A TECHNICAL REPORT ON
THE ACOUSTIC GUIDELINES FOR URBAN DESIGN

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SUBMITTED TO
THE DEPARTMENT OF ARCHITECTURE
SCHOOL OF ENVIRONMENTAL TECHNOLOGY
FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE

IN PARTIAL FULLFILMENT OF THE REQUIREMENT FOR THE AWARD OF A BACHELOR OF TECHNOLOGY (B.TECH) IN ARCHITECTURE

APRIL 2007
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1.0 INTRODUCTION

Acoustics can simply be defined as the Science of sound. The Term “Acoustics” is gotten from a Greek word “Akouein” meaning “to hear”.

Acoustics describes the behaviour of sound in any media, surrounding or environment. It also encompasses the Reflection, Diffraction, Refraction, Diffusion, Transmission, Absorption and interference of sound in both the internal and external environment.

1.1 ARCHITECTURAL ACOUSTICS

This can therefore be defined as the regulation and control of noise and sound levels within and around the spaces of a building design in order to achieve a healthy, functional and comfortable environment for users.

The factors that determine the acoustics of a space include:

- Size and Geometry,
- Background Noise, and
- Room Surfaces

1.2 ORIGIN OF ACOUSTICS

The first ever record of Acoustical knowledge and manipulations can be dated back to 1856 were it was first examined by Joseph Henry an American Physicist. However, the subject was further researched by another American physicist in person of Wallace Clement Sabine in the year 1895.

At the time, he was a twenty seven year old new Assistant Professor of Physics in Harvard University, who was called upon to remedy the Acoustical difficulties of the new Fogg Art Museum situated on the campus grounds.

His success led to breakthroughs, new innovations and ideas concerning acoustics including the Sabine Equation which states that “the Reverberation time of a room is directly proportional to the Cubic volume of the room and directly proportional to the Sound absorption provided at the room boundary surfaces and by the room’s furniture.”

It is further expressed thus:

$$RT \propto \frac{V}{A}$$

Where RT is the Reverberation Time

- $V$ is the Cubic Volume of the Room
- $A$ is the Sound Absorption.
This and many more researches and positions, earned him the title “The father of Architectural Acoustics”

1.3 GUIDELINES

According to the Encarta dictionary the word guidelines/ official advice is an official recommendation indicating how something should be done or what sort of action should be taken in a particular circumstance. In designing the urban environment as a whole, it is necessary to inculcate basic measures to ensure a habitable environment free from damage to human hearing and not constituting a nuisance. The governments develop guidelines.

1.4 THE URBAN ENVIRONMENT

A properly planned community inhabiting more that 2,500 people which possess adequate and functional transportation routes and facilities, natural resources, social amenities and infrastructural facilities led by ideal legal and administrative authorities is referred to as an urban environment.

As a result of its complexity in design, administration, habitation, function and management, the urban environment tends to possess various sources of noise which needs to be either minimized or entirely eliminated in order to arrive at an environment that is healthy, functional and comfortable for its users.
1.5 SECTORS OF THE URBAN ENVIRONMENT

Differing functional parts combine to form the urban environment, which includes:

- The Residential Sector
- The Commercial Sector
- The Industrial Sector
- The Agricultural Sector
- Public and Semi-Public Areas
- Water Bodies

This hence gives rise to the need for acoustic guidelines for urban design.

NOISE AS A MAJOR SOURCE OF POLLUTION

Noise is an unwanted sound. Amongst other things, it is a major source of pollution to both man and animals. There have even been recorded though not confirmed cases of plants experiencing a set back in their normal growth patterns as a result of too much noise. Hence solutions need to be derived to the problems of noise in the society.
2.0 THE RELEVANCE OF ACOUSTIC CONSIDERATIONS IN ARCHITECTURAL AND URBAN DESIGN.

When plans are developed, it is important to bring issues concerning noise and vibration to the table as early as possible. Only then is it possible to select the most effective countermeasures. Sound and vibrations caused by traffic are key consideration in environmental impact assessment reports routinely drawn up whenever local planning will have a measurable effect on the environment, health or the depletion of natural resources. A good local plan should be followed by sound construction planning where issues concerning noise and insulation are explored thoroughly. The architect therefore has the duty of identifying sources of noise and takes steps to control them.

Acoustic considerations are important in planning and building design due to the following reasons:

- Primarily, noise is a source of pollution, which is unhealthy for human habitation.
- Spaces are designed in different shapes, sizes and which tend to create acoustical problems. However, a technical knowledge of acoustics helps the designer to ensure that such spaces are comfortable.
- As Buildings in the urban environment differ, so do their function. Hence different sounds are produced via different means such as mechanical equipments and generating sets, which combine to create noise therefore, there is the need to consider such situations and find solutions to them during and after design.
- Furthermore, the urban environment is zoned into sections in the cause of its design. These areas are not only zoned according to their sectors but also according to the noise levels emitted by each area, this helps in the avoidance of background noise in urban design. For instance, the industrial sector tends to emit the loudest noise in the urban environment hence; they are usually zoned to the urban fringe in order to stop noise from affecting the order areas of the environment.
- Acoustics also helps designers to determine the type of building material to be utilized in the varying parts of the urban environment. It also helps engineers to come up with methods controlling noise derived from equipment and machines such as the use of “silencers” in engines to eliminate noise.
3.0 SOURCES OF URBAN NOISE

A good acoustic environment requires a variety of noise forecasts at an early stage. Silence is a rare commodity and for this reason, there are parts of the countryside that are preserved so that we may continue to enjoy their unique natural features. However there are still problems of urban noise within the environment. Truly quiet ‘zones’ are few and far between.

- **Traffic**- The greatest noise problem is caused by traffic. In Sweden, it is estimated that over 1.5 million people are disturbed by the sound of traffic. Noise from trains and planes is a lesser problem – yet more than two million people (out of a population of nine million) are exposed to traffic noise exceeding 55 dB (A).

- **Industries and plants**- Noise often emanates from a number of sources in an industrial environment, ranging from small fans to big conveyors, and even in entire buildings that literally radiate sound some times. The idea is to muffle noise at the source.

- **Construction sites**- Noise from this source pose hazardous both physically and mentally. For extensive, long-term construction projects there are environmental demands to be met for example, noise must remain within permissible limits for the duration of the project.

- **Recreation and Leisure activities**
  
  Some leisure activities are noisy too; such as motor racing and firing ranges. This goes to show that building and production are not the sole culprits of urban noise.

- **Wind turbines**- Sound is a key environmental issue when setting up wind turbines. Noise raises both discussions and emotions among residents nearby and is very often utilized as basis for appeal once planning permission has been granted.
4.0 CONTROL OF URBAN NOISE

Urban environments are unavoidably noisy but even in the most populous cities, people have a right to a decent quality of life. At the very least, all planning discussions regarding housing should stipulate peace and quiet. A ‘quiet side’ of the house, an undisturbed bedroom or a silent outdoor area should be minimum demands for any residence.

Noise and vibration can be controlled. When local plans are drawn up, it is important to bring issues noise and vibration to the table as early as possible. Only then is it possible to select the most effective countermeasures.

The promulgation of regulations setting maximum noise limits on a gamut of motor vehicles, industrial machinery and household appliances by the governing authority of an urban area could help control noise. One of the first cities in the U.S. to achieve a comprehensive Noise Element of the General Plan was Burlingame, California.

The manufacture of quieter devices can help influence the future of a quieter generation of machines.

Sound and vibrations caused by traffic are key consideration in environmental impact assessment reports routinely drawn up whenever local planning will have a measurable effect on the environment, health or the depletion of natural resources. A good local plan should be followed by sound construction planning where issues concerning noise and insulation are explored thoroughly.

The use of the services of and recommendations acoustical scientists before finalizing highway and transit designs.

Insulation thousands of homes in the vicinity of major airports, based upon computer modeling of alternative insulation.

The muffling noise at the source. Noise varies according to distance and direction. Therefore effective methods for identifying the noise that needs to be muffled and to what extent can be developed.

Noise barriers and landscaping should be viewed as an integrated, complementary system. Choices of materials, textures, profile, and location should be done in such a way that the various elements fit together into an integrated whole. A balance should be struck between wall decorations and landscaping so that they do not compete with each other.
5.0 GENERAL ACOUSTIC GUIDE LINES FOR URBAN DESIGN

The basic acoustic requirements for the urban environment begin with the planning and blueprints of the area. A functional urban area is one in which the acoustic properties are put into consideration from the inception period of planning. In modern urban areas, the problem of noise is multi-dimensional. Since the industrial revolution, the sources of everyday noise have increased dramatically. The advent of modern machinery and equipment that we now depend on, results in an environment with noise levels above what we considered normal. The legislative bodies also play their part in ensuring that healthy noise levels are maintained in the sectors of the environment that are notorious for noise production. Recent noise legislation (in 1994) tries to protect residents from some sonic intrusions, by giving strict guidelines to bars, restaurants, night clubs etc. about interior acoustic insulation and exterior noise levels. Residential areas are not to exceed 45 dB.

Physical control measures deals with the layout and zoning of the urban environment. A hierarchy of quiet, low noise and high noise areas is achieved. There is also the creation of buffers and barriers between zones.

Proper offset of buildings from roads and use of fences, shrubs and trees also help to reduce noise caused by traffic. Parking spaces could be located in front of buildings or underground.

Airports should be located away from the city centre and at the fringes.
Noise from Industrial areas and Engineering can be curtailed by the use of any or a combination any of the following hierarchy of control; Elimination, Substitution, Isolation, and Engineering noise control at source. The “Buy Quiet” means of control alongside zoning can also be by companies whose work processes emanate noise. Administrative measures can also be utilized.

Building materials utilized need to be sound and acoustics friendly for proper function of the total environment.

Awareness can be created about the hazards of loud noise to man and animals. It is achieved through print and television media, internet, political rallies, seminars and conferences such that even the common man has good knowledge of the psychological and physiological effects of sounds and noise to him and therefore tries to avoid it at a very early age.

Other considerations are;

- **Self-Protecting Building Design and Arrangement**
- **Integrated Building-Noise Source Design**
- **Purpose-Built Noise Barriers**

**Acoustic Insulation of Buildings**
6.0 CASE STUDY:

(Hong Kong Special Administrative Region)

Policy Objectives

The Hong Kong Government’s overall policy objectives for noise control are:

(a) To control specific sources of noise through enforcement of the Noise Control Ordinance (NCO) and its associated regulations;

(b) To prescribe noise standards to guide those concerned with development in planning against noise in both the public and private sectors; and

© To have due regard to noise in planning public development projects.

Guidelines of Noise Emitters

Aircraft

Exposure to aircraft noise is described by Noise Exposure Forecast (NEF) contours. Table 1 shows the contours, which are recommended in the Final Report, Kai Tak Consultancy October 1988 and applicable to the Hong Kong International Airport (Kai Tak) operated under an enhanced capacity scenario. Owing to their relatively infrequent movements of Helicopter, it is more appropriate for planning purposes to observe the daytime (7 a.m. – 7 p.m.) permissible maximum noise levels at noise sensitive uses. Night-time operations of helicopters will generally be more intrusive than daytime operations. The severity of Road Traffic noise impact on sensitive uses depends on many variables, some of which can be controlled or influenced by land use planning. These variables include road alignment, traffic composition and volume, line-of-sight and shielding.

Table 1: © Noise Levels from Road Traffic

<table>
<thead>
<tr>
<th>Peak hour traffic flow (veh/h)</th>
<th>Vehicular speed (kph)</th>
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<tbody>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>250</td>
<td>70</td>
</tr>
<tr>
<td>500</td>
<td>73</td>
</tr>
<tr>
<td>1000</td>
<td>76</td>
</tr>
<tr>
<td>2000</td>
<td>79</td>
</tr>
<tr>
<td>3000</td>
<td>80</td>
</tr>
<tr>
<td>5000</td>
<td>83</td>
</tr>
<tr>
<td>10000</td>
<td>86</td>
</tr>
</tbody>
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As a general guide, Table 2 gives the approximate separations required for achieving the noise standard for residential developments fronting various types of roads. For typical Hong Kong situations, the largest reduction would most likely be obtained by using noise tolerant buildings as screening structures, rather than by means of the separation between road and receiver.

Table 2: Broad Guidelines of Separations Required between Various Types of Roads and Residential Development

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Assumptions</th>
<th>Distance Separation to meet L10(1h) 70dB(A)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>without screening</td>
</tr>
<tr>
<td>Traffic flow (veh/h)</td>
<td>Vehicular speed (kph)</td>
<td>approx. 300m</td>
</tr>
<tr>
<td>Trunk</td>
<td>5000</td>
<td>70</td>
</tr>
<tr>
<td>Primary Distributor</td>
<td>3000</td>
<td>50</td>
</tr>
<tr>
<td>Secondary Distributor</td>
<td>2000</td>
<td>50</td>
</tr>
</tbody>
</table>

- **Rail Traffic**: Community reaction to rail noise depends largely on three factors: the maximum pass by noise level, the frequency of movement and the time of the noise events. In Hong Kong, where rapid rail cars inevitably pass through densely populated high-rises for most of the day, planning of new sensitive uses contiguous to existing rail lines and planning of new rail lines must take full cognizance of these factors.

- **Fixed Sources**: all fixed noise sources should be so located and designed that when assessed in accordance with the TM, the level of the intruding noise at the © of the nearest sensitive use should be at least 5 dB(A) below the appropriate ANL.

- **Other Facilities**: Some of the general considerations to be taken during the planning stage are to: locate the facilities so that there is no line-of-sight of the noise sources at the noise sensitive uses; provide screening to the noise sources as far as possible by making use of natural landscape, embankment or noise tolerant buildings, void locating open-form major public transport termini, locations of ingress/egress.

**Guidelines to Reduce Noise Exposure**: In situations where adequate separations between sensitive users and noise emitters cannot be provided, the following methods, find applications in the Hong Kong context:

(a) Self-protecting building design and arrangement;

(b) Integrated building and noise source design (e.g. decking over);

© Purpose-built noise barriers; and

(d) Acoustic insulation in buildings

*Acoustic Guidelines For Urban Design*
7.0 CONCLUSION

Since the level of background noise determines what we can hear in a space, it
determines the level of acoustical excellence. This is truly the secret of great acoustics.
Awareness of this secret in the early stages of design brings excellent acoustics for new
critical-listening space within our grasp.

The basic role of planning against noise is to provide an environment whereby noise
impacts on sensitive uses are maintained at acceptable levels. The principle is to ensure
that:

(a) New noise sensitive uses are located where they will not be exposed to excessive
noise levels;

(b) new noise emitters are located as far as possible so as not to introduce excessive
levels of noise to existing, committed or planned sensitive uses; and

(c) Where other constraints do not permit either of the above, noise reduction designs
should be incorporated into the noise emitters at the earliest stage of planning.
Where a completely acceptable noise exposure cannot be obtained at the noise
sensitive uses, acoustic insulation should be provided.

Excessive levels of noise often interfere with verbal communication, disturb
concentration, disrupt sleep, contribute to stress or otherwise detract significantly from
the quality of life. These problems can occur within dwellings, schools, hospitals, homes
for the aged and in recreational areas. Planning is one of the most effective means to
ensure that such problems are avoided or reduced.

The importance of incorporation acoustic guidelines in urban design cannot be
underestimated. Noise is one of the main polluting factors with damaging effects on our
environment. These effects are reduced to the minimum level only by conscious acoustic
designs.
8.0 RECOMMENDATION

There have been numerous examples of successful housing projects – even in noisy environments. Common to all these success stories are two factors:

1) The problem of noise was raised early in the process and
2) The parties involved applied the principle of a ‘quiet side.

When designing a new critical-listening space, the location of noise producing machinery such as air-handlers, and the design of a silent mechanical ventilation system has to be put into consideration from the very beginning. For instance, few people realize that it is possible to supply cool air to a room without creating any noise. It is. However, since this is not the usual practice, such a silent system must be considered from the beginning of design.

The following is a line up of a few reasons why different spaces in the urban area possess terrible acoustics:

- Most spaces are just too big.
- Nearly every space is too noisy.
- Mechanical ventilation systems deliver noise along with cool air.
- Acoustical conditions are different for differing zones and areas.
- Modern construction makes possible shapes and sizes that create all sorts of acoustical problems that were impossible to construct in the past.
- Sound systems are used as a substitute for good acoustics.
- Buildings are planned and oriented without any regard whatsoever for acoustics.
- No consideration is given to acoustics in design until after construction, when everyone discovers, to their great surprise, that the acoustics are awful!

This sad state of affairs doesn't have to be. There are urban areas which possess wonderful acoustics as can be seen in the case study therefore governing bodies, private individuals and the whole community at large should come together to ensure that their environment is healthy and noise free for the physical and psychological growth of the community.
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