There is much debate about sustainable development but little evidence of radical changes in the way new developments are designed and built. The Millennium Village at Greenwich aims to change this by using the best of modern technology and innovation to create an environmentally friendly, energy-saving, safe and integrated community.

Introduction

Greenwich Millennium Village is an innovative mixed-use residential development on the eastern side of the Greenwich Peninsula adjacent to the River Thames. The proposed scheme currently includes 1377 homes, 20% of which will be designated affordable social houses integrated within the private houses. The village is supplemented by commercial and retail space to provide local facilities and employment. All of the homes will be linked through an IT network and have internal data cabling that enables them to benefit from emerging information and communication technologies.

The developer for the village is a consortium between Taylor Woodrow Capital Developments and Countryside Properties. The value of the project is currently approximately £250 million to be built over the next six years. Construction commenced in late 1999 and the first houses were occupied in December 2000. The consortium is building homes to high standards of environmental performance incorporating energy- and water-saving features. The materials used minimise environmental damage. Management and construction techniques employ best practice. Partnering relationships developed between the project team and suppliers are being used to incorporate new products cost effectively.

Important to the sustainable development plan is the bringing together of economic, social and environmental innovations. When combined with improvements to construction quality and productivity the project will represent a major innovation success. These innovations are typified by an increasing emphasis on energy and water saving, developing local enterprise and communities, prefabricated construction to reduce waste and using information technology.
The village also contains a school and a health centre together with an ecology park. A key aim of the village is to reduce car dependency and dominance by making maximum use of cycle and pedestrian routes together with public transport links that serve the Greenwich Peninsula.

The masterplan

The masterplan comprises approximately 1079 apartments and 298 houses constructed around landscaped squares. The apartment blocks range from 4 to 12 storeys in height. The centre of the village is an ‘oval square’ around which are mixed-use buildings with apartments, shops, offices and community facilities.

The apartment blocks up to 5 storeys high are built from metal and timber panels without the need for an independent framed structure. Above this height, an in situ concrete frame is constructed to which cladding panels are then attached. When an independent framed structure is needed it adds cost to the building and extends the construction period.

The project will be constructed in four phases over a 6-year period. Two phases are currently being built in parallel. Phase 1 comprises high-rise apartment buildings in the area adjacent to the River Thames and the ecology park. Phase 2 consists of low-rise apartments mixed with houses in the southern part of the site.

The masterplan defines the key design principles applied across the whole project. Within phases, separate architects carry out the design to reflect particular themes for that phase. This provides a diverse range of accommodation types across the development to support selling.

The masterplan has some special technical features:

- The buildings are arranged to provide shelter from the wind. The
To lift prevailing winds over the development, building heights progressively increase from the east.

The site is relatively exposed to prevailing winds and wind effects from a long length of the River Thames. Wind effects have been modelled as part of the design at both a strategic and local level. To lift prevailing winds over the development, building heights progressively increase from the east. Organising the buildings around squares provides protective enclosures with streets oriented to minimise wind effects.

- The buildings are oriented to obtain maximum heat energy from solar gain in the winter months. In practice, this results in large glazed areas on southern elevations with reduced glazing levels provided on northern elevations. To avoid overheating in the summer months external shading is provided through balconies or canopies located over the glazing. Internal blinds in practice have limited effect in controlling this overheating.

- To avoid a car-dominated environment, car parking is in purpose-built car parks away from streets. These car parks are located close to the homes, typically beneath landscaped courtyards. There is a car parking space for each home, with an additional 10% allowance for visitors’ parking. The masterplan includes convenient and safe pedestrian and cycle routes that link to public transport. The cycle parking provision is 1 space per 2 apartments.

- Care was taken in the design of the spaces between buildings. Landscaped public spaces are included with additional semi-public areas enclosed within the courtyards. The design encourages people to meet and utilise the spaces for a variety of activities to be decided by the community.

- There is a mix of affordable social and private housing within the same areas, creating an inclusive community. This, however, has required close attention to long-term management issues. Particular attention has been paid to the integration of affordable social and private housing room size and specification standards to ensure that cost effective solutions are available.

**Brownfield regeneration**

The village is being constructed on brownfield land that has been remediated to meet strict health and environmental standards for housing development. The remediation was carried out ahead of the housing development as part of the enabling infrastructure works for the whole of the Greenwich Peninsula.

After the removal of soils with locally high levels of contamination, the whole site was evenly graded. On top of this graded level a plastic marker layer was placed; then 900 mm of clean soil was compacted over the whole site. An extra 600 mm of clean soil is being compacted over the site as part of the housing construction. The entire 1.5 m soil barrier isolates the underlying residual contamination from the housing development. Particular attention has been paid to the selection of these clean soils to ensure that their strength and permeability characteristics will maintain the long-term integrity of the barrier.

In addition, the possibility of contamination within the groundwater was considered. Bentonite slurry walls provide a barrier to groundwater migration. The building foundations include ventilation for the low levels of residual gases from the contaminated soil. The site is being monitored during construction to ensure that the housing development does not compromise the remediation works.

The enabling infrastructure for the primary services and roads was included within the remediation works. This avoided the need for major excavations in the contaminated ground. Excavations for building foundations have been kept to an absolute minimum. Typically, buildings have piled foundations constructed on top of the clean soil layer. The driven ‘cast in place’ pile type that is used results in limited soil arisings and eliminates vertical migration of groundwater around its perimeter.

The laying down of a high quality infrastructure ahead of the housing development works has played a major part in the successful regeneration of the area.

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**Innovation targets**

At the beginning of the project, the consortium set innovation targets to ensure that the momentum for innovation was maintained and to ensure that new ideas were focused to achieve tangible differences. For each innovation target we established a
Greenwich Millennium Village is the first major UK private housing development to incorporate Combined Heat and Power

performance benchmark through which actual differences in performance can be measured as the development progresses.

The technical innovation targets, to be progressively achieved over the development phases of the project, are:

- Primary energy – reduce by 80%;
- Embodied energy used for building construction – reduce by 50%;
- Water consumption – reduce by 30%;
- Construction cost – reduce by 30%;
- Construction period – reduce by 25%;
- Achieve zero defects on practical completions;
- Construction waste – reduce by 50%.

**Primary energy reductions with Combined Heat and Power**

Primary energy is the total energy generated to meet local consumption needs and therefore has a direct relationship to carbon dioxide emissions. The 80% target for the reduction in primary energy includes efficiency improvements to electricity generation and distribution as well as direct energy consumption in the home.

The use of Combined Heat and Power, improved building insulation and better heating controls achieves a 65% reduction in primary energy.

Greenwich Millennium Village is the first major UK private housing development to incorporate Combined Heat and Power (CHP). CHP facilities generate electricity locally and use the associated heat to serve hot water and heating demand. The electrical generator is powered either by a gas-fuelled reciprocating or turbine engine. Identifying a viable approach to CHP was difficult and hampered by the weak specialist supply base in the UK. We paid particular attention to the implementation of CHP with the housing. The solution we developed was a compromise between pure technical efficiency and development financing constraints.

We installed CHP facilities in energy centres that matched development phases. Typically, each energy centre serves a phase of 450 dwellings, although for the first phase there is further subdivision into 100 and 250 dwellings. The generator units are typically set at 0.8 kW (electrical output) per dwelling but the primary size is such that the waste heat they produce matches the base heat load of the dwellings they serve. This avoids unnecessary dumping of heat energy.

A suitable balance between building insulation levels and CHP energy delivery is required. With high levels of building insulation and associated very low heat demand, there is a reduction in the opportunities for electrical generation. This reduction in revenue stream has to be set in the context of capital and fixed operating cost recovery.

Options for renewable energy have been evaluated and found to have limited viability in the housing sector. High capital costs combined with the relatively low available energy currently limit their application. We have evaluated systems including photovoltaic cells and wind turbines; these continue to be under active consideration.

**Green design to reduce embodied energy**

Embodied energy is the energy used to manufacture, transport and install building products. Although major changes have been made to domestic energy use, little impact has been made on the energy required to build houses which currently accounts for 10% of UK energy consumption.

Throughout the design process we are using the BRE Green Guide for the selection of materials and products. The guide provides the environmental profile of a wide range of building products based on their climate change, pollution, transport and recycling characteristics. On completion of the design for the first buildings, an embodied energy audit measured a 25% improvement.

We have placed particular emphasis on the building structure and envelope as 85% of embodied energy is linked to these areas. The selection of cladding materials avoids the use of PVC and extruded polystyrene insulation. Materials given particular preference include timber weatherboarding, terracotta tiling, render and mineral wool insulation.

Low-rise housing in Phase 2 of the development.
Water saving and grey water recycling

Our designs will reduce water consumption from a typical 160 litres per person per day by the amounts shown in the above table.

As can be seen from the table a 20% reduction in water consumption can be achieved through the selection of efficient devices in the home. Potential home buyers understand these and their use is predictable.

This contrasts with grey water recycling which is necessary for the final 30% reduction target. Grey water recycling takes waste water from bathroom washbasins and showers and, after chemical treatment, stores this water for later reuse in flushing toilets. There is a need for regulatory support to define cost-effective water treatment standards if these technologies are to be more widely used.

Information technology for the home and village

A key innovation in the village is the way in which information and communication technologies can support better communities and add convenience around the home. The technologies being used at Greenwich Millennium Village include:

- A village web site, accessible from every home, for up-to-date information on public transport, local events, neighbourhood watch, village management and community issues. It is envisaged that the community will maintain the web site in the long term.
- Adaptable data cabling around the home, able to support entertainment, telephones, computer devices and remote utility reading.
- Systems to make the village secure through CCTV, controlled access and security sensors which will provide information to residents and the managing agents.

For the implementation of these leading-edge technologies we have formed a partnership with British Telecom for design, implementation and medium-term management. Our objective is to ensure that all the homes and the village are able to benefit from future developments in information technology and are technically enabled to incorporate new products and services easily as they emerge.

Off-site manufacture and component assembly

To achieve improvements in construction quality and productivity, fundamental changes are necessary in the constructed product. Off-site manufacture and component assembly underpin these new approaches.

Through the greater use of factory production, we envisage that quality will improve, waste will be reduced and on-site construction will be quicker.

These new approaches require changes to the design of homes; in particular, the detailed design of interfaces early in the design process for the assembly of modular components at scheme design stage. Factory production generally requires greater design effort early in the design process to resolve the way in which factory-produced units are incorporated on site. Another key issue is the incorporation of customer choices into the design and factory production process, even when these occur at a relatively late stage.

Key areas for off-site manufacture include:

- Bathroom modules that meet high quality expectations and speed up construction. The units are delivered as complete rooms fully fitted to include all services that are pre-commissioned. The units are standardised in size with standard services connections.

Factory-made bathroom pods being positioned.
"Science can amuse and fascinate us all but it is Engineering that changes the world" - Isaac Asimov

Taylor Woodrow plc is an international developer with three constituent parts to our group – housing, property and construction – which together provide a special range of skills, particularly in the area of mixed-use and brownfield development.

We are one of the largest industry investors in research and development, and today the group’s engineering consulting arm is regarded as expert in design, technology, testing and innovation.

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we have typically reduced our construction waste by 35%

- Cladding panels that are factory made to provide early weathertightness to the building to allow early internal fit out. The panels are typically storey height, 3m long and include windows.
- Pre-commissioned building services modules such as lifts, plant rooms and services risers for easy incorporation within the building. Building services represent significant construction site complexity. With pre-commissioned factory-produced modules a cost effective, reliable solution is available to reduce this complexity.
- Pre-cast concrete stairs to give early safe access to work areas.
- Complete factory-made roof panels with roof drainage outlets built in.

**Construction waste**

It is important to reduce the amount of waste arising from construction sites which currently accounts for 40% of UK waste. Our own measurements of skip volumes removed from sites show typically 50 m³ per dwelling. The costs associated with this waste, its potential replacement and removal are not well understood.

Our improvement strategy is to measure construction waste on an ongoing basis and identify its causes. Through this process, we have typically reduced our construction waste by 35%.

During construction, there is successful segregation and recovery for recycling of plasterboard, timber and metals. Site measurements show that about 20% of site waste is recovered for recycling.

In general terms, there are very low levels of waste with high levels of prefabrication. This is particularly the case for low-rise housing with timber panel construction which achieves a 65% reduction in construction waste.

**Innovation progress so far**

We have made significant progress in meeting the targets for environmental issues – we have achieved major improvements in energy efficiency, water consumption and reduction of construction waste. All of these are monitored to verify the actual improvements made and to identify where further changes are needed.

Progress in achieving the construction cost and duration targets is proving more difficult. We are now placing more emphasis on these, and are taking several strategic actions as follows:

- Finding economic design solutions for the integrated design requirements for affordable social and private housing.
- International sourcing of products to ensure that we obtain maximum value and innovation. A key issue is to ensure we are aware of available products and their use in the context of UK regulations and market.
- Emphasis on standardisation across the whole project whilst retaining customised design solutions on a phase-by-phase basis to meet market needs. Customers do not see many of the products and these can therefore be standardised without compromising customer choice.
- Through greater standardisation, creating opportunities for significant bulk supply in order to benefit from economies of scale which will provide more cost-effective solutions.

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