

Induced Earthquake Damage Assessment

Bridger W. Baird

CU Collaboratory for Induced Seismicity



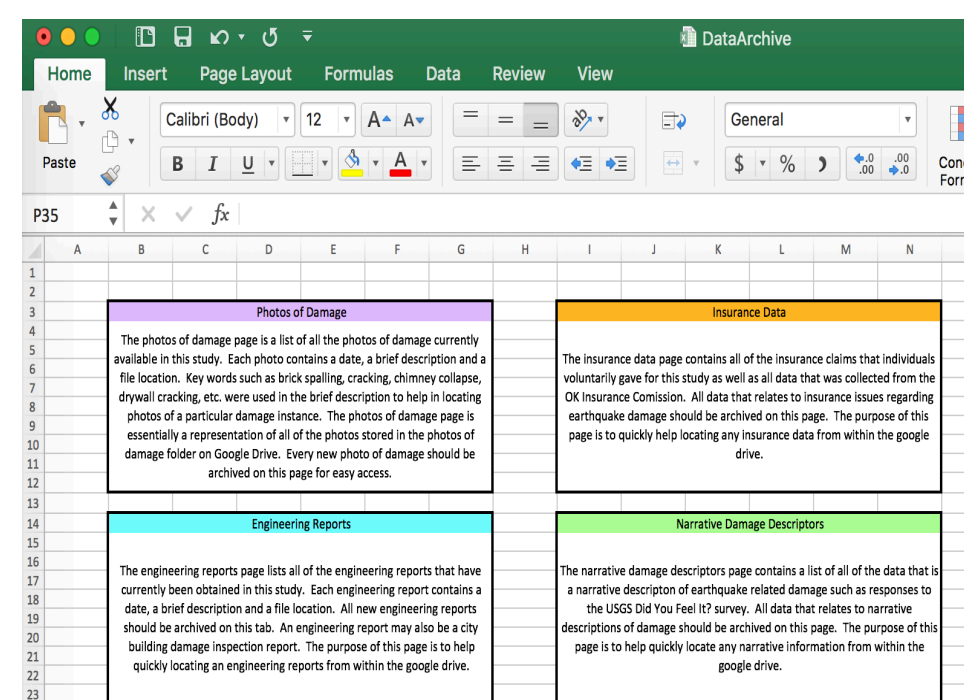
Objectives

1. To develop a systematic method to collect and and archive induced earthquake damage data
2. Survey relevant damage caused by induced earthquakes
3. Quantify the impact on the communities affected



Systematic Data Archive

Tools - Google Drive and Data Archive Spreadsheet



- Photos
- Engineering Reports
- Narrative Damage Descriptors
- Insurance Data
- Impacted Residents
- Media Stories

Challenges - Very different data types to be categorize
All data had to be sorted manually
Many different data sources

Ease of Use - The Data Archive is broken into tabs that allow the user to quickly navigate to the type of data they are looking for

Efficiency -

Each tab provides a brief description of the data, archived by date and a file location

Data Source	Date Archived	Date of Photo	Brief Description of Photo	File Name	File Location
Lisa Griggs	1/17/17	4/30/16	earthquake	DSCN6907.jpeg	Google Drive -> Data Folder -> Photos of Damage Folder -> Lisa Griggs Folder
Lisa Griggs	1/17/17	4/30/16	wall	DSCN6924.jpeg	Google Drive -> Data Folder -> Photos of Damage Folder -> Lisa Griggs Folder

End Result - An archive that allows an individual to quickly locate relevant earthquake damage data
A methodology and tool for systematically collecting and recording additional data

Survey Relevant Data

Post Earthquake Damage Assessment Survey



Building Type
Earthquake Experience
Exterior Damage Survey
Interior Damage Survey
Photos of Damage

Building Type

Type of Structure
 Exterior Wall Finish
 Foundation Type
 Foundation Bolts

All survey options have photos to illustrate selections.

What is your exterior wall finish? (select one)

☐ Stucco



☐ Panel siding



2. Did small objects (vases, books, statues, etc.) rattle, topple over, or fall off shelves? (select one)

☐ No shelves

☐ No

☐ Rattled slightly

☐ Rattled loudly

☐ A few toppled or fell off

Earthquake Experience

Date of Earthquake
 Falling Objects
 Pre-damage photos
 Any professional damage inspection

1. Exterior walls: Do you observe any of the following? Please select as many options as apply to your case. (If you select any options, please try to

☐ Fresh cracking at corners of doors and window openings?



☐ Fresh cracking at building corners?



Exterior Damage Survey

Exterior Wall Damage
 Foundation Damage
 Chimney Damage
 Roof Damage
 Exterior Attachment Damage
 Detached Garage Damage, etc.

6. Floors: Do you observe any of the following? Please select as many options as apply to your case. (If you select any options, please try to upload a photo of the damage(s) in question 6)

☐ Impact damage to floor finishes from falling contents?



☐ A pattern of fresh cracks, gaps, or joint separation in floor finishes?



Interior Damage Survey

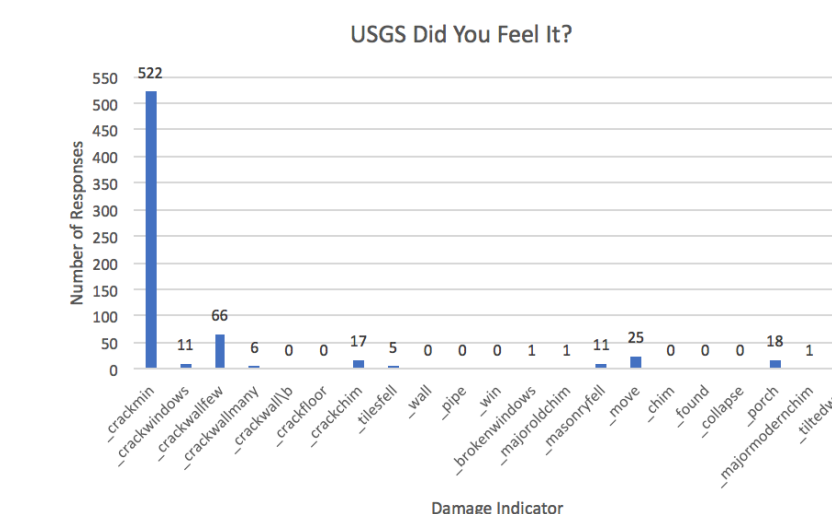
Interior Wall Damage
 Ceiling Damage
 Floor Damage
 Woodwork Damage
 Damage to Other Systems

The survey takes approximately 1 hour to complete.
 Will be distributed for historic earthquakes, and after new earthquake events
 Each type of damage has an option to upload a photo, and Google Form automatically groups the photos by category.

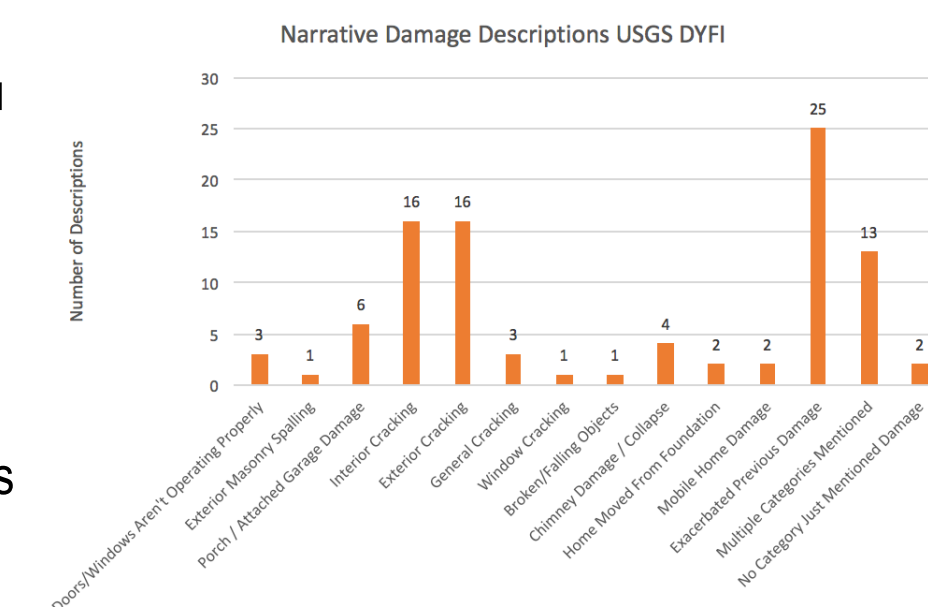
Future Research

Systematically collect data with survey and aggregate with existing data to characterize induced EQ damage and severity.

Quantify Relevant Data



- The USGS provided Did You Feel It? responses containing damage
- The responses were added with the most frequent being minimal cracking to more severe damage like tilted walls



- In addition to quick response, the Did You Feel It? responses contained narrative damage descriptors
- The responses were manually sorted into categories
- Interior and exterior cracking was most frequent, and many reported that previous damage was exacerbated

Reported Damage	Number of Instances
cracked interior walls	35
foundation cracks	12
cracked windows	10
floor cracks	9
cracked exterior brick veneer	9
cracks in sheetrock	8
doors racked	8
ceiling cracks	6
foundation shifted	6
water line broken	5
chimney cracking	4
fireplace cracking	3
brick spalling	3

Reported Damage	Number of Instances
interior or exterior wall cracks	41
structure shifted relative to foundation	16
foundation cracks	10
exterior wall spalling	9
wall shifted	7
roof shifted	6
broken windows	5
porch shifted	4
cracks in porch	3
porch collapse	3
interior wall spalling	3

(Left) Lincoln County, OK aggregate reported damage showing the relative frequency of each type.

Summary for Dwelling	
Line Item Total	60,755.29
Material Sales Tax	895.61
Storage Rental Tax	70.34
Subtotal	61,700.64
Overhead	6,170.20
Profit	6,170.20
Replacement Cost Value	\$74,041.84
Less Depreciation	(10,697.50)
Actual Cash Value	\$63,344.34
Less Deductible	(3,880.00)
Net Claim	\$59,464.34
Total Recoverable Depreciation	10,697.50
Net Claim if Depreciation is Recovered	\$70,161.84

(Right) Cushing, OK aggregate reported damage showing the relative frequency of each type.

- Detailed engineering reports were collected from some residential homes and municipalities
- Often associated with a cost
- High quality data from professional inspections

- Aggregate Insurance Data was collected from OK Insurance Commission
- Was able to look at costs associated with EQ claims



Residential Earthquake Insurance Claims	
Total Claims	1736
Number Denied / Closed without payment/ Below deductible	1433
Number Open / Closed with payment	285
P(denied)	0.83
P(payment)	0.16
Total Claims Paid To Date (\$)	\$4,932,848
\$ / per claim paid	\$17,308
Number of claims paid without engineering report	104
Number of claims paid with engineering report	179
P(report payment)	0.63
P(no report payment)	0.36
Largest claim paid	\$1,422,251

- Photos from all sources (private, municipality, EERI & Pawnee Nation) were manually sorted into categories
- Unique challenges, with 1000+ photos it was time consuming and subjective