UNIVERSITI TEKNOLOGI PETRONAS

Final Year Project

Project title

A Framework Design for Construction Waste Minimization and Recycling in Malaysia

Name	:	JAMES KOK CHENG HAN
SSID	:	15131
SUPERVISOR	:	Dr. AMIRHOSSEIN MALAKAHMAD

Attestation

I understand the nature of plagiarism, and I am aware of the University's policy on this.

I certify that this dissertation reports original work by me during my final year project.

JAMES KOK CHENG HAN	**Date**
15131	**12th August 2014**

Undergraduate of Civil Engineering Department

University Technology Petronas

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Extended Proposal

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Chapter 1

Introduction

Construction Industry had been putting up an accelerated growth around the globe in the last decade.In Malaysia , the bloom in construction industry with the alignment of the vision given by our beloved Tun Dr. Mahathir, Wawasan 2020 had contributed much to the economic growth of the nation. The construction industry provide much opportunities in term of employment rates and investment opportunities thus directly injecting money into a nation's economy. The money that came from major investor which origin is from both local and overseas (M.Agung,2009).

With the increasing of construction and demolition works that bloom across the nations, the expected waste generated from these activities are also increased. In the early years, the Construction and Demolition (C and D) waste generated from these sites are not being treated and sent straight to the dumping site to be treated as general solid waste. This had gave rise to a problems such as the depletion of natural resources (raw materials) and reduce the waste of C andD activity produced ,Priyadarshi (2013) et al. From the study done by Fishbein on reducing the C and D waste generated by the municipal projects, it is suggested that there are approximately 10to 30 per cent of the waste disposed off in general landfills have their origin from C and D activities.

Awareness of the issues related to construction waste had increased. Various research and findings gave the indication that the generation of construction waste are mainly contributed from the urban area, Nazech E.M. (2008) et al. With the advance of technologies and also research findings around the globe, it is time for Malaysia construction industry to adopt some of these methods and technologies to the betterment of the construction industry.

In Malaysia construction industry, following the increased growth in this industry it is necessary to study the waste generation and to manage them wisely. Waste minimization, reuse and recycling practices are limited in the construction sector and natural resources required as building materials are acquired at relatively low cost (Begun et. Al 2009). In addition, there is no mandatory law or requirements for the construction companies in

Malaysia to practice sustainable resource and waste management and in some areas, illegal dumping is still an issue for the authorities (Begun et al 2009).

There are several factors to look into why the contractors in Malaysia were not participating actively in the recycling and waste minimization. In the journal written by Y.Dosho, the aspects of the secondary materials that the contractor look into are (1) the assurance of safety and quality of the secondary materials, (2) the impact on the environment and (3) the increased cost effectiveness of construction (Y.Dosho, 1998).

In Malaysia, the road to became a developed nation by 2020 had been paved with several efforts exerted by the government to face the challenges. One of the major challenge faced by Malaysian government in the construction industry is the challenge of decoupling the economic growth and waste generation (National Economic Advisory Council, 2010).

Most of the C andD waste generated from these activities was sent to the landfills without a proper process of filtering the re-useable and recyclable materials (Salim et al, 1994). These waste that are generated from the construction site, once generated will be very hard to recycle and reuse due to its high toxicity and contamination. Hence, its prevention and minimization had been quite a popular subject to look into.

A sustainable practice should be implemented and this recoverable waste material should be handle separately. Without the correct practices such as recycling of the waste materials generated by the C & D activities, the natural raw materials used in these industries will become depleted soon. Materials such as wood, rocks, sand, gravels are non-renewable resources and they are being used in large quantify in construction industry, Gidley et al (1984).

Chapter 2

Literature Review

Solid waste management had been a major concern in Malaysia due to poor management and handling practices that resulted in affecting both the environment and public interest (Effie.P et al ,2011). These generated wastes have not been treated in the way it should be and hence a few of the consequences follows resulted from the ignorance of the management of C and D waste. These actions are such as depleting of the natural resources and also the increase of wastage of the recyclable materials, (Priyadashi et al, 2013)

According to the Department of Environment of Malaysia 2000, Malaysia construction industry generated about 25,600 ton of C and D materials daily ,(Papargyropoulou et al, 2011). Most of the generated C and D waste materials went straight to the landfill instead of being processed (Mohd F.B.Y ,2006). The total landfill that are available in Malaysia due 2008 is around 230 (Masinin et al ,2008).

Among these wastes, those can be recycled and reused are stated as below:

Concrete /mortar

These concrete and mortar can be used for land reclamation and also be crushed to recycle back the raw materials. The primary market for such recycled materials is the road construction. Cement Concrete & Aggregates Australia report (2008).

Wood

Urban wood waste resulted from trimming of the tress, clearing of the construction sites and left –over from the uses of concrete mold can be recycled. The final usage of the wood is determined by how clean the final product is (California Integrated Waste Management 2001) .

These waste materials are summarized in the table below. (Source : EPD 1995)

Component	Composition of each category of construction & demolition Waste received at landfill sites (% by weight)				
	Road work Material	Excavated soil	Demolition & Waste	Site clearance	Rennovation waste
Soil/Sand	23.0	73.8	21.5	33.0	19.4
Concrete/ Mortar	16.9	1.2	10.8	4.6	7.4
Rock /Pebble	14.4	12.5	27.7	15.0	38.8
Reinforced Concrete	14.2	0.4	5.8	0.9	7.0
Bricks/ tiles	0.8	0.4	12.1	1.4	9.6
Slurry & mud	1.8	9.7	1.5	1.0	3.1
Asphalt	24.7	0.0	0.0	0.2	0.0
Cement contaminated	1.7	0.4	3.2	15.6	3.3
Wood	0.6	0.9	10.5	13.3	7.1
Ferrous metals	0.5	0.0	0.6	1.0	1.3
Non-ferous metals	0.0	0.0	0.7	0.2	0.1
Others (include bamboo, trees,glass,plastics,bulky waste/fixtures, organic & garbage)	1.4	0.7	5.6	13.8	2.9
Total	100.0	100.0	100.0	100.0	100.0
Percentage of total quantity of C&D waste landfill	5.2	59.4	8.5	14.6	12.3

Table 2.1 C&D Waste materials

Among these waste generated , only 76 per cent of them are collected in malysia and around 5 per cent of them are sucessfully recycled, with 95 per cent of the collected wastes are disposed in the lanfills (Effie P et. Al. ,2011).

Source	Causes
Design	1.Error in contract documents 2.Contract documents incomplete at commencement of construction 3.Changes to design
Procurement	1.Ordering error, overordering, underordering, and so on 2.Suppliers error
Material handling	1.Damaged during transportation to site/on site 2.Inappropriate storage leading to damage or deterior-ization
Operations	1.Error by tradesperson or laborer 2.Equipment malfunction 3.Inclement weather 4.Accidents Damage caused by subsequent trades 5.Use of incorrect material requiring replacement
Residual	1.Conversion waste from cutting uneconomical shapes 2.Offcuts from cutting materials to length 3.Overrnixing of materials for wet trades due to a lack of knowledge of requirements 4.Waste from application process 5.Packaging
Others	1.Criminal waste due to damage or theft 2.Lack of on site materials control and waste manage- ment plans

Table 2.2 Sources and Causes of Construction Waste (Gavilan and Bernold, 1994)

Table 2.2 gave us an insights into the sources and causes of construction waste generation in the sites. Different parties in a construction projects has their role to play in waste minimization effort.

The reason why waste minimization and recycling are crucial and helps in providing a sustainable construction industry is stated as below:

Reduce costing / save money

Result of recycling the waste C&D material will reduce the amount of raw material to be purchase and hence indirectly save the contractor money to buy the raw material. From the table above, pebbles, mortar, sand and soil are some of the major C&D waste that will be found at the C&D site, these waste are excellence choice for land reclamation materials.

Environmental benefits

Minerals and raw materials are depleting due to the high activities of construction industry. Recycling in the long run will definitely reduce the amount of raw materials that will be going to use in the site and hence reduce the impact on these resources depletion. The reduced of raw material will also reduce the carbon footprint as the extraction of raw materials produce quite a significant amount of carbon footprint. These carbon footprint are produced mainly from the production and transportation of raw materials to the construction site.

In a construction site, there are many parties that will be involving themselves working together to see a project comes to its completion. These parties play a different role and each of the role are identify and suggested approach summarized at the table below used by Priyadarshi, 1994 will be referred to as a guideline for the further improvement of the approach. This approach is used to minimize the amount of waste generated from the C&D activity and hence reduce the amount of waste going to the landfill area.

Different parties that will be involve in this Construction Waste Management are as such: (Priyadarshi et al ,1994).

Table 2.3 Key issues in implementation of CWM strategy at different stages of housing project (part 1)

Stakeholder	Project Phase	CWM strategy	Key issue in implementing CWM Strategy
Designers, Architect and engineers	Planning and Designing	Design to prevent waste	1. Including CWM in project scope. 2. Efficient design with standard sizes for building materials. 3. Design for deconstruction instead of demolition. 4. Influencing client choices for green and energy efficient materials, durable non-toxic interior finishes or materials. 5. Including waste management in project management scope. 6. Use of recycled material. 7. Design precast concrete members and prefabricated elements. 8. Consider reusing materials.
Developers, builders and contractors/ subcontractors	Construction	Plan for waste prevention	1. Using value chain approach of CWM. 2. Efficient material planning and inventory management. 3. Resource efficient construction methodologies. 4. Implementing CWM strategies and promoting it. 5. Using of professionals and trades crew. 6. Reuse of the discarded materials. 7. Prefer off site prefabrication.. 8. Set up central cutting areas for wood and other materials. 9. Locate recycling stations, storage bins. 10. Standardize the material handling processes and work procedures to avoid rework and errors. 11. Revise the site layouts as project progresses.

Developer, demolition contractor	Demolition and Redevelopment	Demolition and Redevelopment	1. Identify items being reused, salvaged and recycled on site. 2. Plan for protecting, dismantling, handling, storing, and transporting items. 3. Investigate removal and separation techniques. 4. Consider using deconstruction. 5. Identify material of unique or antique feature and material with high resale value that would make it worth saving. 6. Discuss reuse ideas and the project timeline with the owner and the designer.
Product Suppliers	Project Design and construction	Project design and construction	1. Efficient packaging to minimize waste. 2. Avoid wastage in transportation. 3. Emphasize EOQ and similar techniques of material ordering and management. 4. Ensure the correct quantity of each material is delivered at right place. 5. Address recyclability and recycled content of products. 6. Denote specifications for efficiency in product use. 7. Strict control on timely supply. 8. Adherence to quality. 9. Purchase salvaged, recycled, or recycled-content materials. 10. To take back or buy-back substandard, rejected, or unused items.

Table 2.2 Key issues in implementation of CWM strategy at different stages of housing project (part 2)

With the integrated recycling system established on the C and D site, we will be seeing the numbers of total amount of waste generated will come down. The amount of waste generated that will be send off to the landfill area will also be reduced resulted from the good practices (Effie. P, 2011).

This research paper will be done based on the work of several projects of recycling and reuse of the C and D waste materials that are done by several researcher in other nation. The purpose of reviewing the different works of other researcher is to find and identify the systems that works in Malaysia.

Methods of recycling the concrete waste

When structures made of concrete are to be demolished, concrete recycling is an increasingly common method of disposing of the rubble. Concrete debris was once routinely shipped to landfills for disposal, but recycling has a number of benefits that have made it a more attractive option in this age of greater environmental awareness, more environmental laws, and the desire to keep construction costs down.

Concrete aggregate collected from demolition sites is put through a crushing machine, often along with asphalt, bricks, dirt, and rocks. Crushing facilities accept only uncontaminated concrete, which must be free of trash, wood, paper and other such materials. Metals such as rebar are accepted, since they can be removed with magnets and other sorting devices and melted down for recycling elsewhere. The remaining aggregate chunks are sorted by size.

Larger chunks may go through the crusher again. Smaller pieces of concrete are used as gravel for new construction projects. Sub-base gravel is laid down as the lowest layer in a road, with fresh concrete or asphalt poured over it. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants.

Separation methods

1) Heating and Rubbing (Kuroda and Hasida 2005)

In the heating and rubbing method, concrete masses are heated at 300°C and the cement paste content is weakened to remove mortar and cement paste from the aggregate. Figure 2.1 shows an overview of a recycled aggregate production system using this method.

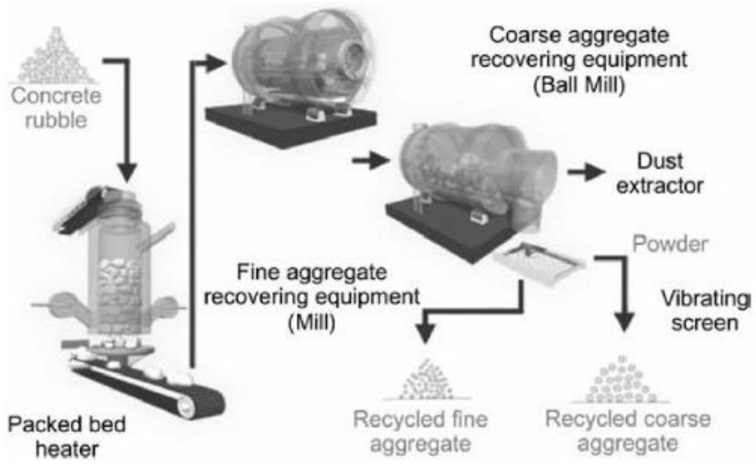


Figure 2.1 Heating and Rubbing Method

The recycled coarse and fine aggregate produced by the system is also being shown in the figure 2.1. While the production of recycled aggregate generated a large amount of fine powder, it also indicated the possibility of using fine powder like this as a substitute solidification material for the deep mixing stabilization method (soil cement walls).

2) Mechanical Grinding (Yanagibashi et al. 2005)

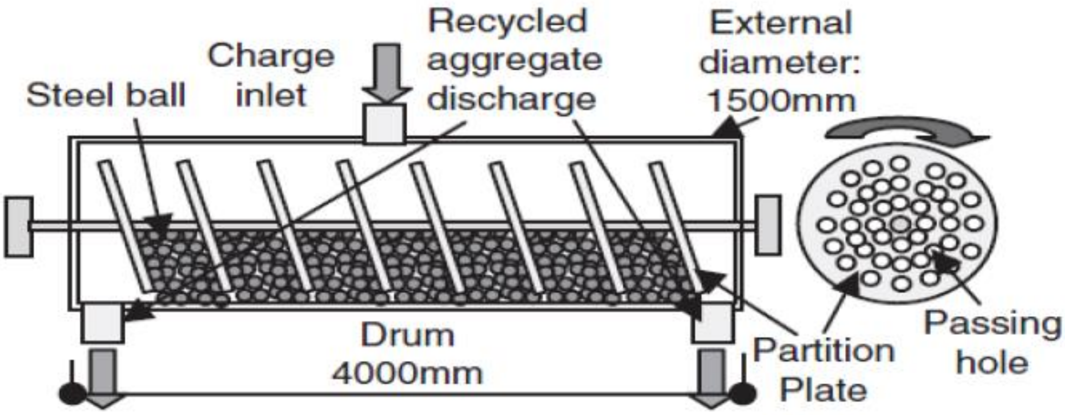


Figure 2.2 Mechanical Grinding

Mechanical grinding is a method used to produce coarse and fine aggregate by separating a drum into small sections with partitions, loading the drum with iron balls for grinding and rotating the partitions. Figure 2.2 shows an overview of the recycled aggregate production system using this method. The coarse aggregate produced by these methods has been used for actual construction projects.

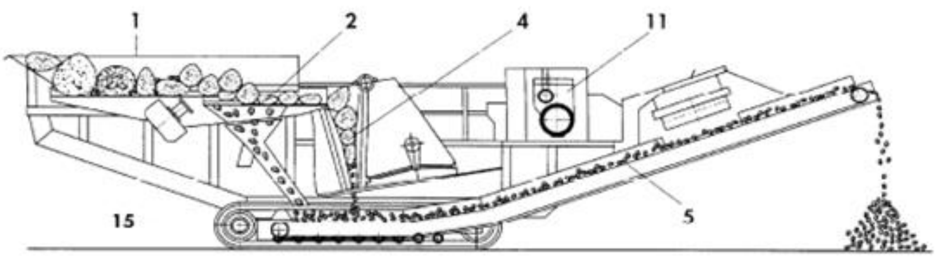
The proposed ways to recycle the construction concrete waste are mobile plant and stationary plant (Kumbhar et al. 2013). The justification of these two ways are shown in the table below, summarized from the studies done by Kumbhar et al. (2013).

From the concepts that presented by Kumbhar et al. (2013) , a mobile plant consists mainly one crusher and some sorting devices as shown in the figure 3.1. This mobile crusher will be deploy where to the site where larger chunks of concrete waste are presence. The concrete waste from the site will be crushed and screen on site. The plant can be moved relatively easily to another site.

Mobile crushing process plant	Stationary crushing process plant
1) Large amount C and C and D waste 2) Economical feasible from amount of 5000 to 6000 ton per site 3) Disposal cost are reduced because of less dumping 4) Reduce the import of aggregates due to the supply of the recycled aggregates 5) Environmental feasible as the processing might produce some sound pollution	1) High density of construction and demolition activity. 2) Reduction in disposal cost due to less dumping 3) High quality of recycled aggregates 4) Demand of aggregates importation is reduced 5) Produce other recycled products due to more processing equipment can be placed in the site 6) High initial investment is justified

Table 2.5 Comparison of mobile and stationary crushing process plant

Mobile Crusher



Main components of a mobile crusher

1-Feeding hopper
2-Oscillating conveyor
4-Jaw crusher
5-Discharging transport belt
11-Diesel engine as power unit
15-Mobile by wheels, crawlers or skids

*Figure 2.3 Main components of a mobile crusher (Kumbhar et al. 2013)*Stationary Crusher plant

Figure 3.2 gave the idea of the typical layout of a stationary recycling plant. The recycling plant usually incorporates a large primary crusher working with a secondary crusher which also include various cleaning and sorting devices to produce a relatively higher quality of recycled aggregates than its counterpart.

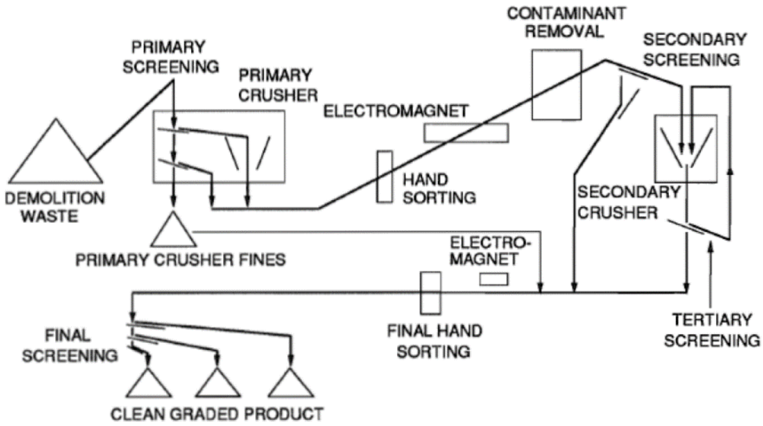


Figure 2.4 Layout of a stationary recycling plant (Kumbhar et al. 2013)

<u>Recommend Application of recycled aggregates</u>

The application of the recycled aggregates on building constructions which major parts of the design involves concrete will replace the raw aggregates in mega projects by a significant amount. The ratio given in the studies from Y.Dosho (2007) are used as reference in this research paper shown in table 3.2. This ratio of replacement of recycled coarse aggregates between 30 per cent to 50 per cent is then applied in the selected local projects to calculate the significant of this reduction in term of CO_2 emission.

To apply the recycled aggregates into construction of either roads and buildings, the quality of the aggregates are monitored by a suitable quality control. A proposed quality control for the recycled coarse aggregates are shown in Figure 3.3 .

Item	Project No.1	Project No.2
Designation	Chiba Heating Power Area - Symbiosis Building Biotope Soga	Yokohama Thermal Power Plant Premises - Incinerator Building
Authorization classification	Approval (Special project) Partial limitation: Foundation, footing beam	Approval All components in TEPCO's owning buildings*
Authorization date	18 January 2002	15 September 2004
Date of concrete placement	June 2002	May to August 2005
Amount of concrete placement	About 200 m^3	About 1,000 m^3
Specified concrete strength	Ordinary portland cement: Fc = 24 N/mm^2	Ordinary portland cement: Fc = 21–33 N/mm^2 Low-heat portland cement: Fc = 21–27 N/mm^2
Replacement ratio of recycled coarse aggregate	30%	50% (Maximum)

**Supply of recycled coarse aggregate concrete is possible only to a joint applicant's ready-mixed concrete factory.

Table 2.5 Actual results of approval by ministry of Land, Infrastructure and Transport ,Japan (MILT)

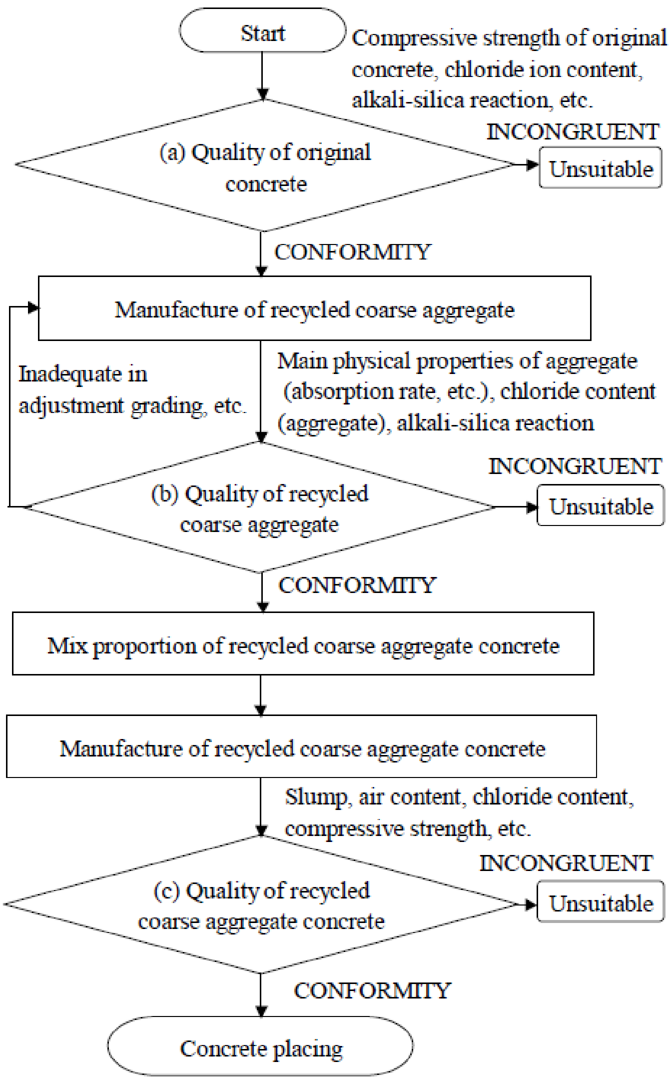


Figure 2.6 Quality control flow for recycled coarse aggregates concrete (Y. Dosho , 2007)

Problem Statement

To achieve a sustainable development alongside with the vision of Malaysia ,the problem concerning the solid waste generated from the construction site have to be dealt with. The current recycling rate of solid waste from construction industry is at 5 per cent (Alam Flora Sdn. Bhd., 2007). To tackle the problem in this sector, a few factors that contributed to this problem had been identified from the studies done by Bossink, 1996.

- Prevention of construction waste is preferable to recycling of construction waste at the end of the pipeline.
- Construction waste is more difficult to recycle due to high levels of contaminations and a large degree of heterogeneity (Brooks et al, 1994).
- Construction waste contains a relatively high amount of chemical waste (Lanning 1993).
- A cost reduction caused by preventing the generation of construction waste is of direct benefit for most of the participants that work on a construction projects.

Objectives

i. To identify the most effective Construction Waste Management plan for the Construction industry in Malaysia

ii. To recommend an effective recycling and reuse of Construction and Demolition waste in Malaysia.

Chapter 3

Methodology

This research paper will focus on providing a framework for the construction industry players to develop their construction waste management (CWM) and thus a way to benchmark their CWM practices.

Framework for Construction Waste Management Practices (CWM)

The most common waste generated from the construction sites had been identified from the previous studies done by Vivian W.Y (2011). A form had been developed based on her studies. The purpose of this form is to record the crucial data from the sites to be processed and serve as the feed for the CWM evaluation.

This simple form is aim to provide the information on what types of the raw materials that this contractor firm is dealing with. By presenting this idea to the workers on site or site supervisors, they will be able to play a role in this investigation.

The data will then be processed to complete the first part of the sources identification & quantification. The data is crucial and is aimed to provide a clear picture for the company to evaluate the data results. If the residue is more than what the company allow it to be, then the process will be evaluate to provide a better understanding of the work of the company and problem can be source out to reduce the wastage.

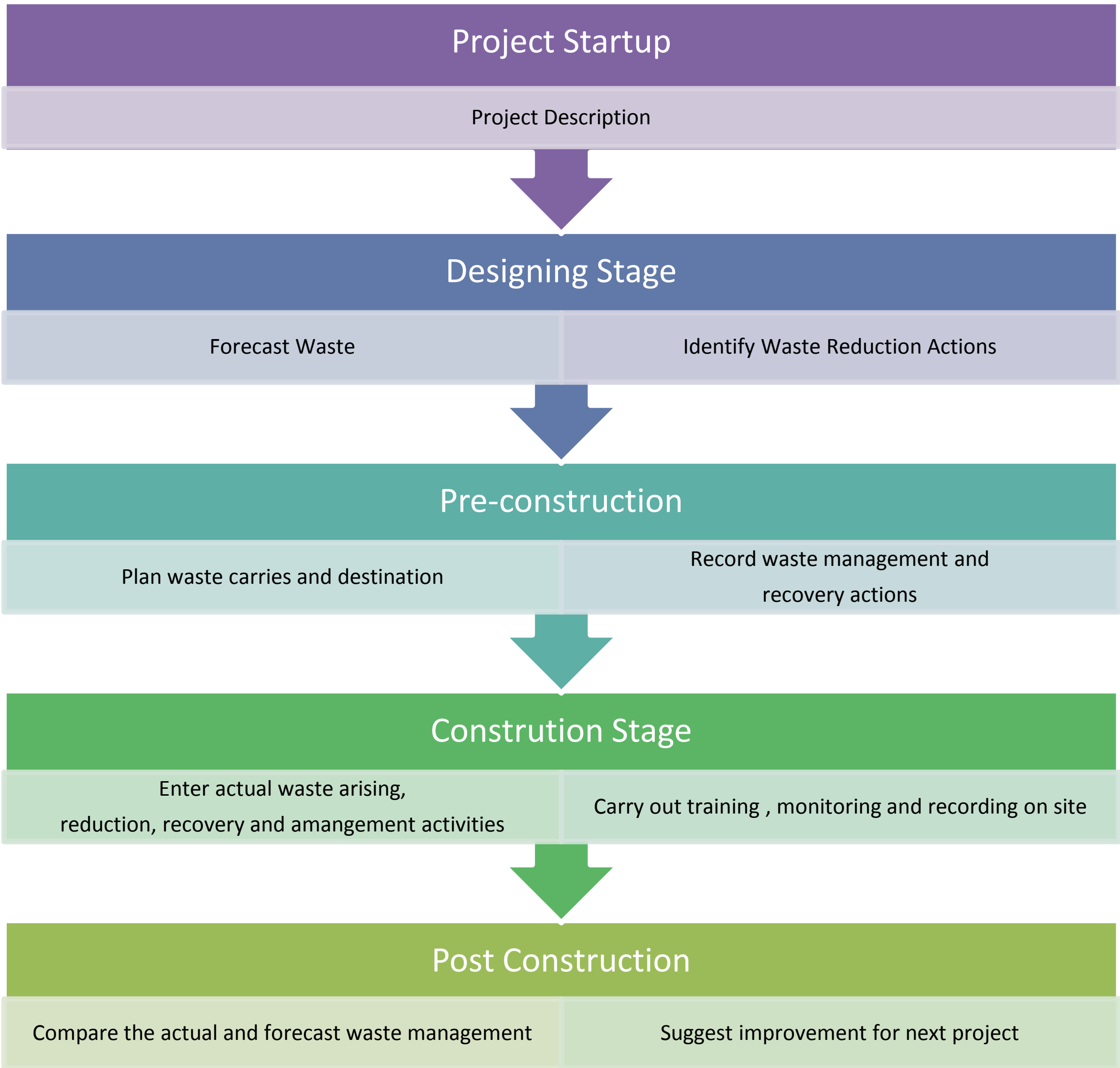
Project name :						
Project Supervisor :						
Date :						
Types of raw materials		Unit	Estimated quantity	Ordered quantity	Actual quantity	Residue quantity
1.	Steel					
2.	Cement					
3.	Concrete					
4.	Sand					
5.	Mortar					
6.	Ceramic Block					
7.	Brick					
8.	Timber					
9.	Hydrated Lime					
10.	Wall Ceramic tile					
11.	Floor Ceramic tile					

Table 3.1 Onsite monitoring and recording form (Outline)

Construction Waste Management Plan (CWMP)

The CWMP introduced in this research paper is adapted and modified from the one used in Site Waste Management Plan (Effie.P et al ,2011). The CWMP is summarized in table 3.1.

Table 3.2 Construction Waste Management Plan (CWMP) outline.



At the beginning of the project stage, the company will have to list down the specification of the projects and the nature of the projects. This is to ease the work of categorize the project according to their nature. The second stage of CWMP is to design the policy concerning the designing stage, pre-construction stage and during the construction stage. The different variable that the company will be anticipating is the forecast waste generation, identification waste reduction actions, route for the waste to be recycled or delivered and also the monitoring works.

At the end of the construction, the actual results from the waste management will be collected and compared with the original forecast value. If the result is satisfactory, it will be benchmarked and reuse in the other project as a tool for the company CWM.

The validity of this SWMP will be done by structured interview. The target for the interview is selected with the background of being in construction industry either directly or indirectly. Among them are experienced project managers and engineers with extensive involvement in construction project and industries (Effie.P et al, 2011). During the interview, the selected respondents were asked to review and give comments on the proposed framework in this research paper. The area that are focused during the interview will be the perceived benefits to the project and its effectiveness in implementing them.

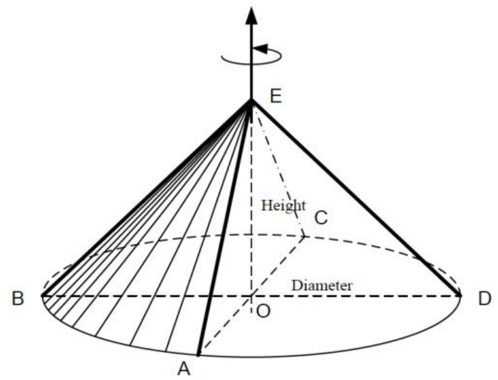
The results of the structured interview will be presented at the results of this research paper.

The collection of data

The data is collected from a medium –small size construction company. The data is collected both from the site directly and also from the design process where the wastage is factored into the quantity surveying process. The data is gathered by estimating the quantity of the waste generated at the construction site with naked eyes. The reason that the data is collected by estimation is because the construction waste that are generated on site are not being separated and hard to categorize into their types.

Approximation method using the simple calculation of the volume of these waste generated on site as shown as the figure below:

$$\text{Cone Volume} = \frac{1}{3} \times \pi \times \text{diameter}^2 \times \text{height}$$



<u>Structured Interview with questionnaire</u>

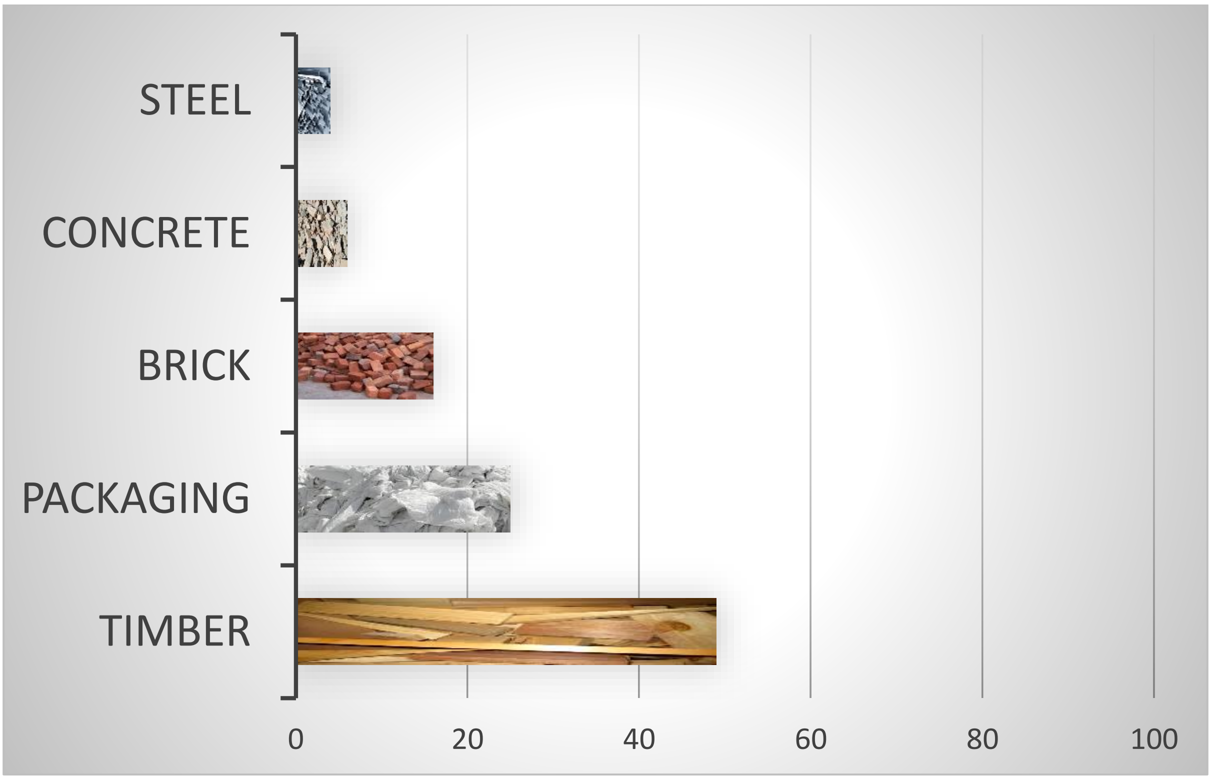
Structured interview is also being done to get the framework validated and also to seek improvement through the comments from the selected contractor firm representative. A simple questionnaire is prepared for this structured interview and the questionnaire is then collected to be included in this research paper.

In order to maximize the response rate, questionnaires are designed to be as simple and clear as possible, with targeted sections and questions. The questionnaire are also designed to be as short as possible. This questionnaire are design to target a selected sampler, so the question is selected based on the literature review and the relevant question is selected and modified to suit the purpose of this research interview. The questionnaire is prepared with blanks to be filled in and also multiple choice questions.

Chapter 4

Results and Discussions

The data was collected and tabulated as below ;



Types of Waste	Weight (Tonne)
Timber	4.9
Packaging	2.5
Brick	1.6
Concrete	0.6
Steel	0.4
Total	10

The result gave us the highest percentage of waste generated is the timber waste with 49% and followed by 25% of packaging waste which mainly consist of plastics wrapping, 16% of brick , 6% of concrete waste and 4% of steel waste. These are the constituents that are found at the project site .

The results of the structured interview are presented at the appendix section.

Chapter 5

Discussion

The project site that was selected in this research is a residential housing project at Simpang Empat, Kedah. The project consist of 29 bungalow houses and it is already at it's 75% completion stage when this research is been carry out. From the data collected throughout this whole research, is was found out that timber was the most generated waste in the construction site. This is due to the project that was selected is residential project and hence most of the building were designed to use concrete. The formwork work that require a lot of the timber to construct the formwork to hold the concrete while constructing the structural part of the building.

Other valuable recoverable construction waste that were found to be part of the constituent of construction waste such as steel were not recycled despite of being as a valuable recyclable material. This is probably caused by the ignorance of the contractor or the waste is manage properly hence it is not being recycled .

The packaging waste which is mostly plastics and because the construction waste is not manage properly hence everything is mixed and require separation process if further reuse and recycling is to be carried out.

The selected construction firm is not practicing any waste management in the whole construction project but through the interview, the company representative was committed to send the staff for any construction waste management education program. The company representative also mentioned in the structured interview where the waste disposal was not included in the planning stage and one of the reason is that there are no guideline or framework that are available for them to follow.

For the reviews of construction waste management plan that were done with the same construction firm representative, 4 out of 6 stages can be improve and 2 of them are considered reliable.

Chapter 6

Conclusion

With the increasingly concern raised for concerning the sustainability of the construction industry, the demand for an effective waste management and ways to prevent environmental destruction and to make the best use of the increasingly scarce natural resources.

This research review the factors that contribute to the generation of C and D waste in Malaysia and successfully develop a framework for the Construction Waste Management (CWM). The validity of the framework had been verified collectively through the structured interview with the selected respondent. A successful of CWM is very much dependent on the involvement of principal parties of a projects : owner, architect ,engineer, contractor and subcontractor (Kumkhar et al. ,2013).

This paper also include a few review on the previous research where the recycling system from other nations especially Japan can be implemented in Malaysia construction industry. The study shows proved that the same technology can produce as good quality of recycled aggregates as compared to the raw aggregates to be used in construction of buildings which require large amount of concrete in their design.

The construction industry which revolves mainly in the concrete building and road construction will significantly benefits from this research as the result of suggested replacement ratio of 30 percent to 50 per cent of recycled coarse aggregates reduce the carbon footprints of the project itself. This reduction serves the country in providing a more environmental friendly and creating a more sustainable environment as the country evolve slowly into a develop nation.

This research paper gave a new and updated picture of the constituent of the recyclable materials in the construction industry. This enable the research for future use of updated data for residential housing projects.

Recommendation and future development

Limitations

Some of the limitations that are discovered during this research is summarized as below:

i. The price of the recycled aggregates are much higher than the natural aggregates due to the process of recycling which requires large amount of initial investment to purchase the technology and equipment.
ii. The initiation of government are much needed in the recycling business where subsidy and tax incentives are absence currently on the recycled construction materials.
iii. The abundant of raw materials which can be required at much lower price than recycled materials makes the recycled materials unfavorable.

Future development

From this stage of the study, the following suggestion can be developed in the future studies:

i. To implement and pilot a recycling plant in Malaysia.
ii. Feasibility studies to be done in Malaysia.
iii. To produce an official Malaysia CWM standard and recycling system for the construction industry.

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Appendices

Survey form (Questionnaire)

Section A: general respondent information:

Just check (√) the suitable option.

1. In which sector dose your organization work?
□ Private □ Public

2. What best describes your construction activities
□Designer □Manufacturer or supplier
□contractor □Others please verify…………

3.Is your company familiar with construction waste management?
□Yes □No

4. In what type of projects your organization is mainly involved?
□General building (commercial and industrial) □Industrial
□Civil (highway and heavy works) _Residential
□Others please verify…………

5. Years of experience in the construction industry:
□0 – 5 years □10 – 15 years
□5 – 10 years □15 – 20 years
□More than 20 years

Section B: Information on the knowledge of CWM in company.

(Please check (√) Yes or NO)

B1) Is the contractor company representatives committed to waste management?
□Yes □No

B2) Is the contractor company willing to send the staff for construction waste management education program?
□Yes □No

B3) Does the contractor firm manage the quality of work to minimize rework?
□Yes □No

B4) Do the drawing plans meet the standard requirements of the materials?
□Yes □No

B5) Is the waste disposal included in the planning stage of the construction?
□Yes □No

B6) Do you think that a proper waste management will benefit the company in terms of profit?
□Yes □No

B7) The location and route for waste disposal should be discussed and identified during the planning stage.
□ Yes □No

B8) Does the company appoint a specific personnel to manage the waste disposal in the construction project?
□Yes □No

Section C: Reviews for CWMP

Construction Waste Management Plan

C1) During the project start up, waste management will be part of the discussion in the project meeting.

1	2	3	4	5

C2) During the designing stage, waste will be forecast and the reduction actions are identified.

1	2	3	4	5

C3)During the preconstruction stage , waste disposal routes and destinations are identified .

1	2	3	4	5

C4)Waste management actions and management will be recorded for future reference purposes.

1	2	3	4	5

C5)Trainings, monitoring and recording on site will be carry out for improvement and evaluation purposes.

1	2	3	4	5

C6) Compare the actual and forecast waste management and suggest improvement for the next project.

1	2	3	4	5

Indicator

1	2	3	4	5
Impossible	Not very reliable	Can be improve	Reliable	Strongly Reliable

Samples of the properties of recycled aggregates done by Y.Bosho (2007)

Item	Project No.1	Project No.2
Designation	Chiba Heating Power Area - Symbiosis Building Biotope Soga	Yokohama Thermal Power Plant Premises - Incinerator Building
Authorization classification	Approval (Special project) Partial limitation: Foundation, footing beam	Approval All components in TEPCO's owning buildings*
Authorization date	18 January 2002	15 September 2004
Date of concrete placement	June 2002	May to August 2005
Amount of concrete placement	About 200 m^3	About 1,000 m^3
Specified concrete strength	Ordinary portland cement: Fc = 24 N/mm^2	Ordinary portland cement: Fc = 21–33 N/mm^2 Low-heat portland cement: Fc = 21–27 N/mm^2
Replacement ratio of recycled coarse aggregate	30%	50% (Maximum)

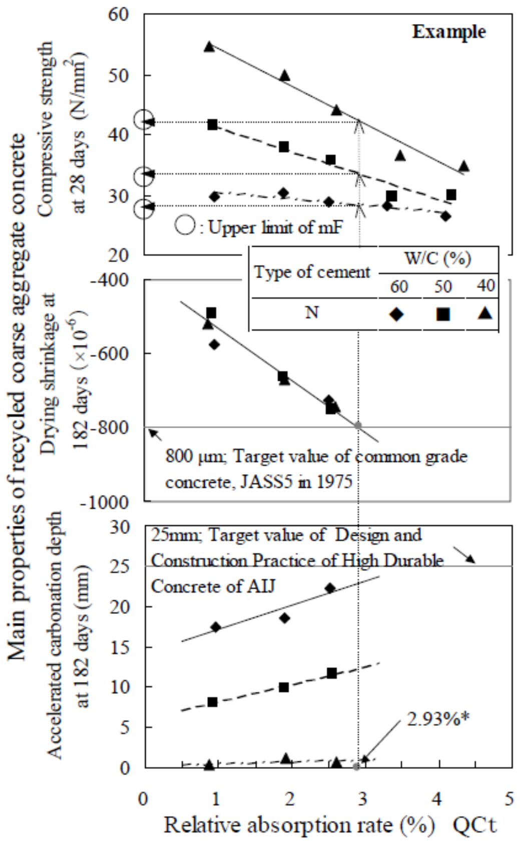
**Supply of recycled coarse aggregate concrete is possible only to a joint applicant's ready-mixed concrete factory.

Figure 5.1 Actual results of approval by MLIT.

Application destination		Project No.1		Project No.2		Test case (Reference)	
Maximum size (mm)		20		20		20	25
Examination item	Measurement method	Value of quality standard	Measurement result	Value of quality standard	Measurement result	Measurement result	
Fineness modulus (F.M.)	JIS A 1102	6.69 ± 0.20*1	6.76	6.60 ± 0.20	6.52	6.44	6.63
Density in oven-dry condition (g/cm^3)	JIS A 1110	2.20 or more	2.28	2.20 or more	2.30	2.25	2.23
Absorption rate (%)	JIS A 1110	8.0 or less	6.59	8.0 or less	6.22	6.02	7.15
Solid content in aggregate (%)	JIS A 1104	55 or more	60.2	55 or more	60.5	59.8	-
Content of materials finer than 75 μm sieve (%)	JIS A 1103	1.0 or less	0.3	3.0 or less	2.1	1.3	2.2
Abrasion of aggregate (%)	JIS A 1121	40 or less	32.3	40 or less	28.9	24.7	33.6
Alkali-silica reaction	JIS A 1804	-	-	Harmless	Harmless	Harmless	Harmless
	JIS A 1146*2	Harmless	Harmless	Harmless	Harmless	Harmless	Harmless
	ZKT-206*3	-	-	No reactivity (A)	No reactivity (A)	-	-
Chloride content (%)	JIS A 5002	-	-	0.01 or less	0.01 or less	0.01 or less	0.01 or less

*1 The value of mixed aggregate both natural coarse aggregate and recycled coarse aggregate used.
*2 Project No.1: Based on JIS A 5308 (1998), Annex 8.
*3 Method of rapid test for alkali-silica reactivity of concrete (ZENNAMA test method).

Figure 5.2 Example of quality standards of recycled coarse aggregate.



*Value of relative quality corresponding to threshold value of demand quality.

Fig5.3Example of relationship between relative absorption rate and main properties of recycled coarse aggregate concrete.

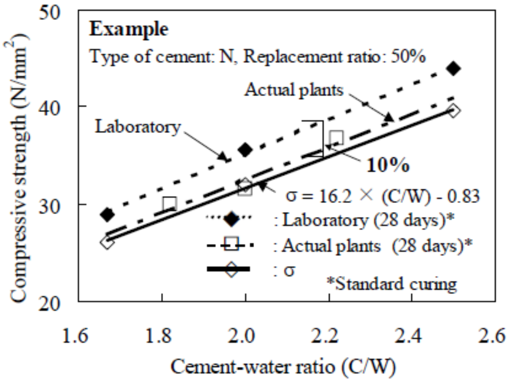
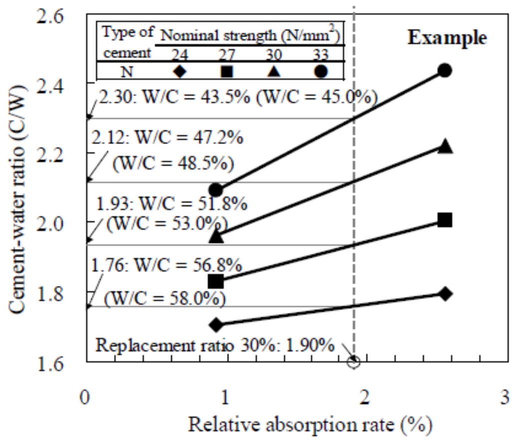


Fig5.4Example of formula for calculating water-cement ratio.



* ( ): Tested values

Fig. 5.5 Example of presumed water-cement ratio on arbitrary replacement ratios

Item	Project No.1		Project No.2		Test case (Reference)
Number of years elapsed (year)	About 40		About 40		About 40
Use of the original structure	Turbine mount of a thermal power plant		Machine foundation of a thermal power plant		Wall section of an office building
Fc (N/mm^2)	21		Unknown		18
Main quality control items	Value of quality standard	Measurement result	Value of quality standard	Measurement result	Measurement result
Compressive strength (Core: JIS A 1107) (N /mm^2)	18 or more	18.7-54.5	18 or more	27.0-46.9	19.2
Chloride ion content (JIS A 1154 or JCI-SC4) (kg/m^3)	0.3 or less	0.12-0.21	0.3 or less	0.16-0.26	-
Alkali-silica reaction	Visual confirmation	No harmful crack	Visual confirmation	No harmful crack	No harmful crack

Figure 5.6 Example of quality standards of original concrete.

Recycled aggregate for concrete-class H (JIS A 5021)		Example of investigation	
Type of impurities	Upper limit (mass %)	Amount of impurities contained (mass %)	
		Project No.2	Test case (Reference)
A: Tiles, bricks, pottery waste and asphalt concrete waste	2.0	0.007	0.107
B: Glass waste	0.5	0	0
C: Gypsum waste and chalk wall waste	0.1	0.003	0.100
D: Mineral material board waste	0.5	0.004	0
E: Plastic waste	0.5	0.005	0.024
F: Wood chips, wastepaper and asphalt concrete waste	1.0	0.004	0.050
Total amount	3.0	0.023	0.28

Figure 5.7 Mixture of impurities.

Project No.	Notation*1	Replacement ratio (%)	W/C (%)	Content per unit of concrete (kg/m^3)						
				Water	Cement	Pit sand	Crushed sand	Crushed stone	Recycled coarse aggregate	Admixture*3
1	27-18-20-N	30	49.4	183	370	720	-	713	273	1.48
2	27-18-20-N	30	53.0	176	332	481	336	683	266	3.59
	27-15-20-N		53.0	170	321	475	330	707	276	3.47
	27-15-20-L		58.0	160	276	517	359	707	276	2.98
	36-15-20-L		40.0	161	402	455	316	707	276	4.34
	27-18-20-N*2	50	53.0	176	332	481	336	489	442	3.59

*1 Nominal strength – Slump – Maximum size of coarse aggregate – Type of cement
*2 Only the sample for monitoring.
*3 AE and water-reducing admixture

Figure 5.8 Mix proportion of recycled coarse aggregate concrete.

Project No.	Notation	Item	Test method	Age	Curing method	Target value	Measurement result
1	27-18-20-N	Slump (cm)	JIS A1101	-	-	18 ± 2.5	17.0-18.5
		Air content (%)	JIS A 1128	-	-	4.5 ± 1.5	4.1-4.5
		Chloride content (kg/m^3)	JASS 5T-502	-	-	0.3 or less	0.05
		Compressive strength (N/mm^2)	JIS A 1108	28 days	Standard curing	27 or more	34.3
					In-site underwater curing		33.7
		Young's modulus (kN/mm^2)	JIS A 1149	28 days	In-site underwater curing	-	28.8
		Drying shrinkage (10^{-6})	JIS A 1129	182days	-	800 or less	676
		Accelerated carbonation depth (mm)	Recommendations of AIJ test method*1	182 days	-	-	16.7
2	27-18-20-N	Slump (cm)	JIS A1101	-	-	18 ± 2.5	15.5-19.5 17.0-18.0*2 (19.0)*3
		Air content (%)	JIS A 1128	-	-	4.5 ± 1.5	3.6-5.2 4.0-4.7*2 (4.5)*3
		Chloride content (kg/m^3)	JIS A 5308 9.6	-	-	0.25 or less	0.02-0.07 0.03*2 (0.04)*3
		Compressive strength (N/mm^2)	JIS A 1108	28 days	Standard curing	27 or more	34.4-36.6 30.4-33.6*2
				364 days		-	40.1
				28 days	In-site underwater curing	27 or more	33.9-38.2 (32.2)*3
			JIS A 1107	28 days	Core	27 or more	31.3-31.6
		Young's modulus (kN/mm^2)	JIS A 1149	28 days	Standard curing	-	27.1-28.5*2 (26.0)*3
		Drying shrinkage (10^{-6})	JIS A 1129	182 days	-	800 or less	683 (658)*3
		Freezing and thawing (Durability factor)	JIS A 1148 A	300 cycles	-	-	84.8 (68.3)*3
	27-15-20-N	Compressive strength (N/mm^2)	JIS A 1108	28 days	Standard curing	27 or more	32.6-35.8
					In-site underwater curing		30.3-36.8
	27-15-20-L			91 days	Standard curing	27 or more	36.4-38.1
					In-site underwater curing		34.6-39.6
	36-15-20-L			91 days	Standard curing	36 or more	49.9-50.0
					In-site underwater curing		47.2-51.6

*1 Based on "Recommendations for Design and Construction Practice of High Durable Concrete., Annex 1 (Recommendations for method of accelerated carbonation test for concrete).", AIJ, 1991.
*2 Test results (one lot: 30m^3, total: 185m^3) of quality variation confirmation in same ship date.
*3 Replacement ratio 50%. Only the sample for monitoring.

Figure 5.9 Typical examples of the quality control result.

Response from Structured Interview

Appendices

Survey form (Questionnaire)

Section A: general respondent information:

Just check (√) the suitable option.

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2. What best describes your construction activities

□Designer □Manufacturer or supplier

☑contractor □Others please verify............

3.Is your company familiar with construction waste managemen

□Yes ☑No

4. In what type of projects your organization is mainly involved?

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□Civil (highway and heavy works) _Residential

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5. Years of experience in the construction industry:

□0 – 5 years ☑10 – 15 years

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Construction Waste Management Plan

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1	2	3	4	5
			✓	

C2) During the designing stage, waste will be forecast and the reduction actions are identified.

1	2	3	4	5
			✓	

C3)During the preconstruction stage , waste disposal routes and destinations are identified .

1	2	3	4	5
		✓		

C4)Waste management actions and management will be recorded for future reference purposes.

1	2	3	4	5
		✓		

C5)Trainings, monitoring and recording on site will be carry out for improvement and evaluation purposes.

1	2	3	4	5
			✓	

C6) Compare the actual and forecast waste management and suggest improvement for the next project.

1	2	3	4	5
			✓	

Indicator

1	2	3	4	5
Impossible	Not very reliable	Can be improve	Reliable	Strongly Reliable