Backfill placement has emerged as the chief focus of investigations into a major tunnel collapse on the Chiltern Railway line near Gerrards Cross last week.

The tunnel, being constructed as part of a £20.3M Tesco “air rights” project, partially collapsed at 7.30pm last Thursday, blocking the railway line.

The alarm was sounded by the driver of a Chiltern line commuter service stopped in Gerrards Cross station and about to enter the tunnel.

Network Rail operations director Robin Gisby told NCE that the backfill operation is its primary cause of concern.

“Something about the method of construction on this section is not right,” said Gisby.

A 320m long section of Victorian railway cutting adjoining Gerrards Cross station was being “tunnellised” to provide a town centre site for supermarket giant Tesco (NCE 9 December 2004).

The operation involved erecting a tunnel of precast concrete segments over the twin track London-Birmingham rail line and backfilling to original ground level.

Work was being done under a design and build contract by Jackson Civil Engineering with consultant White Young Green and precast arch supplier the Reinforced Earth Company.

Jackson chief executive Richard Neall insisted that backfill operations were “in line with what the design allowed”.

“There was a strict loading regime in place,” he said.

White Young Green chief executive John Purvis would only say that “efforts are focused on the clean up operation” and would not comment on the contract at this stage.
The tunnel works as a three pin arch, composed of half span, 2m wide segments leaning against one another under self weight.

It was inherently flexible, allowing 200mm of vertical movement and was reliant on surrounding earth pressure provided by backfill for much of its long term stability.

The backfilling operation had reached formation level over approximately half of the site, allowing steelwork for the supermarket to be erected. Fill operations were advancing towards the south portal at Marsham Lane bridge.

The 30m long collapsed section is around 60m north of Marsham Lane, with between a half and two thirds of the fill operation completed.

It is thought that an imbalance in the placement and compaction of fill either side of the tunnel combined with a surcharge of fill over the tunnel’s crown triggered collapse.

Geotechnical engineers this week expressed surprise at the apparent height differential between fill to the sides of the tunnel, and especially at the quantity of fill placed above the tunnel in the collapse zone.

“The collapse was probably due to too much load on the crown of the arch and not enough fill on the sides,” said the head of one specialist consulting firm.

“Units [appear to] have failed by creating a hinge in the concrete section. The hinge has rotated downwards, which is consistent with the crown of the arch moving downwards under excessive load and/or the sides of the arch moving outwards under too little lateral restraint.

“This problem would have been made worse if there was a significant difference in the level of the fill on the two sides,” he added.

A height difference would have resulted in uneven earth pressure on the walls of the tunnel, causing it to deform asymmetrically, or sway.

“At the section that is still standing the central hinge has bent down indicating an imbalance between the vertical and horizontal loads and a failure by outward spreading of the arch,” the head of specialist consultancy said.

He suggested that monsoon-like rainfall that hit Gerrards Cross on Wednesday could have aggravated the situation.

“It is possible that rainfall increased the vertical load on the tunnel. At the same time, if the fill at the sides is not completely free draining, it could have led to a reduction in the passive pressure available from the fill on the sides.”

A designer of similar precast concrete arch systems added that there was a relatively short transition zone between the area of the site that had been fully filled and that where the collapse happened.

“Movement around the crown can be quite substantial – as much as 200mm up as you fill around the sides and then 200mm back down as you fill over the top. But that’s not a problem if it’s properly controlled.

“You could trigger failure if you go straight from full depth fill over one section straight to no fill; that is, a section that’s fully flexed next to one that’s unflexed,” he said.

To minimise the risk of differential deflection over the length of the tunnel it is normal to raise fill levels evenly along the whole tunnel length, or to provide a gradual, long, ramped transition, he claimed.

Network Rail and Health & Safety Executive investigators expect it to take a month and a half to determine the cause of collapse. “We’re focusing on all aspects of design and construction,” said a HSE spokesman.
The Gerrards Cross tunnellisation was being carried out using a precast concrete arch system developed in France during the early 1990s.

The 20m span tunnel is composed of 2m wide, half span segments, designed and supplied by Reinforced Earth Company, a subsidiary of French contractor Freyssinet. Segments were manufactured by Irish producer Macrete.

Segments are staggered, with each half span element bearing on to the two segments opposite. Formwork was required to support the first five elements, after which the system was self-stable.

An average of four segments were craned into position during each night time possession.

Segments spring from insitu concrete piled foundations. The capping beam is detailed with a 100mm deep trough into which the segments were seated. These footings were grouted up once the erection sequence was complete.

At the crown, a simple stainless steel clad male female ‘hip’ joint provides for up to 200mm of rotational movement as the arch deflects vertically. Movement arises as fill first squeezes the sides of the arch and then, as load is applied to the top of the arch, it returns to its original geometry.

Two longitudinal, cast insitu beams, one either side of the crown joint, transfer stresses between units and provide resistance against longitudinal loading, but no resistance against lateral loading.

Reinforced Earth Company was responsible for defining the geometry, thickness and reinforcement of the segments. It also offered guidance on the backfill operation.

But design of the foundations and of the backfill sequence at Gerrards Cross fell to White Young Green, said Reinforced Earth Company director general Patrick Nagle.

Fill consisted primarily of grade 6N quarry scalpings from the Mendip Hills. This material was specified for the sides and the 1.5m covering the tunnel.

The top layer of fill is graded incinerator bottom ash. Fill was to be placed and compacted in maximum layers of 500mm deep.