# APPLYING THE URBAN CONCEPT OF 'NEIGHBOURHOOD UNIT' TO A RESIDENTIAL SETTLEMENT OF 100,000 PEOPLE AND THE REALISTIC POSSIBILITIES FOR CREATING ENVIRONMENTAL PROTECTION FROM NOISE

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## INTRODUCTION

The recent rapid industrial and social development of European towns is characterised by intensive population growth as a consequence of natural reproduction and migration. This has led to a need for planning and creating many new urban structures.

In the planning of these new urban structures the urban planner must coordinate all building functions in a cost-effective way and according to the principles of urban planning. These principles include noise protection as well as other requirements of modern city living. It is very important that noise protection is considered in the initial planning phase, particularly in the case of residential buildings. If this is not done, fundamental errors are difficult, if not impossible, to correct in the later stages of realisation.

Outside noise is a parameter which determines the urban planner's approach to the orientation and grouping of buildings, the distance of the buildings from the source of the noise, and the building and creation of natural and artificial noise barriers. The outside noise determines the urban approach as well as the architectural conception of buildings. It influences the modelling of the volume of the building, the orientation of certain spaces inside the building, and the choice of building materials and constructions. In the urban concept I am discussing 90% of the buildings' surfaces represent residential apartments. Therefore, noise protection is particularly important. For this reason systematic measuring procedures have been devised and carried out within one realised neighbourhood unit $A_1$-4.

## 1. Essential Characteristics of the Applied Urban Concept

The characteristic which differentiates this urban concept from other similar concepts applied in Europe is that it replaces the usual residential unit of 4800 inhabitants with 'local units' of 13,500 inhabitants each. This increase in the number of inhabitants is sometimes above the optimal level for the organisation of all contents.

The 'local units' are divided into 4 'neighbour hood units' with 3400 inhabitants each in 1000 apartments. This size is very suitable for the organisation of childcare facilities, safe playgrounds and green areas, as well as the creation of shops, markets and various other services.

Two 'neighbourhood units' are connected with green open living space thus forming 'residential units'. The 'residential units' comprise 6000 inhabitants in 2000 apartments. This size is suitable for the organisation of an elementary school and recreation areas for adults. The green open living space takes up the middle area of the local units, thus forming a massive green area. The centre of the local unit begins at the boulevard and divides the unit into two halves. Along its axis is a pedestrian walkway lined with markets, shops, cafes, cinemas etc. The pedestrian walkway is connected with the pedestrian walkways of the neighbourhood units, which creates a network of pedestrian walkways.

## 2. Neighbourhood Unit $A_1$-4

The neighbourhood unit $A_1$-4 where the measurements were carried out covers a surface of 13 hectares with population density of 270 residents per hectare, average height of 6 storeys and 15 blocks of apartments. The blocks are arranged around the 'collector' residential road with parking areas. The local traffic between the residential blocks is carried along 3 pedestrian walkways.

| Subjective evaluation of acceptable noise for residential areas | $L_{eq}$ | TNI | $L_{NP}$ | $L_1$ | $L_{10}$ | $L_{50}$ | $L_{90}$ |
|---|---|---|---|---|---|---|---|
| Quiet- acceptable | up to 55 (night,45) | 63 | 63 | 62 | 54 | 48 | 51 |
| Reasonable - acceptable | up to 62 (night, 48) | 70 | 75 | 73 | 65 | 60 | 54 |
| Noisy - normal unacceptable | values above 'Reasonable - acceptable'. | | | | | | |
| Very noisy - completely unacceptable | over 76 | 85 | 88 | 88 | 80 | 73 | 67 |

Table 1.

Residential blocks with average and tall height are built on the outside of the neighbourhood unit, while the low height blocks (under 4 storeys) are on the inside facing the green recreation areas. The urban location of the blocks is in the shape of a horseshoe, which expresses the symmetry of the planning of the complex, so that the neigh bourhood units are always located between 2 boulevards. These boulevards are the main source of noise. The noise form the boulevards is characterised by the density of traffic, the types of vehicles, and time variation.

3. Measuring Procedure
The measuring procedure was carried out using the portable system of Bruel & Kjaer, which includes a statistical analyser of noise 4426 as well as instruments for measuring weather conditions manufactured by ULTRACUST, W Germany. Later in the paper the Leq values will be shown and the measured statistical values as $L_l$, $L_{l0}$, $L_{50}$ & $L_{90}$. In addition, the TNI Traffic Noise Index) and $L_{NP}$ (Noise Pollution Level) will be shown.

The essential criteria for estimating the measuring values of traffic are shown in Table 1.

4. Measurement Results
Measurement Point No 1 (MP1) is beside Boulevard A. The surrounding grass area is 35 m long, broken up by a residential road with parking spaces on both sides. The nearest reflective surfaces are residential buildings from neighbourhood units at a distance of 65 - 70 m. This means that the measurements at this point (MP1) are taken in an open space without any obstacles, which contributes a great deal towards obtaining real values of the noise created by the characteristics of the traffic flow.

As shown in Table 2, the measurements were taken during 5 periods of the day. The values obtained during peak hour traffic (afternoon and morning) are almost identical and result in an $L_{eq}$ of 75 dB(A) (1424 vehicles per hour) in the afternoon and 75.6 dB(A) (1386 vehicles per hour) in the morning at a speed of 50-60 km/h. The late afternoon period has half the number of vehicles (645 vehicles per hour) compared with the number of vehicles during peak hours, but has the same ratio of light and heavy vehicles (87.1%: 12.9%). The resulting $L_{eq}$ of 72.6 dB(A) compared with the preceding 2 periods represents a decrease of 2.4 - 3 dB(A) of the noise level, which is close to the values cited in the literature. In this case, however, the ratio of light to heavy vehicles has been defined, namely 87% light vehicles and 13% heavy vehicles in the traffic flow.

The period between the morning and afternoon peak hour is characterised by a flow of 810 vehicles per hour which is 20.2% higher than the late afternoon measurement and 42.2% lower than the peak hours. However, the measured Leq of 76.2 dB(A) is higher than those of the other 3 periods. It is 3.6 dB (A) higher than the late afternoon $L_{eq}$; and 1.2 dB(A) and 0.6 dB(A) higher than the $L_{eq}$ of morning and afternoon peak hours respectively. This increase in $L_{eq}$ is the result of the increase of heavy vehicles from 12.7% to 33.3% of the total number of vehicles and the reduction of the total traffic flow by 42.2%. The measurements during the first night period establish $L_{eq}$ of 68.7 dB(A) for a traffic flow of only 208 vehicles of which 82.7% were light vehicles and 17.3% were heavy vehicles. All heavy vehicles were buses. From the statistical values of $L_1$, it is clear that the maximum level of noise created by heavy vehicles of 87.3 dB(A) is 6 dB(A) higher than the maximum noise level created by buses (81.3 dB(A)).

All these measured values prove the fact that the environment closest to a boulevard with this kind of traffic flow is unsuitable for residential buildings.

Measurement Point No.2 (MP2) is in perpendicular line to MP1 and residential building B-13.
MP2 is positioned 2 metres away from the facade of the building in the backyard of the ground floor apartment. The backyard is 80 cm higher than the residential road and parking areas, which are 20 metres away from the building. As the residential road has a number of bends vehicles cannot achieve speed high enough to create a noise level higher than that emanating from the boulevard. In the morning period, for a traffic flow along the boulevard of 892 vehicles per hour (consisting of 70% light vehicles and 30% heavy vehicles), the measured $L_{eq}$ is 60.4 dB(A).

In the afternoon period, for a traffic flow of 796 vehicles per hour (consisting of 85.4% light vehicles and 14.6% heavy vehicles) at a speed of up to 70 km/h, the measured $L_{eq}$ is 59.6 dB(A)The measurements during the first two hours of the night period showed $L_{eq}$ of 55.1 dB(A) for traffic flow of 248 vehicles per hour consisting of 89.5% light vehicles and 10.5% heavy vehicles. These measurements show that the space in front of the buildings facing the boulevard does not fulfil the essential criterion for residential areas considering the existing traffic flow, and is classified as 'Reasonable - acceptable' residential space. From the differences between levels $L_l$, $L_{l0}$, $L_{50}$ & $L_{90}$ at MPI and MP2 it can be proved that the decrease in their values occurs with the decrease in distance from the source of the noise (see Figure 3). The decrease is within the limits cited in the literature.

It is noted that the formula of Shreiber and Wittman gives identical calculated values with the measured values in the process of predicting $L_{eq}$ unlike other known formulae which predict higher levels (by 24 dB(A)) than those actually measured.

$L_{eq}$ = 32 2 dB(A) + 10 log ($N_1$ + 8$N_2$ + 20$N_3$) + l0 log (25/d)
$N_1$ = number of vehicles up o 2.8 tonnes
$N_2$ = number of vehicles from 2.8 - 9 tonnes
$N_3$ = number of vehicles more than 9 tonnes
d = distance from source in metres

Measurement Point No 3 (MP3) is in front of building B-I, 2 metres away from the facade in the same line as MPI and MP2. The measured $L_{eq}$ of 53.8 dB(A) is for traffic flow of 933 vehicles per hour (72% light and 28% heavy), and is within the limits for residential areas.

During the measuring period there were no other influences, so the measured values are product only of the traffic flow on the boulevard. A decrease in noise of 6.6 dB(A) is achieved in relation to the front facade of the building B-13. The literature cites a decrease of 20 dB(A) for such parallel positioning of the buildings and relation between the distance and the height of the buildings. However, considering the layout of the buildings which face the boulevard it can be seen that the residential walkway is half closed by the buildings B-12 and K-3 from whose.entrances the sound waves coming from the boulevard are reflected to the parallel buildings (namely, B-13 and B-I).

Measurement Point No 4 (MP4) is in front of building B-10 very close to the intersection between the residential road and Boulevard B. During the measurement the traffic flow was 434 vehicles per hour. This is half the traffic flow of Boulevard A for the same measuring time. The structure of the traffic flow was 87.4% light vehicles and 12.6% heavy ve hicles with a speed between 60-70 km/h. These conditions resulted in an $L_{eq}$ of 56 dB(A). It should be noted that 25% of the vehicles passed through the residential road at a distance of 15 metres from the measuring point. Boulevard B is the main thoroughfare in the settlement and goes straight to the centre of the city.

The particular urban planning approach adopted for the creation of surfaces with different purposes will have important influence on the reduction of noise. Zoning is one such approach which has the advantage of being able to be applied in every urban project. In this particular case, the thorough fare has a zone for light activities (e.g. administra tive buildings, light industry, warehouses, etc.). For a lower-ranking road (in this case, a residential road) the residential buildings are connected which creates a quiet zone where there are schools and childcare facilities.

Measurement Points No 5 and No 6 (MP5 and MP6) are inside the neighbourhood unit. MP5 is located on the pedestrian walkway and MP6 is on the green area in the middle of the unit. Mea surements at these two points give the noise level of the localised environment. The measured $L_{eq}$ is 54.9 dB(A) at MP5 and 56.3 dB(A) at MP6, which is the result of the normal ac tivities of communication and child play. It is interesting that the noise level in the localised environment is the same as that in front of building B-10 caused by a traffic flow of 434 vehicles per hour.

Measurement Point No 7 (MP7) is between the buildings of the local unit centre and the residential buildings. The measured $L_{eq}$ of 57.8 dB(A) is for only 46 vehicles per hour on the residential road with speed between 30 - 40 km/h. In this area the buildings are parallel, with height of 5 storeys so that even the lowest noise level is reflected many times from the surrounding concrete surfaces, thus creating noise level of 54 dB(A) even from foot steps. The fact that the buildings are parallel creates a tunnel for the noise coming from the bus station on Boulevard B; the noise level is 53 dB(A).

## CONCLUSION

Awareness that motor traffic is almost an exclusive factor in solving the problems of communication in the urban space contributed to the correct and commonsense solution to the roads going through the settlement area. The accepted concept of noise attenuation and protection with increase in the distance from the source of the noise from Boulevard A achieved its maximum usefulness for the existing traffic flow. With every increase in the traffic flow, the efficacy of the concept declines.

The principle of zoning surfaces and contents, particularly in the area of Boulevard B, reduces the influence of the traffic noise inside the residential areas and represents a correct solution in terms of applying urban systems. The main contribution of urban planners is in their vision for creating residential buildings which are mass produced but pleasant to live in, with very lit tle influence of traffic noise but with parking areas no more than 50 metres away from the entrance to the buildings.

The results obtained from the measurements of the noise in the apartments from Boulevard A's traffic are between $L_{eq}$ 38 - 40 dB(A), which is a com pletely acceptable inside noise level. This is a consequence of the built-in facade construction with double-glazed windows. This is the first attempt in architecture to avoid the usual arrangement of buildings. In addition, the pedestrian traffic makes a real con tribution to the solution of the noise problem. Until recently professional opinion held that non-motorised traffic cannot contribute to the solution of the communication problem in big cities. The example of this newly built settlement proves that this is not so. The way the settlement is planned represents a new stage in the development of urban planning thinking and a new way of protecting from noise.

## REFERENCES

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| measure-ment point (M.P) | time of measure-ment | constitution of vehicles during the measurement period (%): cars | 2,8 - 9 t | over 9 t | 2,8 - 9 t + over 9 t | vehicles/h | $L_{10}$ | $L_{50}$ | $L_{90}$ | $L_{eq}$ | TNI | LNP | $L_1$ | weather conditions: t°C | speed of wind m/sec | atmospheric pressure | relative humidity % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M.P. 1 | $6^{15}$ - $6^{45}$ | 87,6 | 5 | 7,4 | 12,4 | 1386 | 78,8 | 72,5 | 64,3 | 75,6 | 92,3 | 90,1 | 85,3 | 0,4 | 0,5 | 995 | 79 |
| | $10^{04}$ - $10^{34}$ | 64,7 | 24,4 | 10,9 | 35,3 | 810 | 80 | 70,3 | 57,8 | 76,2 | 116 | 98,4 | 87,3 | 6,3 | 2,0 | 997 | 59 |
| | $14^{45}$ - $15^{15}$ | 87 | 6,5 | 6,5 | 13 | 1424 | 78 | 71,5 | 62,8 | 75 | 93,6 | 90,2 | 85,3 | 5,6 | 2,4 | 994 | 88 |
| | $16^{45}$ - $17^{15}$ | 87,1 | 7 | 5,9 | 12,9 | 646 | 75,8 | 66 | 55 | 72,6 | 108,2 | 93,4 | / | 13,8 | 1,7 | 987 | 65 |
| | $22^{50}$ - $23^{20}$ | 82,7 | 5,7 | 11,6 | 17,3 | 208 | 71,3 | 57 | 47 | 68,7 | 114,2 | 93 | 81,3 | 5,0 | 0,2 | 995 | 62 |
| M.P. 2 | $11^{06}$ - $11^{36}$ | 70 | 23 | 7 | 30 | 892 | 63,8 | 58,8 | 53,7 | 60,4 | 64,1 | 70,5 | 68,3 | 6,1 | 2,0 | 996,8 | 59 |
| | $16^{32}$ - $17^{02}$ | 85,4 | 6,8 | 7,8 | 15,6 | 796 | 63 | 58,3 | 53,7 | 59,6 | 63 | 69,6 | 66,8 | 5,6 | 3,5 | 994,3 | 89 |
| | $23^{05}$ - $23^{35}$ | 89,5 | 1,6 | 8,9 | 10,5 | 248 | 57,3 | 49,8 | 41,5 | 55,1 | 74,7 | 70,9 | 63,3 | 6,4 | 1,3 | 993,6 | 77 |
| M.P. 3 | $12^{05}$ - $12^{25}$ | 72 | 21 | 7 | 28 | 933 | 56,3 | 52,3 | 48,5 | 53,8 | 48,5 | 61,3 | 60,8 | 8,8 | 0,5 | 994,3 | 48 |
| M.P. 4 | $13^{50}$ - $14^{20}$ | 87,4 | 8 | 4,6 | 12,6 | 434 | 60 | 53,8 | 49 | 56 | 63 | 67 | 65,3 | 8,8 | 0,5 | 994 | 48 |
| M.P. 5 | $15^{45}$ - $16^{05}$ | / | | | / | / | 58,3 | 52,5 | 49,3 | 54,9 | 55,3 | 63,9 | 67,3 | 5,6 | 3,5 | 994 | 89 |
| M.P. 6 | $10^{57}$ - $11^{27}$ | 71 | 22 | 7 | 27 | 832 | 60 | 51,5 | 47,5 | 56,3 | 67,5 | 68,8 | 64,3 | 9,1 | 3,8 | 994 | 59 |
| M.P. 7 | $9^{50}$ - $10^{20}$ | 56 | 8 | 4,6 | 12,6 | 46 | 59,2 | 52,5 | 48,3 | 57,8 | 62,3 | 68,9 | 68,3 | 7,6 | 7,3 | 992 | 60 |

Table 2

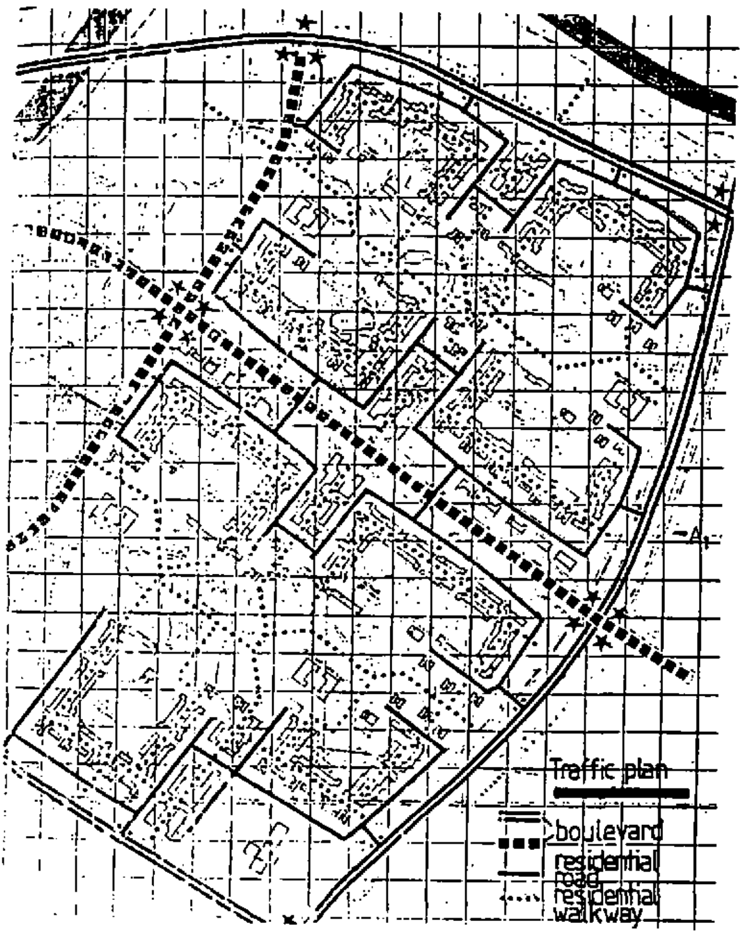


Figure 1a . Neighbourhood unit $A_1$-4

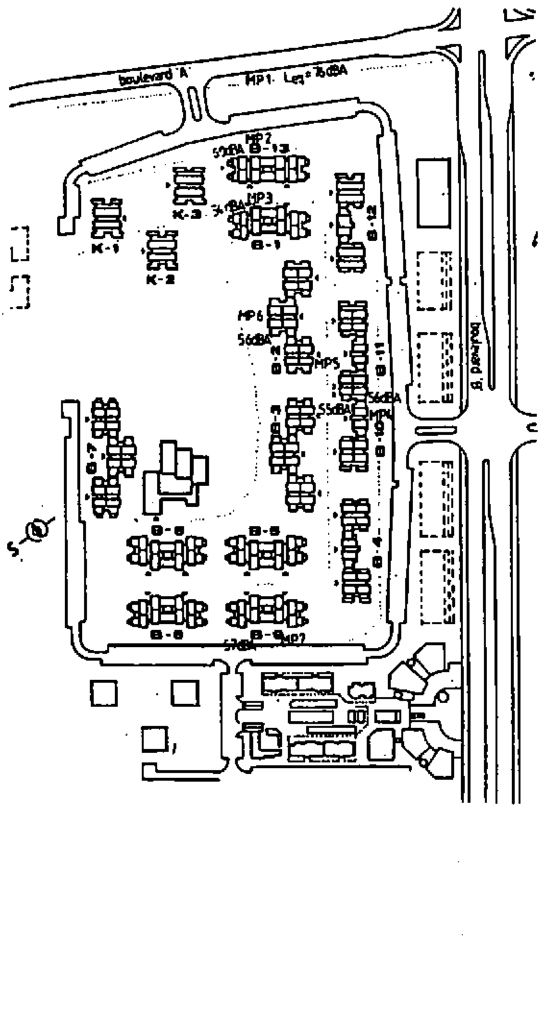


Figure 1b . Neighbourhood unit $A_1$-4 with measuring points.

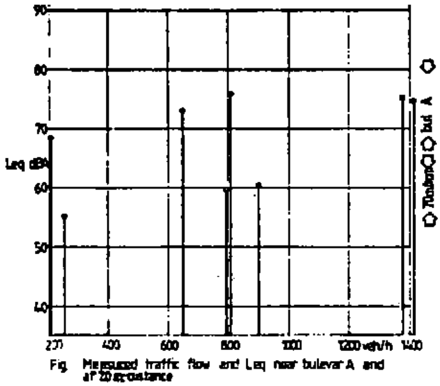


Figure 2. Measured traffic flow and Leq near Boulevard A and at 70m distance.

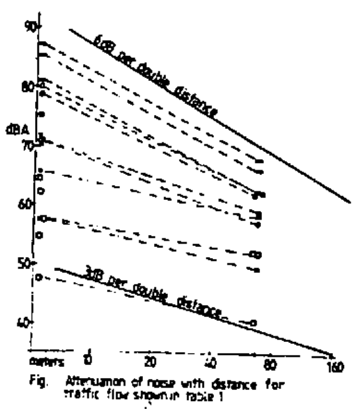


Figure 3. attenuation of noise with distance for traffic flows shown in Table 1.