Determination of CO_2 Emissions using the Example of a specific Road Maintenance Measure

Amina Brzuska, M.Eng.
Institute for Transport Systems and Infrastructure (IVI)
Hochschule Karlsruhe – University of Applied Sciences
e-mail: amina.brzuska@hs-karlsruhe.de

Keywords: Road Maintenance, CO_2 Emissions, Climate Change

Introduction

The concept of sustainable development was defined by the United Nations World Commission on Environment and Development report as "*development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs"*. (BMU 2017) One of the tasks that can be derived from this for our society is to mitigate global climate change by reducing greenhouse gas emissions.

A reduction in greenhouse gas emissions is necessary in all sectors of the economy, including road construction. In order to achieve a reduction, for example, manufacturing processes must be analysed. Based on this analysis, potential savings can be identified and implemented.

In the following, the CO_2 emission determination carried out in (Brzuska 2016) is presented. The aim of (Brzuska 2016) was to identify the main CO_2 emissions caused by the road construction process.

Investigated construction project

The study (Brzuska 2016) determined the main CO_2 emissions emitted using the example of the renewal measures carried out on Kreisstraße 3533 (formerly Landstraße 560) in the district of Karlsruhe, Germany. As part of the renewal measure, the complete bonded pavement was extended over a length of around 1.9 kilometres in autumn 2015. This pavement, which was largely contaminated with PAH-containing binding agents, was replaced by a 14-centimetre asphalt base course and a 4-centimetre asphalt surface course. The bituminous asphalt surface course (4 centimetres) was renewed on a further 400 metres. Furthermore, unevenness caused by the use of the road was compensated by the installation of gravel material in the area of the 1.9 kilometre section. In addition to these measures carried out on the pavement, the banquets, forest road connections, delineators and markings had also been restored or renewed.

Research framework

Only CO_2 emissions that can be directly attributed to the renewal measure were taken into account. Figure 1 shows all of the accounted processes.

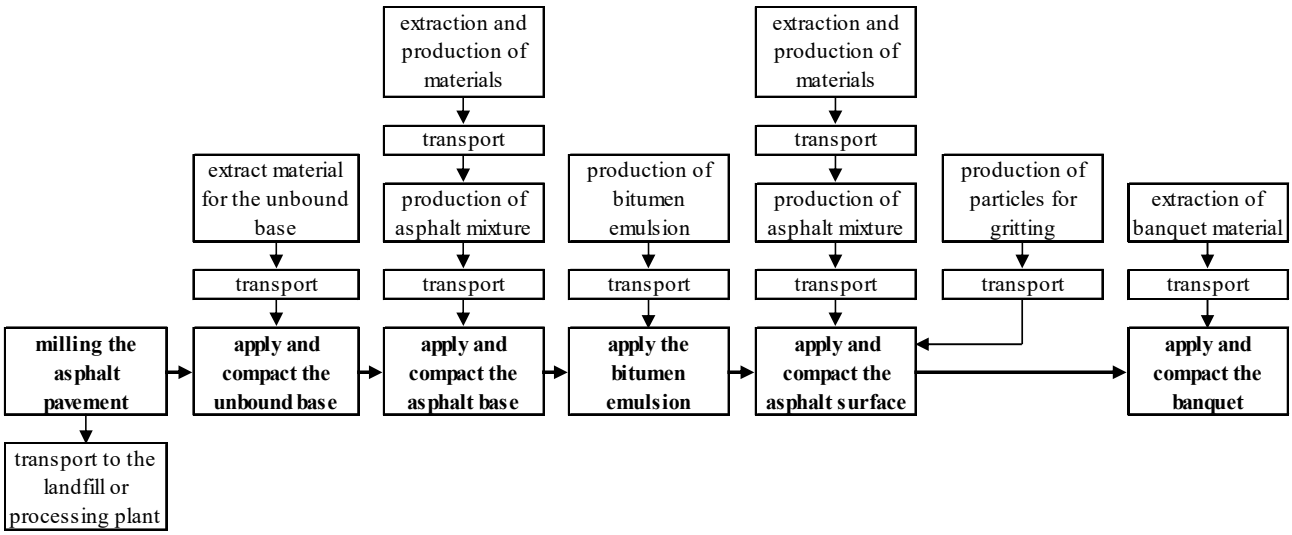


Figure 1: Processes considered in the calculation of CO_2 emissions, cited by (Brzuska 2016)

CO_2 emissions emitted by future maintenance and repair measures or by the deconstruction of the road have not been taken into account. Also

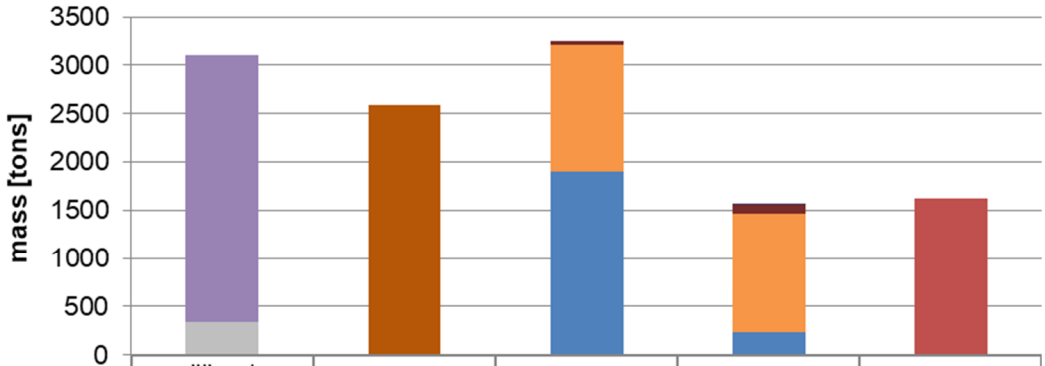
- the arrival and departure of employees,
- the transport of construction machinery,
- the production of road equipment,
- the extraction and transport of the asphalt granulate required for the production of the mixture
- and further energy expenses indirectly attributable to the construction project

were not accounted.

Method

First, the primary energy requirement of the construction project was determined in order to then determine the CO_2 emissions emitted. Primary energy demand or also well-to-wheel demand means that, in addition to the direct energy demand (also called tank-to-wheel demand), the production-related energy demand is also taken into account. When determining CO_2 emissions, it is important not only to consider the direct energy requirement but also the primary energy requirement. This is clearly demonstrated by the example of using electrical energy. While no CO_2 emissions are emitted when electrical energy is used, CO_2 emissions are emitted when electrical energy is produced.

The masses removed and installed during the construction work are shown in Figure 2. These served as the basis for determining the primary energy requirement. As already shown in Figure 1, not only the finished product was considered, but also, for example, the production and extraction of the individual asphalt mixture components. The energy demand values on which the account was based were preferably obtained from the manufacturing companies, the bill of quantities and the construction diary. The data has been checked for plausibility with the aid of literature values.



	milling the asphalt pavement	strengthen the unbound base	manufacture the asphalt base	manufacture the asphalt surface	manufacture the banquet
PAH-containing material	2763				
removed asphalt	344				
material for unbound base		2593			
particles for gritting				15	
bitumen, bitumen emulsion			51	85	
aggregates			1309	1236	
reclaimed asphalt			1896	232	
banquet material					1627

Figure 2: Material masses during the renewal of the Kreisstraße 3533, cited by (Brzuska 2016)

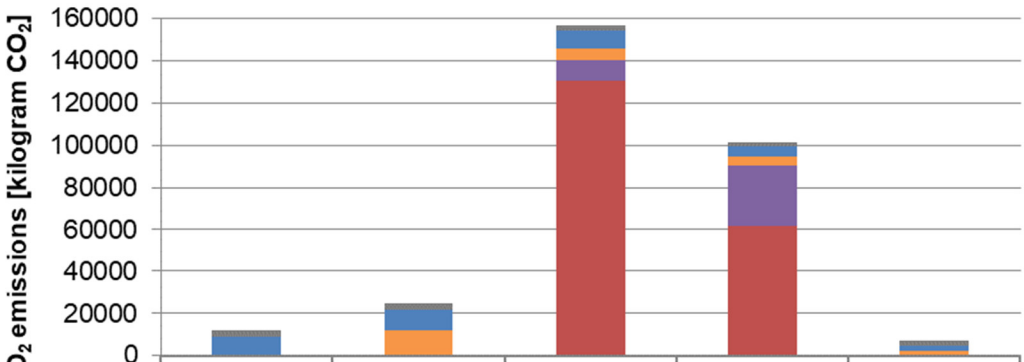
For the transports shown in Figure 1, both transport trips and empty trips on the return routes were taken into account.

The use of machines on the construction site as well as for the extraction and production of the required materials were also accounted. In addition to the exact type of machine, the basis was the service life and the specific fuel consumption.

Research findings

The construction project emitted around 300 tons of CO_2. As can be seen from Figure 3, a large proportion of these CO_2 emissions were caused by the production of the asphalt layers, especially during the production of the mixture in the mixing plant (around 64 percent of total emissions). The reason for the high CO_2 emissions in the production process of the mixture is the high energy consumption.

Regarding the production of bitumen or bitumen emulsion, the CO_2 emissions for the asphalt surface layer are three times higher than for the asphalt base layer. There are two reasons for this. Firstly, the asphalt surface layer required more fresh bitumen due to the lower asphalt granulate content. Secondly, the asphalt surface layer was produced using polymer-modified bitumen. The production of polymer-modified bitumen is much more energy-intensive than the production of conventional road bitumen.



	milling the asphalt pavement	strengthen the unbound base	manufacture the asphalt base	manufacture the asphalt surface	manufacture the banquet
use of machines on the construction site	2948	3151	2389	1864	2573
transporte	9058	9795	8516	4767	2468
material extraction		11699	5442	4472	2217
production of bitumen, bitumenemulsion			9563	28253	
asphalt mixture production			130398	62060	

Figure 3: Resulting CO_2 emissions in kilogram CO_2 taking primary energy consumption into account, cited by (Brzuska 2016)

Perspective

In comparison to the CO_2 emissions of around 300 tons produced by the shown 2.3-kilometre renewal measure, a newly registered passenger car that meets the requirements of (Amtsblatt der Europäischen Union 2011) and emits only 95 grams of CO_2/kilometre in 2020 could cover the distance of 2.3-kilometres around 1.37 million times. And even a passenger car with 120 grams of CO_2 emissions per kilometre could cover the distance about 1.09 million times.

In order to reduce CO_2 emissions from the construction or renewal of roads in the future, either the energy required for transport, machinery and material production would have to be reduced, or a new road structure would have to be developed. For example, the trinational project "Optimal Recycling of Reclaimed Asphalt Pavements - ORRAP", financed by the European Union within the framework of INTERREG, aims to investigate a new recycling strategy in which the negative environmental impact of road construction measures is reduced. In addition, CO_2 emissions for different construction methods will be calculated and compared within the framework of the project. (INSA de Strasbourg)

References

Amtsblatt der Europäischen Union (2011). Verordnung (EU) Nr. 510/2011 des Europäischen Parlaments und des Rates vom 11. Mai 2011 zur Festsetzung von Emissionsnormen für neue leichte Nutzfahrzeuge im Rahmen des Gesamtkonzeptes der Union zur Verringerung der CO_2-Emissionen von Personenkraftwagen und leichten Nutzfahrzeugen. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:145:0001:0018:DE:PDF [15.04.2019].

BMU (2017) Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit. Nachhaltige Entwicklung als Handlungsauftrag. Available at: https://www.bmu.de/themen/nachhaltigkeit-internationales/nachhaltige-entwicklung/strategie-und-umsetzung/nachhaltigkeit-als-handlungsauftrag/ [02.11.2018].

Brzuska, A. (2016). Ermittlung der CO_2-Emissionen bei einer Straßenerneuerungsmaßnahme am Fallbeispiel der K 3533 (ehem. L 560) im Landkreis Karlsruhe. Bachelorthesis an der Hochschule Karlsruhe - Technik und Wirtschaft, Fakultät Architektur und Bauwesen (unveröffentlicht). Karlsruhe, 2016.

INSA de Strasbourg. Optimal Recycling of Reclaimed Asphalt Pavements - ORRAP. Available at: https://www.orrap.org/ [15.04.2015].