Rozelle Interchange
WestConnex

JOHN HOLLAND | CPB CONTRACTORS

WestConnex Rozelle Interchange 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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Introduction

As the most widely used building material in the world, concrete is responsible for about 7-8% of total carbon emissions. Concrete production requires vast amounts of natural resources (water, gravel and sand) but concrete's main environmental impact comes down to its requirement for Ordinary Portland Cement (OPC) as a primary binder.

OPC is versatile, durable, and proven material that continues to be the preferred binder in concrete. Large amounts of energy and extreme heat are required in the production of OPC. It is estimated that every tonne of cement produces at least a tonne of CO2 equivalent (i.e. t CO2-e). Therefore, concrete is the largest contributor to Greenhouse Gas (GHG) emissions in construction, which also presents as a significant opportunity for positive change through innovation.

Virgin sand is also typically used in concrete as fine aggregate. The resulting high demand for virgin sand makes it the second most consumed natural resource on the planet after water. A considerable percentage of virgin sand can be replaced with glass based manufactured sand in concrete applications. Using this recycled resource diverts waste from landfill to promote a circular economy reducing pressure on natural resources.

> **JHCPB have focused on four cost effective, high value, alternative concrete solutions to leave a legacy in sustainable technology for TfNSW and the Inner West.**

The John Holland CPB Contractors Joint Venture (JHCPB) has been contracted by Transport for New South Wales (TfNSW) to deliver the $3.9 Billion Rozelle Interchange and Western Harbour Tunnel Enabling Works Project (RIC) – the final stage of the Westconnex road tunnelling program. The 4.5-year construction program is expected to consume over 500,000m3 of concrete, 70,000 tonnes of steel, 250,000 tonnes of aggregate, and generate over 7,800,000 tonnes of spoil.

JHCPB has used the Project to realise the following opportunities to drive sustainable change in the New South Wales materials market:

- Significantly reducing or removing OPC used in non-structural concrete.
- Recycled crushed glass sand will provide a sustainable alternative to virgin sand where it is viable.
- Recycled plastic fibres will be used in place of traditional reinforcing steel in non-structural applications, where possible.
- Implementation represents a first of its kind opportunity for a major TfNSW road-Project to trial and prove performance of lower embodied carbon alternatives to traditional concrete.

JHCPB have focused on four cost effective, high value, alternative concrete solutions to leave a legacy in sustainable technology for TfNSW and the Inner West.

- The use of ENVISIA concrete in TfNSW Specification R53: Concrete for General Works (R53) applications
- The replacement of traditional reinforcing steel in R53 applications with recycled plastic fibres
- The replacement of virgin sand in flowable fill for tunnel drainage with recycled crushed glass
- Research and development into the use of Geopolymer Concrete (GPC).

Research and development in these areas will enable JHCPB to influence the creation of a steady, cost neutral, fit-for-purpose, alternative supply for pavements, bedding and filling applications in NSW. Following implementation of alternative concrete solutions, JHCPB aims to achieve proof-of-concept for the performance of alternative binding options and transform the NSW concrete market.

The case studies in this document detail the investigation undertaken by JHCPB to date and provide contact details for suppliers involved in this research and development as well as the JHCPB construction representatives responsible for on-site implementation. JHCPB and all parties involved aim to be world leaders in this field. As such, all findings and results will be made publicly available to encourage genuine and sustainable change where it can have the greatest impact.

Case Study
ENVISIA

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Innovation

ENVISIA is an AS 1379 compliant concrete produced by Boral. ENVISIA mixes replace a significant portion of OPC with Supplementary Cementitious Materials (SCM) to achieve large carbon emission reductions whilst maintaining high compressive strength early during the concrete curing process.

ENVISIA reduces carbon emissions, material going to landfill and the need to extract and produce new materials.

ENVISIA concrete uses a high percentage of Ground Granulated Blast Furnace Slag (GGBFS) paired with an alkali activator to achieve a considerable reduction of OPC usage. In doing this, ENVISIA reduces carbon emissions, material going to landfill and the need to extract and produce new materials.

ENVISIA mixes have been used in new buildings across NSW and Victoria with proven workability, durability, high flexural strength, low shrinkage and with the same order lead time as traditional concretes. The Rozelle Interchange is the first NSW road project to utilise a bespoke high SCM replacement (up to 70%) for the construction of temporary roads, temporary bridges and permanent footpaths. The extent of implementation of customised Envisia mix designs paired with glass sand and Emesh at RIC represents an Australian first opportunity involving a major road-Project.

Benefits

Design:

- TfNSW R53 compliant at a 70% Supplementary Cementitious Material (SCM) component
- Superior corrosion resistance, specifically
    - chloride attack resistance
    - sulphate resistance
    - acid resistance
- Greater flexural strength (30% more resistant to breaking)
- Lower shrinkage (up to 50% reduction)
- Higher general durability

Construction:

- Can be placed, pumped, and finished like conventional concrete
- Achieves high early strength
- Reduced number of joints in large slabs
- Light coloured off-form finish

Economic:

- Pricing is comparable with conventional concrete. ENVISIA is a premium product and comes with a small price premium depending on the specific mix characteristics required.

Environmental:

- Reduction of CO_2 by approximately 28-59%
- Increased diversion for materials from landfill (fly ash, slag and glass sand)
- ENVISIA mixes are covered by Environmental Product Declaration (EPD) # S-P-02048. A new EPD for high SCM replacement mixes is under development.

Social:

- Potential longer life span and less maintenance for concrete pavements resulting in a smaller impact on the environment.

Project Implementation

The Rozelle Interchange Project has successfully implemented ENVISIA mixes within temporary and permanent works across different project sites. High profile and highly-trafficked sites where ENVISIA is being used include the Rozelle Rail Yard Civil Construction Site, City West Link Civil Construction Site and Victoria Road East Civil Construction Site.

ROZELLE RAIL YARD AND VICTORIA ROAD EAST HAUL ROAD

This temporary road was constructed to allow the mobilisation of spoil from site and to provide a safe and sealed access for deliveries to the Project. Traffic has been estimated at 1500 individual spoil truck movements per day, hauling approximately 24000 tonnes of material offsite each day.

The project ran initial on-site trials of ENVISIA mix with the below properties:

- 213.7m³ (40% cement replacement as opposed to the RMS paving design mixes ~ 25% OPC replacement)
- 32MPa, 120mm slump, 20mm aggregate

Following its implementation, an increase in SCM content and the incorporation of recycled crushed glass sand was applied within the mix. Revised ENVISIA properties include:

- 300.8m³ (50% cement replacement)
- 32MPa, 120mm slump, 20mm aggregate
- 15% glass sand replacement
- The concrete curing duration increased due to an imbalance with the added components and a potential interaction with the glass sand. The project team decided to reduce the OPC replacement concentration within the mix for the final pour. The final ENVISIA properties included:343.3m³ (40% cement replacement)
- 32MPa, 120mm slump, 20mm aggregate

TEMPORARY CONSTRUCTION GATE (BRENAN STREET TEMPORARY WORKS BRIDGE)

The Project team used ENVISIA to build the temporary access bridge pile caps and deck due to ENVISIA's high early strength and enhanced performance benefits. The 32m³ pour was conducted successfully with a short curing duration, achieving greater than 80% strength within 7 days. This enabled vehicles to use the bridge and the construction program to be accelerated.

Implementation involved:

- 32m³ (50% cement replacement)
- 40MPa, 120mm slump, 20mm aggregate

TEMPORARY CONSTRUCTION GATE (BRENAN STREET BRIDGE - DRIVEWAY)

The City West Link team wanted to extend the limits of performance by trialling a high percentage cement replacement, whilst increasing glass sand use and incorporating recycled polypropylene fibres in place of steel mesh (SL82).

Implementation involved:

- 15.2m³ of a low carbon concrete mix developed by Boral (80% cement replacement)
- 40MPa, 120mm slump, 20mm aggregate
- 40% recycled crushed glass sand as a replacement of fine sand
- 90kg of Emesh (6kg/m³)

PERMANENT SHARED USER PATH

The Project team trialled an ENVISIA mix containing glass sand replacement and Emesh within a section of the Shared-User Path (SUP) connecting Annandale to the Sydney CBD. The SUP represented a key opportunity for the Project to test the material's workability and performance within non-structural concrete pavements and to showcase the product's benefits to the general public.

Implementation involved:

- 83m³ of a low carbon concrete mix developed by Boral (70% cement replacement) – of which ~15m³ corresponds to the section** of the path that incorporated Emesh as a steel replacement (~70lm)
- 32MPa, 120mm slump, 20mm aggregate
- 8% recycled crushed glass sand as replacement of fines
- 60 kg of Emesh (4kg/m³)**

*** used as a replacement to reinforcing steel within section of permanent SUP equivalent to 15m³.*

CASE STUDY | ENVISIA

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Challenges

Implementing ENVISIA on the project came with challenges, including:

- Building up the appetite for the use of a new concrete type that had not been used before in other RMS/TfNSW projects
- Ensuring the proposed alternatives met client specifications (durability and performance)
- Ensuring workability was the same as with normal concrete mixes (no additional lead time on orders, batching and pouring) to avoid delays
- Obtaining quality and design approvals
- The need to seek contractual departure early in the design process from the material originally specified
- Building trust with the construction teams to accept and drive the use of this type of concrete

To overcome these challenges, the sustainability, construction, and design teams worked closely with each other and the material suppliers.

Lessons Learned

Sustainable materials don't have to cost more. Suppliers are often willing to supply the material at a neutral cost as long as research and development benefits are involved with cost likely to be reduced as quantities increase.

Engage early. Touch base with potential suppliers to the Project before contract award to learn about their innovative technologies and drive change.

Start early. Materials innovations are easier to approve and implement if assessed at an early project stage.

Temporary works are a great opportunity workability and performance testing can take place in a low-risk environment. Work with the site teams to identify suitable areas where new materials can be tested.

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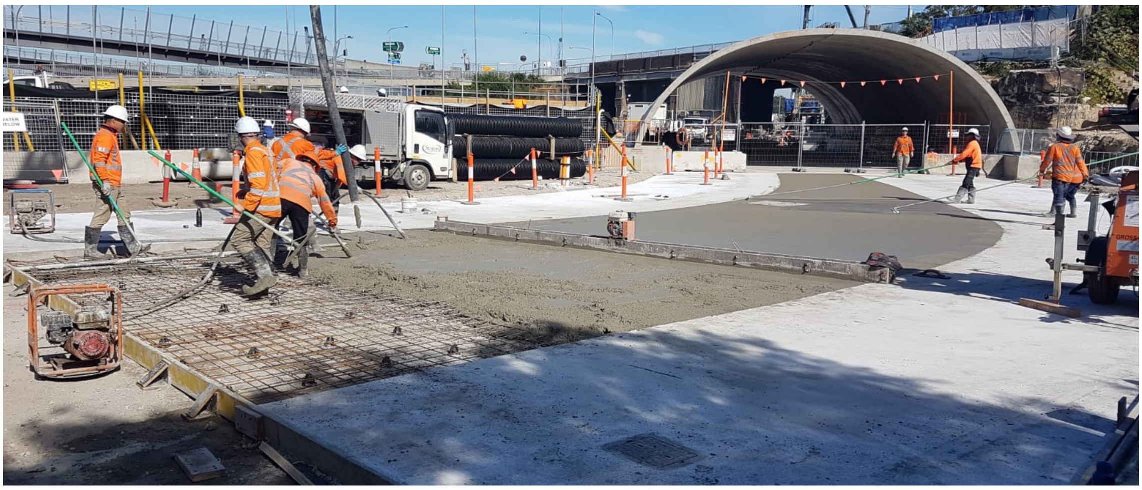
BORAL



Case Study
EMESH

Rozelle Interchange
WestConnex

Innovation

Emesh is an Australian innovation by Fibercon that completely replaces steel reinforcement in concrete pavements. This is done by adding recycled macro polypropylene fibres to the concrete mix.

Emesh controls the risk of shrinkage and cracking over short and long durations, while diverting industrial plastic from landfill and eliminating the use of steel mesh.

This material provides a pathway for the replacement of conventional reinforcement steel, specifically SL82 as per TfNSW Specification R53 (concrete for general works) in NSW and has successfully been used at the Rozelle Interchange as a trial within a section of a permanent Shared User Path (SUP).

> **Emesh controls the risk of shrinkage and cracking over short and long durations, while diverting industrial plastic from landfill and eliminating the use of steel mesh.**

Benefits

Design:

- Superior long-term performance
- Flexibility in the shape of pavements
- Greater flexibility of joint locations
- Corrosion free reinforcement
- Longer life span
- Reduction in earthing & bonding issues

Construction:

- Faster application (applied in the concrete mix at the batch plant)
- Safer, with no requirement to lay steel reinforcement

Economic:

- 20% cost reduction (arrives on site ready to use and does not require engineering inspection for reinforcement)
- Eliminates the requirement to procure steel reinforcement and the labour to install it
- Simple, fast and easier to use as it dispenses with the need to cut steel mesh or manoeuvre mesh and bar chairs.

Environmental:

- Reduces reliance on natural resources and can be recycled and reused the same as traditional recycled concrete aggregate
- Reduces CO_2 emissions by 91%
- 100% recycled product, diverting waste from landfill
- Covered by an Environmental Product Declaration

Social:

- Reduces injury risks for workers as there is no cutting and tying of steel mesh or chairing up required
- Fibrecon supports the National Disability Industry Scheme (NDIS)
- 100% Australian innovated and produced product

CASE STUDY | EMESH

Project Implementation

The Project has successfully trialled Emesh within temporary works and continues to investigate permanent works implementation in various Project footpaths, islands and medians. The Project trials include:

TEMPORARY CONSTRUCTION GATE (BRENAN STRET BRIDGE - DRIVEWAY)

The first trial was conducted together with the implementation of a low carbon concrete mix trial, containing glass sand (virgin sand replacement) and Emesh (steel reinforcement replacement) within a temporary works driveway.

Construction of the temporary gate was under tight time pressures as it provided the only access (over a channel) to a work site. The construction of this gate was critical to the Projects construction program.

Implementation involved:

- 15.2m³ of a low carbon concrete mix developed by Boral (80% cement replacement) (40MPa, 120mm slump, 20mm aggregate)
- 40% recycled crushed glass sand
- 90 kg of Emesh (6kg/m³)

PERMANENT SHARED USER PATH (SUP)

The Project team trialled Emesh within a section of a SUP connecting Annandale to the CBD. The SUP represented a key opportunity for the Project to test the material's workability and performance within non-structural concrete pavement and to showcase the material's benefits to the general public.

Implementation involved:

- ~15m³ of a low carbon concrete mix developed by Boral (70% cement replacement) (32MPa, 120mm slump, 20mm aggregate)
- 8% recycled crushed glass sand
- 60 kg of Emesh (4kg/m³)

CASE STUDY | EMESH

Challenges

Implementing Emesh on the project came with challenges, including:

- Working with regulatory authorities to obtain approval for implementation
- Working with subcontractors to ensure finish quality of the product
- Overcoming prescriptive nature of specifications
- Introducing an innovative technology that had not been used in an RMS road project

To overcome these challenges, the sustainability, construction, and design teams worked closely with each other and the material suppliers.

Lessons Learned

Provide training to ensure the design and construction teams are provided with sufficient training and understanding of the triple bottom benefits of the new material. This will ultimately drive implementation.

Engage with suppliers to build a strong and transparent relationship with the supplier to influence market transformation.

Familiarise teams with the product to ensure the crews familiarise themselves with the product. Improper experience can result in a poor concrete finish (fibres extruding through surface). This was the case with the Project's initial implementation at the temporary construction gate. Familiarisation resulted in a smooth finish in the subsequent implementation.

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Case Study

GLASS SAND FLOWABLE FILL

Rozelle Interchange
WestConnex

Innovation

With the upcoming Council of Australian Governments Waste Export Ban and the Project's commitment to Australia's National Waste Action Plan, JHCPB has taken a lead on identifying and implementing opportunities to divert problematic waste streams through the use of alternative construction materials. The re-use of recovered waste glass in concrete, asphalt, road base and bedding material has the potential to significantly reduce the Project's environmental and social impacts, particularly within the supply chain.

To align with the Project's core value of Innovate, JHCPB has investigated the use of a glass sand flowable fill for backfilling tunnel drainage as part of Back End Works (BEW). Flowable fill is a self-compacting low strength material with a flowable consistency that is used as an economical fill or back-fill material as an alternative to compacted granular fill. Flowable fill is made of cement, fly ash, water, sand, and typically an air-entraining admixture. Flowable Fill is not technically concrete, and is not used to replace concrete for most applications.

JHCPB proposes to substitute the sand component for glass in upwards of 40,000m³ of flowable fill, providing a sustainable and fully compliant alternative for large backfill applications. This joint initiative with industry partners Hanson, leverages glass mix flowable laboratory trials conducted as part of the WestConnex New M5 Project (now M8) (CPB Contractors).

Aside from the benefit of embodied carbon reductions from diverting waste glass from landfill, the development of a recycled glass flowable fill mix has been implemented to transform the clean recycled glass supply market in NSW by significantly driving demand.

Benefits

Economic:

Commercial benefits associated with batching with a manufactured product, such as:

- Reduced water consumption and absorption workability
- Flow and strength properties are easier to achieve producing a longer working time without compromising performance.
- Reduced excess water being forced to the surface of the concrete (concrete bleed)
- Increased batching efficiencies as manufactured sand generally produces a more consistent product as natural sand natural sand has variances in absorption, shape and mineralogy (depending on the feed source).

Environmental:

- Reduced reliance on virgin materials such as natural sand.
- Reduced reliance on landfill as a result of the use of recovered materials.
- Reduction in damage to marine environments as a result of sand mining.
- Reduced water consumption due to low absorption mix (better workability for less water).
- Carbon reductions associated with replacing finite virgin materials with recycled materials.

Social:

- Reduced demand on potable water supply.
- Diversion of a problematic waste stream from landfill.
- Reduced damage to the amenity of marine environments e.g. Stockton Beach.
- Provision of a positive social and environmental legacy for TfNSW, and the Inner West in terms of a circular economy.

CASE STUDY | GLASS SAND FLOWABLE FILL

Rozelle Interchange
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Project Implementation

JHCPB, in conjunction with TfNSW, and concrete suppliers Boral and Hanson, have been working together to investigate opportunities to utilise recovered glass within concrete applications, such as flowable fill (AS 3725: *Design for installation of buried concrete pipes*), R53 (TfNSW Specification R53: *Concrete for General Works*) and B80 (TfNSW Specification B80: *Concrete Work For Bridges*) applications. Opportunities to use glass mixes in R53 non-structural applications have been identified and implemented in collaboration with Boral (surface works). Small temporary works trials have already been undertaken including:

> **Flowable fill is a self-compacting low strength material with a flowable consistency that is used as an economical fill or back-fill material as an alternative to compacted granular fill.**

TEMPORARY CONSTRUCTION GATE (BRENAN STREET BRIDGE - DRIVEWAY)

- 15.2m³ of a low carbon concrete mix developed by Boral (80% cement replacement) (40MPa, 120mm slump, 20mm aggregate)
- 40% recycled crushed glass sand
- 90 kg of Emesh (6kg/m³)

TEMPORARY SHARED USER PATH (CWL)

- ~15m³ of a low carbon concrete mix developed by Boral (70% cement replacement) (32MPa, 120mm slump, 20mm aggregate)
- 8% recycled crushed glass sand
- 60kg of Emesh (4kg/m³)

Currently low carbon concrete trials are largely in development to be compliant with R53 (excluding localised mixes). The exception to this is flowable fill mixes where laboratory testing was undertaken by Hanson on the M8 Project. Laboratory trials have been favourable, leading JHCPB to apply to TfNSW for approval to use an alternative glass mix 5MPa flowable fill in BEW for drainage back-fill applications. The mix design development was conducted by Hanson specifically for the RIC Project, and is detailed below:

Concrete Grade / Exposure	S05	S05	S05	S05
Product Code	ZZR05AA02		ZZR05AA01	
Trial Mix Reference / Equivalent Mix	**200449**	ZZP05AA14	**200410**	ZZP05AA15
SCM Content	50% Fly Ash	30% Fly Ash	50% Fly Ash	54% Fly Ash
Glass Sand	100%	0%	100%	0%
Notes	Fast Set		Normal Set	
Nominal Flow (seconds)	30	30	30	30

	Mix Design Details			
Nominal Aggregate Size (mm) (AS2758.1)	Sand	Sand	Sand	Sand
Indicative Binder Content (kg/m³)*	260	200	260	275
Water Reducing Admixture (AS1478)	Yes	Yes	Yes	Yes
Accelerating Admixture (AS1478)	Yes	No	No	No
Placement Method	Boom Pump		Boom Pump	

	Material			
Cement	GB & SL Compliant			
Coarse Aggregate	Nil			
Sand Type	Glass	Natural	Glass	Natural

CASE STUDY | GLASS SAND FLOWABLE FILL

Rozelle Interchange
WestConnex

Challenges

CULTURAL AND TECHNICAL

Replacing a conventional construction material with a sustainable alternative comes with many challenges, including:

- Building up an appetite within RMS/TfNSW for the use of alternative concrete solutions.
- Obtaining quality, design, Independent Certifier, and RMS/TfNSW approvals.
- Negotiating price neutral supply to generate demand.

JHCPB have provided two options for both flowable fill mix codes to TfNSW for approval. Glass sand will be used whenever possible.

SPECIFICATION LIMITATIONS

Flowable fill for drainage applications is required to comply with AS/NZS3725:2007 *Design for installation of buried concrete pipes*. AS3725 and is focussed on the working loads and installation of buried pipes. The relevant sections in AS3725 applicable to the design of the grout and fill material are quite broad and limited. Although not precluded by the standard, AS3725 does not appear to be well suited to describe the requirements of a cement-based grout (with a strength guarantee). Rather, it seems to be better suited to a stabilised soil type material (as demonstrated by the use of sand as "granular soil material" and references to "typical" proportions and methods).

AS3725 has a strong focus on the design and installation of buried pipes with a reduced focus on the fill material around them. The requirements for the fill material appear to be best suited to a stabilised sand type material rather than to a strength guaranteed grout. In addition, the mix design and delivery is discussed only in "general" or "typical" terms. For Hanson to produce a compliant 5MPa flowable fill with the performance required, the design and production parameters were required to deviate from those deemed as "typical" in AS3725. Instead they complied with the characteristic strength and production requirements stipulated by AS1379. This departure, which required approval from the Independent Certifier (IC) and TfNSW, is expected to produce a higher performing product.

GLASS SUPPLY

Clean, recovered waste glass supply in New South Wales is extremely limited. Only one Supplier has been endorsed by the NSW EPA and they are located on the Central Coast, approximately 80 kilometres north of Sydney. This creates issues in terms of available supply to the batch plant, increased Scope 3 emissions as a result of longer haulage distances to the Sydney CBD, and potential product variability issues based on different feed sources.

Due to the possible limitations of supply, an objective to drive demand without overwhelming the market, and the requirement to maintain consistent and reliable concrete supply, JHCPB have provided two options for both flowable fill mix codes to TfNSW for approval. Glass sand will be used whenever possible, with natural sand used only when glass sand becomes unavailable. This will ensure concrete supply on-site is not impacted by a potential limitation of glass supply.

CASE STUDY | GLASS SAND FLOWABLE FILL

Lessons Learned

Avoid the paper straw effect. Understand the technical specifications and any possible limitations of the alternative material (including workability and durability); don't support an alternative product that underperforms.

Be the conduit between teams wherever possible, drive proactive change by acting as a conduit between Design, Quality and Construction teams to drive proactive change. The only task more difficult in construction than a post-IFC design change is an amendment to an RMS specification, or the development of a project specific specification.

Early engagement with Suppliers and other large customers to drive demand for alternative materials but always be mindful of available supply. All the effort will be fruitless if the market is transformed and supply fails to meet demand.

- **Timing is critical.** Retrospective change is always more costly; which is not at all sustainable.

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Hanson
HEIDELBERGCEMENT Group

Case Study

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GEOPOLYMER CONCRETE

Innovation

Geopolymer concrete (GPC) is a type of concrete made by reacting industrial waste materials such as fly ash and slag with an alkali activator. The activator is a binder that replaces cement in its entirety and significantly reduces the mix's embodied emissions (up to 80%) while diverting waste from landfill.

The development of a GPC mix and its implementation on the Project will provide proof of concept for this type of concrete to become an acceptable alternative.

JHCPB is investigating the use of a GPC mix for TfNSW R53 applications, including footpaths, shared user paths, medians and pram ramps, while incorporating the use of glass sand as a replacement to virgin sand. Implementation of GPC is a joint initiative with industry partners (BORAL), research and development bodies (UNSW), parent companies (John Holland Group) and Sustainability Specialists (EDGE). The concept originated from the award of a Research and Development Grant from the EPA for the diversion of glass waste from landfill through concrete.

In addition to the emissions reduction benefit of GPC, the development of a GPC mix and its implementation on the Project will provide proof of concept for this type of concrete to become an acceptable alternative to OPC based concretes for specification R53.

Benefits

Design:

- Superior chloride attack resistance (corrosion resistance)
- Low shrinkage
- High durability
- Better thermal insulation properties
- Higher temperature/fire resistance
- High compressive and tensile strengths
- Higher uptake of glass sand as compared to traditional concrete

Construction:

- Achieves high early strength
- Ideal for pre-cast applications

Economic:

- Commercial benefits may be achieved through industry partnerships

Environmental:

- Reduction of CO_2 (up to 80%)
- Provision of a viable use for 'waste' materials from landfill (fly ash, slag and glass sand).

Social:

- Longer life span and less maintenance for concrete pavements resulting in a reduced impact on the environment.

CASE STUDY | GEOPOLYMER CONCRETE

Project Implementation

The Project has been granted approval from TfNSW to work with UNSW on the development and implementation of a GPC mix under a Project Specific Specification provided by TfNSW, for non-structural applications including:

- Footpaths
- Cycleways
- Shared user paths

The mix design development will be conducted by UNSW with materials provided by RIC concrete suppliers. Trial R53 areas have been identified around the Rozelle Railyards, Iron Cove and Victoria Road East civil construction sites. Numerous opportunities to apply trial concrete mixes to both temporary and permanent works have been identified.

Industry benefits from a GPC mix design development and implementation at RIC include:

- Proof of concept for the supply, installation and finishing of geopolymer concrete within an RMS/TfNSW infrastructure project.
- Development of reliable technical specifications for geopolymer concrete including sand replacement with recycled crushed glass sand.
- Reduction in Project's virgin material consumption and greenhouse gas footprint by substituting Portland cement with geopolymer based products.
- Facilitation of the reuse of key industrial by-products such as fly ash and/or slags.
- Proof of concept and enhanced technical knowledge on the inclusion of recycled glass in geopolymer concrete.
- Transparent and unbiased mix design development and knowledge sharing to transform the market.
- Providing the concrete market with experience in supplying GPC to infrastructure projects and enabling further market development of geopolymer based products.

Challenges

Implementing GPC on the project comes with challenges, including:

- Obtaining a project specific specification that allows the Project to deviate from the R53 specification.
- Agreeing on commercial aspects and liability including design life with TfNSW, joint venture parent companies, and industry partners.
- Identifying suitable areas for trials and for permanent works applications.
- Obtaining approval from the client and/or third-party landowners for permanent works implementation
- Identifying viable and affordable glass sand supply
- Working with suppliers to achieve a like for like supply chain for GPC
- Overcoming technical concerns regarding GPC concrete mixing, batching and placing
- Assessing safety risks regarding use of alkali activator in concrete mix

Lessons Learned

Workshop risk and opportunities early. Interface with different project teams including safety, environment, quality, design and construction to ensure risks and opportunities are assessed thoroughly before committing Project resources to implementation.

- **Don't reinvent the wheel.** Leverage from technical knowledge of industry partners to develop a robust plan of implementation.

Understand the Project approval pathways. Approval is easier obtained with a plan that includes hold points. Only move forward after satisfying key conditions including commercial, safety, environmental, design, and construction risks.

Make friends. Engage with Suppliers and other market leaders to build a strong and transparent relationship and influence market transformation. Networking is the greatest skill to influence decision making and drive change.

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Conclusion

Concrete has well known significant environmental impacts and as a result, there is justifiable pressure on the construction industry, including JHCPB, to source sustainable concrete alternatives. Performance benefits of low carbon concrete, including high early strength, flexural strength, low shrinkage and enhanced durability, have attracted significant industry attention to high SCM concrete mix variations in recent years. OPC's long legacy of proven workability, and performance, however, paired with its availability and affordability, make it the go-to product in the market.

JHCPB will help set a new standard of excellence in terms of alternative concrete solutions in the Australian market.

The barriers to widespread implementation of low carbon concrete technologies in NSW range from risk aversion (from lack of knowledge and understanding of alternatives to OPC based concrete), to the prescriptive nature of standards and specifications from government bodies. As a result, it has becoming increasingly evident that large, publicly-funded construction projects, such as the Rozelle Interchange, have a significant responsibility to pioneer and champion new materials and technologies. Showcasing proof of performance to the wider industry on such a large scale has the potential to drive demand for alternative concrete solutions.

JHCPB have identified and implemented several opportunities to replace OPC based concrete with more sustainable alternatives. In addition to an overall reduction of embodied CO_2, the use of alternative concrete solutions on the Project has meant that JHCPB has contributed to:

- 46% overall cement replacement within all concrete poured on the Project;
- 136 tonnes of waste glass diverted from landfill (glass sand); and
- 570kg of industrial plastic diverted from landfill (Emesh).

To date, feedback from the workforce regarding workability has been positive, and the sustainable concrete alternatives have performed on par with conventional materials. As a result, JHCPB will continue to drive the use of low carbon concrete and alternative construction materials, by:

- Facilitating a series of GPC temporary works trials to assess commercial viability and performance (with a focus on batching requirements, application of alkali activators, and workability);
- Conducting laboratory and field trials to support the approval of supplementary glass sand concrete mixes;
- Ensuring all laboratory and field trial results and feedback are publicly available to maintain transparency;
- Supporting the creation of a steady, fit-for-purpose, and cost competitive glass sand supply chain for other construction applications including bedding and filling; and
- Continue to collaborate with other key industry partners, such as TfNSW, UNSW, UTS, NSW EPA, Boral, and Hanson, to drive genuine and lasting market change.

JHCPB are committed to transparency within the industry for sustainable concrete advancements, including publishing unsuccessful trials to accelerate the pace of change. The Project seeks to use this research as proof of concept to change TfNSW specification to minimise the need for retesting core principles. As the largest current transport contract in NSW, JHCPB will leverage on the size and scale of the Project to not only trial innovative solutions but permanently change Government specifications. This will enable future projects to stand on the shoulders of the Project to build industry momentum for even greater sustainability gains.

With the commitment evidenced in these studies, JHCPB will help set a new standard of excellence in terms of alternative concrete solutions in the Australian market. As lower embodied carbon alternatives to OPC based concrete become more readily available, JHCPB will continue to unlock the full potential of these materials.