Free, Fast Building Seismic Safety Inspection Software for Smartphones

By Keith Porter, Bill Bell and Neville Pereira

The Federal Emergency Management Agency (FEMA) and the U.S. Geological Survey (USGS) have teamed up to produce a suite of free software for pre- and post-earthquake building safety assessment. The software works on smartphones for fieldwork, as well as on an ordinary PC to act as a web-accessible, secure database server. Field inspections take five to 20 minutes per building, excluding travel time. The ROVER (Rapid Observation of Vulnerability and Estimation of Risk) is an integrated database and a post-earthquake safety evaluation component. The components share data with each other and with two more free tools to help manage seismic risk. The Los Angeles Unified School District, Structural Engineers Association of Utah and New York State Office of Emergency Management, among others, have successfully tested the software. One of the additional tools is *ShakeCast*, a USGS software program that monitors the occurrence of earthquakes that could affect buildings of interest. Once an earthquake occurs, *ShakeCast* automatically displays a map of the shaking (a "ShakeMap"), shows where the buildings are and how strongly they were shaken and estimates which ones are most likely to be considered unsafe. The other tool that can use the ROVER data is FEMA's seismic risk management software, HAZUS®-MH, which can estimate repair costs, casualties and loss-of-use duration for real or hypothetical earthquakes.

How ROVER Works

Before an earthquake occurs, a trained inspector takes a smartphone into the field to perform pre-earthquake screening of buildings for potential seismic risk using an electronic version of FEMA 154, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*. FEMA 154 was designed to enable

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a trained inspector to quickly observe and record the crucial aspects of a building's seismic resistance and distinguish a building that might pose a risk in a large earthquake from one that probably does not. The buildings that fail the FEMA 154 screening then can be examined thoroughly by a structural engineer, which means that building department officials can save time by minimizing retrieval and detailed review of building plans.

All the data that would go on the one-page paper FEMA 154 form (Figure 1, upper right) fit into a tabbed display on the smartphone screen (Figure 2, lower right). The building data includes building location and other identifiers, use, number of occupants, number of stories, sketch, photograph, site soil classification and seismic hazard level, structure type and other features that can strongly affect seismic risk of a building. The data is stored locally on the phone until the user is ready to send it to a database server, which, in this case, is an ordinary Windows or Linux PC. The files from any number of field inspectors can be sent to the central database, either via secure Internet access (using your phone's data plan or alternatively in the local café using the phone's on-board WiFi card) or by bringing the phone back to the office and connecting it with a wire to the server. The phone doesn't need to have a data plan; you can use it as a handy portable computer.

Once the data gets to the database server, the software automatically looks up the soil conditions and seismic hazard at each site from on-board copies of national soil and seismic hazard maps. The server also watermarks the photos with building name, latitude and longitude, etc., for later reference. The inspections are securely accessible from any web browser anywhere in the world, where the inspector or other authorized user can review or modify the data.

As an alternative to entering the data onto the smartphone and later synchro-

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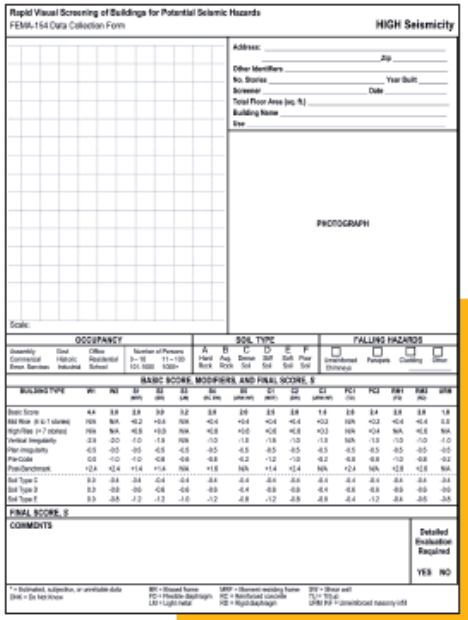

Figure 1: FEMA 154, *Rapid Visual Screening of Buildings for Potential Seismic Risk.*

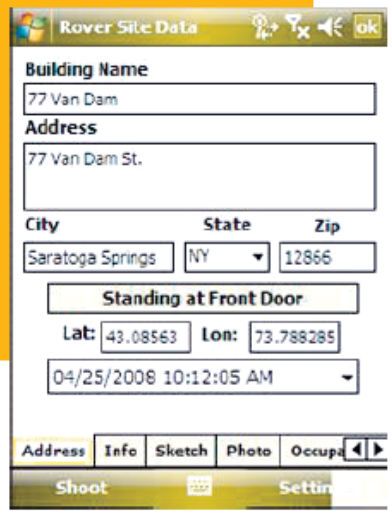

Figure 2: FEMA 154 on the smartphone. This tab shows the address information from the paper form.

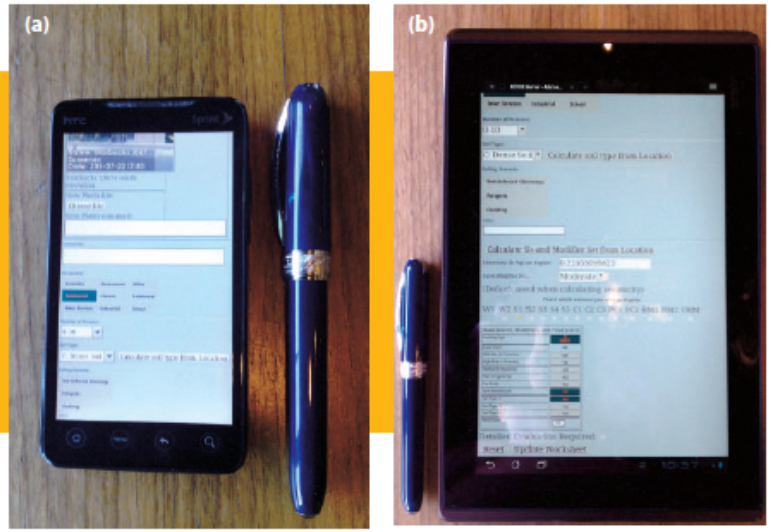

Figure 3: ROVER web client: (a) on an Android ver 2.2 HTC Evo smartphone, and (b) on an Android ver 3.1 Asus Transformer tablet.

Figure 4: ATC-20 post-earthquake safety inspection placards.

nizing with the server, the user with a mobile device (smartphone, tablet, etc.) and active Internet connection can enter data directly into the ROVER server through the device's web browser. This frees ROVER from the constraints of an operating system. So far, we have tested the web client on an Android smartphone (Figure 3a, above, left), Android tablet (Figure 3b, above, right), an iPad and a Blackberry smartphone.

Now, suppose an earthquake actually occurs

ROVER has an inspection module that encodes ATC-20, *Postearthquake Safety Evaluation of Buildings*, the international de facto standard in post-earthquake safety inspection. It has been used in dozens of earthquakes, on thousands of buildings and adapted for use in other countries. The ATC-20 methodology leads to the inspector posting the building with a red ("unsafe"), green ("inspected") or yellow ("restricted use") placard (Figure 4, above). Encoded in ROVER, the data on the smartphone is again sent back to the server, either wirelessly or wired, or directly entered into the server from the device's web browser.

The data on the server can be reviewed or modified through a web interface (Figure 5, next page). A database developer can integrate the ROVER data with municipal databases. The user also can export ROVER data to Google Earth, a free mapping software. This helps, because elected officials and others tend to value maps for decision making and communicating

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with the public (e.g., maps showing red, yellow and green dots for locations of inspected buildings).

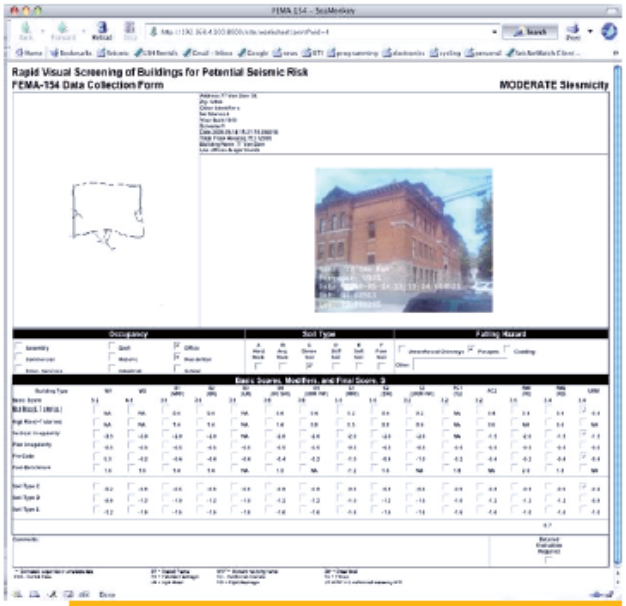

Figure 5: Secure web access to pre- and post-earthquake inspections.

How Do *ShakeCast* and HAZUS-MH Fit In?

ShakeCast can use ROVER data to identify the buildings of interest and watch for the occurrence of earthquakes affecting them, automatically estimate the ATC-20 safety tag color for each building when an earthquake occurs (which can help to prioritize safety inspections) and then send that information back to ROVER. HAZUS-MH likewise can use ROVER data to perform richer, earthquake-risk estimation to help inform public policy about the benefits of seismic risk mitigation.

Benefits: ROVER provides all the advantages of FEMA 154 and ATC-20: efficient, standardized, well-established procedures to assess and manage the seismic safety of a building stock – procedures developed by leading earthquake engineers and endorsed by local, state and federal governments. ROVER offers added advantages of automation. For the inspector, the pre-earthquake data is available in post-earthquake safety inspections. There is no juggling of sheaves of paper, clipboard and camera. For the manager, there is no transcription of paper forms; there is the built-in database (no need to create an ad-hoc database, especially in the post-earthquake environment); automated production of data files for Google Earth; automated linkage of sketch and water-marked photos to the automated site-specific soil and hazard lookup; and automated linkage to *ShakeCast* and HAZUS-MH. For the sophisticated user, ROVER is written in open-source software using an open-source database format, so it can be customized and adapted to interact with other databases.

Remote evaluation assistance: There is another subtle benefit derived from the fact that ROVER works on a smartphone and a web-accessible server. Imagine that an earthquake has occurred and an inspector is examining a damaged building. Oftentimes, the damage evidence is ambiguous, and the inspector needs the advice of a colleague to choose between posting a red, yellow or green tag because the building is obviously damaged, but the inspector isn't certain whether the building poses a significant hazard. With a phone and data plan, the field inspector can send photos and the other data to the database server while standing in front of the building. A colleague then can examine the evidence remotely and securely via a web browser *in real time*. The colleague then can provide advice over the phone without having to go to the building and inspect it personally. Following a large earthquake, a second visit might involve several days' delay and travel time. Following a *very* large earthquake, a

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ICC Members' Handwriting All Over ROVER

Federal task force recruited Utah's Bell and California's Pereira for development of landmark assessment tool

Several years ago, officials from the Federal Emergency Management Agency (FEMA) thought it would be a great idea to have a hand-held device inspectors could use to speed up the assessment process, especially following natural disasters.

Their search led them to Bill Bell, longtime International Code Council (ICC) Member and Chief Building Official in Orem, Utah. Bell had published a story in a trade publication on the city's use of hand-held devices, at that point mostly Blackberrys, for property inspections. Some other jurisdictions also were going paperless, he said, but they were using larger devices such as laptops.

Bell said the hand-held devices made the process more efficient for inspectors and clients, but the move away from hand-written inspection forms was borne of a more practical necessity. "For me, it was because the inspectors' handwriting was poor," he said. "You can laugh, but sometimes, you would have to go back and check two or three different programs to find an answer."

FEMA also found Neville Pereira, now Principal Plans Examiner, City of Pasadena, California, and President of the 90-Member Los Angeles Basin Chapter of ICC. They were among a 15-person task force created to design what ultimately would become a smartphone application called ROVER (Rapid Observation of Vulnerability and Estimation of Risk).

When he finally got the first test versions of ROVER, Pereira, then with the City of Glendale, California, said he thought the units were too small. "But they worked just as we intended them to," he added. Bell agreed.

"I quite like it," he said. "It's so easy to use, even volunteers can operate it with little training. And it's all in real time."

Speaking of time, Pereira and Bell said, saving time, especially following an emergency event, is crucial to adequate response and repair. There is even a function on ROVER that can help jurisdictions do pre-disaster assessments of buildings based on different types of emergencies, such as earthquakes, storms, landslides, etc.

The only problem with that, the two said, is that each jurisdiction needs to input the data about specific structures before ROVER can give them the pre-disaster assessment. Once they get ROVER, Bell said, he'd probably have to have his staff input the data in whatever spare time they have. "I can't let them have a couple days to do only that," he said.

He and Pereira said their jurisdictions may or may not allocate extra funds to enhance the pre-disaster function. Bell said Orem officials value being prepared, even though they haven't had a major disaster along the Wasatch Fault in quite a while.

Pereira said it is difficult to ask for more money to add necessary data on a smartphone application that may not be needed for years. "Pasadena is pretty progressive and likes to be the first in line," he said. "But we're cutting back on personnel right now. … That won't stop me from trying."

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few experts' time will go a lot further, and experts who otherwise couldn't travel to the affected area can help. A larger volunteer workforce is making safety decisions more rapidly and inexpensively (volunteers, many of whom travel from outside the affected area to help make most ATC-20 inspections at large events).

Costs: The ROVER software is free. The smartphone and GPS device together cost about $250. Most users probably already own a Windows or Linux PC. *ShakeCast* is free, as are HAZUS-MH and Google Earth. (However, HAZUS-MH requires ESRI's ArcGIS software, which can cost several thousand dollars.) ROVER training is required, but so is training on FEMA 154 and ATC-20. The same trainers can perform all the training at the same time. Currently, the smartphone must operate Windows Mobile (versions 5 through 6.5) and have a touchscreen, stylus, camera and Bluetooth radio. You also need a Bluetooth GPS device. Alternatively, any Android, Apple or Blackberry smartphone or tablet with an active data connection can be used to enter data directly into the server without the need for an external GPS device. Software for a tablet PC version of the field unit is in the works.

Future plans: FEMA intends to release the ROVER software as free, open-source software (FOSS) dedicated to pre- and post-earthquake safety inspection by the ATC-20 and FEMA 154 methods. The developers – the Applied Technology Council, SPA Risk LLC and Instrumental Software Technologies Inc. (ISTI) – are forming a nonprofit corporation called ROVER Development Partners (RDP), whose mission will be to maintain, distribute, enhance and promote the software Rapid Observation of Vulnerability and Estimation of Risk (ROVER). RDP will ensure that a free version of ROVER is available for use by state and local communities. It will help co-developers add features and provide user support and other ROVER-related services.

How to get it: ROVER can be ordered on CD from the FEMA Publications Warehouse or (800) 480-2520. It also is available online; see www.atc-rover.org, www.sparisk.com or www.isti.com for the URL. The reader interested in training for ATC-20, FEMA-154 or ROVER can find pointers at www.atcouncil.org or www.fema.gov/plan/prevent/earthquake/training_netap.shtm, or by Googling "FEMA NETAP."

Acknowledgments: The Applied Technology Council, under the direction of Thomas McLane, developed ROVER for FEMA. Instrumental Software Technologies, Inc. wrote the ROVER software under the direction of Sidney Hellman. Stuart Moffatt wrote additional ROVER code for integration with HAZUS-MH. *ShakeCast* is a product of the U.S. Geological Survey, developed under the direction of Dr. David Wald

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by Kuo-Wan Lin. FEMA personnel involved in the development of ROVER include Cathleen Carlisle, Mai Tong and Doug Bausch. **bsj**

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As always, your articles, ideas and submissions are welcome. Send them to foliver@iccsafe.org along with a daytime phone number at which to contact you with questions.