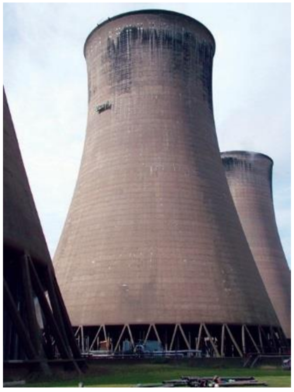
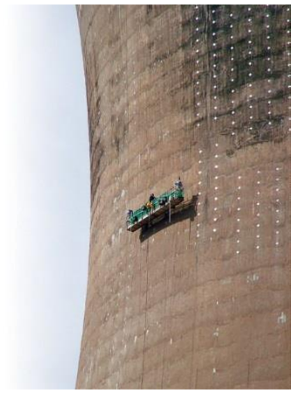
ZENITH

Access Issues Faced and the Technical Issues Raised Whilst Carrying Out Major Repairs to 4no Hyperbolic Cooling Towers

Darren Smith MBA

Introduction





This paper considers the access issues faced and the technical issues raised whilst carrying out major repairs to four Hyperbolic Cooling Towers at British Energy's 2000MW Coal-fired Power Station at Eggborough in Yorkshire, England.

Particular focus will be placed upon the background & repair philosophy adopted. Also, it will highlight the scope of the repairs and Zenith's approach to the project. The paper will also consider the regulations governing the works. Focus will be placed on the access issues raised and the findings following the inspection. The technical queries raised and the solutions adopted will also be analysed together with the repairs actually carried out.

Background

The tower height is 113.1m and the throat diameter is 46.6m. The diameter at the pond sill is 86.6m. The air gap is 7.9m. The shell thickness is nominally 178mm except for the ring beam and the cornices

Eight natural draught cooling towers exist at Eggborough Power Station. These were constructed using an early method of "jump forming", which produced an irregular shape. Two different techniques were used to form the cooling towers. Six towers have a composite skin of 125mm of reinforced concrete, with an additional top surface of 50mm of sprayed gunite material added several years later. Two towers have an overall thickness of 178mm of reinforced concrete.

Movement of the cooling towers has occurred in the past together with natural cyclic movement from the various weather seasons. On going maintenance included crack repairs, removal of defective sections which have separated from the underlying reinforced concrete shell and spalling repairs

The immediate concern was the durability of the towers including the condition of the gunite layer on towers 1, 2, 3 and 6, the integrity of the connection of the gunite to the tower shells and the security of the upper concrete spacer pads.

Repair Philosophy

- Survey.
- Mapping of delaminating area.
- Identify location of reinforcing.
- Trace & remove 'rubble' around pockets (Previous inspection port holes cut out by others but never repaired).
- Splice new re-bar as necessary.
- Drill drain holes below delaminated areas.
- Establish & mark bolt location (area to encompass 1000mm beyond the delaminated area on both the vertical and horizontal planes).
- Drill & secure the 50mm layer of gunite in its current position with M12 bolts & 150 x 150 mm washers (this method would prevent any further movement away from the 125mm reinforced concrete shell and serves to contain the gunite cladding).
- Complete necessary repairs.

Scope of Works

Design / Supply/ Install and remove all temporary access

- Inspection of the full surface of the external shell and removal of any loose concrete and associated sections of concrete including ring beam, columns etc….
- Sample concrete cores and testing for strength & carbonation.
- Patch repairs to the gunited concrete shell.
- Bolting up areas of delaminated gunite.
- Removing or stabilising the upper concrete spacer pads (just below the cornice level)
- Removing or stabilising the concrete spacer pads at the "alimac" locations.

Conditions of Contract:

The contract was awarded under the following Conditions of Contract - The New Engineering Contract (NEC) Option B published by the Institution of Civil Engineers. The Bill of Quantities assumes use of CESMM 3

Approach

The approach adopted by Zenith involved giving due consideration to safe working practices, as safety is priority at all times during all phases of the project. Zenith has a proven track record of this type of project and the method of execution had to be practical for this application. In addition, the solution chosen had to give Zenith a commercial edge over others.

Regualtions - UK Legislation

Factories Act – Various Revisions
Health & Safety at Work Act 1974

Regulations / Accepted Codes of Practice (ACOP'S)

Management of Health & Safety at Work Regulations 1992 (Rev 1999)

Provision and Use of Work Equipment Regulations 1992
Construction (Design and Management) Regulations 1994.
Construction (Health, Safety & Welfare) Regulations 1996
Lifting Operations and Lifting Equipment Regulations 1998.
Work at Height Regulations 2005

British Standards, European Norms and More:

BS 5974	Temporarily installed suspended scaffolds & access equipment.
BS EN 12811-1:2003	Temporary works equipment. Scaffolds. Performance requirements and general design
BS EN 12811-2:2004	Temporary works equipment. Information on materials
BS ISO 4308-1:2003	Cranes and lifting appliances. Selection of wire ropes.

Factories Act – 1961 & Subsequent Revisions
Construction Regulations (1960's)

Health & Safety at Work Act 1974
Management of Health & Safety at Work Regulations 1992 (Rev 1999)
Provision and Use of Work Equipment Regulations 1992
Construction (Design and Management) Regulations 1994.
Lifting Operations and Lifting Equipment Regulations 1998.
Work at Height Regulations 2005

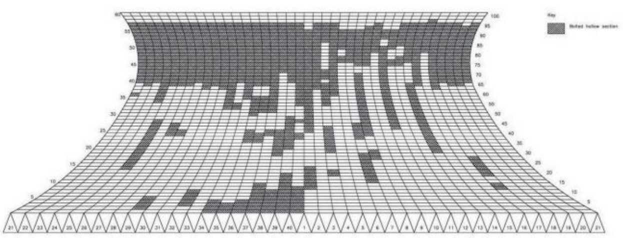
Access

Zenith utilised a bespoke design cathead system based on the cornice detail at the top of the tower. The cathead is engineered to suit individual projects supported by structural calculations and documentation to satisfy regulations and project requirements.

The cathead system is piecemeal constructed at the top of the tower. The manageable components are hoisted into position via a winch and lifting stick. The system is assembled in sections to form one unit. The system is countered with an internally located counter weight or anchorage. The system is tested on completion to a pre-determined safe working load, normally 375kg but it can be adjusted up to 800kgs, with minor modifications.

The cradle platform follows the tower profile by the use of profile wires fixed into the shell and tensioned at ground level. When moving around the perimeter of the tower the load is marginally released and the system can be literally pushed to the next working position. . The system can be adapted to complete work on load to satisfy market demands supported by specific risk assessments.

Figure 1 shows typical mapping of the external shell following detailed hammer testing of the entire area. The shaded area shows the extent of the delaminating requiring bolting.



Findings

Typical findings on this project included the identifying of areas of extensive delaminating requiring between 1000 to 2000 bolts per Tower. Areas of spalling gunite were observed and in addition, previously cut inspection port holes were located which had not been repaired thereby allowing the ingress of weather. Negligible corrosion was noted on the reinforcing although there was no serious loss of section even though light guage steel was incorporated in the construction. Marginal cracking of the outer gunite layer was also recorded.

Theoretical Bolting Pattern.

The theoretical bolting pattern at the design stage proposed the following –

- Drill line of fixings to solid area to right hand side of delaminated area
- Fit bolts and plate washers & torque up, to 60Nm. Side of washers to be fitted at 45° to the horizontal.
- Drill line of fixings to solid area to left hand side of delaminated area
- Fit bolts and plate washers & torque up, to 60Nm. Side of washers to be fitted at 45° to the horizontal.
- Drill fixing holes over remainder of area between previously fixed bolts.
- Fit bolt at bottom right hand side of delaminated area, adjacent to bolts previously fixed and fit plate washer.
- Using wire gauge, dip adjacent drilled hole positions and repeat during bolt tightening to ensure that the gunite is not being drawn back.
- Torque bolt to 60Nm.
- Repeat bolt fitting, dipping & torquing until all bolts installed up the vertical row.
- Move to left hand side of area & repeat steps 12 to 15 until vertical row complete.
- Continue fitting bolts alternately to right & left hand sides of area until all bolts installed.
- Once an area has been completed re-torque all bolts alternating between right & left sides & working bottom to top.

Actual Bolting Pattern

As an alternative to the proposed theoretical bolting pattern, Zenith favoured continuous bolting in one direction. Bolting started to the right lower side of the delaminating area until each vertical row was complete before moving along to fit the next row in sequence. Once again an area of at least 1000mm was bolted beyond the delaminating area on both the vertical and horizontal planes. This had marginal result with the worst case being that minor chasing occurred. The benefits of this approach on productivity outweighed any negative issues. Typically the bolts were located at 1200mm on the horizontal plane and between 600-900mm on the vertical plane.

Bolts Proposed

Hilti HST – R – A4 Stainless Steel

This product has excellent performance and longevity in this environment. The bolts are torqued to 60 Newton Metres.

An alternative to the above product was sourced in the market achieving the same properties as required in the cracked concrete performance bracket. The alternative proved to be fit for purpose and an economical alternative against Hilti. However, delivery proved to be a problem with the manufacturer requiring to turn additional thread and the replacement failure rate increased significantly with more waste generated. Photograph 4 shows typical placement technique.

The specification issued by the Power Station requested the use of A4 components. Zenith argued that A4 hardness was not required for the plate washer and suggested a galvanised or an A2 option. The A2 option was chosen which had significant advantages as far as delivery schedules and progress was concerned.

Spalling Repairs

In relation to the packing of the void between the spalling gunite and the tower shell, it was proposed that a chemical expanding product be utilised. Zenith pointed out the problems with this option due to issues involving hazardous material, waste management and environmental issues. As an alternative, Zenith proposed the use of recycled paper which would address the environmental issues and apply a practical solution to a minor technical problem.

Internal Bolting Impact

As viewed from the cornice at the top of the tower, damage was noted above the tower throat where the wall thickness was thinner than predicted. Spalling was located at the bolt placement positions. An internal repair scheme was proposed by Zenith, however it was deemed that the long term performance would not be affected.

Conclusion

The repair technique adopted at Eggborough Power Station proved to be a successful practical application to this project.