# 9 Sustainability Considerations

Sustainability and reduction of greenhouse gas emissions is a most important consideration in the world today. It is now generally accepted that climate scientists predictions are correct in that man-made emissions, predominantly Carbon Dioxide ($CO_2$), Methane ($CH_4$) and Nitrous Oxide ($N_2O$) are a significant cause.

## 9.1 Diamond Grid and Concrete Pavements

Carbon dioxide emitted during the cement production process represents the most important source of non-energy industrial process of global carbon dioxide emissions. Cement production accounts for around 7% of total global industrial energy use and about 7% of global emissions.

Concrete is the most widely used man-made material in existence. It is second only to water as the most-consumed resource on the planet.

In order to compare the environmental input, consider the case of a concrete pavement constructed in accordance with the design methods of Austroads Guide to Pavement Technology Part 2, Structural design. The trial pavement carries a design traffic of 1 x $10^6$ ESA on a CBR of 8%.

Data used in the determination of the analysis is shown in Table 9-1

**Table 9-1: Carbon footprint of construction materials with reference source**

| Product | Emission factor | Unit | Reference Source |
|---|---|---|---|
| Coarse aggregates – Granite | 0.0459 | t $CO_2$-e/tonne | D Flower & J Sanjayan (2007) *Green House Gas Emissions due to Concrete Manufacture*, Department of Civil Engineering, Monash University, Clayton, VIC 3800, Australia |
| Coarse aggregates – Basalt | 0.0357 | t $CO_2$-e/tonne | |
| Fine aggregates | 0.0139 | t $CO_2$-e/tonne | |
| Concrete 40 MPa | 0.3535 | tonnes/m³ | |
| Concrete 32 MPa | 0.322 | tonnes/m³ | |
| Concrete 25 MPa | 0.29 | tonnes/m³ | |
| Concrete 20 MPa | 0.268 | tonnes/m³ | |
| Cement | 0.82 | t $CO_2$-e/tonne | |
| Steel | 1.85 | t CO2-e/tonne | https://www.google.com/search?q=greenhouse+gas+steel&rlz=1C1CHBD_en-GBAU891AU891&oq=greenhouse+gas+steel&aqs=chrome..69i57j0l6.8031j0j8&sourceid=chrome&ie=UTF-8 |
| Polypropylene new | 1.55 | t $CO_2$-e/tonne | https://archive.epa.gov/epawaste/conserve/tools/warm/pdfs/Plastics.pdf |
| Polypropylene recycled | 0.35 | t $CO_2$-e/tonne | |
| Bitumen | 0.426 | t $CO_2$-e/tonne | P White et al (2010) *Modelling climate change impacts of pavement production and construction,* Resources, Conservation and Recycling Volume 54, Issue 11, September 2010, Pages 776-782 |
| Biochar | -3.5 | t $CO_2$-e/tonne | Determined from molecular weights |

Table 9-2 shows the environmental impact of greenhouse gas emissions for a comparable concrete and Diamond Grid pavement. The impact of the concrete pavement is some 3.5 times greater than the concrete pavement.

**Table 9-2: Greenhouse gas comparison of Concrete vs Diamond Grid pavement**

| Concrete pavement | | Diamond Grid pavement | |
|---|---|---|---|
| Material | Kg GhGe/m² | Material | Kg GhGe/m² |
| 125 mm bound subbase (5% cement) | 21.7 | 160 mm granular subbase (limestone) | 4.0 |
| 205 mm 40 MPa concrete base | 72.5 | 140 mm granular base (hard rock) | 12.8 |
| 3 kg/m² reinforcement | 5.5 | 40 mm Diamond Grid | 1.1 |
| | | 40 mm 20 MPa concrete | 10.7 |
| Total GhG | 99.7 | Total GhG | 28.7 |

## 9.2 Diamond Grid with CarbonCor

Should the concrete fill in the Diamond Grid be replaced by CarbonCor products, the biochar content sequesters carbon into the pavement. Biochar has an equivalency of 3.5 tonnes of $CO_2$/tonne. Biochar is essentially Carbon, and the equivalency with $CO_2$ is determined by the fact that the molecular weight of Carbon is 12, the molecular weight of oxygen is 16, and the $CO_2$ molecular weight is 44.

There are many mixes that can be made with CarbonCor using materials that would generally be considered unsuitable for pavements (eg Pindan) but when combined with 1.5% to 2% bitumen and 3% or more biochar produce an exceptionally strong bound material.

Pindan extraction requires very little energy and calculations show that by replacing the 20 MPa concrete in the Diamond Grid with a 2% bitumen, 3% biochar alternative will lock 5 kg/m² into the fill material. This would then reduce the greenhouse gas emissions associated with the pavement to 12.0 kg/m² or 12% of the concrete pavement option.