Case study of waste material 2 development projects

Mega Waty1* and Hendrik Sulistio2

1Undergraduate Program of Civil Engineering, Universitas Tarumanagara, Jl. Letjen S. Parman No. 1, Jakarta, Indonesia
2Doctoral Program of Civil Engineering, Universitas Tarumanagara, Jl. Letjen S. Parman No. 1, Jakarta, Indonesia

Abstract. We can interpret the waste material in construction as loss or loss of material resources, time (by looking at labor and equipment), and also capital, this is caused by activities that require costs, either directly or indirectly, but do not add value at all. This research compares the material waste that occurs in 2 project case studies, namely the XYZ factory construction project, and the supermarket building project in Jakarta, and compares the causes of material waste in the two projects. The research methodology is by obtaining secondary data from each project and conducting a questionnaire to find out the comparison of the causes of material waste in the two projects. The most waste in the construction of the XYZ factory was: column work at 34%, the second largest was floor slab work at 10% and the third rank was 6% for ground slab main building work while the most supermarket waste building was Steel structure with a percentage of material remaining 14.5765%, concrete Fc 32 F/A with a percentage of remaining material of 11.5912% and iron in diameter 25 with a percentage of remaining material of 9.1921%. The causes of waste in the two projects are different from one another. Even though there are 3 similarities in the causes of waste material.

1 Introduction

In general, the use of materials will cause a lot of waste material that has been estimated in construction projects [1], meaning that waste material is a very urgent problem in Felixius and Waty's research [2]. We can interpret the remaining material in construction as loss or loss of material resources, time (by looking at labor and equipment), and also capital, this is caused by activities that require costs, either directly or indirectly, but do not add value at all. in construction service products [3]. Material is one of the important components that have a fairly close influence on the cost of a project, so with the presence of a large enough remaining construction material, it is certain that there will be swelling in the financing sector [4] Material as one of the components that has a contribution of 40% to 60% of the total project cost [5]. In every implementation of a building construction project, the appearance of residual material is unavoidable [6]. Waste in construction can be interpreted as a loss or loss of various resources, namely material, time (related to labor and equipment), and capital, which is caused by activities that require costs directly or indirectly but do not add value to the final product for service users [7]. Research conducted by Bossink and Brouwers (1996) in the Netherlands focuses on preventing the increase of waste materials in the future. The main goal is to reduce the use of non-renewable materials. Provide encouragement to use renewable materials and secondary resources. Examples of secondary materials are leftover materials from the results of construction and demolition which can be reused as raw materials for production in new construction projects [8].

The research objectives are:

1. Knowing the comparison of waste material calculations for 2 project studies, namely the construction of factories and supermarket buildings.
2. Knowing the comparison of the causes of waste material in 2 project studies, namely the construction of factories and supermarket building.

2 Method

The research methodology uses Pareto diagrams which are used to calculate the waste that occurs in factory Construction and Supermarket Building. Construction and uses the Relative Importance Index method to determine the causes of material waste in the two projects after the questionnaires are validated and reliability is carried out with the SPSS application.

3 Result and discussion

3.1 Case study 1: waste material construction of XYZ factory

The first case study is a factory construction project that has been completed around 2021 with results using Pareto which can be seen in Fig. 1.

All work data were collected and analyzed using a Pareto chart, 11 works with a waste rate above 1% and
15 jobs with a waste below 1% were obtained. Of the 11 most wastes, the 3 highest waste materials were obtained, namely column work by 34% which was caused by the number of connections when working on the column. Furthermore, for floor slab work it was 10% and the third rank was 6% for ground slab main building work [9].

3.2 Case study 2: supermarket building waste material

From the Pareto diagram Fig. 2 can be seen that the 10 items of residual value with the largest to the smallest percent are: steel structure, concrete f’c 32 F/A, steel dia. 25, Steel dia. 16, steel diameter 10, steel dia. 13, steel dia. 32, concrete fc 32 NON F/A, ex Samson liquid floor hardener, and f’c 55 concrete. The highest percentage was in steel structures (14.57%) and the smallest was in fc’ 55 concrete (2.87%) [10].

3.3 Case study 1: main causes of overall material leftover XYZ plant

Taking the 3 main causes as a whole aim so that each of us knows the main causes of any remaining materials that affect the project. Questionnaire result data has been analyzed using RII and has been sorted in Table 2.

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost Waste Material</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Structure</td>
<td>1,200,180,000.00</td>
<td>14,576</td>
</tr>
<tr>
<td>Concrete fc 32 F/A (kg)</td>
<td>954,382,250.00</td>
<td>11,591</td>
</tr>
<tr>
<td>Steel Dia 25 (m³)</td>
<td>756,849,491.00</td>
<td>9,192</td>
</tr>
<tr>
<td>Steel Dia 16 (kg)</td>
<td>728,159,870.00</td>
<td>8,843</td>
</tr>
<tr>
<td>Steel Dia 10 (kg)</td>
<td>663,126,169.00</td>
<td>8,053</td>
</tr>
<tr>
<td>Steel Dia. 13 (kg)</td>
<td>592,733,313.00</td>
<td>7,198</td>
</tr>
<tr>
<td>Steel Dia. 32 (kg)</td>
<td>580,665,553.00</td>
<td>7,052</td>
</tr>
<tr>
<td>Concrete fc 32 NON F/A (m³)</td>
<td>538,480,000.00</td>
<td>6,539</td>
</tr>
<tr>
<td>Liquid Floor Hardener ex Samson (m²)</td>
<td>346,876,464.00</td>
<td>4,212</td>
</tr>
<tr>
<td>Concrete fc 55 (m³)</td>
<td>236,412,000.00</td>
<td>2,871</td>
</tr>
</tbody>
</table>
The design source data from RII is sorted, it can be seen that statement 10 is ranked 1st with RII 0.844 and a very high level of importance, which means that statement 10 has a great influence on overall waste. Statement 10 is “Lack of coordination with contractors and lack of knowledge about construction” [9].

Ranking second after the design source data from RII is sorted, it can be seen that statement 6 with RII is 0.811 and the level of importance is very high, which means statement 6 is very influential on the size of the product used as a whole. Statement 6 is "Not paying attention to the size of the product used” [9].

Statement 16 is ranked third and has an RII value of 0.794 and a high level of importance, which means statement 16 is very influential on the overall waste. The content of statement 16 is "Inadvertent handling of material during unloading to be put into the warehouse" [9]. From this data, the 10 best RII ratings are listed in Table 3.

### 3.4 Case study 2: causes of material waste overall supermarket building project category

The following is the relative importance index ranking method for the entire category.

From Table 4, the relative importance index values of all categories have been sorted from the largest to the smallest. The first rank is design changes with a relative importance index value of 0.875 and the importance level is very high. The second rank is the amount of material needed is unknown due to imperfect planning with the relative importance index value is 0.869 and the importance level being very high. The third rank is ordering errors, excesses, shortages, etc. with a relative importance index value of 0.866 and a very high level of importance. The ranking results are grouped into the 10 largest ratings as shown in Table 5.

### 3.5 Causes of material waste

#### 3.5.1 Analysis of the causes of waste material for the construction of the XYZ plant

Analysis of the causes of waste material for the construction of the XYZ factory are:

1. Lack of coordination with contractors and lack of knowledge about construction. Lack of coordination with contractors, causing errors in ordering goods which cause waste, also contractors or consultants who are less knowledgeable about construction, causing errors that result in waste material.
2. Pay less attention to the size of the product used. Lack of attention to the size of the product used results in an ordering error which results in waste due to inappropriate product sizes such as in ceramic work.
3. Careless handling of materials during uploading to be put into the warehouse. When putting goods into the Warehouse, those who are not careful during...
unloading cause the goods to be damaged or broken, causing reordering which results in waste material on the project.

**Table 4.** Rating (RII) for the Overall Supermarket Category [10].

<table>
<thead>
<tr>
<th>Rank</th>
<th>RII</th>
<th>Variable</th>
<th>Importance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.875</td>
<td>Statement X1.3</td>
<td>Very high</td>
</tr>
<tr>
<td>2</td>
<td>0.869</td>
<td>Statement X4.7</td>
<td>Very high</td>
</tr>
<tr>
<td>3</td>
<td>0.866</td>
<td>Statement X2.1</td>
<td>Very high</td>
</tr>
<tr>
<td>4</td>
<td>0.866</td>
<td>Statement X4.10</td>
<td>Very high</td>
</tr>
<tr>
<td>5</td>
<td>0.856</td>
<td>Statement X5.2</td>
<td>Very high</td>
</tr>
<tr>
<td>6</td>
<td>0.846</td>
<td>Statement X2.3</td>
<td>Very high</td>
</tr>
<tr>
<td>7</td>
<td>0.836</td>
<td>Statement X9.2</td>
<td>Very high</td>
</tr>
<tr>
<td>8</td>
<td>0.833</td>
<td>Statement X1.6</td>
<td>Very high</td>
</tr>
<tr>
<td>9</td>
<td>0.833</td>
<td>Statement X5.3</td>
<td>Very high</td>
</tr>
<tr>
<td>10</td>
<td>0.823</td>
<td>Statement X1.7</td>
<td>Very high</td>
</tr>
<tr>
<td>11</td>
<td>0.823</td>
<td>Statement X5.1</td>
<td>Very high</td>
</tr>
<tr>
<td>12</td>
<td>0.820</td>
<td>Statement X4.5</td>
<td>Very high</td>
</tr>
<tr>
<td>13</td>
<td>0.816</td>
<td>Statement X1.10</td>
<td>Very high</td>
</tr>
<tr>
<td>14</td>
<td>0.816</td>
<td>Statement X4.9</td>
<td>Very high</td>
</tr>
<tr>
<td>15</td>
<td>0.797</td>
<td>Statement X3.2</td>
<td>High</td>
</tr>
<tr>
<td>16</td>
<td>0.781</td>
<td>Statement X1.9</td>
<td>High</td>
</tr>
<tr>
<td>17</td>
<td>0.777</td>
<td>Statement X8.1</td>
<td>High</td>
</tr>
<tr>
<td>18</td>
<td>0.774</td>
<td>Statement X1.4</td>
<td>High</td>
</tr>
<tr>
<td>19</td>
<td>0.774</td>
<td>Statement X4.1</td>
<td>High</td>
</tr>
<tr>
<td>20</td>
<td>0.751</td>
<td>Statement X4.8</td>
<td>High</td>
</tr>
<tr>
<td>21</td>
<td>0.745</td>
<td>Statement X1.1</td>
<td>High</td>
</tr>
<tr>
<td>22</td>
<td>0.745</td>
<td>Statement X3.6</td>
<td>High</td>
</tr>
<tr>
<td>23</td>
<td>0.735</td>
<td>Statement X2.4</td>
<td>High</td>
</tr>
<tr>
<td>24</td>
<td>0.732</td>
<td>Statement X6.3</td>
<td>High</td>
</tr>
<tr>
<td>25</td>
<td>0.728</td>
<td>Statement X3.3</td>
<td>High</td>
</tr>
<tr>
<td>26</td>
<td>0.722</td>
<td>Statement X3.4</td>
<td>High</td>
</tr>
<tr>
<td>27</td>
<td>0.718</td>
<td>Statement X5.5</td>
<td>High</td>
</tr>
<tr>
<td>28</td>
<td>0.705</td>
<td>Statement X1.2</td>
<td>High</td>
</tr>
<tr>
<td>29</td>
<td>0.699</td>
<td>Statement X3.1</td>
<td>High</td>
</tr>
<tr>
<td>30</td>
<td>0.683</td>
<td>Statement X1.5</td>
<td>High</td>
</tr>
<tr>
<td>31</td>
<td>0.679</td>
<td>Statement X7.4</td>
<td>High</td>
</tr>
<tr>
<td>32</td>
<td>0.673</td>
<td>Statement X2.5</td>
<td>High</td>
</tr>
<tr>
<td>33</td>
<td>0.669</td>
<td>Statement X4.2</td>
<td>High</td>
</tr>
<tr>
<td>34</td>
<td>0.669</td>
<td>Statement X7.5</td>
<td>High</td>
</tr>
<tr>
<td>35</td>
<td>0.650</td>
<td>Statement X7.1</td>
<td>High</td>
</tr>
<tr>
<td>36</td>
<td>0.647</td>
<td>Statement X8.2</td>
<td>High</td>
</tr>
<tr>
<td>37</td>
<td>0.640</td>
<td>Statement X6.2</td>
<td>High</td>
</tr>
<tr>
<td>38</td>
<td>0.633</td>
<td>Statement X1.8</td>
<td>High</td>
</tr>
<tr>
<td>39</td>
<td>0.624</td>
<td>Statement X7.3</td>
<td>High</td>
</tr>
<tr>
<td>40</td>
<td>0.601</td>
<td>Statement X3.5</td>
<td>High</td>
</tr>
<tr>
<td>41</td>
<td>0.598</td>
<td>Statement X4.3</td>
<td>Moderate</td>
</tr>
<tr>
<td>42</td>
<td>0.555</td>
<td>Statement X6.1</td>
<td>Moderate</td>
</tr>
<tr>
<td>43</td>
<td>0.552</td>
<td>Statement X4.6</td>
<td>Moderate</td>
</tr>
<tr>
<td>44</td>
<td>0.545</td>
<td>Statement X9.1</td>
<td>Moderate</td>
</tr>
<tr>
<td>45</td>
<td>0.539</td>
<td>Statement X5.4</td>
<td>Moderate</td>
</tr>
<tr>
<td>46</td>
<td>0.526</td>
<td>Statement X7.2</td>
<td>Moderate</td>
</tr>
<tr>
<td>47</td>
<td>0.483</td>
<td>Statement X4.4</td>
<td>Moderate</td>
</tr>
<tr>
<td>48</td>
<td>0.421</td>
<td>Statement X2.2</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

4. Equipment that does not work properly. Equipment that is not functioning properly causes work errors that result in rework or demolition because the tool is not functioning properly.

5. Work accidents in the field. Work accidents in the field result in the death of workers or work being hampered because work must be temporarily stopped so that it can cause job changes which can cause waste to occur.

6. The amount of material required is not known due to imperfect planning. The amount of material needed is unknown because imperfect planning causes work changes in the form of changes in detail drawings and changes in other drawings so that the amount of material needed is not known exactly.

**Table 5.** The 10 biggest RII rankings of supermarket building construction waste [10].

<table>
<thead>
<tr>
<th>Rank</th>
<th>RII</th>
<th>Variable</th>
<th>Importance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.875</td>
<td>Design changes</td>
<td>Very high</td>
</tr>
<tr>
<td>2</td>
<td>0.869</td>
<td>The amount of material required is not known due to imperfect planning</td>
<td>Very high</td>
</tr>
<tr>
<td>3</td>
<td>0.866</td>
<td>Order errors, excess, shortage, and so on</td>
<td>Very high</td>
</tr>
<tr>
<td>4</td>
<td>0.866</td>
<td>Field measurements are not accurate resulting in excess volume</td>
<td>Very high</td>
</tr>
<tr>
<td>5</td>
<td>0.856</td>
<td>Error while cutting material</td>
<td>Very high</td>
</tr>
<tr>
<td>6</td>
<td>0.846</td>
<td>Purchase of materials that do not comply with specifications</td>
<td>Very high</td>
</tr>
<tr>
<td>7</td>
<td>0.836</td>
<td>Poor material control on the project and management planning for the remaining material</td>
<td>Very high</td>
</tr>
<tr>
<td>8</td>
<td>0.833</td>
<td>Lack of incentives affecting employee loyalty</td>
<td>Very high</td>
</tr>
<tr>
<td>9</td>
<td>0.833</td>
<td>Error ordering goods, because it does not master the specifications</td>
<td>Very high</td>
</tr>
<tr>
<td>10</td>
<td>0.823</td>
<td>Designers are not familiar with other types of products</td>
<td>Very high</td>
</tr>
</tbody>
</table>

7. Improper storage cause damage. Improper storage of materials can cause damage to materials such as cement which can cause cement to harden resulting in an increase in cement volume which causes waste which causes waste.

8. Measurements in the field are not accurate resulting in excess volume. Inaccurate measurements in the field cause excess volume of material which causes changes resulting in waste.

9. Purchase of materials that do not comply with specifications. Purchasing materials that are not in accordance with specifications results in the purchase of re-materials resulting in losses in a project.

10. Damage due to transportation to/at the project site. Damage due to transportation to and at the project site causes material to be wasted or material sent needs to be recalculated or material is scattered so that an additional volume of material is needed.

3.5.2 *Analysis of 10 causes of waste material in supermarket building projects*

Analysis of the 10 biggest causes of waste material in Supermarket Building Projects are:

1. Design changes. Design changes are the most common thing that occurs because with an unclear initial design, the consultant completes and
improves the design resulting in changes in both
details and the entire design, which affects the
amount of material needed.

2. The amount of material required is unknown due to
imperfect planning. The amount of material needed
is unknown because imperfect planning causes
work changes in the form of changes in detail
drawings and changes in other drawings so that the
amount of material needed is not known exactly.

3. Order errors, excess, shortage, and so on. Ordering
errors in the field result in excess material, or also a
shortage of material caused because the material
ordered is not as expected so that it turns into waste
which results in leftover material.

4. Inaccurate field measurements resulting in excess
volume. Measurements in the field are not accurate
resulting in excess volume of material that has been
determined.

5. Errors when cutting material. Errors when cutting
the material result in leftover material that cannot
be used anymore, such as in concrete iron which
results in steel structure and fc 32 concrete work.

6. Purchase of materials that do not comply with
specifications. Purchasing materials that are not in
accordance with specifications results in the purchase of re-materials resulting in losses in a
project.

7. Poor material control in the project and
management planning for the remaining materials.
Implementation of work on the project, as well as
material management planning for the remaining
material on a project that is inappropriate and bad
resulting in material waste on the project.

8. Measurements in the field are not accurate resulting
in excess volume. The lack of incentives also
affects employee loyalty, so incentives are really
needed that are properly managed so as to increase
employee loyalty which can reduce the waste that
occurs.

9. Error ordering goods, because it does not master the
specifications. There was an error in ordering goods
because they did not master the specifications
which resulted in repeated ordering of goods so that
the old goods were not used because the logistics
sector did not master the specifications.

10. Designers are not familiar with other types of
products. Designers do not know other types of
products well which results in having to order or
buy only known goods because other products may
be of the same type but the designer does not know
about them resulting in waste because the goods
that arrive can be excessive or reduced depending
on the existing stock.

3.5.3 Comparison of factory waste material and
supermarket buildings are in terms of the most
waste material

In the construction of most waste factories column work
by 34%. Then on the floor slab work by 10% and the
third rank by 6% on the ground slab main building work.
The biggest cause of column work waste is the number
of connections [9] which can be seen in Table 6.

Table 6. Comparison table of 2 project waste material case
studies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Factory project</th>
<th>Supermarket building</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most waste material</td>
<td>Most waste material</td>
</tr>
<tr>
<td>1.1</td>
<td>Column</td>
<td>Steel structure</td>
</tr>
<tr>
<td>1.2</td>
<td>Floor slab</td>
<td>Concrete fc 32</td>
</tr>
<tr>
<td>1.3</td>
<td>Grand floor slab</td>
<td>Diameter reinforcing steel. 25</td>
</tr>
<tr>
<td>2</td>
<td>Causes</td>
<td>Causes</td>
</tr>
<tr>
<td>2.1</td>
<td>Lack of coordination with contractors and lack of knowledge about construction</td>
<td>Design changes</td>
</tr>
<tr>
<td>2.2</td>
<td>Lack of attention to the size of the product used,</td>
<td>The amount of material required is unknown due to imperfect planning.</td>
</tr>
<tr>
<td>2.3</td>
<td>Careless handling of materials during unloading to be put into the warehouse</td>
<td>Order errors, excess, shortage and so on</td>
</tr>
</tbody>
</table>

In the supermarket building, the most waste is steel
structure with a percentage of remaining material of
14.576%, concrete fc 32 F/A with a percentage of
remaining material of 11.591%, and diameter
reinforcing steel 25 iron with a percentage of remaining
material of 9.192% which can be seen in Table 6.

The cause of the most waste in steel structures and
diameter 25 is material cutting errors and the
biggest cause of waste in fc 32 concrete is when concrete
reinforcement is carried out beyond a predetermined
limit so it must be broken into [10].

The main causes of waste material are factory,
construction projects and supermarket building projects.
The main cause of the remaining material from the XYZ
factory are, which can be seen in Table 6 as follows:

1. Lack of coordination with contractors and lack of
knowledge about construction.
2. Lack of attention to the size of the product used.
3. Careless handling of materials during uploading to
be put into the warehouse.

The main causes of material waste in supermarket
building projects are, which can be seen in Table 6 as follows:

1. Design changes.
2. The amount of material required is unknown due to
imperfect planning.
3. Order errors, excess, shortage, and so on.

From the results of the discussion above, the
comparison of waste material in factory construction
projects and supermarket building projects is that there
are similarities for the two causes of waste material
which are the causes of waste in the two projects,

1. Field measurements are inaccurate resulting in
excess volume. Measurements in the field are not
accurate resulting in excess volume of material that has been determined.

2. Purchase of materials that do not comply with specifications. Purchasing materials that are not in accordance with specifications results in the purchase of re-materials resulting in losses in a project.

3. The amount of material needed is unknown due to imperfect planning. The amount of material needed is unknown because imperfect planning causes work changes in the form of changes in detail drawings and changes in other drawings so that the amount of material needed is not known exactly.

There are differences in the comparison of waste material, namely:
1. Lack of coordination with contractors and lack of knowledge about construction, is a rating.
2. Pay less attention to the size of the product used.
3. Careless handling of materials during uploading to be put into the warehouse.
4. Design changes.
5. Order errors, excess, shortage and so on.
6. Error when cutting the material.
7. Equipment that does not work properly.
8. Lack of incentives affecting employee loyalty.
9. Errors in ordering goods, because they do not master the specifications.
10. Designers are not familiar with other types of products.
11. Improper storage causes damage.
12. Damage due to transportation to/at the project site.
13. Work accident in the field.
14. Equipment that does not work properly.

4 Conclusion

4.1 Comparison of factory waste material and supermarket buildings are: in terms of the most waste material

In the construction of most waste factories column work by 34%. Then on the floor slab work by 10% and the third rank by 6% on the ground slab main building work. The biggest cause of column work waste is the number of connections.

In the supermarket building the most waste is Steel structure with a percentage of remaining material of 14.576%, concrete f’c 32 F/A with a percentage of remaining material of 11.591% and diameter reinforcing steel 25 with a percentage of remaining material of 9.192%.

The cause of the most waste in steel structures and iron diameter 25 is material cutting errors and the biggest cause of waste in f’c 32 concrete is when concrete reinforcement is carried out beyond a predetermined limit so it must be broken.

4.2 The main causes of waste material are factory construction projects and supermarket building projects

The main cause of the rest of the factory material are:
1. Lack of coordination with contractors and lack of knowledge about construction.
2. Pay less attention to the size of the product used.
3. Careless handling of materials during unloading to be put into the warehouse.

The main cause of material waste of material waste in supermarket building projects are:
1. Design changes.
2. The amount of material required is unknown due to imperfect planning.
3. Order errors, excess, shortage, and so on.

There are similarities in the comparison of waste from the 10 biggest causes of waste from each project, namely:
1. Field measurements are inaccurate resulting in excess volume.
2. Purchase of materials that do not comply with specifications.
3. The amount of material needed is unknown because of imperfect planning.

There are differences in the 10 biggest causes of material waste from each project, namely:
1. Lack of coordination with contractors and lack of knowledge about construction, is a rating.
2. Pay less attention to the size of the product used.
3. Careless handling of materials during uploading to be put into the warehouse.
4. Design changes.
5. Order errors, excess, shortage and so on.
6. Error when cutting the material.
7. Equipment that does not work properly.
8. Lack of incentives affecting employee loyalty.
9. Errors in ordering goods, because they do not master the specifications.
10. Designers are not familiar with other types of products.
11. Improper storage causes damage.
12. Damage due to transportation to/at the project site.
13. Work accident in the field.
14. Equipment that does not work properly.

5 Suggestion

Suggestions from the conclusions above are pay more attention to the 6 main causes of waste material for factory and building projects, namely:
1. Lack of coordination with contractors and lack of knowledge about construction.
2. Pay less attention to the size of the product used.
3. Damage due to transportation to/at the project site.
4. Design changes.
5. The amount of material required is unknown due to imperfect planning.
6. Order errors, excess, shortage, and so on.

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References