

Earthquake Engineering Research Institute (EERI)—Learning from Earthquakes Program (LFE) Business Resilience Survey Initiative—Summary January 2022

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Summary—Beginning in 2014, engineers and social scientists affiliated with EERI collaborated together to design a survey that could be used to learn from earthquakes, following an earthquake, to track how damage to structures and other factors affect business resilience. The survey was developed, refined and adapted while being administered in Napa, California (in August 2016, 2 years after the 2014 M 6.0 S. Napa earthquake), Cushing, Oklahoma (in November 2016, one week after the M 5.0 Cushing earthquake), and Anchorage and Eagle River, Alaska (in March 2019, 3.5 months after the 2018 M 7.1 Anchorage earthquake). This brief summary describes the survey structure and protocol, alternative methods of administering the survey, implementation challenges and what has been learned from each event, and the potential for longer term use of the survey.

Goals of the Initiative—While statistical tools and some data exist to assess on a macro scale economic vulnerability to earthquake damage (for example studies that compare actual or potential output before and after an earthquake), there was little data available to understand the process of business recovery (or failure) in the context of the details of the building (and neighborhood) damage and repair process. Furthermore, because earthquakes occur periodically in many different contexts, it seemed helpful to provide a standardized way to gather a common set of information that would be useful to structural engineers designing safe and occupiable/functional spaces, business and economic development organizations to prepare before and recover after an earthquake as well as for planners addressing mitigation in the face of risk, or for responders to provide services after a major earthquake. From a broad perspective the survey would be used to:

- Assess physical and business conditions immediately after an event to identify emergency assistance needed by businesses
- Monitor business issues in recovery to provide insight for economic development organizations, building and business managers, and other policy-makers including government agencies providing or orchestrating assistance.
- Inform building design pre-event and permit process during recovery on the relationship between building performance and other sources of disruption and business resumption.
- Inform business decisions on preparedness, building codes, and design of business disaster response for building vulnerabilities and recovery resources (e.g. insurance).
- Provide metrics in support of research and modeling of business and economic impacts from building damage and community disruption.

More specifically, the survey design was intended to:

- Create a standard set of survey questions that address
 - Building conditions over time
 - Business conditions over time
 - And, can be analyzed to understand how the two are related
- Develop a protocol for the survey process
 - When to launch the surveys
 - Who to survey
 - What tools and processes to use to implement the survey

- Make the questions and tools flexible and available to different sets of researchers in each event, so that it may be possible to compare results among events.
- Adapt timing and questions included in survey to fit the level of severity of impacts and time frame of earthquake response, restoration of services, and community recovery.

Survey Structure and Protocols—The survey has two components, including a building damage component and a business disruption component, as shown in Table 1. Building damage information is collected immediately following the earthquake and includes details on the building characteristics and on the damage experienced, such as:

- Basic information (building PIN, inspector name, location)
- General information (area, stories, year built, structural system)
- Component damage (structural, nonstructural, contents)
- Inspection and placard (date inspected, placard color, reasons given)

Business disruption is also addressed in the initial survey, while follow-up surveys may identify how fully businesses recover and how quickly. The initial survey gathers characteristics of the business and this and later surveys ask for information on real-time conditions at different time intervals after the earthquake.

Section	Initial Engineering Survey (visual inspection)	Initial Business Survey	Follow-up Business Survey
0 - Survey Respondent Information	x	x	X
1 - General Building Information (area, height, location)	x		
2 - Business Baseline Conditions (age, type, size, customer base, past disaster experience)		x	X
3 - Physical Damage (structural, nonstructural, ground deformation, contents)	x		
4 - Building Downtime (time period, causes--physical, institutional)		x	X
5 - Business Recovery (to what percent capacity)		x	X
6 - Funding and Financing (need, sources)		x	X
7 - Resilience (advanced preparation, assistance received, provided)			X
8 - Follow-up Permissions & Demographics		x	X

For EERI, survey deployment begins after an earthquake, when the Learning from Earthquakes program and the cochairs of the Business Resilience working group review initial information on the quake size and scope, and assess if the building damage and impacts on businesses are large enough to raise questions about business resilience and its relationship to building performance. Would a survey be useful under the circumstances initially observed? If a survey is to be launched then preparatory steps are needed, including

- Selecting questions to be asked (from the pool of questions originally developed; a detailed survey was administered in Napa, while surveys in Cushing and Anchorage were truncated),
- Applying for clearance related to the US Department of Health and Human Services requirements for protecting human subjects during survey research.
- Identifying the team to administer the survey (the EERI and business resilience teams are all volunteers).

Other steps required to implement the survey include:

- Selecting the survey tool (on-line options include survey monkey, used for Napa, and Fulcrum, used for Anchorage; in person surveys were used in Napa and Cushing, and a paper survey was also available in Napa)
- Selecting the sample to be surveyed (in Cushing a random sample was used, in Anchorage a “snowball” sample focused only on businesses in damaged buildings, while the Napa survey involved hand selecting a range of different business types).
- Determining the timing and frequency of the survey.

A plan for data storage and processing, in place before the survey is launched, is designed to keep responses confidential but accessible to the research team to be systematically analyzed.

Findings and Lessons from Implementing the Survey—The business resilience working group has administered the survey following earthquakes in Napa, California, Cushing, Oklahoma, and Anchorage, Alaska. In Napa, the two initial surveys were administered with an on-line option using survey monkey and in-person with a paper option. In Cushing, a truncated survey was launched in-person in collaboration with a social science team at the local university and in conjunction with the EERI building assessment. In Anchorage, a truncated survey was administered in-person, by the engineers who came to the site for building inspections, using Fulcrum on mobile devices.

For the Napa survey pilot, a range of different business types were targeted and followed up with and extended opportunistically in-person. In Cushing, a random sample was used. In Anchorage and Eagle River, the team began with businesses identified from a database compiled by VERT (a virtual reconnaissance program sponsored by EERI), selecting those to be interviewed through a combination of opportunistic and snowball sampling.

None of these earthquakes were devastating to their communities, although building damage proved quite challenging for some businesses.

Napa, California—Damage from the 6.0 magnitude earthquake was most heavily concentrated in the city’s downtown area. Some buildings were still red-tagged two years after the earthquake, at the time the team surveyed business owners (and some remain vacant today, despite downtown redevelopment efforts). Some businesses closed temporarily to clean up damaged contents, a few closed for years until they could re-established in a new building, and some closed permanently due to damage or inventory losses or personal losses such as damage to homes. Others were able to stay open or reopen as much as a year later thanks to community provided resilience measures, although in the early weeks after the

earthquake, broader damage limited accessibility downtown and tourism related businesses reported lower numbers of customers for 5-6 months. Community members supported each other by helping with clean-up, moving out of buildings, sharing space and resources, congregating in open businesses as “therapy” of a shared experience. Small grants from the Napa Disaster Relief Fund helped cover the immediate needs of businesses. Mitigation measures taken earlier, before the earthquake, enabled some businesses to stay open, although others reported nonstructural disruptions.

Cushing, Oklahoma—The 5.0 magnitude earthquake in November 2016 damaged 52 buildings in and near the city, at least 15 with moderate to severe damage, and lifeline services were lost for short periods. Only a truncated survey was administered, as respondents were resistant to commit time to a longer survey and damage was moderate and recovery on the shorter side. The survey team found 59% of businesses open during the reconnaissance. Many of the closed businesses were seasonal and had closed before the earthquake. The damage was scattered and was not dense, so there was little evidence of “contagion” of impacts from broader damage to the area. Scattered but overall not extensive damage to lifelines meant that repairs could happen quickly, also minimizing the time frame of the economic impacts.

Anchorage, Alaska—In late 2018, a 7.0 magnitude earthquake struck 14km north of Anchorage. Damage occurred in Anchorage and in some smaller communities. In March, 3.5 months after the earthquake, a small team from EERI surveyed businesses in Anchorage and Eagle River. The researchers visited 67 businesses over 3 days, with 23 completed surveys from this effort, mostly from retail, food services or hospitality businesses. Despite the size of the earthquake, most businesses reported only minor damage, mainly to building contents and inventory, and were able to reopen within a few days. By the time the survey was launched, most businesses were able to report they were fully recovered.

Lessons—The survey results allowed the engineers at EERI to better understand the role of building damage, damage to contents, loss of inventory, lifeline disruption, and adjacent damage in business resilience or disruption. Even a moderate earthquake, if the damage is concentrated in a business district, can cause economic losses to local businesses within the district. Firms that already faced narrow margins between solvency and failure could be pushed out of business by the costs of recovery and disruption of commerce. In some cases, consequences of the earthquake outside of the business itself (such as damage to homes or employee stresses) could slow recovery. However, the three case studies also highlighted the resilience of most businesses in the face of the moderate earthquakes. Early interventions, either in the form of informal in-kind assistance, or more formal financial aid, could help business survival.

Survey Challenges and Opportunities—The survey project developed a carefully honed set of questions, informed by surveys conducted after the Christchurch earthquakes, to elicit information that would allow comparing building damage to business disruption. The survey is designed to follow the resilience of businesses as the physical structure recovers. Implementing the survey is not straightforward, but offers both challenges and opportunities.

Challenges in Survey Design and Launch—Ideally, the working group hoped to elicit several types of information from the survey, including detailed building characteristics and damage to structure and contacts, business characteristics pre-earthquake, and changes to employee count, revenues, expenses, location and customer base after the earthquake. The extensive number of questions developed to address these topics had to be traded off against the ability and desire of business and building owners to respond. In addition, timing is tricky. In early days following an earthquake, owners face questions of

their own in terms of how to address damages and business and personal loss, as well as the related emotional trauma and confusion. Yet as time passes, memories of the early details fade, and interest in filling out a survey may also wane over time, but energy for sharing the experience still may persist within conversation. The survey process was adjusted to address these issues by limiting the number of questions and implementing the survey in person. This has worked well with small events, but with more widespread damage, other approaches may be needed, as will be discussed below in *Opportunities*. In addition to challenges of the size of the survey and timing, other concerns that have been addressed with each survey include quickly

- obtaining the certification that the survey is being conducted under the protocols for human subject protection,
- methods of sample selection (which have not been consistent in the three case studies to date)
- data storage and sharing among researchers
- showing benefit to businesses and communities from participating in the survey.
- There is no funding for the research, so it has been dependent on volunteer efforts.

Opportunities for Collaboration in the Future—The work could benefit in the future through various forms of collaboration with other organizations. The survey design and approach can be shared with other Federal government agencies that also track or work with businesses following disaster, such as NIST, the US Small Business Administration, the Census Bureau, that followed the business and household “pulse” during the pandemic, as well as the DesignSafe program funded by NSF. In addition, the resource and technical assistance can help local communities experiencing an earthquake set up their own surveys, either through city and county responding agencies or business organizations such as chambers of commerce. Furthermore, the initial launches of these surveys has been enhanced by collaboration with nearby universities or with academic researchers focused on understanding immediate and longer term impacts of earthquakes.

Future Steps—To ensure a sustainable foundation for future deployments, the working group will share information and prototype questionnaires on the web site, create an interactive site where other researchers can add tools and information on business resilience surveys, expand the effort to focus on longitudinal learning from case studies of individual businesses or using qualitative approaches, and pursue the opportunities for collaboration described above. The working group is also taking steps to collaborate on new projects with other researchers conducting surveys following disasters, including not only earthquakes but also floods, hurricanes and pandemics.