Appendices

(To be read in conjunction with the main document)

Contains Key assumptions and details
(within the affordable design and costings)
1. Court layouts and sports equipment
2. Schedule of areas
3. Building fabric
4. Sports hall flooring
5. Acoustics
6. Structural design
7. Energy and sustainability
8. Building services
9. Artificial lighting
Appendix 1: Court Layouts and Sports Equipment

Introduction

This Appendix contains additional information on the fixed and loose sports equipment included in the indicative designs and cost plans are listed in the following tables. These should be reviewed against the ‘type of activity’ and ‘level of play’ envisaged for a particular project and the range of equipment available on the market.

The indicative designs for both the 4 and 5 court halls have included electrically operated roof mounted drop-down basketball goals. There are options on the market for wall mounted goals for the 4 court hall, but not for the 5 court hall, since the span (for a symmetrically located court) would be excessive.

<table>
<thead>
<tr>
<th>Description</th>
<th>4 court hall</th>
<th>5 court hall</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Court markings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent court markings for the following sports:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badminton</td>
<td>4</td>
<td>5</td>
<td>It is assumed that for school and community levels of play some court markings can be shared with other sports. For example, Futsal might be played on the netball court and Five-a-side football can be played in the full space of the hall and use the centre line of the netball court. Practice level basketball and netball can also be played on the badminton courts.</td>
</tr>
<tr>
<td>Basketball</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Netball</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Volleyball (including 2 no. training courts)</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Futsal</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Handball</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Fixed sports equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basketball goals</td>
<td>2</td>
<td>2</td>
<td>Electrically operated roof mounted units.</td>
</tr>
<tr>
<td>Practice basketball goals</td>
<td>8</td>
<td>8</td>
<td>Fixed practice goals to be centred upon the ends of the badminton courts, except in the 5 court hall where there is a conflict with the central dividing net.</td>
</tr>
<tr>
<td>Cricket netting</td>
<td>2</td>
<td>2</td>
<td>2 lanes assumed, including full width back wall net as a basic provision. However, there is space for 4 lanes in both hall sizes.</td>
</tr>
<tr>
<td>Central division netting</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Additional division net</td>
<td>1</td>
<td>1</td>
<td>May require off-setting to achieve clear side run-off for the badminton courts.</td>
</tr>
<tr>
<td>Deep floor sockets for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Netball goals</td>
<td>2</td>
<td>2</td>
<td>For deep floor sockets for netball and volleyball (required by the respective NGBs), floor slab requires thickening locally, typically to 450 mm deep to accommodate a 300 mm + deep socket, subject to selection of equipment.</td>
</tr>
<tr>
<td>- Volleyball nets</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Standard floor sockets for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Badminton nets</td>
<td>8</td>
<td>10</td>
<td>For standard depth floor sockets typically for badminton (preferred by NGB) and gymnastics (e.g. for trampolines, vaulting equipment), floor slab may not require thickening locally.</td>
</tr>
<tr>
<td>- Gymnastics equipment</td>
<td>Varies</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>Trampoline spotting rig</td>
<td>1</td>
<td>1</td>
<td>Cleats for trampoline spotting rigs need to be located in line with structural roof beams / columns.</td>
</tr>
</tbody>
</table>

1 Risk assessment for the reduced size of run offs required for formal competitions with a requirement for officials or spectators.
2 Subject to selection of equipment
Equipment stores of 12.5% of the area of the sports halls are included in the indicative designs in line with the advice in Sport England’s *Sports Halls: Design and Layouts* Design Guidance Note. Typical schedule of equipment and arrangement of equipment stores for a 4 and 5 court hall are included on pages 7 and 8. Consultation with sports equipment suppliers during the review has suggested that this store size is a reasonable minimum level of provision that generally works well in practice. However, the table above shows that the storage requirement does not change significantly for the court sports that are marked out in the larger hall. For example, the 5 court hall only requires space for an additional set of badminton posts and nets.

On the other hand, the table above also shows other sports and recreational activities that require significant amounts of additional equipment, for example judo / karate, gymnastics, table tennis, trampoline and indoor bowls.

**The equipment storage requirements should be considered in the context of the business plan and the program of activities for the new facilities.**

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### Loose sports equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>4 court hall</th>
<th>5 court hall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badminton</td>
<td>4 sets of posts, 4 nets, 2 spare nets</td>
<td>+ 1 (sets of posts, nets, spare net)</td>
</tr>
<tr>
<td>Scoring equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team benches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable baskets (if no fixed goals)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bowls</td>
<td>4 short mat carpets, rolled, each 1.83 m long x up to 0.5 m diameter</td>
<td>Longer mats</td>
</tr>
<tr>
<td>Cricket</td>
<td>Roll out mats</td>
<td>As 4 court hall</td>
</tr>
<tr>
<td>Five-a-side / Futsal</td>
<td>1 pair of portable goals with football / anchor points, each 3.66 / 4.99 x 1.20 m</td>
<td>As 4 court hall</td>
</tr>
<tr>
<td>Handball</td>
<td>1 pair of goals, each 3 x 2 m</td>
<td>As 4 court hall</td>
</tr>
<tr>
<td>Hockey</td>
<td>1 pair of goals, each 3 x 2 m</td>
<td>As 4 court hall</td>
</tr>
<tr>
<td>Gymnastics</td>
<td>Range of apparatus with anchorage points and floor mats</td>
<td>Space for additional equipment</td>
</tr>
<tr>
<td>Judo / Karate</td>
<td>Mats, each 2 x 1 m (full 14 x 14 m matted area with an 8 x 8 m combat area requires 98 mats)</td>
<td>+ 1</td>
</tr>
<tr>
<td>Netball</td>
<td>1 pair of adjustable posts, each 3.05 m high</td>
<td>As 4 court hall</td>
</tr>
<tr>
<td>Table tennis</td>
<td>6 tables, folded, each 1.855 x 1.830 x 0.65 m, nets and supports</td>
<td>Space for additional equipment</td>
</tr>
<tr>
<td>Team benches</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Trampoline</td>
<td>2 folding trampolines, each 4.60 / 5.20 x 2.75 / 3.05 m x 2.25 / 2.00 m high when folded</td>
<td>Space for additional equipment</td>
</tr>
<tr>
<td>Volleyball</td>
<td>Posts and nets / officials table / chairs</td>
<td>As 4 court hall</td>
</tr>
</tbody>
</table>

---

3 Separate fire proof store required for items classified as a fire hazard. See BB 100 *Design for fire in schools*. 

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4 court sports hall and equipment store

Sports Hall
34.5 x 20.0 x 7.5 m
(690 sq. m.)

Indicative running track for netting

Equipment store
(12.5% of hall floor area)

Clear zone for roof mounted basketball goals

Indicative running track for netting

Flush store door using 'up and over' type

Optional multi-height practice net

Central dividing net

Additional dividing net (may require off-setting to achieve clear run off requirements)

Fixed wall mounted practice basketball goals with backboards projecting 450 mm centred upon badminton courts

Lighting to be coordinated with badminton courts and in particular the type of basketball drop-down goals incorporated

5 rows of 5000 mm fluorescent luminaires to 500 lux for light reflectance values (LVRs) for ceiling, walls and floor of 70-40-40%

Key to sports layouts

- Badminton
- Basketball
- Indoor cricket
- Netball
- Volleyball
- Five-a-side

Floor plan

Reflected ceiling plan

Key to sports layouts

Floor plan
4 court sports hall and equipment store

**Long sectional elevation**

- 5 rows of flou. fluorescent luminaires to 500 lux for light reflectance values (LRV) for ceiling, walls and floor of 70/40/40%.
- Indicative drop down basketball goals - stored position to avoid lighting between badminton courts.
- Secondary steelwork to support basketball goal.
- Cricket nets in stored position.
- Services not indicated.
- Central dividing net.
- Fixed wall mounted practice basketball goals with backboards projecting 450 mm centred upon badminton courts.
- Cleats for trampoline spotting rigs located 2000 mm above floor level in line with structural roof beams / columns - location subject to project specific requirements.
- Additional dividing net (may require off-setting to achieve clear run off requirements).
- Indicative drop down basketball goals in playing position.
- Equipment store with flush ‘up and over’ type doors.
- Optional full length multi-height practice net.
- Cricket nets in stored position.
- Gas fired radiant heating tubes.
- For volleyball and netball floor sockets, floor slab requires thickening locally, typically to 450 mm deep to accommodate a 300mm+ deep socket.

**Cross sectional elevation**

- Fixed wall mounted practice basketball goals with backboards projecting 450 mm centred upon badminton courts.
- Equipment store with flush ‘up and over’ type doors.
**5 court sports hall and equipment store**

**Sports Hall**
40.6 x 21.35 x 7.5 m
(867 sq. m.)

**Key to sports layouts**
- Badminton
- Basketball
- Indoor cricket
- Netball
- Volleyball
- Five-a-side
- Futsal
- Handball

**Reflected ceiling plan**

- Position and width of equipment store varies according to the indicative plans
- Flush store door using 'up and over' type

**Floor plan**

- Additional (central) dividing net
- Optional multi-height practice net
- Fixed wall mounted practice basketball goals with backboards projecting 450 mm centred upon badminton courts
- 6 rows of frosted fluorescent luminaires to 500 lux for tight reflection values (LREF) for ceiling, walls and floor of 70/40/10%
Court markings, floor sockets, fixed and loose sports equipment should be considered at an early stage and integrated into the sports hall and equipment store design.
Schedule of loose sports equipment to be accommodated

(Footprint areas indicated represent equipment in stored configuration)

<table>
<thead>
<tr>
<th>Sport</th>
<th>Description</th>
<th>4 court store (87 m²)</th>
<th>Total area (m²) / sport (% store)</th>
<th>5 court store (108 m²) / additional items</th>
<th>Total area (m²) / sport (% store)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badminton</td>
<td>4 sets of posts, 4 nets, 2 spare nets, fixed, long mated</td>
<td>2.2 (2.5%)</td>
<td></td>
<td>(+ 1 set)</td>
<td>2.6 (2.4%)</td>
</tr>
<tr>
<td>Basketball</td>
<td>Basketball ball cage with table / chair / scoring equipment over</td>
<td>1.0 (1.2%)</td>
<td></td>
<td></td>
<td>1.0 (0.9%)</td>
</tr>
<tr>
<td>Bowls</td>
<td>4 no. short mat carpets, rolled, on trolleys</td>
<td>5.5 (6.3%)</td>
<td>(allowance for longer mats)</td>
<td></td>
<td>6.9 (6.4%)</td>
</tr>
<tr>
<td>Cricket</td>
<td>2 roll out mats on a trolley with protruding handles</td>
<td>2.5 (2.9%)</td>
<td></td>
<td></td>
<td>2.5 (2.3%)</td>
</tr>
<tr>
<td>Five-a-side</td>
<td>1 pair of portable goals with anchor points 3.06 m long x 1.2 (or 1.83) m high (folded)</td>
<td>1.2 (1.4%)</td>
<td></td>
<td></td>
<td>1.2 (1.1%)</td>
</tr>
<tr>
<td>Futsal / Hockey / Handball</td>
<td>1 pair of portable goals with anchor points 3.0 m long x 2.0 m high (folded)</td>
<td>1.0 (1.2%)</td>
<td></td>
<td></td>
<td>1.0 (0.9%)</td>
</tr>
<tr>
<td>Gymnastics</td>
<td>Gymnastics bars</td>
<td>4.9 (5.6%)</td>
<td>(additional allowance)</td>
<td></td>
<td>6.0 (6.0%)</td>
</tr>
<tr>
<td>Gymnastics vaulting table</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gymnastics agility mat, rolled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise mats (29 no.) on a trolley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High bars (folded)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judo / Karate</td>
<td>98 no. mats, each 2.0 x 1.0 m, on 4 no. trolley's (for full 14 x 14 m matted area with 8 x 8 m combat area)</td>
<td>10.7 (12.3%)</td>
<td></td>
<td></td>
<td>21.4 (19.8%)</td>
</tr>
<tr>
<td>Netball</td>
<td>1 pair of adjustable posts, each 3.05 m high, interlocked</td>
<td>1.4 (1.6%)</td>
<td></td>
<td>(+ 1 matted area)</td>
<td>1.4 (1.3%)</td>
</tr>
<tr>
<td>Table tennis</td>
<td>6 no. tables, with nets and support, folded and interlocked</td>
<td>2.8 (3.2%)</td>
<td></td>
<td>(+ 2 tables)</td>
<td>3.6 (3.3%)</td>
</tr>
<tr>
<td>School benches</td>
<td>6 no. benches, each with 3.30 x 0.26 m seating area, stacked</td>
<td>1.1 (1.2%)</td>
<td></td>
<td></td>
<td>1.1 (1.0%)</td>
</tr>
<tr>
<td>Trampoline</td>
<td>2 no. trampolines folded and locked</td>
<td>8.6 (9.9%)</td>
<td></td>
<td>(+ 1 trampoline)</td>
<td>12.9 (12.0%)</td>
</tr>
<tr>
<td></td>
<td>8 no. trampoline spotting platforms folded and interlocked</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volleyball</td>
<td>2 no. pairs of posts and nets, interlocked</td>
<td>0.5 (0.6%)</td>
<td></td>
<td></td>
<td>0.5 (0.5%)</td>
</tr>
<tr>
<td>Storage</td>
<td>Storage rack</td>
<td>0.8 (0.9%)</td>
<td></td>
<td></td>
<td>1.6 (1.5%)</td>
</tr>
<tr>
<td>Circulation</td>
<td>General manoeuvring space</td>
<td>42.8 (49.2%)</td>
<td></td>
<td></td>
<td>44.3 (41.0%)</td>
</tr>
</tbody>
</table>

**Notes:**
All sizes and layouts shown are indicative and based on typical interlocking items of equipment and storage trolleys currently on the market.
4 court hall equipment store (87m²)

The diagram below shows the equipment listed above for a 690 m² (34.5 x 20 m) 4 court sports hall arranged in the 87 m² store with an access route between the two doors. The layout enables direct access to sports equipment without the need to remove other items.

5 court hall equipment store (108m²)

The diagram below shows a similar arrangement for a 854 m² (40 x 21.35 m) 5 court sports hall.

Notes:
All sizes and layouts shown are indicative and based on typical interlocking items of equipment and storage trolleys currently on the market.
### Appendix 2 : Schedule of Areas

**Approximate gross internal floor areas (GIFA)**
(All figures are in m² unless noted otherwise)

<table>
<thead>
<tr>
<th></th>
<th>OPTION 1</th>
<th>OPTION 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) 4 court Sports hall</td>
<td>b) 4 court Sports hall + changing</td>
</tr>
<tr>
<td>Base Accommodation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sports hall</td>
<td>690</td>
<td>690</td>
</tr>
<tr>
<td>Equipment store</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Sub Totals</td>
<td>777</td>
<td>777</td>
</tr>
<tr>
<td>School Accommodation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School changing</td>
<td>- 112</td>
<td>113</td>
</tr>
<tr>
<td>Toilets</td>
<td>- 19</td>
<td>19</td>
</tr>
<tr>
<td>Accessible changing</td>
<td>- 8</td>
<td>8</td>
</tr>
<tr>
<td>Accessible WC</td>
<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>Wheelchair / buggy storage</td>
<td>4 no.</td>
<td>4 no.</td>
</tr>
<tr>
<td>Store</td>
<td>- 9</td>
<td>-</td>
</tr>
<tr>
<td>Vending machine</td>
<td>1 no.</td>
<td>1 no.</td>
</tr>
<tr>
<td>Locker compartments</td>
<td>33 no.</td>
<td>64 no.</td>
</tr>
<tr>
<td>Draught lobby</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Cleaners store</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Plant</td>
<td>3</td>
<td>62</td>
</tr>
<tr>
<td>Plant access</td>
<td>- 3</td>
<td>4</td>
</tr>
<tr>
<td>Lobby / Circulation</td>
<td>38.5</td>
<td>56</td>
</tr>
<tr>
<td>Sub Totals</td>
<td>55</td>
<td>274.5</td>
</tr>
<tr>
<td>Community Accommodation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fitness studio</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fitness storage</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fitness male changing</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fitness female changing</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Accessible WC</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Accessible changing</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fitness gym</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Reception / circulation / office / draught lobby</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wheelchair / buggy storage</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vending machine</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Locker compartments</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Public telephone</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sub Totals</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total GIFA excluding internal walls</strong></td>
<td><strong>832</strong></td>
<td><strong>1,051.5</strong></td>
</tr>
<tr>
<td><strong>Total GIFA including internal walls</strong></td>
<td><strong>850</strong></td>
<td><strong>1,087</strong></td>
</tr>
</tbody>
</table>
Appendix 3: Building Fabric

Key affordable assumptions
(within the design and costings)

Construction details to reduce capital costs and increased affordability:

- Lightweight structural design
- Uncomplicated building envelope
- Selection of robust prefabricated building components
- Avoidance of wet trades

Introduction

This Appendix contains additional information on sports hall specifications and construction and the allowances included in the indicative ‘Affordable Sports Halls’ designs and cost plans.

Sports hall walls and ceiling

Particular attention has been given to the construction options for the internal walls. There are proprietary prefabricated systems available that can be quickly installed and avoid issues associated with ‘wet’ trades such as blockwork. Some options include an acoustic treatment. A number of robust dry lining materials for the lower rebound walls and netting for the areas above have also been evaluated against the criteria in the table below.

Performance specification

<table>
<thead>
<tr>
<th>Walls</th>
<th>Resistance to impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From sports equipment such as footballs.</td>
</tr>
<tr>
<td></td>
<td>From user impact and accidental damage from sports</td>
</tr>
<tr>
<td></td>
<td>and other equipment.</td>
</tr>
</tbody>
</table>

| Flush finish                | Without sharp edges, projection or abrasive surfaces      |
|                            | that could cause injury to users.                        |
|                            | To give a true ball rebound surface.                     |
|                            | Skirting board features to be flush finished with the    |
|                            | sports hall walls above OR to be of a minimum size OR    |
|                            | with a bevelled upper edge that will not create a        |
|                            | hazard to users.                                         |

| Acoustics                   | Upper walls to include sound absorbing surfaces to play  |
|                            | a part in achieving the required reverberation time of   |
|                            | 1.5 - 2.0 seconds (mid frequency).                       |

| Cleaning                    | To be easily cleaned, non-dusting and be non-porous to   |
|                            | prevent staining from body fats.                         |
|                            | To be without ledges or corners that will collect dust   |
|                            | or trap shuttlecocks and balls.                         |

| Structural                  | Capable of providing a firm and secure fixing for wall   |
|                            | mounted sports equipment.                                |

| Visual                      | A consistent colour and a specified light reflectance    |
|                            | value (LRV) as required for badminton.                   |
|                            | With ‘black-out’ provision for any glazing, fittings,   |
|                            | equipment and features that could cause glare for sports |
|                            | that are particularly sensitive to lighting conditions.  |

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1 To be considered with the capital cost and energy reduction implications.
2 For example badminton, basketball, cricket, gymnastics, volleyball.
### Performance specifications

#### Ceilings

- **Resistance to impact**
  - From sports equipment such as footballs.

#### Acoustics

- **To include sound absorbing surfaces to play a part in achieving the required reverberation time of 1.5 - 2.0 seconds (mid frequency).**

#### Cleaning

- To be without ledges or corners that will collect dust or trap shuttlecocks and balls.

#### Structural

- Capable of providing a firm and secure fixing for overhead lighting and roof mounted sports equipment.

#### Visual

- A consistent colour and reflectance value to maximise the efficiency of the artificial lighting system and reduce glare.

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### Construction options

- Painted blockwork for full height (only)
- Painted blockwork for full height with:
  - Acoustic panels
  - Applied acoustic finish
  - Hollow acoustic blocks (built into the masonry wall)
- Painted blockwork for lower rebound walls (up to 2.55* m) with options for areas above incorporating:
  - Acoustic mesh liner
  - Timber panels with acoustic treatment
- Fire rated rebound panels for lower rebound walls (up to 2.55* m) with options for areas above incorporating:
  - Acoustic mesh liner
  - Timber panels with acoustic treatment
- Proprietary sports hall wall systems.

The review concluded that the lowest capital cost option would be for a wall system that could be quickly erected, lightweight to minimise foundation costs and a dry construction system that avoided ‘wet trades’. Advantages were also seen in the adoption of an ‘integrated’ acoustic solution, rather than sound absorbing panels being surface fixed to the wall surface. This avoided the problems associated with matching colours and specifying a precise light reflectance value. The wall system allowed for in the indicative cost plans consists of:

- **Lower perimeter rebound walls (up to 2.55* m):**
  - A fire rated timber prefabricated panel in standard widths screwed to softwood battens fixed to the sheeting rails that are part of the external cladding system.

- **Upper section of perimeter walls: (above 2.55* m)**
  - A fire rated flush hanging netting that can assist with acoustic absorption (RT), be of a specific colour and light reflection value (LRV), restrain balls and shuttlecocks from being lodged on the wall cladding components and be an important visual element within the hall.

See the diagram on the following page.

---

*Flush fitting ‘up-and-over’ doors to the sports hall equipment store*

---

*2.55 m or to match height required for sports hall store door.*
Roof mounted fittings may include photo-voltaic panels, natural wind vents. Access to the roof should be afforded with a fall restraint system.

Built up metal roofing system - based upon 6° pitch consisting of profiled coated steel weather sheet (with anti-drum membrane applied to underside to meet BB93 rain noise limits), breather membrane, thermally broken proprietary support grid, partially compressed mineral fibre thermal insulation to 0.14 W/m²K U-value, vapour control layer, mineral wool acoustic insulation and trough fillers, web-perforated white finished structural trough deck liner LRV 70%.

Eaves gutters and down pipes sized to BSEN12056 colour coated flashings to suit cladding.

Primary structure – hot rolled steel fabricated rafters to be painted white to match liner.

Variable equipment zone for sports equipment / lighting / heating / net track (not indicated) above minimum clear height zone Minimum clear height 7500 mm

Proprietary insulated composite metal faced cladding panels - thickness to meet 0.22 W/m²K U-value. External colour subject to planning requirements. Internal colour to match rebound boards.

Acoustic semi rigid bat white glass tissue faced and edged to be fitted to internal face of composite cladding full height above rebound boards on 1 side wall and 1 end wall of Sports Hall.

Pressed steel sheeting rail members above rebound area reduced in depth - centres to be set out to suit cladding requirements.

Fine gauge coloured specialist netting hung from roof member full height and weighted to align with rebound surface below.

Rebound board to be returned across top of opening to close void below and be close fitted around column profiles.

18 mm WBP ply phenolic coated or plastic laminate faced rebound boards to provide rebound surface up to 2.55 m above floor, to be SS countersunk screwed in regular grid shown to continuous solid sw battens Tek screwed to inner flange of sheeting rails and notched around diagonal bracing as required. Vertical board joints to be continuously supported by strips of 18 mm ply to prevent edge depression - horizontal battens notched to suit.

Pressed steel sheeting rails set at centres to provide support to rebound surface to take lateral impact from sport players.

Primary structure: Columns to be hot rolled steel sections.

Cladding drip cill with enhanced seal to detail including continuous gun applied air seal between flashing and slab edge.

Reinforced concrete floor slab with integral edge thickening and column bases (size shown indicatively) subject to detail & site specific ground conditions. Slab vertical face to receive cementitious board faced insulation. Insulation to U/S slab to be 120 mm extruded polystyrene on dpm on blinded compacted granular bed.

Indicative sports hall construction

(Note: The lower rebound wall has been taken to a height of 2.55 m to accommodate a recommended clear door opening height of 2.5 m to the sports hall equipment store.)
Appendix 4: Sports Hall Flooring

Key affordable assumptions (within the design and costings)

- A multi-sport floor to BSEN 14904
- A ‘low profile / floating’ area elastic (A3)
- Design capability to accommodate alternative types / thicknesses of floors

Introduction

This Appendix contains additional information on the review of sports floor products for inclusion in the indicative designs for the Affordable Sports Halls.

The review considered the National Governing Body (NGB) sports requirements and technical information for a wide range of products to establish general construction details, cost and performance data against BSEN 14904 : 2006. This is the main standard for indoor multi-sport flooring and includes a classification system for deformation and energy absorption characteristics. It includes the terms point elastic (P), mixed elastic (M), area elastic (A) and combined elastic (C)\(^1\) that are often used to describe sports floors.

An affordable sports floor

Typically, the installation costs for sports floor products range from £55 - £90 / m\(^2\) and the thickness ranges from 10 mm to over 100 mm above the structural floor slab. With court markings and fixings, this can represent a cost range from £40,000 to £65,000 for a 4 court sports hall. However, the selection of a multi-sports floor is problematic for a number of reasons:

- No single sports floor surface will fully meet the requirements of all the sports that are likely to be played in a school and community sports hall

- The published advice tends to be focused on the requirements (or preferences) of higher levels of play, rather than on an acceptable compromise for a multi-sports project

- The floor type classification in BSEN 14904 : 2006 allows an overlapping range of values for deformation and energy absorption. For example, an area elastic floor can have similar deflection and energy absorption characteristics to a point elastic or combined elastic. This means that an analysis of the cost benefits under these categories can be misleading.

There are also issues around general practice in school sports halls and perceptions of value for money. In the past, a point elastic (P1) type of sports floor product has often been used for physical education facilities in schools and is at the lower end of the cost range.

Whilst this type of product does give a degree of softness under foot and can be considered as a forgiving surface for activities for younger children, it also has some technical limitations. It does not have force reduction and deflection characteristics that are appropriate for many higher levels of sporting activities. These would include use by older children with higher body weight, training where there are high levels of repetitive actions and competitions where the level of activity may be more intense.

A higher performance multi-sports floor

An energy absorption of above approximately 45% has been taken as appropriate for a school / community facility in order to cater for a full programme of sports activities such as older children, adults, repetitive training and competition and give greater comfort and reduce the risk of injury. This is in line with the inclusion of a P3 point elastic floor as a quality / performance indicators in the Priority Schools Building Programme (PSBP).

However, a range of product types (i.e. point, area and combined elastic) should be considered against the priority sports, levels of play and other activities when deciding on the right sports surface for a particular project. See Sport England document ‘Developing the Right Sports Hall’.

https://www.sportengland.org/media/4659/developing-the-right-sports-hall-2012-rev-2.pdf

\(^1\) See Sport England Design Guidance Note Floors for Indoor Sports.
For this study it was concluded that a ‘low profile’ or ‘floating’ type of (A3) area elastic sports floor would be the best option in the context of the affordable sports hall project. In addition to the energy absorption characteristics already discussed, it is in the mid cost range and has the potential to avoid inconsistency of ball bounce that is perceived to be an issue for cricket and basketball. It also avoided the perception of being a slow surface for wheelchair sports.

Typically, a floor of this type would be between 40 - 50 mm in thickness and consist of:

- a sheet of poured wearing surface on a plywood deck that is laid onto a continuous foam energy absorbing / supporting layer
- Sealed timber planks on a continuous foam energy absorbing / supporting layer.

**Sports floor maintenance**

The establishment of an appropriate cleaning regime is important to ensure a clean, safe, long lasting and attractive sports floor and the manufacturer’s recommendations should be carefully considered.
Typical sports floor construction

**Point elastic:**
The energy absorption is provided by the c 8 mm shock pad.

**Area elastic** ('floating' or 'low profile' system):
This has an additional layer of plywood / timber to spread the loads and stiffen the system. The energy absorption is provided by the deflection in the plywood / timber layer and the c 20 mm shock pad.

**Area elastic** (on an 'undercarriage' system):
This has additional battens (and counter battens) supported on cradles. The energy absorption is provided by deflection in the timber/plywood layer / battens and in the shock pads under the supporting cradles.

**Combined elastic:**
A point elastic system on a ‘floating’ or ‘low profile’ energy absorbing system.

**Combined elastic:**
A point elastic system on an area elastic batten / cradle / shock pad undercarriage system.

- **Point elastic**
  (See BSEN 14904 : 2006 for shock absorption and vertical deformation criteria for types P1, P2 and P3)

- **Area elastic**
  (See BSEN 14904 : 2006 for shock absorption and vertical deformation criteria for types A3 and A4)

- **Combined elastic**
  (See BSEN 14904: 2006 for shock absorption and vertical deformation criteria for types C3 and C4)

Note: All dimensions are indicative. The specification and thickness of the materials used in the make up of a floor system will affect the performance qualities. For example, the deflection, energy absorption, slip resistance and ball bounce characteristics.
Appendix 5 : Acoustics

Key affordable assumptions
(within the design and costings)

Acoustic calculations required to establish the areas and performance of the sound abosrbing materials that are selected for:-

- Perforated roof decking over all of sports hall
- Acoustically ‘transparent' wall lining materials with acoustic absorbing panels behind
- Careful control of intrusive noise sources such as external noise, services, plant rooms and adjacent spaces.

Introduction

This Appendix contains additional information on the acoustic modelling, test results and design standards that have been used in the development of the acoustic design for the indicative 4 and 5 court sports halls.

General

The internal acoustic conditions within a sports hall should be appropriate for its intended use. It will be beneficial to all users that the ambient noise levels are low and that verbal communication is easily intelligible, being especially critical for people with hearing impairments or learning difficulties. This is particularly important for training, teaching / learning situations and activities that are accompanied by music.

In order to promote low ambient noise levels and good speech intelligibility, the control of reverberation within a sports hall is a key factor. Other important factors are the control of intrusive noise from external sources and from within the building such as services, plant rooms and adjacent spaces.

The intelligibility of speech depends upon its audibility as well as its clarity. Audibility is affected by the loudness of the speech relative to the background noise level. An increase in the background noise will cause greater masking of speech and hence will decrease intelligibility. It is possible to speak louder but this effect is limited and can also lead to voice strain.

A room with a long reverberation time of several seconds will cause syllables to be prolonged so that they overlap and hence degrade speech intelligibility. Long reverberation times occur in large rooms with hard wall and ceiling surfaces. Adding acoustic absorption will reduce the reverberation time and improve speech intelligibility.

Long reverberation times also increase reverberant noise levels within a room, which further decrease speech intelligibility. To compensate for this, in reverberant rooms people tend to increase their voice levels to make themselves heard over the reverberant noise, which further exacerbates the situation. This is a common feature of many sports halls with insufficient acoustic treatment.

Acoustic design should allow easy verbal communication with low ambient noise levels for the benefit of all users.

Design criteria

The table below provides a summary of acoustic criteria relating to sports halls.

<table>
<thead>
<tr>
<th></th>
<th>Sport England</th>
<th>Building Bulletin 93</th>
<th>CIBSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid frequency average RT</td>
<td>1.5 – 2.0 seconds</td>
<td>&lt; 2.0 seconds</td>
<td>-</td>
</tr>
<tr>
<td>Internal ambient noise level</td>
<td>NR40 (≈45dBA)</td>
<td>40 dBA</td>
<td>NR40 – 50 (≈45 – 55dBA)</td>
</tr>
</tbody>
</table>

* (for a floor area of >530m²)

Building Bulletin 93: Acoustic Design of Schools defines requirements in terms of the mid-frequency average: the arithmetic average of the three octave bands of 500, 1000 and 2000 Hz. This is required by Part E of the Building Regulations and applies to all school projects and Sport England guidance (see Sports Halls: Design and Layouts Design Guidance Note).
Calculations of reverberation time

The prediction of reverberation time can be divided into two principle categories; statistical formula calculation and three dimensional computer modelling, usually based on ray tracing techniques. For this review the ODEON proprietary room acoustic simulation software was employed with backup checks against statistical calculations using the Fitzroy technique.

Locations of sound absorption material

The location of acoustic absorption within a room is important. Many traditional calculation techniques assume that the absorbent surfaces in a room are reasonably evenly distributed. If this is not so, the reverberation time prediction is not valid and undesirable local variations in the acoustics can occur, particularly in large rooms such as sports halls. If there are large areas of acoustically hard parallel surfaces, flutter echoes can occur, significantly increasing the reverberation time and reducing speech intelligibility. A reasonable distribution of acoustic absorption will reduce this effect.

The acoustic modelling for this review has revealed that it is important for at least one out of each parallel pair of surfaces in the hall to have acoustically absorbent treatment - see diagram below.

Furthermore, the results of the modelling suggest that adding a greater area of acoustic absorption to one wall of a parallel pair may prove a more efficient means of providing the total required treatment than splitting the same area over both walls of a parallel pair. This probably has to do with the ray tracing technique, whereby statistically more rays will hit the larger area of acoustic treatment if applied to one wall only out of each pair than they would if half the area was applied to both. The other issue revealed is that acoustic absorption to the walls should be placed as low down as possible so that it is just above the occupied zone. These principles have been employed in the indicative designs.

Design scheme

The acoustic design for controlling reverberation for the Affordable Sports Hall scheme is to provide acoustic absorption to at least one long wall and one short wall above the rebound wall height of 2.55 m. Typically, to achieve BB93 reverberation time requirements the acoustic treatment should continue up to the underside of the roof on these two walls. However, to achieve a value in the range required by the Sport England criterion, the treatment could stop short of the roof by around 2 m. In addition to the wall treatment, an acoustically absorptive perforated roof deck is employed.

The upper wall finishes of the sports hall employ a tensioned mesh / netting that is hung from the steelwork and flush with the rebound below. This prevents shuttlecocks and balls from lodging on cladding rails and gives a consistent background and visual unity to the space (see Appendix 9). Two options for the mesh have been considered which depend on colour availability and reflectivity. One of the options is a relatively open mesh, the other is a tighter mesh. Some examples of the latter have laboratory measured acoustic absorption coefficients which show reasonably high absorption can be achieved when the mesh is installed over a void without any acoustic insulation behind. The test laboratory rig mounted the mesh sample on a solid framework forming an enclosed air volume. It is unknown how this may affect the acoustic absorption properties when installed in a building as proposed. However, it is likely that the full laboratory measured acoustic absorption performance would not be realised. This may be offset by the fact that there will be a greater area of the mesh than would be theoretically required for acoustic absorption purposes on the basis that the mesh will be applied to all four walls.
The other option considered is with a more open mesh with an acoustic absorption quilt installed behind it. It would be fixed to the inside face of the cladding using stick pins. The quilt would be a tissue faced and edged semi-rigid material and be a sufficiently open weave not to significantly affect the acoustic absorption properties of the quilt. The quilt would be applied to one long and one short wall only. The total area of quilt that should be applied to achieve the alternative reverberation time requirements as discussed above.

**Design approach**

During the development of the design options presented in this review and before developing the final scheme, a range of acoustic lining and panel products were evaluated.

**Ambient noise**

The two principle sources of ambient noise within a sports hall are likely to be external noise intrusion and mechanical services noise. External noise intrusion will be governed by site conditions and proximity to major roads or other sources of noise and the sound insulation of the external building fabric. The regulations for new school buildings require a sports hall to have an internal ambient noise level of 40 dBA. The external building envelope of the indicative designs has been given a sound insulation performance that could achieve the required internal acoustic environment for external noise levels up to 57 dBA, using the school criteria and noise levels up to 63 dBA using the Sport England criteria. The site specific noise characteristics of a particular site may require enhancements to the external building fabric. The weakest element is the cladding followed by the wind catcher roof terminals. To improve the sound insulation of the cladding panels, internal lining could be added but this may affect the void behind the mesh and alter the acoustic absorption properties depending on the enhancement required. The sound insulation performance of wind catcher roof terminals can be improved by adding internal acoustic linings.

Gas radiant heating systems have been selected for the indicative designs. Typically, these employ two lengths of radiant heating tubes, extending the length of the hall, with two gas burners feeding each run, one primary burner at the start of the tube and a slightly smaller booster burner half way along the radiant tube, making four burners in total. The flues from the burners are collected into a single flue which is then ducted to a (usually) remote flue vacuum fan. This system generates some noise at each of the burners, predominately caused by regenerated airflow noise as combustion air is drawn through air inlets on the burners.

Recent factory tests have suggested that the free field sound pressure levels of the primary and secondary burners used in a sports hall system are important in meeting the required standard. The following values were achieved during the tests and when used in calculations for predicting noise levels showed compliance with BB93 and Sport England noise criteria:

- Primary Burner 46 dBA at 1 m
- Booster Burner 46 dBA at 1 m
- Assumed:
  - mounting height 7.5 m above floor level in a 4 court hall
  - reverberation time of 2 seconds
  - predicted noise level at 1.5 m above floor level.

Care should be taken when setting up the flue fan system to ensure that the vacuum fan is located in the plant room and that the appropriate airflow and fan attenuation is provided.

**Affect of ambient noise on speech intelligibility**

For a given vocal effort, speech intelligibility will reduce as the ambient noise level from other sources increases. The three graphics overleaf have been generated from the acoustic models to demonstrate the effect of ambient noise levels on speech intelligibility.

A further indication of the relationship between the value of the speech transmission index (STI) parameter and speech intelligibility is that a STI value of at least 0.5 is considered the minimum permitted value for announcements arising from public address systems in public places.

<table>
<thead>
<tr>
<th>Range of STI values</th>
<th>Subjective impression of speech intelligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.32</td>
<td>Bad</td>
</tr>
<tr>
<td>0.32 – 0.45</td>
<td>Poor</td>
</tr>
<tr>
<td>0.45 – 0.60</td>
<td>Fair</td>
</tr>
<tr>
<td>0.60 – 0.75</td>
<td>Good</td>
</tr>
<tr>
<td>&gt; 0.75</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
The following diagrams depict a single noise source representing a person speaking with a raised voice positioned near the corner of the hall. The graphics vary only by the underlying ambient noise. Three conditions have been chosen:

- no ambient noise representing best case conditions
- a noise level of 40 dBA as would be BB93 compliant
- a noise level of 50 dBA (typically, the noise level generated from an inappropriately installed heating system).

The coloured graduated scale below shows the value of STI at any given position within the hall.

It can be seen that the area around the hall where an STI of 0.5 or greater is achieved becomes increasingly smaller with increasing ambient noise level. However, good speech intelligibility is still achieved in the presence of the high ambient noise level at a reasonable distance from the speaker.

**Internal sound insulation**

Another acoustic consideration within a sports hall building is the provision of appropriate internal sound insulation separating spaces capable of generating high levels of noise from those which may be sensitive to noise intrusion. Examples of spaces capable of generating high levels of noise would include the following:

- Plant rooms
- Dance / fitness rooms
- Changing rooms.

It is good practice wherever possible to separate such spaces with buffer zones such as circulation spaces / corridors or storage areas, etc. In most cases in these schemes high noise level areas are separated in such a way. One direct adjacency that should be considered, however, is between the plant room and the main hall. Some of the mechanical services options include CHP plant which can be quite noisy. The primary aim should be to select plant with lower noise level emissions wherever possible.

It has been found that the noise levels of CHP plant providing the required duty can vary significantly by manufacturer. Once the plant has been selected, the appropriate sound insulation of the separating wall should be chosen to achieve the required noise criterion within the hall. For a school facility, the walls separating the changing rooms from the fitness studio should provide a minimum measured sound insulation of 45 $D_{min}$. This can be achieved with the appropriate configuration of standard stud partitions.
Appendix 6 : Structural Design

Key affordable assumptions
(within the design and costings)

• The structure for the affordable sport hall options comprises a simple braced frame with a 6° pitched roof and central ridge
• The approach gives an economical option for the support of the roof, external walls and fixed sports equipment (retractable basketball goals, lighting, netting)
• The structural grid(s) are coordinated around the badminton courts layout for the 4 and 5 court halls
• The design includes for flush rebound panels and full height lining to the inside and a flexibility to accommodate a range of lightweight external cladding systems
• A modified version of the structure is extended over the support accommodation

Introduction

This Appendix contains additional information on the structural design requirements for an Affordable Sports Hall structure and provides guidance for a detailed design. A number of different options for building materials and superstructure are discussed and a cost effective solution is presented.

The focus is on the main sports hall element as this makes up the bulk of the structure. The different options and layouts for the ancillary buildings are also covered.

Design criteria including general assumptions for gravity and lateral loadings, materials, deflection and site conditions are discussed. These design criteria and assumptions form the guide for a detailed design exercise.

Assumptions

The following has been assumed:

• **Design life** – A 60 year design life.
• **Site conditions** – A flat site with access available for delivery vehicles and construction machinery.
• **Ground conditions** – Ground bearing capacity of 150 kilopascals (kPa) capable of supporting localised concrete pad foundations and ground bearing concrete slabs.
• **Fire requirements** – A stand-alone building with no fire protection required to the structure for the sports hall element. Fire protection may be required for the ancillary and mezzanine plant areas of the building. To establish the fire protection requirements for a particular project, the advice of a suitably qualified specialist consultant should be obtained / appointed at an early stage in the design process. If a portal frame option is chosen, the siting of the building may require ‘boundary condition’ design criteria to be considered.
• **Building form** - A stand-alone building structure with no shelter from wind or snow by any existing structures.

Roof plan of 5 court sports hall (option 2c)
**Design loads**

The following table provides guidance for general loading and should be used as the basis for design where no other information is available. Prior to the final design of any individual project the loading would need to be reviewed to take into account specific site conditions and actual construction materials.

### Permanent loading (Gk)

<table>
<thead>
<tr>
<th>Description</th>
<th>Location</th>
<th>Uniform load</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self weight of all structural elements</td>
<td>All</td>
<td>Calculation based on volume x density</td>
<td></td>
</tr>
<tr>
<td>Roof: photovoltaic panels</td>
<td>Main roof</td>
<td>0.15kN/m²</td>
<td></td>
</tr>
<tr>
<td>Roof: suspended services</td>
<td></td>
<td>0.40kN/m²</td>
<td></td>
</tr>
<tr>
<td>Roof: suspended sports equipment</td>
<td></td>
<td>tbc</td>
<td>See ¹</td>
</tr>
<tr>
<td>Suspended ceilings</td>
<td>Ancillary buildings</td>
<td>0.25kN/m²</td>
<td></td>
</tr>
<tr>
<td>External wall cladding</td>
<td></td>
<td>0.50kN/m²</td>
<td></td>
</tr>
<tr>
<td>Partitions (internal walls, etc.)</td>
<td></td>
<td>1.00kN/m² on plan</td>
<td></td>
</tr>
</tbody>
</table>

### Variable loading (Qk)

<table>
<thead>
<tr>
<th>Description</th>
<th>Location</th>
<th>Uniform load</th>
<th>Point load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof (non-accessible)</td>
<td>Typical roof</td>
<td>0.6kN/m²</td>
<td>0.9kN</td>
</tr>
<tr>
<td>Plant room loading</td>
<td>Plant rooms</td>
<td>7.5kN/m²</td>
<td>4.5kN</td>
</tr>
<tr>
<td>Dance halls, studios, gymnasia</td>
<td>Sports halls, fitness studios</td>
<td>5.0kN/m²</td>
<td>3.6kN</td>
</tr>
<tr>
<td>Public areas</td>
<td>Changing rooms, reception areas</td>
<td>3.0kN/m²</td>
<td>4.0kN</td>
</tr>
<tr>
<td>Construction and ongoing maintenance vehicles</td>
<td>Sports hall</td>
<td>To be assessed</td>
<td>Assume FLT / scissor lift with point load of 25Kn</td>
</tr>
</tbody>
</table>

---

¹ Sports equipment suspended from the roof structure could include separation curtains, cricket nets, drop down basketball goals, score boards, etc.

² On suspended floors design dynamic natural frequency is to be considered.
Deflection limits

The following deflection limits have been assumed based on BSEN 1990-1-1:1984 recommendations for permanent and variable loading. The table illustrates that different materials may attract different deflection criteria and this may increase the weight of structure required to support that finish.

<table>
<thead>
<tr>
<th>Area</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical floors</td>
<td>Lesser of span / 250 or 20mm</td>
</tr>
<tr>
<td>Cantilever floor</td>
<td>Lesser of span / 125 or 20mm</td>
</tr>
<tr>
<td>Typical roof</td>
<td>Span / 150</td>
</tr>
<tr>
<td>Cantilever roof</td>
<td>Span / 75</td>
</tr>
<tr>
<td>Typical columns supporting flexible cladding</td>
<td>Height / 300</td>
</tr>
<tr>
<td>(composite panels)</td>
<td></td>
</tr>
<tr>
<td>Typical columns supporting brittle cladding</td>
<td>Height / 500</td>
</tr>
<tr>
<td>(masonry)</td>
<td></td>
</tr>
</tbody>
</table>

Effects of increased snow and wind loads

Wind and snow loading will vary between sites and will therefore need to be assessed on a site specific basis. Sites with higher wind and snow loading will normally require an increase in structural steel weight to resist the higher loading.

Materials

Reinforced concrete strength and specification

The design of all reinforced concrete elements has been based on using grade RC 28/35 concrete. Concrete should meet the specifications and testing requirements of the relevant national design codes. Consideration will need to be given to any site specific durability requirements for the concrete mix.

Reinforcing steel bars, stirrups and mesh with minimum yield strengths of 500 N/mm² have been used in the design. All reinforcing steel should meet the specifications of the relevant national design codes.

Structural steel strength and specification

Grade S355 steel has been assumed for the design of all structural elements including beams, columns and bracing members. For some elements where member size is governed by deflection criteria, not strength criteria, it may be more economical to use Grade S275 steel. Structural steel should meet the requirements of the relevant national design codes.

Substructure

Foundation options

Foundations will need to be designed on a site specific basis as the design will depend on the ground conditions found at the site and the imposed wind / snow loadings. A detailed geotechnical investigation will be required to determine the below ground conditions.

This will comprise a phase 1 desk study followed by an intrusive phase 2 on-site investigation. The subsequent reporting should be ‘interpretive’, with recommendations on the foundation design criteria, construction constraints, contamination, ground water levels, etc.

Depending on the ground conditions, either shallow foundations such as pads or rafts; or deep foundations such as piles may be required. In all cases, an edge beam would be required around the perimeter of the building, extending to depths that suit both ground conditions and external levels.

For this review, a site with good ground has been assumed. This is ground with a minimum allowable bearing capacity of 150 kPa, flat and homogenous across the site. For sites that meet these assumptions, localised shallow pad foundations were found to be the most economic.

Typical shallow pad foundations consisting of concrete pads nominal 1000 x 1000 mm square, 600 mm deep, are allowed for under column positions. These would vary across the building, with some being smaller and others larger, such as beneath the braced bays. Reinforcement may be required in the pad foundations and ground beams adjacent to the braced bays to resist uplift.

An edge beam is also required around the edge of the building as discussed above. The width and arrangement of the ground beams is dictated by the set-out of the external walls. The ground floor slab is assumed to support all imposed and permanent floor loads.

Floors

The ground floor for the sports hall and ancillary elements of the buildings should be formed of reinforced concrete. For most cases, this will be a ‘ground bearing’ slab, but on sites with very poor ground the slab may require to be a suspended concrete slab spanning between reinforced concrete ground beams. In all cases, a damp proof membrane will be required (refer to Appendix 3 Building Fabric for details).

Floor finishes must be carefully considered in conjunction with the layout and detailing of construction and movement joints in the ground floor slab. Whilst the final arrangements will need
to be agreed with the Building Contractor, a clear strategy regarding slab joints and finishes must be determined.

For this review, a 150 mm thick reinforced concrete slab was found to be adequate to support the permanent and imposed floor loads. This should be supported on compacted hard fill and 50 mm concrete blinding. Under floor insulation will generally be required and will be specified by the Architect. Where this is required it should be capable of supporting minimum imposed loads of 20 kPa or a 20 kN point loadings.

### Slab thickenings and ground beams

Some sports equipment such as volleyball posts require deep support sockets within the floor slab. These are to enable the sports equipment to be put up and taken down as required and to provide a flush floor surface when they are not in use.

This is typically achieved by casting sockets or connection plates into the ground floor slab. The floor slab will require localised thickenings under these connection points. These will need to be designed on a project specific basis as it will depend on the type of sports included and the type of equipment selected.

For the loadings and assumptions listed above, the ground floor slab is capable of supporting all permanent and imposed loads. If, for a particular project, the floor loads increase, the slab may require additional slab thickenings or ground beams. This will need to be assessed on a project specific basis.

### Superstructure

#### Roof structure

Two options were considered for the roofing support structure:

- **Option 1** was to use a structural metal deck, with insulation and profiled deck over. The metal deck spans between main roof beams which removes the requirement for purlins. It also provides full lateral restraint to the main roof beams. The deck is only capable of supporting lightweight services; all other services have to be supported off main roof elements or specifically designed secondary beams.

- **Option 2** was to use Z-purlins spanning between roof beams to support the roof deck, allowing for a lighter and shallower roof deck as the span can be reduced considerably.

For this exercise, **Option 1** was selected, however project specific preferences might determine otherwise as the difference between the two options is not significant.

### Structural frame

For this review several structural framing options were considered for the superstructure of the sports hall. Options considered include both structural steel and Glulam and Cross Laminated Timber (CLT).

Two structural steel options were progressed as structural steel is considered a more economic and widely used material. Timber Glulam roof beams supported on steel columns were also considered, but were not progressed due to the size of timber beams required. Preliminary sizing of the timber beams indicated 1.1 - 1.5 m deep beams, depending on spacing.

The two structural steel options considered were:

- **Option 1** – Steel portal frame:

  Steel portal frames on grids with every second beam on the centre line between badminton courts spanning the width of the sports hall. Bracing against lateral loads is provided by the portal frames in one direction and through steel cross bracing in the other direction. The portal frame option will require larger column sections to provide enough stiffness against lateral loads. A larger portal column would necessitate a change in the elevations of the building as the columns and their cladding would extend beyond the outer face of the outside walls.

- **Option 2** – Braced steel frame:

  Roof beams on a grid with every second beam on the centre line between badminton courts spanning the width of the sports hall. These are supported on steel columns at each beam location. Bracing against lateral loads is provided by cross bracing in the roof and in some wall panels.
Solution

For this design review and based on the assumptions listed above, it was found that the cost differences were not significant when considered as a percentage of the overall budget. The design exercise found that Option 2, for the structural frame, provided the most economic overall design when considered in conjunction with all project requirements. Principal issues relating to that choice included:

- Providing a cost effective frame design
- The design minimises the wall thickness, the internal footprint and allows for columns to be within the wall thickness.
- Internal column projections are not considered acceptable.
- Slender and duo pitched rafters allow for a clear service distribution zone.

Roof beams

Roof beams have been chosen to allow services to pass beneath, provide a structurally efficient solution and also to provide an element of structure to which the track for the court dividing nets can be fixed. The rafter would be duo pitched at 6° to allow for an economical roof build-up.

Columns

For the braced frame option universal column sections will be chosen as columns governed by the gravity roof loads and wind loadings appropriate to the site. The main columns will be located below each roof beam will also be sized to limit horizontal deflections that could cause damage to the cladding. Smaller column sections may be provided at regular centres along each wall to suit the cladding design. Bracing will be provided to resist horizontal wind loads on the building.

Cladding

Composite panels were assumed for the external cladding and a combination of ply / netting assumed for the internal cladding. These are flexible cladding materials and can tolerate a higher level of movement than more brittle cladding types. Brittle cladding materials include block, brick and plasterboard. Deflection criteria would need to be assessed for each project based on the building materials selected. The indicative design may need to be modified for such alternative materials.

The wall cladding would be supported on horizontal cold rolled cladding rails which span between the main columns. Additional wind posts may be required, along with cold rolled trimmers around doorways.

Walls

This review has concluded that the most economic and appropriate solution is for a low level (2.55m high) rebound wall in phenolic coated WBP ply fixed to battens on horizontal cold rolled sheeting rails (refer to the cross section on page 12 of this document). Above 2.55m would be specialist netting.

If an alternative wall construction is used as discussed in Appendix 3, appropriate adjustments would be necessary to the design of the foundation and structural frame. For blockwork, particular attention should be given to the additional dead loading, vertical movement joints at column locations and reinforcement, dependent on the arrangement and aspect ratio of the wall panels. Often the walls are terminated at 2.55m high for the sake of economy.

Secondary structure

Secondary structure may be required to support sports equipment and services that are supported off the walls or suspended from the roof. These will need to be designed for a specific project based on the sports equipment and services that are used.

The fixing of secondary / practice basketball goals to the walls will need careful consideration due to the loads imposed by players swinging on the baskets. Secondary steel may be required to ensure robust fixings for the goals.

Supporting areas

The supporting areas of the building options vary in size and include changing rooms, toilets, entrance lobbies, storage areas and fitness studios and plant rooms. These areas are all integral with the structural design of the main sports hall.

The structure for these areas should be constructed using steel beams and columns similar to the main sports hall where possible. Roof beams should be located at the same gridlines as the sports hall to allow columns in the sports hall to be utilised. An economic solution for the mezzanine floors for plant areas would be concrete slab on metal deck supported by composite steel beams.
Appendix 7 : Energy and Sustainability

Key affordable assumptions
(within the design and costings)

Energy conservation measures
- Natural ventilation to the sports hall
- Mechanical ventilation with heat recovery to the changing rooms, studios and fitness suite with heat recovery
- Demand led controls with variable speed drives to all fans and pumps
- Absence detection lighting controls to ancillary areas, option for different light levels to sports hall
- LED lighting to all areas except the sports hall

Renewable technologies
- Solar photovoltaic panels included within scheme

Water conservation
- Timed shower and wash hand basin flow controls
- 9l/min flow rate shower heads
- Dual flush WC's

Metering and monitoring
- Lighting and small power separately metered
- Mechanical plant independently metered
- Hot water use separately metered

Introduction
This Appendix contains additional information on the energy and sustainability aspects of the indicative design options including the requirements of Part L2A 2013 of the Building Regulations and Local Authority requirements for renewable energy. A comparison with BREEAM ratings and carbon reduction measures are also considered.

Local planning criteria
The renewable energy requirements of the Local Authority (LA) needs to be ascertained for a potential development as part of the overall energy assessment for the site, as this may differ from one LA to another. For example, some may simply request 10% renewables and others, such as the Greater London Authority (GLA), may ask for as much as 30% improvement over and above the current Part L requirements. They may also define their requirements in terms of low and zero carbon reduction targets rather than a percentage of renewables. The indicative designs described earlier in this review incorporate such technologies, for example, photovoltaic (PV) panels or small scale combined heat and power (CHP) unit and these could be used to offset any additional planning conditions. However, this would have to be reviewed on a site-by-site basis.

Building Regulations: Approved Document Part L2A

Since the original publication of this document the Building Regulations part L2A has been updated with the intention of delivering a nine percent reduction in carbon dioxide emissions across the new non-domestic building mix relative to Part L 2010.

Criterion 1 of Part L 2013 requires that the actual Building CO$_2$ Emission Rate (BER) should not exceed the target CO$_2$ Emission Rate (TER). The TER is calculated based on a notional building of the exact same size, location and orientation as the proposed building. The fabric and services specifications of the notional building are given in the National Calculation Methodology (NCM) modelling guide. If the actual building is constructed entirely to the notional building specification then it will meet the TER. However, if any variation on the specification is made then improvements over the notional building will have to be made elsewhere (in the form of improved fabric or services efficiencies or additional low or zero carbon Technologies) to make up for it.

For example, the notional building assumes a certain amount of glazing on all exposed facades. The Affordable Sports Halls have very few windows and hence very little natural light. Therefore, the lighting demand of the actual building is much higher than that of the notional building so improvements over the notional building will have to be made elsewhere.

One area that was found to be particularly sensitive to the output from the National Calculation Methodology was the level of lighting assumed in the sports hall. The lighting level assumed in the Notional Building is 300lux while the base scheme design is for 500lux. Immediately the affordable design is at a disadvantage compared to the Notional Building and compensatory measures must be included. In designing a building to meet part L2A 2013, a design light level of 400lux has been taken as the average of the hall being used at 300lux for 50% of the time and...
500lux for 50% of the time. In addition, calculations have been run assuming four and ten hours of lighting at 750lux per week for cricket use.

Whilst it is not necessary for all fabric properties to meet the standard of the notional building, Criterion 2 of the Building Regulations Part L 2013 sets limiting values on the fabric properties of the building.

In order to lower the BER there are three broad areas that we can make improvements to:
- Fabric efficiency
- Services efficiency and controls
- Addition of Low and Zero Carbon Technology (LZCT)

Thermal envelope U-values

Thermal envelope U-values have been left unchanged from the previous publication of this document. It was found that improving U-values had an ever diminishing return on improvement on the Building Emission Rate and resulted in limiting construction methods that could be used. The table below lists the U-values used in the base scheme design alongside the values assumed in the Notional Building and the legal limiting values within part L2A 2013.

<table>
<thead>
<tr>
<th>Element</th>
<th>Part L 2013 limiting values</th>
<th>Notional building</th>
<th>Base scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>0.25 W/m²K</td>
<td>0.18 W/m²K</td>
<td>0.14 W/m²K</td>
</tr>
<tr>
<td>Walls</td>
<td>0.35 W/m²K</td>
<td>0.26 W/m²K</td>
<td>0.22 W/m²K</td>
</tr>
<tr>
<td>Floor</td>
<td>0.25 W/m²K</td>
<td>0.22 W/m²K</td>
<td>0.20 W/m²K</td>
</tr>
<tr>
<td>Windows and rooflights (if used)</td>
<td>2.20 W/m²K</td>
<td>1.50 W/m²K</td>
<td>1.50 W/m²K</td>
</tr>
<tr>
<td>Air permeability</td>
<td>10 m³/hr/m²</td>
<td>7 m³/hr/m² *</td>
<td>5 m³/(hr/m²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 m³/hr/m² **</td>
<td></td>
</tr>
</tbody>
</table>

* Sports hall
** Rest of building

Thermal bridging

The proposed U-values listed above include a margin of 0.035 W/m²K for repeating thermal bridging that is added to the proposed U-values and used in the thermal and energy models.

Air permeability

The maximum allowable figure under the current Part L2A 2013 legislation is 10 m³/hour/m², at 50 Pa. However, the more airtight the building, the more efficient it becomes. Therefore, an air permeability of 5 m³/hour/m² has been used for the sports hall option and a standard of construction and sealing of the building services in line with best practice has been assumed.

Transparent surface properties

The glazed areas should be designed to limit glare and heat gains but allow sufficient daylight in the buildings. The buildings also need to comply with the solar gain criteria 3 in Part L2A 2013. This limits the amount of heat gain through the transparent surfaces in the buildings. The parameters listed below have been used for transparent elements of the thermal envelope.

<table>
<thead>
<tr>
<th>Element</th>
<th>Minimum daylight transmission</th>
<th>Maximum G-value (BSEN 410)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facade typical windows</td>
<td>0.7</td>
<td>0.4</td>
<td>No windows to sports hall. Black out blinds are not considered essential to windows for ancillary accommodation</td>
</tr>
<tr>
<td>Roof lights (if used) to sports hall</td>
<td>0.55</td>
<td>0.5</td>
<td>Black out blinds are essential</td>
</tr>
<tr>
<td>Blinds</td>
<td>-</td>
<td>0.5</td>
<td>-</td>
</tr>
</tbody>
</table>
Sustainability

The table presented in the Environmental Services section of the main ASH document details the technologies that are required to meet the requirements for the conservation of fuel and power under the Building Regulations Part L2A 2013.

Overview of sustainability factors

<table>
<thead>
<tr>
<th>Energy efficiency measures</th>
<th>Zero / low carbon technology</th>
<th>Minimum waste and pollution measures</th>
<th>Operational performance measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lighting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Movement sensors where appropriate</td>
<td>• Photovoltaic panels (PV)</td>
<td>• Use of recyclable materials</td>
<td>• Energy and water metering, benchmarking and monitoring</td>
</tr>
<tr>
<td>• Use of natural light</td>
<td>• Combined heat and power (CHP) units</td>
<td>• Use of recycled materials</td>
<td>• Ongoing operational and management monitoring</td>
</tr>
<tr>
<td>• Daylight control of lights</td>
<td>• Air source heat pumps (ASHP)</td>
<td>• Packaged plant elements</td>
<td>• Making seasonal adjustments</td>
</tr>
<tr>
<td>• Low energy lamp sources</td>
<td>• Ground source heat pumps (GSHP)</td>
<td>• Insulation with low embodied energy</td>
<td></td>
</tr>
<tr>
<td><strong>Ventilation</strong></td>
<td>• Wind turbines</td>
<td>• Water saving sanitary appliances</td>
<td></td>
</tr>
<tr>
<td>• Variable speed drives on fans (VSD)</td>
<td>• Solar thermal panels</td>
<td>• Grey water harvesting</td>
<td></td>
</tr>
<tr>
<td>• Natural ventilation</td>
<td>• Biomass boilers</td>
<td>• Rainwater harvesting</td>
<td></td>
</tr>
</tbody>
</table>

**Building management system**

- Central and local light switching
- Heating controls to optimise efficiency

**Energy efficiency measures**

A range of energy efficiency measures are available in order to reduce the cost of running the facility, and these will also have a benefit during normal hours of use (outside community usage).

**Lighting**

On lighting, LED and fluorescent are the leading technologies in efficient indoor space lighting, both with competing efficiencies and lifespans. They are still evolving at a fast pace, constantly improving their performances. LEDs still require a higher initial investment, but bring in return a longer lifespan: if used, they should be installed in the areas that need to be lit most in order to improve return on investment, and bring the benefit to switch on at full brightness.

Additionally, limiting lighting to the periods of time when it is strictly required, by improving controls will reduce electricity usage. Presence detectors and photo-sensors are technologies that provide an automatic and localised control for lighting that proves more effective than human control.

The use of daylight should be assessed as it decreases the need for artificial light and increases solar gain to heat the indoor space; however, it does impact on the building’s thermal envelope.
performance. Additionally, some sports do not support the use of rooflights for performance and safety reasons and as a result it is necessary to include black out blinds for the occasions where rooflights interfere with the relevant sport. No rooflights are used in the design of the ASH model.

Further information on lighting can be found in Appendix 9 on lighting.

Ventilation

The design includes roof mounted windcatchers in order to maximise natural ventilation and mechanical booster fans for the summer. Where mechanical ventilation is used, the development of variable speed drives to adjust the aeration fan’s speed will reduce electricity usage significantly.

Building management systems

In order to optimise the usage of lighting, heating and ventilation to the buildings requirements at a specific time, Building Management Systems allow for monitoring of the building’s conditions, and only activate a component when required, avoiding the wastage associated with over-lighting, over-heating or over-ventilating. The more localised the sensing of a building’s parameters and the activation of the correction measure, the more effective the Building Management System.

Zero / low carbon technologies

There are a number of financial incentives available to different forms of low and zero carbon energy technologies which should be considered and included in feasibility studies, such as the Feed-in-Tariffs (FITs) and the Renewable Heat Incentive (RHI). These schemes are updated on a regular basis and the latest rates should be considered from the feasibility study stage.

The energy strategy in each instance should be considered in terms of what fuel sources and capacities are readily available on site, the architectural design, compliance with the building regulations, energy specific planning conditions and the life cycle costs of any low and zero carbon technologies considered.

- **Photovoltaic (PV) panels:** This popular technology generates electricity from ‘free’ solar energy during day time. Typical return is between 5 and 8 years, depending on daytime electricity usage as current FIT financially favours the replacement of in-house electricity usage rather than export to the grid. Return can be optimised by providing excess electricity to the neighbouring buildings (e.g. the main school building) that may require electricity during day time. If roof area for the implementation of photovoltaic panels on sports hall is not an issue, the roof’s ability to bear the panels load should be ensured, and it is preferable to include this extra load from design stage, as well as to allow access for maintenance. A certain amount of electricity from solar PV will have to be generated as part of the scheme in order for the building to comply with the Building Regulations Part L2A 2013 and PV panels are part of the base scheme, but more panels can be installed in order to increase the building’s sustainability rating.

- **Combined heat and power (CHP) or cogeneration:** this technology allows for the generation of both electricity and heat for space or water heating. It is usually gas fired in the scale involved in Sports Halls infrastructure. It does however rely on a steady annual heat demand to be economical so the heat from the CHP can be put to good use. Consequently, the suitability of this technology to specific Sports Hall projects should be analysed carefully in order to ensure there is sufficient heat off take in the building. Neighbouring buildings could be considered too, as long as heating pipes can be installed to deliver the heat.

- **Solar thermal panels:** This technology partially heats water with ‘free’ solar energy; however, it usually requires a ‘top-up’ as the panels’ output temperature is not sufficient for domestic applications, and the technology is affected by climatic conditions. As a consequence, a realistic assessment of the hot water demand is critical to avoid over-sizing of the array. This technology currently benefits from the Renewable Heat Incentive, so this should be included in the feasibility study. If roof area for the implementation of solar thermal panels on sports hall is not an issue, the roof’s ability to bear the panels load should be ensured, and it is preferable to include this extra load from design stage, as well as to allow access for maintenance.

- **Biomass could be used in a dedicated biomass boiler for space and water heating, in which case the current supporting incentive is the Renewable Heat Incentive and should be considered in the feasibility study to ensure financial viability compared with gas. Source and quality of biomass should also be factored into any feasibility study. The availability of the boiler should be checked carefully with the technology provider and ensure some degree of downtime is affordable to the running of the facility otherwise a backup gas option should be installed too. Similarly to CHP, heat requirements from neighbouring buildings should be considered from the feasibility stage in order to optimise the
returns from this technology.

- Air and ground source heat pumps: both use the air conditioning technology with the use of a refrigerant gas changing phase (liquid/gaseous) to create heat or cool where desired. When used in space heating, they pump the energy required to evaporate the refrigerant gas from surrounding natural resources (air or ground), providing up to 4 times the amount of heat than the electricity used to run the system (effectively providing an efficiency of 400%, or Coefficient of Performance of 4 as commonly rated).

However, in most winter days air source heat pumps do not achieve this rating due to the varying surrounding climatic conditions relied upon by the technology. Ground source heat pumps on the contrary, due to the stable ground temperature and good soil / metal heat exchange can reach and keep to a COP of 4, but at an excess cost and space to install the external pipes. Similarly to solar thermal panels, this technology provides low temperature heat sources.

For space heating, it would generally be used in association with under floor heating if no ‘topping-up’ of heating is provided. Both technologies currently benefit from the Renewable Heat Incentive so this should be included in the feasibility study.

Wind turbines were not considered as part of this review as these are very site specific and would entail a local survey of land and buildings in the immediate vicinity.

**Energy efficiency parameters**

The following energy efficiency parameters for the mechanical and electrical systems were used as part of the energy model. Designers should strive to improve upon these parameters, where economically feasible, and hence reduce the requirement for low and zero carbon technologies.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Non-domestic compliance guide</th>
<th>Base scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers efficiency (gas)</td>
<td>91%</td>
<td>95%</td>
</tr>
<tr>
<td>Heat recovery efficiency</td>
<td>50%</td>
<td>60%</td>
</tr>
<tr>
<td>Specific fan power central (includes allowance for heat recovery)</td>
<td>1.8 W/l/s</td>
<td>1.8 W/l/s</td>
</tr>
<tr>
<td>Specific fan power local extract</td>
<td>0.3 W/l/s</td>
<td>0.3 W/l/s</td>
</tr>
<tr>
<td>Variable refrigerant flow</td>
<td>2.6</td>
<td>3.8</td>
</tr>
<tr>
<td>Luminaire efficacy (sports hall)</td>
<td>60 lm/W</td>
<td>57 lm/W</td>
</tr>
<tr>
<td>Luminaire efficacy (support spaces)</td>
<td>60 lm/W</td>
<td>80 lm/W</td>
</tr>
<tr>
<td>Power factor</td>
<td>--</td>
<td>&gt;0.95</td>
</tr>
</tbody>
</table>

The table on the next page details costs for alternative strategies to comply with the Building Regulations part L2A 2013. The overall costs for each scheme option are based on a scheme with LED lighting to the ancillary areas, fluorescent lighting to the Sports Hall and photovoltaic panels. Alternative costs are also provided for a scheme with LED lighting throughout with reduced or no PV requirements.

*It is recommended that all low and zero carbon technologies are considered carefully and with data specific to the project. A full life cycle cost analysis should be undertaken to ensure that the selected energy strategy is the most appropriate for a particular project.*
## Additional indicative base costs of alternative strategies for complying with Part L 2A 2013

<table>
<thead>
<tr>
<th>Scheme options</th>
<th>Description</th>
<th>M&amp;E installation costs</th>
<th>PV element</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option 1a</strong></td>
<td>4 court sports hall</td>
<td>Gas radiant panels to hall and electric heating and hot water to ancillary areas. LED lighting to ancillary and sports hall and 8836 kWhr PV.</td>
<td>£160,000</td>
<td>£27,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas radiant panels to hall and electric heating and hot water to ancillary areas. LED lighting to ancillary areas. Fluorescent sports hall lighting and 17662 kWhr PV.</td>
<td>£150,000</td>
<td>£54,000</td>
</tr>
<tr>
<td><strong>Option 1b</strong></td>
<td>4 court sports hall + changing</td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary and sports hall and 0 kWhr PV.</td>
<td>£208,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary areas. Fluorescent hall lighting and 7856 kWhr PV.</td>
<td>£198,000</td>
<td>£24,000</td>
</tr>
<tr>
<td><strong>Option 1c</strong></td>
<td>4 court sports hall + changing and health and fitness</td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary and sports hall and 0 kWhr PV.</td>
<td>£308,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary areas. Fluorescent hall lighting and 7858 kWhr PV.</td>
<td>£298,000</td>
<td>£24,000</td>
</tr>
<tr>
<td><strong>Option 2a</strong></td>
<td>5 court sports hall</td>
<td>Gas radiant panels to hall and electric heating and hot water to ancillary areas. LED lighting to ancillary and sports hall and 7852 kWhr PV.</td>
<td>£197,500</td>
<td>£24,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas radiant panels to hall and electric heating and hot water to ancillary areas. LED lighting to ancillary areas. Fluorescent hall lighting and 17643 kWhr PV.</td>
<td>£186,000</td>
<td>£57,000</td>
</tr>
<tr>
<td><strong>Option 2b</strong></td>
<td>5 court sports hall + changing</td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary and sports hall and 0 kWhr PV.</td>
<td>£247,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary areas. Fluorescent hall lighting and 10798 kWhr PV.</td>
<td>£236,000</td>
<td>£30,000</td>
</tr>
<tr>
<td><strong>Option 2c</strong></td>
<td>5 court sports hall + changing and health and fitness</td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary areas. Fluorescent hall lighting and 9809 kWhr PV.</td>
<td>£336,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas radiant panels to hall and gas boiler to ancillary areas. LED lighting to ancillary areas. Fluorescent hall lighting and 9809 kWhr PV.</td>
<td>£327,000</td>
<td>£30,000</td>
</tr>
</tbody>
</table>

### Notes
1. No cost entered means there are no additional building works associated with the option.
2. This allows for rooflights with remote controlled blackout blinds.
3. This allows for raising the roof over store / entrance and providing plant room above (part of).
4. This allows for plant room over the store / entrance areas.
5. This allows for full length plant room over store / entrance and raising the roof by approximately 500 mm over the changing area.
In addition to the base scheme design, a further option was tested using LED lighting to the sports hall within a luminaire efficacy of 92lm/W, in line with sports hall lighting products that are currently being marketed. The results are tabulated below.

<table>
<thead>
<tr>
<th>Lux level</th>
<th>Lamp type</th>
<th>1a</th>
<th>1b</th>
<th>1c</th>
<th>2a</th>
<th>2b</th>
<th>2c</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 lux</td>
<td>Fluorescent</td>
<td>180 m²</td>
<td>80 m²</td>
<td>80 m²</td>
<td>190 m²</td>
<td>100 m²</td>
<td>100 m²</td>
</tr>
<tr>
<td>750 lux 4 hr</td>
<td>Fluorescent</td>
<td>190 m²</td>
<td>90 m²</td>
<td>90 m²</td>
<td>200 m²</td>
<td>120 m²</td>
<td>110 m²</td>
</tr>
<tr>
<td>750 lux 10 hr</td>
<td>Fluorescent</td>
<td>200 m²</td>
<td>110 m²</td>
<td>100 m²</td>
<td>210 m²</td>
<td>140 m²</td>
<td>130 m²</td>
</tr>
<tr>
<td>400 lux</td>
<td>LED</td>
<td>90 m²</td>
<td>0 m²</td>
<td>0 m²</td>
<td>80 m²</td>
<td>0 m²</td>
<td>0 m²</td>
</tr>
<tr>
<td>750 lux 4 hr</td>
<td>LED</td>
<td>100 m²</td>
<td>0 m²</td>
<td>0 m²</td>
<td>80 m²</td>
<td>0 m²</td>
<td>0 m²</td>
</tr>
<tr>
<td>750 lux 10 hr</td>
<td>LED</td>
<td>100 m²</td>
<td>0 m²</td>
<td>0 m²</td>
<td>90 m²</td>
<td>10 m²</td>
<td>0 m²</td>
</tr>
</tbody>
</table>

**Notes**
- 400lux lighting level refers to a hall being used at 500lux for 50% of the time and 300lux for 50% of the time.
- 750lux 4hr refers to a hall being used at 750 lux for 4 hours per week for cricket use and then at an average of 400lux for the rest of the time.
- 750lux 10hr refers to a hall being used at 750 lux for 10 hours per week for cricket use and then at an average of 400lux for the rest of the time.

**Energy efficiency measures required to compensate for assumption of rooflights in notional model used in the national calculation methodology.**

- Notional model assumes 300lux internal lighting level.

**Requirement for renewable energy highly dependent of efficacy of lighting and design lighting levels.**

**Approach to part L compliance based on good fabric insulation levels with LED lighting to ancillary areas and photovoltaic panels.**
Appendix 8 : Building Services

Key affordable assumptions
(within the design and costings)

Sports hall

HVAC
- Gas fired radiant heaters
- Roof mounted ventilation terminals

Lighting
- Fluorescent lighting to 500lux with switching to 300lux and control to each badminton court

Changing rooms

HVAC
- Warm air heating from dedicated ventilation system with heat recovery

Lighting
- LED downlights with PIR control

Fitness suite and studios

HVAC
- Dedicated MVHR system with VRF heating and cooling

Lighting
- LED downlights

Common areas

HVAC
- Natural ventilation with LTHW radiator heating

Lighting
- LED downlights

Introduction

This Appendix contains additional information on the building services systems that have been selected for the indicative designs.

Access and maintenance

The access and maintenance requirements of the engineering services have been considered. This includes the legal requirements of modern design and construction, good practice design methods and plant replacement strategies. Risk assessments for any residual hazards need to be completed as part of the final scheme design. Access for major plant replacement will be established in principle. Lifting equipment, provided by a specialist lifting company for the removal of any large pieces of equipment, need to be considered due to the limited space available.

Statutory supplies and services provision

The existing utility services information should be obtained from the relevant supply authorities to establish the existing infrastructure details and capacity with any service diversion and disconnection requirements. If sufficient capacity is not available on the site, then applications for new supplies should be made to utility companies. The following table summarises typical supply capacities which would be required based on the energy strategies adopted. Supply capacity requirements should be reviewed on a site by site basis.

Gas, electricity and water supplies

<table>
<thead>
<tr>
<th>Scheme options</th>
<th>Gas (kW @ 21mbar)</th>
<th>Electricity (kVA)</th>
<th>Water (litres/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>135</td>
<td>35</td>
<td>0.55</td>
</tr>
<tr>
<td>1b</td>
<td>174</td>
<td>42</td>
<td>2.3</td>
</tr>
<tr>
<td>1c</td>
<td>185</td>
<td>105</td>
<td>3.8</td>
</tr>
<tr>
<td>2a</td>
<td>167</td>
<td>40</td>
<td>0.55</td>
</tr>
<tr>
<td>2b</td>
<td>206</td>
<td>47</td>
<td>2.3</td>
</tr>
<tr>
<td>2c</td>
<td>217</td>
<td>110</td>
<td>3.8</td>
</tr>
</tbody>
</table>
Telecommunication service provider connections

A total of two cable ducts should be allowed, one for the main telephone cable and one spare for future provision (cable or alternative providers). Each of the ducts is to run to the data / communications rack position within the reception area or office for the future installation of telecommunications cabling. The ducts are to conform to the specific requirements of the telecommunications companies with regards to construction and installation.

Draw wires are to be installed as necessary and the ends of the ducts adequately weatherproofed at the time of installation. Draw pits are to be provided where necessary for the installation of the telecommunication services. Adequate provision is to be made in terms of plant rooms, routes and risers providing adequate access for operation and maintenance and flexibility for the future. All plant and cabling to be concealed where possible.

Public health services

Codes and standards

The public health services are to be designed in accordance with current legislation and regulations and will also consider the following industry codes and guidelines:-

• Government legislation, regulations, requirements and byelaws
• Local Authority, Fire Officer, Utility Company statutory regulations and requirements
• Chartered Institute of Building Services Engineers documentation (CIBSE)
• Building Services Research and Information Association documentation (BSRIA)
• British Standards and European Norms
• The Chartered Institute of Plumbing and Heating Engineering (CIPHE) guidelines
• Current Building Regulations Approved Documents
• Local Authority Requirements
• Water Regulations Advisory Scheme (WRAS) Water Supply (Water Fittings) Regulations
• HSE Approved Code of Practice and Guidance L8 ‘Legionnaires’ Disease; the Control of Legionella Bacteria in Water Systems
• The buildings are to comprise a gravity drainage system to convey foul and surface water discharge from the buildings to the external public drainage network
• All areas above ground level are to discharge via gravity to new or existing sewer connections
• Drainage is to be provided to serve the areas at lower levels within the building
• Surface water cut off channels at points of entry and exit to the building
• Local drainage systems to wash down / wet areas
• Plant areas to be provided with gullies and drainage inlets.

### Public Health Codes and Standards

<table>
<thead>
<tr>
<th>System</th>
<th>Design Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foul and surface water drainage</td>
<td>BSEN 12056 and BSEN 752 : 2008, updated in 2009 and 2013. Foul water flows based on discharge unit method of calculation. Maximum hydraulic depth of flow 0.75. Velocity of flow 0.75 to 1.2 m/sec.</td>
</tr>
<tr>
<td>Rainwater drainage</td>
<td>BSEN 12056 Part 3.</td>
</tr>
<tr>
<td>Incoming domestic cold water supplies</td>
<td>Sized at 1 bar mains pressure with a maximum velocity of flow of 1.5 m/sec.</td>
</tr>
<tr>
<td>Domestic cold water storage</td>
<td>Hot water storage provided equating to enable supply of peak demand in accordance with BSEN 806-3 : 2006 and the CIPHE loading unit method.</td>
</tr>
<tr>
<td>Hot and cold water pipe work distribution</td>
<td>BSEN 806-3 : 2006 and the CIPHE loading unit method. Maximum velocity of flow restricted to 1.5 m/sec.</td>
</tr>
<tr>
<td>Above ground sanitation</td>
<td>BSEN 12056 Part 2 System 1 based on a frequency factor of 1.</td>
</tr>
</tbody>
</table>
Above ground sanitation systems

The sanitation and rainwater systems are to be designed to comply with Local Authority requirements and the local system network. Disconnecting traps are to be provided on both foul and surface water drainage systems to prevent the egress of foul air from the public sewerage network.

The sanitation systems are to operate by means of gravity serving all fittings from ground level. Soil / waste stacks with anti-siphon / relief vents to collect discharges from all fittings associated with the development. All vent pipes are to terminate through the roof and discharge to the atmosphere.

Above ground rainwater systems

The rainwater systems are to be designed to comply with Local Authority requirements and sewer connections. The rainwater systems are to be designed in accordance with BSEN 12056-3 : 2000. Surface water drainage, including rainwater outlets, hoppers, drains and gutters, are to be provided to serve roof areas.

Potable cold water distribution for domestic purposes

The mains water should be supplied at a minimum of 1 bar at the point of supply. The water meter should be located in an underground chamber on hard surfaces. The incoming mains should be sized to supply potable water to the toilets and showers areas. Incoming mains should be supplied via a magnetic conditioner installed internally. A storage tank and booster set may be required if a suitably sized incoming water main is not available on site.

Hot water generation and distribution

For the stand-alone 4 and 5 court options (options 1a and 1b), local electric heaters provide hot water in the accessible toilet and cleaners store.

For the other building options incorporating changing facilities, hot water generating plant is to be provided to serve the toilet and shower areas designed in accordance with the energy strategies. In the instance where small scale CHP is used, hot water storage capacity needs to be considered to ensure that the heat is used effectively. The heat source for hot water generation will generally be via Low temperature hot water (LTHW) primary flow and return pipe work.
**Mechanical services**

**Design criteria**

The design of the mechanical services should be based upon the design criteria listed below. Each of the identified criteria are to be in accordance with current good practice design and as recommended by the CIBSE, Institution of Engineering and Technology (IET), Building Regulations and British Standards.

### External design conditions

<table>
<thead>
<tr>
<th>Season</th>
<th>Criteria</th>
<th>Criteria Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summer</strong></td>
<td>For sizing cooling installations</td>
<td>31°C dry bulb, 21°C wet bulb</td>
</tr>
<tr>
<td></td>
<td>For natural ventilated</td>
<td>Overheating criteria as set out in CIBSE AM10 for public use. Overheating criteria as set out in Building Bulletin BB101 for school use.</td>
</tr>
<tr>
<td></td>
<td>For sizing of air cooled condensing units and adiabatic heat rejection plant</td>
<td>35°C dry bulb</td>
</tr>
<tr>
<td><strong>Winter</strong></td>
<td>For sizing heating</td>
<td>-5°C / 100% RH</td>
</tr>
<tr>
<td></td>
<td>For sizing protective installations (e.g. trace heating, antifreeze concentrations, etc)</td>
<td>-15°C / 100% RH</td>
</tr>
<tr>
<td></td>
<td>Air frost projection coils</td>
<td>-10°C / 100% RH</td>
</tr>
</tbody>
</table>

### Internal design conditions

<table>
<thead>
<tr>
<th>Area</th>
<th>Season</th>
<th>Temperature</th>
<th>Fresh air</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sports hall</strong></td>
<td>Summer</td>
<td>Overheating criteria as set out in CIBSE AM10 for public use. Overheating criteria as set out in Building Bulletin BB101 for school use.</td>
<td>12 l/s/person and to comply with overheating criteria for the internal summer temperature.</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Set point to vary from 12 to 16°C dry bulb subject to level of activity played on main active sports. However, temperatures of up to 20°C may be required for less physically intensive sports.</td>
<td>3 l/s/person and to comply with indoor air quality criteria set out in CIBSE AM10</td>
</tr>
<tr>
<td><strong>Reception and enclosed offices</strong></td>
<td>Summer</td>
<td>Overheating criteria as set out in CIBSE AM10 for public use. Overheating criteria as set out in Building Bulletin BB101 for school use.</td>
<td>10 l/s/person and to comply with overheating criteria for the internal summer temperature.</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>21-23°C dry bulb</td>
<td>10 l/s/person</td>
</tr>
<tr>
<td><strong>Toilets</strong></td>
<td>Summer</td>
<td>Uncontrolled</td>
<td>&gt;5 ac/h</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>19-21°C</td>
<td>&gt;5 ac/h</td>
</tr>
<tr>
<td><strong>Changing areas and showers</strong></td>
<td>Summer</td>
<td>Uncontrolled</td>
<td>&gt;6 ac/h</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>22-24°C dry bulb</td>
<td>&gt;6 ac/h</td>
</tr>
<tr>
<td><strong>Health and fitness studios</strong></td>
<td>Summer</td>
<td>22-24°C dry bulb</td>
<td>20 l/s/person</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>17-19°C dry bulb</td>
<td>20 l/s/person</td>
</tr>
<tr>
<td><strong>Circulation and lobby</strong></td>
<td>Summer</td>
<td>Uncontrolled</td>
<td>Uncontrolled</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>19-21°C dry bulb</td>
<td>Uncontrolled</td>
</tr>
<tr>
<td><strong>Stores</strong></td>
<td>Summer</td>
<td>Uncontrolled</td>
<td>Cleaner’s stores; &gt;5 ac/h Other Stores; uncontrolled</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>16-18°C dry bulb</td>
<td>Cleaner’s stores; &gt;5 ac/h Other Stores; uncontrolled</td>
</tr>
</tbody>
</table>
Occupancy densities

The indicative designs are based on maximum occupancies levels for a normal level of school teaching (PE) and community use. These are shown in the table below. However, there is potential for the sports hall element to accommodate significantly higher numbers and this should be considered during the development of the fire strategy and services design.

### Maximum occupancy densities

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of people</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-court sports hall</td>
<td>60</td>
</tr>
<tr>
<td>5-court sports hall</td>
<td>60</td>
</tr>
<tr>
<td>Reception</td>
<td>30</td>
</tr>
<tr>
<td>Changing areas (school)</td>
<td>60</td>
</tr>
<tr>
<td>Fitness gym / studio</td>
<td>28</td>
</tr>
<tr>
<td>Small office</td>
<td>2</td>
</tr>
</tbody>
</table>

Natural gas

Natural gas is to be provided to appliances such as the sports hall gas radiant panels and to the heating plant to meet the maximum simultaneous demand for the heating and hot water requirements to comply with the requirements of the Institute of Gas Engineers IGE/UP/2 and 3.

The system should typically include the following:

- A new gas supply connection from the existing utility infrastructure to a boundary placed gas meter enclosure
- A building supply direct to the gas radiant panels and heating plant room
- Provide an automatic isolation fire valve on the new gas supply operated by the building fire alarm system
- A gas distribution system to be provided to serve the heating plant
- All pipework to be distributed via ventilated risers and ceiling voids
- Gas pipework to be exposed in the sports hall area
- All gas pipework to be painted with primer, undercoat and yellow gloss finish.

Heating strategy

Generally the heating strategy for the sports hall options are as follows:

### Stand-alone 4 and 5 court sports buildings

- Gas radiant heaters in sports hall
- Electric air curtain in draught lobby
- Electric radiators elsewhere.

### Sports halls with changing rooms and with changing rooms and fitness studio

- Gas radiant heaters in sports hall
- Gas boiler / small scale CHP for heating and domestic hot water (DHW) generation
- LTHW pipe coils in changing areas (with exclusion of accessible areas)
- LTHW air curtain in draft lobby
- LTHW low surface temperature (LST)
- LTHW radiators elsewhere.

### Low temperature hot water (LTHW) heating / local heating

The LTHW system is to provide heating to the building. The system is to consist of the following:

- Gas fired condensing boiler
- Duty and standby primary pumps
- Pressurisation system complete with expansion vessels and controls
- Dirt / air separator
- Low loss header
- Flues terminated to atmosphere in accordance with Building Regulations, British Standards and the Clean Air Act
- Secondary distribution circuits to serve domestic hot water systems (DHWS), heating and air handling unit heating coils
- All heating pipe work to be distributed from the plant room to the spaces via accessible risers, service trenches and ceiling voids
- All LTHW pipework to be insulated
- Constant temperature LTHW 80°C (flow) 60°C (return) for domestic hot water and AHU heating coils
- Variable temperature for radiators
• Constant temperature LTHW 50°C (flow) 40°C (return) for underfloor heating where used
• Secondary heating pumps with variable speed controls
• All LTHW pipe work to be insulated and clad in the plant room.

Cooling systems
Active mechanical cooling is proposed in the fitness studio and fitness equipment. The system is to consist of the following:

• Air source heat pump variable refrigerant (VRF) system
• Indoor cassette / ducted unit installed in the ceiling voids
• Outdoor units on roof or external space with acoustic screening.

Ventilation to areas other than plant rooms
All ventilation plant is to be located in suitable accessible areas such as plant rooms, ceiling voids and risers. The systems assumed for the various building options consist of the following:

• Natural ventilation
• Louvred openings with dampers to the sports hall, plus roof extract fans for summer use
• Offices (if possible)
• Reception (if possible)

Mechanical ventilation with heat recovery:
• Changing areas
• Offices
• Toilets
• Fitness studio and fitness equipment
• Reception

Mechanical extract ventilation:
• Cleaners stores
• Heat recovery > 60%
• Attenuators where required
• CO₂ sensing to control fan speed

• All air handling units (AHU) and extract fan motors to be inverter driven
• All associated controls and plant integration
• Roof terminal ventilators to be modulating and controlled via CO₂ and temperature sensors to reduce overheating and to provide night time cooling
• Night cooling functions to be included
• Ventilation in changing areas / toilets to be controlled via occupancy sensors with 15 minutes overrun.

Plant room ventilation
Plant rooms should be located to enable natural ventilation for the following:

• Gas fired boilers, CHP and biomass boilers with a rated input less than 70 kW are to comply with BS 5410. Natural vents to comply with gas regulations
• Gas fired boilers, CHP and biomass boilers with a rated input more than 70 kW are to comply with BS 6644 : 2011. Air to be provided by means of natural ventilation via high level extract and low level weather louvres. Natural vents to comply with gas regulations.
Electrical services

Low Voltage (LV) distribution systems

The low voltage distribution systems within the buildings are to comply with the requirements of BS 7671 : 2008 and A3 : 2015.

Main LV distribution

The main LV switchboard is to consist of a single section wall mounted switchboard connected to the incoming utility service head via a multi-core (XLPE/ SWA/LSOH) cable. The switchboard is to be provided with a main moulded case circuit breaker (MCCB) and also MCCB protection for all outgoing circuits. Automatic power factor correction should be provided to keep the power factor between 0.98 lagging and unity.

Sub-main distribution

The various distribution boards and motor control centres (MCC) panels are to be located in plant rooms and dedicated electrical cupboards. All lighting and power to be supplied from 3-phase split metered distribution boards. All meters are to have pulse / Modbus / MBus output for connection to the building management system (BMS). A separate distribution board will be provided for any area requiring a higher level of integrity.

Distribution boards are to be wall mounted with type B or type C miniature circuit breakers (MCB) protection to all outgoing circuits. Boards are to be either type ‘A’ or type ‘B’ and be single or three phase as required.

Fire alarm and smoke detection system

An analogue addressable fire detection system is recommended to BS ISO 5692-1 : 2004 category L2 or L3 and should meet requirements of the Equality Act, Building Control and Fire Authority.

The addressable fire alarm system should comprise automatic detection in the form of an addressable multi-loop fire alarm panel at the entrance / reception. Fire detection should comprise a combination of heat, aspirating, optical and ionisation smoke detection devices in areas in accordance with BS 5839-1 : 2013. Manual break glass call points are be installed to comply with the required travel distances together with audible alarms within all areas. The fire alarm system should provide both local and remote indication. Flashing beacons to be used in areas of high background noise and DDA requirements.

The system should to be based on a double-knock or two state alarm activation where on operation of an automatic smoke detector, the reception will be alerted first. In case the device is not reset within a pre-set investigation time, usually 5 minutes, or if another detector or a manual call point is activated within this period, the system will go into full alarm mode requiring a full evacuation.

Fire alarm interfaces are to be provided to the following equipment for suitable operation during an alarm condition:

- All mechanical plant to allow the equipment to operate in accordance with the Building Control and Fire Officer requirements
- Hardwired interface with the fireman's control panel (where required), to operate mechanical ventilation systems as required by the Fire Officer
- Any access control equipment for fail safe operation
- Any music / public address (PA) system
- Any disabled refuge emergency voice communication (EVC) system
- All fire doors with hold open devices for automatic closing.

The fire detectors and sounders / flashing beacons in the sports hall should be provided with suitable mechanical protection against any ball impact. The manual break glass units in the sports hall are to be provided with ball impact resistant transparent covers and be recessed or chamfered to avoid being a hazard to users.

General power

A small power installation in compliance with BS 7671 should be provided from the dedicated split metered lighting and power distribution board to all areas of the building. All general purpose and cleaners socket outlets should be protected by 30 mA residual current devices (RCD's).

Socket outlets will generally be wired in ring circuits and dedicated fixed equipment by radial circuits. Dedicated cleaners socket outlets should be provided throughout the building for a maximum cleaners cable length of 10 m. Power supplies are to be provided for all equipment around the building including but not limited to mechanical plant, sports equipment, score boards, wind catchers, etc.
All accessories should be of a common type complete with cover plates of the same manufacturer and have the same finish and details. All socket and power outlets to be labelled with the circuit reference numbers. Unless stated otherwise, accessories are to be generally flush mounted, except in plant areas where they are metal clad and surface mounted.

The power socket outlets in the sports hall should be of recessed metal clad type to achieve a flush finish.

All items of fixed equipment are to be provided with suitable means of isolation. These should be located within reach of the equipment served or clearly labelled in a remote position and be accessible at all times.

All containment in the main public areas of the building is to be flush mounted in rendered or tiled walls. Where this is not possible, galvanised steel containment (conduit or trunking) is to be utilised.

**Voice and data services**

A structured cabling system (Category 6 or better) is recommended for distribution of the voice and data services from a central rack to all parts of the building. Data outlets should be provided to sports areas for the use of data equipment in connection with sports education. The system could be supplemented / replaced with a wireless system which allows the use of IT equipment throughout the building, with the wireless systems being more flexible, less prone to damage and reduce the need for hazardous trailing leads. The data system could be an extension of an existing system from adjacent buildings or an independent system.

**TV, radio, audio, visual and CCTV systems**

No provision has been made for TV, radio, audio visual, CCTV or access control. These are normally project specific and could be the extension of an existing system.

**Induction loops**

Audio-frequency induction loop systems (AFILS) complying with BS 7594 : 2011, BSEN 60118 : 2015 and Action on Hearing Loss (formally RNID) recommendations are to be installed at reception, fitness studio and fitness equipment rooms to assist those with hearing impairments. The full extent of induction loop usage is subject to user and / or Building Control requirements. The system consists of suitably located microphone(s) that feeds an amplifier driven loop run around the area. The loop converts audio received by the microphone to an electromagnetic signal. This signal is received by the hearing aid and converted into sound suited to its users specific hearing requirements, thereby allowing them to actively participate in general conversation and particular activities.

An ear symbol denoting the presence of an induction loop should be prominently displayed in these areas, along with a sign explaining clearly, to people using hearing aids, how they can benefit from the induction loop.

**Intruder alarm system**

An intruder alarm system to Grade-2 should be provided throughout the building. The system should conform to BS 4737-4.3 : 1988 and National Approvals Council for Security Systems (NACOSS) Gold accreditation and incorporate sequential alarm confirmation technology and comply with the requirement of DD243 : 2004.

The system is to consist of a main intruder panel located at the reception desk, passive dual technology movement detectors, door contacts, panic alarm buttons and a key pad at entrance.

The system should be able to be set up to monitor selected external doors / fire exit doors during normal working hours when the panel is not armed, but acts as an alarm at reception.

The system must combine notification locally by internal and external audible sounders with the automatic transmission of alarm and fault signals to an alarm receiving centre conforming to BSEN 50518-123 : 2013 and BS 8591 : 2014.

All rooms / areas with external glazing and all corridors are to have complete movement detection coverage. The movement sensors in the sports hall are to be provided with suitable wire cage mechanical protection against ball impact.

**Assistance alarms**

An assistance and disabled alarm conforming to BS 9999 : 2017 should be provided to cover the disabled toilets and showers. Addressable alarm systems are preferred which provide local and remote alarms.

The system should consist of:

- A central remote alarm panel with indication and audible alarm at reception desk (only the audible alarm can be reset at the panel, the visual alarm is only reset at the point of origin of the alarm)
- An alarm push button or pull cord in each area / room
- An indication and audible alarm local to the point
of origin of the alarm

• A reset facility adjacent to the origin of the alarm
• Equipment to be suitably IP rated for location.

Earthing and bonding

Earthing and bonding is to be provided in accordance with BS 7671 : 2008 to provide sufficiently low resistance paths to ensure transfer of electrical current under fault conditions arising within the supply and distribution systems, thereby protecting personnel, the building and equipment therein and to dissipate earth leakage current from equipment under normal conditions.

All earth cables to be green and yellow LSOH (low smoke zero halogen) covered copper cables, except the functional earth cables to have a cream coloured LSOH outer sheath. All mains, sub-mains and final circuits to be provided with separate dedicated circuit protective conductors.

Equipotential bonding

Main equipotential bonding is to be provided to ensure that all extraneous conductive parts are bonded to the main earth bar. This is to consist of bonds to the main incoming water pipes, main gas pipes, ductwork, pipe work, exposed metallic parts of the building structure, thermal insulation metallic cladding, metallic cable sheaths of all cables (except British Telecom) and the lightning protection system.

Supplementary bonding

Supplementary equipotential bonding in accordance with BS7671 is to be made to interconnect all simultaneous accessible conductive parts to the protective conductor system. This to generally be undertaken in shower rooms, boiler rooms, calorifier rooms, all other plant rooms, wet and damp process areas.

Clean earth

An insulated clean earth bar should be provided to any IT equipment. The earth bar should to be wired directly back to the main earth bar.

Lighting protection system

A lightning protection system should be provided conforming to the requirements of BSEN 62305-2 : 2012 utilising building structure where possible, i.e. by copper lightning tape fixed to steelwork. The system is to be discreet with no visible surface mounted conductors down the side of the building. All down conductors are to be concealed within the building walls. The level of protection is to be determined by a lightning protection risk assessment to be undertaken by the specialist.

Metering

Energy meters are to be provided to comply with Building Regulations Part L2A and CIBSE TM 39. The metering strategy will enable monitoring of at least 90% of the estimated annual energy consumption of each fuel to be assigned to the various end-use categories (heating, lighting, etc.) The output of any renewable energy system should be separately monitored. The metering strategy should allow, where required, to monitor separately the energy demand of the separate areas in the building.

Controls

The installation should comply with:

• BS 7671 : 2008 Requirements for Electrical Installations
• BS 6701 : 2016 Communications Installations
• Local Authority and other statutory requirements, including fire officer
• Electricity at Work Act
• Building Services Research and Information Association (BSRIA) guidance documentation
• CIBSE automatic controls application guide
• All relevant British Standards.

New plant will be fitted with new automatic controls and, where appropriate, a new BMS installed. In the stand-alone 4 court and 5 court sports hall options, the services controls are to include the following:

• Heating
• Time control and calendar clock
• Summer / winter / holiday operation is automatically changed over by the built-in calendar clock; 4 no. switching points per day
• 3 no. individual time programmes to be select manually by local management; for example school use, community use, save use
• The ventilation rate in the sports hall will be modulated based on CO₂ levels and room temperature
• In winter the wind catchers will provide minimum fresh air in response to the CO₂ levels within the space
• In summer they will provide purge ventilation in response to the internal temperature above the
set point. The night cooling strategy is to be implemented

- Summer / winter / holiday operation
- Provision is to be made for an event switch to allow the operator to manually switch to a reduced airflow level during badminton play. The air velocities in the hall shall comply with Sport England guidelines for badminton play
- The sports hall wind catchers should be provided with stand-alone controller
- Energy monitoring
- Renewable energy system as appropriate.

In the Sports hall with changing rooms and changing rooms with fitness suite options, the services controls are to include the following:

- A building management system will provide automatic control for the main plant of the building to maintain design conditions and access to users via a front end computer. Faults and alarms are relayed to the same front end. The BMS could be extended to provide a remote monitoring facility that will relay data to the client’s preferred facilities management subcontractor. The BMS could also be used to play a key role in recording and reporting energy consumption obtained from gas, water, electricity and heating meters.

Operation and maintenance

Appropriate provision is to be made for suitable Operation and Maintenance (O&M) manuals and drawings. O&M manuals should hold detailed information in support of summary information in the log book (CIBSE TM31 format). The content of the O&M manuals should be in line with the BSRIA Guide: Handover, O&M manuals and Project Feedback alongside all associated current legislation for operating and maintaining the building services.

The operation element of the O&M information is to include plant room procedures. With the advent of low energy solutions and energy benchmarking, the overall design intent and how the building occupants are expected to control their environment should be included.

The maintenance element of the O&M information should list the maintenance procedures by including a list of relevant services and plant specifications as installed and expected timescales for servicing, cleaning, replacing and checking the building services.
Appendix 9 : Artificial Lighting

Key affordable assumptions
(within the design and costings)

Base scheme
Florescent lighting to achieve uniform 500lux Switchable to 300lux and to individual courts

Option 1
Enhancement for badminton court lighting to 500lux

Option 2
Enhancement to achieve 500lux to central volleyball court

Option 3
Additional lighting to achieve 750 lux for cricket

Introduction

This Appendix contains additional information on the 500 lux multi-sport artificial lighting scheme for the sports hall that has been included in the indicative ‘Affordable Sports Halls’ designs and cost plans.

It includes a provision to switch down to 300 lux as required and is considered to be the most appropriate for a school facility that aims to cater for a full programme of school PE and community sporting activities including training and competition.

The options for adding further switchable lighting for badminton, volleyball and cricket are also covered. Indicative lighting plots and other technical details are also included along with the lighting requirements for other areas also described.

General

Lighting is to be provided throughout all areas of the building to achieve the required lighting levels and uniformity ratios. The light levels are the average maintained illumination levels, taking into account maintenance factors, lamp lumen depreciation, colour and texture of finishes, furniture and equipment (including nets, curtains, etc.) and glare control.

Sports hall lighting

Since the last publication of this document the use of LED lighting has become more widespread, costs have reduced and availability has increased. Sport England is currently carrying out a trial of LED lighting for sports halls and their suitability for a range of sports. However, at this stage the affordable design is based on the use of tried and tested fluorescent lighting to the hall. The luminaires are to be provided with suitable mechanical protection against ball impact and be mounted above the minimum clear zone of 7.5 m and carefully related to the layouts of the courts as discussed later.

Long life lamps are to be used to minimise the frequency of maintenance with the luminaires installed at high level.

LED lighting has been used within all support accommodation.

The sports lighting system should be related to the layout of the court markings.
In addition to the above the National Governing Body (NGB) data sheets sports recommends the following:

- Badminton: no luminaires permitted above the court and a 2 m zone at the back of the court. Any luminaires in the line of sight of the players to be switched off. Windows and roof lights to be screened off to avoid sun penetration and glare.

- Cricket: the row of luminaires should run alongside each wicket and be fixed to the structure.

The above requirements can be met to a large extent by running the row of luminaires in between the badminton courts and checking the location of luminaires for the court markings of the other sports. This means 5 no. rows of luminaires for a 4-court sports hall and 6 no. rows for a 5-court sports hall running between the badminton courts.

The table below shows the current illumination requirements for a number of sports and supersedes CIBSE LG4 and BSEN 12193 : 2007 Guidance.

**Illumination levels**

The base lighting scheme for the multi-sport hall is designed to 500 lux, but with the provision to switch down to 300 lux as might be appropriate for some training and school use. This would consist of rows of luminaires positioned above the spaces between the badminton courts (5 rows of 8 in the case of the 4 court hall and 6 rows of 8 in the case of the 5 court hall). See diagram overleaf.

<table>
<thead>
<tr>
<th>Area</th>
<th>Illumination level, Lux</th>
<th>Uniformity</th>
<th>Limiting glare rating</th>
<th>Min. colour rendering index (Ra)</th>
<th>IP rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance lobby</td>
<td>200</td>
<td>0.5</td>
<td>19</td>
<td>80</td>
<td>n/a</td>
</tr>
<tr>
<td>Reception desk</td>
<td>300</td>
<td>0.8</td>
<td>22</td>
<td>80</td>
<td>n/a</td>
</tr>
<tr>
<td>Office</td>
<td>500</td>
<td>0.8</td>
<td>19</td>
<td>80</td>
<td>n/a</td>
</tr>
<tr>
<td>Store rooms</td>
<td>100</td>
<td>0.5</td>
<td>25</td>
<td>80</td>
<td>IP44</td>
</tr>
<tr>
<td>Plant rooms</td>
<td>200</td>
<td>0.8</td>
<td>25</td>
<td>80</td>
<td>IP65</td>
</tr>
<tr>
<td>Corridor / circulation area</td>
<td>100</td>
<td>0.5</td>
<td>25</td>
<td>80</td>
<td>n/a</td>
</tr>
<tr>
<td>Changing rooms</td>
<td>200</td>
<td>0.5</td>
<td>25</td>
<td>80</td>
<td>IP44</td>
</tr>
<tr>
<td>Shower areas</td>
<td>200</td>
<td>0.5</td>
<td>25</td>
<td>80</td>
<td>IP65</td>
</tr>
<tr>
<td>Toilets</td>
<td>100</td>
<td>0.5</td>
<td>25</td>
<td>80</td>
<td>n/a</td>
</tr>
<tr>
<td>Fitness studio</td>
<td>500</td>
<td>0.8</td>
<td>22</td>
<td>80</td>
<td>60 n/a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area</th>
<th>Average Lux</th>
<th>Min.</th>
<th>Uniformity</th>
<th>Average Lux</th>
<th>Min.</th>
<th>Uniformity</th>
<th>Average Lux</th>
<th>Min.</th>
<th>Uniformity</th>
<th>Average Lux</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badminton</td>
<td>1000</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
</tr>
<tr>
<td>Basketball</td>
<td>750</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
</tr>
<tr>
<td>Netball</td>
<td>1500</td>
<td>0.7</td>
<td></td>
<td>750</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
</tr>
<tr>
<td>Volleyball</td>
<td>1000 - 1500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
<td></td>
<td>500</td>
<td>0.7</td>
</tr>
<tr>
<td>Cricket (indoor) **</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td>750</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Notes:

* See Developing The Right Sports Hall and Sports Data Sheets available from the Sport England website (these supersede the definitions for levels of play in BSEN 12193 : 2007 and CIBSE LG4 2006).

** Community level only covered by Sport England guidance within ‘Sports Data Sheets’
However, a range of options for enhancements have been reviewed to tailor the lighting to the specific needs of badminton, cricket and volleyball.

- **Option 1 - Enhancement for badminton**
  As the 500 lux base scheme, but with switching to allow the end luminaires in each row to be switched off and additional dedicated luminaires adjacent to the centre area of the courts to be switched on.

- **Option 2 - Enhancement for volleyball**
  As the 500 lux base scheme, but with switching to allow the luminaires above the courts to be switched off and additional dedicated luminaires to the side of the courts to be switched on.

- **Option 3 - Enhancement for cricket**
  As the 500 lux base scheme, but with switching to allow additional luminaires to be switched on to achieve a general illumination level of 750 lux.

**Additional cost options**

The table below details costs for the three additional lighting options.

<table>
<thead>
<tr>
<th>Item / allowances in cost plan</th>
<th>Additional specification options</th>
<th>Additional costs (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>£20,000 (4 court) / £24,000 (5 court)</td>
<td>Additional switchable luminaires centred around the 4 no. badminton courts (500 lux) with end fittings switched off.</td>
<td>7,000 8,500</td>
</tr>
<tr>
<td>Allowed for fluorescent 500 lux lighting. All fittings switched on for 500 lux. 3 light fittings in each row switched off to achieve 300 lux.</td>
<td>2</td>
<td>Additional switchable luminaires to the sides of the central volleyball court (500 lux). Luminaires above the court switched off.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Additional switchable luminaires to 4 no. cricket lanes (750 lux)</td>
</tr>
</tbody>
</table>
Light reflectance values (LRVs) of the floor, walls, and ceiling

The LRV's of the floor, walls and ceiling have a considerable effect on illumination levels and light efficacy. For the sports hall base option, the lighting is the dominant load in calculations for the building CO₂ footprint. Initial calculations have shown that this can have considerable impact on the building emission rate (BER) and the amount of low carbon technologies to achieve Part L2A building compliance ¹. The sports hall base option has been modelled assuming LRVs of 70%, 40% and 40% for the ceiling, walls and floors respectively.

¹ See Appendix 7 Energy and Sustainability
Lighting layouts showing the base scheme and the 3 no. enhancement options

**Lighting Enhancement Option 1** - additional switching and luminaires (13 no.) for centralised lighting to the badminton courts - 500 lux

**Lighting Enhancement Option 2** - additional switching and luminaires (8 no.) for side lighting to the central volleyball court - 500 lux

**Lighting Enhancement Option 3** - additional switching and luminaires (26 no.) for general lighting to the cricket lanes - 750 lux

**Base lighting scheme with all 40 no. luminaires switched on - 500 lux** (included in cost plans)

**Base lighting scheme with 15 no. luminaires switched off - 300 lux** (included in cost plans)

**Key**

- Luminaires included in base scheme / cost plan switched on (luminaires switched off not indicated for clarity)
- Additional luminaires for enhancement options

**REFLECTED CEILING / LIGHTING PLANS** (with relevant courts below also indicated)
Lighting control

The base lighting scheme includes manual switching for the high frequency luminaires to provide either 300 or 500 lux levels. The luminaires in the enhanced schemes that are required to be switched on / off should be arranged in separate circuits. A bank of labelled switches should be provided in a panel with the required lighting arrangements clearly marked.

However, the following enhanced controls could be provided:

- **Fully addressable lighting control system**
  A control system could be provided wherein each luminaire can be addressed individually and have a dimmable ballast. The lighting could then be controlled from a scene setting switch panel with a range of buttons or with dimmable options.

  Such a system can be configured with a single switch for the various scene setups, i.e. badminton, central volleyball court and cricket. This may be easier for users but would involve additional costs (from £6-8,000) as shown in the previous table.

- **Energy saving option**
  The above system can be supplemented with presence detectors. The presence detectors in the hall would switch off the lighting after a pre-set period of inactivity in the hall.

- **Daylight dimming option**
  The above system can be supplemented with daylight dimming if rooflights with automatic blinds are introduced in the sports hall. The system measures the amount of daylight light present under each row of light fittings, and automatically adjusts the output of the fittings such that the sum of the daylight and artificial light gives the required illumination, as per the scene selected.

  The following are the main advantages of having a lighting control system:

  - With lower lux level lighting setups and daylight dimming, the lamps will last longer, as they are being dimmed down and driven at lower output thereby reducing maintenance costs.
  - The system can be interfaced with an occupancy sensing PIR in the sports hall, which will further enhance energy savings by switching off the lights after a fixed period of inactivity in the hall.
  - With manual switching, the various lighting control arrangements will need suitably rated contactors for switching the lighting circuit. With the lighting control system, contactors are not required as the fittings are controlled independently to provide full flexibility with re-arranging the lighting control zones.

Glare control

Glare could be either discomfort glare or disability glare. In CIBSE LG4, Sport England and BS EN 12193 : 2007 guidance documents there is no definitive advice on what should be the minimum glare rating of the actual luminaires. The advice is based on the general positioning of the luminaires in relationship to the courts. However, there is a need to limit the discomfort glare as far as possible in principal viewing directions with special attention to selection, positioning and screening of luminaires. Even with these measures glare cannot be eliminated and there will generally be some amount of discomfort glare present.

To minimize glare, luminaires should not be switched on in the following locations during play:

- Badminton: above the court and a 2 m zone at the back of the court and in the line of sight of players
- Basketball and netball: within a 4 m diameter circle above the goals
- Volleyball: directly above the net area and in the line of service.

To further limit glare, fittings can be provided with louvre attachments which reduce the visibility of bare lamps and overall spread of light from the luminaire. A high reflectance value of the surface (ceiling) above, and / or the use of luminaires that give a degree of upward lighting can also help to reduce the contrast (glare).
External lighting

Lighting to be provided to external walkways to allow egress and access to the space with emergency fittings installed as per building control and BS 5266-1:2016 requirements. All final exits from the building are to be provided with emergency luminaires externally above the door.

The external lighting should be controlled via a time clock with photocell override control and designed to minimise spill light in accordance with the Institute of Lighting Professionals (ILP) guidelines. All external luminaires should be vandal resistant and of robust construction.

Emergency lighting

Emergency lighting is to be provided to all escape routes and open plan areas by normal lighting luminaires with 3 hour emergency battery packs as per BS 5266-1:2016 requirements.

Emergency exit luminaires are to be provided at all final exits and in the circulation / escape route. The exit luminaires in sports hall are to be provided with suitable mechanical protection.
Alternative languages and formats

This document can be provided in alternative languages or alternative formats such as large print, Braille, tape and on disk, upon request. Call the Sport England switchboard on 08458 508 508 for more details.

User Guide

Before using this guidance for any specific projects all users should refer to the User Guide to understand when and how to use the guidance as well as understanding the limitations of use.

Click here for ‘User Guide’

Click here for ‘Design and Cost Guidance’

Issue tracker

001 - Initial publication: August 2012
002 - General update: July 2015
003 - General update: March 2017
004 - General update: November 2017
005 - Update to Appendix 4: January 2019

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