

CASE STUDY

PFA FILL AND CONCRETE FOR PORTRACK SEWAGE TREATMENT WORKS

In the early 1970s, prior to the formation of Northumbrian Water, the Teesside County Borough prepared plans and drawings for the construction of a sewage treatment works at Portrack. The works would treat incoming sewage from newly constructed sewers running along the north and south banks of the River Tees which, collected raw sewage and discharged it directly into the river from the Stockton and Thornaby areas.



Portrack is designed to serve a population of 208,000 and provide preliminary and primary treatment to sewage from western areas of Middlesbrough, Thornaby, Norton and parts of Stockton and Billingham. The project makes a major contribution to the elimination of unsightliness and smell from the Tees estuary.

Siteworks

Construction of the treatment works started in early 1979 when a contract was awarded for earthworks on the site to raise by 3 metres the levels of the existing low-lying ground which was subject to flooding. These earthworks also ensured that the ground beneath the proposed structures was properly consolidated before construction started, thereby avoiding damage due to future settlement.

The main civil engineering and building works contract was awarded in 1980 and Portrack was commissioned in August 1983.

PFA as fill

270,000 tonnes of Pulverised Fuel Ash (PFA) were used to raise the existing ground level between 3 – 3.5 metres.

Why PFA?

Difficulties were presented by the poor, marshy nature of the ground with some 18 – 20 metres of soft, alluvial silty clay overlying a 4 metre gravel layer on sandstone bed rock. The site is approximately 3 metres below high tide levels in the adjacent River Tees and protected from flooding by earth embankments. The works had to be elevated by 3 metres above the original site levels to allow gravitational flow to the river at all states of the tide without pumping. A corresponding general raising of the site by 3 metres of fill was required but investigation into the consolidation of the silty clays indicated settlements of up to 600mm due to the placing of fill. Although all tanks and foundations were to be piled, it was considered that the indicated settlements could not be tolerated due to the effects this would have on interconnecting pipework and cables. A decision was therefore made to fill the site prior to commencing construction and then re-excavate where necessary for structures.

This would enable consolidation to take place without causing damage to structures and services.

The fill material required had to be easily compacted, re-excavated and suitable for re-use as fill around structures and pipelines. It was also required to be available in quantity at short notice if the programme was to be met.

Following compaction trials on the site and confirmation that the required quantities were available, it was decided to use lagoon PFA. A total of 270,000 tonnes were used over the site and spread to consolidated depths of 3 – 3.5 metres. The contractors tendering for the site fill were given the opportunity to submit prices for alternative materials but none was able to meet the specification at a lower rate. The fill was compacted in 150mm layers to a specified density of not less than 90% of the maximum dry density as determined by field tests to BS 1377, No 15. Compaction was achieved using 4 to 6 passes of a 5.5 tonne vibrating roller. Settlements of the existing ground were recorded during and after placing the fill and a total maximum settlement of 450mm took place within seven months of commencing placing.

Northumbrian Water considered that the choice of PFA proved economical and sound. No problems were encountered.

in re-excavation for tanks and foundations and the PFA was re-used as backfill. Due to the low density of material, settlement in the second stage backfilling between tanks and structures was minimal.

The Northumbrian Water engineers engaged in the project claim that the reclamation of unstable land on sites is a valuable use for PFA where a source is close at hand.

PFA in concrete

16,000m³ of concrete were supplied in which 30% of the cementitious material was PFA of a selected grade provided by Pozzolanic Lytag Ltd.

Factors taken into consideration when determining the proposed concrete specification included the presence of a class 2/3 sulphate condition in the ground, exposure to sewage, frequent wetting and drying due to variations in the levels of flow through the works and freezing conditions in winter due to the exposed nature of the site. Consideration was given at the specification stage to the possible use of PFA but investigations being carried out by the Authority into the use of this material had not been completed in time for this project. The specification therefore called for a characteristic strength of 30 N/mm² using a minimum of 350 kg/m³ of Sulphate Resisting Portland Cement with a maximum free water cement ratio of 0.5. An additional requirement was the use of an air entraining agent.

The contract was let on the basis of the above specification but prior to the commencement of concrete work the Contractor, Balfour Beatty Construction Limited, requested permission to use PFA in the concrete. The request was made on

economic grounds and the Contractor offered a reduction in the concrete rate of £1.45/m³ where PFA was used. This reduction did not represent the total cost savings made as this was shared between supplier, contractor and client and computed to an estimated £4.34/m³. The total saving to the Authority was expected to be in the region of £23,000.

Following the approval of trial mixes and the successful completion of a trial wall panel, permission was given to use PFA.

Details of the mix used were:

- 280 kg OPC
- 120 kg Pozzolan (PFA complying with BS3892: Part 1 and additional clauses)
- 820 kg 20mm single sized gravel
- 360 kg 10mm single sized gravel
- 610 kg sand
- 170 litres water.

Twenty-eight day strengths at between 40 and 50 N/mm² were achieved throughout the contract.

Whenever placing was to be by pumping, the following mix was used:

- 290 kg OPC
- 125 kg Pozzolan (see note above)
- 720 kg 20mm single sized gravel
- 360 kg 10mm single sized gravel
- 660 kg sand
- 185 litres water.

One concern initially expressed was the possibility of a delay in stripping times for formwork due to a slower strength gain. This problem did not arise.

The Contractor did initially have some problems in placing the concrete, which did not flow easily, but these were soon overcome by additional vibration.

The resulting concrete finish is of a high standard and the Northumbrian Water



Engineers are satisfied that this is at least partly due to the use of PFA.

An extract from Northumbrian Water's Special Specification Clauses for concrete is as follows:

"These special specification clauses are to be used in conjunction with the second edition of the Civil Engineering Specification for the water industry. In so far as these special clauses may conflict or be inconsistent with any provisions of the Civil Engineering Specification for the water industry, these special clauses shall always prevail."

Section 2-Materials

2.121 Cementitious material certificates

1. Daily bulk average cement certificates shall be obtained from the cement manufacturer, a copy of which shall be given to the Engineer, whenever concrete is supplied to the site of the works.

2. Each consignment of PFA delivered to the site of concrete manufacture shall be certified as conforming to the requirements of BS3892 Part 1, and a copy of the certificate shall be given to the Engineer, whenever concrete is supplied to the site of the works.

2.122 Cementitious material

1. Where mixture of PFA and Ordinary Portland Cement is specified or permitted, the constituents shall be blended and not be interground.

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