The Research of Solid Waste in High-Rise Building

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ABSTRACT

With the pace of urbanization, high-rise building solid waste in the proportion of urban waste increased continuously. The paper estimating the solid waste of high-rise building by building GM (1, 1) model firstly, and come up with an adaptable method to sorting the mass. Then, to analysis the reuse of solid waste in high-rise building and increase the recycling rate of these wastes. The success of the building wastes recycling is dependent on the demonstration of the economic advantages associated with it as happened with the techniques.

INTRODUCTION

With the pace of urbanization, high-rise building solid waste in the proportion of urban waste increased continuously. According to statistics, the total domestic high-rise building waste has reached 7 billion tons, and an increase of about 300 million tons a year of. According to incomplete estimate, China's building waste output has accounted for 30% ~ 40% of the total municipal waste[1]. Until very recently, the recycle processes of solid waste were subordinate to a single principle, the minimization of the time spent in this operation, as a consequence the different waste streams would end all mixed up. However, the need to maximize the reuse and recycling of high-rise building wastes has forced the appearance of a new principle named "selective demolition"[2]. The selective reuse processes involves the removal of components of the high-rise building in the inverse direction of its construction.

ESTIMATING SOLID WASTE IN HIGH-RISE BUILDING

The estimation of the quantities of the different solid waste in high-rise building depends on the building system, the characteristics of the demolition and sorting process. It also depends on the amount of buildings under construction, rehabilitation or demolition at any given time, which will influence the quantities of solid waste in high-rise building for a certain area or country. Specific files were also developed for the amount of wastes associated with building construction. The specific card files allow for an estimation of the amount of wastes generated during the construction of a high-rise building based Wambucalc software tool (Table 1).
**TABLE 1. EXAMPLE OF A CALCULATION CHART FOR WAMBUCALC** [3].

<table>
<thead>
<tr>
<th>Construction component</th>
<th>Construction design</th>
<th>SUM (kg)</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>m2</td>
<td>81.97</td>
<td>2156.6</td>
</tr>
</tbody>
</table>

At present, the domestic scholars on the building waste prediction analysis of the research use more conventional regression analysis and time series analysis method. Through the actual construction waste output, the annual construction area, the area and the annual commercial housing sales area and other factors, Feng Yanli has established a multiple regression building garbage prediction model [4]. Zhang Hongyu, Yang Huafei use of the history of the past few years to use the time series of methods to build the ARIMA forecast model of Chaoyang District of Beijing building garbage [5]. Through the establishment of index trend model, Liao Zhiqiang, Zhu Ning get a reasonable forecast of city garbage [6]. However, the amount of building waste is a complicated system which has many factors, and its development process is characterized by continuous and gray dynamic, and is a typical gray system.

By use of grey system theory to build GM (1, 1) model of urban building waste for analysis and prediction, can have a profound understanding of the status of China's building waste yield, and can also be relevant departments of building waste management planning and regeneration utilization and provide an important basis. This has great significance for the building waste management and resource planning and management.

The accuracy of the gray GM (1, 1) forecasting model is generally tested by the residuals and the posteriori difference methods. What’s more the accuracy of the model was evaluated by mean square error ratio $C = \frac{S_2}{S_1}$, average relative error

$$\bar{\Delta} = \frac{1}{n} \sum_{k=1}^{n} \left| \frac{x^{(0)}(k) - x^{(0)}(k)}{x^{(0)}(k)} \right|$$

and small error probability $P = P\left\{ |e(i) - \bar{e}| < 0.6745S_1 \right\}$. The average relative error of the mean square error ratio and the average relative error are smaller, and the smaller the probability of small error, the higher the accuracy of the forecasting model is.

Order $x^{(0)}$ is the original sequence, $x^{(0)}$ is the simulation sequence of GM (1, 1) model, $e^{(0)}(k) = x^{(0)}(k) - x^{(0)}(k)$ is residual error sequence.

When the model by the above inspection is unqualified, the GM (1, 1) model can be established by the residual data sequence, so that the original model can be corrected and the forecast precision of the model can be improved in Table 2.

**TABLE 2. PREDICTION ACCURACY LEVEL.**

<table>
<thead>
<tr>
<th>Prediction accuracy level</th>
<th>$P$</th>
<th>$C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (level 1)</td>
<td>&gt;0.95</td>
<td>&lt;0.35</td>
</tr>
<tr>
<td>Qualified (level 2)</td>
<td>&gt;0.80</td>
<td>&lt;0.50</td>
</tr>
<tr>
<td>Barely (level 3)</td>
<td>&gt;0.70</td>
<td>&lt;0.65</td>
</tr>
<tr>
<td>Unqualified (level 4)</td>
<td>≤0.70</td>
<td>≥0.65</td>
</tr>
</tbody>
</table>
If the characteristics of building components are unknown it is still possible to estimate the quantity of solid waste in high-rise building. For this purpose it is necessary to know the construction area, the type of building (dwelling house, hotel or office building), and the comfort level (low, medium or high). Fig. 1 shows the relationship between the building height and the solid waste mass.

![Solid waste variation trend according to building height](image)

**Figure 1.** Solid waste variation trend according to building height.

Moreover, the solid waste data in high-rise building according to the production of building waste from 2009 to 2013. The examination of the metabolism GM (1,1) model shows that the accuracy grade is good. So the metabolism GM (1,1) model can be used to predict the building waste production. The following formula is the model:

\[
\begin{align*}
    x^{(1)}(k+1) & = 692154e^{0.1463188k} - 602140 \\
    x^{(0)}(k+1) & = x^{(1)}(k+1) - x^{(1)}(k)
\end{align*}
\]

The production increases 300 million tons per year with an average annual growth rate of 14.70%. The high-rise building waste production will be 3 billion tons in 2017 according to the prediction. This is in accordance with the urban economic growth and large-scale infrastructure construction in China.

If the current treatment of building waste keeps on, China’s land resources will be much scarcer and the sustainable development of society will be affected. It is very urgent for China to find an effective way to deal with building waste from the fundamental.

The prediction result is very useful to understand the present situation of building waste production. Meanwhile, the prediction result can help government and enterprise recycle building waste and turn some of them into treasure, and the sustainable development of economic, resources and environment can be achieved.

**THE REUSE OF SOLID WASTE IN HIGH-RISE BUILDING**

Given that the reuse processes of solid waste in high-rise building takes longer and is therefore more expensive than traditional reuse, this means that this technique could only be viable if financial compensation for this option is provided or if the regulations favor selective reuse. Regulations that set very low recycling rates, inhibit the implementation of selective demolition. Harnessing the full
potential of selective demolition implies that in the design phase some principles to enhance the disassembly of the building are met which including the use of recycled and recyclable materials; minimize the number of types of materials; toxic and hazardous materials; composite materials and make inseparable products from the same material; secondary finishes to materials; standard and permanent identification of material types; the number of different types of components; components sized to suit handling at all stages; minimize the number of fasteners and connectors; joints and connectors to withstand repeated assembly and disassembly.

The on-site-sorting allows for the separation of the different stream wastes (paper, wood, metal, plastic, etc.), being a crucial step to increase the recycling rate of solid waste in high-rise building. Wang et al. identified six critical success factors for on-site sorting of construction waste in China[7]. The sorting process can reduce the problem of recycling. Tab.3 shows the sorting process used for the production of recycled aggregate.

| TABLE 3. THE CRITERIA FOR RECYCLING OF SOLID WASTE IN HIGH BUILDING. |
|-----------------|--------|--------|---------|--------|--------|---------|
| Parameter       | Cmax(mg/m3) | Tmax(h) | Cb(mg/m3) | Tb(h)  | R(mg/m2h) | TCE(year) |
| Humidity        | 5.03   | 19.5   | 4.47     | 37     | 5.37     | 10       |
| Calcium sulfate di-hydrate | 4.83   | 19     | 3.17     | 38     | 3.81     | 15       |
| Soluble potassium salts | 7.99   | 10.5   | 7.43     | 26     | 8.93     | 6.8      |
| pH              | 12.4   | 18     | 12       | 25     | 14.4     | 3.8      |
| Toxicity        | 13.8   | 8      | 13.4     | 16     | 16.1     | 3.4      |

The recycling of solid waste in high building is carried out through various fragmentation operations (crushing and grinding). In order to reduce the dimensions of the concrete pieces jaw crushers, hammer mills and other mechanical devices are used. Although sorting operations can separate ceramic aggregates from concrete aggregates it is not easy to separate the rock fraction from the cement paste. Coarse aggregates with a cement paste have a higher water absorption reducing the performance of concrete. Moreover, assuming that the recycling plants will receive and solid waste in high building from numerous sources a dispersion of the properties of the recycled aggregates will increase leading to an increase in the dispersion of the quality of concrete. It is possible to submit the concrete waste to a heat treatment in order to achieve a complete separation between the aggregates and the cement paste. Using a heat treatment between 300 and 500°C allows obtaining aggregates identical to the original ones. The temperature rise causes the evaporation of the hydration water making the cement paste rather fragile, and the use of mechanical energy facilitates the separation between the aggregate and the binder.

CONCLUSION

With the rapid development of social economy and the continuous improvement of people's cognition, the concept of building waste has been improved and perfected. Building waste refers to construction units, the construction unit of the
new, alteration, expansion and removing all kinds of buildings, building materials, pipe network and residents decoration housing in the process of muck, abandoned material and other waste collectively. Since the Earth does not have an unlimited capacity in terms of continuing to support the current level of devastation, the more developed countries must adopt very high environmental standards. The construction industry is one of the sectors that must reduce its environmental impact. Several tools have been developed for the assessment of the environmental impacts of buildings; however, it seems unlikely that it is possible to accommodate the 8,000 million people expected for the year 2050, in buildings with the highest environmental rating under these tools without intolerable environmental consequences. As for construction and building materials, their highest environmental impact is not so much related to their scarcity but to the extraction of raw materials needed for their production.

REFERENCES