Above your station

The sculptural atrium roof of Birmingham New Street station called for an ingenious waterproofing solution

A soaring 24m high atrium, roughly the size of a football pitch and covered in inflated ETFE bubbles, forms the centrepiece of the £750 million refurbishment of Birmingham New Street station.

The arcing roof structure, designed by London-based architect AZPML, is formed from a series of sweeping wishbone lattice steel arches, each clad in white tensile PVC fabric and supporting the teardrop-shaped cushions of ETFE.

The roof of the existing 1960s building, the Pavilions shopping centre, had to be demolished to create a hole for the new atrium. The reinforced concrete structure, divided into nine discrete sections with movement joints in between, posed a serious challenge for the scheme's designers, headed up by lead consultant Atkins.

'The challenge was to keep the building stable with a large chunk taken out of the middle and the addition of a stainless steel facade around the outside of the building,' Stephen Ashton, engineering director at Atkins, told RIBAJ. 'The new steel frame for the atrium had to span a moving structure and these changes in loading altered the way the building moves.'

Atkins utilised 3D global stability analysis software to make sense of the constraints, based on initial designs by AZPML and structural engineer AKT II.

The atrium roof structure channels only vertical loads into the building, the steel arches stand on special bearings on the tops of the existing columns, designed to take horizontal movement of up to 75mm. The columns were strengthened with concrete 'jackets' to increase their vertical capability.

An ingenious waterproofing solution was required for the areas of the roof that surround the atrium, developed by roofing contractor Briggs Amasco in collaboration with SIG Design and Technology, which assisted with the supply of roof waterproofing systems across the project.

A new 600mm concrete upstand separates the atrium roof from the main roof. Outside it, the existing flat roof deck had a series of mastic asphalt falls retrofitted onto the surface, designed to channel rainwater through various outlets.

To design a new 'truck deck' around the atrium, with new sloping falls and outlets, it was necessary to first determine the amount of existing asphalt and the datum of the concrete slab below. Scans through the substrate were carried out using ground-penetrating radar, normally used to scan geological conditions, to avoid the need to core potentially thousands of holes through the existing waterproofing.

View showing the station's complex roof landscape surrounding the ETFE atrium roof.

The atrium roof is just part of a huge roof strategy.

Tony Lawther, operations director at BriggsAmasco, told RIBAJ: 'This data was correlated with GPS location markers across the surface to give us a digital map of relative thicknesses across the roof. It allowed us to design the falls with the minimum economic amount of new product.'

The quick-setting mastic asphalt Flexiscreed, supplied by SIG, enabled the contractor to remove the existing waterproofing layer and install the new layer straight away. 'It was vital to allow us to keep the fully operational building dry, we had 140,000 commuters a day passing through the concourse directly below. A cement screed would have prevented access for about three weeks,' says Lawther.

Flexiscreed is manufactured from selected bitumens, limestone filler and specially graded aggregates. It is designed to provide drainage falls as well as a stable base for the specified roof waterproofing system in modern fast track construction projects.

SIG also supplied around 10,000m^2 of temporary waterproofing to cover targeted areas of the station concourse floor during the atrium roof installation. The Armourplan PVC single-ply membrane, typically used in roofing applications, was considered resilient enough to support site traffic as well as prevent water from penetrating through the concourse to the station platforms below.

The new overlaid roof at Layfield Primary School in Yarm

A lesson well learned

A Yorkshire primary school found an economical solution that succeeded in resolving the problem of its leaking roof

Not long after completion, the Foundation Stage and Children's Centre building at Layfield Primary School in Yarm, north Yorkshire, started leaking. Water ran down internal walls and damp patches spread across ceilings.

'We had problems with water ingress. We had to replace carpets and lots of ceiling tiles,' says the school's business manager, Sarah Powell.

Fortunately the problem has now been solved with the help of SIG Design and Technology, which specified its SIGnature Torch on System to remediate the leaking roofs once and for all. By avoiding complete stripping of the failed roofs, this strategy provided significant cost savings.

The leaking roof area consisted of two pitched oval roofs with a flat roof below. SIG's investigation identified the cause of the problem as the oval roofs, where inadequate detailing around the perimeter upstands and at the intersection with the lower roof had allowed water to ingress and find its way through, beneath the flat roof and down the walls into the school.

'It was a constant battle for the school,' says Ian Dryden, SIG national specification manager – bituminous membranes.

Both flat and pitched roofs needed to be remediated. It was clear that the 450m² flat roof was damaged beyond repair and needed to be stripped right back to deck.

A new roof was then added using the SIGnature system, specified with the self-adhesive SA VCL Vapour Control Layer, tapered insulation, SIGnature 25 Underlay and SIGnature AA Capsheet.

However SIG managed to find an economical solution for the 250m² pitched oval roofs, which enabled the contractor to leave the original single-ply roof in situ beneath the overlay, rather than stripping and disposing of it – saving an estimated £60+ per metre.

SIG worked with contractor Roofix Ltd to install the SIGnature system as an overlay. To address the issue of potential plasticiser migration between the old and new roofs, a 300g separation fleece was fitted on the original roof. followed by a mechanically fixed SIGnature25 underlay and a fully torch-bonded layer of underlay and cap sheet.

The second, crucial phase was the correct detailing of the junctions with the flat roof and the upstands around the roof perimeter. Roofix Ltd found a way to close mitre cut and bend the GRP trim insitu to fully encapsulate the upstand as an alternative to the original failed metal capping.

'Good tradespeople come up with good solutions,' says Dryden, who praised the time and care that went into the detailing.

Thanks to the craftsmanship of the contractor, the repairs were completed over the summer holidays in an aesthetically pleasing manner that came in under budget and – importantly – fully warrantied. 'This ticked all the boxes from the client and the local authority's points of view,' says Dryden.

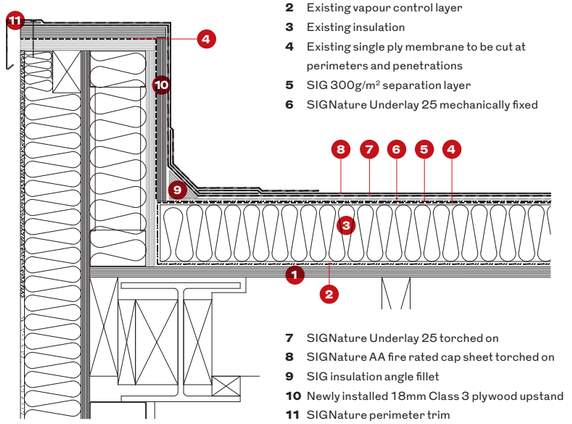
The proof has been 18 leak-free months since the repairs. 'We've had no problems whatsoever ever since,' says Powell. 'It's a massive relief to have had no further disruption caused by the numerous water leaks to providing our services.'

SIGnature Torch on System
Designed for new work or overlays, this bituminous roofing system comprises fire rated torch-on cap sheet, underlay and vapour control layer and is suitable for warm or cold roofs.

There are three underlay options with the potential for either 20 or 25 year warranties:

- SIGnature Underlay25 – A polyester carrier, reinforced, SBS, torch applied intermediate or base layer. Twenty-five year warranty when used with the SIGnature Fire Rated Cap Sheet.
- SIGnature Underlay20 – A glass tissue carrier, reinforced, SBS, torch applied intermediate or base layer. Twenty year warranty when used with the SIGnature Fire Rated Cap Sheet.
- SIGnature UnderlaySA (Self Adhesive) – An elastomeric self-adhesive, polyester fabric reinforced underlay, coated with SBS modified bitumen. Twenty-five year warranty when used with the SIGnature Fire Rated Cap Sheet.

Section of roof and parapet



1 Existing plywood substrate
2 Existing vapour control layer
3 Existing insulation
4 Existing single ply membrane to be cut at perimeters and penetrations
5 SIG 300g/m² separation layer
6 SIGNature Underlay 25 mechanically fixed
7 SIGNature Underlay 25 torched on
8 SIGNature AA fire rated cap sheet torched on
9 SIG insulation angle fillet
10 Newly installed 18mm Class 3 plywood upstand
11 SIGNature perimeter trim

Top The existing roof before remediation. Bad drainage and detailing led to water ingress into the school's interior.

Left After installation of the new roof all these issues have been resolved.

Opposite Before remediation general ponding evident at the upstands to the oval roofs.

Left After remediation parapet detailing is well sealed and robust.

HOW TO AVOID FAILED ROOFS

Following best practice can avoid costly repairs to failed roofing:

- Consult a waterproofing specialist as early as possible during the design stage
- Specify a roofing system that is fire rated and CE marked
- Ensure design details and execution are undertaken by a company that is competent and experienced, with a proven track record, and is covered by PI insurance
- Spend time getting the interfaces detailed correctly, particularly those between different materials and around perimeter upstands
- Make sure all the products and the installation are covered by warranty
- Use approved contractors who are reputable and solvent (warranties depend on the company being in business)
- Ensure manufacturer's inspection of the installation – even the best products can fail with poor installation and detailing.

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On top of your subject

Specifying flat roofs provides a perennial challenge, but many problems can be headed off with the right questions

When we carry out surveys and inspections we come across so many design and installation faults that could have been avoided if more time was spent at the front end designing them out

Flat roofs have been a challenge since before Le Corbusier put pen to paper, yet architects still struggle to understand the specific issues involved and make the correct specifications.

In an effort to help bring them up to speed, SIG Design and Technology has published a free online Flat Roof Specifier Checklist covering the 14 key questions designers need to ask to identify any potential issues on a waterproofing project.

The answers generated can be used to inform ongoing discussions with a roofing specialist, and narrow down choices in the correct order – saving both firms time and, potentially, money.

Ross Finnie, sales director at SIG Design and Technology (pictured above), explains why the checklist was set up: 'Flat roofs might not sound sexy but they are so vital to the function of the building envelope. When we carry out flat roof surveys or inspections we come across so many common design and installation faults that could have been avoided if more time was spent at the front end designing and costing them out.'

SIG supplies a complete portfolio of different flat roofing systems and products, which gives it a unique ability to understand projects from every angle, he adds.

The checklist is divided into three sections: Employer's Requirements, Design Factors and Buildability.

Employer's Requirements covers durability and design life, guarantee period and sustainability, while Design Factors deals with subjects such as aesthetics, structure, drainage insulation, interfaces with other elements and cost. Buildability covers programming, sequencing, protection and cost.

A mistake architects frequently make is to simply specify a system they have used before, says Finnie, either because they didn't encounter a problem with it, or they liked the finish, without properly considering the new context and requirements.

'In other cases, they go to a manufacturer and ask for a single-ply solution, then the manufacturer recommends their best single-ply product, when in fact one of several alternative treatments might have been more effective,' he says.

This guidance is accompanied by a series of blog posts that explain each of the topics in more detail, with impartial advice and case studies.

For example, the Employer's Requirements section on design life points out that different waterproofing solutions have durability statements certificated by the British Board Of Agrément, or European Technical Approval Guidelines, which can be used to differentiate types of product.

A roofing product with a durability statement (design life) of 30 years installed on a building with a 60-year design life is likely to need replacing twice. However, the durability statement for Hot Melt is up to 60 years, so from a design life point of view it might be the preferred solution.

The blog that covers Design Factors points out that the chosen construction method for a building is often a good indicator of the ideal roof structure and waterproofing solution.

Lightweight steel-frame structures, used in commercial or industrial units, or lightweight timber frames, used in residential low rise, give less freedom with roof loading and might favour a more lightweight roof structure and finishes.

Conversely, high-rise residential, public and civil buildings, constructed using dense masonry, might benefit from a heavier roof structure, to increase longevity and protection.

Read the blog posts and download the free checklist from this link: bit.ly/flatroofchecklist