inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 0.7

DESIGN FACTORS FROM EXPERIENCE THAT CAN BE STUDIED IN ARCHITECTURAL ACOUSTICS COURSES

G. Rosenhouse

Faculty of Civil Engineering, Technion, 32000, Haifa, Israel

Tel.: +972 482 35546 / Fax: +972 482 35546 / Email: gsrjudy@techunix.technion.ac.il

Keywords:
URBAN ACOUSTICS, EDUCATION, NOISE POLICY, STANDARDS

ABSTRACT
Academic education establishes fundamentals while experience gives the details. Practice enables the choice of the best out of a variety of alternatives by using common sense and distinguish between the more and the less important. Examples of such considerations are brought in the text. Questions that should be included already in fundamental courses about architectural acoustics are: How exact can acoustic estimations be? What is the preferred solution in different cases? The answers have to be based on experience in acoustic design.

1 - INTRODUCTION: THE PROFESSIONAL BACKGROUND NEEDED IN BUILDING ACOUSTICS DESIGN
The building acoustics consultant is a legitimate partner in the group of experts that participates in the architectural design. Building acoustics involves sound sensation by the ears and the feeling of vibration by other parts of the body. The problems to be solved comprehend sound quality (e.g. in lecture and concert halls), noise nuisance (e.g. in residential areas) noise damages (e.g., in the industry). The acoustic problems have to be solved by combining architecture and engineering design that is aided by experience by case studies, familiarity with regulations and design ingenuity. All these features should be included in courses of architectural and building acoustics, including detailing and exercises during one semester at least (14 weeks), including physical background, technical units and sound level calculations, acoustics of building details (small rooms, walls, openings, and floors) halls, industry and urban premises. The higher levels involve the acoustics of students' projects and in advanced postgraduate courses, including theoretical acoustics, commercial programs (ray-tracing, boundary elements and so on), cost estimates and sound and vibration measurements.

2 - POLITICAL ACOUSTICS AND THE PERMISSION TO BUILD
The architect (even at the stage of studentship) has to satisfy demands for minimizing environmental damage, as a condition for building permission. Hence, during studies in architecture it is common to introduce environmental acoustics. The architect has mostly to confront authorities and too often bureaucrats that are unqualified in acoustics and on the other hand enforce unreasonable limitations on projects or even prevent them. In any case, often for hidden reasons, they do not refer to the real problem [1]. This reality develops a type of "acoustics" that not necessarily uses science, engineering, technology and architecture. We coin the name of this field of acoustics as **political acoustics**, where "right connections" with the "right people" that have the "right to sign" are much more important than acoustics itself. One example to subjectivity in acoustic decisions is a project of **buildings alongside railway lines**: An owner of an area of about 70 × 250 m by a railway (250 m along the railway) dedicated it to be residential. He was not allowed to build at a distance closer than 50 m from the railway. See figure 1, so that only 20 m were left of the 70 m for construction. The obscure demand of the Ministry of Environment was to build within the permitted area an external sound barrier for all 4 floors, in spite of the fact that the buildings were not built yet. The reasonable approach in such cases is to design acoustic protection in the architecture of the flats. Finally, after three years of dispute, the railway management agreed on a small earth berm close to the railway, as an alternative to the unreasonable sound barrier -

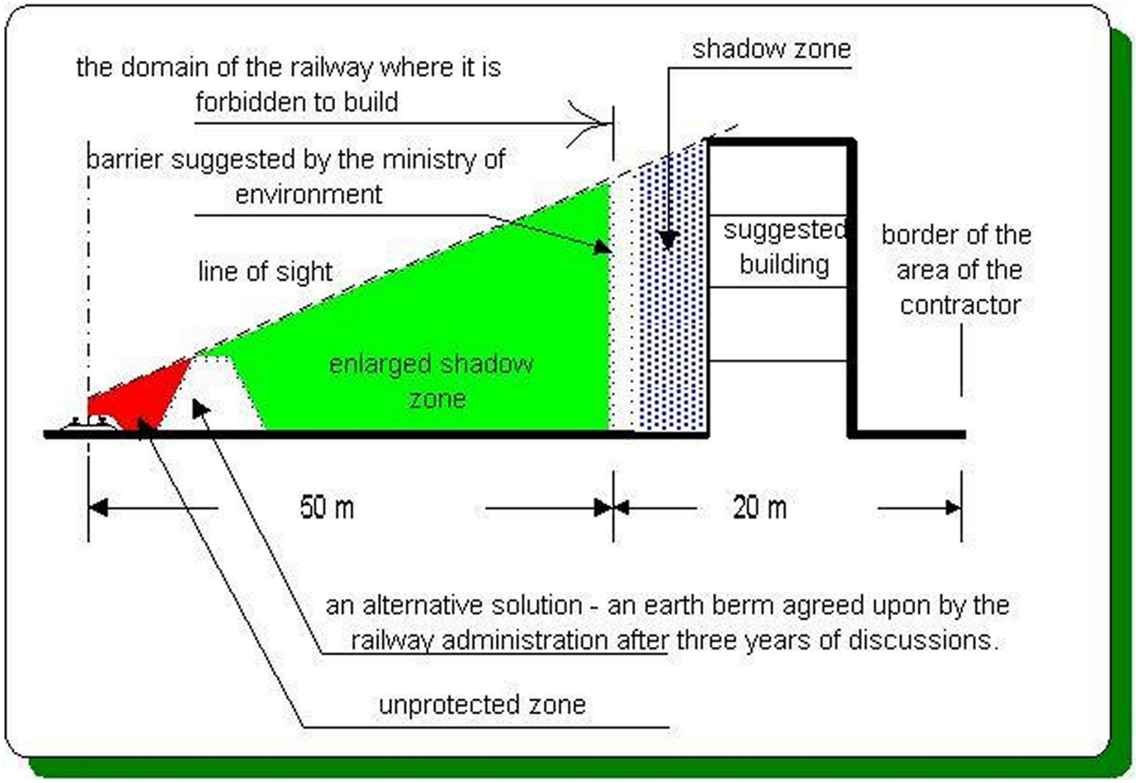

Figure 1: Design of a sound barrier by a railway.

see figure 1. It should be remembered that interests might reverse with time, and the railway managers might be interested in selling areas close the railways for construction purposes, or wish to build roads and railway lines along residential areas.

3 - NUISANCE, TOLERATION AND STANDARDS

Regulations against excessive noise exist all over the world. These regulations include bounds to tolerable sound and vibrations. They distinguish among noise sources in urban areas, transportation (mostly airplanes, vehicles and trains) and industry. Such regulations are agreed upon in committees, whose members include in part lobbyists and environmental extremists. Hence regulations are generally subjective (see figure 2). Yet, in order to encourage new acoustic designs and improvement of acoustic situations, the quantitative acoustic standards should be strictly kept. Sound levels should not exceed the permitted ones, but on the other hand, **acoustic tolerance** is to be established, against complaints of hypersensitive people and abuse by troublemakers (also from the authorities). Noise prevention and tolerance should combine together in order to find the "golden path" of noise reduction.

4 - ORDER OF MAGNITUDE

Prediction of transportation noise for design purposes has become a tool used also by the Ministry of Environment, based on the standards, to object to building projects. If for example, such a prediction shows 63.8 dB (A) in the year 2020 and the standard allows for 64 dB (A) limit in front of the house, the requirement is satisfied, while 64.3 dB (A) can cause rejection of the project. Yet, the error in sound level measurement can reach, say, 1.5 dB (A) under daily circumstances. Consequently, this pseudo-acoustic attitude reflects ignorance, lack of experience, stupidity and probably even evilness. It should be also born in mind that transportation predictions use empirical formulae obtained by statistical regression and data that might be collected in irrelevant areas. Table 1 shows results of measurements as compared with results obtained in a typical project, using advanced transportation prediction programs, TNM and TNCAD. Comparing the results by TNM and TNCAD shows that the results in the latter are higher (50>51, 53.5>47, 55>53). The difference reaches up to 6.5 dB (A). Comparing measurement results with TNCAD shows that sometimes the TNCAD gives higher results (42<55), and sometimes lower results (53.6>51, 54.3>53.5). The difference is between 13 dB (A) and -2.6 dB (A). Even for calibration purposes this margin of difference is too rough. Predictions towards the year 2025 seem

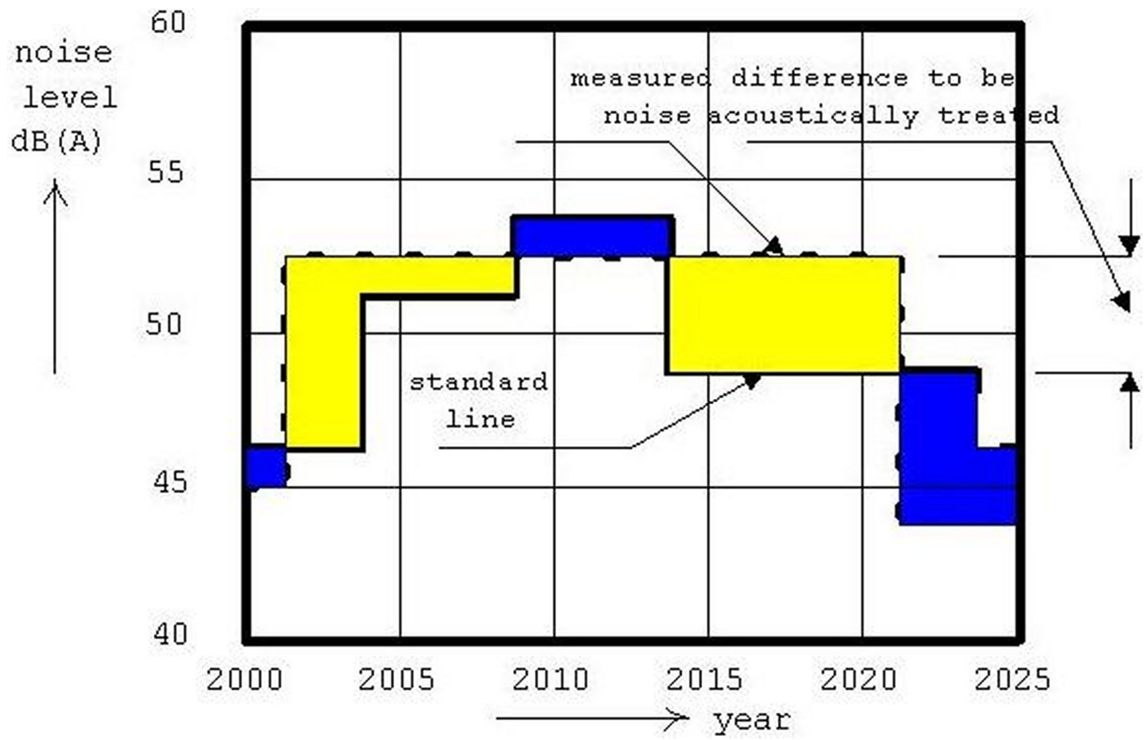

Figure 2: Change of standards and measured noise with time.

to be much coarser. Hence, the use of such programs to stop or limit projects by the Ministry of Environment is wrong, and an engineering design approach should be preferred. Prediction programs or simple approximations are not wrong, but they should serve as design tools, which emphasizes the acoustic design and the use of qualified experts both in practice and teaching.

Control Point	Measurement L_{eq} (dB(A))	Estimated Level-TNM; L_{eq} (dB(A))	Estimated level-TNCAD L_{eq} (dB(A))
P_1	53.6	51.0	50.0
P_2	54.3	53.5	47.0
P_3	42.0	55.0	53.0

Table 1: A comparison of prediction and measurements of transportation noise.

Sensing the order of magnitude is very important. Figure 3 shows a control point P at a distance of 150 m from a source S. Correction of distance due to height difference has been introduced, using units of 50 cm. The Ministry of Environment rejected the calculations and asked to use centimeters as units instead of 50 cm. To be remembered for generations: The difference that could be easily examined before rejection is 0.00002 dB (A) at most!

5 - PHYSICAL INTERPRETATION

A correct physical interpretation is of importance in building acoustics. As an illustration, Figure 4 depicts a cross-section of a shallow valley with a source S (road). At the upper edge of the valley there is a control point P (building). The Ministry of Environment demanded addition of 3 dB (A) due to reverberation of the valley. The trouble is that since the valley is half-open, there is no reverberation in it (compare to a plane). Also, the roughness of the valley adds scattering. After a long dispute, the Ministry has sent a letter of apology.

6 - QUANTITATIVE TRAINING

Up to now it has been shown that acoustics has to be treated as any engineering area. Two examples illustrate this. The first one is of a building site of a high-rise building, near a lawyer's offices. The drilling of piles has caused extremely high noise at the offices. The solution: a. Replacement of relevant windows by acoustically better ones. B. Shielding the drilling domain. c. Locating the generator at a

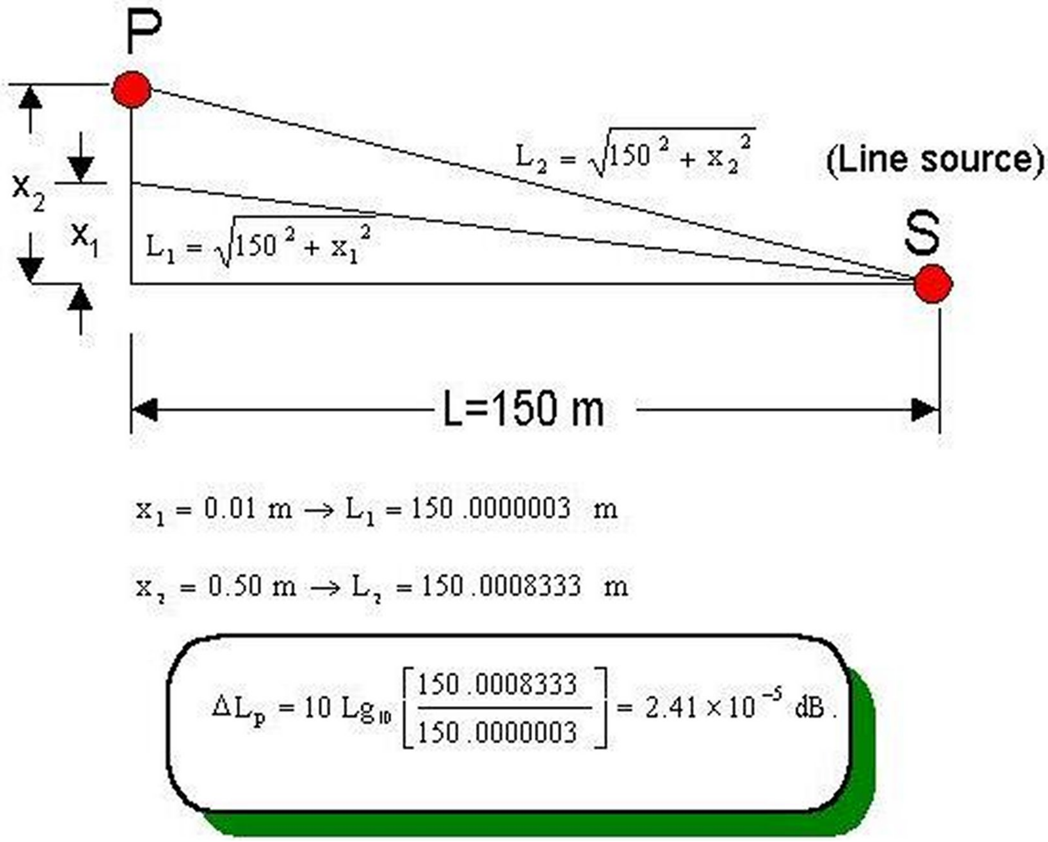

Figure 3: An example of difference in sound level estimation, due an error in distance.

shadow zone in the excavation (see a simplified scheme in figure 5). The reduction was about 25 dB (A), without intervention by the Ministry of Environment and no dispute.
The second example is presented as data for an exercise in Figure 6. The student should calculate sound levels in halls, reverberation time, transmission loss and suggest acoustic treatment. There are about 20 different homework exercises like this each semester in a course.

7 - CONCLUSIONS

Acoustics in its origin is a physical area that appears in many engineering, architectural and medical applications. Hence, proper acoustic solutions are based on both physical understanding and mathematical formulation. Obviously, the description of the physical world in mathematical terms needs simplifications because of abstraction reasons. The consequence is that there is a need to consider the essential and ignore the incidental. This need justifies studying the fundamentals of physics and mathematics in engineering and architecture. The main reason is the development of common sense in the relevant areas. Other reasons are production, testing the graduates' abilities, and preventing as much as possible ignorance and charlatanism (except for the extremely rare example of people who are self-educated or lower level academic graduates). Building acoustics is not exceptional and should be recognized as an academic profession, as are doctors of medicine, structural engineers or lawyers, for example. This is much better and less dangerous than appointing uneducated people to positions in technological areas. Hence, it is important that only people with relevant academic background will be formally authorized to perform acoustic design and to control acoustic projects done by others (a single formal course on acoustics does not suffice for that purpose). Introduction of all these ingredients that are based on centuries of experience is an important task of teaching acoustics to architects.

8 - AN IMPORTANT NOTE

Any resemblance of the above examples to reality is incidental. Reality can be much beyond imagination.

REFERENCES

1. **H. Oalken**, Science burdened by bureaucrats, *Physics Today*, Vol. 3 (88) (August), pp. 15, 1988

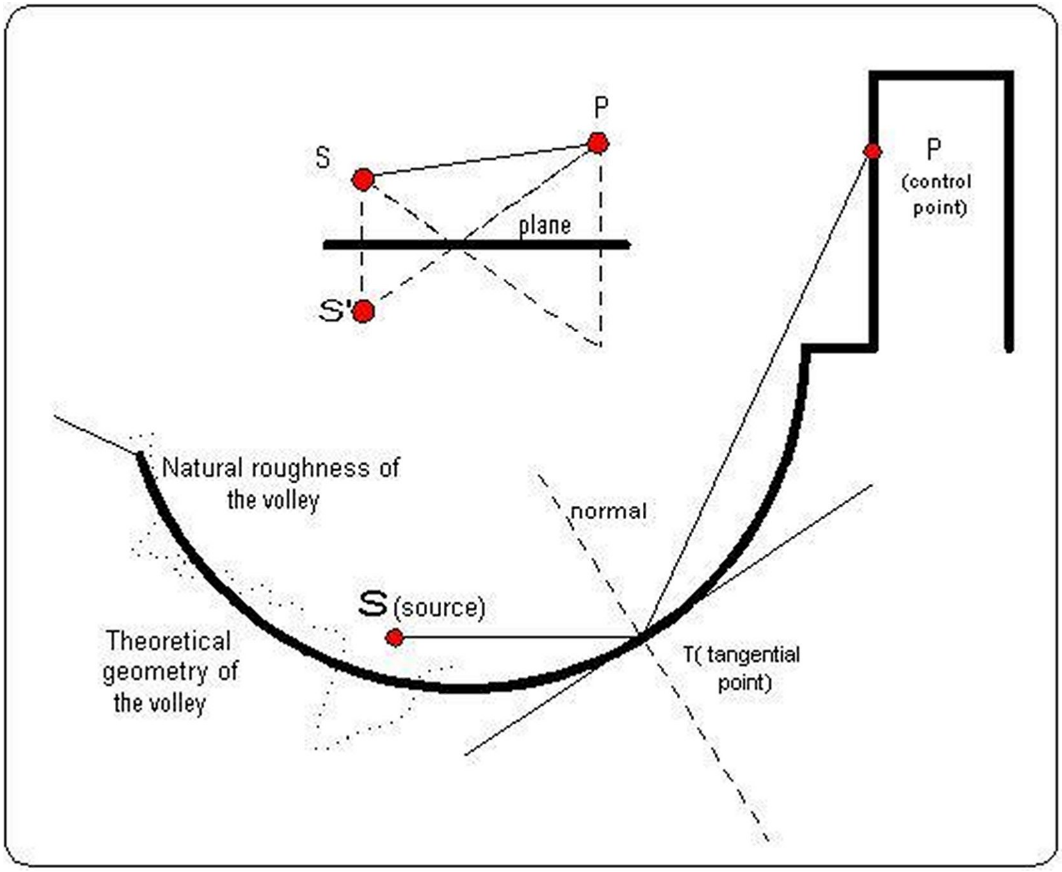

Figure 4: Reflection of sound in a valley.

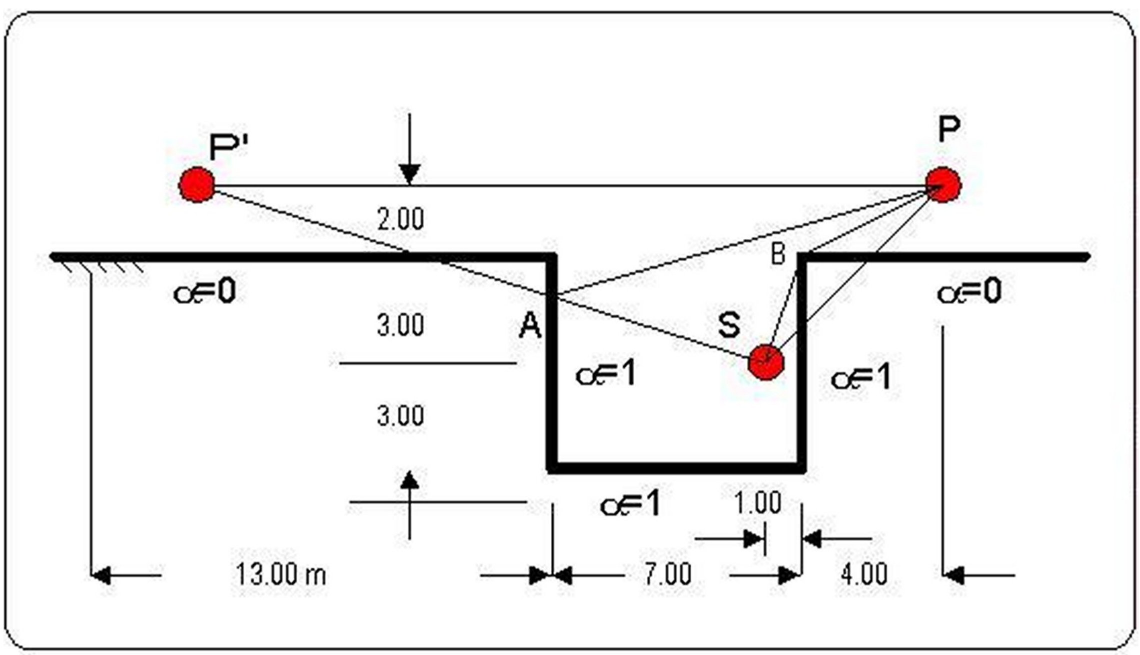

Figure 5: Shielding against noise in a building site.

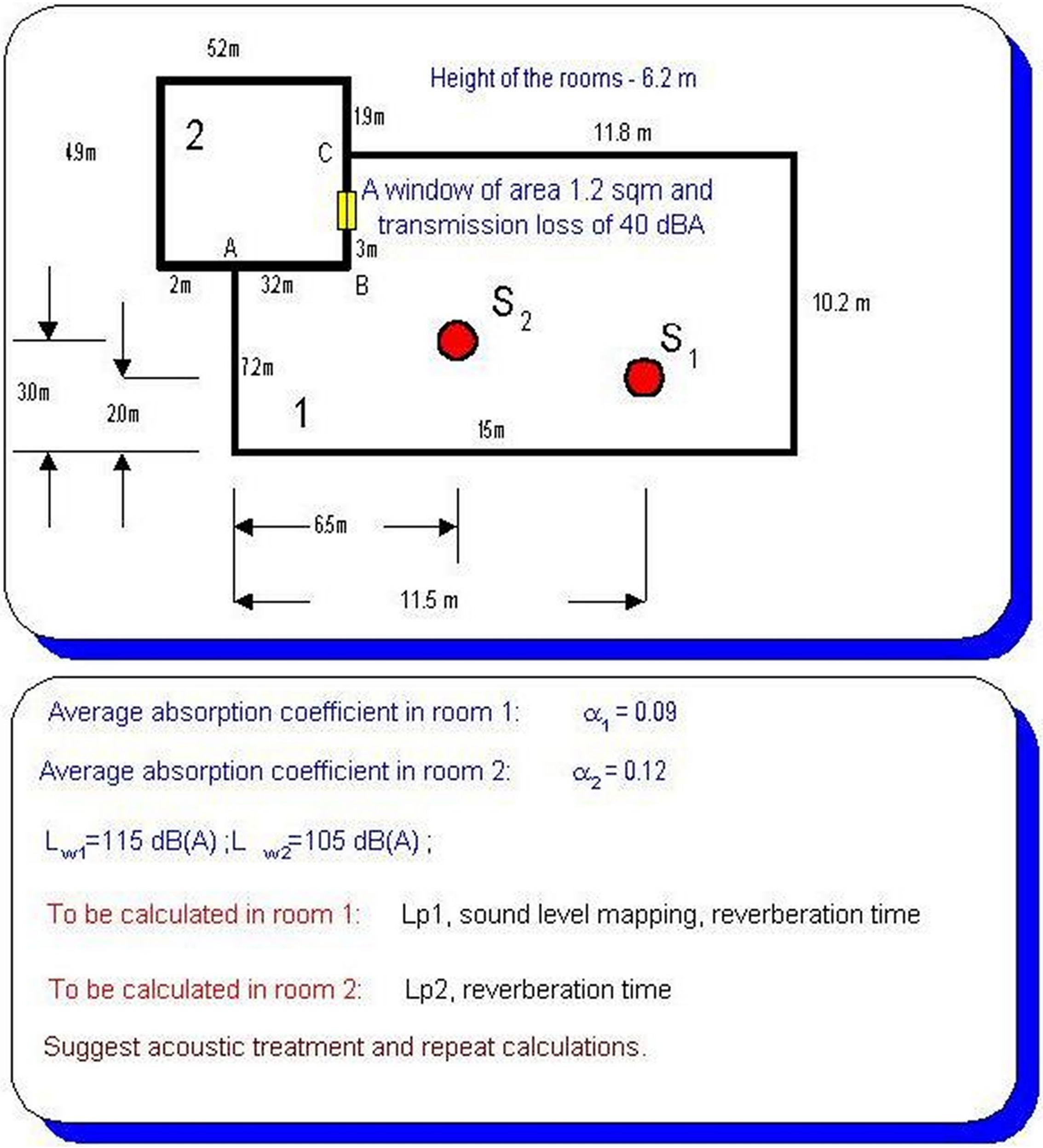

Figure 6: An example to data for student's exercise.