ARUP

Subject	East West Rail Phase 1 – Arup responses to Paul Buckley's correspondence dated 27th March 2015
Date	15 April 2015
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1 Introduction

Oxford City Council (OCC) as a Local Planning Authority (LPA) is in receipt of two applications for the discharge of Condition 19 of the East West Rail Link Phase 1, in respect of a Vibration Scheme of Assessment (VSoA). The VSoA comprises a Plain Line Report, a S&C report and a covering letter, dated 16th May 2014[1,2]. Condition 19 requires that, when submitted, a VSoA must be accompanied by a report from an Independent Expert (IE) which comments on the robustness of the vibration aspects.

The IE for vibration, appointed by the applicant and approved by the LPA, has provided such a report and has concluded that the methods used in the VSoA are robust and may be relied upon. In doing so the IE took account of representations from local residents about detailed technical aspects of the VSoA and the work carried out to produce it.

The Council perceives a gap between on the one hand the position reached by the IE and Council officers and on the other hand, the public perception. The Council is seeking to close this gap by means of external expertise paid for at its own expense.

The Council has therefore appointed Arup as specialist consultant (the Review Expert) with sufficient knowledge, skills and experience:

1. To review the information made available to the IE, the responses he has made to Council officers and the conclusions he has reached, as published in his final report.
2. To advise Council officers of whether the conclusions reached may be relied upon.

On 29th of August 2014 we submitted a report (*R01-OB – 'Our Report'*) which detailed the findings of our review. The report concluded that there were some areas of the VSoA where a material change to the conclusions would occur if more cautious assumptions were adopted. We also highlighted that there were areas where cautious assumptions had been made. Overall, we advised that the applicant should be asked to provide additional evidence of the basis for several VSoA assumptions and therefore broadly how cautious the VSoA is before Arup could advise whether the IE's conclusions could be relied upon or not.

On 12th September a meeting was held between OCC, Network Rail NR (who are seeking discharge of Condition 19) and ERM (technical advisors to NR), Atkins (technical advisors to NR and authors of the VSoA) and Arup. In this meeting it was agreed that NR's technical advisors would respond to several of the recommendations made by Arup in Our Report.

In December 2014, Atkins issued a note which provided further information on the items raised at the September meeting. This technical note was made public in January 2015. On the 10th of

[1] East-West Rail: Phase 1, Chiltern Railways Company Limited, Plain Line Vibration Assessment and Mitigation, reference 5114534-ATK-VIB-RPT-80001, revisions P07, 16 January 2014, prepared for Network Rail by Atkins.
[2] East-West Rail: Phase 1, Chiltern Railways Company Limited, Vibration from Switches and Crossings – Assessment and Mitigation. 5114534-ATK-VIB-80003, Revisions A01 28 January 2014.

February comments were received from the public which identified inconsistencies in the technical note and identified that Switches and Crossings (S&C) had not been considered. Arup made Atkins aware these matters and advised that the S&C should be included in the technical note. The technical note was subsequently revised and re-issued to Oxford City Council 18th February 2015.

On the 11th of March we issued our response (H01-OB) to the final submission of the Atkins' technical note (the Technical Note) to OCC. The note summarised our recommendations to Council Officers (i.e. whether the conclusions reached by the IE, may be relied upon). Shortly afterward our responses were made public.

On the 27th March 2015 Paul Buckley (PB) submitted comments on our response to the technical Note to OCC. The comments were his own but also expressed views shared by a number of track-side residents of the Oxford District portion of the EWR scheme. At a number of points throughout his submission further comment or clarifications were sought from Arup.

This document provides the clarifications requested in PB's submission of 27th March. In the following section direct quotes from PB are made where it is apparent that further clarification is being sought from Arup. Our clarifications are provided below each respective quote.

Our responses are limited to issues raised by PB which directly relate to our advice to OCC. We are aware that since our appointment in August residents have raised concerns on a number of additional matters relating to the VSoA, some of which are also raised in PB's submission of 27th March. We will shortly be providing a further document addressing the other remaining matters raised in separate correspondence.

2 Responses

2.1 Point 1

"*We are puzzled by the view expressed in the Arup Comments' that 'Alternative 2', i.e. the second of the two approaches used by Atkins in the Technical Note, 'provides the best available estimate of the amplification factor for each building'. There are two reasons we are puzzled. Firstly, it does not allow for the extra susceptibility of 2B Bladon Close. Secondly it seems to represent a mis-use of the data in the TNRB, in allowing neither for scatter in the responses of buildings of the same style of construction, nor for the known greater susceptibility of UK houses compared to the US buildings which form the data sets referred to in the TNRB – see Appendix 1 for further explanation of these misgivings. Available evidence suggests that use of the TNRB data in this way is incautious. It could easily lead to under-prediction of vibration amplification by at least 5dB (i.e. a factor of 1.8) – see Appendix 1*"

The Technical note by Atkins reproduces the data presented in the Transportation Noise Reference Book[3] (TNRB) for the range of coupling losses of various building foundations and the range of amplification of vibration due to floor resonances supported on columns. The figures are reproduced below.

Atkins used the coupling loss representing "single family residences" predict vibration levels at properties in Bladon Close. The measurement data used by the authors of the TNRB to derive the "single family residences" curve were measured largely in wood framed buildings in Canada. Also

[3] Transportation Noise Reference Book. Edited by Paul Nelson, Published by Butterworths, 1987. ISBN 0-408-01446.6

the range of amplification factors due to floor resonances presented in the TNRB was derived in part from measurements made in the same study in Canada and therefore include measurements made in timber framed buildings. We can therefore provide assurance to the residents that the amplification factors presented in the Technical Note do take account of the susceptibility of timber framed buildings to vibration.

It is important to note that the 'worst case' Alternative 2 amplification factors used by Atkins do take into account the variability that can occur between the buildings included in the dataset. The data presented in the TNRB provides a range of values. The 'worst case' amplification factor of 3 used for the properties on Bladon Close was derived assuming the minimum attenuation within the range of values for coupling loss of the building foundations (highlighted in red in figure 16.10) while also assuming the maximum amplification within the range of values presented for floor resonances (also highlighted in red in figure 16.11 below).

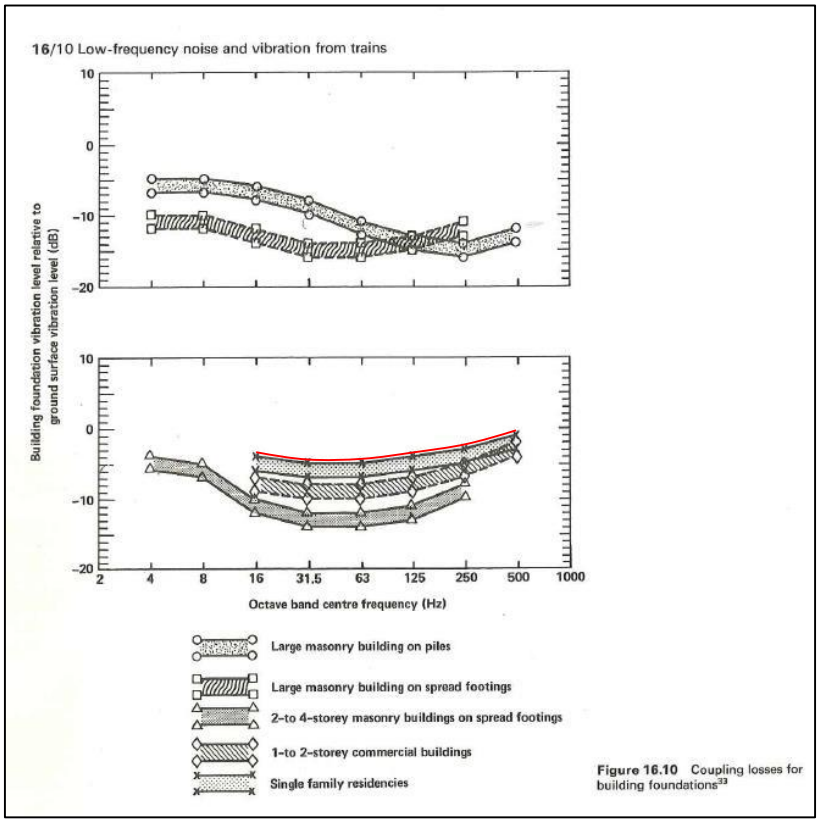

Figure 1: Figure 16.10 from [3].

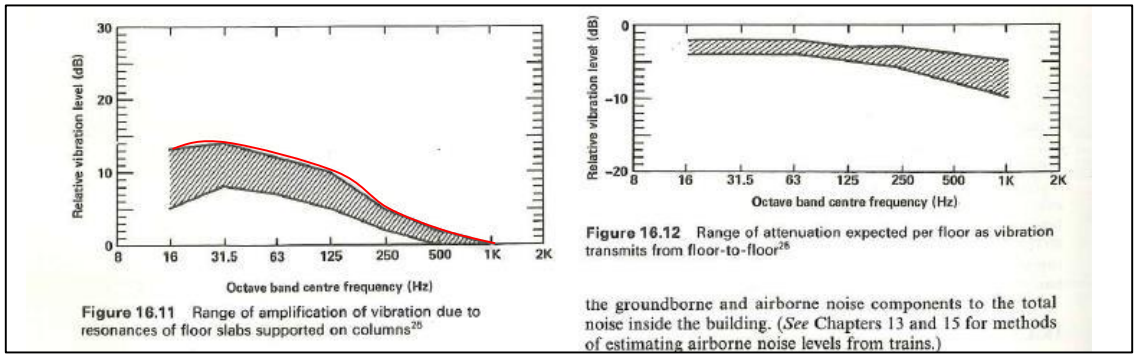

Figure 2: Figure 16.11 from [3].

Regarding the "*known greater susceptibility of UK houses compared to the US buildings*", we are aware of the paper by D'Avillez[4] et al. The paper presents measurements made in six buildings in the UK. Two types of building were studied; four two-storey brick buildings on strip footings with a ground bearing floor slab having the dimensions of approximately 10 by 7 metres; and two three-storey brick terraced buildings, supported also on strip footings with a ground bearing floor slab.

Of particular relevance, the paper presents measurements of the building coupling loss and the amplification due to floor resonances in all six buildings.

With reference to building coupling loss, the paper concludes that when the spread of measured data is considered, the coupling loss factors of all six buildings "*fail to fit a single class of buildings within the Nelson (1987)* [TNRB] *classifications*". It goes on to state that the six building's "*representation could be referred to the model presented in ATF (2006)* [another reference to TNRB data] *by combining both the 'single family residencies' and '1 to 2 storey commercial building' classes of buildings into one class; or, if adopting a conservative approach, then the upper limit of the 'single family residence'*".

This demonstrates that the six different buildings considered cannot be classified by a single TNRB curve.

The approach used by Atkins to address coupling losses actually is cautious because the upper limit of the 'single family residence' classification from the TNRB has been used to derive the worst case amplification factor for 2B, 3 and 4 Bladon Close. This approach is therefore consistent with the 'conservative' approach recommended by D'Avillez et al.

On the amplification of vibration due to floor resonances the paper states that "*an amplification ranging from approximately 5 to 15 dB in the 16 to 64 Hz frequency range* [The values presented in the TNRB], *also misrepresents (approximately by 5 dB) the floor response of the measured UK family dwellings*".

The 5dB 'misrepresentation' is presumably referring to the fact that the vibration measured at a single point on some floors sometimes exceeds the maximum of the range proposed by the TNRB by up to 5dB in some frequency bands. However, we do not believe that this supports the statement that UK properties are known to be more susceptible to vibration than US properties. It does

[4] J.D'Avillez et al 'Issues and limitations on measuring building's transfer function' presented at the 15th International Conference on Experimental Mechanics, Porto, Portugal, 22-27 July 2012.

demonstrate that the response of different floors is highly variable. While the paper highlights that the UK data presented sometimes lies above the ranges proposed by the TNRB, it fails to also highlight that the data are frequently lower than the minimum of the range proposed by the TNRB.

When the combined effect of coupling losses and floor amplification is considered there is nothing to suggest that the approach used by Atkins is not reasonably cautious. We recognise that there is uncertainty in the prediction of vibration when transfer losses have not been measured for specific buildings or classes of buildings. One of the authors of the TNRB discusses factors of safety to apply to ground-borne vibration predictions in another paper [5](referred to in PB's submission of 27th March). In that paper the author describes a full prediction method for train-induced vibration inside a building close to a railway. The foundation coupling loss and floor resonance curves presented in the TNRB form part of the prediction method. The authors state that a safety margin of 5 to 10dB should be applied to predictions made using the full prediction method described in the paper. This is consistent with our view of the overall accuracy of predictions made with ground-borne vibration prediction models. However we do not interpret this advice as specific to single elements of the prediction method presented in the paper.

Our conclusions and recommendations have been informed by our review of how Atkins have dealt with uncertainty in the VSoA prediction method which includes the use of the TRNB curves.

2.2 Point 2

"*A further complication is that the structure of Quadrangle House is unusual. It seems inaccurate to categorise its structure as the same as that of a USA 'typical 2-4 storey masonry' building, as was done by Atkins in the Technical Note. As Arup will have seen if they visited it to verify what Atkins say about this building (and in any case it was designed by Arup, so maybe they were able to check this from their own records), it features exceptionally wide unsupported floor spans, that would lower the frequency of vibration considerably and make it unusually susceptible to vertical feelable vibrations. So we do not understand the Arup Comments' acceptance of the Technical Note's assignment of what seems in the circumstances to be an arbitrary amplification factor of 1.6 for this building.*"

Regarding the response of the floor in the Quadrangle, in the previous section the variability of the response of different floor constructions was discussed. It was also demonstrated that the 'worst case' case frequency dependent amplification factors derived by Atkins led to a cautious approach in considering the potential variability between the floor response of buildings. The same approach was taken in deriving the 'worst case' amplification factor for the Quadrangle.

We do not consider that there is anything unusual about Quadrangle House in respect of its susceptibility to vibration. Consequently, we are of the view that it is reasonable to apply the coupling loss for a larger masonry building to the Quadrangle, particularly as this was done cautiously by Atkins by applying the minimum attenuation within the range of values for coupling loss presented in the TRNB for this class of building.

[5] J.T.Nelson and H.J.Saurenman 'A prediction procedure for rail transportation groundborne noise and vibration' Transportation Research Record 1143 (1988), 26- 35

2.3 Point 3

"*Finally, we do not understand why the Arup Comments follow the VSoA and Technical Note in not considering it necessary to include the effect of the S&C on 3 Bladon Close. As is clearly visible in the lower drawing on p.13 of the Technical Note, 3 Bladon Close is only some 25.5m from the nearest crossing, and 38.3m from the furthest crossing, while the data on p.19 of the S&C VSoA show that at these distances significant amplification is expected from the crossings. The neglect of such amplification causes the 'open ground' VDV for this building to be seriously underpredicted in the VSoA.*"

We have undertaken a thorough review of the predictions provided to us. We note that receivers have been chosen according to their proximity to the railway or the S&C such that the receptors most at risk of vibration impacts from the scheme are assessed. Designing the railway to minimise the impacts at these receptors should also ensure that impacts are minimised at all other properties in the vicinity of the railway.

It is a valid observation that the S&C has the potential to increase vibration levels at 3 Bladon Close. It is possible that this is a result of changes to the track layout referred to in the Technical Note. If other worst case receivers have not been used to assess vibration levels from S&C at this location it may be necessary to consider S&C at 3 Bladon Close.

2.4 Point 4

"*It is true that the Technical Note claims that, for these three buildings and using the Alternative 2 amplification factors, predicted VDVs are below the Condition 19 thresholds. But in view of all the doubts about the data used in the Technical Note's predictions (some of which I refer to above, others have been expressed previously), we do not understand why the Arup Comments conclude without qualification, in relation to these three buildings, that 'the vibration criteria in Condition 19 are achieved"'*

Our responses documented here directly respond to the 'doubts' raised in PB's submission of 27th March. We trust that our responses clearly show that these doubts are not shared by Arup when the plain line assessment is considered. However, as discussed in the previous section further consideration may be necessary for 3 Bladon Close regarding S&C.

To determine if the IE's conclusions may be relied upon we have focussed on matters which in our professional opinion are most likely to be material to the assessment.

We are aware that since our appointment in August residents have raised concerns on a number of additional matters relating to the VSoA, some of which are also raised in PB's submission of 27th March. We will shortly be providing a further document addressing the other remaining matters raised in separate correspondence.

2.5 Point 5

"*A particular uncertainty concerning the train-mix is: what is the likelihood of a higher proportion of freight trains in the future being of the vibration-intensive type: 'stone trains'? The Technical Note states 'there is no indication that there would be intensification in use of the stone train'. But this is unconvincing, because the Technical Note does not explain why Atkins would necessarily be*

aware of any plans currently being developed by commercial freight operators to run more stone trains.

Hence we are puzzled why the Arup Comments say that this clarification provides a 'reasonable degree of confidence' that there are no plans to operate stone trains at night in future. We do not see what provides the confidence referred to here."

The clarification provides confidence because the Technical Note was approved by Network Rail, hence we consider statements made about future operation of the stone train to be authoritative statements made on behalf of the network operator. In addition we have seen no other information to suggest that these statements are incorrect. It is also beyond our remit to speculate about possible changes in the fleet mix and train operations that may occur once the scheme is in operation.

2.6 Point 6

"*I am surprised by the precise numbers quoted in the Arup Comments. I believe the exceedance at 4 Bladon Close is greater than that given in the Technical Note, and quoted in the Arup Comments. If Arup's check of the numbers in the VSoA did confirm the VSoA's predicted VDVs for 4 Bladon Close, I would welcome confirmation.*"

The numbers quoted by us Our Report were only intended to be approximations to demonstrate the potential implications of the choice of modelling parameters. Our checks of predictions are limited to the parts of the prediction method and input data documented in the VSoAs and it is not within in our remit to reproduce the VSoA predictions at all receptors. While we have undertaken a number of checks on Atkins' predictions we have not checked the full prediction chain for 4 Bladon Close.

2.7 Point 7

"*Considering all these sources of uncertainty, there clearly needs to be a significant safety factor applied to the VDV predictions, to achieve a safe comparison with the Condition 19 thresholds. As is clear from above, in predictions made using the Atkins data for the EWR scheme as proposed, assuming trains run at the design speed, the only significant element of caution included is that this train speed is unlikely to be reached in practice. As shown in Appendix 2, without reduction of train speeds, the safety factor for 2B Bladon Close is only .4/.354=1.13. In my judgement this is too small to compensate adequately for all of uncertainties 1,2,3 listed above. However, if actual train speeds are guaranteed to be lower than the design speed, a more reasonable safety margin can be ensured. For example, a speed limit of 50 mph for all trains would provide safety factors of .4/.294=1.36 and .2/.15=1.33 for day and night at 2B Bladon Close. These are still modest, as compared to safety factors commonly used in engineering practice when human health and safety are at stake, but might be considered acceptable.*

In view of these considerations, we are puzzled why the Arup Comments do not also conclude that a reduced speed limit is required, to ensure an acceptably robust prediction of compliance with Condition 19 on plain line sections of the scheme."

We hope that the responses provided in this document provide sufficient reassurance that following a comprehensive review of the information provided to us we consider the VSoA for plain line has incorporated sufficient margins of safety to demonstrate that that the planning criteria can be achieved at properties in the vicinity of plain line track.

It is not within the Arup remit to propose or request mitigation measures such as speed restrictions. Our remit is to review the technical work presented on behalf of Network Rail and provide Oxford City Council with assurance that the assessments provided to them may be relied upon.

2.8 Point 8

"*In addition there is the unresolved situation south of Wolvercote, where there will be additional S&C - e.g. at North Oxford Junction adjacent to the Waterways development. We do not know whether the track layout has been finalised yet, and if so whether Arup have examined it. But there is clear potential for properties there (only slightly further from the track than 4 Bladon Close, and suffering low but frequent background vibration from the DCL main line) to also suffer vibration levels above the Condition 19 thresholds because of amplification from the S&C – a fact ignored in the VSoA and the Technical Note, and by the IE. We are surprised that the Arup Comments do not consider this omission worthy of comment.*"

We have not considered the situation south of Wolvercote because no information has been specifically presented to us to review. We would recommend that this concern is raised directly with Network Rail and their consultants.