstrate the kind of solutions that are possible.

The overall design of the building was intended to engage with and inspire mainstream industry. As the result of this aim, certain materials have not exhibited their strongest and most efficient properties, eg. the design of the straw bale pavilion was a deliberate attempt to challenge the perceptions of what a straw bale building should look like. As a result, some of the design features are not necessarily best suited to this material. In the case of the earth pavilion, the material is widely documented as providing excellent humidity control in buildings and maintaining stable temperatures. By using this material in a situation where the pavilion is constantly open at one end to the wider building, these properties are partially negated.

The decision to omit skirting boards and door plates in certain areas of the building was taken on the basis of reducing material use and aesthetics. Feedback from the facilities management team has been that this has led to premature wear and tear.

Energy and Water Efficiency

The building's pavilions were designed to be heavily insulated, efficiently heated and naturally ventilated to avoid the need for artificial cooling. Each pavilion is individually controlled to enable the building to be used flexibly and efficiently. To reduce water consumption water efficiency components such as spray taps and waterless urinals were specified. Rainwater harvesting was investigated but due to the low water requirement of the building it was found to be significantly more cost effective to draw water from the mains. Water heating was provided by solar panels and a contribution to electricity is made by photovoltaics. Low energy lighting is specified throughout.

Heating

The building was designed to be heated using biomass boiler. The original thinking was that wood waste from the college workshops could contribute to the fuel supply, but upon investigation quantities were insufficient to interest pellet producers to take the waste away. Fuel is now supplied by a local producer of wood pellet from sawmill waste.

The orientation of the building meant that some of the building materials were not used to their full advantage. For instance, building techniques with high levels of insulation such as straw bales were used on the south facing side which, with a lack of adequate shading on the large areas of glazing, put that pavilion at risk of overheating. These large windows also increase reverberation, reducing the beneficial acoustic properties of the bales. Fired clay block and earth walls have better thermal mass and so would have been more appropriate materials for this pavilion.

In some cases the aesthetic of the building and the technologies conflicted. For instance, the thermostat and controls for the wind catcher technology in the lecture theatre were hidden inside a cupboard which was also used to house the IT cabinet. The heat from the equipment gave a false reading to the thermostat causing the technology to be less effective than it was designed.

In the straw and clay pavilions, there was a potential clash between

the shape and dimensions of the buildings and the materials used to construct their walls. In the case of the straw pavilion the bales had to be cut in order to meet the finished wall height. The pentagonal shaped clay pavilion, uses blocks that, when used with rectangular buildings can reduce waste, construction time and thermal bridging.

The design team originally intended to specify the use of sheep's wool insulation in the ceiling voids of the earth and straw pavilions but to reduce costs it was decided to use Innotherm (recycled cotton insulation) instead. The Innotherm was wider than the ceiling voids and the material had to be cut along its length. This was a labour intensive exercise due to the strength of the material and as a result the team felt that this was probably a false economy.

Key Lessons Learnt: Design stage

- Some building materials are suited to certain parts of the building depending on its orientation. Those with high levels of insulation are more suited to north facing walls whereas materials with high thermal mass are better suited to south facing walls
- Operation of the building should be considered at the design stage to make sure the sustainable technology performs efficiently
- The choice of biomass heating system should be designed to take into account the existing supply chain
- Matching shape and dimension with materials can reduce waste, improve energy performance and increase speed of construction

Construction

As the project was designed to be a showcase, many different and unusual products and systems were specified. Many of the contractors had not worked with the sustainable building materials and systems prior to the project. By the end of the project the site workers and notably the project manager became advocates of the materials and saw the advantages they could bring.

The pioneering nature of the project made it difficult to make accurate cost predictions at the design stage. This meant that value engineering had to be employed as the construction progressed which put pressure on the project timetable and inevitably, the project budget needed to be increased. Further delays were caused when the project's window supplier went out of business having already accepted a deposit from the project.

Timber Frame Pavilion

A lightweight, super-insulated, time-frame structure was chosen to house the office space as it has a rapid heating response which can be ideal for sporadic demand environments. It was off-site pre-engineered, timber-clad and insulated with recycled newspaper.

Earth Pavilion

What is Rammed Earth construction?

Rammed Earth construction uses earth, which has suitable proportions of sand, gravel and clay, compressed within a rigid frame to create a solid wall of earth. It has excellent thermal mass properties and can be locally sourced. It is also a cost effective material as it can sometimes be obtained without charge.

The earth pavilion was designed to demonstrate rammed earth, earth blocks and cob construction. To construct the earth pavilion, local sub soil had to be analysed to ensure it was the correct material. Once the correct earth was found, specialists were employed to construct the walls. The high thermal capacity of this building material can not be taken into account when using the current Part L assessment methodology. The commonly adopted strategy is to increase the thickness of the walls and compensate for their high U-value by increasing the insulation levels in other elements such as the floor and the roof space. The limitations this strategy would eventually bring about, led the design team to make the decision to externally insulate the earth walls.

Key Lessons Learnt: Earth Pavilion

- The team felt that using specialist contractors to construct the rammed earth and mass cob walls made a significant contribution to the overall project costs. They felt that, once the correct soil has been identified and if expert guidance was on hand, construction could be completed by non specialists.

Clay Block Pavilion

What is clay block construction?

Using clay blocks as a construction material can have many advantages as they combine structure, external envelope, moisture protection and insulation. The thin horizontal joints and no vertical joints can reduce the mortar requirement by up to 40%. The blocks are currently used in Europe but are not regularly seen in Britain.

The third pavilion was constructed using "Ziegel blocks", clay blocks mixed with sawdust and fired in a kiln. The blocks are thin joint and can be fixed together using glue with no vertical joints. The blocks are best utilised as a whole wall system and have a high U-value.

Key Lessons Learnt: Clay Block Pavilion

- Using clay blocks for curved walls can put stress on the joints putting them at risk of opening up. The clay blocks perform best when used in straight walls.

Operation

One of the key lessons learnt from this project is the importance of including the facilities management team at the earliest possible stage. In hindsight, the project hand over could have been managed over a longer period of time with training provided for the site staff on how to operate the new systems and technologies. Information sheets provided post handover were not seen by the FM team as sufficient and the lack of training caused problems with the maintenance of the building. The lack of knowledge of the specialist systems within the maintenance team also led to issues over fuel quality for the biomass boiler that, at times, caused excessive quantities of fuel to be burnt and the boiler to go out.

Further maintenance issues arose when the outside of the earth pavilion was vandalised. Repairs were made to the render using unsuitable materials and unsuitable paint which could affect the overall performance of the building.

Renewable Energy Technologies

Water heating was designed to be provided by a solar thermal system. The centre was not predicted to have a high level of water use and an original analysis suggested that 60 solar thermal tubes would be required for this building. However, once installed the system persistently lost pressure and frequently broke down. After a year, a report commissioned to investigate the problem with the system, concluded that only 20 to 30 tubes were actually needed for a building with this level of water usage and small, 210 litre, tank size.

Heating for the building was provided by a biomass boiler which had to be manually lit which was impractical for the college. It also meant that the boiler needed to be kept running over the weekend to ensure the building would be warm by Monday morning. As well as this the biomass boiler fire prevention equipment malfunctioned resulting in a fire within the fuel hopper causing it to be out of action for a prolonged period. During this time, due to the lack of any back up heating, electric heaters had to be used.

Water Conservation

Water on the development is managed through a sustainable urban drainage system (SUDs) which has performed well so far. The pond, which forms an integral part of the system has attracted a large amount of fauna and accompanying biodiversity. However, the maintenance team are concerned that inappropriate plants in the reed beds may adversely affect the drainage system. For future projects the provision of a maintenance manual for the SUDs has been identified as a learning point from this project.

Other water saving features have also proved challenging for maintenance staff such as the air flush urinals which meant that conventional cleaning methods such as urinal blocks were not appropriate. This was communicated to the cleaning staff who have experienced no further problems.

Key Lessons: Operation

- Integration of estates and facilities management team into the project at an early stage could have made the handover more smooth and reduced the risk of problems during the operational phase
- The production of training and/or instruction manuals would have ensured that the building systems were properly managed

Social Sustainability

The building is sited on a college campus and originally it was intended to close the site for two days per month to allow for site visits and courses to be run. Delays in the project timetable however, meant that the site could not be closed. There was also concern that involving the students in the build could put the final build quality at risk. Despite this, the project manager was very open to ad hoc requests for site visits and this allowed for around 1200 people to be taken round the site during the construction phase.

Learning Dissemination

The learning from the Genesis project will be taken forward to a large scale regeneration scheme- Project Taunton. The Genesis team have been involved in the development of the Taunton Protocol which requires developers, builders and professionals involved in the design and construction of the new developments to commit to 10 principles related to low carbon development, environmental responsibility, employment and training, design and wellbeing. The team from the Genesis project are putting together technical sheets which Taunton Deane Borough Council would like to send out to those applying for planning permission. Project Taunton will include a Skills Academy where training, developed in the Genesis centre, will be delivered.

As a result of the Genesis Centre, Somerset County Council has chosen to use timber frame, rammed earth and straw bale construction on a forthcoming Park and Ride scheme.

"We have built a very modern building which I hope will change people's perception of sustainable construction. Prior to this project I thought the use of these types of sustainable materials would be difficult to integrate into mainstream construction but this building is proof that they can. I now believe that these materials can and should be used."

Mark Preston

D C Russell, Main contractor

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in the Built Environment
Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 0207 592 1100
W www.constructingexcellence.org.uk

genesis

Tim Simmons, Sustainable Construction Manager, Genesis Project
T 0182 336 6528 **E** Tim.Simmons@somerset.ac.uk

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Daneshill House at night

Daneshill House Refurbishment

Client:	Stevenage Borough Council
Case Study Ref:	343
Project Ref:	3322
Publication Date:	March 2009
Region:	East of England
Sector:	Local Authority
Project Timescales:	First phase 2002 - Last phase 2006
Contract Value:	£2m+
Themes:	Sustainability, refurbishment

In 2002, Stevenage Borough Council decided to close its neighbourhood offices and centralise all staff within the main office, Daneshill House. To achieve this, it was necessary to increase the space efficiency by 20% whilst creating a modern and pleasant working environment. Daneshill house is a six storey, 1950's building which was extended in 1985. Prior to the refurbishment, it suffered from severe overheating in the summer and had poor comfort conditions even in the areas cooled by air conditioning.

Traditional refurbishment schemes for post war offices tend not to include the sustainable technologies that are used in new build offices. The Council wanted to demonstrate that a modern block could be sustainably refurbished to a high standard and adapted to utilise renewable energy generation.

In summary, the Daneshill House project demonstrates:

- How a 'night cooling system' can be installed in a traditional office building with little exposed structural mass, to provide summer cooling with the addition of Phase Change Material (PCM).
- How a 'night cooling system' can be enhanced to create a 'mixed mode' system to deal with extreme overheating caused by exceptionally hot summers.
- Consideration of occupancy performance in relation to the building's energy performance. The refurbishment design has increased the occupancy density and allowed a number of smaller less energy efficient offices to be closed.
- How renewable energy generation can be incorporated in a post war office building. The existing electrically heated hot water system was replaced with a large solar hot water system which is now supplying hot water to 3840m^2 and 350 occupants.
- The installation of one of the first LED lighting schemes in the UK.
- A solar and occupancy controlled lighting system, plus alterations to the operating system and Building Environment Management System (BEMS) controls in an existing air conditioned area of the building.

Enablers

The environmental works formed part of a 5th framework 'ENERGIE' programme EC supported project known as REVIVAL. The REVIVAL project aims to demonstrate how post war public buildings can be improved to good environmental standards as an alternative to demolition and replacement. It requires a client that is committed to using innovative solutions even if they do not always deliver the expected results, first time. The project aims to provide a firm environmental basis for refurbishment rather than replacement and showcase the practical application of established technology. It also recognises the need to involve the maintenance team at an early stage and ensure they are bought into the ethos of the project.

Innovations

The improvement works were categorized into four basic areas:

1. Old Block Refurbishment (floors two, three, and six)

The conversion of existing cellular offices into modern IT based "open plan" office areas with new modular desking and high efficiency layouts that improve occupancy levels. This included the installation of:

- Night cooling with Phase Change Material (PCM)
- Solar and occupancy light controls
- Top up mechanical cooling

2. New Block Atrium Refurbishment (ground and first floor)

To improve occupancy levels, this area was converted to new high efficiency modular desking. This included altering existing air conditioning controls and BEMS to maximize 'free cooling' periods in summer and winter and the heating by using an adaptive temperature control regime and CO_2 controls.

3. Customer Service Centre (ground floor)

The Customer Services Centre is in the 'new block' area of the building and was stripped back to the structural shell before creating the new Customer Service Centre. The new installations included:

- LED Lighting
- Night cooling 'top up' to new air conditioning system to create a mixed mode system.

4. Solar Hot Water System

The new solar hot water system was installed as a 'stand alone' project and it provides 'domestic' hot water to all but approximately 1500m² of the 5,830m² building. The system included a new high efficiency condensing gas boiler and two 500 litre calorifiers.

Energy Efficiency

The existing light fittings in the atrium area were 20 years old and included floor standing, up lighters. The 100 existing uplighters were fitted with radio 'wireless' control switching, which provided three different levels of operation: individual, local and area.

The main lighting in the office is now controlled by solar sensors, which turn off the lighting when sufficient daylight is available. The meeting rooms and open plan office areas have occupancy sensors and the centre rows of lights in the office operate on motion censors. The power consumption for the lighting on the third floor improved area has been measured as 38% better than a typical office.

Air conditioning was deemed appropriate in some areas of the building including the ground and first floor atrium. Controls were improved and this, combined with the BEMS, has so far produced improvement in energy efficiency on the ground floor and on the first floor.

Heating/Cooling

Summertime overheating is a common problem in post war office buildings such as Daneshill House and the traditional approach is to install local mechanical DX air conditioning units that provide localised re-circulated cold air. However, this results in very uncomfortable conditions for those located close to the unit, particularly with the low ceiling heights that are typical for this kind of office building. This system also does not provide any extra ventilation and is often mistakenly used as a first option to cool an area, even when opening a window would be more effective.

The Council wanted the refurbishment to be as environmentally friendly as possible and chose a system which made the best use of natural, free cooling. This system also allowed staff to open windows and avoided the cold draughts usually associated with traditional air conditioning systems.

Cooldeck System

A "Cooldeck" night cooling system, which utilises the hidden mass of the building, was chosen to provide summer cooling. It is designed to improve the transfer of thermal energy from the air to the concrete slab. During the summer, cool outside air is introduced into the offices by window fans at night. Duct mounted ceiling fans circulate this air under the CoolDeck elements to enable the cooling to be stored in the thermal mass. During the following day, the ceiling fans operate without the window fans to release the stored cooling.

The system consists of a steel plate 1800mm long by 450mm wide fixed approximately 25mm from the surface of the concrete soffit with only the 450mm ends left open. A 150mm diameter spigot is fixed to the centre of the plate and this is connected to flexible ducting which delivers air from the room via an 'in-line' fan which serves two plates. The ceiling void acts as a plenum for the system and air is returned to the room via 200mm square open grilles fitted into the

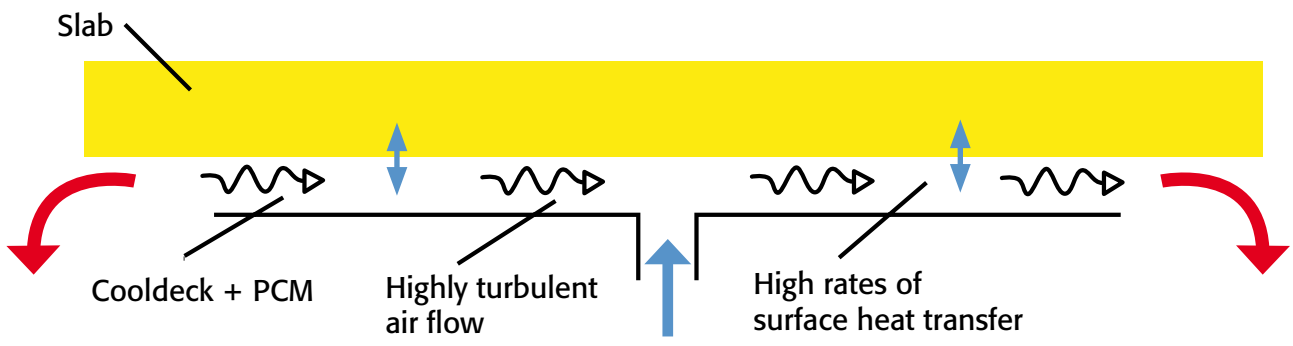

Diagram Showing Cooldeck Plate and PCM

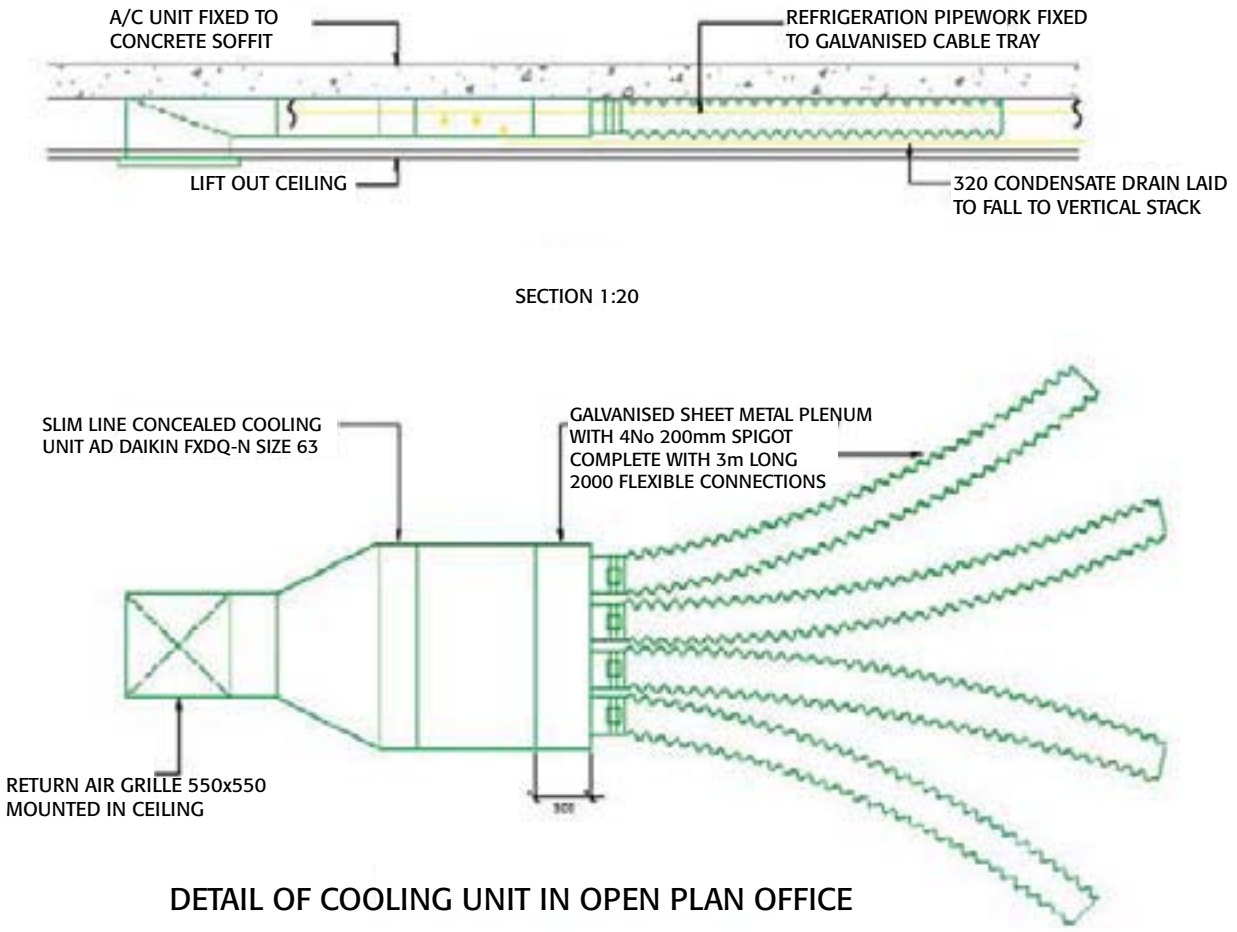

Diagram Showing Cooldeck Plate and PCM

suspended ceiling tiles. In subsequent installations, phase-change material, (PCM) has been integrated with the CoolDeck elements to increase their thermal storage performance.

The fans are controlled to operate at night, when the temperature the previous day exceeded 24ºC. Cool air is then delivered to the area through window fans which supply air from the east side of the building and extract it from the west side. However, night ventilation is held off when the internal temperature falls to 18ºC to prevent overcooling.

In the daytime, when the room temperature reaches 24ºC, the ceiling fans, (which operate on fast speed at night), run at slow speed to circulate warm air through the 'Cooldeck' plates and ceiling void. The air is cooled as it comes into contact with the concrete slab and then returns to the room through the open grilles in the ceiling tiles. The system has been enhanced by the use of highly efficient, solar reflective blinds which reflect a high degree of solar radiation and reduce solar heat gain. Staff has been instructed to close the blinds at night on the east side of the building to reduce increased heat caused by the early morning sun.

The system also demonstrates how the thermal mass capacity of the building can be increased by the inclusion of PCM into the cooling system. The PCM is a salt hydrate contained within foil pouches which lay on the "Cooldeck" plate so that the air passes between the concrete soffit and the PCM as shown below. The PCM "melts" or changes phase at 24ºC when placed in contact with the air on the surface of a room. As the air temperature in the room increases above 24ºC the heat flows into the PCM causing it to melt. Providing there is sufficient PCM, it continues to melt until the peak heat input has past, thus preventing overheating. However, as the PCM solidifies, the latent heat absorbed in the melting process is returned to the room, resulting in the room taking longer to cool down. In this way it performs in a similar way to thermal mass, but because of the heat involved it is very "concentrated". The main advantage of PCM is that it increases the effective thermal mass of a building and requires less space that the equivalent "conventional" mass which makes it particularly useful in refurbishment projects as it can be retro installed.

The design intention of the "Cooldeck" system is to increase the value of the heat transfer coefficient of the ceiling void from 2-3 W/m^2k to around 15 W/m^2k.

Mechanical 'Top Up' Cooling to Third Floor Old Block

The thermal modelling of the old block area had originally been carried out in the 1990's using the 'Heathrow Example Weather Year'. This exercise was updated using the 'CIBSE Design Summer Year for London' and the 'London Test Reference Year' following the

exceptionally hot summers of 2003 and 2005. This new modelling exercise demonstrated that the old block floors would exceed the CIBSE and UK Building Regulations Part 'L' overheating criteria i.e. the temperature within the office must not exceed 28°C for more than 1% of the annual occupied period (approximately 20 hours per year).

The solution to this problem was to install localised direct expansion (DX) refrigeration units within the ceiling void. The units (shown) were nicknamed 'squid' units due to their shape and the flexible ducting attached to the discharge side of the unit, that distribute cool air across the ceiling void.

There are three squid units installed on the second, third and sixth floor old block area of the building and they represent approximately 25% of a traditional cooling load design (30 W/m^2 of cooling). The units are time controlled and switch on automatically when the office temperature rises above 27°C. One advantage of the squid design is that they can be hidden within the very narrow (220mm) ceiling void and the occupants are unaware of their presence or when they are operating. This, combined with the lack of any local control, should enable the operating periods of these units to be restricted to the design criteria and help to stop the mechanical cooling being used as 'a first source of temperature reduction' by the occupants.

Mixed Mode Cooling Using AHU and Night Cooling to Customer Services Centre

A full dynamic thermal modelling exercise was carried out as part of the design of the new Customer Services Centre (CSC) using IES Virtual Environment software. This analysis looked at the varying occupancy levels and the need to maintain the temperature between 21°C and 25°C.

The final system comprises of a mixed mode mechanical ventilation and cooling system which uses a high efficiency Air Handling Unit together with the "Cooldeck" night cooling system to reduce the mechanical cooling load.

Ventilation to the main office area of the CSC is provided by the air handling unit located in the existing adjacent garage. Cooling is provided by the ventilation supply air provided by this air handling unit, in conjunction with cooling provided by the "Cooldeck" units, which utilize the structural slab as thermal storage. By utilizing the potential for thermal storage provided by the slab, in conjunction with phase change material (PCM), it is possible to minimise the requirement for mechanical cooling.

During normal day-time operation the air handling unit supplies conditioned fresh air to fan units located within the ceiling void. These fan units supply the fresh air mixed with return air to the space via ceiling diffusers. The return air is drawn back from the space into the ceiling void. Exhaust air is extracted from the ceiling void by the mechanical ventilation unit. The supply temperature from the mechanical ventilation unit is modulated to provide cooling to maintain a maximum space temperature of 24°C.

When the temperature in the space exceeds 24°C the thermal storage cooling is activated. Thermal storage fans located within the ceiling void draw return air from the ceiling void over the "Cooldeck" units. The air being drawn between the "Cooldeck" units and the structural soffit is cooled by the slab / PCM. This cooled return air is then mixed with the fresh air provided by the air handling unit and then supplied to the space by the fan units.

CoolDeck being installed

Controls Alterations to Existing Air Conditioning Systems - Ground and First Floor Atrium Areas

A design study with full thermal modelling of the existing ground and first floor large modern open plan atrium areas was carried out in 2004. The purpose of the study was to establish if the air conditioning system could be run at night on a fan only basis to use the 'free' night cooling effect on the mass of the exposed structure and reduce the daytime cooling energy requirement.

The study found that the fan energy used in the system was 42% of the total heating and cooling energy and running the fans at night would not provide any cooling efficiency advantage. The study did however show that an energy saving of 22% could be achieved with the installation of automatic damper controls.

The control strategy was further developed to use summer and winter 'Pre-Conditioning Periods' as well as CO_2, monitoring and an adaptive profile for the cooling set point temperature to bring the energy saving nearer to the intended 40%.

Hot Water

The original domestic hot water for the building, was supplied by two electrically heated 800litre capacity calorifiers on a "duty-standby" basis. These calorifiers were located in the basement plant room of the new office block built in 1985. They were heated by separate day and night-time electrical heating elements, each rated at 9kW. The domestic hot water was supplied to the wash room facilities via a pumped distribution system with secondary return.

The water consumption rate varied between approximately 800 litres and 1200 litres per day. The energy required to heat the water was also monitored and the average consumption level was approximately 85kWh/day. This equates to approximately 25.9MWh/year and an annual CO_2 emission rate of 11.148 tonnes, based upon a fuel conversion factor of 0.43kg CO_2/kWh.

The main components of the new solar water system were two new 500 litre capacity high efficiency solar calorifiers located in the basement plant room of the new office block and three sets of

south facing solar arrays on the roof of the same block. The existing secondary pipe distribution system was retained and connected to the new hot water generating system.

A pumped solar circuit is connected to the lower high efficiency heating coil of each calorifier, with a 'back-up' Class 5 gas fired high efficiency condensing boiler connected to the upper coil of calorifier No1. Calorifier No 2 is used as pre-heat to calorifier No 1.

The solar collectors are all-glass, evacuated tubes with an absorber area of 18m^2 and occupying a gross area of 22m^2. The solar system pipe work is filled through a permanent filling station with approximately 120 litres of fluid containing an inhibitor and antifreeze. The system design flow rate is 13.5 l/min, with the flow to the three sets of collectors set at 4.5 l/min to ensure correct distribution of the fluid.

The 'Resol' type ES controller constantly compares the temperature of the solar collectors with the temperature of the water in the calorifiers. Any time the solar collector temperature is higher than the stored water in either calorifier, the controller switches on the appropriate variable speed solar circulating pump to heat the water.

Lighting

The Light Emitting Diode (LED) lighting scheme for the public area of the Customer Services Centre was designed to provide a visually striking lighting effect with low maintenance. If LEDs are designed and controlled appropriately they can have a long life with little maintenance. The Daneshill House system consists of a series of modular LED strips hidden within a purpose made up-lighting trough ceiling system. The LED's consist of three modules - white, blue, and blue and white. They are linked in series and connected to LED drivers and DMX controllers mounted in a custom rack within the CSC mezzanine plant room. The LED lighting is supplemented with compact fluorescent light fittings and perimeter cold cathode feature lighting. So far, the LED lighting system has not delivered energy savings over the previous, traditional lighting system.

Daneshill House Customer Service Centre

Monitoring

Stevenage Borough Council aimed to demonstrate improvements in energy performance against a target CO_2 reduction of 50%. They also wanted to show efficiency improvements in terms of the buildings energy performance (KWh/m^2) and space utilisation efficiency (KWh/person) and are comparing pre and post occupancy levels and energy performance in terms of occupancy density. In addition, the solar thermal energy generation, whole building occupancy hours and hot water consumption are also being closely monitored. The monitoring programme consists of a combination of consumption monitoring for the whole building and detailed consumption and condition monitoring for a number of selected areas where improvements are being carried out.

The monitoring data is collected in terms of "occupancy performance" or CO_2 per person per year or CO_2 per person whilst the building is occupied.

The project is made up of a number of individual elements which are a small part of a multi phase improvement programme covering less than 50% of the building. For this reason the monitoring programme was tailored to suit the particular areas of improvement and "whole building" needs to be interpreted with a clear understanding of the timing and extent of the overall project.

The monitoring method is based upon the establishment of a comprehensive schedule of over 60 monitoring points and referenced monitoring data. This allows the monitoring exercises to be easily repeated. Internal environmental conditions are continually monitored and displayed throughout the refurbished offices showing both the CO_2 levels and room temperatures.

The solar water heating is automatically monitored and a large scale electronic display in the Customer Services Centre provides a continual, visual update on the systems performance. The electronic display board shows the temperature of the solar collectors, stored hot water and cumulative thermal energy produced by the system. The solar hot water system installation is considered to be exemplary and is delivering the expected efficiency improvement over the previous electrically heated system. During 2007, the system produced some 9,707kWh of solar energy and including the change from electricity as the main source of energy to gas as the auxiliary heat source, the system achieved an overall 58% reduction in CO_2 emissions The team have also monitored the amount of clear sky either from direct observation or through the Met Office website so they can gauge the efficiency of the solar hot water system. All of this information can then be compared to previous efficiency and CO_2 data from the building before the new technologies were installed.

All of this information is analysed by the building energy management system which is then used by the Building Services Manager to make any necessary adjustments to the various engineering systems.

Lessons Learnt

Client leadership is important in a project such as this, and it is also important to obtain the buy in of the facilities management team early on. Refurbishment solutions exist which can improve the heating/cooling elements of a building and make it more energy efficient. Electronic control systems can reduce energy usage and provide monitoring data at the touch of a button.

Using new technology can be difficult and this can be particularly true with refurbishment works. The LED lighting installation in the Customer Service Centre was one of the first such systems ever installed and the extra burden that places on the design and construction team cannot be overstated. The fact that almost every part of this system was bespoke turned an interesting idea into a very expensive and time consuming reality.

Commissioning problems have been prevalent throughout the Revival work packages and have caused difficulties in the monitoring stages. In future, installations the team would build in more time for commissioning and would conduct an extended period of post completion monitoring of both system performance and energy consumption.

The most successful work package in the Stevenage project in terms of efficiency improvement, energy saved and commercial viability is the improvements carried out to the existing air conditioning systems in the Atrium area. Whilst the adoption of new and innovative technologies are essential to reducing carbon emissions, this relatively simple and effective way of using energy more efficiently, clearly demonstrates that small improvements to existing buildings can have a large impact on reduction of carbon emissions.

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Performance

The energy performance of the "Cooldeck" system on the third floor old block has been measured and compared directly with traditional air conditioning systems. Potential savings of between 74% and 80% were demonstrated during early monitoring and further studies are being undertaken to comfirm these findings.

On 1st October 2008, it became a requirement in for all public buildings England and Wales with a useful floor area exceeding 1,000 m^2 to have a Display Energy Certificate (DEC). Daneshill House has a DEC with an 'F' rating. It was subsequently reported that of the UK buildings in possession of a DEC on 1st October 2008, 25% had achieved either an 'F' or 'G' rating. The average rating was 'D', with less than 1% achieving an 'A' rating.

This was a little disappointing considering the additions that have been made during the refurbishment. However, as the building relies on some air conditioning and has two non-refurbished old block floors with electric underfloor heating, it was felt that these factors had affected the rating. The calculation for the DEC also makes no allowance for the operational efficiency of the building and the very high occupational density that has been achieved within the refurbished building.

Learning Dissemination

As well as participation in the Constructing Excellence Demonstration programme, a technical author was commissioned by REVIVAL to produce monographs on certain aspects of the project. These include phase change material, adaptive thermal comfort controls for building refurbishment and natural ventilation strategies. The REVIVAL project also gathers learning from each of the projects involved to encourage sharing of information between partners, which will form the basis of a proposed European Handbook due to be published this year.

Future Steps

Since the new systems were installed, Stevenage has experienced quite cool summers and so the systems have not been fully tested. For this reason, Stevenage Borough Council will continue to gather data which can be used to analyse the efficiency of the system and the carbon emissions saved.

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CONSTRUCTING EXCELLENCE
in the built environment

Constructing Excellence
in the Built Environment
Warwick House,
25 Buckingham Palace Road,
London SW1W 0PP

T 020 7592 1100
W www.constructingexcellence.org.uk

Stevenage
BOROUGH COUNCIL

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Constructing Excellence, Warwick House, 25 Buckingham Palace Road, London SW1W 0PP
T 0207 592 1100 **W** www.constructingexcellence.org.uk

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