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REINFORCED INVOLVEMENT

Should early contractor involvement reasoning be used for reinforcement subcontractors?

LIGHTENING THE LOAD

The use of EPS with concrete as a structural fill material

RESTORING HERITAGE

Conserving sculptures, hydro plant and other concrete assets

LIGHTENING THE LOAD

St Margaret's Head Railway Tunnel - Installation of EPS blocks in staggered, interlocking layers.

(Photo: Tony Marsh Photography.)

Simon Poole of **Cordek** discusses the use of expanded polystyrene (EPS) as a structural fill material for transport and infrastructure projects.

(Photo: Michael Molloy Photography Ltd.)

INSET:
EPS blocks being cut to fit by means of a portable hot wire cutter.

Expanded polystyrene (EPS) is being increasingly specified as an alternative to traditional fill materials, taking advantage of its combined load-bearing capability and lightweight attributes.

Since the early 1970s, when Scandinavian authorities adopted the use of EPS for highway and bridge abutment construction, the use of this versatile material has grown in both popularity and the scope of applications for which it has been successfully used. More recently, in the UK, the increased use of EPS within infrastructure projects to both lighten and support concrete structures has helped to overcome the engineering challenges provided by poor load-bearing ground conditions, reducing loading requirements on below-ground structures and locational restrictions.

Without question, concrete has an extensive list of favourable characteristics and properties – durability, strength and versatility, to name just a few. However, the weight of concrete can prove excessive in certain applications and therefore adopting the use of EPS within the design of a reinforced concrete frame or structure can prove to be a beneficial combination.

DIFFERENTIATE

At this stage it is important to differentiate between the two main generic applications for which EPS is used in conjunction with reinforced concrete, namely:

- void formers – for the formation, shaping and positioning of openings (when struck) or non-load-bearing sub-areas/layers of lightweight material (left in-situ)
- structural fill – a lightweight alternative to traditional formation materials positioned beneath concrete structures, for load-bearing applications.

Void formers are commonly subjected only to the weight of poured concrete, until curing and self-support via connection to the adjacent structural elements is achieved. Alternatively, structural fill applications usually result in the EPS providing permanent support to the concrete and any ensuing live loads.

CONSTRAINTS

Where the positive combination of concrete and EPS really comes into effect relates to infrastructure and transport projects where major design constraints have been identified. These constraints often include one or a combination of the following:

- existing below-ground structures, eg, vaults, tunnels, utilities and services that are incapable of supporting or resisting the loads attributed to the proposed development above
- restrictions on access, mechanical plant and/or vehicle movements to the site itself
- ground conditions exhibiting low bearing capabilities.

An example of a project that has taken advantage of amalgamating reinforced concrete and EPS to overcome site-specific design constrictions includes the redevelopment of London Bridge Station, undertaken between 2012 and 2018.

LONDON BRIDGE

To increase the capacity of the station, supplementary lines were added in addition to a major refurbishment and reconfiguration of existing platforms and infrastructure. However, beneath the main track slab and within the confinement of existing retaining walls, a 3m-deep void underlain by pre-existing arch structures required the use of a lightweight structural fill solution.

The proposal to use EPS in lieu of traditional sub-grade materials resulted in a significant reduction in weight (the maximum density of EPS used was 55kg/m^3), reduced vehicle movements (up to 70m^3 of EPS per vehicle) and no compaction requirements – meeting noise restrictions and allowing overnight/weekend working. Most importantly, the heavily reinforced track slab, in excess of 1m in depth, required no design compromise, with support and load distribution provided by the EPS beneath.

Another case in point was the infilling of the now disused St Margaret's Head Tunnel, South Fife

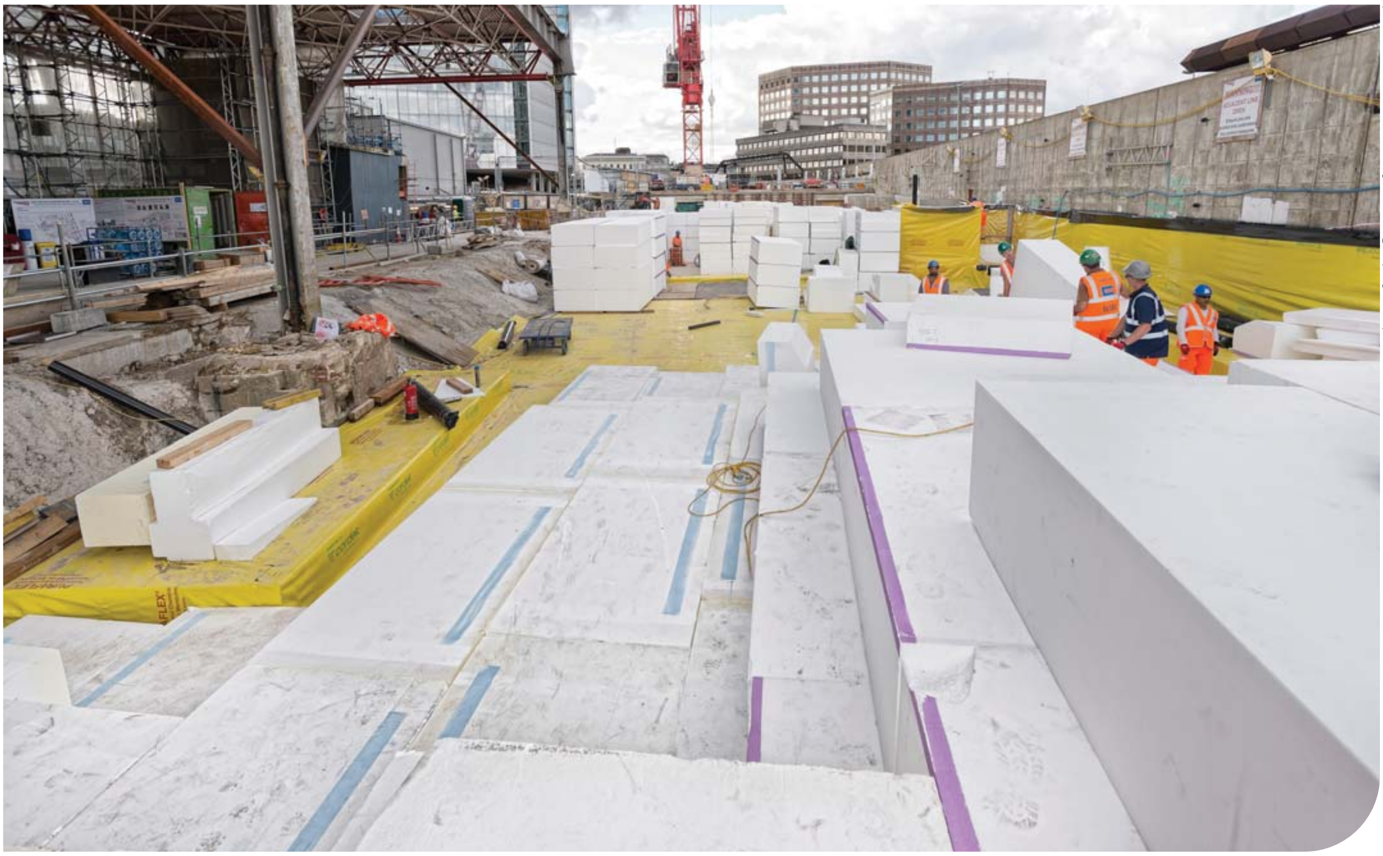
INSET:
St Margaret's Head Railway Tunnel – Installation of a VOC- and hydrocarbon-resistant membrane to protect the EPS blocks from residual contamination.

(Photo: Tony Marsh Photography.)

with a combination of lightweight EPS blocks and a pumped concrete grout, helping to stabilise the structure and support the ground above.

The 420m-long, 4.3m-wide and

BELOW:
Identification of EPS blocks with differing densities by colour-coded markings.



(Photo: Michael Molloy Photography Ltd.)

5.1m-high tunnel had previously been sealed off at both ends, with the adjacent cutting filled in, leaving the remaining entry points restricted to a small number of access shafts. In total, 21,342 EPS blocks were lowered into the tunnel and transported by a temporary monorail system along the length of the tunnel, before finally being positioned by hand in stepped, interlocking layers.

The remaining voids, between the EPS blocks and tunnel lining, were sealed with a concrete grout that was pumped from the surface, to complete the strengthening works required.

The use of EPS has also been adopted elsewhere within UK infrastructure and extends beyond applications relating to the rail network. Road bridge construction within the UK has embraced the use of EPS void formers within reinforced concrete bridge decks for some time, with cylindrical EPS units positioned within the reinforcement prior to the concrete pour reducing the overall weight of the deck without significant concessions to spans or loading capabilities.

Aside from the structural benefits achieved from the use of EPS within reinforced concrete structures, there is a further advantage to be gained from the collaboration of these two materials. The reduction in the volume of concrete used, by virtue of being replaced by EPS, can positively affect the embodied carbon footprint of the structure, which is related to the initial construction phase of its lifespan.

> "Structural fill applications usually result in the EPS providing permanent support to the concrete and any ensuing live loads."

BRIDGE ABUTMENTS

Elsewhere, concrete bridge abutments have been supported by EPS structural fill to overcome issues relating to localised geotechnical challenges. This was the case with the recently completed upgrade of the Datchet Road Overbridge, Slough, as part of the M4 widening scheme. In locations without a pre-existing hard shoulder for conversion to a running lane, a total of 11 overbridges between junctions 3 and 12 required demolition and replacement.

At the Datchet Road bridge, beneath the position of one of the newly constructed embankments, localised peat deposits with poor bearing capability were identified. Furthermore, underlying HV cables required protection from the loadings related to the construction activity above.

Lightweight EPS structural fill, built up to a maximum depth of 5m, helped to create an embankment that was sympathetic to the reinforced concrete bridge abutment, limiting load transfer, which ultimately resulted in a cost-effective and material-efficient design.

Both EPS and concrete have inherent properties that independently make them a favourable choice of materials for a range of infrastructure projects. However, when used together, they provide a solution that can be considered greater than the sum of its parts. C

BELOW:
M4 Datchet Road Overbridge – EPS block installation to form a bridge embankment.