Waste diminution in Construction projects: Environmental Predicaments

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Abstract. Waste diminution in construction projects is not only a behavioural issue, but also an energy consumption and reduction concern. With construction waste equating to the significant amount of exhausted energy together with increased pollution, this contributes to a series of environmental predicaments. The overall goal of construction solid waste Management is to collect, treat and dispose of solid wastes generated by project activities in an environmentally and socially satisfactory manner, using the most economical means available. As cities expand, their construction activities and consumption patterns further drive up the solid waste quantities. Governments are usually authorized to have responsibility for providing solid waste Management services, and various administrative laws give them exclusive ownership over the waste produced. In addition, construction waste processing can be further controlled and minimized according to specialized authorities such as Environmental Protection Agencies (EPA) and their relevant acts and regulations. Moreover, a Construction Environmental Management Plan (CEMP) can further control the treatment of waste and therefore, reduce the amount produced. Key elements of a CEMP not only include complying with relevant legislation, standards and guidance from the EPA; however, also to ensuring that there are systems in place to resolve any potential problems associated with site activities. Accordingly, as a part of energy consumption and lessening strategies, this paper will discuss various effective waste reduction methods for construction projects. Finally, this paper will also examine tactics to further improve energy efficiency through innovative construction waste Management strategies (including desirability rating of most favourable options) to promote the lessening of overall CO₂ production.

1. Introduction
Waste diminution in construction projects is not only a behavioral concern, but is also an energy consumption and lessening apprehension. The overall goal of waste diminution in construction projects is not only to collect, but also to effectively treat and dispose of wastes in an environmentally and socially satisfactory manner, using the most economical means available. As more construction projects are being built, greater quantities of waste are being produced. Moreover, increased traffic congestion adversely affects the productivity of the solid Waste Management. This productivity loss is aggravated by longer hauls since increasingly open land for disposal is further and further away from urban centers [1]. Accordingly, this will also increase the overall cost of e waste diminution. In developed countries, it is common to spend 5-7 percent of their available budget on waste diminution [2]. This high proportion of the cost is due to a comprehensive and thorough waste diminution strategies and recycling practices [3].

The sustainability of waste diminution and subsequent practices is a valuable solution in providing
an effective Waste Management service [4]. Such Waste Management services also satisfy the needs of the end users [3]. Accordingly, a key factor of sustainable solid waste diminution is appropriate strategic planning, as well as adhering to associated acts and regulations. Such acts and regulations are also dynamics of useful analytical tools [5]. On the other hand, various pollution reduction strategies also further enhance the sustainability of waste diminution [3] and [6]. These pollution reduction strategies support global needs and provide appropriate calculations on how to achieve sustainable waste diminution and management procedures. Waste Management procedures thus are crucial components of waste diminution in construction projects.

2. Waste diminution in Construction projects
The crucial components of waste diminution in construction projects not only include effective and appropriate Waste Management procedures; but also a sustainable framework [7]. According to [8] and [9], sustainable waste diminution in construction projects includes):

1. Strategic planning and preparation. Undertaking state and federal strategic planning to design and implement integrated waste systems, which are responsive to dynamic demographic growth.
2. Implementation of a comprehensive framework. An inclusive policy outline is produced at the national, state, and local government level to connect, environmental, social, economic and other community-based policies.
3. Institutional capacity building. The institutions that provide the service typically need to be restructured so that they are more accountable and transparent to the stakeholders which they serve. The creation of specific departments managed by qualified engineers who are trained in systems design and operation’s rationalization.
4. Economic impact. Implement specialized waste transfer stations and long-distance haulage, to reduce the overall cost of collecting, transferring and disposing of construction waste. In addition, utilize government cost-sharing arrangements such as the creation of fund subsidies to further motivate new waste reduction technologies.
5. Analysis of technology choices. To determine the most cost-effective Waste Management systems, carefully analyze various technology-based alternatives. Such technology-based alternatives include, improved computer-aided machines, which are not only faster in processing construction waste, but also are capable of minimizing waste through recycling processes. In evaluating such machines, it is conventional to conduct time-and-motion studies of existing systems and tests of various operating methods.

To further improve waste diminution in construction projects, managers need to first differentiate waste produced from low-rise compared to high-rise buildings. Table 1, represents the material waste differentiation in the USA [10], UK [11] and Australia [12].

| Countries | Waste Material | High Rise Buildings | Low Rise Buildings |
|-----------|----------------|---------------------|--------------------|
| USA       | Metal          | 18%                 | 8%                 |
|           | Concrete       | 28%                 | 11%                |
|           | Timber         | 8%                  | 18%                |
|           | Plastic        | 7%                  | 8%                 |
|           | Ceramic        | 8%                  | 6%                 |
|           | Others         | 31%                 | 49%                |
| UK        | Metal          | 13%                 | 8%                 |
|           | Concrete       | 20%                 | 10%                |
|           | Timber         | 8%                  | 11%                |
|           | Plastic        | 15%                 | 15%                |
|           | Ceramic        | 8%                  | 6%                 |
|           | Others         | 36%                 | 50%                |
| Australia | Metal          | 17%                 | 10%                |
|           | Concrete       | 24%                 | 13%                |

Table 1. A cross-national comparison of waste material production in high and low rise construction.
### Table 1

| Material  | Low-Rise (%) | High-Rise (%) |
|-----------|--------------|---------------|
| Timber    | 8%           | 18%           |
| Plastic   | 8%           | 8%            |
| Ceramic   | 8%           | 6%            |
| Others    | 35%          | 45%           |

While [10] argued that the main waste material in the USA construction industry for high-rise is concrete and subsequent low-rise is timber, [11] claimed that for the UK, concrete is the main waste material for both high and low-rise buildings. Conversely, [12] also maintained that for the Australian construction industry concrete, and timber are the main waste materials.

Due to its composition, timber can easily be reprocessed into reusable materials. Recycling concrete, on the other hand, is a much more complex and costly process. Figures 1a and 1b represent the collective (USA, UK and Australia) average of waste materials for both low and high-rise buildings, derived from Table 1.

**Figure 1a.** Collective (USA, UK and Australia) waste materials of high-rise buildings.

**Figure 1b.** Collective (USA, UK and Australia) waste materials of low-rise buildings.

Compared to other materials, both concrete and metal account for a high percentile of waste for both low and high-rise buildings. Although low-rise buildings have higher timber waste, this material is easily recyclable and is also eco-friendly. It is thus concrete and metal that could cause significant environmental consequences due to the greater difficulty and energy usage in recycling them. As [13] correctly argued, one of the most important issues during the Waste Management process is the overall environmental predicaments. Since construction projects produce a high amount of waste, the environmental predicament is a fundamental issue to contemplate, when considering waste diminution in construction projects.

### 3. Environmental Predicaments

Matching environmental and economic endeavors requires a Waste Management strategy that facilitates ecosystems, protects land and enhances cultural resources [14]. Consequently, waste diminution in construction projects generates environmental dilemmas and predicaments. Figure 2 below represents a generic construction Waste Management outline, with environmental predicaments highlighted.
Figure 2. Generic construction Waste Management outline.

As can be noticed, as a part of the environmental predicaments, the actual control and processes need to be carefully integrated into the Waste Management and regulatory outline phases. Since such environmental predicaments are integral components of any effective waste diminution plans for construction projects, they need to be cautiously premeditated and implemented. Drawing on the work of [15], [16] and [17] such environmental predicaments include:

- How to effectively reduce the amount of waste produced. This includes the reduction of unnecessary waste through the diminution of redundant construction consumptions.
- How to efficiently reuse the waste without reprocessing or remanufacturing. This comprises the reduction of construction waste through reusing packaging, and other useable materials.
- How to successfully recycle the waste without significant pollution production.
- How to proficiently recover the energy for the purpose of heat, electricity and fuel.
- How to resourcefully dispose of the waste through appropriate landfill processes and sites for the unrecyclable waste.

The overall environmental predicaments of waste diminution in construction projects is provided in Figure 3 below.

Figure 3. Environmental predicaments of waste diminution in construction projects.

As can be noticed, the environmental predicaments of waste diminution in construction projects consist of three main factors:
1. Energy Analysis incorporating Greenhouse Assessment (EA&GA). While Energy Analysis provides findings using fields such as Portfolio Impacts Analysis; Greenhouse Assessment, on the other hand, presents methodologies for calculating CO2 emissions [18]. Accordingly, the combination of Energy Analysis and Greenhouse Assessment should further improve the evaluation of alternatives, in particular, for construction material manufacturing methods.

2. Strategic Environmental Impact Assessment (SEIA). This is a process to support decisions in the context of sustainable environment strategies. It further assists with waste policy-making and promoting such guidelines via positioning key environmental milestones together with integrating the green economy [19].

3. Sustainability Impact Assessment (SusIA). This can further assist with governance procedures through improved transparency. It can also enhance decision making because of systematically assessing economic, environmental and social impacts [20].

To further examine these three main factors, their occurrence in US, UK and Australia construction industries were also investigated. Table 2 provides the comparison of the local, state and federal environmental jurisdictions in these countries.

| Countries   | EA&GA | SEIA | SusIA |
|-------------|-------|------|-------|
| USA         | Local●State○Federal● | Local●State○Federal○ | Local●State●Federal● |
| UK          | Local●State○Federal● | Local●State●Federal○ | Local●State○Federal● |
| Australia   | Local●State○Federal● | Local●State●Federal○ | Local●State●Federal● |

As it can be observed, while the EA&GA are applied at the federal level in each country, the SEIA relates to either the local or state level, (or both as in Australia). The SusIA on the other hand, pertains at either the federal jurisdiction in the UK, or at both federal and state levels in the US and Australia. Such variances in the mandates could thus create governing dilemmas. Once again, such governing complexity could also cause additional environmental predicaments especially for construction projects. It is thus fundamental to ensure that all the three main environmental factors (EA&GA, SEIA and SusIA), are treated holistically rather than individually. Even though, these three main environmental factors have different systems and ecological foci, they need to be carefully integrated within the Construction Environmental Management Plan (CEMP). In addition, the three main factors of waste diminution in construction projects need to be carefully applied in all the applicable jurisdictions [21] and [22].

4. Conclusion

The overall goal of construction solid waste diminution is to carefully manage the excess in an environmentally and socially suitable manner. Although an appropriate CEMP would further control the treatment of the waste, it is ultimately the three main factors of waste diminution in construction, which further refines such processes. As a part of the waste diminution for the construction projects, this paper first examined the most common waste materials in the USA, UK and Australia construction industries. Moreover, this paper determined that environmental predicaments of waste diminution in construction consist of three main factors (EA&GA, SEIA, and SusIA). Accordingly, all of these three factors were investigated to prompt recommendations for improved environmental processes for waste diminution in construction projects.

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