The Unreasonable Resource Flow – Construction and Demolition Waste in the City of Cape Town

K. Barnes, L. Basson
GreenCape Sector Development Agency – Cape Town 8001, South Africa.
*Corresponding author: Kirsten Barnes., Tel: +2721 811 0250, e-mail: kirsten@greencape.co.za

ABSTRACT
About 85% of builders' rubble[1] is landfilled in South Africa, in spite of its re-use potential. Based on international experience, the biggest opportunity is in road construction.

A key contributing factor to successful businesses – both locally and globally – is business at a regional scale due to the low value of the material relative to logistics costs. The market for builders' rubble in Cape Town is expanding rapidly, supplying material to private sector construction.

Current drivers of the economy:

- Rising virgin material prices;
- Regulation of waste flows;
- Cost of transporting waste;
- Limited landfill airspace – increasing disposal costs.

This paper outlines GreenCape work to support development of the builders' rubble economy, with emphasis on developing best practice guidelines for the crushing industry to produce high quality products that meet user requirements.

Keywords: construction and demolition waste, crushing, secondary aggregates, road construction
Word Count: 150

1. INTRODUCTION

About 85% of builders' rubble is landfilled in South Africa, in spite of its potential for re-use, and the high financial and societal costs of landfilling. The aim of this paper is to provide information on the status of the economy in builders' rubble processing and use in the construction industry. In addition a number of business opportunities in the sector and points of intervention that enable the uptake of builders' rubble in construction were identified during the course of this work, and will be discussed.

The biggest opportunities for builders' rubble processing and use lie in the construction and rehabilitation of roads, as can be seen in high performing builders' rubble economies, such as Japan and the Netherlands where 80% of the construction and demolition waste diverted from landfill is applied in roads. There are therefore opportunities on both the supply side for the crushing industry, as well as on the demand side in road construction for both the public and private sectors. This paper will focus on uptake in roads.

It is acknowledged that the inclusion of processed builders' rubble in new construction materials for structures is a growing viable business, and a valuable sector in the builders' rubble economy. This sector will be considered further at a later date.

Builders' rubble comprises a large proportion of waste landfilled in the Western Cape, up to 40% by mass recorded in Stellenbosch Municipality. Given the pressures on landfill airspace, as well as the high costs of cleaning up illegally dumped builders' rubble, the stream has been highlighted for intervention. Both the City of Cape Town (CCT) and Western Cape Government (WCG) through the Department of Environmental Affairs and Development Planning (DEA&DP) and the Department of Economic Development and Tourism (DED&T) recognise the potential to stimulate economic development, job creation as well as diversion of waste from landfills by strengthening the economy in builders' rubble in the Western Cape. These departments are allocating resources and conducting studies aimed at supporting this economy.

[1] The mineral component of construction and demolition waste (C&DW) consisting of concrete, bricks – both clay and concrete blocks - and stone

GreenCape's work on builders' rubble as a resource is currently focussed on the City of Cape Town Metropolitan Municipality.

2. IS THERE AN ECONOMY IN BUILDERS' RUBBLE IN THE CAPE TOWN AREA?

2.1 Landfilled rubble – available feedstock

Within the CCT, there was 1.2 million tons clean builders' rubble disposed of at landfill from July 2014-September 2015 (Figure 1). Therefore an estimated 518 000 m^3 was disposed of in 2015[2]. An average of 6% (~31000 m^3) of the builders' rubble disposed of at landfill is currently used as landfill cover and maintenance of landfill roads.

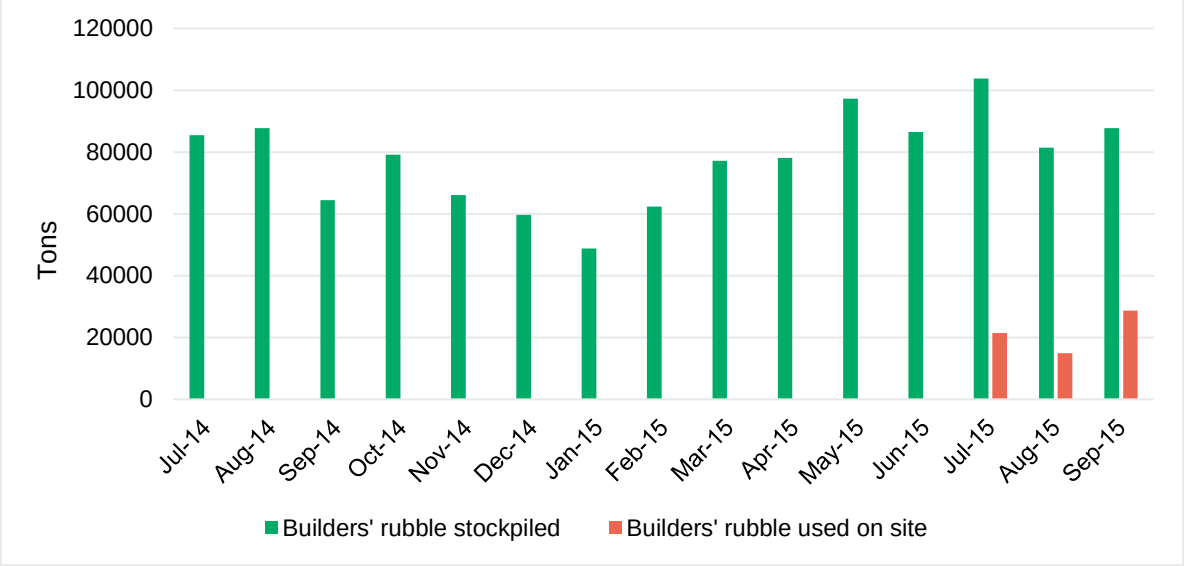


Figure 1 Clean builders' rubble landfilled in the City of Cape Town

Experts in rubble crushing from The Netherlands and South Africa were consulted regarding builders' rubble recovery and processing: it is estimated that

- 50-60% of the material currently being disposed of at landfill is suitable for the higher value applications, such as in foundations of buildings or as sub-base in roads, and
- 20-30% of the total rubble disposed of is suitable for sub-base and even base courses in road construction (Figure 2).

Therefore, it is estimated that at least a further 130 000 m^3/year[3] of high quality material is available in CCT alone. At a current market value of R100-R130/m^3 for sub-base material, the value of the high quality material currently landfilled is R13 – R17 million per year as a conservative estimate. Although these values do not account for costs of separating material at source, or the screening and crushing required for high quality products; the estimate does give an indication of the size of the opportunity in the City of Cape Town.

[2] City of Cape Town, Solid Waste Department, 2015. Note: This figure does not included mixed loads of C&DW disposed of at landfill or illegally dumped material

[3] 25% of material landfilled in 2015

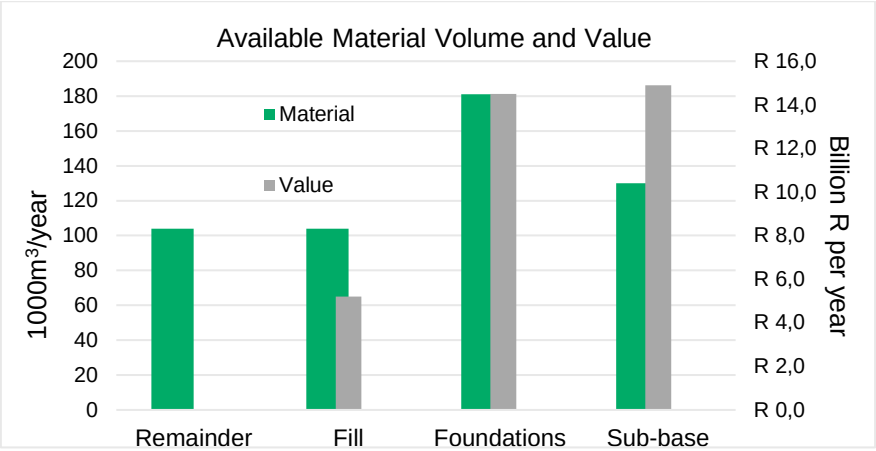


Figure 2 Available Builders' Rubble - Volume and Value

2.2 Crushed material supply and excess capacity

A survey of six major crushing operations resulted in an estimate of the current crushing capacity in the CCT of 619 000 m³/year (Figure 3). With planned investment over the next 2 years from two of the companies visited, and a new crusher to come online in the same timescale, estimated full capacity at the end of two years will be 1.1 million m³/year. Three of the six crushers accept materials from external clients rather than only processing their own wastes, and are confident that material throughput in their business could double overnight, with builders' rubble easily sourced and products moving well.

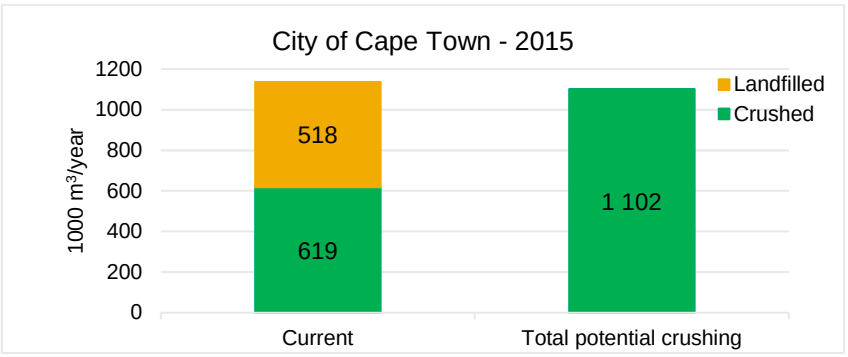


Figure 3 Builder's rubble crushed and available in the City of Cape Town

Crushing capacity is unlikely to outstrip supply of builders' rubble – Current data on builders' rubble generated does not include mixed loads disposed of at landfill:

- Only loads with less than 10% contamination are captured in the data. Segregation at source is not common practice on construction and demolition sites, therefore there are likely to be many mixed loads.
- Furthermore, the builders' rubble illegally dumped at multiple sites around the City nor waste from construction material production is captured in the data.

2.3 End users

2.3.1 Small construction companies

The primary market for crusher operators is composed of smaller construction companies who have been constrained by increasing virgin material prices, with application of the material predominantly in fill, but also in foundations and road sub-base.

2.3.2 Large construction companies

Some of the larger construction companies with the resources to crush on their own sites, report cost savings due to limited logistics and reduced handling of material such that secondary material[4] has a competitive

[4] Material recovered from waste

advantage in a highly competitive market. These companies routinely include secondary material in sub-base layers in roads, where these roads remain under the authority of the private sector, as well as producing secondary concrete aggregate to be included in concrete mixes.

2.4 Drivers of a builders' rubble economy

There are currently few externally imposed drivers, such as policy and legislation dictating diversion from landfill, or industry body oversight governing the handling, treatment and disposal of builders' rubble. Current drivers of the economy, include

- Rising virgin material prices;
- Regulation of waste flows
- Cost of transporting the waste; and
- Limited landfill airspace – which must lead to increasing disposal costs.

2.4.1 Rising virgin material prices

Increasing virgin material prices can be mainly attributed to increasing energy costs. Quarries are generally highly mechanised with energy costs being the main operating expenditure. Quarries are also situated at some distance from points of sale, meaning transport costs are high. A survey of 120 key stakeholders in the construction industry was conducted in the Western Cape in 2013 to understand the main challenges facing the construction industry. Rising costs of virgin materials was the most cited primary factor limiting growth in the industry (Windapo & Cattell 2013).

For many construction materials in the region of Cape Town, including stone aggregate, clays and silica sand, there are decades of supply available (Cole 2011). However the supply of building sand and gravel (ferricrete) is limited, with legal mining sites expected to be depleted in about 15 years (Cole 2011).

The legislative process for siting and operating mines, quarries and borrow pits has been streamlined with the promulgation of the National Environmental Management Laws Amendment Act (NEMLAA, No 25 of 2014), that came into effect from 8 December 2014. Approval for borrow pits for road construction may be achieved in the region of 9 months, with basic assessments costing in the region of R70 000 – R150 000. However, for material from borrow pits requiring crushing or screening, a full environmental impact assessment (EIA) is triggered in terms of The National Environmental Management Act (NEMA), which may take up to 1.5 years and cost in the region of R450 000. These environmental assessments and approvals through the Mineral and Petroleum Resources Development Act (MPRDA) are required of both the public and private sectors, for each borrow pit site established.

2.4.2 Regulation of waste flows

The regulation of waste flows at the national to the provincial and local levels has been strengthened by the promulgation of National Environmental Management: Waste Act (no. 59 of 2008) (NEMWA), with associated provincial regulations and local by-laws passed subsequently. Landfill diversion is a key requirement at all levels, with provisions made for incentives and disincentives to achieve landfill diversion goals. With the promulgation of the NEMWA[5]: National Norms and Standards for Disposal of Waste to Landfill (2013), the requirements for lining and monitoring of landfills have been intensified. Consequently landfill construction and therefore operating costs could increase by up to 50%[6] for general waste, which includes mixed builders' rubble (Godfrey 2014).

2.4.3 Transport and logistics costs

Increasing fuel costs further increase virgin material costs as well as waste disposal costs. This places pressure on construction companies to source construction materials more locally and to reduce or eliminate transport to landfill, ultimately supporting a secondary materials economy.

[5] National Environmental Management Waste Act

[6] Some estimate this as closer to 100% (Eddie Hanekom 2015, pers.comm, 7 December)

2.4.4 Limited landfill airspace

A further factor dictating the increase of landfill fees is the limited landfill volume ('airspace') available in many areas of the Western Cape, as well as nationally.

- Within the CCT, landfills will be at capacity by 2027 or earlier if the proposed new regional landfill continues to be contested.
- The only landfill currently operating in Stellenbosch Municipality has less than 3 years of operating life,
- while the rest of the Cape Winelands District Municipality and Eden District Municipality also have limited landfill capacity (most of the municipalities in the Western Cape have 1-10 years of airspace remaining).

Not only will landfill airspace become more valuable for existing landfills, new landfills are expected to be further away from populated areas and disposal will therefore be more costly due to increased cost of transport/logistics

3. OPPORTUNITIES IN A SECONDARY MATERIALS ECONOMY

3.1 Advantages in the use of secondary vs virgin materials

Opportunities related to a secondary materials economy, as opposed to one founded on virgin materials, are that secondary materials may be generated locally, as well as processed and reused locally. In theory, this should result in lower costs associated with the use of secondary materials due to reduced logistics costs (Figure 4).

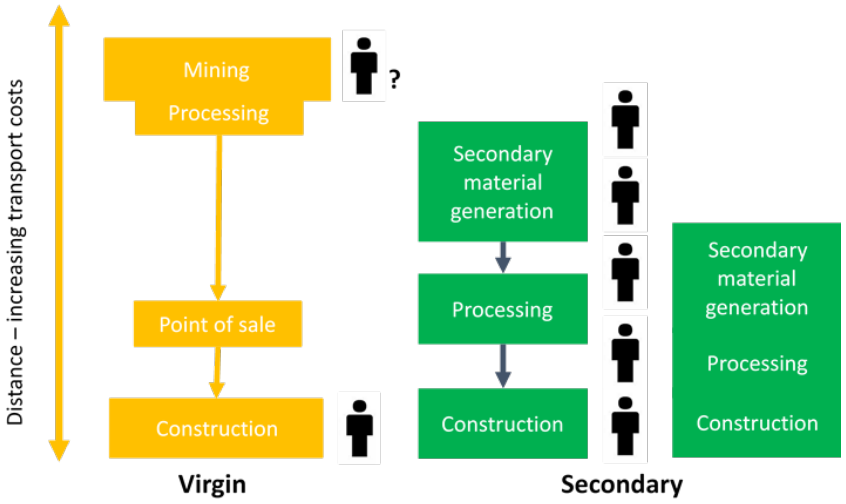


Figure 4 Advantages of a secondary materials value chain, as compared to a virgin material value chain

Furthermore, it is possible to collapse the supply chain geographically to a single site (as illustrated in Figure 4) where demolition or excavation produces material that is processed on-site, and re-used as fill or for construction of buildings, parking lots or roads on the site.

3.2 Benefits of a secondary materials economy

3.2.1 Benefits – job creation

The National Development Plan (NDP) and the 2014/15-2016/17 Industrial Policy Action Plan (IPAP) of the department of trade and industry (dti) both emphasise the need for job creation, with the IPAP highlighting plans to develop income opportunities within South Africa's green economy.
As presented in Figure 4, information collected in the City of Cape Town suggests that for every 1 job in the 'traditional' construction industry where construction and demolition wastes are transported directly to landfill, there are 5 or more jobs in construction and demolition where secondary materials are channelled back into the economy.

Job creation in the City of Cape Town crushing industry is on average 9.7 jobs per 1000 m^3 processed. However there was a large range reported, with 1.2 jobs at the lower end up to 30 jobs per 1000 m^3 processed. The higher job numbers are correlated with the production of higher quality products. Therefore, stimulating the market towards the higher quality applications in foundations and sub-base in roads, will create more income opportunities.

3.2.2 Benefits – municipalities

The diversion of builders' rubble from landfill will save operating costs, and constitute in effect an extra revenue stream for the City of Cape Town as clean builders' rubble is landfilled for free. If 60% of the current volume of builders' rubble entering landfill sites in the City were diverted, with an estimated cost of R400 per ton of waste handled at landfill, the annual cost savings would be R224 million. This figure is equivalent to 95% of the capex budget for the City's 2016/17 budget.

It is important to note that the clean-up costs per ton of illegally dumped material are five times that of refuse removal for the City of Cape Town, a significant cost to CCT at R350 million per year spent on urban cleansing of litter and illegal dumping. The absorption of this material into the formal economy will be of great benefit to municipalities and residents, with further funds available for other municipal projects.

Data from the City of Cape Town documenting the spatial distribution and volumes of illegally dumped materials indicates that illegal dumping largely mimics the infrastructure gaps in the City, i.e. where there are no landfills or crushing operations (Edmund Abrahams, pers.comm. 2016). Therefore, it is expected that development of infrastructure in these areas would capture the majority of the material dumped.

3.3 Largest end use opportunity – road construction

South Africa's market for processed builders' rubble is currently underdeveloped, with large amounts of rubble ending up in landfill. There is therefore large potential for industry growth regarding crushing and processing of recovered builders' rubble. Furthermore, stakeholders in the Western Cape suggest that current demand is greater than supply.

A few big construction companies are including secondary aggregates in road construction and rehabilitation as far as possible. Once the policy and specifications for road building aggregate are inclusive of secondary materials, these companies are planning to include secondary materials in all CCT contracts.

3.4 Opportunities for the crushing industry at landfills

Landfill sites have proved highly successful in the processing of secondary materials internationally. Builders' rubble routinely enters the site, and companies disposing of waste would generally be the end users of secondary material products. In spite of the zero cost at landfill for clean builders' rubble in the CCT, the value of the diminishing landfill airspace is expected to more than offset any processing costs.

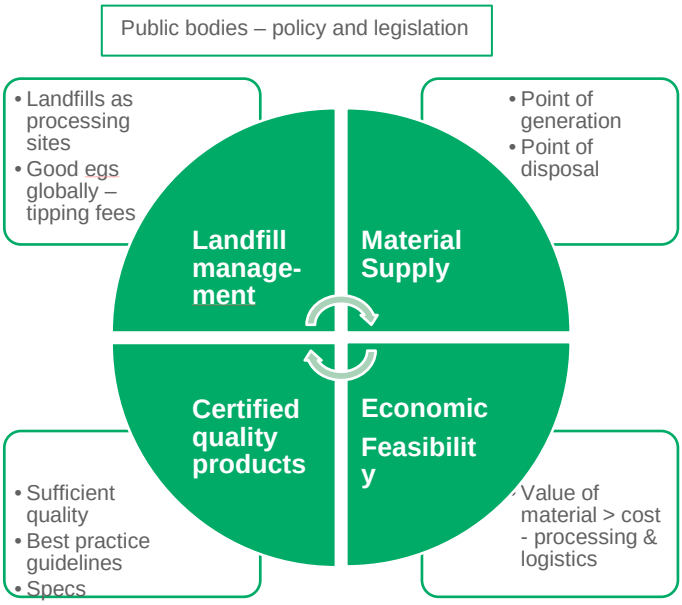
The CCT conducted an assessment of the value of landfill airspace in their region for 2012/13 financial year, aiming at a full cost-recovery figure across municipal waste management services, as mandated by the Municipal Finance Management Act (MFMA) and the Municipal Systems Act (MSA). The Cape Town study returned a figure of R350/ton for general waste[7]. The processing of 1 ton of builders' rubble at landfill – excluding capital costs of the equipment – is in the region of R50-65 per ton.

Therefore there is still sufficient saving for a municipality, that a contractor may take ownership of the material processed and still run a profitable operation on a landfill.
Both the CCT and Stellenbosch Municipalities are preparing tenders for crushing of builders' rubble at landfill sites.

[7] 2015/2016 landfill tariff for general waste in the CCT has been set at R395 per ton

4. ENABLERS OF A SECONDARY MATERIALS ECONOMY

Elements required for a well-functioning secondary materials economy from builders' rubble are material supply, economic feasibility, the availability of and demand for certified quality products, and landfill management that supports a secondary materials economy (Figure 5). Further components are policy and legislation that guide and incentivise the diversion of waste from landfill.



In the City of Cape Town, there is sufficient material supply for current crushing capacity, with demand for secondary materials outstripping supply, satisfying segment 1 of Figure 5. With growing crushing companies operating solely on builders' rubble, the business case is for the secondary materials market is explicitly illustrated, and therefore segment 2 of Figure 5 is also somewhat addressed.

The three main areas requiring intervention are in terms of quality products, landfill management that supports the secondary materials economy (such as crushing tenders at landfill mentioned above in section 3.4), and in strengthening policy and legislation to prevent builders' rubble from ending up in landfill.

Figure 5 Enablers of a secondary materials economy

4.1 Primary enabler of secondary materials economy – certified quality products

Material quality and consistency is the most cited barrier by the public sector to development of the market for processed builders' rubble. The public sector is the largest potential end user of processed builders' rubble.

4.1.1 Separation at source

The main determinant of secondary material quality is effective separation at source to maintain the material at its highest possible value. Current benefits for separation at source are recognised through the Green Building rating of the Green Building Council of South Africa (GBCSA), where diversion of waste from landfill and the use of recycled content in building and interior materials contributes to an overall green building score. The newly constituted Green Roads SA will be developing rating and certification systems for roads, which will be a further incentive for industry to separate effectively at source.

Separation at source includes the effective segregation of wastes on construction sites, with deconstruction or stripping of useful materials before demolition on demolition contracts. Current barriers to preserving the quality of streams in this way are the time and space constraints on construction and demolition sites, with penalties built into contracts for delayed delivery and workers incentivised per unit of work done – with correct waste handling often not specified as part of this.

Regarding demolition sites, an important aspect supporting good segregation of waste at source is the design and construction of the original building/infrastructure. Ideally, the design phase should include 'end of life' of the building with materials and construction techniques suitable for deconstruction and therefore, easier waste separation.

On construction sites, the design of the building/infrastructure and materials used in the construction may likewise allow for good waste separation and reuse or recycling of the wastes generated.

Current construction approaches are a legacy to future generations. With increasing difficulty in siting landfills, and escalating disposal costs, it is wise to consider current construction in the light of future materials handling.

4.1.2 Matching quality and application

An important consideration of material quality is also matching the material with the application. The aim of secondary material recovery from C&DW is not to produce the highest quality material from all inputs. In separation at source and the processing of materials thereafter, the aim would be to preserve the highest value possible with a processing approach that is economically viable for the value of the material recovered.

The matching of quality and application is presented schematically in Figure 6 below, with the particle size represented on the x axis and material grading used in categorising aggregates for road construction on the y axis.

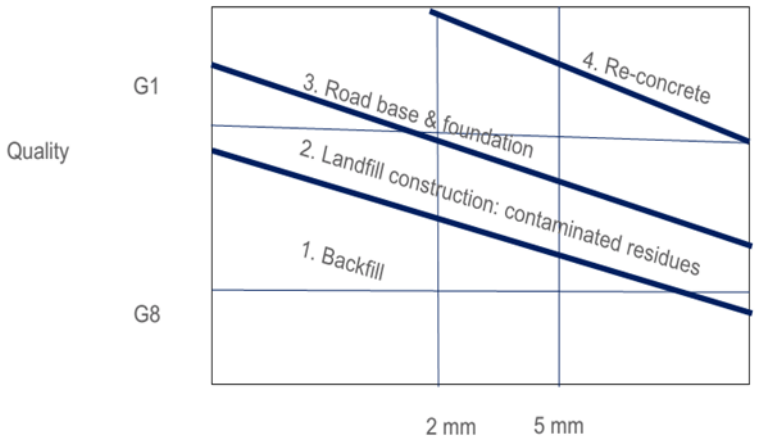


Figure 6 Matching secondary material quality to application

Source: R. Leeftink (2015) Decistor.

Highly mixed streams with acceptable levels of contamination may be useful in fill applications (material 1 in Figure 6), while contaminated fines sieved off from material streams would find a good application in landfill cover and slope stabilisation as landfills are designed to handle contamination (material 2). The use of clean clays for landfill cover and slope stabilisation, as is common practice today, is not a reasonable application for this relatively high value material. This is a real opportunity for utilising secondary materials and preserving of high quality materials for other uses.

The highest value application for builders' rubble is clean concrete crushed for inclusion in cement, readymix or precast concrete production (material 4). This application retains the highest material value. However, in terms of volumes, the size of the opportunity is orders of magnitude smaller than the opportunity in roads (material 3).

4.1.3 Quality control – process and materials

The public sector is the biggest potential end user in the economy due to its role in road construction and rehabilitation. This sector is subject to strict procurement regulations at both national and local levels. Quality control and verification of processes and products is vital to unlock the opportunity of public sector demand.

Many private sector players are producing material of sufficient quality and consistency to satisfy their own needs (construction and demolition companies) and/or the needs of a regular client base. However, some material suppliers do not have quality control measures and material testing to verify quality in place. This has resulted in the failure to move material at certain sites, as well as road failures in CCT projects (pers. comm.

Ian MacDonald, CCT Roads, 2016). It is in the best interest of the private sector to build the confidence of end users of material. Quality control and materials testing are central to this.

The screening and crushing of material is another critical step ensuring high quality products. A portion of the crushing and construction industry follow quality control measures at their plants, include diverting highly contaminated material from their site, screening and removing contamination by hand, blowing off lines between mixed aggregate and masonry processing and the processing of clean concrete, segregating product streams by type and quality, as well as ongoing stockpile management and testing. This is however not widespread.

The processing of builders' rubble in terms of quality is unregulated in South Africa, with focus of quality management systems being on virgin material production for construction. In terms of testing of material suitability for use, the COLTO standard specifications applied to aggregates in South African roads specifically stipulates natural materials, and is therefore exclusive of secondary materials (COLTO 1998). The standards are currently under review, and are expected to include a section on sustainability in roads, and therefore the use of secondary materials.

5. THE WAY FORWARD

To support the growth of the secondary materials market both public and private sector involvement is needed. Strengthening of procurement policies and municipal by-laws to support a secondary materials market would be an important step. To stimulate uptake of secondary materials, two fundamental leverage points are best practice guidelines for the crushing industry and the material standards for road building aggregates that are inclusive of secondary materials. These interventions will improve the confidence of the end users in the products, and as experience has shown, will have a positive feedback for effective segregation of 'waste' materials at the point of generation.

In order to take advantage of opportunities within this economy, there are a few points of improvement needed at each segment of the value chain, within both the public and private sectors. Figure 7 presents an overview of the main areas for development.

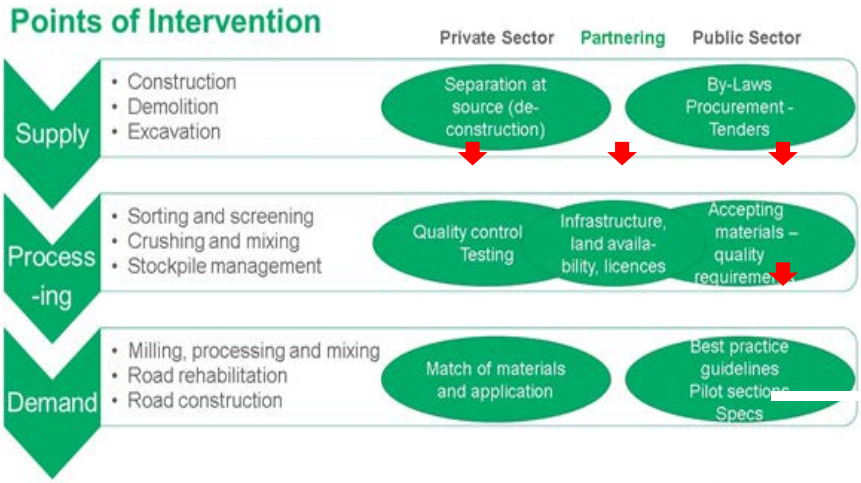


Figure 7 Primary points of intervention along the builders' rubble value chain for the public and private sectors

Within the public sector in addressing the supply of builders' rubble to the market, DEA&DP is developing a model by-law for application province-wide at the discretion of municipalities. The model by-law includes a requirement for Integrated Waste Management Plans (IWMPs) and requires waste minimisation for all construction and demolition activities.

CCT plans to strengthen the requirements for waste diversion from landfill through the application requirements for construction and demolition activities. This will include supplying a database of contacts for alternatives to landfill disposal. Reporting on IWMPs attached to each application is to be addressed, such that site sign off will be dependent on compliance to IWMP goals, as well as reporting on all waste streams.

Best practice guidelines for the secondary material industry in builders' rubble are especially needed to stimulate demand for processed builders' rubble within the public sector. These guidelines are needed for both the processing and application segments of the value chain. Private and public sector stakeholders will be engaged through GreenCape and national industry bodies in 2016 towards the development of such guidelines.

In the long term, consistent demand for processed builders' rubble is dependent on the development of material specifications that are inclusive of secondary materials for roads. At a recent Road Pavement Forum, a resolution was voted for to constitute a working group to develop guidelines for the inclusion of secondary materials in roads. This process will build on current research into secondary material performance in South Africa as informed by international experience. Consensus in the road industry is that for application in the most critical roads in terms of traffic volumes and loading, further performance tests are required to consider long term performance in the South Africa context. This will hopefully feed into Committee of Transport Officials (COTO[8]) standards process currently underway. This process is expected to take at least 5 years.

ACKNOWLEDGEMENTS

The kind assistance and expert input of the following experts is acknowledged with gratitude:

- Chantal Rudman and Prof Kim Jenkins of the Department of Civil Engineering, University of Stellenbosch,
- Herman Huisman, Senior Advisor International Cooperation, Rijkswaterstaat Water, Transport and Environment, a nationwide service of the Department of Public Works, and Robert Leeftink, Owner/Director, Decistor (enabled through the Agentschap NL and the Dutch Ministry of Infrastructure and the Environment), and
- Prof Martin van De Ven of the Technical University of Delft, the Netherlands

Funding for this work, which is part of the GreenCape Waste Economy project, is provided through the Department of Economic Development and Tourism (DED&T) as part of the Western Cape Government's transversal Green Economy initiative.

REFERENCES

Coetzee, B. 2006. City of Cape Town Integrated Waste Management Policy.

Cole, D.I. 2011. Report on economically-viable mineral resources in the City of Cape Town's Administrative Area. Council for Geoscience; City of Cape Town Environmental Resource Management Department.

COLTO 1998. Standard Specifications for Road and Bridge Works for State Road Authorities. Committee for Land and Transport Officials. Pretoria.

Godfrey, L. to Burger, S. 2014. South Africa begins waking up to the economic potential of waste recycling. *Engineering News*, 14 November.

Horvath, A. 2004. A life-cycle analysis model and decision-support tool for selecting recycled versus virgin materials for highway applications. Final Report for RMRC Research Project No. 23.

Windapo, A. O. & Cattell, K. 2013. The South African construction industry: Perceptions of key challenges facing its performance, development and growth. *Journal of Construction in Developing Countries*, 18 (2), pp. 65-79.

[8] Was COLTO