



Low Emission Building Materials

Harish Srivastava, Director Civil Engineering / 27 May 2021

Approach for Carbon Footprint Reduction

- Reduce carbon footprint of **material manufacturing/ processing**
- Full or partial replacement of constituents with a **lower carbon footprint material**
- Full or partial replacement of constituents with **recycled materials**
- **Reduce material quantity** by using higher strength material



Main Construction Materials
Cement, Aggregate, Asphalt, Steel and Aluminium

Cement Concrete

- Made by mixing cement, aggregates (coarse and fine) and water



Source: <https://www.arteazul.com/permanent-or-temporary-work-all-have-one-solution/>

Concrete Facts

- Concrete is the second most consumed substance (after water) in the world^{#1}
- 70% of the world's population lives in a structure that contains concrete^{#1}
- About 29 million cubic metres of pre-mixed concrete is produced in Australia each year^{#1}

#1 https://www.ccaa.com.au/iMIS_Prod/CCAA/Industry/Concrete/CCAA/Public_Content/INDUSTRY/Concrete/Concrete_Overview.aspx?hkey=50e46381-71a1-4a42-a89f-d073f063ed51

Replace Cement with Lower Emission/ Waste Materials

- Replace cement partially with supplementary cementitious materials (SCM) such as fly ash, blast furnace slag, amorphous silica (silica fume) or a combination of two or three SCM types
 - TfNSW specifications B80, R82 & R83 allows up to 30% fly ash and up to 65% slag in concrete
 - Specification B80 - Structural concrete in bridges, buildings etc.
 - Specifications R82 & R83 - Cement concrete pavement

Innovation initiatives: TfNSW, as part of SmartCrete CRC is working with universities to explore possibility of

- using crushed glass as SCM
- increasing permissible limits for fly ash and ground granulated blast furnace slag (GGBFS)
- using alternative cement – Limestone calcined clay cement (LC3)



Lawrence Hargrave Drive

- 65% slag concrete for pier column, box girder



Rooty Hill Station and Commuter Carpark

- 22% fly ash & 20% GGBS in S40 concrete
- 25% fly ash & 22% GGBS in S50 concrete



Bridge over Kalang River – Urunga

- 25% fly ash concrete

Replace Aggregates with Low Emission/ Waste Materials

- Replace aggregate (coarse/ fine) partially with low emission or waste materials such as:
 - Recycled crushed glass
 - Recycled concrete aggregate

Case Study: Pacific Highway Woolgoolga to Ballina (W2B) Project

- Length: 155 km
- Fly ash Used: 90,000 tonnes
 - R82 Lean Mix Concrete (LMC) subbase concrete mix contains min 100kg/m³ of fly ash.
 - R83 Base concrete mix contains 60 - 70kg/m³ of fly ash.
- Recycled Glass Trials (May 2019)
- Total recycled glass used: 201 tonnes (Equivalent to 1,031,166 beer bottles @195gm/bottle)
 - 1213 m³ LMC subbase incorporating 134 tonnes of recycled glass.
 - 600m³ shoulder base incorporating 67 tonnes of recycled glass.



Pacific Highway Woolgoolga to Ballina (W2B) Project
(Sub base course & shoulder base concrete with 15% crushed glass)

Asphalt



Bitumen (~5%)

+



Coarse aggregate (~78.5%),
Fine aggregates (~15%) &
Filler (~1.5%)

Heat



Asphalt

Asphalt Facts

- Asphalt related emission = $35\text{kg CO}_2\text{-e}/\text{t}^{\#1}$ (assuming diesel fuel burner, production temp 155°C , 0% RAP, 2% moisture in aggregates and 40km haulage)

#1 <https://austroads.com.au/publications/pavement/ap-r416-12>



Asphalt with Recycled Materials

Partially replace binder/ fine aggregate with:

- **Crumbed rubber** – provides superior resistance to reflection cracking from underlying stabilised base and sub-base pavement materials.
- **Recycled crushed glass (RCG)** - TfNSW specifications R116, R117, R118 and R121 allow up to 10% RCG in base course and up to 2.5% RCG in wearing course
- **Steel furnace slag** - used in areas requiring higher skid resistance such as intersections
- **Reclaimed Asphalt Pavement (RAP)** - TfNSW specifications allow up to 40% RAP in asphalt mixes

Innovation:

- Asphalt industry is developing a number of asphalt products by mixing recycled plastic in dry or wet form (as binder and fine aggregate), some examples are Alex Fraser - Poly Pave™, Boral - Innovo™, Downer – Reconophalt, Fulton Hogan - PlastiPhalt® etc.
- Increase RAP limit to 50%
- TfNSW is planning a small scale trial of Reconophalt in Redfern Station Upgrade project.



Crumbed Rubber Mix Asphalt Pavement in Hunter Region



Recycled Glass Aggregate Trial on Carlingford Rd, Epping (2019)

Replace Steel with Lower Emission Material

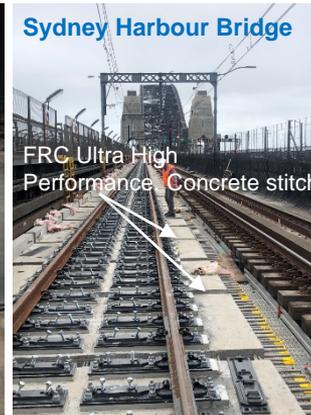
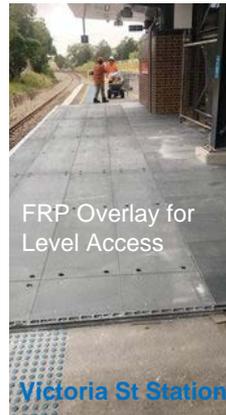
Replace steel (partially or fully) with materials with lower embodied carbon

- Steel reinforcement with glass fibre reinforced polymer (GFRP) reinforcement
- Steel reinforcement with recycled plastic fibre reinforcement (FRC)
- Steel sections with fibre reinforced polymer (FRP) sections for fabrication

Key Steel Facts:

- On average, 1.9 tonnes of CO₂ are emitted for every tonne of steel produced.
- Embodied energy in FRP is approximately 50% of that of steel^{#1}

#1 <https://bellona.org/news/ccs/2019-03-is-steel-stealing-our-future>



Summary and Conclusion

- TfNSW successfully use waste and lower emission construction materials for infrastructure projects
- Further research is required to establish baseline CO₂ emission database for various construction materials sourced from different locations/ processing methods

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