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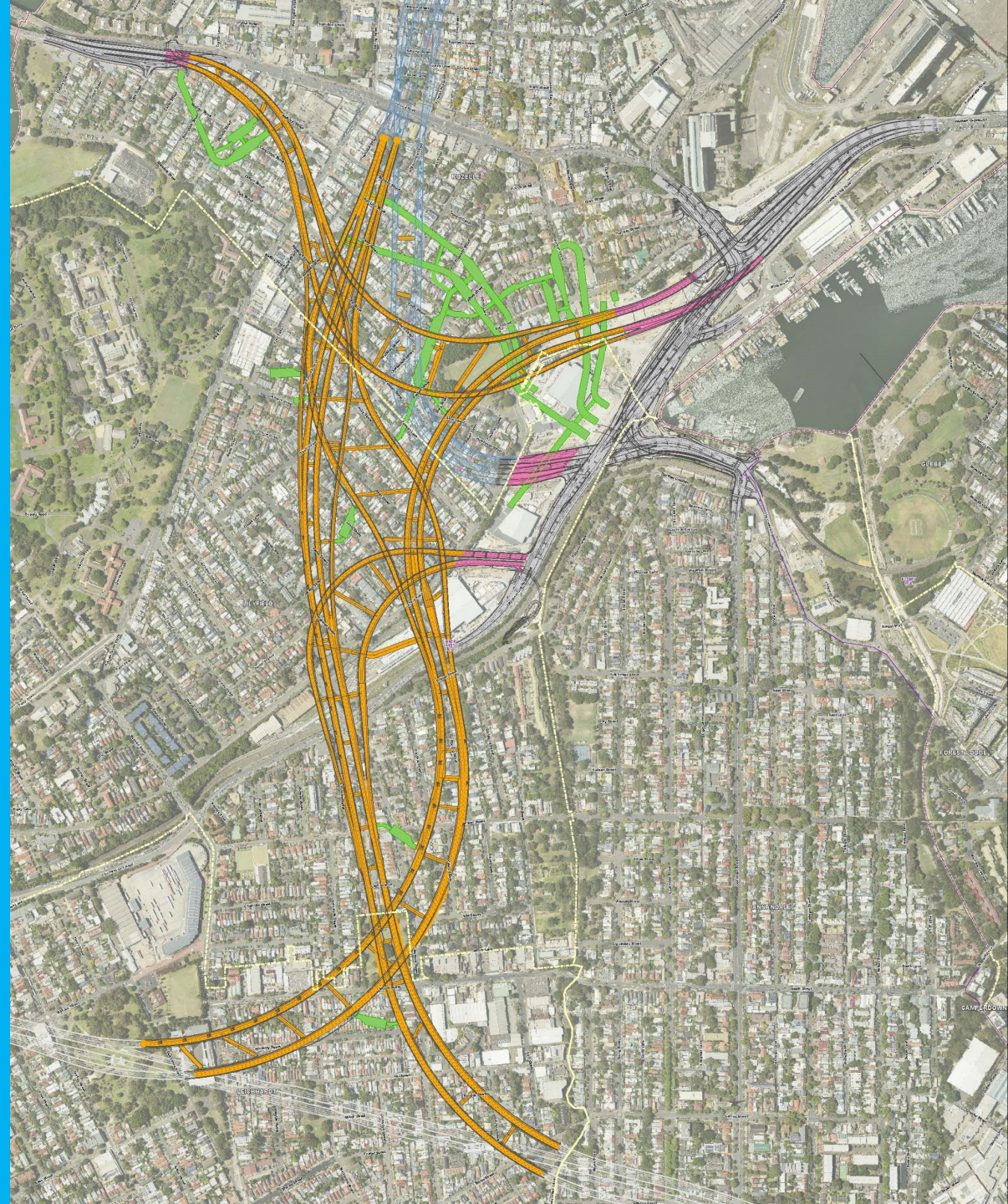
Implementation of alternative concrete solutions at the Rozelle Interchange Project

Project Snapshot

The Rozelle Interchange is the final stage of WestConnex. Constructed by a joint venture between John Holland and CPB Contractors (JHCPB)

- $3.9B Design and Construct contract
- Opening in late 2023
- New underground interchange at Lilyfield and Rozelle connecting the M4-M5 link mainline tunnels to:
  - City West Link
  - Anzac Bridge
  - Iron Cove link
  - Proposed WHT and Beaches link.



Project Snapshot

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- 22.4km of tunnels including motorway, cross passages and support tunnels
- Three Motorway Operation Centres (MOC), two new vent facilities
- Road widening, dive structures, tunnel portals and drainage infrastructure
- Up to ten hectares of new public parkland within the Rozelle Rail Yard site
- New and improved pedestrian and cyclist connectivity (two new bridge connections over City West Link)
- Site establishment began in early 2019.
- ~40% construction progress.

Resource Use- Materials

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- 56,000 Tonnes of Steel
- 88,000 Tonnes of Asphalt
- 477,000 Tonnes of Aggregate
- **1.24M Tonnes of Concrete**

Concrete

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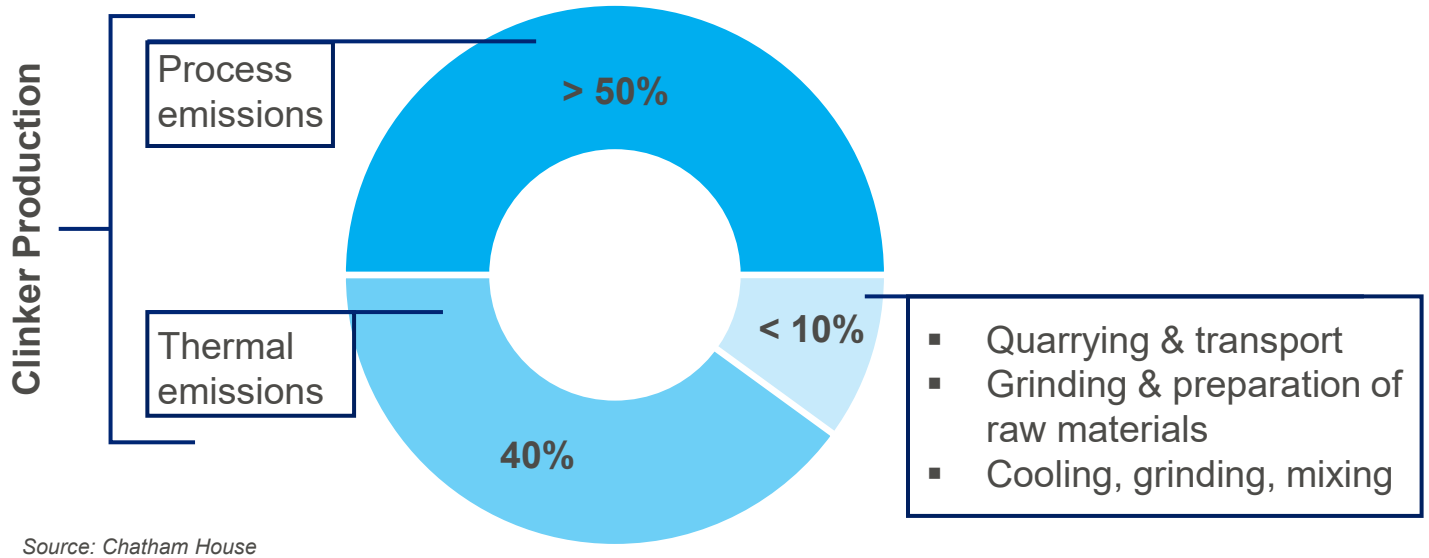
- Main material used in the world –only second to water
- Versatile, available & affordable

But…

- Resource intensive (water, gravel, sand)
- OPC remains the preferred binder in concrete
- Emissions intensity problem

The production of "clinker" accounts for most of the CO2 emissions of cement production



Source: Chatham House

As the biggest offender, concrete represents the greatest opportunity for positive change through innovation

Why Low Carbon Concrete (LCC)?

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- High early strength (if required)
- High flexural strength
- High durability (i.e. chemical attack resistance)
- Low shrinkage
- Workability
- Lower emissions
- Increased use of recycled materials

Examples of successful implementation in Australia:

- Toowoomba Airport – (26,000m^3)
- UQ – Global Change Institute (33 precast floor beams)
- Footpaths, retaining wall, stormwater pipes – Victoria
- Council road & Cycleway – NSW





Opportunity Identification

- Temporary structural and non-structural areas at SW sites.
  - ➢ Haul roads and temp access roads & bridges
  - ➢ Blinding areas
  - ➢ Lay down areas
  - ➢ Medians, Footpaths & Shared User Paths (SUP)

And…

- Keen and motivated design, construction & support teams
- Highly engaged suppliers

Alternatives Investigated

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Type	Description
GPC *	Low to no cement type of concrete, instead a large portion (if not all of the cement) is replaced with SCMs and alkali activator, significantly reducing the mix's embodied emissions while diverting waste from landfill. *Not yet implemented.
+ Envisia by Boral	ENVISIA is an AS 1379 compliant concrete produced by Boral. It replaces a significant portion of OPC with SCM (GGBFS) to achieve large carbon emission reductions. Boral's patented Zep technology improves the early strength, shrinkage and long term durability performance of the concrete when compared to that produced with conventional low carbon concrete.
+ Emesh by Fibercon	Emesh is an Australian innovation by Fibercon that completely replaces steel reinforcement in non-structural concrete pavements with 100% recycled macro polypropylene fibres.
+ Glass sand	Recycled crushed glass sand (8% fines replacement)
= Bespoke Low Carbon Concrete at RIC	Up to 70% cement replacement, 8% glass sand replacement & 4-6kg/m3 recycled macro polypropylene fibres (in lieu of SL81/82 steel mesh).

Key Desirable Characteristics

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Material	Low Carbon Concrete		Recycled Plastic Fibres (Emesh)	Recycled Glass Sand
	Envisia	GPC type		
Availability	✓	✗	✓	✗
Supply Chain	✓	✗	✓	✗
Use of waste materials	✓	✓	✓	✓
Constructability	✓	–	✓	✓
Workability	✓	–	✓	✓
Durability (long term)	✓	✓	✓	✓
Safety	✓	–	✓	✓
Spec & Standards compliance (NSW)	✓	✗	–	✓
GHG reduction	✓	✓	✓	✓
Price	✓	✗	✓	✗

Approval Process

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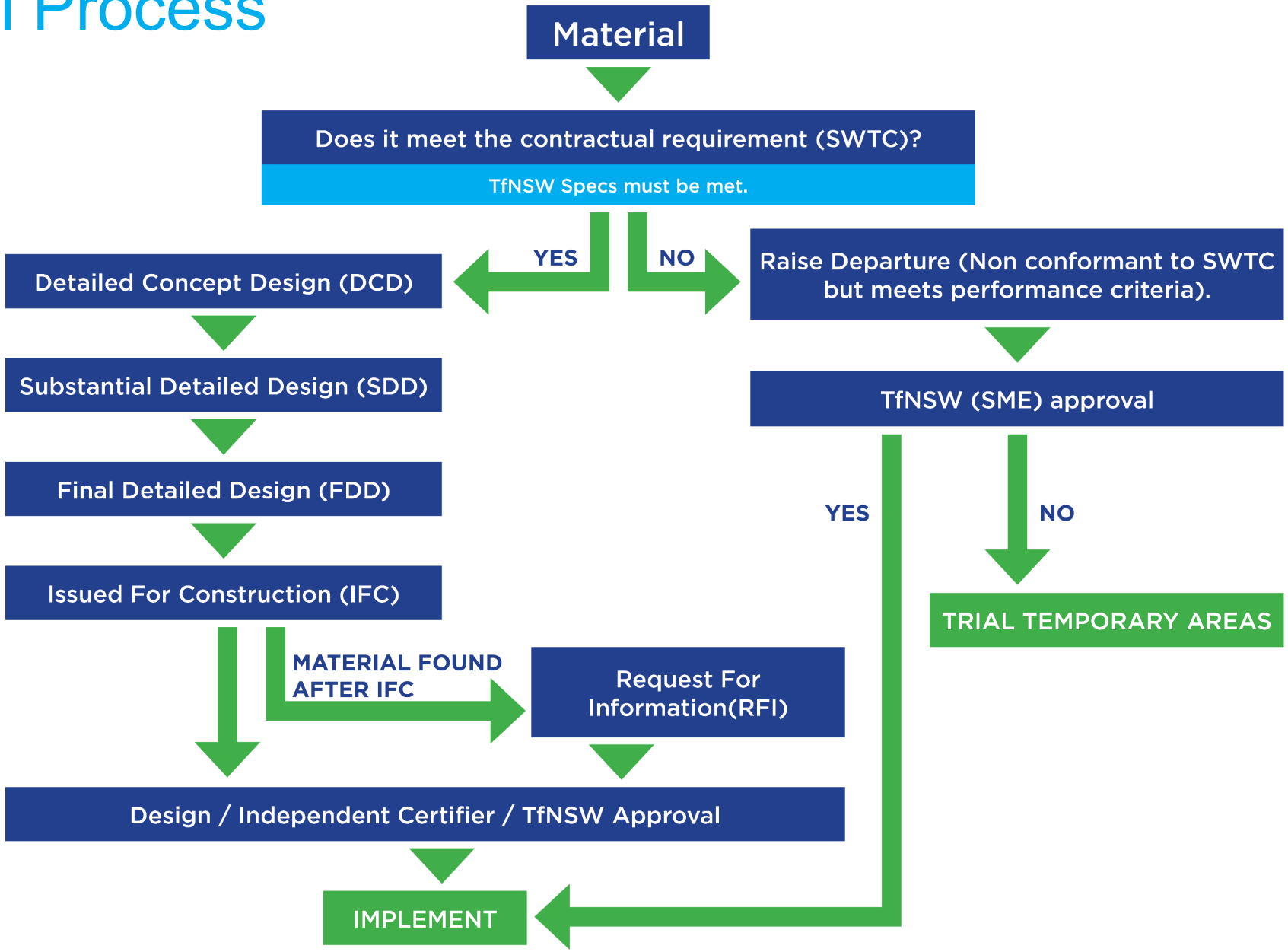

Materials approved PTD

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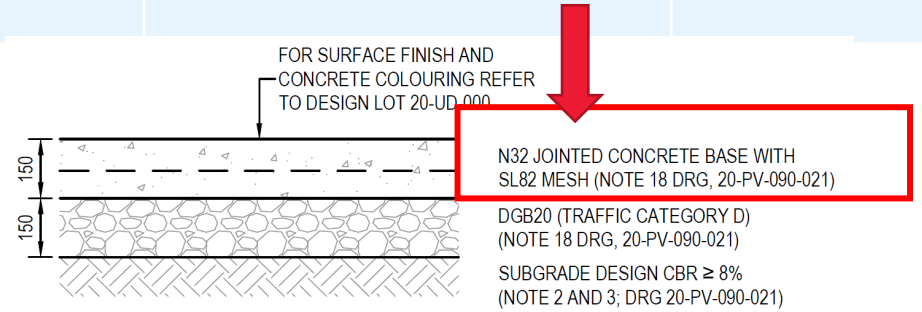
Envisia	Glass Sand	Emesh	GPC
Spec compliant (R53) – Materials must meet RMS 3211 & AS3279	Spec Compliant (R53) Aggregates must meet AS2758	Not Spec Compliant	Not Spec Compliant (R53) but meets performance (confirmed on previous implementation and research)
IC- hold point release on mix design	IC-hold point release on mix design	Temp Trials Conducted	TfNSW- PSS



SHARED CONCRETE PATH

SP1

Implementation Details - Temporary Haul Road

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1: Haul Road (RRY): Temp road for spoil haulage

- Envisia: high flexural strength and low shrinkage cracking
- Highly trafficked
  - 1,500 truck movements/day
  - ~24,000 t/day
- Large scale comparison of OPC vs Envisia over life of the Project

Qty poured (m3)	213.7
OPC replacement (%)	42
Glass Sand Fines Replacement (%)	-
Emesh (kg/m3)	-
MPa	32
Slump (mm)	120
Aggregate (mm)	20

Implementation details - Temporary Haul Road

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2. Haul Road (VRE): Temporary road for spoil haulage

Trial	I	II
Qty poured (m3)	300.8	343.3
OPC replacement (%)	52	42
Glass Sand Fines Replacement (%)	15	-
Emesh (kg/m3)	-	-
MPa	32	32
Slump (mm)	120	120
Aggregate (mm)	20	20

Implementation details –Temp Bridge & Driveway

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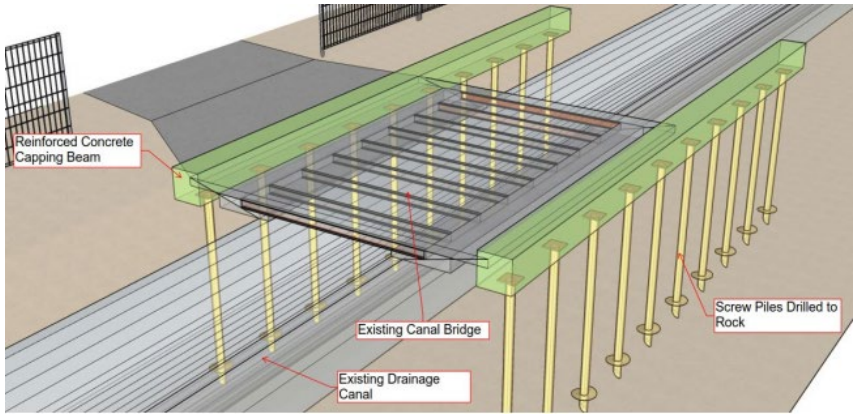
3. Brennan St access Bridge

- Only access (over a channel) to a work site.
- Critical path - Under tight time pressure
- High early strength - needed to sustain heavy plant as soon as possible



Trial	I (Bridge)	II (Driveway)
Qty poured (m3)	21	15.2
OPC replacement (%)	52	83
Glass Sand Fines Replacement (%)	-	40
Emesh (kg/m3) in lieu of SL81	-	6
MPa	40	40
Slump (mm)	120	120
Aggregate (mm)	20	20

Implementation Details- Gas Protection Slab

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4. Jemena Gas Protection Slab

- Road widening at The Crescent.
- Major public road *(*12,000-15,000 Vehicles/day)
- Installation of utility protection slab over shallow gas main
- Time critical traffic switch- early strength required

Qty poured (m3)	10
OPC replacement (%)	72
Glass Sand Fines Replacement (%)	**15**
Emesh* (kg/m3)	4
MPa	40
Slump (mm)	120
Aggregate (mm)	20

* Mesh maintained, Emesh used to trial material behaviour in mix design.

Implementation Details - Permanent Shared User Path (SUP)

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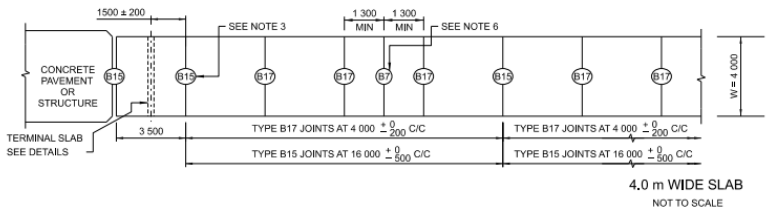
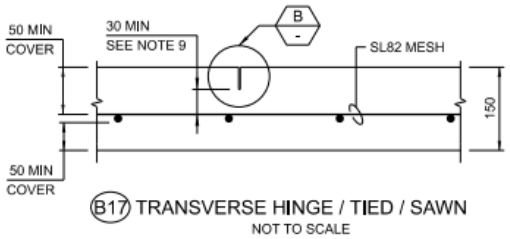
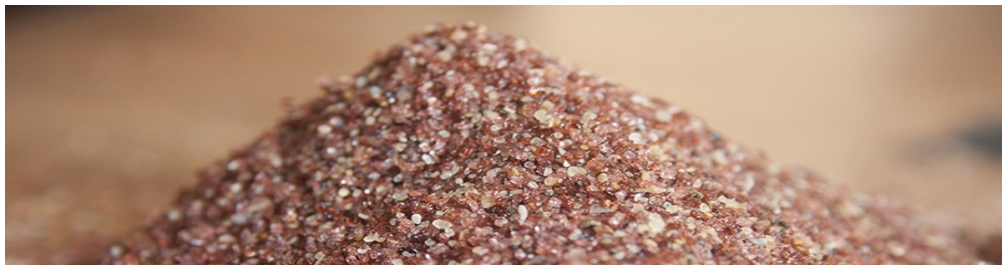
4. Section of Permanent SUP

- High profile footpath
- Connects Annandale- CBD
- Ideal opportunity to trial bespoke LCC in permanent works







Qty poured (m3)	60
OPC replacement (%)	70
Glass Sand Fines Replacement (%)	8
Emesh in lieu of SL82 (kg/m3)	4
MPa	32
Slump (mm)	120
Aggregate (mm)	20

SUP Results (Envisia+ Emesh+ Glass Sand)

Performance

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Attribute	Bespoke LCC	Feedback from Construction team
Lead time on orders	On par with OPC based concrete	No delays on orders, no delays to program, availability is good
Workability	On par with OPC based concrete	Initial pour containing glass sand took longer to set (VRE). Mix design modified to increase cement content (causes may have included time of the day/ quantify of retardant used) Protection slab at the Crescent showed poor workability at 15% glass sand replacement- Reverted to 8% for SUP=Good performance.
Finishing	Discussion + feedback between suppliers and FRP workers required to familiarise construction team / FRP subcontractors with new materials	Acceptable finish
Quality	On par with OPC based concrete	Conforming to Specs. Crack control is good. Had many irregular shaped slabs due to utility pits and bridge tie ins.
Finished Product	Slightly whiter than OPC Concrete Plastic fibres are visible with time	Acceptable finish
Durability	Short Term: On par with OPC based concrete/ Long Term: Yet to be verified	-Initial tests show good performance -No cracks so far -Strength gain is on par with OPC

Challenges & Lessons learned

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Type	Challenge	Lesson Learned
Supply	Availability of fit for purpose, steady, cost-neutral supply	Leverage on direct suppliers relationship with alternative material suppliers (i.e glass sand, emesh)
Interest	Building up the appetite for the use of new materials	-Engage with Design & Construction teams at early stage. Let them own the initiatives. -Risk assessment, Presentations and Q&A with suppliers reduces risk perception.
	Obtaining quality and design teams buy-in (contractual departure may be required)	Understand approval pathways. Use gates / hold points to minimise risk.
Approval (client)	Obtaining client approval	-Small area trials are preferred- build up to larger areas once implementation proves successful. -Start conversation at pre-contract stage (tender point)
Financial	Negotiating viable price with supplier	-It doesn't have to cost more- Leverage on Project size & exposure
Finish Quality	Finish product quality may differ from traditional (emesh)	Familiarise crews/workforce with the new material prior to implementation

WCX 3B– Sustainability Legacy

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- **Implementation PTD**:
  - **Bespoke LCC:** 1293m^3.
  - **Recycled Glass Sand**: 140 T
  - **Emesh:** 570 kg

- **Sustainability & Environment:** Emissions reduction (~127.4 T CO_2-e), increased use of waste materials & ISCA tool

- **Reputation:** Community, Client, JV partners and Industry

- **Innovation:** Provides proof of concept and technical data for inclusion of low cement concrete within TfNSW specs.

What's next?

- Emesh implementation within non-structural permanent works (pending approval – design, ongoing liability ownership etc.)
- Glass sand in Flowable Fill (40,000m^3 of which approx. 29,600m^3 could be replaced with glass sand)
- Geopolymer Concrete - under PSS
- Glass Sand in Asphalt- currently underway

What's required from Client & Industry?

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- Greater flexibility and acceptance of innovative materials within permanent areas
- Continued collaboration client, supplier, contractor, government & academia - similar to GPC working group
- Increased transparency (mix designs) to benefit the entire market
- Supplier to continue pushing the envelope

Knowledge share

Alternative Concrete Solutions- Rozelle Interchange Case Study: [201211-alternative-concrete.pdf (rozelleinterchange.com.au)]

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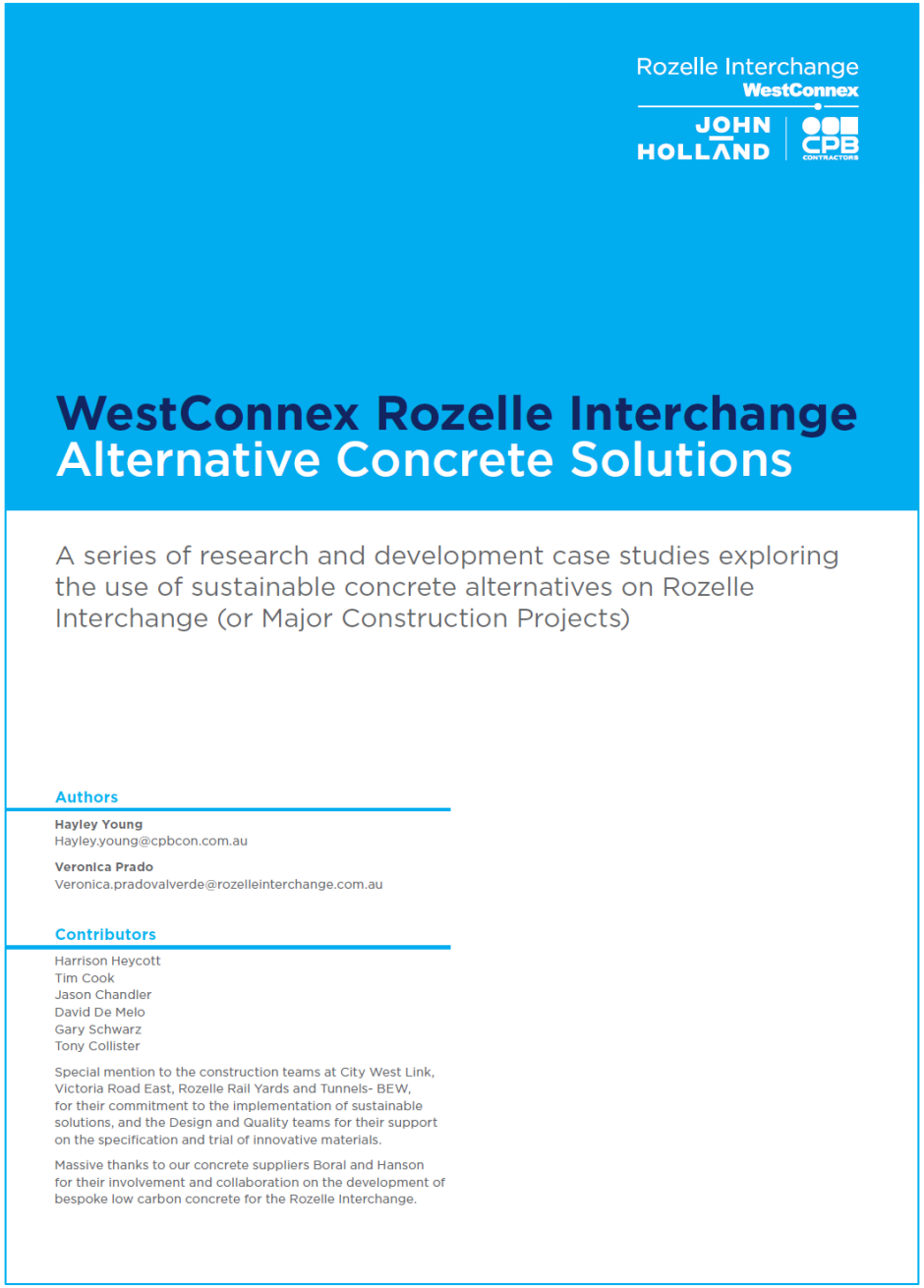
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Alternative Concrete Solutions

A series of research and development case studies exploring the use of sustainable concrete alternatives on Rozelle Interchange (or Major Construction Projects)

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Special mention to the construction teams at City West Link, Victoria Road East, Rozelle Rail Yards and Tunnels- BEW, for their commitment to the implementation of sustainable solutions, and the Design and Quality teams for their support on the specification and trial of innovative materials.

Massive thanks to our concrete suppliers Boral and Hanson for their involvement and collaboration on the development of bespoke low carbon concrete for the Rozelle Interchange.