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京都大学
Disaster Resistance Buildings

Proposer: Eliza ALIAS

- Objectives: a) Introducing, exposing and describing different technologies and types of building designs that are disaster-resistant
   b) Developing creativity and ambition among school children
- Target: High school students
- Type: Illustrated short book

Summary

This short illustrated book describes building technologies and methods to resist different kinds of natural disasters. Most of the technologies were obtained from the Disaster Reduction Hyper base. These technologies include houses with used tires, stilt and uplifted houses, the Casbah of Algiers, structural retrofitting and bamboo T-shelter. Hopefully, this book would broaden the knowledge of school children as well as develop their creativity and ambition.

References
Disaster Reduction Hyper base, http://drh.edm.bosai.go.jp

DRH id below:
DRH 64, DRH 16, DRH 11, DRH 18, DRH 8, DRH 17, DRH 40, DRH 41
INTRODUCTION

Disasters such as earthquakes, tsunamis, storms, and floods are natural phenomena that sometimes could not be avoided. Thus, one way that we can do is try to protect ourselves when it comes, for example, living in disaster-resistant buildings. This short illustrated book describes building technologies and methods in resisting different kinds of natural disasters. It aims to expose young students, especially high school students, to various building design and technologies related to disasters. Whether the method of resistance is structural or non-structural, or a building recommended for post-disasters, they all play significant roles during disasters. Thus, they are all presented in the book.

Most of the technologies shown are obtained from the Disaster Reduction Hyper base and could be referred to in the following website: [http://drh.humanityglobal.org/]. Information on the construction details of each building technology, are only estimation and are recommended not to be used for other purposes. More information for each technology should be directed directly to the researcher of each building technology. Information of the researchers are included in the book.

It is hope that this book would broaden the knowledge of building technologies especially in terms of civil engineering and architecture among school students. It is also hoped that it would generate creativity and ambition among them.

Author,
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Doctoral Student
Department of Civil and Earth Resources Engineering
Kyoto University
Jan 2022

HOUSES WITH USED TIRES

Used tires can be built into house foundations to work as base isolators. It is also called the “Elephant foot on tire” concept, which is based on low cost construction principles and suitable for small scale housing. In the bottom of the foundation, ditches round river stones work as roller bearings. The tires slide on top in an earthquake and help absorb the vertical ground movements. Even though the estimation of the total cost house was not given, the cost of the technology has been mentioned to be very low and could be zero since all the materials used are from recycled items.

RESEARCHER: Ingenear studios

RESISTANCE AGAINST EARTHQUAKE

CONSTRUCTION DETAILS (Estimated)

The construction cost of the technology is zero.

What is this?

- Used Tires
  - Waste products which do not have any particular value (free).
  - Great for recycling
  - Absorbs vertical movements during earthquake

- Round river stones
  - Works as roller bearings
  - Allows horizontal movements during earthquake

- What is this?
  - Foundation: The lowest and supporting layer of a structure. It transfers and spreads the load of a building to the ground.
  - Base isolators: A structural element which decouples a structure from its substrate, resting on a shaking ground, thus protecting a building or non-building structure's integrity.
  - Roller bearings: A round roller which decreases friction.
STILT AND UPLIFTED HOUSES

The mechanism of stilt house building technology is simple: raise the house to a higher level and leave spaces for flood flowing through. The stilt house building technology, an indigenous knowledge in West Hunan Province, China, has been verified by its history of more than 1,000 years. It has also been developed into new forms and applied to modern buildings. Stilt houses could also be found in Malaysia (traditional wooden house) and in coastal areas in the United States. Houses that were uplifted to avoid floods were also implemented in Japan and Bangladesh.

What is this?

Stilt: Stilts are poles, posts or slats used to allow a structure to stand at a distance above the ground.

Uplifted houses

THE CASBAH OF ALGIERS

The Casbah of Algiers, which was rebuilt after the Algiers 1716 earthquake by the Ottoman, is classified as a world cultural heritage by UNESCO. These traditional earthquake-resistant building techniques have played a great role in protecting the Casbah of Algiers from earthquake which affected the site of Algiers during the last three centuries. Easy and cheap to put in place, these techniques have had the time to be tested during several destructive earthquakes which affected the site and thus proven their efficacy in reducing seismic risk. The technique includes logs of thuya being inserted inside the walls and floors.

What is this?

Thuya: A kind of log (tree bark) used as a reinforcement for buildings for ancient buildings in Algeria.

Researchers: Dr. Amina Aicha Abdesslemi.
**Structural Retrofitting**

Retrofitting are applied on structural members of building. These include windows, walls, columns and roof of buildings. In Japan, retrofitting were implemented on school buildings as part of the methods to secure the safety of school children during disasters. The retrofitted school buildings also act as emergency evacuation facilities for local communities. A detail explanation on retrofitting of school buildings in Japan are described in the following website: http://www.nier.go.jp/shisetsu/pdf/taishinjirei.pdf

- Retrofitting of roof
  - Bracings are installed along the entire ceiling to increase rigidity of the roof

- Retrofitting of walls
  - Meshes of steel were installed to form reinforced concrete shear walls

- Retrofitting of windows
  - Installing steel bracings on windows or between columns

**Non-Structural Retrofitting**

Besides building design or structural engineering method, retrofitting non-structural members of buildings could also help in reducing the impact of disasters. Examples of non-structural members in buildings are ceiling material, window and windowspane, exterior wall, lighting fixture, air conditioner and heating unit, bookshelf, storage shelves and gymnasium equipment. Detail explanation on non-structural retrofitting are described in the following website: http://www.nier.go.jp/shisetsu/pdf/taishinjirei.pdf

- Retrofitting of bookshelves
  - Bookshelves are fixed to stand wall, beam, or ceiling with metal brackets

- Retrofitting of air conditioner

**Resistance Against Earthquake, Tropical Cyclones, Tornadoes, Thunderstorms**

- **Construction Costs**: 0.1 - 5 million USD
- **Construction Period**: 3 - 8 months
BAMBOO T-SHELTER

Bamboo T-shelter is a semi-permanent, easy construction and an inexpensive house which could be built by local people who lost their homes after a disaster. The house was designed and targeted for the survivors of Java 2007 earthquake. It does not require special skill to build it. Sufficient strength for a permanent house can be expected. However, connecting the bamboo columns by ropes requires proper care to ensure sufficient strength of the house when it is built. This bamboo T-shelter was officially employed by the Yogyakarta local government and reported in a local newspaper.

FUNCTION

POST DISASTER RECONSTRUCTION

CONSTRUCTION DETAILS

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bamboo</td>
<td>The house is made of bamboo which is easy to find in Java, Indonesia.</td>
</tr>
<tr>
<td>Technique</td>
<td>Connecting the bamboo columns by ropes requires proper technique to ensure sufficient strength.</td>
</tr>
</tbody>
</table>

What is this?

Bamboo: Bamboos are some of the fastest growing plants in the world, as some species have been recorded as growing up to 100 cm (39 in) within a 24 hour period. Bamboos are of notable economic and cultural significance in South Asia, South East Asia and East Asia, being used for building materials, and as a food source.

APPENDICES
PILLAG AND ARCHES

Mosques are one example of a building that is usually designed with pillars, domes and open arches. This allowed tsunami waves to traverse the space without causing any damage to the building. The pillars also act as an energy dissipator against the hydraulic forces acting on the building from the tsunami. Even though no research was conducted, this type of building was proven to resist the tsunami during the December 2004 tsunami in Aceh.

RESISTANCE AGAINST TSUNAMI

CONSTRUCTION DETAILS (Estimated)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (Millions USD)</th>
<th>Time (Years)</th>
<th>Labor (Men)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Costs</td>
<td></td>
<td>1-2</td>
<td>20 - 100</td>
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Open Arches
- Allow tsunami waves to flow though the spaces

Pillars
- Act as an energy dissipator against tsunami

What is this?

Pillars: A column or pillar in architecture and structural engineering is a vertical structural element that transmits the weight of the structure above to other structural elements below.

Arches: A curved structure capable of spanning a space while supporting significant weight.

11 MARCH 2011 TSUNAMI

Pictures below are the courtesy of Negishi (negish@bosai.go.jp) and his family. They were taken after the tsunami hits Ofunato City and Rikuzen-Takata City of Iwate, Japan.

- Destroyed building near coast hit by tsunami
- Prefectural road No. 255 (about 1km from the coast)
- A fishing boat is in the house
- There were houses and stores there before March 11, 2011
- The tsunami reached up to the second floor of this building. Posttraumatia are seen in the second floor
- The tsunami smashed up to the second floor of the building. Posttraumatia are seen in the second floor