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Modelling the real-time performance of noise barriers for the night time operation of a rail-freight terminal

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ABSTRACT

The operation of a Rail-freight Terminal can have many processes associated with the loading and unloading of containers that generate noise of an intermittent or impulsive nature. In particular the use of reach stackers can make it difficult to justify night-time operation when assessing the perceived LAMax levels against the current WHO criterion. This paper examines modelling the real time performance of a noise barrier scheme around an urban rail freight terminal in the UK Midlands. It considers the typical noise signature of a train arriving unloading and departing. It also examines the processes involved in aggregate handling and the use of reach stackers and swing-through cranes for container transportation. Using the model, the worst case combination of transient noise sources was determined. The barrier design was then optimised and specified to meet World Health Organisation (WHO) Guidelines for Community Noise and BS 4142: The Rating of industrial noise in a mixed industrial area.

TELFORD RAILFREIGHT NOISE MODEL

A detailed noise model was constructed for the Rail-freight Terminal in Donnington near Telford, Shropshire in the UK. This study was carried out on behalf of Telford and Wrekin Council with regard to the Regulatory Framework, the Environmental Protection Act 1990, the Town & Country Planning Act 1990 and the Telford Local Plan 1995-2006.

The noise model was used to determine the acoustic viability of the fully operating site, by assessing the predicted noise impact of a typical arrival and departure of a freight laden train realistically combined with all the active processes involved in the unloading and processing of the freight containers and transported aggregates.

The first objective would be to provide a detailed three dimensional acoustic model of the site and surrounding location to demonstrate how noise would spread across the site itself to the surrounding neighbourhood. At the same time detailed noise measurements were taken of the existing site that could be incorporated into the noise model to help determine the current varying background noise levels for the most affected property facades.

Because of the nature of the noise, it would be necessary to model each specific noise source separately in terms of their magnitude, duration and location. By considering actual operational activities, these sources were then combined in the model for different worst case scenarios. “Snapshot” noise maps were then produced to quantify and illustrate the different stages of a typical rail-freight event.

Noise Mitigation

The model was then used to assess the impact of real-freight noise on local residents with regard to the most relevant environmental noise guidance and standards given in the Protection Acts and to determine the best practical means of reducing the noise impact on site through the installation of an appropriate noise barrier scheme and through achievable on site operational controls that would suit all parties. All proposed measures would assume best practice. In other words, they would be realistic and in proportion to the noise impact of the site.

These mitigation measures were then incorporated into the noise model for each of the different “Snapshot” scenarios to show how they would provide sufficient protection to meet the noise requirements. It also would serve to demonstrate where, with best practice, these requirements would only be met subject to specific operational controls and limits being adhered to.

BACKGROUND TO THE SCHEME

Telford & Wrekin Council constructed the new railway terminal at Donnington in Telford, Shropshire. The build process included:

- The reinstatement of approximately 4 km of single line railway, along the former Wellington to Stafford route.
- The construction of a Railfreight Terminal adjacent to the MOD site at Donnington.
- The development of a 360,000 sq foot high bay distribution warehouse by a private sector developer
- The development of 2-3 smaller warehousing units of maximum floor area 90,000 sq ft by the Council’s Asset & Property Development Portfolio.

The Telford Railfreight Terminal (TRT) is located in the North of Telford next to existing manufacturing and warehousing facilities in Hadley Park, Hortonwood Industrial Estates and MOD Donnington.

The project has been promoted through a Transport & Works Act Order (T&WAO) which has the effect of creating a statutory railway. The application for the Order was made to the Department for Transport in July 2003 and was approved by the Secretary of State for Transport in April 2005. The T&WAO contains specific reference to noise levels and stipulates mitigation measures.

The design of the plant had undergone many changes and configurations. This noise model was constructed prior to the plant being built and was the most comprehensive and representative of the final design. All previous environmental impact reports and acoustic designs previously commissioned to assess noise within the TRT, were therefore deemed to either be outdated because of changes in the terminal configuration and proposed operations or inadequate in that they only considered specific noise sources in isolation.

GUIDELINES AND STANDARDS CONSIDERED

According to the Environmental Planning Act 1990, the Town & Country Planning Act 1990 and the Telford Local Plan 1990, the noise model was used to assess noise levels against the most appropriate standards. In this application these would be

- World Health Organisation (WHO) Guidelines for Community Noise
- BS 4142: 1997: The Rating of industrial noise in a mixed industrial area
- Planning Policy Guidance 24 (PPG24) (Referenced in the Policy statement EH6 of the Telford Local Plan)

World Health Organisation

The World Health Organisation Guidelines for Community Noise provides guidance in appropriate noise levels for residential properties. Typically the WHO considers that general daytime outdoor noise levels of less than 55 dB LAeq (16hr) is desirable to prevent significant community annoyance. During the night the condition is more stringent requiring noise levels outside a bedroom window of no more than 45 dB LAeq (8hr). There is also a requirement that the Maximum noise level: LAMax, (measured at the resident's window) should not exceed 60 dB at any time during the night to mimimise sleep disturbance.

The WHO guidelines only consider the impact of the maximum noise level LAMax during the night-time. Whilst residents may complain about sudden impulsive noises during the day, the WHO guidelines provide no specific guidance for its assessment with regard to daytime LAMax levels. Daytime Impactive operations in the Rail-freight terminal would therefore not be covered.

BS4142: 1997

BS4142: 1997 *Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas*, is a method of assessing the level of public nuisance due to industrial noise, in order to determine the likelihood or validity of a noise complaint. The specific noise level or LAeq measured noise at a residents home, generated by an industrial plant is compared to the background noise level in the area.

This study does not in fact apply BS4142 in its strictest sense. The rail-freight terminal does not fit the typical scope of the standard. More correctly, this study provides an assessment against Ambient Noise conditions in accordance with BS4142: 1997.

For night time measurements between the hours of 2300 and 0700, BS4142 requires LAeq levels to be averaged over 5 minute intervals. For intermittent noise sources, the average LAeq noise level should not exceed the background noise level by more than 5 decibels. For relatively continuous sources the exceedence rises to 10 dB. During the daytime, the assessed LAeq level is averaged over 1 hour intervals.

In the case of an arriving freight train, the general process is not really intermittent although some of the associated activities: shunts, clatters and bangs would be classified as intermittent.

PPG24

PPG 24 would normally be applied to assess the suitability of a site for residential development. Potential developments would be categorized for suitability or for potential mitigation based on their predicted noise levels. In this instance, the houses are already present and PPG 24 does not directly apply. In this scenario the key noise levels in PPG 24 match the requirements of the WHO guidelines in any case.

BACKGROUND NOISE MEASUREMENTS

Noise Measurements were therefore taken over a 5 day period from 22nd to 27th November 2007 at the back of a property directly adjacent to the line of the new railway and close to the site boundary. Measurements were taken using 01-dB type SIP95 integrating real time noise analysers in weather proof protection casing.

Measurements were started Thursday afternoon 22nd November and continued over the weekend through to Tuesday afternoon 27th November. The aim was to obtain data that was representative of day time and night time for both weekday and weekend conditions.

The overall daytime and night time LAeq and LA90 values are given in Tables 1 and 2 for both weekday and weekend conditions.

Table 1
Summary of LAeq Noise Measurements

LAeq	WEEKDAY dB(A)	WEEKEND dB(A)
DAY (0700-1900)	56	54
EVE (1900-2300)	54	51
NIT (2300-0700)	47	47
MIN (0700-2300)	52	-
MIN (2300-0700)	43	-

Table 2
Summary of LA90 Noise Measurements

LA90	WEEKDAY dB(A)	WEEKEND dB(A)
DAY (0700-1900)	53	53
EVE (1900-2300)	50	48
NIT (2300-0700)	42	42
MIN (24 hours)	39	39

From these it is immediately apparent that current levels show very little difference between weekday and weekend conditions. This is not so surprising considering the quantity of business activities in the vicinity operating 7 days a week. However the 24 hour profile for the weekday and weekend noise differs quite noticeably.

Background noise for residents prior to the rail-freight terminal being built was dominated by traffic on the adjacent A518 Hortonwood Bridge Road. The traffic noise ensured that background noise levels remain relatively high. Background noise measurements, together with the road traffic loadings were used to model both the daytime and night-time road traffic activity. This enabled a base line noise model to be produced of the current site with no rail-freight development in place.

Once the development is built the background noise level would potentially change due to presence of new site buildings and warehouses. With no site activity these would provide slight protection from the traffic noise on the Hortonwood Bridge Road. Once the proposed noise barrier system is built, this would have the effect of considerably reducing the background noise by masking the residents from the road. When no trains are running this improves the environment but it also has the adverse effect of making the trains more noticeable when they do pass.

METHODOLOGY

Computer Software

In order to assess the impact of the noise from the rail freight terminal being transmitted to adjacent properties, the three dimensional computational package Mithra was used. Mithra allows for precise acoustic modelling of particular noise sources: road, rail traffic or industrial sources of noise. This can be done either using specifically prescribed sources or by using generated point, line and surface sources that best represent typical train arrival and unloading events.

It shows how the noise interacts with adjacent buildings, taking into account different ground conditions and topography. Mithra allows for sources to be modelled in terms of their magnitude, location, duration and frequency content. The large variation of options allows the sources to be represented as realistically as possible in the model.

With regard to noise barrier design, Mithra also allows for performance variation in terms of sound absorption and airborne sound insulation. This enables barriers to be 'tuned' for optimum efficiency for noise mitigation.

Train Source Definitions

A typical rail-freight train event is defined by 10 separate movements associated with the arrival, manoeuvring and departure of the freight train.

Most of these sources were associated with the moving locomotive and their duration would be based on an assumed fixed locomotive speed of 5 miles per hour and a total train length of 500 metres. In contrast, the un-coupling, re-coupling events were assumed to occur over a short time duration based on measurements taken at a similar terminal site.

The total duration from arrival to departure is modelled to last just over 1 hour in the following general pattern:

	Movement	Duration (secs)
1	Locomotive travels through points along Line 1	665
2	Locomotive Un-couples	48
3	Locomotive travels along Line 2 to back of train	877
4	Locomotive Re-Couples	48
5	Locomotive pushes the train to end of Line 8	552
6	Train Un-Couples at Half-way	48
7	Locomotive backs up Half Train past points for 7 & 8	262
8	Locomotive pushes Half of train to end of Line 7	448
9	Locomotive Un-couples	48
10	Locomotive departs through points along Line 3	843
	Total time	3839

Unloading Source Definitions

The second "set of sources" is associated with the container unloading operation. During the day-time, this would be carried out by a reach stacker, at night the operation would be carried out by a swing thru crane. In both cases the operation would be assumed to commence once the locomotive has departed. Both the crane and the reach stacker operate in a confined location. The reach stacker moves between the train where it picks up a container and then transfers it to a stack to unload and move on. The crane would transfer the container directly from the train to a waiting truck:

	Movement – Daytime – Reach Stacker
11	Reach stacker operations commence
12	Reach stacker picks up load (Bang at 6 m)
13	Reach stacker carries load
14	Reach stacker stack load (Bang at 6 m)
15	Reach stacker leaves load – and continues

	Movement – Night time – Swing Crane
11a	Swing thru Crane operations commence
12a	Crane Lifts container from Train to Truck
13a	Crane Feet Fold in (Clang!)
14a	Swing thru Crane moves to next container
15a	Crane Lifts container from Train to Truck

Other Sources

Other sources included in the noise model were:

Container HGV Movements along site roads

Bulk Traffic (for Aggregates and Concrete) – daytime only

HGV Movements associated with Warehouse development

Fork Lift Operations

Aggregate Handling - daytime only

Concrete Batching Plant – daytime only

For the model most of these sources are assumed to operate continuously whilst the freight train is moving through the terminal and whilst the reach stackers are operating. The exceptions would be the Aggregate Handling, the Concrete

Batching plant and associated HGV movements that would only occur in the day.

The quantity of Vehicular movements on site was provided by Telford and Wrekin Council as was data for the Aggregate Handling and Concrete Batching Plant

NOISE ASSESSMENT AND BARRIER DESIGN

For both day-time and night time conditions, in all 15 separate movement scenarios were modelled representing the time-slices of a complete train arrival, unloading, departure event. For each of these models noise levels were predicted for the 98 most exposed properties. The complete event was then analysed in detail to obtain “worst case” values that could be assessed against WHO and BS4142 for daytime and night-time conditions.

Different noise barrier combinations were then inserted into the model and the same calculation was carried out to determine the level of noise mitigation afforded by the scheme.

Operational Controls

Where it was apparent that further noise mitigation may be required, operation control measures were proposed whose impact on noise could be quantified. These were proposed in discussion with the train operator and Telford and Wrekin Council.

DISCUSSION OF RESULTS

Dominant Sources

From the study, it was immediately apparent that in terms of the LAeq, not surprisingly, the train movement was the dominant source. In terms of sudden impulsive noise, the Reach Stacker dominated during the day due to the sudden “clang” of picking up and stacking a container. In contrast, the general HGV movements were of a lower order. This was also true at the Access ramp to the roundabout where HGV traffic was servicing both the transport of Freight and Aggregate and the smaller warehouse development. At night-time, the crane operation was much quieter than the reach stacker and would only dominate when the feet clanged back into place.

WHO Assessment (no noise barriers)

According to the WHO guidelines, the daytime noise limit for external (ground floor) living areas is 55 dB(A) LAeq(16hr). With no barriers in place, 89 % of the 98 properties assessed would exceed this level in the daytime however the assessment was carried out for the LAeq for the duration of the train event which was about 1 hour in duration rather than 16. Since the LAeq is time averaged, this value should be adjusted to take into account the majority of the time when no activity would take place.

According to the WHO guidelines, the night-time noise limit at bedroom facades is 45 dB(A) LAeq(8hr). With no barriers in place, 100 % of the 98 properties assessed would exceed this level based on first floor façade noise predictions.

WHO Assessment (with noise barriers)

With the proposed barrier scheme installed, the daytime WHO noise limit of 55 dB(A) LAeq(16hr) for external (ground floor) living areas, would now be exceeded by 38% of the 98 properties assessed. Again, this was based on a 1 hour averaged LAeq rather than 16. Since the LAeq is time averaged, this value should be adjusted to take into account the majority of the time when no activity would take place.

With the proposed barrier scheme installed, the night-time WHO noise limit of 45 dB(A) LAeq(8hr) at bedroom facades, would now be exceeded by 73% of the 98 properties assessed.

However it was also noted that the predicted night-time background noise only falls below the 45 dB(A) level for 2 hours of the night. In other words, the fact that for most of the night that WHO limit would never be met was due to the background noise level.

Ambient Noise Assessment (no noise barriers)

Interpreting BS4142, the freight train acts as a continuous dominant source. As such there is no need to apply the BS4142 5dB correction.

During the daytime, without barriers, the predicted worst LAeq(1hr) for all 98 properties was assessed and of these, 19% were found to exceed the predicted background noise level by 10dB or more. Complaints from these properties would be likely according to BS4142. A further 46 % were found to exceed the predicted background noise level by 5 dB or more. These would be only of marginal significance.

During the night-time, without barriers, the predicted worst LAeq(5min) for all 98 properties was assessed and of these, 55% were found to exceed the predicted background noise level by 10dB or more. Complaints from these properties would be likely according to BS4142.

Ambient Noise Assessment (with noise barriers)

During the daytime, with barriers, the predicted worst LAeq(1hr) for all 98 properties was assessed and of these, no properties were found to exceed the predicted background noise level by 10dB or more. In fact all properties now exceeded the predicted background noise level by 5 dB or less. These would now all be only of marginal significance.

During the night-time, with barriers, the predicted worst LAeq(5min) for all 98 properties was assessed and of these, 26% were found to exceed the predicted background noise level by 10dB or more. Complaints from these properties would be likely according to BS4142. A further 53 % were found to exceed the predicted background noise level by 5 dB or more. These would be only of marginal significance.

WHO LAMAX Assessment

According to the WHO guidelines, the night-time LAMax noise limit for bedroom facades is 60 dB(A). With no barriers in place, 61 % of the 98 properties assessed would exceed this level in the night. This was due to the dominance of the train arrival on the properties closest to the track and not due to the Swing thru crane.

With barriers in place, none of the 98 properties assessed would exceed the LAMAX limit of 60dB(A) in the night. The barriers would therefore be providing adequate protection against this high maximum level.

PROPOSED OPERATIONAL CONTROLS

With the barriers in place, the following operational controls were proposed to provide further mitigation:

Restricting Reach Stacker Activity to the Daytime

According to this study most of the primary noise sources are containable by barrier protection or operational control. However it was also confirmed that the limitation of reach stacker activity to daytime only was the correct one. Should reach stacker operations be allowed at night, the resultant LAMAX levels would almost certainly result in justifiable complaints.

Whilst it may be difficult to predict the arrival of a night train, this restriction essentially means that the containers themselves cannot be handled until 0700.

Semi-Permanent Container Barrier

At any time there would be about 400 containers on site. Typically according to the operator, a minimum of 10% would be stacked and stored. This gives the potential for a semi permanent barrier to be built to protect properties exposed to the operations of the reach stacker. 40 containers could create a barrier 240 metres long and 6 metre high.

Should there by any future allowance for reach stacker operations at night, this measure could be further enhanced by requiring the container barrier to be stacked and un-stacked during the day, but left un-touched during the night to ensure the barrier is not disturbed but offers the greatest protection.

A further measure could be to examine whether the reach stacker could be limited to only lifting containers off the train at night and placing them on the ground or straight onto a lorry. This would result in “clangs” occurring at a lower height which may receive greater protection behind the semi permanent wall. This is unlikely to remove the problem of the Reach Stacker at night but it may reduce the problem.

Aggregate Handling Confined to the Far Western End of the Track

Part of the barrier scheme would be to install a barrier section in front of the aggregate handling bay. The aggregate handling activity had been confined to the far western end of the unloading track section though this was primarily to restrict the spread of aggregate dust rather than merely being a measure to contain the noise.

Aggregate Handling and Concrete Batching Treated as Daytime Activities Only

It was also proposed that the Aggregate Handling and Concrete Batching be confined to daytime activity. This was already assumed in the model and analysis.

Restrict Train Arrivals during the Night

From an acoustic point of view, it would be beneficial to advice train operators to arrive outside of the hours of 2.00 to 5.00 am. With regard to the ambient noise assessment this would reduce the number of properties that exceed the predicted background noise level by 10dB or more from 26% to only 6%. It was however noted that this could be too restrictive to be practical for the operator.

Furthermore, by restricted the operator to 1 train per night, this would ensure that the LAeq (8hr) WHO night time noise is “dampened” down by 4-6 dB.

IMPACT OF THE PROPOSED OPERATIONAL CONTROLS

WHO Assessment

These measures together with the proposed noise barrier system would result in reducing the number of properties that exceed the WHO daytime limit from 38% to 19%. Furthermore, all of the properties would then be within 1 dB of the background level so this should constitute a best practice solution.

Similarly, although 73% of properties would still be exceeding the night-time WHO limit, they would all be within 1 dB of the background level so again this should constitute a best practice solution.

Ambient Noise Assessment

The proposed noise barrier scheme is already predicted to provide sufficient reduction with regard to BS4142 daytime conditions.

For night time conditions measures would also result in reducing the number of properties that exceed the background noise level by 10dB from 26% to 6%. However it should be noted that these 26% properties are behind the new combined bund-barrier. The only reason that they are predicted to exceed the noise limit in the ambient assessment is that construction has the effect of significantly reducing the background noise from its original level. If compared with current background levels, none of the properties would exceed background by 10dB or more.

WHO LAMAX Assessment

By restricting reach stacker operations to the day-time and resorting to the use of the swing thru crane at night, the intrusive night-time WHO LAMax limit would not be breached.

BARRIER DESIGN AND SPECIFICATION

Three separate noise barriers were proposed as part of the complete noise mitigation scheme, though one of the sections, in front of the warehouse was dependent on further site developments and to date has not been constructed.

The barrier scheme has been based on an acoustic performance specification rather than on any specific material construction.

Primary Barrier Bund Combination

The main barrier comprises a 580 m long, 2.0 m high Absorptive barrier on top of a 3 m high Gabion/Bund. For simplicity of build, the barrier would be situated 1,0m back from the face of the bund to ensure its foundations are not set into the gabion itself.

This 5 metre high barrier provided the main protection for the majority of the properties most exposed to the noise of the rail-freight terminal.

Secondary Aggregate Barrier

A second barrier section was built in front of the aggregate handling zone, which comprised a 240 m long, 3.0 m high basic reflective fence. This would primarily serve as a security barrier being too distant from the reach stacker operations to provide any meaningful protect.

Absorptive Barrier Specification

In the absence of any robust specification standards for noise barriers for rail, the absorptive barrier on top of the gabion/bund was specified with reference to the Specifications standard for road traffic noise reducing devices: EN 14388:2005.

With regard to the acoustic performance, the barrier was specified for sound absorption in accordance with EN 1793-1 and for airborne sound insulation in accordance with EN 1793-2. Both of these test standards refer to and use the normative spectrum for road traffic noise given in EN 1793-3 so care was taken to ensure that the barrier performance in this study related to the noise spectra of the rail-freight terminal.

The absorptive barrier was certified as B3 in accordance with BSEN 1793 Part 2 and certified as A3 in accordance with BSEN 1793 Part 1

Table 3
Minimum Acoustic Coefficients

1/3 Octave Frequency Band	Sound Absorption Coefficient	Sound Insulation Coefficient
100	0.2	15
125	0.4	17
160	0.6	19
200	0.8	20
250	0.8	22
315	0.8	24
400	0.8	26
500	0.8	38
630	0.8	32
800 to 5000	0.8	34

REFERENCES

1 BS4142: 1997 Method of rating industrial noise affecting mixed residential and industrial areas. BSI, 389 Chiswick High Road, London UK W4 4AL.
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3 EN 1793-1(1998): Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 1: Intrinsic characteristics of Sound Absorption. CEN European Committee for Standardization, rue de Stassart, 36 B-1050 Brussels.
4 EN 1793-2(1998): Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 2: Intrinsic characteristics of Airborne Sound Insulation. CEN European Committee for Standardization, rue de Stassart, 36 B-1050 Brussels.