Ground movements near South Heath – Frequently Asked Questions

High Speed Two (HS2) is the new high speed railway for Britain. We have produced this document to answer frequently asked questions about two ground movements (sinkholes) near South Heath, which occurred on 7 and 12 February 2024 during construction of the HS2 Chiltern tunnel, and how we continue work to minimise such occurrences during our works. The information within this document is correct at the time of creation (22.02.2024).

Why were we tunnelling near South Heath?

We were tunnelling near South Heath as this is where the Chiltern tunnel is being constructed along the HS2 line of route, as denoted in the HS2 Act.

Geology

What are the ground conditions in the Chilterns?

The Chilterns are a landscape formed on chalk bedrock. Chalk is a type of limestone composed mainly of calcium carbonate, and over geological time is susceptible to dissolving in rainwater. Chalk is usually white or light grey. Above the chalk it is common to find relatively thin layers of soils such as clay with flints or gravels.

Can you tunnel through chalk?

With chalk as the predominant geology in the area, this is the material within which the tunnels had to be constructed. There are many previous examples of successful tunnelling in chalk in the UK, including the Channel Tunnel Rail Link (High Speed 1), Crossrail (now the Elizabeth Line) and the Thames Tideway super sewer, which all use the same tunnelling techniques as HS2.

What is a sinkhole?

Sinkholes are a well-known geological features, which form through weathering of chalk. Sinkholes are caused by rainwater dissolving the chalk very slowly (over geological timescales) in fissures and fractures in the rock. They are not easily visible from the ground surface because they become infilled with soils. The infilled soils do not always completely fill the void left by the dissolving chalk and so can be unstable.

Do sinkholes happen naturally in the Chilterns and how? Why?

Yes, sinkholes occur naturally, and they occasionally collapse naturally. This can happen when the chalk in and around the sinkhole is dissolved further and gravity causes infill

material to collapse, or when the infill material is loosened by water entering the sinkhole and again collapse occurs as gravity acts on the infill.

Sink holes in the Chilterns were recently reported on by bucksfreepress: https://www.bucksfreepress.co.uk/yourbucks/23569077.buckinghamshire-sinkholes-behind-phenomenon/

When tunnelling in chalk there is a risk of encountering a sinkhole. In most cases the Tunnel Boring Machine (TBM) controls the material infilling the sinkhole, however, occasionally the material in the ground movement is loose and/or there is a void, and this can lead to the infill material falling into the hole, in a similar way to a natural sinkhole collapse.

The chalk of the Chilterns

The chalk of the Chilterns consists of many separate formations. The Chiltern tunnel bores primarily through two formations of chalk - Lewes Nodular and New Pit formations. The tunnel does bore through other formations, though only briefly in comparison to these two mentioned.

Below are the geological definitions of the chalk formations in this area.

Lewes Nodular chalk formation

The Lewes Nodular chalk formation is composed of dense to very dense nodular chalks and hardgrounds with interbedded low to medium density chalk, nodular flints, marls and some interbedded chalks. Nodular flints 50-100mm are typically encountered though examples of >300mm have been found along with laterally expansive sheet flint.

New Pit chalk formation

The New Pit chalk formation is principally blocky, white and firm to moderately hard with numerous marl seams; it is characterised by rare flint occurrence and often massive nature. The New Pit chalk formation is intensely fractured by conjugate joint sets that commonly dissipate along the marl seams.

One of the key differences between the two formations is the presence of flint – within the excavated profile of the TBMs, Lewes can exhibit >10% flint whereas the New Pit is typically 0-0.5%.

The soluble part of the chalk, calcium carbonate, can and has dissolved leaving behind insoluble constituents. In the case of Lewes formation, the flint, formed of microcrystalline forms of silica, is the insoluble constituent. The topography close to the Frith Hill ground movement is relatively flat, this has resulted in insoluble dissolution material staying relatively in-situ rather than being transported by hydrological

processes as may be seen in the Misbourne Valley for example. This means that discrete dissolution features can be commonplace.

Sinkholes near South Heath

Which factors contributed to the sinkhole identified on 7 February?

Florence, one of the Align Tunnel Boring Machines (TBM), had tunnelled under the field near South Heath, three weeks previously in mid-January. On 7 February, surveyors were undertaking their planned daily checks of levelling points in South Heath and visually identified the ground movement on site. The heavy rainfall on the nights of 6 and 7 February weakened the ground and the depression formed. There had not been rainfall of a similar magnitude since the first week of January 2024.

How was HS2 informed about the sinkhole appearing on 7 February?

The Align supervisors were on site to carry out planned monitoring and identified settlement above Florence. We notified the tenant and ensured that the location was fenced off for safety.

Which factors contributed to the sinkhole identified on 12 February?

An existing dissolution feature was encountered by Cecilia the TBM. This was an unknown feature not previously identified by geotechnical investigation techniques. Parameters from the TBM indicated that the feature had been encountered, a surface inspection was carried out and the ground movement identified.

How was HS2 informed about the sinkhole appearing on 12 February?

As a result of interpreting the parameters of the TBM, a surface inspection was arranged, and the ground movement identified the same day by Align.

Why haven't you stopped the TBMs again whilst the ground movement is repaired?

Florence was paused in this area three weeks ago to undertake planned maintenance. This location was chosen because there was no risk to the general public and is an area below an open field. The pause was required to ensure the cutter head's condition before the approach to the North Portal. No abnormalities in readings were identified by the TBM when it travelled through, and tunnelling operations have continued – Florence is now on the approach to the Chiltern Tunnel North Portal. The safest course of action to prevent further ground movement is to continue tunnelling therefore, both TBMs continued tunnelling.

Is it safe for the local community if there are sinkholes in the area?

The ground movements are isolated within an arable field on private land with no public right of way or access. In addition, we have securely fenced the area so that there is no public access.

What precautions will you take when tunnelling under Frith Hill?

We continually monitor parameters from the TBM to ascertain the likelihood of encounter with a dissolution feature. Daily surface level monitoring also takes place when tunnelling under Frith Hill. Additionally, during daytime working hours we will station our "surface watchmen" in the vicinity of Frith Hill. During nighttime working hours regular patrols of the area will take place.

When do you plan to repair these areas impacted by ground movement and how?

We are working closely with the landowner and tenant to secure the right permissions to access the area. We will follow a similar procedure that was agreed with landowners to reinstate previous ground movements at Shardeloes House and Hyde Lane.

The ground movement features will be remediated by layered compaction of topsoil. ALIGN will then monitor the area post reinstatement to ensure the ground remains stable. These remedial measures will be discussed and agreed with the relevant stakeholders, including the landowner and tenant, the Environment Agency, Affinity Water, and any immediate neighbours who may also be affected. Buckinghamshire Council have been informed.

Future tunnelling

How deep are the TBMs and does their depth make sinkholes more common?

Dissolution features, such as sinkholes, develop from the dissolution of the chalk by surface water through fractures. The first few metres of chalk are therefore more prone to dissolution. These features are therefore encountered more commonly at shallow depths (generally <15m) but can in some cases go deeper.

The TBMs and tunnels once constructed are approximately 22 metres below the surface in this area.

Why do you stop the TBMs and how often?

Pausing the TBMs intermittently and for short periods of time happens frequently to carry out maintenance on the tools at the head of the machine that cuts into the ground. We stop the TBMs at the vent shaft sites for a variety of reasons, for example to make a connection to one of the vertical access and ventilation shafts or more commonly to carry out maintenance on the tools at the head of the machine that cuts into the ground.

Are there any further dissolution features between South Heath and the North Portal? Will more ground movement events occur?

We take all necessary precautions to ensure that the tunnelling is carried out safely. We have undertaken extensive monitoring of the ground along the route of the TBMs and accept there may be other unknown features that we could encounter. To provide more stability we have installed 96 barrettes on the approach to the North Portal. These barrettes are vertical concrete ground reinforcement structures that have been built in advance to ensure that the ground remains stable as the TBMs approach break out at the North Portal.

How do HS2 plan for the risk of sinkholes?

What ground investigation do you carry out?

To understand the ground conditions and buried hazards that we may encounter when constructing the Align section of HS2, we have undertaken a significant number of investigations along with the original desk study; including physical boreholes to extract samples of the ground to the depth of the tunnel and non-invasive geotechnical investigations, comprising of LIDAR (Light detection and ranging) surveys, and various geophysical investigations such as electrical resistivity imaging, microgravity and seismic surveys. An extensive regime of physical surveys of land and property prior to construction also play a key role in understanding the ground conditions.

These geotechnical investigations target assets including critical infrastructure, such as the River Misbourne, M25 and the Chiltern Railway, as well as utilities, highways, buildings, overbridges, embankments, retaining walls and other waterways which we have successfully tunnelled below without incident.

We also have a monitoring regime of key assets and structures above the route of the tunnel, including properties, highways, bridges etc. which monitors any changes in ground movement. Our monitoring regime begins before we tunnel through an area, during construction and continues for a period of time after the TBMs have passed.

Water and the aquifer

What danger does this ground movement event have on impacting the chalk aquifer?

The ground subsidence occurred greater than 60 metres above ground water level in superficial deposits. The ground movement at the surface should not have a long-term impact on local groundwater flow paths or hydrogeology. Although potentially

accelerated by the boring of the tunnel, this kind of ground subsidence is a natural phenomenon that commonly occurs in the Chilterns and does not have long or short-term effects on the aquifer. The Environment Agency has concluded that the earlier ground movement event at Shardeloes Estate had no impact on water quality: https://www.bbc.co.uk/news/uk-england-beds-bucks-herts-67030442.amp

Are there risks to the drinking water?

Before any work below the water table is started, a comprehensive risk assessment is completed and provided to the Environment Agency and Affinity Water for review, comment and approval. Each organisation issues a consent to allow the work to progress if the work is approved. The assessments take into account numerous protective measures to reduce the risk of adversely affecting drinking water. The protective measures include the selection of the cleanest construction techniques, choice of materials, the implementation of robust pollution prevention measures, the provision of enhanced protection at pumping stations and an extensive monitoring programme to check on effects and implement additional mitigation if required.

What will the impact be on the chalk aquifer?

HS2 Ltd is committed to protecting the chalk aquifer within the requirements for the construction and operation of the new railway. The ground subsidence occurred greater than 60 metres above ground water level and does not have long or short-term effects on the aquifer. We are undertaking daily monitoring of the boreholes in the South Heath area. We have not observed any changes in water level or water quality outside of typical values. Substantial assessment and liaison with the regulators are undertaken prior to any works starting close to or below the water table and a comprehensive monitoring regime is in place.