

# CASE STUDY

## PFA at Pride Park, Derby

### **Introduction**

Pride Park is an 80ha development site lying to the east of Derby City centre in the east midlands. The whole of the Pride Park has been blighted by its previous industrial history, which has included an engineering works since 1836, and a gas works from the turn of the century.

In the early part of 1991 the government introduced a new programme into its urban development strategy called City Challenge. This initiative was a response to the inner city riots of the early 1980's. The City Challenge scheme was based on a competitive bidding process where the winning Cities had to demonstrate how they would alleviate problems of inner city deprivation.

Derby City Councils successful bid for 37.5m over five years meant that the problems of Pride Park could be tackled.

In 1993 Ove Arup & Partners were employed to design an engineering solution which was environmentally responsible and sustainable, commercially viable and based on sound engineering principles.

Derby City Council was responsible for providing the infrastructure and services for the site.



Aerial of site 1993

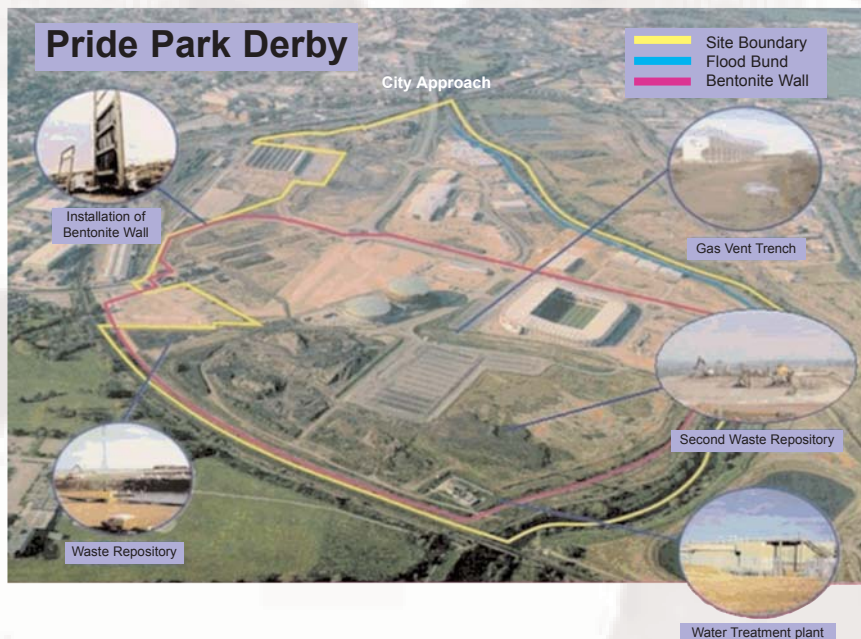


Aerial photograph 1979 showing Old Gas Works and Landfill Site

### **The Problem**

- A relatively flat area giving rise to surface water drainage problems and flooding.
- Remnants of the City's gas works and engineering works.
- Heavily contaminated land as a result of past use.
- A municipal refuse tip producing methane gas.
- Protect adjacent landowners and River Derwent from cross contamination.

## The Solution



- Arup devised a reclamation strategy based on a "suitable for end use" approach.
- Construction of a 3km long bentonite slurry cut off wall.
- Provision of a groundwater treatment plant.
- Provision of a gas vent trench adjacent to existing landfill tip.
- Construction of two on-site fully engineered waste repositories to contain contaminated material.
- Construction of a flood bund adjacent to the River Derwent.
- Raise the general level of the site by "site won" material or imported material.
- Provision of a graded stone isolation layer or capillary break blanket.

## The Construction

Construction on the reclamation work started on Pride Park in June 1994 with the construction of the cut off wall and reclamation of some 54ha of land. Running in parallel to the work was the building of the first of three Bridges for the Park across the River Derwent. During the course of the next 10 years Pride Park would be fully reclaimed and be occupied by over 45 business covering such areas as leisure, manufacturing and commercial enterprises.

The reclamation works associated with the 80ha site generated the following earthwork quantities:

Contaminated Waste, 93,015m<sup>3</sup>  
Excavated Material 152,000m<sup>3</sup>

In order to meet the design levels for the reclamation there was a short fall of material in the order of 171,000m<sup>3</sup>.

## PFA at Pride Park

This material was required in three main areas:

1. General fill to individual plots, 94,000m<sup>3</sup>
2. General fill for base construction to the on site waste repository, 20,000m<sup>3</sup>
3. General fill to bridge abutments, 57,000m<sup>3</sup>.

In order to meet this short fall Arup and Derby City Council looked for an environmentally sustainable and cost effective product. It was decided to use Pulverised Fuel Ash (PFA) for the following reasons:

1. Ready supply available from local sources, Ratcliffe and Drakelow Power Stations.
2. Environmentally sustainable, ie the re-cycling/re-use of a "by-product" from another industry.
3. Generally constant material properties.
4. A "light weight" material.
5. Relatively easy material to place and compact.
6. The material satisfied the requirements of the reclamation strategy for Pride Park.
7. End users, eg Contractors putting up buildings on Plots found excavations in PFA for foundations, drains etc very acceptable as little or no trench collapse took place.

The PFA supplied by Ratcliffe Power Station to Pride Park was "conditioned" ash which came from the power station operating silos or stockpiles on site at Ratcliffe.

The first Plot to require additional imported fill material was Plot 10/11 (8.4ha) or as it is today the home of Derby County Football Club and JJB Sports. This was in July 1996.

After the reclamation site works had been carried out which included removal of contaminated material and buried foundations a total of 6800m<sup>3</sup> of PFA was used to raise the level of the plot before the final stone isolation blanket was placed. The PFA was end tipped from delivery articulated lorries and then spread and compacted in layers using a BW6 Dozer and 3460 vibrating smooth roller. The specification for the compaction was based on the Department of Transport Specification for Highway Works.



PFA being placed and compacted, Plot 9F (Brewsters Restaurant)

This technique was used to place and compact the PFA fill material for all reclamation works associated with the various plots on Pride Park. A total of 12 plots that varied in size went to make up the reclaimed and developed land that is Pride Park today. This resulted in a requirement of 93,938m<sup>3</sup> of pulverised fuel ash being imported.

### ***Case Study: Base construction for second waste repository***

During the course of reclaiming plots of land on Pride Park, a total of 93,015m<sup>3</sup> of contaminated (special) waste required housing in two purpose built waste repositories both constructed within the Pride Park site boundary. The construction of one of these repositories was on the site of an existing landfill tip located in the southeast corner of Pride Park. This repository was constructed to hold 54,679m<sup>3</sup> of contaminated (special) waste. The repository dimensions were 126m x 126m x 12m high.

As part of the base construction for this repository PFA was detailed as a suitable fill material. The construction of the basal formation layer was between October 2002 and December 2002. The total quantity of PFA used in the construction was 20,336m<sup>3</sup>. In general the construction of the basal formation layer was constructed in several layers of PFA using a D6 dozer and BW6 smooth wheeled vibrating roller. The PFA was placed in 250mm layers and rolled, each layer received a minimum of 6 passes, and this was monitored through out the works. The specification called for a Degree of Compaction of 95% or greater to be achieved.



Placing and compacting PFA for waste repository base

The rate of construction was hampered by some of the wettest weather conditions experienced for the last 10 years. The bad weather resulted in several "soft" areas developing in the PFA during construction. These areas were dealt with in several different ways as listed below:

- Total removal of the soft area and replacement with "fresh" imported PFA.
- Removal of the top surface (100mm-150mm) and replacement with "fresh" imported PFA.
- The soft area was left to "dry" before placing the next layer of PFA.

The wet PFA that was removed was stockpiled until dry and then re-used.

## Testing

The specification called for a series of tests to be carried out on the PFA during construction. The tests required are listed below:

- Grading to BS 1377: Part 2 to be carried out 1 per 400m<sup>3</sup> of fill.
- Moisture content to BS 1377: Part 2 to be carried out 1 per 400m<sup>3</sup> of fill.
- Insitu density testing to BS 1377: Part 9 to be carried out at 1 per 400m<sup>3</sup>.

The results of the moisture content and insitu density tests were used to confirm that the specification requirements for a degree of compaction of 95% or more on the compacted PFA be achieved.



Insitu density tests on PFA

In order to monitor the progress of work on site and define where tests were taken the repository "plan" was split into four quadrants, North, South, East and West. Each of these quadrants was approximately 63m x 63m in size. The grading results complied with the requirements of the specification. The insitu tests were carried out at different frequencies at different levels within the basal formation construction. The tests were carried out to BS 1377: Part 9. The total thickness of the PFA basal formation layer was approximately 2.0m at the centre of the repository tapering out to approximately 1.0m at the edge of the repository. The first location for testing taken in the PFA, was 600mm above the base of the PFA layer, then 1200mm above base, then 1800mm above base with the final position being at the finished surface. During the course of insitu density testing several results failed by an unacceptable degree. These areas were "re-worked" by the contractor using one of the methods stated above and the material re-tested.



Removing "wet" PFA from surface of base construction

Arup continually reviewed the results as they were received from the contractor and deemed that the basal formation layer was constructed in accordance with the requirements of the specification and the insitu results were acceptable. The insitu density tests showed an overall average result for the degree of compaction to be 99%.

The average degree of compaction and moisture content result for each quadrant was as follows:

North Quadrant	99%, 26%
South Quadrant	99%, 26%
East Quadrant	100%, 28%
West Quadrant	99%, 30%

Three of the 65 results fell below the 95% requirement, (94% in the North Quadrant, 91% in the South Quadrant and 94% in the West Quadrant. The fact that a small proportion of the results narrowly fell below the acceptance criteria for insitu density probably reflects the experimental error involved in the test method rather than indicating any significant problem with the degree of compaction of the PFA.

## Conclusion

Throughout the regeneration of Pride Park from a highly contaminated brownfield site to the successful business Park today the use of Pulverised Fuel Ash has played an important role.

This has been recognised by the Client, Derby City Council, the Consulting Engineers, Ove Arup and Partners Limited, the Contractors, AWG Construction Services Limited, Birse Construction Limited and Mowlem Construction Limited.

## Acknowledgement

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ARUP