Low carbon product opportunities in the EAFS supply chain

This case study explores how a supply chain approach to turning underutilised Electric Arc Furnace Slag (EAFS) into products is resulting in the identification of new, low carbon road construction product opportunities and new business partnerships for Victorian businesses.

A series of supply chain workshops with OneSteel, Harsco Metals and industry stakeholders in the EAFS sector were conducted by the Australasian (iron and steel) Slag Association and Link Strategy.

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australasian (iron & steel) slag association

Link Strategy

This case study focuses on the potential uses of Electric Arc Furnace Slag in road construction applications.

This study focuses on energy and emission relevant EAFS by-products and project aims of the partnership program.

Disclaimer

This case study does not purport to make any comments or provide evidence regarding the environmental friendliness, sustainability, carbon footprint or otherwise of the Electric Arc Furnace steel manufacturing process as a whole which results in the creation of EAFS as by-products. Rather the case study focus is on the environmental benefits arising from the effective recovery and use of EAFS, which would otherwise most likely go to landfill.

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Electric Arc Furnace Slag (EAFS) is a by-product from the process of melting steel scrap and fluxes during steel manufacture. At the OneSteel processing site in Laverton, more than 90,000 tonnes of EAFS processed by Harsco Metals has the potential to be effectively utilised in other applications. Developing products with EAFS will help reduce future pressure on landfill. A major challenge for partners in the EAFS supply chain is to develop performance criteria and high value add EAFS markets. This case study focuses on the environmental benefits arising from the effective recovery and use of EAFS, which would otherwise most likely go to landfill.

The Australasian (iron & steel) Slag Association (ASA) along with Link Strategy, has conducted a series of supply chain workshops with industry stakeholders in the iron and steel slag (ISS) sector. These companies recognised that real benefits would accrue from the program only if they tackled the inherent complexity of the supply chain and challenged old assumptions and practices about utilising the ISS, in particular EAFS.

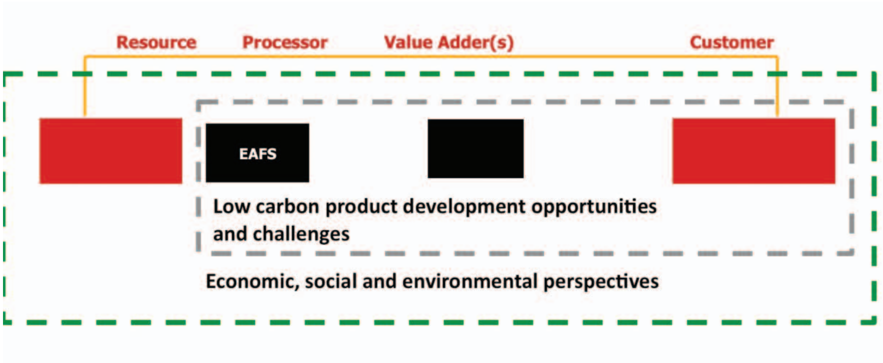
The workshops were supported with funding from Sustainability Victoria through its Business Partnerships program, which supports industry associations and business networks in delivering sustainability programs specific to member needs. The ASA workshop program aims to achieve sustainability improvements by identifying beneficial reuses for EAFS, which are not currently being effectively utilised*. Potential medium and high value end uses identified during the workshops for fine and coarse EAFS aggregates included:

- Sealing and asphalt aggregates (skid resistant)
- Iron supplements to cement feedstock (Fe)
- Water treatment & sub-soil free draining material
- Aggregates (non-concrete)
- Geopolymer binders

Taking a sustainable supply chain approach[1] to product development involves engaging processors, value adders and customers in discussion about the opportunities and challenges of the product. Depending on the position of the organisation in the EAFS supply chain, there are different imperatives, trade-offs and barriers.

* "Effective utilisation" is the sale or utilisation recoverable mineral resources into a valued added construction application that provides both commercial returns [revenue] return on investment or an economic profit [avoided expense], and use is consistent with the criteria of ecologically sustainable development (EDS) principles

The overriding aim of the workshops was to establish mutual understanding about the production of EAFS during the steel making (Electric Arc Furnace) processes among industry stakeholders in the EAFS supply chain, with the ultimate objective of increasing the utilisation of EAFS in products.



Workshops allowed participants to share views and ideas and engage in discussion with invited experts. Knowledge was built quickly and holistically between supply chain groups who would not normally discuss sustainability or low carbon product development issues. Systemic constraints were highlighted during workshop discussions included the history of EAFS both locally and globally, climate change policy, regulations and incentives and procurement policies. For the value adders the challenge was to find new markets and to understand customer needs, while at the same time managing the development time. The absence of performance based specifications in Victoria were considered a key barrier to increasing EAFS procurement by local government and VicRoads. Specifications are focused on natural quarried materials and not recovered materials such as EAFS.

After initial discussions the group decided to focus on engaging more customers in workshop discussions and on developing performance criteria and fundamental information about EAFS to raise customer awareness of their beneficial traits and potential applications.

It is important to note, when referring to the reduced carbon emissions associated with EAFS, processes and associated emissions of the steel mill's (Generator's) primary products were beyond the scope of this study and accordingly not relevant to the project aims of this partnership program for EAFS being by-products.

Taking a supply chain approach can provide significant upstream and downstream payoffs, from improved beneficial use of by-products from manufacturing processes (i.e EAFS) which would otherwise most likely be sent to landfill and the development of new products utilising by-products such as EAFS.

Key challenges with developing products in the EAFS supply chain:

- Managing R&D and product development time spans and obtaining adequate financial backing.
- Developing performance standards with customers.
- Building knowledge about sustainable product design, such as lifecycle analysis, transport, standards, marketing and branding.
- Negotiating vested commercial interests and lobby groups.

- Annual output of steel: 750,000 – 800,000 tonnes
- Employees and contractors at Laverton: >350

- Annual processing capacity of EAFS: 90,000 tonnes
- Aggregate sizes: 70mm, 20mm, 14mm, 10mm and >7-0mm
- Blended Class 3 & 4 products
- Blended hardstand products
- VicRoads approved pavement products

Supply Chain Partnership

Harsco Metals works in close conjunction with its customer - OneSteel at Laverton, Melbourne. EAFS processed as a by-product from the OneSteel steel mill process at Laverton is contracted to Harsco, at their adjoining plant. Particle grading processes at Harsco results in a range of high grade particles (EAFS) that can be utilised in a various road base applications. These can be processed into various finished products to suit customer specifications or requirements.

EAFS production is directly linked to steel demand with between 55-100 kT of slag produced per annum, subject to steel manufacture.

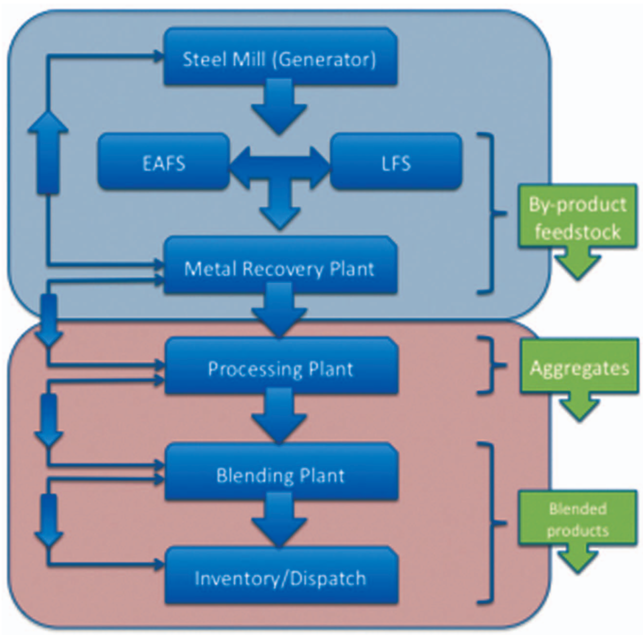
OneSteel is an integrated, global manufacturer and distributor of steel and finished steel products. OneSteel is self-sufficient in iron ore and has the ability to be self sufficient in scrap metal. This provides significant flexibility to the integrated model that ranges from the mining, collection and supply of steelmaking raw materials through to steel production, manufacturing and distribution in Australia and overseas.

Harsco Metals (formerly Multiserv) is an international leader in providing Steel Mill Services. They have 170 operating sites in 37 Countries, with 10,000 employees. Harsco specialises in metal recovery, slag management, scrap management and processing, raw materials management, by-product recycling and melt shop services.

About EAFS

EAFS is the by-product of steel manufacture. In the EAF process, after steel scrap and fluxes are added to a refractory lined cup-shaped vessel, a lip is lowered through which carbon electrodes are passed. An electric arc is induced between the scrap and electrodes and the resultant heat generated melts the scrap and fluxes.

This liquid steel process results in two types of slag: EAFS which forms a blanket on the surface of the molten steel on the ladle; and Ladle Furnace Slag (LFS), a very fine slag, that settles on the bottom of the ladle once all the steel has been removed. The proportions of EAFS to LFS are 80 percent and 20 percent respectively.



EAFS and LFS process flows are shown in the above figure. Processes within the blue shaded boundary are generally attributable to the primary operations and core products, i.e. steel. These aspects are beyond the scope of this study. Energy and associated emission reductions are attributable only to EAFS processes in the red shaded boundary.

The molten EAFS is poured into pits, where, after initial solidification, the slag is cooled with water sprays and then processed through a metal recovery plant. After all the metal is removed the EAFS, now a feedstock, is further processed into aggregates and pavement products within the Harsco aggregate plant.

EAFS properties have been shown to be suitable for - aggregates, specialised surfacing, water treatment and drainage, soil stabilisation and cement process additives.

Effective use of EAFS has significant potential to lower the carbon footprint associated with road construction, when compared with natural quarried materials, provided it meets specified performance criteria, including a minimum 20 years life within the road structure.

Benefits from the effective use of EAFS in applications include[2]:

- Fossil fuel use reduction
- Electricity use reduction
- Emissions reduction for products containing EAFS can be up to 73 percent compared to natural quarried materials.
- EAFS are technically suitable to substitute natural quarried resources.

VicRoads are interested in lowering greenhouse gas emissions from operations and materials use.

VicRoads investigating revision of material specifications to optimisation available natural quarry material whilst encouraging the use of recycled materials where appropriate.

Picture: EAFS used in pavements at OneSteel, Laverton.

Pavements have performed well under high axle load vehicles greater than 60 tonnes.

EAFS products for road construction

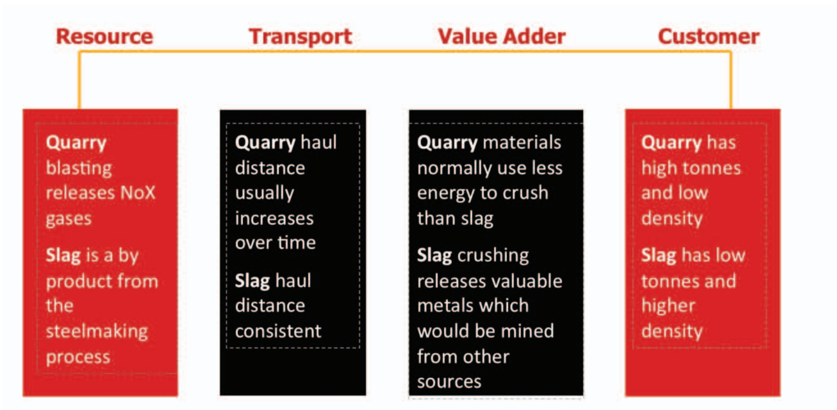
A wide variety of structures use natural earth or rock fills, including roadways, car parks and residential or commercial re-development sites. Roads, embankments and hardstand areas are common projects for large civil engineering construction firms.

They require the use of engineered bulk materials and structural fill - coarse and fine aggregates - which are generally sourced from natural quarried materials. EAFS can complement or replace the use of local quarried materials in large-scale civil applications.

EAFS has many properties, which make it well suited for use in road contruction and bituminous road surfacing applications. It is a hard, dense, durable and well shaped aggregate, making it suitable to replace, supplement and improve other natural materials.

The use of steel furnace slags in these ways also has environmental benefits in reducing the depletion of natural resources from traditonal quarrying activties. EAFS are generally harder, more durable materials than natural aggregates. They offer particular advantages for road construction because EAFS has high density and skid resisitance.

Slag vs natural (quarried) aggregates

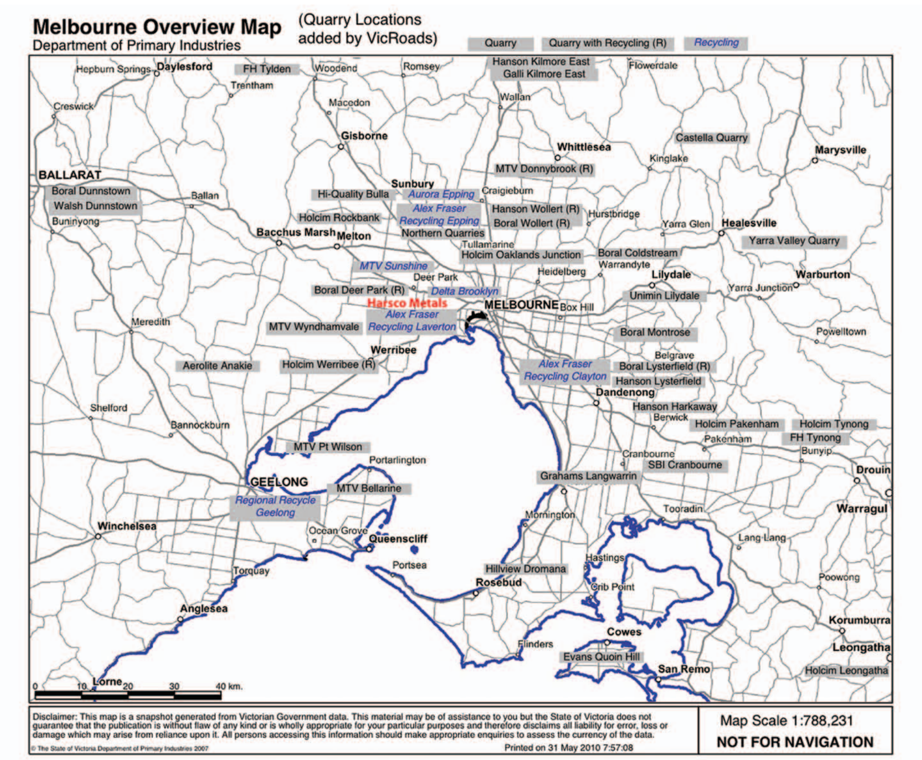


High skid resistance products

The skid resistance properties of steel furnace slag make it a very useful aggregate for asphalt surfacings including open grade asphalt, dense grade asphalt, fine gap graded asphalt and stonemastic asphalt.

In thin bituminous surfacings, the cubical shape and skid resistant properties enhance the performance of surfacings such as slurry seals, sprayed seals and emulsion seals[3]. While densities are slightly higher (20-25%) than those of conventional aggregates, this does not translate directly to a proportional increase in the cost of placed asphalt. The water absorption is similar to naturally occurring aggregates. Polishing Aggregate Friction Value (PAFV) is significantly higher than for most naturally occurring aggregates. The range of PAFV is usually 58 to 63. The naturally occurring aggregates with PAFVs greater than these values are rhyolites and scorias which tend to have lower wet strengths and abrasion resistance than steel furnace slag, but have signficantly higher cost.[4]

Steel furnace slag has been widely used as a premium asphalt aggregate in the US, UK and Europe. EAFS aggregates have been successfully used in high accident areas such as intersections and low radius curves with reduced accident rates resulting.



EAFS have high particle strength, which is an advantage for asphalt.

The cubical shape of steel furnace slag aggregates helps the material interlock and improves the deformation resistance of asphalt. Coarse aggregates (above) are used for high friction materials. Fine aggregates (below) are suitable for pavements.

Over the last decade the use of EAFS in asphalt has become widely accepted, particularly in New South Wales by the Roads and Traffic Authority. Its acceptance continues to increase as natural aggregates become harder to access. The map (adapted by VicRoads from Department of Primary Industries) shows natural quarry locations around Melbourne.

Performance standards that classify the use of EAFS in applications are essential for developing the new low carbon market opportunities.

References

[1] Woodhead, A., Thomas, J., Mah, J. (2009) Sustainability in supply chains. Australian Research Institute in Education for Sustainability, Macquarie University.

[2] Heidrich, C. and A. Woodhead (2010). Benchmarking Report for the Sustainability Victoria Business Partnerships Assessment & Benchmarking Module Wollongong, Australasian (iron and steel) Slag Association Vol 1: pgs 22.

[3] Flower, D. J. M., Sanjayana, J.G. et al. (2007). Environmental Impacts of Concrete Production and Placement. Concrete 07, Adelaide, Concrete Institute of Australia.

[4] ASA (2002). A Guide to the Use of Slag in Roads. Revision 2. Wollongong, Australasian (iron & steel) Slag Association Inc.

What next

Market opportunities for slag in Australia are growing. Effective utilisation by associated industries of these recovered resources has the potential to benefit business economically and provide significant carbon reduction benefits when used to displace other traditional quarried materials and associated carbon footprints.

The benchmarking report[2] demonstrates the use of recovered EAFS has potential to lower the carbon footprint of materials used in road construction, provided they meet specified performance criteria, including minimum design life expectancies within the road structure. However, current specifications give preference to natural aggregates. EAFS performance standards, which classify the use of EAFS in applications, are essential for developing the market opportunities.

Working with customers can help suppliers establish knowledge about market opportunities. Suppliers can help customers to understand the characteristics of the products and sustainability benefits realisable from by-products. Conversely customers can educate suppliers about market entry criteria and supply and demand trends and product gaps.

Workshop discussions led to some agreement that the EAFS supply chain has significant knowledge gaps that hinder the utilisation of EAFS in new and existing product applications. Participants at the workshops noted that many of the potential end use applications held significant technical and commercial risks. Technically sound published data and best practice testing procedures for product development are essential to reduce this risk and increase the likelihood of success when exploring new product applications with customers.

Turning under utilised EAFS materials into value add products can provide environmental [lower carbon footprint], economic [revenues] and social [conservation of virgin resources] benefits to the industry and the community. This case study highlights the need for further well targeted research, to allow for building new business partnerships and knowledge to increase the utilisation of EAFS in Victoria.