# Application of grey model to predict the construction wastes

GAO Shunxi

Handan Polytechnic College,Handan, hebei 056001

Gaoshunxi5128@163.com

**KEYWORD:** Construction waste; Production forecast; Gray model

**ABSTRACT:** With the rapid development of urbanization in our country, production of the construction waste is rapid growth. In this paper, through the production of construction waste is analyzed, we will establish GM (1, 1) model which will forecast the production of construction waste for the next few years. At last, we verify the accuracy of the model.

## INSTRUCTIONS

With the rapid development of urbanization in our country, production of construction waste is rapid growth, and each year hundreds of millions tons of construction waste cause great pressure on the environment. China since reforming and opening, the process of urbanization in our country is rapid. Because of new district developing, municipal infrastructure construction and old city renovation and other activities a large number of construction waste produced. According to statistics, construction waste production reached 40 million ~ 50 million tons in our country every year, the ratio has accounted for 30% ~ 40% of the total waste, and the accelerating rate is growing every year.

In our country, there is not a clear definition on construction waste. In simple terms, construction waste is produced in the process of the construction. The ministry of construction promulgated the regulation on administration of urban construction waste in March 2005, which makes the further definition of construction waste. The construction waste is refers that the building and construction units product discard, muck and other waste residue during the building, rebuilding and expansion and removal of various kinds of the process of building, structures and pipe network, and the process of building decoration of the concrete.

### Analysis of the composition of construction waste

In the process of construction, architecture structure may be different, but construction waste is basically the same in the process of architecture, just composition proportion will be different. To this, we will have some comparison, which is shown in table 1. As table 1, due to the particularity of the structure of brick structure, it produces that the construction waste is more. It is so an effective way to improve the structure of the system of building that that it can reduce construction waste generation. In addition, we can see from the table, the source of the construction waste is mainly construction materials, so we must manage the use of building materials reasonably.

When building demolition, the group of construction waste is different for building structure types. As table 2 shows.

As can be seen from the table 2, the proportion of waste wood, waste brick and waste concrete are 3%, 7% and 3% in the steel structure building demolition waste, and brick structure is 32%, 40% and 32%. This shows that the waste quantity of building demolition is large, and different structure types of building is very difference in demolition composition.

### Production predict of construction waste

Production predict of construction waste mainly uses the known data to forecast the unknown construction waste production. It is need to build mathematical model for predict the number of construction waste. Based on grey system theory, the model has the following advantages: less sample demand, and the relatively simple principle, and the higher prediction precision. It is the study of "small sample", the small sample is need to be part of the known information, unknown sample of the partial information. The information of "poor" or "rich" does not affect the forecast. So it is feasible to use the grey forecasting model to predict the future construction waste production.

 

**Principle of GM (1, 1) model**

Set the original sequence $X^{(0)}$is:$X^{(0)}=\{X^{(0)}(1),X^{(0)}(2),X^{(0)}(3),X^{(0)}(4),\cdots,X^{(0)}(n),\}$

According to the grey system theory to the original sequence do 1 accumulation generation $X^{(1)}=\{ X^{(1)}(1),X^{(1)}(2),X^{(1)}(3),X^{(1)}(4),\cdots,X^{(1)}(n)\}$

$X^{(1)}(n)= \sum_{j=1}^{n} X^{(1)}(j)$

Compared with the original sequence, sequence $X^{(1)}$ is greatly weakened the degree of randomness, and the stability is greatly increased.

Structure matrix

$$B=\begin{bmatrix} -\frac{1}{2}[X^{(1)}(1)+X^{(1)}(2)] & 1 \\ -\frac{1}{2}[X^{(1)}(2)+X^{(1)}(3)] & 1 \\ ...] & \cdots \\ -\frac{1}{2}[X^{(1)}(n-1)+X^{(1)}(n)] & 1 \end{bmatrix}, Y=\begin{bmatrix} X^{(0)}(2) \\ X^{(0)}(3) \\ \cdots \\ X^{(0)}(n) \end{bmatrix},$$

Then the GM(1,1)model is

$\frac{dX^{(1)}}{dt}+aX^{(1)}=\mu$ $a$ as the development of gray, $\mu$ as endogenous control coefficient. Using the least square method we can get $\begin{pmatrix} \hat{a} \\ \hat{\mu} \end{pmatrix} = \left(B^{(T)}B\right)^{-1}B^{T}Y$ ,then $\hat{X}^{(1)}(K+1)=\left[X^{(0)}(1)-\frac{\hat{\mu}}{\hat{a}}\right]e^{-\hat{a}K}+\frac{\hat{\mu}}{\hat{a}}$,

Return the original data $\hat{X}^{(0)}(K+1)=\left[X^{(0)}(1)-\frac{\hat{\mu}}{\hat{a}}\right]e^{-\hat{a}K}(1-e^{\hat{a}})$

From 2003 to 2012, construction waste production arrangement, as shown in table 3.

$X^{(0)}(t)=\{5.14,6.17,6.99,8.13,9.55,10.51,12.75,14.87,17.34,20.23\}$

Then,

$X^{(1)}(t)=\{5.14,11.31,13.16,15.12,17.68,20.06,23.26,27.62,32.21,37.54\}$

$$B=\begin{bmatrix} -5.66 & 1 \\ -6.58 & 1 \\ -7.56 & 1 \\ -8.84 & 1 \\ -10.03 & 1 \\ -11.63 & 1 \\ -13.81 & 1 \\ -16.11 & 1 \\ -18.79 & 1 \end{bmatrix}, Y=\begin{bmatrix} 6.17 \\ 6.99 \\ 8.13 \\ 9.55 \\ 10.51 \\ 12.75 \\ 14.87 \\ 17.34 \\ 20.23 \end{bmatrix},$$

after then $\begin{pmatrix} \hat{a} \\ \hat{\mu} \end{pmatrix} = \left(B^{(T)}B\right)^{-1}B^{T}Y$

Available prediction models:

$$\hat{X}^{(1)}(K+1)=\left[X^{(0)}(1)-\frac{\hat{\mu}}{\hat{a}}\right]e^{-\hat{a}K}+\frac{\hat{\mu}}{\hat{a}}$$

Inspection of the model precision, we find the model precision is level 2, so it is suitable for short or medium term predict.
According to the model to predict the future several years of construction waste production as shown in table 4

## Conclusion

As you can see in the above instance analysis, the GM (1, 1) prediction model is smaller for the amount of data, and the precision is higher. It is strongly practicality and effectiveness. It is ideal prediction method. Therefore, the GM (1, 1) prediction model to predict the results can provide scientific basis for the production prediction of construction waste.

## References


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Table 1 Analysis table of construction waste

| Composition of construction waste | Construction waste composition | | | Construction waste for the proportion of other materials |
|---|---|---|---|---|
| | Frame shear wall | The framework | Brick concrete structure | |
| mortar | 10~20 | 15~30 | 30~50 | 3~12 |
| Broken brick | 10~20 | 10~20 | 8~15 | 5~10 |
| concrete | 15~35 | 15~35 | 8~15 | 1~4 |
| Pile head | 8~20 | 8~20 | _ | 5~15 |
| Packaging materials | 10~20 | 10~20 | 5~15 | _ |
| Roofing materials | 2~5 | 2~5 | 2~5 | 3~8 |
| steel | 2~8 | 2~8 | 1~5 | 2~8 |
| wood | 1~5 | 1~5 | 1~5 | 5~10 |
| other | 10~20 | 10~20 | 10~20 | _ |
| total | 100 | 100 | 100 | _ |
| Waste output(kg/m$^2$) | 40~150 | 40~150 | 50~200 | _ |

Table2 Different structure types of building demolition waste analysis

| Structure Ty / Compo- | Reinforced concrete | brick | Brick and concrete | wood | other |
|---|---|---|---|---|---|
| Wood | 0.0300 | 0.2000 | 0.3200 | 0.0800 | 0.2760 |
| concrete | 0.6010 | 0.0000 | 0.3200 | 0.0000 | 0.2281 |
| brick | 0.0705 | 0.4800 | 0.4000 | 0.0500 | 0.2122 |
| non-metallic | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0011 |
| glass | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| steel | 0.0117 | 0.0000 | 0.0027 | 0.0000 | 0.0074 |
| total | 0.7142 | 0.6810 | 1.0437 | 0.8510 | 0.7256 |

Table 3 construction waste

| year | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| The number(One hundred million tons) | 5.14 | 6.17 | 6.99 | 8.13 | 9.55 |
| year | 2008 | 2009 | 2010 | 2011 | 2012 |
| The number(One hundred million tons) | 10.51 | 12.75 | 14.87 | 17.34 | 20.23 |

Table 4 Construction waste production predict

| year | 2013 | 2014 | 2015 |
|---|---|---|---|
| The number(One hundred million tons) | 24.78 | 29.36 | 35.67 |