## EXHIBIT LIST

Reference No: HOC/00054  
Petitioner: William Murray  
Published to Collaboration Area: Wednesday 16-May-2018

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Legend
Phase 2a hybrid Bill alignment July 2017
Viaduct
Indicative extent of petitioner(s) property
Bored Tunnel
Cutting
Embankment
Cut And Cover Tunnel

High Speed Two
Petitioner Location Plan
Reference Drawing

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## Noise Levels

<table>
<thead>
<tr>
<th>14077</th>
<th>Birch Tree Lane, Whitmore</th>
<th>Existing baseline sound level (dB)</th>
<th>Construction noise levels (dB)</th>
<th>Operational noise levels (dB)</th>
<th>Change (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Daytime</td>
<td>40</td>
<td>56/60</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evening/Weekend</td>
<td>39</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Night-time</td>
<td>36</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>For construction assessment</td>
<td></td>
<td>Daytime</td>
<td>40</td>
<td>46</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Night-time</td>
<td>36</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>For operational assessment</td>
<td></td>
<td>Daytime</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Night-time</td>
<td>36</td>
<td></td>
<td></td>
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</table>
### Table 1. Existing Baseline Sound Levels

<table>
<thead>
<tr>
<th>Assessment Location</th>
<th>Measurement Location</th>
<th>Operational Sound Assessment (dBA)</th>
<th>Construction Sound Assessment (dBA)</th>
<th>Data Source Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Daytime</td>
<td>Night-time</td>
<td>Arithmetic Average</td>
</tr>
<tr>
<td>14077</td>
<td>Birch Tree Lane, Whitmore</td>
<td>40</td>
<td>50</td>
<td>52</td>
</tr>
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</table>

### Table 2. Assessment of construction noise at residential receptors

<table>
<thead>
<tr>
<th>Assessment Location</th>
<th>Impact Criteria</th>
<th>Significance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typical/highest monthly outdoor LpAeq [dBA] at the facade</td>
<td>Construction activity resulting in highest forecast noise levels</td>
</tr>
<tr>
<td></td>
<td>[Assessment category A/B/C]</td>
<td></td>
</tr>
<tr>
<td>14077</td>
<td>Birch Tree Lane, Whitmore</td>
<td>56/60</td>
</tr>
</tbody>
</table>

### Table 3. Operational airborne sound level, noise impacts and effects (residential receptors)

<table>
<thead>
<tr>
<th>Assessment Location</th>
<th>Impact criteria</th>
<th>Significance criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proposed Scheme only (Year 15 traffic)</td>
<td>Do something (Opening year baseline + Year 15 traffic)</td>
</tr>
<tr>
<td>14077</td>
<td>Birch Tree Lane, Whitmore</td>
<td>44</td>
</tr>
</tbody>
</table>
### Vibration Levels

Table 4. Operational ground-borne sound and vibration levels, noise and vibration impacts and effects for residential and non-residential receptors

<table>
<thead>
<tr>
<th>Assessment location ID</th>
<th>Impact criteria</th>
<th>Significance criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area represented</td>
<td>Groundborne sound level dB LpASmax</td>
</tr>
<tr>
<td>14077</td>
<td>Birch Tree Lane, Whitmore</td>
<td>25</td>
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</table>
Dear Mr Murray

HIGH SPEED RAIL (WEST MIDLANDS – CREWE) BILL – HOUSE OF COMMONS SELECT COMMITTEE: PETITION P2A-000054 – WILLIAM PETER MURRAY

I am writing to you in my capacity as the Director of Hybrid Bill Delivery at HS2 Ltd, which is acting on behalf of the Promoter of the High Speed Rail (West Midlands-Crewe) Bill (‘the Bill’) currently before Parliament. I understand that you have a number of concerns about the impact of Phase 2A of HS2 (known as ‘the Proposed Scheme’) and have submitted a petition on that basis against the Bill in the House of Commons.

I understand that you wrote my colleagues on 7 May 2018 requesting further information in respect to the assessment of the ground conditions at Whitmore Heath and any investigations that have been undertaken to confirm that the proposed tunnel is viable.

This letter sets out the Promoter’s position in relation to the issues you have raised and the measures identified to address your concerns.

Ground conditions at Whitmore Heath

The underlying ground conditions for Whitmore Heath comprises bedrock which is part of the Sherwood Sandstone formation comprising sandstone and conglomerate (pebble beds). This is detailed on the British Geological Survey published geological map. The Sherwood Sandstone has a high strength as a rock mass. There is some faulting shown in the wider area around Whitmore Heath but no specific faulting of the rock in the area of Whitmore Heath. Therefore, although we do not have ground investigation data in the Whitmore Heath area at present to confirm the site-specific ground conditions for design, assurance as to the ability of the Sherwood Sandstone to support a tunnel construction - as proposed - without tunnel influenced ground movement can be substantiated.

Tunnel construction and ground settlement

For your reassurance and information I attach the following HS2 Phase 2A Information Papers in hard copy for you to review:

HS2
High Speed Two (HS2) Limited
Sanctuary Buildings
20 Great Smith Street
London SW1P 3BT

Telephone: 08081 434 434
Minicom: 08081 456 472
Email: hs2enquiries@hs2.org.uk
gov.uk/hs2

15 May 2018
I hope that the information set out above in relation to the issues raised in your petition gives you the comfort required in order to withdraw your petition.

Petitions may be withdrawn by sending an email or letter to the Private Bill Office of the House of Commons informing the Clerk to the Select Committee that you wish to withdraw your petition¹.

If you have any further questions in advance of your appearance before the Select Committee next week, please do not hesitate to contact Maya Williams-Orme, Petition Manager, on 079204 12567 or Maya.Williams-Orme@Hs2.org.uk.

Yours sincerely

Oliver Bayne
Director, Hybrid Bill Delivery
High Speed Two (HS2) Limited

¹ Contact details can be found on the Select Committee website at http://www.parliament.uk/business/committees/committees-a-z/commons-select/high-speed-rail-west-midlands-crewe-bill-select-committee-commons/contact-us-17-19/
This paper outlines the policy on ground settlement proposed for the Proposed Scheme.

It will be of particular interest to those potentially affected by the Government’s proposals for high speed rail.

This paper was prepared in relation to the promotion of the Bill: High Speed Rail (West Midlands-Crewe). Content will be maintained and updated as considered appropriate during the passage of the Bill.

If you have any queries about this paper or about how it might apply to you, please contact the HS2 Helpdesk in the first instance.

The Helpdesk can be contacted:

by email: HS2enquiries@hs2.org.uk
by phone (24hrs): 08081 434 434
                  08081 456 472 (minicom)

or by post: High Speed Two (HS2) Limited
            2 Snowhill, Queensway
            Birmingham
            B4 6GA

Version 2.0
Last updated 1 February 2018
1. Introduction

1.1. High Speed Two (HS2) is the Government’s proposal for a new, high speed north-south railway. The proposal is being taken forward in phases: Phase One will connect London with Birmingham and the West Midlands. Phase 2a will extend the route to Crewe. Phase 2b will extend the route to Manchester, Leeds and beyond. The construction and operation of Phase One of HS2 is authorised by the High Speed Rail (London – West Midlands) Act (2017).

1.2. HS2 Ltd is the non-departmental public body responsible for developing and promoting these proposals. The company works to a Development Agreement made with the Secretary of State for Transport.

1.3. In July 2017, the Government introduced a hybrid Bill\(^1\) to Parliament to seek powers for the construction and operation of Phase 2a of HS2 (the Proposed Scheme). The Proposed Scheme is a railway starting at Fradley at its southern end. At the northern end it connects with the West Coast Main Line (WCML) south of Crewe to allow HS2 services to join the WCML and call at Crewe Station. North of this junction with the WCML, the Proposed Scheme continues to a tunnel portal south of Crewe.

1.4. The work to produce the Bill includes an Environmental Impact Assessment (EIA), the results of which are reported in an Environmental Statement (ES) submitted alongside the Bill. The Secretary of State has also published draft Environmental Minimum Requirements (EMRs)\(^2\), which set out the environmental and sustainability commitments that will be observed in the construction of the Proposed Scheme.

1.5. The Secretary of State for Transport is the Promoter of the Bill through Parliament. The Promoter will also appoint a body responsible for delivering the Proposed Scheme under the powers granted by the Bill. This body is known as the ‘nominated undertaker’. The nominated undertaker will be bound by the obligations contained in the Bill and the policies established in the EMRs. There may be more than one nominated undertaker.

1.6. While the UK has notified its intention to withdraw from the European Union, the UK remains a member until withdrawal, meaning that rights and obligations under EU law apply until the date of departure. The Government has announced its intention to convert all EU law into UK law, through the European Union Withdrawal Bill, so that the same rules and

\(^1\) The High Speed Rail (West Midlands – Crewe) Bill, hereafter ‘the Bill’.

\(^2\) For more information on the EMRs, please see Information Paper E1: Control of Environmental Impacts.
laws will apply on the day after exit as on the day before. It will then be for democratically elected representatives in the UK to decide on any changes to that law, after full scrutiny and proper debate.

1.7. These information papers have been produced to explain the commitments made in the Bill and the EMRs and how they will be applied to the design and construction of the Proposed Scheme. They also provide information about the Proposed Scheme itself, the powers contained in the Bill and how particular decisions about the Proposed Scheme have been reached.

2. Overview

2.1. Construction of the Proposed Scheme will require a range of underground works including tunnelling. This information paper sets out HS2 Ltd's approach to assessing and reducing, as far as reasonably practicable, any ground settlement that could result from underground works.

2.2. There are two short tunnels in the Proposed Scheme, namely Whitmore Heath tunnel and Madeley tunnel. For more information on the tunnels included as part of the Proposed Scheme, please see Information Paper F2: Phase 2a Tunnels.

3. Tunnelling

3.1. A number of major tunnelling projects have been or are being undertaken in London in recent years, including Crossrail, the London Water Ring Main, Heathrow Express, Jubilee Line Extension, extensions to the Docklands Light Railway, the Channel Tunnel Rail Link and the Heathrow Express and Piccadilly Line extensions to Heathrow Terminal 5. As a result, there is extensive experience of how the ground behaves when tunnels are constructed and how to minimise settlement affecting buildings above.

3.2. In September 2013, HS2 Ltd published a report - Impacts of Tunnels in the UK - on the likely effects on people and property from tunnel construction and from trains running in tunnels. The main report together with a non-technical summary can be found at www.gov.uk/HS2

3.3. The construction of the Proposed Scheme's tunnels will lead to settlement of the ground at the surface. The amount of settlement (ground movements) will depend on a number of factors including the depth and volume of the works below ground, soil and groundwater conditions and the presence and nature of building foundations. The amount of settlement will vary across the area affected, and for some buildings, the magnitude of settlement varies across the building. This is known as differential settlement.

3.4. If there is no differential settlement and all of a building settles the same amount then the building is very unlikely to be damaged, whereas differential settlement has the potential to damage buildings and other
infrastructure, including utilities. If damage were to occur, it could range from small internal cracks in plaster to effects on the structural integrity of the building, although in most cases there is no discernible effect on the structure itself. An assessment has already begun to identify potential settlement along the route of the railway. It will assess the risk of damage to all buildings within the zone affected by settlement. Depending on the level of risk, no action may be required, buildings will be monitored during construction, or special protective measures will be implemented to protect the buildings.

3.5. This paper covers the following issues:

- method of assessing settlement;
- monitoring;
- protective works;
- defects surveys;
- repairs;
- listed buildings; and
- settlement deed.

4. Settlement Assessments

4.1. Buildings which may be affected by structural excavations carried out by the nominated undertaker are assessed using a three phase process similar to that developed on other projects including the Jubilee Line extension, Channel Tunnel Rail Link and Crossrail and this assessment consists of one, two or three phases as described below.

**Phase 1 Assessment**

4.2. The Phase 1 assessment is based on “green-field” site conditions. This means that the effect of building foundations on the pattern of settlement is ignored.

4.3. For bored tunnels the settlement predictions for “green-field” site conditions are produced based on empirical methods such as those described by O’Reilly and New (1982) and Attewell and Woodman (1982) using parameters for ground loss determined from case histories and taking into account the method of tunnelling and ground conditions.

4.4. For excavations comprising shafts, boxes and retained cuttings, a conservative methodology for predicting settlements has been developed.

4.5. Where the predicted settlement from bored tunnels and from the excavations referred to above is less than 10mm and the predicted ground slope is less than 1/500 (equivalent to damage risk/damage category 1 as defined by Rankin, 1988) buildings are not subject to further assessment. Those for which predicted settlement is 10mm or more, or for which
predicted ground slope is 1/500 or more, are subject to a Phase 2 assessment.

**Phase 2 Assessment**

4.6. In Phase 2 the settlement calculated for “green-field” conditions is imposed on buildings, i.e. it is assumed that buildings behave completely flexibly and their own stiffness has no influence on the settlement behaviour. In addition the deformation due to horizontal ground movement is taken into account. This is a conservative assumption as, in reality, a building’s structure and foundations will modify the settlement effects and limit the development of horizontal strain, reducing the potential for damage.

4.7. A generic area-wide assessment of settlement, identifies zones in which buildings might be at risk of sustaining damage at levels which require individual investigation (that is, in which they may be in risk/damage category 3 or above) based on correlation with the calculated maximum tensile strain values (see Harris and Franzius (2005). For the buildings within these zones, an individual assessment is required in Phase 3 of the assessment process (see paragraph 4.11).

4.8. The potential for damage in this area-wide assessment is defined using the procedure described by Burland (1995) and Mair et al (1996). Each building is categorised into one of six risk/damage categories by reference to maximum tensile strain as described in column 2 of Table 1.1. This classification is conservative as it assumes a simple brick masonry construction, whereas other forms of construction, such as framed buildings, are more robust.

4.9. This generic assessment is only sufficiently informative for buildings with relatively shallow foundations. Buildings with a foundation level deeper than 4m, or (in the case of a bored tunnel) greater than 20% of the depth to tunnel axis, automatically qualify for a Phase 3 assessment after the Phase 2 process.

4.10. Subject to paragraph 4.9 above and 4.12 below, buildings assessed to be in risk/damage category 0, 1 or 2 after the Phase 2 assessment are not subject to further assessment.

4.11. All buildings which are placed in risk/damage category 3 or above in the Phase 2 assessment are subject to a Phase 3 assessment.

4.12. Any building which has been subject to a Phase 2 assessment but which does not qualify for further assessment under paragraph 4.11 above is nonetheless subject to a Phase 3 assessment if:

- it is on shallow foundations and is within a distance from a retained cutting, shaft or box equal to the excavated depth of superficial deposits or 50% of the total excavation depth (whichever is the greater). In this
context, superficial deposits are taken to be soils such as Made Ground, Alluvium or Terrace Gravels;

- it has a foundation level deeper than 4m, or (in the case of a bored tunnel) greater than 20% of the depth to tunnel axis;
- it is a listed building; or
- the nominated undertaker considers that for some other reason the determination of whether protective works for the building are required, or the form that such protective works should take, requires further assessment in Phase 3 to be undertaken.

**Phase 3 Assessment**

4.13. In Phase 3 of the assessment procedure, each building is considered individually in contrast to the first 2 phases where the area of interest is analysed generically.

4.14. The Phase 3 assessment consists of several sub-steps (referred to as “Iterations”), each refining the building and tunnel model to a higher degree. In this phase both the strain developing within the building and the applicability of the standard risk/damage categories (which are based on masonry structures) is reappraised. In the first Iteration the same model is used as in the Phase 2 assessment. This model is then successively refined in the following Iterations. If necessary, the tunnel-excavation-soil-building interaction problem is modelled numerically. The approach is to use simplified assumptions in the first instance and refine the analysis to see if a more accurate approach results in the risk of damage reducing to an acceptable level.

4.15. A structural survey will be undertaken to determine the structural form and condition of the building where reasonably necessary for the assessment. In every case where a building is subject to a Phase 3 assessment, a desktop structural appraisal by a qualified structural engineer will be carried out for the purpose of confirming the likely structural behaviour and determining whether such a structural survey is so necessary.

4.16. As a result of the Phase 3 assessment, the risk/damage category of the building is assessed or reassessed, the requirement for any protective works is established and the design and implementation of any protective works and associated specialised monitoring are determined. These matters are stated in the settlement assessment report for the building.

**Other matters**

4.17. Settlement assessments for listed buildings have already been completed as far as the first iteration of Phase 3 as set out in paragraph 4.14 above (and paragraph 9.2 below). Non-listed building assessments have been completed to the end of Phase 2. Where buildings have qualified for further
assessment, this will take place as part of the on-going detailed design process when the precise construction programme and methodology have been determined.

4.18. Building owners may request a copy of the assessment report from the nominated undertaker. This will be supplied and discussed with the owners if the building has progressed to at least Phase 2 of the assessment process.

5. Monitoring

5.1. Requirements for monitoring will be confirmed by the settlement report during detailed design. Selected buildings in risk/damage category 3 or above will be monitored during tunnel construction. Monitoring for category 2 and below will be covered by the general background surface monitoring undertaken to confirm ground movements are within predictions. If unexpected movements occur they will be fully investigated and, if necessary, modifications made to the tunnelling method and/or protective works taken to safeguard the building. In addition to this, general settlement monitoring will be carried out over the whole area affected by settlement.

5.2. Where practicable, it is proposed to carry out a full year of area background monitoring to establish seasonal trends, with building specific monitoring commencing at least one month prior to commencement of the works. Monitoring will continue until all potentially damaging settlement due to the HS2 works has ceased. This is defined as when the rate of settlement is less than or equal to 2mm/annum.

5.3. Generally, construction phase monitoring will consist of precise surveying of studs or targets installed on the outside of the building or inside subsurface structures. Occasionally, dependent on structure size and extent of settlement, precise levelling will take place inside structures. Other forms of monitoring may also be employed, which will be determined on a case by case basis.

6. Protective measures

6.1. It is intended that the primary form of mitigation will be to use good tunnelling practice, including continuous working, erecting linings immediately after excavation and providing tight control of the tunnelling process to reduce the magnitude of settlement. Where these are considered insufficient to mitigate the risk of damage to buildings as forecast in the Phase 3 assessment, intrusive mitigation measures will be considered. These may include direct works on the building, as well as ground treatment around and beneath the building. These three categories are described in more detail below:
at-source measures. These include all actions taken from within the tunnel, shaft or box excavation during its construction to reduce the magnitude of ground movements generated at source;

- ground treatment measures. These comprise methods of reducing or modifying the ground movements generated by tunnelling/shaft/box excavation by improving or changing the engineering response of the ground. Categories of ground treatment include: compensation grouting, which involves injecting grout into the ground above the tunnel to compensate for the ground loss at the tunnel face; permeation or jet grouting which involves the creation of stiffer ground to reduce settlement; and control of ground water to avoid changes which could potentially cause ground movement; and

- structural measures. These methods reduce the impact of ground movements by increasing the capacity of a building or structure to resist, modify or accommodate those movements. Typical measures would include underpinning or jacking. Underpinning involves the introduction of a new strengthened foundation system to a building or structure potentially affected by settlement. Jacking is a technique whereby a system is introduced between the structure and its existing foundations to compensate for the settlement.

6.2. These mitigation measures are tried and tested. They have proven effective in mitigating potential settlement effects on other major projects involving a similar scale and complexity of tunnelling and excavation (see Mair (2001)).

7. Survey

7.1. Defect surveys will be undertaken on all properties assessed to experience 10mm or more of settlement in the assessment carried out under section 4 above with respect to the nominated undertaker's structural excavations. These will capture the condition of the properties immediately prior to tunnel construction commencing in an area. They are a written and photographic record of existing cracking and the state of the finishes and structures. They will be carried out by a chartered building surveyor commissioned by the nominated undertaker at the nominated undertaker's cost but in joint names with the building owner and any other persons as the nominated undertaker may determine. Owners are free to commission their own survey but this will be at their own cost since the nominated undertaker's survey is an objective survey/record of pre-existing defects and is not intended to draw any conclusions as to the cause.

7.2. An electronic copy of the report will be available to the owner on request.

7.3. If, following the construction of the Proposed Scheme's tunnels or other sub-surface works in the vicinity of the building, the owner responsible for repairing a building reasonably believes damage has occurred then he
should notify the nominated undertaker in writing before the end of the period of two years from the date of opening for public traffic of the railway comprised in the authorised works in the vicinity of the building, or if later, the end of the period of three months from the day on which any monitoring specific to the building ceased. A second survey will then be undertaken by the nominated undertaker’s surveyor to record changes from the first survey. The owner may request his own surveyor to attend when the second survey is undertaken and to comment on the draft survey report produced by the nominated undertaker. Reasonable professional fees (agreed in advance) incurred by the owner in making a successful claim will be reimbursed by the nominated undertaker.

7.4. A comparison of the two surveys may form the basis of any claim. The nominated undertaker may appoint a loss adjuster to assess the extent to which the damage has been caused by construction of the Proposed Scheme and agree the remedial works to be undertaken at the expense of the nominated undertaker.

8. Repairs

8.1. The Promoter will require the nominated undertaker to reimburse property owners for the reasonable cost they incur in remedying material physical damage arising from ground settlement caused by the authorised works, provided:

- the damage is caused by the nominated undertaker’s works;
- the owner gives not less than 28 days notice in writing to the nominated undertaker of the proposal to carry out the repair work;
- the owner takes reasonable steps to obtain three competitive quotes for the repairs beforehand where required by the nominated undertaker; and
- any claim is made before the end of the period of two years from the date of opening for public traffic of the railway comprised in the authorised works in the vicinity of the building, or if later, the end of the period of three months from the day on which any monitoring specific to the building ceased (see paragraph 5.2 above).

8.2. The nominated undertaker may, on receiving the advanced notice of the proposal to carry out the repair work, elect to undertake the repair work itself.

8.3. If there are any pre-existing defects which have worsened as a result of the Proposed Scheme then the recoverable loss will be limited to the additional cost of repair over and above that which would have been required to deal with existing defects.
8.4. If it can be demonstrated that the undertaking to assess the compensation claim based on the reasonable cost of repairs does not compensate the claimant fully for the reduction in value of his interest in the property then this does not prejudice a further claim for compensation in accordance with the Bill and the Compensation Code within the normal limitation period applying to such claims.

9. Listed Buildings

9.1. All listed buildings are subject to the provisions of this paper as set out in Sections 3 to 8 above. In particular, as stated in paragraph 4.12, all listed buildings (with settlement of 10mm or more) automatically qualify for a detailed assessment at Phase 3.

9.2. In the first iteration of the Phase 3 assessment, the heritage value of a listed building is considered by reviewing the sensitivity of the building structure and of any particular features against the risk/damage category assigned in Phase 2. The heritage assessment examines the following:

- the sensitivity of the building/structure to ground movements and its ability to tolerate movement without significant distress. The potential for interaction with adjacent buildings/structures is also considered. A score within the range of 0-2 will be allocated to the building/structure in accordance with the criteria set out in Table 1.2 below;

- the sensitivity to movement of particular features within the building/structure and how they might respond to ground movements. A score within the range of 0-2 will be allocated to the building in accordance with the criteria set out in Table 1.2, below; and

- in addition, a score corresponding to the Phase 2 settlement assessment risk/damage category within the range of 0-5 is allocated to the building.

9.3. The scores for each of the three categories (paragraph 9.2) are added together to inform the decision making process. In general, listed buildings which score a total of three or higher are subject to further assessment as part of the Phase 3 iterative process. Buildings which score a total of two or less are predicted to suffer a degree of damage which will be easily repairable using standard conservation based techniques and hence no protective measures for the building’s particular features are required. However, ultimately the professional judgement of engineering and historic building specialists will be used to determine whether additional analysis is required. Upon conclusion of the Phase 3 iterations, a final composite score will be arrived at, comprising the risk/damage category of the building (ignoring the fact that it is a listed building) assessed in accordance with the normal principles of Phase 3 assessment, to which will be added final scores for each of the two additional sensitivities referred to in paragraph 9.2.
bullet points one and two in accordance with Table 1.2, below, and this final composite score will constitute the risk/damage category of the listed building for the purposes of paragraph 4.16 above.

9.4. The relevant local authority will be consulted on the results of the listed building assessment reports for listed buildings subject to Phase 3 assessment and the proposals for protective measures, if any are required. Historic England will also be consulted in relation to listed buildings subject to Phase 3 assessment where they would normally be notified or consulted on planning applications or listed building consent applications (as set out in DETR and DCMS Circular 1/01).

9.5. When considering the need and type of protective measures, due regard will be given to the sensitivity of the particular features of the building which are of architectural or historic interest and the sensitivity of the structure of the building to ground movement. Where the assessment highlights potential damage to the features of the building which it will be difficult or impossible to repair and/or if that damage will have a significant effect on its heritage value, the assessment may recommend appropriate measures to safeguard those features either in-situ or by temporary removal and storage off-site if those with relevant interest(s) in the building consent.

9.6. The form of monitoring of listed buildings will be determined based on the results of the assessment process.

9.7. If repair works are necessary, the arrangements for their carrying out or for reimbursement referred to in section 8 above will apply. Reimbursable costs will include the costs of any necessary expert advice from a person suitably qualified to advise on heritage issues. The carrying out of the relevant works will however require the consent of those with relevant interest(s) in the building.

10. **Settlement Deed**

10.1. The Promoter has developed a Deed which the owner of a building may request. This is a formal legal undertaking concerning settlement, giving effect to the matters set out in this paper. The qualifying criteria for the Deed are attached as Annex A and the Deed itself, the terms of which are subject to change whilst the Bill is in Parliament, as Annex B. Subject to paragraph 11.1 below, and to paragraph 4.1 of the qualifying criteria, the Secretary of State will require the nominated undertaker concerned to enter into a deed in substantially the form of the final version of those terms, in accordance with the procedures set out in the qualifying criteria, with eligible owners complying with those procedures. It is not necessary to enter into the deed in order to benefit from the process set out in this paper.
11. New buildings

11.1. The requirements set out in this paper (including the requirement for the nominated undertaker to enter into a settlement deed) do not apply to a new building, for the construction of which planning permission was granted after 17 July 2017. They also do not apply to any new buildings which are not substantially completed by the date for giving notice referred to in paragraph 1.2 of the qualifying criteria for the settlement deed in Annex A. References to a building in the qualifying criteria are to be construed accordingly.

12. More information

12.1. More detail on the Bill and related documents can be found at: www.gov.uk/HS2

13. References


Table 1.1 – Building Damage Classification

<table>
<thead>
<tr>
<th>Risk/Damage Category</th>
<th>Max Tensile Strain %</th>
<th>Description of Degree of Damage</th>
<th>Description of Typical Damage and Likely Form of Repair for Typical Masonry buildings</th>
<th>Approx Crack Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.05 or less</td>
<td>Negligible</td>
<td>Hairline cracks.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>More than 0.05 and not exceeding 0.075</td>
<td>Very Slight</td>
<td>Fine cracks easily treated during normal redecorations. Perhaps isolated slight fracture in building. Cracks in exterior brickwork visible upon close inspection.</td>
<td>0.1 to 1</td>
</tr>
<tr>
<td>2</td>
<td>More than 0.075 and not exceeding 0.15</td>
<td>Slight</td>
<td>Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible; some repointing may be required for weather-tightness. Doors and windows may stick slightly.</td>
<td>1 to 5</td>
</tr>
<tr>
<td>3</td>
<td>More than 0.15 and not exceeding 0.3</td>
<td>Moderate</td>
<td>Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Repointing and possibly replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Weather tightness often impaired.</td>
<td>5 to 15 or a number of cracks greater than 3</td>
</tr>
<tr>
<td>4</td>
<td>More than 0.3</td>
<td>Severe</td>
<td>Extensive repair involving removal and replacement of sections of walls, especially over doors and windows required. Windows and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably, some loss of bearing in beams. Utility services disrupted.</td>
<td>15 to 25 but also depends on number of cracks</td>
</tr>
<tr>
<td>5</td>
<td>Very Severe</td>
<td>Major repair required involving partial or complete reconstruction. Beams lose bearing, walls lean badly and require shoring. Windows broken by distortion. Danger of instability.</td>
<td>Usually greater than 25 but depends on number of cracks</td>
<td></td>
</tr>
</tbody>
</table>

Notes
1. The table is based on the work of Burland et al (1977) and includes typical maximum tensile strains for the various damage categories (column 2) used in phase 2 settlement analysis.
2. Crack width is only one aspect of damage and should not be used on its own as a direct measure of it.
Table 1.2 – Scoring for the Sensitivity Assessment of Listed Buildings

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Masonry building with lime mortar not surrounded by other buildings. Uniform facades with no particular large openings.</td>
</tr>
<tr>
<td>1</td>
<td>Buildings of delicate structural form or buildings sandwiched between modern framed buildings which are much stiffer, perhaps with one or more significant openings.</td>
</tr>
<tr>
<td>2</td>
<td>Buildings which, by their structural form, will tend to concentrate all their movements in one location.</td>
</tr>
</tbody>
</table>
Annex A

Qualifying Criteria For Deed Concerning Settlement

1. Criteria for Eligibility

1.1. The person must have a legal estate in all or part of a building (which where relevant is treated as including any bridge, tunnel or major service media in which the person has a legal estate or interest and which is connected to the building) within 30 metres on plan of the tunnels, retained cuttings, shafts and boxes forming part of the works authorised to be carried out under the Bill by the nominated undertaker concerned, as finally designed by the nominated undertaker. The legal estate he holds must be sufficient for him to comprise an “owner” within the meaning of the Acquisition of Land Act 1981.

1.2. The person must give notice to the nominated undertaker concerned at least ten months before construction of the part of the tunnel, retained cutting, shaft or box concerned is intended to be begun by the nominated undertaker. After delivery to him of the unexecuted deed, he must within 21 days return both parts of the deed to the nominated undertaker duly executed by him whereupon the nominated undertaker will execute and complete the deed and return to him one part. This is to give sufficient time after completion of the deed for the nominated undertaker to prepare a settlement report and for its discussion where required under the deed.

1.3. To ease administration, any person whose building falls within the limits of deviation for a part of a railway work which is shown on the deposited plans and sections as intended to be in tunnel, retained cutting, shaft or box, or which is within 30 metres of those limits, is to be able to give notice to the nominated undertaker in advance of final design of the works concerned by the nominated undertaker (or in the period before his appointment, to the Secretary of State). The nominated undertaker would then be under a duty to deliver the deed if, on final design within the relevant limits of deviation, it is found that the building is within 30 metres of a tunnel, retained cutting, shaft, or box.

1.4. To give notice to the nominated undertaker in advance of final design (pre-register for a settlement deed), you will need to provide:

- the name and address of applicant;
- an email address and/or telephone number for future communication; and
- the address of the building or part of the building for which the Settlement Deed is required.
1.5. Pre-registration will be brought forward in due course, with details of where to apply published here.

1.6. Pre-registration is optional – you do not have to pre-register to be considered for a Settlement Deed. Eligibility checks will not be undertaken at pre-registration, but will be completed at a time consistent with the construction schedule.

1.7. In the deed, the expression “the Building” in clause 1(1) will be defined to be the whole building to which any assessment to be carried out under clause 2 of the deed relates, and “the Protected Property” as the particular part of the Building in which the person holds a legal estate or has repairing obligations.

2. Multiple owners of a building

2.1. If any particular building has more than one person who is an “owner” (within the meaning of the Acquisition of Land Act 1981), each of them is to be entitled to a deed. However, the deed makes provision (amongst other matters) in clause 2(14) for the appointment of a single engineer for the building, and in clause 9(12) for a single consolidated dispute resolution proceeding in cases where clause 2(8) to (15) apply.

3. Other Matters

3.1. Where there is more than one person responsible for repair of the building concerned the nominated undertaker is to be able to insert provision in clause 6 of the draft deed limiting the application of that clause in relation to any particular owner to the damage for which the owner has a repairing responsibility.

3.2. The notice mentioned in paragraph 1.2 above must give sufficient information to enable the nominated undertaker to prepare the relevant deed, and in particular must identify the building concerned, the nature of the interest in it of the person giving the notice and of his repairing obligations, and whether there are other owners within the meaning of the Acquisition of Land Act 1981 of the building or occupiers.
Annex B
Settlement Deed
DEED

between

HS2 LIMITED

and

Deed concerning the mitigation of the effects of settlement arising from the construction of HS2
THIS DEED is made on the day of between HS2 Limited whose principal office is at ........................................ (hereinafter called “the Undertaker”) of the one part and [ ] (hereinafter called “the Owner”) of the other part.

WHEREAS

1. The Undertaker has been appointed a nominated undertaker under section [45] of the HS2 Act 20XX (“the Act”) for the purpose of works authorised by the Act;

2. Pursuant to the requirements of an agreement between the Undertaker and the Secretary of State the Undertaker is obliged to enter into this Deed with any person falling within certain qualifying conditions who so requires and who wishes to be a party to it;

3. The Owner falls within those conditions and has required that this Deed be entered into.

NOW IT IS HEREBY PROVIDED AS FOLLOWS:

DEFINITIONS

1. (1) In this Deed:

“the authorised works” means the works authorised by the Act for which the Undertaker is the nominated undertaker under the Act;

“the Building” means the building [insert address and description of the building concerned] together with any bridge, tunnel or water, sewerage, gas, electricity or other major service media connected thereto in which the Owner has a legal estate or legal interest;

“the Owner” includes the Owner’s successors in title to and assigns of the Protected Property

“the Protected Property” means such of the Building as is that in which the Owner has a legal estate or for which the Owner has repairing obligations;

“the Surveyor” means the surveyor or engineer appointed by the Owner for the purposes of this Deed;
“the Undertaker” Includes any subsidiary of the Undertaker within the meaning of the Companies Act 2006;

“the Secretary of State” means the Secretary of State for Transport or any successor Secretary of State or Minister holding the Transport portfolio.

(2) The Undertaker may appoint any of its contractors or sub-contractors for any of the authorised works as agent in relation to the exercise of any of its functions under this Deed (but without prejudice to any liability of the Undertaker in the event of a failure to comply with the terms of this Deed).

(3) References in this Deed to a person or persons include references to bodies corporate.

SETTLEMENT AND PROTECTIVE WORKS

2. (1) In this clause and clause 3 and the Appendix to this Deed:

“the Assessment” means the Assessment described in paragraph (2) below;

“box” means an excavated structural box of a depth of 3 metres or more;

“listed building” means a listed building within the meaning of the Planning (Listed Buildings and Conservation Areas) Act 1990;

“the Notice” means the Notice described in paragraph (8) below;

“the Owner’s Engineer” means the Engineer appointed in accordance with paragraph (14) below;

“protective works” means works for the supporting or strengthening of the Building or its foundations undertaken to reduce damage to the Building arising as a result of the relevant construction as far as is reasonably possible;

“the relevant construction” in relation to the Building, means any part of:

(a) the bored, mined or cut and cover tunnels, or

(b) the excavations comprising shafts, boxes and retained cuttings,

\[\text{3 If the title of the minister responsible for transport issues has changed by the time the deed in question is entered into, insert the then current title of the minister or Secretary of State concerned and for “or any successor” substitute “and any predecessor or successor” (prejudice to any liability of the Undertaker in the event of a failure to comply with the terms of this Deed).}\]
comprised in the authorised works and which is within 30 metres on plan of the Building;

“the Report” means the Report for the Building described in paragraph (3) below;

“retained cutting” means a retained cutting of a depth of 3 metres or more;

“sent” means (in relation to the sending to the Owner of the Report under this clause 2 and of the notice mentioned in paragraph (14)(b) below) posted by ordinary first-class post addressed to the address referred to in clause 10(1) below, or with the prior agreement of both parties by electronic means and “send” shall be construed accordingly;

“settlement” means movement of the ground in response to the construction of the relevant construction;

“shaft” means an excavated shaft of a depth of 3 metres or more.
Preparation of Assessment and Report

(2) Before it commences the relevant construction, the Undertaker shall carry out an Assessment (to be undertaken by a suitably qualified person with appropriate experience) to predict any settlement to the Building that may result from that construction and any damage to the Building which may be caused by such settlement.

(3) The Assessment shall be carried out in accordance with the procedures in the Appendix to this Deed; and following the Assessment the Undertaker shall prepare a Report in respect of the Building which shall contain such of the following as may be applicable:

(i) an assessment of predicted settlement to the Building caused by the relevant construction;

(ii) if the Building has been subject to a Phase 2 or Phase 3 assessment as described in the Appendix to this Deed, the assessed maximum tensile strain and an assessment of the predicted damage to the Building;

(iii) the results of any structural inspection of the Building;

(iv) any proposed monitoring specific to the Building;

(v) an assessment of the need for protective works, if any;

(vi) details of any such protective works, including designs, method of working and programme of such protective works; and

(vii) if the Building is a listed building, particulars of any such additional safeguarding measures as are referred to in paragraph 22 of the Appendix.

(4) The Report shall be sent to the Owner before commencement of the relevant construction, following which the Undertaker will (subject always to paragraphs (6) to (15) below in a case where those paragraphs apply) be entitled to proceed with that construction without prejudice to any claim for compensation which the Owner may have.

(5) Without prejudice to paragraphs 1, 2(6) and 3(7) of Schedule 2 to the Act the Undertaker may, as often as it may reasonably require and upon giving not less than 14 days’ notice in writing to the Owner, enter the Protected Property at any reasonable time for the purposes of carrying out the Assessment.

Cases in risk/damage category 2 or below

(6) Subject to paragraph (7) below, if following the carrying out of the Assessment (as described in the Appendix to this Deed) the assessment of the predicted damage to the Building concerned contained in the Report assesses that the Building falls into Risk/Damage Category 2 or below, the Undertaker, if so requested by the Owner by notice given in writing to the Undertaker not later than 20 working days after the day on which the Report is sent to the Owner, shall seek to consult with the Owner regarding the Report following which the Undertaker shall be entitled to proceed with the relevant construction without prejudice to any claim for compensation which the Owner may have.
Cases in risk/damage category 3 or above

(7) Paragraphs (8) to (15) below apply if following the carrying out of the Assessment the assessment of the predicted damage to the Building concerned contained in the Report assesses that the Building falls into Risk/Damage Category 3 or above or if the Report recommends that protective works should be carried out wholly or partly from within the Building.

(8) The Owner’s Engineer may, not later than 25 working days after the day on which the Report was sent to the Owner, give written Notice to the Undertaker stating whether or not the Report is agreed.

(9) If the Owner’s Engineer does not agree the Report the Notice shall contain detailed reasons for the Owner’s objections.

(10) In the event that the Notice contains reasonable objections the Undertaker and the Owner’s Engineer shall seek to agree such amendments to the Report as are reasonably necessary to address those objections.

(11) In the event that no Notice is served within the period specified in paragraph (8) above the Report shall be deemed to have been agreed.

(12) In the event that the Undertaker and the Owner’s Engineer fail to agree the Report within 25 working days of the giving of the Notice or in the opinion of the Undertaker the objections contained in the Notice are unreasonable, the dispute shall be referred in accordance with Clause 9 (Disputes) of this Deed.

(13) Upon the Report being agreed or deemed to be agreed or upon determination of the dispute (as the case may be) the Undertaker shall be entitled to proceed with the relevant construction and any protective works specified in the Report in accordance with the Report as so agreed or determined; but if the Notice contains objections to the Report and the Report has not been agreed or finally determined within the period of 90 working days after the day on which the Report was sent to the Owner then provided that the Undertaker has used its reasonable endeavours to agree the Report and facilitate the determination of the adjudicator the Undertaker shall be entitled to proceed with the relevant construction and any protective works specified in the Report in accordance with its terms without prejudice to any claim for compensation which the Owner may have.

(14) The Owner’s Engineer shall be appointed by the Owner save that:

(a) in the event of the Undertaker entering into a Deed with any other person or persons (whether on, before or after the date of this Deed) in relation to the whole or part of the Building containing provisions similar to this clause 2—

(i) the Owner’s Engineer shall be appointed jointly by the Owner and the other person or persons (or, failing agreement between them, by the President of the Institution of Civil Engineers on the written application of either or, as the case may be, any of them), and

(ii) as regards any disputes concerning the Report and the appropriate protective works for the Building (if any), for the purpose of obtaining a consistent outcome with respect to the Building capable of implementation by the Undertaker clause 9(12) has effect;

(b) where the Undertaker enters (or is to enter) into such a Deed as is mentioned in sub-paragraph (a) above with any other person or persons, to enable the joint appointment referred to in sub-paragraph (a)(i) above to be made the Undertaker shall either send a notice in writing to the Owner specifying the other person or persons before the
beginning of the period of 35 working days ending with the day on which the Report is
sent to the Owner under paragraph (4) above, or shall send that notice at some later
time before the Report is sent (in which case the Report shall be deemed to have been
sent for the purposes of paragraphs (4) to (13) above on the day 35 working days after
the day on which that notice is sent).

(15) The Undertaker shall repay to the Owner all reasonable costs, charges and expenses properly
incurred by the Owner, including VAT thereon insofar as the same is not recoverable by the
Owner (whether as a deduction against output tax or as a VAT credit or otherwise), in connection
with:—

(a) the services of the Owner’s Engineer under paragraphs (8) to (10) above; and

(b) the services of architects, surveyors, engineers and other technical advisers to whom the
Owner’s Engineer finds it reasonably necessary to refer in connection with paragraph (10)
above.

General

(16) Subject to paragraph (17) and (18) below, if the Undertaker carries out the relevant construction
it shall also carry out the relevant protective works (including the method of working and
programme therefor); and for this purpose “the relevant protective works” means the protective
works described as necessary in the Report (whether as consulted on under paragraph (6) above
or as agreed or deemed to have been agreed under paragraphs (10) and (11) above or as
determined as mentioned in clause 9 or in the form that the Undertaker prepared and sought to
agree in accordance with paragraph (13) above, as the case may be) which the Undertaker is able
to carry out in accordance with that method and programme under paragraph 2 of Schedule 2 to
the Act.

(17) The duty to carry out protective works under paragraph (16) above has effect subject to the
obtaining of any necessary consents, agreements or other approvals (which the Undertaker shall
use reasonable endeavours to obtain) required for the purpose, whether required under any
provision having effect under statute, or under any undertaking or agreement given or entered
into by the Secretary of State or the Undertaker which governs the exercise of the powers given
by the Act, or otherwise; and the obligation to use reasonable endeavours to obtain such
consents, agreements or other approvals includes an obligation—

(a) where the Report in the form sent to the Owner identifies protective works as necessary,
to serve notice under paragraph 2(1)(b) of Schedule 2 to the Act not later than one week
after the day on which the Report is so sent to the Owner (or if earlier not later than 8
weeks before, under the Undertaker’s construction timetable, it is to carry out the
protective works so identified), on all persons who have not entered into a Deed in
relation to the whole or part of the Building containing provisions similar to this clause 2
and who after reasonable inquiry by the Undertaker are (as at that time) found eligible to
receive such notice in relation to the Building and the protective works so identified; and

(b) after the sending of the Report to the Owner, to do what else is reasonable under
paragraph 2 of Schedule 2 to the Act to enable the protective works referred to in
paragraph (16) above to be carried out at a time consistent with the Undertaker’s
construction timetable including, if a person gives notice of dispute under paragraph
2(2) of that Schedule in relation to the Building (whether in consequence of a notice by
the Undertaker given pursuant to sub-paragraph (a) above or subsequently)—

(i) to pursue the arbitration with all due despatch; and

(ii) to do all that is reasonable to argue the case in the arbitration in favour of the
protective works concerned in consultation with the Owner.
(18) For the avoidance of doubt –

(a) for the purposes of paragraph (16) above the circumstances in which the Undertaker shall be treated as not being able to carry out any protective works under paragraph 2 of Schedule 2 to the Act include a case where the decision of an arbitrator under paragraph 2(2) or (3) of Schedule 2 to the Act precludes those works being carried out, or makes the carrying out of those works impractical; and

(b) if the Undertaker has done the things required by paragraph (17)(a) and (b) above but, on an arbitration under paragraph 2(2) or (3) of Schedule 2 to the Act relating to the Building, a decision of the arbitrator has not been obtained by the time that would be required in order to maintain the Undertaker’s construction timetable for the relevant construction (or for the protective works referred to in paragraph (16) above), the Undertaker may carry out the relevant construction in accordance with its construction timetable without carrying out such of the protective works referred to in paragraph (16) above as it could not or cannot lawfully or practically carry out in accordance with that timetable because the decision has not been obtained.

(19) Protective works carried out in accordance with paragraph (16) above shall be treated as carried out under the powers conferred by paragraph 2 of Schedule 2 to the Act, save that the Owner agrees that:

(a) sub-paragraph (2) of that paragraph 2 shall not apply to the Owner, and

(b) the reference to 8 weeks in sub-paragraph (1)(b) of that paragraph 2 shall be treated in relation to the Owner as a reference to 14 days.

MONITORING OF PROTECTED PROPERTY

3. (1) If the Report prepared under clause 2(3) above recommends that monitoring specific to the Building should be carried out, subject to paragraph (6) below the Undertaker shall, if it proceeds with the construction of the authorised works, undertake monitoring of the Building.

(2) Except so far as further or different times or methods of monitoring are recommended in that Report, monitoring shall generally consist of precise surveying of studs and targets on the outside of the Building, and shall take place prior to the commencement of the carrying out of the relevant construction and during the period that any settlement of the Building arising from it is occurring until the monitoring indicates that building settlement arising in consequence of the relevant construction has reduced to a rate of 2mm per annum or less.

(3) As soon as practicable after the monitoring results have been obtained the Undertaker shall make them available for inspection by the Owner and those results shall remain available until the end of the period of three months from the date when the monitoring ceases; and the Undertaker shall send to the Owner a copy of such of those results as the Owner may before the end of that period request.

(4) Such monitoring will be recommenced at the written request of the Owner if:

(a) the Owner can show reasonable grounds for concluding that building settlement arising in consequence of the relevant construction of a rate greater than 2mm per annum has started again after the monitoring period specified in paragraph (2) above or a monitoring period under this paragraph has elapsed, and

(b) that request is made within two years from the date of opening for public traffic of the railway comprised in the authorised works in the vicinity of the Building;
and any such recommenced monitoring shall continue until the monitoring indicates that building settlement arising in consequence of the relevant construction has reduced to a rate of 2mm per annum or less.

(5) The Owner hereby agrees that prior to and during the construction of the authorised works the Undertaker may as often as it may reasonably require, upon giving not less than 7 days’ notice in writing to the Owner, enter the Protected Property to monitor the effect of the authorised works (including entering to place and maintain studs and targets for the purposes of monitoring referred to above): Provided always that such inspection, entering, placing and maintaining shall be conducted with a duly authorised representative of the Owner and at reasonable hours and that before placing such studs and targets on any of the Protected Property the Undertaker shall consult with the Owner on their positioning.

(6) The obligations of the Undertaker to carry out monitoring under this clause 3 are subject to the obtaining of any other necessary consents, which the Undertaker shall use its reasonable endeavours to obtain.

COSTS

4. (1) The Undertaker shall repay to the Owner all reasonable costs charges and expenses properly incurred by the Owner, including VAT thereon insofar as the same is not recoverable by the Owner (whether as a deduction against output tax or as a VAT credit or otherwise), in connection with:-

(a) the services of the Surveyor under clause 5(2) (Schedules of Defects) of this Deed;
(b) the services of the Surveyor in connection with the successful proving of a claim under clause 6(1) (Compensation for Damage) of this Deed; and
(c) the services of architects, surveyors, engineers and other technical advisers to whom the Surveyor finds it reasonably necessary to refer in connection with the successful proving of a claim under sub-paragraph (b) above.

(2) Before any services in respect of which repayment may be claimed under paragraph (1)(b) and (c) above are undertaken, the Owner or the Surveyor shall give the Undertaker not less than 28 days’ notice in writing of the services proposed to be undertaken, the basis on which any costs charges or expenses are to be calculated, and an estimate of the total amount of those costs charges and expenses.

(3) Any amount payable under paragraph (1) above shall be paid by the Undertaker within 30 days of that amount being agreed between the Undertaker and the Owner or being determined in accordance with clause 9 (Disputes) of this Deed.

SCHEDULES OF DEFECTS

5. (1) In a case where the settlement assessed for the Building under the Report prepared under clause 2(3) above is 10mm or more, before it commences construction of so much of the authorised works as will or may affect the Building, the Undertaker shall at its own expense appoint in the joint names of the Undertaker and the Owner (and such other persons as the Undertaker may determine so that the Undertaker shall not be obliged to prepare more than one such schedule for the Protected Property) a reputable firm of chartered building surveyors or chartered engineers to prepare a schedule of defects existing in the Protected Property (including, so far as relevant and it can be established from the visual inspection normally conducted in relation to the preparation of such schedules, a description of the apparent magnitude of any defect) and that firm shall submit a copy of the schedule of defects to the Undertaker and the Owner.

P205 (27)
(2) In a case where paragraph (1) above applies, after the Undertaker has constructed the authorised works in the vicinity of the Building and at the written request of the Owner a schedule shall be prepared by and at the expense of the Undertaker in consultation with the Surveyor similar to (and with similar inspection techniques as) the one prepared in accordance with that paragraph but setting out what changes of defects appear to have occurred to the Protected Property since the preparation of the schedule under that paragraph, provided such request is made before the end of the period of 2 years from the date of opening for public traffic of the railway comprised in the authorised works in the vicinity of the Building or if later (and building-specific monitoring of the Building is carried out under clause 3 above) the end of the period of three months from the day on which that monitoring ceased, and provided further that the Undertaker will not be obliged to prepare more than one such schedule for the Protected Property.

COMPENSATION FOR DAMAGE

6. (1) In addition to any claim which the Owner may make under the provisions of any enactments incorporated with or applied by the Act with respect to compensation for lands taken or injuriously affected, the Owner may (subject to paragraphs (2), (3) and (6) below) make a separate claim upon the Undertaker for compensation for the reasonable and proper cost properly incurred by the Owner in remediying any material physical damage caused to the Protected Property by ground settlement arising from the construction of the authorised works, provided that the claim is made before the end of the period of two years from the date of opening for public traffic of the railway comprised in the authorised works in the vicinity of the Building, or if later (and building-specific monitoring of the Building is carried out under clause 3 above) the end of the period of three months from the day on which that monitoring ceased.

(2) For the avoidance of doubt, if the Building or the Protected Property suffers from a pre-existing defect or defects which are worsened by the construction of the authorised works, the compensation payable under paragraph (1) above is limited to the additional costs of repair of the Protected Property which go beyond those that would be incurred upon remedying the pre-existing defect or defects (assuming the authorised works had not been constructed).

(3) Before carrying out any work in respect of which a claim may be made under paragraph (1) above, the Owner shall give not less than 28 days’ notice in writing to the Undertaker, specifying the material physical damage concerned and the proposed remedial work; and if within the period of 28 days after the giving of such notice—

(a) the Undertaker elects by notice in writing to the Owner to remedy all or part of that damage, then no claim may be made under that paragraph in respect of the damage or part, but the Undertaker shall be under a duty to remedy the damage or part to the reasonable satisfaction of the Owner as soon as reasonably practicable thereafter in accordance with a specification agreed with the Owner or in default of such agreement, determined under clause 9 below, and/or

(b) the Undertaker by notice in writing to the Owner requires the Owner to obtain competitive quotes for all or any of the remedial work, then before entering into a contract for or arranging for the carrying out of the work concerned the Owner shall (i) take reasonable steps to obtain not less than 3 competitive prices for the work and (ii) obtain the consent of the Undertaker to the quote to be accepted, such consent not to be unreasonably withheld.

(4) If it appears to the Owner or the Undertaker that any damage in respect of which notice is given by the Owner under paragraph (3) above is likely to be of a recurring nature by reason of the programme for or the nature of the authorised works, either of them may, in the relevant notice, require a timetable for the carrying out of the remedial work relating to the damage (including a timetable and specification of any interim repairs reasonably necessary in consequence of the
damage) to be agreed or, in default of agreement, determined under clause 9 below; and for this purpose “the relevant notice” means –

(a) where the requirement is made by the Owner, the notice given by him under paragraph (3) above;

(b) where the requirement is made by the Undertaker, and the Undertaker gives a notice of election under paragraph (3)(a) above, the notice of election;

(c) where the requirement is made by the Undertaker, and the Undertaker gives notice requiring competitive quotes under paragraph (3)(b) above, the notice requiring competitive quotes;

(d) where the requirement is made by the Undertaker and the Undertaker gives no such notice of election or notice requiring competitive quotes, a separate notice in writing stating the requirement, which is given within the period of 28 days after the giving of the notice by the Owner under paragraph (3) above.

(5) The Owner hereby agrees that the Undertaker may as often as it may reasonably require and upon giving not less than 14 days’ notice in writing to the Owner, enter the Protected Property at any reasonable time to carry out works in compliance with any duty under paragraph (3) or (4) above, but in doing so the Undertaker agrees that it will have due regard to any activities carried out by those with an interest in the Building.

(6) For the avoidance of doubt, the Owner shall not be entitled to (and hereby accepts the fulfilment of the obligations of the Undertaker under this clause in satisfaction of any right to) compensation under any enactment as regards any damage or claim in respect of which the Owner is entitled to payment under paragraph (1) above or which the Undertaker is under a duty to remedy under paragraph (3) or (4) above.

(7) So far as concerns compensation payable by the Secretary of State under any enactment, the Owner acknowledges that the Undertaker holds the benefit of paragraph (6) above for, and may assign it to, the Secretary of State.

(8) In paragraphs (6) and (7) above, reference to “any enactment” includes reference to the Act.

AS TO THE UNDERTAKER’S LIABILITY IN CERTAIN CASES

7. The fact that any work or thing has been executed or done in accordance with a Report prepared or agreed under clause 2 above or in accordance with any decision of an adjudicator shall not relieve the Undertaker from any liability for damage caused to the Protected Property or affect any claim by the Owner in respect of such damage.

POWERS OF THE UNDERTAKER

8. For the avoidance of doubt nothing in this Deed shall be taken to detract from any powers of the Undertaker, other than powers conferred on the Undertaker under the Act.

DISPUTES

9. (1) Any dispute or difference arising between the parties hereto as to their respective rights duties and obligations under this Deed or as to any matters arising out of or in connection with the subject matter of this Deed shall be determined by adjudication in accordance with the provisions of this clause.

(2) Either party may give notice in writing to the other referring the dispute to adjudication under this clause, and that notice shall briefly state the matter which is in dispute between them.
(3) Unless the dispute in question is one that falls to be consolidated under paragraph (12) below with other disputes relating to the Building and an adjudicator has already been appointed for any of the disputes (under a provision in another Deed similar to this clause 9) which fall to be so consolidated (in which case that adjudicator shall act on the consolidated proceedings), the party giving notice under paragraph (2) shall upon giving that notice forthwith request the appointing body to nominate an independent person to act as adjudicator, who shall be a person professionally qualified for not less than 10 years and who is also a specialist in relation to the subject matter of the dispute, and the request shall ask the appointing body to nominate the adjudicator within 7 days of the notice being given with a view to the matter being referred to the adjudicator within that period.

(4) Except in the case of a dispute or difference with regard to the meaning or construction of this Deed, the appointing body for the purposes of paragraph (3) shall be the President, Vice-President or other duly authorised officer of the Institution of Civil Engineers, and in the case of a dispute or difference with regard to the meaning or construction of this Deed, the appointing body shall be the President, Vice-President or other duly authorised officer of the Law Society.

(5) The terms of reference of the adjudicator shall be as follows –

(a) the adjudicator is to reach a decision within 28 days of the dispute being referred to him or within such longer period (if any) as may be agreed by the parties after the dispute has been referred to him;

(b) the adjudicator may extend that period of 28 days by up to 14 days without the agreement of the parties to the dispute if the party referring the dispute consents;

(c) the adjudicator must act impartially;

(d) the adjudicator may take the initiative in ascertaining the facts and the law.

(6) In reaching his decision, the adjudicator shall act as an expert and not an arbitrator and he shall accordingly take into account his expert knowledge and judgement.

(7) The parties hereto agree that the decision of the adjudicator shall be final and binding except in a case of manifest error.

(8) In a case of manifest error the decision shall (so far as consistent with the terms of this deed) be binding until the matter is finally determined by legal proceedings or by agreement between the parties.

(9) The adjudicator shall not be liable for anything done or omitted in the discharge or purported discharge of his functions as adjudicator unless the act or omission is in bad faith, and any employee or agent of the adjudicator shall be similarly protected from liability.

(10) The incidence of the adjudicator’s reasonable costs and fees in the adjudication shall lie (as between the parties to the dispute) at the award of the adjudicator.

(11) This clause 9 shall apply to disputes falling both within and outside section 108 of the Housing Grants, Construction and Regeneration Act 1996, and (in the case of a dispute falling within that section) if there is any inconsistency between the provisions of this Deed and the requirements of subsections (1) to (4) of that section the inconsistency shall be resolved in favour of those subsections and those subsections shall to the extent of such inconsistency be deemed to be incorporated in this Deed and have effect accordingly (so that amongst other matters the Scheme for Construction Contracts is not intended to apply).

(12) In the event of the Undertaker entering into a Deed with any person or persons other than the Owner (whether on, before or after the date of this Deed) in relation to the whole or part of the Building containing provisions similar to clause 2 above, then–
(a) all disputes of the kind mentioned in clause 2(12) relating to the Building shall be consolidated into a single proceeding with a single adjudicator for all of them and this clause 9 shall have effect accordingly; and

(b) the finding of the adjudicator shall have effect with respect to the Building for the purposes of clause 2 with respect to the Owner even if the Owner did not become or did not remain a party to the adjudication.

SERVICE OF NOTICES

10.(1) Any notice in writing that is to be given by the Undertaker to the Owner shall be deemed effectively given if left at, or despatched by a postal service in which receipt is recorded, addressed to, [specify address within United Kingdom] or such other address within the United Kingdom as the Owner notifies to the Undertaker in writing, and in the case of the documents referred to in the definition of “sent” in clause 2(1) above, the documents shall be deemed effectively given if posted by ordinary first class post to that address (whether or not received).

(2) Any notice in writing that is to be given by the Owner to the Undertaker shall be deemed effectively given if left at, or sent by a postal service in which receipt is recorded addressed to, the address as set out in this Deed or at such other address within the United Kingdom as is notified in writing by the Undertaker to the Owner.

IN WITNESS of which the parties have executed this document as a Deed on the day and year first before written
Executed as a deed by HS2 Limited acting by:

______________________________
DIRECTOR

______________________________
DIRECTOR/SECRETARY

Signed as a deed² by the said [ ]

______________________________
In the presence of

______________________________
Witness name

Address:

Occupation:

² Or other appropriate execution provision(s) for a deed having regard to the status and legal personality of the Owner.
APPENDIX REFERRED TO IN CLAUSE 2

(SETTLEMENT AND PROTECTIVE WORKS)

INTRODUCTION

1. The assessment consists of one, two or three Phases as described below and (subject always to the provisions of this Appendix) is carried out in accordance with the general approach set out in the HS2 Deliverable Approach Statement.

PHASE 1

2. The Phase 1 assessment is based on “greenfield” site conditions. This means that the effect of building foundations on the pattern of settlement is ignored.

3. For bored tunnels the settlement predictions for “greenfield” site conditions are produced based on empirical methods such as those described by O'Reilly and New (1982) and Attewell and Woodman (1982) using parameters for ground loss determined from case histories and taking into account the method of tunnelling and ground conditions.

4. For excavations comprising mined tunnels, cut and cover tunnels, shafts, boxes and retained cuttings, a conservative methodology for predicting settlements has been developed based on relevant case studies of similar excavations in stiff clay.

5. Where the predicted settlement from bored tunnels and from the excavations referred to above is less than 10mm and the predicted ground slope is less than 1/500 buildings are not subject to further assessment. Those for which predicted settlement is 10mm or more or for which predicted ground slope is 1/500 or more are subject to a Phase 2 assessment.

PHASE 2

6. In Phase 2, the settlement calculated for “greenfield” conditions is imposed on buildings, i.e. it is assumed that buildings behave completely flexibly and their own stiffness has no influence on the settlement behaviour. In addition the deformation due to horizontal ground movement is taken into account. This is a conservative assumption as in reality, a building’s structure and foundations will modify the settlement effects and limit the development of horizontal strain, reducing the potential for damage.

7. The Phase 2 assessment comprises a generic area-wide assessment of settlement which identifies zones in which buildings might be at risk of sustaining damage at levels which require individual investigation (that is, in which they may be in risk/damage category 3 or above) based on correlation with the calculated maximum tensile strain values (see Harris and Franzius (2005). For the buildings within these zones, an individual assessment is required in Phase 3 of the assessment process (see paragraph 11 below).

8. The potential damage in this area-wide assessment is defined using the procedure described by Burland (1995) and Mair et al (1996). Each building is categorised into one of six risk/damage categories by reference to maximum tensile strain as described in column 2 of Table 1 below. This classification is conservative as it assumes a simple brick masonry construction, whereas other forms of construction, such as framed buildings, are more robust.

9. This generic assessment is only sufficiently informative for buildings with relatively shallow foundations. Buildings with a foundation level deeper than 4m, or (in the case of a bored tunnel) greater than 20% of the depth to tunnel axis, automatically qualify for a Phase 3 assessment after the Phase 2 process (see paragraph 12(b) below).
10. Subject to paragraph 12 below, buildings assessed to be in risk/damage category 0, 1 or 2 after the Phase 2 assessment are not subject to further assessment.

11. All buildings which are placed in risk/damage category 3 or above in the Phase 2 assessment are subject to a Phase 3 assessment.

12. Any building which has been subject to Phase 2 assessment but which has not qualified for further assessment under paragraph 11 above is nonetheless subject to a Phase 3 assessment if

   (a) it is on shallow foundations and is within a distance from a retained cutting, shaft or box equal to the excavated depth of superficial deposits or 50% of the total excavation depth (whichever is the greater). In this context, superficial deposits are taken to be soils such as Made Ground, Alluvium or Terrace Gravels,

   (b) it has a foundation level deeper than 4m, or (in the case of a bored tunnel) greater than 20% of the depth to tunnel axis,

   (c) it is a listed building, or

   (d) the Undertaker considers that for some other reason the determination of whether protective works for the building are required, or the form that such protective works should take, requires further assessment in Phase 3 to be undertaken.

PHASE 3

13. Paragraphs 14 to 17 below apply to all buildings subject to Phase 3 assessment. In addition, paragraphs 18 to 23 below apply to listed buildings which are subject to Phase 3 assessment (all listed buildings which are assessed to experience settlement of 10mm or more automatically qualify for an assessment at Phase 3).

Provisions applying to all buildings which are subject to Phase 3 assessment

14. In Phase 3 of the assessment procedure, each building is considered individually in contrast to the first 2 Phases where the area of interest is analysed generically.

15. The Phase 3 assessment consists of several sub-steps (referred to as “Iterations”), each refining the building and tunnel model to a higher degree. In this Phase both the strain developing within the building and the applicability of the standard risk/damage categories (which are based on masonry structures) is reappraised. In the first iteration the same model is used as in the Phase 2 assessment. This model is then successively refined in the following Iterations. If necessary, the tunnel-excavation-soil-building interaction problem is modelled numerically. The approach is to use simplified assumptions in the first instance and refine the analysis to see if a more accurate approach results in the risk of damage reducing to an acceptable level.

16. A structural survey will be undertaken to determine the structural form and condition of the building where reasonably necessary for the assessment. In every case where a building is subject to Phase 3 assessment, a desktop structural appraisal by a qualified structural engineer will be carried out for the purpose of confirming the likely structural behaviour and determining whether such a structural survey is so necessary.

17. As a result of the Phase 3 assessment, the risk/damage category of the building is assessed or reassessed, the requirement for any protective works is established and the design and implementation of any protective works and associated specialised monitoring are determined. These matters are stated in the settlement assessment report for the building.
Provisions also applying to listed buildings which are subject to Phase 3 assessment

18. In the first iteration of the Phase 3 assessment, the heritage value of a listed building is considered by reviewing the sensitivity of the building structure and of any particular features against the risk/damage category assigned in Phase 2. The heritage assessment examines the following:

   (a) the sensitivity of the building/structure to ground movements and its ability to tolerate movement without significant distress. The potential for interaction with adjacent buildings/structures is also considered. A score within the range of 0-2 will be allocated to the building/structure in accordance with the criteria set out in Table 2.

   (b) the sensitivity to movement of particular features within the building/structure and how they might respond to ground movements. A score within the range of 0-2 will be allocated to the building in accordance with the criteria set out in Table 2.

19. In addition, a score corresponding to the Phase 2 settlement assessment risk/damage category within the range of 0-5 is allocated to the building.

20. The scores for each of the three categories (18(a), 18(b) and 19) are added together to inform the decision making process. In general, listed buildings which score a total of 3 or higher are subject to further assessment as part of the Phase 3 iterative process. Buildings which score a total of 2 or less are predicted to suffer a degree of damage which will be easily repairable using standard conservation based techniques and hence no protective measures for the building’s particular features are required. However, ultimately the professional judgement of engineering and historic building specialists will be used to determine whether additional analysis is required. Upon conclusion of the Phase 3 iterations, a final composite score will be arrived at, comprising the risk category of the building (ignoring the fact that it is a listed building) assessed in accordance with the normal principles of Phase 3 assessment, to which will be added final scores for each of the two additional sensitivities referred to in paragraph 18(a) and (b) in accordance with Table 2, and this final composite score will constitute the risk/damage category of the listed building for the purposes of paragraph 17 above and clause 2(6) to (15) of this Agreement.

21. The relevant local authority will be consulted on the results of the listed building assessment reports and the proposals for protective measures for the building’s particular features, if any are required. English Heritage will also be consulted in relation to buildings where they would normally be notified or consulted on planning applications or listed building consent applications (as set out in DETR and DCMS Circular 1/01).

22. When considering the need and type of protective measures, due regard will be given to the sensitivity of the particular features of the building which are of architectural or historic interest and the sensitivity of the structure of the building to ground movement. Where the assessment highlights potential damage to the features of the building which it will be difficult or impossible to repair and/or if that damage will have a significant effect on its heritage value, the assessment may recommend appropriate measures to safeguard those features either in-situ or by temporary removal and storage off-site if those with relevant interest(s) in the building consent. If the Owner so requires, and provided that all relevant consents and other approvals are obtained from the local authority and/or English Heritage and/or any other relevant authority (whether by way of listed building consent, or under any undertaking or agreement requiring similar approvals given or entered into by the Secretary of State or the Undertaker, or otherwise) and from those with relevant interests in the building or its fabric, the Undertaker is to use all reasonable endeavours to implement any such safeguarding measures recommended in the Report. The Owner is to assist in obtaining such consents and approvals.

23. The form of monitoring of listed buildings will be determined based on the results of the assessment process.
24. If repair works are necessary, the arrangements for their carrying out or for reimbursement referred to in clause 4 (Costs). Reimbursable costs will include the cost of any expert advice from a person suitably qualified to advise on heritage issues. The carrying out of the relevant works will however require the consent of those with relevant interest(s) in the building.

REFERENCES


<table>
<thead>
<tr>
<th>1 Risk/Damage Category</th>
<th>2 Max Tensile Strain %</th>
<th>3 Description of Degree of Damage</th>
<th>4 Description of Typical Damage and Likely Form of Repair for Typical Masonry buildings</th>
<th>5 Approx(^2) Crack Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.05 or less</td>
<td>Negligible</td>
<td>Hairline cracks</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>More than 0.05 and not exceeding 0.075</td>
<td>Very Slight</td>
<td>Fine cracks easily treated during normal redecorations. Perhaps isolated slight fracture in building. Cracks in exterior brickwork visible upon close inspection.</td>
<td>0.1 to 1</td>
</tr>
<tr>
<td>2</td>
<td>More than 0.075 and not exceeding 0.15</td>
<td>Slight</td>
<td>Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible; some repointing may be required for weather-tightness. Doors and windows may stick slightly.</td>
<td>1 to 5</td>
</tr>
<tr>
<td>3</td>
<td>More than 0.15 and not exceeding 0.3</td>
<td>Moderate</td>
<td>Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Repointing and possibly replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Weather tightness often impaired.</td>
<td>5 to 15 or a number of cracks greater than 3</td>
</tr>
<tr>
<td>4</td>
<td>More than 0.3</td>
<td>Severe</td>
<td>Extensive repair involving removal and replacement of sections of walls, especially over doors and windows required. Windows and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably, some loss of bearing in beams. Utility services disrupted.</td>
<td>15 to 25 but also depends on number of cracks</td>
</tr>
<tr>
<td>5</td>
<td>Very Severe</td>
<td></td>
<td>Major repair required involving partial or complete reconstruction. Beams lose bearing, walls lean badly and require shoring. Windows broken by distortion. Danger of instability.</td>
<td>Usually greater than 25 but depends on number of cracks</td>
</tr>
</tbody>
</table>

**Notes**

1. Table 1 is based on the work of Burland et al (1977) and includes typical maximum tensile strains for the various damage categories (column 2) used in Phase Two settlement analysis.

2. Crack width is only one aspect of damage and should not be used on its own as a direct measure of it.
TABLE 2
Scoring for Sensitivity Assessment of Listed Buildings

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
<th>Sensitivity to movement of particular features within the building</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Masonry building with lime mortar not surrounded by other buildings. Uniform facades with no particular large openings.</td>
<td>No particular sensitive features</td>
</tr>
<tr>
<td>1</td>
<td>Buildings of delicate structural form or buildings sandwiched between modern framed buildings which are much stiffer, perhaps with one or more significant openings.</td>
<td>Brittle finishes, e.g. faience or tight-jointed stonework, which are susceptible to small movements and difficult to repair.</td>
</tr>
<tr>
<td>2</td>
<td>Buildings which, by their structural form, will tend to concentrate all their movements in one location.</td>
<td>Finishes which if damaged will have a significant effect on the heritage of the building, e.g. cracks through frescos.</td>
</tr>
</tbody>
</table>
HIGH SPEED TWO
PHASE 2a INFORMATION PAPER

F2: PHASE 2a TUNNELS

This paper outlines the range of proposed tunnelling methods to be deployed on the Proposed Scheme, the factors that influence the choice of method and the means of mitigating the construction and operational impacts associated with tunnelling.

It will be of particular interest to those potentially affected by the Government’s proposals for high speed rail.

This paper was prepared in relation to the promotion of the Bill: High Speed Rail (West Midlands-Crewe). Content will be maintained and updated as considered appropriate during the passage of the Bill.

If you have any queries about this paper or about how it might apply to you, please contact the HS2 Helpdesk in the first instance.

The Helpdesk can be contacted:

by email: HS2enquiries@hs2.org.uk

by phone (24hrs): 08081 434 434
                 08081 456 472 (minicom)

or by post: High Speed Two (HS2) Limited
           2 Snowhill, Queensway
           Birmingham
           B4 6GA

Version 1.0
Last updated 17 July 2017
F2: PHASE 2a TUNNELS

1. Introduction

1.1. High Speed Two (HS2) is the Government’s proposal for a new, high speed north-south railway. The proposal is being taken forward in phases: Phase One will connect London with Birmingham and the West Midlands. Phase 2a will extend the route to Crewe. Phase 2b will extend the route to Manchester, Leeds and beyond. The construction and operation of Phase One of HS2 is authorised by the High Speed Rail (London – West Midlands) Act (2017).

1.2. HS2 Ltd is the non-departmental public body responsible for developing and promoting these proposals. The company works to a Development Agreement made with the Secretary of State for Transport.

1.3. In July 2017, the Government introduced a hybrid Bill1 to Parliament to seek powers for the construction and operation of Phase 2a of HS2 (the Proposed Scheme). The Proposed Scheme is a railway starting at Fradley at its southern end. At the northern end it connects with the West Coast Main Line (WCML) south of Crewe to allow HS2 services to join the WCML and call at Crewe Station. North of this junction with the WCML, the Proposed Scheme continues to a tunnel portal south of Crewe.

1.4. The work to produce the Bill includes an Environmental Impact Assessment (EIA), the results of which are reported in an Environmental Statement (ES) submitted alongside the Bill. The Secretary of State has also published draft Environmental Minimum Requirements (EMRs)2, which set out the environmental and sustainability commitments that will be observed in the construction of the Proposed Scheme.

1.5. The Secretary of State for Transport is the Promoter of the Bill through Parliament. The Promoter will also appoint a body responsible for delivering the Proposed Scheme under the powers granted by the Bill. This body is known as the ‘nominated undertaker’. The nominated undertaker will be bound by the obligations contained in the Bill and the policies established in the EMRs. There may be more than one nominated undertaker.

1.6. While the UK has notified its intention to withdraw from the European Union, the UK remains a member until withdrawal, meaning that rights and obligations under EU law apply until the date of departure. The Government has announced its intention to convert all EU law into UK law, through the “Great Repeal Bill”3, so that the same rules and laws will apply on the day after exit as on the day

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1 The High Speed Rail (West Midlands – Crewe) Bill, hereafter ‘the Bill’.
2 For more information on the EMRs, please see Information Paper E1: Control of Environmental Impacts.
before. It will then be for democratically elected representatives in the UK to decide on any changes to that law, after full scrutiny and proper debate.

1.7. These information papers have been produced to explain the commitments made in the Bill and the EMRs and how they will be applied to the design and construction of the Proposed Scheme. They also provide information about the Proposed Scheme itself, the powers contained in the Bill and how particular decisions about the Proposed Scheme have been reached.

2. Overview

2.1. This paper provides an overview of the range of proposed tunnelling methods to be employed on the Proposed Scheme and the means of mitigating the construction and operational impacts associated with tunnelling.

2.1. Tunnelling is often necessary on railway lines where, due to the rolling nature of the landscape, it would not be possible to align the track without steep inclines, which are not compatible with railway operations. This is also the case for the Proposed Scheme.

2.2. Tunnels have also been introduced into the Proposed Scheme for environmental reasons, for example, to pass beneath built-up areas where disruption at the surface would be severe.

3. Tunnels on Phase 2a

3.1. A brief overview of the types of tunnel planned for the Proposed Scheme is as follows:

- **cut-and-cover tunnel** (also referred to as green tunnel) – where a trench is excavated and a concrete structure with a base, roof and walls is constructed in the trench. Fill material and soil is then used to backfill the trench and cover the top. The ground above is then restored and graded to blend it into the surrounding landscape. A short length (about 200m) of the southern part of the Whitmore Tunnel will be in cut-and-cover. See Figure 1 below for the cross section of a typical cut-and-cover tunnel;
3.2. For safety reasons, when bored tunnels exceed 500m in length, they are required to have cross passages to connect the two tunnel bores as well as escape routes that run the full length of the tunnel and are connected to the surface at tunnel portals. Cross passages and escape routes are required to provide safe exit routes and emergency services access in the event of an emergency. Figure 2 below for a typical cross-section of a twin-bored tunnel with cross passage.
On long tunnels, ventilation shafts may also be required at intermediate points along the tunnel to provide further emergency service access and evacuation points.

4. Tunnel Construction Methods

4.1. Bored tunnels are constructed either by starting from one entrance and constructing the whole tunnel or by starting at both entrances and meeting in the middle. The construction strategy will be to construct tunnels from the most suitable entrance or entrances, based on:

- distance from sensitive locations;
- ease of access for logistics by road and rail;
- impact on overall construction programme; and
- economic use of plant and machinery.

4.2. At present, to construct the Whitmore and Madeley tunnels it is assumed that Tunnel Boring Machines (TBMs) will be launched from the main tunnelling worksites at the southern portal of each tunnel. It is assumed that the tunnels will be bored in a south to north direction.

4.3. The main tunnel worksites are required for the removal of excavated material from the tunnel. They also form the main logistics area to take construction material and operatives into the tunnel. Depending on the construction method, the main worksite may also contain an area for casting concrete tunnel segments.

4.4. Cut-and-cover tunnels are constructed either in an open excavation or in a retained excavation.

4.5. The open excavation method involves excavating from the surface. Once the final depth is reached the tunnel floor is constructed, followed by the walls and roof to form a twin-cell box. Cut-and-cover tunnels in open excavation are generally constructed in shorter bays. The bays gradually advance over the full length of the tunnel section, with excavation being carried out from the ends of each box section. On shorter lengths of cut-and-cover tunnel the full tunnel length could be excavated at the same time.

4.6. The retained excavation method involves first constructing the walls using diaphragm walling or bored piling, followed by excavation and construction of the roof. Excavation of the tunnel is then undertaken beneath the roof slab from the open ends of the box. This method is likely to be adopted where space limitations restrict the width of an open excavation with side slopes.

5. Tunnel boring machines

5.1. HS2 Ltd has put together a high performance TBM specification that is specifically designed to limit both tunnel construction risk and ground
movements to a practical minimum. The TBMs used to construct HS2 will be purpose-built machines, using proven state-of-the-art technology and will operate 24 hours a day, seven days a week. They will be designed specifically for the project to ensure their reliability of performance, settlement control and to cope with the range of ground conditions expected along the Proposed Scheme.

5.2. During the Jubilee Line extension, HS1 and Crossrail projects, bored tunnels were driven successfully through ground conditions that would once have been considered extremely difficult, and similar to the ground conditions on some of the HS2 tunnels, proving the capability of modern construction techniques.

5.3. There are several types of TBM that employ different methods of supporting the tunnel face during excavation depending on the ground conditions, but they all involve essentially similar construction operations in terms of logistics. More details can be found in the HS2 Impacts of Tunnelling in the UK September 2013 Report.

5.4. The TBMs most likely to be used on the Whitmore and Madeley tunnels are Earth Pressure Balance Machines as shown in Figure 3 below. These types of machine have performed well on the Jubilee Line, HS1 and Crossrail projects.

![Figure 3: Earth Pressure Balance TBM](image)

5.5. To ensure the TBMs are operating safely, information will be relayed to a dedicated monitoring room manned by suitably experienced engineers. The monitoring room will have displays of real-time surface, subsurface and tunnel movements, together with TBM tunnel progress and TBM parameters.

5.6. This will ensure that the tunnel construction is being carried out to specification and that ground movements and temporary vibration effects remain within acceptable limits.

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4 [http://assets.hs2.org.uk/sites/default/files/inserts/Impacts%20of%20tunnels%20in%20the%20UK.pdf](http://assets.hs2.org.uk/sites/default/files/inserts/Impacts%20of%20tunnels%20in%20the%20UK.pdf)
6. TBM operation

6.1. The TBMs will weigh over 1,000 tonnes when fully operational. They will be delivered in smaller components and assembled near the tunnel entrance.

6.2. Where sufficient space is available, the TBM will be fully assembled before launch, with all back-up equipment installed. Otherwise, the TBM will be advanced and a sufficient length of tunnel constructed to allow the back-up equipment to be assembled in the tunnel.

6.3. Where necessary, ground treatment will be carried out around the TBM launch chamber structure to allow the TBM to be buried safely. This will also allow the full stabilising effects of the TBM to be brought into operation.

6.4. Once the TBM is launched, the following tunnel construction cycle will begin:

- excavation will be undertaken one tunnel lining ring at a time. First the TBM will excavate a short section of tunnel. Next, the tunnel lining ring segments will be built within the tail-skin of the TBM using a mechanical erector to form a complete ring. Following this the next short section of tunnel will be excavated, with the TBM propelled forwards by hydraulic jacks shoving off the previously erected tunnel lining ring; Figure 4 below shows the layout in a typical TBM.

![Figure 4: Sectional View of TBM Copyright Herrenknecht](image)

- grouting of the tunnel lining rings will be undertaken as a continuous process through the tail-skin of the TBM to fill the voids between the tunnel lining rings and the excavated surface of the ground behind;

- materials (such as tunnel lining rings and grouts) will be delivered to the TBMs by a narrow-gauge construction railway or other system such as pumping from the surface; and

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5 The tunnel will be built progressively through the building of joined ‘rings’ approximately 1.5 m in length.
• excavated materials may be removed by railway, specially designed rubber tyre vehicles, conveyors or pumping, depending on the type of TBM and the length of the tunnel.

6.5. TBM parameters will be monitored continuously both underground and within a dedicated tunnel monitoring control room. An excavation/grout check will be carried out to ensure all voids have been filled to minimise the risk of settlement.

6.6. The tunnelling operation will be continuous, which will minimise ground movements. On completion of the tunnel drives, the TBMs will be dismantled and removed from the tunnels.

7. Tunnelling Construction Phase Impacts

7.1. Noise and vibration due to tunnel boring during construction have been assessed based on previous experience at the Dublin Port Tunnel, the Jubilee Line Extension, HS1 and Crossrail. In general, the levels are low and occur for a limited period only.

7.2. As with any underground works, ground movements affecting buildings could occur during tunnel excavation or shortly thereafter. While the vast majority of tunnelling projects are successful, with very low recorded ground settlements, occasionally an incident occurs that results in higher localised ground settlements or subsidence.

7.3. The impact of ground movements on buildings will be assessed through a well-established three-stage process to determine whether there is a risk of potential building damage. This process has been used successfully on both HS1 and Crossrail. Full details of this process are set out in Information Paper C14: Ground Settlement.

7.4. The environmental impacts of tunnelling are considered within the ES and within the report ‘Impacts of Tunnels in the UK’\(^6\).

8. Tunnelling Operational Phase Impacts

8.1. Modern tunnelling methods mean the impact of ground-borne noise and vibration from railway operations are relatively low and may be effectively controlled. The main reasons for this are:

• better quality track;
• straighter track alignments;
• smoother running surfaces on the rails;
• fewer rail joints and the use of continuously welded track (reducing the dynamic loads and consequently the wear and tear on the rolling stock); and

\(^6\) [http://assets.hs2.org.uk/sites/default/files/inserts/Impacts%20of%20tunnels%20in%20the%20UK.pdf](http://assets.hs2.org.uk/sites/default/files/inserts/Impacts%20of%20tunnels%20in%20the%20UK.pdf)
better suspension on the trains (which improves passenger comfort, as well as reducing the impact forces on the track).

8.2. For high speed trains, the need for better performance requires that the track is maintained to a very high standard. The process of calculating noise and vibration from rail tunnels is well understood and the effects can be accurately predicted. Where noise and vibration levels are considered to be an issue, well-tried mitigation measures are available.

8.3. Recent projects, such as the Jubilee Line Extension and HS1 tunnels under London, have shown that modern railways can run in tunnels under large residential areas without noise and vibration affecting the people who live there or disturbing other highly sensitive non-residential uses.

8.4. Further information on noise and vibration control, and mitigation is available in Information Papers: E10 Control of ground-borne noise and vibration from the operation of temporary and permanent railways; E11 Control of noise from the operation of stationary systems; and E13 Control of construction noise and vibration.

9. Tunnel lining design

9.1. Tunnel linings are required to;
- structurally retain the earth and water pressure; and
- provide an internal space appropriate to the function of the operational railway.

9.2. Tunnel linings will be designed in accordance with the relevant regulatory standards, guidelines and current practice. These are based on proven design and construction technology that has been used successfully worldwide.

9.3. The linings will be designed to withstand all foreseeable loading, including construction loads and those from the surrounding ground and groundwater. They will also meet fire resistance and durability requirements.

9.4. As well as the train itself, the internal diameters of the tunnels have been sized to accommodate the swaying movement of trains, the overhead power supply, evacuation and access walkways, track slab, cables and associated furniture, and construction tolerances. Their sizing also takes account of the aerodynamic requirements of high speed trains.

9.5. The majority of the bored tunnels will be lined with pre-cast concrete tunnel lining segments, reinforced with steel fibres and polypropylene fibres. To enable connection between the twin bored tunnels, at intervals along the length of the route, cross-passages will be constructed and the openings for these formed using round graphite iron linings or steel frames encased in concrete alongside precast concrete tunnel linings. The linings are made up of a number of tunnel segments which are joined to form a ring.
9.6. The mined and cross passage tunnels, which are lined with sprayed concrete, will have a primary sprayed lining of fibre-reinforced concrete with a waterproof layer. A secondary lining of fibre-reinforced concrete will be either sprayed or cast in place. These construction techniques have been used successfully on the Crossrail project.

9.7. The lining of cut-and-cover tunnels will be conventional reinforced concrete.

10. **Tunnel Porous Portals**

10.1. A tunnel portal is the entry or exit section of a tunnel.

10.2. On high speed railways, the purpose of a porous portal at the entry of a tunnel is to ensure that the micro pressure waves produced by the 'piston effect' of the train moving through the tunnel, which can otherwise result in noise as the train exits the tunnel, are controlled and kept at a level which does not adversely affect the surrounding area.

10.3. A 'porous portal' is generally achieved by providing perforated structures, usually of concrete, at the tunnel portal. These structures have openings of increasing diameter, open to the outside air, running along their length.

10.4. Figure 5 and 6 below illustrate how porous portals on the Proposed Scheme could look:

![Figure 5: Example of porous portal (1)](image-url)
11. Fit-Out of Tunnels

11.1. Once tunnels are excavated, lined and cleaned out, the following activities take place:

- construction of walkways and drainage;
- installation of rail track and formation;
- installation of mechanical and electrical systems; and
- testing and commissioning.

12. More information

12.1. HS2 Ltd published a report on ‘Impacts of Tunnels in the UK’ in September 2013, which provides useful additional information on the potential operational and construction phase impacts of tunnelling and how these can be mitigated. This can be found here: [http://assets.hs2.org.uk/sites/default/files/inserts/Impacts%20of%20tunnels%20in%20the%20UK.pdf](http://assets.hs2.org.uk/sites/default/files/inserts/Impacts%20of%20tunnels%20in%20the%20UK.pdf)

12.2. More detail on the Bill and related documents can be found at: [www.gov.uk/Hs2](http://www.gov.uk/Hs2)