THE FEASIBILITY AND PRACTICALITIES OF RECYCLING GYPSUM
PLASTERBOARD WASTE IN NEW ZEALAND

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Introduction:
In New Zealand, Winstone Wallboards Limited (WWB) is the sole board manufacturer and operates production facilities in both Auckland and Christchurch. For some time, WWB has been investigating the possibility of recycling waste plasterboard product into a new wallboard material. They therefore initiated this research into wallboard recycling.

Given the nature of the formation process of the gypsum mineral, deposits are fairly widely spread around the globe. Over the last century, the production and utilisation of this mineral has grown considerably to meet the demands, primarily of the building industry for plasterboard (Groves, 1958). Global production of gypsum is in excess of 107 million tonnes per annum in over 90 countries (Olsen, 1999) while estimated gypsum reserves exceed 10,000 million tonnes (EMY, 1998). Additionally, gypsum derived from chemical processes is increasingly becoming available, generating a greater volume of gypsum than is presently consumed. This plentiful supply of gypsum and seemingly guaranteed future availability does not suggest that gypsum is a material in need of conservation and recycling.

Nevertheless, there are several associated factors that contribute to a desire to recycle gypsum in New Zealand. Firstly, New Zealand has no commercially exploited gypsum reserves of its own and imports in excess of 316,000 tonnes per annum, primarily from Australia. While these imports represent an estimated monetary value of over NZ$14.5 million, in fact the value for duty for the imports (ie. excluding freight and insurance costs) is less than NZ$6 million (Statistics New Zealand, 1998). The potential savings from obtaining gypsum from within New Zealand and avoiding these freight-associated charges are obvious. The cost of shipping from Australia represents an almost direct penalty on the financial bottom-line of WWB.

Beyond the financial implications, there are other reasons to suggest that recycling of gypsum is desirable. Previous studies of waste generation estimate that in excess of 20,000 tonnes of plasterboard waste is disposed of in the Auckland region alone every year (Kemper & Shilton, 2000). From studies in the US, it has been estimated that between 10-12% of board sold will be discarded during the installation process providing the sort of easily targeted, 'clean, uncontaminated' board suitable for recycling (Yost, 1993 & Musick, 1992). Not only does this increase the cost to the construction contractor, most waste board is sent to landfill, taking up limited disposal space. In landfills, under anaerobic conditions, hydrogen sulphide, a hazardous gas, can be produced. As a result, recycling is the most acceptable option for uncontaminated plasterboard waste.
Objectives:
The purpose of this research was to investigate recycling gypsum plasterboard waste at Winstone Wallboards Limited’s Auckland production facility. Within this research goal, three primary objectives were identified as critical to the success of a recycling program.

Objective 1: Investigate the feasibility of recycling gypsum plasterboard waste. Gypsum plasterboard production was investigated, as were possible board contaminants, in an attempt to ascertain whether any of the contaminants would in any way hinder the board production process and thus need exclusion from a recycling program. Contaminants considered to be hazardous were identified so as to assess the legal requirements faced by Winstone Wallboards Limited should they be encountered in the recaptured waste materials. With knowledge of the potential feedstock characteristics, an assessment of the available waste volumes was made using estimation techniques identified in literature. A further estimate was derived from the findings of the site trial on The Spencer on Byron development.

Objective 2: Assess the feasibility of recapturing clean construction site gypsum plasterboard waste for reprocessing at a wallboard production facility. An assessment of the suitability of a range material recapture programs investigation of existing similar programs was made while also looking at the legislative environments in which they exist to assess the drivers behind their success.

Objective 3: Provide an assessment of methods for the recapture of construction plasterboard waste. A trial waste wallboard recapture program was undertaken as a means of identifying not only a physical recapture method but also the effort and investment by all parties necessary to effectively recapture contaminant-free waste board from construction sites. Calculations of the observed quantity of waste generated on the project and the quantity of board product delivered to site was used to ascertain the percentage of board waste during the construction phase. This percentage provided the basis for the aforementioned estimate of board waste volumes in the Auckland region.

Sources and Components of Plasterboard Waste:
Before any material recapture and recycling program is initiated, there is a need to ascertain the material constituents of the material likely to be recovered. This is especially pertinent for the recycling of post-consumer products, as the material must meet the requirements of the end-user so that it may directly compete with the virgin raw material in the marketplace (Thomas, 1993). Gypsum plasterboard waste exists in the community in two general forms, construction and demolition wastes, while the production process is an internal source of waste. The chemical characteristics of each type need to be known to the potential recycler to ascertain their suitability for the reprocessing technologies.

The wastes generated by Winstone Wallboards’ production facilities can be classified into three categories. In order of generation along the production process, the waste categories are wet-waste, end-saw dust and dry waste. Wet waste consists of all production wastes generated prior to the final drying process. It is termed wet-waste as the water content within the material is believed to be in the region of 35% (Rowse, 2000) a level far greater than that acceptable for the final marketable product. Boards that do not meet product standards prior to the drying process are diverted from the production line and sliced into small pieces prior to waste disposal.
Although rotary knives slice the wet board into individual board-type lengths, final trimming is left until after the drying process to form a neat finish prior to taping (King, 2000). This end-saw process generates a very fine gypsum dust. This material is presently fed through a pin mill and back into the gypsum kettle with the virgin ore (Rowse, 2000). Like end-saw waste, dry waste is obtained from post-dryer activities. It includes full sheets of plasterboard that have failed the quality inspection after exiting the drier. The remainder of this waste stream is derived from dispatch and storage activities within the production plant.

Typically, gypsum plasterboard constituents are the basic gypsum stucco, two sheets of paper and an array of additives possibly including perlite, starch, fibreglass, vermiculite, soap foam and appropriate accelerators (EPA, 1995). The end-saw waste product contains no paper backing (Rowse, 2000) but otherwise all the wastes contain similar components to the plasterboard.

Construction wastes consist primarily of plasterboard off-cuts generated during the installation process. Additional whole boards are sometimes included in onsite wastes due to boards being damaged during storage and onsite movements. Consequently, the waste product generally contains the same materials as the finished board products from the factory. Some contaminants may affect the plasterboard however. These can include screws and nails as well as more general dirt and soil substances (Kemper & Shilton, 2000). Dirt, soil and clay are not desirable materials for gypsum manufacturing purposes as the soluble salts contained within can compromise the formation of healthy gypsum crystals or alter the characteristics of the gypsum plaster (Winstone Wallboards Limited). Overseas experience at New West Gypsum Recycling Inc. suggests that all traces of metal fragments need to be removed from the waste by hand-sorting and magnetic extraction (Musick, 1992).

Plasterboard waste generated from demolition projects and also residential and commercial renovations and alterations presents a different type of material contaminant. For gypsum to be recovered from renovation and demolition sites, special contaminant reduction procedures need to be followed. Wallboard may be covered with lead-based or other paints, wallpaper and other surface compounds. All or any may be unsuitable for recycling processes (Clean Washington Center (CWC), 2000a). Moreover, secondary installation products such as nails, screws and joint tapes will be included with the plasterboard waste recovered from demolition sites (Robb, 1999). In addition, the constituents of the plasterboard itself need consideration to ensure that they are suitable for the secondary purpose intended after recycling (Burger, 1993). Plasterboard product with asbestos or pumice content is no longer compatible with the manufacturing process at Winstone Wallboards Limited, thus eliminating significant quantities of used plasterboard from being recycled. Since pumice use ceased some time after both lead and asbestos materials were restricted, it can be used as an indicator mechanism for recyclable plasterboard.

**Plasterboard Waste Recapture Trial:**
The wastes generated on the Penrose production facility consist of wet and dry categories. The characteristics and quantities of this waste are known to Winstone Wallboards Limited, and the logistical and technical requirements for capturing and reprocessing it have been researched at numerous levels within the organisation. What had been unknown
to Winstone Wallboards Limited were the characteristics of the external material waste generated on construction sites that is at present being disposed of directly to landfill or cleanfill facilities. A plasterboard waste recapture trial at The Spencer on Byron on Auckland's North Shore was undertaken to determine the waste characteristics.

At the preliminary meeting for all parties to the trial (Multiplex Constructions, Waste Management NZ Ltd, Winstone Wallboards Limited and The University of Auckland), the need for adequate signage was discussed as was the adoption of a 'source separation' approach to the plasterboard recapture. This was achieved with the installation of a plasterboard-dedicated waste chute feeding a similarly dedicated 15 cubic metre 'Smartskip'. Waste Management stipulated that each plasterboard load weigh at least 3000kg in order for the material to be accepted. Each individual load was weighed and recorded to allow the calculation of wastage rates at the conclusion of the trial.

With the preliminary considerations and tasks completed, the physical trial began on the 18th of October 2000 with the initial bin delivery to the construction site. Waste material inspections commenced at a rate of approximately one per week. This frequency was adopted for several reasons: to monitor the site at a frequency that could be sustained by Winstone Wallboards staff should a waste recapture scheme be implemented; to reduce the inconvenience to the Multiplex project team; and to observe whether relatively infrequent investigations were sufficient to ensure the collection of uncontaminated gypsum plasterboard. Allowances were also made to increase the regularity of the inspections should the collected waste material prove less than homogeneous.

Results:
The waste plasterboard was generally very clean and in plate-sized fragments, a result of passing the waste from a 240 litre 'wheelie' bin on each floor through the waste chute without risking blockages. On several occasions as the project progressed, changes in circumstance onsite led to contamination of the waste receptacle. When the waste chute was removed to allow the installation of windows, the bin became a general waste bin, until the chute was reinstalled and instructions were re-attached to the entrance. Similarly, when the waste area was reorganised, previously inaccessible sides to the 'Smartskip' were uncovered. With no clear instruction provided on those sides, some general waste contamination did occur from labourers on the construction site. Solutions to contamination problems were to either provide instructional signage on each side of the receptacle by 'sign-writing' the plasterboard-specific bins or to work more closely with the project construction administration team to ascertain exactly when such changes in circumstance may occur, so that allowances could be made.

Over the 141 day duration of the trial twenty-one bin-loads of clean plasterboard waste were monitored and measured. All twenty-one exceeded the 3 tonne weight stipulated by Waste Management and all but one exceeded the common packed density of 230kg/m³ identified by Auckland Regional Council (Patterson, 1999). The average packed density was found to be some 26 percent higher at 291kg/m³, attributed to the small fragment size observed throughout the trial. When the total waste generated was tallied and compared with the quantity of board delivered to site, the installation wastage rate of 14.3 percent was found to exceed several of the more recognised international estimates which suggest 10-12 percent as the accepted level of plasterboard wastage during construction. The elevated rate of waste generation was believed attributable to the fast-track nature and the physical characteristics of the project. It was stated that waste generation increases on
multi-storey developments and space-restricted sites as there can be considerable
difficulties for plasterboard contractors (in this instance) in transporting materials from
one quarter of the development to another. The problem is exacerbated further when all
materials are supplied by the primary contractor as sub-contractors have little incentive to
conserve materials as such an approach is not directly related to their job revenue
(McCulloch, 2001).

**Waste Material Recapture Options for WWB.**
Throughout the duration of the research, means of recapturing waste plasterboard were
investigated. The experience gained on The Spencer on Byron trial, and discussions held
with waste contractors and Winstone Wallboards Limited staff uncovered four basic
options for the recovery of waste wallboard from the marketplace:
(1) waste board ‘back-loading’ by Winstone Wallboards Limited delivery vehicles;
(2) material recapture from Transfer Stations and other strategically sited depots,
throughout the distribution network;
(3) random, waste wallboard material delivered to WWB’s Penrose facility;
(4) third party material capture, sorting, storage and delivery.

Each of the material recapture options represents a distinctly different approach to the task
of collecting waste board for a recycling program. The alternatives range from a totally
self-regulated option to a process that more or less allows the board manufacturer/recycler
to remove itself from the logistical day to day management of a recapture process, instead
merely offering an end-market for the gypsum plasterboard material.

**Option 1: Back-Loading of Waste**
From Winstone Wallboards Limited’s (WWB) Auckland production facility, much of the
new board is delivered to site on ‘flat-bed’ lorries of varying sizes (dictated by the volume
of the delivery). Globally, it is common practise for these delivery vehicles to return to the
production facility with empty cargo decks (Yost, 1993) and WWB is no different. The
significance of such an occurrence is that the costs associated with the running of the
transport vehicles are largely incurred whether a load exists or not. There would clearly be
benefits to back-hauling a product or material that would otherwise also incur delivery
charges, purely from a financial standpoint. By utilising existing vehicle movements and
transportation contracts, WWB would be retaining control of the recapture program, and
as such would be able to clearly dictate from where material was received. Such a
situation would offer WWB the opportunity to extend existing customer relationships by
offering the waste collection and haulage as a goodwill gesture to preferred customers. To
this end, WWB would have total control over the pricing structure of the service to its
customers.

There are several problems associated with implementing such a program. Clearly, the
more waste board recovered, the greater the economic benefit to WWB, and yet a pure
back-loading option would target only about 50 percent of the market (as the proportion of
board delivered directly). There could also be a lag between product delivery and waste
generation which would complicate this alternative. Specific pickups may be required to
recapture waste from sites that had no need for a collection at the time of delivery.

**Option 2. Capture from Strategically Located Depots**
With this option, the construction contractor bears responsibility for the waste onsite, but
it is then hauled to predetermined waste depots that store the separated waste until there
are sufficient quantities for transportation to the plasterboard recycling plant. WWB is thus relieved of the control over the waste onsite. The inefficiencies associated with partial loads are overcome, as the depots act as a volume buffer so that material is only collected and transported to the recycling facility when volumes are sufficient to justify the transport costs. In the Auckland area there are a number of transfer stations that could provide the necessary assistance, while distributors could also collect some of the plasterboard waste from customers should suitable space be available. Such an approach should provide a reasonable level of quality control although some monitoring would be required at all collection points to ensure a secondary sorting facility is not required.

The problems with this approach arise from the fact that some waste haulers would be faced with a conflict of interest between either providing waste for Winstones or disposing of it at their own facility. Winstone Wallboards Limited would therefore be at the mercy of non-affiliated waste companies to provide the quantity of waste board necessary to justify the investment in the recycling technology. Logistically, drawing in waste from many sources would generate multiple vehicle movements at the plasterboard production facility that the present layout could not incorporate safely without interfering with day to day activities.

Option 3. Delivery to Winstone Wallboards Limited
This option requires that clean, waste plasterboard off-cuts be hauled to the Penrose production facility by the producer or waste contractor. There are three primary benefits to implementing such a system: a) limited logistical effort and expenditure would be required to implement the process; b) potentially all markets from small to large developments are targeted offering the maximum potential waste recapture rate; and c) potential contractual breaches associated with construction-site waste collection would be limited. The utilisation of existing waste handling procedures and contractors to handle all waste capture and transportation eradicates the need for the product manufacturer to invest time, effort and capital in the introduction of containers and lorries with which to perform such tasks, not to mention avoids the potential contractual wrangles associated with multiple waste contractors servicing the same job.

The negatives for this approach relate primarily to logistics at the production facility in Auckland. By having no control over capture and storage, all quality control would have to be carried out at Winstones itself. This would necessitate a dedicated covered area to allow waste loads to be delivered and sorted prior to treatment. In terms of the capital investment of such an option, it would be prohibitively expensive to construct a warehouse of suitable scale to safely cater to heavy waste lorries and private consumers. Moreover, the level of vehicle activity on the site inherent in such an operation would again prove difficult and undesirable at the present site. From a market penetration viewpoint, with no way of actively targeting the waste plasterboard from construction projects, the volume of waste recaptured would be determined by the cost structure of market competition for waste volumes and the convenience factor for waste haulers.

Option 4. Third Party Material Capture, Storage, Sorting.
The final of the four alternatives is also the one for which Winstone Wallboards Limited has to contribute the least, in terms of management, labour and expenditure. This option would require a strategic alliance to be formed with a waste handling company which could administer and manage the collection and separation of waste board from construction sites. The waste would then be transported to a storage facility where the
material would be sorted to remove contaminants and boards stipulated as being unsuitable for recycling by Winstone Wallboards Limited. The contaminant-free gypsum material would then be stored in a dry area until required by the recycling plant at which point a bulk load would be delivered to the plant. With this option, WWB would be avoiding the capital investment in the waste collection infrastructure for the pre-processing stage of the recycling process. This would allow greater focus to be placed upon the physical material-processing phase of the recycling project. Moreover, the labour and logistical side of the material collection would be managed by a waste company with the experience and expertise to carry out the recapture effectively within the scope of their existing business operations.

One of the fundamental attractions of this recapture alternative is the ability for WWB to control the delivery of the waste material. This offers an ideal opportunity to co-ordinate the quantities of recaptured plasterboard delivered with the raw gypsum volumes processed into new wallboards. Any difference in the volume of waste available and volume in demand would be buffered by the store at the waste handler’s storage depot.

From a marketing perspective the opportunity to use waste containers purposely sign-written with Gib® logos and notification of the recycling program could greatly increase the awareness and recognition of the program within the construction industry and the community as a whole. Such an association could only strengthen WWB’s product and company image and by using a waste company with expertise and a profile in the marketplace, the potential exists to target all board consumers, from domestic renovators to multi-national construction contractors.

The problems related to the adoption of this option are similar to second option. Winstones would be dependent on one waste contractor to provide the desired quantities and qualities to make the recycling program financially viable. This would be compounded if friction developed between waste companies that prevented co-operation on construction sites. Similarly, should the waste company prove incapable of meeting the demands of the recycling process, Winstones would be left with a recycling plant, but no material supplier until a new partnership could be formed.

Conclusions:
(1) Given that pumice is incompatible with the manufacturing process, hazardous substances such as lead and asbestos should not be an issue for the recycling program.
(2) Demolition board should not be included in a recycling program until thorough trials can be conducted with the recycling plant on the effects of paint/wallpaper on the plant and the marketability of the paper backing for resale.
(3) There is sufficient waste plasterboard to justify the expense of implementing a recycling program.
(4) It is possible with some supervision and effective planning to recapture uncontaminated plasterboard waste from construction sites.
(5) The internationally accepted rates of plasterboard wastage during installation don't necessarily hold true in the New Zealand building context.
(6) A recapture program incorporating third-party material capture, storage and sorting is the most desirable for WWB as long as the strategic partner has long-term stability.
(7) Winstone Wallboards Limited should continue to plan and implement a plasterboard recycling program while finding a suitable strategic partner.
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