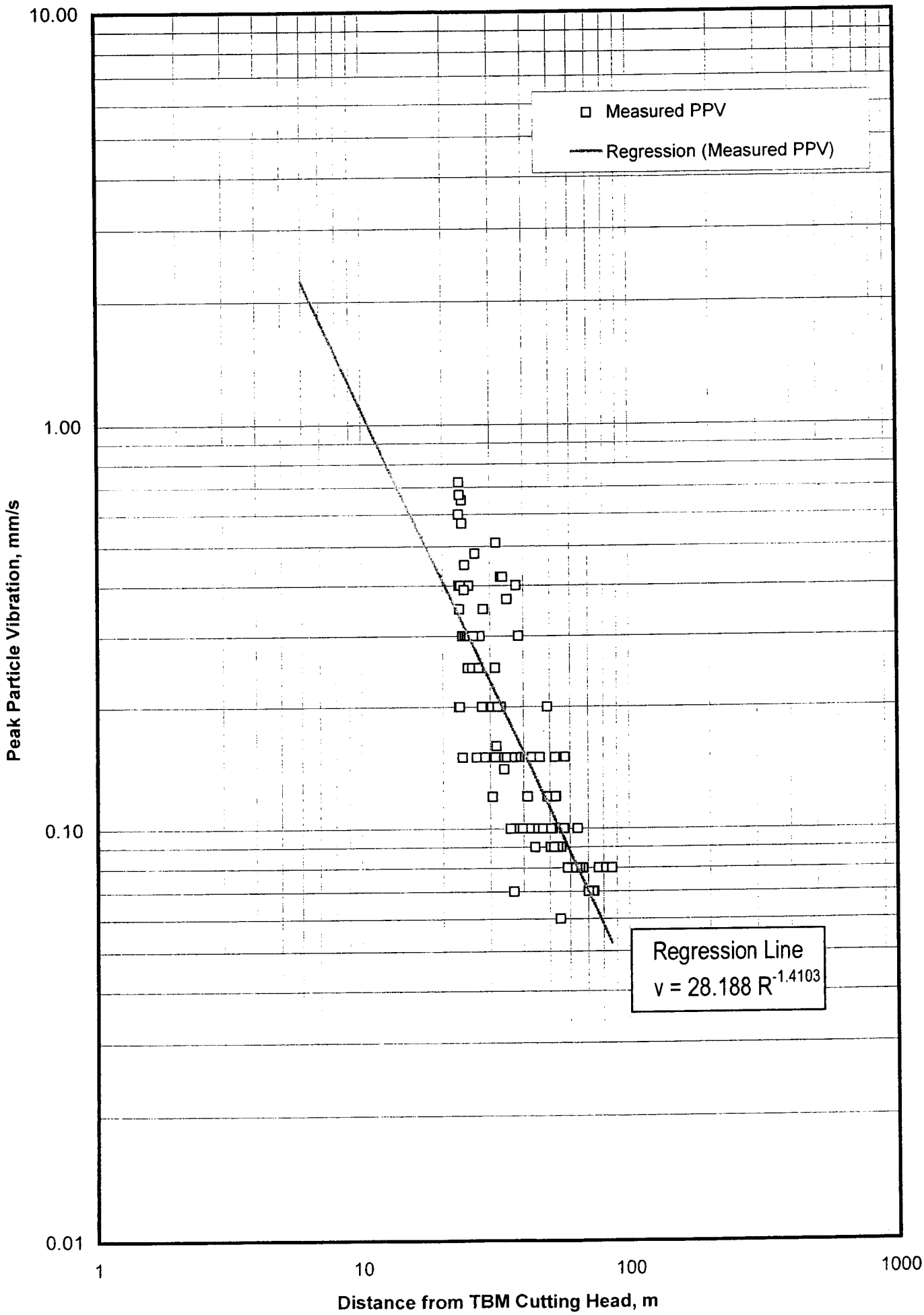
APPENDIX – 7-1

Construction Groundborne Vibration Sources and Ambient Noise Measurements

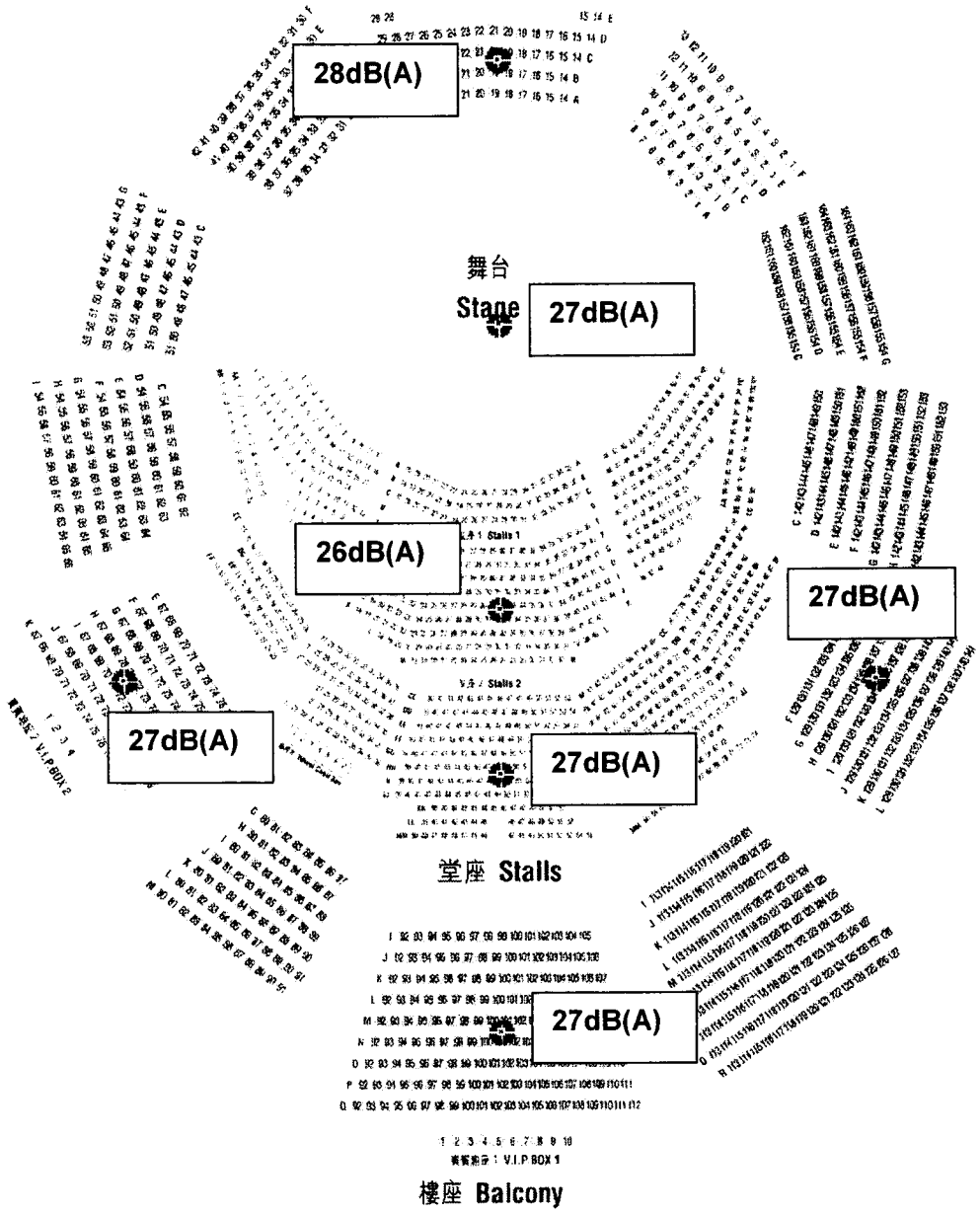
Vibration Measurement for Construction TBM
KCRC DB320 Kwai Tsing Tunnel



KSL Construction ground-borne noise for drilling and breaking operation
Site Vibration Measurements - Typical

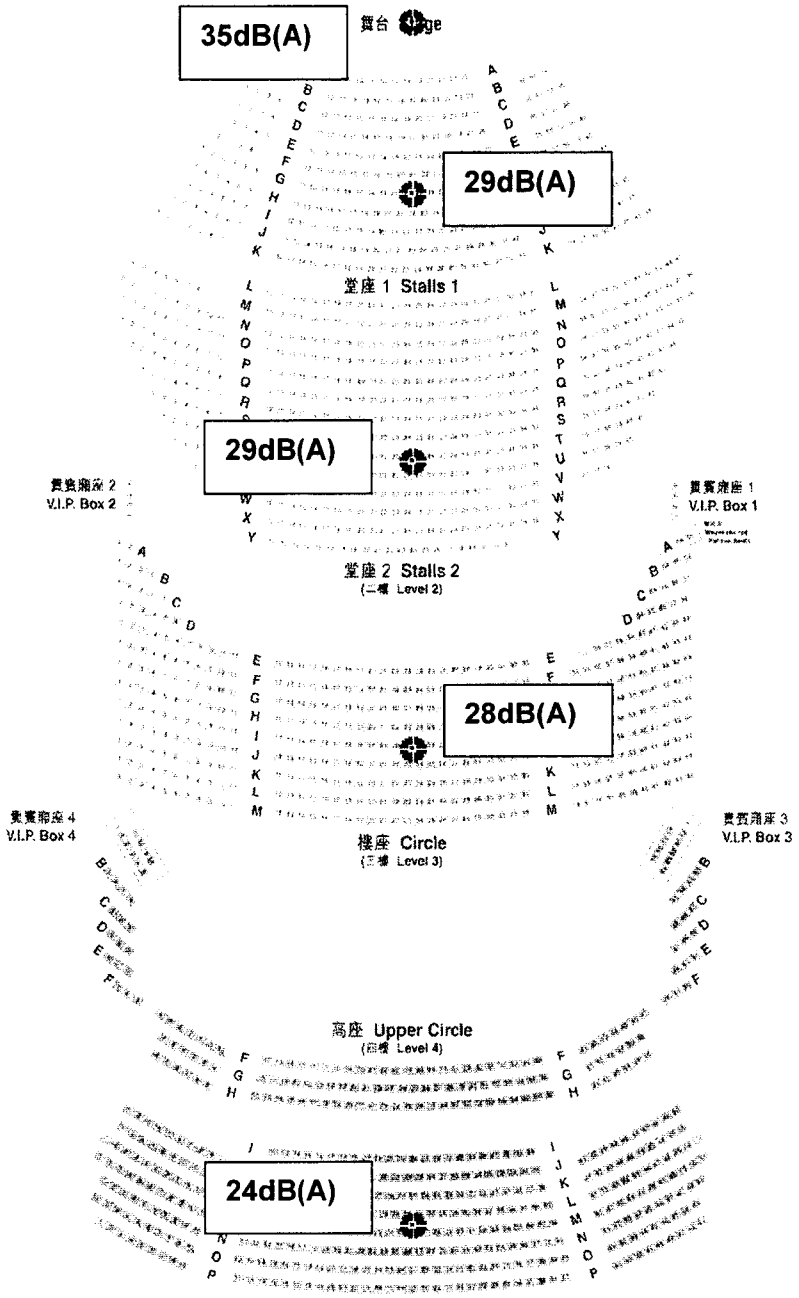
Plant	Construction Site	Vibration (rms) at the reference Distance 5.5m from source	Vibration (ppv) at Distance 2m from source
Drilling Rig I	Salisbury Road Overrun Tunnel	0.536 mm/s	-
Handheld Breaker	New world centre site	0.279 mm/s	-
Hydraulic Breaker	TST site	0.298 mm/s	-
Pipepile	MTRC TST Modification	-	19.3 mm/s

Note:
[1] Crest factor of 4 is assumed in accordance with FTA guidance Manual.
[2] In the Project Profile for FMPH project, ppv of 1.5 mm/s at 10m is adopted, the converted ppv at 2m is 16.8 mm/s. This is comparable to ppv of pipepile in this study.



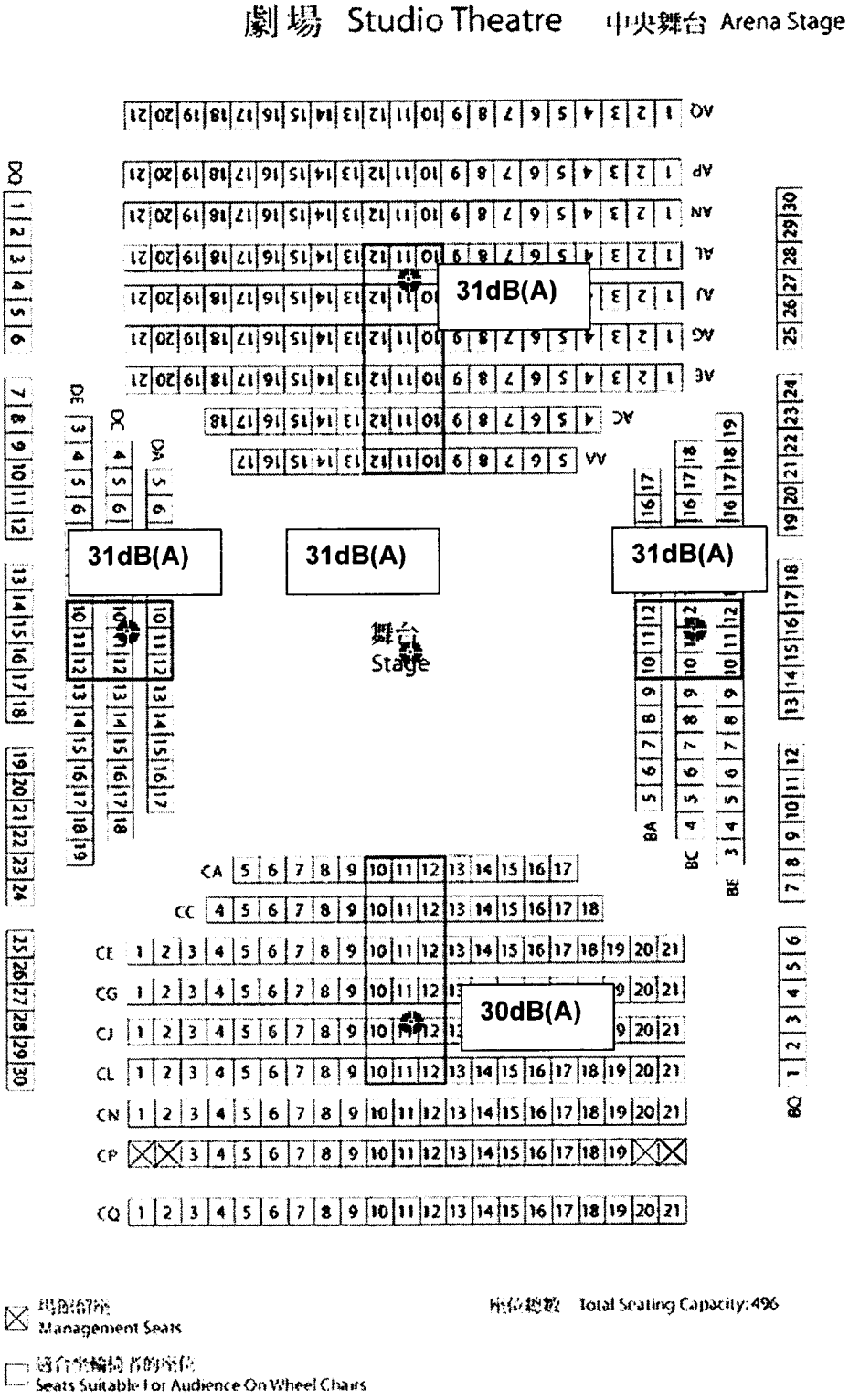
音樂廳座位圖 Concert Hall Seating Plan

✤ Proposed measurement locations (A/C ON)



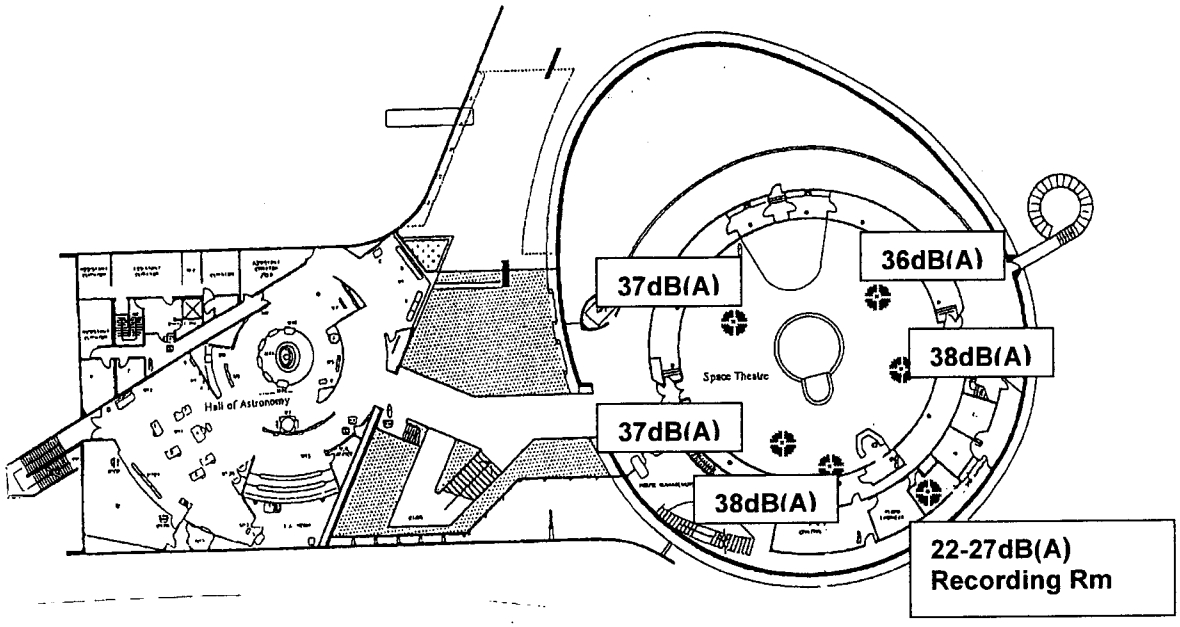
大劇院座位圖 Grand Theatre Seating Plan

✣ Proposed measurement locations (A/C ON)

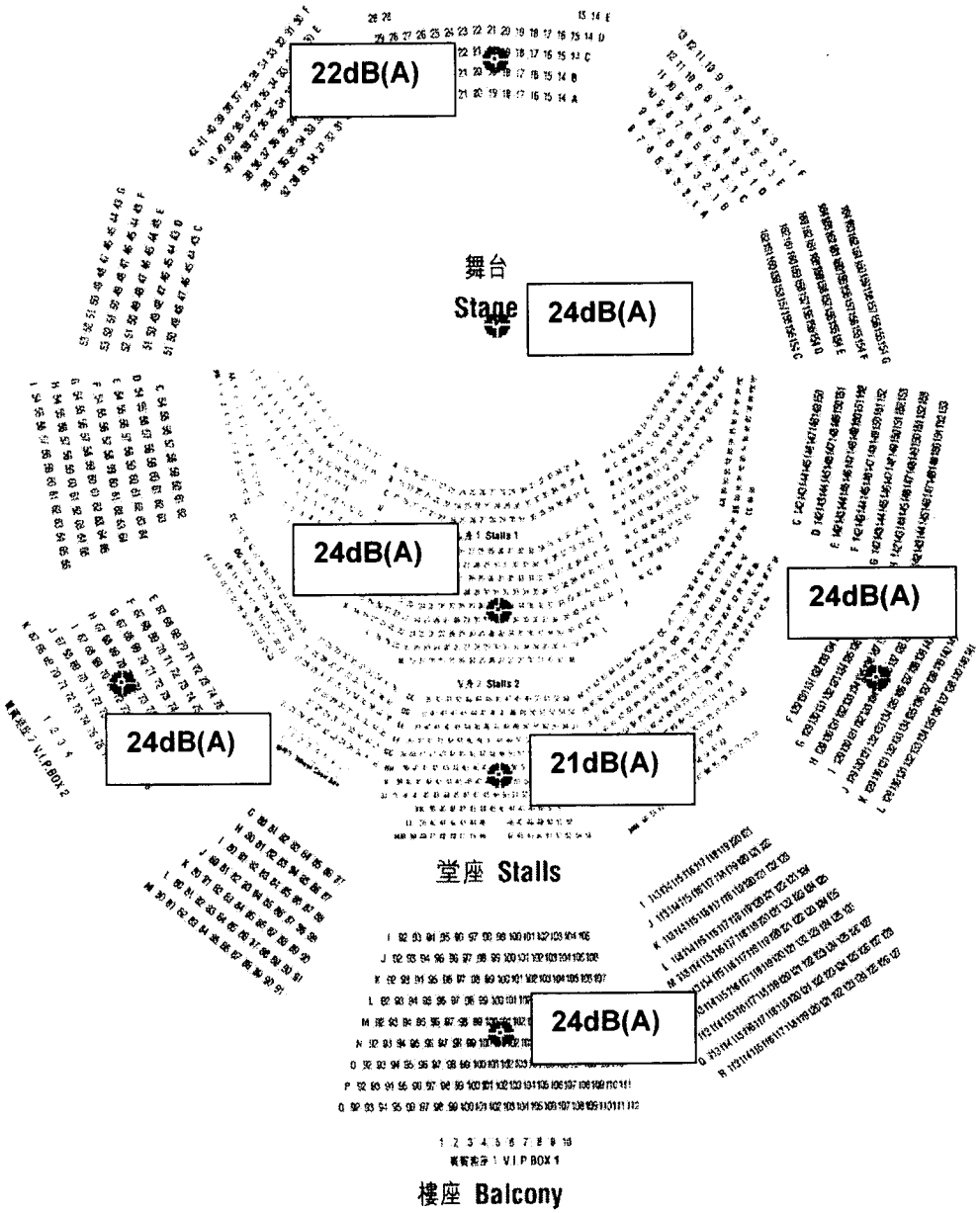


Proposed measurement locations (A/C ON)

AMBIENT NOISE MEASUREMENTS IN HK CULTURAL CENTRE & HK SPACE MUSEUM

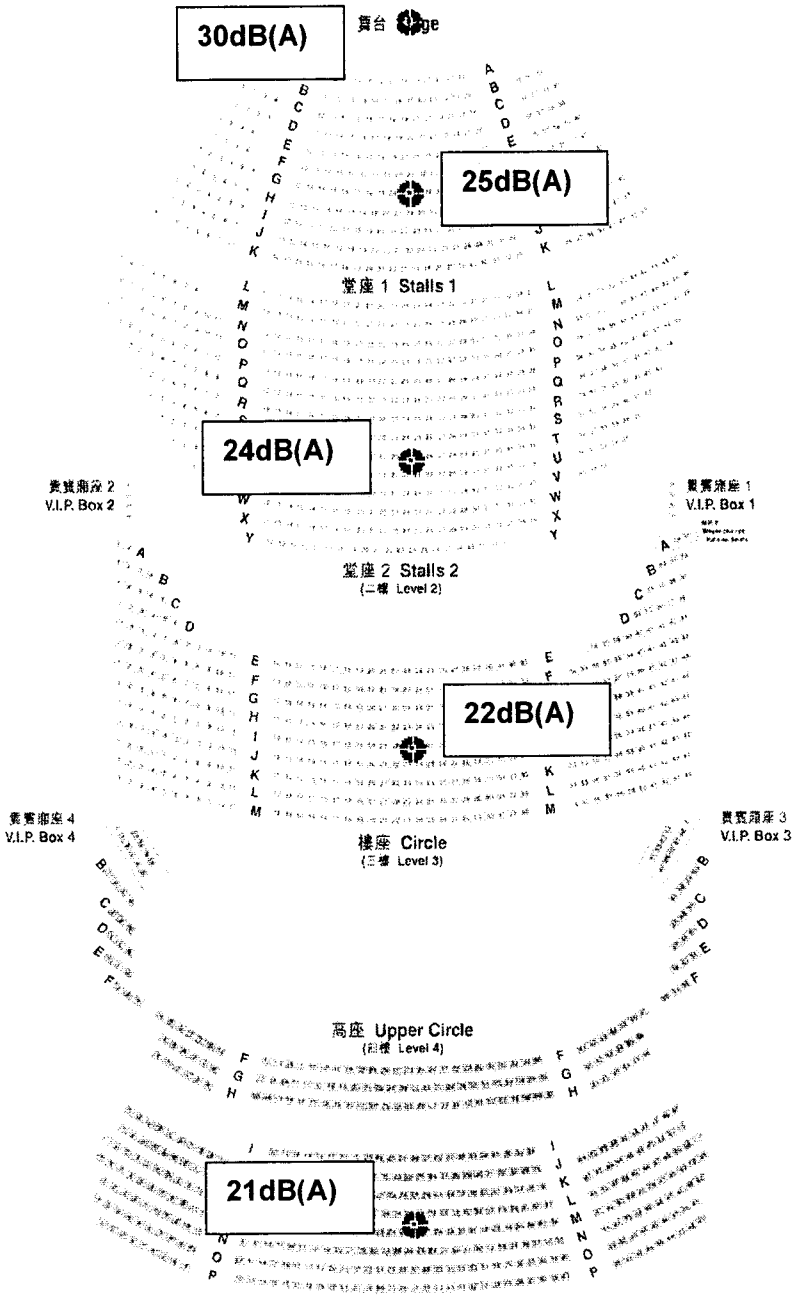


⊕ Proposed measurement locations (A/C ON, except recording studio)



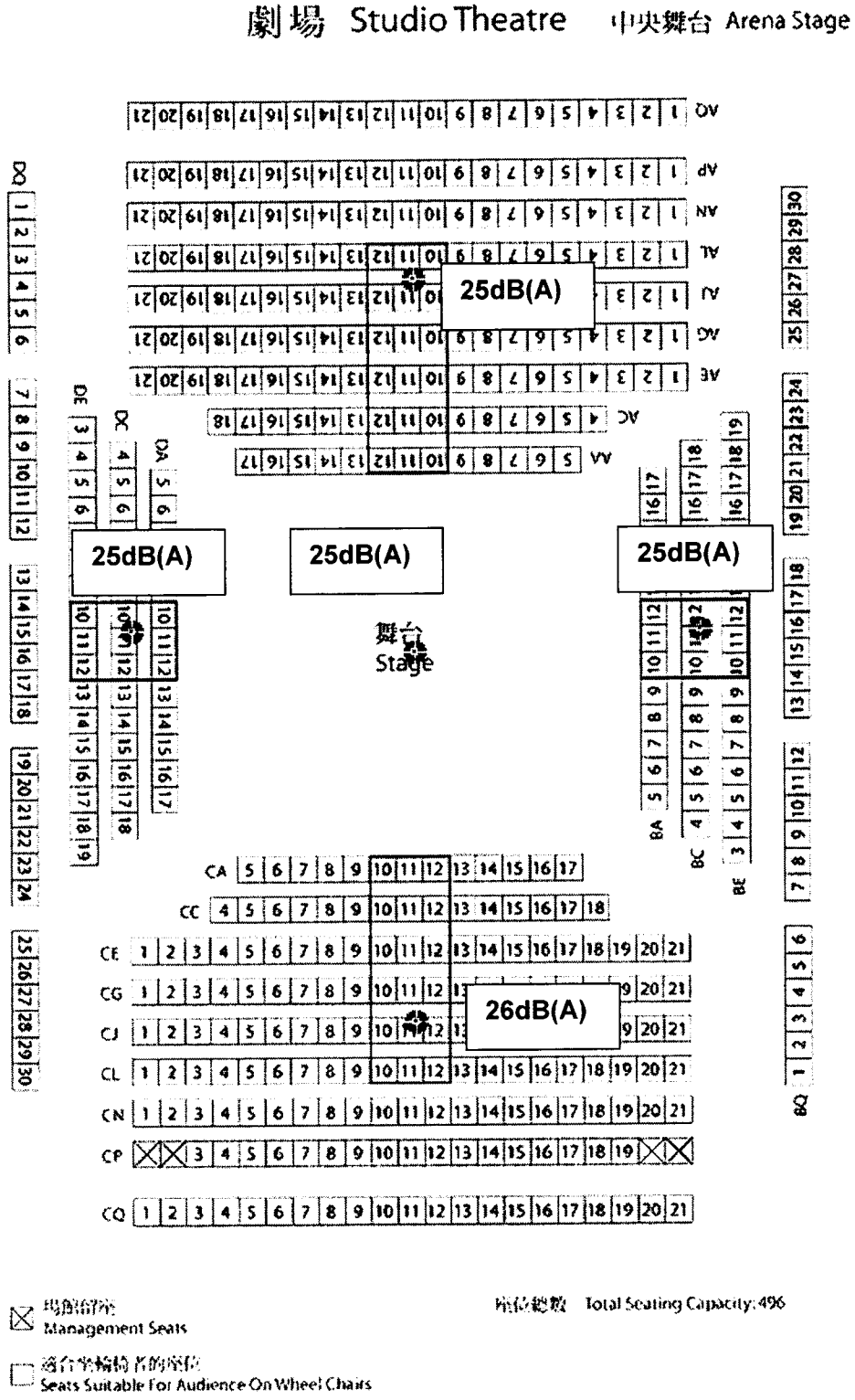
音樂廳座位圖 Concert Hall Seating Plan

⊕ Proposed measurement locations (A/C OFF)



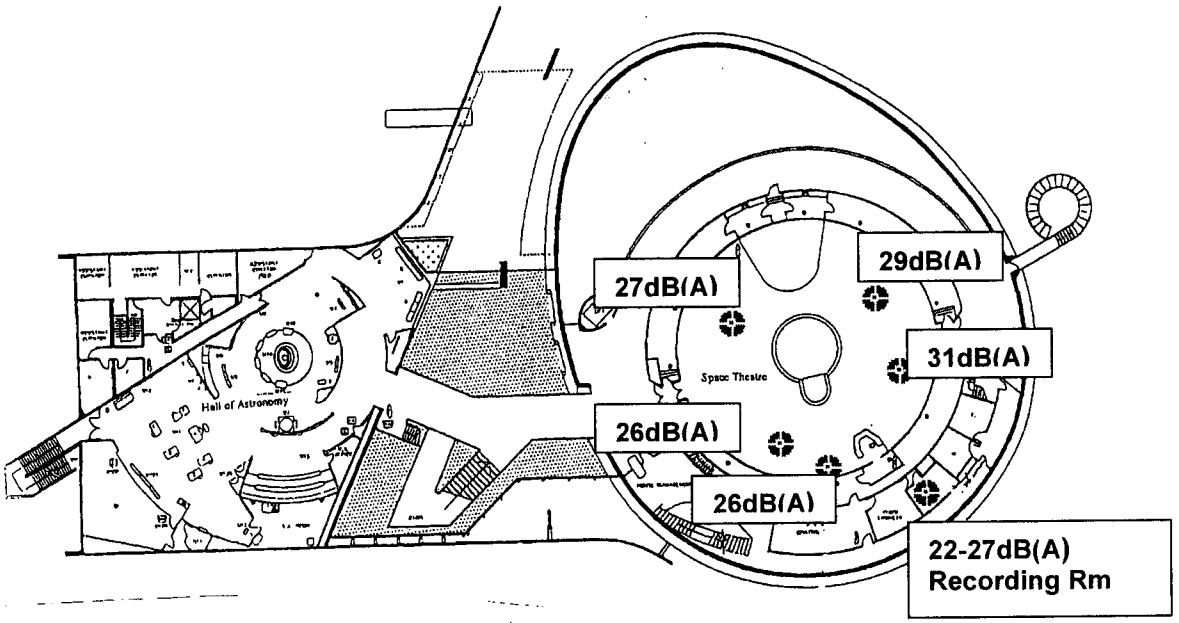
大劇院座位圖 Grand Theatre Seating Plan

✣ Proposed measurement locations (A/C OFF)



Proposed measurement locations (A/C OFF)

AMBIENT NOISE MEASUREMENTS IN HK CULTURAL CENTRE & HK SPACE MUSEUM



Proposed measurement locations (A/C OFF)

Project : KSL EIA
Title : Calculation of Conversion Factors from Floor Vibration to Noise Levels
Date : Jan 2004

Uses	Input Data		Correction, dB(A)			$L_p - L_v$ dB(A)
	H, m	RT, s	h	RT	Others	
Hotel	2.5	0.5	-4.0	-3.0	-20	-27
Residential	2.2	0.5	-3.4	-3.0	-20	-26
Classoom	2.2	1	-3.4	0.0	-20	-23
Studio	2.2	0.5	-3.4	-3.0	-20	-26
Concert Hall	7	1.8	-8.5	2.6	-20	-26
Auditorium	7	1.4	-8.5	1.5	-20	-27

Note :

$L_w = L_v + 10 \log S + 10 \log \sigma - 34$ (Ref: Eqt 9.65 of "Noise and Vibration Control Engineering", 1992, Edited by Leo Beranek

$L_w = L_p + 10 \log(V/RT) - 14$ (Ref: Eqt 3.4 of "Woods Practical Guide to Noise Control", 1972, Ian Sharland

Then,

$L_p = L_v + 10\log S + 10\log\sigma - 34 - 10\log V + 10\log RT + 14$

assume : $\sigma = 1$ (worst case)

$V = S \times h$

Hence,

$L_p - L_v = -10 \log h + 10 \log RT - 20$

Where

L_w - Sound Power Level

L_v - Vibration level

L_p - SPL

V - Volume

RT - Reverberation time

σ - Raditaion efficiency

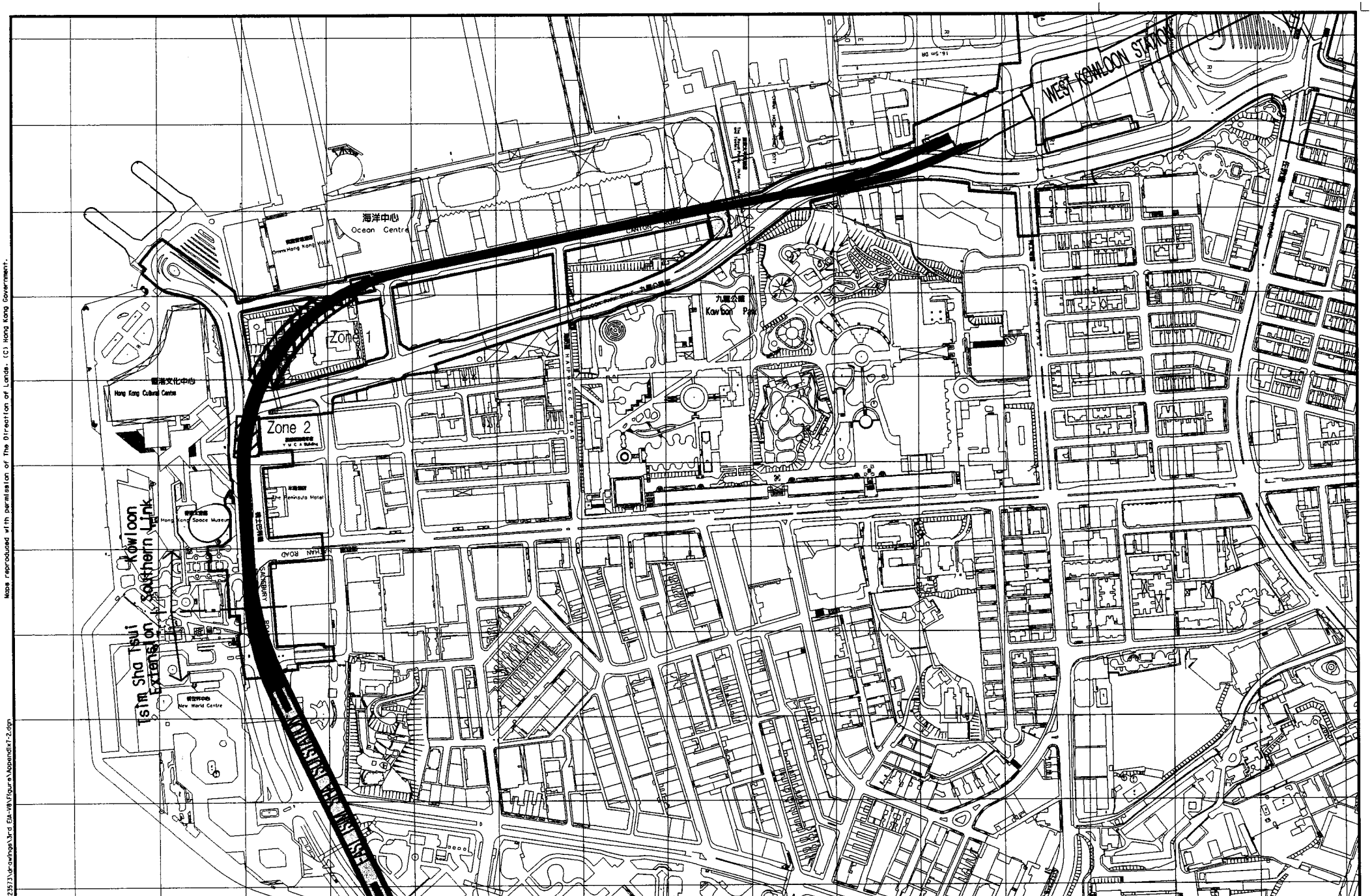
h - average height of volumn

APPENDIX – 7-2

Sample Calculations for Construction Groundborne Noise

APPENDIX – 7-2-1

Sample Construction Groundborne Noise Calculations
NSR - HKCC and HKSM



FILENAME: G:\env\projects\25573\drawings\3rd EIA-WA\Figure\Appendix7-2.dgn

REV	DATE	BY	SUB	APP	DESCRIPTION
A	DEC2003	SW	FC	ST	EIA REPORT
B	NOV2003	SW	FC	ST	EIA REPORT
C	JUNE2003	SW	FC	ST	EIA REPORT
D	7MAR2003	SW	FC	ST	EIA REPORT (2ND DRAFT)
E	110CT2002	SW	FC	ST	EIA REPORT (1ST DRAFT)

DESIGNED BY	SW
DRAWN BY	JF
CHECKED BY	FC
IN CHARGE	ST
DATE	5 DEC 2003

KCR

New Railway Projects
新鐵路策劃

Ove Arup & Partners Hong Kong Limited ARUP

KOWLOON SOUTHERN LINK KSL GSA-5100
EIA & ASSOCIATED SERVICES

Sources Location of Groundborne Noise

CADD FILENAME	CADD DATE 5 DEC 2003
SCALE	1 : 4000 @A3
DRAWING NUMBER	Appendix 7-2
SHEET NO	STAGE CODE P REV E

FULL SIZE A1

KSL Construction ground-borne noise for drilling and breaking operation
Summary of predicted groundborne noise levels
Date: 16 Nov 2003

Zone 1 (FMPHQ)

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Estimated Distance from Plant to NSR	Ref.
2 nos. Hydraulic Breakers	HKSM	Marine deposit	1/F Recording Studio	<10	140 m	A1
			1/F Space Theatre	<10	140 m	A1
	HKCC	Granite	Grand Theatre	11	110 m	A2
			Concert Hall	16	70 m	A3
			Studio Theatre	24	30 m	A4
4 nos. Rock drills	HKCC	Granite	Grand Theatre	19	110 m	B1
			Concert Hall	24	70 m	B2
			Studio Theatre	32	30 m	B3

Note: See attached sample calculations.

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Estimated Distance from Plant to NSR	Ref.
2 nos. Hydraulic Breakers + 4 nos. Rock drills	HKSM	Marine deposit	1/F Recording Studio	<10	140 m	Note [1]
			1/F Space Theatre	<10	140 m	Note [1]
	HKCC	Granite	Grand Theatre	20	110 m	Note [1]
			Concert Hall	25	70 m	Note [1]
			Studio Theatre	33	30 m	Note [1]

Note: [1] Noise summation from individual noise levels above due to construction plant in Zone 1.

Zone 2 (Salisbury Road between KPD to Hankow Road)

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Estimated Distance from Plant to NSR	Ref.
4 nos. Hydraulic Breakers	HKSM	Marine deposit	1/F Recording Studio	<10	50 m	C1
			1/F Space Theatre	<10	50 m	C1
	HKCC	Granite	Grand Theatre	16	95 m	D1
			Concert Hall	19	75 m	D2
			Studio Theatre	30	22 m	D3

Note: See attached sample calculations.

Zone 1 + Zone 2

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Estimated Distance from Plant to NSR	Ref.
Zone 1 :	HKSM	Marine deposit	1/F Recording Studio	<10	50 m	Note [2]
2 nos. Hydraulic Breakers			1/F Space Theatre	<10	50 m	Note [2]
+ 4 nos. Rock drills						
Zone 2 :						
4 nos. Hydraulic Breakers	HKCC	Granite	Grand Theatre	21	95 m	Note [2]
			Concert Hall	26	75 m	Note [2]
			Studio Theatre	35	22 m	Note [2]

Note: [2] Noise summation from individual noise levels above due to construction plant in Zone 1 and Zone 2.

Appendix - Groundborne Noise Evaluation

Ref. A1

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 04-Feb-04
Site : Zone 1 (FMPHQ)
NSR : Hong Kong Space Museum

Construction Activities: Excavator mounted breakers
NSR Distance, R : 140 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-28	-28	-28	-28	-28	-28
d	Soil Damping Loss [3], Type = "Clay"	-19.6	-38.5	-40.0	-40.0	-40.0	-40.0
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
f	Floor to Floor Attenuation [5]	-2	-2	-2	-2	-2	-2
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	3	3	3	3	3	3
I	Noise Level at NSR, dB [8]	15	-3	-8	-13	-12	-6
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-42	-42	-34	-29	-21	-10

-9 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Report Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Appendix - Groundborne Noise Evaluation

Ref. A2

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 1 (FMPHQ)
NSR : Hong Kong Cultural Centre - Grand Theatre

Construction Activities: Excavator mounted breakers
NSR Distance, R : 110 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-26	-26	-26	-26	-26	-26
d	Soil Damping Loss [3], Type = "Rock"	-0.1	-0.3	-0.5	-1.0	-2.0	-4.1
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-1	-1	-1	-1	-1	-1
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	3	3	3	3	3	3
l	Noise Level at NSR, dB [8]	19	20	16	11	11	14
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-37	-19	-10	-5	2	10

11 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref. F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Appendix - Groundborne Noise Evaluation

Ref. A3

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 1 (FMPHQ)
NSR : Hong Kong Cultural Centre - Concert Hall

Construction Activities: Excavator mounted breakers
NSR Distance, R : 70 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-22	-22	-22	-22	-22	-22
d	Soil Damping Loss [3], Type = "Rock"	-0.1	-0.2	-0.3	-0.6	-1.3	-2.5
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-1	-1	-1	-1	-1	-1
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	3	3	3	3	3	3
I	Noise Level at NSR, dB [8]	23	24	20	15	16	19
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-33	-15	-6	-1	7	16

16 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref. F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Appendix - Groundborne Noise Evaluation

Ref. A4

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 2 (Salisbury Road between KPD to Hankow Road)
NSR : Hong Kong Cultural Centre - Studio Theatre

Construction Activities: Excavator mounted breakers
NSR Distance, R : 30 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-15	-15	-15	-15	-15	-15
d	Soil Damping Loss [3], Type = "Rock"	0.0	-0.1	-0.1	-0.2	-0.5	-1.0
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-2	-2	-2	-2	-2	-2
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	3	3	3	3	3	3
I	Noise Level at NSR, dB [8]	30	31	27	22	23	27
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-27	-9	1	6	14	24

24 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref. F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Ref. B1

KSL Construction ground-borne noise Calculations for Rock Drill

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 21-Nov-03

Zone 1 (FMPHQ)

Item	Description	Quantity
1.	Calculated 2 nos. Hydraulic Breakers	= 11 dB(A)
	Noise Level at HKCC Grand Theatre	Extracted from calculation sheet Ref. A2
	when breaking granite at 110m away	
2.	Calculated 1 nos. Hydraulic Breakers	= 11 dB(A) minus 3 dB(A)
	Noise Level at HKCC Grand Theatre	= 8 dB(A)
	when breaking granite at 110m away	
3.	Correction to Rock Drill Noise	= + 20 log (V1 / V2)
	V1 = Vibration (rms) of Drilling Rig	= + 20 log (0.536 mm/s / 0.298 mm/s)
	V2 = Vibration (rms) of Hydraulic Breaker	= + 5.1 dB
	Ref.	
	See vibration measurement table in Appendix 7-1	
4.	Multiple source correction	= + 10 log (N)
	for 4 Rock Drills	= + 10 log (4)
		= + 6 dB
5.	Predicted Groundborne Noise	= 19 dB(A)
	Adding items [2], [3] and [4]	

Ref. B2

KSL Construction ground-borne noise Calculations for Rock Drill

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 21-Nov-03

Zone 1 (FMPHQ)

Item	Description	Quantity
1.	Calculated 2 nos. Hydraulic Breakers	= 16 dB(A)
	Noise Level at HKCC Concert Hall	Extracted from calculation sheet Ref. A3
	when breaking granite at 70m away	
2.	Calculated 1 nos. Hydraulic Breakers	= 16 dB(A) minus 3 dB(A)
	Noise Level at HKCC Concert Hall	= 13 dB(A)
	when breaking granite at 70m away	
3.	Correction to Rock Drill Noise	= + 20 log (V1 / V2)
	V1 = Vibration (rms) of Drilling Rig	= + 20 log (0.536 mm/s / 0.298 mm/s)
	V2 = Vibration (rms) of Hydraulic Breaker	= + 5.1 dB
	Ref.	
	See vibration measurement table in Appendix 7-1	
4.	Multiple source correction	= + 10 log (N)
	for 4 Rock Drills	= + 10 log (4)
		= + 6 dB
5.	Predicted Groundborne Noise	= 24 dB(A)
	Adding items [2], [3] and [4]	

Ref. B3

KSL Construction ground-borne noise Calculations for Rock Drill

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 21-Nov-03

Zone 1 (FMPHQ)

Item	Description	Quantity
1.	Calculated 2 nos. Hydraulic Breakers	= 24 dB(A)
	Noise Level at HKCC Studio Theatrel	Extracted from calculation sheet Ref. A4
	when breaking granite at 30m away	
2.	Calculated 1 nos. Hydraulic Breakers	= 24 dB(A) minus 3 dB(A)
	Noise Level at HKCC Studio Theatrel	= 21 dB(A)
	when breaking granite at 30m away	
3.	Correction to Rock Drill Noise	= + 20 log (V1 / V2)
	V1 = Vibration (rms) of Drilling Rig	= + 20 log (0.536 mm/s / 0.298 mm/s)
	V2 = Vibration (rms) of Hydraulic Breaker	= + 5.1 dB
	Ref.	
	See vibration measurement table in Appendix 7-1	
4.	Multiple source correction	= + 10 log (N)
	for 4 Rock Drills	= + 10 log (4)
		= + 6 dB
5.	Predicted Groundborne Noise	= 32 dB(A)
	Adding items [2], [3] and [4]	

Appendix - Groundborne Noise Evaluation

Ref. C1

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 04-Feb-04
Site : Zone 1 (FMPHQ)
NSR : Hong Kong Space Museum

Construction Activities: Excavator mounted breakers
NSR Distance, R : 50 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-19	-19	-19	-19	-19	-19
d	Soil Damping Loss [3], Type = "Clay"	-6.5	-12.8	-25.5	-40.0	-40.0	-40.0
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
f	Floor to Floor Attenuation [5]	-2	-2	-2	-2	-2	-2
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	6	6	6	6	6	6
I	Noise Level at NSR, dB [8]	40	35	18	-1	0	5
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-17	-5	-8	-17	-9	2

4 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Report Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Appendix - Groundborne Noise Evaluation

Ref. D1

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 1 (FMPHQ)
NSR : Hong Kong Cultural Centre - Grand Theatre

Construction Activities: Excavator mounted breakers
NSR Distance, R : 95 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-25	-25	-25	-25	-25	-25
d	Soil Damping Loss [3], Type = "Rock"	-0.1	-0.2	-0.4	-0.9	-1.7	-3.5
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-1	-1	-1	-1	-1	-1
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	6	6	6	6	6	6
I	Noise Level at NSR, dB [8]	24	25	21	15	15	18
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-33	-15	-6	-1	7	15

16 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref. F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Appendix - Groundborne Noise Evaluation

Ref. D2

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 1 (FMPHQ)
NSR : Hong Kong Cultural Centre - Concert Hall

Construction Activities: Excavator mounted breakers
NSR Distance, R : 75 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-23	-23	-23	-23	-23	-23
d	Soil Damping Loss [3], Type = "Rock"	-0.1	-0.2	-0.3	-0.7	-1.4	-2.7
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-1	-1	-1	-1	-1	-1
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	6	6	6	6	6	6
I	Noise Level at NSR, dB [8]	26	27	23	18	18	21
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-31	-13	-3	2	9	18

19 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref. F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Appendix - Groundborne Noise Evaluation

Ref. D3

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 2 (Salisbury Road between KPD to Hankow Road)
NSR : Hong Kong Cultural Centre - Studio Theatre

Construction Activities: Excavator mounted breakers
NSR Distance, R : 22 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-12	-12	-12	-12	-12	-12
d	Soil Damping Loss [3], Type = "Rock"	0.0	0.0	-0.1	-0.2	-0.3	-0.6
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-2	-2	-2	-2	-2	-2
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	6	6	6	6	6	6
I	Noise Level at NSR, dB [8]	35	37	33	28	29	33
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-21	-3	7	12	20	30

30 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref, F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Appendix - Coupling Loss Calculations from Bedrock to Piles

Ref. F

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
NSR : Hong Kong Cultural Centre

Statistical Energy Analysis (SEA)
Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996.

1. In SEA, the dynamic variable is energy E. Energy attenuation is related to coupling loss factor η_{12} between two subsystems 1 and 2, and the total loss factor η_2 of subsystem 2:

   $$\text{Coupling Loss in dB} = 10\,\text{Log}[E_2/E_1] = 10\,\text{Log}\,[\eta_{12}/\eta_2]$$

2. Coupling loss factor (CLF) from one structure to another is given by Equation (4.32) in the Reference:

   $$\eta_{12} = 0.1365\,[h_1 c_{L1}/f]^{1/2}\,(L_{12}/S_1)\;\tau_{12}$$

   where h_1 = Bedrock thickness in m;
   c_{L1} = Longitudinal wave speed in rock in m/s;
   f = Frequency in Hz;
   L_{12} = Structural joint length of piles to bedrock in m;
   S_1 = Impact surface area in sq.m;
   τ_{12} = Transmission loss coefficient.

3. Approximation to total loss factor of concrete or similar is given by:

   $$\eta_2 = f^{-1/2} + 0.015$$

4. Input Parameters:

		Remark:
h_1 =	55 m	Based on geological figures near HKCC.
c_{L1} =	3500 m/s	Propagation through rock.
L_{12} =	3 m	Depth of piles embedded into bedrock.
S_1 =	3200 sq.m	Tunnel width = 2 nos. x 8m = 16m; Tunnel section along HKCC = 200m.
τ_{12} =	1/3	Power splitted - assume one part in piles and two parts in bedrock. This is considered as a conservative approximation due to the large difference between bedrock thickness (>55m) and typical piles size (1~3m in diameter)

5. Coupling Loss Calculations:

f, Hz	h_1,m	c_{L1}, m/s	L_{12}, m	S_1, sq.m	τ_{12}	η_{12}	η_2	Coupling Loss, dB
16	55	3500	3	3200	0.333	0.00468	0.26500	-18
32	55	3500	3	3200	0.333	0.00331	0.19178	-18
63	55	3500	3	3200	0.333	0.00236	0.14099	-18
125	55	3500	3	3200	0.333	0.00167	0.10444	-18
250	55	3500	3	3200	0.333	0.00118	0.07825	-18
500	55	3500	3	3200	0.333	0.00084	0.05972	-19

APPENDIX – 7-2-2

Sample Construction Groundborne Noise Calculations
NSR - YMCA

KSL Construction ground-borne noise for drilling and breaking operation
Summary of predicted groundborne noise levels
Date: 23 Dec 2003

Zone 1 (FMPHQ)

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Estimated Distance from Plant to NSR	Ref.
2 nos. Hydraulic Breakers	YMCA	Granite	Guestroom	24	30 m	E1
4 nos. Rock drills	YMCA	Granite	Guestroom	32	30 m	E2

Note: See attached sample calculations.

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Estimated Distance from Plant to NSR	Ref.
2 nos. Hydraulic Breakers + 4 nos. Rock drills	YMCA	Granite	Guestroom	33	30 m	Note [1]

Note: [1] Noise summation from individual noise levels above due to construction plant in Zone 1.

Zone 2 (Salisbury Road between KPD to Hankow Road)

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Estimated Distance from Plant to NSR	Ref.
4 nos. Hydraulic Breakers	YMCA	Granite	Guestroom	37	11 m	E3

Note: See attached sample calculations.

Zone 1 + Zone 2

Construction Plant	NSR	Soil Material	Area	Max. Predicted Noise Level, dB(A)	Ref.
Zone 1 : 2 nos. Hydraulic Breakers + 4 nos. Rock drills Zone 2 : 4 nos. Hydraulic Breakers	YMCA	Granite	Guestroom	38	Note [2]

Note: [2] Noise summation from individual noise levels above due to construction plant in Zone 1 and Zone 2.

Appendix - Groundborne Noise Evaluation

Ref. E1

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 1 (FMPHQ)
NSR : YMCA Building

Construction Activities: Excavator mounted breakers
NSR Distance, R : 30 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-15	-15	-15	-15	-15	-15
d	Soil Damping Loss [3], Type = "Rock"	0.0	-0.1	-0.1	-0.2	-0.5	-1.0
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-2	-2	-2	-2	-2	-2
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	3	3	3	3	3	3
I	Noise Level at NSR, dB [8]	30	31	27	22	23	27
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-27	-9	1	6	14	24

24 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref. F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

Ref. E2

KSL Construction ground-borne noise Calculations for Rock Drill

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 24-Dec-03

Zone 1 (FMPHQ)

Item	Description	Quantity
1.	Calculated 2 nos. Hydraulic Breakers	= 24 dB(A)
	Noise Level at YMCA Building	Extracted from calculation sheet Ref. E1
	when breaking granite at 30m away	
2.	Calculated 1 nos. Hydraulic Breakers	= 24 dB(A) minus 3 dB(A)
	Noise Level at YMCA Building	= 21 dB(A)
	when breaking granite at 30m away	
3.	Correction to Rock Drill Noise	= + 20 log (V1 / V2)
	V1 = Vibration (rms) of Drilling Rig	= + 20 log (0.536 mm/s / 0.298 mm/s)
	V2 = Vibration (rms) of Hydraulic Breaker	= + 5.1 dB
	Ref.	
	See vibration measurement table in Appendix 7-1	
4.	Multiple source correction	= + 10 log (N)
	for 4 Rock Drills	= + 10 log (4)
		= + 6 dB
5.	Predicted Groundborne Noise	= 32 dB(A)
	Adding items [2], [3] and [4]	

Notes:

[1] Groundborne noise level at other distance is calculated similarly.

Appendix - Groundborne Noise Evaluation

Ref. E3

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 05-Feb-04
Site : Zone 2 (Salisbury Road between KPD to Hankow Road)
NSR : YMCA Building

Construction Activities: Excavator mounted breakers
NSR Distance, R : 11 m

Item		Octave Band Frequency, Hz 16	31.5	63	125	250	500
a	Source Vibration Velocity, mm/s [1]	0.05886	0.06816	0.06195	0.05033	0.06225	0.12091
b	Vibration Velocity Level, dB ref. 10^-6 mm/s	95	97	96	94	96	102
c	Distance Correction = -20 log (R/Ro) [2]	-6	-6	-6	-6	-6	-6
d	Soil Damping Loss [3], Type = "Rock"	0.0	0.0	0.0	-0.1	-0.1	-0.2
e	Building Coupling Loss, BCF [4]	-7	-7	-10	-13	-14	-14
e'	Coupling Loss from bedrock to piles [*]	-18	-18	-18	-18	-18	-19
f	Floor to Floor Attenuation [5]	-2	-2	-2	-2	-2	-2
g	Conversion to Noise [6]	-27	-27	-27	-27	-27	-27
h	Multiple Source Effect [7]	6	6	6	6	6	6
I	Noise Level at NSR, dB [8]	41	43	39	34	35	39
j	A-weighting Correction	-56.7	-39.4	-26.2	-16.1	-8.6	-3.2
k	A-weighted Noise Level, dB(A)	-15	3	13	18	26	36

37 dB(A)

Notes:
[1] Based on site measurement with an excavator-mounted breaker operating at the reference distance Ro = 5.5m.
[2] Reference: "Transit Noise and Vibration Impact Assessment" issued by the FTA of the U.S. Department of Transport.
[3] Calculated in accordance with "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-2).
Damping loss limited to no greater than 40 dB in any frequency bands.
[4] Reference: "Transportation Noise Reference Book", 1987 (see EIA Report Table 7-3).
[*] Reference: "Sound Transmission through Buildings using Statistical Energy Analysis", 1996 (see attached calculation Ref. F).
[5] Floor to floor attenuation = -1 dB per floor for a conservative assessment.
[6] Standard acoustic principles (see EIA Table 7-4).
[7] Breakers in simultaneous operation.
[8] Octave Noise Level in dB = Items [b] + [c] + [d] + [e] + [f] + [g] + [h].

APPENDIX – 7-2-3

Sample Construction Groundborne Noise Calculations for TBM

KSL Construction ground-borne noise Calculations for TBM

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 11-Dec-03

NSR : HKCC

Item	Description	Quantity
1.	Source Term, from Graph	= 2.5 mm/s
	DB320 Kwai Tsing Tunnel by Extrapolation	
	PPV at 5.5m	
2.	Conversion to rms velocity	= 0.625 mm/s
	based on Crest factor of 4	
	Reference: FTA Guidance Manual	
3.	Vibration Velocity	= 20 log (V / Vref)
	ref. 10^-9 m/s	= 116 dB
4.	Distance Attenuation	= - 20 log (R / Ro)
	R = 150m between TBM and HKCC	= - 20 log (150 / 5.5)
		= - 29 dB
5.	Soil Damping	= 0 dB
	Through granite, assumed zero	
6.	Building Coupling Loss	= -10 dB
	at dominant frequencies	
	between 63 Hz to 250 Hz	
	See Note [1]	
7.	Coupling Loss from	= -18 dB
	Bedrock to pile	
	(see attached calculation using SEA Ref. F)	
8.	Floor to floor attenuation	= -1 dB
	See Note [1]	for a conservative assessment
9.	Conversion from Vibration to Noise	= - 27 dB
	See Note [1]	
10.	Conversion to A-weighted Noise	= -20 dB
	Ref. FTA Guidance Manual Table 6-1	for a conservative assessment
11.	Predicted Groundborne Noise	= 11 dB(A)
	Adding items [3] to [10]	

Notes:

[1] Also see Section 7 of EIA Report on detailed description of items

KSL Construction ground-borne noise Calculations for TBM

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 22-Dec-03

NSR : Typical Schools along Canton Road

Item	Description	Quantity
1.	Source Term, from Graph	= 2.5 mm/s
	DB320 Kwai Tsing Tunnel by Extrapolation	
	PPV at 5.5m	
2.	Conversion to rms velocity	= 0.625 mm/s
	based on Crest factor of 4	
	Reference: FTA Guidance Manual	
3.	Vibration Velocity	= 20 log (V / Vref)
	ref. 10^-9 m/s	= 116 dB
4.	Distance Attenuation	= - 20 log (R / Ro)
	R = 5m between TBM and NSR	= - 20 log (5 / 5.5)
		= 0 dB
5.	Soil Damping	= 0 dB
	Through granite, assumed zero	
6.	Building Coupling Loss	= -10 dB
	at dominant frequencies	
	between 63 Hz to 250 Hz	
	See Note [1]	
7.	Coupling Loss from	= -18 dB
	Bedrock to pile	
	(see attached calculation using SEA Ref. F)	
8.	Floor to floor attenuation	= -2 dB
	See Note [1]	-1 dB per floor for a conservative assessment
9.	Conversion from Vibration to Noise	= - 23 dB
	See Note [1]	
10.	Conversion to A-weighted Noise	= -20 dB
	Ref. FTA Guidance Manual Table 6-1	for a conservative assessment
11.	Predicted Groundborne Noise	= 43 dB(A)
	Adding items [3] to [10]	

Notes:

[1] Also see Section 7 of EIA Report on detailed description of items

KSL Construction ground-borne noise Calculations for TBM

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 11-Dec-03

NSR : Typical Hotel Rooms along Canton Road

Item	Description	Quantity
1.	Source Term, from Graph	= 2.5 mm/s
	DB320 Kwai Tsing Tunnel by Extrapolation	
	PPV at 5.5m	
2.	Conversion to rms velocity	= 0.625 mm/s
	based on Crest factor of 4	
	Reference: FTA Guidance Manual	
3.	Vibration Velocity	= 20 log (V / Vref)
	ref. 10^-9 m/s	= 116 dB
4.	Distance Attenuation	= - 20 log (R / Ro)
	R = 10m between TBM and NSR	= - 20 log (10 / 5.5)
		= - 5 dB
5.	Soil Damping	= 0 dB
	Through granite, assumed zero	
6.	Building Coupling Loss	= -10 dB
	at dominant frequencies	
	between 63 Hz to 250 Hz	
	See Note [1]	
7.	Coupling Loss from	= -18 dB
	Bedrock to pile	
	(see attached calculation using SEA Ref. F)	
8.	Floor to floor attenuation	= -3 dB
	See Note [1]	-1 dB per floor for a conservative assessment
9.	Conversion from Vibration to Noise	= - 27 dB
	See Note [1]	
10.	Conversion to A-weighted Noise	= -20 dB
	Ref. FTA Guidance Manual Table 6-1	for a conservative assessment
11.	Predicted Groundborne Noise	= 33 dB(A)
	Adding items [3] to [10]	

Notes:

[1] Also see Section 7 of EIA Report on detailed description of items

KSL Construction ground-borne noise Calculations for TBM

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 11-Dec-03

NSR : Typical Residential units along Canton Road

Item	Description	Quantity
1.	Source Term, from Graph	= 2.5 mm/s
	DB320 Kwai Tsing Tunnel by Extrapolation	
	PPV at 5.5m	
2.	Conversion to rms velocity	= 0.625 mm/s
	based on Crest factor of 4	
	Reference: FTA Guidance Manual	
3.	Vibration Velocity	= 20 log (V / Vref)
	ref. 10^-9 m/s	= 116 dB
4.	Distance Attenuation	= - 20 log (R / Ro)
	R = 10m between TBM and NSR	= - 20 log (10 / 5.5)
		= - 5 dB
5.	Soil Damping	= 0 dB
	Through granite, assumed zero	
6.	Building Coupling Loss	= -10 dB
	at dominant frequencies	
	between 63 Hz to 250 Hz	
	See Note [1]	
7.	Coupling Loss from	= -18 dB
	Bedrock to pile	
	(see attached calculation using SEA Ref. F)	
8.	Floor to floor attenuation	= -3 dB
	See Note [1]	-1 dB per floor for a conservative assessment
9.	Conversion from Vibration to Noise	= - 27 dB
	See Note [1]	
10.	Conversion to A-weighted Noise	= -20 dB
	Ref. FTA Guidance Manual Table 6-1	for a conservative assessment
11.	Predicted Groundborne Noise	= 33 dB(A)
	Adding items [3] to [10]	

Notes:

[1] Also see Section 7 of EIA Report on detailed description of items

APPENDIX – 7-2-4

Sample Construction Groundborne Noise Calculations
for Pipepile

KSL Construction ground-borne noise Calculations for Pipepile

Job No. : 23573
Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES
Date : 5-Jan-04
NSR: HKCC Studio Theatre

Item	Description	Quantity
1.	Calculated 4 nos. Hydraulic Breakers	= 30 dB(A)
	Noise Level at HKCC Studio Theatre	Extracted from calculation sheet Ref. D3
	when breaking granite at 22m away	
2.	Calculated 1 nos. Hydraulic Breakers	= 30 dB(A) minus 6 dB(A)
	Noise Level at HKCC Studio Theatre	= 24 dB(A)
	when breaking granite at 22m away	
3.	Correction to Pipepile Noise	= + 20 log (V1 / V2)
	V1 = Vibration (rms) of Pipepile	= + 20 log (0.638 mm/s / 0.298 mm/s)
	V2 = Vibration (rms) of Hydraulic Breaker	= + 6.6 dB
	Ref.	
	See vibration measurement table Appendix 7-1	
5.	Predicted Groundborne Noise	= 31 dB(A)
	Adding items [2] and [3]	

Note:

[1] Pipepile vibration ppv at 2m = 19.3 mm/s, converted to rms using crest factor of 4 and distance 5.5m

Pipepile Vibration (rms) at 5.5m = ppv/crest factor x (distance / reference distance)^2

= (19.3/4)x(2/5.5)^2

= 0.638 mm/s

KSL Construction ground-borne noise Calculations for Pipepile

Job No. : 23573

Project : KOWLOON SOUTHERN LINK KSL GSA-5100 EIA & ASSOCIATED SERVICES

Date : 5-Jan-04

NSR: YMCA Building

Item	Description	Quantity
1.	Calculated 4 nos. Hydraulic Breakers	= 37 dB(A)
	Noise Level at YMCA Building	Extracted from calculation sheet Ref. E3
	when breaking granite at 11m away	
2.	Calculated 1 nos. Hydraulic Breakers	= 37 dB(A) minus 6 dB(A)
	Noise Level at YMCA Building	= 31 dB(A)
	when breaking granite at 11m away	
3.	Correction to Pipepile Noise	= + 20 log (V1 / V2)
	V1 = Vibration (rms) of Pipepile	= + 20 log (0.638 mm/s / 0.298 mm/s)
	V2 = Vibration (rms) of Hydraulic Breaker	= + 6.6 dB
	Ref.	
	See vibration measurement table Appendix 7-1	
5.	Predicted Groundborne Noise	= 38 dB(A)
	Adding items [2] and [3]	

Note:

[1] Pipepile vibration ppv at 2m = 19.3 mm/s, converted to rms using crest factor of 4 and distance 5.5m

Pipepile Vibration (rms) at 5.5m = ppv/crest factor x (distance / reference distance)^2

= (19.3/4)x(2/5.5)^2

= 0.638 mm/s