01.02 Sealing (Edition 2004)

Overview

Definition

The sealing of the natural soil by construction has a number of negative effects on the ecosystem and the human habitat. In the following, the soil is considered sealed if it is covered with solid material. Sealed areas are categorized as either **built-up** or **non-built-up sealed** areas. In addition to structures and surfaces completely sealed with asphalt or concrete, surface sealed with more permeable coatings are also considered “sealed,” although, as in the case of lawn pavers or wide-seamed pavement, they may still permit reduced plant growth.

The effects of sealing are primarily noticeable in cities and urban areas, where a high share of the total area is sealed.

Effect of Sealing on the Ecosystem

The effects of sealing on the climate, the water balance, the soil, the flora and fauna and the human habitat will be described briefly below.

Sealing contributes to the creation of a specific **urban climate**, with the high heat-accumulation capacity of buildings and asphalt streets causing the air to heat up. Especially during the summer, this reduces nighttime cool-off (cf. Fig. 1).

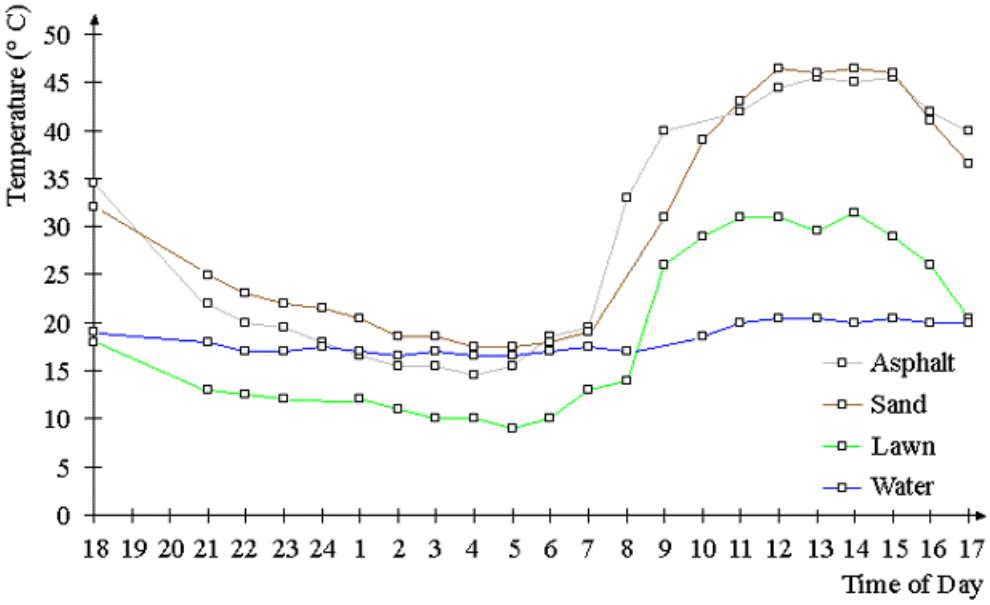

Fig. 1: Temperature curve above various surfaces (Kessler 1971 in: Mählenhoff 1989)

At the same time, the relative atmospheric humidity is also reduced, since vegetation surfaces and the resulting evaporation are lacking (cf. Maps 04.04, 04.05, 04.06, 04.07 SenStadtUm 1993). This can lead to the occurrence of extreme values, which can impair human well-being considerably.

The effects of sealing on the Berlin urban climate are shown in detail in various maps in the Climate section.

In this regard, non-sealed areas such as parks play a major role; even areas of one hectare in size can demonstrably have a positive climatic effects on human well-being. Vegetation-covered areas also affect the dust and pollutant-content levels of the air, since their large leaf surfaces can bind dust and other air pollutants.

The sealing of the soil also causes significant changes in the **water balance**, due to the loss of seepage surface for precipitation. **Groundwater recharging,** which is necessary for water supply, is reduced. Rainwater which falls on sealed areas is heavily polluted by tire abrasion, dust and dog excrement, and is then drained into the river tributaries via the sewage system, either directly or through a treatment plant (cf. Map 02.09, Disposal of Rain and Waste Water). In municipal areas with separate systems for rainwater and sewage, the rainwater flows directly into the local bodies of waters, and pollutes especially smaller bodies with its high load of pollutants. In areas with mixed-sewage systems (common treatment of rainwater and sewage), overloading of the sewage system or pumping stations may occur at times of strong rainfall, which will also cause untreated mixed water to enter directly into the local bodies of water. In addition, the increased degree of sealing can lead to aggravated danger in flood-prone areas; this is a considerable factor in areas such as the catchment area of the Panke (Geiger 1992).

Sealing and compression strongly affect the functions of the **soil**. Blocking of the water and oxygen supply destroys soil organisms. Since no more water can seep away, pollutant immissions from the air are no longer held in the soil, but are washed into surface waters by precipitation.

The total sealing of a segment of soil causes the complete loss of **flora and fauna** there. Partial sealing, however, also always causes habitat loss. Biotopes are cut off or fragmented, and sensitive species are replaced by more adaptable species.

In addition to the above-described effects on the ecosystem, the degree of sealing of a municipal area also has an immediate effect on **human habitat**. Thus, a high degree of sealing usually goes hand-in-hand with a low supply of green and open spaces per capita of the population. And endless row of buildings, interrupted only by asphalt or concrete surfaces, can have a depressing, monotonous effect on residents. People can no longer experience such factors of nature as the change of the seasons directly in their immediate surroundings. In order to recapture some part of the experience of nature, it is necessary to make relatively long trips to the outskirts of town or to the surrounding countryside.

Development of Sealing

The description of the development of sealing in the text of the 1993 Version was based on the expansion of developed and transportation areas as recorded in the statistics of the **State Statistical Agency**. However, these quantitative facts on land consumption **provide only limited informational value** for the description of actual soil sealing. For example, green and open spaces within developed areas are not recorded, so that if they are later built upon, such activity is not included as an increase in sealing. Even if no further increase of settlement and traffic areas were to take place, sealing of the city could nevertheless increase, e.g. by densification of existing developed areas.

Since the Land Register is the basis for the survey, actual land coverage will continue to be inaccurately assessed in the future. Thus, many large lots identified as a “buildings and open areas” do not in fact currently contain buildings.

The figures for developed and transportation areas are thus more suitable for the characterization of the increase in the developed area as such. Land consumption thus means purely and simply the development of woodland and farmland. Since the wooded areas in Berlin are largely protected, land consumption in effect means the reduction of farmland; building on allotment gardens and parks is not included.

For the time period **before 1989,** for **West Berlin,** these figures provide at best a rough summary of impacts within developed areas, and hence of a potential increase in sealing.

For the time period **after 1989,** no comparable data of the State Statistical Agency on residential development are available, because of the differently defined statistical quanta for West and East Berlin.

The text for Map 06.03 Green and Open Spaces describes the development of land consumption through 2000 on the basis of higher-resolution **block-referenced data from the Environmental Atlas** and the **GIS "Areas with Change Potentials of Overall Urban Significance."** This shows that land consumption within the city boundaries of Berlin was reduced dramatically during the decade 1990-2000 (from 370 hectares per annum between 1980 and 1990 to 48 ha/a). At the same time, however, a major increase in land consumption could be ascertained in the nearby surrounding countryside.

Aside from the development of land consumption, the development **of the overall degree of urban sealing** is of interest with regard to this Map. The data now available make possible the calculation of changes carried out in the interval. However, it should be noted that the methodologically-based differences in data collection allow only a limited comparison of firm values. The data base for sealing

is primarily based on a calculation of environmentally-related models, with greater importance attached to the precision and topicality of the recorded data than to its methodological comparability with that from earlier time periods.

The block-based sealing degrees (cf. Methodology) of the present updated Map, ascertained for the time period between **1990 and 2001,** show only a **very low increase in the level of sealing**, which corresponds to the low land consumption during that time period. It must be taken into account that any changes carried out in the meantime in the not-updated stock have not been included. The main-focus update carried out concerns only the approx. **20% of the blocks** the use of which was fundamentally changed during the time period stated.

Statistical Base

The information on the degree of sealing has been obtained from aerial photography, satellite images and topographical maps (cf. 1993 Version).

For **West Berlin,** the pixels of the satellite image interpretation were transferred to the block structure and compared with aerial photography, and the degree of building ascertained from basic urban-planning data. For **East Berlin,** the non-built-up sealed area was estimated based on aerial photography. The degree of building (coverage with building structures) was also estimated.

Based on the 1993 Version, a **main-focus update** was undertaken for the approximately **20% of the block areas** the use of which had changed fundamentally since 1990.

All tests undertaken in the interval to ascertain the development of the degree of sealing for all of Berlin, be it with **higher-resolution data bases,** e.g. satellite data of the imaging systems Landsat TM 7 and SPOT, or sealing data gathered terrestrially and lot-referenced by the Berlin Waterworks, has not yielded any satisfactory results. The values obtained differed strongly from each other, due to the different ascertainment methods.

The **bases** used to update the data stock for the **2004 Version** (AGU 2002, 2003) included information from the geodata bases "Areas with Change Potentials of Overall Urban Significance," of the Senate Department for Urban Development's Urban Information, Urban Development Monitoring and Population Forecast Group, 2000; CIR aerial photography at various scales, 1999, 2000; digital ortho-images, 1:10,000, 1998; and the following digital maps: the Automated Properties Map (ALK) 1998, for the area within the Urban Rail Ring line (S-Bahn); the Digital Basic Map 1:5000 (Digk5), 1999, 2000; and the Map of Berlin, 1: 5000. Moreover, the utilization information on all existing basic planning projects of the State of Berlin (BEP) was evaluated.

With the aid of that data, a total of 5312 areas were updated **as of 31 December 2001**.

Methodology

The map shows the degree of sealing, i.e., the surface coverage with impermeable materials **as a percentage of the reference surface**.

For a detailed methodological description, see (Methodology, 1993 Version).

On the basis of the stated data sources, the **degree of building** (coverage with building structures) per block area and the **share** of non-built-up sealing were ascertained. The addition of those two quanta yields the degree of sealing for a block area, i.e., 100% of the non-built-up sealed proportion is used to determine the **overall degree of sealing**.

That explains, for example, the degree of sealing of railway areas, 73%, which appears very high at first glance, but consists of 7% buildings and 66% non-built-up sealed areas. Moreover, 90% of the latter were assigned to Surface Class 4, the "most permeable" category (see Surface Classes).

Since the degree of building is the quantum that can be ascertained more exactly, the information on the degree of sealing has a tendency to be more precise the higher the share of the built-up area is. Terrestrial random sampling surveys were carried out to provide a statistical safeguard for the data.

For the use categories **Woodlands** and **Agriculture,** a degree of sealing of 2, or 2%, was automatically assigned; for **Ruderal Areas,** this was 7%, and for **parks** 10%. In these cases, the actual degree of sealing was ascertained if the recognizable degree of sealing differed considerably from the degree to be assigned. For roadways and railway areas, no degree of sealing is shown on the map.

The ascertainment of the degree of sealing was carried out only for areas of a minimum size of one hectare; for linear area structures, a minimum width of 20 meters applies.

All information on sealing is administered and processed by the City and Environment Information System (ISU). The ISU's **Basic Digital Topographical Map** in a scale of 1:50,000 (ISU 50) serves as a spatial reference system. There, each statistical block, which is as a rule delimited by streets, is shown with its block number. The numbering and delimitation of the **blocks** are managed by the State Statistical Agency. The smallest data surface is the **block segment,** which is delimited on the basis of differing utilization within a statistical block.

For the present Map, 24,690 block areas have thus been defined. The representation is **generalized and not true-to-location**. Streets have no area in the ISU spatial reference system, and can therefore not be referenced for data purposes. The course of the roadways emerges from the boundaries between the statistical blocks.

Surface Classes

In order to ascertain the **effects of sealing on the ecosystem** in as great detail as possible, various angles of perspective are conceivable. The climatic impact, for example, can be interpreted better if it is known whether the sealed areas are built-up or non-built-up, and how high the buildings are. A special analysis of the effects on the new groundwater formation and the drainage behavior of precipitation has resulted in the realization that all artificial surface coverings do not have the same environmental impacts. Thus e.g. a broad-seamed mosaic pavement is much more permeable to water than a concrete-sealed surface, and a parking lot paved with lawn pavers has a different micro-climatic effect than an asphalt parking lot.

The available types of surface covering have been grouped into four **surface classes** with different effects on the ecosystem. (cf. Tab. 1).

Tab. 1: Overview of Surface Classes

Sealing class	Estimated effects on ecosystem	Sealing type
1	extreme	Asphalt, concrete, paving stones with joint sealer or concrete substructure, plastic materials
2	high	Artificial stone and plates (edge length > 8 cm), concrete-stone composites, clinker, medium and large-sized paving stones
3	medium	Small and mosaic paving stones (edge length < 8 cm)
4	low	Grass trellis stones, water-bound cover (i.e. ash, pebbles, tamped ground), crushed rock, gravel

Tab. 1: Overview of surface classes

The distribution of surface classes of the non-built-up sealed area for every reference area was derived via a categorization of the reference areas and the representative determination of the distribution of surface classes (cf. Tab. 2) (AGU 1988). For newly investigated area types, the surface class distribution of comparable area types was used. These data are also used for the implementation of more far-reaching methods (such as e.g. the calculation of seepage, Map 02.13).

Tab. 2: Average Degree of Sealing and Construction and Surface Sealing Class Distribution for Non-Built-Up Sealed Areas by Area Types

Area type	degree of sealing	of which		sealing class for non-built-up areas			
		built-up sealed areas	non-built-up sealed areas	1	2	3	4
	%	%	%	%			
Residential areas							
Courtyard	81	51	30	56	22	3	19
Decorative and garden court	60	37	23	62	27	10	1
Reconstruction area	75	45	30	62	17	8	13
Shed court	58	30	28	46	29	13	12
Post-war block-edge	68	38	30	41	27	4	28
Unplanned reconstruction	68	37	31	45	28	13	14
Large-scale residential area	48	22	26	15	67	7	11
Residential area of the nineties >= four floors	52	29	23	20	60	10	10
Residential area of the nineties < four floors	51	29	22	20	35	35	10
Large court	45	29	16	20	37	32	11
Fifties and later row	40	21	19	49	46	3	2
Row yard	27	15	12	25	65	3	7
Yard	26	13	13	18	74	2	6
Park-like garden	28	16	12	15	60	12	13
Yards / semi-private re-greening	32	18	14	20	64	4	12
Open settlement development	22	13	9	18	74	2	6
Village	32	17	15	21	39	22	18
Core areas	83	49	34	50	34	9	7
Industrial / small business areas							
Mixed area II / industry and small business (built-up area < 50 %)	76	27	49	48	38	1	13
Mixed area II / industry and small business (built-up area >=50 %)	91	57	34	74	20	1	5
Utilities Areas	69	25	44	31	56	1	12
Public facilities							
Law enforcement	51	15	36	54	25	3	18
Postal	83	36	47	54	25	3	18
Administrative	66	32	34	41	42	15	2
Cultural	66	30	36	41	42	15	2
University/ reasearch	53	26	27	15	70	12	3
Hospital	40	20	20	42	38	8	12
Schools	63	23	40	45	40	2	13
Sports f+Z(31)Sacility	45	6	39	18	28	1	53
Water sports	32	14	18	46	29	13	12
Church	42	18	24	65	7	16	12
Child day care center	41	18	23	7	42	5	46
Playground	40	1	39	14	29	3	56
Retirement home	47	25	22	4	62	18	16
Youth center	29	12	17	4	62	18	16
Green and open spaces							
Allotment garden	20	10	10	5	31	4	60
Cemetery	16	2	14	14	27	5	54
Tree nursery / horticulture	33	15	18	35	45	9	11
Green space / park	11	1	10	30	20	5	45
City square / promenade	55	6	49	50	20	10	20
Forest	2	0	2	5	5	0	90
Agriculture (farmland)	2	0	2	10	10	0	80
Vacant areas	7	0	7	20	10	0	70
Campground	13	2	11	20	20	0	60
Weekend Cottage area	25	12	13	11	43	2	44
Traffic areas							
Parking lot	71	5	66	31	53	7	9
Railroad property	40	1	25	5	5	0	90
Airport	94	4	90	85	10	0	5
Other traffic areas	82	3	79	42	32	19	7

Green spaces within traffic areas or industrial and small business areas have been treated as vacant areas (e.g. vacant areas adjacent to airport taxiways); airports are only the sealed parts, streets were not considered
* sealing class is not yet determined

Tab. 2: Average area-weighted degree of sealing, built-up and non-built-up sealed areas and surface-class distribution of non-built-up sealed areas, by area type

The average sealing values of the individual area types **have changed only insignificantly** in comparison with the 1993 Version. Only in the case of the area type “Other Transportation Areas” has the average degree of sealing dropped by approximately half. The reason for this has been the new inclusion of numerous planted, unsealed traffic islands and the center strips of avenues.

Map Description

The overall degree of sealing of Berlin is 34.7%, more than half of which is non-built-up (cf. Fig. 2)**.** The stated “average degree of sealing” refers to the total area of a borough, or of the city as a whole, respectively. Moreover, the share of built-up area and the share of roadway surfaces in the total area of a borough is shown.

Treptow-Köpenick has the lowest degree of sealing among the boroughs, with 19%, while **Friedrichshain-Kreuzberg** and **Mitte** are the boroughs with the highest degrees of sealing, 68 and 61%, respectively. The share of built-up areas is also highest in these boroughs.

The **relationship between built-up, non-built-up and roadway surfaces** comes to one fifth each of the total area in the inner-city boroughs, while for the outlying areas, the non-built-up sealed share is considerably higher than that of the built-up areas, which is in turn higher than that of the roadway surfaces.

The highest degrees of sealing appear within the urban-rail ring line in the old residential buildings. Residential areas which still have predominantly closed dooryards show degrees of sealing of more than 90%. But the major **industrial and commercial districts** are also sealed to a high degree. Particularly the areas of long-standing industrial us along the Spree from Spandau to Köpenick, and the extensive industrial areas in Lichtenberg, Marzahn and Hohenschönhausen are more than 90% sealed

Overall the **degree of sealing drops as one moves from the center toward the outskirts**. This corresponds to the fact that the density of buildings is reduced toward the outskirts, and these outskirts are either completely undeveloped (woods, farmland), or characterized by detached housing. Certain exceptions stand out: The **traditional centers** of cities like Spandau and Köpenick, which were independent until 1920, are more than 60% sealed, climbing to over 90% sealed in their core areas. The major new development areas in the outskirts, such as Marzahn, Hellersdorf and Hohenschönhausen, Gropiusstadt in Rudow, or the Thermometer District in Lichterfelde, are between 50% and over 80% sealed.

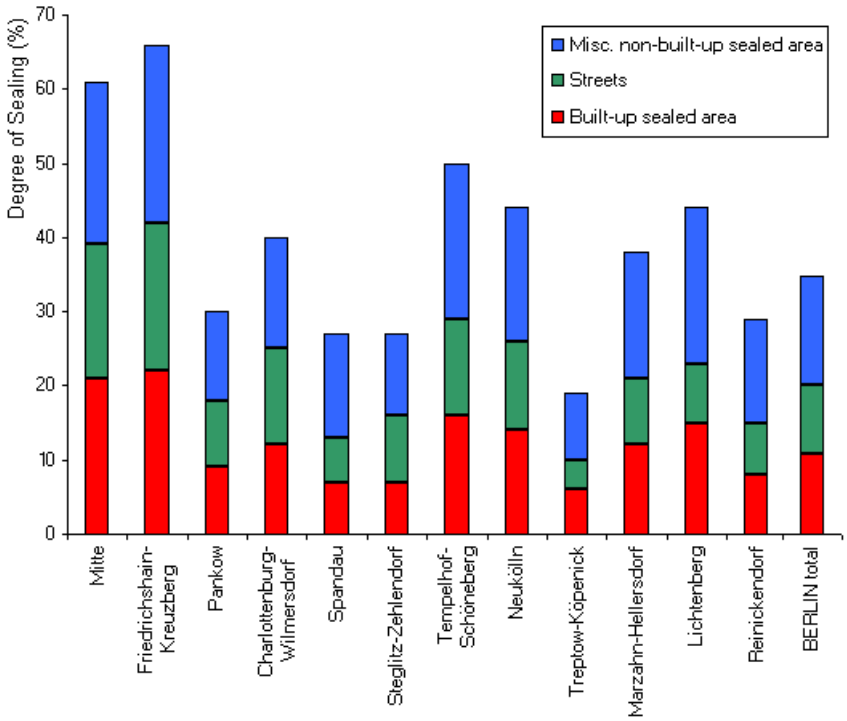

Fig. 2: Degree of sealing by borough

In order to permit comparison with the 1993 Version, the values under Data Bases are also referenced according to the borough division that existed prior to the local-government reform of 2000 (consolidation of 23 boroughs to the present 12).

The **more loosely-built developed areas at the outskirts** have differing degrees of sealing. Remote areas such as Heiligensee, Frohnau, Kladow or Müggelheim show the lowest densities, with degrees of sealing of between 10 and 30%. The classic single-family and row-house areas like Lichterfelde, Marienfelde, Kaulsdorf, Mahlsdorf, Karow or Blankenburg have degrees of sealing of around 20-40%, while areas which include more municipal functions, like Dahlem, Westend or Friedrichshagen are up to 60% sealed.

As a rule, **woodland and agricultural land** is unsealed. Nevertheless, here too there are uses which have a notably high degree of sealing. Especially the Grunewald looks like a patchwork on the map, due to its many and various uses. Military and former military areas (the Teufelsberg, the shooting range and the ammunition depot), a tree nursery, allotment gardens and riding facilities have in some cases high degrees of sealing. Notably high degrees of sealing are shown by the communications tower on Schäfersberg hill in the Düppel Forest, and the two big excursion restaurants with a large-scale parking lot on the southern shore of Müggel Lake in the Köpenick Heath.

Of the total sealed area of Berlin, 9.3% are occupied by **roadways**. These accounts for a full 20% of the area of the borough of Friedrichshain-Kreuzberg, approximately the same amount as each of the other two categories, built-up and non-built-up sealed. In the outer borough of Treptow-Köpenick, roadways occupy only 4%, or approximately half the area attributed to built-up and non-built-up sealed areas, which is in effect an expression of the considerably lower development density of that borough.

Comparing these 2001 figures with those of 1990 (1993 Version), the forecast made at that time of an **increase in the overall degree of sealing has failed to materialize**. As has already been stated, land consumption has been greatly reduced in this decade, so that available figures do not indicate any major increase in the overall level of sealing.

However, we should stress once again that such factors as greater density in detached-home areas with hitherto looser building patterns, or de-sealing measures in inner-city developed areas in the non-updated stock, have not been included in these figures.

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