ERGONOMIC DESIGN FOR MOBILE AND PORTABLE EMERGENCY DISASTER KITCHEN

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ABSTRACT

Indonesia is a high-level-risk-of-disaster country which lies along Sumatra to Maluku Island. But the government had not perceived this condition yet with a proper refugee caring, management and emergency disaster facilities. The people were not aware of disaster and management disaster as well. Emergency disaster management facilities, i.e. emergency kitchen, nowadays hasn’t been built properly yet. This paper described the emergency disaster kitchen built by PMI (Indonesian Red Cross), TNI (Indonesian Army), or other organizations, which had not fit the refugee’s needs. This circumstances might result in an idea of building up a mobile and portable emergency disaster kitchen design which easy to use by people around disaster area. Field research and observation had been conducted in Bojonegoro regency. This observation had been done in two ways, individual questionnaire and focus group discussion. Data analysis showed that emergency disaster kitchen had not accommodate operator’s requirement and even the aid which arrived late. This also resulted in disaster victim whom easy to have disease. Although this emergency kitchen had not been yet fulfill ergonomic concept concerning comfort and safety. This research aim to give a recommendation of mobile and portable emergency disaster kitchen design that suit the refugee’s and operator’s needs effectively and easily. This research is financially supported by RUSNAS 2009 (National Strategic Superior Research) Contract No. 10473/I2.7/PM/2009 date 1 April 2009

Keywords: ergonomic, design, mobile and portable, emergency disaster kitchen

1. INTRODUCTION

In the last few years, Indonesia has been bumped by many kinds of natural disaster such as earthquakes in Aceh that is followed by tsunami at Aceh and Nias in 2006, earthquake disaster at Bantul, Yogyakarta in 2006, Lapindo’s mud disaster, Sidoarjo in 2007, yearly flood disaster bandang at Bojonegoro up to earthquake disaster insident at West Java in 2009. Natural disasters had destroyed residences, infrastructures, and changes the sosial-economy terms. This matters will force a large scale of evacuation and force the victims to stay until the recovering process for their area is finish.

At the evacuation place, refugee will experience lots of problems. For example food logistics, medical facilities, and mental problems. If this problems doesn’t treated well, the refugees will suffer from hunger to a large spread of disease.
By looking at Indonesia’s geographical condition and the effects from natural disasters (Djoko, 2002), we think that this country needs a proper design of mobile and portable emergency public kitchen. This kitchen is designed by looking at many kinds of aspects, such as natural condition aspect, position of basic food commodity and drink, road access, social condition and local society habit (people behavior) as the object with the kitchen operator as the subject, etc (Frick, 2002).

This research is held at two places that suffers natural disasters in Indonesia. They are Bojonegoro and Bantul, the reason of choosing this two cities is based on the similarity of natural disaster features at this two cities.

This research is held by surveying at the related areas with the kitchen user (object) and operator (subject) as the respondents. Hopefully by involving the object and subject, this research could develop the proper design of mobile and portable emergency public kitchen for the victims of natural disaster that can fulfill every specification and expectation in every way (QFD’s concept). Data are collected from after surveying will be the main reference to design the kitchen.

2. LITERATURE REVIEW
2.1 Previous related researches.

In the year 2008, Baroto Tavip Indrojarwo, Ellya Zulaikha, and Eko Nurmianto was holding a research entitled “Studying Design of Ergonomic Kitchen for Small Residences” by using family interaction concept that came with summaries:

Design Concept : Interactive and Ergonomic

Interactive Design Criteria
1. Kitchen design gives the user a clear view for the whole family member.
2. Kitchen design gives enough space for the whole family to have a meal together at the same time and place.
3. Kitchen design gives a proper space to watch other things, such as watching children.
4. Minimizing unproper position, such as facing straight to the wall so that family members can interact at each other.

Ergonomic:
1. Ergonomy at kitchen (Panero, 2003; Nurmianto, 2004):
   a. Ideal body posture when slicing
      Appropriate height of working desk that related with body posture based on antropometry is 90 cm.
   b. Ideal body posture when crushing and mixing ingredients
      The ideal height of working table for crushing and mixing ingredients related to body posture based on antrophometri is 70 cm (min). Lower table height is choose for heavier activities.
   c. Ideal body posture when cooks
      Ideal height for stove according to body posture based on antrophometri is 70 cm. By that, the height of the stove and mixing table are the same.
   d. Ideal body posture doing dishes (theory)
      The appropriate height of sink table according to antrophometry based on body posture 90 cm, aline with the stove and the mixing table.
   e. Configuration arrangement based on device priority
      Positioning tools priority and kitchen configuration are based on the usefulness and the intensity of using it will be based on the survey results.
2. Ergonomic triangle work zone at kitchen based on blocking area and kitchen configuration.
3. Safety terms in the kitchen.
   a. Sharp and fragile things must be sorted.
b. For the safety reasons in the cooking area, for example chances of small explications and fire, LPG barrels should not be placed near the stove and must provide enough space for air circulation.

3. RESEARCH SUBJECTS AND METHODS

3.1 RESEARCH METHODS

1. Research preparation
   This preparation starts by forming the surveyor team or data processor team and the design team. Below are the tasks for each team:
   - Surveyor team will prepare questionnaires that will be distributed. There are 3 kinds of questionnaires, for users, for operators, and for the FGD (Discussion's Group Focus). Questionnaires is made to know the characteristics of respondents, the condition of the present kitchen, respondents expectation for the new design of kitchen.
   - Design team will use 3Ds Max and AutoCAD software to support visualisation and design work picture after disaster happens.
   - Literature study for team surveyor is cluster analysis. The function of cluster analysis for classifying respondents that has similar characters.
   - Literature study for design team is ergonomy and anthropometry that is used as reference to analyse comfortness, safetiness, and health aspect for the public kitchen after disaster design.

1.) Study and Analysis
   a.) Technical analysis. Consists of form, configuration, mechanism, materials and production process, colours, components, zoning, volume, and system.
   b.) Non technical Analysis. Covers food distributions, ideal loads for operator work, logistics pattern, kitchen activities pattern.
   c.) Ergonomic analysis. Covers anthropometry, lighting, ventilation, temperature, noise, safety.
   d.) Alternative designs. New ideas as an alternative design that will be developed for further study and analysis.
   e.) Design development. Development process for design from the early concept and alternative design based on study and analysis.
   f.) Making of work picture. Covers detailing size and materials from chosen designs.
   g.) Building prototype I
   h.) Post test
   i.) Overall test for prototype I.
   j.) Finishing/ prototype II.

3.2. RESEARCH SUBJECT

Subjects (cities) that is used in this research are places that has different characteristics of natural disasters.

Bandang flood is a yearly flood disaster that happens in Bojonegoro city and isolates an area because it destroys the access road. Characteristic of the isolated areas are low level landmarks, lots of evacuation camp that spreads around the related area, recovers (from the disaster) in a short periode, and the condition of the public kitchen is wet and flooded.

Earthquake disaster in Bantul City in 2006 had a main characteristic where it doesn’t isolates areas but the surface area is in the middle of hills, recovers in a long periode, evacuation camp spreads along the related area, and the condition of the public kitchen is dry. The condition that is seen in Bantul city is the same as Sidoarjo (mud disaster) in 2007, West Java (earthquake) in 2009, and other areas in Indonesia.
4. ANALIZING SURVEY RESULTS

Analyzing survey results, using statistic tools, covers analyzing technical operational of the public kitchen after disaster using descriptive statistic methods, analyzing topographic disaster area condition using questioners and direct observation, analyzing FGD’s (Focus Group Discussion) questionnaire results that will be used to summarize all the demands from the refugees that hasn’t been gathered from the individual questionnaire, determining the anthropometry for the operators of public disaster kitchen, analyzing health problems using statistic descriptive analysis, determining area of cooking using cluster analysis, analyzing fuel for cooking using cluster analysis, analyzing the gap between the expectations of the kitchen operators and the condition of the present kitchen (Jusuf, 1998).

The analyzing methods from above are used in the two cities, Bojonegoro and Bantul. Parameter of the design for the public kitchen after disaster will be gained after combining the analyzing results from the two cities and be re-analyze.
## Design Parameter for the Public kitchen After Disaster.

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Recomendation</th>
<th>Technical Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How many times have you become an operator for the public kitchen after disaster?</td>
<td>1</td>
<td>The kitchen is easy to assemble by a new operator.</td>
</tr>
<tr>
<td>2</td>
<td>Average spending time of an operator per day (hours)</td>
<td>12 - 24 hours</td>
<td>The kitchen has rooms for rest.</td>
</tr>
<tr>
<td>3</td>
<td>Average number of people that operates in the kitchen each day</td>
<td>5 people</td>
<td>5 people</td>
</tr>
<tr>
<td>4</td>
<td>How many days it took to build one kitchen?</td>
<td>1-3 days</td>
<td>Emergency kitchen is designed to last for three days till receives logistic helps.</td>
</tr>
<tr>
<td>5</td>
<td>Average number of people that is served each meal time.</td>
<td>300 - 500 orang</td>
<td>The kitchen can serve 500 people at one time.</td>
</tr>
<tr>
<td>6</td>
<td>How long does refugees needs food after disasters happens ?</td>
<td>5 - 8 hour</td>
<td>Emergency kitchen must start operating at least 5-8 hours after disaster happens.</td>
</tr>
<tr>
<td>7</td>
<td>How many times does refugees receives food?</td>
<td>3 times</td>
<td>Kitchen can fulfill the daily meal needs three times a day.</td>
</tr>
<tr>
<td>8</td>
<td>How does refugees get/ receive foods?</td>
<td>Provide it directly to the evacuation.</td>
<td>Help is provided by giving it directly to the refugees.</td>
</tr>
<tr>
<td>9</td>
<td>Surface texture</td>
<td>Dry</td>
<td>Kitchen’s contour must be build dry.</td>
</tr>
<tr>
<td>10</td>
<td>Road access condition</td>
<td>Flooded</td>
<td>Road access to the kitchen is flooded.</td>
</tr>
<tr>
<td>11</td>
<td>Road access width</td>
<td>3 m</td>
<td>Kitchen tools can be carried by vehicles with maximum width of 3m.</td>
</tr>
<tr>
<td>12</td>
<td>How far is the kitchen located from the main city?</td>
<td>0 - 2 Km</td>
<td>Kitchen is built between main city and regency.</td>
</tr>
<tr>
<td>13</td>
<td>Emergency kitchen - water supplies.</td>
<td>0 - 2 Km</td>
<td>Kitchen is built near water resource.</td>
</tr>
<tr>
<td>14</td>
<td>Emergency kitchen – refugees camp.</td>
<td>0 - 2 Km</td>
<td>Distance from kitchen to evacuation camp at least 0-2 km.</td>
</tr>
<tr>
<td>15</td>
<td>Emergency kitchen – fuel</td>
<td>0 - 2 Km</td>
<td>Kitchen is built near fuel resource.</td>
</tr>
<tr>
<td>16</td>
<td>Average of charity foods per day.</td>
<td>0 - 100 wrap</td>
<td>Kitchen fulfill all the refugees needs.</td>
</tr>
<tr>
<td>17</td>
<td>Place to gather food</td>
<td>Surrounding citizen</td>
<td>The kitchen has a stove that can work with any kind of fuel.</td>
</tr>
<tr>
<td>18</td>
<td>Kind fuel that is used</td>
<td>Any kinds of fuel</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Fuel storage place</td>
<td>Outside the kitchen, in a special place</td>
<td>The kitchen has it’s own ergonomic fuel storage room.</td>
</tr>
</tbody>
</table>
Ergonomic design that produced based on parameter shall be as follows

<table>
<thead>
<tr>
<th>No</th>
<th>Tools</th>
<th>Size specification (mm)</th>
<th>Volume (kg)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RICE STEAMER</td>
<td>520 x 520 x 630</td>
<td>20</td>
<td>Serving the needs of rice for 500 people a time requires 100 kg of rice.</td>
</tr>
<tr>
<td>2</td>
<td>WOK</td>
<td>720 x 720 x 220</td>
<td>7</td>
<td>Serving the needs of meat and others for 500 people for each meal time requires 30 kg of meats, so the number of wok that should be provide is two.</td>
</tr>
<tr>
<td>3</td>
<td>PAN</td>
<td>530 x 530 x 320</td>
<td>70</td>
<td>Serving vegetables for 500 people a day needs 90 kg of vegetables. So there should be one pan available.</td>
</tr>
</tbody>
</table>
| 4  | BUCKET      | 560 x 560 x 200          | 6 kg        | • 2 for meat storage.  
• 5 for rice storage.  
• 2 for fruits and vegetables storage. |
| 5  | STOVE       | 1600x800x800             |             | The stove that will be used is also used as mixing table. This stove could be assembled and re-assembled easily. This stove can be used with any 3 kinds of fuel, woods, gas, and gasoline. |
5. STUDY AND FORM ANALYSIS
5.1. Study and Analizing Kitchen Utensiles

The pictures below are the examples of kitchen utensiles that is usually been used in emergency disaster kitchen.

Analyzed from the form and shape, we could conclude that all of the tools is not proper to be used in emergency disaster kitchens. Because the form of the tools are not the same, so it’s goin to be difficult when stacking them. Because the main concept that is used in this research is modul, by that all of the tools should be form in modul and portable form. The following is the comparison of alternative tools for cooking (Harry, 2005).

**Table 3. Comparison of alternative tools for cooking**

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>FORM</th>
<th>alt 1</th>
<th>alt 2</th>
<th>alt 3</th>
<th>alt 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty level to use</td>
<td></td>
<td>50</td>
<td>20</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Volume capacity</td>
<td></td>
<td>40</td>
<td>20</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Cooking efficiency (time requirement)</td>
<td></td>
<td>40</td>
<td>40</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Difficulty level to pack (Kemudahan packing)</td>
<td></td>
<td>50</td>
<td>30</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Difficulty level production process</td>
<td></td>
<td>50</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Total score</td>
<td></td>
<td>230</td>
<td>120</td>
<td>80</td>
<td>190</td>
</tr>
</tbody>
</table>

*Rate 10 – 50*

The alternative form that should be use is alternative #1, because:
1. Easy to stack in a modul shape.
2. Low level of difficulty in production process

The following are the example pictures of proper design kitchen tools for emergency disaster kitchen:

<table>
<thead>
<tr>
<th>RICE STEAMER</th>
<th>PAN</th>
<th>BUCKET</th>
<th>WOK</th>
</tr>
</thead>
</table>

3" INTERNATIONAL CONFERENCE ON OPERATIONS AND SUPPLY CHAIN MANAGEMENT, MALAYSIA, 2009 | 7
5.2. Study and Stove Analysis

The pictures below are examples of kitchen utensiles that is used in emergency disaster kitchen:

<table>
<thead>
<tr>
<th>Alternative #1</th>
<th>Alternative #2</th>
<th>Alternative #3</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Alternative #1" /></td>
<td><img src="image2" alt="Alternative #2" /></td>
<td><img src="image3" alt="Alternative #3" /></td>
</tr>
<tr>
<td>1000 x 800 x 800</td>
<td>1600 x 800 x 800</td>
<td>800 x 800 x 400</td>
</tr>
</tbody>
</table>

The form that should be use in alternative #2, by scoring system, because:
1. Low level of difficulty in stacking in modul shape.
2. High level of safety and comfortness.
3. Low level of difficulty in production process.

The following are the examples of proper design stove for emergency disaster kitchen:

![Stove Design a)](image4) ![Stove Design b)](image5) ![Stove Design c)](image6) ![Stove Design d)](image7)

Figure a) stove design b) for wok use c) for rice steamer use d) for wok and gas fueled stove or wood fueled stove.

5.3. Study and tent analysis

Below are the alternative choices of tent for emergency disaster kitchen.

<table>
<thead>
<tr>
<th>Alternative #1</th>
<th>Alternative #2</th>
<th>Alternative #3</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image8" alt="Alternative #1" /></td>
<td><img src="image9" alt="Alternative #2" /></td>
<td><img src="image10" alt="Alternative #3" /></td>
</tr>
</tbody>
</table>

The result is the alternative tent that should be use is alternative #3, by scoring system, because:
1. Low level of difficulty in stacking in modul form.
2. Safety and comfortness achieved.
3. Suitable in add facility.

The following are the example pictures of proper design tent for emergency disaster kitchen:
6. CONCLUSION

The result of this research is developing the design of mobile and portable emergency disaster kitchen that can be move from one place to another and easy to carry. Also fulfilling the demands of the people of Indonesia when dealing with any kinds of natural disaster.

7. REFERENCES


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BARKONAS PB, 2 - 4 April 2005, Indonesia Disaster


Frick, Hinz, Ilmu Konstruksi Perlengkapan dan Utilitas Bangunan, 2002, Cara Perlengkapan Gedung Ilmu Konstruksi Bangunan 2, Seri Konstruksi Arsitektur 5, Kanisius, Jakarta

Harry Gon, E. Mayari, Adrianto Budiarsa dan Robetus Pawang, 2005, ”Kombinasi Warna”, Serial Rumah Spesial, setakan ke 2, Jakarta

Jusuf Talib, 1998, Pedoman Penyelenggaraan Dapur Umum, Jakarta

Panero, Julius AIA, ASID dan ZELNIK, Martin, AIA, ASID, 2003, Dimensi Manusia dan Ruang Interioir, Erlangga, Cetakan ke 1, Jakarta


WALHI dan JATAM, 23 Juni 2006, Pemerintah Dituntut Serius dalam Mengelola Bencana Ekologis <URL:http://www.walhi.or.id/kampanye/bencana/060623_benceko_sp/>

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