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A PASSION FOR RED

The distinct precast cladding of a Manchester hotel

LOW-CARBON CONSTRUCTION

Decarbonising concrete with no impact to cost or programme

REPAIR AND STRENGTHENING

Carbon savings of a repair and rehabilitation alternative

BOULBY MINE, NORTH YORKSHIRE

At the height of the pandemic, construction was one of the few sectors that continued working. One such project being worked on was the repairs to a mine-shaft building in North Yorkshire. In this article, **Matt Robinson** of **Concrete Repairs Limited** reveals how the works were carried out, and what made the project a success, and reports on the carbon emission savings achieved for the client.

Boulby Mine is located on a 490-acre (198-ha) site in North Yorkshire, situated on the north-east coast of the North York Moors National Park. It is operated by Cleveland Potash, a subsidiary of Israel Chemicals Limited (ICL) and is the world's first and only polyhalite mine. Polyhalite is a natural multi-nutrient fertiliser and a source of potassium, calcium, magnesium and sulfur.

The main shaft building is a cast-in-situ concrete structure with primary and secondary steel reinforcement. It houses a steel sheave wheel and supporting structure which provides access to the UK's deepest mine to a depth of 1200m. The external elevation of the structure extends 45m above ground level and is 12.5m in diameter to the outer face with a 300mm-thick concrete wall.

The structure is approximately 50 years old and needed structural refurbishment. Concrete Repairs Limited (CRL) was appointed as the principal contractor and structural refurbishment specialist, with the works commencing on-site in October 2020.

CRACKING AND SPALLING

Extensive survey works identified that significant areas of repair were required to both the external and internal faces of the 300mm-thick concrete wall. There were large areas of cracking and spalling to a depth of between 80 and 100mm, as a result of corrosion of the reinforcing bars. The effect of this was large volumes of concrete were

LEFT:
Figure 1 – Boulby Mine.

BELOW LEFT:
Figure 2 – shaft with scaffolding in place.

RIGHT:
Figure 3 – area of spalling prior to breaking out.

BELOW RIGHT:
Figure 4 – typical area requiring repair.

delaminating from the structure and falling to the ground below, which if left unchecked would pose a significant safety hazard.

From the client's perspective, one of the key obstacles to overcome on the project was to ensure that the man-riding shaft was kept operational while the internal repair works were carried out. In this respect, refurbishment was a much better option than demolition and renewal.

HYDRO-DEMOLITION

Externally, the works involved the design and erection of a 45m-high, fully encapsulated scaffold/access system around the perimeter of the shaft. Hydro-demolition was used to remove 31m^3 of defective concrete. Replacement reinforcement steelwork was fabricated to match the curvature of the structure prior to installation, while the remaining steelwork was cleaned and fully prepared by removing all rust and laitance.

Over 1500 sacrificial anodes were then fixed into the broken-out areas to slow down the corrosion of the reinforcement and prolong its life, thus enhancing the service life of the structure. The concrete repair mortar was then applied using a mixture of hand-applied, and dry-spray techniques. Hand repairs were carried out using Fosroc HBS high-strength, high-build, R4 concrete repair mortar, with the sprayed repairs carried out using Fosroc DS dry-spray repair mortar. The whole structure was then thoroughly cleaned to remove all surface contaminants prior to two layers of a Hydron anti-carbonation coating being applied to help protect the reinforcement from future corrosion problems.

Aggregate	Replacement option (benchmark)	Carbon savings (CRL approach vs benchmark)
Concrete	100%	91%
Steel	100%	96.5%
Carbon savings (tCO_2e)	100%	93.8%

ABOVE:
Table 1 – Boulby Mine sustainability.

Further external works included: the application of a non-slip, fully waterproof Vulkem decking system to the roof of the shaft to prevent further water ingress; the design and installation of external guide-rope cowls; and the design and installation of stainless-steel pipe and cable supports up the face of the structure.

BESPOKE ACCESS

Internally, CRL developed a bespoke access system that ensured the man shaft could remain totally operational at all times. A fully encapsulated scaffold was installed around the lift during night hours while the shaft wasn't in operation. This was then sheeted and enclosed to ensure nothing could inadvertently enter the shaft. A further scaffold system was then installed from ground to roof level to provide access for carrying out the work. Owing to the presence of an

Source of emissions	Replacement option (benchmark)	Carbon savings (CRL approach vs benchmark)
Materials	100%	93.8%
Waste	100%	93.7%
Commuting (tCO_2e)	100%	85%
TOTAL	100%	90.7%

ABOVE:
Table 2 – Boulby Mine project emission savings.

BELOW:
Table 3 – social impact of project.

Source value area of focus	Social value (£)	National TOM's reference
Local employment	£94,383.00	NT1
Carbon savings	£43,617.30	NT31
Total delivery	£138.000.30	

airlock on the fourth floor, a crane lift was required from ground level to roof level for the scaffolding of the top two levels of the shaft.

Due to the internal structure containing electrical equipment, hydro-demolition of the concrete was not an option. Therefore, 26m^3 of concrete was removed via hand breakout using 110V breakers. This was a labour-intensive undertaking with due consideration given to noise, dust and HAVS requirements for the operatives. Over 1200 sacrificial anodes were installed in the broken-out areas and the concrete sprayed back to restore the original profile. Two coats of an anti-carbonation coating were then applied to all exposed concrete surfaces.

ACCESS SOLUTION

Due to the arrangement of the shaft lift, with clearance required during operational hours, the beam repairs on level 3 of the structure were severely restricted. CRL developed a solution of installing and removing the scaffold access each night and applying a carbon-wrap system to the beams. This eliminated the need for heavy breakout, increased the strength of the beams, and ensured operations weren't interrupted. This remedy ended up providing a long-term, fully encapsulated solution, which saved both time and money and was of enormous benefit to the client.

Prior to commencing with both the external and internal works, hazard assessment workshops were held between the key project stakeholders to identify the main hazards and ensure that sufficient control measures were put in place to mitigate the risks.

CARBON EMISSION SAVINGS

Compared with rebuilding the shaft, a 93.8% reduction in CO_2e was made on this project. To illustrate these savings, the UK Government's conversion factors (2021 – revised January 2022) were used to calculate the embodied carbon emissions by comparing the concrete and reinforcing requirements. CRL's restoration approach offered estimated savings of 91% in the volume of concrete required, and 96.5% in the volume of steel required (see Table 1, page 43).

Through our waste management suppliers, 100% of site waste was diverted from landfill, being either recovered or recycled. Using the waste volume:emissions ratio from our suppliers' reports, we estimate the waste management emissions

BELOW LEFT:
Figures 5 and 6 – typical areas requiring repair.

RIGHT:
Figure 7 – hydro-demolition to get behind the reinforcing and prepare the patch for reinstatement.

BELOW RIGHT:
Figure 8 – completed repair.

"The project cost an estimated 6–10% of the rebuild alternative and allowed the shaft to remain operational throughout the construction phase."

of the replacement option would have been 93.7% higher.

For both internal and external phases, 66.67% of our full-time employees were from the north-east, helping to reduce emissions from commuting. Those who commuted from further afield stayed in accommodation to further reduce travel emissions. We estimate a saving of 85% in carbon emissions due to a reduction in commuting.

In summary, CRL's restoration approach offered estimated savings of 90.7% of carbon emissions (see Table 2) and £138,000 (see Table 3) versus the replacement alternative, just from the materials, waste management and employee commuting alone. While our calculations have not accounted for all emissions from the project, they have accounted for the main sources.

BENEFITS

CRL's restoration approach also offered significant economic and environmental benefits to the client and interested third parties, such as the local community. The project cost an estimated 6–10% of the rebuild alternative and allowed the shaft to remain operational throughout the construction phase. This figure does not include the impact of any loss of production or the potential risk to production. Periods of unplanned shaft inactivity would have significantly increased the total project cost.

With over 57m^3 of concrete broken out and replaced, several tonnes of structural steelwork fitted, over 2700 anodes installed and over 3500m^2 of anti-carbonation coatings applied (while also strengthening key elements using carbon fibre), the mine-shaft building has been significantly refurbished using numerous modern structural rehabilitation techniques. In addition to all the works issues that had to be contended with, the project was undertaken during the height of the global pandemic between 2020 and 2022.

SUSTAINABLE CONSTRUCTION

The project is an example of the benefits of repair/refurbishment over replacement. The cost savings to the client, the ability to maintain operations and the environmental benefits make this an excellent example of a sustainable construction project. It also demonstrates how early contractor involvement (ECI), a positive forward-thinking approach in overcoming the challenging aspects of the scheme and a collaborative approach from a very receptive, intelligent client are key to ensuring the success of a concrete repair project.