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External Building Materials in a Norwegian Town, Sarpsborg - Quantities and Degradation

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SUMMARY

The quantities of the different types of external building materials in the town of Sarpsborg have been estimated from inspections of a statistical sampled buildings. The quantities are given in groups following the age and type of houses inspected. The degradation of the materials used on roof, walls and window frames was evaluated.

The estimates show that 60% of the total amount of external building material in the town were found on single and two-family houses, 16% were on official and commercial buildings, 15% on apartment houses and 9% on industry. The dominating materials found were 30% wood, 22.5% rendering and concrete, 13% roof tiles and brick tiles.

The degradation of the inspected materials was shown to increase with decreasing distance to local pollution sources such as industries and roads with heavy traffic.

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EXTERNAL BUILDING MATERIALS IN A NORWEGIAN TOWN, SARPSBORG - QUANTITIES AND DEGRADATION

1 INTRODUCTION

The increasing request for knowledge on the longterm performance of building materials and components within the building sector put high demands on research. A central theme in durability research is to create knowledge and methods for predictions of service life.

In spite of the fact that service life predictions to such a great extent have to rely on experience based on the use of the products in actual buildings, there is in general a lack of in-service performance data. Another problem is that the available data from practice often have a poor quality because of lack of accurate procedures for collection and collation of the information. Reliable knowledge on the service life can be generated from field performance if the data come from systematic inspections of the state of thoroughly characterized buildings in well described environments.

Another central theme to reliable predictions of service life is the poor knowledge of the environmental actions affecting materials under in-use conditions. Exterior building materials are subjected to both static and dynamic loadings, and to degradation factors coming from the environment. The deterioration processses taking place are of chemical and physical nature, often in a complex joint action. For metals and for many polymeric materials the chemical corrosion processes may be dominating. To increase the understanding of the degradation processes experimental research on the dose/response of degradation factors to materials is highly important. Inspection of buildings add to this knowledge by giving, mostly descriptive, information on the complex synergistic effects. The explanatory research will usually require tests under controlled conditions in laboratories.

To obtain better understanding of the factors and processes involved in the degradation mechanisms a Nordic project was started in 1983. The project was planned to include three sequential studies.

1. Study the existing technical and economical methods and data availability for economical assessments and prediction of service life. The study should include recommendations for further studies to improve the data and methods needed for a field study.

2. Carrying out "Case"-studies in selected towns in the Nordic countries to improve the data and methods for technical and economical assessments.

3. A complete study of the degradation costs on building materials in the Nordic countries.

The Sarpsborg study is together with the Stockholm study the second part of this Nordic project. To get comparable results the strategy and methodology used were the same in both towns (Henriksen et al., 1989; Tolstoy et al., 1989).

2 PURPOSE

The purpose of the project was to develop a methodology for the representative inventory of material quanitities and corrosion damage in building structures and, using this methodology:

- To establish material quantities with reference to different categories of building.
- To establish the geographical distribution of the stock of materials in Sarpsborg and its relation to the air pollution situation.
- To assess corrosion damage to important building materials such as sheet metal, rendering and organic surface finishes, with reference to the air pollution situation.

In this article the presentation of results will focus mainly on the assessment of actual degradation and not so much on the inventory of material quantities.

3 METHODS

Selection of inspection area

Based on the recommendations from the previous Nordic study (Haagenrud et al., 1986), the following goals for an inspection area were put through:

- The town must have a complete data index for all properties and preferably also buildings in the area.
- To study the dose-response degrations of materials we need to know the pollutant situation in the town in detail.
- To have a variation of the pollutant levels in the area.

Sarpsborg is one of the towns in Norway which fulfil all these requierments when the case-study started in 1986.

Selection of houses

A database for the properties, adresses and buildings has been developed during the 1980s (GAB). This database was almost completed for the whole town when we started the inspection in Sarpsborg and we were able to use the database for randomly selecting houses for inspection. To reduce the number of houses needed for inspection the stock of buildings were divided in nine groups with comparable characteristics. The types of houses grouped were:

Group 1-3: Single and two-family house in three age classes
< 1920, 1920-1960 and > 1960.
Group 4-6: Apartment houses in three age classes
< 1920, 1920-1960 and > 1960.
Group 7: Official and commercial buildings.
Group 8: Industrial buildings.
Group 9: Farmhouses.

4 AIR POLLUTION AND CLIMATE SITUATION

Most buildings materials are subjected to atmospheric corrosion through the combined action of a number of meteorological and chemical factors. Some degradation will occur by entirely natural processes, even without any human influence on the environment. However, both practical observations and systematic studies have shown that the corrosion rate may be significantly higher in polluted urban and industrial atmospheres than in clean rural atmospheres. Since many corrosion processes only occur when the surface of the degrading surface is wet, atmospheric corrosion may to a large extent be considered as a discontinuous process. The total corrosion effect during a certain period, accordingly, is mainly determined by the "time of wetness" and the concentration of air pollutants. One of the purposes of this project was to assess the impact of acid air pollution on important building materials. The following sections, accordingly, contain a short overview of the influence of the main climatic parameters on the corrosion processes and of the documentation employed in characterising the air pollution and climate situation for the real estates inspected.

5 METEOROLOGICAL PARAMETERS

5.1 TIME OF WETNESS

The time of wetness vary a great deal according ot circumstances, being governed as a rule by the interaction of the following factors: relative humidity, temperature, precipitation and the occurrence of pollution and corrosion products on the surface. Direct measurements on the surface of the material are the most reliable method for determining time of wetness in a particular microclimate. For practical purposes, time of wetness for metals is often defined as the time during which relative humidity is >80% and temperature, simultaneously, exceeds $0^{\circ}C$. This definition is also employed by ISO in classifications of atmospheric corrosiveness (ISO Standard 9223). By this standard, time of wetness is divided into five classes:

Category	Time of wetness, hours/year
$\tau 1$	<10
$\tau 2$	10-250
$\tau 3$	250-2 500
$\tau 4$	2 500-5 500
$\tau 5$	>5 500

Sarpsborg, as indeed most areas in the temperate climatic zone come in class $\tau 4$.

5.2 TEMPERATURE

Temperature has a complex effect on atmospheric corrosion. On the one hand the corrosion rate increases, because temperature accelerates the electrochemical and chemical reactions and also the diffusion rate. On the other hand, rising temperature causes moisture films to dry out faster, which means a shorter time of wetness. At temperatures below about 0° C, the electrolyte on the surface of material freezes, which greatly reduces corrosion. In porous building materials especially, material damage resulting from frost cracking can be of great practical significance.

6 ATMOSPHERIC POLLUTION

The concentration of atmospheric pollutants often has an increasing effect on the corrosion rate resulting from atmospheric corrosion. The airborne pollutants may occur in three forms, as soluble gases, solid particles, and substances dissolved in water droplets or in a liquid film on the surface of the solid particles. Sulphur dioxide (SO_2), nitrogen oxides

(NO_x) and chlorides are usually most important in connection with degradation processes. These pollutants are deposited on the surface, either through dry deposition (adsorption of gases or precipitation of particles), or by wet deposition (rain, snow).

6.1 SULPHUR DIOXIDE (SO_2)

In a great number of field and laboratory experiments, sulphur dioxide has proved to have a highly corrosive effect on metallic materials like steel and zinc and also on calcareous stone and rendering. Its impact on the economic life of painted surfaces has been less well investigated and documented. In ISO 9223, the corrosion due to sulphur pollutants is classified with reference to the ambient SO_2 concentration on yearly basis, as follows:

Category	SO_2 concentration, $\mu g/m^3$
P_0	≤ 12
P_1	12-40
P_2	40-90
P_3	90-250

Sarpsborg is dominated of pollutant emissions from industry and the monthly average concentrations have comparable levels throughout the whole year.

6.2 NITROGEN OXIDES (NO_x)

Nitrogen oxides were long believed to have virtually insignificant effect on atmospheric corrosion. In recent years, however, laboratory tests have shown that SO_2 and NO_2 can produce a strong synergistic effect. The following reaction

$$SO_2 + NO_2 + H_2O \longleftrightarrow H_2SO_4 + NO$$

causes corrosion to accelerate, for example, in cupreous materials. NO_2 is not included in the ISO system referred to above.

Emissions of NO_2 come primarily from vehicular traffic. An indication of the local effect of NO_2 can therefore be obtained by looking at the traffic situation in the streets as annual average daily traffic (AADT)

low effect with traffic below 5 000 AADT,
medium effect with traffic between 5 000-15 000 AADT,
high effect with traffic above 15 000 AADT.

6.3 CHLORIDES

The corrosive impact of chlorides has also been documented on motor vehicles through exposure in marine atmosphere and from practical experience of the corrosive impact of de-icing salt. The corrosion rate is greatly increased for both metals and painted metals. In ISO 9223, contamination by airborne salt is classified as chloride deposition rate measured throughout a year by the wet-candle method as follows:

Category	Chloride deposition rate, $mg/m^2 x\ d$
S_0	<3
S_1	3-60
S_2	60-300
S_3	300-1 500

In Sarpsborg the chloride classification is S_1. Inside the paper industry close to the bleaching plant the chloride concentration will be even higher.

7 VARIABLES INVESTIGATED IN THE INSPECTIONS

The primary variables in the survey are material quantities on external surfaces in the groups of accounting. Secondary survey variables include, for example, the state of a particular roofing material in the different land areas or the ageing of paint on sheet metal.

Amount of materials and surface finish were recorded for every part of the building.

7.1 PART OF BUILDING

- FOUNDATIONS: main part, ventilators, joints, other parts.
- WALL: main part, ventilators, signs, joints, lamps, ladders, fixtures, other parts.
- DOOR
- BALCONY: top, underside, girders/beams, rail, screen, other parts.
- ROOF: main part, barge boards, weatherboards, chimney, ventilation ducts, mountings, ladders, snow rail, other parts.
- CEILING: main part, underside of eaves, other parts.
- DE-WATERING: gutters, cornice channels, downpipes, other parts.
- SUPPLEMENTARY BUILDINGS: foundations, wall, window, door, roof, ceiling, de-watering, other parts.

7.2 MATERIALS

- NATURAL STONE: granite, gneiss, sandstone, marble, limestone, slate, other materials.
- CONCRETE, LIGHT CONCRETE: concrete, site-cast concrete, prefabricated concrete, concrete masonry, lightweight-aggregate concrete, lightweight concrete.
- BRICK AND SANDLIME BRICK: mortar, other materials.
- ASBESTOS CEMENT

- WOOD: timber, boarding, fibre board, asphalt-impregnated fibre board, chipboard, plywood, other materials.
- RENDERING: finishing coat, finishing coat on concrete, finishing coat on lightweight concrete, finishing coat on sheet metal, other material, coarse stuff, coarse stuff on lightweight concrete, coarse stuff on concrete, coarse stuff on brick, coarse stuff on wood, other materials, render and set i.e. two-coat plasterwork.
- METAL: steel, stainless steel, zinc-coated steel, cortene-steel, aluzinc steel, copper, aluminium, lead.
- OTHER MATERIALS: plastic, rubber, ceramics, glass, gravel, millboard, putty (jointing compound), other materials.

7.3 SURFACE FINISHING

- WOOD: untreated, stain, latex (water-based), alkyde and oil paint (solventbased), other materials.
- CONCRETE: Concrete (natural grey or through-coloured), smooth surface, profiled surface, ground surface, structured surface, exposed aggregate, concrete painted, lime and cement paint (inorganic), other finishing paint (organic), latex paint (water-based), alkyde and oil paint (solvent-based), asphalt, other materials.
- RENDERING, MASONRY, ROOFTILING: untreated, lime and cement paint, other finishing paint, latex paint, alkyde and oil paint, asphalt, glaze, other materials.
- METAL: untreated, factory-varnished finishing paint, latex paint, alkyde and oil paint, plastisol, PVF2, finishing paint applied on site, latex paint, alkyde and oil paint, asphalt, anodisation, other materials.
- SUNDRY: gravel, slate and asphalt, asphalt compound and suchlike, other materials.

For roof, facade and window, a record was also made of status, cause of status and age of material as well as surface treatment. In addition, certain environmental factors were described for each item. The distance from the surfaces proximity to traffic, local pollution source, water, etc. was recorded.

7.4 STATUS DESCRIPTION

For roof, windows and walls, an assessment was made of the status of surface finish and underlay. Both were evaluated on a three-point scale: 0 = intact, 1 = minor damage (no repairs needed), 2 = repairs advisable.

The inspectors employed special checklists, in matrix form, as an aid to status assessment.

Example: MOBAK Status description of sheet metal and surface finishing.

SUBSTRATE	SURFACE FINISHING		
	00 Intact Blistering >8F Cracking >8 Chalking >8 Flaking >8	10 Minor damage 6F < Blistering <8F 4 < Cracking <8 4 < Chalking <8 4 < Flaking <8	20 Repairs needed Blistering <6F Cracking <4 Chalking <4 Flaking <4
00 Intact No damage such as scratches, dents or flaking Corrosion >8	00 Intact No attachment damage, no mechanical damage Corrosion >8 Blistering >8F Cracking >8 Chalking >8 Flaking >8	10 No mechanical or attachment damage Corrosion >8 6F < Blistering <8F 4 < Cracking <8 4 < Chalking <8 4 < Flaking <8	20 No mechanical or attachment damage Corrosion >8 Blistering <6F Cracking <4 Chalking <4 Flaking <4
01 Minor damage Few and small scratches (not down to the metal), dents and flaking. Limited attachment damage 5<Corrosion<8	01 Few and small items of mechanical and attachment damage 5 <Corrosion <8 Blistering >8F Cracking >8 Chalking >8 Flaking >8	11 Small mechanical or attachment damage 5 <Corrosion <8 6F <Blistering <8F 4 <Cracking <8 4 <Chalking <8 4 <Flaking <8	21 Small mechanical or attachment damage Corrosion >8 Blistering <6F Cracking <4 Chalking <4 Flaking <4
02 Repairs needed Serious dents, flaking, scratches down to the metal and attachment damage Corrosion <5	02 Serious mechanical and attachment damage Corrosion <5 Blistering >8F Cracking >8 Chalking >8 Flaking >8	12 Serious mechanical and attachment damage Corrosion <5 6F <Blistering <8F 4 <Cracking <8 4 <Chalking <8 4 <Flaking <8	22 Serious mechanical and attachment damage Corrosion <5 Blistering <6F Cracking <4 Chalking <4 Flaking <4

8 SAMPLE

The sampling was based on experience and recommendations from the National Swedish Institute for Building Research. However, in Sarpsborg we were able to use the officical building register (GAB-register) for the random selection of buildings. For the later comparison between the city of Stockholm with the town of Sarpsborg the buildings were grouped in the same nine building types and construction year classes as in Stockholm. A total of 191 buildings were selected for inspection.

Table 1: Number of buildings in Sarpsborg, amount and percentage of building inspected in the ten buildings categories.

Reporting group	1	2	3	4-5	6	7	8	9	Sum
Type of building	Single family houses			Apartment houses		Industry	Official and commercial buildings	Farm-houses	
	< 1920	1920-60	> 1960	≤ 1960	> 1960				
Number of buildings	624	1165	794	78	72	71	390	0	3195
Number of buildings inspected	19	46	23	22	20	20	41	0	191
% inspected	3.0	3.9	2.9	28.2	27.8	28.2	10.5	-	100

The geographical places for the inspected buildings and the areas with different SO_2 levels are shown in Figure 1. 87.9% of the area have a SO_2 concentration between 20-60 µg SO_2/m^3, 6.9% between 60-90 µg SO_2/m^3 and 5.2% mainly industry above 90 µg SO_2/m^3.

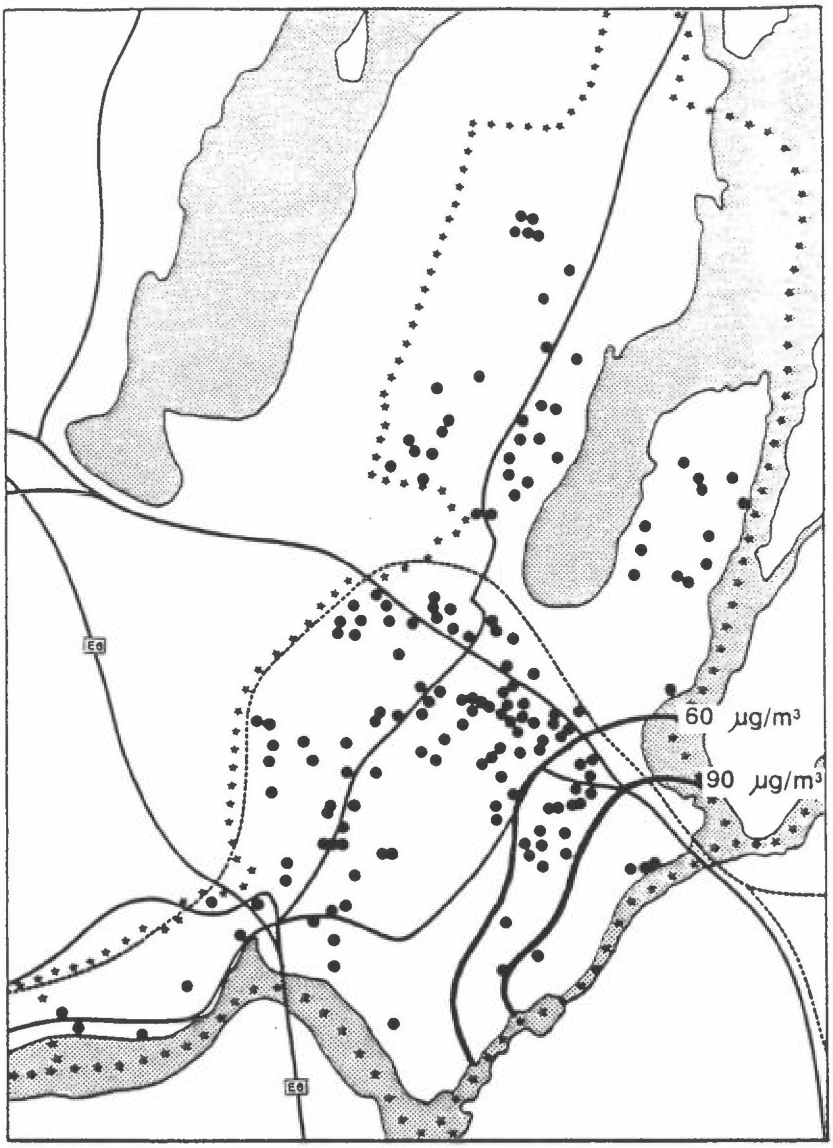

Figure 1: Map of Sarpsborg showinge inspected buildings and isolines for the SO_2 concentrations 60 µg/m³ and 90 µg/m³. The rest of the area has SO_2 concentrations between 20-60 µg/m³.

9 RESULTS AND DISCUSSION

9.1 EXTERNAL AREA

The total external area of buildings in Sarpsborg is estimated at 1.98 mill. m^2. In Table 2 the results are presented for each reporting group.

Table 2: Total external area.

Reporting group	External area		Average area per house	
	$m^2 \times 10^6$	%	m^2	Std.d.m^2
Single family houses < 1920	0.30	15.3	486.6	± 117.6
" 1920-1960	0.49	24.7	419.5	± 99.5
" > 1960	0.40	20.3	507.2	± 146.4
Apartment houses ≤ 1960	0.12	6.0	1515.2	± 641.5
" > 1960	0.19	9.6	2648.1	± 1305.6
Industry	0.17	8.8	2449.5	± 3732.4
Official and commercial build	0.30	15.4	781.4	± 687.6
Total	1.99	100.0	1086.4	± 1546.8

Single family houses accounts for 60% of the total area. These reporting groups had external areas which were quite similar and the standard deviation was quite small. The spread in building size was much greater for the other groups particularly the industry.

9.2 AMOUNT OF MATERIALS

The distribution in per cent of the different materials used in houses is shown in Figure 2.

In Table 3 are the same results reported according to the reporting groups.

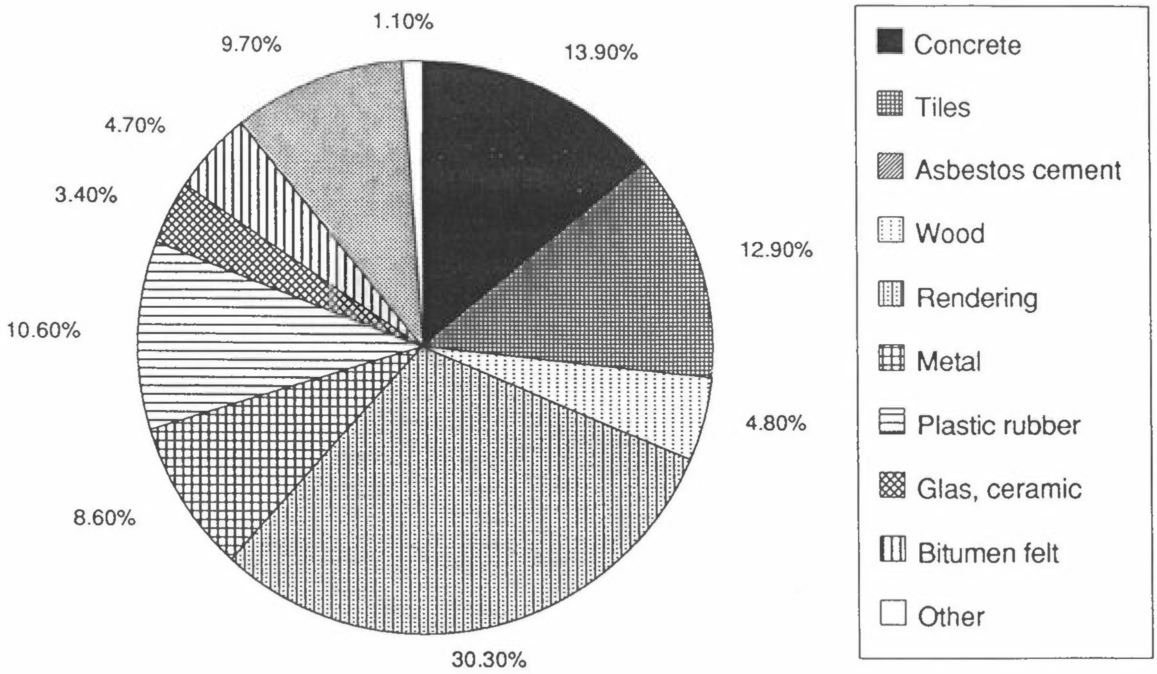

Figure 2: The distribution of materials used externally on houses in Sarpsborg.

Table 3: Percentage material amounts for the different reporting groups.

	Single family houses			Houses		Industry	Commercial	Total
	<20	20-60	>60	≤60	>60			
Natural Stone	3.4	0.5	0.6	0.4	0.2	0.3	0.8	1.0
Concrete	12.6	10.4	16.5	16.2	23.7	11.9	11.3	13.9
Bricks	8.9	13.0	12.9	6.0	6.4	18.3	20.0	12.9
Asbestos cement	6.7	3.2	5.8	5.8	6.7	1.5	4.4	4.8
Wood	42.7	43.1	41.6	6.0	15.4	2.9	18.1	30.3
Rendering	4.4	12.1	8.1	7.0	7.8	1.0	13.2	8.6
Metals	11.9	6.9	4.8	21.1	11.7	23.0	10.8	10.6
Glas	4.2	3.8	3.6	5.6	5.0	5.4	7.2	4.7
Bitumen felt	3.8	5.9	5.5	4.9	15.5	32.6	12.0	9.7
Plastic, rubber	1.3	1.1	0.6	26.8	7.6	2.1	2.0	3.4
Other	0	0	0	0.2	0.2	0.9	0.2	0.2

The dominating material is wood with 30.3% of the total amount of materials. On single houses this amount is more than 40%, which indicates that wood dominates completely as material for walls. Bricks are frequently found as wall material in industry and in official and commercial buildings. Roof tiles, including both concrete tiles and clay tiles, contribute to the high amounts of concrete and tiles/bricks materials for single houses and apartment houses.

Asbestos cement is found mainly on houses built or rebuilt in the 1950s and '60s. The large amount of plastic materials on apartment houses is caused by a special type of wall material (plastic sheets with stone gravel) used when old apartment houses were reinsulated in 1970-80s.

9.2.1 Surface treatment of wood

Most of the wood used on external surfaces had a surface treatment either as stain or as oil paint. Over all was 57% oil painted and 40% stained. Oil paint dominated for old buildings and stain on new buildings and on old building where the external lining had been replaced.

On single houses this can be illustrated by the results from the houses built before 1920 and after 1960. On single houses from before 1920 21.8% were stained and 75.4% were oil painted. For houses built after 1960 67.7% were stained and 30.5% were painted.

9.2.2 Surface treatment of concrete

Most of the concrete observed was used as foundation walls. About 90% of the total was found there. It was also observed that foundation walls were normally untreated. In total 79.7% were untreated and 20.4% painted. Painted concrete was only observed in higher quantities on apartment houses and official buildings.

9.2.3 Surface treatment of rendering

Latex paint was the dominating surface treatment for rendering, 53.5% was latex painted. Untreated rendering covered 27%. Lime and silicate paints covered only 8.9%.

Mortar used in brick walls is not included in the amount of rendering reported.

9.2.4 Surface treatment of metals

Sheet materials used as facades, roofing and gutters dominates in the metal material. 55.3% of all metals was coil coated materials either galvanized steel or aluminium. 20.9% was painted after mounting on the houses, and 19% was unpainted. The unpainted material consisted mainly of aluminium in window frames and of galvanized steel used as roofing material.

9.2.5 Fouling

The facades of the buildings inspected are devided into three fouling classes: insignificant, moderate and heavy.

Figure 3 and 4 illustrate how the fouling varies with distance from roads with heavy traffic and distance from local pollution of SO_2. Both figures show that fouling is linked both to traffic and to SO_2 pollution. The percentage of facades with heavy fouling is small. One reason is that the maintenance periodes for facades in Sarpsborg is short and very few facades will reach the class "heavy fouling" before they will be repainted.

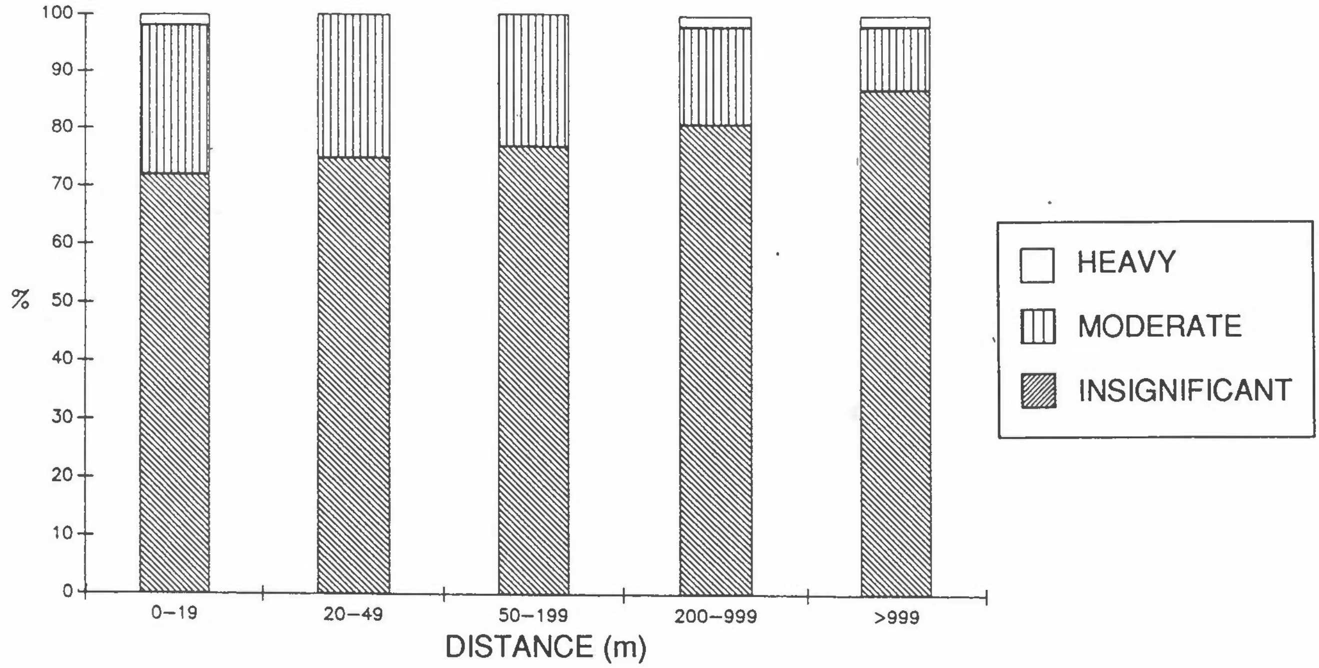

Figure 3: Fouling of facades at different distance from roads with heavy traffic.

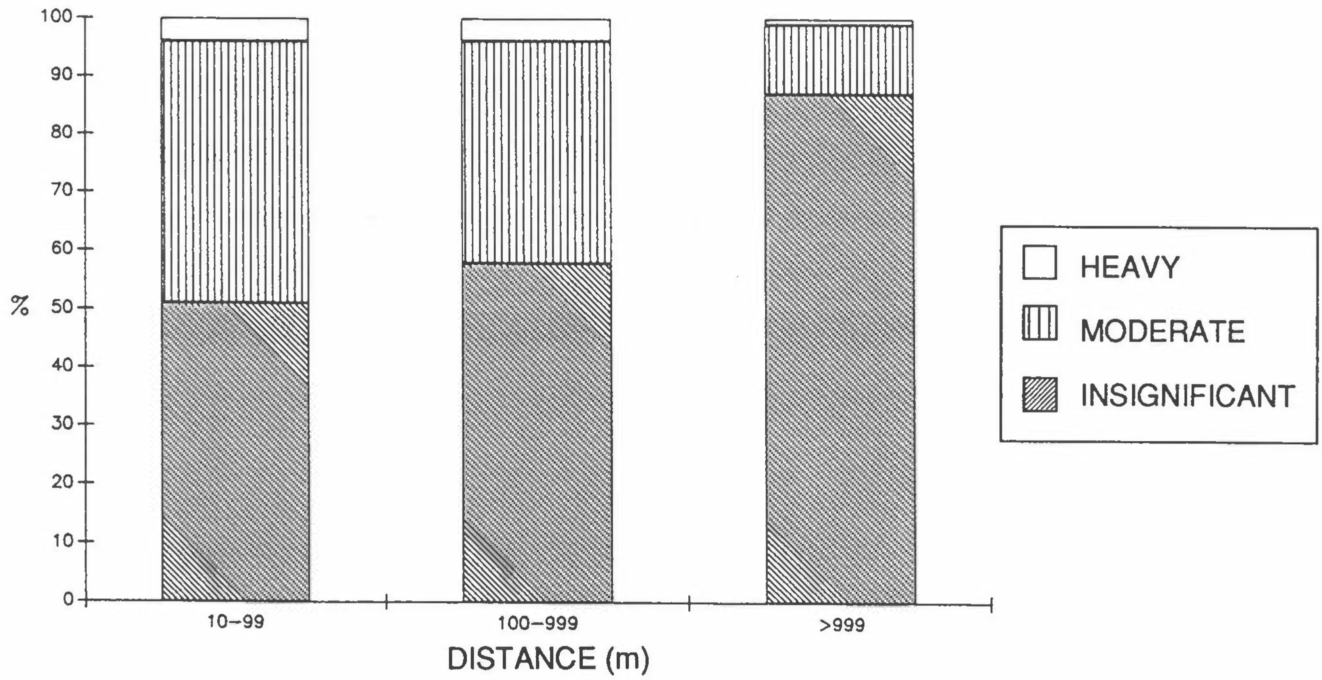

Figure 4: Fouling of facades at different distance from local SO_2-pollution.

9.2.6 Amount of galvanized steel

Galvanized steel is known to be sensitive to SO_2 pollution. On houses galvanized steel is normally found as roofing and in gutters. However, a great part of the galvanized material in towns is found outside the building itself. Fences and poles for street light and powerlines are important use for galvanized materials in towns.

Information from local authorities for poles and estimates for the fences were used to provide more complete figures for galvanized steel for Sarpsborg.

Table 4: Estimated amounts of galvanized steel outside the buildings.

Galvanized profiles:	
poles railroad	1 750 m^2
poles light	6 000 m^2
street sign	350 m^2
Total	8 100 m^2
Galvanized wire:	
fences total	13 800 m^2

10 COMPARISON OF THE RESULTS FROM STOCKHOLM AND SARPSBORG

Since the method for the inspection carried out in Stockholm and Sarpsborg are quiter similar, a comparison of the results will be of great interest (Tolstoy et al., 1990).

Basicly there are few similarities between a capital like Stockholm and a small industry town like Sarpsborg. If we still have comparable results for the different material groups and for the inspection groups, it could indicate that the database could be applicable for other towns in Sweden and Norway too.

Table 5 shows that the data from Stockholm and Sarpsborg in fact are surprisingly similar and the deviations found are easily explained. Rendering as a normal wall-covering material on large apartment houses increases the total percentage of that material in cities, while wood dominates more in small towns. The specific high amount of asbestos cement and plastic sheets in Sarpsborg was explained above.

Table 5: Comparison of amount of material in Stockholm, Sweden (S) and Sarpsborg, Norway (N) in per cent.

Reporting group		Single houses			Apartments			Official and Commercial	Industry	Farm-houses	Total
Year of building S		<1920	1902-1960	>1960	<1920	1902-1960	>1960				
Year of building N		<1920	1920-1960	>1960	<1920	1902-1960	>1960				
Stone	S	2.3	1.1	0.2	4.1	0.6	0.2	1.5	1.5	1.0	1.0
	N	3.4	0.5	0.6	-	0.4	0.2	0.8	0.3	-	1.0
Concrete	S	9.7	15.1	20.5	0.5	5.6	31.8	8.0	5.9	4.9	13.9
	N	12.6	10.4	16.5	-	16.2	23.7	11.3	11.9	-	13.9
Tiles and bricks	S	21.3	15.8	9.1	10.1	11.7	2.9	12.3	8.6	9.6	11.2
	N	8.9	13.0	12.9	-	6.0	6.4	20.0	18.3	-	12.9
Wood	S	38.5	33.8	38.3	5.4	6.6	7.8	18.9	3.6	34.2	23.5
	N	42.7	43.1	41.6	-	6.0	15.4	18.1	2.9	-	30.3
Metal	S	12.1	10.5	9.7	33.4	20.9	17.9	25.0	39.5	21.8	17.8
	N	11.9	6.9	4.8	-	21.1	11.7	10.8	23.0	-	10.6
Rendering	S	9.2	13.9	3.8	37.8	41.2	16.4	8.8	5.0	1.2	14.6
	N	4.4	12.1	8.1	-	7.0	7.8	13.2	1.0	-	8.6
Glass	S	3.9	3.5	3.7	8.3	7.8	7.3	5.3	4.7	11.1	5.3
	N	4.2	3.8	3.6	-	5.6	5.0	7.2	5.4	-	4.7
Bitumen felt	S	2.0	3.5	10.5	0.0	2.5	13.2	19.0	21.1	0.2	9.2
	N	3.8	5.9	5.5	-	4.9	15.5	12.0	32.6	-	9.7
Asbestos cement	S	0.3	0.4	1.7	0.0	2.1	1.9	0.4	3.5	9.0	1.5
	N	6.7	3.2	5.8	-	5.8	6.7	4.4	1.5	-	4.8
Plastic rubber	S	0.6	2.3	1.9	0.1	0.1	0.2	0.5	6.3	6.4	1.5
	N	1.3	1.1	0.6	-	26.8	7.6	2.0	2.1	-	3.4
Other	S	0.1	0.1	0.6	0.3	0.9	0.4	0.3	0.3	0.6	0.5
	N	0.0	0.0	0.0	-	0.2	0.2	0.2	0.9	-	0.2

11 CONLUSIONS

11.1 INVENTORY OF MATERIALS

This survey is the first survey in Norway and Sweden in which an inventory of the total quantity of external materials on buildings in a built-up area has been carried out by inspection of a statistically selected amount of buildings.

Material quantities are reported for different types of buildings in different geographical areas with different pollution levels. Single family houses account for around 60% of all external area on buildings in Sarpsborg. The total external area of buildings in Sarpsborg is estimated to 1.98 million m^2 which gives a material density of 0.2 m^2 material area per m^2 land area.

Wood material has the largest total surface area in Sarpsborg with 30.3% followed by 22.5% for rendering and concrete and 12.9% of tiles and bricks.

11.2 STATUS OF MATERIALS

The surface-finish status is evaluated for facades, windows and roofs. The results show that the maintenance in the town is very good but also that the maintenance periods are short. For wood facades 50% of all the facades inspected were repainted during the last 3 years. For rendering 50% of the facades had been maintained during the last 8.5 years.

Fouling was the factor where the effect of the pollution was easiliest observed. Both from the traffic and from local SO_2 sources, the data indicated an increased fouling with a shorter distance to the pollution source.

Some types of materials inspected gave indications of deterioration with time. Coil coated sheets show weakness after

13-20 years. Bitumen felt seemed to have to be replaced after 9-15 years. Asbestos cement tiles were generally in bad shape and 35% of these roofs needed repair.

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STIKKORD

Building materials	Degradation	Pollution

REFERAT
En kvantifisering av materialmengder og deres tilstand er gjennomført i Sarpsborg. 60% av alle materialer finner en på småhus og tre er det mest brukte materialet, 30,3%. Tilsmussingen av fasaden økte når en nærmet seg forurensningskilder som trafikk og industri.

TITLE

ABSTRACT
A quantification of the amount of materials and their performance has been carried out in Sarpsborg. 40% of all materials were found on small houses and 30.3% of the materials were wood structures.

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C