National Trust

Building design guide

- local amenity
- sustainable technology in a traditional building
- access for all
- use of natural materials

Gibson Mill

Historic mill renovation to provide visitor and education facilities

September 2005

Background

- Gibson Mill, built around 1800, is situated within Hardcastle Crags woodland beside Hebden Water. It was one of the first mills of the Industrial Revolution. The mill was driven by a water wheel and produced cotton cloth up until 1890. In 1833, 21 workers were employed, each working an average of 72 hours per week and living in the adjacent mill workers cottages.

- In the early 1900s, Gibson Mill began to be used as an entertainment emporium for the local people. The facilities included dining saloons, a dance hall, a roller-skating rink, refreshment kiosks and boating on the mill pond. A hydro-electric turbine, dating from 1926, remains.

- After the Second World War, the mill slipped into disuse, and was acquired by the National Trust in 1950. It has remained largely unused since.

Project brief

- Preserve the historic quality of this nineteenth-century mill and former entertainment emporium whilst respecting the unique spirit of the place.

- Achieve a building autonomous of all mains services, including electricity, gas and water. The building must rely solely on the natural resources found on the site including water and daylight for heating/lighting, spring water for washing/drinking, and all waste treated on site.

- Provide lavatory and catering facilities for visitors.

- Provide space for educational and community use.

Aerial view of mill roof showing full solar array

- Provide high quality information and interpretation for visitors.

- Provide permanent accommodation for an on-site warden.

- Provide a manually powered lift system for disabled access to higher floors.

- Minimise the impact of increased visitor numbers on the local community.

- Achieve a building capable of demonstrating the Trust s Sustainability Principles during the construction phase as well as when in use. Use of local labour and recycled materials and, if this is not possible, all materials to be obtained from sustainable, preferably local, sources.

- New facilities to be set entirely within the historic fabric of the existing buildings.

Former stables, now toilet block

Sustainability

■ Sustainable development, ecological design and eco-tourism are key themes. These, together with the use of renewable energy and a mains autonomous approach, fulfil the objective of respecting the spirit and sensitivity of the whole property.

■ A rigorous environmental design strategy employs local non-polluting renewable energy sources available on the site.

■ The hydro system of the mill is used to provide electricity. This includes a restored 1926 turbine and a smaller turbine for use during periods of low water levels.

■ Solar evacuated panels and solar photovoltaic panels provide hot water and electricity.

■ A woodland management system linked with highly efficient thermal mass wood-burning stove and boiler provide cooking, hot water and space heating. The annual fuel requirement for the whole site is 17 green tonnes. This is easily met from arisings from the woodland management on the estate s 66 hectares of mixed woodland under a sustainable management regime.

■ The mill uses the natural spring water from Hardcastle Crags as its water supply. The quality is monitored and, by installing a simple filtering system, it provides water for drinking, washing up and the toilets.

■ Dry compost (or minimal water use) lavatories deal with waste streams generated by the new facilities. Composting Aquatron toilets have been installed to treat human waste so that it can be recycled as fertiliser for use on the property.

Water tank feeding hydroelectric turbines

■ A series of measures are incorporated into the building and operational running to help conserve energy. Thermafleece insulates the roof and walls in the caf . Low energy appliances have been used in order to reduce the amount of energy used in the mill. The design of the caf area maximises the use of natural light.

■ Water-saving measures reduce normal usage by up to 70%.

■ A manually operated counterbalance lift has been installed to provide disabled access to the first floor.

■ Green transport is promoted as part of the sustainable strategy for the mill.

■ Domestic waste is collected and recycled wherever possible.

■ The log-burning boiler, installed in the former engine house for the caf s hot water supply, was oversized to allow once a day firing and will operate at a higher than required temperature to minimise environmental effect.

Sluice gate operating motor

Key factors

■ The Trust's flagship project for sustainability
■ Development appropriate to unique setting
■ No mains services

Consultees

- Heritage Lottery Fund (HLF)
- Local community
- National Power
- National Trust members and visitors
- Parish Council
- Yorkshire Forward

Designations

- Grade II* listed building
- National Nature Reserve

Site issues

- It is a remote site with no services, located at the end of an unmade track, a mile from the main car park. The location made communications difficult.

- It was essential to be sensitive to the unique setting of the mill within the wooded valley of Hardcastle Crags.

Original stepping stones were left in situ

Nature conservation

- A bat survey of the mill and the surrounding area was carried out in February 2004 before any building work began. A report by the Ecological Consultant, gave detailed recommendations regarding the timing of alterations to the roof structure and the types of timber treatment used. It also made recommendations on how to improve the provision for access for bats within the building.

Design approach

■ Ensure the concept, design and operation meet the Trust s principles of conservation, sustainability and engagement.

■ A Conservation Plan set out the necessary repairs and restoration which would enable new facilities to be incorporated entirely within the historic fabric of the existing buildings.

■ The design team, led by the architect, produced all the working drawings for the project. The outline designs were fed into the Trust s project team prior to the HLF bid being submitted. The Architectural Panel was consulted at this stage and approved the outline proposals. Once the HLF bid was accepted the detailed design process began.

■ The key to the project s renewable energy strategy was to minimise demand through design. A comprehensive energy feasibility study investigated the balance of supply and demand at different critical periods i.e. varying weather conditions. This study provided enough information to enable a detailed energy specification to be developed that combined both energy efficiency and renewable energy technologies.

■ The strategic aims were also realised by opting for existing proven technologies and avoiding advanced complex units requiring specialist maintenance input.

■ The general principle was to create a building that would be totally self-sufficient without bringing in mains services. The sustainable technologies resulted in a 20% saving, when compared with the cost of installing new mains, which would also have required a new substation.

The mill now houses a caf in the weaving shed, a shop and reception in the entrance lobby, and interpretation, education and community space over three floors

■ Feasibility studies of energy use were undertaken at conception stage. The challenge was to demonstrate the amount of power that could be generated under different climatic/river flow conditions. A hierarchy of options was developed and it was agreed that even in the worst case (low river levels and cloud) sufficient power could be generated to operate the building. Detailed design only commenced following this outcome from the feasibility study.

The tail end of the turbine race where the water rejoins the river

Construction

Pre-project repairs

- Major roof repair to mill in 1994
- Excavation of mill pond
- Repair of sluice gate
- Removal of turbine and generator for restoration by National Power

The interior during restoration works. The mechanism of the dumb waiter is in the foreground.

Project team

The project team comprised people and companies providing internal and external expertise including:

Area manager
Project manager
Buildings surveyor
Territorial curator
Property manager
Rural surveyor
Sustainability
Archaeology
Nature conservation
Finances
Customer services
Interpretation
Conservators
Access
Architect and lead consultant: Eco Arc, York
Mechanical, electrical and sustainability: Environmentally Conscious Building Services, Stroud
Hydro services consultant: Dulas, Machynlleth, Powys, Wales
Water and sewage consultant: Elemental Solutions, Hereford
Quantity surveyors: Turner and Holman, York
Planning supervisor: RWS Partnership
Main contractor: William Birch Ltd., York
M&E consultant: Gifford and Partners, Chester

- Internal project team roles were agreed at the start of the project in order to clearly define lines of communication and to highlight areas where individual members were either accountable or advisory. The Project Manager led the team and was the client representative in respect of contracts with the consultants and contractors. Meetings were held jointly with the internal team and the consultants.

- The external project team were all appointed directly by the Trust at conception stage, and reported to the Project Manager. They were held accountable for the design and delivery of the project. Feasibility studies formed an integral part of the project development and HLF bid.

Weaving shed reconstruction

Roof

■ The original roof was lost many years ago. New oak was selected from the Trust s woodland and dressed for use by a local mobile sawyer. The roof was insulated with Warmcel recycled newspaper between 300mm deep Masonite rafters and covered externally with locally sourced, natural, reclaimed stone slates.

■ The open cathedral ceiling was underdrawn with Sisalkraft 410 breather paper and finished with beech boarding sourced from the site woodland. Extensive computer daylight modelling and the need to minimise the use of internal energy-consuming electric lights determined the size of the central ridge Vitral roof glazing. Every third roof light along the ridge can be manually opened with a telescopic pole to avoid summer over-heating and provide good ventilation.

Retrofitting the existing walls

■ Two main factors determined the approach to retrofitting the walls. Firstly, the existing thick masonry walls provided thermal mass, but there was no insulation to retain heat. Secondly, the projected intermittent use of the main space required a lightweight insulated enclosure that would allow a quick room warm-up period after lighting the space-heating stove. It was decided to dry-line the walls on the inside with a ventilated cavity panel made out of Sisalkraft 410 breather paper and 25mm thick natural clay board plastered with Claytec plaster, and finished with natural casein distemper paint. This was an alternative to gypsum plaster board which uses high levels of energy in its manufacture. The cavity was filled with 200mm of Thermafleece insulation between the (locally sourced) softwood studs.

The hydroelectric turbines are fed by this water tank

■ Rather than use concrete blocks, the internal structural walls were formed with 150mm wide natural clay blocks which were finished with natural clay plaster and casein distemper paint to match the other walls.

Floor

■ The existing stone flag floor was very damp and many of the stones were severely cracked. The floor was accurately surveyed with each flagstone drawn out and numbered. The stones were lifted up and set aside for re-use. The new floor was insulated with 150mm of insulation and the existing flags were reset in exactly the same position on a lime mortar bed and re-pointed.

Renewable energy

Hydroelectric power

■ The original 1926 Gilkes Francis turbine was carefully removed from site and fully refurbished in the National Power workshops. Once refurbished, the open flume machine was built back into the sump wall in the main building. The output figure of 14kW was down-rated to 9kW to allow for worn condition but in reality it has performed much better than expected giving a surplus above its designed output. Since the main turbine would only work at times of high river flow rate, a smaller cross flow type turbine was installed to use at low flow rates to provide 1.5kW. The hydro energy output from both machines is integrated into the building energy management system and works within the bounds of the abstraction regime designated by the Environment Agency.

Solar photovoltaics (PV)

■ The rooftop positioning of the PV array was accepted only on the grounds that it could at some point be removed with negligible impact on the listed building historic fabric. For this reason the PV array is set up above the existing stone slate roof on proprietary 150mm stand off Oatey integrated upstands and flashings. Proprietary stainless steel and aluminium rails formed a framework to support 24 Kyocera 120Wp (peak) PV modules and 24 60Wp PV modules. The total PV array rating was 4,320Wp connected in parallel to a junction box mounted in the attic space and hard wired to the public display switch gear exhibit.

Biomass heating systems

Caf   hot water supply

■ A 60kW peak downdraught log-burning boiler was installed in the former engine house, supplied by Ecoenergy. The boiler has a batch feed hopper and is capable of operation under natural draught conditions. A single skin, stainless steel flue exits from the stove outlet and runs up a new lining in the existing mill chimney. This primary stove supplies hot water to a 2,300 litre pre-insulated stainless steel accumulator tank located in the caf kitchen to provide 85 C water for hot drinks and 65 C hot water for washing-up. The hot water for drinks is topped up to 100 C with an electrically operated instantaneous water heater at the caf   serving hatch.

Caf   space heating

■ A 14kW traditional Swedish Kakkelovn thermal mass log-burning space heater stove was installed in the caf   seating area by the Ceramic Stove Company. It draws air from the room through a duct, past, but not through, the firebox and out through vents in the doorframe. After only one burn process in the morning, the heat deposited in the thermal mass of the stove is emitted over a 12-hour period during the rest of the day.

■ The ceramic stove is the principle source of high quality heat permeating throughout the café space. This efficient heating system saves on the use of traditional fossil fuel, extends the life of the heating system output beyond the initial burn process, and reduces indoor pollution.

Resident warden s house

■ A 20kW Warmsler biomass timber-fuelled kitchen stove and combined boiler producing central heating, cooking, and domestic hot water was fitted in the kitchen hearth. A 5kW clean burning Clearview Vision space-heating stove was also fitted in the warden s living room.

The refurbished 1926 hydroelectric turbine and the new 1.5kW turbine for low water levels

Solar panels (right) and pv panels, viewed from the courtyard

Battery storage

■ A battery store consisting of 24 x 2 volt lead-acid cells has a total available capacity of 48kWh. The store is used to smooth inputs and demand peaks, and to provide electrical energy to appliances in periods of low hydro and PV input.

Renewable energy control system

■ A central feature of the public display sustainability exhibition is the renewable energy control system switch board and data logging panel, laid out to be easily interpreted by the public. The control panel was designed to be flexible, and automatically prioritises key loads in times of low energy input. It also incorporates easily understood status displays, easy to read dials and data logs giving staff the necessary information to manage the energy resource and avoid blackout during opening times.

Solar water heating

■ An AES solar water-heating system was integrated onto the end of the PV array to supply domestic hot water service to the warden s cottage during the spring, summer and autumn.

Site sewage treatment system

Public toilets

■ A private water supply and wastewater treatment system was the only practical option for this remote site, but the autonomy brief also called for sewage solids to be treated rather than tankered away. Dry compost toilets were considered for the public but rejected in favour of standard water-efficient WC's.

■ Access to the public toilets is by a narrow bridge so a sludge-free system made sense. The solution chosen was based around the Swedish Aquatron separator. This simple passive (non-electric) device uses surface tension to separate the solids from the flushed water, for composting in one of two pre-fabricated bio-chambers located in the room under the toilets. These dry composting chambers are primed with worms to accelerate the decomposition process of the solid faeces. In time the dried out and fully composted solids will be returned to the woodland floor as a benign fertilizer.

■ The separated urine and flush water liquid effluent from the Aquatron separator flows to an un-powered dosing device, which delivers pulses of liquid black water effluent along a below-ground infiltration trench. The sandy soil provides filtration and biological treatment without odour pollution or energy use.

Stable block toilets

■ Robust but super efficient 4litre Ifo Cera WCs are used for the stable block toilets with traditional leak-free siphons and Ifo Cera waterless urinals.

Staff and cottage toilets

■ The warden's cottage is fitted with a single Canadian Sunmar Excel dry compost toilet. The historic building precluded the use of larger vault-type toilets which are more robust but would have required excavation of the building floor. The Toll House toilets for the disabled and staff were fitted with Swedish Separett dry compost toilets linked to a single fan-assisted extract flue fed up through the existing chimney.

Battery array for smoothing electricity supply

Aquatron toilet system

Water supply

■ Fortunately, a reliable, pure spring was found on site that was just high enough to supply all the buildings by gravity without the need for pumps or treatment. A concealed and landscaped header tank was built to provide a small backup supply if short-term demand exceeded the natural supply flow rate.

■ By significantly reducing water use, the property was able to simplify wastewater treatment and onsite disposal design. Following a low water use regime also demonstrates best practice to visitors and provides performance and reliability advantages.

■ With limited power, hot water was not considered feasible for the remote toilet block but the use of spray taps minimises the discomfort whilst further reducing effluent volumes.

Biomass from the woodlands

■ Wood generated as part of the estate s woodland management is dried over a three-year cycle and used to fire the boiler which provides hot water for the caf   and the cafe s biomass space heater.

Products and services

Architects
EcoArc
www.ecoarc.co.uk

Main contractor
William Birch Ltd.
www.williambirch.co.uk

M&E and Structural Engineering Consultants
Gifford Consulting
www.gifford-consulting.co.uk

Power and hydroelectric
Dulas Limited
www.dulas.org.uk

Electrical sub-contractors
Reginald Maude
Globe House, Miall Street,
Halifax, West Yorkshire
HX1 4AE
Telephone: 01422 252525

Water and toilets
Elemental Solutions
www.elementalsolutions.co.uk

The 60kW downdraught log-burning boiler installed in the former engine house, supplies hot water to the cafe

Space-heating stove
Ceramic Stove Company
www.ceramicstove.com

AES solar-heating installation
Ecoheat Limited
www.ecoheat.co.uk

Counter-balanced, hand-powered lift
George Johnson Lifts Ltd
Telephone: 020 7732 4444
info@georgejohnsonlifts.co.uk

Log-burning boiler
Ecoenergy
www.econergy.ltd.uk

Toilets
Aquatron
www.aquatron.se
Separett
www.separett.com
Ifo Cera
www.ifosanitar.com
Sunmar Excel
www.sun-mar.com

Funding

- **Heritage Lottery Fund** 50%
- **Yorkshire Forward (Regional Development Agency)** 10%
- **Landfill Tax credits, National Trust Association and central funds** 40%

Procurement

- The contractor was appointed following a competitive tender exercise on a best value basis . Partnering was considered but since the detailed designs were very detailed it was not considered appropriate. Eight contractors were invited to visit the site to assess the scope of works and to write in with a brief Method Statement. Five contractors were then invited to tender. The three lowest tenders were interviewed and their method statements were scrutinised. The lowest tender was appointed.

Project duration

- Project first mooted: 1994
- Project start: March 2004
- Project complete: July 2005
- Official opening: September 2005

The Toll House (right) has nature interpretation on the ground floor, and the first floor is used for storage

Post project review

The mill is 100% self-sufficient in energy, water and waste treatment, and the only mains connection with the outside world is the phone line. The combination of technologies used, the size of the building and the fact that it does not link up to the National Grid, make the mill unique in Great Britain.

It survives solely on processed wood prepared on the site, together with spring water captured at source. It was the first heritage building, used as a visitor centre with the prerequisite facilities, open all year round, to operate solely in a sustainable way.

On a typical day the mill generates more electricity than is required, and has only closed once in three years since project completion. The property recognises that it took the first two years to fully understand the operational aspects of the services at the mill, and to build up an understanding of the impact various weather conditions can have on production at different times of the year.

The mill has become a source of inspiration for others considering sustainable developments with visits from individuals looking at applying the principles to domestic dwellings through to councils interested in more commercial operations.

The mill has also become a national focus for green living, hosting many meetings, both formally and informally.

Detail of turbine before restoration to working order

Best practices

- The Project Team used the Planning Supervisor, as a post box for all drawing revisions. This ensured he had access to all design drawings and could input into the design from a Health and Safety standpoint. A visit by the Health and Safety Executive inspector midway through the project held this practice to be exemplary.

- The Conservation Plan was contracted out to an external company. It proved useful for fresh eyes to evaluate the proposals.

This log-burning space heater stove, a Swedish Kakkelovn , is in the caf seating area

■ The early dialogue with the HLF proved very productive and the Project Manager had regular contact with the Case Officer when writing the business plan. The HLF were comfortable with the project management structure and decided it was not necessary to allocate a Project Monitor to the project.

■ Planning and Listed Building approvals were required. Additionally, a Water Abstraction licence was required to extract water for the water turbines. It was worthwhile having early dialogue with the Planners and the Environment Agency. This led to both Planning and Listed Building Consent being granted under delegated powers. Good relationships still exist that will benefit future projects.

■ With its central biomass space-heating stove, the new super-insulated space provides a warm and naturally lit public facility with environmental performance standards in excess of current (2006) Part L Building Regulation standards, all set within the historic fabric of the listed building.

■ Initial problems with the laying of the water pipe have been overcome. The installation of a three-way valve has been hugely beneficial, providing the property with the functionality to release air locks, and increasing the self sufficiency of the property by reducing the need to call out a specialist maintenance team.

Approach view, with cottages in foreground

Lessons learnt

■ At the stripping out stage archaeological remains of a previous structure were discovered. This delayed the work programme whilst the remains were examined, recorded and protected. Given the known nature of the site, the archaeologist should have been an integral member of the project team.

■ The over-production of electricity was not forecast. The original project assumed the turbines would only operate during the day, but there has been sufficient water flow to leave them running 24 hours a day. This means the battery back-up system remains well charged, and rarely drops to critical levels.

■ The river flow rate has also been faster than was originally expected, as less water is being extracted up stream by Yorkshire Water. However, this may vary in future, which the property must be prepared for. Calculations suggest this will result in the loss of eight days worth of power to the mill.

End user feedback

General feedback from both staff and visitors is that the PV panels have blended in well with the building and quite frequently go unnoticed by visitors.

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The newly repaired sluice gate

Energy control board for integrating hydro-generated electricity, solar-generated electricity and battery storage. The control panel also allows visitors to monitor the site s power generation and usage

Awards

- Building Magazine Sustainable Building of the Year 2006
- RIBA Yorkshire White Rose Award Winner 2006
- Museums & Heritage Awards for Excellence 2006 - Use of Renewable Technology Winner
- International Green Apple Awards for Architectural Heritage and the Built Environment
- The West Yorkshire Built in Quality Award for Sustainability

Further information

If you require this information in alternative formats, please telephone 01793 817791 or email buildingdesignguide@nationaltrust.org.uk

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