OPEN SYSTEMS & SERVICES
KINEMETRICS

222 Vista Ave.
Pasadena, CA 91107
+1(626)795-2220
www.kmioss.com
oss@kmi.com

PROJECT BRIEF

OASIS BUILDINGS

ONLINE ALERTING OF STRUCTURAL INTEGRITY AND SAFETY

PROJECT OBJECTIVE

OASIS systems provide information towards enabling rapid post-event assessment of critical and essential structures that cannot easily evacuate or sustain expensive downtime waiting for a qualified safety inspection following a significant earthquake.

PROJECT ACHIEVMENTS

Beginning in 2006, six critical or essential buildings along the United States West Coast were equipped with permanent seismic monitoring systems as part of an enhanced post-earthquake assessment and inspection service offered from leading engineering consulting companies.

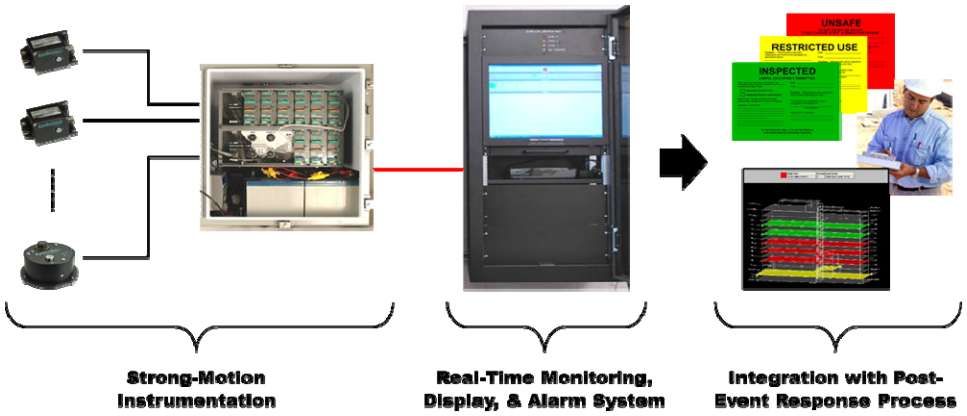
OASIS BUILDINGS

Overview

Occupants in essential facilities such as hospitals, emergency operations centers, strategic military installations, critical financial institutions, and nuclear power plants, cannot easily evacuate immediately after an earthquake and wait for a detailed safety assessment to reoccupy the facility and resume operations. Hospitals and medical facilities, in particular, have a profound need to maintain building operational status and function in the aftermath of strong earthquakes to allow continued care for current patients and also to receive new patients injured by the disaster. A proactive solution to performing rapid, detailed, and accurate post-disaster safety evaluations of these facilities is needed.

Post-earthquake safety standards and response programs not only benefit building owners and municipality officials, they help to create new and proactive solutions for performing rapid and accurate post-disaster safety evaluations.

San Francisco, for example, and several other forward-thinking jurisdictions established Building Occupancy Resumption Programs (BORP) that permit the building's "engineer-on-call" to be pre-deputized to perform ATC-20, Post-earthquake Building Safety Evaluation Procedures; Red/Yellow/Green building tagging in lieu of official inspectors.



OASIS system overview illustrating strong-motion instrumentation (sensors and data loggers), real-time user interface and alarm system, and information integration into

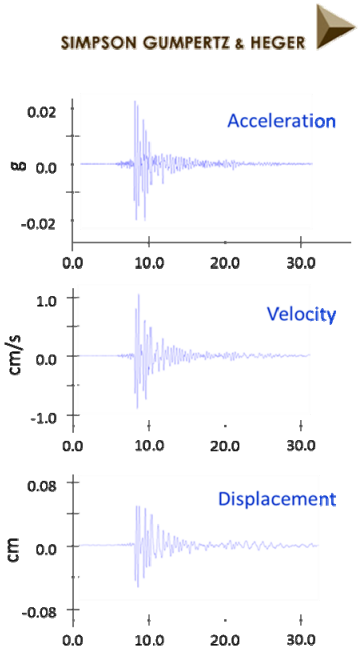
Traditional visual-based post-earthquake inspections can impose high costs and inconvenience on building owners and occupants alike. For example, physical access to structural members usually requires the removal of non-structural components such as interior partitions and fire proofing. The post-earthquake detailed inspection requirements of welded steel moment frame buildings with pre-Northridge Earthquake style connections can be especially time consuming and costly to implement. Prolonging expensive downtime, limited resources such as qualified inspectors may not be immediately available after a damaging event, especially for dense urban areas.

Beginning in 2006, several buildings along the United States West Coast were equipped with permanent seismic monitoring systems as part of an enhanced post-earthquake assessment and inspection service offered to building owners from leading engineering consulting companies. The primary goal of these systems is to provide useful information to the post-earthquake inspection and recovery process by enhancing the traditional visual-based inspection process in terms of both speed and quality.

Critical Financial Institution

Downtime of critical financial institutions can be extremely costly to the tenant institution and its customers. One company with its headquarters in Downtown San Francisco has opted to minimize its potential downtime by implementing an enhanced BORP compliant program with seismic monitoring system.

As part of this project, two separate buildings were instrumented; one consisting of a 31 channel system, the other with a 42 channel system. The larger system is installed in a building with two structures seismically isolated by an expansion joint. Although separate data acquisition systems are used for each structure, all data and results are available and displayed in a single OASIS PC.



On October 20, 2011, this particular system captured responses to two small earthquakes of M4.0 and M3.8 with epicenters near Berkeley approximately 10 miles away. The figure on the right displays an example of data from the event files provided immediately by the OASIS system.

Caltrans District 4 Headquarters

Degenkolb Engineers designed a seismic retrofit scheme for this 15 story steel moment-resisting frame constructed in 1991 and located in Oakland, California. The building is the headquarters for Caltrans District 4 and houses the Transportation Management Center for the San Francisco Bay Area. Previous testing indicated that the welded connections were vulnerable to fracture, and consequently the building presented a risk to life safety in the event of a major earthquake.

After considering several retrofitting schemes, one that included strengthening some existing connections and adding viscous dampers was selected. To meet the seismic performance requirements of the State of California, Department of General Services this scheme reduced interstory drifts to 1.8% in a 475-year return period event.

Non-linear time history analyses were performed to verify the performance of the retrofitted structure. Full scale connection testing and detailed finite element analyses were also performed to verify the deformation capacity of the proposed retrofit details. The extra steps taken beyond typical engineering practices were intended to provide better assurance that the project's performance goals would be met during the design basis seismic event.

As part of the project, Caltrans elected to install a 36 channel seismic monitoring system to provide improved post-earthquake inspection and recovery process. The system includes an onsite OASIS monitoring system that is remotely monitored in real-time by Degenkolb Engineers from both the nearby Oakland office and the Portland, Oregon office. This increases the likelihood that event data from the building can be evaluated shortly after an event while inspecting engineers are in transit to the building.

The monitoring system is an integral part of the post-earthquake response process that includes provision for the three phases of response described in Enhanced Rapid Post-Event Assessment Service document on http://www.kmioss.com. As part of this process Degenkolb Engineers is contracted to monitor the system, and to perform post-earthquake building inspections. A comprehensive post-earthquake inspection manual was developed which integrates the monitoring system into the overall response process.

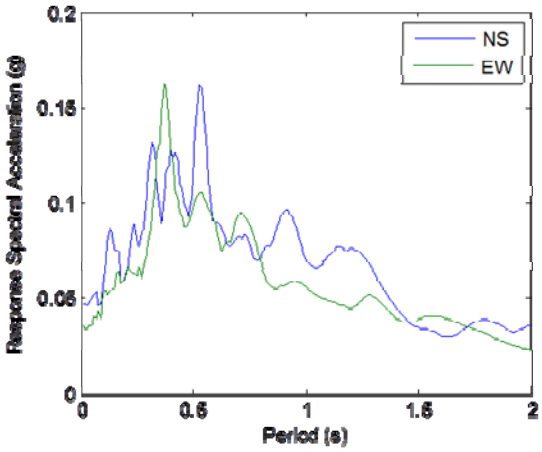
Results from the analysis performed as part of the retrofit project were used to set the drift performance limits. The alarms are intended to provide direction on what floors have experienced the highest levels of demand. The overall alarm level for the building will be triggered if three or more drift measurements are above the alarm thresholds described in the Table below.

N/A	Not Triggered	No Action
0.1%	Noticeable building movement	Perform remote evaluation
0.5%	Expected threshold for fracture of some unretrofitted pre-Northridge connections	In conjunction with other triggers activate the engineering inspection of the building
2.0%	Expected threshold for damage to the primary lateral system	Evacuation not triggered automatically but may occur after remote review of data

US NAVY Hospitals

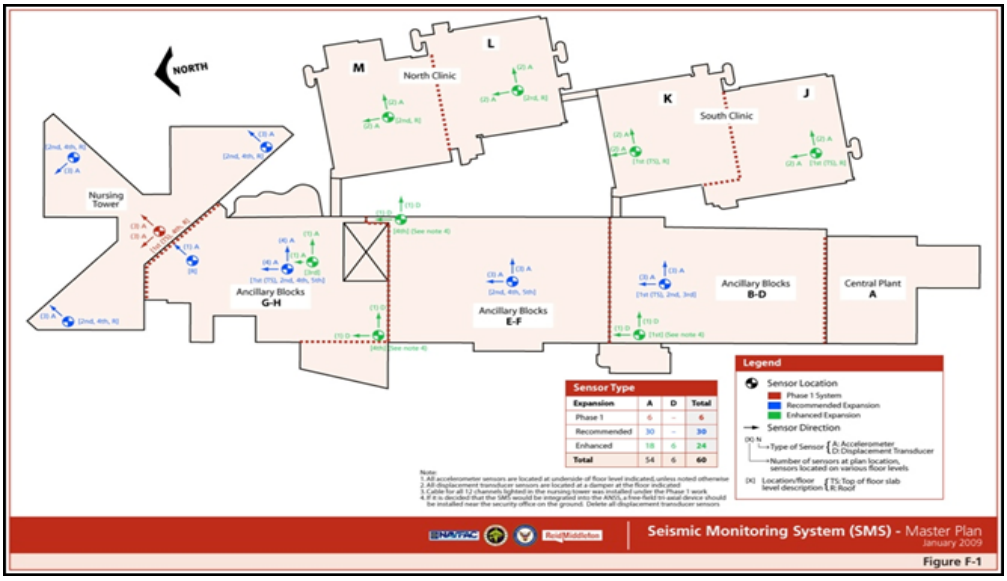
As early as 2002, the US Navy developed and deployed building-specific post-earthquake evaluation plans utilizing seismic instrumentation to facilitate rapid and accurate post-earthquake evaluations of several of their essential medical facilities.

Since then this program has evolved in to the Rapid Evaluation and Assessment Program (REAP). This program utilizes facility-specific inspection criteria and seismic monitoring systems to provide occupants of these essential facilities post-disaster inspection tools that can be used to perform fast, accurate and detailed building safety evaluations. Combining the principals of Performance Based Earthquake Engineering (PBEE), known drift limit states of various building materials and structural systems,



and the Post-Earthquake Safety Evaluations of Buildings (ATC-20) standard of care, the REAP utilizes a Seismic Monitoring System (SMS) to help facility managers quickly and accurately evaluate the post-disaster safety of these important facilities. This innovative post-disaster safety assessment program has been deployed at the three of the US Navy's West Coast based healthcare facilities: Naval Hospital Bremerton (NHB), Naval Medical Center San Diego (NMCSD), and Naval Hospital Twentynine Palms (NHTP). NMCSD is the world's largest military medical facility.

As part of their design of seismic upgrades to the 6-story, 1.2 million square-foot NMCSD facility, Reid Middleton developed and deployed the REAP and SMS for this essential facility. The SMS consists of an initial phase of 36 channels of real-time seismic monitoring with a full build out of 60 channels when the program is fully deployed. The Kinemetrics OASIS system was utilized in this project. The REAP makes use of the SMS to measure earthquake performance of the facility and provide real-time feedback to the post-disaster inspection team.



The map details sensor locations, types and number of sensors placed in a particular section of the structure.

OASIS System Experience

The following is a selection of important projects carried out over the last two decades using the OASIS Concept Solution for structural monitoring, in general, as well as dynamic structural monitoring, structural health monitoring, seismic monitoring or post earthquake assessment applications in particular.

2011 Critical Financial Institution
Post Earthquake Occupancy Resumption Assessment & Monitoring System
Freemont, California, USA

2010 ArcelorMittal - Lazaro Cardenas, Michoacan
Metallurgy Plant
Post Earthquake Assessment & Seismic Monitoring System
Mexico

2009 United States Geological Survey – Menlo Park
Multiple VA Hospital Buildings
Post Earthquake Occupancy Resumption Assessment & Monitoring System
USA

2009 Catholic Healthcare West
Marian Medical Center, Santa Maria
Post Earthquake Occupancy Resumption Assessment & Monitoring System
California, USA

2009 Naval Facilities Engineering Command Northwest (NAVFAC NW)
Naval Hospital Bremerton, Washington
Post Earthquake Occupancy Resumption Assessment & Monitoring System
Washington, USA

2008 Naval Facilities Engineering Command Northwest (NAVFAC NW)
Naval Medical Center San Diego
Post Earthquake Occupancy Resumption Assessment & Monitoring System
California, USA

2008 California Department of Transportation - CALTRANS
District 4 Headquarters Building
Post Earthquake Occupancy Resumption Assessment & Monitoring System
California, USA

2007 Universidad Autónoma de México - UNAM
Institute of Engineering
Portable Structural Monitoring System
Mexico

2007 University of Porto
Bridge INFANTE D HENRIQUE
Structural Health Monitoring System
Portugal

2007 United States Geological Survey – Menlo Park US
Federal Building San Francisco
High-Resolution, Real-Time, Seismic Monitoring
California, USA

2006 Critical Financial Institution
Post Earthquake Occupancy Resumption Assessment & Monitoring System
San Francisco, California, USA

2004 US Federal Highway Administration
Cape Girardeau Bridge
High-Resolution, Real-Time, Seismic Monitoring
Missouri, USA

1999 Suez Canal
Seismic Monitoring System
Egypt

1999 Bangkok Peninsula Hotel
Displacement Monitoring System
Thailand

1996 The Ministry of Construction and Transportation (MOCT)
NAMHAE Great Bridge
Dynamic Monitoring System
Republic of Korea

1994 The Expressway and Rapid Tran sit Authority of Thailand (ETA)
Bangkok RAMA IX Bridge
OASIS Real-Time Monitoring System
Thailand

Kinemetrics Inc.
Open Systems & Services
222 Vista Avenue
Pasadena, CA 91107
PH: 626.795.2220
www.kmioss.com
oss@kmi.com