ASBESTOS REMEDIATION IN THE COOK ISLANDS

A LONG-TERM SOLUTION FOR MAKING SCHOOLS SAFER

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TE WHARE WĀNANGA O WAIRAKA

ABSTRACT

Asbestos contamination in the South Pacific originates mainly from construction products containing asbestos (SPREP, 2011). In Rarotonga, asbestos contamination in the soil surrounding two schools examined (Nikao Maori and Avatea) is believed to have originated from the Super Six roofing product that previously covered all existing classrooms on the site. This type of roofing becomes brittle and susceptible to increased weathering as the product ages. The weathering process from the sun, wind and rain releases the asbestos fibres into the environment (Bowler, 2014). The roofing has only recently been replaced with corrugated iron. The aim of this research was to identify remedial solutions for the removal and disposal of contaminated soil around the schools and for the future earthworks in Rarotonga. Four potential solutions were identified including: i. Capping the contaminated material on-site; ii. Removal and disposal of the contaminated material to local landfill; iii. Removal and disposal of the contaminated material internationally; iv. Removal and disposal of the contaminated material at sea. Solutions considered the feasibility of each option (both in the short and long-term), minimising impact on the residents and the workers exposed, reducing environmental impact and assessing the financial implications for each option.

INTRODUCTION

Asbestos is a general term applied to a number of fibrous silicate-based minerals, for which there are two distinct configurations, namely serpentine and amphibole. Chrysotile (white asbestos) is derived from serpentine minerals and accounts for 95 per cent of all the asbestos used in the twentieth century and 100 per cent of the asbestos used in the world today (Virta, 2005; Natural Resources Canada, 2006). Of the amphibole minerals, the most commercially successful forms include amosite (also known as brown asbestos) and crocidolite (or blue asbestos) (LaDou et al., 2010).

The world's largest producers of asbestos include Russia, China, Brazil, Kazakhstan and Canada, and current global production is estimated at around two million tonnes per annum. (Haynes, 2010; LaDou et al., 2010). Asbestos production reached its peak in the 1970s (Radetzki, 2010) due to its valuable physico-chemical properties including resistance to heat and fire, insulation capability and strength (Godish, 1989). Asbestos-containing materials (ACM) have been used for floor and ceiling tiles, as a surfacing material, as thermal insulation around pipes and boilers and as roofing material as well as for many other uses where its inert properties are particularly valuable (Godish, 1989; New Zealand Ministry for Education, 2015).

Unfortunately, despite its value for use in building products, overwhelming proof from the scientific community has classified asbestos as a non-threshold toxicant – a substance which can cause harm at any concentration. Health risks from exposure are well-documented (WHO, 2014; Haynes, 2010; LaDou et al., 2010), there is no safe level of exposure to asbestos and no exposure to asbestos is without risk (LaDou et al., 2010; Welch, 2007). Microscopic asbestos fibres are dangerous as they can be inhaled easily. There is little research which proves that it may be harmful by other entry routes into the body although the risks of ingestion have been questioned by research but with no causal link between colon cancer and exposure (Gamble 2002). As duration and regularity of exposure to airborne fibres increases so does the risk of asbestos-related disease, such as asbestosis, lung cancer and mesothelioma (Haynes, 2010). While it has been observed that ACMs left undisturbed do not pose "any immediate significant health risks" (Fentons, 2012), those thought to be most at risk are tradespeople or contractors who are responsible for repairs and maintenance. Estimates of those affected by asbestos exposure are variable and made difficult by

the long latency period of asbestos-related diseases which can take up to 50 years before symptoms develop (Fentons, 2012; Haynes, 2010).

Despite the evidence against the use of asbestos in building materials, only 55 countries have banned all forms of asbestos, with influential countries such as USA and Canada continuing its use. The majority of South Pacific Islands, including Samoa, Fiji and the Cook Islands, as well as New Zealand, have yet to join this initiative (Kazan-Allen, 2014). As more developed countries ban the use of asbestos, producer nations continue to export asbestos and ACM to developing nations, where imports are growing (Dooley, 2012). It has been observed that greater than 85 per cent of the world production of asbestos is currently used to manufacture products in Asia and Eastern Europe (Virta, 2005). Although there are a number of safe alternatives available for the building industry, asbestos continues to be popular in poorer nations due to its low cost.

ASBESTOS IN SCHOOLS

The production of inexpensive, mechanically strong and heat-resistant building materials containing asbestos has inevitably led to its use in many public buildings globally. It is therefore not surprising that, since the asbestos boom in the 1970s, some 30 years later the risks of this hidden danger have been exposed. These observations have been made due to many factors, including the latency period of the symptoms of asbestos exposure, the recent research clarifying the health risks associated with exposure and the deterioration of building materials over time. Recently, a particular concern has been the potential for asbestos exposure in school buildings. Children are more at risk from asbestos exposure than adults; the estimated lifetime risk of developing mesothelioma for a five-year-old is about five times greater than for a 30-year-old adult (Shponline, 2013). Schools may contain friable asbestos-containing materials which are particularly dangerous as the asbestos is not bound within the cement matrix (Godish, 1989). Materials in a friable form or those caused (usually by maintenance or deterioration) to release fibres into the air pose a potential risk of exposure and asbestos related disease.

Evidence from the Medical Research Council, United Kingdom (Abrams, 2015) estimates that within poorly maintained schools asbestos fibre levels are between five and five hundred times greater than those found in outdoor air within schools that are maintained to a good condition. Evidence of health risks to both teachers and students is mounting and with this, a realisation that the removal of asbestos from schools globally may be a huge financial and environmental burden (Abrams, 2015; Shponline, 2011; Cooney & Conway, 2013). In New Zealand, asbestos was used widely from the 1930s to the 1980s, in a number of building products, often mixed with cement. In 2010, a Wellington-based former teacher was diagnosed with mesothelioma thought to be caused by work-related exposure (Education Aotearoa, 2010). In 2014, the disturbance of asbestos during renovations at an Auckland primary school raised further concerns about safety (New Zealand Ministry of Health, 2014).

It is apparent that identifying asbestos in schools followed by safe removal and disposal will be a time-consuming and costly operation for the future. As poorer countries continue to use asbestos and its products, how do we prepare for the long-term disposal of these products and should a worldwide ban of their use be encouraged?

ASBESTOS USE IN THE COOK ISLANDS

The following case study examines asbestos fibre contamination of schools in the Cook Islands, specifically in Rarotonga. Of the Cook Islands, Rarotonga is the largest and most densely populated, with approximately 15,000 permanent residents, served by ten local schools. Nikao Maori and Avatea schools (situated in Northwest Rarotonga), had previously been selected for reconstruction, however the topsoil surrounding the main building was identified as containing high levels of

asbestos contamination (K2 Ltd, 2014).

Asbestos contamination in the South Pacific originates mainly from construction products containing asbestos (SPREP, 2011). Asbestos contamination in the soil surrounding these two schools is believed to have originated from the Super Six roofing product that previously covered all existing classrooms on the site. The roofing has only recently been replaced with corrugated iron. Super Six roofing becomes brittle and susceptible to increased weathering as the product ages. The weathering process from the sun, wind and rain releases the asbestos fibres into the environment (Bowler, 2014). In addition to the contaminated soil, ACM was observed in the wall cladding of both schools. A recent survey of asbestos and ACM in the Pacific Islands has identified that approximately three per cent of houses and public buildings, e.g. schools, contained these materials (SPREP, 2015).

The aim of this research was to identify remedial solutions for the removal and disposal of contaminated soil around the schools and for the future earthworks in Rarotonga. Rarotonga does not currently have its own legislation or policy on asbestos, New Zealand legislation and best practice was reviewed and incorporated into the work methodology.

METHODOLOGY

School Selection

Prior to this investigation, Cook Islands Investment Corporation (CIIC) carried out asbestos air sampling of a number of government schools in Rarotonga. Initially, Avarua Primary school was identified with high levels of asbestos in the soil. The soil around the perimeter buildings was excavated and buried off-site and replaced with clean soil materials. Subsequently Nikao Maori and Avatea schools were selected for deconstruction and during this initial assessment phase, asbestos contamination was identified in the soil around the school buildings and within the buildings themselves. This research project was carried out to identify more sustainable solutions to the removal and disposal of this contaminated waste.

Assessment and viability studies

The type and quantity of asbestos contaminated waste and soil was estimated during site visits and using laboratory studies carried out previously. Both contaminated soil and building materials could be retained on site with adequate capping/encapsulation or removed for disposal elsewhere. An assumption has been made that the removal and disposal solutions for these schools could be adopted for other buildings in the Cook Islands and hopefully for the Pacific region in general.

Viability studies were conducted to determine the options available for disposal using a combination of desktops studies and site visits to potential disposal areas (e.g local landfill). This included investigations into previous disposal solutions for this hazardous waste (e.g sea disposal). Discussion with government, local companies, K2 Ltd and CIIC as well as SPREP was essential to these investigations.

Disposal Solutions

Potential solutions (Figure 1) for the contaminated soil and wall cladding were identified including:

i. Capping (sealing, enclosing or encapsulation) internally and externally
ii. Removal and disposal off-site to a local landfill
iii. Removal and disposal internationally (to landfill)
iv. Removal and disposal at sea

Evaluation of solutions considered the feasibility of each option (both in the short and long-term), minimising impact on the residents and the workers exposed, reducing environmental impact and

assessing the financial implications for each option. The initial disposal options put forward are similar to those recommended globally. Reuse and recycle options were not considered in this case as they are not applicable for the contaminated soil, and for the ACM present further hazards to human health if not handled and stored properly. Options of treating asbestos waste via vitrification, high temperature transformation (Haynes et al., 2011), plasma arc technology (Deegan et al. 2007), degradation by hydrofluoric acid (Kakegawa et al., 2008) and thermochemical inactivation (Yvon & Sharrock, 2008) etcetera are not feasible based on cost, reliability of energy source and also the relatively small volume of waste produced from the Pacific Islands.

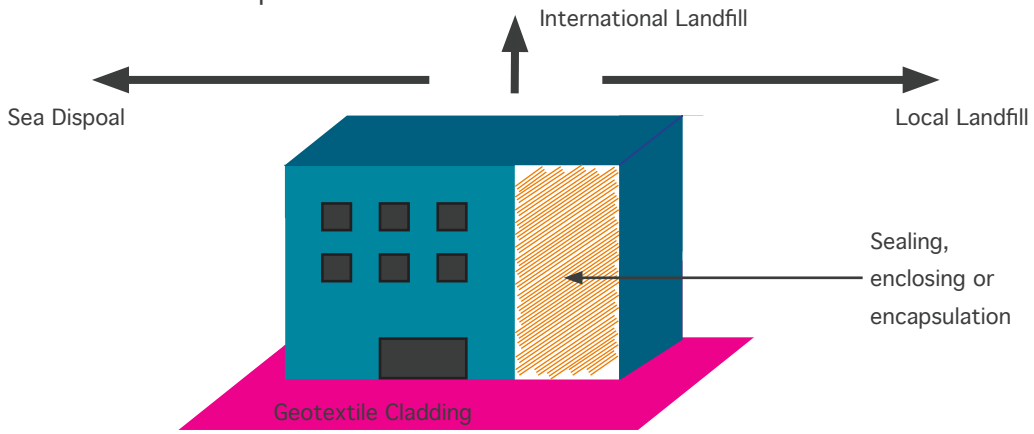

Figure 1. Options for removal and disposal of asbestos contaminated soil and ACM at Nikao Maori and Avatea schools, Cook Islands.
Source: Authors own

The evaluated disposal options were based on those recommended by the Secretariat of the Pacific Regional Environment Programme (SPREP) and The World Health Organization (WHO) in 2014. All standards used were based on a combination of current New Zealand and Australian codes of practice on how to safely remove asbestos.

The relative merits and risks associated with each of the four options are summarised in Table 1. Following evaluation of the four options, the safe removal of contaminated soil and ACM from both schools was initially found to be preferable to capping. This was based mainly on cost but also on local preference. Removal and disposal to landfill requires creation of an asbestos management plan to ensure correct procedures and control measures are used. In addition, a significant upgrade of the landfill facilities would be required, including lining and covering the waste material. Alternatively disposal to containers for later removal from Rarotonga to a specialised waste disposal unit overseas has potential for the future, however strict quarantine regulations (in New Zealand and Australia) combined with high costs may make this option prohibitive.

Soil Removal and Transportation Procedure

The removal of the contaminated soil from the site should involve excavation of the existing soil and disposal off-site to the landfill facility at Arorangi. The asbestos plan should contain all the procedures and control measures needed for this part of the operation. Removal of contaminated soil and disposal off-site, would involve removing the top 200-500mm of soil from the site and transporting it to a disposal facility on the island, then replacement with clean soil. Previously at Avarua school, Rarotonga, removal of contaminated soil reduced the level of asbestos dust in the air to <0.01/ml. This is the recognised safe limit according to the Health and Safety in Employment (Asbestos) Regulations 1998.

Option	Advantages	Disadvantages
Capping Including sealing, enclosing or encapsulation within building and multi-layer capping externally	- Very little disturbance to the area - Least potential to cause harm to human health - Successful model observed (multi-layer capping) (Tomasicchio, 2010)	- Requires careful labelling - Public opposition - Additional weight (additional long-term hazardous waste) - High level of skill and knowledge and expertise required - Expensive (multi-layer capping) - Requires on-going maintenance
Removal and disposal at local landfill	- Removes any future risk to human health once removed - No on-going maintenance required	- Landfill close to capacity - No current specialist hazardous waste disposal - Requires strict removal procedure to ensure public health - Labour–intensive
Removal and disposal internationally	- Reduces human health risk - No on-going maintenance required - Provides a longer-term disposal solution - Specialised hazardous waste treatment - Overall reduction in number of disposal sites	- Requires strict removal procedure to ensure public health - Labour-intensive - High cost for transportation - Potential quarantine issues - Temporary storage required prior to shipping - Reliance on external party(ies)
Removal and disposal at sea	- Reduces human health risk - No on-going maintenance required - Reduces pressure on landfill - Long-term storage solution.	- Establishing suitable area with the Exclusive Economic Zone (EEZ) - Dependent on permit - Questionable permanency of location - Public opposition

Table 1. Summary of disposal options: Advantages vs Disadvantages
Source: Authors own

The area around each of the school buildings to be excavated would require a trench 2m (w) x 200mm (d). The trench should start at the dripline of the roof, to ensure all contaminated material will be removed.

All trucks involved in the removal operation would need to be covered, and all soil loaded would need to be dampened down during the excavation process to reduce the amount of dust created. Once contaminated soil is unloaded and before uncontaminated soil is loaded the truck bed would need to be cleaned. All trucks should follow the route designated and all drivers should have a copy of the designated route.

Wall Cladding Management and Removal

As samples of wall cladding panels tested positive for asbestos, an assumption was made that the majority of the panels would contain asbestos fibres. The cladding can be left on the building when it is demolished. While there is a risk of contaminating the area with dust, risk mitigation via water soaking is an option. Despite the legality of this option (there is no current asbestos legislation in the Cook Islands) and the low cost, this proved to be unpopular with the local community.

The cladding may be removed safely by following recommended guidelines (Safe Work Australia, 2011). Once removed, these panels can be stored off-site in a sealed shipping container, until a disposal option can be established. Shipping containers are used to seal the ACM from external weathering elements and any other disruptions. These containers may also be transported

off-site easily without exposing the public to any dust or debris. Once panels have been removed, it would be necessary to swab test the framing to confirm no further asbestos contamination is present.

Cost Summary

Total costs for the safe removal and temporary disposal of ACM and contaminated soil for both schools were estimated. All soil volumes are estimated from the plans provided by CIIC. A depth of 200mm was selected based on evidence from sampling and analysis. A total of 588 cubic metres of soil was estimated to need to be removed. Costs were based on estimates provided by CIIC for removal and disposal of the contaminated soil (at NZD 330 per m^3). The storage of the wall cladding would require three standard shipping containers. The total cost was estimated to be NZD 340 000.

DISCUSSION

The prolific use of asbestos containing materials in the Pacific Islands is an issue of global concern for many reasons. In terms of cost, the removal and disposal of asbestos at the two schools was estimated at NZD 340 000. These schools represent a small fraction of the buildings believed to contain ACM. The predicted cost of the removal of all the ACM in the Pacific Islands is NZD 150 million (S.Williams, personal communication, June 24, 2015). This value does not cover disposal costs, only removal, and it appears that the long-term disposal solution for these hazardous materials has no strategy on a regional, national or global level,

Although legal (with a permit), under the London Convention (Coenen, 2011) and the Noumea convention in the case of the Cook Islands (SPREP, 1986), disposal at sea is not generally a publically acceptable option. This was clearly demonstrated by the public debate which followed the deliberate sinking of the vessel, *Miss Mataroa*, which contained ACM from the Cook Islands (Asbestos.net., 2014). Whilst more careful selection of disposal area at sea may increase the potential of this disposal route, is it a viable long-term solution?

Disposal to landfill requires strict adherence to control factors such as soil depth, planned segregation of asbestos waste and careful labelling (UK Landfill Directive, 2010; Worksafe New Zealand, 2015). These measures ensure that there is no risk to human health by preventing airborne particles. The practicalities of this approach are tested by the increasing pressures on landfill operations due to increasing waste volumes and land area limitations. In this case, the landfill in Rarotonga is close to capacity and unable to deal with large volumes of ACM. To meet recommended guidelines, this contaminated waste requires a lined excavation, covered with the same polythene liner and covered, with at least 1m of fill and compacted soil.

An alternative disposal route via international destinations (Australia and New Zealand) is controlled by the Basel and Waigani Conventions (Basel Convention, 1992; SPREP, 2001). Once again, it is a viable option, already demonstrated in New Zealand but not Australia. Only, recently the New Zealand Government approved and financed 20 shipping containers containing asbestos waste to be shipped from Nuie and disposed of to a New Zealand landfill (PacificGuardians.org, 2014). This precedent underpinned the recommendation of storing wall cladding materials in shipping containers, as outlined in this report. However, as ACM continues to enter the Pacific Islands, there is doubt that this is a long-term solution. It is also cost-prohibitive and is often complicated by quarantine restrictions.

As well as careful selection of a suitable long-term disposal route, the technical expertise and knowledge for the safe handling and disposal of these materials must be passed on to these and many other small communities. This is especially important given the generally lack of painting and maintenance for these buildings (which prevents damage of the ACM) and the high occurrence of extreme weather events which may expose asbestos from its binding material. Experience from

Figure 2. Factors affecting the choice of disposal route for asbestos contaminated soil and building materials
Source: Authors own

the devastating effects of the 2015 Cyclone Pam in Vanautu has demonstrated that despite the development of an inventory for ACMs in the area, the clean-up procedure did not use this data to ensure public health and safety (S.Williams, personal communication, June 24, 2015). Further evidence from events such as the collapse of the World Trade Centre, USA in 2001, the 2011 earthquake and tsunami in Japan, and the tropical cyclone Yasi which hit Queensland, Australia in 2011, has demonstrated that asbestos contamination following these events should be considered from both a human health perspective as well as an ecological perspective. At Ground Zero, improper clean-up and communication compromised the health of people living and working there (Sheer, 2011). After natural disasters, the disposal options appear to be limited to on-site storage or landfill (Ryan et al., 2014; Asari et al., 2013).

Factors affecting the best disposal option include (placed in order of importance): public health, cost, public opinion, longevity (how long will the materials be safely retained?) and sustainability (the long-term capacity of the disposal option) (Figure 2). Using the example as provided by the remediation at these schools, it could be possible to list the preferable disposal options with respect to each factor (Figure 3) and then further use this data to determine numerically which of the options is most suitable (determined by the lowest value) (Table 2).

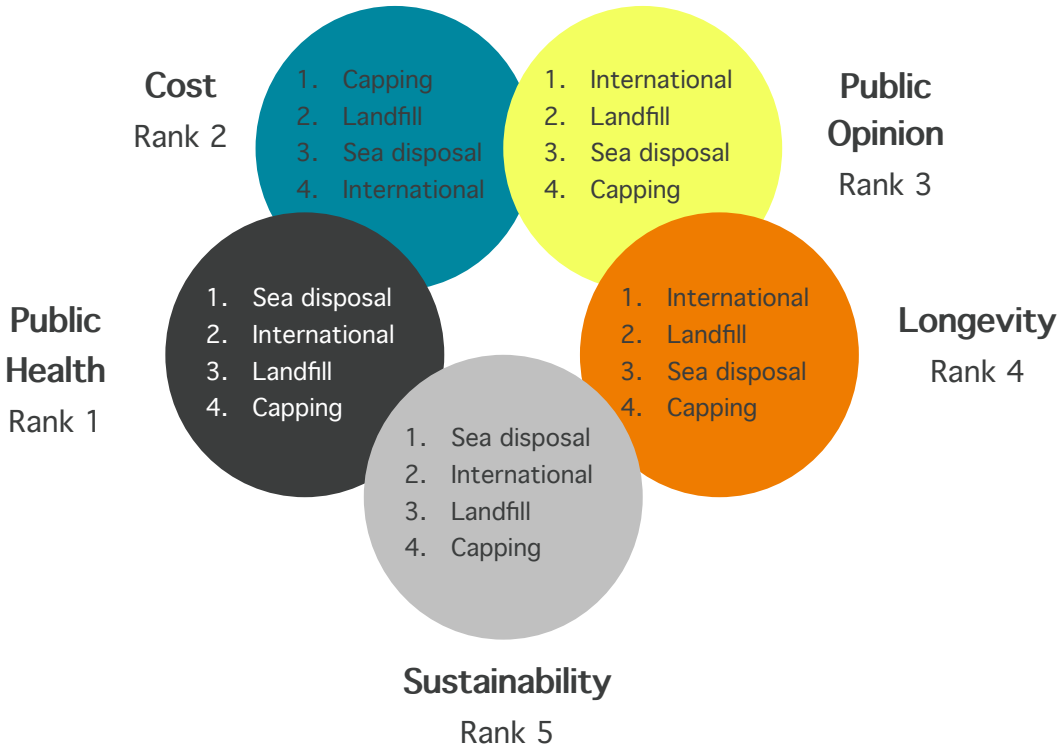

Figure 3. Preferred disposal options for ACM for each of the factors affecting the disposal decision (where option 1 is most preferred and option 4 is least preferred)
Source: Authors own

Although public health is unarguably the most important single factor affecting disposal choice, the rank of the other factors may be debated. It is interesting to note that by changing either the rank of the factor affecting the decision (Figure 2) or the impact of the disposal option on that factor (Figure 3); the choice of disposal option may change. The factors and weightings will be specific for any given scenario.

Option	Public Health (5)	Cost (4)	Public Opinion (3)	Longevity (2)	Sustainability (1)	Total
Capping	20	4	12	8	4	48
Landfill	15	8	6	4	3	36
International	10	16	3	2	2	33
Sea Disposal	5	12	9	6	1	33

Table 2. Selection of the preferred disposal route for ACM for Nikao Maori and Avatea schools (value = rank in brackets x preference of option, lowest value indicates preferred option). Source: Authors own

CONCLUSIONS

There are a number of options available for the safe removal and disposal of asbestos from buildings in the Cook Islands. In Rarotonga, as funding to upgrade the island's other schools is extremely limited, interim measures to protect those schools on the 'waiting list' from the health and environmental impacts of asbestos contamination could include sealing wall panels with paints and covering existing play areas with an extra layer of soil. Air monitoring tests at each school would indicate the priority needed for asbestos mitigation measures.

Despite public opposition, the eventual solution at the two schools in this case study was on-site burial (which involved three-metre deep burial with 200μm polythene covering), which was mainly based on cost. Although the overall aim of this research was to identify more sustainable solutions, low cost appears to have outranked these alternative options. This highlights the requirement for a unified approach to a global problem which is dealt with only in the short-term and without considering the legacy of multiple sites of marked (or unmarked) contaminated land. In addition, the lack of available land for safe disposal of hazardous chemicals in these islands highlights the requirement for larger countries with a greater capacity for both treatment and disposal to consider aid on a case–by-case basis.

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