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Short Communication

A note on material flows of construction aggregates in Taiwan

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Abstract

Recent decades have witnessed accelerated growth in the demand for construction aggregates in Taiwan. The ecological pressures caused by riverbed mining of aggregates have resulted in shortages in domestic supply. Simultaneously, Taiwan must contend with the accumulated generation of construction wastes. Industrial ecology offers solutions that recover resources from construction wastes. For example, in areas of high-density urban construction, the use of crushed concrete can be economically attractive. To investigate environmentally sound and economically feasible solutions for satisfying future demand, researchers at National Taiwan University and Columbia University propose a study of the long-range consequences of utilizing domestic supply sources including construction waste. © 2001 Elsevier Science Ltd. All rights reserved.

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Several decades of sustained economic and industrial development have accelerated construction activity and led to significant growth in the demand for construction aggregates in Taiwan. Simultaneously, environmental pressures have led to recent interruptions in the domestic supply. Resulting shortages in the domestic supply of construction aggregates have led the Taiwanese government to focus attention on this resource to accurately account for its existing reserves and identify options for satisfying future requirements. Several complementary options offer themselves for satisfying future aggregate demand: domestic riverbed mining, land mining, sea area mining, foreign imports, and recovery from demolished structures. Using principles industrial ecology, we propose to map the material flow of construction aggregates in the Taiwanese economy and investigate environmentally sound and economically feasible solutions for satisfying future demand.

The high population density of this East Asian nation coupled to its growing industrial and social infrastructure, distinguishes the Taiwan case study. The total area of Taiwan, 36,000 km², hosts a population over 20

million. The vast majority of this population resides along the western coastal plain that comprises about a third of total national area. Compared to other industrialized nations, like Japan and Germany, Taiwan consumes twice as much construction aggregate per unit area (Anon, 1997, 1998:50–75). Compared to large and sparsely populated nations like the United States, the ratio is more than 30.

Until the late 1990s, excavation of domestic supplies of aggregates from domestic riverbed sources went essentially unregulated. Years of massive digging have revealed ecological damage from this activity and a reserve base showing signs of depletion. Government efforts to protect rivers and riparian zones by limiting the area available for mining aggregates have rendered this source of domestic aggregate supply scarce. Continued reports of unregulated, illegal digging have grown and with them the detrimental ecological impact of these practices.

Construction aggregate represents the most voluminous mined resource with demand in the 1990s nearing 200 million metric tons (MMT). Because of irregularities in past government data collection, we deduce national demand for construction aggregates based on demand data for other more closely monitored building materials, cement and asphalt. Established correlations linking demand between these materials show that aggregate

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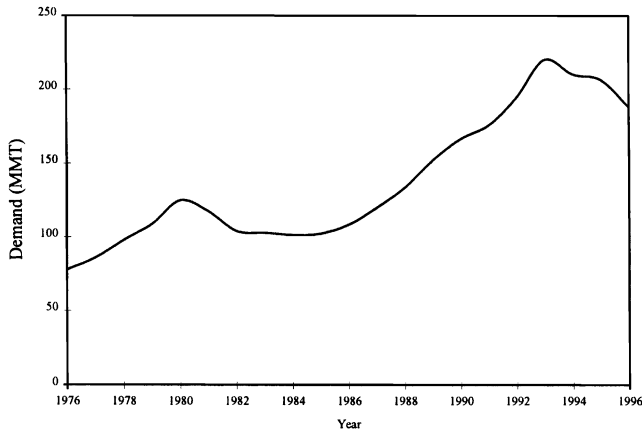


Fig. 1. Construction aggregate demand evaluated from cement and asphalt consumption, Taiwan: 1976–1996. Source: ABRI (1998).

consumption in Taiwan rose more than 75% since 1980 (Fig. 1).

In the second half of the 1990s official recognition emerged of the ecological damage resulting from unregulated excavation of aggregate from the Taiwan river system. To relieve the ecological pressures caused by riverbed mining, the central water authority set a timetable for reducing the supply of riverbed aggregates 50% by 2003 and 70% by 2006. In June 1997, the

Bureau of Foreign Trade began allowing imports of construction aggregates (primarily from mainland China and the Philippines) to address the resulting shortages in domestic supply. Imports of construction aggregate are considered a short-term measure in response to immediate shortages and according to the government, the long-term approach focuses on excavation from land-based sources.

Industrial ecology advocates solutions that capture the value of waste from the economic system for economic benefit. For the case of construction aggregates, this suggests seeking solutions that recover resources for construction wastes, specifically crushed concrete, to supplement future supply. Data on annual construction wastes generated by public and private construction projects in Taiwan amount to approximately 5.5 million m³ (~11 MMT) requiring disposal. Recent studies evaluating the suitability of waste concrete for use in new construction (Kelly, 1998; Wilburn and Goonan, 1998) show that in areas of high-density construction, the use of crushed concrete can be economically attractive for projects with a low threshold for quality and uniformity. Due to poor properties such as broader particle size distribution, more fine particles, lower average density, and different mixing characteristics than natural aggregates, the material is suitable primarily for use as a substrate for building roads.

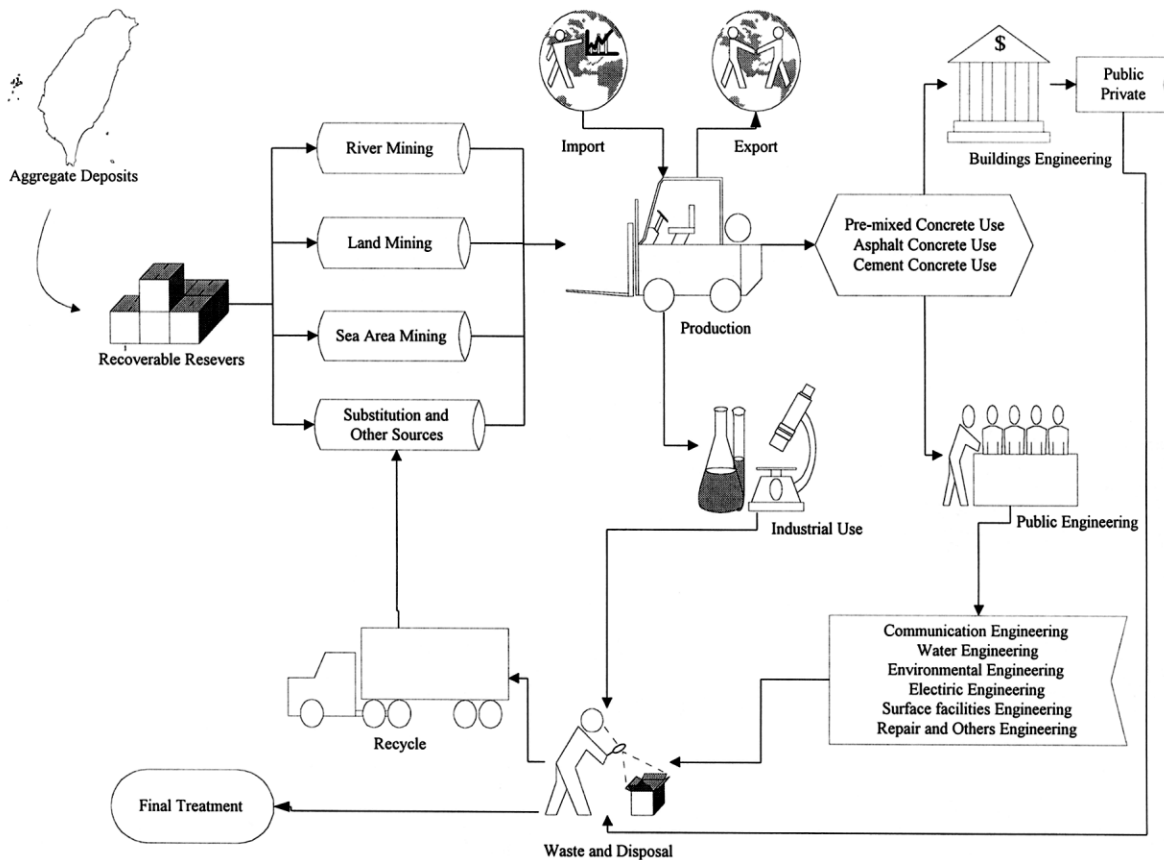


Fig. 2. The framework of materials flow analysis on construction aggregates in Taiwan.

Examples of efficient utilization of construction wastes comes from how nations have dealt with spikes in the supply of waste concrete from large scale seismic events. Over 60% of the millions of tons of demolition wastes resulting from the October 1989 San Francisco earthquake and January 1994 Northridge earthquake were recovered. Similarly, approximately 300,000 t of material recovered after January 1995 Kobe earthquake in Japan was converted to concrete blocks used for land reclamation (China News Foundation, 2000). Data from Taiwan's 1999 Chi-Chi earthquake, which generated over 10 million m³ of solid waste, show that concrete, bricks and other construction materials represent the bulk of demolition waste and suggest that about 60% may be recycled and reused.

Taiwan, a densely populated island nation, faces the double plight of aggregate shortages as well as increasing amounts of construction wastes. Proposed measures to deal with the recent disruption to demand for aggregate in Taiwan have responded to immediate shortages but have not considered the long-range consequences of utilizing domestic supply sources and the accumulated generation of construction wastes. To assist the Taiwan

government in the development of management strategies we propose a materials flow study of aggregates as well as an evaluation of the economic and technical feasibility of large scale recovery of waste resources (Fig. 2). This work aims to provide a precedent for combining natural resources management with economic analysis in an effort to promote sustainable economic development.

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