SUSTAINABILITY IN SUPPLY CHAINS

Using systems thinking to work towards sustainability in corporations and their supply chains

CASE STUDY:
Sustainable concrete supply chain

Australian Government
Department of the Environment, Water, Heritage and the Arts

ARIES
AUSTRALIAN RESEARCH INSTITUTE IN EDUCATION FOR SUSTAINABILITY

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SUSTAINABLE CONCRETE SUPPLY CHAIN*

With the accelerating pace of globalisation and increasing emphasis on sustainability, it was inevitable that those in the construction sector increased their focus on reducing carbon in buildings. Global trends indicate that Australian government legislation and market pressure will eventually require developers to build zero-carbon buildings. Cement accounts for 5% of the world's CO_2[1]. Cement, when combined with aggregates, water, chemicals and energy makes concrete. Concrete provides excellent thermal mass, has durability, can last for over 100 years and can be recycled. Therefore effective building design can contribute significantly to a building's energy efficiency and longevity, which means a building's lifetime carbon footprint can be reduced.

Given the complexity of this problem, the foundation companies, Bovis Lend Lease, Stockland and Landcom, recognised the need to collaborate. Over 20 companies from the concrete supply chain became involved.

This case study facilitates discussion on using critical systems analysis with multi-stakeholders to understand options for procuring sustainable concrete.

Learning objectives:

1 > Understand the diversity of perspectives in the concrete supply chain

2 > Work with multiple stakeholders using CSA and developing systemic thinking

3 > Build ongoing dialogue and making sense of complex issues

4 > Work with the barriers to change in the concrete supply chain

5 > Explore critical systems analysis for developing corporate sustainability policy and strategy.

1 Australian Cement Industry Sustainability Report 2007

** This case study was developed as part of the ARIES project, Sustainability in Supply Chains (Woodhead et al 2009)*

BACKGROUND

Three companies – Bovis Lend Lease, Stockland and Landcom – were invited to participate in the Sustainability in Supply Chains program. Bovis Lend Lease is an Australian-based global project management and construction company; Stockland is one of Australia's largest diversified property groups. Both companies provide a range of expertise, including construction management, project and program management, design management, design engineering, procurement and facilities management. Landcom is a state-owned corporation and a development arm of the New South Wales Government. Landcom's primary focus is planning and developing residential and commercial properties in NSW.

All three companies identified the carbon impact of the use of concrete in construction as an intractable, messy problem that no one organisation by itself could address. It was agreed that collaboration was needed and independent facilitation would be important to bring stakeholders together.

The sustainable concrete supply chain project required time, insight and input from a wide range of industry players, including developers, engineers and architects, builders, cement and concrete manufacturers and associations, power stations, industry standards organisations and the financial sector. The team conducted extensive interviews and systemic analysis of the concrete supply chain – first identifying the key stakeholders, then the changes required and the barriers. We explored why more sustainable practices were not happening and who had the power and influence. A sense of powerlessness and inertia existed, mainly due to the complexity and interconnectedness of the concrete production process. So we invited a group of industry stakeholders to come together in March 2008. The intention was to establish mutual understanding of the barriers and incentives towards a more sustainable construction sector. The participants included some of the nation's top concrete and cement companies, joined by leaders from several of the industry's raw material suppliers, associations and government agencies. For a day they worked their way through the issues in the concrete supply chain and, in the end, they agreed on ways each sector could contribute to the sustainability of the supply chain.

PARTICIPATING SUPPLY CHAIN COMPANIES:

Cement and Concrete

Boral

Cement Australia

Cemex

Hanson

Independent Cement and Lime

Associations

Ash Development Association of Australia & Australasian Slag Association

Cement Concrete and Aggregates Australia

Concrete Institute of Australia

Green Building Council

Energy

Delta Electricity

Macquarie Generation

Finance

AMP

Government

Australian Government Department of the Environment, Water, Heritage and the Arts

NSW Department of Environment and Climate Change

City of Sydney

CRITICAL SYSTEMS ANALYSIS

Between June 2007 and August 2008 exploratory meetings were held with the construction companies and associated concrete supply chain agencies. The objective was to develop understanding of the diversity of perspectives in the supply chain along with the:

- impact of policies, including unintended consequences
- role that each stakeholder can play in implementing change
- potential levers and barriers for change.

Initial enquiry found that the construction companies wanted facilitated discussion that built on their knowledge of the barriers and opportunities for increasing the use of sustainable concrete in the construction sector. They also wanted to understand how sustainable was sustainable concrete, and under what conditions. For example, what were the options for reducing embodied energy and increasing energy efficiency? Sustainable concrete is a messy problem because there are many drivers, complex influences and perverse policy outcomes due to:

- a complex range of contractual relationships
- a complicated product with numerous inputs, uses and specifications
- many vested interests, entrenched positions and lobby groups
- a wide range of opportunities and barriers to influence decision making processes
- perceptions of high risk in relation to certain applications of sustainable concrete
- a culture of long hours and tight deadlines.

Supply chain issues are particularly complex due to the many stakeholders involved. To influence the system requires an understanding of the social, institutional and policy processes, as well as the production and operational systems.

An adaptation of the OECD's Pressure State Response model (see Chapter 3 of Sustainability in Supply Chains, Woodhead et al 2009) was provided as a framework for the dialogue and analysis. Putting the 'system at the table' (a supply chain or inter-disciplinary group) is a powerful and effective approach to breaking down barriers and building common knowledge.

WHAT IS CONCRETE MADE FROM?

Concrete is a combination of cement and materials that when combined with water can be poured into virtually any form. It hardens into a strong, durable material that is predominant in building and construction.

The materials in concrete can include many combinations of coarse aggregate (crushed rock or gravel), fine aggregate (sand), chemical admixtures (used for mix enhancement), special additives, water and supplementary cementitious materials (SCMs) and cement. The production of Portland cement involves a chemical reaction that produces CO_2. SCMs can be substituted in some cases to reduce the CO_2 impact.

WHY USE SUSTAINABLE CONCRETE?

Reducing the carbon footprint of a building (the volume of greenhouse gases expressed in equivalent units of CO_2) is becoming an increasingly important driver for builders and developers. One way to achieve this is to improve the efficient use of energy in operation during the life of a building. Another is to reduce the embodied energy in the materials and construction of a building; particularly concrete.

Members of the concrete supply chain gathered for a one-day focus group in Sydney on 19 March 2008. The objective of the session was to build a broader understanding of the range of perspectives and to jointly develop plans and initiatives for a more sustainable concrete supply chain. The participants were seated at tables of 7–8 people each with representatives from sectors of the concrete supply chain. Groups alternated between small and whole-of-forum discussion. 'Thought starter' talks identified key issues in the sector and helped to start discussion around the following areas:

- Understanding the production of sustainable concrete.
- Exploring project management, procurement and sustainability drivers.
- Understanding the current standards, incentives and regulations.

Systemic, messy problems often have complex drivers, numerous influences and interdependencies.

Systemic solutions require a collaborative approach with a shared vision and mutual benefits.

No single person or entity can control the issue or determine its outcome.

A diversity of perspectives is needed to make sense of the issue.

PRESSURE: WHY SUSTAINABLE CONCRETE IS IMPORTANT

From the developer and construction companies' perspective, reducing the levels of embodied energy (the energy used in production) in the production of concrete and the use of concrete in buildings, and increasing the information about concrete purchasing options are the key drivers for change. The inability of the companies' sustainability managers to influence decision making in the concrete supply chain was a key driver for this project.

Issues putting pressure on the sector to increase its focus on sustainable concrete are:

- increasing demands by clients and tenants for 'green' buildings
- limited specification of sustainable concrete by architects and engineers (specifiers)
- project Directors lack the incentives or knowledge to critique concrete procurement specifications
- limited information on how to specify sustainable concrete and to support the range of sustainability issues
- lack of sustainable concrete products to provide specifiers with options.

The sum result was low awareness of opportunities, optimum applications and benefits of sustainable concrete. With the prospect of an emissions trading scheme, stakeholders expressed the view that the sector will have to change its production practices and develop knowledge and practices about how to be more sustainable. The foundation participants held a vision of responsible business practice that could cut GHG emissions in excess of that required by the new ETS.

CURRENT STATE OF THE CONCRETE SUPPLY CHAIN

A systemic enquiry of the concrete supply chain systems, links and boundaries is shown in Figure 6. This diagram was developed after initial discussion with the key participants. It was used during meetings to discuss the roles of the supply chain stakeholders, to help them explore from their perspective at their point in the system their risks, uncertainty, influence and control. The diagrams and other learning materials were adapted as new knowledge emerged. There are numerous interactions and a range of relationships among customers, developers, construction companies, specifiers and builders in this supply chain, which the diagram sought to generalise into a working model. Hence it was referred to as a 'generic sustainable concrete model of stakeholders and processes'. For example, architects and/or engineers and project directors can be in-house or outsourced, and this can vary from project to project, or between different arms of a given corporation.

THE STAKEHOLDERS

The key stakeholders in this supply chain are clients and tenants, developers, construction companies, concrete and cement suppliers and contractors, raw material suppliers, builders, associations and building standards corporations. The context is the use of concrete in the construction of the built environment. Participants described the cultural context as very market-oriented and pressured. The key elements are productivity and competitiveness. Project managers received financial incentives for projects delivered on time and on budget.

The boundaries of the system analysis for this project extended from the developers through to building construction (represented by the grey background in the diagram below). Key sub-systems included: transport and logistics; supplementary cementitious materials (SCMs); concrete and cement production; building policies and standards agencies; specifiers; and environmental and social systems.

Construction / Sustainable concrete supply chain: Generic model

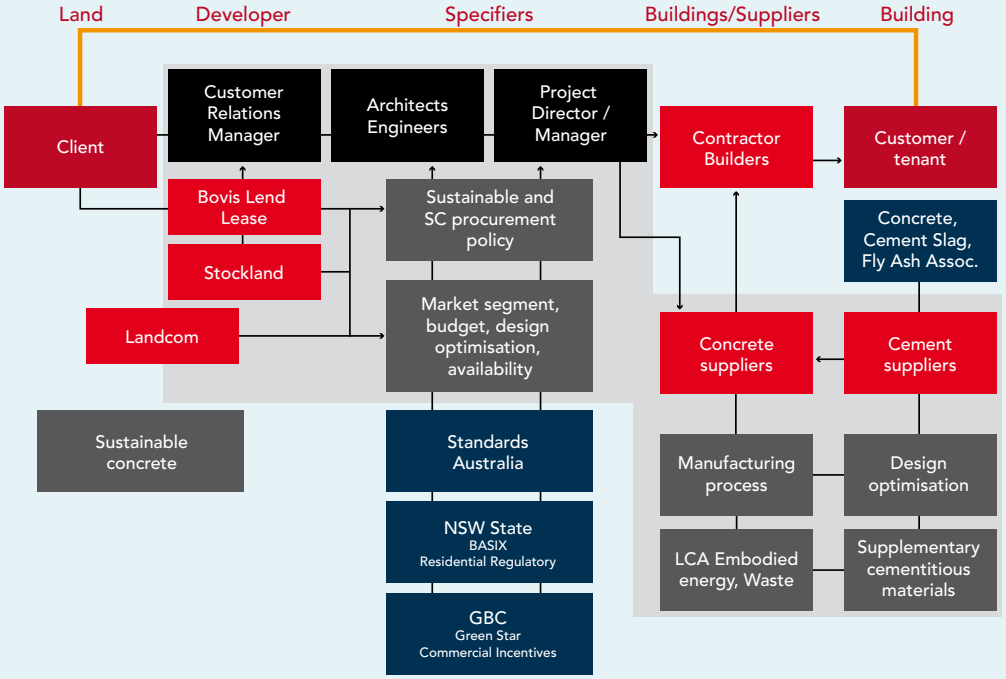

Figure 6 Sustainable concrete model of stakeholders and processes

The focus group discussion provided insights into the perspectives and issues in the concrete supply chain. While not a key group in the concrete supply chain, the financial sector and building tenants provide leadership within the construction sector. Financial institutions are facing increasing demands to ensure that their funds have sustainable investments and the practices used in construction support their investment principles. These institutions can provide leverage for change in corporations; e.g. through dialogue with CEOs about corporate performance against world's best 'sustainable' practices.

Concrete and cement suppliers are a key group. The exact specification for the use of concrete in buildings is highly contextual, i.e. concrete specifications are dependent on the particular building and site location. Factors that influence the use of concrete include design and engineering specifications: e.g. strength and setting time; location (distance from concrete silos and resources); timing/scheduling and availability of materials and logistics; and structural function of the building element.

MATERIALS AND RESOURCES

There are large quantities of supplementary cementitious materials (SCMs) available that are presently under-utilised in some regions of Australia, such as New South Wales.

SCMs are currently viewed as a commoditised waste product rather than a specialist product. Considerable potential exists to increase the use of SCMs in concrete and in new building products. Other important factors in the availability and sustainable use of SCMs in concrete and building products include:

- availability of water and materials
- uneven distribution of SCMs in Australia, the associated transport distance, economic and carbon costs
- existing contractual arrangements that restrict the capacity of SCM suppliers (e.g. power stations that produce fly ash) to develop the market to its full potential.

The concrete suppliers have infrastructure constraints on their capacity to utilise SCMs in concrete mixes. Their current capacity is highly location dependent – mainly driven by the number of silos on site. Increasing silo infrastructure would enable the concrete sector to provide a greater range of concrete blends. High silo infrastructure costs, space and council planning requirements are major restrictions to this development.

Performance specifications of built structures are also an important factor in the use of concrete. Some participants expressed concern about the emphasis on SCMs as the principal vehicle to create a more sustainable concrete product.

Over-reliance on rating systems to provide incentives to use SCMs, without considering the context for their use, does not necessarily achieve more sustainable outcomes. For example, specified concrete mixes that 'prescribe' SCMs as part of a percentage of replacement materials may produce unintended outcomes. Longer curing times of SCMs can affect concrete pour cycles, which in turn may result in subcontractors charging builders extra. To compensate, additional cement may be used to reduce curing times, which is counter-productive.

SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCMS).

Fly ash, ground granulated blast furnace slag, or other pozzolanic materials are collectively referred to as supplementary cementitious materials (SCMs).

SCMs can be

- included in concrete, either as an ingredient added at batching, or as a component of a blended cement, or both.
- added during batching along with Portland cement.
- added to concretes made with blended cements. The advantage of using SCMs and other recycled materials is that it reduces the embodied energy.

Source

City of Sydney

www.cement.org/tech/faq_scms.asp

Other alternatives exist to reduce carbon footprints, such as design optimisation to reduce the amount of concrete required and the use of post-tensioned slabs.

Developers and construction companies have specific criteria for the supply of some other building products (such as certified timber products) to ensure their 'sustainable' credentials. However, which supplier provides the concrete for a particular project is largely determined by proximity (the weight and curing time of concrete makes logistics and transport important). This means the companies are unable to manage this supply chain in the conventional manner – they can't work with a preferred supplier to an agreed standard. They have been unable to implement consistent sustainable concrete product standards across the range of suppliers.

Whole-of-supply-chain thinking introduces systems considerations. Design optimisation needs a 'cradle to grave' view that includes GHG emitted from mining and production processes through to end-of-life disposal or reuse. Improvements to the operational energy efficiency of a building that draws on non-renewable energy sources by itself won't reduce the volume of GHG in the atmosphere.

Developing a shared understanding of a supply chain system can support more effective decisions and solutions to messy problems.

CHALLENGES

Specifications for concrete need to support sustainable outcomes through the more effective use of SCMs in a) building design optimisation; b) performance specifications for the % of SCMs in different applications; and c) improved time and logistics management to reduce waste. Key challenges are:

- How to increase the specification of SCMs to reduce the embodied GHGs in the built environment. There is currently limited specification of SCMs by engineers. Pressure from developers and construction companies for the fast laying of concrete does not support the use of SCMs as they take longer to cure.
- How to balance sustainability tradeoffs – reducing GHG from embodied energy vs energy efficiency during the operational life of a building. For example, concrete provides insulation benefits that are closely aligned with concrete mass and effective building design: i.e. concrete can significantly improve energy efficiency by reducing the need for air conditioning and heating. For this reason, attempts to reduce the use of concrete could adversely impact on the energy efficiency, durability and longevity during the operational life of the building.
- How inefficient practices such as a lack of quality control, over-ordering of product, and rigid timing/scheduling of deliveries can lead to considerable concrete and energy waste. For example, currently twice the number of trucks are used to meet morning deadlines than would otherwise be required if deliveries could be spread evenly throughout the day. Note: participants indicated that attempts by the concrete industry to manage logistics and scheduling with clients have achieved limited success so far.

The process of defining the problem and solutions constantly evolves and can take new forms throughout the project and afterwards.

POLICY TOOLS AND MEASUREMENT

Depending on the position of the organisation in the supply chain, there are different drivers, trade offs and barriers. People also have a range of incentives and constraints to achieving outcomes. These contextual issues need to be taken into account when considering the policy tools for sustainable concrete.

The Green Star rating system is a building standard for commercial 'green buildings'. There is limited incentive for their increased use of SCMs due to the small allocation of points. It was argued that a higher point allocation would help to address this issue. However, a key question is whether SCM rating criteria create better sustainability outcomes. The limitations to the current rating system were discussed. For example, the rating system does not accommodate embodied energy or energy efficiency design considerations for concrete.

The Green Building Council is planning to review the rating criteria and will consider how to ensure that point allocations do not create unintended impacts on the sustainable performance of the building. Addressing the issues raised above may take up to three years.

When searching for solutions to problems, consider the impacts of the solution on the external and internal environment. Align policies with sustainability vision, strategies and corporate culture.

The Life Cycle Analysis (LCA) of a product within the supply chain is needed to fully understand the embodied GHG and other resources used to produce the product. Currently, LCA tools are fairly simplistic. LCA tools are not currently recommended state practice, nor are they consistent between states. An LCA can be information intensive and costly to conduct, and is limited to a defined product in a point in time, so allowance needs to be made for parameters that change. There are numerous mixes of cement and concrete and a large variety of input materials available. It's also uncertain whether the results of an LCA will align with the incentives of a future ETS. In assessing the impact and longevity of a building, an LCA needs to inform not just the decision of what to build, but how to build. This would include a focus on optimal design upfront: a) to extend the life of a building; and b) to provide decision support on whether to refurbish or rebuild an existing structure.

CO_2 from products is undervalued and the ETS will help to solve this issue by placing a price on carbon. Over time, carbon pricing will become an integral part of incentives, regulations and other market and legislative instruments.

The Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) has started dialogue with the Building Products Innovation Council (BPIC) to develop a nationally consistent approach to carbon accounting in the built form. The scope of the ETS in measuring carbon performance may include design, material, utility and construction/ operations considerations. A carbon accounting methodology will need to determine where in the supply chain the transaction costs reside for existing and new products (e.g. the trade of 'packets of emissions').

Considerations include: the equitable distribution of benefits from carbon savings; who would bear the costs of an ETS; and at what point would a carbon price translate into change. Participants expressed a need for

communication/education to enable decision-makers in the supply chain to interpret these signals and respond with product and design choices that reduce carbon. Irrespective of a national carbon accounting scheme, participant construction companies expressed the need to proactively reduce CO2 emissions as a moral imperative.

THE WAY FORWARD, THE RESPONSE

Corporations within the construction sector need to demonstrate leadership in order to build momentum for change. The culture of 'fast turn around' in this sector limits the ability of staff to engage in sustainable initiatives. Senior management can provide support by allocating time and resources, incentives and performance KPI for their staff to drive sustainability outcomes.

Participants indicated that there is a need for stronger collaboration throughout the concrete supply chain and consistent messages, policies and incentives for stakeholders. To build the capacity of people and organisations to better understand the issues, and effectively work towards a sustainable concrete supply chain, the recommendations were:

- Develop a range of communication and education material on the use of sustainable concrete products and processes for a broad range of stakeholders across the supply chain, such as project managers, specifiers, suppliers, etc.
- Improve decision-making support tools such as LCA, design, product and performance optimisation tools to enable more informed decision-making at all levels of the supply chain.
- Develop incentives, standards and best practice performance specifications that provide assurance of the sustainable credentials of products, a consistent message, and market drivers that do not lead to unintended/unsustainable outcomes.
- Develop contracts and procurement policies that encourage the use of sustainable concrete and support green building criteria.
- Encourage leadership and cultures within corporations that support sustainability practices in the concrete supply chain.

There are extensive knowledge gaps within and across the supply chain about sustainability in the supply of concrete. This lack of knowledge and awareness often drives behaviour and practice that produce unsustainable outcomes. Questions raised included:

- What is the impact of different concrete mixes?
- What are the links to other issues within the supply chain such as water, waste and logistics?
- What does a 'green building' actually mean?

More industry-wide and stakeholder-specific information is needed to help support decision-making (e.g. case studies about the trade-offs between embodied energy and energy efficiency). This type of information will enable stakeholders to make more informed decisions about the options for sustainable design and the use of construction materials, and how to most effectively achieve sustainable outcomes.

REFLECTIONS ON THE PROJECT

The 'walk the supply chain' approach at the focus group and during meetings, using diagrams and critical system analysis learning tools, broadened participants' knowledge and understanding of other parts of the supply chain. Below are comments recorded by the participants on review forms after the focus group:

- 'Positive development of our understanding of other areas of the supply chain – get feedback from downstream members on their view of your sections.'
- 'Write up results and circulate, hold another meeting, ongoing collaboration.'
- 'Very informative and insightful. It helped me to understand the key factors and drivers into sustainable concrete.'
- 'Good to meet the participants and hear their concerns.'
- '… challenge to convey complexity of issues across influencers – specifiers.'
- 'Increased awareness and collaboration between various sectors [are] important.'

Sustainable concrete is a complex issue and a messy problem. When working with so many stakeholders from different disciplines and sections of the supply chain, there are major challenges. A collective response to make sense of complex issues that have persistent, systemic barriers to change can generate simple communication material. Fact sheets, when written in a credible style with relevant, useful information, can help build shared knowledge and can become a tool for leveraging change. One outcome from this project is the development of a Sustainable Concrete Fact Sheet. The Concrete Institute of Australia (CIA) is taking a leading role and is working with its members and participants from the construction project.

Participants indicated that ongoing discussion in the form of a follow-up focus group or small working groups to review the findings and explore next steps would be helpful. An extensive set of recommendations for future research and policy development was formulated during the focus groups and interviews. These recommendations provided incentive for the CIA to develop its own research and development forum and the fact sheet.