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REDUCTION OF ROAD TRAFFIC NOISE.
COST AND EFFECT OF NOISE CONTROL MEASURES.

Matias Ringheim
KILDE, Bergsliplass 2, N-5700 Voss, Norway.

1. Background.

A national program for the reduction of the noise impact near existing roads where introduced in Norway in 1978. This program has resulted in the spending of approximately 25 Mill.Nkr.* annually over the last six years. Approx. 40% of this sum has been used on building improvements, the rest on noise screens. Due to the limited resources available, priority is given to buildings exposed to outdoor, 24h-Leq levels exceeding 68 dBA.

New regulations for land usage near new and existing roads were introduced in 1979. These emphasize the need for awareness of possible noise problems when the 24h-L_{eq} levels exeed 55-60 dBA, or when the outdoor, night-time, maximum noise level exeeds 70-80 dBA. These levels are "trigger" levels for noise control action. The magnitude of the noise problem and cost/effect of the possible noise control measures will determine the final result in each case. It is often not possible to attain the goal of 55-60 dBA (or similar indoor criteria) along the busiest roads.

Slightly stricter noise emission criteria for new vehicles were finally introduced in Norway in 1982. (80 dBA for private cars and 88 dBA for the heaviest lorriers, according to ISO R362).

2. Comparison of cost/effect factors for various noise reduction measures.

An estimated 40 km of noise screens and earth barriers have been built so far, and significant experience has been gained, both as regards construction techniques and cost/effects. Cost/effect - results from 85 screen projects are summarized in fig.1.(1). The table shows that 1803 dwelling units have received an estimated, average noise reduction of 8 dB for a total expenditure of 41,5 Mill.Nkr. The average cost of the screens=1600 Nkr/metre and the average cost/effect factor =

2800 Nkr/dB/dwelling

The relatively high screen costs reflect the necessity of using "frost resistant" screen foundations.

* £1 = 11 Nkr. 1983 kr.value is used throughout the paper.

FIGURE 1.

Cost and effect of 85 screen projects.

COST/EFFECT FACTOR 1000kr per dBA/dwelling	NO. OF DWELLINGS	TOTAL COST 1000kr	Mean values for NOISE RED. dBA	SCREEN COST 1000kr/meter
0.0				
2.0	1075	8620	8.6	1.0
2.0				
4.0	265	5156	7.3	1.4
4.0				
6.0	232	9398	8.1	1.7
6.0				
8.0	27	1800	9.1	1.7
8.0				
10.0	124	9211	8.3	2.2
10.0				
12.0	22	2093	9.1	2.6
12.0				
14.0	24	1743	5.5	2.5
14.0				
16.0	0	0	0.0	0.0
16.0				
18.0	2	263	8.0	3.8
18.0				
20.0	23	2078	4.8	2.4
20.0				
22.0	0	0	0.0	0.0
22.0				
24.0	5	441	4.0	1.8
24.0				
26.0	4	497	5.0	3.4
26.0				
28.0	0	0	0.0	0.0
28.0				
30.0	0	0	0.0	0.0
30.0				
32.0	0	0	0.0	0.0
32.0				
34.0	1	186	5.5	1.7
AVERAGE 2.8	1803	41486	8.2	1.6

So far, the results from the sound-proofing of buildings have not been collected systematically. However, figure 2 shows the results from 12 projects in OSLO (2). For 10 of these projects, the average indoor noise reduction with windows closed was 9,6 dB for 348 dwellings. This gives a simple "cost/effect factor" of

2000 Nkr/dB/dwelling

The cost of improving wooden buildings will probably be higher than this.

For comparison, the cost/effect factor of introducing new emission criteria (75 dBA for light vehicles and 80 dBA for heavy vehicles, ISO R362) is estimated to be

1100-2500 Nkr/dB/dwelling

The simple cost/effect factor is, of course, only one of several criteria involved when chosing a sensible noise reduction policy. All the noise reductions mentioned refer to the A-weighted 24h-L_{eq} level. For further details see (3).

FIGURE 2. Cost and effect of 12 building improvement projects.

SITE NO.	ADDRESS	dBA NOISE REDUCTION	NO. OF DWELLINGS	TOTAL COST 1000xKR	TOTAL WINDOW+ DOOR AREA.M^2	1000KR / dBA.DWELLING	1000KR / M^2 WINDOW
1.	BRATENALLÉEN 36	6	20 W*	550	194	4.6	2.8
2.	CHR.M.GT. 4-8	8	24 B	330	97	1.7	3.4
3.	FAGERH.GT. 11	9	19 B	400	120	2.3	3.3
4.	GALGENB. 3	10	95 B	1400	422	1.5	3.3
5.	LØKKEVN. 5	6	- B	230	108	-	2.2
6.	REFSTAD B.R.L.	9	72 W	2400	317 WINDOW 1300 WALL	3.7	-
7.	REKTORHAUGEN	5.5	9 S	220	50	4.5	4.4
8.	TRONDHEIMSV.111	9	20 B	400	129	2.2	3.1
9.	TRONDHV.120-182	13	52 B	660	316	1.0	2.1
10.	GRENSEVN.12-26	-	99 B	635	278	-	2.3
11.	TRONDHEIMSV.102	10	22 B	255	164	1.2	1.6
12.	TRONDHEIMSV.110	10	15 B	179	113	1.2	1.6
	OVERALL	9.6**	447+	7659	1991***	2.0**	2.6***

* EXTERNAL WALL CONSTRUCTION: W=WOOD, B=BRICK, S=SIPOREX LIGHT WEIGHT CONCRETE.

** EXCLUDING SITE 5 & 10

*** EXCLUDING SITE 6

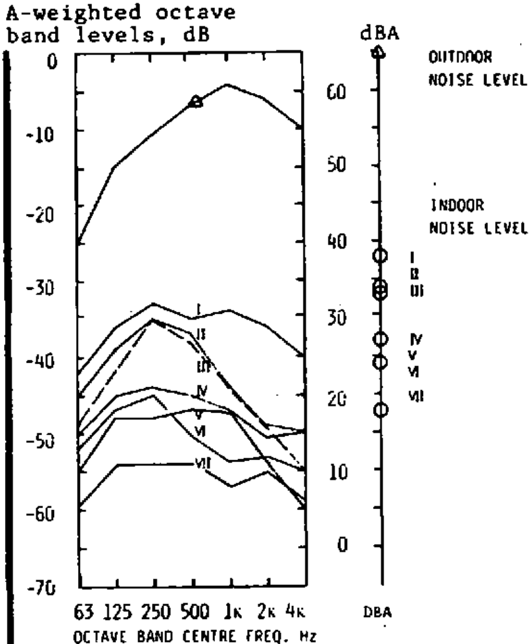
3. Examples of noise reduction solutions and effects.

Improvement of the facade sound insulation is often the only short-term solution to noise problems in a town centre. The difference between the outdoor and indoor noise level is critically dependent, not only on the type of facade construction, but also on details of maintenance and quality of workmanship for the various facade elements. The mounting of windows and vents with good insulating properties, requires such attention to detail that it has been found necessary to provide practical training courses for otherwise experienced craftsmen. Assuming a reasonable good standard of work, it is possible to calculate the sound attenuation of a given facade. A litterature survey of available field and laboratory data is used as a basis for a relatively detailed prediction method (4). An example of the usefulness of this method is given in fig.3.

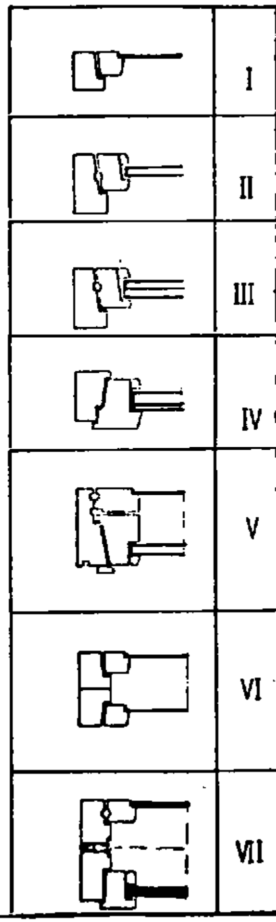
Due to the increased emphasis on noise control, the availability and quality of Norwegian sound proofing windows have improved significantly over the last few years (5). The window producers and contractors have also significantly reduced their prices during this period (e.g. site 11 and 12, fig.2).

Some recent developments as regards the use of screens should be mentioned. Firstly, the use of sound absorbing screens in densly populated areas, where it may be necessary to use screens on both

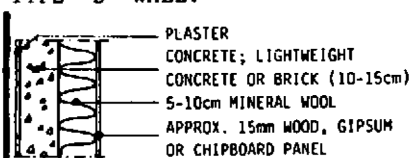
FIGURE 3. EXAMPLE CALCULATION. FACADE NOISE REDUCTION WITH ROAD TRAFFIC AS NOISE SOURCE. EFFECT OF MOUNTING DIFFERENT TYPES OF WINDOWS IN TYPE "B" WALL.
Window area = 30% of total facade area. The relationship between room volume and facade area, $V(m^3)/S(m^2) = 3$. Reverberation time 0.5sec.



WINDOW TYPES:-



TYPE "B" WALL.



sides of a road. Possible maintenance problems caused by the continuous freezing and thawing of moisture in fibrous materials and clogging by asphalt dust from the extensive use of studded tires are the main reasons for the earlier reluctance to use sound absorbing screens. However, a 1420m long and 2m high wooden screen, as shown in fig. 4 was built, as a trial, at Lillehammer in 1982, at a cost of Nkr. 1130 per metre. This cost is significantly lower than for many similar projects,despite the use of sound absorbing materials on the upper part of the screen surface, and the use of hefty 2"planks with tongue-and-groove joints. This sturdy construction was chosen in order to reduce future maintenance and also to make it possible to use the "garden side" of the screen as a hanging space for tools, shelves plants, etc. So far the experience with this screen construction is good and similar screens are proposed for other sites.

In some cases it may be possible to position relatively low screens close to the road edge. The screening solutions shown in fig.5 cost approximately 700-800 kr/m, and can be placed directly on the road shoulder. The screen base consists of slightly modified concrete elements of types widely used in road building. The height of the upper part of the screen can be varied according to local requirements, but will typically give a total screen height of approximately 1,5 metres. The upper part of the screen may consist of a sound absorbing material covered with a "perforated" plate (e.g. wood chippings in concrete). It is gradually being accepted that the screen materials should be visually compatible with the materials used in the surrounding buildings, and that planting of grass, bushes and trees near the screen surface is necessary for a satisfactory final result.

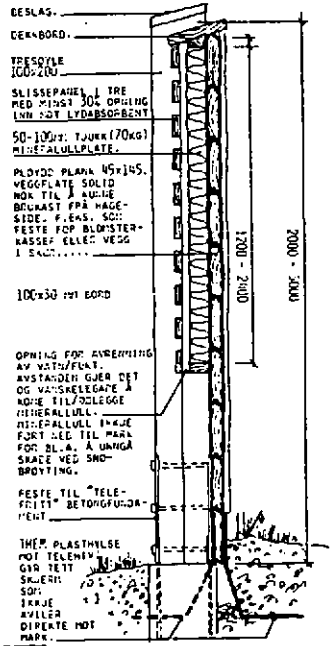
The future.

Dispite significant noise reduction efforts in Norway, the available resources are not sufficient to keep up with a gradually increasing number of people exposed to high noise levels.
The Pollution Control Authority (SFT) is working on a revised action plan against road traffic noise which will be presented to the Government early in 1985. A number of studies are being carried out in 1983-84 in order to provide background knowledge for an optimum choice of noise control actions in the future. These studies include

- an updating of the national noise impact registration carried out in the mid-nineteenseventies, and
- detailed studies of cost and effect related to various noise reduction aims and methods, based on detailed data from 6-7 major town areas.

It seems quite clear that major noise reduction efforts will be required in the future, and that there is a clear choice between active noise control and passive noise control. The present

REDUCTION OF ROAD TRAFFIC NOISE. COST AND EFFECT...



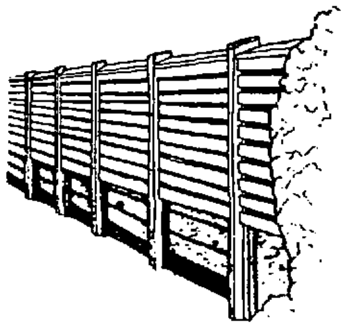
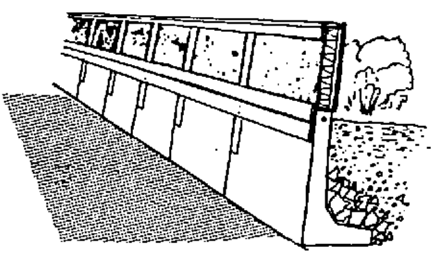
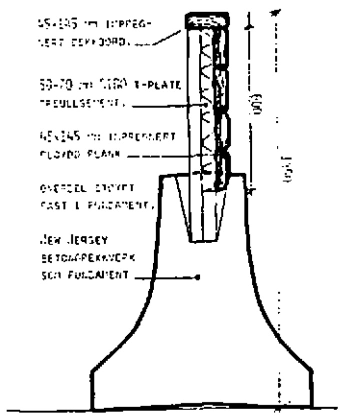


FIGURE 4. Noise screen with sound absorbing surface on the road side. The Lillehammer screen.

FIGURE 5. Two examples of noise screens that can be mounted on the road shoulder.





regulations have mainly resulted in the latter, but the knowledge gained over the last decade represents a possible foundation for active, preventive noise control. Such action would require an emphasis on

- traffic planning and area planning that reduce the need for motorized transport,
- creating favourable conditions for the use of low noise transport forms (e.g. it is possible to transport 5-10 times as many people by suburban rail as by private cars, for the same noise impact),
- improving the placing of roads in relation to noise sensitive areas,
- introduction of traffic regulations at critical times, for certain vehicles or roads, etc.,
- stricter noise emission criteria for road vehicles,
- informing the population of the consequences of their daily choice of transport,
- etc, etc,...

Many of these noise control measures will not require massive economic efforts, but rather insight and knowledge of the noise problem at all decision levels in the transport and regional planning process.

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