Virtual Assessment Structural Team (VAST) Handbook: Data Enrichment and Quality Control (DE/QC) for US Windstorms

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Note that StEER is responding to events while its policies, protocols and membership are still in active development. All policies, procedures and protocols in this handbook should be considered preliminary and will be refined with community input as part of StEER's operationalization throughout 2019.

PREFACE

The National Science Foundation (NSF) awarded a 2-year EAGER grant (CMMI 1841667) to a consortium of universities to form the Structural Extreme Events Reconnaissance (StEER) Network (see https://www.steer.network for more details). *StEER builds societal resilience by generating new knowledge on the performance of the built environment through impactful post-disaster reconnaissance disseminated to affected communities.* StEER achieves this vision by: (1) deepening structural engineers' **capacity** for post-event reconnaissance by promoting community-driven standards, best practices, and training, as well as their understanding of the effect of natural hazards on society; (2) **coordination** leveraging its distributed network of members and partners for early, efficient and impactful responses to disasters; and (3) **collaboration** that broadly engages communities of research, practice and policy to accelerate learning from disasters. StEER works closely with other extreme event reconnaissance organizations and the Natural Hazards Engineering Research Infrastructure (NHERI) to foster greater potentials for truly impactful interdisciplinary reconnaissance after disasters.

Under the banner of NHERI's CONVERGE node, StEER works closely with the wider Extreme Events Reconnaissance consortium including the Geotechnical Extreme Events Reconnaissance (GEER) Association and the networks for Nearshore Extreme Event Reconnaissance (NEER), Interdisciplinary Science and Engineering Extreme Events Research (ISEEER) and Social Science Extreme Events Research (SSEER), as well as the NHERI RAPID equipment facility and NHERI DesignSafe CI, long-term home to all StEER data and reports. While the StEER network currently consists of the three primary nodes located at the University of Notre Dame (Coordinating Node), University of Florida (Atlantic/Gulf Regional Node), and University of California, Berkeley (Pacific Regional Node), StEER aspires to build a network of regional nodes worldwide to enable swift and high quality responses to major disasters globally.

StEER's founding organizational structure includes a governance layer comprised of core leadership with Associate Directors for each of the primary hazards as well as cross-cutting areas of Assessment Technologies and Data Standards, led by the following individuals:

- **Tracy Kijewski-Correa (PI),** University of Notre Dame, serves as StEER Director responsible for overseeing the design and operationalization of the network and representing StEER in the NHERI Converge Leadership Corps.
- **Khalid Mosalam (co-PI),** University of California, Berkeley, serves as StEER Associate Director for Seismic Hazards, leading StEER's Pacific Regional node and serving as primary liaison to the Earthquake Engineering community.
- **David O. Prevatt (co-PI),** University of Florida, serves as StEER Associate Director for Wind Hazards, leading StEER's Atlantic/Gulf Regional node and serving as primary liaison to the Wind Engineering community.
- **Ian Robertson (co-PI),** University of Hawai'i at Manoa, serves as StEER Associate Director for Assessment Technologies, guiding StEER's development of a robust approach to damage assessment across the hazards.
- **David Roueche (co-PI),** Auburn University, serves as StEER Associate Director for Data Standards, ensuring StEER processes deliver reliable and standardized reconnaissance data suitable for re-use by the community.

DOCUMENT SCOPE & ACKNOWLEDGEMENTS

This document assembles guidance and instructions to support StEER members participating in Virtual Assessment Structural Teams (VASTs) and should be at minimum reviewed by all Level 1 StEER members, as participation in VASTs is the primary mechanism by which StEER members elevate to Level 2 status eligible to deploy to conduct field assessments. This document specifically establishes a Data Enrichment and Quality Control (DE/QC) process for individual building damage assessment forms (DAFs) logged through the Fulcrum app by Field Assessment Structural Teams (FASTs) assessing windstorm-induced impacts on the built environment. This handbook and other materials to support VASTs in this and other functions within StEER are archived in the Resources folder on the StEER Members Google Drive. In addition to this document, StEER will be releasing online modules and conducting webinars to assist in training VAST members. These will be available at https://www.steer.network/resources.

StEER is indebted to the open platform and support provided by Fulcrum Community, which is the primary data acquisition framework for its door-to-door damage assessments.

For questions or suggestions, contact the StEER Associate Director for Data Standards:

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Photographs used in this document were taken by David Roueche or other StEER FAST members unless otherwise noted.

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ABBREVIATIONS

ASTM	American Society for Testing and Materials (formerly)
DE/QC	Data Enrichment and Quality Control
EARR	Early Access Reconnaissance Report
EF Scale	Enhanced Fujita Scale
EIFS	Exterior Insulated Finish System
FAST	Field Assessment Structural Team
FFDR	Front wall Fenestration Damage Ratio
GEER	Geotechnical Extreme Events Reconnaissance Association
GIS	Geographic Information System
GPS	Global Positioning System
HUD	Housing and Urban Development
ISEEER	Interdisciplinary Science and Engineering Extreme Events Research
LiDAR	Light Detection and Ranging
MWFRS	Main Wind Force Resisting System
NEER	Nearshore Extreme Events Reconnaissance
NHERI	Natural Hazards Engineering Research Infrastructure
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OSB	Oriented strand board
PVRR	Preliminary Virtual Reconnaissance Report
PI	Principal Investigator
QA/QC	Quality Assurance and Quality Control
QC	Quality Control
RAPID	Type of NSF grant intended to support capture of perishable data Also refers to NHERI EF renting equipment to capture perishable data
RV	Recreational Vehicle
StEER	Structural Extreme Events Reconnaissance
SSEER	Social Science Extreme Events Research
TAS	Testing Application Standard
UAS	Unmanned Aerial Survey
UAV	Unmanned Aerial Vehicle
URL	Universal Resource Locator
VAST	Virtual Assessment Structural Team

StEER Products

StEER mobilizes its membership as Virtual Assessment Structural Teams (VASTs) and possibly Field Assessment Structural Teams (FASTs) to assess damage to the built environment after notable tsunamis, earthquakes, hurricanes, tornadoes and other natural hazard events. The level of mobilization is determined by StEER's leadership based upon many factors including the intensity and size of the event, its impact on communities and the opportunity to observe unique phenomenon/performance issues. As part of its response, StEER produces up to three written products: Event Briefings, Preliminary Virtual Reconnaissance Reports (PVRRs) and Early Access Reconnaissance Reports (EARRs). The latter two reports are the most in-depth assessments of damage, with the EARR focused on initial observations gathered by the FAST. For additional information on these products, or StEER's response protocols, please refer back to the Member Guidelines. However the final and perhaps most valuable product of a StEER mission is the final data enriched and quality controlled dataset curated in DesignSafe. VASTs play a critical role in moving field-acquired data into a format suitable for long-term curation and reuse by the wider community.

VAST EXPECTATIONS

StEER's efforts to preserve perishable data following natural hazard events is an undertaking that requires committed effort of many. The immediate VAST members plays a crucial role in several phases of a StEER mission: (1) in the early days following an event, reporting on the immediate observations through the Preliminary Virtual Reconnaissance Report (PVRR), enabling StEER to determine whether a Field Assessment Structural Team (FAST) should be deployed, (2) processing assessments acquired by the FAST within days of their deployment to generate the Early Access Reconnaissance Report (EARR), and (3) for weeks following the event, continuing to examine the collected data set and assure its quality and prepare it for long-term curation. As this third activity is particularly essential to generating data that can be used for ongoing academic research, it is expected that VAST members participating in these activities reference this handbook and attend other webinars and training opportunities.

First Steps

All StEER members will be automatically added to StEER's Fulcrum Community account. It is expected that members will complete the following steps well before they join a VAST:

1. You will receive a notification email from Fulcrum once the StEER Administrator has added you to the platform. Complete the process outlined in that email to set up your Fulcrum account and access the mobile application StEER uses for door-to-door (D2D) damage assessments;
2. Verify that your DesignSafe Slack account is active: https://designsafe-ci.slack.com. Contact the DesignSafe team of any issues with Slack.
3. Familiarize yourself with the Fulcrum web-interface on your computer: https://www.fulcrumapp.com/;
4. When available, access and complete the training modules or attend the webinars advertised by StEER. Modules (when released) and recordings of all webinars will be available at https://www.steer.network/resources.

VAST Activation

1. When StEER is mobilizing an event response, it will reach out to all members by email to invite participation in the event VAST. Once joining the FAST, all coordination and communication will be managed in the secure Slack channel dedicated to that event's VAST. As VAST activities can span weeks following an event, StEER may initiate subsequent rounds of recruitment via email to ensure adequate support for later stages of the effort, if needed.
2. It is expected that VAST members will interact on this dedicated Slack channel for all of their efforts, sharing resources and information. Key resources will be pinned to this dedicated Slack channel for easy access by VAST members.

3. FAST members should familiarize themselves with the Pre-Deployment Briefing issued by StEER to its FAST to be aware of the objectives and scope of any field deployment.
4. StEER's goal is to share its findings of its FAST as swiftly as possible, and generally within a week of their deployment. Given the speed with which StEER hopes to share its findings, VAST members must use StEER's coordination channels, protocols, and report templates.

1 Data Enrichment and Quality Control Stages

The Data Enrichment and Quality Control (DE/QC) process is broken into the five stages specified below. If all supplemental data sources are available to the VAST, it is more efficient to complete Stage 2, 3 and 4 simultaneously. If VASTs are supporting the FAST in near real-time during deployment, it may only be possible to complete Stage 1 as records come in, as Unmanned Aerial Surveys (UAS) or Pictometry data may be necessary to get complete views of the building in order to assign accurate damage ratings.

Table 1. Summary of DE/QC Stages.

Stage	Purpose	Target Timeframe
1	Verify the location of the record.	1 week after FAST deployment completes
2	Validate or fill out the minimum fields that can be considered a complete record in accordance with the StEER data standards. These fields are marked as QC Stage 1 in Table 1.	1-3 weeks after FAST deployment completes
3	Verify, update, or add missing information in the app for parameters that should be available through photographs, or supplementary data sources for the majority of records, e.g., damage ratios, building attributes.	3-6 weeks after completion of DE/QCStage 1
4	Verify, update or add information that was not captured in the field and may not be available or applicable for all buildings, e.g., roof sheathing fastener type, roof-to-wall connection type. Typically these fields are noted as Field Priorities, and can generally be evaluated more readily in damaged buildings than undamaged buildings. Trained investigators are often needed to identify these fields in undamaged buildings while on-site.	3-6 weeks after completion of Stage 1
5	Final QC validation and checks in preparation for curation on DesignSafe. Check for blank fields, inconsistencies (e.g., Gulf vs GULF County), etc.	6-7 weeks after completion of Stage 1

2 Summary of Data

Table 2 provides a summary of all data collected within the StEER Building - US (Windstorm) app. The DE/QC stages are described later in this document.

Table 2. Summary of all primary data fields in the 2018-2019 StEER Building – US (Windstorm) data collection app.

Category	Input Heading	Variable Name	Input Type	DE/QC Stage
Fulcrum Information	Record Identification	fulcrum_id	read-only	-
	Date Created	created_at	read-only	-
	Date Last Updated	updated_at	read-only	-
	User	created_by	read-only	-
	User Updated	updated_by	read-only	-
	Overall Damage Rating	status	single choice	2
	Project	project	single choice	1
	Latitude	latitude	numeric	1
	Longitude	longitude	numeric	1
Basic Information	Name of Investigator	name_of_investigator	text	1
	Date of Investigation	date	text	1
	General Notes	general_notes	text	1
	Assessment Type	assessment_type	single choice	1
Media Attachments	Front Photograph	front_photo	photograph	2
	Front Photograph Caption	front_photo_caption	text	-
	Front Photograph URL	front_photo_url	text	-
	All Photographs	all_photos	photograph	2
	All Photograph Captions	all_photos_caption	text	-
	All Photograph URLs	all_photos_url	text	-
	Audio	audio	audio file	2
	Audio Caption	audio_caption	text	-
	Audio URL	audio_url	text	-
Overall Damage Ratings	Overall Damage Notes	overall_damage_notes	text	
	Hazards Present	hazards_present	multiple-choic e	2
	Wind Damage Rating	wind_damage_rating	single choice	2
	Surge Damage Rating	surge_damage_rating	single choice	2
	Rainwater Ingress Damage Rating	rainwater_ingress_damage_rating	single choice	2
	Damage Indicator (EF Scale)	damage_indicator	numeric	2*
	Degree of Damage (EF Scale)	degree_of_damage	numeric	2*
Building Attributes	Building Attributes Notes	attribute_notes	text	2
	Address Number	address_sub_thoroughfare	text	1
	Address Street	address_thoroughfare	text	1
	Address Suite	address_suite	text	1

	Address City	address_locality	text	1
	Address County	address_sub_admin_area	text	1
	Address State	address_admin_area	text	1
	Address Zip Code	address_postal_code	numeric	1
	Address Country	address_country	text	1
	Full Address	address_full	text	1
	Building Type	building_type	single choice	2
	Number of Stories	number_of_stories	numeric	2
	Understory Area (% of Building Footprint)	understory_pct_of_building_footprint	numeric	2
	First Floor Elevation (ft)	first_floor_elevation_feet	numeric	2
	Year Built	year_built	numeric	2
	Roof Shape	roof_shape	single choice	2
	Roof Slope	roof_slope	numeric	3
	Front Elevation Orientation	front_elevation_orientation	numeric	3
Structural Attributes	Structural Notes	structural_notes	text	2
	Main Wind Force Resisting System	mwfrs	multiple-choice	3
	Foundation Type	foundation_type	single choice	3
	Wall Anchorage Type	wall_anchorage_type	multiple-choice	4
	Structural Wall System	wall_structure	multiple-choice	2
	Wall Substrate	wall_substrate	multiple-choice	4
	Wall Cladding	wall_cladding	multiple-choice	2
	Soffit Type	soffit_type	multiple-choice	2
	Front Wall Fenestration Ratio	front_wall_fenestration_ratio	numeric	3
	Front Wall Fenestration Protection Type	front_wall_fenestration_protection	multiple-choice	3
	Left Wall Fenestration Ratio	left_wall_fenestration_ratio	numeric	3
	Left Wall Fenestration Protection Type	left_wall_fenestration_protection	multiple-choice	3
	Back Wall Fenestration Ratio	back_wall_fenestration_ratio	numeric	3
	Back Wall Fenestration Protection Type	back_wall_fenestration_protection	multiple-choice	3
	Right Wall Fenestration Ratio	right_wall_fenestration_ratio	numeric	3
	Right Wall Fenestration Protection Type	right_wall_fenestration_protection	multiple-choice	3
	Sectional/Rollup/Garage Door Indicator	large_door_present		3
	Front Sectional/Rollup/Garage Door Type	large_door_opening_type_front	multiple-choice	3
	Left Sectional/Rollup/Garage Door Type	large_door_opening_type_left	multiple-choice	3
	Back Sectional/Rollup/Garage Door Type	large_door_opening_type_back	multiple-choice	3
	Right Sectional/Rollup/Garage Door Type	large_door_opening_type_right	multiple-choice	3
	Roof System	roof_system	multiple-choice	3
	Roof-to-wall Attachment	r2wall_attachment	multiple-choice	4

	Roof-to-wall Attachment Type	r2w_attachment_type	text	4
	Roof Substrate	roof_substrate_type_other	single choice	4
	Roof Cover Type	roof_cover	multiple-choice	2
	Overhang Length (inches)	overhang_length	numeric	3
	Maximum Parapet Height (inches)	parapet_height_inches	numeric	3
Wind-Induced Damage	Wind Damage Notes	wind_damage_details	text	3
	Roof Structure Damage Ratio (%)	roof_structure_damage_	numeric	3
	Roof Substrate Damage Ratio (%)	roof_substrate_damage	numeric	3
	Roof Cover Damage Ratio (%)	roof_cover_damage_	numeric	3
	Wall Structure Damage Ratio (%)	wall_structure_damage_	numeric	3
	Wall Substrate Damage Ratio (%)	wall_substrate_damage_	numeric	3
	Wall Cladding Damage Ratio (%)	building_envelope_damage_	numeric	3
	Front Wall Fenestration Damage Ratio (%)	front_wall_fenestration_damage	numeric	3
	Left Wall Fenestration Damage Ratio (%)	left_wall_fenestration_damage	numeric	3
	Back Wall Fenestration Damage Ratio (%)	back_wall_fenestration_damage	numeric	3
	Right Wall Fenestration Damage Ratio (%)	right_wall_fenestration_damage	numeric	3
	Sectional/Rollup/Garage Door Failure	large_door_failure	multiple-choice	3
	Soffit Damage Ratio (%)	soffit_damage	numeric	3
	Fascia Damage Ratio (%)	fascia_damage	numeric	3
	Stories with Damage	stories_with_damage	text	3
Water-Induced Damage	Water-induced Damage Notes	water_induced_damage_notes	text	2
	% of Building Footprint Eroded	percent_of_building_footprint_eroded	numeric	3
	% Damage to Understory	_damage_to_understory	numeric	3
	Maximum Scour Depth (inches)	maximum_scour_depth_inches	numeric	3
	% Piles Missing or Collapsed	_piles_missing_or_collapsed	numeric	3
	% Piles Leaning or Broken	_piles_leaning_or_broken	numeric	3
	Cause of Foundation Damage	cause_of_foundation_damage	multiple-choice	3
Retrofits	Reroof Year	reroof_year	numeric	4
	Retrofit 1	retrofit_type_1		4
	Retrofit 1 Year	retrofit_1_year	numeric	4
	Retrofit 2	retrofit_type_2		4
	Retrofit 2 Year	retrofit_2_year	numeric	4
QA/QC	Data Librarians	data_librarians	text	1
	QC Progress Code	qc_progress_code	single choice	1
	QC Notes	qc_notes	text	1

3 Supplemental Data Sources

The following describe supplemental data sources that are available for use in performing quality control (QC).

3.1 Pictometry Eagleview

Ten license seats for Pictometry Eagleview imagery have been purchased for VAST members to use in hurricane-impacted areas. The imagery generally consists of nadir and oblique imagery of impacted areas at various resolutions. Access the imagery through the website https://explorer.pictometry.com/login.php. Contact David Roueche[1] for access instructions and training.

3.2 County Property Appraiser Websites

County property appraiser websites are useful in a number of ways. They serve as the only official resource for determining the correct address for a record. During Stage 1 of the DE/QC process, it is important to verify the address assigned to the record matches the address provided by the county for the given record's GPS coordinates. If the GIS database can be obtained from the county, spatial data science techniques can be used to automate the process of verifying the accuracy of the record location and ingesting public attributes available from the county websites.

3.3 NOAA Aerial Imagery

For hurricanes, NOAA provides aerial imagery of various quality and resolution over the majority of impacted regions following hurricane landfalls, typically within 2-3 days of the event. Links to any such resources, if available, information will be pinned in the Slack channel dedicated to the VAST's efforts.

3.4 Fulcrum Layers

Certain data sources are made available directly within the Fulcrum app or web interface by means of Layers. Layers may consist of orthomosaics processed from unmanned aerial vehicle (UAV) imagery, parcel polygons, or other data. The process for activating layers differs by platform, as shown in Figures 1-3.

[1] dbr0011@auburn.edu, Slack: david.roueche

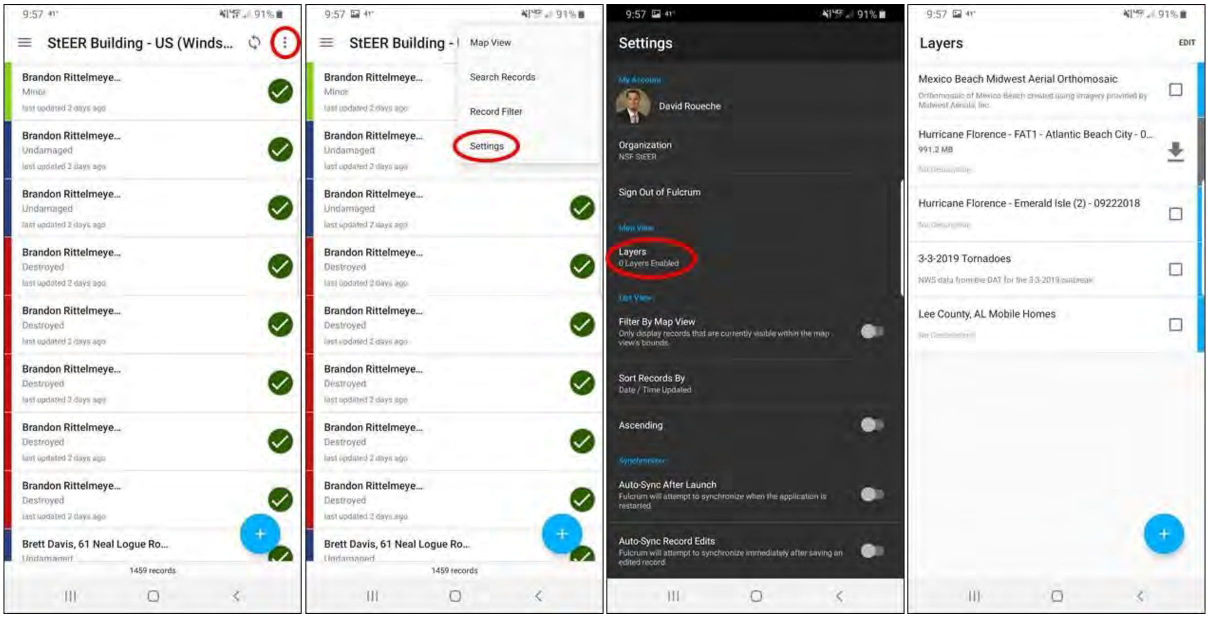


Figure 1. Process for activating layers in the Android Fulcrum app.

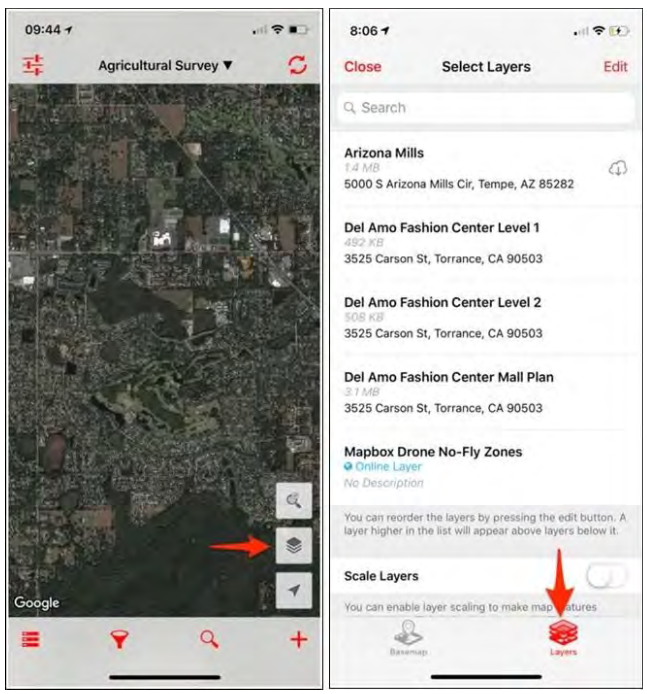


Figure 2. Process for activating Layers in the iOS Fulcrum app.

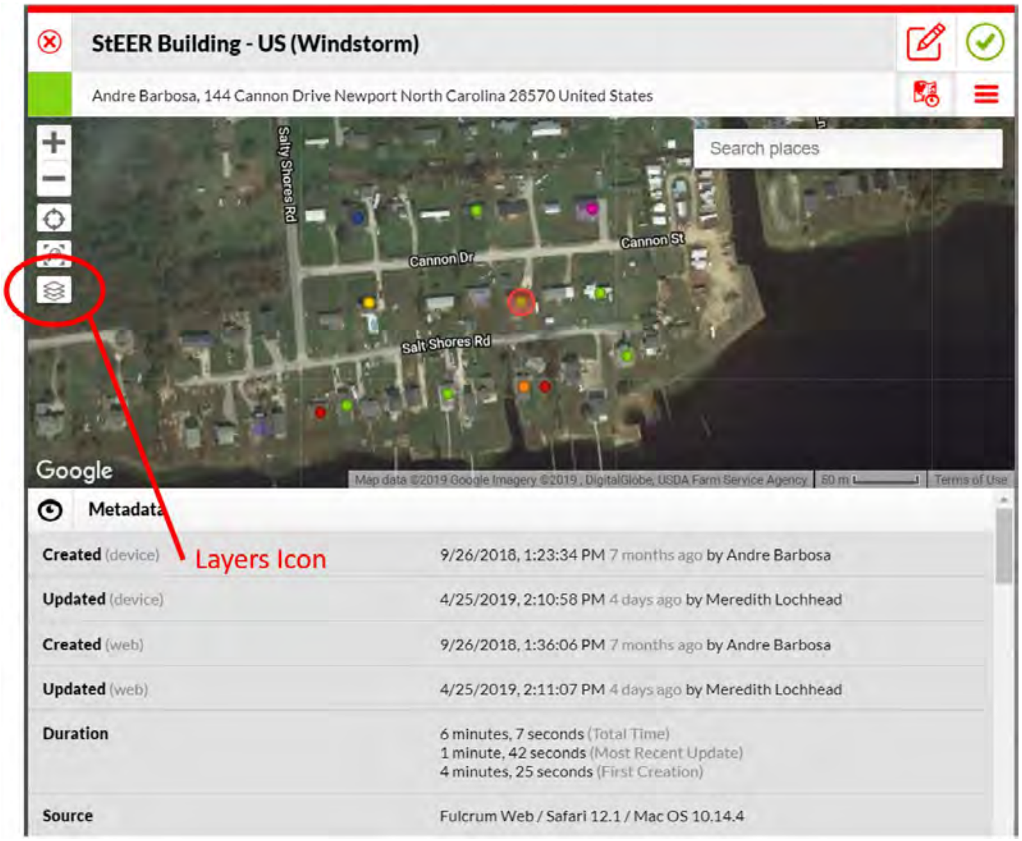


Figure 3. Process for activating layers in the Fulcrum web interface.

3.5 Pix4D for Processed UAV 3D Point Clouds

As UAV datasets are processed, they are made available through the Pix4D web platform for viewing and inspecting the 3D models. A unique feature of the Pix4D web viewer is the ability to virtually inspect any point in the processed model to see the full-resolution UAV imagery. To use this feature, click the crosshairs icon, then click on any point which you'd like to view in full-resolution. The Virtual Inspector tool will then bring up in the side panel any images in which that point is visible (see Figure 4). You can view the images in full screen and annotate if needed.

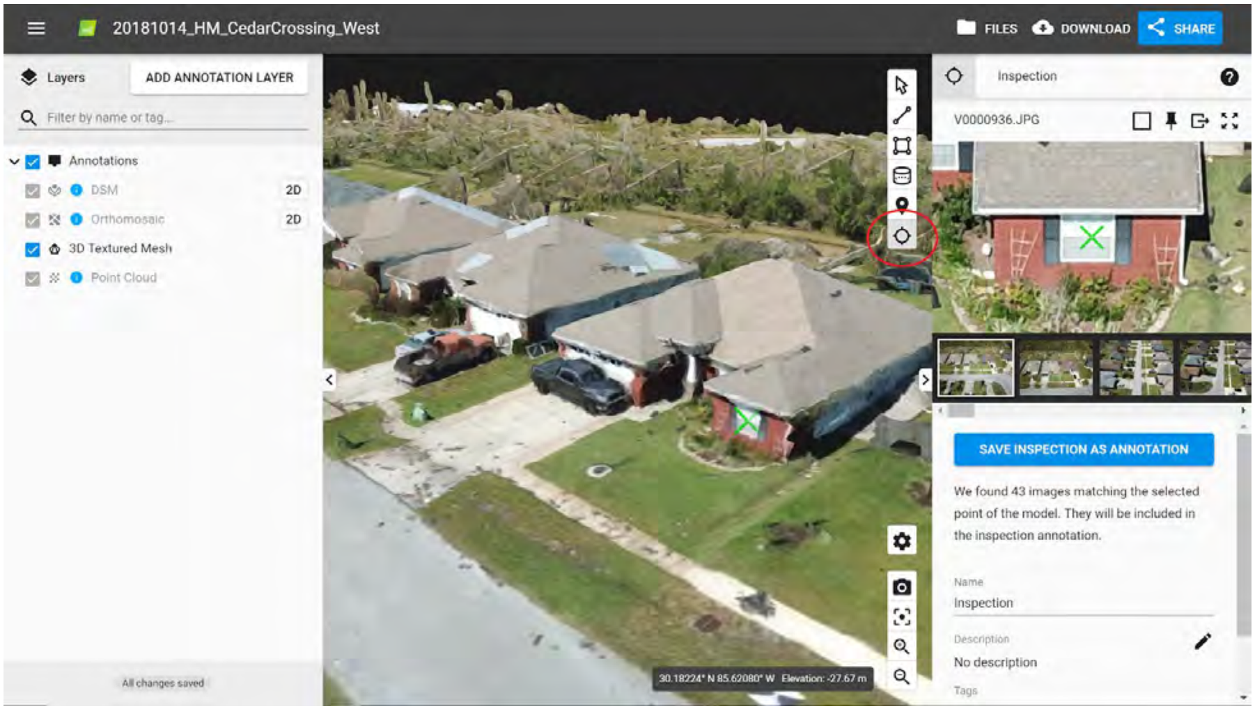


Figure 4. Use of Pix4D web platform to interrogate UAV imagery for a given property.

3.6 Potree Viewer (through DesignSafe)

Densified point clouds generated from UAV imagery and/or LiDAR scans can be accessed and viewed using the Potree Viewer visualization tool on DesignSafe. Before utilizing the Potree Viewer, the densified point cloud must be converted using Potree Converter. This process will not need to be repeated, but must be completed before accessing the point clouds.

To view a processed and converted point cloud using Potree Viewer, login to DesignSafe (https://www.designsafe-ci.org/) and navigate to the Workspace. Once there, select Visualization Tools and run Potree Viewer shown in Figure 5. Once the application loads in the web browser, navigate using the Data Depot browser to the correct project and folder containing the processed UAV data, and then drag and drop the *processed_converted* folder into the Input field in Potree Viewer. Assign a descriptive job name and click *Launch*. The app can take up to a minute to queue and process. Once it does, a pop-up will indicate the viewer is ready to launch. Clicking on Launch will open a new browser tab or window running the Potree Viewer. Once in the viewer, the user can orbit, pan or zoom around the model and interact with it using a suite of tools to measure distances, angles, areas, volumes, etc. A list of datasets available through Potree Viewer will be maintained in the Supplemental Data Sheet for each event.

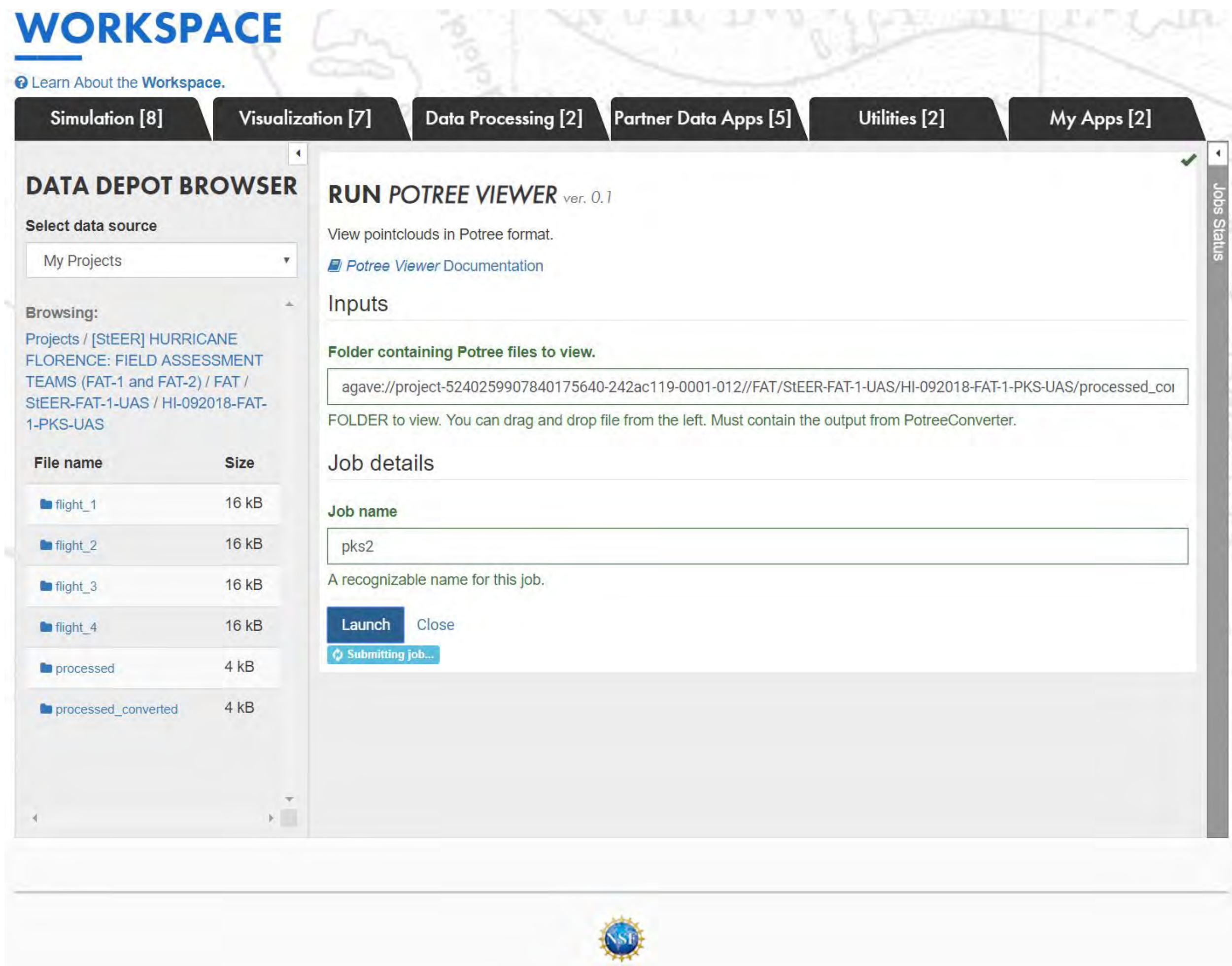


Figure 5. Launching the Potree Viewer tool through the DesignSafe Workspace.

4 Description of App Fields

The following provides an overview of each app field with guidance on the DE/QC process required.

4.1 Fulcrum Fields

4.1.1 Record Identification

The Fulcrum record identification is a 36 character string that is unique to every record. An example ID is 8eed72d9-db8f-4aea-9ae6-7dd86c9f089a. This ID cannot be changed. When discussing a specific record, it is preferred that VASTs refer to the Record ID as postal addresses may be incorrect or duplicated in early stages of the QC process. By default, the Record ID may not be visible in the Fulcrum Web Platform. To activate, turn on the field in the Column Setup tool as shown in Figure 6.

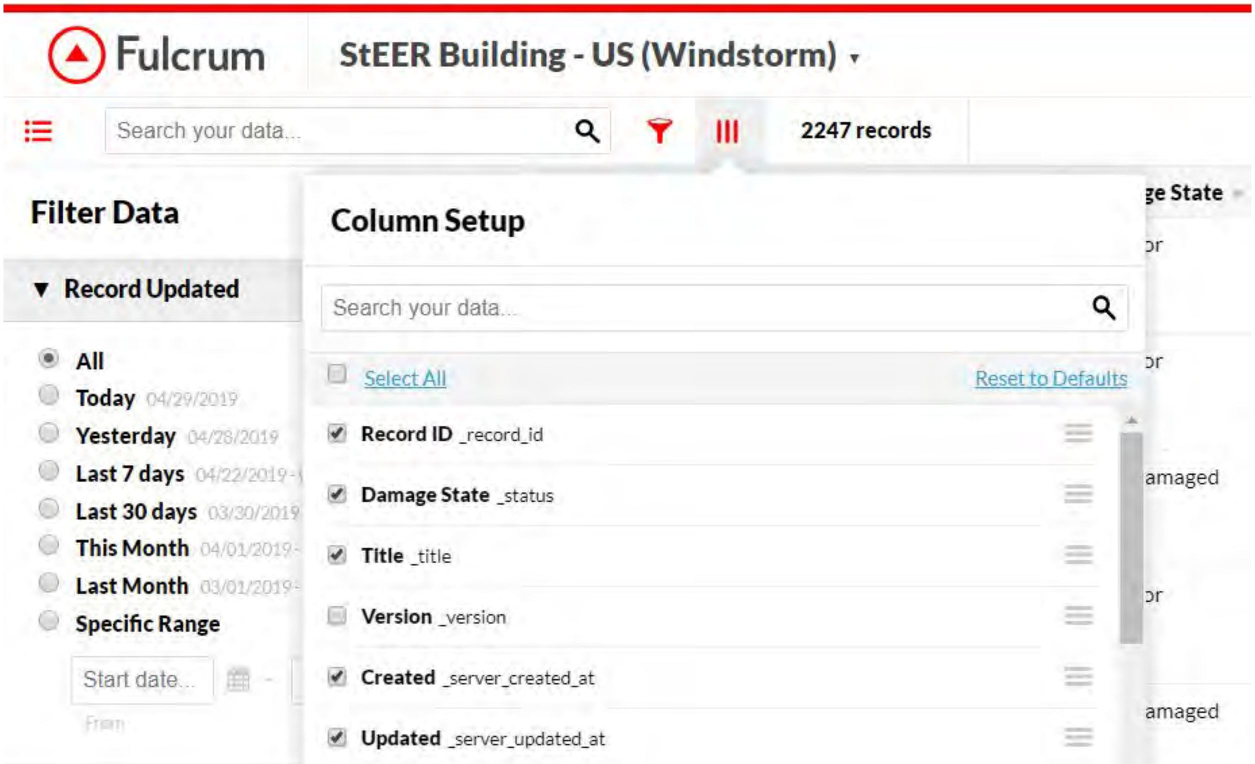


Figure 6. Making the Record ID visible in the Fulcrum web interface.

4.1.2 Date Created

Read-only field automatically generated by Fulcrum, indicating the date and time at which the record was created. This can be used to validate the Date of Investigation field.

4.1.3 Date Last Updated

Read-only field automatically generated by Fulcrum that indicates when the record was last updated.

4.1.4 User

Read-only field automatically generated by Fulcrum that indicates which user created the record.

4.1.5 User Updated

Read-only field automatically generated by Fulcrum that indicates which user last updated the record.

4.1.6 Status - Overall Damage Rating

Used to assign a color to the marker for the record representing the overall damage state of the building. This field is simply a visualization tool, and is not intended to be a precise representation of any formal damage rating process. Best practice is to define it as the maximum of the *Wind Damage Rating, Surge Damage Rating*, and *Rainwater Ingress Damage Rating*. Options include **Undamaged, Minor, Moderate, Severe, Destroyed**, and **Unassigned**.

4.1.7 Project

Each record should be assigned to a specific project that is set up by the StEER administrators. Relevant projects from 2018-2019 include the following:

- **Hurricane Michael (2018)** – all records associated with StEER deployments following Hurricane Michael in 2018, which primarily focused on regions in the Florida Panhandle.
- **Hurricane Florence (2018)** – all records associated with the StEER deployments following Hurricane Florence (2018), which primarily focused on regions in coastal North Carolina.
- **19 Jan 2019 Tornadoes** – all records associated with deployments to Wetumpka, AL and surrounding communities following a tornado outbreak.
- **3 March 2019 Tornadoes** – all records associated with deployments to areas of Alabama, Georgia, and Florida following a tornado outbreak.

4.1.8 Latitude and Longitude

GPS coordinates define the location of the record to which all photographs, building attributes and other information is attached. The coordinates are automatically set when the assessment is created in Fulcrum, using the location services of the smartphone.

This verification should be performed simultaneously with verification of the Building Address, and may require an iterative process. Use the record location, the attached photographs, and Google Streetview to verify the location of the building. Once the location is confirmed, use a county parcel database (available through the county GIS platforms) to confirm the correct address. Alternatively, if the address number is visible in the photographs, it is permissible to verify the address directly without using county parcel databases. Once the Building Address has been confirmed, the location should be edited so that the GPS coordinates coincide with approximately the center of the building that was surveyed. There are two options to do so:

- Option A – Use the map and mouse cursor to select the new location. Select the "Layers" icon at the bottom of the toolbar on the left side of the screen and use Satellite, OpenStreet basemaps, or supplemental data layers for best results.
- Option B – Directly input the GPS coordinates

NOTE: ONLY UPDATE THE LOCATION IF THE ADDRESS HAS BEEN CONFIRMED CONCLUSIVELY.

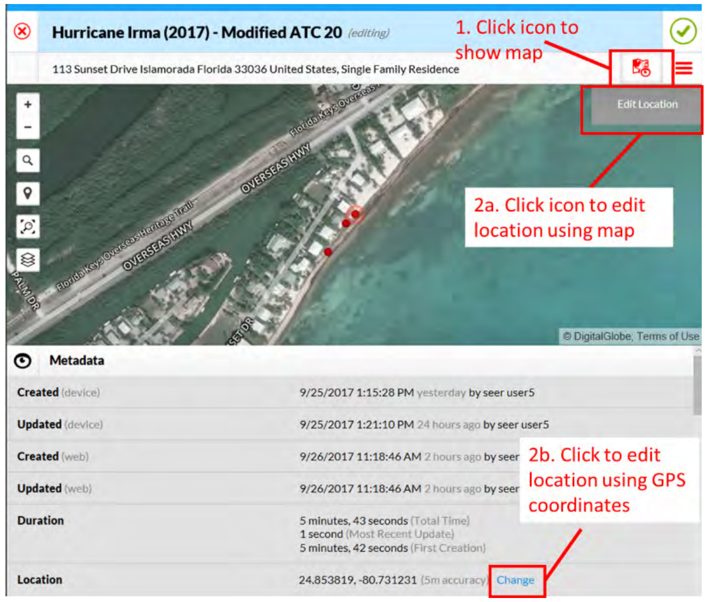


Figure 7. Methods for editing the location of the record.

4.2 Basic Information

4.2.1 Name of Investigator

Text field for the name of the field surveyor who created the form and added photographs, building information or damage information while in the field. Verify that it uses a consistent form between records (e.g., John L. Doe, John Doe, JLD need to be converted to a consistent form).

4.2.2 Date of Investigation

Date field for the date the survey was performed. Default is the day that the assessment was created. Verify that this matches the Date Created field automatically generated by Fulcrum.

4.2.3 General Notes

Text field providing the surveyor space to describe any relevant details about the building being investigated.

4.2.4 Assessment Type

A multiple choice field defining the assessment type or class. Available options include:

- **Aerial** – an assessment derived primarily from aerial imagery such as the NOAA post-hurricane imagery.
- **Drive-by** – an assessment conducted from the street. This assessment type is typically intended to rapidly build out a dataset of broad assessments. Minimal information is

likely included in the initial assessment, and supplemental data sources must be relied upon to build out the minimum assessment fields.

- **On-site** – this is the default assessment and consists of an investigator being present at the building site for a sufficient length of time to characterize the building attributes and damage and capture multiple views of the building.
- **Remote** – this assessment type is used to represent assessments relying primarily upon remotely sensed data such as UAV or LiDAR point clouds, aerial imagery, etc. These assessments may not have a ground-based photograph available and can be used to fill in gaps in the door-to-door assessments.

4.3 Media Attachments

4.3.1 Front Photograph

This is a photograph representing the "front" orientation of the building. The front defines the orientation of the building so that subsequent fields can refer to relative orientations such as front, left, back, etc. For Hurricane Florence and Hurricane Michael, a front photograph was not specified, so ignore this field.

4.3.2 Front Photograph Caption

Caption for the Front photograph. Ignore for the present.

4.3.3 Front Photograph URL

URL for the Front photograph. Ignore for the present.

4.3.4 All Photographs

This field contains the unique photograph IDs associated with the record. Verify that each photograph is referring to the same building. If a photo appears to be erroneously attached to a record, note as such in the caption and determine whether the photo should be reassigned. Contact the VAST DE/QC team lead before removing any photographs.

4.3.5 All Photograph Captions

If captions for the photographs are present, verify for spelling, and ensure any relevant facts are utilized as needed to fill out the record's fields if appropriate.

4.3.6 All Photograph URLs

Unique URLs for each photograph. This is a read-only field that should not be modified.

4.3.7 Audio

This field contains audio recording attachments. Verify that the audio is relevant to the assigned record, and transcribe any information contained therein into the appropriate fields of the form.

4.4 Overall Damage Assessment

4.4.1 Overall Damage Notes

This field contains free-from text to describe any aspects of the observed damage that are supplemental to the assigned damage ratings. Verify spelling and that any relevant info is used to inform the subsequent damage fields of the app form as needed.

4.4.2 Hazards Present

Multiple-choice field used to indicate which hazards were present at the building site. Check all that apply. Only indicate surge or flood hazards are present if there are obvious, visible signs of such, or if interviews with eyewitnesses indicates the hazards were present. **Wind-borne debris** should be selected only if there are obvious signs of potentially damaging debris having been in flight in proximity to the building.

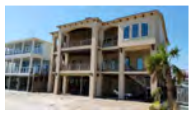
Available options include:

- Flood
- Rain
- Surge
- Tree-fall
- Wind
- Wind-borne debris
- Unknown

4.4.3 Wind Damage Rating

The wind damage rating is a required field for creation of a record, so it must be filled out on site by the investigator. However, it is important that consistent quantitative criteria be followed in assigning the rating. For residential buildings, the quantitative damage criteria provided in Table 3 should be used (Vickery et al. 2006). For other buildings, similar criteria can be used. It is recommended to define the more precise quantitative ratios to individual building components (as described later in this document) before assigning the overall wind damage rating.

Table 3. Quantitative guidelines for assigning overall wind damage rating

			Presence or Extent of Failure in:				
Damage State [1]	**Short Description**	**Illustrative Example**	**Roof or Wall cover**	**Window or door**	**Roof or Wall sub-strate**	**Roof struct.**	**Wall struct. [2]**
0 No damage or very minor damage	*No visible exterior damage*		0%	No	No	No	No
1 Minor damage	*Damage confined to envelope*		> 2% and ≤ 15%	1	No	No	No
2 Moderate damage	*Load path preserved, but significant repairs required*		> 15% and < 50%	> 1 and ≤ the larger of 3 and 20%	1 to 3 panels	No	No
3 Severe Damage	*Major impacts to structural load path*		> 50%	> the larger of 3 and 20% and ≤ 50%	> 3 and ≤ 25%	≤ 15%	No
4 Destroyed	*Total loss. Structural load path compromised beyond repair.*		> 50%	> 50%	> 25%	> 15%	Yes

Notes:
[1] A building is considered to be in the damage state if any of the shaded damage indicators in the corresponding row are observed.
[2] Wall structure refers to walls in living area only. The ground floor of elevated structures often have breakaway walls that can be easily damaged by storm surge. This damage should be ignored in assigning the overall damage rating.

4.4.4 Surge Damage Rating

Similar to the Wind Damage Rating, the Surge Damage Rating is also required to be filled out on-site if a flood or surge hazard is indicated. Ratings should be verified after surge/flood damage has been more precisely quantified. Criteria for the rating is as follows (based on Friedland, 2007).

The following apply to residential structures. Other building types should use as similar a criterion as possible.

- **None or Very Minor Damage**: No floodwater impacts.
- **Minor Damage**: Breakaway walls or appurtenant structures damaged or removed WITHOUT physical damage to remaining structure. No flood impacts the building.
- **Moderate Damage**: Some wall cladding damage from flood-borne debris. Breakaway walls or appurtenant structures damaged or removed WITH physical damaged to remaining structures.
- **Severe Damage**: Removal of cladding from "wash through" of surge without wall structural damage.
- **Very Severe Damage**: Failure of wall frame, repairable structural damage to any portion of building, or < 25% of building plan area unrepairable.
- **Partial Collapse**: Building shifted off foundation, overall structure racking, > 25% of structure unrepairable.
- **Collapse**: Total structural failure (no intact structure).

4.4.5 Rainwater Ingress Damage Rating

If known, indicate the degree of damage induced by rainwater ingress. The criteria to use in assigning the ratings are as follows:

- **Unknown:** use when no information concerning rainwater ingress is available
- **None Visible:** use when access is granted to the interior but no rainwater ingress is visible
- **Minor:** Minor ingress through doors, windows, or isolated roof leaks
- **Moderate:** Visible puddles of water or damaged contents around multiple doors and windows and multiple roof leaks leading to puddling or damage to contents
- **Severe:** Severe inundation leading to partial collapse of roof ceiling, extensive puddling and interior contents loss
- **Complete:** Complete inundation throughout the structure with majority of contents affected

TIP: Do not guess. Typically this rating must be assigned by the field investigator, otherwise it should be classified as “Unknown” unless photographs documenting evidence of a specific rating are available.

4.4.6 Damage Indicator (EF Scale)

This field is primarily used in tornado damage assessments to define the type of building that was investigated in accordance with the Enhanced Fujita (EF) Scale. Refer to the Enhanced Fujita Scale report for more information.

4.4.7 Degree of Damage (EF Scale)

This field is primarily used in tornado damage assessments to define the specific degree of damage to the building that was investigated in accordance with the EF Scale. Refer to the Enhanced Fujita Scale report for more information.

4.5 Building Attributes

4.5.1 Building Attributes Notes

This field is a placeholder for any free-form text noting unique aspects of the building that are not definable within the limitations of the app. Verify spelling, formatting, and incorporate any observations reported in this field into the rest of the app as appropriate.

4.5.2 Full Address

The address is automatically inputted using the Fulcrum app's built-in geocoding services. It is not always perfectly accurate and needs to be verified. The address can be verified in any number of ways, including the following:

- Check photographs to see if a house number is visible
- Search the address on the form in Google Streetview to check that the building at a given address matches that shown in the photographs. If a match is not found, look at nearby locations using Google StreetView to identify the correct location if possible. Once the building has been identified in StreetView matching the photographs, best practice is to use the county property appraiser website to verify the correct local address is chosen. Property records sometimes contain both the owner mailing address and the physical address. It is the physical address that should be used in the form.

4.5.3 Building Type

This single-choice list defines the type or use of the building. The following options are available:

- Single Family
- Apartment
- Condominium
- Manufactured Home (HUD plate is visible or manufactured after 1976)
- Mobile Home
- Office
- Park Shelter (typically open buildings, with roofs supported by columns with no infill walls)
- Professional
- Religious
- Restaurant
- Retail

- RV
- School
- Service station
- Shed
- Warehouse
- Unknown
- Other (use only if no other building types fit adequately)

4.5.4 Number of Stories

This decimal input defines the number of stories of living space above ground in the building. Where posts or piers elevating the structure are clearly visible, the first story is elevated and the space below should not be considered a story, even if there are some walls or a garage present. In Figure 8, the left image shows an elevated one-story structure, indicated by the posts and exterior staircase. The right image shows a typical two-story home, where the first and second stories are all contained within one uniform building envelope.

Figure 8: Defining the number of stories in a building

4.5.5 Understory Area (% of Building Footprint)

This field only applies to elevated buildings, such as the one in the left side of Figure 8. Define the size of the understory as a percentage of the overall building footprint. For example, in Figure 8, the understory area is approximately 75% due to the large open hallway in the middle of the understory.

4.5.6 First Floor Elevation (ft)

This decimal input defines the height of the first floor above ground level. Primarily used for elevated structures but can be used for manufactured homes as well. If not measured in the field, the height can be estimated from photographs using the standard height of a door or other object in the same depth plane of the photograph for scale, as shown in Figure 9. Note that this home should be considered a one-story elevated home, not a two-story home. In Pictometry or Potree Convertor, heights can be directly measured using the height tools.

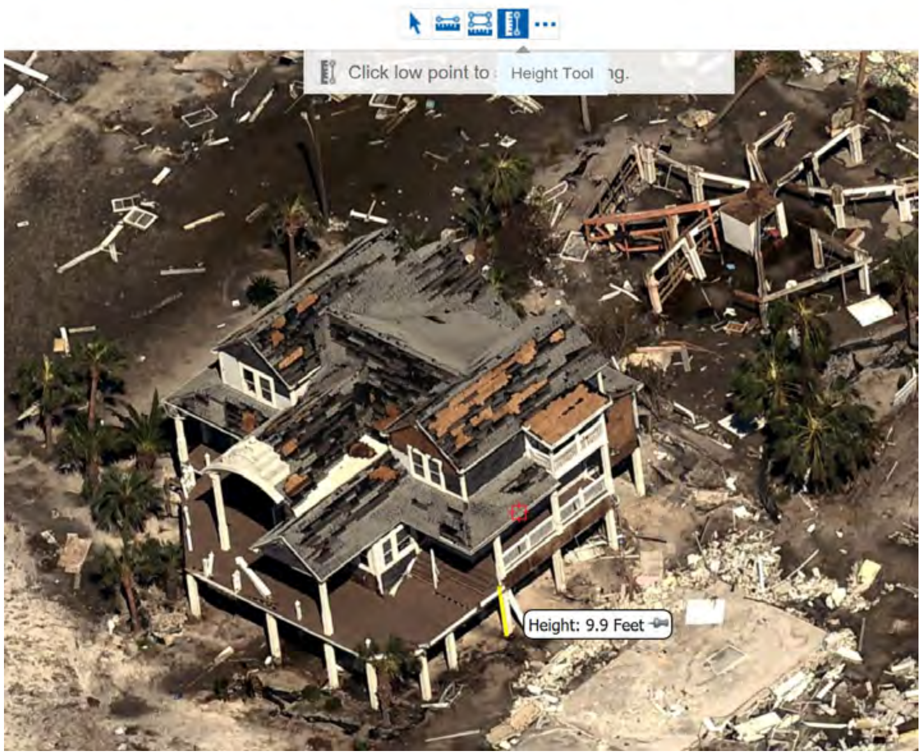


Figure 9: Measuring first floor elevation in Pictometry Eagleview.

4.5.7 Year Built

Year built is an integer field that defines the year in which the structure was originally constructed. The year built can be obtained from the county property appraiser website or real estate sites such as Zillow.com. Year built may not be available for mobile homes that are part of a larger mobile home community. Year built can also be approximated for some buildings by looking at historical imagery using Google Earth.

4.5.8 Roof Shape

Multiple-choice input defining the shape of the roof. More than one shape may be present. Select all that apply. Roof shape options in the app include gable, hip, hip/gable, flat, monoslope, complex, gambrel and other. Figure 9 shows the basic roof shapes for guidance.

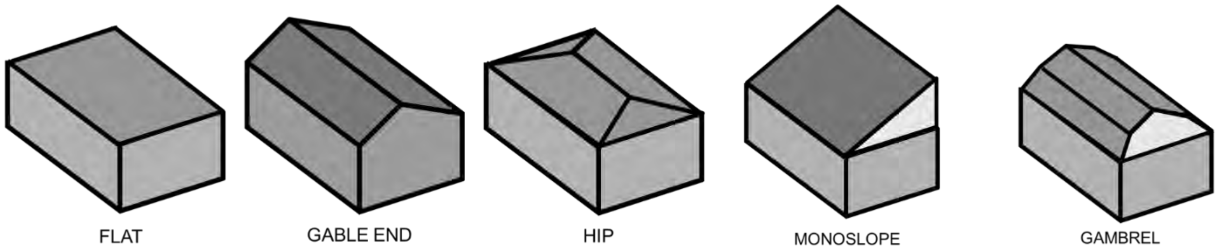


Figure 10: Common roof shapes.

Roof shapes can be quite varied. If the majority of the roof structure fits a certain roof shape, use that shape. Use the hip/gable option if the roof shape is simple but has both hip and gable elements. A complex roof shape is one where there are multiple hip, gable, or monosloped areas intersecting in the same roof structure. A general guideline is to use complex if more than 10 ridgelines are present in the building. For example, in the roof in Figure 11, hip could be considered the dominant roof shape but a large intersecting gable is present as well as a smaller gable above the front entry door. Classify this as a complex roof.

Figure 11: Example of a complex roof shape.

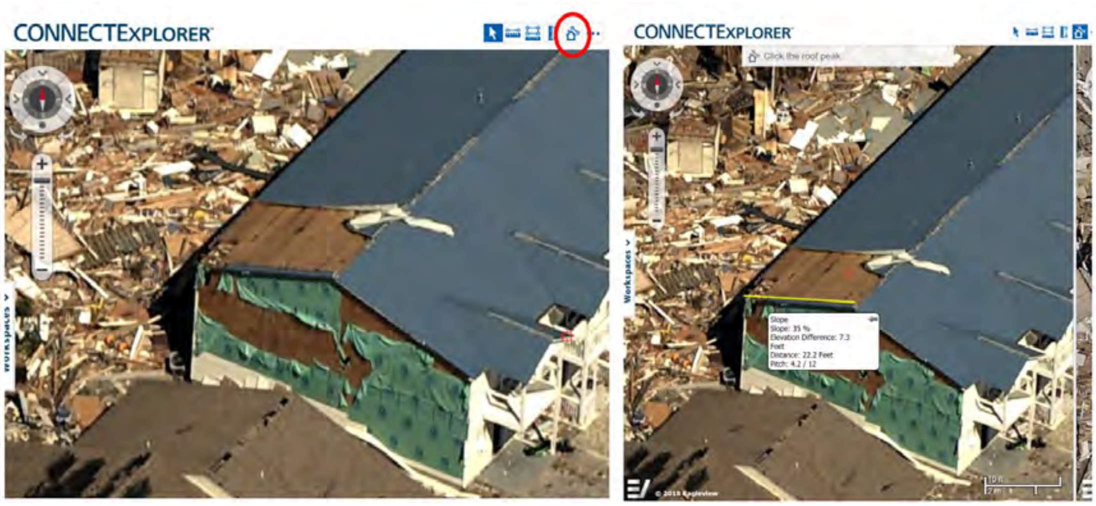
4.5.9 Roof Slope

Roof slope generally must be measured using Potree Viewer or Pictometry Eagleview. If imagery for the specific building is not available in these platforms, it can be estimated from the geometry visible in the photograph. Try to be as accurate as possible, but decimal-level precision is unwarranted. Where multiple roof slopes are present in the same building, use the roof slope that represents the greatest proportion of the roof.

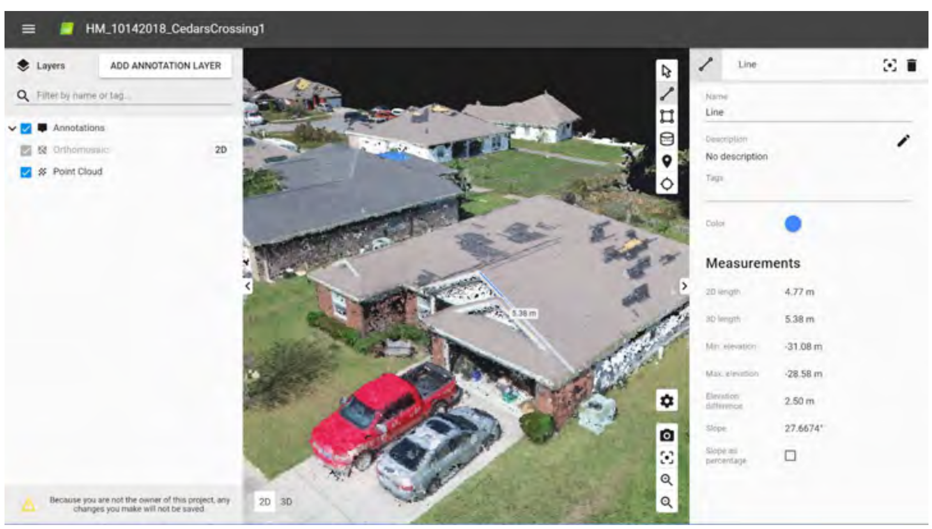
Slopes can be measured in either Pictometry Eagleview or by use of the point clouds (e.g., Pix4D web viewer or Potree Viewer). Pictometry Eagleview has a roof slope tool, illustrated in Figure 12a. Follow the prompts to define the roof ridge and eave in the oblique view, then define the same ridge and eave points in the nadir view. The result is a slope given as a percentage of rise over run. To get the roof slope in degrees from the roof slope as a percentage, you must calculate it as follows:

$$Slope = tan^{-1}(Slope\%)$$

If a point cloud is available for the building being assessed, the slope can be measured in either the Pix4D web viewer or Potree Viewer. In Pix4D, simply draw a line up the roof slope of interest and the line properties will include the slope in degrees as shown in Figure 12b.



(a)



(b)

Figure 12: (a) Example of calculating roof slope using Pictometry Eagleview ConnectExplorer toolbox, (b) Calculating roof slope using Pix4D web viewer.

4.5.10 Front Elevation Orientation

The Front Elevation Orientation is defined in degrees clockwise from north. For example, if the front is facing north, the angle is 0 degrees. If it is facing east, the angle is 90 degrees. Resolution to the nearest 15 degrees is acceptable. An example is given in Figure 13 for a building where the Front is designated as the wall elevation facing the main access road, Industrial Dr. This building axis is such that the Front elevation is then 310° clockwise from north. The right and left are then defined based on an observer facing the front elevation. For example, if a building is oriented such that Front is at 0 degrees, then Left would be East (90 degrees), Back would be South (180 degrees), and Right would be West (270 degrees).

Figure 13: Defining the orientation of the building.

4.6 Structural Attributes

4.6.1 Structural Notes

This field contains any notes regarding the structural system that provide information beyond that contained in the designated structural attribute fields. Verify spelling, formatting, and ensure any key information contained herein is represented as necessary in the designated structural fields.

4.6.2 Main Wind Force Resisting System

This multiple-choice field defines the overall lateral main wind force resisting system (MWFRS) of the building. Both the roof and walls will typically need to be defined, and they do not necessarily have to be the same. Available options include the following (select all that apply):

- Roof Diaphragm, wood
- Roof Diaphragm, steel
- Roof Diaphragm, concrete

- Roof Diaphragm, composite
- Roof, X-bracing
- Wall Diaphragm, wood
- Wall Diaphragm, steel
- Wall Diaphragm, concrete
- Wall, X-bracing
- Moment Frame
- Unknown
- Other

Most low-rise residential buildings will rely upon wood roof and wall diaphragms (assemblage of light wood frame members connected by engineered wood panels such that the system acts as a deep beam or shear wall to transfer in-plane loads to the foundation). For other building types, the MWFRS may not be discernible unless it was significantly damaged or unless structural drawings are available. If this information was not provided during the on-site investigation, and cannot be confidently assigned based on engineering judgement, then leave as Unknown.

4.6.3 Foundation Type

The foundation type defines the system responsible for transferring all lateral and vertical loads to the soil. Available pre-defined options include the following:

- Slab-on-grade
- Cast-in-place concrete piers
- Ground anchors and strapping (primarily relevant for manufactured homes)
- Masonry piers, reinforced
- Masonry stem wall, reinforced
- Masonry piers, unreinforced
- Masonry stem wall, unreinforced
- Masonry piers, unknown reinforcement
- Masonry stem wall, unknown reinforcement
- Wood Piers <= 8 ft spacing
- Wood Piers > 8 ft spacing
- Unknown
- Other

Some illustrative examples of these systems are given in Figure 14. Describe any special foundation types using the Other option.

Slab-on grade

Concrete cast-in-place piers. No joints in the piers are visible.

Ground anchors and straps

Wood piers (≤ 8 ft spacing)

Reinforced masonry piers

Unreinforced masonry stem wall

Figure 14: Examples of building foundation types.

4.6.4 Wall Anchorage Type

This field broadly defines how the wall is anchored to the foundation. The available options include the following (check all that apply):

- Anchor bolts with nuts and washers
- Anchor bolts with missing nuts and washers
- Metal straps
- Concrete nails
- Unknown
- Other

The pictures in Figure 15 illustrate these anchorage types:

Anchor bolt with nuts and washers anchoring a failed column baseplate.

Anchor bolt with no nut or washer

Metal straps

Cut nail (Photo: Tim Marshall)

Figure 15: Wall to foundation anchorage types

4.6.5 Structural Wall System

The structural framing system is a multiple choice field that describes the structural skeleton of the walls. The structural wall system is typically different from the exterior wall cladding, except in cases such as tilt-up concrete walls where no exterior cladding is used. The following list reviews common wall systems. Note that it is possible to have multiple systems present in the same building, with either different systems used in different stories, or one system acting as the

MWFRS with a secondary system acting as an in-fill wall (e.g., steel moment frame with cold form steel in-fill walls). Choose all that apply.

- **Wood-frame -** also called simply “Frame” in county records. Consists of repetitive, closely-spaced wood studs forming walls with attached wood sheathing.
- **Concrete masonry block (unreinforced) -** also called concrete block. May sometimes be listed as C.B. in county records. If portions of the masonry block walls are crumbled with no evidence of vertical rebars, you can assume unreinforced.
- **Concrete masonry block (reinforced) -** also called concrete block. May sometimes be listed as C.B. in county records. Includes vertical steel rebar through masonry blocks and horizontal steel rebar through lintels and tie-beams. Reinforcement is not typically visible. Only use if rebar is clearly visible in photographs or identified by investigator. If present, reinforcement will generally be at regularly-spaced intervals (e.g., 8 ft. on center).
- **Concrete masonry block (unknown) -** use if the reinforcement cannot be determined.
- **Concrete, tilt-up** – tilt-up concrete walls are cast horizontally, typically as large panels, before being tilted-up into place in a final vertical orientation. Vertical joints are typically visible between individual panels.
- **Concrete, moment resisting frame** – cast-in-place concrete frames commonly used in tandem with continuous concrete slabs.
- **Steel, moment resisting frame** – steel moment frames consist of a series of columns and beams, where the attachments are rigidly formed using welds or bolted connections designed to transfer moment from the beam to the column. Such systems often have tapered cross-sections with deeper webs at the knee joint (between columns and beams).
- **Steel, braced frame** – steel braced frames consists of a series of columns and beams that rely upon discrete bracing systems (typically x-bracing in some or all bays or a diaphragm) to resist lateral forces.
- **Steel, cold formed** - similar construction style to wood-frame, with closely spaced, repetitive members, but using light-gauge steel rather than heavy structural steel.
- **Insulated Concrete Form** – foam blocks that are filled with reinforced concrete.
- **Solid Brick Wythe** – typically found in historic buildings. Walls consist of multiple layers, or wythes, of brick masonry units mortared together. Not to be confused with brick veneer which are non-structural single brick veneer overlaying a wall structure.
- **Unknown** – use if the structural wall system is not visible and cannot be reasonably assumed based on engineering judgement.

For buildings that have exterior wall cladding systems, and that experience little to no damage, it can be difficult to ascertain the structural wall system. In some cases, wall thickness can indicate one system over another. For example, a concrete masonry block wall will typically be more than 8 inches thick (the width of a concrete masonry unit), while a wood-frame stud wall will typically be around 4 inches thick (the width of the 2x4 wall studs, wood sheathing, and cladding elements). Figure 16 shows some typical structural wall systems.


Wood-frame

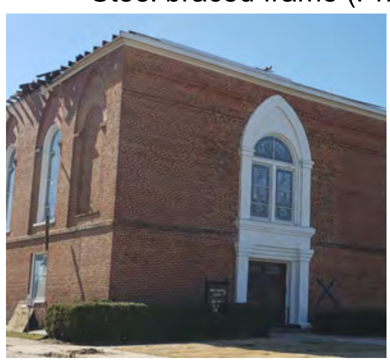

Concrete masonry block


Tilt-up concrete


Steel moment frame


Steel braced frame (Photo Credit: PACO Steel)


Cold-formed steel


Solid brick wythes


Cast-in-place concrete (Photo Credit: Nishkian)

Figure 16: Typical structural wall systems.

4.6.6 Wall Substrate

The wall substrate refers to the wall components supporting the exterior wall cladding, if present. Figure 17 shows some typical wall substrate materials. In some wall systems, the substrate also acts as a diaphragm to resist lateral forces. This is most common in light wood-frame systems, where the substrate is typically OSB or plywood sheathing. Not all buildings have a wall substrate, so use the “Not Applicable” field if none is present. Some buildings will have multiple substrates present. Choose all that apply. Pre-defined options consist of the following:

- Wood, sheathing
- Wood, sheathing (corners only)
- Wood, dimensional planks
- Insulated foam board
- Non-engineered wood panel
- Metal panels
- Not Applicable
- Unknown

Engineered wood sheathing

Insulated foam board


Diagonal wood planks

Figure 17: Typical wall substrate materials

4.6.7 Wall Cladding

Multiple-choice field that defines the wall cladding material, which is the outermost layer of the walls. Choose all that apply. Figure 18 illustrates the most common wall cladding options.

Use “Other” to input any wall cladding systems that are not captured in the common options. It is not always easy to determine the wall cladding type from photographs alone. For example, stucco and exterior insulation and finish system (EIFS) can look identical from the exterior. Horizontal wood planks, fiber-cement boards, and vinyl siding can also look identical from photographs. Comparison against the county property appraiser website is strongly recommended.

A simple test to judge whether a system is vinyl siding or fiber cement board is to identify whether the planks are individual or in pairs. Vinyl siding typically uses two “planks” in one continuous piece so it will always fail in multiples of two “planks”, whereas fiber-cement planks can fail individually. Joints in the material can also indicate this same difference.

Brick Veneer

Stucco

Vinyl Siding (note failures along double planks)

Wood plank siding (note wind-borne debris damage)

Wood panel siding

Sheet metal

Exterior Insulated Finish System (EIFS)

Fiber-cement board (note the failures along single planks)

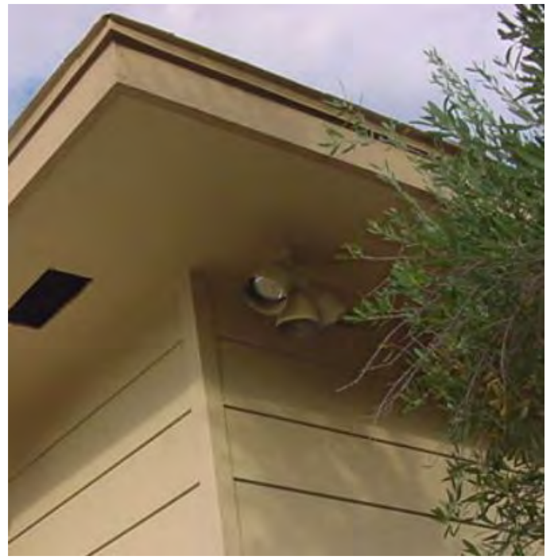
Figure 18: Common types of wall cladding systems.

4.6.8 Soffit Type

Soffits cover the underside of the roof overhang and limit the ingress of wind-driven rain into the attic space. Figure 19 shows examples of typical soffit systems. Various materials and installation systems are used, but in the StEER Building – US (Windstorm) app the soffits are broadly categorized as follows:

- **None** – if no soffits are present
- **Vinyl** – vinyl soffit systems
- **Metal** – metal soffit systems
- **Wood** – wood (typically plywood) soffit systems
- **Unknown** – if soffits are present but material is unknown

Vinyl soffit (can be perforated or continuous)



Plywood soffits (typically have a smooth finish)

Figure 19: Typical soffit systems

Unless photographs are specifically taken to document the soffit, it is often difficult to define the soffit system. One way to identify them is by texture, with vinyl siding having a textured "plank" look, while wood and metal soffits are typically of a smooth finish. If portions have failed, the flexibility of any failed material that is hanging can also be used to differentiate between the systems. Precise definition of the soffit system is beyond the scope of this app, but the goal with this field is to identify what soffit systems are present so that more in-depth classifications or follow-up work can be conducted if necessary.

4.6.9 Front Wall Fenestration Ratio

Openings are critical to estimating the wind loads on the building, so it is important to accurately identify openings in the building investigations. Fenestration refers to the arrangement of windows and doors in the exterior building envelope. This includes all windows, entry doors, sliding glass doors, large vents, garage doors, rollup doors, etc. The front wall fenestration ratio is defined as follows:

$$FFR = \frac{\sum(Area_{FrontWallWindows})+\sum(Area_{FrontWallDoors})}{Area_{FrontWall}}$$

Estimate this ratio visually or using area calculation tools available in Potree Viewer or Pictometry ConnectExplorer. Note the front wall is the wall designated as such in the earlier field, Front Wall Orientation. This must be kept consistent throughout the assessment.

4.6.10 Front Wall Fenestration Protection Type

This multiple-choice field is used to identify whether opening protection was present during the storm event. Choose all that apply. Pre-defined options consist of the following:

- None
- Shutters
- Plywood/OSB
- Impact-resistant glass
- Unknown

The Shutters option should be used when a **manufactured hurricane** shutter was used to cover the windows and/or doors. These are often made of corrugated metal, but can also be made from a translucent corrugated plastic or wood. Manufactured shutters often have visible frames permanently fastened to the exterior wall into which the shutters are inserted. The plywood/OSB option should be used when sheathing panels are simply fastened into the exterior wall covering the openings.

Impact-resistant openings typically cannot be determined from photographs alone. Assumptions can be made based on location and the building code in place at time of construction, but do not make such assumptions at this stage. Impact-resistant openings must have a certification label referencing the appropriate standards, which are typically ASTM E1886/E1996 or TAS 201/203. In windows this is typically a gold certification label provided in the frame head of the window. Examples are provided in Figure 19. Impact-resistant openings typically use laminated or tempered glass, which is also required to have a permanent mark on the glass (typically in the corners or on the window label) indicating as such. Having laminated or tempered glass however does not necessarily indicate impact-resistant opening, as ASTM E1996 is for “whole product” qualification (glass and frame). Figure 20 shows typical fenestration protection systems.

4.6.11 Left Wall Fenestration Ratio

See guidance above for Front Wall Fenestration Ratio.

4.6.12 Left Wall Fenestration Protection Type

See guidance above for Front Wall Fenestration Protection Type.

4.6.13 Back Wall Fenestration Ratio

See guidance above for Front Wall Fenestration Ratio.

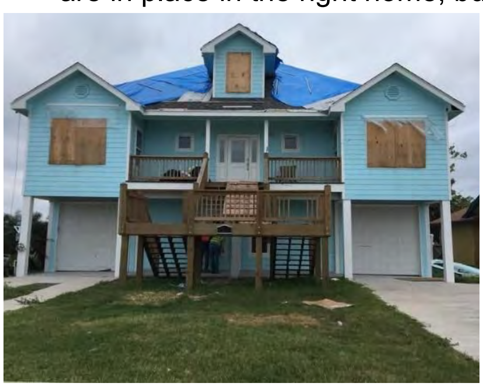
4.6.14 Back Wall Fenestration Protection Type

See guidance above for Front Wall Fenestration Protection Type.

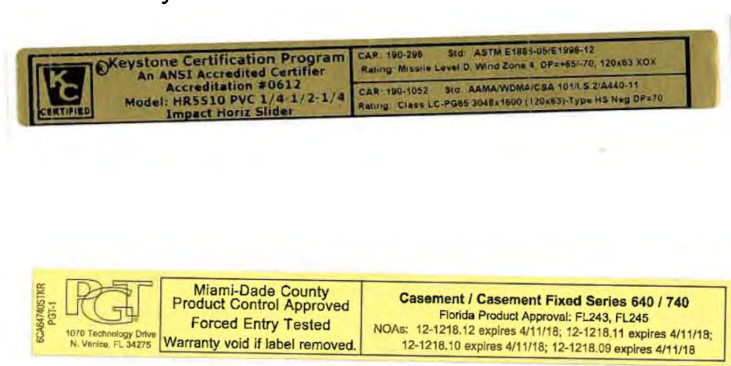
4.6.15 Right Wall Fenestration Ratio

See guidance above for Front Wall Fenestration Ratio.

A duplex with hurricane shutters still in place in the left home. Frames for hurricane shutters are in place in the right home, but have already been taken down after the hurricane.



Plywood opening protection



Typical impact-resistant window labels

Figure 20: Typical fenestration protection systems.

4.6.16 Right Wall Fenestration Protection Type

See guidance above for Front Wall Fenestration Protection Type.

4.6.17 Sectional/Rollup/Garage Door Indicator

This multiple-choice field identifies whether any large door openings are present in the building. This does not include standard entry doors or sliding glass doors. Examples of these doors are illustrated in Figure 21 and listed below:

- Single garage door
- Double garage door
- Single garage door (wind-rated)
- Double garage door (wind-rated)
- Single garage door (unknown)
- Double garage door (unknown
- Sectional door
- Roll-up door

Double garage door

Single garage door

Wind-rated garage door

Sectional door

Exterior view of roll-up door
(Photo Credit: Rumahara.com)

Interior view of roll-up door
(Photo Credit: PWS)

Figure 21: Typical large door classifications.

If the garage door wind rating is unknown, use the “garage door (unknown)” option. Some buildings may have multiple openings present. Select all that apply.

4.6.18 Front Sectional/Rollup/Garage Door Type

See guidance in Sectional/Rollup/Garage Door Indicator section above.

4.6.19 Left Sectional/Rollup/Garage Door Type

See guidance in Sectional/Rollup/Garage Door Indicator section above.

4.6.20 Back Sectional/Rollup/Garage Door Type

See guidance in Sectional/Rollup/Garage Door Indicator section above.

4.6.21 Right Sectional/Rollup/Garage Door Type

See guidance in Sectional/Rollup/Garage Door Indicator section above.

4.6.22 Roof System

This field defines the structural roof system. Figure 22 shows some typical roof structural systems. Pre-defined options consist of the following:

- Steel, cold formed trusses (often has a smooth, light grey finish)
- Steel, hot rolled (may look red due to red oxide primer that the steel beams are coated with to prevent corrosion)
- Steel, bar joists
- Concrete slab
- Wood, rafter (typically used with roof slopes > 30 degrees)
- Wood, trusses (typically used with roof slopes < 30 degrees)
- Wood, unknown (use if engineering judgement suggests a wood roof [e.g., single family home], but the roof structure is not visible to determine whether truss or rafter system.)
- Unknown

4.6.23 Roof-to-wall Attachment

If visible, classify the roof-to-wall connection using one of the following options, some of which are illustrated in Figure 23:

- Toe-nails
- Metal clips (3 nails or less into each member of connection)
- Metal straps (4 or more nails into each member of connection)
- Bolted connection
- Welded connection
- Unknown

Cold formed steel roof (Photo Credit: Janesroofs.co.za)

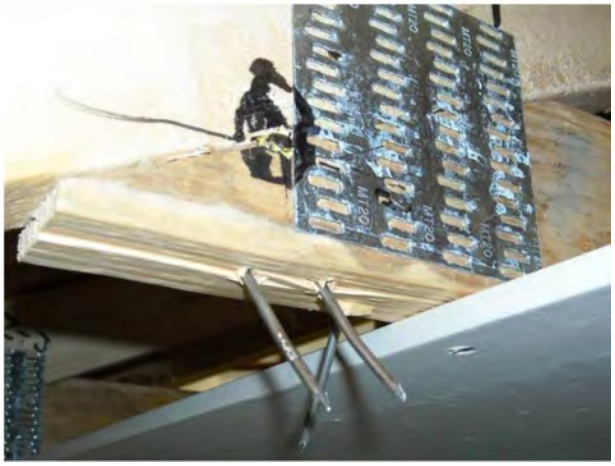
Hot rolled steel roof

Steel joists

Wood rafter system

Wood truss system

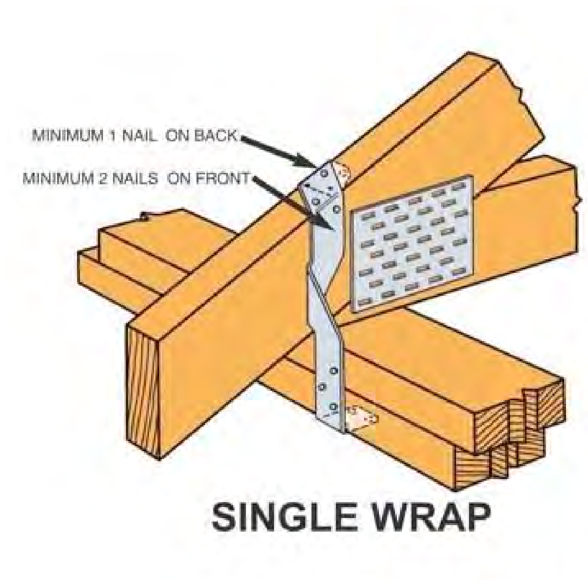
Figure 22: Common roof structure systems.



Toe-nail connection (Photo Credit: NAHB)

Metal clip

Metal strap – H2.5 or similar (Photo Credit: IBHS)



Metal straps – wrapped connection (Graphic Credit: Simpson Strong-Tie)

Figure 23: Examples of typical roof-to-wall connections

4.6.24 Roof-to-wall Attachment Type

Text field to allow the investigator to specify the exact manufacturer and product number if available. Check for standardization of this field in Stage 4 of DE/QC (e.g., h-2.5 to H2.5).

4.6.25 Roof Substrate

Single-choice field to define the roof substrate, if present. Pre-defined options consist of the following:

- Plywood/OSB
- Dimensional lumber (typically wood planks, sometimes observed in older low-rise buildings)
- Metal deck
- Concrete
- None
- Unknown

4.6.26 Roof Cover Type

Multiple-choice input that defines that type of roof cover used on the building. Roof cover options include those shown in Figure 24.

Select the roof cover type that best matches that seen in the photographs. Note that more than one roof cover material may be present. Use “Other” and input a value if a unique roof cover type is present. The county property appraiser website can be used to verify the choice as well. If you cannot discern the difference between similar materials from the photos, aerials, pre-event imagery, and property appraisal data, then use engineering judgement and note any concerns in the Notes field.

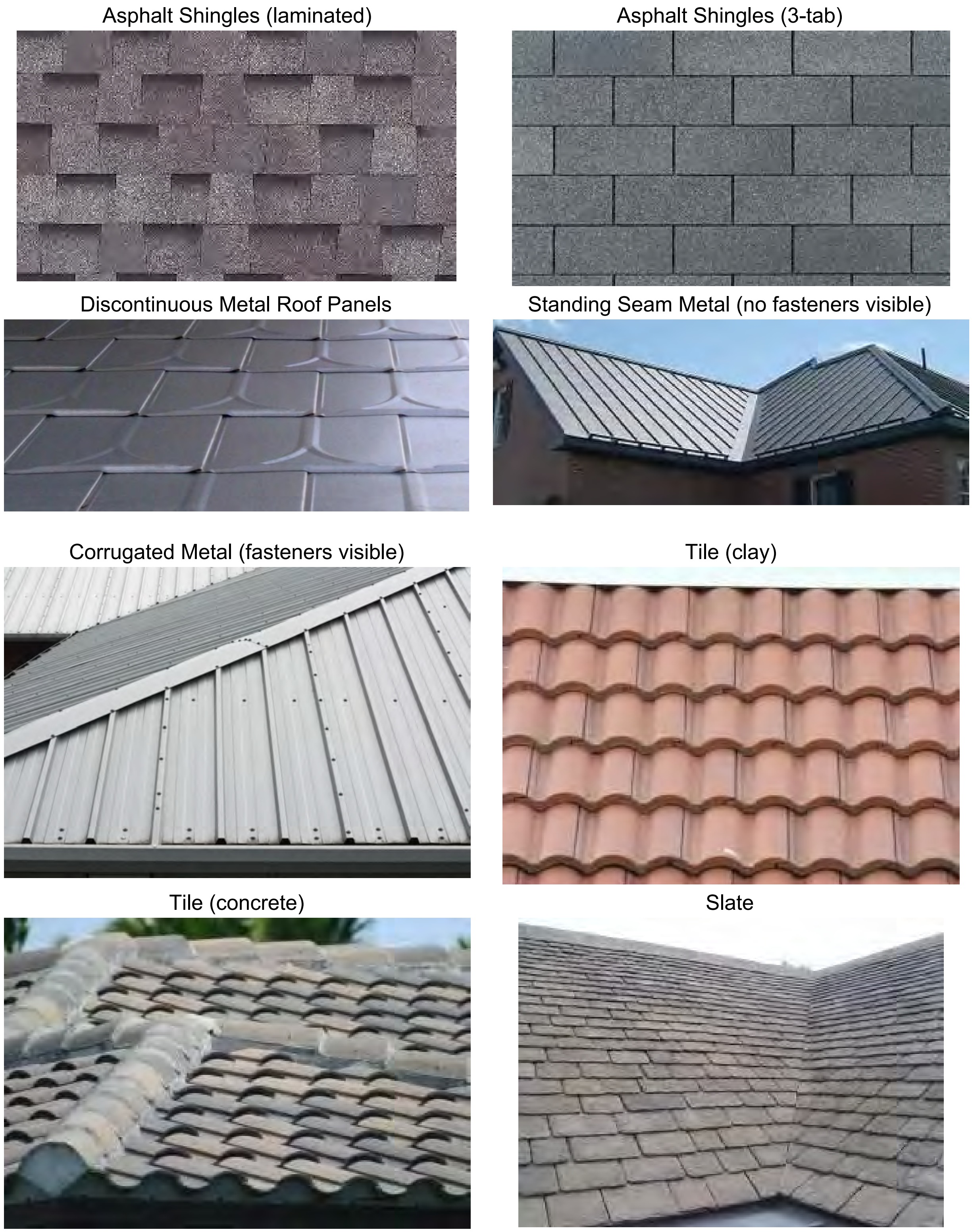


Figure 24: Common types of roof cover

4.6.27 Secondary Water Barrier

Classify any secondary water barriers that are visible, using one of the following options:

- Fully adhered membrane
- Self-adhering membrane over joints (~4" strips)
- High performance underlayment
- Closed-cell urethane foam adhesive
- Unknown
- Other

Avoid identifying secondary water barriers from photographs or aerial imagery, as it can be difficult to distinguish the secondary water barrier from standard underlayment options. The easiest to distinguish is typically the self-adhering membranes installed over joints (i.e., peel and stick), as these strips are not present in standard underlayment systems (see Figure 25).

Figure 25: Peel and stick membrane over joints in the roof sheathing. (Photo Credit: IBHS)

4.6.28 Overhang Length (inches)

Estimate the overhang length of the roof system past the walls. Enter "0" if no overhang is present. Unless the overhang length is measured in the field, a precision of 6 inches is sufficient. Potree Viewer or Pictometry Connect Explorer may be used to measure the overhang length but several measurements should be made to gauge the uncertainty and obtain a mean value. If multiple overhang lengths are present, use the dominant one (the overhang length used throughout most of the roof perimeter). Do not consider large overhangs such as porches in this field unless they are continuous around the majority of the roof perimeter.

4.6.29 Parapet Height (inches)

Estimate the parapet height in inches. If no parapet, enter “0”. If multiple parapets are present, use the most common height (e.g., applicable to the majority of the building). Note any differences in parapet height in the structural notes field if necessary.

4.7 Wind Damage Assessment

4.7.1 Wind Damage Notes

Use this field to indicate any unique wind damage features that are important to note but do not fit within the standardized fields.

4.7.2 Roof Structure Damage Ratio (%)

Estimate the percentage of the primary roof structure that is damaged or destroyed. Typically this must be done using the supplemental sources of aerial imagery, such as the orthomosaics available as Fulcrum layers, Pictometry Eagleview, or the NOAA aerials. Do not include appurtenant structures unless the roof structure is continuous with the main roof structure. If the percentage was assigned during the on-site investigation, verify against UAV imagery, Pictometry Eagleview, or other sources of aerial imagery and update as necessary. Precision of 5% is sufficient.

4.7.3 Roof Substrate Damage Ratio (%)

Estimate the percentage of the roof substrate that is damaged or destroyed. Typically this must be done using the supplemental sources of aerial imagery, such as the orthomosaics available as Fulcrum layers, Pictometry Eagleview, or the NOAA aerials. If no substrate is present, leave blank. Do not include appurtenant structures unless the roof structure is continuous with the main roof structure. If the percentage was assigned during the on-site investigation, verify against UAV imagery, Pictometry Eagleview, or other sources of aerial imagery and update as necessary. Precision of 5% is sufficient.

4.7.4 Roof Cover Damage Ratio (%)

Estimate the percentage of the roof cover that is removed. Typically this must be done using the supplemental sources of aerial imagery, such as the orthomosaics available as Fulcrum layers, Pictometry Eagleview, or the NOAA aerials. Do not include appurtenant structures unless the roof cover is continuous with the main roof structure. If the percentage was assigned during the on-site investigation, verify against UAV imagery, Pictometry Eagleview, or other sources of aerial imagery and update as necessary. Precision of 5% is sufficient.

4.7.5 Wall Structure Damage Ratio (%)

Estimate the percentage of the primary wall structure that is damaged or destroyed. Do not include appurtenant structures unless the wall structure is continuous with the main wall structure. Do not include damage to breakaway walls or other components of understories. Precision of 5% is sufficient.

4.7.6 Wall Substrate Damage Ratio (%)

Estimate the percentage of the wall substrate that is damaged or destroyed. Do not include appurtenant structures unless the wall structure is continuous with the main wall structure. Do not include damage to breakaway walls or other components of understories. Precision of 5% is sufficient.

4.7.7 Wall Cladding Damage Ratio (%)

Estimate the percentage of the wall substrate that is damaged or destroyed. Do not include appurtenant structures unless the wall structure is continuous with the main wall structure. Do not include damage to breakaway walls or other components of understories. Precision of 5% is sufficient.

4.7.8 Front Wall Fenestration Damage Ratio (%)

Estimate the percentage of the front wall fenestration that is breached. **Note the ratio should be based on area not number**. In equation form, the front wall fenestration damage ratio (FFDR) is stated as follows:

$$FFDR = \frac{\sum Area_{DamagedFenestration}}{\sum Area_{Fenestration}}$$

Be careful in interpreting damage based on windows or doors covered by OSB or plywood panels, as these may be temporary protection installed prior to the storm (if investigating a hurricane event). From overall photographs alone it is sometimes not possible to evaluate whether a particular window was boarded up post-storm due to damage or protected pre-storm to protect against debris. Some tips for differentiating are as follows:

- Typically, if the panels are cut to fit within the opening frame (including within arches) or are labeled, this is an indication that the panels were installed pre-storm (Figure 26).
- The fastening pattern may also be useful for properly identifying opening protection vs covering post-storm damage. Noting how many nails/screws were used on a typical sheathing panel could help identify between these two possibilities.
- Damaged glass windows or doors may also have pieces of broken glass in front of or around the opening.

If no other conclusive evidence is available, assume fitted or labeled panels were installed pre-storm and thus do not constitute damaged fenestration. To assume a covered opening is damaged, there should be some evidence to that effect beyond just that it is covered.

Figure 26: Labeled panels covering openings, indicating these were installed pre-storm.

4.7.9 Left Wall Fenestration Damage Ratio (%)

See guidance for Front Wall Fenestration Damage Ratio.

4.7.10 Back Wall Fenestration Damage Ratio (%)

See guidance for Front Wall Fenestration Damage Ratio.

4.7.11 Right Wall Fenestration Damage Ratio (%)

See guidance for Front Wall Fenestration Damage Ratio.

4.7.12 Sectional/Rollup/Garage Door Failure

Document any damage to large doors such as sectional, roll-up or garage doors, noting on what wall the damage was observed. During final DE/QC checks, ensure that any orientations with large door damage indicated also have large door type defined in the Structural Attributes section.

4.7.13 Soffit Damage Ratio (%)

Estimate the percentage of soffit that is damaged. If soffit is only visible along a portion of the building, assume the soffit is undamaged in any portions of the building not visible. Include any soffit on the underside of porches that are connected to the main living area.

4.7.14 Fascia Damage

Estimate the percentage of fascia that is damaged, if any. Use 0 to indicate no fascia was damaged. Leave blank to indicate no fascia is present or visible. An example of fascia damage is shown in Figure 27.

Figure 27: Example of facia damage

4.7.15 Stories with Damage

Broadly categorize the presence of damage by story, using only numbers, commas, and dashes. This should not include any roof damage, as that is already accounted for in the roof damage ratio fields. Use 0 to indicate the understory. For example: 0,1,4-7,9 would indicate damage on the understory and stories 1,4,5,6,7, and 9.

4.8 Surge-induced Damage Notes

Use this field to describe in more detail any water-induced damage or related information that is not contained within the standard fields.

4.8.1 Percentage of Building Footprint Eroded

Define the percentage of the building footprint that has eroded (Figure 28). If no erosion is present, enter "0". Use the percentage of the building footprint even if the building is elevated on piers. Typically there is a slab at the ground level that can be used to indicate the building footprint.

4.8.2 Percentage Damage to Understory

Define damage to the understory as an overall percentage. If no understory is present, leave blank.

4.8.3 Maximum Scour Depth (inches)

If scour is present, indicate the maximum scour depth in inches and note the location and other relevant details in the Water-induced Damage Notes.

Figure 28: Scour around a foundation of a coastal single-family home.

4.8.4 Percentage Piles Missing or Collapsed

Estimate the percentage of piles that are no longer attached to the structure. In the photograph in Figure 29, approximately 25% of the piles are missing.

Figure 29: Missing or collapsed piles. (Photo Credit: US Army Corp of Engineers)

4.8.5 Percentage Piles Leaning or Broken

Estimate the percentage of piles that are structurally compromised, but still attached to the structure (Figure 30).

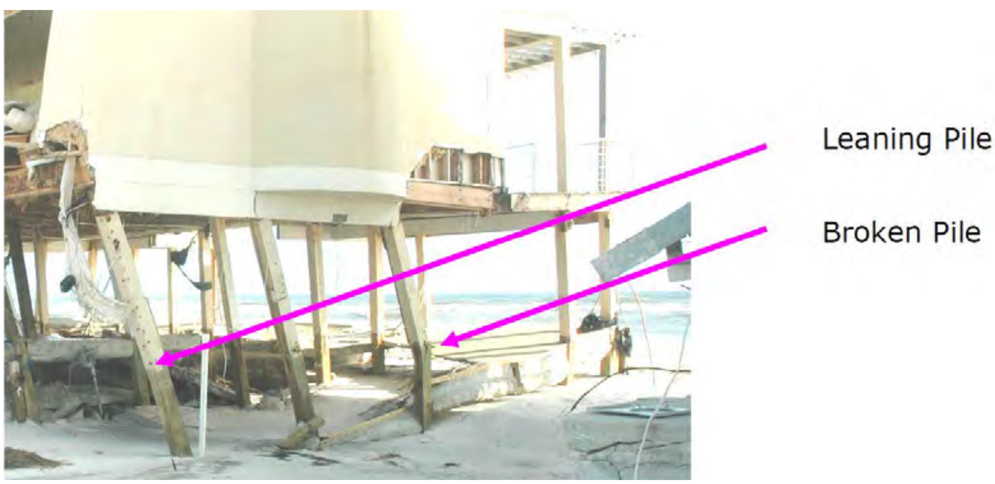


Figure 30: Leaning or broken piles. (Photo Credit: US Army Corp of Engineers)

4.8.6 Cause of Foundation Damage

Indicate the primary causes of damage to the foundation. Select all that apply.

- Erosion
- Wave loading
- Flooding
- Floating Debris impact
- Velocity Scour
- None
- Unknown

4.8.7 Reroof Year

The age of the roof cover is an important factor in roof cover systems, particularly for asphalt shingle roof systems. Identifying the reroof year, if the building has been re-roofed at all, typically requires finding roofing permits for the building. Some counties make this information publicly accessible through a website, but others do not. Check with the Data Standards Lead or the VAST Lead for more information on whether this information is being collected or not.

4.8.8 Retrofit 1

If a structural retrofit is known to have been implemented (e.g., impact-resistant windows, upgraded roof sheathing fasteners), describe it here. This is primarily helpful when the investigator is able to speak with the building owner or occupant, or when permits for the building are available.

4.8.9 Retrofit 1 Year

Indicate the year in which Retrofit 1 was installed, if known. Typically this would be sourced from the building owner or public permit information.

4.8.10 Retrofit 2

See above for Retrofit 1.

4.8.11 Retrofit 2 Year

See above for Retrofit 1.

4.9 DE/QC Tracking

4.9.1 Data Librarians

VAST member that inspects and/or makes changes a particular record are considered its *Data Librarian* and are required to record their initials in this field.

4.9.2 QC Progress Code

The codes in Table 4 are to be used to track the DE/QC progress.

Table 4. DE/QC process codes

Code	Meaning
1	Location and address have been verified. The record location is positioned directly over the building that is the focus of the investigation.
1e	The location and address have not been verified due to an error or uncertainty. The exact location or address of the building is not able to be confirmed. If a record is at 1e, it may not be possible or worthwhile to advance into additional stages.
2	Stage 1 has been completed, and the minimum information for a completed assessment has been verified or added. For example, the correct building type is assigned, overall damage ratings are confirmed to be in agreement with the standard quantitative guidelines, and basic building attributes such as year built are present.
2e	Stage 1 has been completed but there is insufficient information to meet the minimum data standards for a complete assessment, or there is considerable uncertainty in assignment of one or more critical fields. If a record is at 2e, it may not be possible or worthwhile to advance into additional stages.
3	Stage 2 and below has been completed. The majority of Stage 3 fields as identified in Table 2 have been completed and validated with reasonable confidence in accuracy and precision.
3e	Stage 2 and below has been completed, and some Stage 3 fields have been completed, but lack of data (e.g., only 2 sides of the structure are visible) prevents the assessment from being completed without undue uncertainty.
4	Stage 3 and below has been completed, and more detailed forensic fields such as roof-to-wall connection type and foundation anchorage type have been added and verified. Most fields are filled in for the record with reasonable levels of confidence. Most records will not get to Stage 4. Records that do get to Stage 4 may be good candidates for detailed case studies.
5	Final QC validation has been completed with automated and manual checks. The record is ready to be published in DesignSafe.
5e	Final QC validation has been completed but errors have been identified that need to be corrected manually. Once the errors are resolved, the code should be changed to “5”.

4.9.3 QC Notes

Use this text-entry form to identify any relevant information beyond the QC Code. This form should particularly be used if codes 1e, 2e, or 3e are used, to identify what fields need further review.

References

Friedland, Carol J. (2009) *Residential building damage from hurricane storm surge: proposed methodologies to describe, assess and model building damage*. LSU Doctoral Dissertations. 2897

Vickery, P.J., Skerlj, P.F., Lin, J., Twisdale Jr., L.A., Young, M.A., Lavelle, F.M. (2006) "HAZUS-MH Hurricane Model Methodology. II: Damage and Loss Estimation," *Natural Hazards Review,* 7(2): 94-103.