Sustainable Construction Waste Management Strategic Implementation Model

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Abstract: - All stakeholders should participate in striving towards sustainable construction in order to embark upon the environmental impact issues. Since waste perceived as major obstacle particularly in the construction industry, the government is obligated to develop tools or model to enhance the quality of waste management during the construction life cycle. The aim of the paper is to develop a conceptual framework of sustainable construction waste management implementation. There were four components that have been identified in the conceptual framework; regulation, policy, technology and guideline. The established framework will react as mechanisms in strengthening the government performance. Furthermore, the framework helps in engaging all stakeholders to collaborate with the government in construction waste management implementation.

Key-Words: - Environmental impact, sustainable construction, waste management

1 Introduction

Presently, the world now is faced with several environmental problems which continue to harm lands, jeopardizing production of natural resources [1]. According to [2], the greenhouse gas effects which caused by carbon dioxide emissions is predicted to be increased to 40 billion tons in year 2030 if no tremendous effort is thrown in to mitigate it. In addition, the construction industry is resulted of great impact on the environment and the consideration of sustainable construction becomes a top agenda at the global level [3, 4, 5]. Therefore, to facilitate the enhancement of sustainable construction implementation, the International Council for Research and Innovation in Building and Construction (CIB), in partnership with the United Nations Environment Program, commissioned the preparation of an Agenda 21 for Sustainable Construction in Developing Countries (A21 SCDC) [6].

The definition of sustainable construction defined by [7], as a way forward to balance the need to continue development without ignoring the responsibility to care for the natural environment whilst creating healthy, comfortable and economically prosperous places for people to live, work and play. There are three important aspects are emphasized in the construction industry to drive towards sustainable development [8][3]:-

Dimensions	View(s) Towards Sustainable Construction
Social	Enhancement of people's quality of life.
Economic	Employment creation, competitiveness enhancement, lower maintenance cost, high quality of working environment leading to greater productivity.
Environment	Deals with design, construction, operation deconstruction approaches to minimize the adverse impact on the environment

Table 1

People nowadays paying greater attention to the environmental issues [9] and look as if a vital aspect rather than social and economic indicators [9, 6]. According to [11], the government contribution is necessary in attaining the sustainable construction because at the end, it may give the benefits to the economical dynamics of society. At the moment, government bodies in each developed countries extensively developing the environmental assessment schemes which use to measure the environmental performance buildings as a means of attaining sustainable construction [12]. In the perspective of environment, [13] said, the criteria of sustainable construction is developed from the sub-issues arise during the construction process which describe as follows:-

Sub-issues	Footprint	Rationale of the Issues	Citation
Energy consumption	Air emission	The International Energy Agency is estimated, a 53% increase in global energy consumption is foreseen by 2030, with 70% of the growth in demand coming from developing countries.	[14]
Raw material use	Waste generation	Estimates that 70 million of waste is generated in the construction industry.	[15]
Water / land use		Human has influenced 83% of the earth's surface and the balance of the surface remains untouched by human influence. Due to the rapid development it is likely to change over time.	[16]; [17]

Table 2

However among these three aspects, construction waste has given significant impacts due to the large amount of waste generated per year as well as expensive to discard because of landfill space are becoming more limited [15]. Furthermore, by 2020 all European Union countries have to achieve a 70 % reduction by weight of this waste put into landfill [18]. As well in Hong Kong, material waste is the major environmental concern since there the material produced annually by local construction activities increased by more than 75% [19]. Therefore, most of developed countries being proactively minimized the issues of waste in the construction industry.

However, execution of waste management in attaining sustainable construction still not assist the stakeholder practices it in the construction. Refer to [20] points out that lack of knowledge about construction waste management constituted as one of the barriers in attaining towards sustainability. It is also supported by [21] who stated that lack of demonstration of tools and approach being difficult for stakeholders to deal with the waste created during construction. It might be caused of several complicated activities in construction associated with aspect planning which probably reflect to three main important elements in construction which are time, money and material [22]. Table 3 shows the current problems regarding to waste management strategy in the construction industry. Through the issues, the waste management strategy implementation model is felt urgent as a way to tackle the issue.

The Rationale of Waste Management Strategy Implementation Model	References
A lack of an industry norm or performance standard for managing waste causing uncertainty and confusion among operatives about waste management relative importance.	[23]
A proper methods/strategy is an urgent demand to improve construction management to realize the mission of sustainable development.	[24]
A lack of consideration given to waste reduction during planning and design stage, well-established waste minimization strategic model and adoption of it will help much on it.	[25]
An effective material control strategy should be implemented to control wastage during the life cycle of the construction process.	[26]
A lack of experience, inadequate planning and scheduling may causing construction waste are poor management and handling.	[27]

Table 3

Due to the recommendation from previous research, Policy maker are suggested to execute waste strategy implementation model to clearly indicate the actual flow of waste handling in the construction industry in order assist in accelerating the process towards the sustainable development. The existence of the strategic model in developing countries is also assisting in meeting the criteria of sustainable construction. Therefore, the purpose of the paper is to overview the waste management strategy being implemented in the United Kingdom, China and Singapore. At the end of the comparative study the paper attempts to identify the main component that shall be considered by policy makers to enhance the quality of waste management in the construction industry.

2 Sustainable Construction Waste Management

Since years ago, some opinion says that waste management is something that related to the achievement of sustainable construction. For instance, [28, 19] points out the advantages a well-performed construction and demolition waste management allowing a smooth implementation of construction activities while minimizing the impacts to the environment. It is aligned with the two pillars of sustainability in construction, which minimize resource consumption and alleviating environmental pollution [29]. Therefore, new strategic instruments are necessary which waste prevention aims not only at reducing the amounts of waste, but also at reducing the hazards of the waste towards the environment.

2.1 Sustainable Construction

Sustainable development establishment has been evolving worldwide for almost 25 years [30] and it is used as a measure to imbalances the ecologists in the world due to three pillars; social, economic and environment. In addition, sustainable development is interpreted straightforward by [6] as correlation of human and their environment which allowed the human right moving towards development without exceeding the critical environmental parameters. In the meantime, [21] researched that sustainable construction is vital concept should be considered in attaining sustainable development by deliberating environment, social economic and cultural issues. In fact, sustainable construction perceived as a vital subcomponent to drive in sustainable development [3].

According to [30], who the first person interpreting the sustainable construction defined it as "the creation and responsible management of a healthy built environment based on resources efficient and ecological principles". In addition, [6] clarified terms "construction" at four levels; as a comprehensive project cycle, site activity, the process of human settlement creation and relationship in the business of the construction. Based on the report published in CIB Agenda 21 for sustainable construction, outlined the six principles to be applied to the construction life cycle in achieving the sustainable construction (Figure 1) [3, 30, 20].

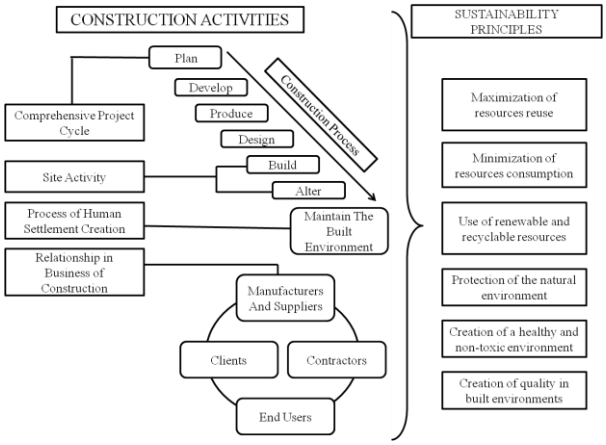

Fig 1

However, the principles adopted might be various in each country (DETR, 2000). Even differ principle adopted in each country, [32] mentioned, the sustainable construction implementation still have a potential to obtain an investment in the future and create the best performance throughout the construction life cycle activities.

2.2 Construction Waste Management

The terms "waste" is defined as portable objects that abandoned by the owner (subjective definition of waste) [33]. The definition is rephrased and understandable among communities as the symbol of inefficiency of any modern society and a representation of misallocated resources [34]. According to [36] cited from Bilitewski et al. (1994) and Gilpin (1996), waste management encompasses the collection, transporting, storage, treatment, recovery and disposal of waste, and is defined as a comprehensive, integrated, and rational system approach towards achievement and maintenance of acceptable environmental quality and support of sustainable development. To ensure construction waste is manageable, the waste management

strategy is developed now and then by government, journalism, experts and practitioners [35].

Waste management in construction perceived more intricate since it is possible to be generated in each activity during construction project (Figure 2) [37].

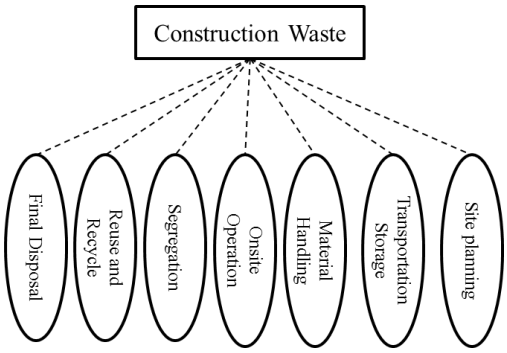

Fig 2

Nevertheless, [38] specified that there are three principal components should be concerned with construction waste which namely; labor, material and machinery waste. The principle components are relevant but it is seeing robust enough by inserting a perception from [39] who simplified the waste types into two, namely physical waste and non-physical waste. The physical waste is formed from material loss during the construction stage and non-physical waste may cause by poor management such as time overrun and cost overrun. Due to the clarification, new principle components of construction waste are formed as following figure:-

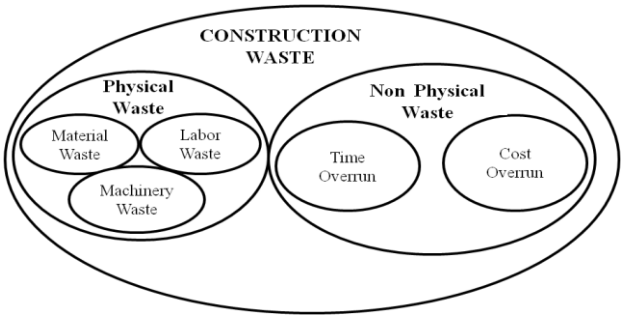

Fig 3

Viability of sustainable construction to reduce the issues of environmental being passionate promoted over the world [39, 6, 40]. Since the researcher and practitioners around the world forecasting that waste in construction has major impact on environmental aspects and tend to increase [25, 26, 41], it is relevant for government to take some actions as well as develop various ideas to create appropriate techniques in handling the issues. Refer to the assessment criteria of sustainability published in each country, less of a concern given towards waste management. There is only some of the countries highlighted waste management as one of the criteria of sustainability. It shows as follows [43, 44, 45]:-

Assessment Criteria	Australia	China	United Kingdom	United States	Japan	Canada	Singapore	Malaysia	Philippines	Brazil	Indonesia
Management	•	•	•		•					•	•
Indoor Environmental Quality (IEQ)	•	•		•	•	•	•	•	•		•
Energy	•	•		•	•	•	•	•	•	•	•
Transport	•			•	•						
Water	•	•		•	•	•	•	•	•		•
Materials	•	•	•	•	•	•			•		•
Land Use and Ecology	•	•		•							
Emissions	•				•						
Innovation	•						•	•			
Sustainable Site Development				•		•			•	•	
Waste Management			•		•		•		•	•	
Preservation of Cultural Contexts					•				•		
Outdoor environment		•	•	•	•		•	•			•
Occupant Comfort			•	•	•						
Procurement			•								
Intelligent Buildings				•						•	
Residential Building										•	
Applications and Case studies										•	

Table 4

The assessment criteria are based on the green assessment criteria established in each country which aim to reduce the overall impact of the built environment on human health and the natural environment [46]. Summarized, the Table shows that government in developed countries still takes too lightly on the waste management issues which only 4 out of 11 developed countries are stressed on the waste management in attaining sustainable construction.

3 Governments Strategic Planning for Waste Management

A. United Kingdom

Due to the statistic of waste produced in the UK, it is about 335 million tonnes of waste and 220 million tonnes consists of construction and demolition wastes [47]. The deduction of waste generation is perceived through the statistic issued by the UK Government, construction and demolition waste generated in the UK is estimated at 120 million tonnes per annum and 13 million tonnes of unused material [48]. Combination of waste management regulation, economic instruments and voluntary agreements, one of the strategies has been implemented by government to reduce the waste generation as well as to achieve targets of ethical, social and environmental performance in driving the

waste management agenda [49]. Furthermore, the introduction of new legislation is also supported by the existence of new technologies and practices in both waste disposal and recovery plus the increasing of public awareness which all uniting to deal with the waste management [36, 46]. Seen that, the UK government is proactively contribute towards waste management since it contributes to the adverse effects of climate change and being one of the top issues nowadays [50].

Refer to [51], Her Majesty's Government's Annual Report, United Kingdom, session 2010-2013, The Site Waste Management Plans (SWMP) constitute of the regulations were made law under Section 54 of the Clean Neighbourhoods and Environment Act. The act is described that the site waste management plan should be prepared by both the client and main contractor of the project worth at least 300,000€ [47, 50].

Additional, the United Kingdom (UK) Department for Environment, Food and Rural Affairs (Defra) also has published a paper entitled "Government Review of Waste Policy in England 2011" which has outlined the action should be done to achieve "zero waste economy" [52]. Aligned with the goal, the strategy calls as "zero construction waste to landfill by 2020" is also being implemented in the construction industry as a means to reach the target [52, 47]. It shows that some of the policies developed by UK government mainly focused on how to achieve a reduction of construction waste to landfill since it is one of the key areas that highlighted in the "Strategy Sustainable Construction", [54]. Refer to [48], the UK Government also keeps on striving to enhance the efficiency of waste management through the introduction of other fiscal measures and legislation which will drive the construction industry towards a closed loop production system. Closed loop production systems, refer to [55]:-

"Conceptualization of a sustainable approach to managing the entire life cycle of a consumer product, whereby all material not safely consumed during the use of the product is designed to be a valuable input into the same or other processes"

In the context of green and sustainable manufacturing, [56] revealed, closed loop production system may give the benefit in terms of economic and ecological of the whole project life cycle. Therefore, the implementation of the government's policy, regulation and guidelines is can be said as the significant approach to achieve sustainability in development. While the UK government as a top body is called to play the roles in attracting the stakeholders to develop the countries by way of embedding the environmental friendly concept.

In terms of guideline, the 'three Rs' principle of waste (reduction, re-use and recycle), otherwise known as the waste hierarchy also has been widely adopted in the UK [56, 57, 58]. These waste hierarchy broadly used as guidance for designers to adopt a waste minimization approach in their projects [60]. Another, in the waste hierarchy, waste avoidance and reduction is the prior choice of measures in the management of waste. Refer to [61], stated that the waste cannot be avoided, rather it should be recovered, reused, recycled and treated as well as it should only be disposed of as a last resort. However the 3R strategy deemed not practically relate to all parameters of the designers' environment and it is discredited because the waste occurrence during the architectural design stages is different and unpredicted [48]. As a solution, the Waste and Resources Action Programme (WRAP) was established by the government to help the UK improve its waste management practices [59]. For instance, "SMARTWaste" is introduced by WRAP as tools to facilitate on-site auditing, waste management, and cost analysis deal with waste that has already been produced [58, 47, 61] while tending to improve contractors' waste management strategy [63]. Moreover, WRAP has also introduced a waste management framework based on eight key areas (figure 4) that should be taken into consideration in construction activities from start until project completion [59]. This key area is viewed a holistic process of waste management and stakeholder roles in handling the waste management.

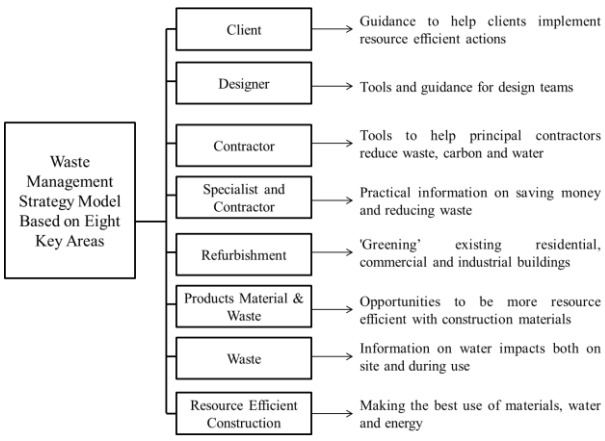

Fig 4

The step taken by the UK government to initiate better waste management in construction and demolition sector is creditable. The good thing is some of the developed countries is starting to use this approach to tackle environmental issues and reduce the burden on natural resources [64]. It shows that all of the approaches are viable to be successfully implemented and accepted widely.

B. China

In China, the government is taking some action to tackle the waste problem by establishing a policy, requiring the preparation of waste management plans for all stakeholders of the project [64, 26, 65]. According to [67], the trip ticket system also introduced as government approach to control waste transfer for public work contracts and it is a form detailing the waste load for disposal that shall be filled by the contractors. The purpose of the system is to ensure the contractors will properly dispose the construction waste through tracking its destination as well as complying with the government policy [68]. Furthermore, through the recent technologies and intensive research conducted in China, Recycled Aggregate is accepted as a sustainable building construction material [68, 69]. Another, China's government also allows the use of recycled aggregates derived from construction waste for use in government projects [65]. Research by [71] who cited from Zhang Chao (2002) and Chi Sun Poon (2006) where the utilization of recycled aggregate in road engineering is one of effective ways to deal with construction waste. Afterward, the recycled concrete aggregate (RCA) derived from concrete wastes is growing interest [72].

Since the China's Government bodies is strictly to minimize the amount of C&D waste entering Landfills [72, 73], the "Polluter Pays Principle" has introduced by the China's government which enacted under environmental law [75]. According to [76], the "Polluter Pays Principle" defined as:-

"Whoever is responsible for damage to the environment should bear the costs associated with it." (Taking Action, the United Nations Environmental Programme)

In other hence, while reducing the construction and demolition waste, it also provides an economic incentive for building professionals [76, 76, 64].

In terms of guidelines, China has developed the same 3R principle but different way of implementation is recognized [78]. Similarly to other developed countries, the hierarchy of waste management is emphasizing on reduce, recycle and reuse the waste and it is said to be the best approach in China [79]. Regarding limited landfill space and costly, the policy makers in China and waste producers are entitled to do something to avoid the waste from landfills [41, 79]. However, there will still be a substantial amount of construction materials that require disposal, either at public fill reception facilities or at landfills [80, 81, 82]. Hence, "A Policy Framework for the Management of Municipal Solid Waste (2005-2014)" has established by the government [84]. The framework includes the exchanges of hierarchy of Construction and Demolition waste in Hong Kong as shows below:-

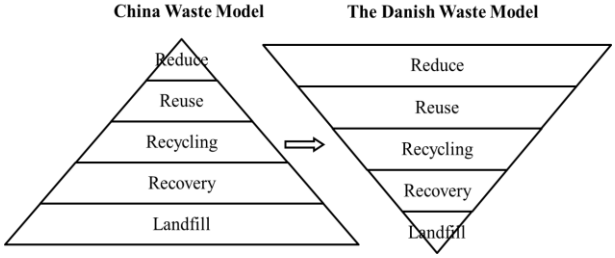

Fig 5

The earlier of China's waste hierarchy model, the landfill occupied more than 80% for waste disposal and landfill is the least priority in the waste hierarchy [85]. Next, China's government review and improve China's waste management system by way of changing the "China Waste Model" into "The Danish Waste Model", which means to reduce the landfill proportion and increase the proportion of waste reduce, reuse, and recycling (3R) as described in figure 4 [86]. This model was also executed in Denmark and has succeeded in reaching a high recycling rate for construction and demolition waste [87]. Summarized, the scarcity of landfill faces in China might be the reason why "The Danish Waste Model" adopted as well as the model is assisting to minimize the usage of land for waste disposal by way of maximizing the waste reuse and recycle.

In the context of construction and demolition waste management, there are few numbers of strategic model has been proposed by researchers and journalist in China. According to [88], the construction project life cycle is the corner stone to predict the possibility of waste production especially during the construction stage, maintenance stage and demolition stage. It is supported by [89], effective management of any future risks would be

possible if these risks are managed from the perspective of a project life cycle as well as allowed all parties involved making appropriate actions to cope with them. In addition, [88] point out, the waste material life cycle, "reuse', "recycle" and "disposal" are also the significant stage should be looked. In a way towards sustainable construction, adequate information is necessary to enable contractors considers the most environmentally friendly materials to be used, recycled and disposed. Therefore, the holistic observation towards the process of the construction project life cycle should be monitored systematically by the construction team at an early stage of the project since it is important as a guideline to predict the production of waste.

C. Singapore

Singapore is an Asian country constitutes a city-state with one of the highest per capita incomes in the world. However, waste management is an obstacle in attaining rapid development in Singapore [90]. The depletion of natural resources and government encouraging towards green buildings are driving stakeholders comes out with other alternative in obtaining building materials [91]. Therefore, to prevent the increasing of waste issues, the Building Construction Authority (BCA) drawn up an ISO 14000 Certification Scheme as a surveillance audit for construction firms towards environmental performance [92] Besides that, since limited land faces which is only 682 square kilometres, Singapore aim for "zero landfill" which attempt to minimize the amount of waste generated and recycling as much as is feasible. It can be perceived through the Singapore Green Plan (SGP) 2012 execution which listed out the targets and aims of the zero landfill [93] [94].

Another, in attaining to sustainability concept, Singapore's industry is trying to develop some industries that can develop products from recyclable waste, consume less natural resources and increase the reusability of such materials and products for the same or similar purpose [95]. In addition, while an efficient system for waste collection and disposal is critical in Singapore, The National Environment Agency (NEA) has also called for plans, develops and manages Singapore's advanced waste management system [96]. Refer to The National Environment Agency in Singapore, there are four dimensions were emphasized regarding on waste management strategy:-

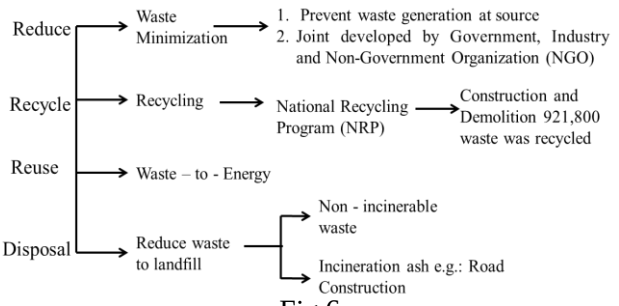

Fig 6

Actually, it is recognized that this agenda seems parallel to the government implementation in the UK which aim of sustainability for the next few decades. The fundamental of waste management strategy (reduce, reuse and recycle) mainly corresponding with other developed countries. Conversely, [92] opine that the waste management adopted by various countries are different and it is supposed to be influenced by a number of factors such as geographical area, population density, transportation infrastructure and environmental regulation. Therefore, clarified that the implementation of waste management in developed countries is various but the basis of 3R principles is perceived as main pillars in dealing with waste creation.

4 Research Methodology

To obtain the aims and objectives, the essential stages of methodology were performed in several stages. This research begins with completion of literature reviews from publication, current issues and report from the government. Related facts to figure waste management strategy adopted in developed countries. Comparative analyses being used as approach to identify the main aspects that government supposed to be considered in improving the management of waste in construction. A review and a series of observation is on the three of developed countries namely United Kingdom, China, Singapore since these countries facing a high urbanization and rapid development in terms of technologies, construction and others. In addition these countries also emphasize the waste management in the criteria of sustainability. Through studies on the previous research and research that has been successfully conducted, the conceptual framework of strategic construction waste management to be developed at the end of the stage.

5 Results and Discussion

Since the construction waste is the major obstacle in attaining sustainable construction, the government in developed countries keeps on striving to develop and generate idea to overcome the issues of construction waste. The strategic framework model for construction waste management is used to enhance the efficiency of waste management among all stakeholders. In Tandem, it is one of the criteria should be considered in attaining sustainable construction. In other hence, an improvement of waste management strategy should be periodically done since the issues of limited landfills faces by some of the developed countries becomes crucial.

The strategic implementation of the waste management in construction industry supposed to be commenced by the government body which is main pillar in formulating a strategic plan. Refer to figure 7, the conceptual framework for strategic planning of construction waste management emphasizes few aspects that the government could use in ensuring the successful implementation of construction waste management. It is namely regulation, policy, technology and guideline. These four measures are used to ensure the 3R strategy being implemented efficiently.

Moreover, from the comparative analyses, it is identified that the fundamental of the waste management still based on the three principles which are reduce, reuse and recycle in achieving sustainability. However, it is recognized that the principles of waste in developed countries being evolved by adding the 'disposal' at the end of the stage.

It is due to the several of the journalist opine that there will still be a substantial amount of construction materials that require disposal. Therefore, from the conceptual framework indicates that less waste to dispose and more reuse and recycle of waste should be done. It is based on the comparative analysis of the developed countries which mainly emphasized in reducing waste disposal to landfill due to the limited landfill.

6 Conclusions

In a way forward in sustainable construction, the obstacle for the government to deal with rapid development especially in construction that continuously comes out with the issues related to the environment. Government is called as main pillars endeavor to cut off the serious issues of waste that arise during construction.

The research is developed the four measures that should use by government to encourage and guide the stakeholders in dealing with waste. The strategic waste management that recognized from developed countries is seems to be the strategic formulation planning for any developing countries.

While allowing the development growth, it is important for government formulate the strategic planning of waste management based on these four measures to facilitate all stakeholders identified how strategic action could be made in dealing to the waste created in different stage of the construction industry. Otherwise is to standardize the waste management in the construction industry.

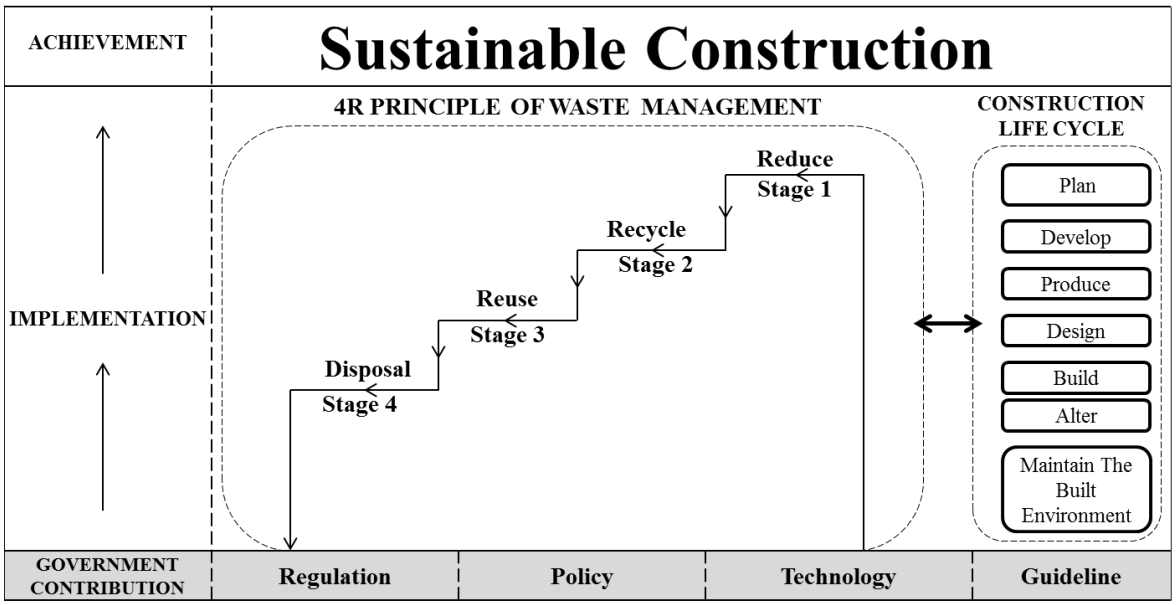

Fig 7

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