Buro Happold

ENGINEERING THE LIBRARY OF BIRMINGHAM

PROJECT DATA

Construction cost	£188m
Size	39,000m²
Predicted operational energy	160 kWh/m²/a
Regulated carbon emissions	19 kgCO_2/m²/a
EPC rating	B
BREEAM rating	Excellent

DESIGN TEAM

Client	Birmingham City Council
Architect	Mecanoo architecten b.v.
Civil engineer	Buro Happold
Structural engineer	Buro Happold
Building services engineer	Buro Happold
Lighting designer	Happold Lighting
Acoustics consultant	Buro Happold Acoustics
Fire engineer	Buro Happold FEDRA
BREEAM consultant	Buro Happold SAT
Design manager	Davis Langdon Schumann Smith
Project manager	Capita Symonds
Cost consultant	Capita Symonds
Main contractor	Carillion

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INTRODUCTION

Since opening in 1974, the original Library of Birmingham has become the most visited public building in the city and the busiest public library in the country. It houses an extensive anthology of books, photographs, historical archives, and rare printed collections of both national and international significance. While the library has served the city well for nearly 40 years, the building is outdated and no longer meets the needs of the community. Birmingham City Council decided to construct a wholly new library with the aspiration to be the best library in the world and the busiest in Europe

The new Library of Birmingham has been designed to create a new focus for the centre of the city. The library will provide a dramatic setting as a centre for knowledge and a place of entertainment. While books will remain as the prime medium of learning, they will be complemented with digital technology to allow access to the cities huge book collection. The building sits next to the existing REP theatre which has been refurbished as part of the project. A new 300 seat auditorium has been constucted and is shared between the theatre and library in addition to a new open performance space beneath Centenary Square.

The library building has two main functions: to encourage people to visit and use the public collection and also to house the huge archive of historic data recording Birmingham's history. These need very different building types, one open and light, the other closed and highly controlled.

The building elegantly resolves the range and scale of the different accommodation types on a tight urban site. A series of large offset circular floor openings create an atrium that draws the eye upwards through the library's twelve levels. Travelators rise up through the openings to create excitement and movement and the library connects back to the city through views from a series of landscaped terraces. The centre piece of the design is a huge circular book-wall of steel and timber that lines the atrium. Mezzanine staircases will allow access to tiers of bookshelves rising through the building. The very top of the building houses the restored Victorian Shakespeare Memorial room, which will now have views over Birmingham and beyond.

1 STRUCTURAL ENGINEERING

CONCEPT

The massing and form of the building is articulated with dramatic cantilevers that protect the building entrance and defy the weight of the book collection.

The transfer structure needed for the offsets of the central atrium is concealed within the archive that sits in the upper levels of the building. The need for both strength and lightness is achieved through a post-tensioned concrete structure that sits on the piled retaining wall of the basement. Elsewhere, a filigree new steel structure has been laced into the REP building to expand and improve its facilities.

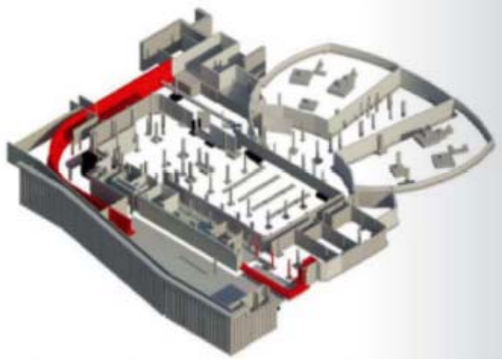
The first three floors cantilever 9m out over the entrance area. This was achieved in a structurally efficient manner by using storey-depth cantilever structures which were coordinated with the internal partitions to minimize their impact on the building layouts. There are large voids within the building for the central atrium and over the acoustically isolated structure of the studio theatre. The areas of building above these voids are hung from transfer structure at levels 5 and 6 – again, this is structurally efficient storey-depth transfer structure, coordinated with the archive storage layouts at these levels.

SITE & GROUND CONDITIONS

The site lies near a listed building with shallow foundations, and next to an underground railway tunnel. The extent and depth of the basement were developed to minimize any impact on the listed building or the tunnel.

The ground conditions comprised contaminated canal basins, overlying soft natural materials and overlying rock.

The basement level was set to be at rock surface level – this allowed the contaminated canal infill material and the soft ground material to be removed, eliminated any costly excavation into the rock, and gave a firm rock formation at basement level for the construction of foundations and basement slabs.



1.1 3D view of REP existing foundations and new basement pile wall

The foundations are pad footings on the rock for smaller columns loads, and bored cast in place piles for larger loads. Pad footings were used wherever possible to reduce costs and foundation programme. Bored piles were used due to their large capacity (to carry high building loads, and to reduce pile numbers and hence pile programme) and to penetrate the sandstone bedrock with minimal disturbance to neighbouring properties.

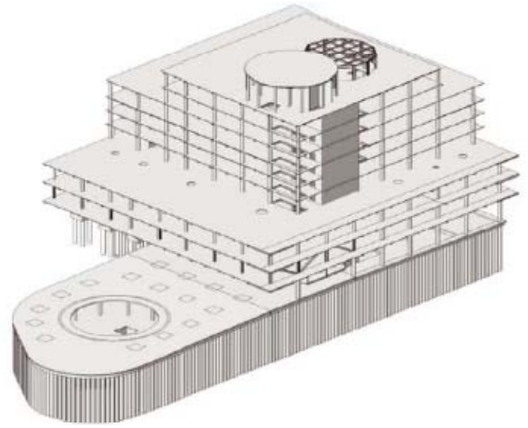
1.2 Substructure & retaining wall construction

The general water table is below basement level and is not anticipated to rise to basement level within the life of the building. The surrounding hard landscaping and cohesive ground materials mean that only limited rainwater is anticipated in the ground outside the basement walls. Accordingly, a permeable contiguous piled retaining wall was adopted, with a drained cavity to collect any seepage water which is disposed of to an external soak-away. Inside the drained cavity, a damp-proofed lining wall protects the basement storage areas from damp.

SUPERSTRUCTURE & STABILITY

A 7.2m x 7.2m structural grid was adopted throughout the building, broken by the voids and hanging structure for the central atrium and studio theatre.

The building structural layout was suitable to be constructed in both steelwork and concrete. The contractor adopted a concrete solution, which had the benefits of smaller delivery loads to a congested site, and a shorter overall programme due to reduced following trades. Floor plates are post tensioned flat slabs generally, with shallow beams used for longer spans and cantilevers. Slabs and beams are supported on columns which are founded on pad footings or piles. Over the central atrium and studio theatre, columns are replaced by hangers, and the hangers supported on storey-height transfer walls at levels 5 and 6. Two concrete cores provide lateral stability.



1.3 3D view of building structure including basement

There are roof terraces at levels 3 and 7, and a roof with plant equipment at level 9 – these roofs are formed using concrete slabs. The roof over the central atrium is glazed and supported on aluminium framing.

The two cores were located in the corners of the building to carry wind loads in a structurally efficient manner. Fire protection is inherent in the concrete structure. Archive storage standards usually require 4 hour fire protection, but the fire engineers developed a fire engineered solution so that a reduction to 2 hour fire protection was possible – this resulted in smaller structural sections and reduced costs of structural fire protection.

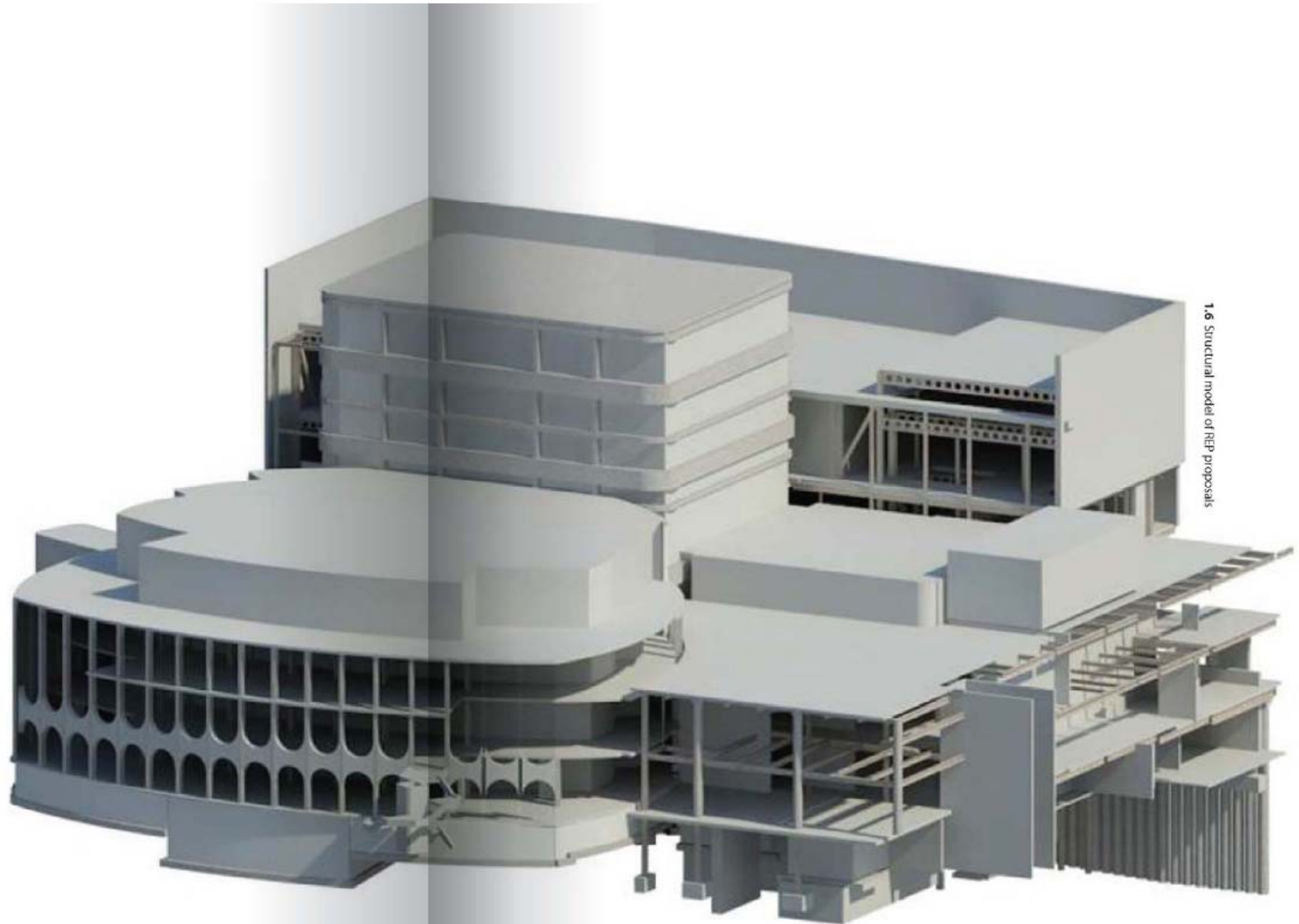
1.4 Main atrium space
1.5 Construction of 2 main cores

STUDIO THEATRE

The studio theatre is located between levels 0 and 2 in the library.

The acoustic requirement was for the studio theatre to be isolated from the main structure to prevent the transmission of noise and vibrations. This was achieved by building the studio theatre as a separate independent structure within a void in the main library structure, supported on acoustic bearings.

As a result, the main structure at levels 3 to 7 needs to be supported over the studio theatre void – this is achieved using hangers from transfer walls on levels 5 and 6.



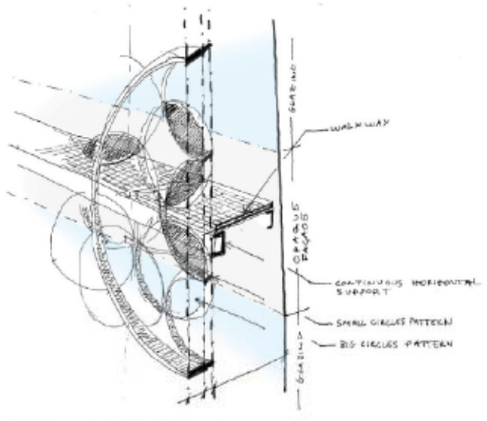
1.6 Structural model of REP proposals

2 FACADE SOLUTIONS

The facade engineering design evolved through close collaboration with the architect and the other design engineering disciplines, commencing from the initial concepts, through the building envelope procurement period and during the construction installation.

PRINCIPAL FACADE TYPES

The building main façade is wrapped by a pattern made out of aluminium circles from the first to the eighth floors. This filigree is fixed through brackets to the façade behind, which is mostly glazed, but also opaque at archives and louvered at plant-rooms. The glazed part is subdivided according to the ventilation strategy. The mixed mode ventilation areas have required the installation of controlled dampers and acoustic attenuators. The remaining façade is subdivided according to thermal and solar requirements.

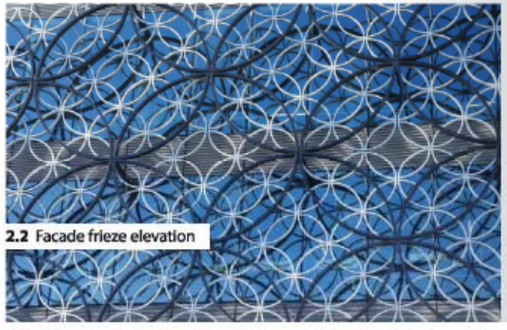


2.1 Early concept development

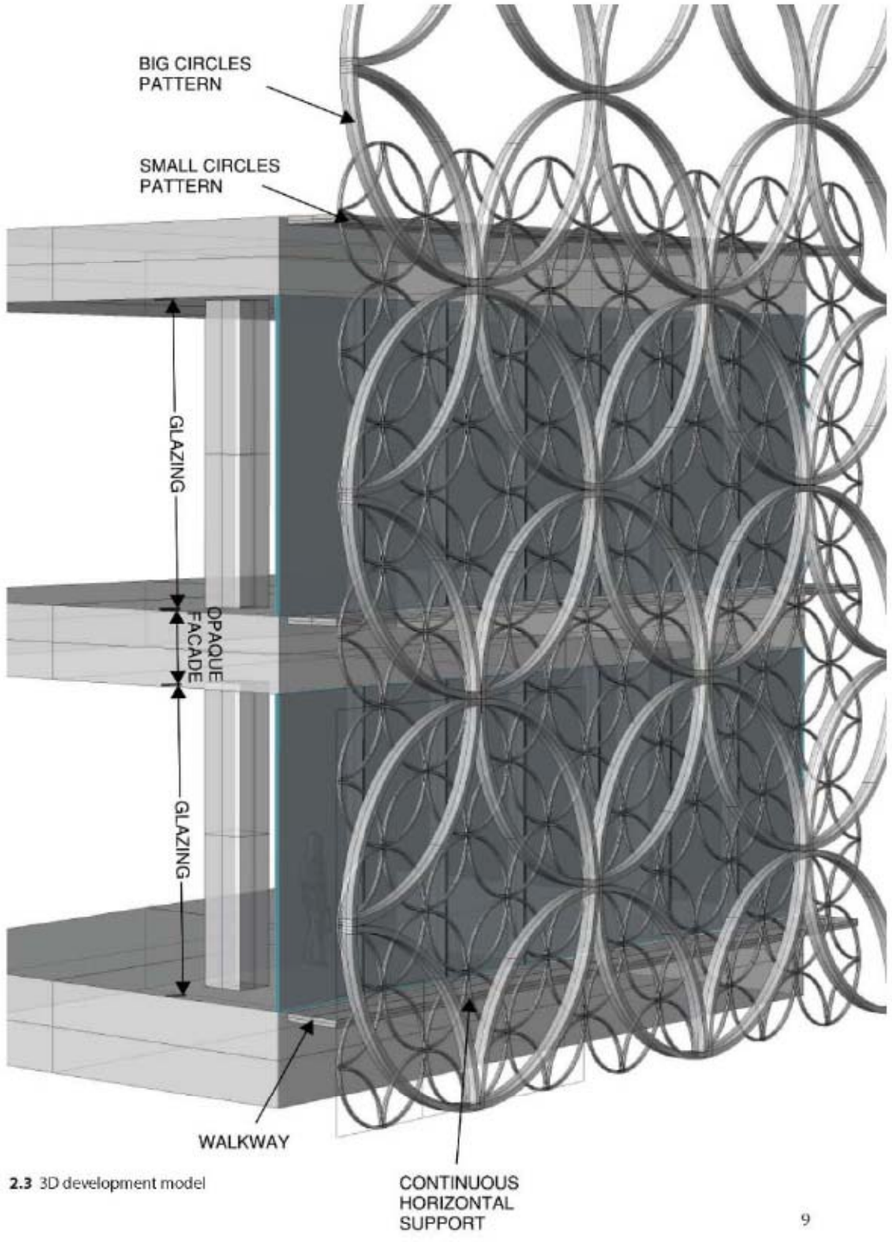
The overall façade pattern consists of an inner pattern layer based on 1800mm diameter circles and an outer pattern layer based on 5400mm diameter circular pattern. The inner 1800mm diameter circle sections are aluminium extruded and curved RHS (100mm deep, 50mm high, and 4mm thick). Two quarter circumference extrusions are welded at their two ends to form a double arch. This double arch is finished in plain PPC RAL silver colour to match. Four double arches are connected through bolted connection plates flush with the interior plane. The outer 5400mm diameter circle sections are aluminium extruded and curved RHS (200mm deep, 100mm high, 5mm thick). The double arches are then bolted through the smaller circles to the connection plates.

The frieze unit that was assembled at the factory in 5.4m high x 1.8m wide units. Gaskets and weather proofing were provided at every bolted connection to prevent noise issues and to avoid water filtering into the RHS.

The glazed part of the main façade of the building generally consists of thermally broken bespoke aluminium framed unitised flush curtain wall system. The units are generally rectangular shaped with glass panes notionally 4000mm high x 1800mm wide and spandrels 1400mm high x 1800mm wide but the height varies.



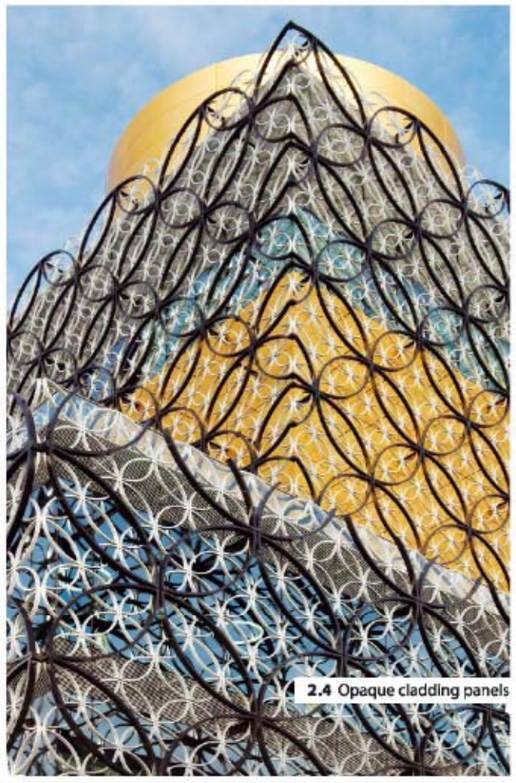
2.2 Facade frieze elevation



2.3 3D development model

INTELLIGENT FACADE

An intelligent sub-system is integrated at levels 1, 2 and 3 within the facade. The intelligent system incorporates dampers and acoustic attenuators in the spandrels to allow a mixed mode ventilation strategy, in coordination with the ventilation strategy. These attenuators are also acoustically treated to adhere to the tight acoustic requirements of the envelope.



2.4 Opaque cladding panels

OPAQUE FEATURE CLADDING

This opaque feature is the cladding to the archive facility, located at level 5 and 6 on the elevations.

This feature consists of a thermally broken bespoke aluminium framed unitised flush curtain wall system with aluminium infill panels.

REP THEATRE FACADE

The main facade of the Rep Theatre has been upgraded as part of the project.

The scope of work included cleaning and restoring the prefabricated existing concrete and replacing the old single glazing with high performance double glazed units within new frames. The opaque elements of the façade were insulated from the inside, with an internal vapour barrier to avoid condensation issues.

The glass units are generally rectangular shaped with glass panes notionally 2000mm wide and some edge units are cut in curved shapes. The double glazed units are four edges restrained to the steel framing behind with structural silicone rebates – the units have a maximum mid pane U value of 1.1 W/m2K to meet the maximum overall thermal performance target U value of 1.6 W/m2K for the glazed areas. The back of house has been clad with a performance back-wall with rain screen for opaque areas, translucent operable glazing and cantilevered fixed vision glazing. An external single Reglit cladding has been used, installed flush with the cantilevered vision glazing.

MAINTENANCE STRATEGY

This was developed to provide ease of access and maintenance for all parts of the building in order to enable the building to be maintained to a good standard and also provide the mechanisms to carry out more major items of maintenance over the life of the building.

PIGEONS

The issue of pigeons perching, roosting and nesting on the principal facades was investigated thoroughly by the facade engineering team who consulted with acknowledged academic experts in the field. This influenced the design of fixing points and access strategies and finishes in order to mitigate as far as is practical the nuisance and maintenance issues pigeons bring to civic buildings.

DURABILITY

Design life of the building is 50-60 years and the façade has been designed to achieve a similar life span with repair and replacement of elements.

WEATHER TIGHTNESS

All systems have been designed with the principle of pressure equalisation with drained and ventilated cavities and continuous air seals. There are two lines of defence for all systems and interfaces, not dependent on the use of wet sealants. The façade systems were tested to ensure weather tightness under pressurised conditions.

AIR TIGHTNESS

Air leakage (into or out of a building) causes increased heating and cooling loads to the building. The cladding has been designed to minimise air leakage and the façade systems were tested to ensure air tightness under pressurised conditions to exceed the requirements of the English Building Regulations Part L

2.5 Facade under construction

3 ENERGY & ENVIRONMENT

CONCEPT

The building has been designed to be an exemplar low energy and sustainable building, minimising the impact on the external environment and to be less than 50% energy demand as the existing Central Library building.

The environmental and indoor climate strategy heavily influenced the building massing and form, in particular the size and shape of the atrium space, and responded to the design brief set by the Client to achieve an exemplar and innovative design with a BREEAM Excellent rating.

Additional 'free cooling' is provided from a ground water cooling system that pumps water from the aquifer below Centenary Square to provide cooling to the areas utilising chilled beams.

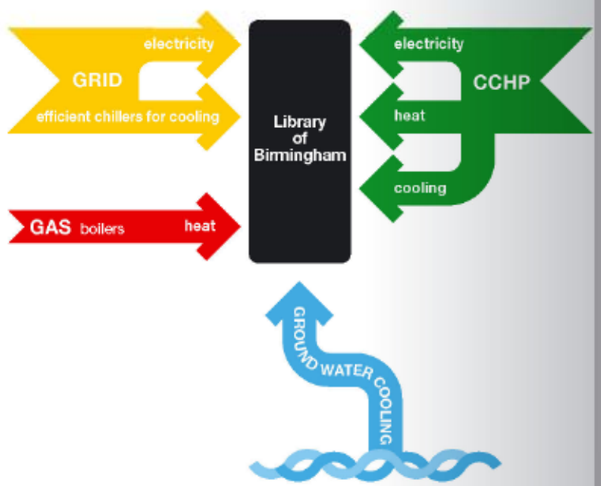
The overall result for the library is a building that delivers an impressive 40% reduction in carbon emissions when compared to the Target Emissions Rate defined by the Building Regulations.

ENERGY

The library and new build sections of the REP theatre have been designed to minimise energy consumption through the integration of passive design measures, high efficiency systems, intelligent building controls and energy monitoring. The energy demand for the existing REP building has been significantly reduced through upgrades to the building envelope and replacement of certain aging systems with new more energy efficient products.

An energy centre has been integrated into the building to provide low carbon heating, cooling and electricity. The energy centre is also connected to the district heating scheme providing additional resilience to the building and to the network itself, contributing to the expansion of the low carbon district heating network in the area.

Within the energy centre, a combined heat and power engine and absorption chiller provide cooling, heating and power (CCHP). Supplementary heating is provided from high efficiency gas boilers and cooling from high efficiency chillers utilising water towers with acoustic treatment to meet the onerous acoustic requirements for the REP Theatre.



3.1 Energy tri-generation system

INDOOR CLIMATE

A hybrid mixed-mode ventilation strategy was developed to minimise the need for active cooling and mechanical ventilation while still achieving excellent internal comfort levels throughout the year. The reduction in energy compared to a conventional mechanically ventilated building is key to meeting the energy targets and achieving the BREEAM Excellent rating.

The mixed-mode ventilation strategy allows natural ventilation to condition the building when the external conditions are favourable and then reverts back to a mechanical system during peak summer or winter conditions.

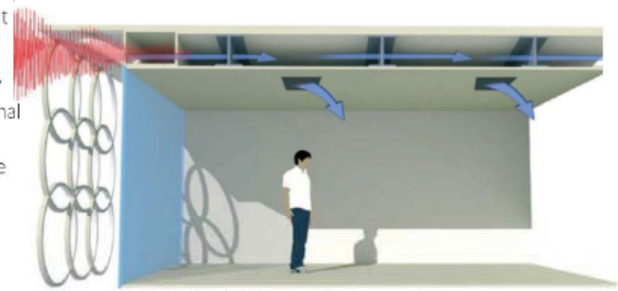
The form of the building and space planning evolved during the design process to maximise the potential for natural ventilation in the reader services areas. The building utilises the stack effect to draw air through ventilators on the façade and up through the building to exhaust at roof level. Placing the reader services areas in the lower part of the building with the sealed volumes of the archives levels above maximised the available stack pressure. The voids that cut through the floor plates on each level provide a natural exhaust path for the air to pass to the roof. The offset nature of the openings required careful analysis and refinement to ensure air movement through the building did not create draughts.

Due to the city centre constraints and close proximity to the busy Cambridge Street and Broad Street, external noise was a key consideration when developing the ventilation strategy. The North elevation is sealed due to the more onerous external conditions so cellular spaces and mechanically ventilated spaces have been located on this elevation.

Open plan spaces are naturally ventilated via acoustically treated ventilation louvres on the south, east and west façades.

The benefits of a mixed mode system are:

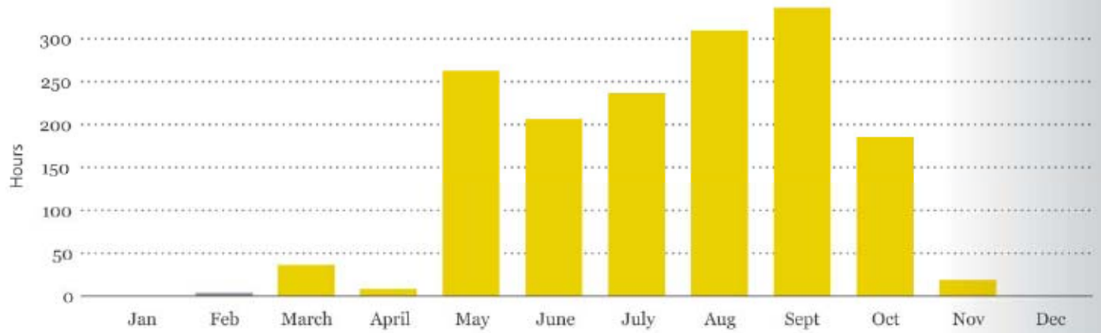
- Reduced cooling energy from consumption, as cooling is provided by natural means when the external conditions are suitable
- Reduced fan energy consumption, as the mechanical ventilation system can be shut down when the system is operating in natural ventilation mode
- Reduced fan energy consumption when the building is operating in cooling mode (when there is no benefit in recovering heat), as the air can be exhausted naturally
- During the winter, the mechanical system can be used to provide controlled amounts of fresh air, and also allow heat recovery – which is not possible with a natural ventilation strategy
- Reduced requirement for risers and ductwork as the central voids form the air return path



3.2 Hybrid ventilation concept

NATURAL VENTILATION OPERATION

The number of occupied hours during each month when natural ventilation can be utilised is shown on the graph below. Occupied hours were taken as 08:00 to 20:00 with the external temperature range for natural ventilation operation being 13°C and 21°C. This is approximately 30% of the occupied hours.

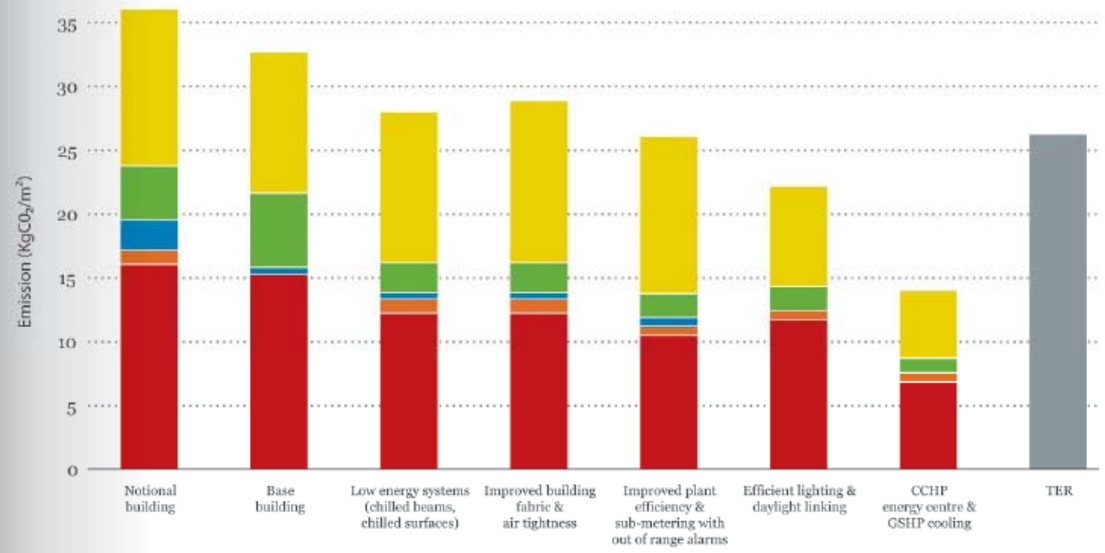


3.3 Periods of natural ventilation operation

BUILDING PHYSICS

The performance and criteria for the building physics was developed in close conjunction with the design team and the following key parameters were defined during the design process:

Building air tightness	5m3/hr/m2@50Pa.
Archive air tightness	1m3/hr/m2 @ 50Pa
U-values	30% improvement beyond Building Regulations
Facade glazing 	g-value <0.32, with a light transmittance of 0.60
Facade glazing 	g-value <0.65 with a light transmittance of 0.76.



3.4 Carbon emission data

4 BUILDING SERVICES ENGINEERING

INTRODUCTION

The following key elements provided direction for the Building Services Engineering design:

- **Flexibility –** to allow for varied use with a range of different opening hours required flexible services solutions, clear zoning and intelligent control systems.
- **Adaptability –** to allow for the changing needs and aspirations of the users' the building services are adaptable and allow modification to meet the building's future needs.
- **Sustainability** – achieving BREEAM Excellent rating.
- **Functionality** – enhancing the users' experience of the building and protecting the precious materials in the archives is achieved while minimising the complexity of operating it through robust services strategies and intelligent controls systems.

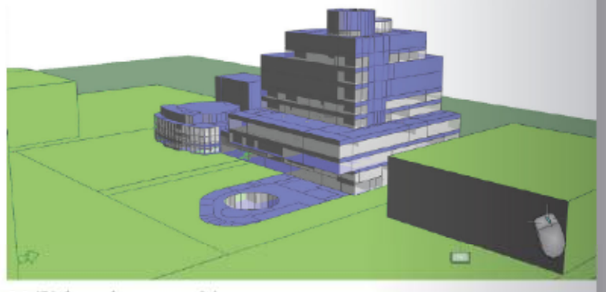
HVAC STRATEGY

The mixed-mode ventilation strategy adopted for first four floors of the building allows the building to operate in a different mode depending on the internal and external conditions to achieve excellent thermal comfort throughout the year while minimising energy consumption.
During the mid-season, the fresh air is introduced through high-level attenuated louvres on the south, east and west façades. A rafted open ceiling allows the air to enter the occupied space, as well as providing easy access for maintenance. The warm air discharges through the atrium and out of louvres located at roof level.

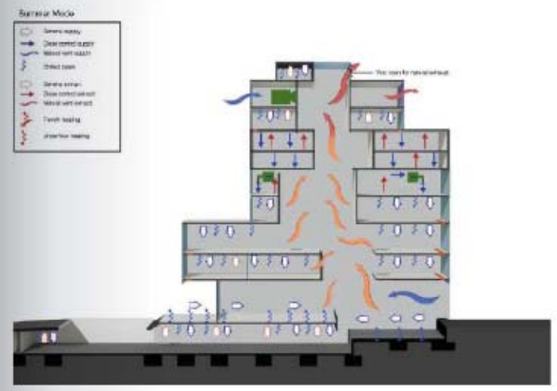
In summer, when the external temperature is too high to maintain comfortable conditions, the openings on the façade are closed and the spaces are supplied with mechanical ventilation for fresh air (controlled on CO2 levels) and cooling is provided by chilled beams. To minimise the energy consumption the warm air is allowed to discharge naturally through atrium and out at roof level again.

In winter, air is supplied mechanically in the same manner but is mechanically extracted from the top of the atrium to recover heat. Trench heaters around the perimeter of the open plan spaces on the upper floor provide heating, while the ground floor and lower ground floor areas utilise underfloor heating.

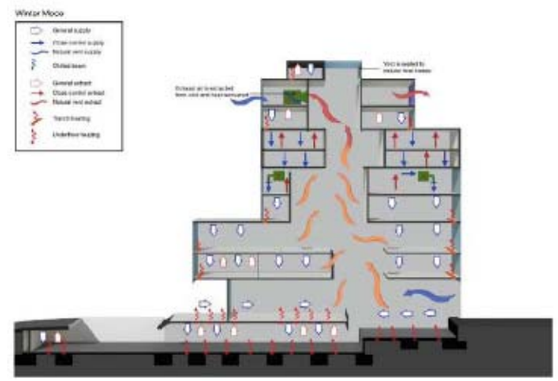
The archive spaces located on the upper floors of the building require specific temperature and humidity conditions to protect the archive materials and therefore are sealed off from the atrium and utilise mechanical ventilation and cooling. The repositories are constructed to very low u-value and air leakage rates to minimise energy demand



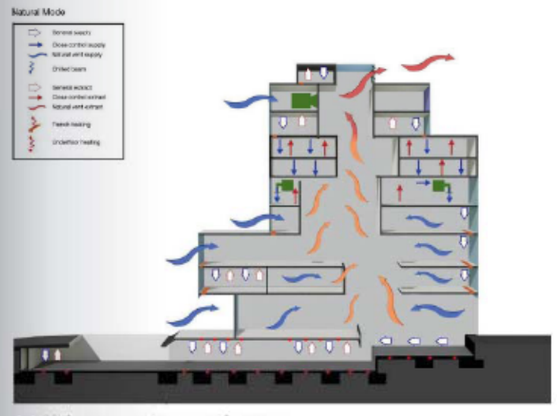
4.1 IES thermal energy model



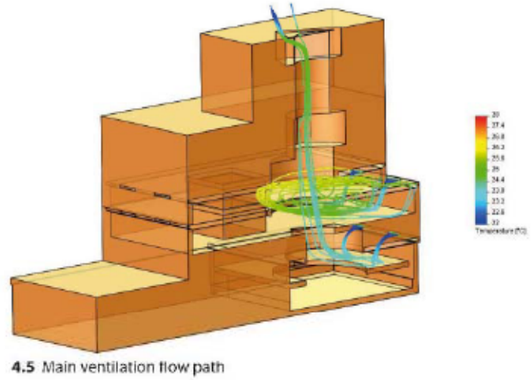
4.2 Summer environmental strategy



4.3 Winter environmental strategy



4.4 Mid season environmental strategy



4.5 Main ventilation flow path

PUBLIC HEALTH

Hot and cold water systems are provided throughout the building, with hot water derived from the central CHP system. To minimise water consumption low flow outlets as well as leak detection and prevention systems have been incorporated.

A grey water recycling system is used to reduce the on-site demand for potable water by collecting water from wash hand basins, and treating and re-using to flush toilets, allowing maximum BREEAM scores to be achieved within this sub-category.

ELECTRICAL SYSTEMS

The combined heat and power unit located within the energy centre provides a low carbon source of electricity on site.

Power is distributed throughout the building fully in accordance with BS 7671. Power factor correction, automatic metering and monitoring is used to minimise consumption. A standby low voltage generator has been provided on-site to provide back-up power for the life safety systems.

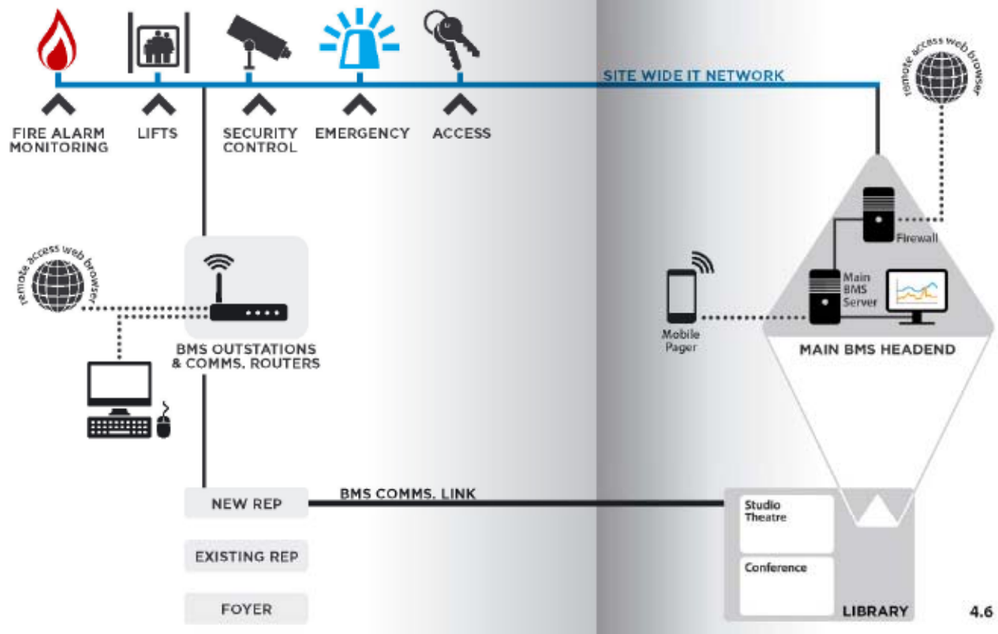
Automatic fire detection systems are provided throughout the building, designed in accordance with the phase evacuation strategy and to provide L1 level of detection.

Security, CCTV and access control systems are provided throughout the building in accordance with BCC security advisors specification.

Lightning protection system is provided in accordance with BS EN 62305.

Building Management System (BMS)

The BMS automatically controls, monitors and meters the energy consumption of the various building systems. The complexity of having new and existing buildings, separate building owners with some shared spaces and highly serviced areas, such as theatres and archive repositories, means the BMS is an essential tool to operating the building efficiently and effectively. The main BMS head end provides the users with an interface to the BMS on site while remote access is also provided. An open protocol system has been used to allow future flexibility.



4.6 Integrated BMS system using open protocol system

VERTICAL TRANSPORTATION

Due to the form of the building vertical transportation plays a key role in the user's experience of the building. Escalators weave through the shifting atrium spaces and book-wall and a scenic lift on the upper floors further adds to the sensory experience of the journey through the building.

Passenger lifts provide quick and convenient access to all floors for those that are mobility impaired or in a rush. A number of goods lifts are strategically placed to assist with the functional operation of the building while fire fighting and evacuation lifts are also provided in case of an emergency.

5 ENVIRONMENTAL SIMULATIONS

INTRODUCTION

Simulation was deployed extensively to optimise the design for maximum passive performance and minimising energy demand. Along with a high performing envelope, one of the key low energy design concepts was the incorporation of a mixed-mode ventilation strategy.

Advanced building simulation techniques were used extensively throughout the concept and schematic design stages to predict building performance, allowing informed decisions to be made at these critical early stages of the project and giving overall confidence in the design.

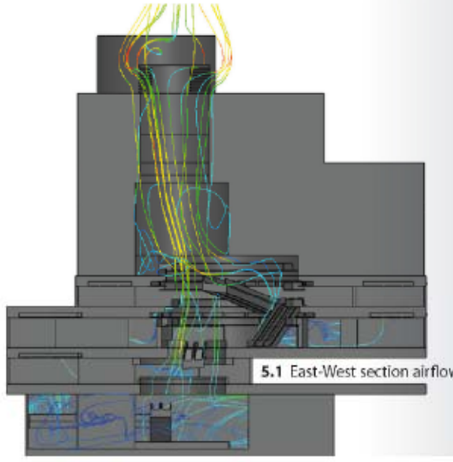
SIMULATION PROCESS

Whole building dynamic thermal modelling was used to provide quantitative data on the energy saving potential of various design features including solar shading strategies, thermal mass, insulation, air-tightness standards and daylight harvesting features, and to appraise the performance of the building HVAC systems. These detailed studies informed design decisions relating to building form, layout and façade design, as well as the choice of HVAC strategies and the potential yield from the various Low and Zero Carbon Technologies (LZCT) being considered. This process was central to ensuring that the project's ambitious energy efficiency targets and sustainability goals could be met, and in the most cost-effective way.

Influencing the building form and space planning at the outset of the project was critical to maximising the potential for natural ventilation and delivering a building that would meet the onerous energy targets required to secure a BREEAM Excellent rating. In this vein, the building was arranged such that spaces that inherently required mechanical ventilation systems were located in deeper plan areas or on the north elevation where the external acoustics were such that a closed façade was required.

Working with the architect to configure the layout so that the series of offset voids running up the centre of the building existed could be used as the exhaust air path for stack driven natural ventilation was another key element of the work of the building physics and simulation team.

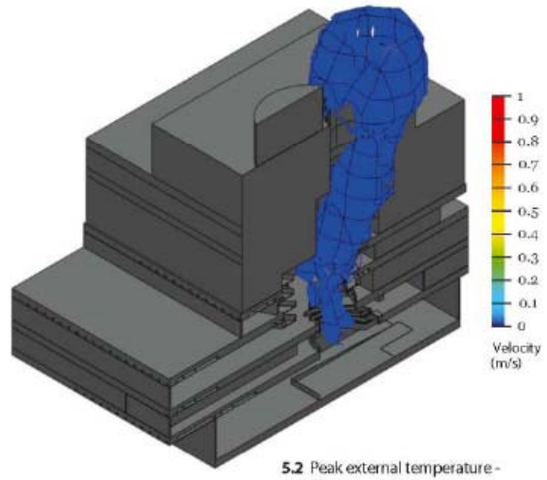
Computational Fluid Dynamics (CFD) software - which is computer based thermal and airflow simulation -was used extensively to inform this iterative design process and optimise the performance of the natural ventilation system. This ability to make detail predictions of local air speeds, temperature distribution and buoyancy pressures available to drive the natural ventilation system was critical for determining the required size and location of the natural ventilation inlets and exhaust, as well as the dimensionality and positioning of the central voids running up the building



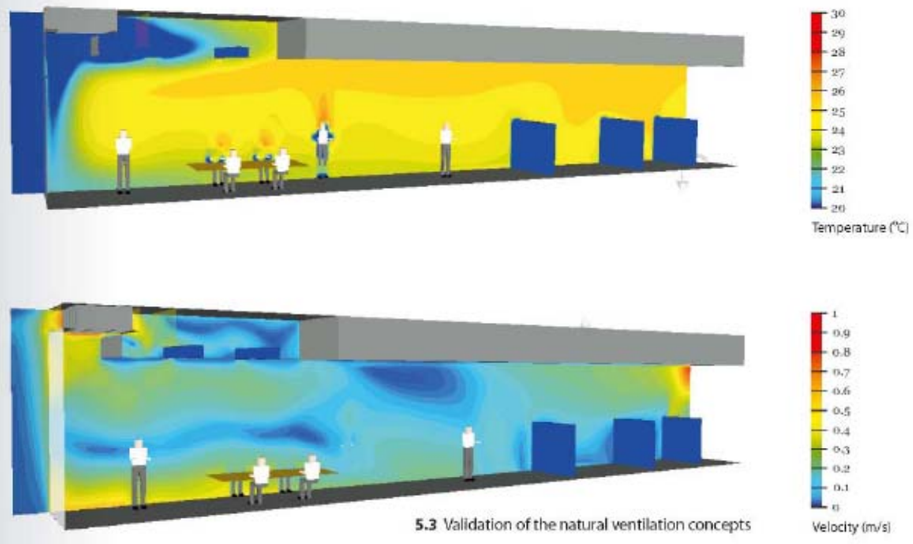
5.1 East-West section airflow simulation

This detailed CFD modelling also allowed any sources of potential discomfort - such as draughts caused by excessive air movement, overheating due to localised areas of air recirculation, vertical temperature stratification or warm/cold radiant effects experienced adjacent to the glazed façade – to be identified and designed out.

Daylight simulations were undertaken to develop the perimeter facade design and enable accurate predictions of daylighting factors to be obtained.



5.2 Peak external temperature - (design requirement, velocities less than 0.5m/s)



5.3 Validation of the natural ventilation concepts

6 LIGHTING SYSTEMS

The lighting of the Library of Birmingham supports the distinctive architectural language of the building while providing the functional lighting requirements for each floor.

Lighting is largely delivered from down-lights from high level to meet the CIBSE light level recommendations for the wide variety of spaces across the floors. The down-lights are warm colour temperature metal halide fittings with integral electronic control gear which are the most energy efficient systems currently available on the market, to meet the exacting energy targets for the building.

The down-lights are set out in a grid arrangement to provide a background level of light this is then overlaid with smaller fittings in a higher density over areas where a greater amount of light is needed to bookshelves and reading areas. This provides a constellation of fittings, when the down-lights are viewed against the black soffits in the main public spaces and on the ground floor. This down-light arrangement moves out onto the external building canopy. To assist visitors with orientation through the spaces, key walls are illuminated to draw attention to circulation routes such as stairs and lifts and general information.

The Book Rotunda is a key building feature. A central escalator, which is lit in blue, guides visitors through the circular bookshelves that are lit from an LED bookshelf light integrated into the shelving system. At night within the Rotunda, the gold soffit is uplit to provide a central lantern to the lower areas, The upper void houses a series of light halos that provide a soft appearance to the circular void space beyond.

At the top of the building, the Royal Shakespeare Room is lit to enhance the timber panelling and to provide a sense of daylight through the mock skylight by means of artificial daylight dimmable lamp sources.

Break out spaces and social spaces and meeting rooms are lit with a combination of down-lights and more decorative lit circular light rings that echo the circular motifs on the unique building façade.

Externally the Terrace areas are lit with low level bollards to provide path lights while ensuring views across the cityscape at night are not obscured.

The intention is to switch off internal lighting when spaces are not in use during the evening. In order to give the building a prescence at night, fittings mounted to the back of the facade frieze illuminate the circle pattern and provide a wash of colour to the Library. The colours on the façade can be changed and programmed for different events to form a backdrop for events on Centenary Square. The façade lighting is programmed on the DMX control system and controlled using the system programmer allowing different settings to be easily programmed by the Library and Birmingham City Council.

Inside the building, a fully integrated lighting control and monitoring system is provided to control all artificial light in relation to the time of day, daylight and presence to maximise the energy usage. The system is controlled from a central PC provided to the building. In areas where sufficient natural light will be present, daylight linking ensures that the artificial illumination is only on when needed

Within the REP foyer, the lighting is being upgraded and due to the lower ceiling heights a compact fluorescent and series of LED downlighters and linear fittings are installed to provide good ambient levels of lighting. A series of lighting bars and tracks have been installed in these spaces to allow the Client team flexibility in how they light the Foyer space for the promotion of particular productions.

Within the Main Library Foyer spaces, the connection to the Rep Theatre is emphasised where a sense of drama is achieved where theatre projectors are installed on tracks at high level to pool into and high light areas of the ground floor entrance foyer at night for events. Outside, this idea is continued where pools of light around the building are provided via a series of columns that house spotlights that pool onto the newly formed landscape paths, and recessed amphitheatre that allows visitors to view performances during the day and into the evening in the stage area below.

6.1 Daylight control principle

7 FIRE ENGINEERING

INTRODUCTION

Given the library's vast collection of rare books and other materials, a great deal of consideration was given to fire protection, and a detailed fire engineering strategy approach was developed as part of the integrated design process

FIRE ENGINEERING STRATEGY

The fire engineering strategy was developed to demonstrate compliance with Part B of the Building Regulations and provided substantiation on our approach and compliance, covering the following key aspects of the design:

- Structural Fire Precautions
- Escape Provisions
- Fire Fighting Facilities
- Fire Protection Systems

Calculations were developed to prove Occupancy Capacities and Smoke Control Provisions. The strategy was approved by Birmingham City Council Building Control.

The strategy has been developed using a phased evacuation system due to the complexities of the shared spaces.

MAIN ATRIUM

Concrete is inherently fire resistant, eliminating the need for additional fire protection within the framing.

The desired openness of the building has been maintained through a discrete series of containment and safety measures. The open sides of the atrium conceal smoke curtains and a smoke exhaust system.

ARCHIVE STORAGE

While archive storage standards typically require a fire-resistance rating of four hours, the design team developed a solution that allowed it to reduce the fire protection to two hours. The solution involves a series of discrete containment and safety measures, including concealed smoke curtains and a smoke exhaust system. A low-oxygen system, rather than sprinklers, will protect the archives from fire, while a climate-control system will protect it from humidity. This has allowed larger, more space efficient storage solutions, than conventional fire protection measures.

7.1 High level smoke exhaust

8 ACOUSTICS

INTRODUCTION

The acoustics design formed a key design discipline within the Library of Birmingham and the acoustics team formed an integral part of the design team from the initial planning through to the final commissioning of the building.

The key issues for the acoustic design and performance included:

- Control of noise emission from building services plants, internal and external
- Provisions for façade sound insulation
- Provisions for internal sound insulation
- Room acoustics including internal ambient noise and reverberation time control
- Control of structure borne noise in sensitive areas
- Multipurpose acoustics design of the Studio Theatre

NOISE SURVEY

Due to the city centre location and close proximity to busy Cambridge Street and Broad Street, noise from traffic was a key challenge when developing the design concepts. An external noise survey carried out by Buro Happold Acoustics suggested that noise levels were appreciable on all elevations, particularly the North. The design of the building systems needed to respond to these issues. Vibration from trains running through the Monument Lane tunnel was also considered in the development of the building plan.

FACADE DESIGN

The design of the building envelope was coordinated with the building services and façade engineers. The construction of the façade was integrated with the ventilation strategy and a double glazed unit (DGU) curtain wall was developed as the primary façade cladding structure. Passive ventilators were also incorporated in areas where natural ventilation is allowed. A sealed façade to the north side has been proposed to reduce the noise and pollution from Cambridge Street.

VENTILATION NOISE

The design overcame the high levels of external noise through the use of acoustically attenuated ventilation louvres on the south, east and west façades, but with the north elevation being fully sealed due to the more onerous external noise conditions. Spaces in this north side of the building were mechanically ventilated, including the rehearsal studios, workshops, apartments and offices. Other mechanically ventilated areas include the LoB offices and meeting rooms in the main building and archive and heritage areas. These ventilation systems were provided with duct borne noise control.

WORKSHOPS

Workshop activity and machinery produce significant vibration that can be transmitted to adjacent spaces through the building structure. For example, the rehearsal rooms in Level 2 could be disturbed by structure borne noise due to such vibration. On this basis, the machinery in the workshops was mechanically isolated from the floor and walls. Isolating connection points to the wall and rubber floor pads have been used to reduce the structural transmission.

This type of solution should reduce the annoyance in sensitive adjacent areas.

Some of the general activities in the workshops (e.g. hammering, etc) will also produce some mechanical

impact on the floor, which can lead to structure borne noise transmission to other areas of the building, including the existing theatres. Therefore, in addition to the measures described above, a resilient material was installed between the floor slab and any screed.

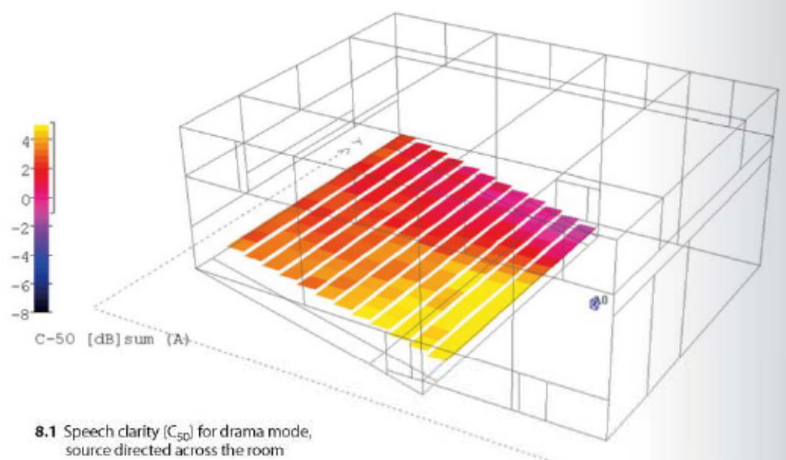
STUDIO THEATRE

The Client brief required the Studio Theatre venue to be used for the following performance types:

- Primary Use – Drama plays & acoustic (unamplified) music
- Secondary Uses – Amplified music, conferences & lectures

The wide range of performance types has required an adjustable acoustic, with variation achieved by introduction of sound absorbent drapes to supplement the permanent materials installed at high level above the trampoline grid and on the rear wall. Seating is upholstered bleacher units, which can be retracted to provide a large flat floor configuration. The design mid-frequency reverberation time range (unoccupied) was set at 0.8 to 1.2 seconds for drama and from 1.2 to 1.5 seconds for unamplified music. The image below illustrates an example result from the acoustic modelling that formed part of the design process.

The need for a high standard of separation between the Studio Theatre and surrounding building was clear from the outset and the room was developed as a box within a box, structurally separated with a system of elastomeric bearings



8.1 Speech clarity (C_{50}) for drama mode, source directed across the room

REHEARSAL STUDIOS

Two rehearsal studios are included as part of the new extension to the back of the REP Theatre. These rooms will be located above the main workshops. In order to achieve NR 25 internal ambient noise limit, special measures were taken as part of the internal sound insulation of these rooms.

Structural isolation measures (box-in-box) similar in approach to those used in the Studio Theatre were incorporated in these rooms to reduce noise transmitted from adjacencies, in particular the workshops below, and to improve sound insulation between both studios. This approach has ensured a high degree of protection for the rehearsal rooms. The arrangements for isolation were based on elastomeric bearings supporting the rehearsal room and walls are carried on the floor slab. All bearing materials were selected to provide a natural frequency of 10-12Hz.

ACOUSTICS IN OPEN PLAN AREAS

A key element of the new library is the openness and continuity of the large internal volumes, particularly the central atrium. Acoustically the design has to strike a balance between the natural tendency for reverberation in these spaces and the need to provide comfortable conditions for visitors and staff. Buro Happold worked closely with the architect to look at other successful library buildings, making measurements and using acoustic modelling to help present the intended design to the client team.

Visitors to the building will be aware of the acoustic of the spaces changing as they move through the building, but most will not notice the large areas of sound absorbent materials that are incorporated above the ceiling finishes in the public areas of the building.

9 SUSTAINABILITY & BREEAM

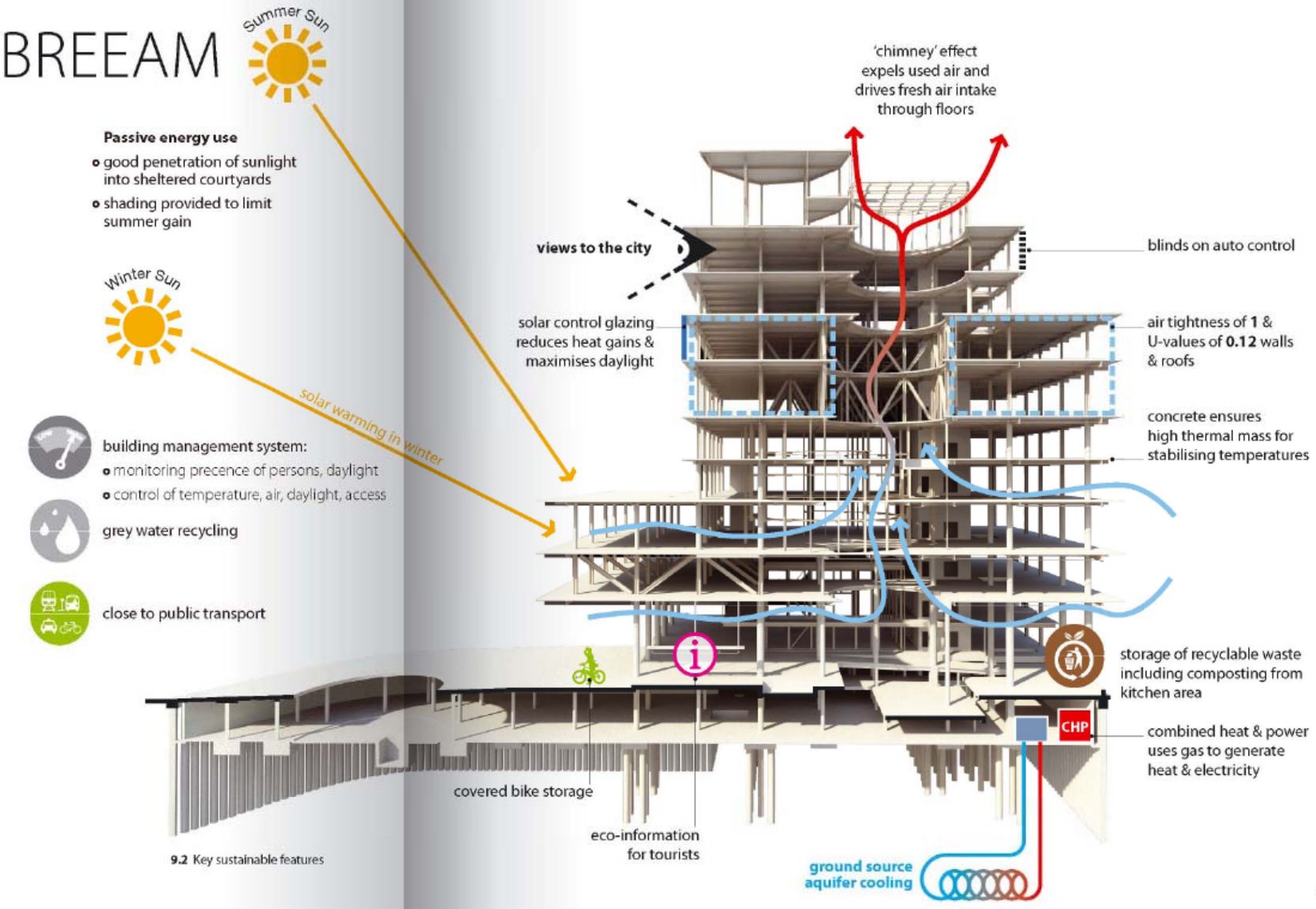
INTRODUCTION

Birmingham City Council has strong sustainability goals for this development and the wider city of Birmingham. One of the key sustainability aims for the new Library of Birmingham development has been to achieve a BREEAM Excellent rating for the new build element of the library.

9.1 Sustainability Strategy

INTEGRATED DESIGN APPROACH

At the design stage, the project achieved the targeted BREEAM Excellent rating and is currently on track to achieving this at Post Construction Stage for the final certification. The building has, where possible, utilised natural daylighting and ventilation to provide a healthy and comfortable environment throughout the building.



9.2 Key sustainable features

The carbon dioxide emissions as a result of the building's operation have been reduced through the use of a Combined Heat & Power (CCHP) engine unit which simultaneously generates usable heat in the form of hot water and electricity in a single process using a single fuel source. The building also utilises ground source aquifer cooling to provide 'free cooling' reducing the reliance on energy intensive cooling systems. The total reduction of carbon dioxide emissions for the development is a significant saving of approximately 40%, helping the building to be an environmental landmark in Birmingham's City Centre.

The building has installed a grey water harvesting system which will re-use water from taps for toilet flushing and along with low water sanitary fittings, will lead to savings in the potable water consumption.

A major water leak detection system is in place which covers all the mains water supply between the building and the site boundary, and has been provided to warn facilities management if a leak has occurred. In addition to preventing major leaks, sanitary supply shut off valves have been implemented to reduce the risk of minor leaks in toilets by shutting off the water when there is no movement detected.

To enhance the ecological value of the site, the building has incorporated several species of plants as well as bird and bat boxes following a site survey by an ecologist. The roof top incorporates a brown roof (i.e. a non-seeded green roof system that allows local plant species to populate the roof over time, thus harmonising its appearance with its immediate surroundings), as well as raised planting beds that have been introduced on the third and seventh floor terraces to enhance the biodiversity of the site.

Planting on the third floor will also include fruits, vegetables and herbs with the purpose to help promote healthy and sustainable lifestyles within the community, including children and families, connecting with a range of books, resources, events and activities in the Library.

The building also aims to promote sustainability throughout the city and is to be used as a learning resource for schools, visitors and locals, raising awareness about sustainable issues and teaching them about the many sustainable features that the building has employed and the linked benefits of these in terms of energy reduction, lower carbon emissions, water efficiencies and many more.

"Throughout the design and construction period, the design team have maintained excellent co-operation with the Client team and users, working together to deliver this common vision.

The Mecanoo architecten led design team has delivered this vision, with passion, enthusiasm and skill to meet these high standards.

Buro Happold has delivered the services with a high level of quality and to our full satisfaction."

Brian Gambles Project Director, Birmingham City Council

Buro Happold

Rod Manson
Regional Director

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