THE RECYCLING OF CONSTRUCTION & DEMOLITION WASTE TO RECLAIM BORROW PITS IN TOWNSHIPS

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SUMMARY:

In developing countries, such as Botswana, during the construction of urban areas gravel was taken from sources on the fringes of the areas. With continued urban sprawl these borrow pits have now become incorporated into these townships. They were rarely rehabilitated and are now targets for uncontrolled dumping of C&DW waste and have become sterile areas. This paper reviews the potential of rehabilitating these sites by reclaiming C&DW.

INTRODUCTION

The original motivation for this concept arose from an article written in a waste management magazine by D. Macozoma who was at that time working for the C.S.I.R.. At the time the author was working on a road project in Gaborone which passed through an area that had been extensively worked for gravel early in the city's history and also contained a small quarry. This area, whilst in the city limits, had been effectively sterilised by these workings and illegal dumping of rubble in terms of any further use and thus the concept for a joint recycling and reclamation project was conceived.

The Botswana construction industry generates a significant amount of construction and demolition waste (C&DW) commonly known as rubble of which very little is disposed in a friendly, environmental manner. The rubble is mainly comprised of broken bricks, top or fresh soil dug for a building foundation, concrete from the demolition process, metal, plastic and other debris from construction process such as left over cement, broken glass, wood and packaging material. This kind of waste has becoming a problem especially in Gaborone and its surrounding areas. Significant cases of illegal dumping are often noted in open spaces, parkways and outskirts of the city, backyards, and other unsuitable areas. This not only leads to environmental degradation but leads to an unsightly view of the city.

Most if not all construction industries in Gaborone use materials from natural sources that have left significant numbers of borrow pits within the city's vicinity. As the city has expanded borrow sites which were previously peripheral to the city have now become incorporated in the city limits and effectively sterilised valuable building or recreational land. These borrow pits then become target for illegal uncontrolled dumping as perpetrators try to avoid transport and disposal costs of managing the C&D waste.

Currently there is no attempt to recycle the construction and demolition waste at any level of application like backfilling, site levelling, and as secondary application for road or building constructions. The recycling of C & D waste will offer the opportunity to rehabilitate old borrow pits. The infilling of the pits with controlled recycled waste as opposed to unsorted, uncompacted waste would mean a more pleasing environment and would enable a quicker and more effective vegetation regeneration thereby maintaining habitats and biodiversity.

This paper examines the concept of replacing these practices by rigorous recycling schemes based at an old borrow pit with a view to encouraging disposal of C&D Waste at this site,

recycling the material on sustainability principals and rehabilitate the site in the process. In addition the process would eliminate the need to fill up landfill sites with materials that could otherwise be recycled but thus conserve them and extend their working lives.

OBJECTIVES OF THE STUDY

On the basis of the above a study was undertaken with the following objectives:

- To determine how much Construction and Demolition waste is being produced in Gaborone, its main sources and current method of disposal.
- To determine the extent (number), size and location of old borrow pits in the immediate vicinity of the city and their status.
- To liaise with interested parties such as Department of Mines, City Council, Town and Regional Planning, Land Boards in Tribal Land areas and engineering companies to determine the level of support for the project.
- To determine the effectiveness of using an abandoned Borrow Pit as a plant and storage area. In particular determine the optimum location/s to ensure that transport costs would be lower than the distance to the landfill sites or dumping areas with the long-term view of restoring the site and making it suitable for development.
- To review the type of plant available regionally for this project.
- To review the balance between amount of material received, amount of material converted to secondary products, and non-recoverable material sent to spoil to determine the economic feasibility of the project.
- To determine the costs of recycling C & D waste.
- To learn from other countries more experienced in this process the lessons of recycling in order to benefit from them.

DATABASE

As indicated above the original motivation for this concept arose from an article written in a waste management magazine by D. Macozoma who was at that time working for the C.S.I.R.. He kindly supplied the author with further background literature, Macozoma, (1999, 2000 and 2001) and ICRIBC/CSIR; (2001) on the concept. Further information was obtained from Government guidelines and Acts, (1997, 1998, 1998 and 1999). However the most informative article was a previous study by Geoflux (1994) commissioned by the Department of Town and Regional Planning studied the extent of extraction of sand and gravel, borrow pits and illegal dumping in the Gaborone area and this formed the basis of the initial work. This was supplemented by examination of maps of the city and to lesser extent aerial photographs.

In addition to literature search we visited the Gaborone City Council Engineer and offices associated with the solid waste management and disposal to obtain current and historical data on the estimated volume passing on to the solid waste dump.

CURRENT AND HISTORICAL EXTENT OF C&D WASTE PRODUCTION AND DUMPING

The main sources of construction and demolition waste are the building construction companies. The larger companies normally dispose of their rubble (no recycling) at the landfill site for which they are charged. The smaller companies dispose of the rubble in abandoned borrow pits, backyards and fly tipping. It was also found that the rubble is disposed at the nearest place possible to avoid any transport costs.

The Department of Waste Management (DWM) indicated that there are difficulties relating to the estimation of quantities of C&D waste. Poor record keeping, mixed waste and sometimes weighing facilities that are not working makes it difficult to have at least a rough estimate of such data. The Department also confirmed that C&D waste is one of the most problematic materials to dispose of in that it is produced at a large scale and is responsible for filling up the landfills at an unacceptable rate with non-biodegradable waste. Currently no recycling of the rubble is taking place and heaps of rubble, illegally dumped, are often found behind yards and those produced at large scale are dumped into borrow pits.

We obtained some historical data on the disposal of inert material at Gaborone Landfill Site from the now defunct National Conservation Strategy Agency is given below in Table 1.

Table 1

Year	1998	1999	2000	2001	Total	%
Inert Material	141,288	121,828	190,364	114,457	453,480	70.95

Figures are in tonnes.

We have been unable to obtain any recent information but a figure of 120000 tonnes p.a. would be a reasonable estimate.

The Gaborone City Council also has no data specifically for C&D waste and currently they allow free disposal of C&D waste at the landfill to reduce the illegal dumping from companies wanting to avoid payments. The Contractors also do not practice waste management and minimization on site and all generated waste is stockpiled unsorted and transported to the landfill site or dumped illegally. The concept of controlling waste at site is seen to be too expensive to implement.

The Geoflux study (op.cit.) confirms that dumping (and borrowing) in the Gaborone area is not a recent phenomena and that it is an extensive and significant problem. In the former case the dumping ranges from very small volumes to over (estimated) 500,000m^3.

We used their database, which included locations, as the basis for targeting the larger dumps and borrow pits for field visits. The smaller dumps which range from 1-5 to 1000m^3, whilst still being unsightly it would not be economically feasible to recycle such small quantities of material.

The Geoflux report also highlighted the problem arising from the fact that byelaw officers have no power to prosecute and can only report to the police and fines are not high enough to deter dumping. Since the 1990's the regulations and enforcement have been tightened up considerably and there is better supervision of restoration of borrow sites. However control of illegal dumping still seems to be a problem.

A summary of the locations, which we initially considered as having the best potential and our findings, is given in Table 2 overleaf.

TABLE 2

Locality	Geoflux Ref. No	Est. Vol. (m^3)	Original Description	Original Remarks *Analytika Remarks*	Lat./Long
Tlokweng	Bg 109	750 000	An active gravel pit currently being exploited	*Old borrow pit approximately 1km from housing with no sign of recent exploitation. There is no attempt to rehabilitate.*	24 41 59.9/ 25 58 05.5
Tlokweng	Bg 112	None	A major gravel exploitation behind Morning Star Hotel	*Area appears to have been reclaimed and now being developed*	24 40 34/ 25 58 51
Gaborone	None	225 000	None	*A borrow pit acting as a dumpsite at the School of Arts proposed site next to the landfill. A geotechnical investigation done at the site showed unconsolidated C&D waste going down to >5m.*	24 41 09.5/ 25 55 34.5
Mogoditshane	Drib 48 (?)	262 500	Waste material include; bricks, drainage pipes, wires, electrical cables, roof tiles	*An old borrow pit that acts as dumpsite for C&D waste. No obvious Domestic waste*	24 39 03.0/ 25 50 37.0
Gabane	Bg1	50 000	Site is now abandoned. It was used during the construction of the Gaborone Kanye road.	*Site is too far from the city*	24 38 44/ 25 47 40
Mogoditshane	Bs9	100 000	Waste material is also dumped in the site. The waste material includes construction waste and weeds from backyards..	*Site is too far from the city*	24 36 12/ 25 50 13
Gaborone Ext 46	BS 168	437 500	Obscured from road by mounds on the edges and within the industrial area.	*Old borrow pit in the Broadhurst industrial, which is being filled by uncontrolled dumping. 5m deep*	24 37 12.7/ 25 55 04.1
Gaborone	None	44 000	None	An old borrow pit filled by uncontrolled dumping.	24 39 26.8/ 25 51 11.4
Mogoditshane	Bs10	300 000	Waste material includes construction waste and car scraps.	*Site is too far from the city.*	24 36 12/ 25 50 13
Mogoditshane	Bg14	60 000	The site is currently being refilled with material from the quarry.	*Site is too far from the city*.	24 35 56/ 25 50 17
Mogoditshane	Bg 17	50 000	The site dams water and is also used for dumping construction waste and electrical cables.	*Site is too small and too close to residential areas.*	24 36 32/ 25 50 55
Metsimotlhaba	Bg31	200 000	The site is on the outskirts of the village.	*Site is too far from the city*.	24 34 10/ 25 49 00
Broadhurst	Bg70	750 000	Operating	*Site reclaimed as sewage*	24 37 32/

Locality	Geoflux Ref. No	Est. Vol. (m^3)	Original Description	Original Remarks *Analytika Remarks*	Lat./Long
				ponds	25 57 37
Tlokweng	Bg 122	480 000	Abandoned site, probably used during road construction	*Site is too far from the city*.	24 40 16/ 26 01 21
Tlokweng	Bg 123	240 000	Abandoned site, probably used during road construction	*Site is too far from the city*.	24 41 41/ 26 04 45
Tlokweng near border post	Bs 123	Not applicable	No evidence of recent exploitation some vegetation developing..	Site is too far from the city.	24 41 41/ 26 04 45
Mogoditshane	Bs39	Not applicable	Waste material is also dumped in the site. The waste material includes construction waste and household waste..	Site is too far from the city.	24 41 41/ 26 04 45
Gaborone (Broadhurst) Ext 26	Bg 70	Not applicable	The site is on the outskirts of the city near the broadhurst cemetery.	The site couldn't be located.	24 37 32/ 25 57 37
Mogoditshane along Gabane Road	Drib 91	Not applicable	Construction waste forms 90% of the material. The rest is scrap material and household refuse..	Site is too far	24 39 58/ 25 46 55
Tlokweng near border post	Bg 123	Not applicable	No evidence of recent exploitation some vegetation developing..	Site is too far from the city.	24 41 41/ 26 04 45
Tlokweng	Bg 122	Not applicable	Abandoned site, probably used during road construction	Site is too far from the city.	24 40 16/ 26 01 21

Examples of borrow pit and dumping sites around Gaborone are illustrated below in Plates 1-3.

Plate 1
Borrow Pit in Gaborone West Industrial area. Approximately 5m deep. Uncontrolled and uncompacted dumping of mixed material

Plate 2
Illegal dumping of blasted rock and soil covering an area of approximately 500x150m.

Plate 3
Old borrow pit filled with a high percentage of C & D Waste. Area approximately 300x200m

OPERATING PRACTICES IN FIRST WORLD COUNTRIES

Within the European Union recycling of C&D Waste is seen as an essential part of reducing the amount of rubble that goes to the landfill. The recycling of C&D Waste increases the lifespan of landfills and at the same time provide cheap quality secondary construction materials.

Plants are usually set up at the demolition site and as the building is demolished waste is sort by type prior to crushing and screening on site. The processed material is then used on site as backfill or fill with minimal transport charges.

As part of this study we made a visit to UK to locate operators of C&DW plant and sites. We located an operator, Elvanite in Colchester, Essex whose scale of operation was, we believe, in the same order as we would anticipate the Gaborone. The owner-operator, Mr. Bailey, was extremely helpful and spent sometime discussion the logistics of an operating plant and we were able to visit his yard and two operating sites. Examples of plant and site practices are illustrated below in Plates 4-7.

Plate 4
Example of stock pile of selected material at Elvanite yard.

Plate 5
Stockpile of crushed material

Plate 6
Mobile crusher used by Elvanite

Plate 7
Screening plant on site

ECONOMIC ASSESSMENT OF THE PROPOSED RECYCLING PLANT

Raw material

In Botswana, unlike sites in UK the raw material is mixed and "contaminated" by unsuitable material e.g. plastic and will have to undergo sorting prior to processing. Material from new sites may be easier to control but a substantial amount of "producer" education will be required.

It is essential (from our discussions in UK and Botswana) that the raw material be acquired without charge to us. If charges are restored at the landfill site then this will encourage contractor to bring it to the recycling plant. More stringent and enforceable regulations and fines would also discourage illegal dumping.

The existing Landfill accepts something in the order of 120,000tpa of inert material. On the basis of the through put indicated above our production requirements would be in the order of 80,000tpa which could be easily met from existing material going to the Landfill let alone the volume that is being illegally dumped. However it must be recognized that it will not be possible to recycle all material, as some will be oversize and certain percentage unsuitable.

There are illegal dumps of material estimated at 500,000m^3 so by siting the plant at one of these dumps would ensure that we have a minimum of five years of resources plus the year on year production of new material.

Plant and Equipment

We have sourced what we believe is suitable processing plant that is custom designed for this process. The supplier, Pilot Crushtec, being based in South Africa is ideally situated to provide to supply product support and maintenance.

Other equipment, such as a front-end loader, and screen are standard items of equipment and can be purchased "of the shelf". Infrastructure items such as offices and grizzlies (coarse screens) are budgeted for.

In Economics of Recycling Construction Waste, (CSIR/RSA; 2000) it is indicated that an area of approximately 0.8Ha is required for a stand-alone site. The area of the recycling operation is governed by the need to have enough stockpile for it to operate effectively. There should also be enough space to allow pre-sorting of mixed waste as well as to manoeuvre between the various stages of the production process. Wastes that are not needed will then be used to backfill the site area and potentially other borrow pits within the city in a controlled manner that will reclaim the land for either agricultural, recreational or development use.

Labour Utilisation

Staffing is based on the following: Manager/Foreman/Two operators/Accounts Clerk/unskilled labour. In the latter case we would propose using an all female staff for sorting of recyclable and unacceptable waste out of the raw mix.

Production Costs

Our estimates of running costs are tabulated below in Table 3.

Table 3

Preliminary Cost Estimates for a Construction and Demolition Waste Recycling Plant

		Year 1	Year 2	Year 3	Year 4	Year 5
Capital Costs	**ZAR Cost**	**BWP**	**BWP**	**BWP**	**BWP**	**BWP**
Mobile Crusher	800,000	707,965				
Transport Charges	40,000	35,398				
VAT on import		74,336				
LHD Plant (e.g. Cat 360)		780,000				
Grizzly Plant		350,000				
Infrastructure		400,000				
Contingencies 10%		234,770				
		2,582,469				
Interest Charges over 5 year period		464,844				
Total		**3,047,313**				
Estimated monthly finance charges		**50,789**	**50,789**	**50,789**	**50,789**	**50,789**
Monthly Running Costs		**BWP**	**BWP**	**BWP**	**BWP**	**BWP**
Manager (part time)		15,000	16800	18816	21074	23603
Foreman		10,000	11200	12544	14049	15735
Operators (2)		14,000	15680	17562	19669	22029
Accounts Clerk/Secretary		3,500	3920	4390	4917	5507
Unskilled Labour for sorting		11,000	12320	13798	15454	17309
Fuel and consumables		29,400	32928	36879	41305	46261
Maintenance		35,000	39200	45080	54096	64915

Preliminary Cost Estimates for a Construction and Demolition Waste Recycling Plant

		Year 1	Year 2	Year 3	Year 4	Year 5
Capital Costs	**ZAR Cost**	**BWP**	**BWP**	**BWP**	**BWP**	**BWP**
Insurance		2,000	2240	2509	2810	3147
Laboratory Testing		3,000	3360	3763	4215	4721
Contingencies 10%		12,290	13764.8	15417	17267	19339
		135,190	**151,413**	**170,758**	**194,856**	**222,566**
Total Monthly Running Costs		**185,979**	**202,201**	**221,547**	**245,644**	**273,355**
Annual Production Estimates						
Current Cost per m^3		**BWP**	**BWP**	**BWP**	**BWP**	**BWP**
G6 Gravel at Pula 70/m3		70	78	88	98	110
Est. production m^3						
Based on 30tph ($42m^3$), 8 hour day,	**82,320**	**5,762,400**				
5 day week, 49 week year						
(Rubblebuster capacity is 50tph max.)						
Average Monthly Income		**480,200**	**537,824**	**602,363**	**674,646**	**755,604**

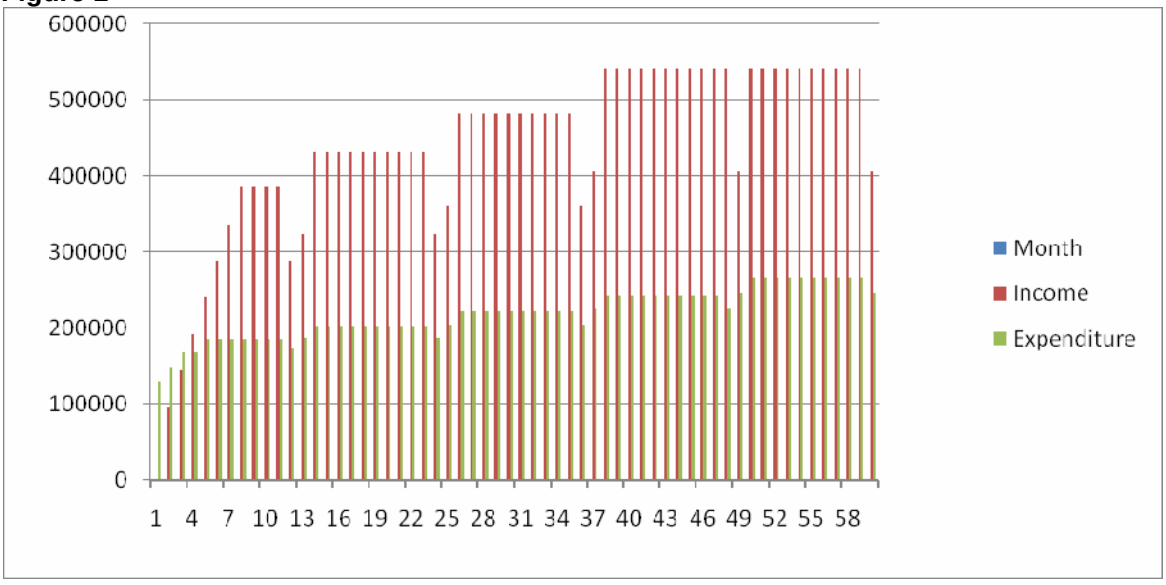
We have built inflationary costs of 12% with repairs increasing year on year from 12-15-18-20% to take into account the aging of the equipment. The main item is fuel with water and electricity. We have made a provision for 10% contingencies to cover unforeseen costs.

Based on our preliminary estimates we have calculated that capital costs and interest would be P51,000pm and production costs for year one being P135,000pm.

Sales

The Rubblebuster has a capacity of between 10-50tonnes per hour (tph) depending on the coarseness of its feed. We based our production on an average of 30tph ($54m^3$) over a 40-hour week for a 49-week year. During the first year we discounted this figure considerably to allow for delays in start up, training, teething troubles etc. Only in year two do have allowed for production to reach this level. Current price is approximately P70/m^3 and will continue to rise as pressure on resources grows. Figure 1 below indicates our cash flow estimates based on the premises given above.

Figure 1



Market

There are no figures for consumption of fill material but we are advised it is probably in the order of 150-200,000m^3 per annum in the Gaborone area and becoming increasingly scarce. This would be substantiated by the fact that prices have gone up by over 50% in the period since August 2006 and the time of compiling this paper.

CONCLUSIONS AND THE WAY FORWARD

- Recycled materials are less costly and more readily available than primary materials and play a competitive role in keeping the price of those primary materials within manageable limits.
- Naturally are increasingly in short supply and as a consequence subject to significant price pressure having recently risen by some 50% in six months.
- Separation of the material at source will make the process of recycling much easier and the waste will be processed to a known quality that could prove easier to deal with than the natural unpredictable materials.
- Construction industries will also be made aware of the ongoing research for the use of secondary materials and the benefits of using such material.
- Contractors do not see any problem with the use of recycled material as long as it reaches the level of compaction required and specified by the Engineer.
- The successful completion of the recycle plant will fulfill a demand for building materials that are increasingly in short supply.
- The plant will contribute in helping to restore previous environmental damaged areas to usable conditions.
- It will also provide employment at the site and recycle material previously sent to waste.

The positive response from interested parties, particularly Government Departments encourages us to take this study a step further. We have received several expressions of interested from potential technical partners to assess the conditions, equipment and market in Botswana. In addition CDE and their associated institution ESIPP have indicated their willingness to continue funding additional studies to fill this role.

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