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Designing A Disaster Preparedness Bag by Considering Ergonomics Aspect

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ABSTRACT

Disasters may make people having to evacuate. When evacuating, evacuee may bring items required in evacuation place. The items must be ready previously in a bag, called a disaster preparedness bag. In case a disaster occurs, evacuee just grabs it and go for evacuation. Many bags used are not dedicated for disaster situation. Many types of items stored together and mixed causing of difficulty in retrieval. In addition, use of inappropriate bag will interfere with evacuee movement and slow down the evacuee while the evacuation time is too short. This research aims to design ergonomics disaster preparedness bag that can accommodate needs for 3x24 hours. Design process was started with planning phase to find out disaster preparedness bag development opportunity. The second phase is concept development. People who have evacuation experience are asked report their complaints regarding the bag used during previous evacuation and their needs for a disaster preparedness bag. Based on the needs, target specification is determined then concept alternatives are generated and selected. Then, main parts of the bag are identified. Continued with detailed design process, the dimensions of the proposed bag are determined using anthropometric data and dimension of required item in the first 72 hours of evacuation time. The design of proposed bag is such a backpack with multi compartments adjusted to item stored. The shoulder straps are designed like a vest then the load is not focused only on the shoulder but distributed to other part of body such as abdominal and chest muscle.

Keywords: *Evacuation; Disaster preparedness bag; Ergonomics.*

INTRODUCTION

Some disasters such as an earthquake that potential to tsunami and volcanic eruption result in people having to evacuate to safe zone [1]. Usually, people do not have much time to do an evacuation. The research related to the tsunami simulation in Padang City states that the time of tsunami to reach land is 37 minutes and the effective evacuation time for the community is only 17 minutes [2]. Due to this short time, research related to evacuation movement suggested that walking is better than moving using vehicles because of road density [3] [4].

When evacuating, people often carry items which are possible needed during evacuation period. The items must be ready in the bag before a disaster. In case a disaster occurs and having people to do an evacuation, they just pick it up and go for evacuation immediately. Then, this bag is called a disaster preparedness bag. Preparing a disaster preparedness bag is

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one form of preparedness effort that is needed when facing a disaster especially for people who live in disaster prone area [5]. A disaster preparedness bag contains a logistical source required for survival for the first 3x24 hours of evacuation period. It will be very helpful for evacuee until relief aids arrive in refugee camp. BNPB's Pocket Book [1] identified list of items may be required by evacuee during evacuation time, shown in Table 1.

Table 1. List of Items Needed During a Disaster

No	Item
1	Water
2	Food
3	First aid kit
4	Medications
5	Flashlight and extra batteries
6	Radio
7	Cash and important documents
8	Clothes, jacket, and shoes
9	Tools
10	Personal hygiene items

Since people is recommended conducting an evacuation by walking rather than using a vehicle, while the time is short, the disaster preparedness bag carried by evacuee is supposed not interfere with their movement or slow down the evacuee in save himself. Currently, disaster preparedness bags can be found on online shopping sites such as Amazon. The disaster preparedness bag sold has already contained the required items to be carried to evacuation place and the price is quite expensive. From consumer's review, it is found their complaint regarding the placement of items in disaster preparedness bags that the items mix with one another, as seen in Figure 1.

Figure 1. Placement of American Ready Disaster Preparedness Bag

Based on discussions with some of disaster stakeholders such as Indonesia Red Cross (PMI) of West Sumatra province, BPBD Padang City, and KOGAMI and questionnaires distributed to respondents who had evacuated using their respective versions of disaster preparedness bags, it is found that the bag used has not been ergonomics which is the potential for causing injury

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and slowing down evacuation process. In addition, the items inside are messy. A disaster preparedness bags must be practical in that they do not make it difficult for evacuees during the evacuation process and make it easier to place and retrieve items needed during evacuation. Thus, this research is aimed to design a disaster preparedness bag by considering ergonomic aspects and able to accommodate the logistical needs for 3x24 hours.

METHOD

In this research, designing a disaster preparedness bag is conduct as follows [6]:

1. Planning Phase: People who have an experience conducting evacuation and some disaster stakeholders are interviewed to identify disaster preparedness bag development opportunities. They are asked relating their bags used during the previous evacuation. At the planning stage, alternative opportunities are also collected and then one or more existing alternatives are selected.
2. Concept Development Phase: In this phase, some activities are performed including (a) identifying evacuee needs, (b) determining target specification, (c) generating disaster preparedness bag concept alternatives, (d) selecting one or more concept alternatives to be developed.
3. System Level Design Phase: In this phase, the proposed disaster bag is divided into some sub assembly according to its functional specifications.
4. Detailed Design Phase: Parts of the proposed disaster bag are designed according to the shape and size of the product stored as well as anthropometric data.

RESULTS AND DISCUSSION

Based on discussions with disaster stakeholder disaster such PMI, BPBD of Padang City, KOGAMI, and questionnaire's result of 65 respondents regarding their experience during the previous evacuation, six needs relating disaster preparedness bags were identified, namely:

1. The bag capacity may accommodate the needs during a disaster
2. The items stored are not easily spilled/ safe
3. The bag has an ergonomic backrest design (supports back position and air circulation)
4. The bag has an ergonomic main strap (adjustable and soft)
5. The bag is easy to load and retrieval
6. Affordable prices

Then, it is identified as follows:

a. A disaster preparedness bag can be loaded items needed during evacuation for 3x24 hours.
b. Bags with lids to prevent the items being stored from easily spilling/getting out.
c. The back pad is soft and not hot. This part of the bag that comes into contact with the user's back is covered with soft and not hot material so that the user is comfortable when using it.
d. The strap is adjustable and soft, that is, the length of the bag strap can be changed according to user comfort. It is soft so that the user is comfortable when using it and does not experience shoulder pain.
e. Easy to arrange and retrieve items, namely whether the design of the bag makes it easy for the user to load and remove the items needed.

Based on the attribute of the bag, some alternative concepts are established for each attribute, shown in Table 2. Then, the total alternative of disaster preparedness bag concepts produced is "2×4×3x3x4=288" concepts. However, not all of the concepts produced is suitable in disaster situation and/ or match so several alternative concepts need to be eliminated. Other aspects that

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are taken into consideration in eliminating the existing alternative concept lies in the user's need for a disaster preparedness bag that is easy to use, strong, and comfortable.

Tabel 2. Concept alternatives

Attribute	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Bag strap	One strap 	Two straps 		
The way to use	Thrown over 	Carry 	Pulled 	Backpack 
Storage	One compartment 	Multi compartment 	Adjusted 	
Shape	Round 	Square 	Rectangle 	
Bag cover	Tied with rope 	*Zipper* 	Magnet 	*Buckle* 

Regarding the bag strap, variations on the one-strap bag concept are not recommended to be used because the heavy load will interfere with evacuee movement. The slung method of use, which only requires one strap, is also not suggested for a disaster preparedness bag since this way make load of the shoulders become not balance. It is discomfort to the evacuee [7], [8]. Two shoulder straps help reduce the discomfort in the waist, knees, feel less pressure in the shoulder region, reduce percentages of weight, reduce ventilatory disorders in the lung function [9], [10], [11]. The alternative concept of hand-carried bag is also not appropriate to be applied. Use by carrying make only one side of the user's body experiences stress in time of use. Using a disaster preparedness bag by pulling it is also not suitable since the road taken during evacuation may be uneven and rocky, thus slowing down the evacuee's journey. Alternative on the bag concept with only 1 compartment are also not implemented. Considering that disaster preparedness bags are used to carry various kinds of items needed during evacuation,

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alternative concept of a bag with only 1 compartment will result in all items being mixed as the current problem. This does not meet the user's need for ease in retrieving the required items because it will require a search process among items that have been mixed up. As a result, the pickup process will take time. Bags with too multi compartment are also less effective if there are more than its required number. In addition, it results in the size of the storage being too small so that they cannot accommodate large items. This results in variations of the bag concept with lots of multi compartments not being used. Regarding the shape of the proposed bag, round bags should not be used since most items are square or rectangular in shape, then it will result in the bag's capacity not being utilized optimally. The alternative concept relating bag cover using a rope does not meet user convenience about the ease of storing and retrieving items. It takes time longer to untie/ tie the rope compared to using a zipper. Use of magnets make it easier for users to close and open the bag, but the bag cover will easily come off/ open especially when the bag is full. As a result, items stored in the bag will easily come out. Thus, the concept of bag cover using magnets is inappropriate. Like a magnet, use of buckle may also easily for item stored come out.

After several concept alternatives were eliminated, it is found that two (1×1×1×2x1=2) concept alternatives. Alternative 1 is using two straps, backpack, adjusted, square, and using zipper for bag cover, while Alternative 2 is using two straps, backpack, adjusted, rectangle, zipper. The two alternative bags are differentiated by its shape: square and rectilinear. Figure 2 shows the Geometric shape of proposed disaster preparedness bag

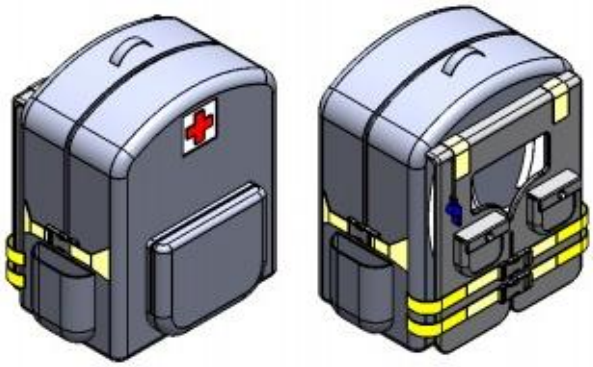

Figure 2. Geometric shape of disaster preparedness bag

The disaster preparedness bag consists of 5 main parts: main pocket, front pocket, main strap, chest strap, side pocket. Using Indonesian anthropometric data [10] (Table 3) and dimensions of the items that will be put into the bag according to the BNPB Pocket Book [1], the dimension of part of the bag is determined. Figure 3 shows the final designed of the proposed disaster bag.

Table 3. Anthropometric data used in disaster preparedness bag design

Data Measured	Part of the Bag
High back	Bag height
Hip width	Bag width
Shoulder height in sitting position	Bag height
Thick tights	Bag height
Thick chest	Main rope length
Head width	Distance between main strap

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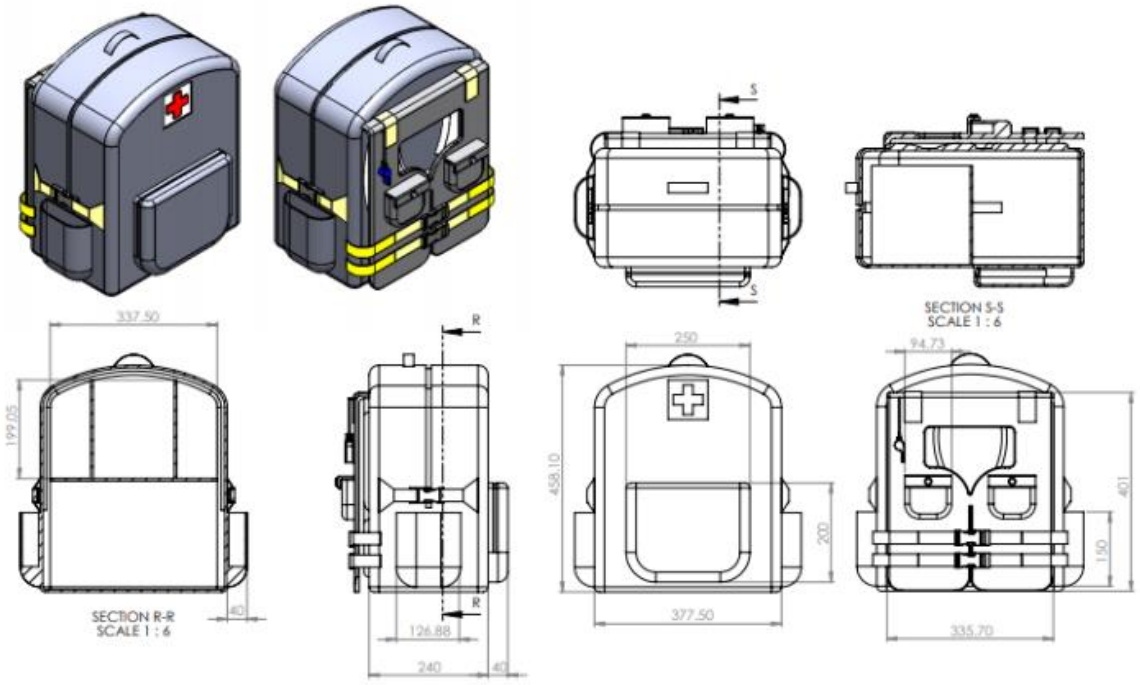

Figure 3. Final design of disaster preparedness bag

An analysis of the disaster preparedness bag was carried out to see how well the bag design was made to meet the user's needs. The bag is designed to be able to contain 10 types of items required by evacuee during evacuation time according to the BNPB's pocketbook [1]. The bag is designed to have multi compartments whose number and size are adjusted to the items to be stored. This way ensures the items do not mix with one another as well as ease of retrieval. On the other hand, many pockets require more material. But even so, this does not significantly increase the weight of the bag since it uses light materials. The material is waterproof so that items remain safe even if it rains or is exposed to water.

The design of the disaster preparedness bag has considered anthropometric characteristics, ergonomics aspects, ease of both retrieval and placing items, and the weight of the bag. The design of the back base and main strap of the bag refer to a body anatomy atlas (specifically around the shoulders, back, and waist). Two shoulder straps are designed like a vest so that the load is not focused on the shoulders alone, but on other muscles such as the abdominal muscles and chest muscles [13]. This design makes the bag seem to be attached to the user's body.

To evaluate the weight of the bag, the lifting limits used as a reference are the legal lifting limits according to the UK Occupational Health and Safety Commission. Based on the weight of the bag and the weight of the items to be carried for the 3x24 hour evacuation period, the estimated weight of the empty bag is 1.256kg and the weight of the items is 7.9kg with a total weight of 9.156kg. This value is below the maximum lifting limit for adult men (35-50 years), namely 20.2 kg or 12.5 kg for adult women (35-50 years). In addition, total weight of bag is supposed no more than 15% of bodyweight [14].

CONCLUSION

This study introduces an ergonomic disaster preparedness bag. This bag is used to store and carry items needed by evacuee in the early of 72 hours in evacuation place. The design of the disaster preparedness bag has considered anthropometric characteristic, ergonomic aspects, ease of both storing and retrieving items, as well as weight of the bag. The design of the main strap of the bag which resembles a vest makes the weight of the bag is not only focused on the shoulders but also distributed to other part of body such as the chest and stomach. The bag has multi compartment which number and size are adjusted to the items to be stored so that the items will be not mix with one another and ease of retrieval.

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