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MITIGATING TSUNAMI RISK IN INDONESIA VIA PRACTICAL PLANNING AND CONSTRUCTION GUIDELINES

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ABSTRACT

Indonesia has the fourth largest population on earth with over 260 million individuals and houses one of the most densely populated places worldwide on the island of Java. That said, much of Indonesia rests above active subduction zones. It is one of the most seismically active areas on the planet and has had several significant tsunamis over the recent years. However, there is little in place regarding seismic building construction safety practices and documentation. Because available guidelines for mitigating tsunami risk through planning and construction come from developed countries such as Japan, it is necessary to adapt them to suit the social, economic, and natural context of existing areas in Indonesia. The primary purpose of the guidebook, located in draft form at http://www.inharmsway.info/indonesia-tsunami-guidebook/, is to improve safety for individuals with less emphasis on the life of the building itself. The guidebook exists as a living document which can continue to be refined by others well in to the future. It is designated as Creative Commons attribution non-commercial.

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Introduction

Indonesia has the fourth largest population on earth with over 260 million individuals and houses one of the most densely populated places worldwide on the island of Java. Across Indonesia the terrain is largely coastal lowlands although the larger islands have interior mountains. While Indonesia contains the most volcanoes of any country in the world, their natural hazards also include tsunamis and earthquakes [1]. That said, much of Indonesia rests above active subduction zones. Actually, it is one of the most seismically active areas on the planet. It is surrounded by many tectonic plates including the Indo-Australia plate, the Pacific plate, the Philippine Sea plate, and the Sunda plate. It also has several faults such as Sumatra, Lembang, Sorong, and Timor. The Sumatran faulty, for example, is a large strike-slip that runs the entire length of the island of Sumatra. It ends just below the city of Banda Aceh, where a devastating earthquake and tsunami occurred in 2004. In that earthquake, Banda Aceh lost 30% of its

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inhabitants (>130,000), had another 7000,000 homeless, and had property losses of more than 4.4 billion dollars [2,3]. However, even with above circumstances, there is little in place regarding seismic building construction safety practices and documentation. In part this may have to do with economics. The gross national income per capita in U.S. dollars is only $3,400 [4]. Regardless of income or the dollar value of structures either being built or already in place, there are steps that can be taken to improve safety. Safety of individuals should be a priority for all construction, followed secondarily but less importantly with overall building resilience.

Project Description

Indonesia has had several significant tsunamis over the recent years. The 2004 magnitude 9.1 earthquake and tsunami in Sumatra as previously mentioned, but even smaller earthquakes have a sizeable impact. The magnitude 6.3 earthquake near Jogjakara in 2006 had a death toll of over 6,200 with thousands more injured and more than 60,000 houses destroyed [5]. Another is the 2006 magnitude 7.7 earthquake and associated tsunami in Pangandaran, West Java. While there was only weak shaking and no ground motion damage from the earthquake, there was extensive damage and losses of over 600 lives from the tsunami. An inspection after the earthquake showed extensive damage caused by the tsunami to wooden and unreinforced masonry buildings that were located within several hundred meters of the coast [6]. Many areas of Indonesia may also be in harm's way (Harris and Major, 2016). The goal of the project is to define, develop, and distribute best practices for planning and construction on Indonesian coastlines to reduce tsunami risk. This includes electronic and print materials that relate to land use, new buildings, and retro-fitting of established structures.

This work is being completed as part of an already-established collaboration with Brigham Young University (Profs. Ron Harris and Chad Emmett, and students), the non-profit In Harm's Way, the Red Cross, Universitas Pembangunan Nasional (Indonesia, Carolus Prasetyadi and students), the Indonesian Federal Science Organization (LIPI), and the Indonesian Federal disaster management agency (BPBD) where related projects have been implemented to assess and reduce Indonesian tsunami risk. We are building on work successfully completed on Java in 2015-2016. Our work on this project comprises planning, three weeks of field work which occurred in Indonesia during summer 2017, and compilation, analysis, distribution and presentation of results during the 2017-18 academic year.

Because available guidelines for mitigating tsunami risk through planning and construction come from developed countries such as Japan, it is necessary to adapt them to suit the social, economic, and natural context of existing areas in Indonesia and related areas with fewer established resources, lower income, and less familiarity. To do so, existing and proposed coastal development was assessed on site, giving researchers opportunities to identify practical, inexpensive mitigation technologies. Guidelines for implementation of these methods are being compiled and disseminated in hardcopy and digitally, including through the non-profit In Harm's Way (http://www.inharmsway.info) website.

Field Work

During spring and summer terms in the 2016-2017 academic year, local research was done on

seismic construction handbooks worldwide via projects in two different courses, Tech 4200 Marketing and Distribution, and Tech 495R Undergraduate Research. Additional local research was completed on the geologic situation in Indonesia as well as the current state of publicly available building construction requirements there. This information gave us a general foundation from which to work for the project.

Dr. Ron Harris of Brigham Young University (BYU), with the support of Deb Harris, worked in direct collaboration with Dr. Carolus Prasetyadi of Universitas Pembangunan Nasional (UPN) to arrange permissions and plans for all group travel to Indonesia—including lodging, transportation, guides, translators, required documentation and permissions, finances, and tentative schedules. They arranged for four related interdisciplinary projects which worked together across not just these institutions but also Utah Valley University (UVU) and the Indonesian Institute of the Sciences (LIPI). The project groups included:

- Geologic research of past Tsunami events via trenching and ground work led by Dr. Ron Harris (BYU) with students Chelsea Grady (BYU), Bryce Berrett (BYU), Hanif Ibadurrahman (BYU), Claire Ashcraft (BYU), Mike Lowry (BYU), Torri Duncan (BYU), and Jake Voorhees (BYU).
- Education, outreach and both qualitative and quantitative research of tsunami awareness led by Dr. Chad Emmett (BYU) and Dr. Sarah Hall (UVU) with student Amelia Cope (UVU).
- Geologic research of past Tsunami events via unmanned aerial systems led by Dr. Michael Bunds (UVU) with students Serena Mercedes Smith (UVU) and Alexander Uribe (UVU).
- Building construction practices research led by Dr. Anne Arendt (UVU) with students Rubi-Hernandez-Turner (UVU) and Khaliun Amarjargal (UVU).

Each of above groups worked collaboratively. Spanning all the projects was direct involvement of four native speakers and residents of Indonesia, all of whom spoke English as a second language: Dr. Ir. Carolus Prasetyadi (UPN), Purna S. Putra (LIPI), Gilang Setiadi (UPN), and Irina Rafliana (LIPI).

Funding for the travel was made available in part by Utah Valley University institutional engaged learning grants, Geoscientists Without Borders, contributions by the non-profit In Harm's Way, travel funds from Brigham Young University, and personal funds. In early July, 2017, a group of students from Brigham Young University, led by Dr. Harris arrived in Indonesia to finalize authorizations, scout, and establish research plans. A week later Dr. Bunds, Dr. Hall, and three students arrived to finalize authorizations and begin research. On July 12th, Dr. Arendt and the two students involved in the construction research met the group in Bali to begin their work, following the plans established by Harris. The trip entailed research in Bali, Lombok, and Sumba as last year the group had visited Java and the years prior had visited East Indonesia. The building construction team remained with the larger group from July 12th, 2017 to July 25th, 2017 and then travelled to Flores until July 31st, 2017. Other segments of the party remained in Indonesia through early August.

Each morning throughout the duration of the Indonesia travels, the full group would meet and discuss plans for the day. This encouraged interdisciplinary collaborative work. In some cases, individuals would opt to spend the day on a project outside their primary area which also facilitated teamwork and a larger connection between the related areas. The construction group primarily focused on walking through different communities and documented their observations

in writing and with photography. When possible, the group informally interviewed individuals to learn more about both perceived tsunami/earthquake risk and intentionality in building with such circumstances in mind. Over 500 photos were taken in the cities of Jakarta, Bali, Denpasar, Lombok, Mataram, and Labahanbajo, among others.

Guidebook Development

The primary purpose of the guidebook, located in draft form at http://www.inharmsway.info/indonesia-tsunami-guidebook/, is to improve safety for individuals with less emphasis on the life of the building itself. Based on on-site observations as well as research on similar materials from other areas, major topic categories were developed which include: tsunami and earthquake risk overview, building site location considerations, residential building construction recommendations, material use recommendations, and post event considerations. On the topic of building site location, areas of earthwork, site grading, and at-risk building sites are addressed. For building construction, building response is described. This is followed by specific recommendations for building structure, footings and foundation, stairways, means of egress, wall support and framing, and roofing. A segment about materials is also incorporated which includes concrete and masonry, natural fibrous materials, and metals. The guidebook concludes with several post event building safety considerations. The guidebook exists as a living document and can continue to be refined by others well in to the future. It is designated as Creative Commons attribution non-commercial.

Conclusions

With the potential for the Sunda trench and others around Indonesia to cause massive earthquake and tsunami damage, our goal for this project is to save lives wherever possible by preventative strategies. One means of accomplishing this is through improving building safety, if even at the most basic levels. In a recent 6.4 magnitude earthquake that struck a province of Aceh in December of 2016, the death toll was 104 persons, over 18,752 homes were damaged, and another 387 individuals where hospitalized [7]. If even some of these casualties could be avoided in similar future events, the intention of the work on this guidebook will have been met. Hopefully, as it continues to be refined, its positive impact and reach can broaden to as many areas and circumstances as possible while remaining practical and feasible for the locations both financially and resource-wise.

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