KKU Engineering Journal

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Recycled Concrete Aggregate (RCA) Thai reverse logistics supply chain management for ready mix plants

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Received April 2016
Accepted June 2016

Abstract

Thailand and namely Bangkok is currently experiencing a construction boom. New condominiums are being erected throughout the city and the construction material of choice is concrete. Concrete is being produced by mixing water, cement and aggregates. The concrete plant can be either on-site or off-site, in this case the concrete needs to be trucked from the ready mixed plant to the job site. The raw materials (cement and aggregates) for the concrete have to be shipped to the concrete plant. Aggregates are either fine or coarse and are made by crushing rocks or hardened concrete which results in so called recycled concrete aggregates (RCA). The composition of concrete waste (RCA) is Ca (21.9%), Si (8.27%), Al (4.58%), O (53.51%), C (11.74%) [1] and RCA has similar strength and properties as rock from the mountain. In this case the RCA can be either generated on-site by demolition the existing structure or from a designated quarry site or other demolition site. The objective of the study was to look at all three cases and the advantages and challenges associated with the RCA production site from a logistics management perspective. The main savings found are in terms of transportation costs (fuel and time) when comparing RCA to aggregates from a remote natural quarry. There are additional intangible savings in terms of global warming in the production process and the energy used in mining the raw material as well as disposal costs for the existing structure. The study used an on-line web enabled survey of young logistics management professionals to compare their perceptions of the various scenarios in a Thai context and analyzed the findings statistically using SPSS in order to create a theoretical model for RCA as part of a sustainable ready mixed concrete supply chain in Thailand and ASEAN.

Keywords: Recycled Concrete Aggregate (RCA), Ready mix concrete, Logistics, Supply Chain Management (SCM), Reverse logistics

1. Introduction

Recycled Concrete Aggregate (RCA) and its properties have been discussed in many papers but the true business problems is the logistics associated with RCA [2]. One has to understand that production of ready mixed concrete at its core is a transportation issue. Cement, water and aggregates have to be transported to the site where the concrete is produced by mixing. The "manufacturing" of concrete if you want to call it this, is actually a very simple process, the mixing of cement, water and aggregates. As concrete and concrete aggregates are heavy, serious costs and transportation issues come into play. It in the USA and Europe it is not unusual that the aggregates are transported by company owned short train lines from the rock quarry to the concrete mixing plant or aggregate storage. The logistics issue is that aggregates are less time sensitive to be shipped and to be stored, they don't have a shelf life and don't need to be protected from the elements except from severe flooding and wash-out. Cement is more sensitive to be shipped as cement enters a chemical reaction with water and hardens, so cement has to be protected from the elements namely freezing and water. The admixture for coloring, early strength, or delayed hardening are very expensive and have to be protected not only from the elements but also from shrinkage. Mixed concrete however is an entirely different story. Concrete which is the mixture of water cement and aggregates hardens in time and has to be worked within hours. Therefore aggregates are being transported to the mixing site (on-site or off-site) in terms of construction site and the mixed concrete has to be as close to the site as possible. Ready mixed concrete is being transported by special rotary drum trucks from the concrete plant to the construction site. The concrete mix truck has a drum similar to that of a concrete mixer, by constantly rotating separation of the aggregates water and cement is limited and the shelf life of the concrete is extended by preventing the concrete from hardening. The problem is, if extra water is added to the concrete mix the water/cement ratio is altered and more water means a strength reduction of the hardened concrete which reached its final strength after 28 days [3-4]. As with any logistics transportation issue there is a trade-off between proximity to the customer and transportation costs, a balance between storage and transportation has to be found. The proximity becomes an issue particular in areas such as the Bangkok Metropolis, where the majority of demand is for

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doi: 10.14456/kkuenj.2016.69

concrete. The problem is that the aggregate quarries are outside of Bangkok and aggregate and or concrete would need to be shipped for several hours to reach the Bangkok construction sites. On the other hand old buildings and other concrete structures are being demolished in Bangkok. These demolished building and structures provide an ample source of recycled concrete aggregates. The research question remains if it is more advantage to recycle the concrete on the demolition site, a centralized storage site or on the place of consumption namely a ready mix plant at the new construction site or in close proximity to it. The typical plant set-up is depicted below in Figure 1.

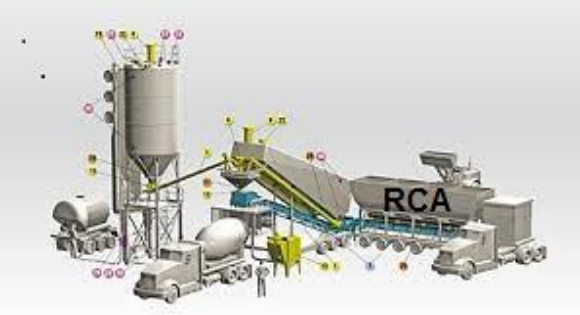

Figure 1 RCA in the Concrete Ready Mix Plant (adapted from warngroup.com)

2. Methods

This research looks at recycled concrete aggregates (RCA) in Thailand, and the perception of young logistics professionals after completion of coop in terms of RCA usage and their impact on the ready mix concrete industry in Thailand. Of the 88 participant 33 (37%) were male and 55 female (63%) depicted in Figure 2. This was a convenience sample. In terms of age and gender distribution the sample represents the young Thai logistics management professionals which in majority are female. To capture their perception an on-line questionnaire created by the principal investigator (PI) was administrated to the participants. The data was analyzed using SPSS and was summarized in table format.

Figure 2 Demographics

3. Results

The research results of this study can be grouped according to (1) location of the recycled concrete aggregate (RCA) crushing plant, (2) type of recycled concrete aggregate (RCA) crushing equipment with or without integrated cleaning facilities and (3) types of material handling equipment for RCA on the job site utilizing trucks, loaders, and or conveyor lines. The results combined provide inside into the reverse supply chain of building materials in Thailand and in particular in the RCA supply chain and its potentials in Thailand and ASEAN. The results help to further optimize the use of RCA in the Thai ready mix concrete industry.

3.1. Location of RCA crushing plant

The majority of RCA (50%) was generated at the demolition site, followed by 25% at the construction site and only 12.5% at the central concrete mixing plant, 6.8% at the quarry along with natural virgin aggregate and 5.7% at other often third party location such as a recycling plants according to Table 1.

Table 1 RCA plant location

Problem	*n*	Percentage	Disc. Index	Std. Dev.
Demolition Site	44	50%	0.58	0.42
Construction Site	22	25%		
Central Plant	11	12.5%		
Quarry	6	6.8%		
Other	5	5.7%		

3.2. RCA plant equipment

The majority of RCA crushing plants use mobile equipment (45.45%) and 22.75% of the plants are mobile equipment with integrated cleaning devices. Stationary RCA plants account for 22.75% and only 9.05% of the equipment is stationary with built-in automated cleaning process, while the remainder rely on manual cleaning and foreign object removal either through magnets, water or multiple screening and hand picking according to Table 2.

Table 2 RCA plant equipment

Problem	*n*	Percentage	Disc. Index	Std. Dev.
Mobile Equipment	40	45.45%	0.45	0.55
Mobile Equipment with Integrated Cleaning	20	22.75%		
Stationary Equipment	20	22.75%		
Stationary Equipment with Integrated Cleaning	8	9.05%		

3.3. RCA material handling

The majority of RCA (50%) are transported by loaders, 37.5% of the plants also use trucks for material handling, while only 10.21% use some type of conveyor belt system to transport the RCA in the plant. Only one plant uses a slurry line system and another plant uses an alternative manual way of moving RCA on the job site described in Table 3. Volume and weight are the two major factors which drive the selection of the material handling method.

Table 3 RCA plant location

Problem	*n*	Percentage	Disc. Index	Std. Dev.
Loaders	44	50%	0.53	0.47
Trucks	33	37.5%		
Conveyor Belts	9	10.21%		
Slurry Lines	1	1.13%		
Other	1	1.13%		

4. Discussion

The discussion of this research includes a comparison with the existing research dealing with RCA which focuses mostly on the structural and chemical properties of RCA and the use of RCA in Europe and the USA. There is however a growing concern for RCA applications in emerging markets and in ASEAN in particular. The author would like to replicate the study in an ASEAN framework to allow for comparison of RCA in the various ASEAN partner countries as well as industry best practices worldwide.

5. Conclusions

In conclusion recycled concrete aggregate (RCA) are still relative new in Thailand and the ready mix industry is slowly embracing RCA as replacement of virgin aggregates. The logistics of the plant equipment and material handling as well as the cost of the equipment are some of the major factors limiting efficient RCA usage in comparison to standard aggregate quarry operations. Mobile RCA crushing plants as depicted in Figure 3. At the demolition site appear to be the preference which leads to additional transportation savings if the demolition and new construction site are in close proximity. Cleaning is predominantly done by hand as integrated automated equipment both stationary and mobile is costly due to high import taxes. Material handling on small job sites can be efficiently accomplished by loaders only larger sites utilize trucks and conveyor lines, besides the built-in conveyor lines as part of the RCA plant while slurry line are practically unheard of on sites as depicted below in Figure 3.

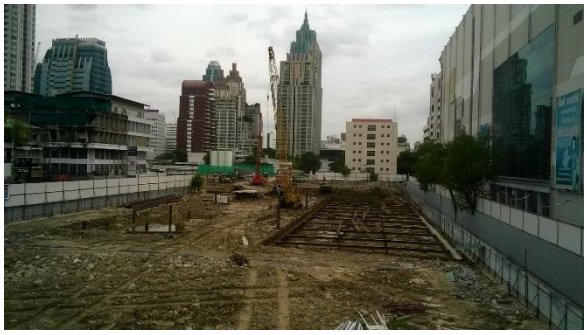

Figure 3 Typical Construction Site in Bangkok with RCA in the front

6. Acknowledgements

The author would like to show his gratitude to Burapha University International College (BUUIC) for its research support of faculty and acknowledge the dedication of BUUIC and its dean to excellence in research, teaching and service in the area of logistics management and supply chain management, with BUUIC serving Thailand and ASEAN as a center for logistics management education and research.

7. References

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