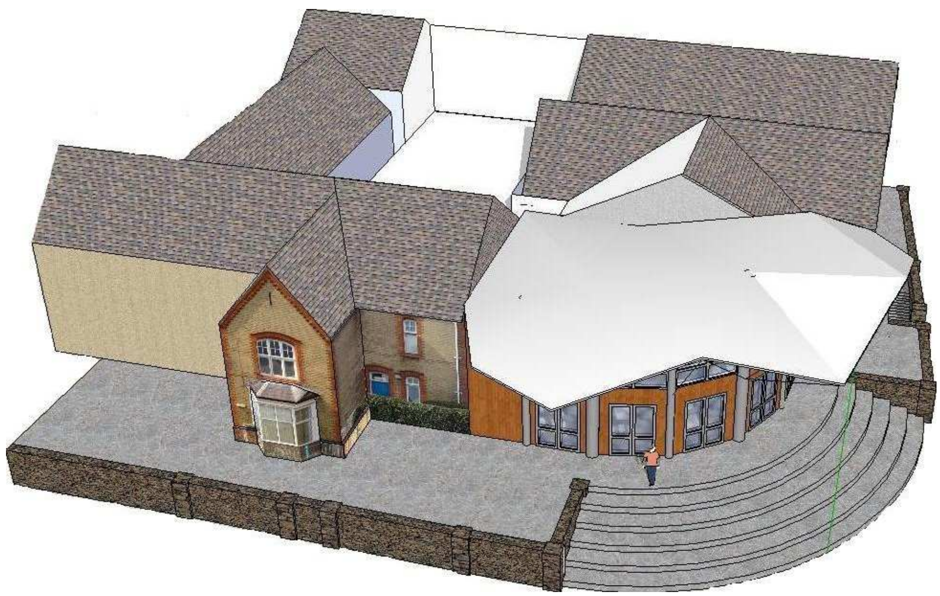
Investigation Report for the Requirements and Options Available for the Superstructure of a Proposed Building.



Performing Arts Centre at Gipsy Lane, Bishops Hull, Taunton.

Contents;

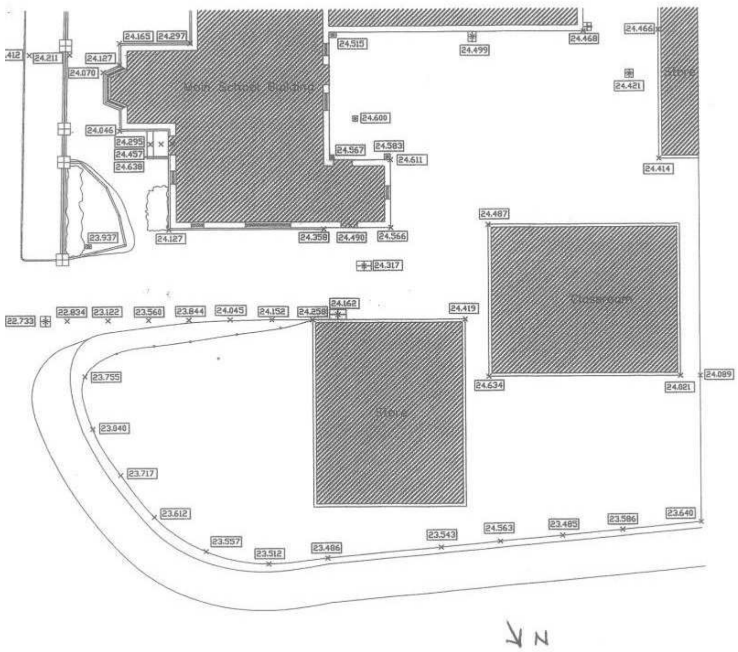
Summary of Requirement of Report;

The aim of this report is to analyse the superstru cture requirements at the proposed Performing Arts Centre in Bishops Hull, Taunton.

For each building element the report will consider the functional requirements and performance specifications. From this analysis, potential building solutions will be determined and compared. Subsequently a particular technology will be proposed for the construction of each element.

Analysis of Site;

The site itself is situated in a residential development in Gipsy Lane, Bishops Hull in Taunton and is the site of an old Victorian School shown in red on the site location plan below;



Project:
Bishops Hull

Description
Site Plan & Levels

Date: Nov 07	Scale: 1:200	Jason Keswick Somerset College of Arts and Technology 190938
Drn by: JK	Drg No: SCAT/BH/exg02	
Chkd by JK		

The levels shown on the site plan above clearly illustrate that the site is fairly level and from previous soil reports undertaken by an external consultant it is known that the soil is Type 4.

Building Proposal;

The proposed structure for the PAC is a 2 storey height auditorium with store and access area, the cantilevered atrium at the entrance, a single storey office building and performer facilities with single storey corridor connecting to the old school building and original structure itself.

The floor plan attached below , has been annotated to reflect these separate areas.

Building Elements;

The separate elements to be considered for this report are as follows;

- Superstructure (load distribution structure).
- External Envelope (load bearing or non -load bearing).
- Internal Finishes.
- Roof Structure

For each of these building elements the report will di scuss the functional requirements, Buildability requirements, various options available to satisfy the requirements, a comparison of these options and eventual decision based upon this comparison.

Single Storey link from original building to new construction

Single Storey

Two Storey

Purpose made cantilevered atrium

Investigation Report for the Requirements and Opti ons Available for the Superstructure of a Proposed Building.

As the introduction explained the following building elements will now be discussed in depth consequently delivering a conclusion as to the preferred method of construction.

- Superstructure (load distribution structure).
- External Envelope (load bearing or non -load bearing).
- Internal Finishes.
- Roof Structure

Superstructure;

The functional requirements of the superstructure are such that it needs to have the strength to maintain the loads impose d on it, for example; able to support the roof and maintain stability. It should be durable, fire resistant and far as reasonable considering its proximity to other buildings and preferably affordable and sustainably sourced or recyclable.

The performance specifications required to meet these functional requirements with regards the loading capabilities of the Superstructure can be seen in Approved Document A and Approved Document B of the Building Regulations which cite;

A1. (1) "The building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to th e ground;

- *Safely; and*
- *Without causing such deflection or deformation of any part of the building, or such movement of the ground, as will impair the stability of any part of another building"*

Making reference to the f ollowing British Standards for Loadings;

Dead and Imposed Loads; BS 6399 -1:1996 Loading for Buildings. Code of practice for dead and imposed loads. Wind Loads; BS 6399 -2:1997 Loadings for Buildings. Code of prac tice for wind loads. Imposed Roof Loads; BS 6399-3:1998 Loadings for Buildings. Code of practice for imposed roof loads.

And;

B3. (1) "The building shall be designed and constructed so that, in the event of a fire, its stability will be maintained for a reasonable period.
(2) A wall common to two or more buildings shall be designed so that it adequately resists the spread of fire between those buildings.
(3) Where reasonably necessary to inhibit the spread of fire within the building, measures shall be taken, to an extent appropriate to the size and intended use of the building, comprising either or both of the following;

- *Sub-division of the building with fire resistant construction.*
- *Installation of suitable automatic fire suppression systems.*

(4) The building shall be designed and constructed so that unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited."

The functional requirements of the superstructure and its subsequent performance criteria could potentially be achieved with the following solutions;

- Framed Structure
- Load Bearing Walls

Framed Structures;

These consist of skeletal frames;

Figure i

Figure ii

Figure iii

Portal frames;

Figure iv

Figure v

And Panel frames;

Figure vi

Load Bearing Walls;

Usually consisting of block and brick or solid pre-cast concrete and a traditional method of construction;

Figure vii

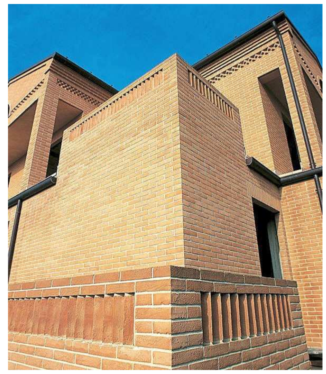


Figure viii

Comparison of Options - Materials characteristics and properties;

By comparing the types of materials which can be used ; such as timber, steel, block and brick and reinforced concrete; and each type of frame or wall in turn a conclusion may be reached as to the preferred method of construction technique.

Timber and steel are the most commonly utilised materials in structural frames. However, reinforced concrete is becoming a very popular modern method of construction as well. Regarding traditional construction brick and block methods are most usually utilised. The table, in document 2.2 figure i, and below shows the comparison of the materials in the form of timber, concrete, steel and brick to give quantitative figures for the following aspects; strength, elasticity, density, porosity, water absorption, moisture movement, thermal transmittance, electrical conductivity, durability, workability and melting points for each material.

	Concrete		Steel		Timber		Brick	
	Tensile	**Compressive**	**Tensile**	**Compressive**	**Tensile**	**Compressive**	**Tensile**	**Compressive**
Strength	1.38N/mm^2	6.90N/mm^2	695.00N/mm^2	927.00N/mm^2	9.65N/mm^2	31.00N/mm^2	5.52N/mm^2	15.90N/mm^2
Elasticity	28'600^{2}N/mm^2		207'000N/mm^2		18'600N/mm^2		8000^{3}N/mm^2	
Density	2300 kg/m3		7850 kg/m3		500 kg/m3		2000 kg/m3	
Porosity (%) & Water Absorption (%)	5.5-14.2% / 0%		Non-porous / 0%		Treated Timber non-porous / 0%		48.9% / 22-37%	
Moisture Movement	0.02-0.08%		N/A		2.10%		0.02-0.08%	
Thermal Transmittance (U-Value)	0.22W/m^2K		0.65W/m^2K		0.30W/m^2K		0.41W/m^2K	
Electrical Conductivity	N/A		1.611 to 7.496 × 10-7 Ωm		N/A		N/A	
Durability	Dependent on Water / cement ratio - Approx 100yrs		Approx. 200 yrs		Approx. 300 yrs		Generally unaffected by most soild or other building materials	
Workability	Once set not very workable at all, although lots of things can be achieved before this stage		Easily alloyed and produce strong bonds - very workable		Strong joints achieved with adhesive andf easily worked with hands or tools		Once in place and mortar set this is not at all workable, however, like concrete, lots of things can be achieved before this stage.	
Melting Point	N/A		1900°C		N/A		N/A	

Figure ix

From figure ix, it can be clearly discerned that steel is the strongest, most durable, workable and dense however, it also has an electrical conductivity level and melting point to take into consideration.

The functional requirements of the construction insist that it must be strong, durable and flexible yet remain resistant to moisture movement and water absorption, due to the size in height of the main structure a skeletal frame is the most viable choice. Regarding material choices; steel would consider all of these aspects but with regards fire resistance would have to be treated (galvanised) to withstand and meet the guidelines in the Building Regulations.

Comparison of Options - Materials limitations;

The table in document 2.2 figure ii, shows the material s in the form of timber, concrete, steel and brick to give comparative information for the following aspects; corrosion, fungal attack, insect attack, frost attack, sulphate attack, efflorescence. Ultraviolet degradation and water attack (rising damp, wate r penetration) for each material.

It can be discerned from this comparison table that Steel is the strongest performing for each of the properties and limitations of the materials discussed. By using a steel frame, the superstructure will perform well in strength, density, non-porosity and elasticity and from sustainability point of view will be recyclable at the end of the building lifecycle due to its durability.

From a Buildability perspective, ease of use regards manoeuvrability, rapid construction and, relatively, cost is without question when comparing to reinforced concrete or a traditional load bearing brick and block wall. A Timber frame would also achieve this but is less successful as a material due to its susceptibility to fungal, frost, water and insect attack.

<u>External Envelope;</u>

As the external envelope is not actually part of the structure it does not carry any loads. The functional requirements of the external envelope for this type of structure, therefore, are such that it needs to have thermal and sound insulation, give enough natural light, provide security and privacy, be durable, prevent against water absorption and rising damp, be non -combustible, sustainably sourced, stable, prevent vapour movement, provide adequate ventilation, giv e little in the way of thermal or structural movement due to diurnal expansion and contraction and be affordable.

The performance specifications required to meet these functional requirements can be seen in Approved Document C of the Building Regulations, regards water absorption, which cite;

> *As well as giving protection against moisture from the ground, an external wall should give protection against precipitation. This protection can be given by a solid wall of sufficient thickness, or by cavity wall, or by impervious or weather resistant cladding.*

Making reference to the following British Standards;

BS 8104:1992 Code of Practice for assessing exposure of walls to wind driven rain; BS 5628-3:2001 Code of practice for use of masonry. Materials and components, design and workmanship; BS EN 998 -2: 2003 Specification for mortar for masonry. Masonry mortar; BS 5626: 1991 Code of practice for external renderings.

Approved Document E of the Building Regulations, regarding Resistance of the passage of sound will give guidance as to materials likely to enhance sound insulation.

Approved Document F, regards Ventilation states;

F1. There shall be adequate means of ventilation provided for people in the building.

Making the following references for Educational Structures such as the Performing Arts Centre;

Ventilation provisions in schools can be made in accordance with the guidance in DfES Building Bulletin 101, Ventilation of School Buildings (see http://www.teachernet.gov.uk/iaq) and in the education (School Premises) Regulations. Building Bulletin 101 can also be used as a guide to the ventilation required in other educational buildings….

Approved Document N; Glazing - safety in relation to impact, opening and cleaning states;

***Protection Against Impact; N1**. Glazing, with which people are likely to come into contact whilst moving in or about the building shall;*

If broken on impact, break in a way which is unlikely to cause injury; or
resist impact without breaking; or
be shielded or protected from impact.

***Manifestation of Glazing; N2**. Transparent glazing, with which people are likely to come into contact whilst moving in or about the building, shall incorporate features which make i apparent.*

Making reference to the following British Standards;

BS 6206:1981 Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings. BS 8213-1:1991 Windows, doors and roof lights.

Comparison of Options Available;

There are four basic systems of enclosing a framed structure; facings, infill, cladding and curtain walling. Due to the requirements of the building as a Performing Arts Centre a cladding system has been given further consideration.
Facings;

The fascia is applied to a solid background on the frame of the superstructure, in this case the steel skeletal frame. The background in this instance needs to be stru ctural to support the facing and needs to ensure it is weather proof before erection.

Infill;

This system fills in the gaps in with panels or masonry. The system needs to allow for movement and be structural stable. With regards to weather proofing this system it requires a cavity to do this. Infill systems are labour intensive which may prove difficult on the type of site the Centre is being constructed on.

Cladding;

This system is designed to fix to the frame in panels. There are many different options of materials available when using this type of external envelope system. The system can be weather proofed very quickly and already allow wind deflection and thermal movement.

Curtain Walling;

This system is similar to the above cladding in that it is made up of panels and can be manufactured off-site to include all windows and doors already in situ. As above they already allow wind deflection and thermal movement. They are very quick to erect and are fairly cost effective.

Comparison of Systems and Final Choice;

Having assessed the above information a cladding system would be the most sensible choice for the external envelope. The system is quick to install, is fairly cost effective, is designed with wind loads and thermal movement in mind and allows the greatest flexibility of the internal space. The fascia would be masonry in keeping with the original school building as requested in the design.

Internal Finishes;

Functional Requirements;

The functional requirements of the internal finishes are su ch that it needs to be able to control light reflection, provide privacy and sound & thermal insulation.

Performance Requirements;

The performance requirements can be found in Approved Documents B and E as cited below;

B3 (I) *The building shall be designed and constructed so that in the event of fire, its stability will be maintained for a reasonable period.*
(2) *A wall common to two or more buildings shall be designed and constructed so that it resists the spread of fire between those buildings*

E 1 *Dwelling-houses, flats and rooms for residential purposes shall be designed and constructed in such a way that they provide reasonable resistance to sound from other parts of the same building and from adjoining buildings.*

Protection against sound within a dwelling -house;
E2 *Dwelling-houses, flats and rooms for residential purposes shall be designed and constructed in such a way that;*
(a) *internal walls between a bedroom or a room containing a water closet, and other rooms; and*
(b) *internal floors provide reasonable resistance to sound.*

Reverberation in common internal parts of buildings containing Bats or rooms for residential purposes
E3 *The common internal parts of buildings which contain flats or rooms for residential purposes shall be designed and constructed in such a way as to prevent more reverberation around the common parts than is reasonable.*

Acoustic conditions in schools
E4 (I) *Each room or other space in a school building shall be designed and constructed in such a way that it has the acoustic conditions and the insulation against disturbance by noise appropriate to its intended use.*
(2) *For the purposes of this part - 'school' has the same meaning as in section 4 of the Education Act 1966 and 'school building' means any building forming a school or part of a school.*

Options Available;

Many options are available for the internal finishes of a building, such as partition walls or masonry load bearing walls. The cladding on a partition wall in the atrium or auditorium areas as opposed to the office space would have to be given careful consideration due to the spaces differing functional requirements. The auditorium for example requires much more sound insulation than, say, the office or corridors.

In using a cladding system, insulation may be used in the cavity to provide further sound and heat insulation which makes this one of the more sensible choices for the internal finishes. Different materials may be used to clad, such a wood or drylining. Wood would give a more aesthetically pleasing, modern finish. The cladding system provides not only the cavity for insulations but also the space for services which would usually have to be boxed in should another finish be decided upon.

Roof Structure;

The functional requirement of the roof structure are such that it needs to be weather tight, support loads, allow adequate drain off of water, provide security and protection from weather.

The performance specifications required to meet these functional requirements can be seen in Approved Document A, B, C. F and H which cite;

> ***A1. (1)*** *"The building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground;*
> - *Safely; and*
> - *Without causing such deflection or deformation of any part of the building, or such movement of the ground, as will impair the stability of any part of another building"*
>
> ***B3 (1)*** *the building shall be designed and constructed so that in the event of fire, its stability will be maintained for a reasonable peri od.*
>
> ***C4*** *the roof of the building shall resist the passage of moisture to the inside of the building.*
>
> ***F2*** *Adequate provision shall be made to prevent excessive condensation.*
> ***(a)*** *In a roof; or*
> ***(b)*** *In a roof void above an insulated ceiling*
>
> ***H3 (1)*** *Adequate provision shall be made for rainwater to be carried from the roof of the building.*

Due to the potenti al of inclement weather, the roof needs to be constructed quickly but with minimal risk to health. The Auditorium area is two storey height so a particular method must be chosen so that the roof can be constructed quickly crating the least risk to health a nd safety. This may be achieved by making use of Mobile Elevated Working Platforms and scaffolding.

The systems available for the roof system are a pitched trusses, cut -pitched roof, structural panels or a flat roof with false exterior.

The pitched trusses are manufactured off -site usually from timber or steel, and brought to site ready for putting in place. This makes the installation very quick from the delivery time to site and would be a good solution, however, because of the roof space being filled with bracing as is a requirement of this type of system useful space would be lost which may otherwise have been utilised for alternative heating systems or water storage.

The void would be usable however, if a cut pitched roof system were implemented. This would take more time though. The purlins required to carry the load of the rafters can be made from timber, steel or laminated timber (Glulam) which has very good sound insulation properties.

Figure x

Figure xi

The Structural Panels on the roof are the same as the Structural Panels as in walls; manufactured off-site and installed with very little requirement of operatives spending excessive amounts of time at height. It is stable and can be constructed very quickly once delivered to site.

The flat roof is constructed in this way also, but covered with a waterproof membrane and sealed with the false pitched exterior placed at the end. This provides a fast, safe option with the potential to use the interior of the roof sp ace as mentioned in the paragraph above. From a sustainability perspective the systems which are manufactured off-site provide less waste.

After consideration a flat roof with false pitched exterior would be a sensible option for the Performing Arts Centr e using a timber structural panel solution.

Comparison of materials;

Due to the type of frame chosen it is more feasible to choose a timber frame roof structure. This is a cheaper and more sustainable material and will be quicker to fabricate off-site from a Buildability perspective and manoeuvre onto site.

<u>Service Requirements;</u>

The building itself with have a number of requirements specific to its needs as a learning and performing centre. The table below gives an overview of the service provision, the regulatory control and relevant governing legislation, the design applications of each system and where this information was obtained and further useful sources.

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
Cold Water Supply and distribution	Water Authority Water Byelaws • BS 6700 1997 'Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their cartilages': and BSEN 806, together with • SI 1999/1148 Water Supply (Water fittings) Regulations 1999, relevant statutory regulations, local byelaws, and other relevant British Standards. The requirement for a water supply company to supply water to a property, other than for domestic purposes, is covered by the Water Act 1989, section 46	Primarily, for the supply of cold water for drinking. May be used for foul (toilet flushing etc) Main design specification is the prevention of contamination in the form of back siphoning and legionnaires disease.	• BS 6700: 1997 'Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages' • BSEN 806 'Specifications for installations inside buildings conveying water for human consumption' Part 1: 2000 'General', Part 2: 2005 'Design' • CIBSE Guide G 'Public health engineering' 2004 • CIBSE TM13 'Minimising the risk of legionnaires' disease' 2002 • HSE Legal series L8 'Legionnaires disease - the control of legionella bacteria in water systems - approved code of practice and guidance' 2004 • SI 2000/2531 'Building Regulations, England and Wales' (or national equivalents) • SI 1999/1148 'Water supply, water fittings, regulations' (as amended) **For details/drawings See** • **'Hot and cold water supply' from BSI by R Garrett' for diagrams and details – Available as a PDF in 'T' Drive** • **'Building Services and Equipment ' Vol 1 by Fred Hall - available in the ILC**
Hot water supply	Water Authority	Domestic hot water systems are designed to deliver water to take-off points at a temperature of not less than 500C and not exceeding 600C. However, temperatures of hot water supply in specialist applications may change due to the nature of the occupants. For example, in healthcare premises	• BS 6700: 1997 'Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages'

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		the outlet temperature must be limited to avoid the risk of harm to the patients, but without increasing the chances of contracting legionella by a high risk group. This is generally achieved by distributing the water above 500C, but then blending down the water locally to the required temperature (430C). Check any particular requirements or design standards that the client/end user may have. Health Authorities have an extensive list of their own publications to which their facilities must be designed, as does the nuclear industry. All hot water services systems, including hot water storage and heat source capacities, should be designed and installed in accordance with BS 6700 together with CIBSE Guide G 'Public health engineering', SI 1999/1148 'Water supply, water fittings, regulations', relevant statutory regulations, local byelaws, and other relevant British Standards.	• BS 7206: 1990 'Specification for unvented hot water storage units and packages' • BRE Report 125 'Unvented domestic hot water systems' 1988 • BRE Report 309 'Potential health risks associated with expansion vessels in hot water installations' • CIBSE Guide G 'Public health engineering' 2004 • CIBSE TM13 'Minimising the risk of legionnaires' disease' 2002 • HSE Legal Series L8 'Legionnaires disease - the control of legionella bacteria in water systems - approved code of practice and guidance' 2004 • ODPM Building Regulations Approved Documents L1 and L2, 2002 (or national equivalents) • SI 2000/2531 'Building Regulations, England and Wales' (or national equivalents) • SI 1999/1148 'Water supply, water fittings, regulations' (as amended) • Water Act 1989
Below Ground Drainage	Water Authority	The below-ground drainage system should comprise the minimum pipework necessary to carry foul water away from a building in an effective and healthy manner. See Build Regs for details http://www.odpm.gov.uk/index.asp?id=1130645#P136_12203 It is necessary to ensure that the sewage system is adequately protected against the emission of noxious fumes and the introduction of explosive mixtures. All sanitary appliances should be fitted with an adequate water seal to prevent fumes from the drainage system entering the building. The fumes in foul water systems contain many chemicals, which can result in a potentially lethal mixture when combined. Typical chemicals found include: • Hydrogen sulphide • Carbon monoxide • Carbon dioxide • Methane Check that the calculated effluent outflow can be accommodated without the possibility of the drainage system flooding as a result of sewer surcharge. Details on calculation methods for below-ground drainage are contained in BRE Good Building Guide 38 'Disposing of rainwater', and the CIBSE Guide G 'Public health engineering'. The surface water flow component can be calculated in accordance with BS EN 12056 'Gravity drainage systems inside buildings'	• BS EN 752: 1996 'Drain and sewer systems outside buildings' Parts 1-7 • BS EN 12056: 2000 'Gravity drainage systems inside buildings' Parts 1-5 • BRE Good Building Guide 38 'Disposing of rainwater' 2000 • CIBSE Guide G 'Public health engineering' 2004 • NHBC Standard 5.3 'Drainage below ground' 1999 • ODPM Approved Document H 'Drainage and waste disposal' 2002 (or national equivalents) • SI 2000/2531 'Building Regulations, England and Wales' • http://www.marleyplumbinganddrainage.com/u_uk_euro_stds.asp Design Guide http://www.marleyplumbinganddrainage.com/u_design.asp Technical product guide http://www.hunterplastics.co.uk/underground/drain/default.html http://www.marleyplumbinganddrainage.com/u_install_pl.asp#

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
Sewage disposal	Water Authority	Three basic methods of sewage disposal are available: septic tanks, cesspools and package sewage treatment plants.. **Septic Tanks** A septic tank system consists of the tank itself and a drainage field. Raw sewage is fed to the tank, and settled sewage is discharged to the drainage field. Sludge accumulates at the bottom of the tank and has to be removed periodically. The drainage field typically consists of either a soakaway or a system of sub-surface irrigation pipes which allow the effluent from the tank to percolate into the surrounding soil. Due to the poor soil porosity in the north of the District this system is not usually suitable. A "Percolation Test" must be undertaken in all cases to determine the length of distribution drain required. Despite the simplicity of operation and maintenance, it is generally recognised that proper care is rarely given to septic tanks. This is believed to be due to the costs of desludging and lack of knowledge of maintenance requirements. http://www.klargester.com/pdf/TDS0006-5OperationofKlargesterSepticTanks.pdf **Cesspools** A cesspool is a watertight tank, installed underground, for the storage of sewage. No treatment is involved. Cesspool capacity is specified in terms of 45 days holding time, with a minimum capacity of 18m3. The cesspool should be sited at least 15m from habitable dwellings, and preferably downslope and downwind. http://www.klargester.com/CAD/pdf/Foul%20Tanks/DS0552-04_2800-4600ltr_Septic_&_Cesspool_Installation_Detail.pdf **Package Sewage Treatment Plants** Modern package plants are compact and those using the activated sludge process produce less sludge than other methods. Primary settlement can also be eliminated and secondary sludge can be stored aerobically for long periods with negligible odour. These advantages over septic tanks and cesspools come at extra cost: initial outlay and maintenance costs are higher and power is required to operate the tanks. http://www.klargester.com/download.htm#treatment_systems As the discharge is of a higher quality it is usually piped direct to a watercourse. This will generally require the consent of the Environment Agency before any work is undertaken. This method of disposal is often the only option available in areas with clay subsoil as soil porosity is not a concern.	• BS EN 752 Parts 1-7: 1996-1998 'Drain and sewer systems outside buildings' • BS EN 12056-2: 2000 'Gravity drainage systems inside buildings - sanitary pipework, layout and calculation' • BRE IP 2005/5 'Self-dealing waste valves for domestic use – an assessment' 2005 • CIBSE Guide G 'Public health engineering' 2004 • ODPM Approved Document H 'Drainage and waste disposal' 2002 (or national equivalents) • SI 2000/2531 'Building Regulations, England and Wales' http://www.klargester.com/download.htm http://www.netregs.gov.uk/commondata/105385/ppg4_126916.pdf http://www.johnstonsmith.co.uk/facts.html http://www.water.org.uk/home/resources-and-links/publications/waste-water-treatment-and-recyling/wastewater-web--2-.pdf

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
Above ground drainage	Water Authority	**Rainwater pipework/gutters** **Guidance** Roof outlets should be selected to suit the particular roof construction arrangement or system as the construction of the roof can greatly affect the outlet type used. Gutters and downpipes must be sized according to the anticipated or design rainwater volumes for the particular location. This is termed as the rate of run-off and is dependent on the area of the roof, the number of outlets or downpipes, the rainfall intensity, the strength and direction of wind, and any fall from adjacent walls. A rainwater outlet is normally designed to receive discharges from gutters or channels so that it performs as a square or circular weir. If the outlet is undersized the height of the water standing will force the water to act more like an orifice. To perform like this effectively, however, it is necessary to provide a deep box at the entry to the outlet to increase the head of water at entry, and detailed calculation techniques are given in the Institute of Plumbing 'Plumbing Engineering services design guide' and BS EN 12056-3 'Gravity drainage systems inside buildings: roof drainage, layout and calculation for the design for drainage of roofs and paved areas'. The capacity of a vertical discharge is very much greater than that for the inlet from the gutter, and as a general rule, the downpipe can be two thirds of the diameter of the inlet. For halfround gutters, the sizes can be as set out in BRE Good Building Guide 38 'Disposing of rainwater'. Pipes sized according to BRE Good Building Guide 38 'Disposing of rainwater' will tend to flow full and joints should be sealed to prevent leaks. The flow is influenced by the shape of the inlet, whether sharp-cornered or round-cornered, and figures are given for both in BRE GBG 38, as well as allowances for the position of the inlet in relation to the end of the gutter. Where rainwater pipes pass through heated parts of a building, considerations should be given to providing insulation to prevent the forming of condensation. **Design parameters** Refer to BS EN 12056-3 'Gravity drainage systems inside buildings: roof drainage, layout and calculation for the design for drainage of roofs and paved areas'. Symphonic systems must be designed to meet the needs of the individual project and the manufacturer's systems. Check also the requirements of the Building Regulations, Local Authority, as well as data for rainfall intensity relevant to the particular site location. Where rainwater downpipes are routed through the building, it may be necessary to use a heavy material such as cast iron to help reduce the transference of noise.	• Institute of Plumbing • 'Plumbing engineering services design guide' and BS EN 12056-3 'Gravity drainage systems inside buildings: roof drainage, layout and calculation for the design for drainage of roofs and paved areas'. • For halfround gutters, the sizes can be as set out in BRE Good Building Guide 38 'Disposing of rainwater'. Pipes sized according to BRE Good Building Guide 38 'Disposing of rainwater' Design Guides: http://www.hunterplastics.co.uk/rainwater/gutterdesign/default.html http://www.marleyplumbinganddrainage.com/r_design.asp Technical product guides http://www.marleyplumbinganddrainage.com/r_install.asp http://www.marleyplumbinganddrainage.com/r_uk_euro_stds.asp
Above ground foul drainage	Water Authority	The above ground drainage system should comprise the minimum pipework necessary to carry foul water away from a building in an effective and healthy manner. The fumes in foul water systems contain many chemicals as below in below ground foul drainage. All sanitary appliances should be fitted with an adequate water seal to prevent fumes from the	• BS EN 752 Parts 1-7: 1996-1998 'Drain and sewer systems outside buildings' • BS EN 12056-2: 2000 'Gravity drainage systems inside buildings - sanitary pipework, layout and calculation'

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		drainage system entering the building. Kitchen areas with appliances discharging grease contaminated waste water should be connected to a separate waste and vent system which, in turn, should be connected to a grease converter (grease trap) before discharging to below ground drainage. These are also available as portable appliances to allow use on local sanitary fittings. Anti-siphon and venting pipes (and anti-siphon traps) protect the traps on the appliances from loss of water/seal. Falls on soil waste and vent pipes shall not fall below the minimum stated in BS EN 12056-2 'Gravity drainage systems inside buildings - sanitary pipework, layout and calculation'. Anti-siphon pipework and vent pipes must be installed in such a manner as to not create a trap. Access must be provided at all changes of direction and above the connection point to the below ground drainage. Generally, main soil/waste vent pipes shall rise to roof level and terminate with a vent cowl before discharge to the atmosphere. Where plastic pipework passes through fire compartment floors and walls, intumescent fire sleeves to BS 476 'Fire tests on building materials and structures' shall be fitted. Thermal expansion must be allowed for on PVC and polypropylene soil, waste and vent pipework.	• BRE IP 2005/5 'Self-dealing waste valves for domestic use – an assessment' 2005 • CIBSE Guide G 'Public health engineering' 2004 • ODPM Approved Document H 'Drainage and waste disposal' 2002 (or national equivalents) • SI 2000/2531 'Building Regulations, England and Wales' (or national equivalents) • Environmental Protection Act 1990 • http://www.marleyplumbinganddrainage.com/sw_uk_euro_stds.asp Product technical guides http://www.marleyplumbinganddrainage.com/sw_install.asp http://www.hunterplastics.co.uk/plumbing/soilandwaste/default.html http://www.marleyplumbinganddrainage.com/downloads.asp for CAD drawings Design Guides http://www.marleyplumbinganddrainage.com/sw_design.asp# http://www.odpm.gov.uk/index.asp?id=1130645#P136_12203
Sanitary appliances, fittings and fixtures	All installations to conform to the requirements of the Water Supply (Water Fittings) Regulations 1999	Facilities for disabled All fittings etc are amended/adjusted to cater for disabled as necessary to BS 8300 and the Disability Discrimination Act (DDA). It is important to ensure that sanitary appliances are all fitted to suit all recommendations in designing for semi-ambulant and disabled persons where appropriate. Due to the multiplicity of types of sanitary fittings, the specifier should select a manufacturer/supplier and produce a 'Schedule of Fittings' to include for all requirements ie sanitary ware, brassware, fixtures and fittings etc, and include manufacturers/suppliers identification reference numbers. The schedule should form part of the specification and be added as an Appendix. Refer to BS 6465-1 for guidance on selection of sanitary ware, design of installations and the required provision of sanitary installations for different building types relative to the number of people that will be using it. Refer to BS 6465-2 for the space requirements for sanitary appliances. Any sanitary appliances specified should carry Water Regulations Advisory Scheme approval or equivalent. In these cases the manufacturer should be consulted on the suitability of the product in question. **<u>WC's, cisterns & wash hand basins</u>** Generally manufactured from vitreous china although some uPVC cisterns for domestic use are available. Specific uPVC cisterns can also be used in a commercial application where they will be concealed and not accessible to the general public. In public conveniences it is recommended that stainless steel appliances be used to reduce the possibility of vandalism. Under current Water Regulations WC's may only have a maximum flush volume of 6 litres.	• BS 1189: 1986 'Specification for baths made from porcelain enamelled cast iron' • BS 1390: 1990 'Specification for baths made from vitreous enamelled sheet steel' • BS 4305: Parts 1 & 2: 1989 'Baths for domestic purposes made of acrylic material' • BS 6465 'Sanitary installations' • Part 1: 1994 'Code of practice for scale of provision, selection and installation of sanitary appliances' • Part 2: 1996 'Code of practice for space requirements for sanitary appliances' • BS 8300: 2001 'Design of buildings and their approaches to meet needs of disabled people - code of practice' • BS EN 274-1 – 3: 2002 'Waste fittings for sanitary appliances' • BS EN 12056-1 – 5: 200 'Gravity drainage systems inside buildings' • NHS Estates Health Technical Memorandum HTM 64: 1995 'Building components – sanitary installations'

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		Urinals Generally manufactured from vitreous china, fireclay, stainless steel and GRP. In public conveniences it is recommended that stainless steel or fireclay appliances be used to reduce the possibility of vandalism. The detailing when using fireclay is important to prevent the ingress of water and urine behind and under the appliance. Under current Water Regulations, urinal cisterns may only have a maximum flush volume of 7.5 litres/hour. Urinals should always be fitted with water saving device. Waterless urinals are now available. Advice should be sought from the manufacturer on a suitable device for their product. This is a requirement of the W ater Regulations/Byelaws. **Baths** Generally manufactured from plastic materials (BS 4305), steel with an enamelled finish (BS 1390) or cast iron (BS 1189). Cast iron is the most robust of the baths. Baths should always be mounted on suitable cradles to restrain the movement of the bath and to evenly transmit the load of the bath to the floor. These cradles often provide fixings for side and end panels where required. Where a bath sits on a timber floor it is essential that additional joists be provided within the floor construction to provide adequate support for the bath when it has been filled with water and containing one or more persons. **Taps** There are many types and styles of taps to choose from when specifying. It is important to ensure that chosen taps comply with a British Standard in its operation. Although dimensions in standards are metric, taps are designated ½ or ¾ inch to indicate the old imperial pipe size for connections. The basic types of taps are pillar, bib, combination tap assembly, self-closing and single lever joystick. Advice should be sought from the manufacturer on the suitability of a particular application. **Traps** Generally manufactured from plastic materials (BS EN 274) and chrome plated. It is essential to ensure that the specified trap is compatible with the pipe work and that they are easily cleanable. Standard traps are tubular, bottle and resealing. Advice should be sought from the manufacturer on the suitability of a particular application. ***PIPEWORK*** Generally manufactured from plastic materials and sizes as follows (BS EN 12056) - • 32mm - wash hand basins, drinking fountains and bidets • 40mm - sinks (domestic and commercial), urinals, baths, shower trays, domestic food waste disposal units and sanitary towel macerators. • 50mm - industrial food waste disposal units. • 65mm - urinal stall where there are less than six stalls in one range (more than six will requires additional outlets). When specifying non-standard sanitary items then advice should be sought from the manufacturer on the suitability of a particular application. Always bear in mind water consumption and reduction of water consumption when specifying sanitary appliances.	• Building Regulations/Approved documents, especially Part M (or national equivalents) • Water Supply (Water Fittings) Regulations 1999 (as amended)
HEATING SYSTEMS			
Medium temperature	Water Authority	All hot water services systems, including hot water storage and heat source capacities, should be designed and installed in accordance with BS 6700 together with CIBSE Guide G 'Public health engineering', SI 1999/1148 'Water supply, water fittings, regulations', relevant statutory regulations,	• BSRIA TM 1/88 'Commissioning of HVAC systems'. 1988 • BSRIA AG 2/89.2 'Commissioning of water systems in buildings'. 1989

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
hot water heating		local byelaws, and other relevant British Standards. A water central heating system consists of basically the boiler, the radiators and the interconnecting piping. The boiler heats the water and (normally) a pump circulates the water through the pipework and radiators and back to the boiler. There are a number of different arrangements of boiler, pipework and supply to the radiators; each systems has its own advantages and drawbacks. This basic design works well and is usually used where a hot water cylinder is used to store the domestic hot water. The system works at natural atmospheric pressure as the feed/expansion tank is open to the air. The feed/expansion tank is fitted high up above the rest of the system, often in the loft. The tank is fitted with a ball valve so that any water lost due to evaporation etc. is automatically replaced, the tank also allows for the water in the system to expand when it is heated, the ball valve need to be set very low so that the expanded water does not cause an overflow. The tank also allows for any water vented from the system up the vent pipe to be recovered, the vent pipe is connected from near the boiler and is bent over the tank. From the tank, the water is fed down to connect into the system near to the boiler.	• BSRIA AG 20/95 'Commissioning of pipework systems'. 1995 • BSRIA AG 1/01 'Pre-commissioning cleaning of water systems'. 2001 • CIBSE Commissioning Code B: 2002 'Boiler plant' • CIBSE Commissioning Code W: 2003 'Water distribution systems' • CIBSE Guide B1: 2002 'Heating' • NHS Estates Health Guidance Note 1: 1998 'Safe hot water and surface temperatures'
HEAT SOURCES			
GAS/OIL FIRED BOILERS		BOILER PLANT Boiler selection strategy will depend upon the use of the system and the facility being served. For instance, critical installations may require standby or redundancy plant in order to ensure that the total design load can be met in the event of one boiler failing. Similarly, it may be considered worthwhile having duel fuel boilers equipped with two sources of primary energy in the event of an interruption in supply. The efficiency of boiler plant varies according to type and construction. Higher efficiency units can have a large impact on energy consumption and running costs. For boiler applications see CIBSE Guide A and BS 6880. Condensing boilers are generally the most efficient, but careful design of the systems is necessary to make the most of the potential energy savings, with particular attention to return temperatures, back end protection and controls. In many cases, multiple boiler units can prove more energy efficient than a single large unit with a single or two-stage burner. Modulating burners can offer a cost effective alternative to multiple boiler units, providing improved efficiency and space saving, but do not provide any spare plant in the event of a boiler failure. FLUES When laying out boiler plant rooms, be sure to allow sufficient space for the flues. Check where the flue connections are, either off the top of the boiler or from the back, and take that into account when laying out the plant. In some cases, the available head height may determine the type of boiler that can be used. Where it may be difficult to route flue systems up to discharge at high level, possibly due to space or visual considerations, a flue dilution system may be the answer. The system inlet and outlet should be on the same wall to avoid air pressure differences that may occur on different faces of a building, although they should normally be above head height. Depending on the application it may be necessary to get the local authority – the building control or planning department - to agree to the	• BS 5440-2: 2000 'Installation and maintenance of flues and ventilation for gas appliances of rated input not exceeding 70kW net (1st, 2nd and 3rd family gases) - specification for installation and maintenance of ventilation for gas appliances' • BS 5978 Parts 1-3: 1989 'Safety and performance of gas-fired hot water boilers (60kW to 20MW input)' • BS 6644: 2005 'Specification for installation of gas-fired hot water boilers of rated inputs between 70kW and 1.8MW net (2nd and 3rd family gases)' • BS 6798: 2000 'Specification for installation of gas-fired boilers of rated input not exceeding 70kW net' • BS 6880 Parts 1-3: 1988 'Code of practice for low temperature hot water heating systems for output greater than 45kW' • Barbour Report 'Greening – a guide to sustainable engineering specification' 2002 • BRE 'SAP 2005 – Governments standard assessment procedure for energy rating of dwellings' 2005 • BSRIA TN 85/7 'Factors influencing boiler efficiency' 1985 • CIBSE Commissioning Code B 'Boilers' 2002 • CIBSE Guide A 'Environmental design' 2001 • CIBSE Guide B 'Heating, ventilating, air conditioning and refrigeration' 2005 • Energy Efficiency Best Practice in Housing, CE 29 'Domestic heating by oil – boiler systems – guidance for

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		louvre locations. They may have regarding where the products of combustion may be discharged, even those which have been greatly diluted. Flue dilution systems can represent cost savings over more traditional arrangements where the length of the flue would be considerable. However, there may be a penalty in terms of the amount of internal plant room space required to route the flue and locate the fan. CONTROLS Check what control functions are available with the boiler being specified. Do not duplicate functions with the BMS or main control system. Boiler manufacturers will often provide their plant with volt-free contacts for linking to a BMS to monitor various boiler and system functions. VENTILATION IN BOILER ROOMS Ventilation should be provided in such a way so as to provide adequate air for combustion, as well as satisfying health and safety requirements for occupants. It should be introduced into the space to ensure maximum effectiveness, without leaving dead areas that remain unventilated. Cross ventilation is generally favourable. Ensure that ventilation for the boiler room complies with CIBSE Guide B and Local Authority requirements. For equipment with rated output of less than 60kW, comply with BS 5440-2 for air supply to gas burner. Also, refer to any specific requirements that the boiler manufacturer may ask for, to suit their particular plant. COMMISSIONING Ensure that the division of responsibility between the designer and the commissioning specialist contractor is clearly defined to avoid duplication of work and possible site disagreements. Select pipework components and layouts to ensure that the system is as inherently stable and self-balancing as can be economically justified. This will reduce the time required to regulate branch flow rates and will often make it unnecessary to balance flow rates through terminal units. Consider the requirements for two and three port valves, gauges and fittings for measuring system performance. Check that design pressure losses across terminal units fed from the same branch are not significantly different, e.g. within around 20kPa of each other. Mixing low resistance terminal units such as radiators with high resistance units such as fan coils should be avoided. Where possible ensure that terminal unit design pressure losses on reverse return branches are the same in order for flows to these terminal units, fed from a reverse return branch, to achieve some degree of self-balancing. Check that flow regulating and measurement valves are properly located. Usual locations include risers, branches, sub-branches, terminal branches, by-passes from three way control valves, pump sets, individual boiler and chiller circuits. Only where a degree of self-balancing is achieved may they be omitted. Check that design flow rates are achievable with regulating valves more than 25% open. Select regulating valves to ensure their design flow rates the required pressure losses across them can be achieved without the need to close below the 25% open position. Valves closed beyond this point can be prone to dirt and air blockages. Low flow 15mm valves have a minute orifice and should be considered with caution.	installers and specifiers' 2005 • Energy Efficiency Best Practice in Housing, CE 30 'Domestic heating by gas – boiler systems – guidance for installers and specifiers' 2005 ODPM 'Guide to condensing boiler installation – assessment procedure for dwellings' 2005 Produced with BRE and DEFRA.

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		Check the accuracy of the specified flow measurement device is adequate to achieve the required flow balance tolerance. Depending on the device selected, accuracy can vary between +/-3% and +/-10%. Flow measurement devices should be selected to ensure that at design flow rates, the pressure signals across them are greater than 1kPa. Anything less than this becomes difficult to measure with site instruments, which affects accuracy. Tolerances of final flow measurements should be assessed and specified, and the commissioning specialist given a realistic flow rate tolerance within which to establish a flow balance (see CIBSE Commissioning Codes and BSRIA Guides). Note that the total of tolerances may affect pump selection. Valve and flow measurement device locations should be indicated on schematic design drawings and contractor installation drawings with commissioning data. Components within this section may be eligible for attracting an Enhanced Capital Allowance. To select equipment that qualifies for an ECA, refer to the Energy Technology List at http://www.eca.gov.uk/. For details on how the scheme works see the guidance section in the Barbour Report 'Greening – a guide to sustainable engineering specification'. Page Units such as fan coils can be grouped together to reduce the number of commissioning valves required. Eligibility for Enhanced Capital Allowances	
Heat pumps		Consider whether the heat pump will be used for a heating application, cooling application or both. Reverse cycle heat pump types include: • air to air • air to water • water to water • water to air • ground to air • ground to water • air to ground • dehumidifiers *Key issues* Do not extrapolate performance curves beyond the manufacturer's published data. Check that the design takes into account ambient and extreme conditions at the design location, e.g. temperatures at roof level may be higher than the ambient design temperature. Problems such as coil freezing can arise if standard units are supplied for high sensible load applications. The frequency and duration of defrosting and the energy required to achieve defrost should be considered. Check that the energy required for defrost is taken into account when estimating the overall power consumption. Heat pump protection should include: • high and low refrigerant pressure cut outs • compressor delay starter timers • high temperature cut outs • system flow switches • defrost mechanisms in air source units	• BRE Information Paper 1985/7 'Cost-effectiveness of heat pumps in highly insulated dwellings – assessment'. • BRE Information Paper 1985/8 'Assessment of cost-effectiveness of heat pumps for domestic hot water heating' • BS EN 255-3: 1997 'Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - heating mode - testing and requirements for marking for sanitary hot water units' • BS EN 378 Parts 1-4: 2000 'Refrigeration systems and heat pumps - safety and environmental requirements' • BS EN 1736: 2000 'Refrigerating systems and heat pumps - flexible pipe elements, vibration isolators and expansion joints - requirements, design and installation' • BS EN 1861: 1998 'Refrigerating systems and heat pumps - system flow diagrams and piping and instrument diagrams - layout and symbols' • BS EN 12263: 1999 'Refrigerating systems and heat pumps - safety switching devices for limiting pressure - requirements and tests' • BS EN 12309 Parts 1-2: 2000 'Gas-fired absorption and absorption air-conditioning and/or heat pump appliances with a net heat input not exceeding 70 kW' • BS EN 13136: 2001 'Refrigerating systems and heat pumps - pressure relief devices and their associated

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		The potential noise problems arising from the use of heat pumps need to be considered early in the design process. Check that at low temperature the heat pump can satisfy the requirement i.e. examine the full range of operating conditions, not only the characteristics at the design temperatures. Consider part load operation when selecting heat pumps to optimise performance and maximise part load efficiency. Refrigerant piping should be kept as short and simple as possible between the indoor and outdoor units. The vapour line should be fully insulated. Check that the insulation is capable of withstanding the high temperatures of the vapour discharge. Check that the diameter and length of the refrigerant lines meet the manufacturers' recommendations for the particular unit being installed. Ensure that the discharge from the outdoor units does not compromise the performance of adjacent units. A condense drain must be fitted to units that will be operating at temperatures below the dew point. All tubing connections should be tested for leakage before starting the unit to check that there are no refrigerant leaks Check that the control systems include a means of matching the space loads efficiently and without excessive cycling. *Access and maintenance* Check that there is sufficient clearance around the unit for proper airflow and service access. In-built condensate pumps are susceptible to malfunction and must be cleaned and maintained regularly. Safety guards and an emergency stop facility should be provided for all pump and motor exposed moving parts. Make sure that local electrical isolation is provided for each piece of equipment, particularly remote plant. Oversizing of heat pumps will cause excessive cycling, reduced performance and reduced life. Avoid the inefficient use of supplementary heating. It is the most common problem in heat pump applications, giving rise to running costs in excess of predictions. *Eligibility for Enhanced Capital Allowances* Components within this section may be eligible for attracting an Enhanced Capital Allowance. To select equipment that qualifies for an ECA, refer to the Energy Technology List at http://www.eca.gov.uk/. For details on how the scheme works see the guidance section in the Barbour Report 'Greening – a guide to sustainable engineering specification'.	piping - methods for calculation' • BS EN 13313: 2001 'Refrigerating systems and heat pumps - competence of personnel' • BS EN 14511 Parts 1-4: 2004 'Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling' • BS EN 60335-2-40: 2003 'Specification for safety of household and similar electrical appliances - particular requirements for electrical heat pumps, air-conditioners and dehumidifiers' • DD ENV 12102: 1996 'Air conditioners, heat pumps and dehumidifiers with electrically driven compressors - measurement of airborne noise - determination of the sound power level' • BSRIA TN 18/99 'Ground source heat pumps - a technology review' 1999 • CIBSE Guide F 'Energy efficiency in buildings' 2004 • CIBSE Guide H 'Building control systems' 2000 • IEA Heat Pump Centre HPC-AR08 'Domestic heating and cooling distribution and ventilation systems and their use with residential heat pumps' 2001 • IEA Heat Pump Centre HPC-AR09 'Retrofitting with heat pumps in buildings' 2001 • IEA Heat Pump Programme HPP-AN22-4 'Guidelines for design and operation of compression heat pump, air conditioning and refrigeration systems with natural working fluids – final report' 1998
Fire precautions, fire protection and sprinkler systems			
Fire detection and alarm			• BS 5839-1: 2002 'Fire detection and alarm systems for buildings - code of practice for system design, installation, commissioning and maintenance'

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
			• BS 5839-6: 2004 'Fire detection and alarm systems for buildings - code of practice for the design, installation and maintenance of fire detection and fire alarms systems in dwellings' • BS 7807: 1995 'Code of practice for the design, installation and servicing of integrated systems incorporating fire detection and alarm systems and/or other security systems for buildings' • BS EN 54 Parts 1-13: 1996-2005 'Fire detection and alarm systems' • BSRIA AH 92/3 Pt 2 'Installation, commissioning and maintenance of fire and security systems – fire detection systems' 1992 • CIBSE Applications Manual AM4 'Security engineering' 1991 • CIBSE Guide E 'Fire engineering' 2003 • ODPM Building Regulations, Approved Document B 'Fire safety' 2004 (or national equivalent) • SI 2000/2531 'Building Regulations, England and Wales' (or national equivalents)
SPRINKLER Systems		A pipework distribution system charged with water or air, with a network of heat sensitive sprinkler heads. Should the temperature rise above a critical point the sprinkler head will activate and a water spray will be emitted. Key points: • Only the sprinkler head subject to the heat source will activate. • The sprinklers must be correctly rated according to the level of protection required/type of risk. Sprinkler systems are designed to control fires at a very early stage in their development and not necessarily to halt the advance of an already established fire. *Brief system description:* All areas of the building to be protected are covered by a grid of pipes with sprinkler heads fitted at regular intervals. Water from a tank via pumps or from town main (if it can give sufficient flow) fills t he pipes. Each sprinkler head will open when it reaches a specific temperature and spray water onto the fire. The hot gases from a fire are usually enough to make it operate. Only the sprinklers over the heat source open, the others remain closed. Sprinkler heads can be placed in enclosed roof spaces and into floor ducts to protect areas where a fire can start without being noticed. In a large warehouse sprinklers may be placed in the storage racks as well as the roof. At the point where the water enters th e sprinkler system there is a valve. This can be used to shut off the system for maintenance. For safety reasons, this should be kept locked open, and only authorised persons should be able to close it. If a sprinkler opens and water flows through the valv e it	• BS 5306-2:1990 'Fire extinguishing installations and equipment on premises - specification for sprinkler systems'. • BS 5588-6:1991 Fire precautions in the design, construction and use of buildings: code of practice for places of assembly' • BS 5588-7:1997 'Fire precautions in the design, construction and use of buildings: code of practice for the incorporation of atria in buildings' • BS 7273-3: 2000 'Code of practice for the operation of fire protection measures: electrical actuation of pre-action sprinkler systems'. • BS EN 12259 'Fixed fire fighting systems - components for sprinkler and water spray systems'I. • BS EN 12845: 2003 'Fixed firefighting systems - automatic sprinkler systems - design, installation and maintenance' • DD251: 2000 'Sprinkler systems for residential and domestic occupancies - code of practice'. • DD252: 2002 'Components for residential sprinkler systems - specification and test methods for residential sprinklers'

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		lets water into a secondary pipe which activates an alarm bell. *Types of sprinkler system:* The most common types of sprinkler systems currently in use are: • Wet system: the whole system is full of water permanently to its design pressure allowing wa ter to be discharged immediately on activation of a sprinkler head. This is the most common system in use. • Dry system: these systems are permanently charged with air under pressure, and the resulting pressure drop on activation of a sprinkler head activates a water control valve. This should generally only be used where a wet or alternate wet and dry system cannot be used. • Alternate wet and dry system: the system is full of water during warm months and drained and charged with air under pressure in winter months where there may be a risk of freezing. When the system is charged with air it operates as described for dry systems above. • Pre-action system: this system incorporates an electronic form of detection to pre -arm the system with water. The system is generally filled with air under pressure, and activation of a sensor or detector lets water into the system. Water is then released into the space on activation of the sprinkler head. These are used in applications where it is not acceptable to have the pipework full of water at all times. *Hazard classification:* The sprinkler system is designed according to the hazard it is protecting against. The typical classifications are: • Light hazard: This category covers non-industrial applications. Typical examples are hospitals, hotels, offices, schools, etc. • Ordinary hazard: This category covers commercial and industrial applications involving ordinary combustible materials and is split into four further groups: • Ordinary hazard Group I • Ordinary hazard Group II • Ordinary hazard Group III • Ordinary hazard Group III Special • High hazard: This category covers commercial and industrial applications having abnormal fire hazards due to the activities taking place, the type of goods being stored, etc. *Sprinkler heads:* The sprinkler head has a heat sensitive element which helps seal the head until activated by the fire. However, 'open' sprinklers do not have these elements and the system is activated by other means. Different heat sensitive elements are available depending on the anticipated operating conditions, and are normally selected to have an operating temperature not less than 300C above the highest expected ambient temperature. The following table shows the bulb colours for various operating temperatures. **Temperature 0C Bulb Colour** 57 Orange 68 Red	• BSI Drafts for comment 89/40170 'Components for sprinkler systems Part 4 specification for alarm bells' • BSI Drafts for comment 89/40172 'Components for sprinkler systems Part 6 specification for pipe couplings' • BSI Drafts for comment 89/40173 'Components for sprinkler systems Part 7 specification for pipe hangers' • BSI Drafts for comment 89/40174 'Components for sprinkler systems Part 8 specification for pressure switches' • BSI Drafts for comment 99/540206 'Components for sprinkler and water spray systems Part 9 deluge valves' • BSI Drafts for comment 99/540207 'Components for sprinkler and water spray systems Part 10 multiple controls' • BSI Drafts for comment 99/540206 'Components for sprinkler and water spray systems Part 11 medium and high velocity water sprayers' • BSI Drafts for comment 99/540206 'Components for sprinkler and water spray systems Part 12 sprinkler pumps' • ISO 6182-9 'Fire protection -automatic sprinkler system: requirements and test methods for water mist nozzles' • LPCB LPS 1039: 2000 'Requirements and testing methods for automatic sprinklers' • LPCB LPS 1040: 2000 'Requirements and testing methods for wet alarm valve sets' • LPCB LPS 1041: 2000 'Requirements and testing methods for dry pipe valve sets' • Building Regulations Approved Document B 'Fire safety' (or national equivalent).

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		79 Yellow 93 Green 141 Blue 182 Mauve 227-260 black	
VENTILATION and AIR CONDITIONING			
Ventilation		**GENERAL VENTILATION** **GUIDANCE** This covers general ventilation systems not covered by the other, more specific systems such as kitchen and toilet extract, which have their own guidance elsewhere. Typical applications may be office fresh air ventilation (not providing air conditioning), general make-up air supply for local extract systems, boiler room ventilation, etc. Ventilation requirements are not necessarily the same as fresh air requirements. A recommended air change rate for a space can be based on a number of factors including room ir diffusion requirements, extract requirements or provision of fresh air for combustion. Actual supply rates for offices may have to meet heating and cooling loads as well as fresh air needs. Select the fresh air rate to suit the use of the particular space, based on recommended guidelines. Increase the supply rate above the standard recommended values only where required, such as in areas permitting smoking, or for process requirements. The greater the fresh air supply rate, the more energy required to temper the air to acceptable temperature levels before it is introduced into the space. If the system is to be a balanced one i.e. not positive or negative pressure in the space, then produce an air flow diagram to make sure that all air paths balance. If there is an extract from an area but no source of air to make up or replace that being extracted, then the system will not perform adequately. Assess conditions in the occupied zones to check that reasonable air velocities can be achieved for each space without undue drafts or stagnant zones. This can be done by considering room air diffusion patterns, details of throws from diffusers, etc. together with use of space and other sources of air movement. Complex room air flow modelling can also be done but is unlikely to be justifiable for most spaces. A quick cross check can be done for offices by calculating the room air change rate and checking against published guidelines. FIRE – Maintaining fire BARRIERS and COMPARTMENTATION When passing through fire barriers or compartments, ensure that adequate protection measures are put in place, e.g. fire and/or smoke dampers. Details of the fire compartmentalisation should be shown on the architect's drawings, as well as in the specification. The proposed measures need to be discussed with the local authority, particularly in Section 20 buildings. Make sure that any such dampers are accessible for maintenance and testing. Should a damper fail, it may need to be replaced with minimum disruption to the occupants. Adequate maintenance should	• BS 5925: 1991 'Code of practice for ventilation principles and designing for natural ventilation' BS EN 12101: 2005 'Smoke and heat control systems – specification for pressure differential systems – kits' • BS EN 13779: 2005 'Ventilation for non-residential buildings – performance requirements for ventilation and room-conditioning systems' • PD CR 1752: 1999 'Ventilation for buildings – design criteria for indoor environment' • Air Infiltration and Ventilation Centre 'Guide to energy efficient ventilation' 1996 • BRE Digest 398 'Continuous mechanical ventilation in dwellings – design, installation and operation' 1994 • BSRIA Technical Memoranda 1990/2 'Displacement ventilation' 1990 • BSRIA Technical Note 2000/12 'Location of fresh air intakes' 2000 • Butterworth Heinemann 'Faber and Kell's heating and air-conditioning of buildings' 2002 • CIBSE Application Manual 13 'Mixed mode ventilation' 2000 • CIBSE Guide B 'Heating, ventilating, air-conditioning and refrigeration' 2005 • HVCA 'Guide to air distribution technology for the internal environment' 2000 • ODPM Building Regulations Approved Document F 'Ventilation' 2000 (or national equivalents) • SI 2000/2531 'Building Regulations, England and Wales' (or national equivalents)

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		be discussed and agreed with the architect at the design stage. PRESSURISATION Some tall buildings, or those with internal escape stairs, may require pressurisation. This is intended to provide a protected route for fire fighters to access the building to fight a fire. Pressurisation provides positive pressure in the fire lobbies so that smoke cannot get in. It should be designed in accordance with BSEN 12101-6 'Smoke and heat control systems – specification for pressure differential systems – kits'. The local authority will ultimately decide on whether you have to provide pressurisation at all, so check with them at an early stage. Make sure that upon activation of the pressurisation system, any other ventilation systems that may possibly have an affect on the pressurisation system are isolated. PLANT Air handling units and separate supply and extract fans can be heavy consumers of electrical energy, so choose fans that operate at the maximum possible efficiency. Some designs of fan are inherently more efficient than others, so try to select these wherever possible. When specifying air-handling units, make sure that the quality of construction is adequately described. A lower quality unit may save money but result in poor performance through excessive leakage, reduced operating life or poor reliability. *Terminal devices* The correct selection of terminal devices is vital for successful air distribution. Factors to be considered include: • volume of air • distance the air is to be thrown • temperature of the air • height of the terminal device above the ground • location relative to surrounding surfaces The performance of the terminal device may vary considerably as the volume of the air passing through it changes. This may be very important if an air supply temperature changes to provide cooling and heating at different times of the year. Avoid short circuiting between supply and extract points in a space. *Coils* When selecting air-handling units, the face velocity across the various coils is an important factor. Excessive velocity across cooling coils may result in moisture carry-over into the air stream, and ultimately into the space. Typical velocities across coils are: • Heating coil: 3.5m/s • Cooling coil: 2.5m/s *Filters* Choose the grade of filtration appropriate for the application. Some specialist systems or facilities will	

Service Provision	Provider/ regulatory control Governing Legislation	System Design Applications/principles	References
		have very particular requirements designed to address life safety issues. If in doubt, check if the client has any particular filtration requirements necessary for their business operations. Examples of businesses that are particularly sensitive to filtration levels include the nuclear, medical and pharmaceutical industries and some manufacturing processes. The inclusion of panel filters will provide a relatively coarse filtration, which may be used on their own in many situations. They may also extend the life of bag filters, when used together, to provide a higher level of air cleanliness. Panel filters are also less expensive to replace than bag filters. *Intake/discharge positions* The location of intake and discharge air streams is very important. This must avoid recycling vitiated discharged air back into the system intake and bringing contaminated air from other sources into the system, such as boiler flues and factory chimneys. High air velocities across intake and discharge grilles or louvres can generate excessive noise levels. In the case of intake applications, it can also pull moisture and other air borne detritus such as leaves and dust into the ductwork system. In areas that experience particularly gusty wind conditions, intakes facing into the oncoming wind can cause excessive positive/negative system pressurisation problems. Check the local prevailing wind direction and locate the intakes away from any strong air currents. **KITCHEN VENTILATION** GUIDANCE Such systems can range from a simple through-the-wall or hood mounted axial fan for a domestic application, to a large system with supply and extract plant and ductwork serving commercial catering applications. These systems are generally designed to have a negative pressure within the space to remove moisture and odours, preventing them from travelling into adjacent spaces. Produce an air flow diagram to make sure that all air paths are compatible with the design philosophy, particularly where some air is drawn from adjacent restaurant areas. If there is an extract from an area but no source of air to make up or replace that being extracted then the system will not perform adequately. **TOILET VENTILATION** GUIDANCE Such systems can range from a simple through-the-wall axial fan for a small individual lavatory, to a large system with supply and extract plant and ductwork serving many areas on a number of different locations throughout the building. These systems are generally designed to have a negative pressure within the space to remove smells and odours, preventing them from travelling into adjacent spaces. Produce an air flow diagram to make sure that all air paths are compatible with the design philosophy. If there is an extract from an area but no source of air to make up or replace that being extracted then the system will not perform adequately. This can often be satisfied by undercutting doors, or providing simple transfer grilles so that air can be drawn in from adjacent areas. In all such cases, be aware of the various fir compartment requirements and fit dampers wher e necessary.	

References;

http://www.livingsteel.org/building -with-steel (Accessed 17.02.10)

http://www.sips.org/content/about/ (Accessed 17.02.10)

Building Regulations Approved Document B, Fire available at http://www.planningportal.gov.uk/uploads/br/BR_App_Doc_B_v2.pdf (Accessed 17.02.10)

Building Regulations Approved Document A, Structure available at http://www.planningportal.gov.uk/uploads/br/BR_PDF_AD_A_2004.pdf (Accessed 17.02.10)

http://www.trada.co.uk/ (Accessed 24.02.10, 03.03.10 & 10.03.10)

Figure i available at http://www.alibaba.com/product -gs/251339525/steel_structure_frame/showimage.html (Accessed 24.02.10)

Figure ii available at http://images.google.co.uk/imgres?imgurl=http://www.channel4.com/4homes/images/mb/Channel4/4homes/diy-and-self-build/diy-building-advice/eco-projects/guide-to-buying-a-used-timber-frame/wood-frame-lg.jpg&imgrefurl=http:// www.channel4.com/4homes/diy-self-build/diy-build-advice/eco-projects/how-to-buy-an-old-timber-frame-08-05-29_p_1.html&usg=__ZuW9K5wjxjVynYsGV2jBogBC77U=&h=325&w=500&sz=113&hl=en&start=7&um=1&itbs=1&tbnid=8e7BflsqcsflfM:&tbnh=85&tbnw=130&prev=/images%3Fq%3Dtimber%2Bframe%26um%3D1%26hl%3Den%26tbs%3Disch:1 (Accessed 24.02.10)

Figure iii available at http://www.healylongjevin.com/christina_landings.jpg (Accessed 24.02.10)

Figure iv available at http://www.sanctuaryco.com.au/images/eng_img_3.jpg (Accessed 24.02.10)

Figure v available at http://www.somersetarchitect.co.uk/Images/Projects/ParsonageFarm/Residential%20Projects0027.jpg (Accessed 24.02.10)

Figure vi available at http://brtw.com/Photos/TimberFr amePanel.jpg (Accessed 24.02.10)

Figure vii available at http://www.byoh.com/images/Concrete -flatwork-pic1.jpg (Accessed 24.02.10)

Figure viii available at http://img.archiexpo.com/images_ae/photo -g/solid-clay-facing-brick-for-load-bearing-walls-143091.jpg (Accessed 24.02.10)

Information in Figure ix gleaned from appe ndix A (attached)

Building Regulations Approved Docume nt F, Ventilation available at http://www.planningportal.gov.uk/uploads/br/BR_PDF_ADF_2006.pdf (Accessed 03.03.10)

Building Regulations Approved Document E, Resistance to the Passage of Sound available at http://www.planningportal.gov.uk/uploads/br/BR_PDF_ADE_2003.pdf (Accessed 03.03.10)

Building Regulations Approved Document N, Glazing; Safety in Relation to impact, ope ning and cleaning available at http://www.planningportal.gov.uk/uploads/br/BR_PDF_ADN_1998.pdf (Accessed 03.03.10)

Figure x Available at http://fortresshomes.co.uk/images/P2070052.JPG (Accessed 14.03.10)

Figure xi Available at http://www.djgcarpentry.co.uk/images/stories/gallery/cutpitchsteel.png (Accessed 14.03.10)