13th World Conference on Earthquake Engineering
Vancouver, B.C., Canada
August 1-6, 2004
Paper No. 2413

RAPID EVALUATION AND ASSESSMENT CHECKLIST (REACH) PROGRAM – A CASE STUDY AT NAVAL HOSPITAL BREMERTON

Douglas R. WILSON, P.E. [1], Russell D. KENT, P.E.[2],
Stephen STANEK, P.E. [3], and David B. SWANSON, P.E., S.E.[4]

SUMMARY

The Rapid Evaluation and Assessment Checklist (REACH) system provides an inspection team responding to a facility after a seismic event with specific building information. It also provides a building-specific evaluation process, using a customized checklist and values from a seismograph. With the system, the team can quickly and effectively determine if the building is safe to re-occupy and post the building appropriately. This paper will present an overview of the REACH package developed at Naval Hospital Bremerton. This case study may assist other agencies formulate a program for post-earthquake safety evaluation of other operation and mission critical facilities.

INTRODUCTION

The Naval Hospital Bremerton, with a staff of over 1,200 personnel, provides health care for over 60,000 families (active duty, dependents, and retirees) in the area. It is one of only two hospitals in Kitsap County (the second most densely populated county in the state of Washington) and could be called on to serve an overall population of 250,000 people after a disaster. The hospital provides emergency services, surgery, obstetrics, and inpatient services as well as housing numerous outpatient clinics. These services are needed without interruption, particularly following an earthquake or other catastrophic event. Damage to either the building structure or to the contents could result in the disruption of essential hospital functions for an indefinite time period. The Rapid Evaluation and Assessment Checklist (REACH)

[1] Project Engineer, Structural Engineering Group; Reid Middleton, Inc., 728 134th Street SW, Suite 200; Everett, WA 98204 (425) 741-3800; dwilson@reidmidd.com
[2] Facility Manager, Naval Hospital Bremerton, Facility Management Department, Code 014, One Boone Road, Bremerton, WA 98312-1898 (360) 475-4124; kentr@pnw.med.navy.mil
[3] Project Lead, Engineering Field Activity Northwest, 19917 – 7th Avenue N.E., Poulsbo, WA 98370-7570 (360) 396-0217; stephen.j.stanek@navy.mil
[4] Director, Structural Engineering Group; Reid Middleton, Inc., 728 134th Street SW, Suite 200; Everett, WA 98204 (425) 741-3800; dswanson@reidmidd.com

Program provides a means to make much more accurate and timely recommendations to the hospital Commanding Officer regarding the safety and operability of the hospital following an earthquake or other disaster. This will greatly improve the hospital's ability to maintain continuity of medical services – critical in time of natural disaster.

EXPERIENCE FROM 2001 NISQUALLY EARTHQUAKE

Naval Hospital Bremerton is a 249,000-square–foot, nine-story building constructed in 1976 (see Figure 1). On February 28, 2001, the Nisqually earthquake, with a magnitude 6.8, rocked the Puget Sound area of Washington State. The epicenter of the earthquake was approximately 30 miles away from the hospital, which experienced peak horizontal ground acceleration of approximately 11% g and a peak acceleration at the roof of approximately 47% g.

Figure 1 - Overall photo of the hospital from the southeast. A detached outpatient clinic and parking garage are visible to the left. The main hospital is beyond.

The hospital structure experienced significant drifts during the earthquake– particularly on the upper floors. Figure 2 depicts recorded roof displacements during the Nisqually earthquake.

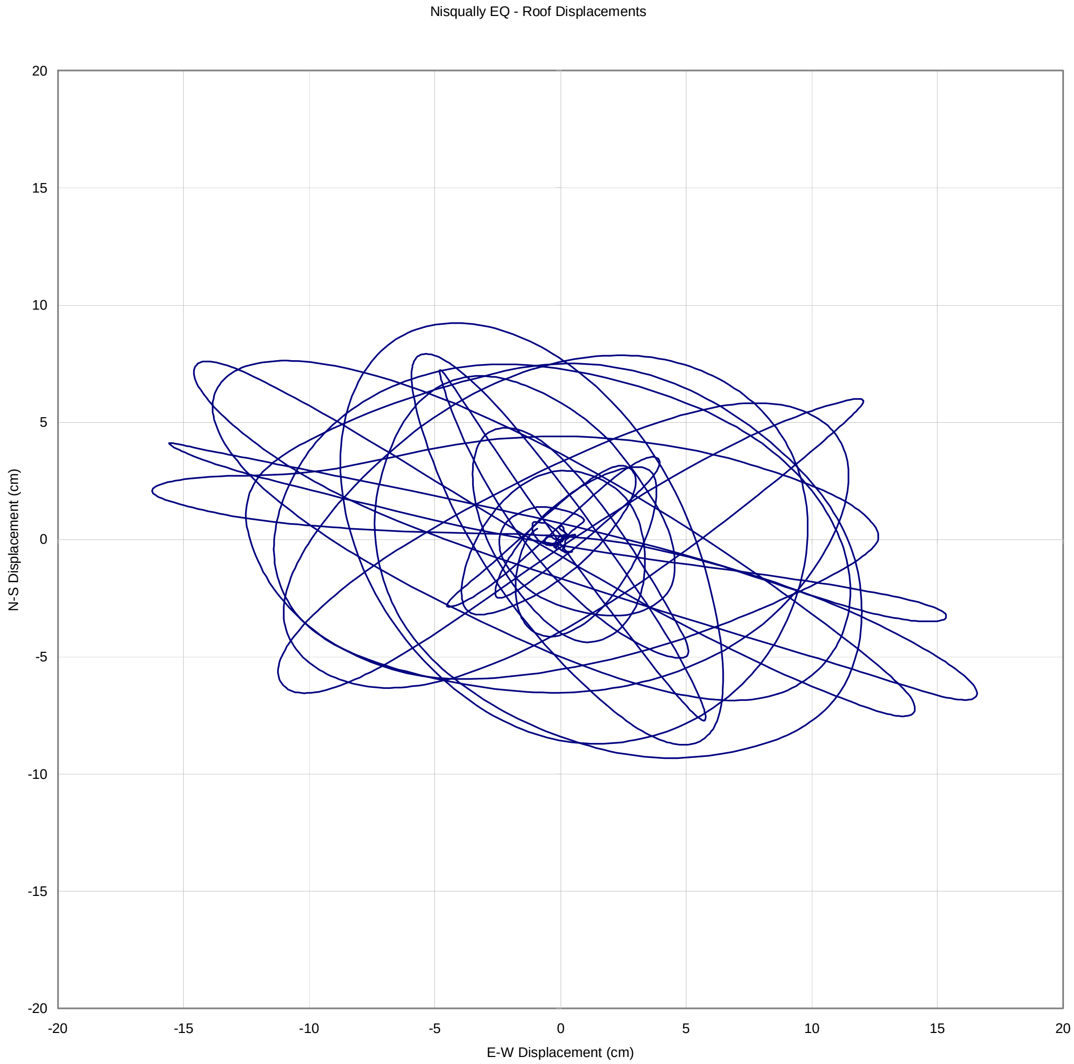

Figure 2 – Roof displacements recorded during the Nisqually earthquake.

This displacement caused extensive non-structural damage to the facility, including gypsum wall board damage, displacement of light fixtures in suspended ceiling, overturning of bookshelves, cabinets, and computer workstations, and the rupture of a fire sprinkler pipe in an elevator roof penthouse (the sprinkler leak was not located for over 30 minutes, which caused water intrusion from the elevator shaft on all levels of the hospital). The displacement also caused personnel to be thrown about. This, combined with the non-structural damage, caused widespread confusion and chaos, even bordering on panic in some cases (refer to Figure 3).

Figure 3 - Typical effect on the contents of office space from the Nisqually Earthquake

Luckily, the earthquake occurred during working hours and the Facility Management staff was present. However, most of the engineering staff was relatively new to the facility, and did not have a clear understanding of the type of building construction, nor were any of the staff familiar with post-earthquake evaluation protocols. The initial recommendations regarding immediate action came from the Fire Department, who recommended evacuation of the building. The Commanding Officer ordered non-essential personnel to evacuate the building, and some patients were evacuated to a nearby Mobile Field Hospital training site.

Concurrently, the facility engineering and maintenance staff was frantically performing inspections, scouring files, and consulting with former staff members and area structural engineers to obtain information about the building construction and to determine the actual level of building damage and risk of building collapse. After approximately 6 hours, enough information had been gathered to allow the hospital to be reopened for further operations, though it took several days for the utilities and systems to be fully restored, and several weeks for all repairs to be made.

Based on the experiences following the Nisqually earthquake, and because of the essential functions of the hospital, it was obvious that there was a need for a program to better evaluate the hospital for continued occupancy following a natural disaster.

THE RAPID EVALUATION AND ASSESSMENT CHECKLIST PROGRAM (REACH)

The Rapid Evaluation and Assessment Checklist Program (REACH) is similar to the Building Occupancy Resumption Program (BORP) system in the City of San Francisco, California. The BORP system originated with the San Francisco Building Department in 1997 as a result of experiences in the Northridge and Loma Prieta earthquakes. The system in San Francisco allows building owners to pre-certify their building with the building department to allow the owner's engineer to inspect and post the building after an earthquake. In order to qualify, the owner hires an engineer to develop a written inspection program for the particular building. Then, when an earthquake occurs, the engineer can inspect and post the building with a placard stating whether the building is safe to reoccupy. After a significant earthquake, it could take weeks before the building department would be able to dispatch personnel to evaluate and post a building. The benefit of the BORP to the owner is the ability to resume use of their building more quickly since the owner's staff engineers can evaluate the building on behalf of the building official.

At an essential facility like the hospital, it is particularly important to be able to resume occupancy of the building. Because Naval Hospital Bremerton is a federal facility, it does not fall under the regulation of a local building official. As a result, the REACH for Naval Hospital Bremerton is not required to be pre-certified with a building official. Instead, the intent of the REACH in this instance is to provide the hospital's post-earthquake inspection team with as much information as possible, which allows the inspection team to make an informed decision as to the structural safety of the building.

THE REACH PROCESS

The REACH process is shown graphically in Figure 4. The process begins when a potentially damaging event occurs. Since it is difficult to accurately perceive the severity of an earthquake, any event that is felt should be considered a potentially damaging event. Provided that there are not obvious signs that the building is unsafe for occupancy (such as partial collapse), the next step is to review the recorded seismograph data. Through engineering analysis, trigger values were developed, which are compared with the recorded ground and building accelerations and displacements. If the triggers are not exceeded then no evaluation is required. If the trigger values have been exceeded then a preliminary evaluation using the REACH checklist is warranted. Based on this evaluation, a determination of the acceptability of continued occupancy can be made and the hospital can be posted appropriately.

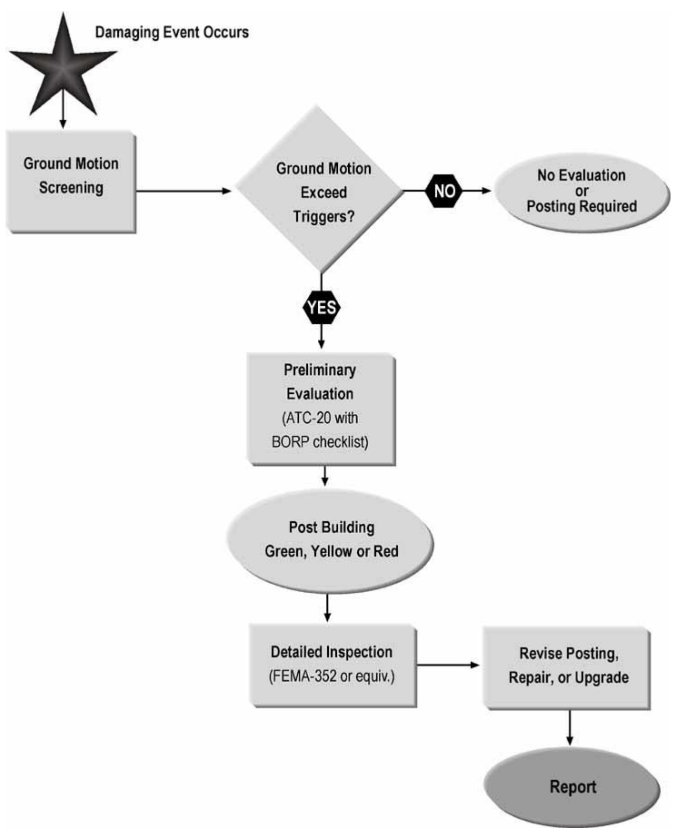

Figure 4 - REACH Process Flow Chart

ROLE OF THE SEISMOGRAPH

A seismograph with accelerometers in the basement, mechanical floor (approximately mid-height of building), and roof was installed at the hospital in 1980. The 1970s era instrument records strong motion accelerations on photographic film. With this type of recorder, the film must be retrieved from the recorder after an event and developed in a dark room. From the developed film, information such as length of the event, peak acceleration, and general building response relative to the ground motion can be obtained. However, in order to perform detailed analysis, the record must be digitized, corrected, and processed to generate additional information such as peak building displacements and a detailed time history of the ground and building motion. Though the seismograph provided valuable data for performing analysis and retrofit design at the hospital, extraction of the data takes time, preventing the information from being used for rapid post-earthquake evaluation.

To take advantage of the benefits that quickly accessible seismograph data can provide to the REACH program, the seismograph was recently upgraded to a digital 12-channel recorder with a dedicated laptop computer for processing the data. In addition, the sensors were reconfigured to add offset horizontal accelerometers. This will provide additional data on the torsional response of the building.

TRIGGER VALUES

Trigger values are intended to provide guidance regarding the likelihood of damage having occurred for a given recorded value. They do not provide a guarantee of the existence or absence of damage. Other information must be used together with the trigger values to formulate a decision on the structural integrity of the building following an event.

The following values are given in metric units because the recorder collects and provides values in centimeters, cm/sec, and cm/sec^2. Empirical units are provided in parenthesis for those more familiar with these units. Two parameters are used, each with two directions recorded, for a total of four values to compare. Refer to Figure 5.

Seismograph Trigger Values

Peak Ground Acceleration (PGA) – Data Channels 1 and 3

PGA (cm/sec^2)	Trigger Source	Action	Possible Initial Posting [1]
Less than 90 cm/sec^2 (0.09g)		None required	Green
Greater than 90 cm/sec^2 (0.09g)	PGA from Nisqually EQ – no structural damage observed	Check roof displacement triggers. If not exceeded, no further action required.	Green/Yellow
Greater than 150 cm/sec^2 (0.15g)	0.15g PGA is trigger value in FEMA 352	Complete preliminary evaluation	Yellow

Peak Roof Displacement – Data Processed from Channels 7 and 9

Peak Roof Displacement	Trigger Source	Action	Possible Initial Posting [1]
Less than 13 cm		None required	Green
Greater than 13 cm	Drift at which 5th floor exceeds FEMA 351 limits for Immediate Occupancy	Preliminary evaluation of 5th floor framing at a minimum	Green/Yellow
Greater than 15.5 cm	Maximum drift during Nisqually EQ	Complete preliminary evaluation	Yellow
Greater than 20 cm	Drift at which global building drift exceeds FEMA 351 limits for Immediate Occupancy.	Complete preliminary evaluation	Yellow/Red
Greater than 31.5 cm	Drift at which local inter-story drifts exceed FEMA 351 limits for Collapse Prevention	Complete preliminary evaluation and detailed inspection	Red

Note:
[1] Use of judgment is essential in post-earthquake building safety evaluations. The guidelines listed above do not replace the need for qualified personnel to evaluate the building and post it appropriately. The possible initial posting colors are intended to provide guidance with regard to continued use of the

Figure 5 – Seismograph Trigger Values at Naval Hospital Bremerton

MOMENT FRAME CONNECTION INSPECTIONS

Unlike recent construction practice where only a few bays of a building are used to resist all of the earthquake forces, when the Naval Hospital was designed and built, it was common to make all beam-to-column connections moment connections. This redundant system reduces the demand on any one-moment connection to a lower level. In the case of the Hospital, there are approximately 1,550 steel moment frame connections in the building. It is impractical to inspect every one of these connections.

Inspection of a representative fraction of the welded joints would be warranted after another event where damage is suspected. However, because of the time involved in removing fireproofing and finishing materials, this would not likely be performed immediately following an event. Instead, the inspection team may choose to analyze the ground and building acceleration readings to determine if detailed inspection is required. Because the building's lateral system is highly redundant, there are no telltale areas on which to concentrate inspection efforts. The results of inspections performed after the Nisqually earthquake have been documented, and re-inspection of those same locations would provide an indication of damage attributed to the new event. The same inspection procedures, or those representing current standard of care at the time of inspection, should be used.

EVALUATION CHECKLIST

The REACH program also included the development of a "Post-earthquake Safety Assessment Form". This form is based on the ATC-20 Rapid and Detailed Evaluation Safety Assessment Forms, but was modified to apply specifically to Naval Hospital Bremerton. The checklist provides a building specific form to assist the staff evaluating the building look at specific features of the building that are critical for the facility. It will be used to assist in the determination of the appropriate building posting following an event that has exceeded the seismograph triggers or when observed damage warrants.

THE DISASTER RESPONSE PLAN

In a future seismic event, the ability to refer to the pre-engineered content of the REACH will allow the hospital engineering staff to make much more accurate and timely recommendations to the hospital Commanding Officer regarding the safety and operability of the hospital. This will greatly improve the hospital's ability to maintain continuity of medical services – critical in time of natural disaster. The recent upgrade of the seismograph will provide the additional ability of real-time understanding of the lateral forces on the structure and their relationship to predetermined "trigger values", making this rapid feedback even more accurate.

The REACH will also help bridge the knowledge gap encountered if facility engineering staff members are not fully knowledgeable of the hospital structural system, or if an earthquake occurs on a weekend or backshift when full manning is not present. Finally, the REACH will provide a significant head start for performance of in depth post-earthquake structural analysis and inspection.

The REACH and associated structural drawings have been duplicated and are stored in the facility engineering spaces, as well as the facility disaster response site. The hospital facility engineering, safety, and maintenance staff has been trained regarding the content and use of the REACH, and future training of the fire department is planned.

CONCLUSION

The Rapid Evaluation and Assessment Checklist (REACH) program provides a package of building specific information, checklists, and criteria for the rapid evaluation of operationally critical facilities. It provides a means to make much more accurate and timely recommendations regarding the safety and operability of the facility following an earthquake or other disaster. This will greatly improve the ability of the facility management staff to maintain continuity of essential services – critical in time of natural disaster.

REFERENCES

1. Field Manual: Post-earthquake Safety Evaluation of Buildings, Applied Technology Council, ATC-20, 1989.

2. Recommended Post-earthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings, Federal Emergency Management Agency, FEMA-352, June 2000.