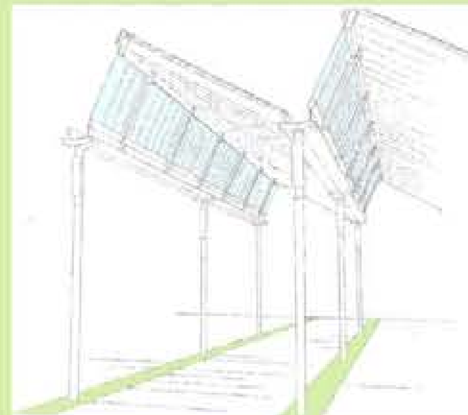
'NORTHERN LIGHTS'

THE P E N N I N E L A N C A S H I R E N O R T H L I G H T W E A V I N G S H E D STUDY



- M A I N REPORT 2010

Pennine Lancashire

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1.0 INTRODUCTION

This study was commissioned by Design & Heritage Pennine Lancashire with the support of English Heritage, HTNW, LCC and the local authorities of Pennine Lancashire. Its objective is to provide a practical guide to all those involved in the conservation and development of the unique north light weaving sheds of the region and to generate enthusiasm for their retention and future use.

This report has been produced under the direction of a steering group. The members of the group are listed below:

Jo Clark - Elevate (Project Director)
Darren Ratcliffe - English Heritage
Andrew Rudge - Blackburn with Darwen Borough Council
Doug Moir - Lancashire County Council
Cecelia Whitaker and Erika Eden Porter - Burnley Borough Council
Rosemary Lyons - Pendle Borough Council
John Miller - HTNW

The study has been researched and produced by Purcell Miller Tritton staff including Niall Phillips, Jamie Coath, Liz Humble, Tim Rolt, Neil Wall and James Ball and with support and input from specialist consultants including Mann Williams (Building Structures), Martin Thomas Associates (Environment & Services), Trevor Humphries Associates (Cost Consultancy) and a number of local surveyors and agents.

It is intended that the study will be made available in a short summary document and electronically through partner websites including Heritage Trust for the North West and Lancashire County Council

We would like to thank all those many people who have contributed their knowledge, commitment and expertise towards the completion of the study.

We believe the study will provide a good foundation for securing the future of the majority of the Pennine Lancashire weaving sheds and hope that it will inspire many to consider the potential they offer for providing interesting new places to work, live and enjoy and in doing so to reinvigorate an exceptionally important part of our unique industrial heritage.

Purcell Miller Tritton LLP January 2010

2.0 HISTORICAL BACKGROUND

The Pennine Lancashire north light weaving sheds represent the industrialisation of the spinning and weaving production that had its origins in the domestic system of family run workshops that developed in Lancashire during the 17th Century. The Domestic System comprised small workshops located as part of family dwellings where the processes of spinning and weaving were carried out by family members on basic spinning machinery and hand looms. These gradually developed into rows of weavers' cottages which enabled a more coordinated production and a corresponding increase in output.

The 18th and early 19th Centuries witnessed the transformation of the economy across Britain, and the expansion of trade, overseas markets along with a series of technological inventions and discoveries lead to the industrialisation of manufacturing and the emergence of the factory system of production.

This included spinning and weaving where the development of more mechanised forms of production and the implementation of powered processes using water mills and the later development of steam driven power lead to the large scale factory style integration of spinning and weaving with all processes, housed in single large textile mill buildings.

Initially mill buildings were developed as multi-storey buildings with relatively shallow floor plans and large windows to provide as much daylight to the interiors as possible.

The mid 1800's saw the emergence of single storey north light weaving sheds as a new type of building. These were often associated with a multi-storey mill which housed the spinning processes. The single storey north light weaving sheds enabled large numbers of power looms to be housed together on the same floor and greatly increased production efficiency. The sheds offered significant advantages over multi-storey buildings which by comparison suffered from a greater risk of fire, due to the use of timber internal floor structures, and a greater reliance on gas lighting. The north light weaving sheds were also relatively cheap and simple to build which meant that more companies were able to set them up and establish businesses.

The key characteristics and benefits of the north light weaving sheds were:

- Large single storey making it easier to house and supervise large numbers of power looms leading to greater production efficiency.

- The single storey, 'modular' nature of the structure enabled it to fit to irregular sites and for the buildings to be readily extended as businesses grew.

- The single storey sheds were structurally more secure as they avoided the problems of accumulative weight and vibration induced by power looms in multi-storey mills by spreading the loads across the ground floor.

- The provision of high levels of north light uniformly distributed across the full extent of the floor area was imperative to the process of weaving as it increased worker's efficiency and removed shadows which could otherwise disguise faults in the quality of the cloth. The uniformity of the lighting enable looms to be distributed freely throughout the floor plan.

- The provision of top lighting freed the restrictions on size imposed by side lighting or floor spans in multi-storey building which enable very large deep plan buildings, often housing many hundreds of power looms, to be developed.

- Simple and relatively cheap construction using a 'standardised' structural system of cast iron columns and beams, timber rafters, slate roof coverings and glazed timber north lights enclosed within coursed stone outer walls. The cast iron structure offered improved fire resistance over the timber floors of multi-storey mills and the structure incorporated the all the bracketry necessary to support the power line shafting and belt drives enabling new companies to set up and establish businesses relatively cheaply.

Weaving sheds were built and developed as businesses by two main groups. The first were capitalist entrepreneurs who tended to build entire sheds, particularly in the late 19th and early 20th Centuries. The other group of builders / owners were small scale ventures, often former handloom weavers and entrepreneurs who formed co-operatives and many of these sheds were operated on the 'room and power' system.

The 'room and power' system comprised landlords, including individual owners, limited companies or co-operatives who built or purchased existing weaving sheds and leased space to tenant manufactures. Rent was based on loom space and included motive power from the engine.

The location of weaving sheds was often determined by a common set of requirements as follows:

- Fast Flowing / abundant water source. This was likely to have been a key factor in the origin and growth of the textile industry in the Pennines Lancashire. Water was needed originally as a direct source of power to drive water-wheels and then, with the advent of steam power was required for condensing engines and boilers.

- Damp Climate and humidity. The damp atmospheric conditions prevalent in the Pennine Lancashire region are ideal for the manufacturing process involved in cotton weaving. Much of the region is hilly and to create the large floor areas required and to maintain high level of humidity within the building the sheds were often deliberately deeply terraced into the ground to encourage damp through the outer walls.

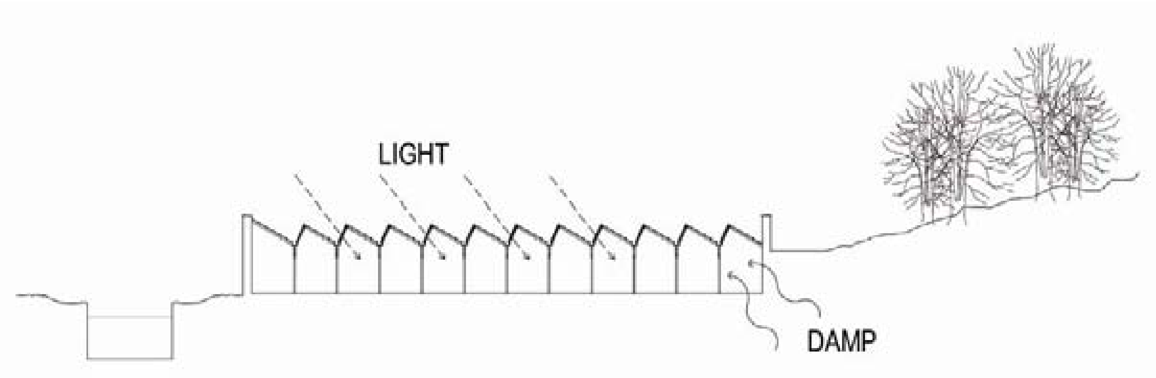

Figure 1. Location diagram

- Good transport links. The early-mid 19th century mills in the Lancashire region tended to cluster around the Leeds and Liverpool Canal which provided a source of water and excellent transport for materials such as coal, raw materials and the finished products. Later mills, for example those in Nelson, were able to take advantage of railways routes such as the East Lancashire Railway.

The cotton industry prospered into the early 20th century. However, the onset of the First World War greatly slowed the pace of building of new textile mills and those built after the war tended to be smaller than the vast cotton sheds built previously and often specialised in branches of the industry, such as tapering and sizing, rather than cotton weaving itself.

Traditional textile industries steadily declined throughout the 20th century and although many weaving sheds remained in operation until the 1970s, often by diversifying into synthetic materials and specialist products, by the late 1990s only a handful of manufacturer's remained in business and many weaving sheds had been put to new uses, lay vacant or had been demolished to make way for new development.

Today almost all manufactories' and mills in the region have closed. Many extant weaving sheds have been converted for other uses such as small workshops, light industrial, garage or storage functions. These sheds are often in poor condition and, where altered, the fabric has been modified in the most expedient way with little care for the preservation or repair of the original fabric and structure.

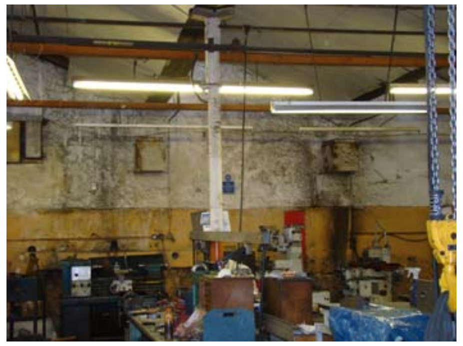
Figure 2. Modified for use as engineering works

A few sheds have been converted for higher grade uses, such as retail outlets, business centres and, as at Queen Street Mill in Briercliffe restored and opened to the public as a working textile industry visitor centre and museum.


Figure 3. Retail


Figure 4. Museum

These however, are few and far between and today most sheds either have short-term low grade uses or lay vacant in a poor and declining state of repair and face the future threat of demolition.

The number and scale of the weaving sheds has had a significant impact on the urban and semi-rural character of the Lancashire region. As a group of buildings they stand testament to the significance of the textile industry in the region and contribute greatly to our understanding and knowledge of the ways in which the industry transformed the urban and rural life of the area, influencing the development of towns and elevating small villages to important manufacturing centres. As a group the buildings themselves reflect changes in technology, from water to steam power, advances in manufacturing machinery and the consequential effect on the industrial economy.

Demolition of the sheds has most often occurred where land values are highest close to the centres of towns to make way for recent retail and commercial enterprises. Fewer demolitions have occurred on the urban fringes where many sheds have been put to new low grade uses. In the more rural areas the survival rate is better still.

Despite the survival rate to date, few mills are legally protected and the pressure to demolish and redevelop the large and potentially profitable sites they occupy intensifies.

3.0 PHYSICAL DESCRIPTION

3.1 External form

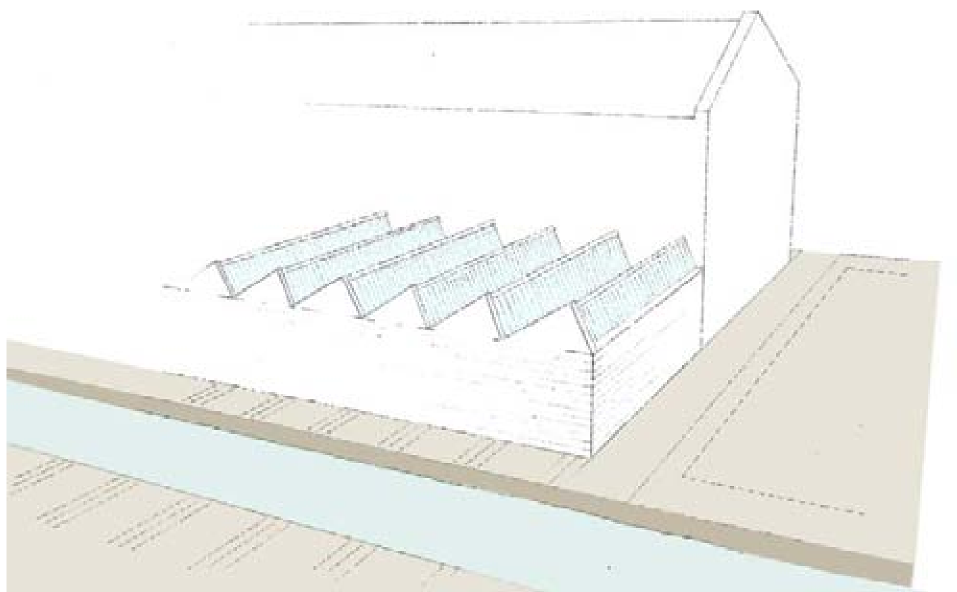

Fig. 5 Relationship of multi-storey mill building to weaving shed

North light weaving sheds were designed as working industrial buildings, built as cost effectively as possible using simple and efficient means of providing the internal conditions best suited to the process of weaving.

This placed emphasis on the provision of north light glazing, simple slate south sloping roofs with white-washed plastered soffits to maximise internal light levels and solid enclosing perimeter walls with the minimum number of doors and windows. Due to the industrial nature of the buildings the external elevations have little or no ornamentation.

As with all buildings of the period the walls and roofs were not insulated and heating would not have been provided, especially given the physical nature of the work. Original north lights were single glazed into timber frames and in most surviving sheds these are either in a poor state of repair or have been replaced with single glazed aluminium patent glazing.

The process of weaving also favoured damp internal conditions which meant that sheds were often partially built into sloping ground in a deliberate attempt to draw moisture into the building through the retaining walls and floors.

The external materials used in the construction of the sheds were robust and locally sourced. External walls were generally in either coursed rubble stone or brickwork and roofing was in slate.

3.2 Structural system

The weaving sheds were constructed using a 'standardised' system of simple structural components, comprising cast-iron columns, 6 metre long structural 'gutter beams' and raking T-section roof props bolted to the sides of the gutter beams which supported the timber ridge beam at the apex of the north light section. The south facing un-glazed roof slopes were constructed using a simple system of 150x50mm (6x2 inch) common rafters with lime plaster of lath soffits and slate roof coverings.

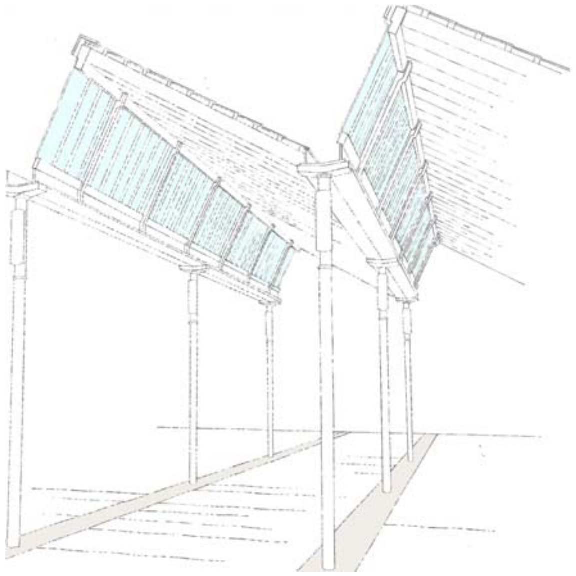

Fig. 6. Internal view of the north-lights a support column

The cast iron beams that support the rows of north lights are ingeniously designed as inverted channel sections so that they both carry the load of the roofs and act as rainwater gutters. The gutter beams were laid flat with joints aligned over column heads. The end of each gutter section has an external flange enabling sections to be bolted together over the column head bracket. Interestingly it appears that the bracket could have been designed to collect any resulting leak at the joint and channelled it down the inside of the hollow columns.

` The structural system imposed grid of columns throughout the plan with columns spaced 6 metres apart along the line of the gutter beams and 3 metres apart parallel to the line of the gutter beams, thereby creating structural column bays each measuring 3 x 6 metres (10 x 20 feet).

To increase the area of floor free of columns some later sheds were designed with 6 metre long cross beams arranged perpendicular to the line of the gutter-beams thereby enabling every other row of columns to be removed resulting in a 6 x 6 metre grid of column.

The clear height to the underside of the gutter beams in most weaving sheds is 3.5 metres (11.5 feet) from the floor. The clear height to to the underside of the north light ridge is 4.6 metres (15 feet).

The standardisation of the structural components formed a 'modular' building system which could be made to fit the available site area or the developer's space requirements and, if demand for space grew, could be easily extended.

The structural system provided an economic and efficient means of providing shelter and natural north light over the large floor areas required to house the power looms with, a floor space relatively free of structure. The design of each component has an elegant simplicity resulting from both its efficient structural design and the incorporation of purpose designed bracket castings to the column heads and the undersides of the gutter beams required to support the mechanism of shafts and drive belts forming the power train from the steam driven engines to each individual loom.

3.3 Materials and construction

The perimeter walls to the weaving sheds were constructed of solid masonry, in either coursed rubble stone or brick. Masonry was detailed simply and robustly, often with few windows and doors and little or no ornamentation. In some instances the sheds were deliberately built into slopes to encourage damp into the building.

The pitched solid roofs of most sheds were constructed with 30 degree pitched 140x50mm (6x2 inch) timber common rafters bearing on a ledge forming part of the gutter beam casting and at their head a timber ridge beam supported off raking cast-iron T-section struts bolted to the sides of the gutter beams. The south facing unglazed roofs had slate on batten roof coverings with lime plaster on lath internal soffits.

The original roof-lights were made as large timber units, each approximately 2 metres long, fixed at each end to the raking cast iron T-sections supporting the ridges. Each glazed unit was subdivided by slim section timber mullions into small, approximately 300m wide single glazed panes, which were putty beaded in place. Many of the original timber north lights have decayed and been subsequently replaced with single glazed aluminium patent glazing systems which will have been cheaper and require less maintenance.

In their original construction the floors were often formed using stone slabs laid directly on prepared ground. As damp humid conditions favour the working of cloth there would have been little or no attempt to prevent damp rising through the floors. This would not have been detrimental to the building fabric as the entire floor area would have 'breathed' which allowed any moisture below the floors to evaporate harmlessly across the floor area.

4.0 CONSTRAINTS AND PERCEPTIONS

4.1 Original siting of the weaving sheds

The original siting of the weaving sheds was often determined by a common set of requirements as follows:

- Fast flowing or abundant water source. Early sheds used power generated directly from water wheels and were by necessity sited adjacent to fast flowing water sources. Although later sheds were powered by steam these need to be close to a large reservoir of water, such as mill ponds or canals, for use in condensing steam engines and for filling boilers.

- The damp climate and humidity prevalent in the Pennine Lancashire region was of great benefit to manufacturing process involved in cotton weaving where high humidity greatly assists in the working of cotton. Much of the region is hilly and to create the large floor areas required and to maintain high level of humidity within the building the sheds were often deliberately deeply terraced into the ground to encourage damp through the outer walls.

- Good transport links. The early-mid 19th century mills in the Lancashire region tended to cluster around the Leeds and Liverpool Canal which provided a source of water and excellent transport for materials such as coal, raw materials and the finished products. Later mills, for example those in Nelson, were able to take advantage of railways routes such as the East Lancashire Railway.

- Workers housing. Weaving sheds and associated mill buildings employed substantial numbers of people, this would often have fuelled the expansion of small villages and towns and weaving sheds and workers terraced housing were often built in relatively close proximity to one another.

The above criteria meant that many weaving sheds were located along water courses and canals and, because towns often grew around the mills they are often embedded within or on the periphery of modern urban centres.

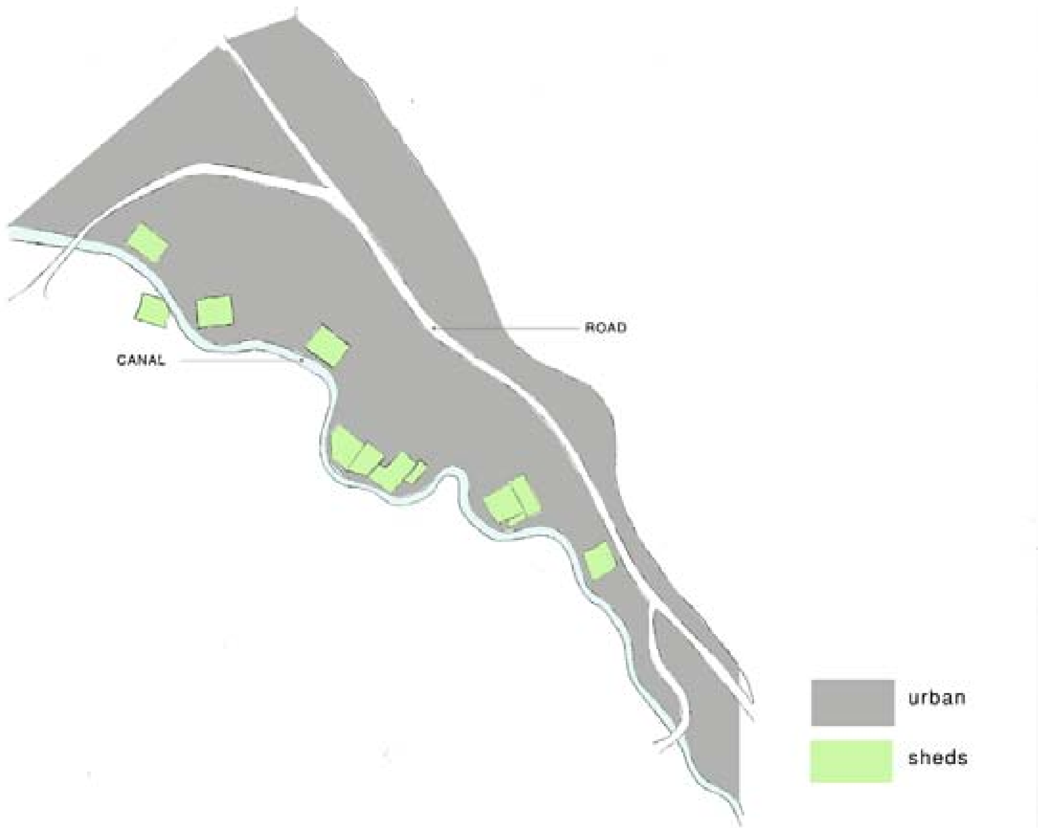

Fig. 7. Siting of weaving sheds

Fig. 8. Aerial view of Whitefield

4.2 Location analysis

The key issues relating to the current location of the weaving sheds in relation to their reuse are:

- Their location in relation to urban areas, local amenities, housing or industry
- The proximity of surrounding buildings
- The availability of vehicular access or the potential for creating new points of access
- The availability of adjacent or nearby parking
- The availability of open space adjacent to the sheds

A current assessment of the location of weaving sheds in the Burnley area has identified the following:

- Most weaving sheds are embedded within urban environments and of these 54 percent relate to industrial areas and 42 percent are more closely related to housing areas. About 4 percent of weaving sheds are located on urban fringes or semi-rural areas.
- The analysis indicated that approximately 32 percent of weaving sheds are surrounded on 3 or more sides by adjacent buildings and this restricts vehicular access to one side only
- The analysis indicates that approximately 40 percent or weaving sheds are surrounded on 2 sides by adjacent buildings
- The analysis indicates that approximately 28 percent of weaving sheds have adjacent building on 1 side or are detached from any adjacent building.
- The analysis indicated that approximately 76 percent of weaving sheds have adjacent open space which, subject to ownership, has the potential to provide related neighbouring development or parking.

4.2.1 A survey of Lancashire textile mills is currently being undertaken by Oxford Archaeology North, on behalf of Lancashire County Council. It is due for completion in January 2010

4.3 Vehicular access and parking

The weavings sheds were designed and constructed as single storey buildings that often maximised the available site area, and as a result many sheds are bounded on one or more sides by adjacent buildings and in extreme cases may be nearly entirely 'land-locked' with associated mill buildings or more recent development on nearly their entire perimeter.

Being wholly top-lit the sheds had little or no requirement for windows and often access doors were limited to a few single doors for workers and service doors for carts or motorised wagons.

The constraints to parking and vehicular access are:

- The availability of existing access points and the potential for locating new access points on the building perimeter may be limited by adjoining buildings or the building being partially built into sloping ground.

- The location of the weaving sheds adjacent to neighbouring buildings or street limits the availability of parking immediately outside of the buildings and this may also restrict vehicular access and turning space for larger vehicles.

- Few weaving sheds lay adjacent to undeveloped adjacent land which could be used for parking. However, as demonstrated in Section 5.1 it is possible, particularly in larger sheds, to accommodate vehicular access and parking within outer perimeter walls of the buildings themselves to alleviate these issues.

4.4 Deep plan form

The optimum space requirements for the processes of weaving required large open plan floor areas with as much natural light distributed as evenly across the plan as was technically feasible. There was no requirement for windows and access only required one or two doors for workers and movement of materials

The development of the north light roof profile, supported on a simple structure of columns and gutter-beams, enabled very large deep plan single storey structures to be created, and the limiting factor to the size of the sheds effectively became the ability to transmit power from the steam engine to each power loom through the system of high level drive shafts and pulleys over the available site area.

The deep plan form is often perceived to be an obstacle to many types of re-use due to the lack of open space, views and light. However, as demonstrated in the sample projects described in Section 7.0 the creation of open or semi covered courtyard and circulation spaces within the buildings can over-come the problems associated with the deep plan form and consideration could also be given to the provision of discrete pockets of multi-storey 'towers' to increase floor area and to provide space with distant views that are not available at ground floor level within the sheds.

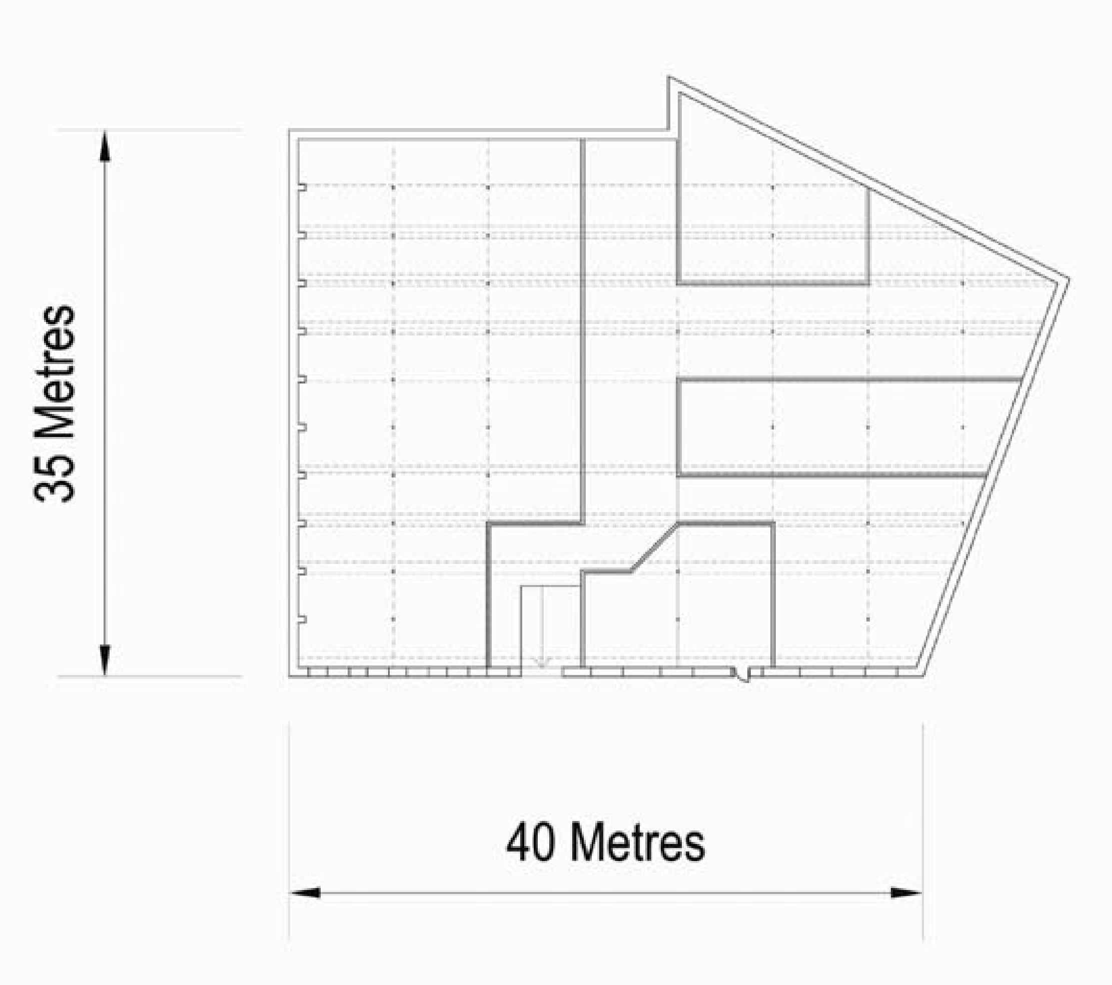

Fig. 8. Deep plan form

4.5 Single storey low site density

As described above the development of the north light profile enabled large, deep plan structures to be created which suited perfectly the requirements for well lit open plan spaces required the process of weaving. There was no benefit to constructing the sheds over two or more floors as the lower floors would have lost the essential benefit of the north light roof profile. Whilst some mills had weaving looms floors located in multi-storey buildings, they had limited floor plan depths to maximise the light penetration from windows and would have been more dependant on gas lighting which posed a considerable fire risk and attracted higher insurance premiums.

Consequently the most efficient form for the sheds were deep plan single storey north-lit structures which either filled their sites or had largely window-less solid perimeter walls.

The low site density of the weaving shed would not have been an issue when they were constructed but now effectively sets limits on the maximum value of their redevelopment if the buildings are to be retained. This puts pressure on the demolition of the sheds and the re-development of their sites with higher density multi-storey buildings.

However, as demonstrated in Section 7.0 there are many uses that the sheds may be adapted for that can successfully exploit the single storey open-plan top-lit space that the weaving sheds offer, these uses include workshops, studio spaces, craft spaces, supermarkets, retail outlets to name but a few.

Fig. 9. Low rise deep plan

4.6 Structural system, column spacing and clear heights

The weaving sheds were constructed using a 'standardised' system of simple structural components, comprising cast-iron columns, 6 metre long structural gutter beams and roof props. This system imposed a grid of columns throughout the plan with columns spaced 6 metres apart along the line of the gutters and 3 metres apart parallel to the line of the gutters, thereby creating structural column bays measuring 3 x 6 metres (10 x 20 feet).

To increase the area of floor free of columns some later sheds were designed with 6 metre long cross beams arranged perpendicular to the line of the gutter-beams thereby enabling every other row of columns to be removed, resulting in a 6 x 6 metre grid of column.

The clear height to the underside of the gutter beams in most weaving sheds is 3.5 metres (11.5 feet) from the floor. The clear height to the underside of the north light ridge is 4.6 metres (15 feet).

The key perceptions and constraints relating to the existing structural system are:

- Suitability of the cast-iron structure for reuse in relation to structural performance, stability, repair and maintenance.
- The restrictions imposed by the column spacing and the ability to modify the structure to increase free floor area.
- The restrictions imposed by the clear height to the underside of the gutter-beams
- The integration of new walls and partitions with the existing structure.

The 3 x 6 metre spacing of the columns and the height to the underside of the gutter beams can be perceived as being restrictive to the re-use of the weaving sheds, especially in relation to large free span structures commonly used in modern industrial units. However, as demonstrated in the sample projects described in Chapter 7.0 the clear height is rarely restrictive to use and the columns can be relatively easily incorporated in to many, if not all potential uses, without serious compromise, and where necessary columns could be removed and replaced with bridging beams to provide larger areas free of columns as detailed in Section 5.3.

Many uses will require internal sub-division, either to adapt the open plan space to new uses or to create separate units. With careful planning new internal walls can be successfully integrated with the column grid, and the regularity of the structure enables sufficient planning flexibility to create new spaces compatible with a very broad range of new uses.

Issues relating to structural engineering design and the repair of the building structure are detailed in Section 5.11 of this report.

Fig 10. Structure - Internal view of the weaving shed

4.7 Reuse and adaption of historic buildings

It is often the case that buildings with unique and interesting historic fabric are perceived to be problematic for adaptive re-use, either through potential difficulties in obtaining consents, the physical difficulties in adapting the buildings for new uses or the expense of retaining or conserving the fabric of the buildings.

Many historic buildings are multi-storey and cellular in plan and these characteristics can present substantial difficulties when adapting them for new uses. Difficulties often arise in relation to improving access, the provision of disabled access and lifts, the need to modify the existing cellular plan layouts to fit new uses and re-servicing the buildings. To resolve these issues whilst retaining inherent qualities of the buildings requires a careful and considered approach and often involves complex and protracted negotiations with Statutory Authorities and other interested bodies to reach agreement on the design and achieve necessary consents. The conversion costs may also be expensive due to the scope of adaption required, the requirement for new lifts and stairs or the necessary repair and conservation of historic features which may often require specialist skills or materials.

However, The problems associated with the reuse of multi-storey historic buildings are not present when considering the reuse of the north light weaving sheds. The historic interest of the sheds lies primarily in the quality of their 3-dimensional space and light, the unique industrial quality of their cast-iron structures and the historic significance of the buildings as a group in relation to the development of the weaving industry. The buildings themselves are simple, robustly constructed with little or no ornamentation and their simple open plan single-storey structures lend themselves well to numerous types of new use without the need for extensive modification of the core historic fabric. More often than not the re-use of the weaving sheds will require the incorporation of new building fabric as opposed to the modification or removal of the existing fabric, and with care these new insertions can be designed to exploit rather than obscure the inherent qualities of the sheds.

Where it is deemed necessary to remove parts of the existing fabric or structure, for example to create an open courtyard within the deep plan form, the modular nature of the buildings construction makes this relatively straight forward and, if required, reversible at some future date. Furthermore, the uniformity of the structural system means that one part of the structure is no different to the other and therefore the removal of part of the structure does not risk the loss of ‘precious’ or unique fabric usually associated with other historic buildings.

A ‘spare part bank’ could also be set up where removed structural components are registered and made available to other commonly constructed sheds. Consideration could also be given to a pay-back scheme for the original donors of original parts.

4.8 Fire risk, protection and management

As with any building project or reuse of an existing building careful consideration will need to be given to aspects of fire safety which will include the identification of fire risk, requirements for fire protection, means of escape and fire management strategies for the occupied building.

The specific requirements for fire safety will vary with individual project and uses and advice should be sought from Building Control Services and Fire officers when developing proposals. However, fire safety considerations for the adaption of the weaving sheds should not be any more onerous than the reuse of other existing buildings and in fact the single storey form of the sheds should prose less problems than reuse of multi-storey buildings.

4.9 Contamination risk and removal

The original industrial processes carried out in the north light sheds involved weaving cotton or wool with power supplied to each loom via an over-head system of drive shafts, the preparation and dying of yarns, storage of materials and the generation of power through either water or coal fired steam boilers. Early processes would have used natural organic dyes and materials, but use of man-made inorganic dyes was developed throughout the later 19th and early 20th Centuries. Coal fired boilers will have created large quantities of boiler ash which contains heavy metal and sulphates.

The contaminants produced during the original weaving processes were largely restricted to chemicals involved in the processing of yarn and boiler ash. However, over time these processes evolved and throughout their history many sheds will have been converted or adopted for other industrial processes, each with their own contamination risks. The re-use of the buildings may also have introduced the use of asbestos either within the building fabric, services or industrial machinery.

Therefore the risk of contamination for any particular weaving shed site will depend largely on the individual history of the buildings and the range processes and materials produced. Whilst many sheds may have a low risk of contamination it is recommended that each site is investigated to determine which if any contaminants are present. Specialist companies exist to undertake investigations and arrange for their safe disposal.

Further detailed advice on contamination risk and removal can be sought on the ODPM website at www.odpm.gov.uk. The Government's planning advice on contaminated land is set out in ODPM Planning Policy Statement 23 (PPS 23) on **Planning and Pollution Control** (2005) and **Annex 2** to that document on **Development on Land Affected by Contamination.** Both of these documents can be found on this website.

5.0 CHALLENGES AND SOLUTIONS

5.1 Vehicular access and parking

Where parking and access to the sheds are severely constrained or limited outside of the sheds it may be necessary to form additional access doors or gates for vehicle loading and the provision for parking within the perimeter walls.

5.1.1 Provision of vehicular access

In their original function the weaving sheds had little or no requirement for windows and often access doors were limited to a few single doors for workers and service doors for carts or motorised wagons.

However, new openings can easily be formed through the solid masonry perimeter walls to provide new vehicular access points. The regularity of the structure gives great flexibility in the location of new access points which can be provided where required to suite internal planning. Multiple access points could also be provided to suit multi-occupancy schemes.

5.1.2 Parking within the buildings

Where it proves necessary to provide parking within the perimeter walls this will need to be achieved in a manner that retains as far as possible the original structure and fabric of the building. The structural columns are generally set out on a 3 x 6 metre grid, which can be made reasonably efficiently for car parking as illustrated in Fig. 10. This will create standard 6 metre wide isles with 6 x 3 metres parking bays off these, this compares favourably to the standard 2.5 5 metre pay and 3 x 5 bay for disabled or parent / child bays. The larger bay would also accommodate larger vehicles and vans.

Gated parking within the perimeter walls of the shed would also offer the advantage of secure parking.

The existing gutter beams restrict head-room to 3.5 metres but this is more than adequate for most vehicles including cars, transit and Luton vans which are typically 3 metres high. If it is necessary to accommodate large vehicles within the outer walls then it may be necessary to create open service yards by the removal of parts of the roof structure.

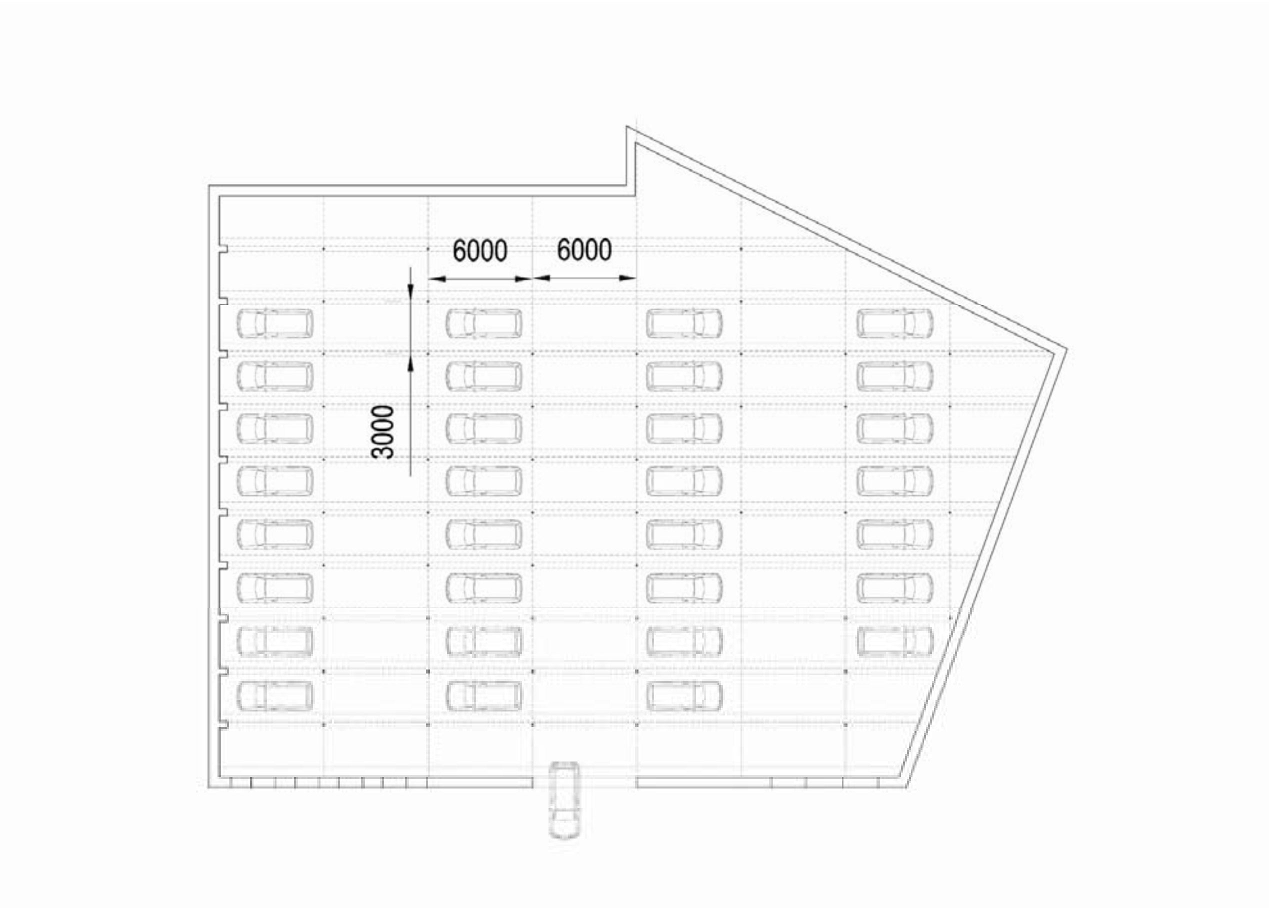

Fig. 9. Potential parking arrangement

5.1.3 Protection of the existing structure

Allowing cars and light commercial vehicles into the building envelope will risk damage to the cast iron columns and structure above and columns will require physical protection to alleviate the risk of collision damage, especially where larger vehicles are used. Fig. 10 illustrates how this could be simply achieved with the use of 'wrap-around' bollards adjacent to the base of columns.

5.1.4 Accommodation of larger vehicles within the outer walls

Accommodating larger vehicles that either exceed the available head room or are unable manoeuvre within the column grid will require the removal of parts of the structure to provide an external service yard within the confines of the existing outer walls.

Given that the structural system comprises a 'kit of parts' of cast iron columns, beams and raked T-sections supporting the timber roofs, the structure could be dismantled relatively easily and if necessary and stored for future re-use. New external walls between the service yard and remaining portion of the shed can be erected (See Fig. 11). Service yards should be designed to be as small as possible but, if carefully designed, could also double up as valuable landscaped external space for the benefit of the building users.

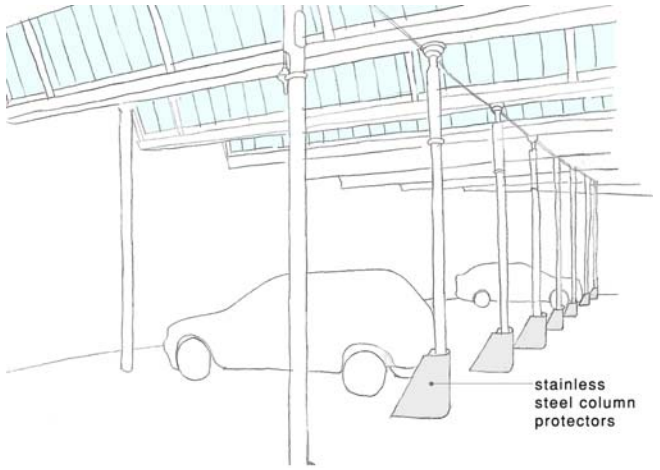

Fig. 10. Column protectors

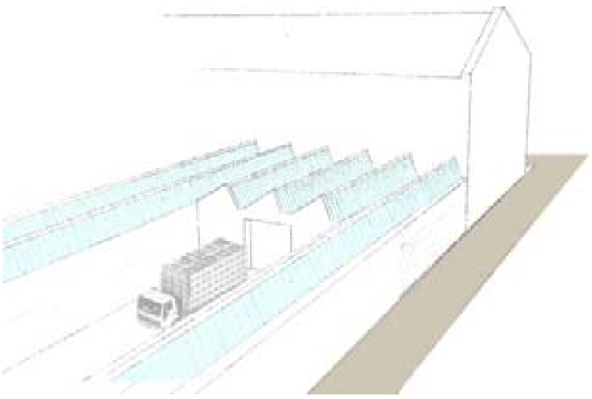

Fig. 11. Sections of roof removed to form a service yard

Fig. 12. Sections of roof being removed at Trafalgar Mill in the Weaver's Triangle, Burnley,

5.2 Sub-division of internal space

Weaving sheds were designed as large open plan spaces with a regular grid of columns and beams supporting the north-light roof profile.

If the heritage asset and architectural qualities of the weaving sheds are to be fully exploited and appreciated in their adaptive re-use then the sub-division of the open plan space will need to be carried out in a manner that retains the existing historic fabric and, in particular, leaves the primary structural components, the roof profile and north light glazing that give the weaving sheds their unique industrial quality exposed to view.

Where new walls and partitions are required to be full height and sealed to the roof to provide party walls or separate cellular spaces they will need to be carefully located in relation to the columns and gutter beams. The method and relative complexity of achieving this will depend on whether the new sub-dividing walls run parallel with the gutter beams or at right angles to them, in which case they will be cutting across the saw-tooth profile of the north lights.

5.2.1 New partition walls parallel to the gutter-beams

New walls running parallel with the gutters beams are relatively straight-forward and simple to accommodate, either to the side of, or directly under the gutter beams as illustrated in Fig. 13 and described below:

- New walls could be located to the side of the gutter beams under the bottom edge of the southern roof slope will have the benefit of leaving the underside of the gutter beams and the columns fully exposed to view thereby allowing the original structural system to be appreciated. However, this will result in one side of the wall being interrupted by a column, albeit that this only occurs every 6 metres.

- New walls located directly under the gutter beams removes the issue of columns offset from one side of the wall but the underside of the gutter beams and the columns themselves will become embedded in the walls and therefore lost to view. However this location could be used to form wall panels set between columns as indicated.

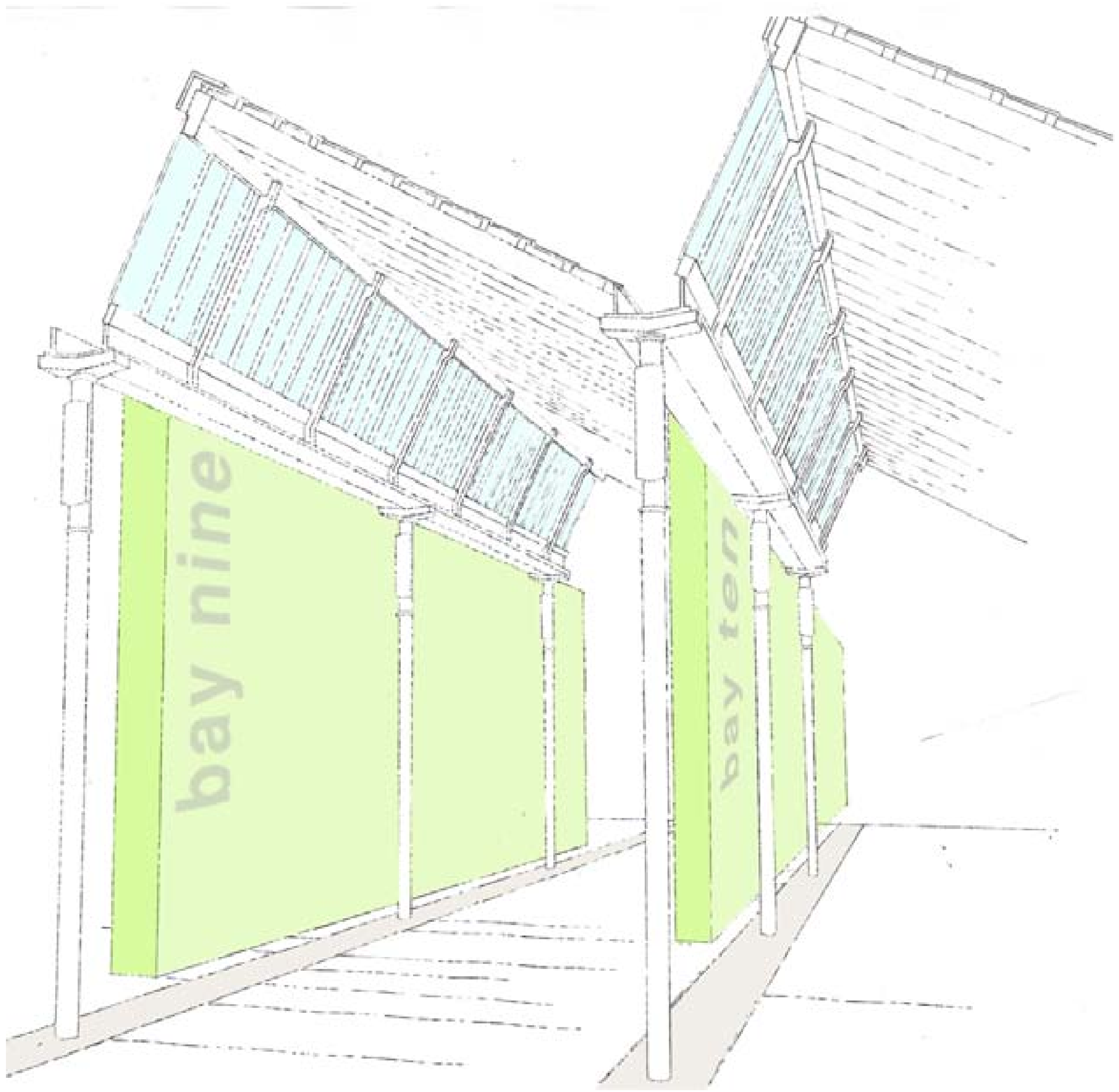

Fig. 13. New walls running parallel with gutters

5.2.2 New partition walls perpendicular to the gutter-beams

New cross walls running at right angles to the gutter-beams are more complex to accommodate, especially if they need to be sealed against the north-light glazing. However, as illustrated in Fig. 14 the raking cast iron T-sections supporting the ridge of the north lights form ideal locations for locating and sealing new walls. These are regularly spaced at 2 metre intervals (off-set 1 metre from columns) and therefore provide good flexibility in planning the location of new cross walls. The use of glazing to the upper part of the walls above the beam section as an infill to the north light will enable the linear quality of the roof profile to be retained.

5.2.3 Free standing partition walls

Where new partitions are not required to be sealed to the roof structure above this frees up far greater flexibility in their design. A range of options including, simple wall planes, angled self-supporting enclosures to the use of free-form curved 'pod' like structures.

New partitions that are visually separated from the existing structure will be clearly differentiated as new insertions independent of the original historic fabric and will therefore not obscure the original industrial architectural qualities of the sheds.

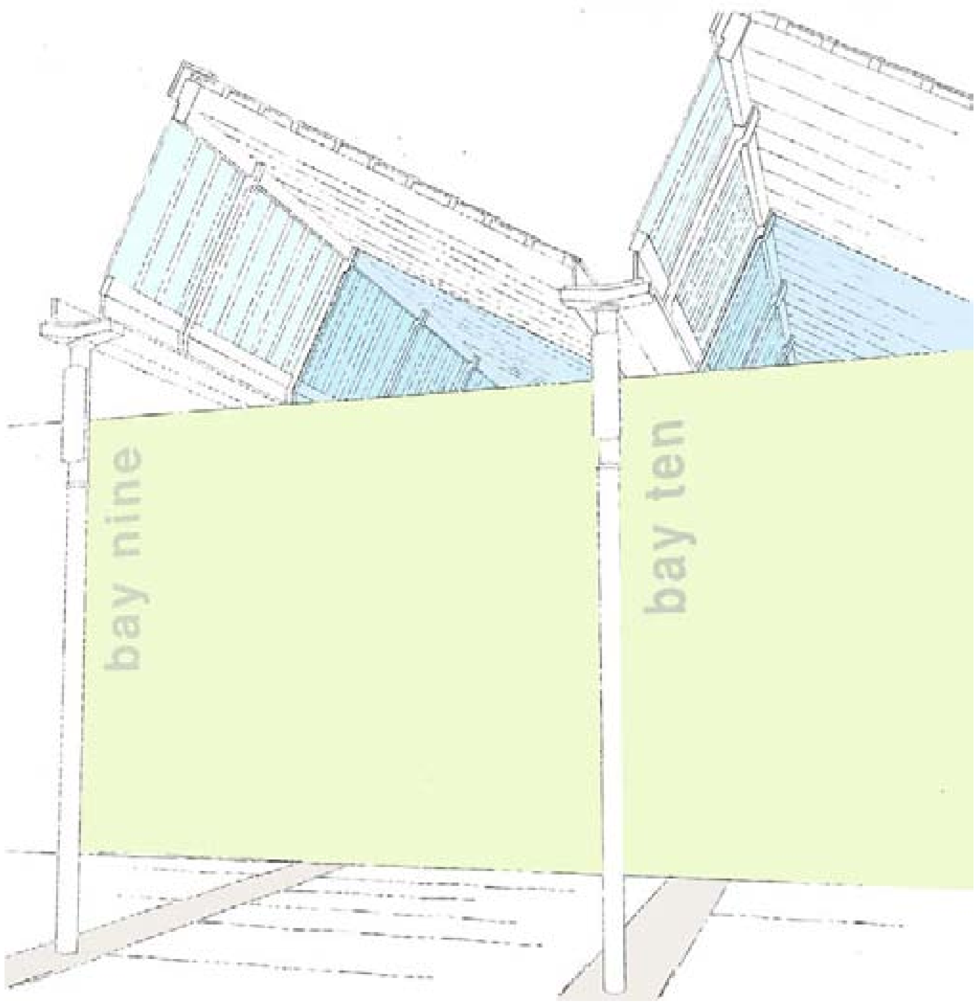

Fig. 14. New walls at 90 deg to the gutter beams sealed to the underside of the ridge T-Sections. Potential for glass infill at high level as illustrated

Fig. 15. Example of a pod type structure inserted into a historic context by RRA Architects

5.3 Structural column spacing and free floor area

The weaving sheds were constructed using a simple 'standardized' system of columns and gutter beams set out on a 3 x 6 metre (10 x 20 feet) grid supporting the north light roofs over large open plan working areas. Later sheds used larger beam and column sections on a 6 x 6 metre grid.

As demonstrated in Section 7 Use Options Analysis, the standard 3 x 6 metre grid can be made to work successfully for many uses the sheds may be put to. However, there will inevitably be occasions where new uses are adversely constrained by the structural bay spacing and in these instances means of removing columns to increase the area of uninterrupted floor space in parts of the building will need to be investigated.

Each column within the structural system supports the end of, or junction between ends of gutter beams, and the column heads also incorporate a bracket to connect beam ends together. Therefore removing the column will require the ends of the beams to be re-supported and the ends of the gutters to be re-connected.

If spaces are orientated counter to the run of the north lights then they will have a clear width of 6 metres between columns and can be as long as required within the limits of the size of the shed (see figure 16). Therefore, large areas free of columns are available without requiring columns to be removed providing a limiting free width of 6 metres is acceptable.

With spaces orientated along the line of the roof lights the clear width is limited to 3 metres. However, the removal of a single column will increase the bay size from 3 x 6 metres to 6 x 12 metres. Fig 16 shows how alternate columns could be removed by introducing either new single or paired cross beams spanning either side of the existing column line.

- The use of paired beams will enable existing columns to be retained at their point of support and will be shallower single beams thereby reducing the loss of clear head room. Paired beams will not be deep and therefore have a modest impact on the available headroom.

- The use of a single column will necessitate the removal of the existing cast-iron beam at either end to provide a point of support at the existing columns were not designed to take the additional load. A single beam will be slightly deeper and with headroom reduced.

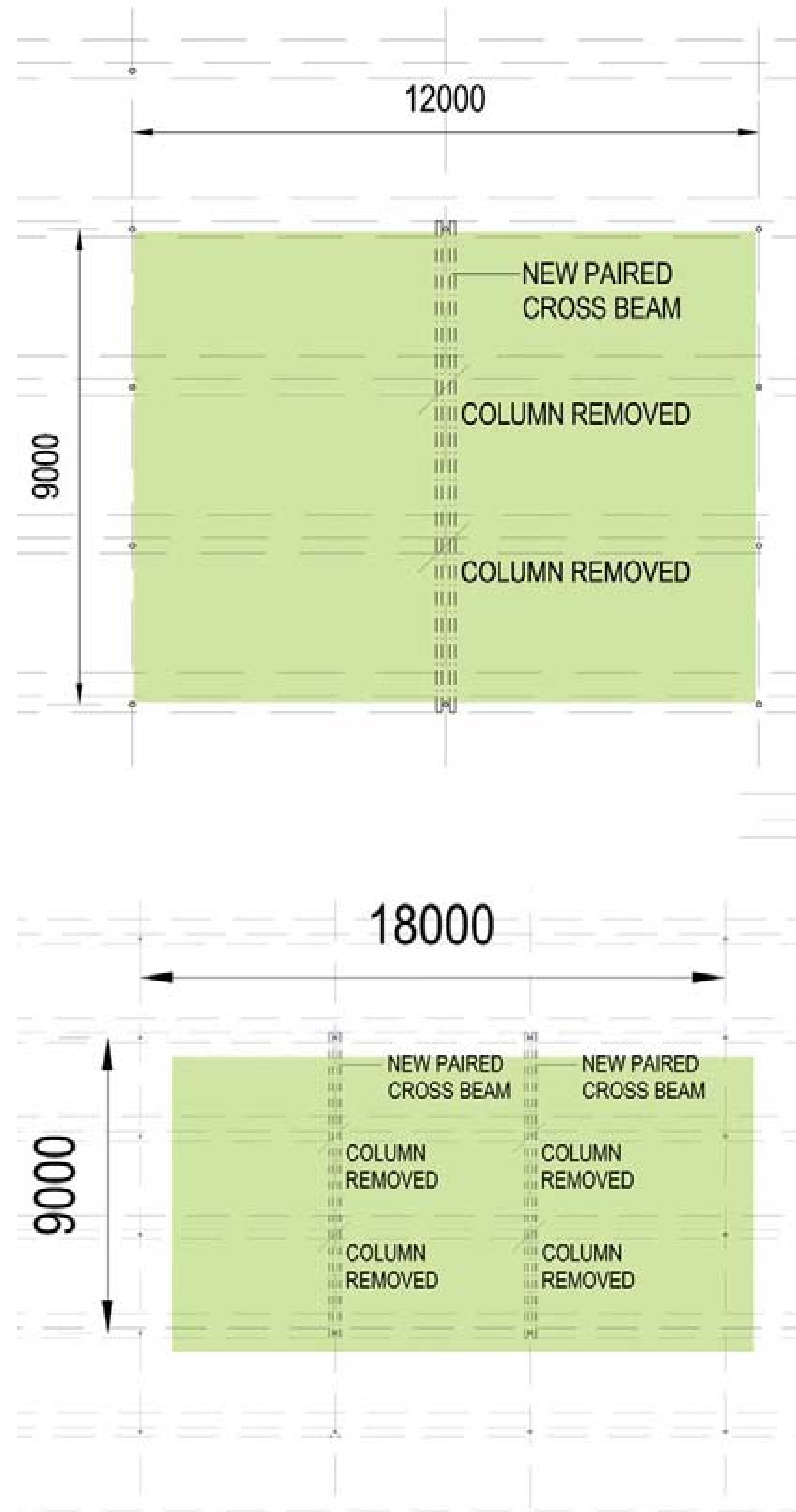

Fig. 16. Column removal

To create floor areas free of columns with widths greater than 6 metres 2 or more adjacent columns will need to be removed. Beam spans will increase in 3 metres increments with correspondingly deeper section sizes. Anticipated beam depths, are as follows:

- 6 metre span 250 Beam depth headroom reduced to 3.25 metres
- 9 metre span 350 Beam depth headroom reduced to 3.15 metres

It is not recommended that 3 consecutive columns are removed as the resulting 12 metre span will require excessively heavy and deep supporting beams to limit deflection sufficiently to avoid the risk of inducing harmful stresses in the supported existing structure.

It is unlikely that clear floor areas in excess of 9 metres are required but if they are the exiting head room is also likely to be low and therefore consideration could be given to the replacement of part of the shed with a new higher volume insertion as described in Section 5.5.

5.4 Clear heights and new internal floors

The structural system of columns and beams used in most weaving sheds provides a clear height of 3.5 metres (11.5 feet) from the floor to the underside of the gutter beams, with a height of 4.6 metres (15 feet) to the underside of the north light ridge. (refer to Figure 17).

The clear height should meet or exceed the height requirements for most uses that the sheds might be used for.

The presence of the structural gutter beams at 3.5 metres may pose risk of collision damage if the space is used by larger vehicles or fork-lift trucks. To alleviate the risk height limiters can be placed on entrances and a system of high wires, could be placed just below the height of the beams to act as physical warnings or electronic beam detectors to be used to provide an audible or visual alarm.

The relatively high volume of the north lights does however offer opportunities for creating small mezzanine or loft spaces as illustrated in Figure 18. The height of the gutter beams will restrict mezzanine floor within the confines of each beam strip and there will be a limitation on head room towards the bottom of the solid roof slope, but with careful planning these could create interesting spaces for use as bed-lofts in residential units, storage lofts or well lit study and office spaces.

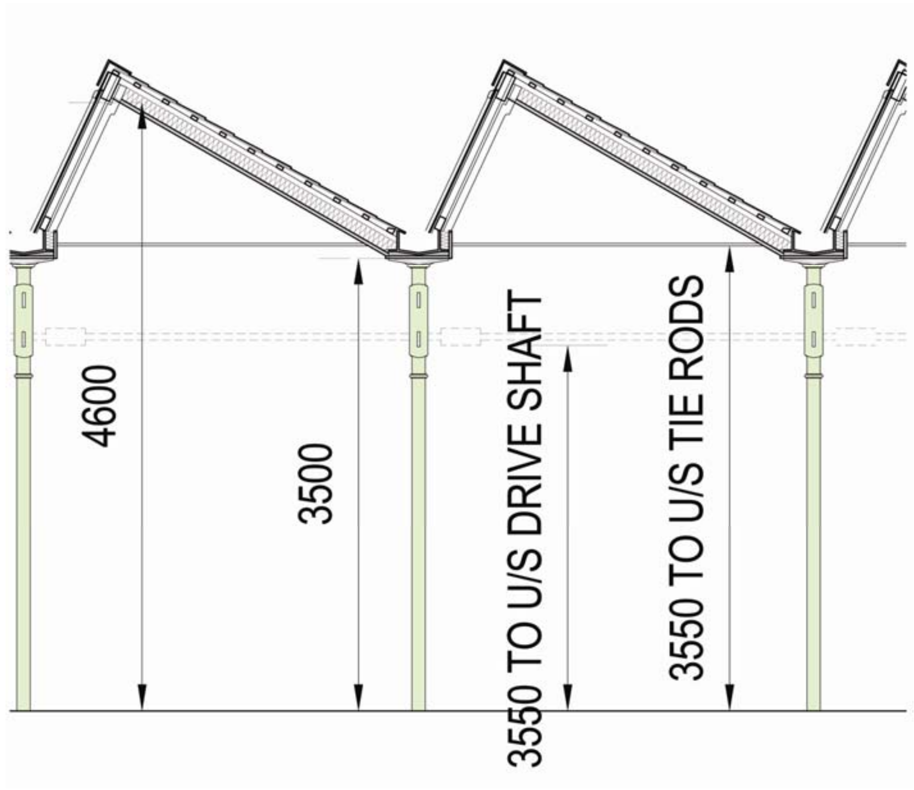

Fig. 17. Typical section of a weaving shed illustrating typical clear heights.

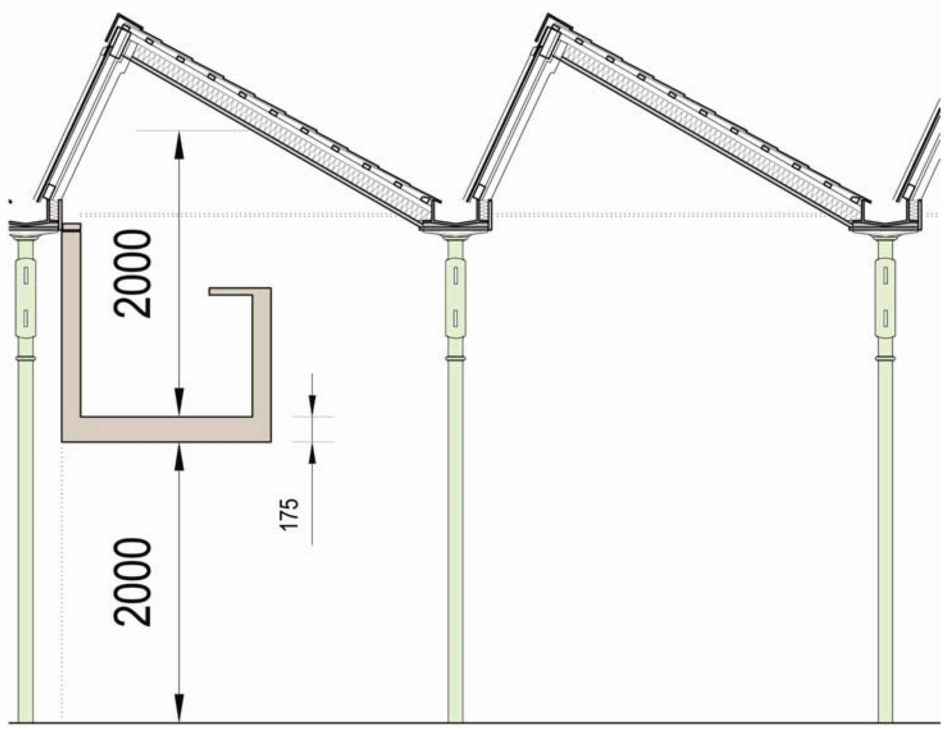

Fig. 18. Typical section illustrating clear heights for possible mezzanine insertion

5.5 Incorporation of larger volume or multi-storey insertions

There will inevitably be occasions where additional height or volume is required. If this is a general requirement for the particular use then it is un-likely that it can be accommodated without substantial and uneconomic modifications to the structure. However, there will also be occasions where the existing clear height is adequate for the general use but there may be a requirement for small areas within this of greater height, examples might include:

- Workshops that require raised areas to accommodate large machinery or equipment
- Children's play spaces that may benefit from higher spaces to accommodate soft play apparatus
- Gymnasium climbing walls.

Small insertions of higher volume construction projecting above the ridges of the north light roof to provide areas of greater volume within the plan could be considered if this enables specific uses to be accommodated, the shed to be reused and the project to progress (refer to Figure 19).

There may also be occasions where multi-storey insertions may be desirable either to:

- Provide additional floor space
- Provide a 'landmark' or architectural punctuation to give the otherwise uniform appearance of the sheds a point of focus and individual identity
- Take advantage of views which otherwise would not be available from within the single-stored walled enclosure of the sheds
- Provide small raised living spaces or 'towers' with views in housing schemes.

Where multi-storey insertions are incorporated these would ideally be small scale almost tower like structures that do not dominate the architectural character of the original buildings (refer to Figure 20). Alternatively larger linear multi-storey insertions could be formed if greater floor space is required as illustrated in Figure 19.

New insertions could be designed and detailed in a contemporary manner so as not to confuse them with the original historic fabric. It could be feasible for insertions to sit over the existing building on stilts as suggested in Fig. 21.

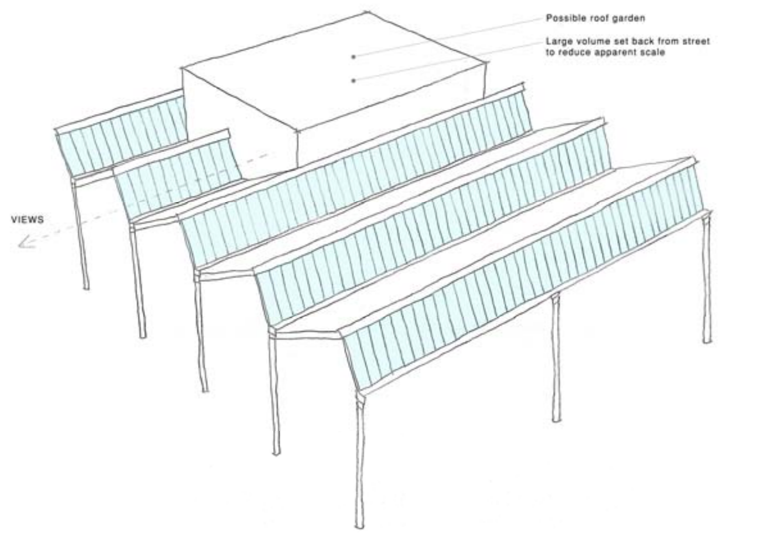

Fig. 19. New build volumes built over and out of the weaving shed roof to offer views over

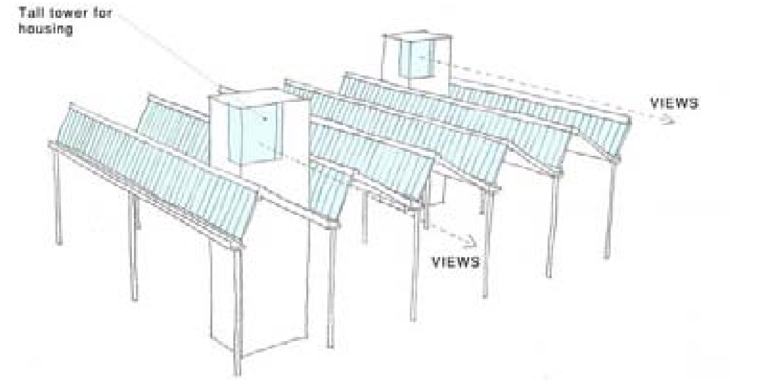

Fig. 20. New build tower pods that sit over the roof. Potential for elevated views over and out of the sheds.

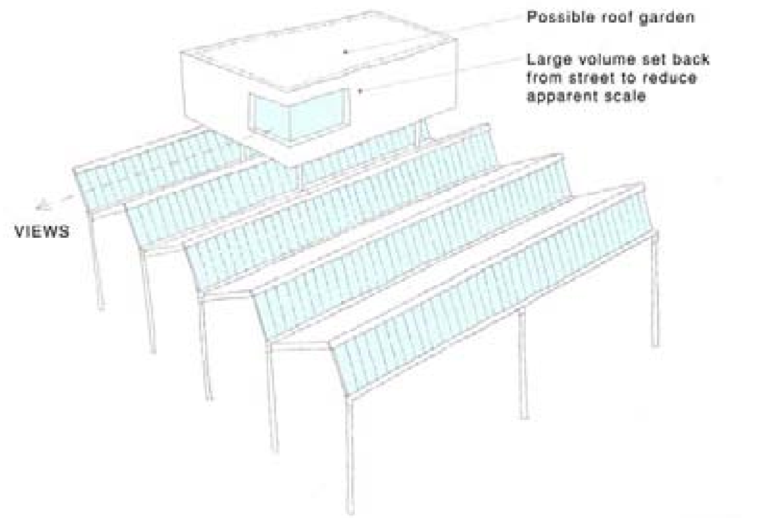

Fig. 21. New build volumes on stilts. Minimal damage to existing fabric

5.6 Creation of external space within the plan

A key characteristic of the weaving sheds is their deep plan form with north lights to give large open plan areas ideally suited for the industrialised weaving processes they housed. Whilst this may benefit many new uses that the sheds may be put to, (such as workshops, studios, etc) there will be other new uses, such as housing or office accommodation that if they are to be developed successfully will require pockets of external space to be created within the plan to provide:

- External space in the form of gardens or courtyard spaces
- Ventilation and 'external' views from the interior rooms
- A source of east, west and south light providing direct sunlight and variable qualities of natural light otherwise lacking from the interiors.

Figure 22 illustrates how open spaces can be integrated into the plan. The gutter beams and raking cast iron T-sections supporting the roof ridges make sealing of new walls or glazing enclosing the courts to the roofs relatively straight forward and the regularity of the structural grid allows for great flexibility in where open courts could be located throughout the plan.

Open spaces could be successfully developed as either relatively small courtyard gardens or larger communal courts and gardens. The existing roof form and structure can also be exploited as an opportunity to create a diverse and interesting range of external spaces as follows:

- The roof structure could be removed entirely to open the space to the sky

- Parts of the roof structure could be retained to create either fully or partially covered external space that is open to outside

- The slate on the south facing roofs could be replaced with glass to create small atria or 'green houses'

- The structural frame and rafters could be retained to create interesting 'pergola' structures over which planting could be trained.

The location of open courts within the deep plan form will provide well sheltered and secure external space ideally suited to sheltered housing, children's play areas and communal areas within workplace or housing developments.

The roof structural framework could be retained to opened areas as describes and illustrated to the right. This approach retains more of the historic fabric while also adding structural benefits. Architect's Howard and Setton have produced a scheme for Pagefield Mills and sheds in Wigan which proposes this. See Figure 23 to the right. Please follow the link below to investigate the details of this project further.
http://www.mcrproperty.com/search/view/5/#commercial

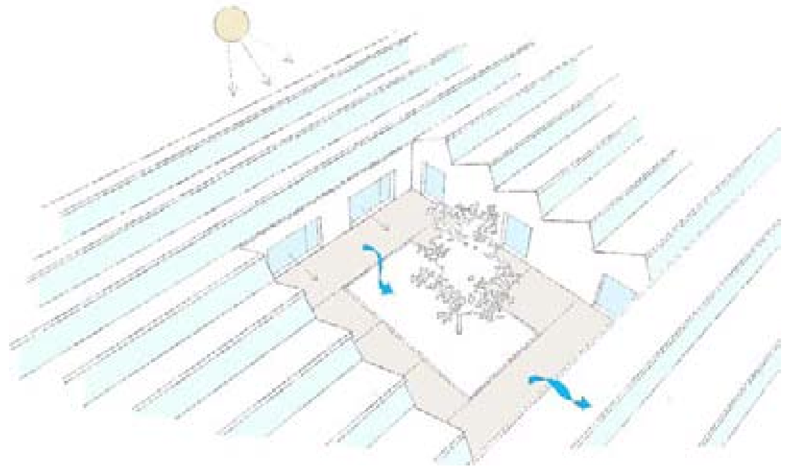

Fig. 22 – Courtyard providing sunlight, ventilation and external views to inner rooms. This diagram shows the roof removed in its entirety to the open area. The roof structural framework could be retained. This approach would mean that more historic fabric could be retained and could also offer an added structural integrity to the building and a stiffness to the roof.

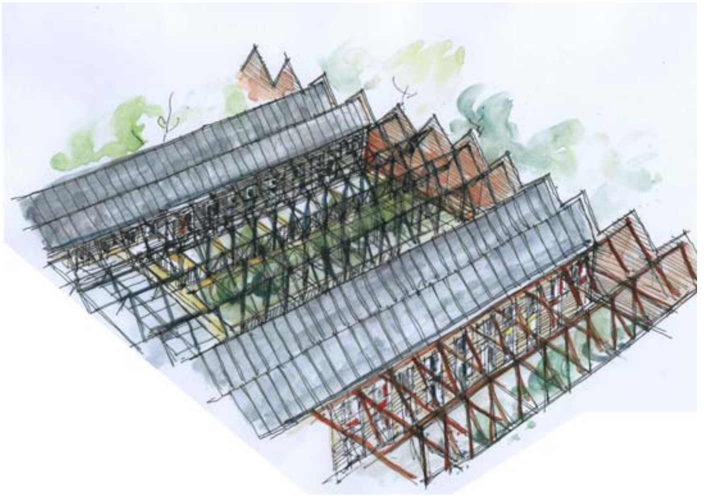

Fig. 23 – Visualisation of a proposed residential scheme for Pagefield Mills and sheds in Wigan by architects Howard + Setton. Roof frame retained to opened courtyard spaces

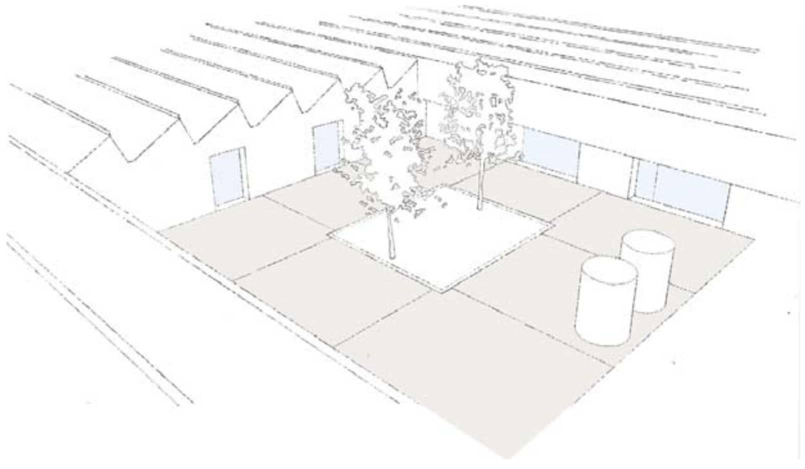

Fig. 24 – Inner court external space created. Possibility of grey water harvesting in tanks as illustrated

Planting could be successfully integrated into newly created external courts. It is likely that most sheds had flagstone laid directly onto prepared ground, it would therefore be relatively easy to remove the existing floors, excavate out and replace them with soil for planting. Alternatively courts could be hard landscaped and planting established in raised beds. Plants species will need to be considered carefully to avoid invasive species or risk of leaves blocking gutters. Care would need to be taken in the management of rain-water and new below ground drainage would need to be provided, although if rainwater harvesting (as described in Section 5.0) were used the collected water could be used to water plants, particularly those located under covered roofs.

5.7 Light quality

Whilst the sheds provide a very even north light, it has by nature a very 'flat' and relatively cold quality which lacks the variation, changeable quality and warmer colour that south light offers.

The introduction of external courtyards within the plan will create opportunities for introducing direct sunlight into interior spaces with the added benefit of controlled solar gain for passive heating that this provides.

Alternatively the judicial use of new roof-lights in the southern facing slate roofs will provide south light into the interiors.

5.8 Repair of the building fabric

The weaving sheds were simple working industrial buildings and the external materials generally used in their construction are robust and simply detailed. If repaired and properly maintained the building fabric will offer long service life with relatively low cost maintenance. The components of the original building fabric are:

- External walls were generally in coursed rubble stone or brick and there was little in the way of ornamentation
- The few openings or windows were in simply detailed timber joinery
- The north light roofs to majority of weaving sheds were constructed with simple 30 degree pitched roofs, comprising a simple structure of common rafters with slate roof coverings
- Internal materials comprised stone flag floors, exposed cast iron structure, timber joinery and boarded partitions and lime plaster on lath soffits to the south facing roof slopes.

The repair and on-going future maintenance of the building fabric should therefore be relatively straight forwards and inexpensive, the key components are as follows:

- Repair of structural cast iron components
- Repair or replacement of slate roofs
- Repair of external walls
- Repair or replacement of floors
- Repair of cast iron gutter beams

A full description of the technical aspects of the repair and maintenance of the existing building fabric is provided in Section 8.0 of this report.

5.9 Up-grading of the building fabric

North light weaving sheds were designed as working industrial buildings, built as cost effectively as possible using simple and efficient means of providing the internal conditions best suited to the process of weaving. This placed emphasis on the provision north light glazing with simple slate south sloping roofs with white-washed plastered soffits to maximise internal light levels and solid enclosing perimeter walls with the minimum number of doors and windows.

As with all buildings of the period the walls and roofs were not insulated and heating would not have been provided, especially given the physical nature of the work. Original north lights were single glazed into timber frames and in most surviving sheds these are either in a poor state of repair or have been replaced with single glazed aluminium patent glazing.

The process of weaving also favoured damp internal conditions which meant that sheds were often partially built into sloping ground in a deliberate attempt to draw moisture into the building through the retaining walls and floors
The issues that need to be addressed when considering the up-grading of the fabric of the sheds to meet higher performance criteria are:

- Up-grading the thermal performance of roofs, walls and floors
- Up-grading the thermal performance of the north light glazing
- The control of damp and moisture ingress
- Gutter-beams and control of rainwater drainage
- Exploiting possibilities for sustainable design.

If the re-use of weaving sheds is to be worthwhile then meeting the required improvements to the fabric will need to be carried out in a manner that retains the historic fabric and preserves the unique architectural qualities of the sheds. Where more invasive up-grades become unavoidable then these should ideally be reversible to enable the original construction or fabric to be reinstated at a later date.

Investigations into possible methods of up-grading the fabric are detailed in Section 8.0.

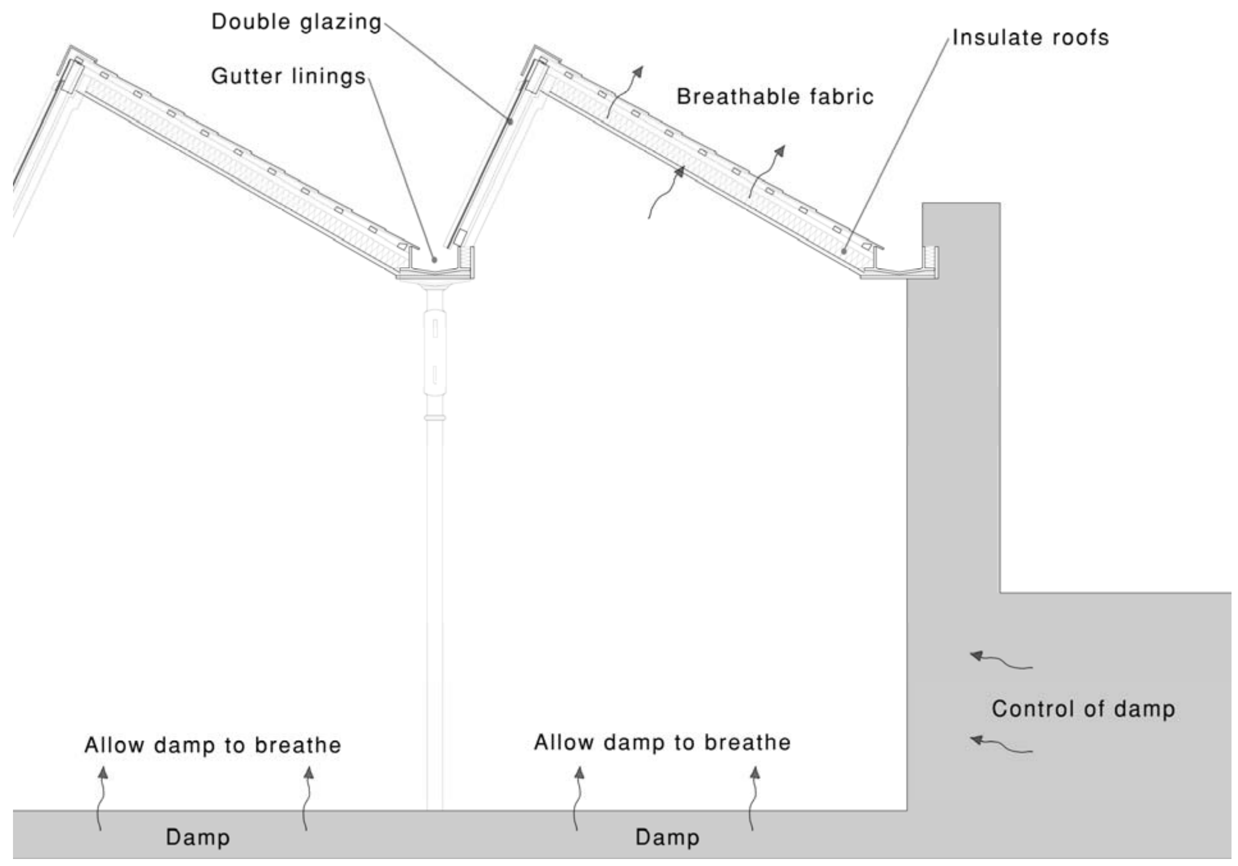

Fig 25. Upgrade of building fabric

5.10 Sustainable Design

At first sight it may appear that the antiquated and traditional method of the construction of the weaving sheds is not compatible with achieving sustainable development.

However, it is arguable that the very act of re-use is inherently sustainable and the form of sheds offer opportunities that can be positively exploited in relation to achieving good levels sustainability in their adaptive re-use, these opportunities are:

- High levels of north light with limited risk of over-heating due to solar gains
- Extensive south facing roof slopes to exploit solar energy sources
- Extensive roof areas to exploit possibilities of rainwater harvesting
- The sheds are extremely adaptable to a variety of new uses with little or no adaption of the existing building layout or structure other than up-grading the fabric and the addition of new partitions and modern services.

The key principles to consider in the design of sustainable buildings are:

- Thermal insulation and air leakage
- Alternative energy sources
- Method of providing heating
- Efficient use of natural light
- Rainwater harvesting
- Selection and specification of new materials

Of these by far the most important is achieving high levels of thermal performance and good air-tightness to minimise heat loss and energy use. The weaving sheds will lose most heat energy through their roofs and therefore most effort should be put into maximising the thermal performance of the roofs and north lights and ensuring the construction is well sealed. The use of high performance north light glazing systems and insulation materials with an increase in the available roof insulation depth by a modest increase in the depth of the roof construction will provide sufficiently high insulation standards to be achieved. From this base other technologies such as heat recovery and solar thermal systems can be added to further reduce energy use and to provide more sustainable developments.

The technical issues relating to achieving sustainable design principles are detailed in Section 8.0 of this report.

Guidance on sustainable design can be obtained at
http://www.bre.co.uk/page.jsp?id=634

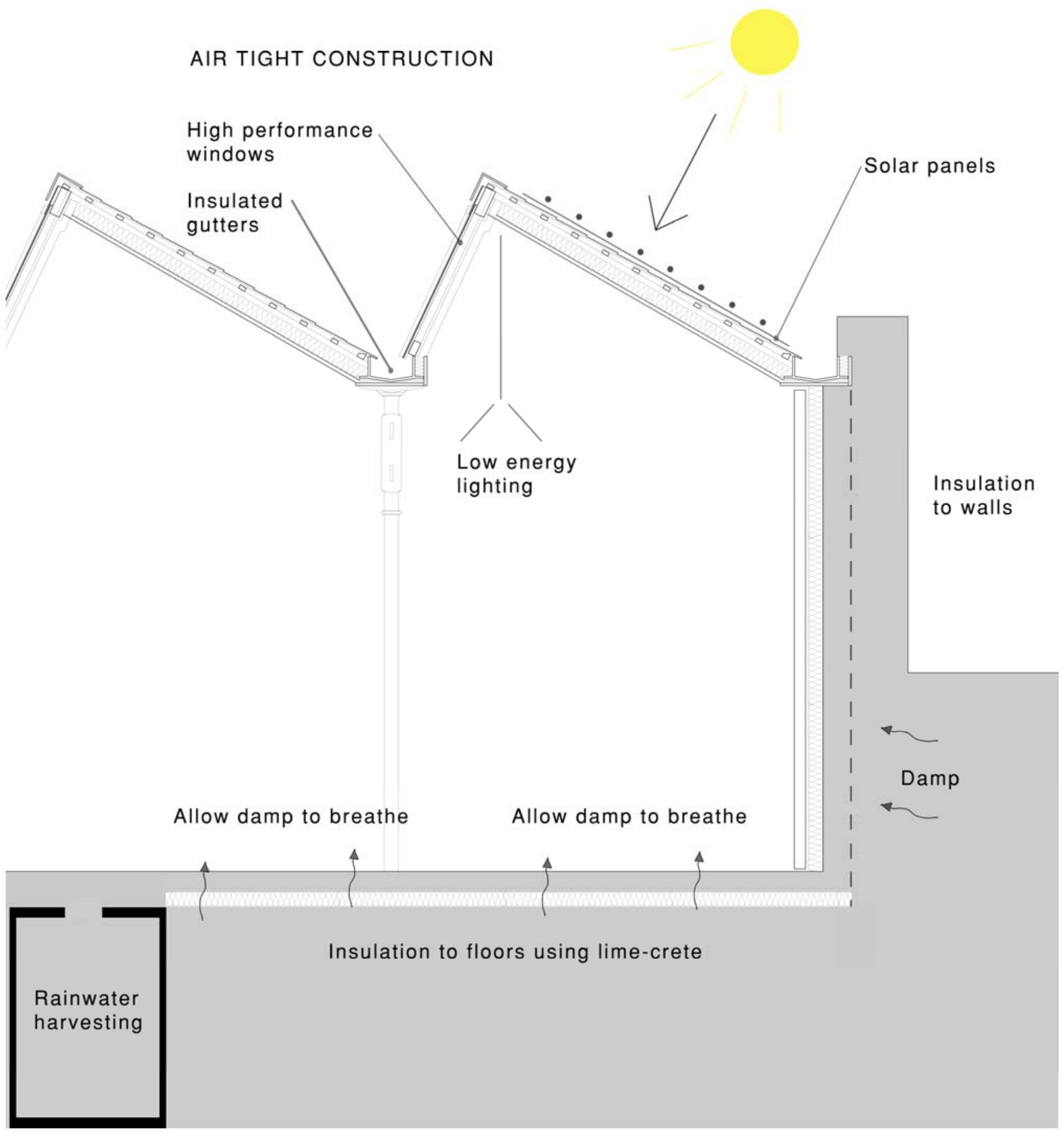

Fig. 26. Possible sustainable upgrades. Solar panels could be located on the south slopes in the optimum position for gathering solar energy

5.11 Structural Engineering and Repair

There is a perception that the original cast iron structures of the weaving sheds are structurally unfit for new uses and difficult to repair and maintain. However, cast iron structures are inherently robust and have been successfully retained in numerous historic building conversions and there is no reason why they should be considered an obstacle to the reuse of the weaving sheds.

As with any existing building structure, the services of a suitably experienced Structural Engineer should be sought to evaluate the current condition of the structure, to identify the need for any repairs, and to formulate proposals for the modification of the existing structure and the structural design of new elements of construction. The key issues to address will be:

- An understanding of how the original structure was constructed and how it was intended to work
- An assessment of the current condition of the building structure and the effects of past modifications
- Proposals for the repair and stabilization of the structure as required.
- Proposals for the structural design of new components of construction relating to the conversions and their impact on the existing structure.

The scope of works associated with most conversions will involve relatively simple construction ranging from new external entrances, internal partitions, mezzanine floors and the creation of new external courtyard by removing parts of the original fabric and these are unlikely to pose any complex structural engineering issues.

Issues relating to structural engineering design and the repair of the building structure are detailed in Section 8.0 of this report.

Guidance on the use of conservation accredited engineers can be obtained from http://www.ice.org.uk/downloads//Principles%20of%20Operation.pdf

5.12 Building services integration

A key component of any weaving shed adaption will be the design and integration of the building services systems. In their original form the weaving sheds had little in the way of mechanical and electrical building services other than the high level distribution of shafts, pulleys and belts that transmitted the power from the steam engine to each individual power loom. (Refer to Figure 27.)

The adaption of the weaving sheds to new uses will present an entirely different and varied set of servicing requirements than the original mechanical power system, and if the original industrial character of the sheds are to preserved these will need to be carefully integrated into the historic fabric. The key to achieving this will be the location of primary plant spaces and the distribution of services throughout the building.

Fig. 27 – Original mechanical services to power looms

5.12.1 High level services distribution

The original high level distribution of shafts, pulleys and belts that transmitted the power from the steam engine provide a strong precedent for the careful design of exposed high level services distribution. There will be different design considerations depending on whether services are routed along or perpendicular to the line of the gutter beams:

- Services routed along the line of the gutter-beams can be integrated discretely either by concealing them within an extension of the boards to the underside of the gutter or by routing them in an exposed containment system adjacent to the gutter-beams, and in either case the services need not sit below and therefore reduce the clear height to the underside of the structure.

- Services routed perpendicular to the line of the gutter-beams will need to run under the existing gutter beams thereby reducing the clear head height, although to mitigate this 'header' runs could be run perpendicular to the line of the gutter-beams with secondary 'feeder' runs running out into the plan at higher level adjacent to the line of the gutter beams (refer Figure. 28)

High level service distribution will offer the following advantages:

- Simple to install
- Relatively flexible and will enable services to be easily adapted
- Good access to high level lighting without the need for service risers
- Air handling and ventilation ductwork can be installed within the north light volume with direct access to outside air
- If carefully designed exposed services can relate to the original system of drive shafts and pulley's used to power the weaving looms

High level service distribution will offer the following disadvantages:

- Potential lowering of the clear height to the underside of the gutter-beams
- Where multiple occupancy or cellular spaces are formed by separating walls or partition high level services may need to pass through these. This will deter from the clarity of the high-level services system, need careful control of detailing and may required fire control dampers for larger services.

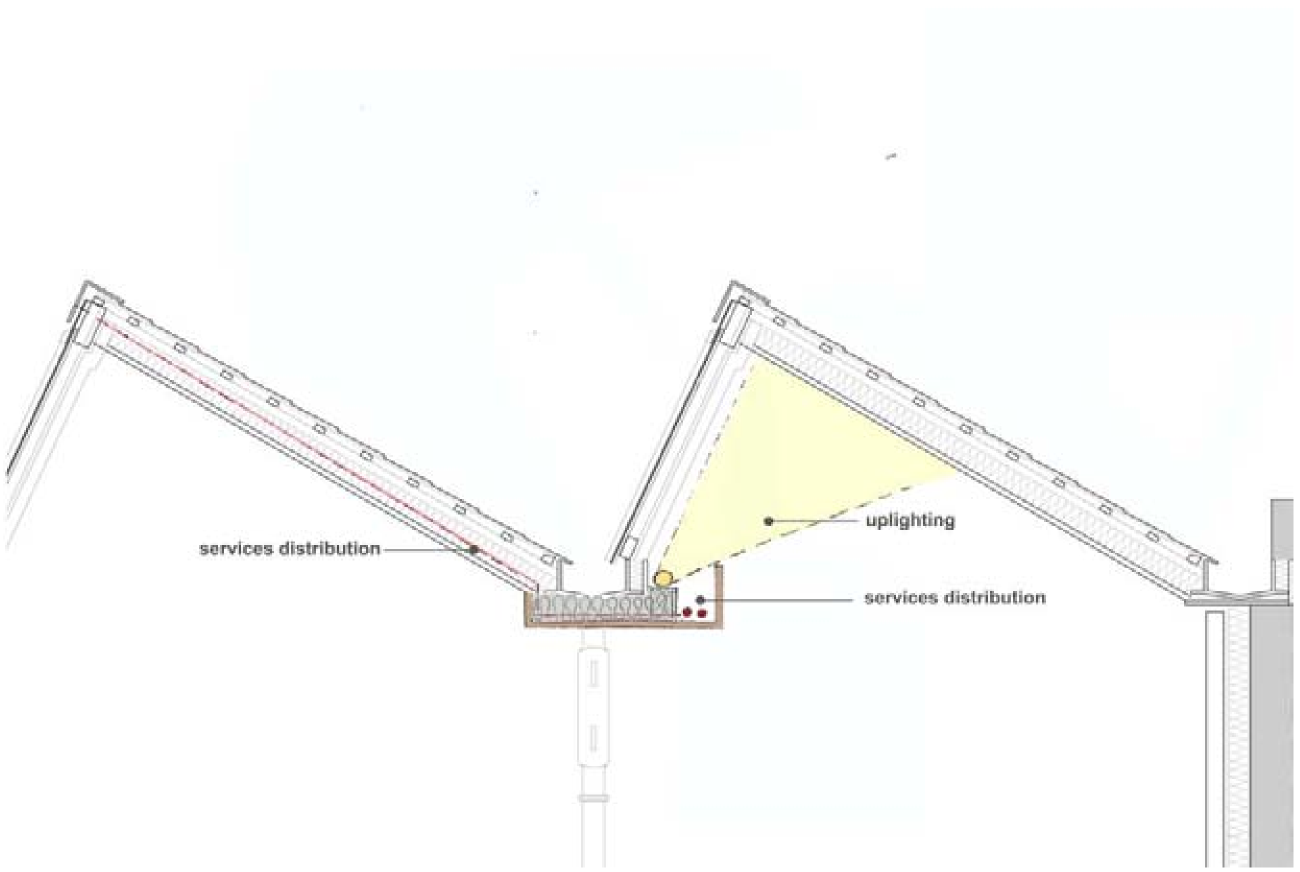

Fig. 28. High level services routed under gutter beams

5.12.2 Low level services distribution

An alternative to the distribution of services at high level would be to form floor trenches and route services below the floors; this may be valued where maintaining clear heights and a clear view of the north light sections is critical. Simple lift out access panels could be provided at strategic point along floor trenches to provide maintenance access and allow replacement or additional services to be installed at a future date.

Low level service distribution will offer the following advantages:

- Potential to have no loss of clear head room. This may be advantageous for spaces where fork lift trucks are used (which could run into an damage high level services)
- Potential for clear uninterrupted views of the original north light sections which may be valued in high grade uses such as galleries, exhibition spaces or libraries
- Services can be routed under separation walls without the visual disruption caused by high level services.

Low level service distribution will offer the following disadvantages:

- The requirement for floor trenches will make it more expensive than high level services distribution
- Localised vertical distribution will be required to switches and lighting which would need to be integrated into new walls or bespoke designed service risers
- Less flexibility and adaptability than high level services.

It would be anticipated that schemes could utilise both high and low level distribution as required to best optimise the services distribution strategy.

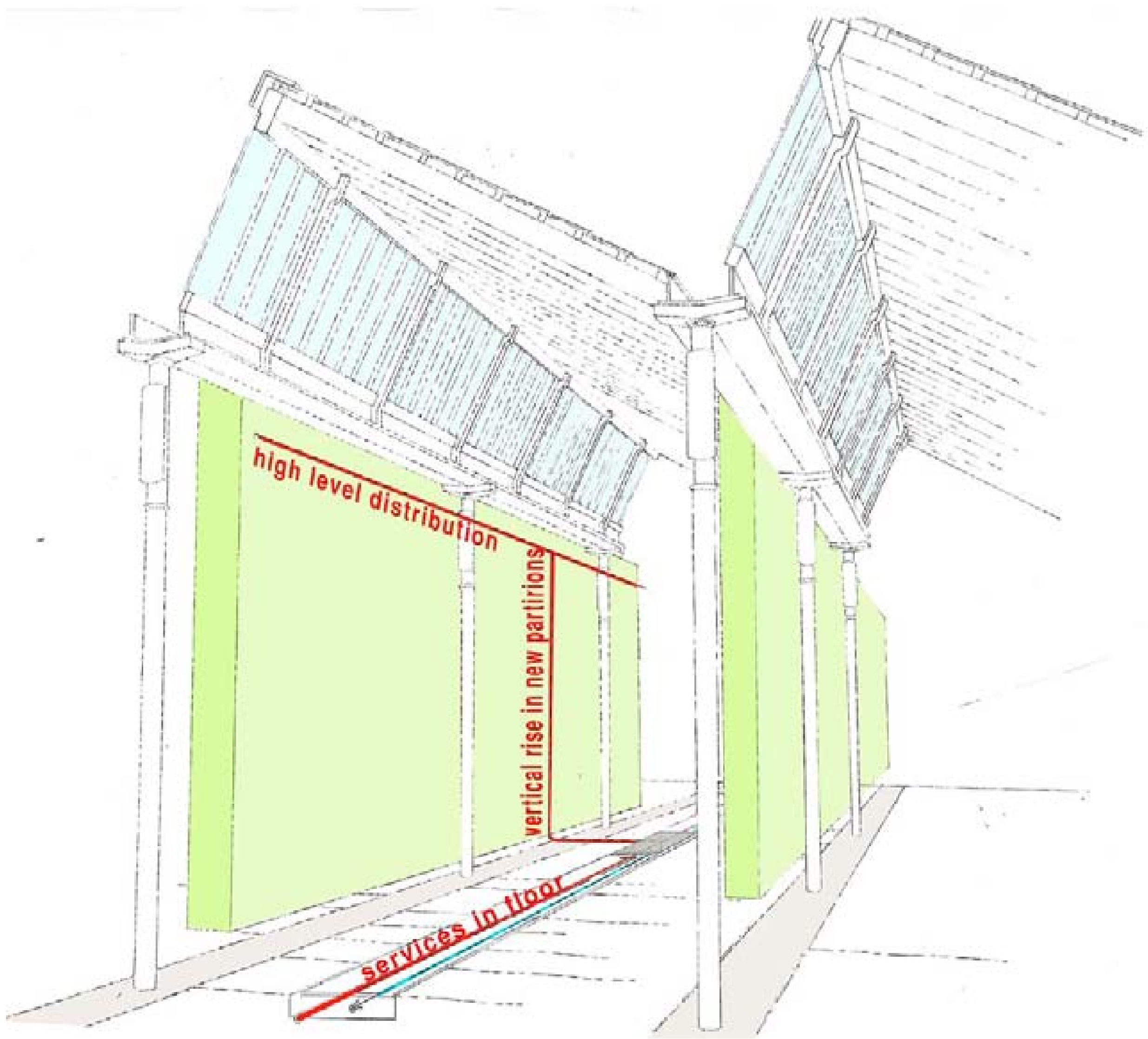

Fig. 29. Services distribution

5.12.3 Artificial lighting

The weaving sheds benefit from high levels of natural north light which for most uses will require more than adequate lighting during daylight hours. However, artificial lighting will be required to supplement the natural lighting during heavily overcast conditions, winter evenings and of course after dark.

The north light profile of the sheds offer opportunities for the discrete integration of artificial lighting without detracting from the historic industrial qualities of the buildings as follows:

- The soffit of the south facing roofs would make an ideal reflector for up-lighting schemes and up-lighting in the form of slim section linear fluorescent batten fitting could be concealed in troughs formed by extending the linings to the underside of the gutter-beams. This system would work well in supplementing the transitional loss of natural light as daylight fades. (Refer to Figure 30)

- Linear fluorescent lighting could be suspended from the ridge of the north light sections. Linear fluorescent lighting is available in an extensive range of systems from simple industrial grade fittings to more sophisticated systems for office or retail use and as such can cater for a broad range of uses and costs. Systems incorporating up-lighting are also available that could be used to throw a wash of background lighting on the soffit of the south facing roofs. (Refer to Figure 30)

- Track mounted spot lighting could be suspended from the ridge of the north light sections. Track systems are also available with up-lighting to throw a wash of background lighting on the soffit of the south facing roofs. (Refer to Figure 30)

- New partitions could incorporate wall lights to enable the volume and soffits of the north light sections to be kept free of light fittings, such systems could be used successfully with up-lighting incorporated into the sides of the gutter-beams as described above. (Refer to Figure 30)

- Lighting in domestic, workplace or studio environments could be supplemented with task lighting. (Refer to Figure 30)

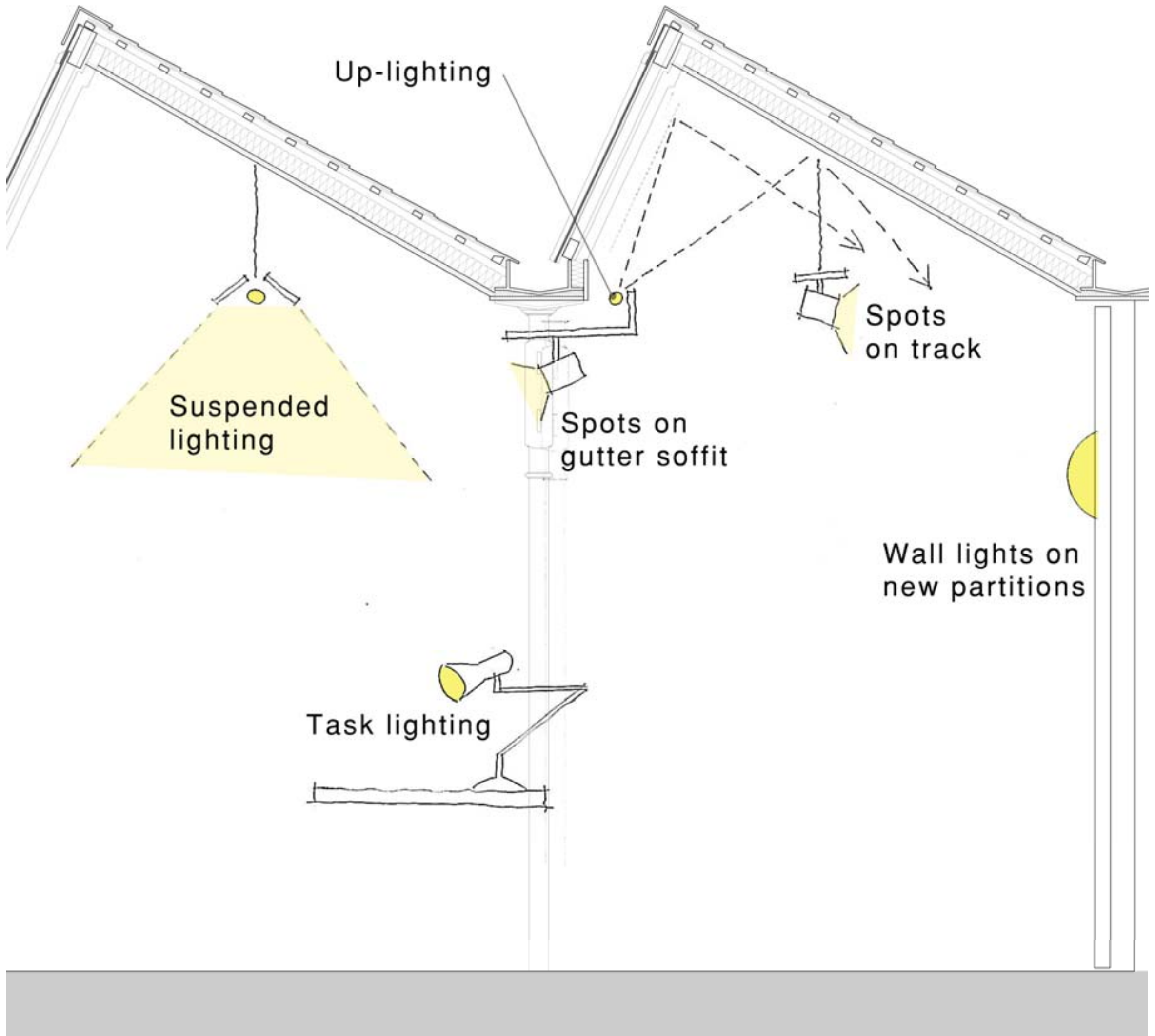

Fig. 30. Possible lighting proposals

5.12.4 Ventilation and cooling

In their original form the weaving sheds had no designed provision for natural (or mechanical) ventilation and would have relied on natural air leakage through the construction to provide sufficient background ventilation for occupation.

The adaption of the sheds to new uses with the potential upgrading of thermal performance and heating may require both natural background ventilation and controlled ventilation for cooling to be designed into conversion projects. There may also be requirements to incorporate extract ventilation from toilets and kitchens, etc as well as larger mechanical ventilation plant associated with industrial uses.

Clearly the type and extent of ventilation requirement will vary considerably with different proposed uses. However, the form of the weaving sheds offers opportunities for incorporating modern ventilation requirements as follows:

- Background ventilation can be readily incorporated into up-graded north light glazing systems in the form of trickle ventilators.

- Up-graded north light glazing systems could incorporate top hung outward opening lights to provide for greater level of natural ventilation and cooling. Opening lights could be operated from low level using mechanical winding systems or alternatively, electric powered actuators could be used which can be fully concealed as part of the glazing sections. The use of power operation would allow windows to be automatically opened and closed at night and could also be linked to rain sensors. Fully opening north lights would also offer potential access to the gutters for maintenance inspections.

- Where mechanical extract is required this can easily be incorporated at high level in the north light section where it can extract direct to outside air via grilles set within the north light glazing or via cowls through the south facing roofs.

- The creation of open courtyard or garden spaces within the deep plan form will provide opportunities for providing additional opening windows which will be beneficial in encouraging cross ventilation and introducing ventilation air at low level. (Refer to Figure 22).

- The north light profile of the roofs provide high levels of natural light without introducing solar gains and, providing the south facing roof are well insulated with a ventilation gap provided under the roof coverings the buildings will have a natural resistance to over-heating and therefore are unlikely to require mechanical comfort cooling or mechanical environmental control except in extreme cases where internal processes create large amounts of heat.

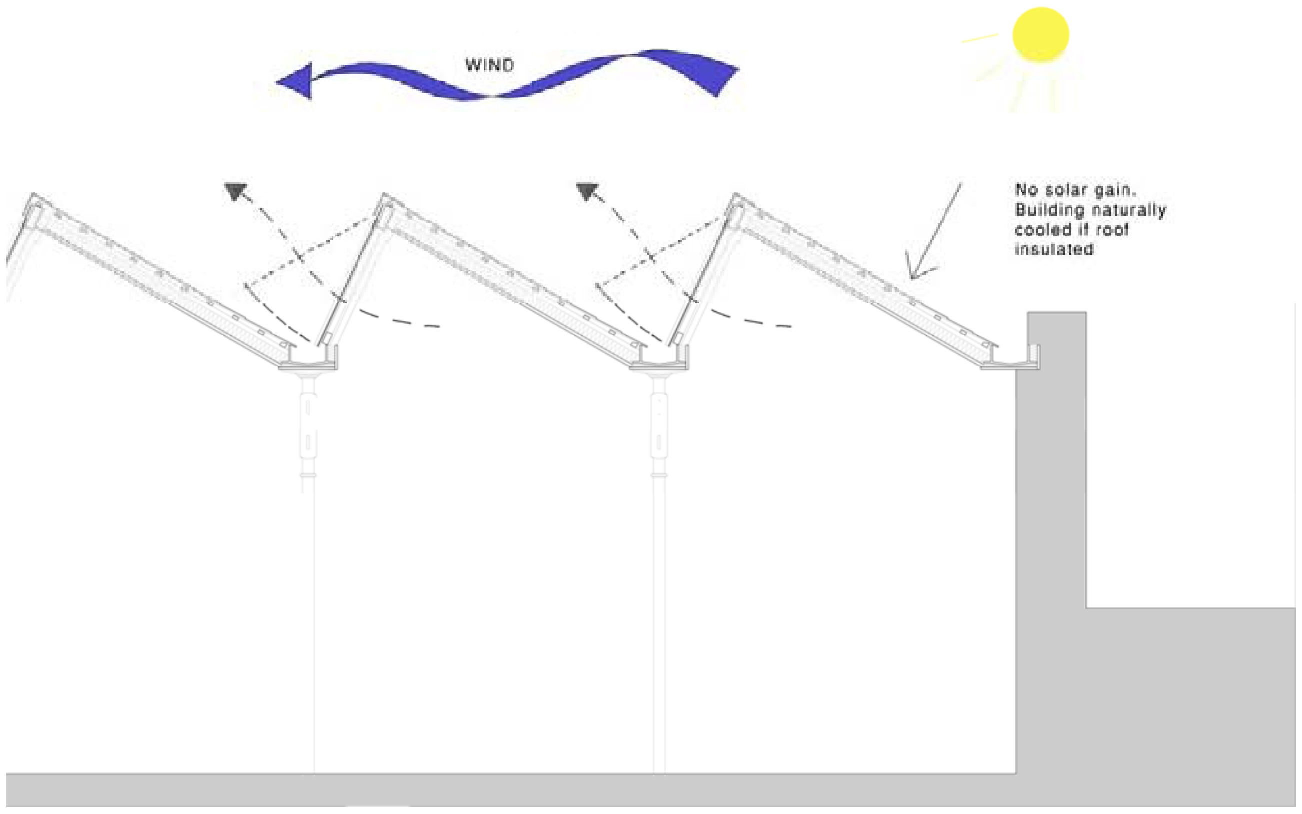

Fig. 31. Natural Cooling of the fabric by introducing opening lights into the north glazed roof sections

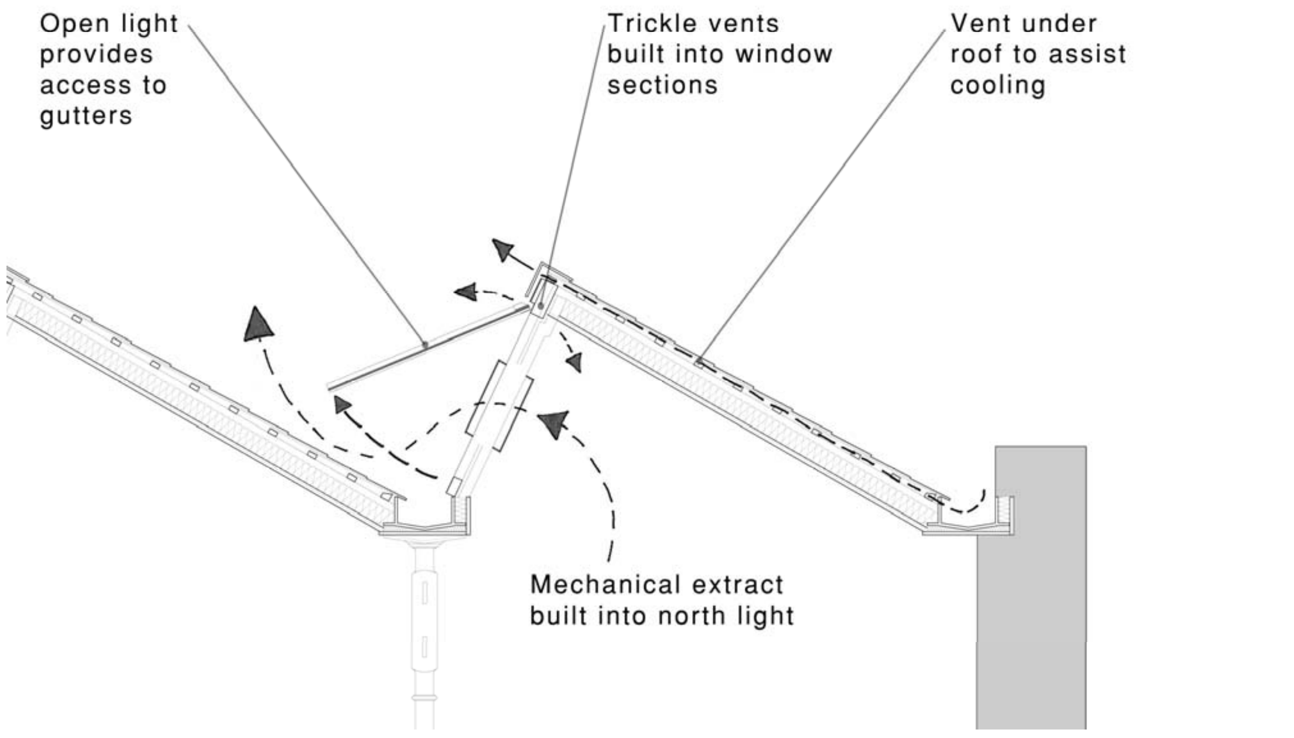

Fig. 32. Possibility of additional ventilation provisions

5.12.5 Heating methods

The method heating to a building has a significant impact on energy use and also to the degree of visual intrusion to the internal environment. Therefore, the selection of the type of heating used needs to reflect the form and construction of the building and its function and pattern of occupation. Available forms of heating include:

- Warm air heating
- High level radiant heating
- Under-floor heating
- Traditional radiators
- Fan convectors

These are described in detail below.

5.12.6 Warm air heating

This works by pumping ducted warm air directly into a space with the heat normally provided by gas fired boilers. Warm air can either be ducted into the space from a central boiler plant or provided by more localised gas fired heaters blowing air into the space they occupy. The key features of warm air heating are:

- Best suited to larger open plan spaces of moderate height
- Fast start-up times enabling spaces to rapidly be brought up to temperature
- The heated warm air rises to the top of the space causing 'stratification' of the air temperatures, to alleviate this it is recommended to use high level fans to move the heated air down to lower levels to improve efficiency
- If centralised boiler plant is used the ventilation air to the space can be pre-warmed at source and heat exchangers used to improve efficiencies
- Centralised systems with ducted air will require relatively large ducts to be accommodated and distributed at high level. These are easily run parallel to the gutter beams where they can be located within the roof volume but will be more difficult to distribute counter to the line of the gutter beams as they will need to sit under them.

Fig. 33. Warm air ducting

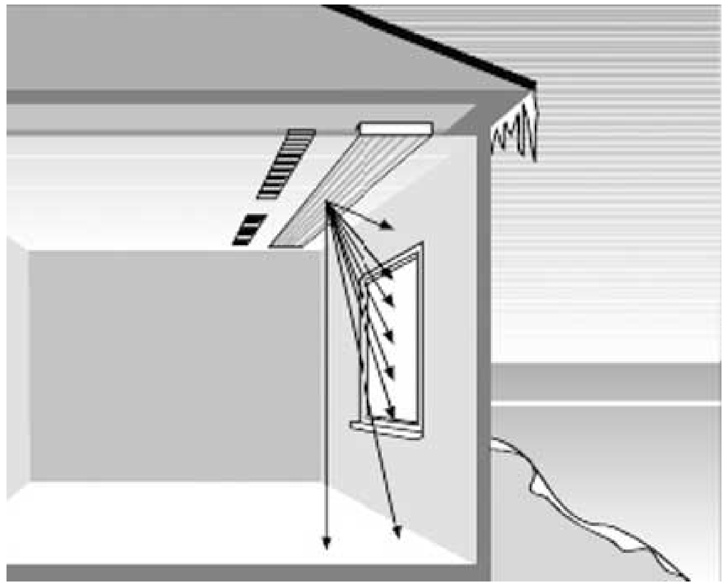

Fig. 34. High level radiant heating

5.12.7 High level radiant heating

Radiant heaters work by radiating infra-red heat from either gas fired or electric emitters with back reflectors control the direction of the radiant heat. They do not directly heat the air but work by warming surfaces and occupants in the line of sight of the emitter. The key features of high level radiant heating are:

- Best suited to tall high volume spaces where it would be highly inefficient to attempt to heat the mass of air
- Ideal system where high air change rates are required or where doors are often open as in workshops or warehouse loading bays. This is because the internal air is not directly heated
- The high temperature required to initiate radiation means that the heating effect is not as comfortable as more traditional convection, under-floor or warm air systems
- Radiant heating is 'instantaneous'
- Because the system relies primarily on direct radiant heat lower air temperature are required for occupants comfort leading to less heat loss through the building fabric. This results in improved efficiency or conversely less reliance on high level of thermal insulation. It is therefore an attractive option for use in low grade warehousing, workshops or studios where less capital cost may be available for conversions
- Emitters come in a large variation of types, including panel heaters and high level linear tubes. They can be either gas or electric, but electric can be very expensive to run and the electricity is at present likely to be from relatively inefficient coal fired power stations.

5.12.8 Under-floor heating

Under-floor heating works by warming the floor through either piped low grade warm water or by electric heating mats. The floor both warms the air adjacent to it and provides radiant heat to the space. The key features of under-floor heating are:

- Well suited to a large variety of spaces and uses
- The system provides good comfort levels for occupants
- Heat is introduced at low level where it is needed as both radiant and directly heated air. Because the heating effect is distributed uniformly across the floor there is less of a tendency for heated air to rise and cause temperature stratification at high levels with associated convection currents
- The floor requires low grade heat, typically 45 degrees for warm water, which can be supplied very efficiently from gas fired condensing boilers. The requirement for low grade heat makes the system ideal for use with low carbon technologies such as ground or air source heat pumps and in the case of weaving sheds, solar thermal water panels could be used on the south facing roofs to provide pre-heated water for the system
- The requirement for low grade heat and the benign nature of the heating makes warm water under-floor heating very efficient
- The system requires space within the floor construction for integrating pipe work into screeds and sufficient levels of insulation, typically 50-75mm, to ensure heat is not lost to the ground. Weaving sheds will therefore require existing floor to be removed and excavated out to enable the system to be installed. Where floors require up-grading for higher grade uses this may not be overly problematic, but will be an obstacle where existing floors need not be renewed or in situations where capital costs are insufficient to justify new floor slabs.

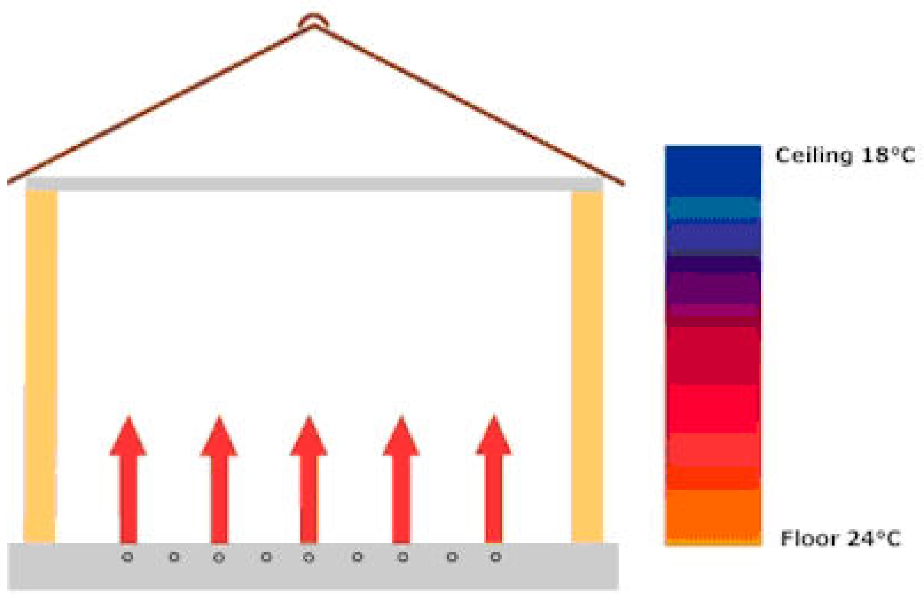

Fig. 35. Under-floor heating

5.12.9 Traditional radiators

Despite their name traditional hot water, or electric storage, radiators do not function by radiating heat but work by heating air adjacent to the radiator which induces convection currents which circulate air into the space. The key features of traditional radiators are:

- Best suited to small scale spaces
- Radiators use up wall space which may be critical for some uses
- The convection currents can induce thermal stratification of the air leading to loss of efficiency especially for higher volume spaces such as the weaving sheds
- Radiators are relatively cheap and can be installed without need of specialist knowledge
- Hot water radiators feed from gas fired condensing boilers result in a relatively efficient heating system.

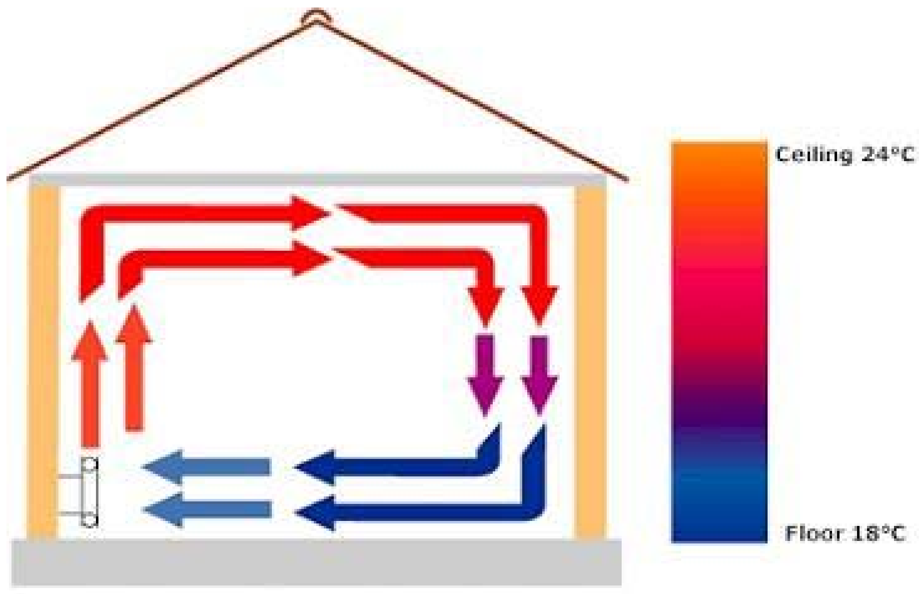

Fig. 36. Convection heating

5.12.10 Fan Convectors

Fan convectors function by drawing air across a heating element with a fan and circulating this into the space. The heating element is fed by hot water and they work in a similar way to traditional radiators but have the advantage of providing higher outputs enabling them to heat large spaces and volumes. The key features of fan convectors are:

- Best suited to medium scale spaces
- Fan convectors use up wall space which may be critical for some uses
- The convection currents can induce thermal stratification of the air leading to loss of efficiency especially for higher volume spaces such as the weaving sheds.

Salts Mill –
Retail + Gallery + Technology Digital Communication Company

Salts Mill, Saltaire, Bradford

Salts Mill is set in the UNESCO World Heritage Site, Saltaire. The Grade II Listed historic mill building was built in 1853 by Sir Titus Salt. A village was built alongside to house his workers.

The mill now contains four comprehensive art galleries including the 1853 Gallery, which altogether feature over 400 works by David Hockney. Salts Mill is also home to a variety of shops and places to eat.

Within the site, a single storey weaving shed has been converted to form the UK headquarters of Pace Micro. In addition research and development facilities for 400 staff, the conversion contains reception, meeting and demonstration spaces.

Fig. 37

Fig. 38

Angouleme Mill

Art School and Paper Manufacturing Museum

Angouleme
France

A disused paper mill converted for use as an art school and paper manufacture museum.
The art school occupies the top floor of the 2 storey complex, the museum covers most of the lower floor.

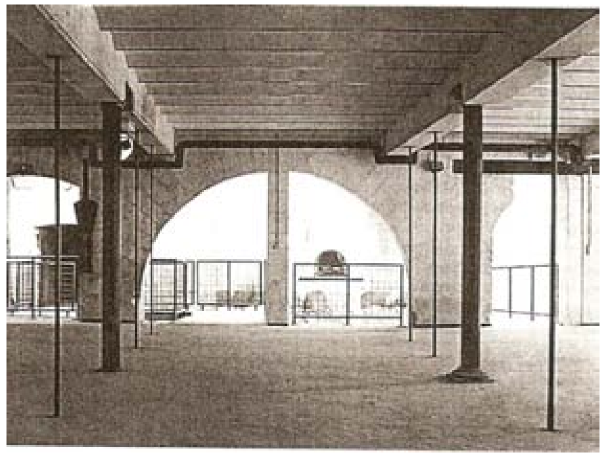

Fig. 39

Fig. 40

Swindon Designer Outlet Village (Former GWR Works)

Swindon Designer Outlet Village
Kemble Drive, Swindon

The conversion of Isambard Kingdom Brunel's former GWR locomotive works to form a designer outlet shopping village for McArthur Glen

The site is also occupied by the headquarters of the National Trust, English Heritage, the National Monuments Record and Steam – the Museum of the Great Western Railway.

Fig. 41

Fig. 42

Kingsway, Lancaster
Residential development

A residential development of one and two-bedroomed apartments built on stilts on top of the facade of the former Kingsway bus depot, a Grade 2 listed bulding. Car parking and landscaping are provided at ground level contained within the listed historic facades.

Fig. 43

Fig. 44

Credit: Stephen Gardner (Conservation Officer) Lancashire County Council

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Pagefield, Wigan
Residential development

The mill was built in 1867, to designs by George Woodhouse for John Rylands, one of the area's largest cotton manufacturers. The Grade II listed complex includes the former spinning mill, weaving sheds and engine house and chimney.

The mill's new owners propose to convert the building for residential use, with a total of 316 new apartments, houses or duplexes in the mill, weaving sheds and in new-build blocks on the site.

Fig. 45

Fig. 46

Lister Mill, Bradford
Multi-use development

Lister Mills is a collection of Grade II* Listed mills and warehouses which are being restored into new homes for sale and commercial property to let. Lister Mills will provide 675 new homes in Bradford and 170,000 sq ft of commercial property. Silk Warehouse and Velvet Mill already offer apartments for sale or flats for rent and offices to let.

The first mill to be converted was the Silk warehouse. Velvet Mill followed.

Fig. 47. Interior before

Fig. 48. Interior after

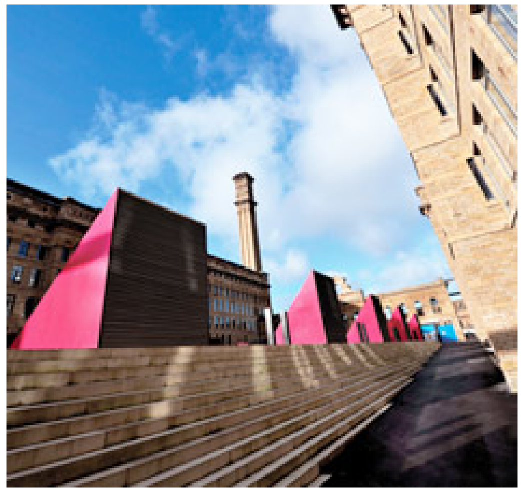

Fig. 49

The Museu de la Ciència i de la Tècnica de Catalunya
Industrial Museum

Rambla d´Ègara 270
08221 Terrassa

The mill, (known in Catalan as a Vapor or Steam after the steam engine used to drive it), contained all the industrial processes to transform wool, from the moment when the raw wool entered the building to when it left as finished cloth.

The building now houses the Museu de la Ciència i de la Tècnica de Catalunya, the Aymerich, Amat and Jover mill, is an example of Art Nouveau industrial architecture. Designed by the architect Lluís Muncunill i Parellada (Sant Vicenç de Fals, 1868 - Terrassa, 1931), work began on building the factory in the Rambla d'Ègara in 1907 and it was opened barely a year later.
The Museu de la Ciència i de la Tècnica de Catalunya exhibits industrial heritage, through which it explains the industrialisation of Catalonia. Exhibits include set scenes of textile mills along with industrial products such as farm equipment and motorcars.

http://www.mnactec.cat/index.php


Fig. 50


Fig. 51

Lomeshaye Bridge Mill + Weaving Shed

Lomeshaye Road
Nelson
Lancashire

A four storey steam powered cotton spinning mill and adjoining north light weaving shed, the project proposals include full internal and external repairs and conversion of the buildings for use as studio workshops, secure storage, meeting and conference space and parking within the weaving shed.

www.htnw.co.uk


Fig. 52. Lomeshaye weaving shed proposed plan


Fig. 53. Lomeshaye Bridge Mill +Weaving Shed – Existing Building

Stockport College
Town Centre Campus
Wellington Road South
Stockport

A north-light building dating from the Edwardian period and constructed originally as a teaching and demonstration space for engineering technologies. The building has since been converted to provide the college's Information Technology and Training Centre.

Fig. 54

Fig. 55

Firth Street Mills, Huddersfield
Huddersfield University - Computing + Mathematics Department

Canalside West,
Firth Street.
University of Huddersfield.

The Grade II listed Firth Street Mill has been converted for the University of Huddersfield computing + mathematics department as teaching accommodation. The adjoining Larchfield Mill (East Mill) provides space for design, technology and engineering studies.

www.helm.org.uk/upload/pdf/shared_interest_p2.pdf

Fig. 56

Fig. 57

Queen Street Mill, Briercliffe

Harle Syke
Burnley
BB10 2HX.

Tel: (+44) 01282 412555

Approx 4745 m^2

Queen Street Mill is the last surviving, operational steam powered weaving mill in the world. Closed in 1982, The Queen Street Mill was owned by a workers cooperative, "The Queen Street Manufacturing Company". It now operates as a museum, visitor centre and shop/café, and still contains a huge collection of artefacts and machinery from its fully operational days, including the original Lancashire boiler, several hundred looms and other weaving machines and a large library of books relating to the Lancashire textile industry.
http://www.lancashire.gov.uk/education/museums/queen/.

Fig. 58

Fig. 59. Queen Street Mill Interior – Current Us

King Street Mill, Briercliffe

Harle Syke
Burnley
BB10 2HX

Approx 4580 m^2

Adjacent to Queen Street Mill, above, this Mill ran over 1000 looms at its peak in 1940. It was the last mill/weaving shed to be built in the Briercliffe area (in 1912/13) and the shed is now utilised by an Antiques company. Other parts of the Mill have been used as a Call Centre in the recent past.
http://www.kingsmill.demon.co.uk/

Fig. 60

Fig. 61. King Street Mill Exterior – Historical Photo

Oswaldtwistle Mills

Moscow Mill
Colliers Street
Oswaldtwistle
Lancashire
BB5 3DE
Tel: (+44) 01254 871025

Approx 6500 m^2

A large mill complex currently operating as a shopping centre of sorts, offering retail spaces, attractions, workshops and events. The Mill also has a heritage centre, illustrating its long industrial history to visitors.
http://www.o-mills.co.uk

Fig. 62

Fig. 63. Oswaldtwistle Mills – Current Use

Stanley Mill

Shackleton Street, Burnley

Approx 7208 m^2

A grade II listed Mill and weaving shed that has been subdivided into units for small businesses. The mill has a long history of multiple occupancies, dating back to around 1867, and seems to have been extended many times over the years.

Fig. 64

Fig. 65. Stanley Mill Exterior – Historical Photo

Briercliffe Business Centre

Burnley Rd
Briercliffe
Burnley
BB10 2HG

A Mill building and weaving shed which started life as a 'room and power company' under the name of the Briercliffe Mill Co in 1880. The Mill has now been converted into a range of retail, industrial and storage units and parking space.

Fig. 66

Fig. 67. Briercliffe Business Centre – Current

Barden Mill

Barden Lane
Burnley
Lancashire
BB12 0DX
Tel: (+44) (01282) 420333

Approx 3000 m^2

An original cotton weaving mill built in 1920 that was turned into a warehouse for imported goods and has gradually evolved into a large warehouse style shop for clothes, shoes, fabrics, home ware etc. New tea rooms and a wharf for canal boats were added in the early 21st century offering boat trips.

http://www.bardenmill.co.uk/

Fig. 68

Fig. 69. Barden Mill – Current Use

Other useful references and links

- **Ilex Mill, Rawtenstall**
  sheds converted to car parking by PJ Livesey.

- **Lomeshaye Shed and Higherford Mill Shed**
  Contact John Miller, Heritage Trust for the North West

- **Oats Royd Mill, Luddenden Valley, Near Hebden Bridge, Calderdale**
  http://www.lowryhomes.com/oatsroyd/index.asp

- **Temple Works, Holbeck, Leeds**
  A huge weaving shed. Plans have been submitted by SJS Proprty Management to convert the shed into a cultural and retail facility including space for exhibitions and a new style of retail outlet.

  http://www.holbeckurbanvillage.co.uk/history/temple-works.htm

  http://www.cabe.org.uk/default.aspx?contentitemid=1270

- **Pecket Well Mill, Hebden Bridge, Calderdale**
  Residential Conversion by Mango Homes. Architect: Studio Baad

  http://www.pecketwellmill.co.uk/Mango Homes

- **Gibson Mill, Hard Castle Craggs, Near Hebden Bridge, National Trust**
  Eco-Rennovation Project, including part re-construction of shed as a café.
  http://www.buildingforafuture.co.uk/summer06/gibson_mill.pdf

- **North Light Gallery, Huddersfield**
  North-light converted to gallery, conferencing facility and cafe

  http://www.northlightgallery.org.uk/

7.0 USE OPTION ANALYSIS

7.1 Residential

North Light sheds with their deep plan form, lack of external open space and industrial architectural language may not be considered as suitable for conversion to residential use. However, there are many examples of industrial buildings that have been successfully converted for residential use such as Lister Mill, Bradford and the Royal William Yard, Plymouth and with considered design that exploits the inherent qualities of space and light intrinsic to the buildings form and the careful insertion of open garden courts successful residential schemes could be developed.

The key challenges faced in converting North Light sheds for residential use are:

- The provision of open external garden courts. The deep plan form of the North Light sheds will necessitate the creation of open spaces within the curtilage of the outer walls by the removal parts of the structure, or roof coverings to provide 'green lungs' giving views and ventilation from the interior spaces. These could take the form of small courtyard spaces, larger garden courts or, with the conversion of larger sheds, communal gardens. Figure's 22 - 24 illustrate how these can be achieved.

- The provision of parking spaces. North Light sheds with access to parking space outside of the perimeter walls will be most suitable for conversion to housing, although larger sheds, with good perimeter road access will offer more opportunity for developing schemes that incorporate parking within the curtilage of the outer walls with the added benefit of the security for vehicles this provides.

- The single storey nature of the sheds. This will require dwellings to be planned on a single ground floor level with only limited provision for additional floor space in the form of mezzanine floors, which might be used for storage, study rooms or bed lofts. However, the height of the roofs combined with north light glazing have the potential to provide internal spaces with unique and dramatic character with the benefit of high quality natural lighting.

- Up-grading of the existing fabric. Ideally this should be achieved in a manner that retains the essential qualities of the historic fabric and will need to meet or exceed modern standards, especially if high standards of sustainable development are sought. The form of North Light sheds offer advantages that can be positively exploited in relation to sustainability, the north lights provide opportunities for high levels of internal lighting and the south facing slate roofs offer ideal locations for solar energy collection. With the use of high-efficiency insulation to roofs, floors and outer walls and the use of modern high-performance double glazing to the north lights detailed carefully to minimise air leakage the thermal performance of the fabric could be up-graded to meet modern standards. (Refer to Figure. 25).

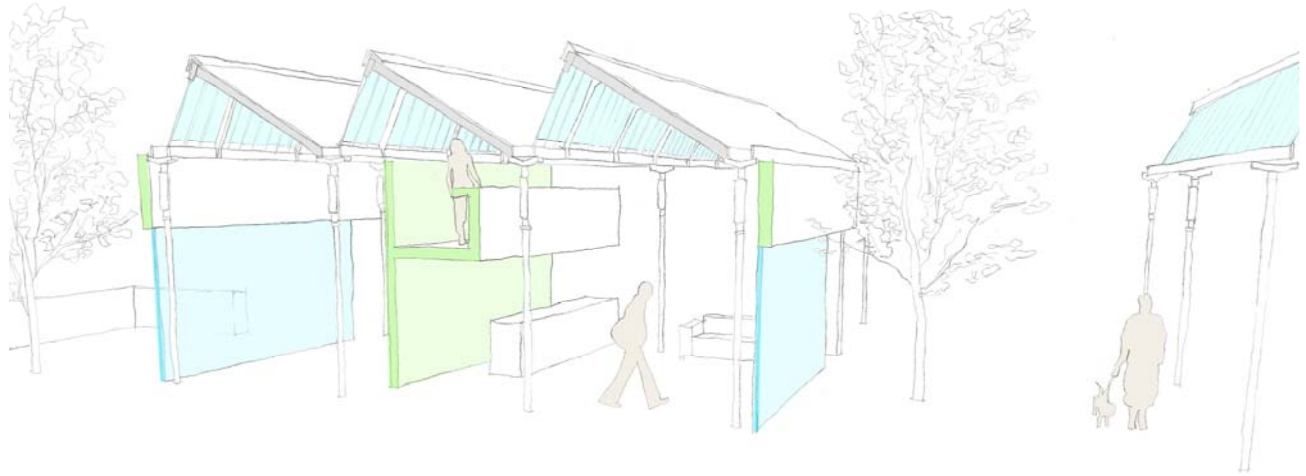

Fig. 70. Potential residential use

Fig. 71. Small private dwellings/sheltered housing

- Variation in light quality. Whilst the sheds provide a high level of north light which is ideally suited to some uses, it is by nature a very flat and uniform and lacks the changing quality of natural daylight. The introduction of external courtyards within the plan will create opportunities for introducing direct sunlight and this could be supplemented by the judicial use of new roof lights in the southern facing slate roofs.

- Location and context. Sheds located within or close to neighbouring housing areas with good access to local amenities will offer the best opportunities for conversion to residential use. The historical analysis indicated that North Light Sheds were often built in close proximity to workers housing and therefore, it likely that many sheds should be well located for potential residential use.

It is likely that the principal constraints concerning the provision of parking, single storey use and the creation of external gardens will most likely favour small scale residential dwelling units such as:

- Small private dwellings with up to 2 bedrooms
- Student Accommodation
- Sheltered Housing

However, dwellings with 3 or more bedrooms targeted towards families could be created in larger sheds where the enclosing perimeter walls offer the potential to create secure communal garden spaces providing a communal focus and a safe environment for children's play; a feature often lacking in much of today's housing.

7.1.1 Opportunities and Benefits

- The north light section of the weaving sheds offers the potential to create dramatic interior spaces with high levels of controlled natural light with the possibility of creating small mezzanine work spaces or sleeping lofts.

- The regularity of the structural system enables great flexibility in planning of both internal and newly created external space, allowing a mix of dwelling types to be readily incorporated within individual sheds.

- The regularity of the structural system enables open spaces to be incorporated into the deep plan form of the weaving sheds to create sheltered courtyards and gardens. These spaces will provide ventilation and enable south light and sunlight to be drawn into the interiors.

- The introduction of external courtyards within the plan will create opportunities for introducing direct sunlight and the changing quality of natural daylight into the internal rooms. This could be supplemented by the judicial use of new roof lights in the southern facing slate roofs to provide additional south light and controlled solar gain.

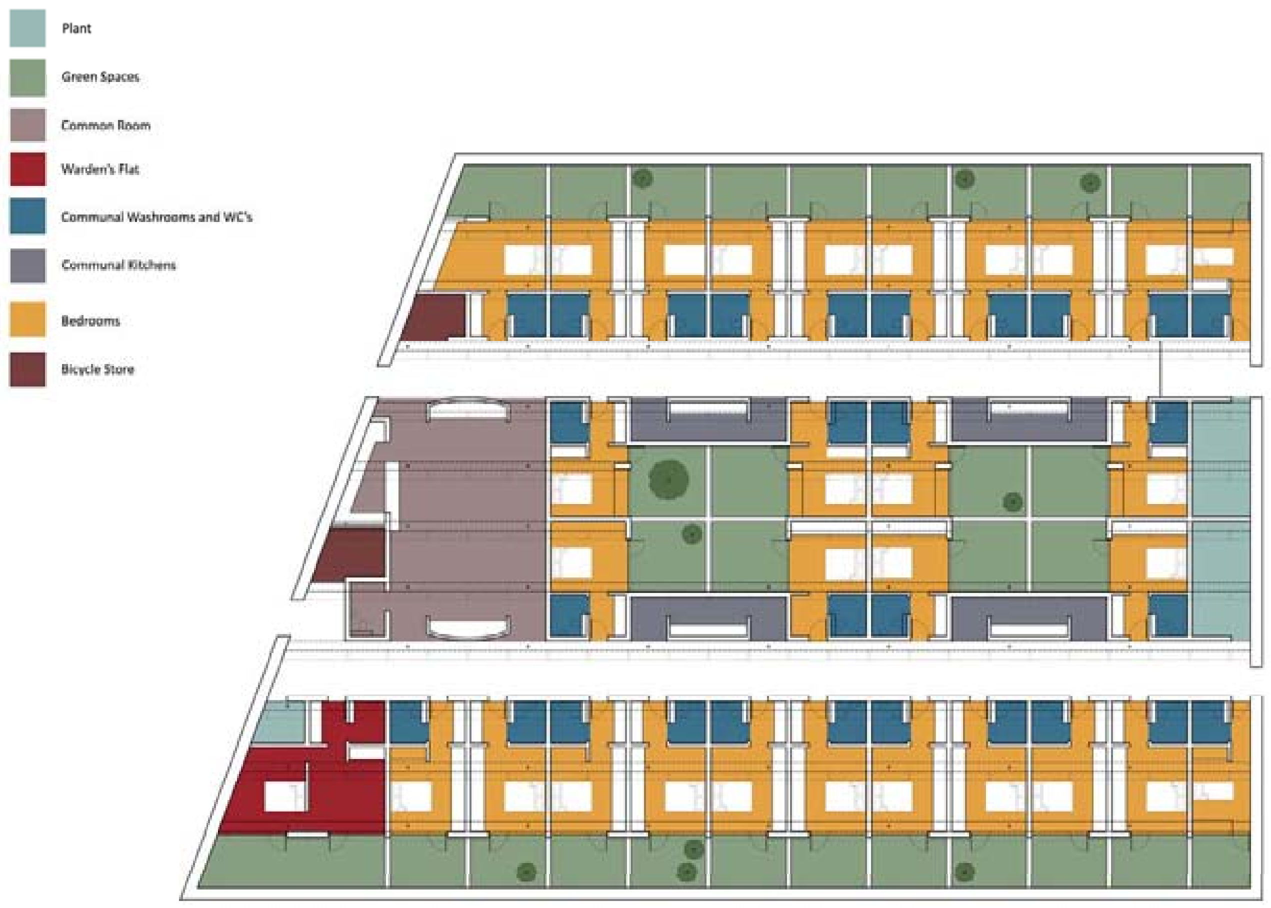

Fig. 72. Student accommodation

- Weaving sheds were often built alongside workers housing, much of which still survives and the close location to existing housing will provide new residential schemes with local amenities and transport links.

- The perimeter walls offer opportunities for the creation of safe external environments, perhaps partially covered to provide weather protection by retaining parts of the roofs which provide positive benefits in the provision of sheltered housing or homes for the elderly or disabled users.

- Single storey ground floor occupation will suit the development of residential schemes for disabled people or those with special needs without the need for lifts.

- Dwellings with 3 or more bedrooms will most likely be used by families with children for whom the provision of parking and external garden spaces will be more of an issue. However, the larger sheds could be converted for family housing and the enclosing perimeter walls offer the potential to create secure shared garden spaces providing a communal focus and a safe environment for children's play; a feature often lacking in much of today's housing.

7.1.2 Summary

Weaving sheds have the potential to create interesting and workable residential schemes. The 3 dimensional qualities of their internal spaces, their industrial character and the natural security provided by their enclosing perimeter walls can be fully exploited to create interesting and unique residential environments.

With careful design external spaces can be successfully integrated into the deep plan form of the sheds without detriment to their existing character. Some of the larger weaving sheds may have the potential to create sufficiently large external spaces to enable small family housing to be developed.

Fig. 73. Aerial view of Whitefield

7.2 Workshops

The key qualities of North Light Sheds; natural high-quality north light, open, voluminous interior space and their industrial architectural language make the sheds very well suited for workshop or studio use with relatively minor up-grading and intervention required.

A broad range of workshop and studio uses could be accommodated including:

- Artists Studios
- Craft workshops
- Cultural industries
- Commercial workshops / light industrial

The key challenges faced in converting North Light sheds for workshop and studio use are:

- Parking provision. The requirement for the provision of adequate numbers of parking spaces will vary significantly depending on use and whether the building is designed for multiple occupants. Consideration will also need to be given to accommodating larger commercial vehicles for both parking and turning.

- Access and loading for vehicles. As with parking the issue of vehicular access is likely be more onerous for multiple occupancy schemes where each occupant may require separate vehicular access. Many sheds have at least one elevation fronting onto a road or open space and by forming new openings within this elevation multiple entrances and loading points could be provided. Where this is not possible, either because the shed is substantially land-locked or, as is sometimes the case, the shed is partially set below ground level, vehicular access for loading within curtilage of the outer perimeter walls may need to be provided. this will have the added benefit of provide secure loading which is often an important consideration.

- Restrictions imposed by column bay sizes. Many studio or workshop uses will be able to operate well within the constraints of the 6x3 metre structural column grid and the grid with its corresponding north light forms a natural structure for sub-dividing the buildings into multiple occupancy arrangements. However, there may also be occasions where larger scale workshop operations will be adversely constrained by the structural grid, diagram xxx illustrates how alternate columns can be removed by introducing paired beams to carry the gutter beam resulting in a 6x12 metre grid.

- Protection of columns. It is likely that workshop operations may require either vehicle access or use of fork-lift or heavy pallets which risk damage to the relative slim section cast iron columns. Various methods can be employed to protect columns depending on the anticipated impact load. An example is illustrated in Figure 10.

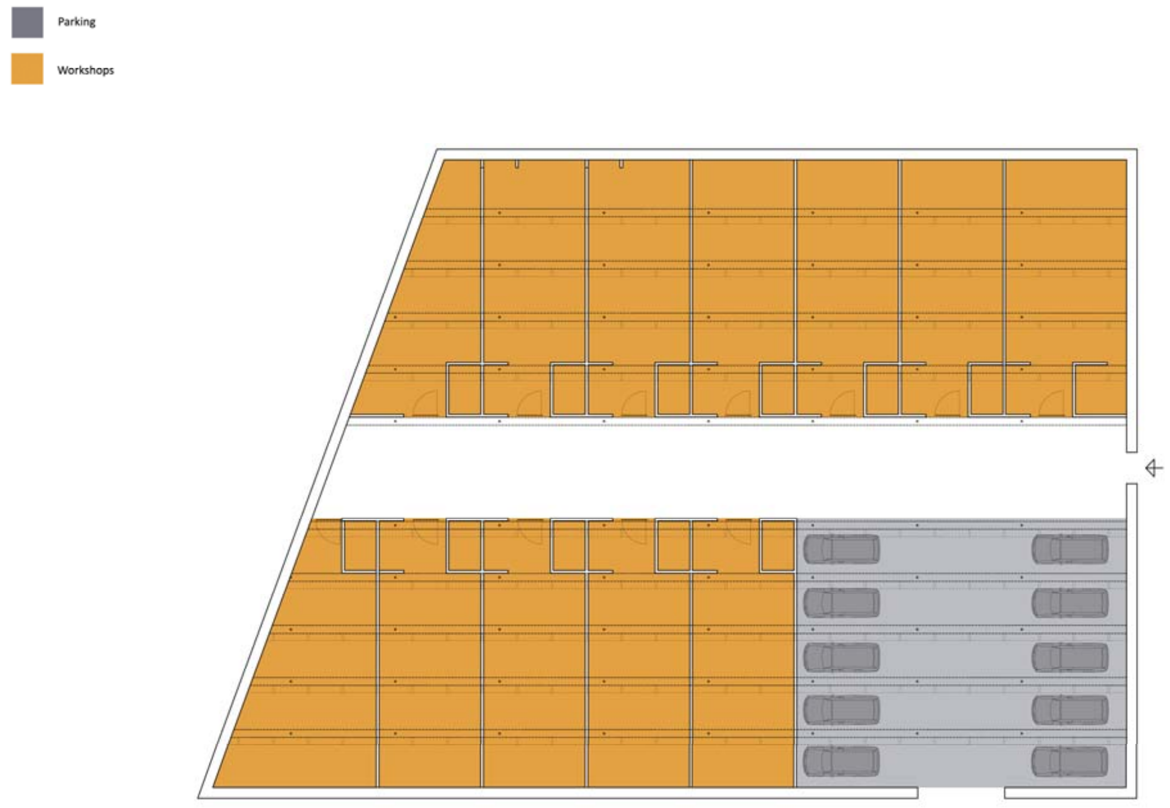

Fig. 74. Workshops and parking


Fig. 75. Example of an existing workshop use

- Height restriction imposed by the gutter beams. At 3.5 metres (11.5 feet) to the underside of the gutter beams most work shop and studio uses should not find the existing clear height problematic. Localised raising of the roof could be accommodated to accommodated larger scale machinery. Where required, localised raising of parts of the roof this could be formed by the careful removal of parts of the existing modular cast iron structure which could be retained and stored on site for future re-use. In other words the heritage asset need not be destroyed in forming the modification, or given that most sheds were constructed from a common kit of parts, removed sections could be put to re-use in other sheds that require replacement components.

- Up-grading of building fabric / floors. The requirement for up-grading of the external fabric to improve thermal performance will vary with use. Some workshops or light industrial uses will require relatively modest improvement whereas craft workshops and studios are more likely to require higher levels of up-grading. Figure 22 illustrates that good levels of thermal performance can be achieved without compromising the integrity of the historic fabric. A key consideration will be the type of heat source used, warm air or convection heating will require high levels of insulation to retain heated air whereas high level radiant heaters (or possibly under-floor heating), which do not directly heat the air may be more appropriate.

- Integration of services. In their original function the sheds were designed to service hundreds, if not thousands, of individual power looms via a system of high level drive shafts and belts often driven from a single steam engine. The same principle of high level service distribution for electrical, mechanical and ventilation services can therefore be employed in a manner that is entirely sympathetic to the original architectural design of the sheds. The north light profile also provides opportunities for both natural ventilation using opening lights and mechanical ventilation terminals across the entire floor area which will allow for great flexibility in space planning.

Fig. 76. Craft Workshops. Including retail frontages and a gallery/exhibition space

7.2.1 Opportunities

- The sheds provide high levels of north light. Whilst this may seem obvious it is often very difficult to achieve this when considering the adapted re-use of almost any other form of building, especially historic buildings, where there will be limitations on acceptable studios, limits the extent that buildings can be adapted to provide additional natural light.

- Modular structural system and bay spacing make adaptable sub-division straightforward and relatively easy to accommodate a system of movable partitions to create flexible units and layouts. This can be achieved simply without obscuring the original historic fabric and industrial structural expression of the buildings.

- Large floor area of most sheds make them well suited for multiple occupancy schemes or co-operative organisations.

- The north lit roof form uniformly distributed across the plan in tandem with the opportunities for flexible servicing infrastructure provide opportunities for flexible internal space planning without loss of the key qualities required for workshops and studios.

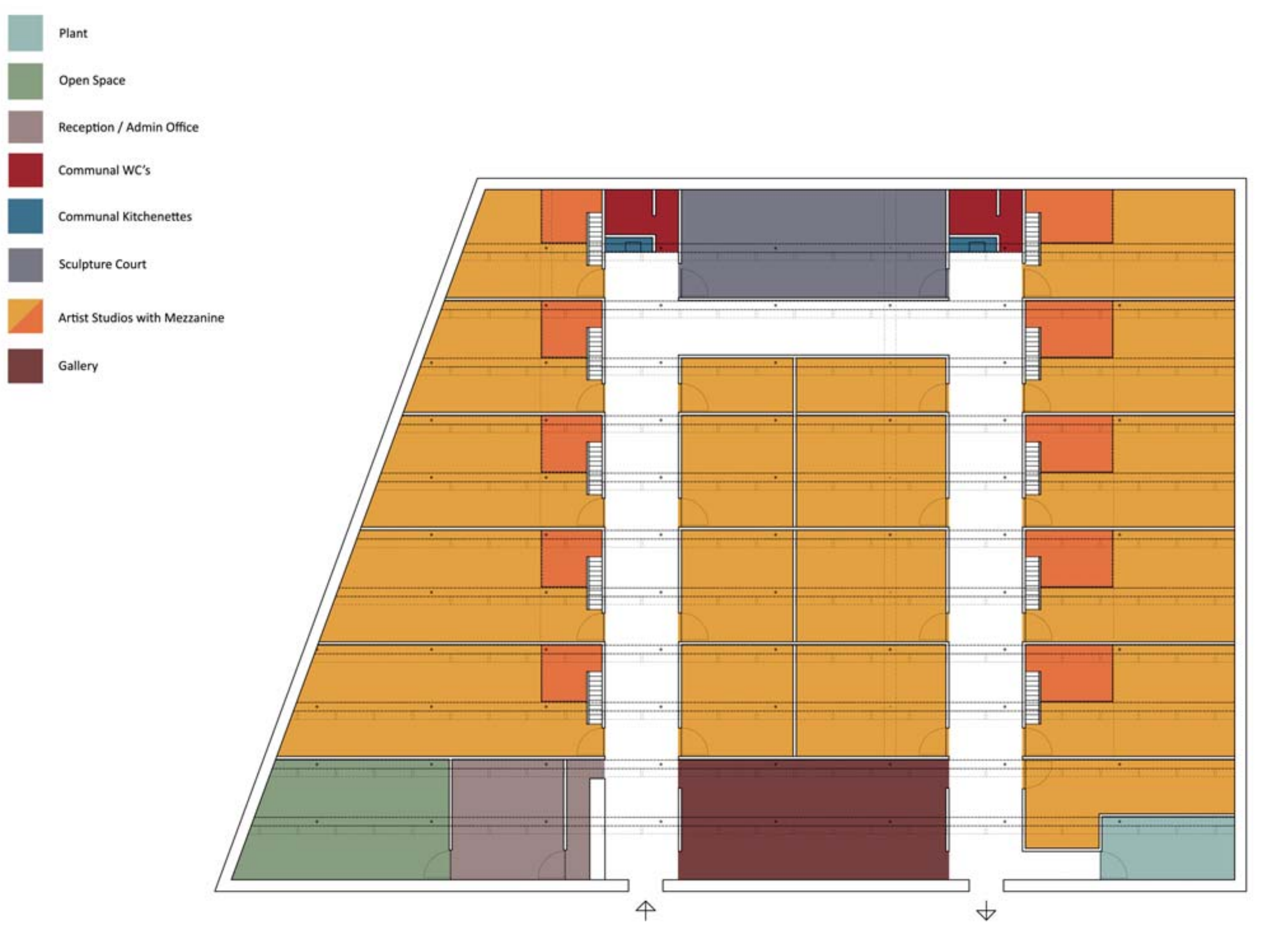

Fig. 77. Artist Studios. Including a gallery/exhibition space and sculpture court

7.3 Workplaces

North Light sheds with their deep plan form, lack of open space and industrial architectural language may not be considered as suitable for conversion to office use, especially as the sheds lack windows and external views. However with considered design that exploits the inherent qualities of space and light intrinsic to the buildings form and the careful insertion of open courtyards successful office schemes can be developed.

- Rented office space
- Serviced office accommodation
- Design studios
- Call centres

The key challenges faced in converting North Light sheds for workspace use are:

- The deep plan form lack of external space within the weaving sheds. To provide 'external' views and ventilation open spaces within the deep plan form of the North Light shed will need to be formed by the removal parts of the structure, or roof coverings.

- The provision of parking spaces. North Light sheds with access to parking space outside of the perimeter walls will be most suitable for conversion to workplaces, although some larger sheds, with good perimeter road access will offer more opportunity for developing schemes that incorporate disabled and visitor parking within the curtilage of the outer walls with the added benefit of the security for vehicles this provides.

- The single storey nature of the sheds. This will require to be planning on a single ground floor level with only limited provision for additional floor space in the form of mezzanine floors, which might be used for storage. However, the height of the roofs combined with north light glazing have the potential to provide internal spaces of unique character with the benefit of high quality natural north lighting ideally suited to most workplace tasks.

- Up-grading of the existing fabric. Ideally this should be achieved in a manner that retains the essential qualities of the historic fabric and will need to meet or exceed modern standards, especially if high standards of sustainable development are sought. The potential for exploiting the form of North Light sheds for sustainable development are set out in section 5.0. With the use of high-efficiency insulation to roofs, floors and outer walls and the use of modern high-performance double glazing to the north lights detailed carefully to minimise air leakage the thermal performance of the fabric could up-graded to meet modern standards. Figure 25 illustrates this.

Fig. 78. Office Space

7.3.1 Opportunities and Benefits

- The 3-dimensional form of the weaving sheds offers the potential to create workplace environments with unique character and high levels of controlled natural light.

- The high quality north light will provide ideal natural lighting for many forms of workplace use, free from the problems of glare associated with computer screens and perfectly suited for uses such as graphic design or design based work.

- Where required external courtyards or gardens can readily be created within the regular structural grid. These spaces will enable ventilation and south light to be drawn into the interior spaces and will provide attractive and sheltered external spaces for occupants use. Figures 22 - 24 illustrate how these can be achieved. Newly created external spaces could take the form of small courtyard spaces, or communal larger communal gardens for shared workspaces schemes. Whilst the form of the sheds suits open planning, smaller scale individual office accommodation could be planned and grouped around internal courtyards.

- The structural grid of columns and beams, the uniform quality of natural controlled north light and the open plan floor space offers the potential for great flexibility of internal planning, both in the creation of a range of different workspace units with an individual weaving shed, or for adaptable space planning within each unit. Services can be distributed along the lines of the structural grid to enable space planning to be adapted and changed over time allowing new uses to be readily incorporated into workspace units.

- The north light section offers the potential to create dramatic interior spaces with sufficient height within each roof section to create small mezzanine work spaces to increase floor area ratios.

- Where required parking could be provided within the curtillage of the sheds as illustrated in Figure 9.

7.3.2 Summary

Weaving sheds are extremely well suited to a variety of workspace uses. Their open plan form, regular structural grid and uniform distribution of high quality natural light enables great flexibility in the planning of both units within each individual shed and space planning within workspace units thereby creating highly adaptable workspace that can change over time to suit new patterns of use, functions or tenants.

Where required external spaces can readily be formed to break-up the existing deep plan form to provide ventilation and courtyard gardens for occupants.

7.4 Education

Weaving sheds could be put to a variety of educational uses, these include:

- Nurseries
- Crèches
- Primary Schools
- College Accommodation
- Adult Education
- Conferencing

Most weaving sheds will have floor areas in excess of the anticipated floor areas for nurseries and crèches but this type of use could readily be incorporated into mixed use community schemes. College accommodation could include teaching, seminar and lecture space or off campus studio and workshop spaces.

The key challenges faced in converting North Light sheds for educational use are:

- Up-grading of the existing fabric. Ideally this should be achieved in a manner that retains the essential qualities of the historic fabric and will need to meet or exceed modern standards, especially if high standards of sustainable development are sought. With the use of high-efficiency insulation to roofs, floors and outer walls and the use of modern high-performance double glazing to the north lights detailed carefully to minimise air leakage the thermal performance of the fabric could up-graded to meet modern standards for retail use

- The north light section and glazing will be advantageous for many education uses which can benefit from the high levels of natural lighting they provide. However, it is likely that some spaces, such as seminar or lecture room space, will require control of daylight for projection internal conditions to enable scene and display lighting to be provided to enhance sales areas. The north light glazing can be up-graded and high quality blinds or shutters used to control the levels of natural light, these could either be used to 'black out' natural light or by using diffusing blinds to provide reduced lighting levels to suit use.

- Nurseries and crèches often require quiet small scale spaces which do not fit well with the large scale of the north light sections. However, this type of space could be provided by creating 'pods' within the plan and in doing so a variety of open activity spaces and quiet places can be combined under the north light roof section.

Fig. 79. Crèche and Softplay

Fig. 80. School

- Restrictions imposed by column bay sizes and roof height. It is un-likely that the structural grid of 3x6 metres will impose any major constraint on most educational uses. However, where larger teaching or lecture spaces are required consideration may need to be given to removing columns to increase the un-interrupted floor area. This can readily be achieved as illustrated in Section 5, Figure 16. Some lecture rooms with raked seating or activity spaces may require clear heights in excess of the existing roofs, to accommodate these parts of the roofs may need to be removed to allow larger volumes to be constructed within the plan. Where possible these insertion should be created in a manner where they can be removed at a future date to enable the original roof structure to be reinstalled.

- Acoustic separation will be critical to many education uses where noise will need to be controlled between adjacent teaching spaces. New partition walls can be constructed with modern levels of acoustic isolation and if these are planned to coincide with the grid of gutter beams acoustic isolation between adjoining spaces can readily be achieved.

7.4.1 Opportunities and Benefits

- The 3-dimensional form of the weaving sheds offers the potential to create education environments with unique character and high levels of controlled natural light.

- The high quality north light will provide ideal natural lighting for many forms of educational use. Where more control over lighting levels is required, blinds or shutters can be used to limit the level of natural lighting or to provide full blackout for projection.

- The north light section and high levels of natural daylight they provide gives the potential to provide covered internal routes or 'arcades' and 'break-out' spaces. These secondary spaces often form an important role in educational establishments in promoting social networking and a sense of community amongst students.

- Consideration could also be given to the removal of parts of the roof structure to create external courtyard or external activity spaces. These spaces could be open to the air but retain the original structural frame and part of the roof covering to provide sheltered covered spaces.

- The structural grid of columns and beams, the uniform quality of natural controlled north light and the open plan floor space offers the potential for great flexibility of internal planning, both in the creation of a range of different education spaces with an individual weaving shed, or for adaptable space planning within each space. Services can be distributed along the lines of the structural grid to enable space planning to be adapted and changed over time.

- The single storey forms of the weaving sheds are well suited to creating fully accessible educational environments without the need to provide costly stairs, passenger and service lifts.

- The scale of the North light section presents opportunities for the creation of small scale mezzanine study spaces, perhaps with storage or quite spaces underneath.

7.4.2 Summary

Weaving sheds offer the potential to create stimulating learning environments that can be used for a variety of education uses ranging from pre-school facilities, children's education and more advanced larger scale facilities for colleges and adult education courses.

The quality of natural light and it's uniform distribution across the plan of the shed will enable great flexibility in planning and use. The sheds can be readily adapted to accommodate large spaces for lectures, studios or workshops and, through the use of new insertions or 'pods' smaller scale intimate spaces can also be formed enabling the creation of mixed and varied learning environments.

7.5 Retail

Weaving sheds are well suited for conversion to retail use and there exist many examples of sheds that have been successfully adapted for a variety of retail applications as illustrated in the Precedent Study section of this report (refer to Chapter 6.0)

The range of retail uses that could be accommodated include:

- Small scale shops
- Covered Market Stalls
- Shopping 'Villages'
- Larger shops or 'Designer Outlets'
- Discount Warehouses
- Furniture or Department Stores
- Metro style supermarkets
- Garden Centres

The key challenges faced in converting North Light sheds for retail use are:

- The provision of parking spaces and access for deliveries. The requirement for parking and deliveries will vary considerably with the type of retail use proposed. Smaller shop units, covered markets and metro style supermarkets will have a limited requirement for parking immediately adjacent to the sheds as this type of retail unit is often located within town centres where access is primarily on foot. Nearby centralised parking and proximity to transport links will be important.

  With larger scale retail uses on-site parking and deliveries will become more of an issue and weaving sheds that have existing parking in close proximity or adjacent land that can be used for parking will be more suitable.

  Larger sheds with good road access will offer opportunities for developing schemes that incorporate disabled and visitor parking or collection points within the curtilage of the outer walls, with the added benefit of the security for vehicles this provides.

- Up-grading of the existing fabric. Ideally this should be achieved in a manner that retains the essential qualities of the historic fabric and will need to meet or exceed modern standards, especially if high standards of sustainable development are sought. With the use of high-efficiency insulation to roofs, floors and outer walls and the use of modern high-performance double glazing to the north lights detailed carefully to minimise air leakage the thermal performance of the fabric could up-graded to meet modern standards for retail use.

Fig. 81. Retail 1

Fig. 82. Retail 2

The north light section and glazing will be advantageous for many retail uses which can benefit from the high levels of natural lighting they provide. However, some retail uses will require more controlled internal conditions to enable scene and display lighting to be provided to enhance sales areas. The north light glazing can be up-graded and high quality blinds or shutters used to control the levels of natural light, these could either be used to 'black out' natural light or by using diffusing blinds to provide natural background lighting a levels that enable supplementary display lighting to be effective.

- It should be anticipated that some retailers will also prefer to install flat suspended ceilings to provide servicing flexibility and ensure the visual focus is on the sales displays. It is understandable why retailers would wish to do this but this will obscure the key architectural qualities of the space. It should be noted that, with careful design, suspended ceilings can be installed without damage to the historic fabric and will be fully 'reversible', they therefore should not be ruled out on principle.

  There are however, alternative methods of providing servicing flexibility and a more controlled or 'neutral' sales environment without obscuring the historic qualities of the weaving sheds, and indeed these qualities should be assessed and exploited advantageously. High level services distribution can be provided using modern attractive containment systems and the regularity of the column and beam structure will enable a flexible display layout to be provided. The use of suspended ceiling 'rafts', as seen in many modern retail environments, could be used to provide a focus for displays whilst enabling the historic and architectural qualities of the space to be retained.

- Restrictions imposed by column bay sizes. It is anticipated that many retail uses will be able to operate comfortably within the constraints of the 6x3 metre structural column grid and the grid itself forms a natural structure for sub-dividing the buildings into multiple occupancy arrangements. However, there may also be some retail operations, such as metro style supermarkets, that will find the structural bay spacing to be a constraint on the layout of internal displays or isle widths. Where this become a severe obstacle there is the option to remove columns to increase floor areas free of columns (as illustrated in Chapter 5.0 Figure 16) and thereby provide greater flexibility in space planning.

- Location and context. The key issue is likely to be the proximity to good local transport links, parking and proximity to other retail environments. An analysis of the location of most sheds indicates that they are usually embedded within areas of urban development and are therefore likely to have good transport links. The weaving sheds are distributed throughout urban areas and it is likely that many will be close to central parking areas and other retail centres. The suitability of sheds for different retail uses in relation to their context will inevitably need to be assessed on an individual basis and in relation to the local planning policies.

7.5.1 Opportunities and benefits

- The 3-dimensional form of the weaving sheds offers the potential to create retail environments with unique character and high levels of controlled natural light.

- The high quality north light will provide natural lighting for many forms of retail use. Where more control over lighting levels is required, blinds or shutters can be used to limit the level of natural lighting to background levels to enable the effective use of display lighting to enhance sales areas.

- The north light section and high levels of natural daylight they provide gives the potential to provide covered internal routes or 'arcades' to enhance the retail environment, this will be especially suited to the creation of developments of smaller scale shop units, market style stalls or shopping 'villages'. Consideration could also be given to the removal of part of the roof structure in the centre of such developments to provide an external courtyard, perhaps providing external seating for cafés or coffee houses, which will also enable sunlight to be drawn into the heart of such developments to further enhance the environment.

- The structural grid of columns and beams, the uniform quality of natural controlled north light and the open plan floor space offers the potential for great flexibility of internal planning, both in the creation of a range of different retail units with an individual weaving shed, or for adaptable space planning within each unit. Services can be distributed along the lines of the structural grid to enable space planning to be adapted and changed over time. This inherent flexibility is critical to enable the developments to accommodate a variety of retail uses.

- Where required parking could be provided within the curtillage of the sheds as illustrated in Figure 9. This will be especially suited to the provision of disabled parking or pick-up points for stores, such as furniture outlets, selling larger items.

- The single storey forms of the weaving sheds are well suited to creating fully accessible retail environments without the need to provide costly stairs, passenger and service lifts.

- Weaving sheds nearly always present window-less facades to the street. This can be seen as a benefit for larger retail outlets or metro style supermarkets which often require only limited window display space to draw in customers.

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Where developments involve smaller retail outlets the provision of window display and shop frontage will be much more critical to their success. To achieve this, developments need to draw customers into the sheds and north light section can be positively exploited to create naturally lit internal covered 'streets' or 'malls'. Careful consideration needs to be given to the design and location of entrances to such developments and to maximise foot-fall through routes should be created where possible. Shop windows could be created in the perimeter walls albeit that there will be a limitation on the extent of these due to structural and planning consideration and the fact that many sheds were partially buried into slopes.

7.5.2 Summary

Weaving sheds are extremely well suited to a variety of retail uses and many sheds have already been successfully converted. Their single storey open plan form, regular structural grid and uniform distribution of high quality natural light enables them to accommodate almost any form of retail use.

Fig. 83. Garden Centre

7.6 Cultural and Entertainment

Weaving sheds could be put to a variety of cultural and entertainment uses, these include:

- Galleries
- Cultural Industries
- Restaurants and Bars

The key challenges faced in converting North Light sheds for educational use are:

- Up-grading of the existing fabric. Ideally this should be achieved in a manner that retains the essential qualities of the historic fabric and will need to meet or exceed modern standards, especially if high standards of sustainable development are sought. With the use of high-efficiency insulation to roofs, floors and outer walls and the use of modern high-performance double glazing to the north lights detailed carefully to minimise air leakage the thermal performance of the fabric could up-graded to meet modern standards.

- The north light section and glazing will be advantageous for many cultural uses, especially gallery spaces, which can benefit from the high levels of natural north lighting they provide. However, it is likely that some uses will require control of daylight and this can readily be achieved through the use of blinds or shutters.

- Uses such as restaurants or bars with catering facilities will need to have clean kitchen environments with extract ventilation. If properly up-graded using modern materials for soffits and new roof light glazing the existing north light sections could be converted for catering use. The north light section will also make provision of kitchen extract relatively simple by incorporating ventilation fans directly into sections of north light glazing (or through the south facing slopes of the roof), if planned away from the building edge these will be relatively discrete and not visible from street level.

- Existing column bay sizes and roof heights are unlikely to prove restrictive for cultural or entertainment uses, many of which can be flexibly planned around the grid of columns. There may instances where large floor areas in galleries are required but, as illustrated in Figure 16 columns can easily be removed with the introduction of relieving beams to create large floor spaces with clear widths of 6 or even 9 metres which is likely to be sufficient for the largest of gallery spaces.

Fig. 84. Cultural Centre

7.6.1 Opportunities and Benefits

- The north light section and the high quality north light will provide ideal natural lighting for many forms of cultural use and will be especially suited to gallery or display use. Where more control over lighting levels is required, blinds or shutters can be used to limit the level of natural lighting or to provide full blackout for projection.

- The height and volume of the north light sections offers the potential to create dramatic interior spaces with high levels of controlled natural light which, with considered design, can exploit the industrial qualities of the original construction.

- External courtyards, activity or seating spaces could be created within the deep plan form of the sheds through the removal of parts of the existing roof fabric or structure. These spaces could be open to the air but retain the original structural frame and part of the roof covering to provide sheltered covered spaces.

- Where required parking could be provided within the curtillage of the sheds as illustrated in Figure 9. This will be especially suited to the provision of disabled parking or for secure delivery bays.

- The single storey forms of the weaving sheds are well suited to creating fully accessible environments without the need to provide costly stairs, passenger and service lifts.

7.6.2 Summary

Weaving sheds are well suited for conversion to a range of cultural and entertainment uses.

7.7 Storage and Warehousing

The single storey open plan form of the weaving sheds make them well suited for storage or warehouse use, the range of uses could include:

- Self-service storage units
- Managed archival storage
- Distribution warehousing
- Controlled parking

The key challenges faced in converting North Light sheds for storage use are:

- Security will be a key issue for many storage facilities. The existing masonry outer walls of most sheds have very few windows or doors and will offer good levels of security to the perimeter of the building without the need for substantial upgrading or alterations. However, because the buildings are single storey it is relatively easy to access the roofs particularly where the outer wall are partially buried into slopes and improved security may need to be provided to the outer wall tops and the north light glazing.

To improve the physical security to the perimeter of the buildings and roof railings could be fitted to the top of the outer walls. However, without careful design, these are likely to appear utilitarian and will detract from the historic character of the sheds. To avoid this railings could be considered as creative design opportunities in their own right and could incorporate signage or commissioned civic art.

The security of north light glazing could be improved by installing grills or security bars, or where natural light is not critical to the interior, glazing could be replaced with solid panels rather the new roof glazing. These new components can be discretely designed so as not to detract from the original historic appearance of the sheds.

- Access and loading for vehicles. Many sheds have at least one elevation fronting onto a road or open space and by forming new openings entrances and loading points could be provided directly from the street. Where this is not possible, either because street access is restricted, the shed is substantially land-locked or, as is sometimes the case, the shed is partially set below ground level, vehicular loading bays within curtilage of the outer perimeter walls may need to be provided, this will have the added benefit of provide secure loading which is often an important consideration.

- Restrictions imposed by column bay sizes. Many storage uses will be able to operate well within the constraints of the 6x3 metre structural column grid and within this a range of bay sizes and access circulation could be provided. The grid with its corresponding north light section also forms a natural structure for sub-dividing the space into separate storage zones.

- Protection of columns. It is likely that some storage or warehousing operations may require either vehicle access or use of fork-lift or heavy pallets which risk damage to the relative slim section cast iron columns. Various methods can be employed to protect columns depending on the anticipated impact load. An example is illustrated in Figure 10.

- Height restriction imposed by the gutter beams. At 3.5 metres (11.5 feet) to the underside of the gutter beams should be able to accommodate a range of storage types, including self-service storage, many types of archival storage, parking, etc. It is only larger distribution warehousing which relies on high level racking accessed with fork-lift trucks to increase storage capacity that could not be accommodated.

- Up-grading of building fabric / floors. The requirement for up-grading of the external fabric to improve thermal performance will vary with the type of storage required. Low grade storage will require relatively modest improvement and perhaps only as far as unsuring the buildings are weather-proof, whereas archival storage uses will require higher levels of up-grading to provide controlled conditions. Where higher levels of environmental control may be required these might be achieved by installing 'sealed' and secure enclosures within the sheds to provide localised control without the need to substantially up-grade the entire building fabric.

7.7.1 Opportunities and benefits

- The sheds provide high levels of north light. This will reduce reliance on artificial lighting and therefore keep running costs to a minimum.

- Modular structural system and bay spacing make sub-division straightforward and relatively easy to create separate secure storage bays.

- The single storey large open plan arrangement of sheds make them well suited for storage use in providing level access.

- Many types of storage will require very little up-grading or alteration works to the existing fabric other than making the buildings weather proof, the provision of background heating basic services and vehicular access.

- New concrete or preferably lime-crete floors can be easily installed to control the ingress of damp through the floors and to provide a level floor surface suitable for installing racking or traffic by fork-lift trucks.

7.7.2 Summary

Weaving sheds are ideally suited for re-use as storage or warehousing facilities and will require relatively little alteration and up-grading works to achieve the standards required for most types of storage. Where higher levels of security and environmental control are required the fabric can be up-graded to achieve this without detriment to the historic fabric of the buildings.

7.8 Community Use

Weaving sheds could be put to a variety of community uses, these include:

- Libraries
- Community Centres
- Youth Centres
- Children's Activity Centres

The key challenges faced in converting North Light sheds for community use are:

- Up-grading of the existing fabric. Ideally this should be achieved in a manner that retains the essential qualities of the historic fabric and will need to meet or exceed modern standards, especially if high standards of sustainable development are sought. With the use of high-efficiency insulation to roofs, floors and outer walls and the use of modern high-performance double glazing to the north lights detailed carefully to minimise air leakage the thermal performance of the fabric could up-graded to meet modern standards.

- The north light section and glazing will be advantageous for many community uses, especially libraries, gathering and meeting spaces which can benefit from the high levels of natural north lighting they provide. However, it is likely that some uses will require control of daylight and this can readily be achieved through the use of blinds or shutters.

- Many weaving sheds are contained within solid perimeter walls, often without windows or doors, which present an un-welcoming and 'blind' façade to the street with no obvious points of entrance. This is at odds with the requirement for community buildings to present a public face to the world and to be welcoming and accessible. To improve accessibility care will need to be taken in the design and placement of new entrances and emphasis should be placed on the design of the 'interior' gathering and circulation spaces to provide a sense of place and community focus within the curtillage of the outer walls. This could be achieved by creating new 'courtyards', either open to the sky or covered by the existing roofs that serve to draw visitors into the heart of community use schemes.

- Existing column bay sizes and roof heights are unlikely to prove restrictive for community uses, many of which can be flexibly planned around the grid of existing columns. There may be instances where larger floor areas free of columns are required. Columns can easily be removed with the introduction of relieving beams as illustrated in Section 5.3.

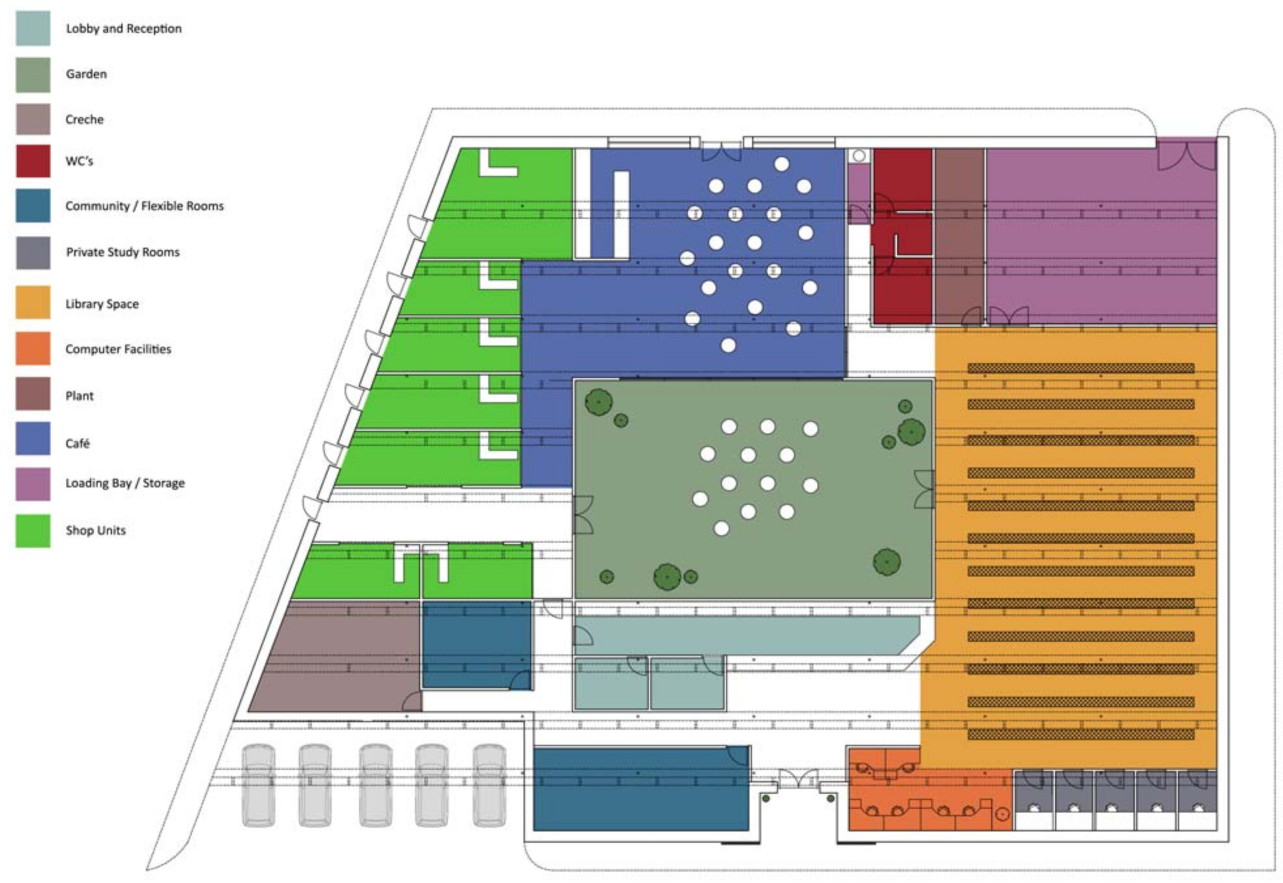

Fig. 85. Library

7.8.1 Opportunities and Benefits

- Many weaving sheds are embedded within urban areas and are located in close proximity to the workers housing that supported them, this makes them ideally located for many community uses placing them in the heart of local communities and in close proximity to local transport links.

- The north light section and the high quality north light will provide ideal natural lighting for many forms of community use and will be especially suited to libraries, meeting spaces and children's activity spaces.

- The height and volume of the north light sections offers the potential to create dramatic interior spaces with high levels of controlled natural light which can exploit the industrial qualities of the original construction. The scale of the original spaces will be ideally suited to public buildings, gathering and meeting spaces without the need for substantial alteration.

- External courtyards, activity or seating spaces could be created within the deep plan form of the sheds through the removal of parts of the existing roof fabric or structure. These spaces could be open to the air but retain the original structural frame and part of the roof covering to provide sheltered covered spaces .

- Where required parking could be provided within the curtillage of the sheds as illustrated in Section 5. This will be especially suited to the provision of disabled parking or for secure delivery bays.

- The single storey forms of the weaving sheds are well suited to creating fully accessible public environments without the need to provide costly stairs, passenger and service lifts.

- The masonry perimeter walls offer schemes good levels of physical security.

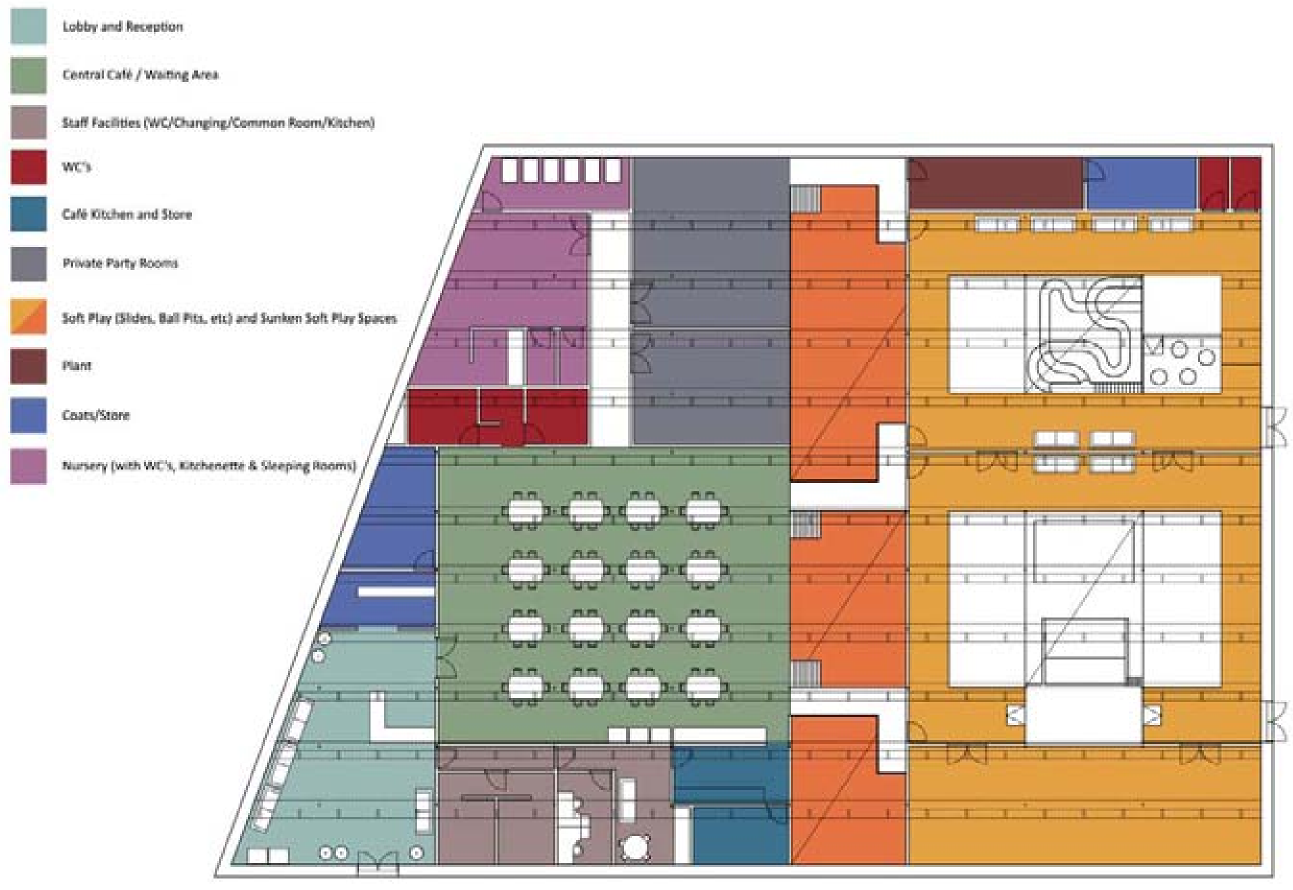

Fig. 86. Creche and softplay

7.9 Mixed Use Developments

As described in the preceding sections weaving sheds can successfully be adapted to an extremely wide range of uses.

Inevitably some of the proposed uses will have floor area requirements that are substantially smaller than some of the sheds, particularly the medium to larger scale ones. These uses might include nurseries, crèches, small retail units, café and community uses, and to make these viable they would benefit from incorporation in a mixed use developments.

There will also be uses that will benefit from being developed alongside other compatible use types, where the synergy between the uses will lead to a more viable and successful development.

Typical uses that could benefit from the synergistic relationships established in mixed use developments might include:

- Workshops / associated retail outlets / café
- Artists studios / education studios / galleries / café
- Craft studios / Small Scale Retail / Adult Education Space
- Small scale retail / Metro Style Supermarkets / Coffee shop
- Business Centres / workshops / offices
- Child Activity Centres / crèches / Nurseries

Other forms of mixed use development might involve the subdivision of larger sheds onto separate and distinct units which will enable different uses to be developed within the curtillage of the original shed. The single storey arrangement of the weaving sheds and their regular structural grid make such subdivision relatively easy to achieve without the need for multiple stairs and lifts and the more complex access and circulation requirement introduced when multi-storey buildings are subdivided into separate units.

Examples of existing buildings that have been successfully converted to mixed use developments include:

- Brewery Arts Centre, Cirencester
- Spike Island Artist Studios – Bristol

The key challenges faced in converting weaving sheds for mixed use developments are:

- Most weaving sheds are contained within solid perimeter walls with very few point of access. Conversion for mixed use will often require multiple entrance and access arrangements. Where the perimeter walls relate to external roads it should be relatively easy to form new entrances directly off the street. However, there may be situations where sheds are substantially land-locked, road traffic and pedestrian safety requirements preclude direct access of adjacent streets or, as often was the case, the shed is partially buried into sloping ground. In these situations there may be limited opportunities for forming new entrances and to over-come these difficulties it may be necessary to introduce new 'internal' streets or courtyard spaces within the curtilage of the perimeter walls to facilitate access to multiple uses. The north-light roofs could be retained, either fully or in part, to provide shelter from the elements to these new access spaces thereby making them a positive attribute to the new development.

- The need to provide sub-division between adjoining uses that meet fire and noise separation requirements. The single storey form and the regular linear structural grid of the weaving sheds make sub-division simple and cost effective. Separating walls can be designed to meet the fire and noise separation requirements and being aligned on the grid of gutter beams or perpendicular to them can be easily sealed to the existing roofs. The regularity of the structure will also enable great flexibility in planning enabling a variety of unit sizes to be created.

- Different uses may have different environmental requirements.

7.9.1 Opportunities and Benefits

- The regularity of the structural grid and the repeating north light section of the roofs will enable the building fabric for separate units to be up-graded to suit use. For example, if a development mixes low grade workshop use with higher grade offices the spaces created for each use can be up-graded separately to different standards as required.

- The single storey forms of the weaving sheds are well suited to creating fully accessible multi-occupancy environments without the need to provide costly stairs, passenger and service lifts. There will not be the requirement for each separate unit to have its own stair and lift as would be the case in multi-storey building conversions.

- To provide a focal space for mixed use developments 'external' courtyards, activity or seating spaces could be created within the deep plan form of the sheds through the removal of parts of the existing roof fabric or structure. These spaces could be open to the air but retain the original structural frame and part of the roof covering to provide sheltered covered spaces. Similar covered spaces could also be formed to provide independent access to separate units without the need for new access point in the perimeter walls.

- Where required parking could be provided within the sheds as illustrated in Section 5.3. This will be especially suited to the provision of disabled parking or for secure delivery bays.

7.9.2 Summary

Many sheds are of sufficient size to enable mixed use schemes to be developed and the synergistic relationships formed between compatible uses as seen in other building conversions are of great benefit and can often increase the viability of a development as a whole.

The single storey form and repeating structural grid and roof profile of the weaving sheds enables them to be them readily sub-divided into separate units and make them ideally suited for conversion to mixed use developments.

The size of some of the larger sheds means that mixed use or multi-occupancy schemes will be a valuable and viable option for securing their re-use where it proves difficult to find a single use to fully occupy the entire shed.

8.0 TECHNICAL SOLUTIONS

8.1 Repair of the building fabric

The weaving sheds were simple working industrial buildings and the external materials generally used in their construction are robust and simply detailed. If repaired and properly maintained the building fabric will offer long service life with relatively low cost maintenance. The components of the building fabric were:

- External walls were generally in coursed rubble stone or brick and there was little in the way of ornamentation.
- The few openings or windows were in simple detailed timber joinery.
- The north light roofs to the majority of weaving sheds were constructed with simple 30 degree pitched roofs, comprising a simple structure of common rafters with slate roof coverings.
- Internal materials comprised stone flag floors, exposed cast iron structure, timber joinery and boarded partitions and lime plaster on lath soffits to the south facing roof slopes.

The repair and on-going future maintenance of the building fabric should therefore be relatively straight forwards and inexpensive, the key components are as follows:

8.1.1 Repair and replacement of slate roofs

The north light roofs to most weaving sheds were constructed with simple 30 degree pitched roofs, comprising a simple structure of common rafters with slate roof coverings.

Whilst many slated roofs survive they will often be in need of repair or stripping and re-roofing. Where the roof is to be insulated it is likely that slates will need to be removed and re-laid to allow the insulation and breather membranes to be properly installed.

The repair or stripping and re-laying of the roofs is straightforward and may only require new battens and replacement of damaged slates. The opportunity should be taken to replace existing roofing felt with a breather membrane, especially where thermal insulation is also introduced.

The re-laying or replacement of slate roofs is relatively expensive in comparison to alternative roof coverings and these should be considered where costs are constrained if this enables the building to be occupied and re-used. Alternative roof coverings will however be subject to local conditions, over-looking, planning and listed building status. Additionally, a number of early weaving sheds are roofed in stone slates and, in these cases, the particular historic importance of this roof covering should be respected

Alternative roofing would need to be relatively light-weight to avoid over-stressing the structure and the most likely material would be profiled sheet metal, in aluminium, steel or zinc, all materials which have an aesthetic resonance with the industrial character of the weaving sheds. Aluminium and steel are available as coated material which could be colour matched to slate and zinc is now available with a dark grey patina. Fixing profiled metal sheeting to the existing timber structure is both straightforward and 'reversible' enabling the roofing to be reinstated as the original slate at a future date.

8.1.2 Repair of external walls

The perimeter walls to the weaving sheds were constructed of solid masonry, in either coursed rubble stone or brick. The masonry was detailed simply and robustly, often with few essential windows and doors and little or no ornamentation. As would be expected they generally survived well other than the normal deterioration of mortar pointing and copings.

Repairs to the walls should be relatively straightforward and if repairs are properly carried out using appropriate materials and well maintained the existing walls should be expected to give many years of continued service. Care needs to be taken to ensure that the external walls are allowed to breather by use of appropriate lime mortars. Where cement based mortars or render have been used these should be removed and replaced with lime based material.

Weaving Sheds were often deliberately built into slopes to encourage moisture ingress into the interior to provide the damp conditions ideally suited to weaving processes. Where walls are partially below ground the base of the walls will need careful inspection to ensure they are not deforming under the load of the retained ground.

Consideration should also be given to installing 'French drains' to the underground base of the walls with a drainage board laid against the wall to relieve below ground water pressure against the wall.

8.1.3 Gutter-beams and rainwater drainage

The cast iron beams that support the rows of north lights are ingeniously designed as inverted channel sections such that they both carry the load of the roofs and act as rainwater gutters. However, this results in very long runs of gutters with outlets only at their extremities, resulting in the risk of blocking and limited maintenance access.

The gutter beams were laid flat with joints aligned over column heads. The end of each gutter section has an external flange enabling sections to be bolted together over a bracket to the head of the column. Interestingly it appears that the bracket could have been designed to collect any resulting leak at the joint and channelled it down the inside of the hollow columns.

The existing cast-iron gutter beams were directly exposed to rain water without secondary linings and if any paint or bituminous coatings had been used these have now worn off leaving the gutter directly exposed to water and air with the resulting risk of corrosion.

Whilst minor leaks at joints may not have been a serious issue during the working life of the sheds, they will need to be properly sealed when sheds are put to new uses. The gutter-beams should be inspected, repaired and up-graded with new gutter linings and access points as follows:

- Gutter beams should be inspected for corrosion and structural integrity prior to their re-use and any necessary repairs carried out. Providing the gutter-beam has not corroded so far as to effect its required structural strength the existing surfaces can be shot-blasted to bare metal and re-coated with careful inspection at joints or connections where surfaces may not be visible.

- Cast-iron gutter-beams will require protective coatings or new secondary linings to provide protection from corrosion in use.

  If coated gutter beams should be shot-blasted to bare metal and coated with 2-pack epoxy primer + modified epoxy water-resistant coating system. This will provide a degree of protection but coatings will require regular inspection, maintenance and re-application.

  To give longer-term protection secondary gutter linings laid or fixed over protected cast-iron could be used. To avoid a substantial reduction in the overall internal dimensions and water carrying capacity of the gutter a thin walled system using a single ply membrane pre-bonded to a galvanised steel liner could be used. These systems incorporate joint systems that can accommodate movement which is essential for long runs of gutters and the use of a drainage board under the gutter lining will provide ventilation over the surface of the original gutter and prevent a build up of water on the cast iron surface. Where some reduction of capacity can be tolerated secondary gutter linings could include pre-bonded insulation to reduce the effects of cold-bridging caused by the cast-iron gutter beams.

- Consideration will need to be given to the provision of regular points for routine inspection and for access to clear blockages. To provide this, opening lights could be incorporated into the north light glazing system at regular intervals to provide access to the gutters. These would be best placed adjacent to columns to permit easy access for inspection of joints over the gutter heads.

- Many sheds have long runs of gutters with only a single outlet at either end. Where gutter lengths exceed modern standards and risk over-flow new down-pipe locations may need to be formed. Where required these could be formed by core drilling the sole of the gutters and welding on a cast-iron spigots to connect down-pipes. Advice from a structural engineer should be sought on the size and placement of new outlet location to ensure sufficient strength remains in the cast iron gutter beam.

8.2 Up-grading of the building fabric

North light weaving sheds were designed as working industrial buildings, built as cost effectively as possible using simple and efficient means of providing the internal conditions best suited to the process of weaving.

As with all buildings of the period the walls and roofs were not insulated and heating would not have been provided, especially given the physical nature of the work. Original north lights were single glazed into timber frames and in most surviving sheds these are either in a poor state of repair or have been replaced with single glazed aluminium patent glazing.

The process of weaving also favoured damp internal conditions which meant that sheds were often partially built into sloping ground to draw ground moisture into the building through the retaining walls and floors.

The issues that need to be addressed when considering the up-grading of the sheds are:

- Up-grading the thermal performance of roofs, walls and floors
- Up-grading the thermal performance of the north light glazing
- The control of damp and moisture ingress through walls and floors
- Gutter-beams and control of rainwater drainage
- Exploiting possibilities for sustainable design (refer to Section 5.10)

If the re-use of weaving sheds is to be worthwhile then meeting the required improvements to the fabric will need to be carried out in a manner that retains the historic fabric and preserves the unique architectural qualities of the sheds. Where more invasive up-grades become unavoidable then these should ideally be reversible to enable the original construction or fabric to be reinstated at a later date.

Investigations into possible methods of up-grading the fabric are detailed below:

8.2.1 Up-grading of thermal performance of roofs

The pitched solid roofs of most sheds are of simple timber common rafter construction bearing on a ledge forming part of the gutter beam casting and a timber ridge beam supported off the raking cast-iron T-section struts. Roof coverings were generally in slate on battens and the internal soffits were lime plastered on timber laths.

The rafters are generally 140mm (5.5 inches) deep and can be filled with insulation material providing a ventilation zone of at least 25mm is under the slating battens. The provision of insulation will introduce the risk of condensation and, to control this, a vapour control membrane will need to be installed on the underside and a breather membrane provided under the slates. If the soffit plaster is installed directly under the rafters this will provide an insulation zone depth of about 100mm as illustrated in Figure 25.

A number of insulation materials could be considered, each will offer varying performance and cost:

- Mineral fibre insulation. This is a relatively inexpensive commonly used material, and offers average performance.

- Ridged foam insulation. This offers the highest performance for any given insulation depth.

- Cellulose fibre (re-cycled newspaper). Cellulose fibre is ideally suited to timber frame construction as, un-like many other forms of insulation (such as mineral fibre and foam) it absorbs moisture and is 'breathable'. This ensures that, provided it is used with the recommended vapour control and breather membranes, any moisture that gets into the structure (something that happens in any inhabited heated building) always migrates safely to the external atmosphere where it is harmlessly expelled. It also has good sustainable credentials and is fire resistant.

Where up-grading of insulation is carried out target performance values likely to be required in the current building regulations are:

Dwellings in existing buildings	0.2 w/sqm.k
Other buildings	0.2 w/sqm.k – 0.25 w/sqm.k

Good standards of insulation can be achieved using standard insulation materials without the need to alter the overall depth and construction build-up of the original construction, other than the installation of suitable vapour control membranes.

Higher standards of thermal performance can be achieved by increasing the overall insulation depth and, or by using the highest performing insulation materials. This will necessitate modifying the original construction to provide the addition depth and care will need to be taken to ensure compatibility with the detailing at the gutter and ridge of the north light glazing and that the overall appearance of the roof profile is not adversely affected. The additional depth can be achieved by:

- Replacing existing rafters with deeper section timbers.

- Adding counter-battens above and below the existing rafters. This is more beneficial than using deeper rafters as it will enable insulation to be continued above and or below the rafters which will maximise thermal performance by minimising 'cold bridging' through the timber structure.

8.2.2 Up-grading of gutter beams

In their original form the undersides of the gutter beams were sheathed in timber boarding (as seen at the working museum housed in Queen Street Mill, Briercliffe). There is just sufficient void depth between the boarding and underside of the gutter sole to provide enough insulation material to alleviate the effects of cold bridging. To improve thermal performance high-performance multi-foil insulation could be used.

The junction between the column head and the underside of the gutter beams will also be a source of cold bridging with the consequent risk of condensation, especially if the building is well insulated, sealed and heated.

In situations where the building fabric is to be substantially up-graded an insulated gutter lining could be used, this will alleviate the effect of cold bridging through both the column heads and the T-section cast iron props bolted to the side of the gutter beams which support the roof ridge.

8.2.3 Up-grading of thermal performance of north light glazing

The original roof-lights were made as large timber units, each approximately 2 metres long fixed between the raking cast iron T-sections props supporting the ridges. Panels were subdivided into small approximately 300m wide single glazed panes which were putty beaded in place. Many of these have decayed and been subsequently replaced with cheaper single glazed aluminium patent glazing systems requiring less maintenance.

Up-grading the thermal performance of the north lights can be achieved through the use of a double glazed system, in either aluminium or timber.

The size and relative simplicity of the north light profiles will enable a wide choice of double glazed aluminium / thermally broken powder coated steel systems to be used. The units can be fully supported at the head and cill, and given the relatively short span of 1200mm (4 feet) and their steep pitch of 65 degrees, small, relatively unobtrusive section profiles can be used.

Alternatively a system of timber double glazed roof lights could be used. The timber sections provide improvements to the thermal performance of aluminium, and are more in keeping with the timber lights originally used. Timber frame sections with aluminium capping beads can be used to reduce maintenance and improve service life.

Sealing of the roof-lights to minimise air leakage, whether they be in aluminium or timber, will be critical to achieving low heat loss. Modern glazing systems are inherently well sealed and, with careful detailing, the units can be relatively easily sealed to the existing structure.

8.2.4 Up-grading of thermal performance of walls and floors

The perimeter walls to the weaving sheds were constructed of solid masonry, in either coursed rubble stone or brick. They were not insulated, and in some instances deliberately built into slopes to encourage damp into the building. Whilst the wall area in relation to the floor area is low they will, being un-insulated, be a source of heat loss.

Critical to how they may be up-graded to improve thermal efficiency will be the control of damp, either rising from the ground or directly through the wall in locations where they are built into slopes. The original construction was by nature 'breathable' in large part due to the air leakage through the original construction, and whilst damp and moisture was present, and indeed encouraged, it would have breathed or ventilated harmlessly out of the buildings without risk of damaging the fabric.

Up-grading the thermal performance of the sheds will raise the internal temperature thereby creating greater humidity and risk altering the way damp in the floors and walls is naturally controlled, and it would be advisable to check the levels of ground water or *moisture* present under the floors before specifying upgrading works to the walls and floors. Where ground moisture is found to be present under the floors, it is strongly recommended to use a breathable floor construction in tandem with a breathable roof system using cellulose fibre insulation is for the reasons detailed below.

8.2.5 Up-grading of ground floors

In their original construction the floors were often formed using stone slabs laid directly on prepared ground and, whilst there was no barrier to moisture, the floors breathed and moisture would have evaporated uniformly across the entire floor area.

If the floors are up-graded and damp proofed by using modern impermeable damp proof membranes and new concrete ground slabs this will cause any moisture below the floors to be trapped. This will have the effect of forcing and concentrating the moisture to the edge of the floors where it will be drawn up or 'wick' through the outer walls at relatively high rates with the consequent risk of damage and salt staining. The effect is exacerbated by provide modern standards of heating.

Careful consideration should therefore be given to the control of damp through the up-graded ground floor construction and it would be highly advisable to use 'breathable' forms of construction for new floors.

Figure 26 illustrates a floor construction using insulated 'limecrete'. This type of construction uses lime based concrete to create a breathable construction, without the use of a damp proof membrane, through which moisture can permeate, recycled aggregate in the sub-floor layer provides insulation and under-floor heating can also be incorporated. If used in tandem with a breathable roof construction using cellulose fibre insulation (refer to Section 8.1.2) this will enable moisture to be managed and controlled.

Limecrete has less strength than concrete floors of the same depth and whilst it performs well under uniformly distributed loads it is not suitable for resisting highly concentrated 'point' loads. However, the addition of fibre reinforcement will improve the strength of Limecrete by 25% and if carefully designed and specified this should be sufficient to accommodate light fork-lift use.

Where high loads are required these could be accommodated within a Limecrete floor by considering:

- Concrete pads for machinery could be incorporated within a Limecrete floor. These will accommodate high concentrated loads but will not affect the overall performance of the Limecrete floor.

- Areas of concrete floors for higher loads could be used in tandem with Limecrete. If the use of concrete is restricted to defined, high traffic or 'external' spaces this will have little effect on the overall performance of the Limecrete floor.

8.2.6 Up-grading of the outer walls

For use categories such as workshops where high levels of thermal performance are less critical it will be simplest to leave the walls un-insulated and rely on their thickness and high thermal mass to provide a degree of thermal insulation.

If walls are repaired and pointed in lime mortars they will be able to breathe thereby naturally controlling moisture content within the wall.

Improving the thermal performance of the external wall by applying insulation directly to the inside face of the wall will introduce the risk of trapping rising moisture within the wall with consequent risk of damp problems becoming manifest on the inside face of the wall and should therefore be considered carefully. To avoid this, the existing wall will need to breathe and options for achieving this include:

- The provision of a ventilated zone between existing walls and new insulated inner wall panels to allow moisture within the wall to evaporate and vent without causing damage, for this to be effective the ventilation will need to be to outside air and careful detailing will be required to achieve this.

- The provision of a vertical damp proof membrane between the new insulated panel and the existing wall. This will protect the new wall and force the existing wall to breathe to its outer face. Care would need to be taken where the outer wall was below ground level and therefore may not be appropriate where this condition occurs.

8.3 Sustainable design.

The form of sheds offer opportunities that can be positively exploited in relation to achieving good levels sustainability in their adaptive re-use. These opportunities are:

- High levels of north light with limited risk of over-heating due to solar gains
- Extensive south facing roof slopes to exploit solar energy sources
- Extensive roof areas to exploit possibilities of rainwater harvesting
- The sheds are extremely adaptable to a variety of new uses with little or no adaption of the existing building layout or structure other than up-grading the fabric and the addition of new partitions and modern services.

Weaving sheds also provide opportunities for high levels of natural lighting, thereby limiting electrical lighting and the south facing slate roofs offer ideal locations for solar energy collection, either in the form of photovoltaic cells or direct solar water heating.

Key factors to consider in the design of sustainable buildings are:

- Heat Loss
- Methods of providing heating
- Efficient use of natural light / electric lighting.
- Alternative energy sources
- Rainwater harvesting
- Selection and specification of new materials

8.3.1 Minimising heat loss

The most important principle in developing sustainable design solutions is to minimise heat loss and as a consequence minimise energy use. To achieve this buildings need to be as well insulated as possible and air-tight.

With the use of high-efficiency insulation to roofs, floors and outer walls and the use of modern high-performance double glazing to the north lights detailed carefully to minimise air leakage the thermal performance of the fabric could be up-graded to meet modern standards and form the back-bone the sustainable re-use of the weaving sheds.

8.3.2 Thermal performance of roofs and gutter-beams

Weaving sheds are deep plan with a relatively low area of external wall in relation to their floor areas and therefore most heat loss will be through the roof.

The best way to achieve high thermal performance is to use high-performance ridged insulation board. There may appear to be 'greener' insulation materials available, such a natural sheep wool or recycled newspaper, however, the insulation performance of a ridged board is significantly higher and the improved thermal performance afforded by it will out-weigh the other benefits, such as lower embodied energy, offered by the 'greener' alternatives.

The rafter depth to the south facing roof slopes is nominally 140mm (5.5 inches), this is relatively small and to provide high levels of thermal insulation in line with sustainable design principles it is recommended that the depth of the structure is increased to maximise the available depth of insulation. Adding counter-battens above and below the existing rafters will be the best way of increasing insulation depth because it will enable insulation to be continued above and or below the existing rafters which will maximise thermal performance by minimising 'cold bridging' through the timber structure will have a significant effect on reducing heat losses – see figure 26. Care will need to be taken with the detailing at the gutter and ridge of the north light glazing so that the overall appearance and profile of the roof is not adversely effected.

8.3.3 Thermal performance of roof-lights

Modern timber framed double or triple glazed roof lights will offer the highest thermal performance when considering the up-grading of the north lights to meet sustainable objectives. The sealing of the roof-lights to the existing fabric to minimise air leakage will also be critical to achieving low heat loss. Modern glazing systems are inherently well sealed and given the simple linear nature of the roof light opening defined by the gutter-beam at the base of the windows and the timber ridge at the head this should be straight forward and easy to achieve an airtight seal.

8.3.4 Thermal performance of walls

To improve the thermal performance of the walls insulation would need to be applied to the inside face of the outer walls. There is no limit to the thickness of the insulation and therefore extremely high level of insulation could be achieved. Care needs to be taken to ensure that any moisture 'wicking' up the walls from the ground can permeate harmlessly to the outside air .

Consideration should also be given to locally improving the thermal efficiency of walls to suit the building use. For example, office spaces within light industrial workshops could be provided with very high levels of insulation with the remaining as workshop areas which require less heat input in line with their use provided with more modest levels of insulation.

8.3.5 Cold bridging through the structure

The cast iron gutter beams are exposed to the outside air through the gutter sole and therefore if not insulated will be a source of cold bridging, both directly through the underside of the gutter beam and via the structural connections to the column head and T-section props supporting the north light ridge. This will result in heat loss and will pose a significant condensation risk, especially in well insulated heated buildings.

The underside of gutter beams could be insulated with high-performance multi-foil insulation which will provide good levels of insulation for a minimal insulation depth and in conjunction with high performance insulated gutter linings will alleviate the effects of cold bridging through the structure.

8.3.6 Heating methods

The method of heating to a building has a significant impact on energy use, and the selection of the type of heating used needs to reflect the form and construction of the building and its function and pattern of occupation. Available forms of heating are described in Section 5.12 and include:

- Warm air heating
- High level radiant heating
- Under-floor heating
- Traditional radiators

Of these the best would be either high level gas fired radiant heating for uses such as warehousing or workshops or under-floor heating which uses low grade heat available from alternative energy sources such as solar thermal or air source heat pumps. To best meet sustainable design objectives the heating method employed should where possible be used in tandem with heat recovery systems to further minimise heat loss and energy use.

8.3.7 Alternative energy sources

Most buildings use a combination of gas and electricity, supplied from the national grid as the primary source of energy. The environmental issues relating to CO^2 emissions associated with the use of these energy sources are widely known, however, alternative energy sources with the benefit of zero carbon emission and localised energy generation could be considered for supplying weaving sheds, these include:

Solar thermal energy

Solar thermal energy is generated by heating water in solar thermal collectors mounted on the roof, or walls of the building. The heated water can then be used for heating and the hot water use.

The south facing slopes of the north light roofs of the weaving sheds make them ideally suited for the use of solar thermal energy collection. A collector will be ideally placed and orientated to maximise the sun's energy and, if mounted away from the edge of the buildings will be discrete and unseen from street level. As the technology improves and becomes more widely available pay back periods for solar thermal have improved significantly in recent years and continue to do so.

Photo-voltaic electricity

Photovoltaic systems generate electricity from solar radiation, either directly from sunlight or indirectly from an overcast sky. As with solar thermal energy the south facing slopes of the north light roofs of the weaving sheds make them ideally suited for the use of photovoltaic electricity generation. An installation of this type has been utilised in conjunction with the new-build north light roof of the National Trust Headquarters in Swindon. Systems are available as roof mounted units that can be bolted onto the existing roofs or can now be integrated into roof coverings such as zinc or profiled metal roofing systems for more discrete installations. The payback on investment depends on both the intensity of solar radiation and the pattern of energy use, ongoing developments in photovoltaic cell technology make units increasingly cheaper and more efficient leading to a shortening of payback periods.

Air source heat pumps

An air source heat pump extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can extract heat from the air even when the outside temperature is as low as minus 15 degrees C. This heat can then be used to provide heating by warming water for radiators or under-floor heating systems, or to directly warm the air in the building. There are two main types:

- An air-to-water system uses the heat to warm water. Heat pumps heat water to a lower temperature than a standard boiler system would, so they are more suitable for under-floor heating systems than radiator systems.

- An air-to-air system produces warm air which is circulated by fans to heat the building.

8.3.8 Passive solar gain

The weaving sheds have high levels of north light which benefits from having no component of south light which can cause over-heating through un-controlled solar gains. However, there will be many uses, such as housing or office accommodation that could benefit from a controlled amount of direct south light both to provide passive solar heating and also to counter the otherwise cold uniform nature of north light.

South light could be introduced to schemes through the creation of internal courtyard gardens with south facing windows or through the judicial use of roof lights on the south facing roof slopes. To limit solar gains to avoid over-heating in high summer these could be fitted with controllable blinds or louvres adjustable to allow sunlight into the building in the cooler months and to provide shade in summer.

8.3.9 Exploitation of natural lighting

The weaving sheds have the major advantage of the high levels of natural light available through the north light sections and to meet sustainable design objectives this should be exploited as fully as possible. The natural lighting is uniformly and fully distributed across the plan which allows it to be fully exploited for any new uses the sheds may be put to. The north light also has the advantage that it will generate little or no solar gain which can otherwise lead to over-heating. Where some component of south light is required to either counter the 'flat' uniform nature of north light or to generate controlled solar gains for passive heating this can be relatively easily introduced by incorporating roof lighting into the south facing roof slopes or by creating internal courtyards.

8.3.10 Efficient use of artificial lighting

Artificial lighting can account for as much as 20 percent of the total energy use in buildings. Lighting energy reductions can be made by:

Recent advancements in artificial lighting technology has lead to light sources with significantly greater output efficiencies and of these high frequency fluorescent would be the most applicable to use in weaving sheds.

Modern high frequency fluorescent lighting is almost twice as efficient as tungsten lighting and generates far less waste in the form of heat. It is available in a large range of fitting types to suite almost any application or price point, ranging from linear industrial type fittings, compact down-lights and spot lights. Modern high frequency lamps do not suffer from 'flickering', are dimmable, have excellent colour rendering and are available in a large range of colour temperatures ranging from daylight to warm 'tungsten' effect for domestic applications.

Another fast developing light source is high output LED which offers high efficiency outputs from a very compact light source. The development of LED lighting is moving apace and new fittings are being produced for commercial applications. A significant advantage is their compact size which allows them to be discretely integrated into historic buildings.

8.3.11 Lighting management systems

Modern lighting systems are available with sophisticated control systems that can significantly reduce energy use, these include:

- Daylight linking with automatic progressive switching and dimming
- Presence detection for automatic switching on and off to prevent lights being inadvertently left on
- Programmable control of switching for public buildings

8.3.12 Rainwater harvesting

Weaving sheds are characterised by their expansive roofs covering the entire floor plan that could be used for rainwater harvesting. Rainwater could be easily collected and stored and re-used in many non-drinking water uses including:

- Grey water for appliances and wcs
- Watering of gardens created as part of the buildings re-use
- Industrial processes that require water

Modern packaged harvesting systems include purpose made tanks, filtering and UV cleaning, pressurization and pumps that can be tailored to specific uses making installation and operation straightforward.

8.3.13 Sustainable design summary

The form of the weaving sheds offer opportunities that can be positively exploited in relation to achieving good levels of sustainability in their adaptive re-use. If the thermal performance of the roofs, north lights and external walls are maximised as far as possible and careful consideration is given to the type of heating, energy sources, lighting and controls then it is feasible to achieve good levels of sustainable design in their reuse, with the environmental benefits, low energy usage and building running costs that this will provide. Furthermore, it is arguable that the very act of re-use, as opposed to demolition and redevelopment, is inherently sustainable.

8.4 Fire protection

The weaving sheds will need to be up-graded to meet modern standards of fire protection, and whilst the requirements for different uses will vary the essential principals will be as follows:

8.4.1 Fire protection of the building fabric

The existing building fabric of masonry outer walls and plastered roof soffits is largely inert and will require little or no additional fire protection. Where existing timber boarded partitions are retained these may require upgrading depending on their location and function in the newly converted proposals. New elements of fabric, such as partition walls or mezzanine floors can be constructed to required standards.

8.4.2 Fire protection of the cast iron building structure

Cast iron can withstand temperatures of up to 400 deg C without its basic strength being adversely affected and when tested loaded cast iron columns to BS 476: Part 8 have achieved fire resistances of 60 minutes or more. However, due to the brittle nature of the material problems can arise when cast iron is subject to sudden temperature changes as caused by dousing in cold water by the fire brigade which can cause structural sections to crack, or even to shatter. The effect of sprinklers on cast iron structures has been questioned due to the risk of cracking, but in reality the sprinklers will extinguish the fire before sufficiently high temperatures are reached to cause thermal shock to the structure.

As the structure only holds up the roof and is likely to have sufficient integrity to provide time for occupants evacuate the building no additional fire protection may be required. However, requirements for up-grading the fire resistance of the structure will vary with each proposed new use and will depend on factors such as:

- The function of the building
- The availability of exits
- Occupancy levels and patterns of use
- Means of access for the fire brigade

8.4.3 Surface spread of flame protection

The existing building fabric primarily comprising masonry walls and plastered roof soffits will not require up-grading to meet modern surface spread of flame requirements. Existing timber boarded surface can be coated with spread of flame treatments and new fabric can be installed to meet modern standards in full.

8.4.4 Compartmentation

Where new uses require multiple-occupancy, or single floor areas are large, fire resisting separating walls will need to be installed. Care will need to be taken to ensure that fire separation is maintained where new walls abut the existing structure.

- Where new walls align along or immediately adjacent to the gutter-beams this should not be difficult to detail.

- Where new separating walls run perpendicular to the line of the gutter-beams they will need to be sealed to the underside of the south facing walls and to the north light glazing both of which will be feasible with careful detailing.

8.4.5 Means of escape

The provision of means of escape will vary considerably with the new use of the building, occupancy levels and patterns of use. The single-storey form of the sheds will make escape provision simpler than with multi-storey buildings and new exit doors can be formed in the outer walls as required. Therefore emergency escape should not be an obstacle to the re-use of the buildings.

Where the sheds abut adjoining buildings or are built into slopes and therefore make exit through these sides of the building impossible, careful planning will be required to ensure sufficient provision for means of escape can be provided elsewhere on the building perimeter, and if necessary internal fire protected routes will need to be provided.

8.5 Structural engineering

8.5.1 Properties and use of cast iron

The primary structure of the most commonly occurring weaving sheds were made from cast-iron with timber framed roofs. Cast iron began to be used structurally for columns and beams towards the end of the eighteenth century and some of the first buildings to use structural cast iron were industrial mills where it was seen to provide a fire-proof form of construction. This was especially important in textile mills where cotton fibres were handled in an oily, often candle-lit atmosphere. By the 1790s the roll-call of disasters relating to timber frame structures was such that the first steps were taken to substitute cast iron for timber, initially in columns but later in beams as well.

Cast iron is an alloy of iron and carbon with a relatively high carbon content of up to 5%. Because it is cast by pouring molten metal into a mould, and as a consequence of its high liquidity in the molten state, cast iron is well-suited to the production of components, both structural and decorative, of intricate shape. The principal properties of cast iron are:

- Cast iron has a crystalline structure and is relatively brittle and weak in tension. Sections can fracture under excessive tensile loading with little prior distortion

- Cast iron performs very well under compression loads

- Cast iron has a greater resistance to corrosion than either pure (wrought) iron or steel, under corrosion a powdery deposit forms on the surface of the metal and un-like steel or wrought iron it does not delaminate.

- Cast iron has good fire resistance.

8.5.2 Structural description and behaviour of weaving sheds

The weaving sheds were constructed using a 'standardised' system of simple cast-iron structural components, comprising slender 100mm diameter columns, 6 metre long structural gutter-beams and, bolted to these, raking cast iron T-sections supporting the timber ridge of the north light sections. The heads of columns were often tied with rods running perpendicular to the line of the gutter beams. The southern slopes of the roofs were constructed using a simple system of timber common rafters with lime plaster on lath soffits and slate roofs.

This system imposed a grid of columns throughout the plan with columns spaced 6 metres apart along the line of the gutter-beams and 3 metres apart between parallel lines of north lights, thereby creating structural column bays each measuring 3 x 6 metres (10 x 20 feet).

The 'standardised' structural system provided an economic and efficient means of providing shelter and natural north light over the large floor areas required to house the power looms with, for its time, a floor space relatively free of structure and often with minimal internal sub-divisions.

8.5.3 Function of tie rods

Many weaving sheds were constructed with iron tie rods connecting the heads of columns between rows of gutter beams. Their main function appears to have been to prevent tendency for the roof structure to slump along the line of the gutter beams. As the solid low pitched timber roofs are heavier than the steeper glazed pitches, they generate thrust which will push the gutter beams and columns out sideways. The tie rods resist the thrust imposed by the asymmetrical roof loading and limit ability of each column head to move thereby limiting potential for the gutter beams to bow outwards and in doing so slump between columns.

There may be circumstances where it is desirable to remove the tie rods to provide an unrestricted head height within the volume of the north light section. Tie rods can be removed providing an alternative method of resisting the thrust of the roofs is used and the simplest means of achieving this is to stiffen the southern sloping timber roofs by installing ply sheathing to the underside of the common rafters. The use of ply sheathing will also provide additional lateral stability to the structure as a whole.

8.5.4 Lateral Stability

The stability of the typical weaving shed structures as originally constructed are reliant on a combination of contributory factors as follows:

- The mass masonry perimeter walls provide lateral support required to prevent it collapsing sideways
- The gutter beam ends are built into the mass masonry perimeter walls which provides a degree of portal action which assists in providing lateral stability
- The column / beam head provides a small portal action, again contributing to the lateral stability.
- The continuous run of inclined timber roofs act like shear plates and form 'stiff' inclined panels which assist in stabilising the structure. Originally the structure had lath and plaster soffits to the underside with slates on battens and these would have had a minimal effect on the stiffness of the roof, as a consequence, installing sarking boards or sheathing ply will greatly increase the stiffness of the roofs.

8.5.5 Removal of parts of the structure to create open spaces within the plan

The stability of the structural frame is in large part due to the continuity of the structure and the fact that it is built into and supported by the mass masonry perimeter walls. Removal of parts of the structure will therefore compromise the stability of the structure as a whole.

Where parts of the structure are removed to create open spaces, such as gardens or courtyards, within the plan the structure will need to be stabilised around the perimeter of the new opening, this could be achieved in a number of ways as follows:

- Use of ply sheathing on roofs to increase the stiffness of the roof plane to increase their contribution to the lateral stability of the structural frame as a whole
- Where openings are formed, piers or new 'shear walls' could be designed around the edge of, or in close proximity to the openings to provide additional lateral stability
- Pairs of columns local to the new openings could be cross braced to provide additional stability.

8.5.6 Removal of columns

There may be circumstances where it is desirable to remove columns to create larger open plan spaces. The removal of columns is possible and but will require new supporting beams to pick up the load of the ends of the gutter beams over the head of the removed column. New supporting beams need to be designed carefully to limit as far as possible their deflection under load to avoid the existing gutter beam joint at the next column along being put into tension which could cause the cast iron to crack. It would be advisable to loosen bolts at this joint when installing new supporting beam and then retighten them afterwards. Issues relating to the removal of columns to create larger floor areas are discussed in 5.3.

8.5.7 Restraint of new walls or partitions

The existing gutter beams are set relatively high (3.5 metres) from the floor levels and therefore, if taken full height, the head of new internal walls or partitions will need to be laterally restrained or designed as self-supporting structures.

New internal walls could be designed as self-supporting structures by forming them with angles or curves, or they could be anchored to the existing gutter beams and roofs to provide head restraint, this could be achieved as follows:

- New walls could be secured to gutter beams via holes drilled in the flanges of the beams, this would work providing supplementary gutter lining were also used to prevent water ingress through the new fixings.

- New walls could be fixed to the flanges of the gutter beams proprietary clamp fixings. The advantage of this method is that the cast iron beams will not require drilling or adapting thereby leaving them intact.

8.5.8 Capacity of the existing gutter beams and columns to accommodate greater loads

The existing gutter beams will have some additional capacity as they will have survived high snow loads throughout their history. It is likely that the cast iron columns will have thick walls and therefore should have good load carrying capacity and the more limiting factor is likely to be the capacity of the gutter beams to accommodate greater roof loads or lateral loads imposed by new walls or partitions. The inherent strength of the beams may also have been weakened through corrosion or defective joints. The following could be used to increase the load carrying capacity of the gutter-beams:

- The provision of supplementary beams alongside or under the existing
- The provision of intermediate supports along the beam to reduce their effective spans, although care will be required to ensure that 'inverse' stresses are not introduced into the existing gutter-beams and joints.
- The provision of new structure to carry roof loads independent of the existing beams which could be left in situ.

When modifying, strengthening or provide secondary support for the existing structure although care will be required to ensure that new stresses are not introduced into the existing gutter-beams, columns and joints which could cause it to fail.

8.5.9 Assessment and surveying of the existing structure

The loading capacities of the cast iron gutter beams and columns can be readily calculated by suitably qualified and experienced Structural Engineers. It is likely that the condition of individual sheds will vary considerably and many will have been modified over time and therefore it will be important to survey the condition of the structure and in particular the degree of corrosion and integrity of existing structural connections to fully understand the load capacity and performance of the structural frame. When assessing the structure it is important to consider the following:

- An understanding of how the original structure was constructed and how it was intended to work

- An assessment of how the structure is working in its current condition as a result of modification or defects, it is especially important to understand the tensile, compressive and compound stresses within the cast iron structure

- The condition of the structure, both as a whole and of individual components, with particular attention given to vulnerable parts such as footings, connections, concealed joints and water traps.

- Bolted or riveted connections should be carefully inspected, with bolts removed to check for hidden corrosion.

- An accurate level survey can be invaluable in identifying areas where significant movement may have occurred, this will also assist in targeting parts of the structure for assessment and inspection.

Methods of surveying the structural condition of the cast iron structure include:

- Visual Inspection. To assist in identifying cracks or other defects it is recommended to blast clean off all paint to bare metal.

- Drill hole Testing. Small diameter holes can be drilled into the cast iron to determine its thickness. This is especially relevant to the hollow columns where several holes on different sides can be made to check the consistency of wall thickness around the column. As the holes are small they can easily filled and made good.

- Ultrasonic testing. Ultrasonic techniques can be applied to cast iron but does not always yield clear results, given the simple nature of the weaving shed structure visual inspection may prove more effective.

The assessment and inspection of the structure should be undertaken by suitably qualified Structural Engineer ideally with experience of cast iron structures and it is important to reach a full understanding of the structure as it now stands before alterations or repairs are proposed.

8.5.10 Structural repairs

Where it has been identified that structural repairs are required, or modifications need to be made to the structure to redistribute or accommodate increased loads the following options are available:

Leave alone – if the structure has reached a new equilibrium and the components are deemed not to be stressed beyond their capacity it is advisable not to interfere with the structure providing any deterioration of the fabric is stabilised and repairs where required are made.

Reduction in loading – Where the structure is over-stressed due to corrosion or defects reducing the load capacity of the structure, an alternative to replacing defective components could be considered, the introduction of new structure to relieve the defective components. Where the proposals for the shed involve new internal walls and partitions the new 'structure' can be carefully designed as part of new insertions to minimise their visual impact.

Revisions to the existing 'stress regime' – As cast iron structures are more likely to fail under stress loads than compression loads it may be possible to redistribute existing stresses through the introduction of tension rods or by removing structure that has been added to the original and as a consequence has complicated the distribution of loads.

Strengthening and reinforcement – Existing components that are severely corroded or damaged can be strengthened or reinforced, either in-situ or by partially dismantling the structure. Methods include:

- Additional of stiffening plates, these can be welded or bolted to the existing structure.
- Interior columns can be filled with a material of good adhesion, such as resin, providing they have not been exposed to moisture. This may not be applicable to weaving sheds to to the high probability of moisture but its use could be investigated on a case by case basis.
- In theory cast iron is suitable for strengthening using recent developments in resin bonded techniques – cast iron naturally has good compressive strength, but poor tensile strength, so it is the tensile strength that determines the strength of a beam. Bonding plates or carbon fiber to the tension zone will significantly increase the tensile strength and therefore the overall strength of the beam. There are several cases where cast iron bridges have been strengthened in this way.

Welding of cast iron – Cast iron can be welded but it takes great care and expertise and the integrity of the finished welds cannot always be guaranteed. During welding the metal becomes extremely hot and it can undergo 'thermal shock' resulting in a weakening of the material and therefore, to ensure good quality welds it is recommended that welding is carried out in workshop conditions where the material can be pre-heated before welding and gradually cooled after. Successful welding is relatively expensive and it is therefore often preferable to use cold repair methods.

Cold repair methods – Fractures to cast iron sections can be repaired through the employment of several cold repair methods which have the benefit that little or no heat is applied to the cast iron, these include:

- Strapping
- Threaded studs screwed into both sides of a fracture
- Use of dowels with ends threaded and or glued into prepared recesses
- Cold metal stitching

Dismantling and re-erection – There may be occasions that warrant the dismantling of the structure, either wholly or in part, perhaps where the existing fabric is severely corroded or where replacement sections appear necessary. Cast iron structures are not usually difficult to dismantle and re-erect and the single storey repetitive nature of the weaving shed structures should make this procedure relatively straight forward. Dismantling has the following advantages:

- A thorough understanding of the structure and its condition is gained
- The original components can be used for re-casting
- Concealed parts of the structure, such as the hidden surfaces of connections can be cleaned, repaired and bolts or rivets replaced.
- Cleaning and re-painting can also be more thoroughly undertaken.

Components should be dismantled in the reverse order to their original construction and the structure should only be dismantled as far as is necessary. Each section should be numbered to enable the structure to be reassembled exactly as originally constructed.

8.5.11 Roof loads and materials

The roof structure was designed to accommodate the load imposed by the original construction, comprising single glazed north lights, timber common rafters with lime plaster soffits and slate roof coverings. There was a slight additional loading imposed by the drive shafts and belts mounted on the beams and the roof needed to resist snow loading which could be significant given that the profile of the roofs created a series of valleys within which snow could drift and collect.

Where the fabric weaving sheds are required to be up-graded to accommodate new uses there will inevitably be a modest increase in load imposed by the up-grading of the roofs from single to double glazing and the introduction of insulation. It is un-likely that these alone will require the original structure to be strengthened (subject to a survey of its current condition).

However, where additional dead loads are added, for instance through the installation of solar panels then consideration may need to be given to using solar panels in conjunction with a lighter pressed sheet metal roof or methods of strengthening the existing structure or reducing the spans of beams to increase their load capacity.

8.5.12 Foundations / under-pinning of columns

Where new foundations or under-pinning of existing columns are required this should not be problematic. It is relatively easy to provide temporary support to the surrounding beams given the light roof loads and the works can readily be sequenced across the large plan areas of most sheds to avoid temporary propping of the entire roof area.

8.5.13 Provision of additional drainage outlets from existing gutter beams

Where it is deemed necessary to provide additional rain water outlets from the existing gutter beams the best means of doing this would be to provide new outlets through the base of gutter beams which will involve drilling through the cast iron

Holes can be formed using non-percussive drilling methods although it is important to limit the hole diameter because removing material will increase the tension forces in the remaining parts of the beam which could lead to failure.

Holes limited to 75mm would be preferable (even if this means the provision of extra outlets) and the best location would be one quarter span away from columns to reduces stress loads caused by shear at column heads and bending at mid span. The preferred method would be to provide new outlet and down-pipe in conjunction with a point of support such as a new wall although consideration should be given to avoiding compromising future flexibility with new load bearing walls which may then be difficult to move.

8.5.14 Fire performance of structural cast iron

Cast iron can withstand temperature of up to 400 deg C without its basic strength being adversely affected and when tested loaded cast iron columns to BS 476: Part 8 have achieved fire resistances of 60 minutes or more.

However, due to the brittle nature of the material problems can arise when cast iron is subject to sudden temperature changes such as caused by cold water dousing by the fire brigade which can cause structural sections to crack, or even to shatter. The effect of sprinklers on cast iron structures has been questioned due to the risk of cracking, but in reality the sprinklers will extinguish the fire before sufficiently high temperatures are reached to cause thermal shock to the structure.

The other issue effecting cast iron under the action of fire is thermal expansion. Whilst cast iron has a lower coefficient of expansion than steel it is vulnerable to distortions of the surrounding structure inducing stress cracking and failure. The relatively long lengths of the gutter beams in the weaving sheds may also expand sufficiently along their accumulative length to push out and cause distortion in the outer walls.

9.0 Financial appraisal

9.1 Financial information & analysis

Probably the most important factor in the development of the north light weaving sheds in the study area is the financial viability of their reuse and this section seeks to identify the key constraints behind financial viability in the local market and how this might be improved. In preparing this section of the report we have undertaken a survey of the local property market and discussed the current market and issues particular to the weaving sheds and related industrial buildings in the study area with a number of specialist agents. We have also obtained costs for the conservation and conversion works for typical weaving shed structures and both the costs and values quoted are current at August 2009.

We have had particular assistance from two agents in the study area who are heavily involved in the letting of commercial and industrial space, HWPetty and Trevor Dawson, and who between them have over one million sqft of pre-1900 mill and weaving shed space available for sale in the study area at the time of writing. In addition they have similar or even larger sized portfolios of both post-1900 and modern 1960-70's space available for sale and lease.

9.2 Market analysis

9.2.1 Pre-1900 mill & weaving shed market

There is significant pre-1900 space available for sale in mill and weaving shed complexes across the study area. Sales asking prices range from as much as £26-30/sqft (£280-320/sqm) for industrial space in mills and weaving sheds in good condition to as low as £11/sqft (£120/sqm) where the condition of the building is poor or the area is has a significant amount of available space on the market, such as in Nelson.

Rental levels depend on both the condition of the space and the size of the available units. Larger units of over 8-10,000 sqft (750-1000 sqm) in fair condition attract rents of only between £1.50/sqft and £2.00 sqft (£16-22/sqm) whereas smaller units in good condition attract rents of up to £3.50-4.00 sqft (£38-43/sqm).

The form of tenure also has a significant impact on rental levels with longer traditional leases achieving rentals some 30-40% below 'easy in easy out' forms of tenancy. For mill and weaving shed space converted to higher value uses such as office accommodation asking rents are as high as £11-12/sqft (£120-130/sqm); typical of these buildings is the Globe Works in Accrington or Lodge House in Burnley. In general asking sales prices and rents seem to be consistent across the study area except as where identified above.
However in the current depressed market, actual sales and rentals achieved are believed to be falling as much as some 25-30% below the levels of asking prices outlined above, a figure confirmed by the amount of space on the market and the incentives available.
This market sector is typified by north light weaving sheds with high levels of site coverage, usually 80-90% and/or adjacent multi-storey mill space with regular internal plans and relatively low ceiling heights – clear ceiling heights for both rarely more than 3.5m.

9.2.2 Post- 1900 and modern industrial space

There is a very considerable amount of modern industrial space available in the study area which strongly suggests that the problem of availability and market demand is across the industrial building sector and does not relate specifically to pre-1900 industrial buildings.

Typical asking prices for the sale of such property is in the region of £35-45/sqft (£380-480/sqm), the difference across the range being related to location relative to the motorway and main roads and the availability of secure external yard areas. With most pre-1900 industrial space being located away from motorway links and main roads and in congested urban areas it is likely that this accounts for a significant element of the difference in sales asking prices between pre and post-1900 and modern industrial space.

Asking rentals as with pre-1900 buildings depend largely on the size of unit available with larger units at between £3-3.50/sqft (£32-38/sqm) and smaller units between £3.50-6.00/sqft (£38-65/sqm). Again sales and rental levels being achieved are some 25-30% below asking prices. Lease tenure tends towards conventional fixed term longer leases rather than more flexible terms, probably due to the landlord funding arrangements rather than being a reflection of market demand.

Typically the modern industrial units available have internal working ceiling heights of more than 5.5-6.0m and have clear span portal frame structures giving complete flexibility of internal space use. Most have a section of two storey space internally providing administrative space to the main warehousing or manufacturing use but none were identified as having been converted to provide higher value space independently of their original industrial use.

9.2.3 Development site values

A survey of the comparative values of development sites in the study area reveals that there is actually little difference in site values or asking prices irrespective of if the site is cleared and the existing buildings demolished or not. For example asking prices for sites with planning permission for residential development such as Brock Street in Early, Stanley Mill in Burnley or the Trafalgar Street site in Burnley are the equivalent of £700,000 – 1,000,000 per acre whereas cleared sites such as Pollard Street in Accrington, Union Road in Oswaldtwistle or Abinger Street in Burnley are consistently being marketed at the equivalent of around £800,000/acre. All the approved residential development sites identified were either cleared or had pre-1900 industrial buildings and none were identified which had modern industrial units for which demolition was proposed.

Where planning consents have not been granted for residential use asking prices for industrial sites are lower at between £450,000 – 500,000 per acre although there are few being offered on the market at present. It is not clear from our appraisal whether sites which involve conversion of existing industrial buildings are of lower or higher value than those for where consent for demolition has been obtained although it appears that sites where existing buildings are retained have slightly lower density developments proposed.

Development sites with modern industrial and commercial buildings being marketed without any residential consent appear to vary significantly according the their location either close to town centres or to main traffic routes and motorways and the specification of the building but average site asking prices would appear to be the equivalent of £600,000 – 1,000,000 per acre.

Until the collapse in the housing market from mid-2007 the development pressure on the sites of typical pre-1900 industrial buildings whether north light weaving sheds or multi-storey mills was for their residential development. However, in the current market very few sales are being achieved and development of such sites in the near future seems unlikely which is resulting in a 'hangover' of unsold industrial buildings waiting for the development market to change.

There were no sites identified on the market for which non-residential uses were being proposed, such as leisure or commercial.

9.2.4 Summary of values

From the market information outlined above it is possible to identify clear value ranges for the different types of industrial properties available and to draw conclusions as to the values of pre-1900 industrial buildings such as weaving sheds. These conclusions are summarised on Table 1 below.

Table 1: Current Market Values and Comparative Values of Weaving Sheds & Industrial Buildings

Pre-1900 Buildings & Sites	Modern Buildings & Sites	Variation in Values
Sale Asking Prices £26-30/sqft (£280-320/sqm)	Sale Asking Prices £35-40/sqft (£380-480/sqm)	£9-10/sqft (£96-110/sqm)(approx 30%)
Rents – Larger units (10,000 sqft +) £1-2/sqft (£16-22/sqm)	Rents – Larger units (10,000sqft +) £3-3.50/sqft (£32-38/sqm)	£1.50-2.00/sqft (£16-22/sqm) (approx 100-150%)
Rents – Smaller units (under 10,000sqft) £3.50-4.00/sqft (£38-43/sqm)	Rents – Smaller units (under 10,000sqft) £4-4.50/sqft (£38-65/sqm)	£0.50-1.00/sqft (£6-11/sqm) (approx 15%)
Sites Values £700-1,000,000/acre	Site Values £600-1,000,000/acre	-

Finally, a further difficulty in assessing values is the tenancy basis under which many pre-1900 industrial buildings are let – essentially to multiple users on short tenancies with poor investment covenant. For these buildings despite surprisingly high rental income the conventional property valuations outlined above are low due to the lack of security of income. Correspondingly an owner's ability to raise funds against them as assets is also low with the banks relying on formal valuation advice rather than proven track record in terms of income.

or example; the asking price for a typical weaving shed in fairly good condition in the study area and with a floor area of between 8-10,000sqft is in the region of £210-300,000 with a probably eventual sales value of £160-225,000. However, such a weaving shed could be generating a rental income assuming 20% voids of approximately £28,000, which is equivalent to a yield on the value of 12-18% and significantly higher than most investment property yields. This anomaly in the way values and yields are considered is a constraint on the development of weaving sheds for continued industrial and other non-residential uses.

9.3 Costs & comparative development costs

The use options analysis set out in Section 7 of this report demonstrates conclusively that the simplicity of the design and planning of north light weaving sheds allows their conversion to a very wide range of different uses across all development sectors. However, although it may be possible to convert weaving sheds to a range of different uses a key issue is the comparative cost of their development and conversion compared with equivalent new build development. This section explores the issue of development viability.

9.3.1 Construction costs

Based on the 'model' weaving shed used to illustrate the use options analysis we have calculated the cost of the repairs to the main fabric assuming the weaving shed to be in poor condition. The costs are set out on Table 2. The basic specification for the 'shell' repairs is assumed to be as follows:

a. External masonry walls to have local structural repairs including any underpinning, missing or altered masonry reinstated to match original and the walls re-pointed externally in lime mortar.

b. Roofs to be stripped and secondary structure repaired as existing, new breather membranes, insulation and ceiling soffit. New slate coverings assuming no reuse of original slates. Rainwater goods renewed and gutters lined.

c. North light frames to be repaired and new toughened double glazing installed.

d. Internal cast iron structure to be repaired or replaced as existing with structure adapted by removal of alternate columns to increase internal clear span to approximately 6x6m.

e. Existing floors to be taken up and new concrete ground slabs with insulation to be laid at levels suitable for either reinstatement of stone slabs or screed for alternative finishes. The costs illustrated allow for preliminaries and a 5% contingency but exclude fees and other development costs including acquisition, interest, legal or sales costs etc.

For each main use option for the 'model' weaving shed we have identified a conversion cost to cover all other elements including internal subdivisions, services, drainage, mains connections etc – see Table 2 below. These costs have then been combined with the shell costs to give a total construction cost for the 'model' weaving shed for each use option, also set out on Table 2.

9.3.2 Table 2 : Typical weaving shed repair & construction costs

Use Option	Shell Repair Cost/sqm	Conversion Cost/Sqm	Total Cost/Sqm
Shell Repair Only	£254	O	£254
Light Industrial/Warehousing	£254	£256	£510
Studio/Workspace Centre	£254	£552	£806
Commercial Office Non-AC	£254	£536	£790
Commercial Office AC	£254	£667	£921
Private Residential	£254	£585	£839
Social Residential	£254	£530	£784
Educational – Nursery/Primary	£254	£620	£874
Educational – Secondary	£254	£686	£940
Library Resource Centre	£254	£815	£1069
Retail – Single User	£254	£680	£934
Retail – Multiple User	£254	£795	£1049
Hotel – Local Budget	£254	£804	£1058
Healthcare – GP Surgery	£254	£1065	£1319

The costs for each weaving shed use option is compared with the equivalent new build cost (sourced from current Building & BICS indices July 2009) on Table 3 below.

9.3.3 Table 3: Comparative weaving shed & new build equivalent costs

Use Option	Weaving Shed Cost/SqM	New Build Cost/SqM
Light Industrial/Warehousing	£510	£275-660
Studio/Workspace Centre	£786	£650-850
Commercial Office Non AC	£770	£750-950
Commercial Office AC	£821	£850-1000
Private Residential	£839	£750-900
Social Residential	£784	£450-750
Education – Nursery/Primary	£874	£650-1150
Education – Secondary	£940	£750-1250
Library/Resource Centre	£1069	£1300-1750
Retail – Single Tenant	£934	£1900-3000
Retail – Multiple Tenant/Outlet	£1049	£2170-3350
Hotel – Local Budget	£1058	£1250-1700
Healthcare – GP Surgery	£1319	£1100-1400
Leisure – Health Club (Dry)	£872	£800-1300

The exercise indicates that for most use options the cost of reusing a typical weaving shed should be approximately the same or slightly lower than for an equivalent new build on the basis of core construction costs. For residential options the costs of weaving shed conversions are likely to be towards the higher end of the costs for an equivalent new build due to inefficiencies in the building planning and the reduction of the extent to which repetition can reduce costs. For retail use the costs are significantly lower than equivalent new build costs.

9.3.4 Cyclical Fabric Maintenance Costs

Once the fabric of a weaving shed is brought back into good condition and assuming simple tasks such as gutter clearance are maintained the long term cyclical maintenance costs based on the fabric repair costs set out in Para 9.3.2 Table 2 are likely to be in the region of 1.5-2% of the capital costs per annum. This equates to an annual investment in maintenance of between £3.80-5.00/sqm/pa or £0.35-0.45/sqft/pa. It should therefore be possible to meet future cyclical maintenance costs even at quite modest rental levels.

9.4 Summary – viability & the constraints on development

Our analysis in earlier sections of this study demonstrates that weaving sheds are very flexible, loose fit buildings and with just a little imagination are easy to convert to a very wide range of end uses probably more so than most other building types.

The financial analysis above also illustrates that for most use options the cost of the repair and conversion of a typical pre-1900 weaving shed is broadly comparable with the cost of equivalent new build construction costs for the same use; with it being cheaper for some uses such as retail and commercial but more expensive for others such as residential.

The viability of the re-use of weaving sheds should not therefore be measured in comparison to equivalent new build costs but relative to the current market demand for any given use at a particular time. So, for example, the value for a weaving shed for residential use is related to the strength of the housing market rather than the equivalent build costs for new residential accommodation.

The key issue behind the problem of the large number of weaving shed and industrial buildings in the study area therefore relates to the strengths and weaknesses of its economic infrastructure and base, its well-being and the areas of demand in the local property and development market rather than significant inherent problems in weaving shed as a building type. This suggests that solving the problems of such buildings needs to focus on issues such as wider economic development, removal of the constraints on their development and the funding difficulties owners face.

Given these conclusions what are the issues that have to be overcome in undertaking the repair and conversion of a pre-1900 weaving shed for a new use?

10.0 Resolving the constraints to development

This study has concluded that neither the physical constraints relating to the typology of a typical weaving shed nor the cost of its repair and conversion relative to comparable new build options are the over-riding problems that need to be overcome in promoting their repair and reuse. The key constraints on development and how they might be tackled are outlined below.

10.1 Volume of buildings

There are over 160 weaving sheds in the study area alone with over two million sqft of space. Given the current economic climate in the study area it is unlikely that local regeneration efforts alone will ensure that all the weaving sheds in use are maintained in use and those that are empty and unused are brought back into use without a co-ordinated strategy and long term efforts by all the agencies active in promoting the economic development of Pennine Lancashire. Some of the initiatives and strategies that would help in developing a co-ordinated approach might be:

- Maintaining a register and data base of weaving sheds based on the gazeteer produced as part of this study and tracking their condition, owner's intentions and development potential and actively using the data base to promote the buildings and their reuse.
- Seeking to develop a cross-agency strategic approach to planning and funding of the reuse of redundant weaving sheds that prioritises, facilitates and encourages their development over replacement and new build options especially where it can be demonstrated that their conversion is practical and feasible.
- Encouraging funding agencies and their programmes adopt a co-ordinated approach to local economic regeneration through conservation and sustainable development of the existing building stock, especially those of historic interest and value, such as the weaving sheds, rather than clearance and renewal.
- Providing a longer term vehicle for the promotion of a wider understanding of the value of weaving sheds in the study area with a focus on encouraging potential building commissioning and developing agencies to consider weaving sheds as an option to be appraised for their building needs.

10.2 Individual weaving shed size, scale & fit

Most weaving sheds are substantial buildings, usually in the region of 15-18,000 sqft (1400-1650sqm) which gives a minimum cost for repairing their external fabric of £350-425,000 and hence even a small weaving shed is a substantial development project. In a weak national and local economic climate breaking down the development scale of a weaving shed project to meet the levels of available resource and reduce risk will help secure their development in the longer term. A further problem is the difference between the brief requirement for the use of a weaving shed and the space offered by the building and the economy with which a building can be converted with the consequent impact on viability. Some of the initiatives that might assist in reducing the scale and risk of weaving shed development projects might be:

- Encouraging balanced incremental development through smaller grants and initiatives targeted at phased development where the development can be progressed in line with the funding available and to retain flexibility to respond to the market demand through a longer development period.
- Promoting enveloping schemes with supporting financial assistance or planning incentives to bring the basic fabric of weaving sheds back into good condition allowing their small scale incremental development and significantly reducing development risk and the wider impact of blight.
- Encouraging owners to keep buildings occupied through soft tenancies even when they may be pursuing larger development objectives to ensure deterioration is checked, use is encouraged and income is maintained.
- Establishing a development trust for the study area focussed on assisting owners in developing their weaving shed and industrial buildings and to undertake the direct development of a number of weaving sheds as exemplars to other owners.
- Encourage funding and grant agencies, planning authorities to be flexible on proposals for partial re-use of buildings to overcome the problems of fit between the use and the space and to encourage balanced incremental development to assist with problems of fit as well as risk, funding availability and other problems.

10.3 Funding access & availability

The availability of funding at an affordable cost for the development of weaving sheds is limited and particularly because conventional funding sources like easily quantifiable low risk options which new build solutions offer more readily. Some grant schemes are available particularly through the regional development agency but they are complex, often focussed on other objectives such as employment and the application process can by labyrinthine and time consuming. Supplementing funding for development through grants, loans or loan guarantees could provide significant encouragement for the development of weaving sheds. Some of the initiatives which might help improve funding for owners might include:

- Providing a co-ordinated information service perhaps in association with other initiatives, such as a development trust, advising owners of the sources of grant aid available and how to apply.
- Reviewing with the funding agencies how existing grant programmes might be tuned or extended and new targeted funding schemes established to provide easy access grants or loans and loan guarantees towards weaving shed owners.
- Seeking to establish a grant fund for the initiation of balanced incremental development schemes for weaving sheds and for repair and enveloping schemes and which are accessible for both private sector and third sector building owners. For example THI schemes and their successors which enable private owners to access grant agencies such as the Heritage Lottery Fund through a co-ordinated area scheme.
- Assisting in providing information in support of owners seeking to access bank funding and loan guarantee schemes.
- Lobbying central government and relevant agencies on issues such as imposition of Council Tax on empty buildings, VAT, and tax relief on investment in weaving sheds and similar historic industrial buildings.

10.4 Planning constraints

Most weaving sheds are located in sensitive and constrained urban sites and have very high levels of site coverage, limited parking and difficult access. Local authorities in the study area are concerned to encourage the development of weaving sheds and are aware that local planning policies can be a constraint on their development. Local plan policies could also be adopted which discourage speculative applications for development of weaving sheds for high value market led uses which has led over the past few years to high levels of vacancy and consequent deterioration. The area where LDF policies might be adapted could include:

- Discouraging new build development where there are local options for the reuse of weaving sheds which are feasible and financially viable.
- Flexibility on zoning of uses to establish a precedent for reuse of weaving sheds.
- Flexibility on parking and other requirements where these are difficult to comply with on weaving shed sites or where they have a significant impact on either feasibility or viability.
- Permitting higher levels of development and densities where a weaving shed is to be retained rather than demolished.
- Conditioning applications involving speculative development to impose stricter timescales than normal on commencement and completion to limit speculative development applications not backed by development resources and long term vacancy and dereliction.
- Providing a co-ordinated ‘design guide’ based on the information in this study which assists owners in achieving viable solutions which will comply with LDF policies.

10.5 Location, access & parking

The most significant factor identified in our market research which affected value was the proximity of buildings and sites to the motorway and trunk road networks and the ease of access to them. This was followed by constricted access and lack of parking. There are a number of initiatives that can help mitigate these problems as follows:

- Reviewing local infrastructure plans to identify highway, access and other traffic improvements which will assist in improving access, prioritising access improvements to groups of weaving sheds co-located on adjacent sites.
- Reviewing options for local authorities to assist in acquisition of land for access improvements to assist weaving shed developments.
- Reviewing options for the provision of area parking sites to service groups of weaving sheds where individual owners are unable to make adequate provision on an individual basis.
- Exploring options for better signage to key groups of weaving sheds and important or key individual sheds.
- Review the possible relaxation of parking requirements and normal highway and access standards in situations where their imposition prejudices viability.

10.6 Changing the perception of weaving sheds and creating a 'vision'

The lack of vision amongst owners, developers and others about what can be achieved is perhaps as important a constraint as all the problems outlined above and changing the vision of what weaving sheds are, from one where they are seen as redundant, poorly built buildings that have no future to one which sees them as an opportunity for exciting, viable and sustainable developments that can provide interesting and enjoyable spaces within which to live, work and relax, is fundamental to achieving a significant improvement in the retention and development of the study area's stock of weaving shed and other industrial buildings. The 'vision' for weaving sheds can be improved by;

- Wide publication of this report, supporting exhibitions and easily accessible information through electronic and printed media.
- Completing some exemplar projects to demonstrate the potential for other conversions and their viability.
- Encouraging local museums, amenity societies and educational institutions from schools to colleges to explore the history of their local buildings and the contribution they have made to society and the community of the area.
- Establishing an accessible local resource of material on weaving sheds including visual, written and oral archives, historical records and other information.
- Holding workshops for owners on the issues highlighted in this study and the potential for the reuse of weaving sheds.
- A co-ordinated approach by the local authorities in the study area to the development of policies, the support of owners and the encouragement of weaving shed development.

11.0 Recommendations

Given the wide potential for the reuse of weaving sheds and the broad equivalence of their conversion costs with new build costs demonstrated by this report and taking into account the constraints on their development, it is our opinion and recommendation that the stakeholders undertake the following:

11.1.1 **Recommendation 1**
Identify key typical weaving sheds from the gazetteer for consideration for listing.

11.1.2 **Recommendation 2**
Review conservation area designations with a view to inclusion of more weaving sheds within conservation areas, where appropriate

11.1.3 **Recommendation 3**
Establish a 'schedule' of acceptable changes and alterations to weaving sheds such as removal of sections of roof to create external spaces, roof covering materials, rooflight upgrading and similar works to give owners and their agents clarity as to the extent that alterations are feasible and likely to be acceptable in planning terms – a design guide.

11.1.4 **Recommendation 4**
Review options for an administered grant scheme targeted at weaving sheds and industrial buildings for assisting towards owner led options appraisals and feasibility studies, funding incremental conversion start-up schemes and bridging viability gap where fit between use and available space is marginal – contributors should include the Pennine Lancashire local authorities, Regional Development Agency and English Heritage.

11.1.5 **Recommendation 5**
Establish and provide support to a development trust, or similar existing third sector agency willing to become engaged, with the remit of promoting and advancing the development of weaving sheds, completing exemplar projects, supporting owners and holding an accessible resource of material, information and expertise on the development of weaving sheds.

11.1.6 **Recommendation 6**
Maintain an ongoing review of the buildings listed on the gazetteer and establish contacts with all owners to offer advice and assistance and to ensure early warning of intention to dispose of, demolish or repair and convert is obtained along with information on current uses and condition and any key changes in circumstances. The gazetteer should be used in pro-active management of the stock of weaving sheds.

11.1.7 **Recommendation 7**
Seek to ensure the process for all public sector procurement for construction works for any new uses and new projects within the study area include for exploring the feasibility of reusing weaving sheds in the locality with conservation officers or appropriate staff acting as 'brokers' between potential users and owners.

11.1.8 **Recommendation 8**
Review the potential for public sector led infrastructure works, particularly with respect to access to sites and vehicle parking, to encourage and improve the feasibility and viability of weaving shed reuse and conversion – based on the concept that investment in infrastructure is returned through increased local tax revenue and employment and environmental benefits.

11.1.9 **Recommendation 9**
Review local plan policies/emerging LDF policies within Pennine Lancashire local authorities to identify which policies can be interpreted with flexibility to encourage weaving shed reuse and development.

11.1.10 **Recommendation 10**
Encourage local understanding of the significance of the weaving sheds to the local area through exhibitions, displays and information in converted weaving sheds (eg Oswaldtwistle) and other suitable mechanisms – possibly grant aided through Recommendation 4 provisions.

11.2 **Next Steps – Weaving Shed Forum**

A forum for the implementation of these recommendations needs to be maintained and should consist of representatives of the organisations which have contributed to the commissioning of this report. The forum should seek to agree the recommendations and determine the appropriate route for their inclusion in relevant LDF's, conservation, economic development and other local and regional policies.

Making the information included in this study available to a wide audience should be progressed by the forum on agreement of the recommendations.

12.0 Summary

The weaving sheds of the Pennine Lancashire are an integral part of its landscape and the fabric of its towns. The decline of the manufacturing economy in the region and changing requirements for industrial spaces has left a surplus of unused industrial buildings and many vacant and empty weaving sheds. The loss of these buildings will have a significant impact on the identity of this area and its cultural, social and community life and in the longer term its economic strength.

As a building type this study illustrates the wide range of uses to which weaving sheds can be put and the feasibility of their conversion. It also demonstrates that such development should be as viable as new build development for the same use.

There are already many good examples of how similar buildings have been effectively converted and reused in a viable and sustainable way and provide a demonstration of how the constraints can be resolved. This precedent should be used to help local owners consider a wider range of development options.

The local authorities and regional and national agencies active in Pennine Lancashire can do much to help remove and mitigate these constraints and provide encouragement and support to weaving shed owners. They should do so through maintaining a forum to promote and support the development of weaving sheds, considering undertaking some exemplar schemes through a development trust or other local third sector conservation agency, possibly working with interested owners, and through implementing changes to LDF and other relevant economic and planning policies.

With enthusiasm and commitment from those involved in the care of the historic environment, our economic development and our community life and the encouragement and support of their owners this study has concluded that there is no reason why the unique weaving sheds of the Pennines Lancashire should not have a bright and productive future.

Purcell Miller Tritton LLP　　　　January 2010

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