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ST JAMES ESTATES LIMITED

11 ST JAMES SQUARE, MANCHESTER

INTERNAL NOISE VERIFICATION REPORT

MARCH 2021

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DATE ISSUED:	**23RD MARCH 2021**
JOB NUMBER:	**GM10442**
REPORT NUMBER:	**0007**
VERSION:	**V0.1**
STATUS:	**FINAL**

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INTERNAL NOISE VERIFICATION REPORT

MARCH 2021

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EXECUTIVE SUMMARY

Measurement and assessment of noise have been undertaken to determine the noise attenuation which is provided by the building façade. The work has been done to support the discharge of Condition 3b in the Prior Approval (Ref: 122770/P3OPA/2019) and Condition 5b in the Planning Approval (Ref: 123025/FO/2019). The conditions relate to the verification of the noise attenuation provided by the facade of 11 St James Square, Manchester.

The assessment comprises a summary of the correspondence undertaken to date, noise monitoring carried out internally and externally at the development, and an assessment of the noise attenuation provided by the façade of the completed development.

The measured façade sound insulation level has been compared against the façade attenuation requirements recommended in the noise assessment report prepared to support the prior approval and planning application.

The noise measurements were undertaken within the studio apartments of the completed development. However, the noise measurements included noise from both external noise sources and internal noise sources.

This contribution of noise from internal noise sources results in an artificially high measured noise level. This results in the sound attenuation of the building façade appearing to be less than it is. Because of this the building façade does not appear to meet the requirements set out in the February 2019 noise assessment report, however, the true sound attenuation of the façade is very likely to be higher than is shown here. Therefore, we recommend that further noise measurements are undertaken when typical activities resume following the lifting of the current government restrictions.

1 INTRODUCTION

1.1.1 Wardell Armstrong LLP (WA) was instructed by St James Estates Limited to undertake noise measurements to support the discharge of Condition 3b in the Prior Approval reference 122770/P3OPA/2019 and Condition 5b in the Planning Approval reference 123025/FO/2019, for the redevelopment of 11 St James Square, Manchester.

1.1.2 To the north, the site is bordered by commercial office spaces, with a service yard associated with these offices, together with existing offices at the site and commercial businesses at ground floor level. To the east, the site is bordered by Four Yards (a narrow street), with a mixture of residential apartments and commercial properties beyond which lies the Metrolink tram line on Cross Street. To the south the site is bordered by John Dalton Street with a mixture of commercial and residential properties beyond. The Ape and Apple public house is located approximately 20m to the south west of the site. To the west the site is bordered by St James Square with commercial properties beyond.

1.1.3 The development of 11 St James Square comprises the redevelopment of the upper floors of the former office building to a residential development comprising studio apartments over four floors.

1.1.4 Wardell Armstrong prepared a noise assessment report to support the discharge of condition 5a in July 2019 which specified the glazing and ventilation required to meet internal noise levels. Conditions 3b and 5b require verification sound tests to be carried out, to confirm that the required criteria are met.

1.1.5 Condition 3b states.

> *"3b) Notwithstanding condition 2 and part a, upon completion and prior to first occupation of the development, a verification report will be required to validate that all agreed mitigation and acoustic insulation measures such as glazing and ventilation recommendation and any building improvements have been implemented and complied with. Validation should include final sound testing to confirm that the internal noise criteria has not been exceeded during day or night time. Any instances of non-conformity with the above criteria shall be detailed along with any measures required to ensure compliance. The report and any necessary measures shall be submitted to and approved in writing by the City Council as Local Planning Authority and the development shall be*

implemented in full in accordance with the approved details before the plant is first brought into use."

1.1.6 Condition 5b states.

"5b) Upon completion of the development and before the new residential use becomes operational, a verification report will be required to validate that the work undertaken throughout the development conforms to the recommendations and requirements in the acoustic consultant's report, as will be approved under part a) of this condition. The report shall also undertake post completion testing to confirm that above criteria is met. Any instances of non-conformity with the recommendations in the report shall be detailed along with any measures required to ensure compliance with the noise criteria. The report and any necessary measures shall be approved in writing by the City Council as Local Planning Authority and the development shall be implemented in full in accordance with the approved details before the new use becomes operational."

1.1.7 The prior approval condition and planning condition both set out, effectively, the same requirements. Therefore, this report has been prepared to support the discharge of both conditions.

2 CORRESPONDENCE AND ASSESSMENT METHODOLOGY

2.1 Introduction

2.1.1 This section of the report discusses the consultation undertaken with Manchester City Council (MCC), and our assessment methodology.

2.2 Correspondence

2.2.1 WA has undertaken consultation with Ms Carolyn Parry, Planning Officer (PO) at MCC to discuss an appropriate methodology to discharge the planning and prior approval conditions.

2.2.2 Due to the restrictions imposed as a result of the on-going global pandemic, the undertaking of typical and representative noise measurements would not be possible. Therefore, an alternative methodology was proposed, where simultaneous noise measurements would be undertaken externally and internally. The difference between the measured levels would be used to determine the sound attenuation provided by the 'as-built' façade. The results would be compared against the recommendations set out in the February 2019 Noise Assessment Report.

2.2.3 The PO stated that noise measurements should not be undertaken until "typical" conditions return, which, in their view, was likely to occur in the coming weeks. There is no justification for such a view, and the delay it would cause to the discharge of the conditions would not reflect the pragmatic approach which is required of the planning system during the pandemic.

2.2.4 Following discussions with the client, it was agreed that the above noise measurements would be undertaken, to enable the timely discharge of the planning conditions.

2.3 Summary of February 2019 Noise Assessment Report

2.3.1 A noise assessment report was prepared by Wardell Armstrong LLP, dated February 2019, to support the prior approval application for the conversion of the upper floors of the former office building into residential accommodation.

2.3.2 The assessment included the measurement of noise at the northern, eastern, and southern facades of the building between 31st January and 5th February 2019. These measured noise levels were used to determine the façade attenuation which would be needed to ensure the following internal noise guideline levels would be achieved.

- Daytime noise levels within living rooms and bedrooms should not exceed 35dB L_{Aeq}.
- Night-time noise levels within bedrooms should not exceed 30dB L_{Aeq}, and 45dB L_{AFmax} more than 15 times (typically).

2.3.3 The following façade attenuation levels stated in Table 1 and Table 2 were recommended.

Table 1: Attenuation Required to Achieve the Internal Daytime Noise Guideline Levels at 1st and 2nd Floor Level (Figures in dB(A))

Living Rooms and Bedrooms Closest to:	Noise Level at the Façade	Level of Attenuation Needed to Achieve 35dB L_{Aeq}
Northern façade, facing into the courtyard.	60	25
Eastern façade, facing on to Four Yards.	63	28
Southern and western façades, facing John Dalton Street.	69	34

Table 2: Attenuation Required to Achieve the Internal Night-time Noise Guideline Levels at 1st and 2nd Floor Levels (Figures in dB(A))

Bedrooms Located Closest to:	Noise Level at the Façade of the Building (L_{Aeq})	Maximum Noise Level at the Façade of the Building (L_{Amax})	Level of Attenuation Needed to Achieve the Noise Guideline Levels in Bedrooms
Northern façade, facing into the courtyard.	58	79	34
Eastern façade, facing on to Four Yards.	61	82	37
Southern and western façades, facing John Dalton Street.	67	87	42

2.3.4 It is therefore necessary to demonstrate that the required façade attenuation levels are achieved.

2.4 Noise Survey

2.4.1 As part of this assessment, Wardell Armstrong LLP has carried out an attended noise survey to assess the current ambient noise levels both internally and externally at the proposed development.

3 NOISE MEASUREMENT SURVEY

3.1 Introduction

3.1.1 This section of the report details the site conditions, observations, and noise measurements undertaken to show that the as-built development meets the recommendations set-out in Table 1 & 2.

3.2 Covid-19

3.2.1 The noise measurements have been undertaken during the Government's 'Lockdown 3' in England. During this lockdown, residents were expected to stay at home, only to travel where journeys were essential and to go to work only where it cannot be done from home. Furthermore, all non-essential shops, pubs, night-clubs and entertainment venues were closed.

3.2.2 Therefore, road, rail and pedestrian movements were lower than the same time in 2019. Current government statistics show that road traffic movements were reduced to around 75% of its level in typical years.

3.2.3 For this reason, external measurements would not be truly representative of typical noise levels. Therefore, simultaneous measurements were taken both internally and externally to the façade being examined, with the intention of calculating the noise attenuation provided by the façade

3.3 Site Conditions & Observations

3.3.1 All the internal noise measurements were undertaken in studio apartments. The space forms a bedroom and living area for the tenant.

3.3.2 During the noise measurements the studio apartments were furnished and occupied, although there were no residents present in the studio apartments being tested.

3.3.3 Constant steady noise from ventilation systems was just audible in all apartments, particularly so in Apartment No.15 on the 1st floor. Short periods of noise from internal pipe systems were also observed. Occasional low-level clicking noises from kitchen appliances (e.g fridge compressors) were observed for a short duration in the majority of apartments. Low level noise from general activities in adjacent apartments was observed and included movements in adjacent corridors.

3.3.4 Road traffic noise together with pedestrian noise on John Dalton Street was observed internally within the facades facing to the south. External plant (fan) located in the car park area to the north was observed but was barely audible internally with windows

closed. Construction noise from renovation works at the adjacent building to the east, including drilling works, was occasionally audible.

3.3.5 We are of the view that noise from both internal and external sources was contributing in approximately equal measure to the measured internal noise level.

3.4 Details of Noise Measurements

3.4.1 The noise measurements were undertaken on the 5th March 2021 during the daytime.

3.4.2 Wardell Armstrong carried out simultaneous attended noise monitoring, both internally and externally, at the development to assess the sound attenuation provided by the 'as-built' facade. Details of the surveys undertaken are described in detail in this Section of the report.

3.4.3 The internal and external noise measurements were undertaken at the first floor, and second floor at the northern, eastern, southern, and western facades. However, there was no access to the western façade on the 2nd floor.

3.4.4 The internal and external noise measurements were taken simultaneously so that the measured noise levels could be directly compared. Internal noise measurements were undertaken within the apartments in three locations and for a period of around 10 minutes in each location.

3.4.5 The noise measurements were made using two Class 1, integrating sound level meters. For the internal noise measurements, the microphone was mounted vertically on a tripod and more than 1.5 metres from the walls and floor. External noise measurements were undertaken on a boom protruding from an open window of an adjoining apartment on the façade under consideration. The microphone was located between 0.5m and 1.0m from the façade.

3.4.6 A-weighted L_{eq} noise levels and in one-third octave bands were measured to enable the façade noise attenuation to be calculated. The measured noise levels are set out in full in Appendix A.

3.4.7 The sound level meters were calibrated to a reference level of 94dB at 1kHz both before, and on completion of, the noise survey. No drift in calibration was measured during the survey.

3.4.8 The noise measurements are described below in Table 3.

Table 3: Details of Measured Noise Levels					
Facade	**Floor Level**	**Apartment**	**Date**	**Start Time (hrs)**	**End Time (hrs)**
Northern	1st Floor	No.2	5th March 2021	1300	1330
	2nd Floor	No.4		1550	1621
Eastern	1st Floor	No.6		0954	1025
	2nd Floor	No.5		1404	1435
Southern	1st Floor	No.13		1102	1132
	2nd Floor	No.12		1502	1533
Western	1st Floor	No.15		1209	1239

3.5 Summary of Measured Noise Levels

3.5.1 The following broadband sound levels were measured at each façade. The sound attenuation provided by the facade has been considered in more detail, in one third octave bands, in Appendix A. A summary of the measured noise levels is given in Table 4 below.

Table 4: Details of Measured Noise Levels (Figures in dB(A))			
Facade	**Floor Level**	**Measured External Sound Level**	**Measured Internal Sound Level**
Northern	1st Floor	55.3	28.6
	2nd Floor	55.4	28.7
Eastern	1st Floor	63.7	33.7
	2nd Floor	70.0	35.0
Southern	1st Floor	68.9	33.4
	2nd Floor	68.0	34.1
Western	1st Floor	68.8	37.7

4 ASSUMPTIONS, LIMITATIONS AND UNCERTAINTY

4.1 Introduction

4.1.1 The assessment is affected by the following limitations, and the measures detailed below have been undertaken to minimise uncertainty.

4.2 Limitations

4.2.1 External activities are not considered to be representative due the pandemic at the time of the noise survey.

4.2.2 Noise from internal noise sources is a significant contributor to the measured internal noise level, thereby limiting the maximum façade noise attention which can be measured.

4.3 Uncertainty

4.3.1 To reduce the level of uncertainty within the assessment, the following steps have been taken:

- In accordance with guidance, the microphone was mounted vertically on a tripod and 1.5m away from internal walls and floors
- The noise measurements were undertaken during suitable weather conditions.
- The results of each measurement period were reported to the nearest 0.1dB.
- Noise measurements were made using two Class 1, integrating sound level meter.

4.3.2 The sound level meters were calibrated prior to and following the noise survey, no significant drift in calibration was recorded.

5 CALCULTION OF FACADE NOISE ATTENUATION

5.1 Introduction

5.1.1 The measured noise levels have been used to determine the as-built sound attenuation of the building façade using the methodology described in this section. This calculated sound insulation has been compared against the recommendations set out in the February 2019 noise assessment report, shown in Tables 1 and 2 of this report.

5.2 Calculation of the Sound Attention Provided by the Building Facade

5.2.1 The façade sound insulation has been calculated from the difference between the measured internal and external noise levels. This difference in noise is shown below in Table 5 and is shown in Appendix B in one third octaves.

Table 5: Details of Measured Noise Levels (Figures in dB(A))

Facade	Floor Level	Measured External Sound Level	Measured Internal Sound Level	Apparent Attenuation provided by the Façade
Northern	1st Floor	55.3	28.6	26.7
	2nd Floor	55.4	28.7	26.7
Eastern	1st Floor	63.7	33.7	30.0
	2nd Floor	70.0	35.0	35.0
Southern	1st Floor	68.9	33.4	35.5
	2nd Floor	68.0	34.1	33.9
Western	1st Floor	68.8	37.7	31.1

5.2.2 The apparent sound attenuation has been calculated by a simple linear subtraction of the measured external sound level with the measured internal sound level.

6 ASSESSMENT OF RESULTS

6.1.1 The measured façade attenuation levels in Table 6 have been compared against the façade attenuation requirements stated in Table 1 and Table 2. The apartments are studios and therefore provide both living space and bedroom space in the same room. Therefore, the sound attenuation provided by the façade should meet the higher sound attenuation requirements, as the living rooms will also be used as bedrooms during the night-time, shown in Table 2.

6.1.2 The results are shown in Table 6.

Table 6: Details of Measured Noise Levels (Figures in dB(A))

Facade	Floor Level	Maximum Façade Attenuation Requirement	Apparent Attenuation provided by the Façade	Difference
Northern	1st Floor	34	27	-7
	2nd Floor		27	-7
Eastern	1st Floor	37	30	-7
	2nd Floor		35	-2
Southern	1st Floor	42	36	-6
	2nd Floor		34	-8
Western	1st Floor		31	-11

6.1.3 The assessment of the façade attenuation shows that the maximum sound attenuation required by the façade is not being met at any façade and this is considered to be an instance of '*non-conformity*'.

6.1.4 However, our observations identified that noise from within the building, from residents within adjacent apartments, household appliances and building services was contributing towards the measured internal sound level. The increased internal noise level reduces the difference between the internal and external sound levels and limits the apparent effectiveness of the mitigation provided by the facade.

6.1.5 We recommend that further noise measurements are undertaken when typical activities resume following the lifting of the current government restrictions. In this way a more accurate verification process can be carried out.

7 CONCLUSIONS

7.1.1 Wardell Armstrong LLP has carried out noise measurements and an assessment to determine the noise attenuation provided by the building façade. This assessment is required to discharge Condition 3b of the Prior Approval reference 122770/P3OPA/2019 and Condition 5b of the Planning Approval reference 123025/FO/2019, for the redevelopment of 11 St James Square, Manchester.

7.1.2 The assessment comprises a summary of the correspondence undertaken to date, noise monitoring internally and externally at the development, and an assessment of the noise attenuation provided by the façade of the completed development.

7.1.3 The measured façade attenuation levels have been compared against the recommended requirements for façade attenuation as set out in the noise assessment report which was prepared to support the prior approval.

7.1.4 The internal noise measurements were undertaken within the studio apartments of the completed development. Therefore, the noise measurements included noise from both external noise sources and internal noise sources.

7.1.5 The contribution of noise from internal noise sources results in a measured internal noise level which is higher than it would otherwise be. The measured level therefore reduces the apparent sound attenuation of the building façade.

7.1.6 The measured internal noise levels suggest that the building façade does not meet the requirements set out in the February 2019 noise assessment report.

7.1.7 However, due to the limitations discussed in this report, the actual sound attenuation of the building façade is very likely to be higher than this assessment shows.

7.1.8 It is recommended that further noise measurements are undertaken when typical activities resume following the lifting of the current government restrictions, so that a proper verification process can be carried out.

APPENDICES

Appendix A – Measured Noise Levels

Façade	Northern
Floor	1st Floor

	External Level	Internal Level	Attenuation
LAeq	55.3	28.6	26.7
20Hz	58.0	42.0	16.0
25Hz	57.9	50.5	7.4
31.5Hz	57.1	39.2	17.9
40Hz	58.0	46.7	11.3
50Hz	58.1	43.6	14.5
63Hz	58.3	33.3	25.0
80Hz	60.0	33.4	26.6
100Hz	61.0	33.4	27.6
125Hz	63.0	33.1	29.9
160Hz	57.3	28.3	29.0
200Hz	52.1	27.8	24.3
250Hz	50.9	26.7	24.2
315Hz	51.4	20.4	31.0
400Hz	48.5	19.9	28.6
500Hz	46.6	17.0	29.6
630Hz	46.0	17.0	29.0
800Hz	43.5	15.3	28.2
1kHz	42.5	15.6	26.9
1.25kHz	42.0	13.8	28.2
1.6kHz	41.1	14.1	27.0
2kHz	39.4	13.8	25.6
2.5kHz	37.6	13.9	23.7
3.15kHz	36.9	14.5	22.4
4kHz	36.7	14.0	22.7
5kHz	35.6	13.1	22.5
6.3kHz	32.0	12.5	19.5
8kHz	29.5	12.2	17.3
10kHz	26.6	11.7	14.9
12.5kHz	21.1	11.6	9.5
16kHz	17.0	11.9	5.1
20kHz	13.7	11.7	2.0

Façade	Eastern
Floor	1st Floor

Type	External Level	Internal Level	Attenuation
Leq	63.7	33.7	30.0
1/3 Oct 20Hz	66.7	49.1	17.6
1/3 Oct 25Hz	68.9	47.3	21.6
1/3 Oct 31.5Hz	63.4	46.7	16.7
1/3 Oct 40Hz	65.3	48.7	16.6
1/3 Oct 50Hz	66.4	45.3	21.1
1/3 Oct 63Hz	64.5	38.2	26.3
1/3 Oct 80Hz	64.1	37.5	26.6
1/3 Oct 100Hz	60.0	30.9	29.1
1/3 Oct 125Hz	59.6	36.2	23.4
1/3 Oct 160Hz	56.9	30.2	26.7
1/3 Oct 200Hz	55.7	29.6	26.1
1/3 Oct 250Hz	56.7	30.8	25.9
1/3 Oct 315Hz	56.6	31.5	25.1
1/3 Oct 400Hz	54.7	24.5	30.2
1/3 Oct 500Hz	54.3	23.0	31.3
1/3 Oct 630Hz	55.9	25.1	30.8
1/3 Oct 800Hz	54.9	22.8	32.1
1/3 Oct 1kHz	54.4	20.9	33.5
1/3 Oct 1.25kHz	54.0	20.7	33.3
1/3 Oct 1.6kHz	53.2	21.5	31.7
1/3 Oct 2kHz	51.2	20.3	30.9
1/3 Oct 2.5kHz	49.7	19.2	30.5
1/3 Oct 3.15kHz	48.5	18.0	30.5
1/3 Oct 4kHz	45.7	17.2	28.5
1/3 Oct 5kHz	44.2	16.3	27.9
1/3 Oct 6.3kHz	40.3	15.3	25.0
1/3 Oct 8kHz	36.8	14.7	22.1
1/3 Oct 10kHz	35.8	14.0	21.8
1/3 Oct 12.5kHz	31.9	13.3	18.6
1/3 Oct 16kHz	28.0	12.7	15.3
1/3 Oct 20kHz	25.7	12.3	13.4

Façade	Southern
Floor	1st Floor

Type	External Level	Internal Level	Attenuation
Leq	68.9	33.4	35.5
1/3 Oct 20Hz	70.2	47.9	22.3
1/3 Oct 25Hz	76.7	59.3	17.4
1/3 Oct 31.5Hz	72.0	46.8	25.2
1/3 Oct 40Hz	71.0	43.4	27.6
1/3 Oct 50Hz	71.6	44.4	27.2
1/3 Oct 63Hz	70.6	38.4	32.2
1/3 Oct 80Hz	68.9	39.4	29.5
1/3 Oct 100Hz	63.7	32.3	31.4
1/3 Oct 125Hz	62.2	32.1	30.1
1/3 Oct 160Hz	60.8	33.2	27.6
1/3 Oct 200Hz	60.8	31.6	29.2
1/3 Oct 250Hz	60.5	29.5	31.0
1/3 Oct 315Hz	60.3	26.6	33.7
1/3 Oct 400Hz	58.9	25.9	33.0
1/3 Oct 500Hz	59.3	25.2	34.1
1/3 Oct 630Hz	59.7	24.0	35.7
1/3 Oct 800Hz	60.1	25.5	34.6
1/3 Oct 1kHz	59.6	21.9	37.7
1/3 Oct 1.25kHz	59.4	19.3	40.1
1/3 Oct 1.6kHz	58.3	19.2	39.1
1/3 Oct 2kHz	57.3	21.3	36.0
1/3 Oct 2.5kHz	56.4	18.3	38.1
1/3 Oct 3.15kHz	54.4	16.0	38.4
1/3 Oct 4kHz	52.0	14.6	37.4
1/3 Oct 5kHz	50.5	13.8	36.7
1/3 Oct 6.3kHz	46.5	12.8	33.7
1/3 Oct 8kHz	42.2	12.3	29.9
1/3 Oct 10kHz	45.2	12.0	33.2
1/3 Oct 12.5kHz	38.7	11.8	26.9
1/3 Oct 16kHz	41.5	12.0	29.5
1/3 Oct 20kHz	26.6	12.0	14.6

Façade	Western
Floor	1st Floor

Type	External Level	Internal Level	Attenuation
Leq	68.8	37.7	31.1
1/3 Oct 20Hz	68.0	53.8	14.2
1/3 Oct 25Hz	74.5	55.4	19.1
1/3 Oct 31.5Hz	71.8	49.2	22.6
1/3 Oct 40Hz	71.6	47.5	24.1
1/3 Oct 50Hz	71.5	47.7	23.8
1/3 Oct 63Hz	68.7	44.5	24.2
1/3 Oct 80Hz	66.9	39.9	27.0
1/3 Oct 100Hz	63.0	36.9	26.1
1/3 Oct 125Hz	60.3	35.4	24.9
1/3 Oct 160Hz	60.7	36.9	23.8
1/3 Oct 200Hz	60.2	35.7	24.5
1/3 Oct 250Hz	59.4	33.6	25.8
1/3 Oct 315Hz	59.1	34.0	25.1
1/3 Oct 400Hz	59.1	31.6	27.5
1/3 Oct 500Hz	61.2	33.6	27.6
1/3 Oct 630Hz	59.7	30.5	29.2
1/3 Oct 800Hz	60.0	28.2	31.8
1/3 Oct 1kHz	59.4	23.2	36.2
1/3 Oct 1.25kHz	59.4	21.3	38.1
1/3 Oct 1.6kHz	58.4	21.5	36.9
1/3 Oct 2kHz	57.0	24.3	32.7
1/3 Oct 2.5kHz	56.2	22.3	33.9
1/3 Oct 3.15kHz	53.9	18.0	35.9
1/3 Oct 4kHz	51.2	15.9	35.3
1/3 Oct 5kHz	49.7	14.8	34.9
1/3 Oct 6.3kHz	46.2	13.7	32.5
1/3 Oct 8kHz	43.9	13.0	30.9
1/3 Oct 10kHz	41.3	12.6	28.7
1/3 Oct 12.5kHz	39.1	12.2	26.9
1/3 Oct 16kHz	35.3	12.2	23.1
1/3 Oct 20kHz	29.2	12.0	17.2

Façade	Northern
Floor	2nd Floor

Type	External Level	Internal Level	Attenuation
Leq	55.4	28.7	26.7
1/3 Oct 20Hz	58.3	38.8	19.5
1/3 Oct 25Hz	60.8	47.8	13.0
1/3 Oct 31.5Hz	63.3	39.3	24.0
1/3 Oct 40Hz	58.1	34.6	23.5
1/3 Oct 50Hz	58.7	34.8	23.9
1/3 Oct 63Hz	60.5	29.7	30.8
1/3 Oct 80Hz	56.9	25.9	31.0
1/3 Oct 100Hz	58.7	28.1	30.6
1/3 Oct 125Hz	58.1	30.2	27.9
1/3 Oct 160Hz	55.2	27.7	27.5
1/3 Oct 200Hz	50.1	26.7	23.4
1/3 Oct 250Hz	52.3	23.6	28.7
1/3 Oct 315Hz	51.0	21.6	29.4
1/3 Oct 400Hz	50.1	22.5	27.6
1/3 Oct 500Hz	48.3	19.7	28.6
1/3 Oct 630Hz	48.6	22.6	26.0
1/3 Oct 800Hz	46.0	17.9	28.1
1/3 Oct 1kHz	43.4	15.2	28.2
1/3 Oct 1.25kHz	43.2	14.3	28.9
1/3 Oct 1.6kHz	42.2	14.4	27.8
1/3 Oct 2kHz	39.7	14.5	25.2
1/3 Oct 2.5kHz	37.4	14.3	23.1
1/3 Oct 3.15kHz	35.7	13.7	22.0
1/3 Oct 4kHz	34.5	13.5	21.0
1/3 Oct 5kHz	32.0	13.3	18.7
1/3 Oct 6.3kHz	28.4	12.5	15.9
1/3 Oct 8kHz	24.4	12.0	12.4
1/3 Oct 10kHz	21.4	12.2	9.2
1/3 Oct 12.5kHz	16.6	12.3	4.3
1/3 Oct 16kHz	13.5	12.0	1.5
1/3 Oct 20kHz	11.5	12.2	-0.7

Façade	Eastern
Floor	2nd Floor

Type	External Level	Internal Level	Attenuation
Leq	70.0	35.0	35.0
1/3 Oct 20Hz	62.8	46.5	16.3
1/3 Oct 25Hz	67.7	50.8	16.9
1/3 Oct 31.5Hz	65.7	42.5	23.2
1/3 Oct 40Hz	64.1	38.3	25.8
1/3 Oct 50Hz	70.4	36.2	34.2
1/3 Oct 63Hz	68.7	40.5	28.2
1/3 Oct 80Hz	65.5	32.3	33.2
1/3 Oct 100Hz	62.7	31.4	31.3
1/3 Oct 125Hz	60.3	31.3	29.0
1/3 Oct 160Hz	59.4	36.1	23.3
1/3 Oct 200Hz	58.2	29.9	28.3
1/3 Oct 250Hz	57.6	30.6	27.0
1/3 Oct 315Hz	60.9	29.2	31.7
1/3 Oct 400Hz	59.3	26.7	32.6
1/3 Oct 500Hz	60.1	25.5	34.6
1/3 Oct 630Hz	60.4	27.5	32.9
1/3 Oct 800Hz	60.1	25.7	34.4
1/3 Oct 1kHz	60.1	22.0	38.1
1/3 Oct 1.25kHz	60.8	21.8	39.0
1/3 Oct 1.6kHz	59.7	23.2	36.5
1/3 Oct 2kHz	58.3	24.4	33.9
1/3 Oct 2.5kHz	58.0	22.3	35.7
1/3 Oct 3.15kHz	57.4	18.8	38.6
1/3 Oct 4kHz	55.0	16.0	39.0
1/3 Oct 5kHz	54.0	14.6	39.4
1/3 Oct 6.3kHz	53.0	13.4	39.6
1/3 Oct 8kHz	49.2	12.7	36.5
1/3 Oct 10kHz	48.7	12.2	36.5
1/3 Oct 12.5kHz	46.5	12.0	34.5
1/3 Oct 16kHz	42.3	12.1	30.2
1/3 Oct 20kHz	35.7	12.1	23.6

Façade	Southern
Floor	2nd Floor

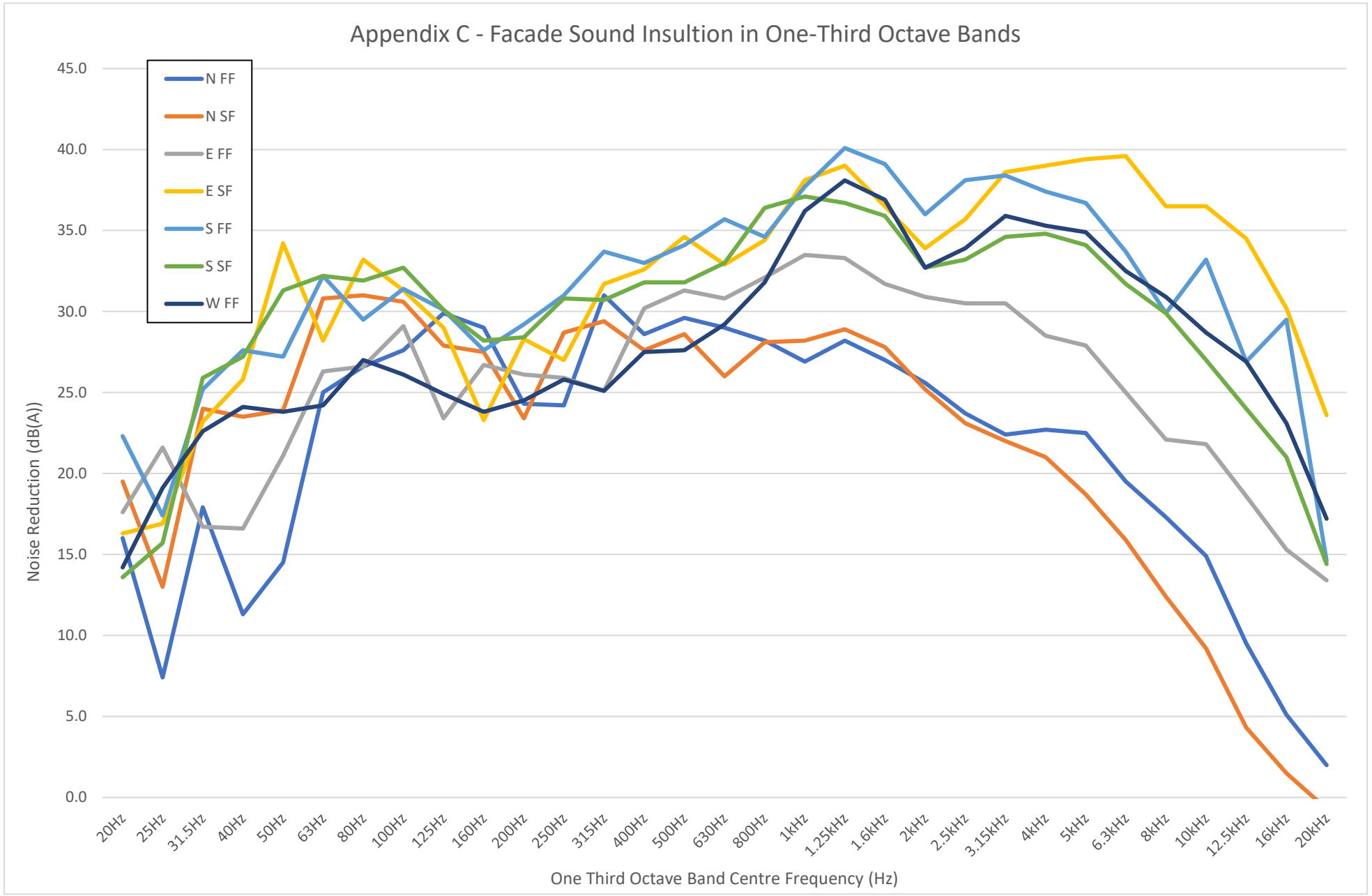
Type	External Level	Internal Level	Attenuation
Leq	68.0	34.1	33.9
1/3 Oct 20Hz	67.8	54.2	13.6
1/3 Oct 25Hz	73.9	58.2	15.7
1/3 Oct 31.5Hz	69.6	43.7	25.9
1/3 Oct 40Hz	70.4	43.2	27.2
1/3 Oct 50Hz	70.7	39.4	31.3
1/3 Oct 63Hz	68.4	36.2	32.2
1/3 Oct 80Hz	66.0	34.1	31.9
1/3 Oct 100Hz	61.5	28.8	32.7
1/3 Oct 125Hz	60.9	30.8	30.1
1/3 Oct 160Hz	60.7	32.5	28.2
1/3 Oct 200Hz	58.4	30.0	28.4
1/3 Oct 250Hz	58.0	27.2	30.8
1/3 Oct 315Hz	57.4	26.7	30.7
1/3 Oct 400Hz	58.9	27.1	31.8
1/3 Oct 500Hz	57.7	25.9	31.8
1/3 Oct 630Hz	58.3	25.3	33.0
1/3 Oct 800Hz	60.1	23.7	36.4
1/3 Oct 1kHz	58.9	21.8	37.1
1/3 Oct 1.25kHz	58.7	22.0	36.7
1/3 Oct 1.6kHz	57.9	22.0	35.9
1/3 Oct 2kHz	56.4	23.7	32.7
1/3 Oct 2.5kHz	55.5	22.3	33.2
1/3 Oct 3.15kHz	53.5	18.9	34.6
1/3 Oct 4kHz	51.3	16.5	34.8
1/3 Oct 5kHz	49.4	15.3	34.1
1/3 Oct 6.3kHz	46.0	14.3	31.7
1/3 Oct 8kHz	43.7	13.8	29.9
1/3 Oct 10kHz	39.9	12.9	27.0
1/3 Oct 12.5kHz	36.5	12.5	24.0
1/3 Oct 16kHz	33.4	12.4	21.0
1/3 Oct 20kHz	26.8	12.4	14.4

Appendix B – Measured Façade Noise Attenuation

Appendix B - Façade Attenuation

Façade Facing	Northern Façade		Eastern Façade		Southern Façade		Western Façade
Floor	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**
LAeq	26.7	26.7	30.0	35.0	35.5	33.9	31.1
20Hz	16.0	19.5	17.6	16.3	22.3	13.6	14.2
25Hz	7.4	13.0	21.6	16.9	17.4	15.7	19.1
31.5Hz	17.9	24.0	16.7	23.2	25.2	25.9	22.6
40Hz	11.3	23.5	16.6	25.8	27.6	27.2	24.1
50Hz	14.5	23.9	21.1	34.2	27.2	31.3	23.8
63Hz	25.0	30.8	26.3	28.2	32.2	32.2	24.2
80Hz	26.6	31.0	26.6	33.2	29.5	31.9	27.0
100Hz	27.6	30.6	29.1	31.3	31.4	32.7	26.1
125Hz	29.9	27.9	23.4	29.0	30.1	30.1	24.9
160Hz	29.0	27.5	26.7	23.3	27.6	28.2	23.8
200Hz	24.3	23.4	26.1	28.3	29.2	28.4	24.5
250Hz	24.2	28.7	25.9	27.0	31.0	30.8	25.8
315Hz	31.0	29.4	25.1	31.7	33.7	30.7	25.1
400Hz	28.6	27.6	30.2	32.6	33.0	31.8	27.5
500Hz	29.6	28.6	31.3	34.6	34.1	31.8	27.6
630Hz	29.0	26.0	30.8	32.9	35.7	33.0	29.2
800Hz	28.2	28.1	32.1	34.4	34.6	36.4	31.8
1kHz	26.9	28.2	33.5	38.1	37.7	37.1	36.2
1.25kHz	28.2	28.9	33.3	39.0	40.1	36.7	38.1
1.6kHz	27.0	27.8	31.7	36.5	39.1	35.9	36.9
2kHz	25.6	25.2	30.9	33.9	36.0	32.7	32.7
2.5kHz	23.7	23.1	30.5	35.7	38.1	33.2	33.9
3.15kHz	22.4	22.0	30.5	38.6	38.4	34.6	35.9
4kHz	22.7	21.0	28.5	39.0	37.4	34.8	35.3
5kHz	22.5	18.7	27.9	39.4	36.7	34.1	34.9
6.3kHz	19.5	15.9	25.0	39.6	33.7	31.7	32.5
8kHz	17.3	12.4	22.1	36.5	29.9	29.9	30.9
10kHz	14.9	9.2	21.8	36.5	33.2	27.0	28.7
12.5kHz	9.5	4.3	18.6	34.5	26.9	24.0	26.9
16kHz	5.1	1.5	15.3	30.2	29.5	21.0	23.1
20kHz	2.0	-0.7	13.4	23.6	14.6	14.4	17.2

Appendix C – Graphical Analysis of the Measured Façade Noise Attenuation


Appendix C - Facade Sound Insultion in One-Third Octave Bands
N FF
N SF
E FF
E SF
S FF
S SF
W FF
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Noise Reduction (dB(A))
20Hz
25Hz
31.5Hz
40Hz
50Hz
63Hz
80Hz
100Hz
125Hz
160Hz
200Hz
250Hz
315Hz
400Hz
500Hz
630Hz
800Hz
1kHz
1.25kHz
1.6kHz
2kHz
2.5kHz
3.15kHz
4kHz
5kHz
6.3kHz
8kHz
10kHz
12.5kHz
16kHz
20kHz
One Third Octave Band Centre Frequency (Hz)

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