DETERMINATION OF THE CONCENTRATIONS OF HARMFUL HEAVY METALS, PAHs, AND VOCs IN THE VAPORS OF DIFFERENT TYPES OF ASPHALT AT DIFFERENT TEMPERATURES IN THE AIR

FARKLI ASFALT TÜRLERİNİN BUHARLARINDAKİ ZARARLI AĞIR METAL, PAH VE VOC'LERİN FARKLI SICAKLIKLARDA, HAVADA ULAŞTIKLARI YOĞUNLUKLARININ BELİRLENMESİ
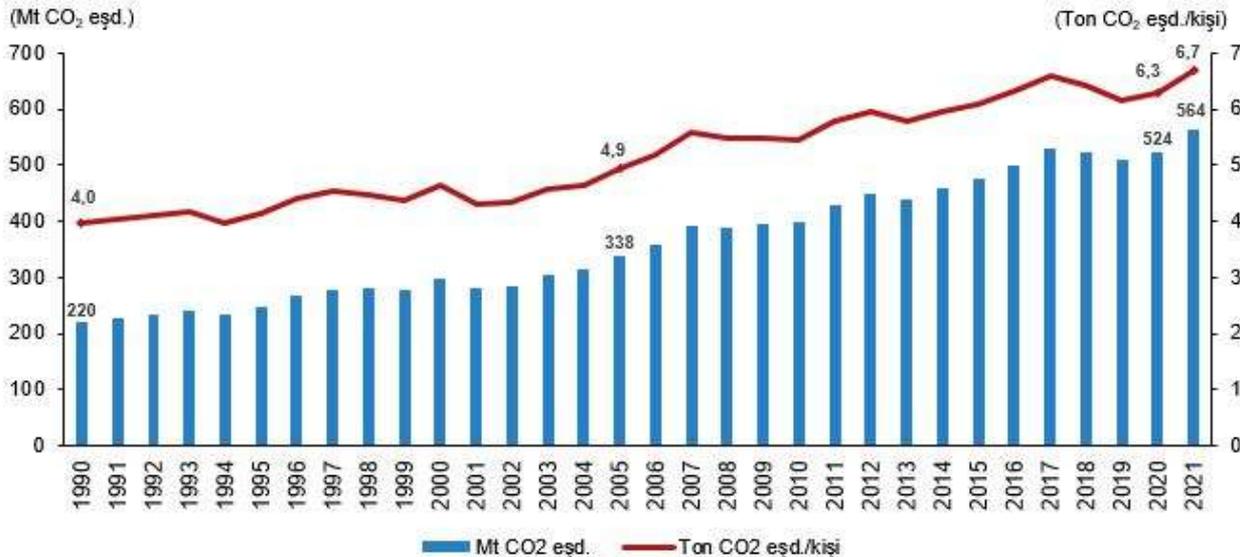
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GLOBAL GREENHOUSE GAS EMISSIONS

- Total greenhouse gas emissions in 2021 were calculated as 564.4 million tons (Mt) CO2 equivalent (eq.), an **increase of** 7.7 % compared to the previous year.
- Total greenhouse gas emissions **per person** were calculated as 6.3 t of CO2 eq. in 2020 and 6.7 t of CO2 eq. in 2021.
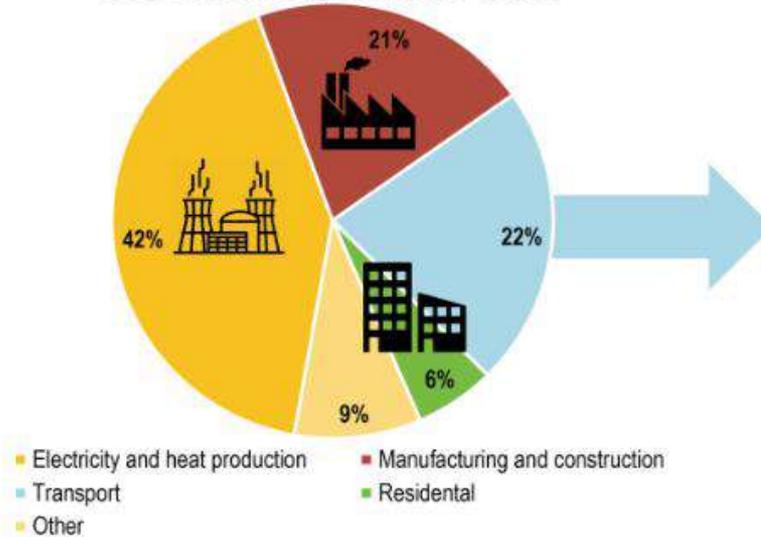
GLOBAL GREENHOUSE GAS EMISSIONS

CO2 Emissions by Economic Sector

- Electricity and heat production
- Transport
- Other
- Manufacturing and construction
- Residental

CO2 Emissions by the Transport Sector

Automobiles · Trucks · Aviation · Marine · Railways
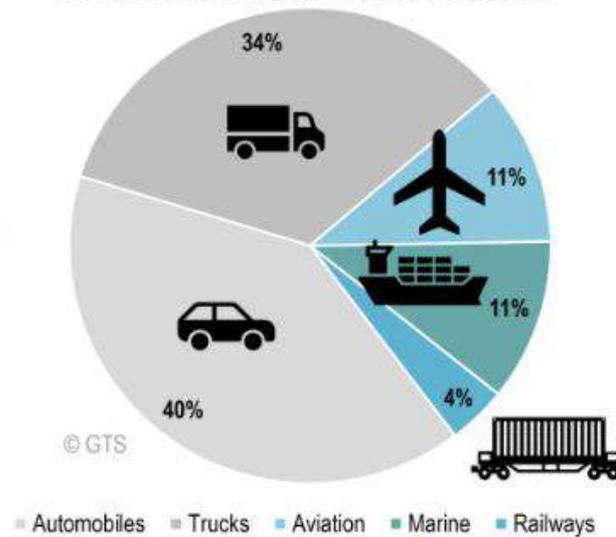
Source: International Energy Association. IEA and IPCC Summary for Policymakers. FRANCE

EMISSIONS SOURCES IN ROAD CONSTRUCTION
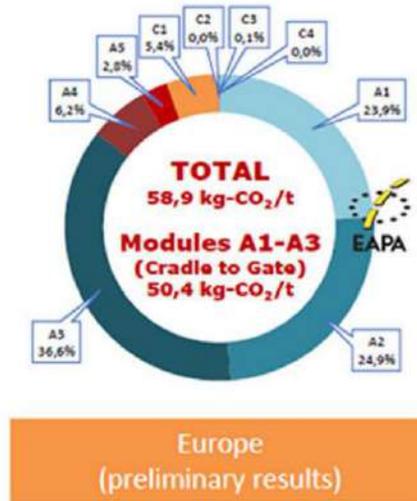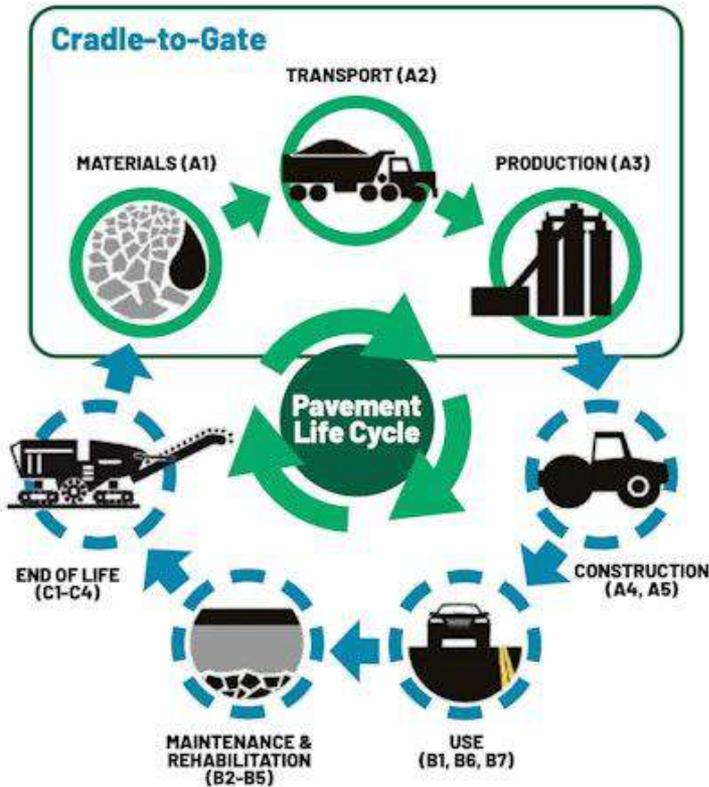
Source: «Key stages of the asphalt pavement life cycle with reference to the ISO 21930 life cycle information modules.» National Asphalt Pavement Association 2024, USA

LAYERS OF ROAD PAVEMENT

Asphalt concrete is the primary material used in the road construction sector.
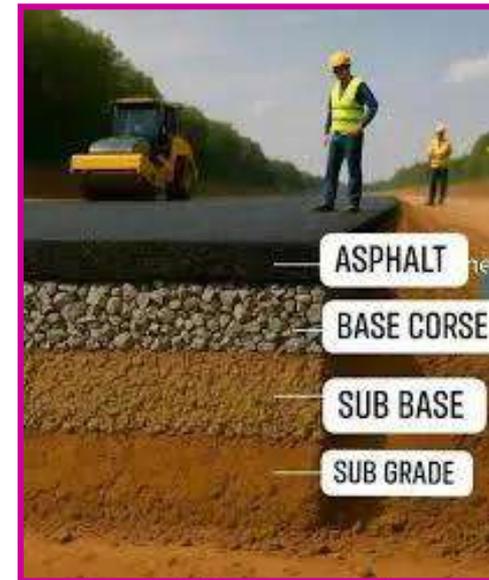
BITUMEN **+** AGGREGATE **=** ASPHALT

145-165°C

ASPHALT

BASE CORSE

SUB BASE

SUB GRADE

OCCUPATIONAL DISEASES FOR ASPHALT WORKERS

HIGH DANGEROUS

Asphalt Workers are affected by,

- Dust
- Polluting Gases
- Asphalt Fumes
- PAH
- VOCs
- Heavy Metals
- Phenol
- CO
- SO_2

- ❑ Respiratory system diseases
- ❑ Digestive system diseases
- ❑ Circulatory system diseases
- ❑ Skin diseas
- ❑ Eyes diseas
- ❑ Loss of hearing
- ❑ Psychological illnesses

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Asphalt Tonnage Calculation Guide

1.FORMULA:

Tonnage = Area (m²) × Thickness (m) × Density (ton/m³)

2. KEY COMPONENTS

- **Area (m²):** The total surface size of the application area
- **Thickness (m):** The height of the asphalt layer.
- **Density (ton/m³):** This value is approximately **2.4 ton/m³** for standart hot mix asphalt

3. EXAMPLE CALCULATİON

If you want to pave a **100 m²** area with a thickness of **5 cm** using standard asphalt:

- ✓ **Area:** 100 m²
- ✓ **Thickness:** 0.05 m (5 cm converted to meters)
- ✓ **Density:** 2.4 ton/m³
- ✓ **Calculation:** 100 × 0.05 × 2.4 = **12 Tons**

The top 10 countries leading asphalt production in 2025

Rank	Country	Production (Million Metric Tons)	Share of Global Production (%)
1	United States	420	32.8
2	China	38.7	30.2
3	Russia	30	2.3
4	Canada	28	2.2
5	India	25	2.0
6	Germany	38	3.0
7	France	31.9	2.5
8	Turkey	31.7	2.5
9	South Korea	0.655	0.05
10	Japan	20	1.6

Source: (Statranker.org, 2025)

OUR RESEARCH STUDY…

We experimentally determined the concentrations of **heavy metals**, **PAH** and **VOCs** emitted from the vapors of different hot mix asphalt types at different temperatures, as well as the concentrations of toxic gases and vapors.

TYPES of HMA	TEMPERATURES	
Binder Asphalt	125 °C	150 °C
Wearing Course Type-1 Asphalt	125 °C	150 °C
Stone Mastic Asphalt	150 °C	175 °C

OUR RESEARCH STUDY...

- We used as asphalt samples by **1 kg.**

- Time: 8,5 h

- Environmental conditions were in the laboratory;

  - ✓ Temperature: 24,1 °C

  - ✓ Pressure: 100,59 kPa

  - ✓ Humidity: 60,2 %RH

Determination of Heavy Metals

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Binder Asphalt 125 °C	Aluminium (Al)	0,158 ± 0,0398
	Antimon (Sb)	<LOQ ± -
	Arsenic (As)	<LOQ ± -
	Copper (Cu)	0,016 ± 0,0037
	Barium (Ba)	0,060 ± 0,0139
	Zinc (Zn)	0,019 ± 0,0046
	Ferrous (Fe)	0,340 ± 0,0804
	Cadmium (Cd)	<LOQ ± -
	Stannic (Sn)	0,035 ± 0,0089
	Cobalt (Co)	<LOQ ± -
	Chrome (Cr)	<LOQ ± -
	Plumbic (Pb)	<LOQ ± -
	Manganese (Mn)	0,006 ± 0,0015
	Molybdenum (Mo)	<LOQ ± -
	Nickel (Ni)	<LOQ ± -
	Selenium (Se)	<LOQ ± -
	Thallium (Tl)	<LOQ ± -
	Titanium (Ti)	0,012 ± 0,0029
	Vanadium (V)	<LOQ ± -

Determination of Heavy Metals

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Binder Asphalt 150 °C	Aluminium (Al)	0,070 ± 0,0177
	Antimon (Sb)	<LOQ ± -
	Arsenic (As)	<LOQ ± -
	Copper (Cu)	0,027 ± 0,0063
	Barium (Ba)	0,147 ± 0,0340
	Zinc (Zn)	0,033 ± 0,0077
	Ferrous (Fe)	0,481 ± 0,1135
	Cadmium (Cd)	<LOQ ± -
	Stannic (Sn)	0,041 ± 0,0103
	Cobalt (Co)	<LOQ ± -
	Chrome (Cr)	<LOQ ± -
	Plumbic (Pb)	<LOQ ± -
	Manganese (Mn)	0,009 ± 0,0020
	Molybdenum (Mo)	<LOQ ± -
	Nickel (Ni)	<LOQ ± -
	Selenium (Se)	<LOQ ± -
	Thallium (Tl)	<LOQ ± -
	Titanium (Ti)	0,010 ± 0,0022
	Vanadium (V)	<LOQ ± -

Determination of Heavy Metals

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Wearing Course Type-1 Asphalt 125 °C	Aluminium (Al)	0,094 ± 0,024
	Antimon (Sb)	<LOQ ± -
	Arsenic (As)	<LOQ ± -
	Copper (Cu)	0,059 ± 0,014
	Barium (Ba)	0,132 ± 0,031
	Zinc (Zn)	0,029 ± 0,007
	Ferrous (Fe)	0,618 ± 0,146
	Cadmium (Cd)	<LOQ ± -
	Stannic (Sn)	0,022 ± 0,006
	Cobalt (Co)	<LOQ ± -
	Chrome (Cr)	<LOQ ± -
	Plumbic (Pb)	<LOQ ± -
	Manganese (Mn)	0,008 ± 0,002
	Molybdenum (Mo)	<LOQ ± -
	Nickel (Ni)	<LOQ ± -
	Selenium (Se)	<LOQ ± -
	Thallium (Tl)	<LOQ ± -
	Titanium (Ti)	0,007 ± 0,002
	Vanadium (V)	<LOQ ± -

Determination of Heavy Metals

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Wearing Course Type-1 Asphalt 150 °C	Aluminium (Al)	0,086 ± 0,0217
	Antimon (Sb)	<LOQ ± -
	Arsenic (As)	<LOQ ± -
	Copper (Cu)	0,043 ± 0,0101
	Barium (Ba)	0,127 ± 0,0295
	Zinc (Zn)	0,032 ± 0,0075
	Ferrous (Fe)	0,512 ± 0,1209
	Cadmium (Cd)	<LOQ ± -
	Stannic (Sn)	0,027 ± 0,0068
	Cobalt (Co)	<LOQ ± -
	Chrome (Cr)	<LOQ ± -
	Plumbic (Pb)	<LOQ ± -
	Manganese (Mn)	0,007 ± 0,0017
	Molybdenum (Mo)	<LOQ ± -
	Nickel (Ni)	<LOQ ± -
	Selenium (Se)	<LOQ ± -
	Thallium (Tl)	<LOQ ± -
	Titanium (Ti)	0,007 ± 0,0016
	Vanadium (V)	<LOQ ± -

Determination of Heavy Metals

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Stone Mastic Asphalt 150 °C	Aluminium (Al)	0,087 ± 0,0218
	Antimon (Sb)	<LOQ ± -
	Arsenic (As)	<LOQ ± -
	Copper (Cu)	0,016 ± 0,0038
	Barium (Ba)	0,064 ± 0,0148
	Zinc (Zn)	0,025 ± 0,0060
	Ferrous (Fe)	0,312 ± 0,0736
	Cadmium (Cd)	<LOQ ± -
	Stannic (Sn)	0,018 ± 0,0047
	Cobalt (Co)	<LOQ ± -
	Chrome (Cr)	<LOQ ± -
	Plumbic (Pb)	<LOQ ± -
	Manganese (Mn)	<LOQ ± -
	Molybdenum (Mo)	<LOQ ± -
	Nickel (Ni)	<LOQ ± -
	Selenium (Se)	<LOQ ± -
	Thallium (Tl)	<LOQ ± -
	Titanium (Ti)	0,009 ± 0,0021
	Vanadium (V)	<LOQ ± -

Determination of Heavy Metals

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Stone Mastic Asphalt 175 °C	Aluminium (Al)	0,068 ± 0,0170
	Antimon (Sb)	<LOQ ± -
	Arsenic (As)	<LOQ ± -
	Copper (Cu)	0,392 ± 0,0923
	Barium (Ba)	0,091 ± 0,0210
	Zinc (Zn)	0,062 ± 0,0145
	Ferrous (Fe)	0,933 ± 0,2204
	Cadmium (Cd)	<LOQ ± -
	Stannic (Sn)	0,021 ± 0,0053
	Cobalt (Co)	<LOQ ± -
	Chrome (Cr)	<LOQ ± -
	Plumbic (Pb)	<LOQ ± -
	Manganese (Mn)	0,010 ± 0,0024
	Molybdenum (Mo)	<LOQ ± -
	Nickel (Ni)	<LOQ ± -
	Selenium (Se)	<LOQ ± -
	Thallium (Tl)	<LOQ ± -
	Titanium (Ti)	0,010 ± 0,0024
	Vanadium (V)	<LOQ ± -

Determination of VOCs

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Binder Asphalt 125 °C	Acetone	201,01 ± 48,70
	Chloroform	134,84 ± 33,83
Binder Asphalt 150 °C	Acetone	119,93 ± 29,06
	Chloroform	229,55 ± 57,59
Wearing Course Type-1 Asphalt 125 °C	Acetone	34,76 ± 8,42
	Chloroform	12,52 ± 3,14
Wearing Course Type-1 Asphalt 150 °C	Acetone	10,79 ± 2,61
Stone Mastic Asphalt 150 °C	Acetone	55,45 ± 13,44
Stone Mastic Asphalt 175 °C	Acetone	66,27 ± 16,06

Determination of PAH

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Binder Asphalt 125 °C	Naftalin	0,2287 ± 0,055236
	Asenaften	<0,0025 ± -
	Asenaftalin	<0,0025 ± -
	Fluoren	0,3246 ± 0,078942
	Fenantren	0,7583 ± 0,183431
	Antrasen	<0,0025 ± -
	Floranten	<0,0025 ± -
	Piren	0,7377 ± 0,178014
	Krizen	0,3972 ± 0,096088
	Benzo-a-antrasen	<0,0025 ± -
	Benzo-b-floranten	<0,0025 ± -
	Benzo-k-floranten	0,2087 ± 0,049959
	Benzo-a-piren	<0,0025 ± -
	İnden-1,2,3-cd-Piren	<0,0025 ± -
	Dibenzo-a-h-antrasen	<0,0025 ± -
	Benzo-g-h-i-perilen	<0,0025 ± -

Determination of PAH

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Binder Asphalt 150 °C	Naftalin	0,3211 ± 0,000004
	Asenaften	<0,0025 ± -
	Asenaftalin	0,5892 ± 0,000007
	Fluoren	0,4012 ± 0,000005
	Fenantren	0,8470 ± 0,000011
	Antrasen	<0,0025 ± -
	Floranten	<0,0025 ± -
	Piren	0,7377 ± 0,000009
	Krizen	0,3972 ± 0,000005
	Benzo-a-antrasen	<0,0025 ± -
	Benzo-b-floranten	<0,0025 ± -
	Benzo-k-floranten	0,2041 ± 0,000000
	Benzo-a-piren	<0,0025 ± -
	İnden-1,2,3-cd-Piren	<0,0025 ± -
	Dibenzo-a-h-antrasen	<0,0025 ± -
	Benzo-g-h-i-perilen	<0,0025 ± -

Determination of PAH

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Wearing Course Type-1 Asphalt 125 °C	Naftalin	0,2639 ± 0,000003
	Asenaften	<0,0025 ± -
	Asenaftalin	0,5892 ± 0,000007
	Fluoren	0,3607 ± 0,000005
	Fenantren	0,8026 ± 0,000010
	Antrasen	<0,0025 ± -
	Floranten	0,3675 ± 0,000005
	Piren	0,7333 ± 0,000009
	Krizen	0,3926 ± 0,000005
	Benzo-a-antrasen	<0,0025 ± -
	Benzo-b-floranten	<0,0025 ± -
	Benzo-k-floranten	0,2087 ± 0,000000
	Benzo-a-piren	<0,0025 ± -
	İnden-1,2,3-cd-Piren	<0,0025 ± -
	Dibenzo-a-h-antrasen	<0,0025 ± -
	Benzo-g-h-i-perilen	<0,0025 ± -

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Determination of PAH

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Wearing Course Type-1 Asphalt 150 °C	Naftalin	0,2463 ± 0,000003
	Asenaften	0,2928 ± 0,000004
	Asenaftalin	0,6290 ± 0,000008
	Fluoren	0,5004 ± 0,000006
	Fenantren	0,9445 ± 0,000012
	Antrasen	0,7531 ± 0,000009
	Floranten	0,3765 ± 0,000005
	Piren	0,7333 ± 0,000009
	Krizen	0,3926 ± 0,000005
	Benzo-a-antrasen	<0,0025 ± -
	Benzo-b-floranten	<0,0025 ± -
	Benzo-k-floranten	0,2132 ± 0,000003
	Benzo-a-piren	<0,0025 ± -
	İnden-1,2,3-cd-Piren	<0,0025 ± -
	Dibenzo-a-h-antrasen	<0,0025 ± -
	Benzo-g-h-i-perilen	<0,0025 ± -

Determination of PAH

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Stone Mastic Asphalt 150 °C	Naftalin	0,4750 ± 0,000006
	Asenaften	0,3294 ± 0,000004
	Asenaftalin	0,6202 ± 0,000008
	Fluoren	0,4779 ± 0,000006
	Fenantren	0,9312 ± 0,000012
	Antrasen	0,7531 ± 0,000009
	Floranten	0,3856 ± 0,000005
	Piren	0,7333 ± 0,000009
	Krizen	0,3926 ± 0,000005
	Benzo-a-antrasen	<0,0025 ± -
	Benzo-b-floranten	<0,0025 ± -
	Benzo-k-floranten	0,2041 ± 0,000003
	Benzo-a-piren	<0,0025 ± -
	İnden-1,2,3-cd-Piren	<0,0025 ± -
	Dibenzo-a-h-antrasen	<0,0025 ± -
	Benzo-g-h-i-perilen	<0,0025 ± -

Determination of PAH

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Stone Mastic Asphalt 175 °C	Naftalin	0,2287 ± 0,000003
	Asenaften	<0,0025 ± -
	Asenaftalin	0,5715 ± 0,000007
	Fluoren	0,5320 ± 0,000007
	Fenantren	<0,0025 ± -
	Antrasen	<0,0025 ± -
	Floranten	<0,0025 ± -
	Piren	0,7333 ± 0,000009
	Krizen	0,3880 ± 0,000005
	Benzo-a-antrasen	<0,0025 ± -
	Benzo-b-floranten	<0,0025 ± -
	Benzo-k-floranten	0,2132 ± 0,000003
	Benzo-a-piren	<0,0025 ± -
	İnden-1,2,3-cd-Piren	<0,0025 ± -
	Dibenzo-a-h-antrasen	<0,0025 ± -
	Benzo-g-h-i-perilen	<0,0025 ± -

Determination of Toxic Gases and Vapors

Measurements	Parametres	Detected Concentration (ppm) ± Measurement uncertainty
Binder Asphalt 125 °C	Phenol Sulfur dioxide Carbon monoxide	-*
Binder Asphalt 150 °C	Phenol Sulfur dioxide Carbon monoxide	-*
Wearing Course Type-1 Asphalt 125 °C	Phenol Sulfur dioxide Carbon monoxide	-*
Wearing Course Type-1 Asphalt 150 °C	Phenol Sulfur dioxide Carbon monoxide	-*
Stone Mastic Asphalt 150 °C	Phenol Sulfur dioxide Carbon monoxide	-*
Stone Mastic Asphalt 175 °C	Phenol Sulfur dioxide Carbon monoxide	-*

-* Not detected

- In the asphalt industry, the use of alternative materials and Asphalt 4.0 technologies is essential to reduce greenhouse gas emissions that affect asphalt workers and environmental health.

- Reducing carbon emissions on highways will contribute to mitigating the destructive effects of global climate change.

- In line with the objectives of our study, it is recommended that awareness be raised in the asphalt sector; that regulations resulting from international policies be adapted to our country that OHS 4.0 and Asphalt 4.0 technologies be disseminated and implemented nationwide by all stakeholders in the private and public sectors.

THANK YOU!
TEŞEKKÜRLER...

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