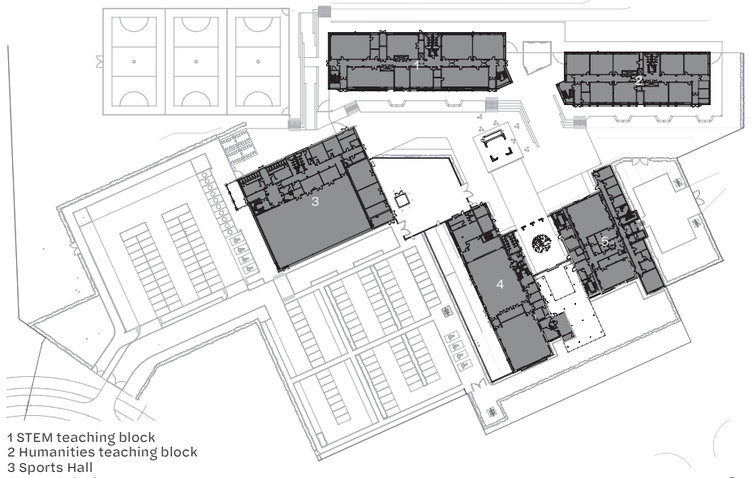
Building study

Fine tuning

From the listed remains of the historic Rugby Radio Station, van Heyningen and Haward Architects has created a new school for the emerging mini-town of Houlton



1 STEM teaching block
2 Humanities teaching block
3 Sports Hall
4 Power Block
5 Transmission Block

Houlton School is a new six forms of entry (6FE) state secondary school for Houlton, an emerging district that will eventually provide 6,200 homes on the site of the former Rugby Radio Station in Warwickshire. Developed in a partnership between Urban&Civic (U&C), the Department for Education (DfE), Rugby Borough Council and Homes England, the school, designed by van Heyningen and Haward Architects (vHH), has been created by the conversion of C Station, a listed transmitter complex, with the addition of three new blocks. The school will be a focal point of the larger Houlton development, masterplanned by JTP.

Words Fran Williams
Photography James Brittain

After the First World War the government set about building a Long Wave Wireless Station, capable of worldwide communications. Technically, it was one of the largest projects the General Post Office had ever undertaken. Its huge, very low frequency transmitter was designed a hundred years ago and came into service at Hillmorton, not far from Rugby in Warwickshire, on 1 January, 1926. Today it has a surprising new life as a secondary school for 1,200 students. The Grade II-listed transmitter building, formerly known as C Station, sits at the heart of a developing mini-town, named Houlton to commemorate the first transatlantic call made from the radio station, which was to a receiver site in Houlton, Maine, in 1927.

Once featuring an array of 12 aerial masts, 250m-high, everyone in the area knows C Station. Despite being in private use for many years, it had 'become a public building' by reputation, says vHH partner James McCosh. It consisted principally of two linked volumes – its Power and Transmission blocks – plus ancillary structures. The larger of the two main buildings housed the long wave transmitter itself.

The development of Houlton is currently in the first phase of delivery, its first residents having moved in in December 2017. The entire development, masterplanned by JTP, is a 50:50 joint venture between U&C and Aviva Investors. Once completed, it will provide 6,200 new homes, three primary schools, a GP surgery and community facilities, in addition to the secondary school. A 1.5 mile-long link road to Rugby town opened in 2019, which accelerated the completion of the school.

Despite the bleak, post-industrial landscape the site presents as you approach – a bare, grassy expanse yet to be built upon – there's something appealing about this unusual project. It has to do with the way it has been so thoroughly thought-through, making something so complex work – and on such a large scale. As you enter the school gates into the first courtyard it feels powerful and inspirational, and uncannily akin to a mausoleum. The brief initially called for a 6FE secondary school on an 8ha site. As part of Houlton's Section 106 agreement, U&C was

instructed to retain the listed radio station and make it a 'building with viable use'. The idea of turning it into the required school was tabled very quickly and vHH – known for its extensive school experience – was approached to do a feasibility study for a light-touch conversion in 2015.

It was clearly going to be a challenge: possible, but only with additions on the immediately surrounding site and extensive, complex restoration of the existing buildings. 'Lots of it was going to be retained, but it needed maintenance,' recalls vHH project architect Carol Meteyard. 'Otherwise it was going to cost the school a lot in the future.'

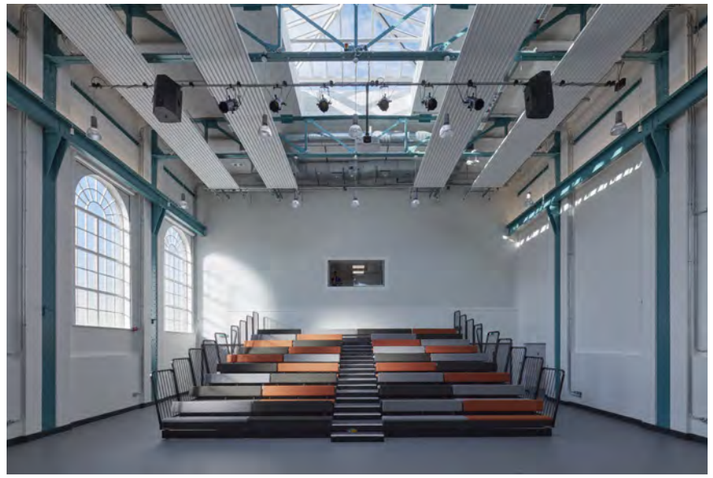
The DfE 'struggled to get their heads round' converting a listed building into a secondary school, says McCosh. But contractor Morgan Sindall was on board with the concept early on, helping the DfE to relax, particularly when the funding agreement was in place. It was agreed that the DfE would 'forward fund' most of the school's build, an unusual model for them, and then U&C would pay it back through Section 106. This complicated deal – which U&C project director Mike van den Berg describes as an 'alignment of the stars' – allowed them to bring the school successfully forward as one of the first parts of the development to complete. 'It's probably the only school in the country funded like this,' observes McCosh.

> The challenge was fitting things into dimensions that weren't designed for that purpose

The school consists of five blocks in total. It is a scheme of two parts in which two distinct objectives come together: the sympathetic repurposing of the two listed structures and the design of three very high-performance new buildings. Working with C Station's old buildings was a 'best fit exercise', says McCosh. The challenge was fitting things into existing dimensions that clearly weren't designed for that purpose – and in compliance with DfE's strict space standards for a 6FE school.

The decision was made to group all standard classrooms into two of the new blocks to the north of the radio station. A sports hall would occupy the third new block. Everything else would be fitted in the existing buildings. The restoration and repurposing of these two main blocks would create a modern school that was able to 'operate with an old building'. The former Power Block, which is to the left as you enter through the new main entrance under a south-eastern canopy, has been lightly adapted to become dining and assembly halls. The former Transmission Block opposite consisted of two 'cathedral-like' spaces, one almost 12m-high, and required heavier alteration to fit in several more storeys of accommodation for art and music rooms, a library and sixth form spaces. Wishing to restore the building's historic proportions (its timber roof had been destroyed in a fire), vHH has added a new top floor clad in a crinkly rainscreen that catches the light, a glint of contemporary styling above the existing building's historic characteristics.

To the east of the Transmission Block is a single-storey wing once containing workshops. A stair tower to the end of this had the most intricate façades of the complex. C Station was originally built of loadbearing brick. Where the brick has been repaired, the architects matched the stock carefully. But where infill was required, it has been patched in with a contrasting brick – a visual reminder of the building's history. The large existing windows gave the team much to think about. Leaking and single-glazed, their ongoing maintenance was a worry, yet Historic England wanted them to be retained, as they were a distinctive part of C Station's character. After undertaking thorough energy modelling and looking into the costs and visual impact of various options, vHH persuaded Rugby Borough Council and Historic England that replacing the windows was a better option in the long term and they have been replaced like-for-like with new, high-performance bespoke units. They are now openable – which they weren't before – so the spaces inside can be mechanically or naturally ventilated as needed.

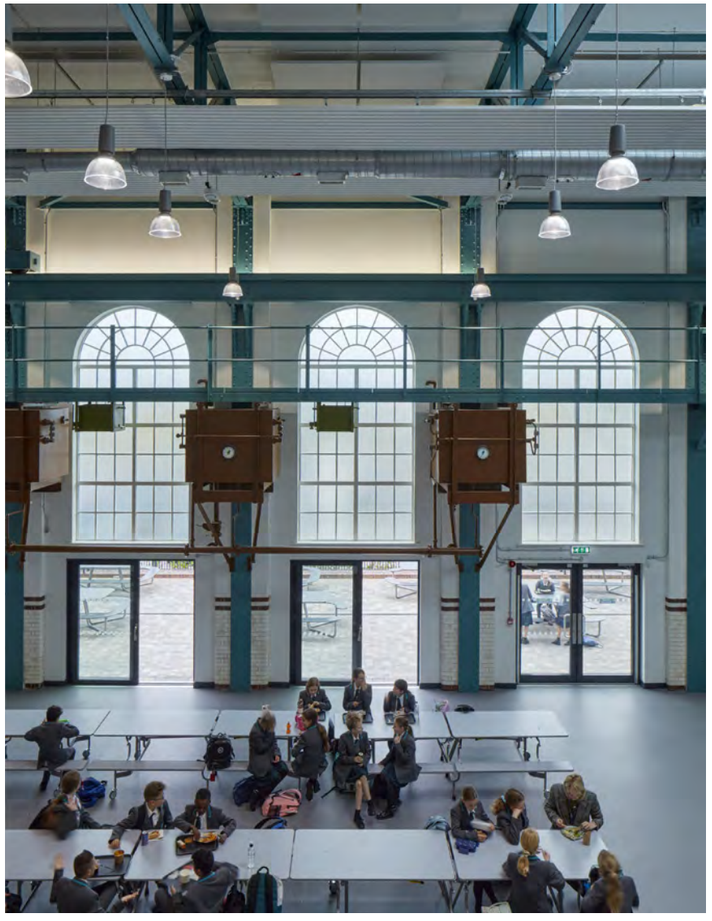


Another challenge was presented by the enabling works to strip out equipment, undertake decontamination (such as removing lead paint and diesel oil) and demolish unadaptable structures between the two blocks, for which Listed Building Consent was required.

A process called 'quilling' – essentially a wet abrasive pressure blast – was used to remove historic plaster from the brick walls. 'This allowed us to discover nearly all the big issues with the existing fabric, other than one particularly hidden eccentric wall-to-roof junction,' says McCosh. Once the walls had dried out, all the windows could be surveyed and the brickwork checked for internal repairs.

Unusually, a Pavatex board system was used to insulate the walls internally. The boards consist of a lime plaster bedding, wood-fibre insulation and a lime plaster parge coat on top to provide the airtightness layer. A Fermacell lining provides a robust finish and maintains a voidless wall build-up that will avoid trapping moisture that could damage the historic fabric. Covering almost 3,500m², it is probably the most extensive use of such a system in the UK to date. When it came to fire protection on the other hand, the architects weren't able to test every option and this is where the project process became more reactive to the found fabric. 'A lot of existing details on the market weren't appropriate for these historic conditions,' says McCosh. In the end, intumescent paint and gypsum board became key materials, as they came with the most reliable advice.

Houlton School has been designed to use as little energy as possible within the constraints of the listed buildings and construction budget. Naturally, the old part of the school would never perform as well as a new build, so one of the priorities was to deliver the new blocks to the highest standard possible to offset this energy loss. The two new teaching blocks sit to the northern edge of the site and in plan are slightly cranked in geometry to suit the sightlines and to fit neatly within the campus. Aesthetically, they are simple, constructed out of a dark brick to complement and relate to the existing and with a scholastic massing slightly reminiscent



of an Oxbridge college – cleverly done so as not to take too much attention away from C Station, the visual highlight of the campus.

Overall, the upgraded historic buildings use significantly less energy than a standard refurbishment, through insulation, high-performance windows, ventilation with heat recovery and upgraded airtightness. Sustainability engineer Etude estimates there has been a 50 per cent reduction in heating energy need compared with a standard refurb. In terms of regulated energy, Etude reckons there is a reduction of 53 per cent.

Within the stair tower, decorative steel frames have been retained and double-glazed secondary glazing provides airtightness. The fuel source for C Station's heating and hot water is gas. Boilers have been located in the sports block to dispense with the need for a flue on the historic blocks. Air handling plant is generally located internally to maximise efficiency and to avoid visible additions to the existing fabric, while air intakes and exhausts use louvres behind dummy windows or rooflights to minimise their visual impact and to avoid fabric losses.

This project shows almost any kind of repurposing is possible with a historic structure

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if you are open to the possibilities and think strategically. 'Sequencing was key,' says Meteyard. McCosh adds: 'If we did it again, we would be more prepared to set out our aims,' recalling that the process was a bit more reactive than it might have been, with a few unintended consequences.

But the architects deserve a lot of credit. Not only is Houlton School aesthetically beautiful and powerful but it is also impressive for demonstrating how a highly complicated project with lots of stakeholders can be completed successfully. Intensive energy modelling was undertaken to LETI guidance – as it should be – but it feels as though the architects really understood the calculations and took them in to make challenging, sometimes contradictory, decisions.

It's not every day that you convert a huge, abandoned radio station into a secondary school. We should be prioritising retrofit of our existing building stock over demolition, so it is important that architects and clients fight for projects like this. Although it isn't appropriate in every context, what Houlton School confirms is that, with intelligent design, thinking outside the box and belief in your cause, elegant retrofit can succeed.

Project data

Start on site August 2019 (enabling works); March 2020 (main works)
Completion August 2021
Gross internal floor area 12,134m²
Construction cost £39 million
Construction cost per m² £3,214
Architect van Heyningen and Haward Architects
Client Urban&Civic/Aviva Investors (joint venture)
Structural and civil engineer Price & Myers
MEP consultant Hoare Lea
Cost consultant Rider Levett Bucknall
Planning consultant David Lock Associates
Energy consultant Etude
Acoustics consultant Ramboll Acoustics
Landscape architect PlanitIE
Fire consultant OFR
Lighting designer GIA Equation (external); Hoare Lea (internal)
Heritage consultant The Heritage Collective; Heritage Project Management
Project manager UCPM (Urban&Civic Projects)
Principal designer RPS
Approved building inspector Warwickshire Building Control
Main contractor Morgan Sindall Construction
CAD software used Revit

Architect's view

We set out to achieve all of Urban&Civic's fundamental aspirations: to create excellent school facilities, to celebrate the radio station's heritage, and to integrate C Station into the Houlton masterplan. Underpinning this was our ambition to maximise its social, environmental, and heritage legacies.

The inception charrette, attended by masterplan and school teams and key stakeholders, established very high shared aspirations, and embedded a collaborative approach among all participants. This continued with early and regular engagement with the school operator.

It became clear that our proposals for CLT structures and Passivhaus certification for the new blocks were impossible within the budget and/or the DfE Output Spec. So our team's environmental priority became maximising the quality of the buildings' envelopes and services: minimising operational energy, costs, and carbon, and future-proofing the school. Detailed pre-app meetings proved key to securing LBC and planning swiftly. Restoration of the historic façades balanced the impacts of the conversion, including insulating and replacing windows. Fundamental to the performance upgrade, these enabled us to comply with the Output Spec, enabling U&C and the DfE to agree funding.

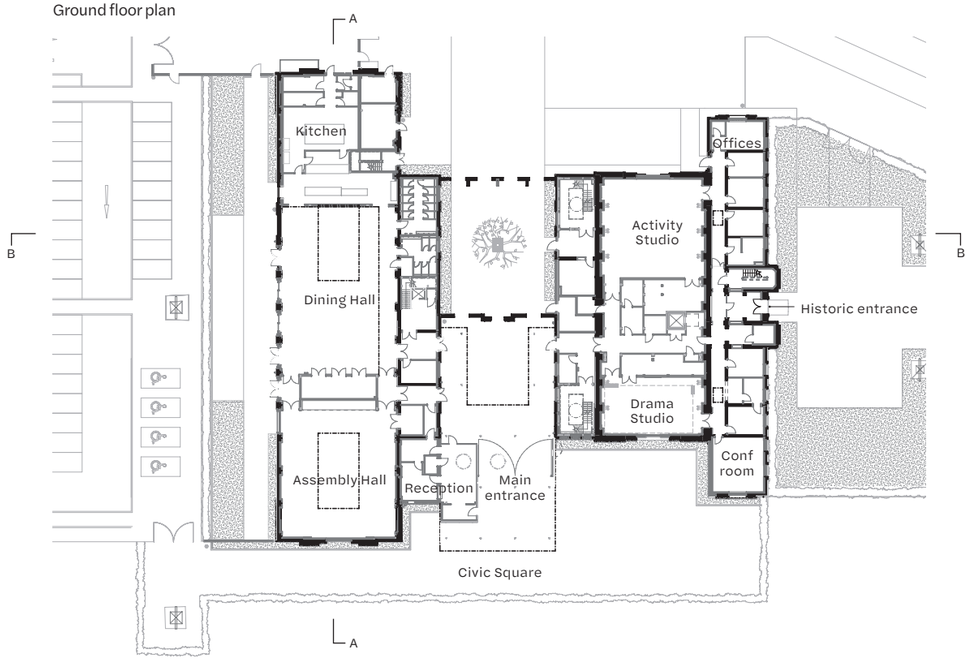
The early involvement of Morgan Sindall from RIBA Stage 2 mitigated the inherent risks associated with the listed buildings. The resilience of that teamwork allowed the project to be delivered – despite Covid and some surprises buried in the historic fabric – ready for start of term, and has established an iconic and sustainable public building at the future heart of Houlton.

James McCosh, partner, van Heyningen and Haward Architects

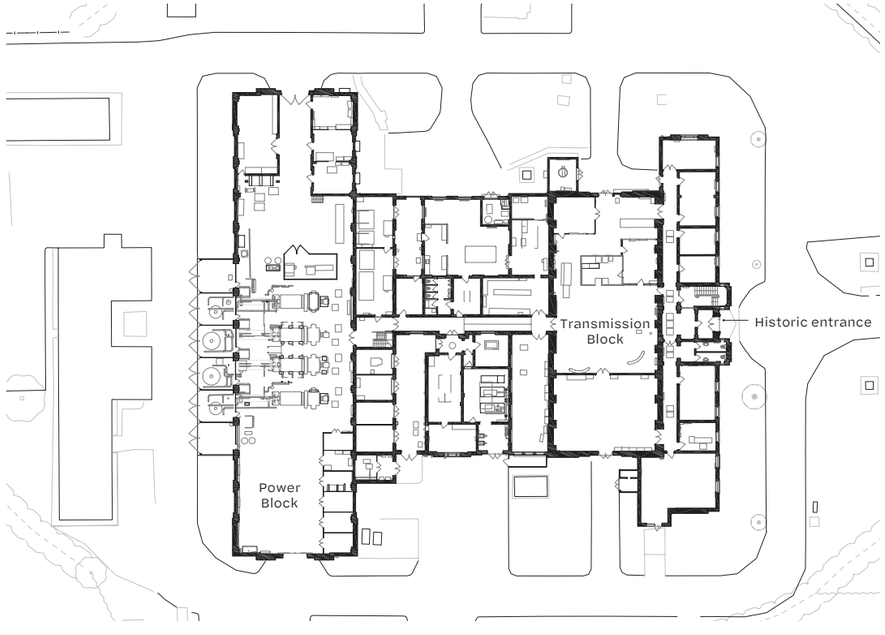
Timeline

1922-26 • Design and construction of the radio station
Jan 1926 • Regular transmissions start with a worldwide range
1936 • Extensions to the link block
1943 • Transmitter coil and roof destroyed by fire; concrete roof installed
1965-66 • Cold War alterations, including security and locomotive engine installations in the Power Hall
1987 • Double-skin roof and rooftop aerial outfeed installed
2003 • Transmissions halted
2004 • Eight of the long wave masts demolished by BT. BT-Aviva begins work on legacy use for the site
2005 • C Station Grade II-listed
2007 • Last four long wave masts demolished
2011 • Site allocated in Rugby Core Strategy
2013-14 • Urban&Civic and Aviva agree terms for a joint venture partnership at Houlton; U&C assumes responsibility for obtaining outline planning application
2014 • Outline consent received for entire Houlton development
Jan 2016 • vHH undertakes feasibility study on the use of C Station as part of new secondary school
Feb 2019 • Enabling works gain Listed Building Consent
Mar 2019 • Locomotive engines removed by Severn Valley Railway
Mar 2020 • Main works contract starts
Aug 2021 • Practical completion

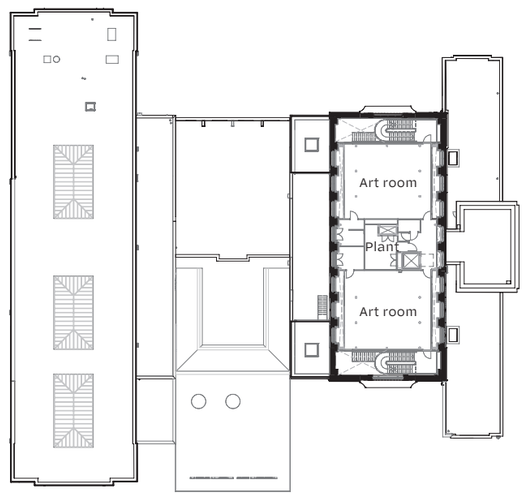
Ground floor plan



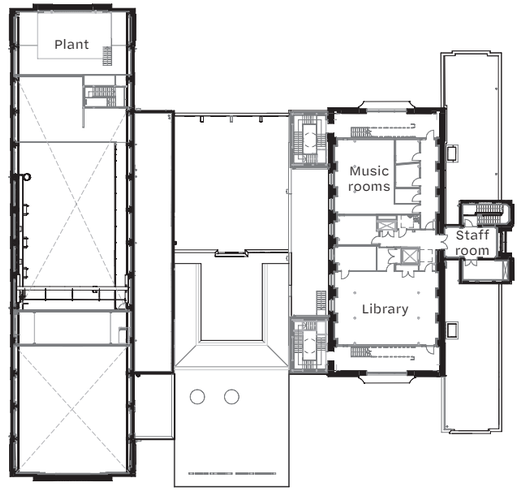
Existing ground floor plan



Third floor plan



First floor plan



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Performance data

RETROFITTED BUILDINGS

Percentage of floor area with daylight factor >2% 26%
Percentage of floor area with daylight factor >5% 8%
On-site installed energy generation Nil
Heating and hot water consumption 88 kWh/m²/yr (PHPP predicted)
Total energy load 154.6 kWh/m²/yr (PHPP predicted)
Carbon emissions (all) 8.1 $kgCO_2/m^2/yr$
Annual mains water consumption Not calculated
Airtightness at 50Pa 4.1 m³/hr/m² (as built)
Overall thermal bridging heat transfer coefficient (Y-value) 0.028 W/m²K
Overall area-weighted U-value 0.221 W/m²K
Embodied/whole-life carbon 404.8 $kgCO_2eq/m^2$ (calculated using LCA OneClick, MEP estimated as 20%)
Predicted design life 60 years

NEW BUILDINGS

Percentage of floor area with daylight factor >2% 87%
Percentage of floor area with daylight factor >5% Nil
On-site installed energy generation Nil
Heating and hot water consumption 24 kWh/m²/yr (PHPP predicted)
Total energy load 67 kWh/m²/yr (PHPP predicted)
Carbon emissions (all) 3.6 $kgCO_2/m^2/yr$
Annual mains water consumption Not calculated
Airtightness at 50Pa 2.4 m³/hr/m² (as built)
Overall thermal bridging heat transfer coefficient (Y-value) 0.034 W/m²K
Overall area-weighted U-value 0.157 W/m²K
Embodied/whole-life carbon 589.5 $kgCO_2eq/m^2$ (calculated using LCA OneClick, MEP estimated as 20%)
Predicted design life 60 years

Engineer’s view

The project has two distinct parts: the sympathetic repurposing of listed buildings, and very high-performance new buildings. Our ambition was to achieve the DfE Output Specification’s stretching energy requirements for the whole site without derogation.

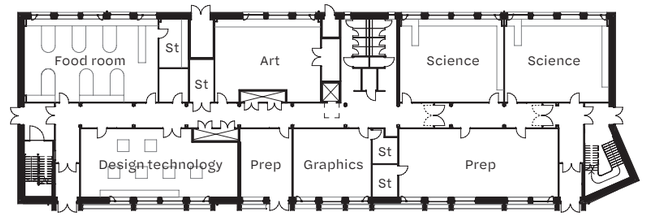
About a third of the accommodation is in existing buildings that were generally unheated industrial spaces with solid brickwork walls and concrete roofs. These needed sympathetic but significant improvements to provide suitable teaching environments and lower energy costs and carbon emissions.

We challenged vHH to insulate areas externally, but internal wall insulation was inevitable given the façades’ significance. This changes the internal conditions of the 100-year-old walls, introducing the risk of moisture build-up and damage. We used common sense and dynamic hygrothermal simulation (WUFI) to assess the risks of insulating. While these were increased by exposure and old cement modifications, they could be reduced by the quality and thickness of the brickwork, mortar repair, limiting the U-value achieved to >0.4 W/m²K, using moisture-open woodfibre insulation, mechanical ventilation, and low air permeability targets.

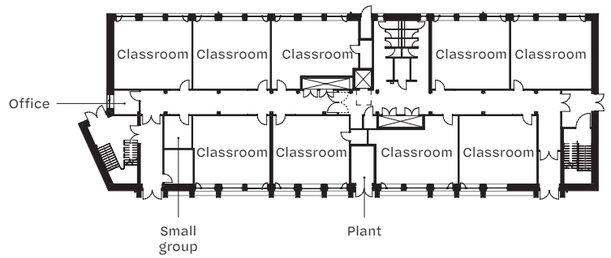
The new buildings compensate for the lower performance of the conversion. Passivhaus design, supplementary predicted energy calculations, defined targets, and painstaking construction quality checks all reduced the performance gap.

The teaching blocks are heated with air source heat pumps, but the sports hall and converted buildings use gas, due to cost pressures. The converted buildings’ transformed envelope provides a basis for the future transition to a fully electric school. The final (as-built) predicted energy consumption meets DfE requirements, and is in the 10th percentile for new schools, with an average heating energy demand of about 25 kWh/m²/yr.
Will South, engineer and director, Etude

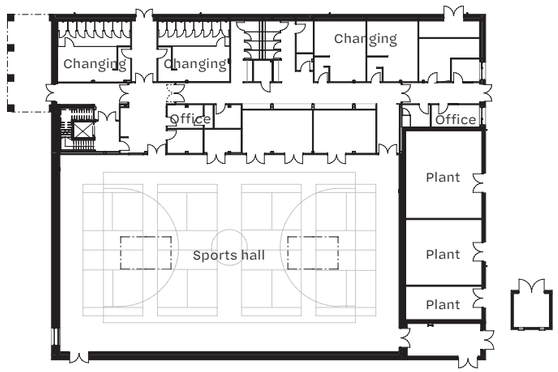
STEM block ground floor plan



Humanities block ground floor plan



Sports Hall ground floor plan



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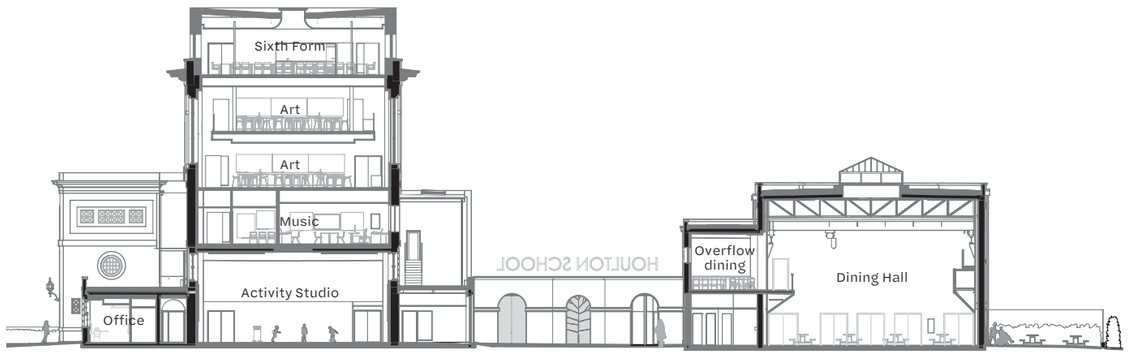
Section A-A



Section B-B

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Client's view

The repurposing of the former Rugby Radio Station buildings for education was a key part of our vision for the wider site from the outset.

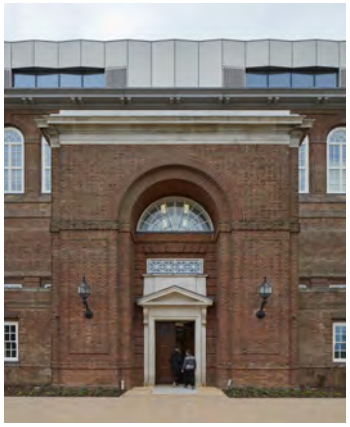
As a developer of large-scale new communities, we are enthusiastic to repurpose and integrate existing buildings and structures into our developments. Heritage brings a new place to life, retaining the back story of the location and adding interest and depth to its character. We were keen not to shy away from our responsibility to the heritage of the buildings and the former use of the site, but to build upon the glories of the past to create a sustainable future.

At Houlton we saw an opportunity to build on the heritage, retaining the listed C Station buildings and creating a unique secondary school. We wanted to make sure this prominent building, which had dominated the landscape locally for almost 100 years, was restored to become a focal point for the new community, with a sustainable long-term occupier, so that the buildings live on well into the future.

The resulting school has not only restored the listed buildings but has created a fantastic secondary school campus and re-established a prominent landmark, anchoring the heart of the community with a strong civic presence.

We are delighted that, through overwhelming support and collaboration, the many challenges of this project were overcome and we are thrilled by the enthusiastic appreciation of the new school.

Richard Coppell, group development director, Urban&Civic



Working detail

In 1944 the original timber hipped roof and cornice of the Transmission Block were destroyed by fire, ruining the proportions of C Station. This project offered us the opportunity to restore the building's proportions by reinstating the cornice and creating a contemporary replacement and an additional floor.

The idea was enthusiastically supported by Historic England, and the top floor, clad with an undulating rainscreen, became the sixth form centre. The cladding matches that of the new Sports Hall across the campus.

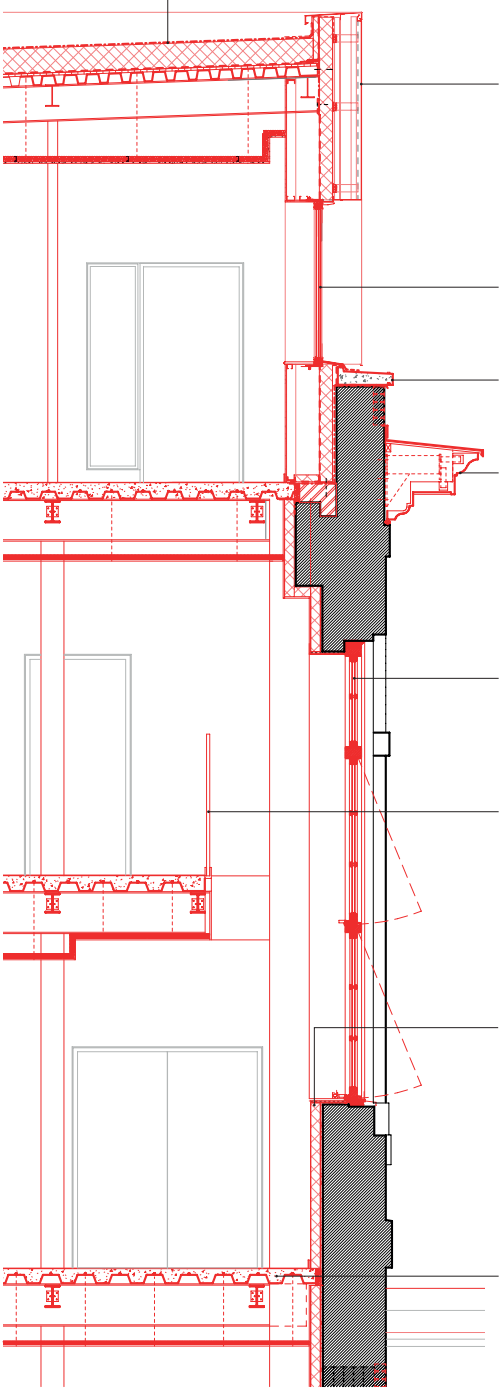
To minimise maintenance we reinstated the cornice in lead-weathered glassfibre-reinforced concrete, rather than timber. It is recreated from archive photos and drawings. At each end the cornice conceals ring beams that brace the walls around the stair voids.

The interface between the new top floor and historic walls is complex, due to the transition from historic, permeable walls with internal insulation to modern, impermeable construction, and the changing position and nature of the air barrier. Morgan Sindall's preference was to use composite panels to minimise working at height and get weathertight quickly.

The top-floor windows have conventional aluminium frames, with fixed glazing and louvre vents. In the historic walls below, the windows are careful replicas of the original timber windows, double glazed and actuated. In both conditions, the windows sit within the insulation zone, and are very carefully sealed to the air barrier.

James McCosh, partner, van Heyningen and Haward Architects

Transmission Block top level detail section



Roof Fully bonded single-layer membrane
Rigid 250mm PIR insulation, mechanically fixed
Felt vapour control layer
18mm oriented strand board
Metal deck supported on new steel frame to falls
Suspended acoustic plasterboard ceiling
Suspended exposed services (radiant panels, lighting, vent ducts)

New wall Large-format anodised aluminium rainscreen panels and parapet copings
Aluminium rainscreen support frame fixed with stainless steel brackets to composite panels
Ventilated cavity
125mm insulated composite panels
Intello tape at all penetrations and membranes to maintain airtight layer
Airtight membrane to inner side of composite panel, lapped onto inner slab, under drywall
Cavity with rigid insulation at base to overlap slab edge insulation
Drywall independent lining, one layer of plasterboard and MDF window boards

New windows PPC aluminium windows with thermally broken frames and triple glazing
PPC pressed aluminium sills and anodised aluminium head and side reveals
Natural ventilation panels at sides, internal louvre grille behind perforated section of rainscreen

New coping In situ concrete coping stones on DPM lapped up face of composite wall panels
Linear uplight fittings to rainscreen above

Reinstated cornice Prefabricated glass-reinforced concrete cornice units with internal hot dip galvanised steel framework bolted to historic masonry
Pale stone grey finish to match existing Portland stone
Stainless steel plates and fixings
Lead weathering with welted joints and lead flashing
18mm WBP plywood and treated softwood wall plates

Timber windows Replica timber double-glazed windows to match original. Openable lights actuated with local control for summer cooling
Installed and taped to internal brickwork with plasterable airtight tape prior to parge coat
Blinds mounted in window reveal

New glazed guarding 1500mm cantilevered glass balustrade along edge of set-back floor

New wall lining to existing walls Existing masonry stripped internally, repaired and repointed externally
Lime plaster levelling and 20mm parge coat
5mm lime plaster bonding coat
92mm Pavadry wood-fibre insulation with bonded fibreboard to wall faces
Pavatherm reveal board to window reveals
12.5mm gypsum fibreboard to wall faces, lime plaster to curved reveals
Painted timber skirting

New floor Vinyl floor finish on 3mm underlayment
Powerfloated 150 RC slab on permanent metal shuttering with soft joint to historic walls
Steel frame with restraint connections through thermal breaks to historic walls
Suspended acoustic plasterboard ceiling
Suspended exposed services (radiant panels, lighting, vent ducts)

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