Episode 1: What Do Estimated Annualized Earthquake Losses Show Us about the Potential Impacts and Costs of Earthquakes?

Introduction: Welcome to *Ready to Recover*, a podcast series in which guest experts take a closer look at what people may experience when seeking to finance their recovery after a damaging earthquake. These discussions consider common challenges and options, including what can be done to prepare before disaster strikes. This podcast series is produced by CREW@crew.org with funding from the National Earthquake Hazards Reduction Program.

In this episode, guest host Althea Rizzo leads a discussion of the 2023 Hazus Estimated Annualized Earthquake Losses report, which provides a nation-wide view of rising earthquake risk and potential losses—information that can help disaster planners identify priorities, guide decision-making, and draw attention to the need for mitigation and recovery planning.

Althea Rizzo is the Geologic Hazards Program Coordinator at the Oregon Department of Emergency Management. She manages the state's Earthquake, Tsunami and Volcano Program, including emergency planning, preparedness, response, mitigation, and public education.

She's joined by two of the report's authors:

Kishor Jaiswal is Chief of the Engineering and Risk Project at the U.S. Geological Survey. As a research structural engineer, he leads the development of earthquake risk products for buildings and critical infrastructure, including casualty and economic loss estimation models.

Jesse Rozelle is the Program Manager for the Natural Hazards Risk Assessment Program within the Federal Emergency Management Agency. His team serve as subject matter experts in the development of methodological guidance, datasets, and risk assessment tools that support emergency management and risk-reduction decision making—tools that include Hazus and the National Risk Index.

Althea Rizzo Welcome Jesse, and welcome Kishor. I'm looking forward to this opportunity to talk with you today about Hazus and earthquake losses and how we can use the information provided by the data tools to ensure that we are making our communities safer from earthquakes and tsunami.

So we're going to hop right into this. The first question is for Kishor:

What is the main purpose and scope of the Hazus Estimated Annualized Earthquake Losses report?

Kishor Jaiswal — Hello, everyone. Before I answer this question, Althea, let me take the opportunity to thank the entire CREW team here. The work that you guys are doing for the community is phenomenal, and I wish you the best for the future.

Now, let's come back to your question. The main objective of this report is to provide a systematic account of seismic risk by making use of the best available science data and models on earthquake hazards, as well as the latest information on built environments, exposure, and vulnerability to such hazards. As we all know, earthquakes can't be predicted yet; however, we do know where they are most likely to occur and how severe the shaking will be when they occur. The USGS, as a part of the four-agency NEHRP program established by Congress, is responsible for monitoring and reporting on earthquakes, assessing earthquakes' impacts, and conducting targeted research on studying the causes and effects of earthquakes. This report makes use of the latest hazard models from the USGS and updated building stock inventory data from variety of different sources. All this data is brought into FEMA's Hazus software to compute seismic risk. Thus, the ultimate purpose here is to provide clear and credible earthquake risk information at a national scale to support variety of risk reduction efforts.

Althea Rizzo — Perhaps we could back up here a little bit. So, what exactly are earthquake losses?

Kishor Jaiswal — Yeah. As we all know, when large earthquakes occur in a community, they can inflict both societal as well as economic disruptions. Poorly designed and constructed buildings may experience damage, and depending upon the severity of shaking, they can collapse and kill people. Repairing and replacing such damaged buildings can require substantial sums of money. Thus, this report is trying to estimate both societal as well as economic disruptions caused from earthquakes.

Althea Rizzo — So what is *annualized* losses and why is that information important to have?

Kishor Jaiswal — Yeah. A typical metric used in evaluating seismic risk is defined in terms of long-term eligible earthquake loss estimated on per yearly basis. So you can imagine that earthquakes don't occur–, large earthquakes don't

occur frequently. But when they occur, they can have significant impact. So the idea of long-term average is looking at earthquake activity coming from a moderate size to a very large earthquake and quantifying it probabilistically to get an average sense on a per yearly basis.

But remember that $14.7 billion per year is a long-term average. A moderate size earthquake, even a magnitude 6.5 or 7, if it occurs near a large population center in California or the west coast of the United States can easily cause tens of billions of dollars of loss, as we have seen in recent earthquakes, [inaudible] or other recent earthquakes in the country. And thus a single earthquake can easily exceed that number, easily. So like I said, a moderate size earthquake like magnitude 6.5 or 7 occurring near an urban population center can easily cause a loss of tens of billions of dollars. And thus this long-term average is only representing a view or a snapshot on a per yearly basis, but any single earthquake can easily exceed losses of that proportion.

Althea Rizzo — What are the main assumptions and methods used in the report to model earthquake hazards and exposure?

Kishor Jaiswal — There are a number of assumptions and approximations being made throughout this study when calculating annualized earthquake losses. Many of these assumptions are clearly stated in the report. Before I give some examples, let me state that the estimates provided by the study are not determination of total risk. This is because not all aspects of earthquake impacts are considered. For example, the study only addresses direct economic losses to buildings. Indirect and long-term impacts to economic activities are not considered. Similarly, impacts to non-building infrastructures are also not considered. In addition, there are a number of simplifications being made in the Hazus methodology when defining probabilistic hazard on a site-by-site basis. As we all know, the built environment exposure also changes from time to time, and thus the latest exposure data can only represent a snapshot of that exposure at a given time. Finally, the occurrence of large earthquakes in any given region may influence the likelihood of subsequent activity. We call them time dependence. Such time dependence in earthquake hazard is also not considered in our analysis.

Althea Rizzo — What are some of the key findings and implications of the report for disaster planning and mitigation?

Jesse Rozelle — The study estimates annualized earthquake losses to the United States at about $14.7 billion per year. A higher majority of those annualized losses,

about 65 percent—or about $9.6 billion per year—is not surprisingly concentrated in the state of California. In addition, overall, the West Coast—to include California, Oregon, and Washington account for 78 percent of the total annualized earthquake losses in the nation. And the remaining 22 percent, about $3.1 billion, is distributed throughout the rest of the United States, including Alaska, Hawaii, Puerto Rico, and the US Virgin Islands as well. Also, even though most economic loss is concentrated, not surprisingly, along the West Coast, when we look at the distribution of relative earthquake risk as measured in annualized earthquake loss ratio, our snapshot of risk across the country is much broader and reinforces the fact that earthquakes are a national problem. Relatively high earthquake loss ratios are found throughout the western and also the central United States—so states within the New Madrid seismic zone and in the Charleston, South Carolina, area, for instance.

Althea Rizzo — Excellent. Follow up question: So what are the main drivers and contributors to earthquake losses in the US?

Jesse Rozelle — That's a great question. So, as we estimate earthquake risk through the Hazus model and through this study effort, a high proportion of the losses are driven by the built environment and the way that we quantify buildings across the nation. We have detailed documentation of how we do that in our Hazus Inventory Technical Manual, but also the updates in the earthquake ground motions from the USGS team.

Althea Rizzo — Excellent. How can state, county, and disaster planners use the report to identify and prioritize their earthquake risk reduction strategies?

Jesse Rozelle — This study can help in a variety of different ways. The study and knowing the regional risks due to earthquakes across the nation, across the state, and across from one census tract to another, can be used to help highlight priorities for developing seismic mitigation plans for instance. It can be used to prepare inventories and conduct seismic safety inspections of critical structures and lifelines. It can also be used to drive discussions on updating building codes, zoning codes, and ordinances to enhance seismic safety. Also, it can be used to increase earthquake awareness and education with the broader public.

We're also building a dashboard to show different mapping and visualization snapshots of the earthquake risk around the nation that will be available publicly and can help drive some of those public risk communication efforts as well. It can also be used to encourage the development of multi-state groups for prioritizing risk reduction

strategies to look at not only risks within a state, but risks across regions and across state borders. It can also be used to evaluate the costs and benefits of seismic building code provisions, and in addition, to support disaster response and recovery planning. When we know that earthquake risk is higher in certain communities due to the built environment and the ground motions in those areas, we can help plan for which areas may need more help in a response or recovery event.

Althea Rizzo — Excellent, thank you. How does the report account for uncertainties and limitations in the data and methods used for analysis?

Kishor Jaiswal — There are inherent uncertainties in computing earthquake losses. As your listeners may know, the process of data compilation, assessing the building values, and defining the building characteristics mapped for the study region require a number of assumptions, and there are uncertainties involved in making such assessments.

Similarly, the earthquake hazard is defined on a point-by-point basis for millions of sites across the whole United States, and the hazard defined at each location may have inherent uncertainties, and those uncertainties are not directly accounted for in terms of propagating them through earthquake loss estimation.

Althea Rizzo — Okay. Follow up question (and feel free to not answer this one): But if you had a magic wand and you could fix any limitation in your data, the sources of your data, what would that one fix be?

Kishor Jaiswal — Well, in the loss modeling world, there is not a single issue. We have multiple issues which we need to address. But if we were to pick one, I think the uncertainties in ground motions is a huge factor to consider. Ground motions vary from one point to another point significantly. We only have a limited number of seismic stations. When a big earthquake occurred, we really don't know what fault triggered that earthquake or how the shaking varied from one site to another site.

And that understanding of seismic shaking from one point to another point is an important input for quantifying losses from such shaking. So that is, I think, the number one uncertainty that we need to cater. But if I had to basically add one more, I would say we know very little about our building stock, even though we have probably the best available data on building inventory. However, the way they are built, especially the buildings built prior to 1960s and '70s and '80s for example, many of those structures are probably–, are not designed to the seismic standard and definitely not designed to the modern seismic standard that we know of.

And thus predicting their response in a large earthquake is a huge question mark in front of many of us. And thus we really need to work together, both seismological and engineering community, to address these issues.

Althea Rizzo — Thank you. How often is the report updated and what are some of the future plans for improving it?

Jesse Rozelle — Yeah, thank you. So we released this version of the study and the report in April of 2023, and previously, our last publication for this nationwide study was in 2017. We don't currently have a set update cycle, but we don't plan to wait six years for the next release. But we're still talking about the right timing for the next update. And a lot of it ties to significant improvements in both the Hazus model and the ground motions data that's available.

So this update to the model in the study in particular had some significant improvements with the release of Hazus 6.0 that we use for this study. We updated and improved what we call the general building stock, so the representation of all buildings across the nation, across the country throughout the model at a national scale using the Army Corps of Engineers National Structure Inventory. So it was a vast improvement in the quality and accuracy of what we know about the built environment. We also updated it for the 2020 census as well, and then using the 2018 USGS ground motion data. So the availability of all of those improvements to the model led to the decision on the timing of this study update. And we are having talks with the USGS on what would make the most sense for the next available study as far as the timing for the next release, but don't quite have that date yet.

Althea Rizzo — So how can the public and decision makers access and understand the report results?

Jesse Rozelle — Yeah. It's all publicly available online. The report itself is available on fema.gov, and I can provide a link so you can share with the Cascadia community. We're also releasing the data results themselves in a couple places. One place being the Hazus loss library. They'll be available up there soon. And that's an online web mapping resource that we maintain here at the Hazus program that has a variety of Hazus loss results for not only earthquakes, but floods, tsunami, and hurricane wind scenarios around the country. And we'll also have a dynamic dashboard available as well with a lot of different ways to break down and view the data, both looking at not only annualized loss but loss ratios and some of the other

outputs as well. And all of the data sets themselves will be publicly available for download as well.

Althea Rizzo — So what are some of the best practices or examples of how the report has been used or applied by different stakeholders?

Jesse Rozelle — Yeah, that's a great question. At a national scale, information from this study is directly feeding into FEMA's National Risk Index and serves as the earthquake hazards expected annualized loss factor in that product. The National Risk Index is an online application that identifies communities most at risk to 18 different natural hazards, and this application visualizes natural hazard risk metrics and includes data about expected annualized losses from natural hazards, social vulnerability, and community resilience. And then we use that data here at FEMA in the National Risk Index to help enable a refined understanding of earthquake hazard risk in this multi-hazard spectrum.

For more of a city planner's perspective, the annualized earthquake loss study can help to highlight specific parts of the community that are more likely to be higher at risk. And using this information, which includes information on more vulnerable building inventory and expected higher ground motions and the losses sustained for those, at a local scale there have been notable successes using information like this to drive efforts on the ground, including the unreinforced masonry programs in Seattle and Salt Lake. Also, in 2015, for instance, the City of Los Angeles adopted an ordinance to retrofit 14,000 pre-1978 wood-frame soft-story buildings and non-ductile concrete buildings. In addition, the city of Los Angeles invested 1.3 billion in retrofitting over 8,000 buildings through 2022. And although a large investment, the average annualized loss estimated for Los Angeles County in that particular instance was 2.68 billion dollars. That's one example how that can help drive a lot of those discussions and prioritizations on the ground.

Althea Rizzo — Excellent. I'm going to ask a more difficult question here, and it's kind of a follow-up to that question. You mentioned the National Risk Index. So for the National Risk Index, there are some deficiencies that have caused concern in its application, especially as a source of funding for the future. The National Risk Index only goes back for historical earthquakes 221 years I want to say. But that completely ignores the geologic record, especially here in the Pacific Northwest when the last major Cascadia earthquake was over 300 years ago. Does this report take into account that longer geologic scale, or is there the cutoff as there is in the National Risk Index?

Jesse Rozelle — Well, the National Risk Index for the earthquake component leverages the ground motion data from the USGS probabilistic seismic hazard map. I would have to defer to Kishor on more detail on the geologic period of record for that.

Kishor Jaiswal — Yeah. So my understanding is that National Risk Index assessments for the earthquake side of things are directly leveraged from the FEMA-366 latest seismic report that we have produced, which does account for a long-term hazard defined using the USGS hazard model. So I think in terms of the frequency of earthquake, they might have considered a shorter time window. However, the risk is pretty much defined using and leveraged from the FEMA-366 study.

Althea Rizzo — Thank you very much, Kishor and Jesse. I really appreciate your time today to talk about this report. And I'm sure that there are going to be a lot of listeners out there that are going to be interested in what it says about their communities.

Jesse Rozelle — Absolutely. Thank you for having us.

Kishor Jaiswal — Thank you for having us.

Pascal (CREW) — This episode of the Ready to Recover podcast series was produced by CREW.org, with funding from the National Earthquake Hazards Reduction Program.

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Thank you for listening.