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Reducing the environmental impact of construction tunnelling

The construction industry is among the top three drivers of resource use in the EU. This study investigated the environmental impacts of a common construction method, drill and blast tunnelling, using life cycle assessment. The researchers assessed 20 years of data on tunnelling in Norway to identify areas that could be targeted to reduce its environmental impact. They recommend reduced consumption of explosives and increased use of renewable energy.

The construction industry has adverse effects on the environment; it uses energy, water and raw materials and contributes to water and air pollution, landfill waste and climate change. Increasing awareness of the environmental impact of the construction industry has led to appeals for more sustainable technologies and methods.

An example of a technique in need of improvement is tunnelling, which consumes natural resources and emits pollutants with corresponding environmental impacts. One of the most common tunnelling methods is drill and blast (D&B) tunnelling, which involves drilling holes into rock and filling them with explosives, causing the rock to collapse.

Few studies have investigated the environmental impact of D&B tunnelling. This study addressed this knowledge gap using 20 years of data on rock tunnelling in Norway.

The authors used life cycle assessment (LCA) to investigate the impact of tunnelling on the environment; the effect of tunnel size and length on pollutant emissions; and to identify areas with potential for optimisation. They followed the International Organization for Standardization (ISO) methodology for LCA and carried out modelling using SimaPro software. They used an impact assessment approach called ReCiPe with the following impact categories: climate change, human toxicity, photochemical oxidant formation (pollutants typically found in photochemical smog, including ozone), formation of particulate matter, acidification of soil, and toxic effects on soil.

The researchers compared impacts of creating a standard Norwegian road tunnel with different sizes and length tunnels. In total, 22 different scenarios were analysed. They found that all categories of environmental impact increase with tunnel size, owing to an increase in drilling, blasting and ventilation. In particular, the size of the cross section has a significant influence on environmental impact. For example, one metre of tunnelling for a tunnel with a 20 m^2 cross section emits 0.4 tonnes of CO_2, while nearly 1.4 tonnes are emitted for a 120 m^2 cross section. Expansion of tunnel length also increases the environmental burden, due to a longer transport distance and increased need for ventilation.

Analysis identified three main sources of environmental damage, the first of which was explosives use. The production of explosives and the blasting process was found to have significant effects in all impact categories. The authors recommend improving the efficiency of explosives use via better designed tunnel cuts and layout of drilling holes.

The second key factor was diesel consumption. Diesel is used to power the engines of tunnelling machines and vehicles and particularly contributes to climate change, human toxicity and toxic effects on soil. The authors say using biodiesel would reduce CO_2 emissions and could be implemented relatively easily with existing technology.

The final source of environmental damage was electricity consumption, used for drilling and blasting and ventilation. This was the major contributor to climate change. To reduce this, the authors recommend tunnelling from both sides (which is usually possible when a tunnel is longer than 3 km) and optimising the design of ventilation systems. They also recommend use of renewable sources of energy like hydropower to cut CO_2 emissions.

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The researchers also identified that the biggest contributions to climate change and soil toxicity are produced at the stage of loading and hauling. Furthermore, the stage of drilling and blasting has the largest impact on human toxicity, photochemical oxidant formation, particulate matter formation and acidification of soil.

This study shows that improving tunnelling is relevant to climate change mitigation, with CO_2 emissions ranging from 0.42 to 1.45 tonnes per metre. Overall, the authors say the drilling and blasting process should be optimised to reduce use of explosives and increase use of renewable energy. Although this study was based on Norwegian practices, the authors say their findings can be applied to industry elsewhere in the world, as D&B tunnelling is one of main methods used for hard rock.

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