CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 SUMMARY

Learning being the main function in classrooms, hearing what the teacher teaches becomes most important. In many of the classrooms this is not fully achieved around the world. The Speech Intelligibility determines how good a classroom is, to achieve its function of learning. Speech Intelligibility is dependent on the background noise and Reverberation time (RT) in the classrooms. However, in classrooms in tropical warm-humid climates, as the natural ventilation plays an important role for comfort levels in classrooms, windows and doors are kept open, supplemented by fans. This aspect adds to the fact that background noise in classrooms gets increased thereby influencing the Speech Intelligibility in such classrooms.

Investigation was carried out in 120 classrooms in schools spread over Nagercoil—a town at southern most part of India with tropical warm-humid climate. The classrooms were classified as i) schools at Noisy- site, that is the schools situated very near to the noise sources-National highways and public roads, ii) schools at Housing site, that is the schools near residential areas and iii) Schools at Quiet area remote from noise sources. The background noise in the classrooms when the classes are unoccupied, occupied by students and when the teacher is teaching were measured. The external noise in schools in different regions was also measured to identify the influence of external noise on internal noise within the classrooms. The
Reverberation time in the classrooms was measured in occupied and unoccupied condition. These values were compared with the national/international standard values of BN and RT. A versatile software ClassTalk was used to calculate RT and those values were compared and found as quite close to the measured values. Using ClassTalk, the Speech Intelligibility parameters such as Signal-to-noise level difference, Speech Intelligibility value (SI) and Speech Transmission Index (STI) were calculated for all the classrooms and critically discussed. A parametric study was conducted to identify the influence of BN and RT. A few suggestions to improve the Speech Intelligibility in the classrooms were suggested and those suggestions were implemented in a few classrooms. It was observed that the suggestions were cost effective and they improved the Speech Intelligibility to a certain extent.

The total measurements, observations and computations carried out are summarized below:

- Measurement of Background noise in 120 classrooms in unoccupied condition. Measurements were taken at different parts of the day at different times and the mean was calculated in each of these 120 classrooms.

- Measurement of BN in 120 classrooms in occupied condition at three positions namely when students are silent, when teacher is speaking and measurement taken in the front row of the student seating and in rear row. Measurements were taken at different parts of the day at different times and the mean was calculated in each of the three positions in these 120 classrooms.

- Measurement of external noise at 75 locations inside and outside the school compound to study the various external
sources that influence the internal noise. At different parts of the day and at different times the measurements were taken.

- Measurement of noise made by fans in the classrooms.
- Measurement of noise made by students during test taking, during opening and closing of pencil box, books, rubbing of shoes on the floor.
- Measurement of BN with coir mat and wall covering in 10 classrooms.
- Measurement of dimensions of the classrooms and other details for calculating surface area, volume, window, door area (opening area). The nature of walls, floors and ceiling were noted along with the number of students in the classroom, the teacher sex and position, the noise inside and outside classrooms. This is used as an input to calculate RT using ClassTalk.
- RT measurement in 30 classrooms each at three positions within each class at different parts of the day and at different times of the day.
- Measurement of RT in occupied and unoccupied condition in same classrooms to calculate the absorption coefficients of children.
- Measurement of RT in those classrooms with Coir mat and wall covering.
- Calculations of RT in 120 classrooms in occupied and unoccupied conditions.
• Computation of SI, STI, SNA, SLA for all 120 classrooms at various positions of student.

• Computation of STI and SI for different Background noise in classrooms.

• Computation of SLA, SNA, STI, SI for various teacher positions in the classroom.

• Computation of STI, SI, SNA, SLA for the BN and RT values suggested by NBC 2005.

• Computation of STI, SI for the classes with Coir mat and wall covering at various student positions.

The conclusions based on these measurements and computations are briefed below:

7.2 CONCLUSIONS

The external noise has an important influence on the background noise in classrooms, and this becomes the basis for determining the Speech Intelligibility in classrooms. It was seen that the average external noise at the façades of schools at Noisy-sites was 60.2 dB $L_{Aeq}$; at the schools of Housing sites and Quiet sites it was 53.6 and 50.6 dB $L_{Aeq}$, respectively. For the same schools the BN values in classrooms were respectively, 51.6, 48.8 and 45.3 dB $L_{Aeq}$. When external noise of such magnitude exists, this noise intrudes into classrooms with open windows and doors, and the BN in the classrooms are of levels which are above the national/international standards. However, for some of the schools at Quiet sites the average BN is around 45 dB $L_{Aeq}$, which is the upper limit of BN for school classrooms as stipulated by NBC 2005. Nevertheless it should be the aim of the planners of schools to locate
the schools at locations which would conform to the recommended BN in classrooms.

The classrooms located closer to external noise sources showed higher average sound levels than those located farther away from the external sources. When the classroom in the school is nearest to the noise source, BN was 56.9 dB $L_{A_{eq}}$, whereas a class, which is away from the noise source has a BN of only 46.0 dB $L_{A_{eq}}$. Thus it is emphasized that by locating the learning spaces within the school as far as possible away from the noise sources it would definitely be possible to meet the requirement of BN for the classrooms. The international guidelines for background noise seem to be difficult to achieve in countries where schools are in tropical warm-humid climates, and closed enclosures for classrooms are not practicable. The background noise in the classrooms is influenced by the external noise in the surrounding environment. If proper care is taken to locate the schools away from noisy surroundings, the acoustic performance of the school classrooms can be made acceptable.

The BN of occupied classrooms, even when the students are silent, increased by about 9 dB $L_{A_{eq}}$ above that of empty classrooms in all the three sites of schools. The BN in the occupied classroom is the basis for finding the signal-to-noise level difference in the classroom and therefore in determining the Speech Intelligibility. Though the background noise in the empty classrooms may to some extent indicate the acoustical quality, to assess the acoustical performance in classrooms, it is desirable to specify the background noise in the silent, occupied classrooms as well as a standard. It is better to monitor the Speech Intelligibility in classrooms when students are present, rather than in unoccupied classrooms.
The intelligibility of speech in a classroom was influenced not only by the background noise, but also by other parameters like Reverberation time, and the distance between the teacher and the students. The acoustical quality of classrooms depends on signal-to-noise level difference and RT, as is well established by researchers. The mean Reverberation Time for the unoccupied class is around 1.3 s, and the average RT in the occupied class is 0.7 s. The RT values are higher than the international standards; however, they are closer to the value of RT stipulated by the Indian standard of 1.25 s for the unoccupied class. For the occupied classrooms the RT is below the value of 0.75 s stipulated in the Indian standard. As the classrooms are of smaller size, the length and breadth of the classrooms are around 6 m, the Early Reflection Time of the speech signal of a teacher would be about 35 ms, and this also enhances the Speech Intelligibility of the classroom. With this measured BN and calculated RT, the Speech Transmission Index was calculated for the classrooms. It was found that 90% of classrooms at Quiet sites were in the acceptable range and at Housing sites 68% of the classrooms were acceptable. However, at Noisy-sites which were located near highways on public roads, with open windows and doors, the BN in classrooms in the occupied condition reached about 61.2 dB A and hence only about 28% of classrooms were acceptable. When the students occupy the class, the noise level rose by about 9 to 10 dB A in classrooms at all sites, as discussed in the earlier part of this study, and so the Speech Intelligibility is in the ranges discussed above. However, as shown, if the increased noise level of 9 to 10 dB A can be reduced by a small amount the resulting intelligibility in classrooms can be enhanced to ‘Good’ and ‘Fair’ conditions. Thus if the background noise in the classrooms could be maintained as close as practicable to the BN of the unoccupied condition, in which it was seen that all the classrooms had SI within the acceptable range of ‘Good’ and ‘Fair’.
The National Building Code (NBC 2005) stipulated for school classrooms BN of 40 to 45 dB A and RT of unoccupied class 1.25s and occupied class 0.75s. In order to study the Speech Intelligibility of classrooms with these values, some classrooms with these values were analyzed to evaluate Speech Intelligibility parameters. With BN of 45 dB A and RT of 0.7 s the classroom was in the range of ‘Good’ and ‘Very Good’ only, though in many classrooms around the world have ‘Excellent’ Speech Intelligibility range when they conform to the respective regulations. But in reality even with 45 dB A for unoccupied condition, as it was observed in the whole study the background noise increased by about 9 dB A when the students occupied and with these (NBC 2005) BN and RT the Speech Intelligibility could be only at the level of ‘Good’, which is two stages below the ideal condition. In the rear row the Speech Intelligibility was much less than at the front row.

The BN and RT being the parameters influencing the Speech Intelligibility, to improve BN and RT in classrooms, the cement floor was covered with coir mat and a few wall coverings were provided and it has reduced BN by 3 to 4 dB A and RT getting reduced by about 0.1 s. These two reductions had good influence on Speech Intelligibility parameters and the Speech Intelligibility has improved a step higher towards acceptability. The measures tried are also cost effective. The coir mat was the coconut fibre mat. The cloth used for the wall covering was also a thin cotton material of affordable range (for the schools to purchase if necessary). If thicker material for wall covering was used better SI reduction could have been achieved.

It was observed that by proper layout of classrooms within the schools kept away from noise sources, Speech Intelligibility can be improved. Similarly by properly locating the schools away from the noise sources like National highways etc, students can really enjoy the learning environment in the classrooms.
7.3 LIMITATIONS

All the classrooms studied are rectangular in plan; however there may be other shapes like hexagonal plan for some classrooms etc. Though measurements for background noise and RT in classrooms have been done and compared with calculations, for Speech Intelligibility, only computations have been done. Measurements could be done to verify the computational values. The activity based teaching involving 4-6 students in a group which being introduced by the Government very recently has not been included in this study.

7.4 SCOPE FOR FUTURE RESEARCH

It is observed that the regulations for Acoustics in school classrooms in India according to NBC 2005 appear to be very liberal and more measurements and computations at other types of classrooms such as open type classrooms could be done to make a detailed study for improvement. Present introduction of activity based teaching in some schools also changes the scenario of background noise in classrooms and a detailed study would lead to better acoustics in classrooms for such teaching methods. The light clothing of children in warm-humid climates has been taken for this study, whereas for other climates appropriate clothing may be required and their influence on classroom noise environment can be further studied. To reduce BN and RT other materials and methods though not cost effective can be studied.