Protect Utility or Industrial Activities

Earthquakes threaten 1 in 4 Americans. Earthquakes currently cannot be predicted, but people can act beforehand to reduce the harm when earthquakes occur. One way to do that is to implement earthquake early warning, which refers to a system that rapidly detects earthquakes just after they begin, quickly calculates how strongly the ground will shake, and notifies people or systems just a few kilometers or tens of kilometers from the epicenter before the shaking arrives. With a few seconds' warning, people and systems can take useful protective actions. The next few pages answer key questions for people deciding whether and how to adopt earthquake early warning to protect utility or industrial activities. This material was written by leading earthquake engineers, seismologists, emergency managers, and other pioneers of earthquake early warning, including people who developed, implemented, and use earthquake early warning in real life.

This is one of seven guidelines for various ways to use earthquake early warning. Find the full set at http://www.sparisk.com/pubs/Porter-2020-EEW-Set.pdf

Essence of the Practice

An Internet-connected device (sometimes called a monitor or control) listens for the earthquake early warning message. When the message is received, the software evaluates the alert to determine whether it meets the criteria for acting. If so, the device operates an electrical relay, which either starts or stops electric equipment. The relay could be attached to almost any downstream device to cause an automatic action. For example, at a water or wastewater utility, the monitor could cause an outlet valve to close at a water supply reservoir, protecting the reservoir from draining through damaged buried pipe lower in the system. Other examples include stopping rotating machinery, opening a door, stopping a magnetic resonance imaging machine, sounding an alarm, or shutting off power to prevent an electrical fire.

Figure 1. Earthquake early warning can automatically close or open valves, start or stop electrical equipment, open doors, sound alarms, or shut off power to protect water and wastewater systems. (Image: Khepster, 2008, Creative Commons Attribution 3.0)

Context in Which the Use Case Would Work

The use case works in a facility with power and an Internet connection and where one wants to stop or start electrical or hydraulic equipment or operate valves automatically, without human intervention. Time of day and culture mostly don't constrain it, but it only works where there is an earthquake early warning network in operation: California, Oregon, Washington, Mexico, Japan, Turkey, Romania, China, Italy, and Taiwan. The use case does not address the situation where the actions must be chosen based on information beyond what is included in the early warning message.

Realistic Expectations

Expect approximately the same reliability as any automated supervisory control and data acquisition (SCADA) function, bearing in mind that earthquake shaking can damage equipment and other vulnerabilities listed below. Some actions can take several seconds or longer, such as closing a valve on a large-diameter pipe. Some locations will be too close to the epicenter to complete the action before the arrival of strong motion.

Clear Behavior

All the actions are automated and determined at the time of installation or as the user updates the actions that the device initiates. When a warning arrives, the device activates an electrical relay, for example one attached to a hydraulic or electrical actuator that positions existing isolation valves.

Potential Vulnerabilities

The potential exists for false alarms and missed alarms from the earthquake early warning system, and for the facility in which the device is installed to be so close to the earthquake that strong shaking arrives before the warning. Even if the warning arrives promptly, slow telemetry or and the large number of turns required close large valves could limit the number of actions that can be taken before shaking arrives. All mechanical and electrical equipment require testing and maintenance and eventually become inoperative. The potential exists for user error as well: the user might accidentally set the device's tolerances or non-fail-safe actions too high or too low and not learn of their error until after the earthquake. The user might accidentally shut off the device prior to the earthquake. The format of the alert occasionally changes (to date, on the order of every two months), and the earthquake could happen while the vendor is dealing with that change. The potential exists for earthquake shaking, ground failure, or other secondary hazards such as sloshing or seiche to damage the equipment being controlled. The user can manage the potential for such damage by having a structural engineer use the Federal Emergency Management Agency's document FEMA E-74 to examine and seismically secure equipment (Federal Emergency Management Agency 2011).

Implementation Costs

For a typical water system with a SCADA system and that has completed state-mandated requirements for emergency response planning, the systems currently range in total cost from $15,000 to $25,000, including design, hardware, software, startup, and training, but excluding valve actuators and other water-system hardware. The industry is young. Costs could vary as new vendors and products enter the market. A few large utilities may have the resources to develop and implement such a system in house.

Hardware and Software Requirements

The system requires the monitor or control, which is connected to the Internet and to the SCADA system. Absent a SCADA system, or if required for Internet security, a separate monitor or control can be connected to the Internet and to each piece of equipment that will be controlled.

Training Materials, Requirements, and Frequency of Training

At a minimum, the developer (whether a vendor or an in-house engineering team) trains SCADA operators on how to use and maintain the hardware and software when the system is first installed and again when new SCADA operators start work. Alternatively, the vendor or in-house developer may provide written documentation and the user can ensure that all SCADA operators read and learn the operation. Most users over the course of the first year of use have not requested refresher training from one vendor, although that might change as more vendors and devices enter the market and the length of use in practice grows.

Maintenance Requirements

The user generally does not have to maintain the device if the vendor or the in-house developer does so.

Examples of Past Use

Northeast Sammamish Sewer and Water District (2020) in Sammamish, Washington installed such a system on its water distribution system (Porter 2018). The system controls water wells, water pump stations, and water storage reservoirs. For example, the Crest Reservoir is a buried 0.5-million-gallon reservoir that cannot deliver water by gravity to the water system; water must be pumped. The earthquake early warning system shuts down the pumps at the pump station, preserving the pumps and the water in the reservoirs. In an emergency, people could fill up jugs, etc. at the reservoir.

Lakewood Water District in Lakewood, Washington, has a similar system, monitoring wells, pump stations, and reservoirs (Lakewood Water District 2020).

Silverdale Water District in Silverdale, Washington, also monitors wells, pump stations, and reservoirs (Silverdale Water District 2020).

The City of Anacortes, Washington, monitors a water treatment plant. The device will shut off various treatment processes: blowers, pumps, chemical injection system, digesters, among other actions. (Anacortes City Council 2019).

Currently, Varius Inc. sells such a device, a commercial product called OmniMonitor. For more information, contact the Engineer in Responsible Charge Dan Ervin, dan.ervin@variusinc.com, 1-425-269-8479.

RH2 sells a commercial product called Advanced Seismic Control (ASC). For more information, contact RH2's Seismic Resilience Planning Project Manager, 1-541-665-5233.

References

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