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USE OF TRANSMISSION LOSS (TL), ABSORPTION COEFFICIENT $(\overline{\alpha})$, REVERBERATION TIME (T_R), AND TRANSMISSION COEFFICIENT (τ) APPLYING REVERBERANT ROOM METHOD, FOR ASSESSMENT AND EVALUATION OF ACOUSTIC QUALITY OF SOME RESIDENTIAL BUILDINGS IN CALABAR CITY, NIGERIA

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Abstract

The use of transmission loss (TL), absorption coefficient $(\overline{\alpha})$, reverberation time (T_R), and transmission coefficient (τ) at frequency of 1000Hz (1kHz) to assess and evaluate the level of acoustic quality of some residential buildings in Calabar City, Nigeria, applying sound reverberation room method was investigated. A digital sound level meter (SLM)- Bruel & Kjaer (B&k), type 732 with frequency level range (31.5 – 8000Hz) and sound level range (30-150 dB) was used to obtain sound pressure levels (Lps) directly in both source room (SR) and reception room (RR) at various residential buildings under study. Lps were taken at frequency of 1000Hz which is (our frequency of interest). Measuring tape (MT) was used to obtain dimensions (in metres, m) of the reception rooms (RRs) in length (L), width (W) and height (H), to help calculate the various total surface areas (S) in metre –squared (m^2) and volumes (V) in metre – cube (m^3) of the RRs. Stop clock was used to obtain reverberation times (T_R) in the RR_s from which absorption coefficients ($\overline{\alpha}$) were obtained applying appropriate sabine equation. From the results obtained, most residential rooms in our buildings were not acoustically comfortable because of poor TL, poor $\overline{\alpha}$, large T_R and weak τ generated. Results obtained from this work as shown in table 3 (a-f) indicated that the reverberation times (T_{Rs}) ranged from 2 to 5 seconds, absorption coefficient ($\overline{\alpha}$) ranged from 0.14 to 0.34 sabins, transmission loss (TL) ranged from 15.69 to 32.70 dB (A) and transmission coefficient (τ) ranged from 0.075 to 0.051 (ie 2.5 to 5.1%). It was observed that all the values obtained of the acoustical parameters analyzed in this study to ascertain or assess the acoustic quality of some of our residential buildings in Calabar metropolis, far exceeded the building standard recommendations.

Keywords: Sound transmission loss, reverberation time, sound absorption coefficient, sound transmission coefficient and sound pressure level.

1.0 Introduction/ Theoretical Background

The most important acoustical requirement in residential buildings is control of intruding sound. Private homes typically rely on open windows for ventilation, and so, are sensitive to outdoor sounds (Cunnif, 1977; Magrab, 1975). Architectural acoustics encompasses the process through which acoustical conflicts can be avoided, unwanted sounds controlled, and wanted sounds enhanced by building design (Crocker et al; 1998).

Buildings affect the acoustic signal that arrives at the ears, both spectrally and temporally, and both within spaces and between them. Loud sounds are the background issues to be dealt with in the choices of functional criteria and the engineering of the fabric of buildings to achieve them. Efforts to eliminate or reduce loud sounds impacts in our buildings must be done at the design stage otherwise, there may not be a concrete solution available (Crocker et al; 1998).

The building design should be based on the realities of the physics of sound and of properties of hearing at the design stage of the project (Roth, 2007; Don et al; 2012).

Sound transmission through walls, openings in doors, ceilings, windows and floors of buildings has been a common concern. This is not surprising because in buildings (ie houses, multi- family apartments, etc) we are concerned with reducing the sound transmitted from one room to another. We are also more concerned with the keeping of loud exterior sound out of the building (ie reduction of loud sounds transmitted already into the buildings, a process called “sound emission”. Again, sometimes we are concerned with the prevention of loud exterior environmental sound from reaching buildings or residential community, a process called “Sound emission”. This is the area our architect, building engineers and acoustics professional could not adequately address. Transmission of loud sound away of the buildings from the sound source should be the paramount concern of all.

Sound transmission loss (TL) is an important acoustic parameters used to quantify the ability of a partition to prevent sound transmission. This requires that the walls, floors, and ceilings have desirable sound transmission characteristics. Sound transmission loss (TL) was expressed (in decibel, dB) for the partition between two reverberant rooms as in eqn 1.

$$TL = L_{P1} - L_{P2} + 10\log_{10}\left(\frac{S}{A}\right) dB \quad (1)$$

(Cunnif, 1977)

Where

L_{p1}, L_{p2} = Time spaced average sound pressure level in the source or transmission room (SR) and reception room (RR), respectively.(in dB).

S = Total radiation surface area of the partition (in m^2).

$A = \overline{\alpha} S$ = Total sound absorption area in the reception room (in sabins m^2)

$\overline{\alpha}$ = Absorption coefficient (in Sabins).

$L_{P1} - L_{p2}$ = Noise reduction (NR) of the partition (in dB)

Reverberation is generally, a sound that persists in an enclosed space due to multiple reflections, after the source of sound has ceased. It is an important parameter for describing speech intelligibility and perception of music, and is used to correct or normalize sound insulation and sound power measurements (Roth, 2007). Reverberation time (T_R) is the time taken for a sound pressure level (L_p) to decay by 60dB of the original level after sound source has ceased. It is measured in 1/1 or 1/3 – octave frequency bands. It may range from 0.1 second (or less) in anechoic (ie echo-free) chambers, to 10 seconds (or more) in large public spaces (Cunniff, 1975; Fields, 1993).

Reverberation times (T_R) are used in sound insulation rating measurements. They are strongly influenced by the absorption coefficients ($\overline{\alpha}$) of the surfaces as well as the volumes (V) of rooms as expressed eqn 2 (Sabine Equation)

$$T_R = \frac{0.161V}{A} = \frac{0.161V}{\overline{\alpha} S} \qquad (2)$$

It is shown that a room with $T_R < 0.3$ second is acoustically “dead” and anechoic (ie has no echo), while the one with $T_R > 1.5$ seconds is acoustically “live” and echoic (ie reverberant room). A heavily furnished room with thick carpets, curtains and upholstered furniture may tend to be anechoic, while a large empty room with painted, plastered walls and tiled floors may be echoic or reverberant.

Sound absorption coefficient ($\overline{\alpha}$) was expressed (from eqn 2. above) as in Eqn 3:

$$\overline{\alpha} = \frac{0.161V}{T_R S} \text{ Sabins} \qquad (3)$$

Sound absorption coefficient ($\overline{\alpha}$) of 1.0 means the material or chamber is 100% sound absorbing, while $\overline{\alpha}$ of 0.0 means the material is 0% sound absorbing (ie it absorbs no sound).

Sound transmission coefficient ((τ) is a single number rating scale that measures the ability of a wall, ceiling, or floor assembly to block sound transmission. The higher the rating, the greater the drop in decibel levels transmitting through the surface. The transmission coefficient ((τ) is seen to be a rating system that measures an overall wall, ceiling or floor surface’s ability to block and contain unwanted sound transmission. It is also a rating system that is used to measure a product’s ability to block and contain noise. The stronger the rating, the more protection from noise or loud sound one receives. Sound transmission coefficient is related to sound transmission loss as expressed in Equation 4 or 5.

$$TL = 10\log_{10}\left(\frac{1}{\tau}\right) dB \quad 0 < \tau \leq 1 \qquad (4)$$

(Magrab, 1975)

Or $$\tau = \frac{1}{10^{0.1TL}} \qquad (5)$$

2.0 MATERIALS AND METHODS

2.1 MATERIALS

Materials used for this study included:

(i) Two (2) Precision digital sound level meters (SLM_S), Bruel & Kjaer, 732 with sound pressure level range (30-150dB) and frequency range (31.5 –

8000H$_z$), each mounted in the source and reception rooms respectively.

(ii) Stop clock used to measure reverberation time (T_R).

(iii) Measuring tape (MT) to measure length, width and height of the reception rooms under study.

(iv) Sound source- six (6) horn – loaded Loud speakers with three mounted in the SR and another three in RR to produce the needed loud sound.

(v) B&K multifunction acoustic calibrator, model 4226 used for calibration before and after each measurement, following ISO 1996 – 1, 2; ISO 3891; IEC 651, and IEC 804 standards.

2.2 METHODS

The reverberant room method employed in this study consists of the use of two reverberant rooms (source and reception rooms), which are separated by a panel or partition which was a brick wall in this study (Crocker et al, 1982). A steady sound at the frequency of interest – 1000H$_z$ was made in the transmission or source room by means of three (3) horn-loaded loudspeakers mounted in the source room (SR). A diffuse sound field was created in the source and reception rooms by means of these loudspeakers, each mounted to face different direction in each room, radiating sound of 1/3- octave bandwidth. The wall under the test transmitted sound from the source room to the reception room. The sound transmitted through the test wall gave rise to a random sound field in the reverberant reception room. The sound level in the reception room was obtained by SLM mounted in the room. L_{p1} and L_{p2} were the SPL$_s$ obtained from source and reception rooms respectively.

The study area, Calabar city was zoned into six (1-6 zones) and residential buildings were randomly selected from each zone, from which reception rooms (rooms under study were randomly selected. Ten (10) rooms were selected randomly from buildings in each zone. In all sixty (60) test rooms were selected, and assessment and evaluation of their acoustic quality was carried out using T_R, , TL, $\overline{\alpha}$ and τ as acoustic parameters for the evaluation and analysis.

The total surface area S (in m^2) of the reception rooms was expressed as in Eqn 6:

$$S = S_1 + S_2 + S_3 \ \ m^2 \qquad (6)$$

where $S_1 = 2\,(L.H + W.H)$ = Area of the four (4) walls of the reception room (m^2)

$S_2 = (L.W)$ = Area of the ceiling (m^2) of the reception room.

$S_3 = (L.W)$ = Area of the floor (m^2) of the reception room

where L, W, H are the length, width and height (in metres, m) of the reception rooms respectively.

The volume (V) of a reception room was expressed as in Eqn 7

$$V = SH \ (m^3) \qquad (7)$$

Absorption area (A) of reception room was expressed from Eqn 2) as in Eqn 8

$$A = \overline{\alpha}S \ \ (\text{sabins.m}^2) \qquad (8)$$

3.0 RESULTS AND DISCUSSION

The results obtained from this study were as summarized in Table 3 (a-f). From this table, it was observed that the values of all the acoustical parameters used in assessing the acoustic quality of some of our residential buildings in this study, to some reasonable extent, disagreed with the theoretical submissions as shown in tables 1 and 2. The values in table 1 are crucial for determine appropriate surface treatments to control echo and enhance speech intelligibility or musical quality in different environments. Reverberation times (T_{Rs}) recorded in this study as shown in table 3 ranged from 2 to 5 seconds across the study areas, showing that sound transmitted through the walls, ceilings, floors, doors, windows, or any other openings of buildings persisted in rooms even after the source of sound had ceased for the duration of about 2 to 5 or more seconds. This affected speech intelligibility, perception of music and general comfort of the residents. An unfavourable reverberation time can cause cognitive fatigue, thereby making individuals loose memory resources gradually (Yerges, 2009).

Although optimum reverberation time for auditorium or room depends on its intended use, a desirable T_R for general purpose room or auditorium should be 1.5 to 2.5 seconds for both speech and music or even less in residential rooms or buildings (ie < 1.0 second) (ASTM, 1996). It was observed that most rooms in our residential buildings have highly reflective surfaces, and these lengthen T_R. It is observed also that large rooms have large T_{Rs} than smaller rooms, although rooms that are heavily furnished with thick carpets, curtains and upholstered furniture, tend to have shorter T_{Rs} than those not heavily furnished, irrespective of the size of the rooms, as observed in table 3. T_R is important in showing how an auditorium or room responds to sound. Sound absorption coefficient ($\overline{\alpha}$) is a common quantity used for measuring the sound absorption of a material or degree of absorption in a room, and is known to be the function of frequency of the incident sound wave. Resistance to the passage of sound defines the absorption coefficient ($\overline{\alpha}$) (Oliver et al; 2014). A critical look at table 3 shows that $\overline{\alpha}$ ranges from 0.14 to 0.34 sabins, implying a very low sound absorption in the rooms under study. What this means is that the reverberant rooms under study are sound reflective to a large extent, and so could not be comfortable acoustically to the residents (Crocker, 2007). From this table 3, it was also observed that as T_R increases $\overline{\alpha}$ decreases, in agreement with the Sabine equation. From the table 14 to 34% of the incident sound wave was absorbed by the partition, while the rest of the sound energy (ie 66-86%) was allowed into the residential rooms under study. This level of sound may pose significant health risks to occupants.

In table 2, maximum recommended or acceptable sound pressure levels (Leq) at some locations were reported. A critical look at table 3 shows that the mean SPL (ie L_{p2}) in the reception rooms (RR_S) which were sitting rooms, bedrooms, study rooms, etc under study ranged from 56.0 to 81.0dB (A). The experimental dB values far exceeded the recommended theoretical values, implying that most residents seriously suffered from sleep interferences, annoyance, speech disturbances, and communication interferences among other psycho-physiological and social discomforts.

Transmission loss (TL) is an acoustical quantity or parameter that shows the sound insulation performance of acoustical materials or chambers. Table 3 shows the values of TL calculated by use of equation 1. Depending on noise reduction (NR) of the partition, total radiating surface areas of the partitions (S) and total sound absorption areas in the reception rooms (A), TL appears low in all the reverberant rooms under study. The implication here is that most sound energy in the form of sound pressure levels (SPLs) in dB got transmitted through the brick walls (partitions) between the source and reception rooms, making RR_s more echoic with accompanying physiological and psycho-social health challenges such as rest, sleep, communication and hearing interferences (Pass-chier-Vermeer, 1996; Rosen and Olin, 1995).

Still from table 3, values of sound transmission coefficient (τ) obtained from this study were recorded. These values suggested poor sound proofing in our various residential buildings. The ability of wall, floor or ceiling assembly to block and contain unwanted sound transmission was very weak, as observed in this study. Transmission coefficient values recorded range from 0.025 to 0.051 (ie 2.5% to 5.1%) showing that only 2.5% to 5.1% of sound generated in our buildings are blocked, where the rest allowed to disturb. It appears residents or people occupying the buildings and rooms under study are not protected from loud unwanted sound transmitted into the buildings.

Table 1: Acceptable mean sound absorption coefficient ($\bar{\alpha}$) and reverberation time (T_R) for some types of rooms (Engineering Tool box, (2003)

	Room characteristics	T_R (in seconds)	$\bar{\alpha}$
1.	Very soft room (Radio and TV studio)	0.20 – 0.25	0.40 (40%)
2	Soft (Restaurant Theatre, Lecture Hall)	0.40 – 0.50	0.25 (25%)
3	Normal (Office, Library, Flat)	0.90-1.10	0.15 (15%)
4	Hard (Hospital, Church)	1.80-2.20	0.10 (10%)
5	Very hard (Large Church, Factory)	2.50 – 4.50	0.05 (50%)

Table 2: Maximum acceptable equivalent sound level (Leq) at some location (Engineering Toolbox (2003): www.engineering toolbox.com)

	Locations	Effects	Leq (dB(A)	Time (Hrs)	Time of day
1.	Bedroom	Sleep disturbance, annoyance	30	8	Night
2	Living area	Annoyance, speech interference	50	16	Day
3	Outdoor living area	Serious annoyance	55	16	Day
4	Outdoor living area	Sleep disturbance, with open window	45	8	Night
5	School classroom	Speech interference, communication disturbance	35	8	Day
6	Hospitals, patient rooms	Sleep disturbance, communication interference	30-35	8	Day & Night

Table 3: Showing measured sound pressure levels (SPL) in dB(A) at 1000H_Z as well as reverberation time (T_R), and calculated absorption coefficient ($\bar{\alpha}$**),** transmission loss (TL), and transmission coefficient (τ) in reception rooms

Table 3 (a): Zone 1, Calabar South : Anantigaha, New Airport, Jebs Road and Ibesikpo road

Room Number	Mean L_p1 (dB (A) (A)	L_{p2} (db	Mean $L_{p1} - L_{P2}$ (dB (A)	Room dimensions (m) L	W	H	Total surface area S(m^2)	Room Volume (SH) (m^3)	T_R (sec)	$\bar{\alpha}$ (sabin)	A $(\bar{\alpha}S)$ (sabin m^2)	TL (dB)	τ
1	91.0	73.0	18.0	4.7	4.0	3.7	101.98	337.34	2.5	0.21	21.42	24.78	0.032
2	86.0	66.0	20.0	5.9	4.5	3.9	134.22	523.46	3.0	0.21	28.19	26.78	0.030
3	89.0	75.0	14.0	6.8	4.7	4.1	158.22	648.70	2.5	0.26	41.14	19.85	0.040
4	92.0	67.0	25.0	5.9	5.0	3.6	137.48	494.93	2.5	0.23	31.62	31.38	0.025
5	90.0	68.0	22.0	6.2	6.0	4.0	211.88	847.52	4.0	0.16	33.90	30.00	0.026
6	85.0	68.0	17.0	4.9	4.2	3.9	125.00	437.35	3.0	0.21	23.55	23.78	0.033
7	88.0	69.0	19.0	4.8	4.6	4.3	112.14	537.50	3.5	0.20	25.00	25.99	0.031
8	90.0	79.0	11.0	6.4	5.0	4.2	125.00	670.99	2.0	0.34	54.32	15.69	0.051
9	90.0	76.0	14.0	5.2	4.9	3.7	125.70	465.09	2.5	0.24	30.17	20.20	0.039
10	87.0	69.0	18.0	6.5	4.0	3.8	131.80	500.84	2.5	0.24	31.63	24.20	0.033

Table 3 (b) Zone 2: Calabar South Mbukpa Road, Calabar Road, White House, Ekpo Abasi and Mayne Avenue

Room Number	Mean L_p (dB) (A) (A)	L_{p2} (dB)	Mean $L_{p1} - L_{P2}$ dB(A)	Room dimensions (m) L	W	H	Total surface area S(m^2)	Room Volume (SH) (m^3)	T_R (sec)	$\bar{\alpha}$ (Sabins)	A $(\bar{\alpha}S)$ (sabin m^2)	TL (dB)	τ
1	86.0	73.0	13.0	8.4	5.0	4.9	215.32	1055.07	3.5	0.23	49.52	19.38	0.041
2	82.0	68.0	14.0	9.0	6.2	5.0	263.60	1318.00	3.0	0.27	71.17	19.69	0.040
3	80.0	66.0	14.0	7.5	6.1	4.9	224.78	1101.42	3.0	0.26	58.44	19.85	0.040
4	79.0	59.0	20.0	6.7	5.8	4.3	185.22	796.45	3.0	0.23	42.66	26.38	0.030
5	76.0	56.0	20.0	10.0	5.1	4.0	222.80	891.20	4.0	0.16	35.65	27.96	0.028
6	80.0	66.0	14.0	4.9	4.8	4.0	124.64	498.56	4.5	0.14	17.45	22.54	0.035
7	87.0	73.0	14.0	6.3	4.3	3.8	134.74	512.01	3.0	0.20	26.95	20.99	0.038
8	90.0	79.0	11.00	10.1	5.4	4.3	236.18	968.34	3.0	0.22	51.96	17.58	0.045
9	91.0	69.0	22.0	11.2	4.8	4.2	241.92	1016.06	3.0	0.23	55.64	28.38	0.028
10	88.0	65.0	23.0	6.8	5.0	4.5	174.20	783.90	4.0	0.18	31.36	30.45	0.026

Table 3 (c) Zone 3 Calabar South: Eta Agbor, Akim, Mount Zion, Goldie and Bogobiri

Room Number	Mean L_p (dB)(A) (db)(A)	L_{p2}	Mean $L_{p1} –$ L_{P2} dB(A)	Room dimensions (m) L	W	H	Total surface area S (m^2)	Room Volume (SH) (m^3)	T_R (sec)	$\bar{\alpha}$	A $(\bar{\alpha}S)$ sabin m^2)	TL (dB)	τ
1	95.0	76.0	19.0	6.4	4.6	4.3	153.48	659.96	3.0	0.23	35.30	25.38	0.031
2	94.0	79.0	15.0	10.2	5.0	4.2	229.68	964.66	3.0	0.23	52.83	21.38	0.037
3	90.0	77.0	13.0	8.1	6.4	5.0	248.68	1243.40	5.0	0.16	39.79	20.96	0.038
4	91.0	74.0	17.0	7.6	6.0	4.3	208.16	895.09	3.5	0.20	41.63	23.99	0.033
5	90.0	68.0	22.0	8.1	5.1	4.0	188.22	752.88	3.0	0.21	39.53	28.78	0.028
6	90.0	70.0	20.0	5.8	5.0	4.2	148.72	624.62	2.5	0.27	40,15	25.69	0.031
7	88.0	70.0	18.0	6.3	5.1	3.9	153.18	597.40	3.5	0.18	27.57	25.45	0.031
8	95.0	80.0	15.0	5.8	4.8	3.8	139.54	530..25	3.5	0.17	23.72	22.70	0.035
9	86.0	71.0	15.0	4.9	3.6	3.5	84.78	296.73	3.0	0.19	16.11	22.21	0.036
10	86.0	68.0	18.0	6.0	4.7	4.5	152.70	687.15	3.0	0.24	36.65	24.20	0.033

Table 3 (d) Zone 4: Calabar North : Marian, MCC, Akai Effa axes

Room Number	Mean L_p (dB)(A)	L_{p2} (db)(A)	Mean $L_{p1} –$ L_{P2} dB(A)	Room dimensions (m) L	W	H	Total surface area (m^2)	Room Volume (SH) (m^3)	T_R (sec)	$\bar{\alpha}$ (sabine m^2)	A $(\bar{\alpha}S)$ (sabin m^2)	TL (dB(A))	τ
1	80.0	60.0	20.0	7.0	4.9	3.8	159.04	604.35	3.0	0.20	31.81	26.99	0.029
2	80.0	65.0	15.0	6.8	5.0	4.1	164.76	675.43	3.0	0.22	36.25	21.58	0.037
3	82.0	68.0	14.0	5.5	5.3	3.8	140.88	535.34	2.5	0.22	31.00	20.57	0.039
4	86.0	61,0	25.0	6.0	5.5	4.3	164.90	709.07	4.0	0.17	28.03	32.70	0.024
5	93.0	76.0	17.0	10.0	6.7	4.1	270.90	1110.69	4.5	0.15	40.64	25.24	0.031
6	97.0	80.0	17.0	9.2	6.0	4.0	232.00	928.00	4.0	0.16	37.12	24.96	0.032
7	89.0	76.0	13.0	8.4	5.9	5.0	242.12	1210.60	4.5	0.18	43.58	20.45	0.039
8	92.00	76.0	16.0	4.5	4.1	4.2	109.14	458.39	2.0	0.34	37.11	20.68	0.038
9	90.0	74.0	16.0	6.1	5.9	4.0	167.98	671.92	3.0	0.21	35.28	22.78	0.035
10	95.0	78.0	17.0	5.6	4.2	4.3	131.32	564.68	2.5	0.28	36.77	22.53	0.035

Table 3 (e) Zone 5 Calabar North Zone : Parliamentary, State Housing

Room Number	Means L_p (dB) (A)	L_{p2} (db) (A)	Mean $L_{p1} - L_{P2}$ dB(A)	Room dimensions (m)			Total surface area (S) (m^2)	Room Volume (SH) (m^3)	T_R (sec)	$\bar{\alpha}$ (sabins)	A $(\bar{\alpha}S)$ (sabin m^2)	TL (dB (A))	τ
				L	W	H							
1	88.0	69.0	19.0	4.8	4.2	3.8	108.72	413.14	2.0	0.31	33.70	24.09	0.033
2	80.0	68.0	12.0	4.6	4.0	4.1	108.96	446.74	3.0	0.22	23.97	18.58	0.043
3	83.0	69.0	14.0	5.0	4.6	3.7	117.04	433.05	2.0	0.30	35.11	19.23	0.041
4	79.0	60.0	19.0	7.1	6.3	4.5	149.76	673.92	3.0	0.24	35.94	25.20	0.032
5	72.0	58.0	14.0	8.2	7.1	4.6	257.20	1183.12	4.0	0.19	48.87	21.21	0.037
6	81.0	61.0	20.0	5.9	4.4	4.1	136.38	559.16	3.0	0.22	30.00	26.58	0.030
7	88.0	70.0	18.0	5.3	4.8	4.8	143.80	661.48	3.5	0.21	30.20	24.78	0.032
8	90.0	69.0	21.0	6.1	5.0	4.2	144.24	605.81	3.5	0.19	27.41	28.21	0.028
9	76.0	57.0	19.0	6.4	5.5	4.1	167.98	688.72	3.0	0.22	36.96	25.58	0.031
10	78.0	59.0	19.0	8.0	6.6	5.0	251.60	1258.00	4.5	0.18	45.29	26.45	0.030

Table 3 (f) Zone 6 Calabar North Zone : MM High way, Federal Housing

Room Number	Means L_p (dB) (A)	L_{p2} (db) (A)	Mean $L_{p1} - L_{P2}$	Room dimensions (m)			Total surface area S (m^3)	Room Volume (SH) (m^3)	T_R (sec)	$\bar{\alpha}$ Sabins	A $(\bar{\alpha}S)$ (sabin m^2)	TL (dB(A))	τ
				L	W	H							
1	91.0	78.0	13.0	6.3	5.1	4.3	162.30	697.89	3.0	0.23	37.33	19.38	0.041
2	90.0	70.0	20.0	6.4	5.2	4.0	159.36	685.25	4.0	0.17	27.09	27.70	0.021
3	90.0	68.0	22.0	5.5	4.6	4.3	137.46	591.08	4.0	0.17	23.37	29.70	0.025
4	88.0	70.0	18.0	4.8	4.2	3.8	108.72	413.14	3.0	0.20	21.74	24.99	0.032
5	85.00	70.0	15.0	4.7	4.5	4.0	115.90	463.60	3.0	0.21	24.34	21.78	0.036
6	78.0	61.0	17.0	5.3	5.0	4.4	143.64	632.02	4.0	0.18	25.86	24.45	0.032
7	95.0	81.0	14.0	6.7	5.4	5.1	195.78	998.48	4.5	0.18	35.24	21.45	0.037
8	90.0	75.0	15.0	7.3	6.3	5.0	227.98	1139.90	5.0	0.16	36.48	22.90	0.035
9	87.0	75.0	12.0	8.0	7.5	5.6	293.60	1644.16	5.0	0.16	46.98	19.96	0.040
10	90.0	76.0	14.0	10.3	7.8	5.3	352.54	1868.46	5.0	0.17	59.93	21.70	0.037

4.0 CONCLUSION AND RECOMMENDATIONS

From this study it was shown that most of our residential houses in cities and even rural areas are not constructed and built with acoustic comfort in mind. Our architects and building engineers, and other professionals in construction industry tend to have less or no interest in preventing external loud sound from getting to our buildings, a process called emission of sound. It appears they promote the process of emission – reduction of loud sound already allowed into the buildings, and this even is not effectively done, as this study appears to show.

To militate the effect of excessive indoor noise the use of dB – Bloc facility is readily recommended. The dB – Bloc is an ultra-thin, ultra-dense sound barrier membrane that layers inside a common wall or floor/ceiling assembly to help deaden the transfer of sound waves through to the adjoining rooms(s). The density of this membrane prevents sound vibration. Where there is no vibration of sound energy through a structure there is no sound transmission through the structure too. The dB –Bloc is a sound barrier membrane that can be fixed on walls, floors, ceilings of buildings, to prevent transmission of structure borne sound wave.

Further recommendations include the following: (1) Governments should consider the protection of populations from loud community sound as an integral part of their policy for environmental protection (2) Government should include noise as an important issue when assessing public health matters, and support more research related to the health effects of noise exposure. (3) Government should encourage home owners to embark on aggressive sound insulation of their houses, especially residential buildings located in noise pollution areas. (4) Dissemination of information should be created and provided by governments, agencies and sound professionals/ scientists, to promote public awareness; and (5) further research(es) on the relationship between noise levels inside buildings and health effects should be encouraged and supported by governments, agencies, building industry and general public.

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REFERENCES

ASTM E90 -70 (1996). Recommended practice for laboratory measurement of airborne sound transmission loss of building partitions. *American Soc. For testing & Materials* (ASTM); Philadelphia p. 54.

Crocker, M. J. (1998). Hand book of acoustics. London: John Wiley & Sons Inc. Pp. 920.

Crocker, M. J. (2007). Hand book of noise and vibration control. John Wiley & Sons, P.54.

Cunnif, P. F. (1977). Environmental noise pollution. John Wiley & Sons, N. Y, 68.

Don, D; Eugene, P. and Pat, B. (2023). Sound system Engineering 4th edition. P. 215.

Fields, J. M. (1993). Effect of personal and situational variables upon noise annoyance in residential area, *Journal of Acoustical Soc. Of America*; 93, 2753 – 2763.

Magrab, E. B (1975). Environmental noise control. London: Wiley-Interscience John Wiley & Sons Inc P. 157.

Malcolm, M. J. and Frederick, M. K. (1982). Noise air Noise control. Vol. 1. CRC Press Inc, Florida, pp 28-31.

Obisung, E. O; Onuu, M. U. Menkiti, A. I., and Akpan, A. O. (2016) Road traffic noise induced sleep disturbances in some cities in Eastern Nigeria. *British Journal of Applied Science & technology* 12 (4): 1-15.

Obisung, E.O; Onuu, M. U. and Menkiti, A. I., (2016). Human auditing communication disturbances due to road traffic noise pollution in Calabar city, Nigeria. *International Journal of Engineering Research and Application.* Vol. 6, Issue 10, (Part -3), pp 39-50.

Oliver, R; Alain, B; Oliver, D. and Noureddin, A. (2014). Measurement of absorption coefficient of sound absorption materials under a synthesized diffuse acoustic field. *Journal of Acoustical Soc. Of America*, 136.

Passchier – Vermeer, W. (1996). Effects of noise News International 137 – 150.

Reverberation time measurement www.nti_audio.com Retrieved July 30,2019

Rosen, S. and Olin, P. (1995). Hearing loss and coronary heart disease. Archieves of Otollaryngology, 82: 236.

Roth, L.M (2007). Understanding Architecture. West view Press, Pp 104-105.

Yerges, L. E (2009). Sound, noise and vibration control. van Nostrand Reinhodl, 23.