Smart Dubai Municipality Seismic Systems

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Introduction

United Arab Emirate is situated close to two main seismic zones: the Zagros fold and thrust belt and the Makran subduction zone, which are capable of generating medium to very large earthquakes. These earthquakes, despite occurring hundreds of kilometers away, will generate long-period (slow rolling) long-duration surface waves that impact tall and ultra-tall buildings in Dubai Emirate causing them to balance and sway while underground structure experience slight deformation. Even after these waves pass the tall buildings will continue to shake beyond the human level of discomfort for a long period of time.

The November 27, 2005 strong Qeshm Island earthquake, was felt in Dubai high-rise buildings, and sparked panic in schools and businesses. A seismic monitoring system became a necessity and priority then. Dubai Municipality (DM) responded quickly and installed the first earthquake monitoring system in UAE in April 2006 (Fig. 1).The system monitor the local and regional earthquakes, which may have an effect on UAE and especially on Dubai Emirate.

The earthquake information system provides strong support to the governmental organizations, Police and Civil defense in case of any felt earthquake in the region. Ongoing public awareness program for earthquakes and safety instructions is one of the Municipality contributions to the community services to reduce the earthquake hazard. The network is running properly, online data exchange between National Center of Metrology of UAE, neighboring countries (Oman, Saudi Arabia and and Kuwait) and few stations from Global Digital Seismic Network is established which increases the delectability and aperture of the network.

On April 2012, DM extended the monitoring capabilities and installed five strong motion stations within Dubai urban areas. These new stations supports the automatic generation of real time ShakeMaps that describe the extent of potentially damaging shaking following any felt or effective earthquake. This project is a part from DM promotion to the disaster countermeasure of Dubai City for emergency response, loss estimation, and for public information through the media.

Investments in towers construction represent a large part of its economy.Recently Dubai is called the city of towers since it owned around 20 percent of the highest 100 skyscrapers that make DM to pay a lot of attention for the safety of these towers residence during any felt earthquakes. It is true that a damaging earthquake in Dubai is very unlikely given the expected level of shaking and Dubai's high standard of building design. However, there is a very real safety hazard stemming from mass evacuations with potentially panicked crowds and unprepared managers. Even worse if the earthquake occurs during hot summer months. In fact, Dubai has

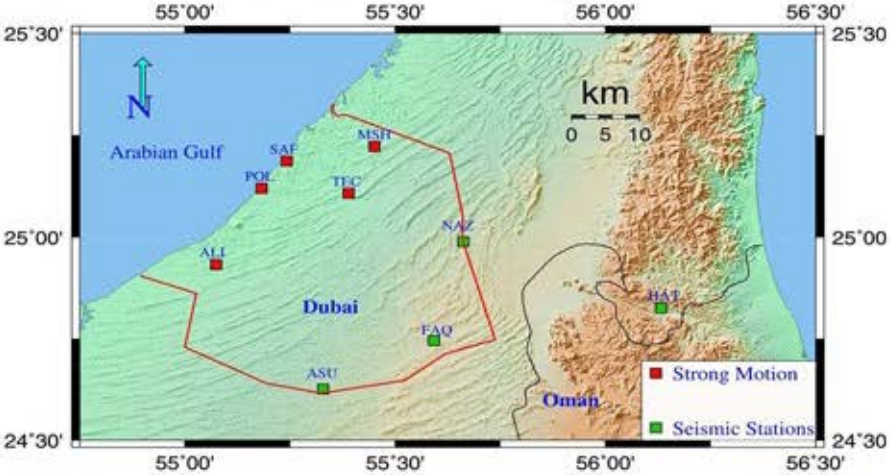

Fig. (1): Locations of DM seismic stations.Dubai Emirate

witnessed such evacuations during recent south Iranian (2013, 2014) events that caused general panic and many building evacuations (Fig. 2). In addition to safety concerns, there is also a high risk for widespread economic loss due to business interruption and reputation damages from unnecessary downtime and lack of preparation. Neither Tall building tenants, managers and owners, neither municipality nor civil defense have adequate tools to deal with situations before, during and after a felt earthquake.

inside these buildings that will experience earthquake situations in the future. A smart application called DB-safe (Oasisplus for Dubai) became available ob mobile phones for the equipped strategic buildings residents and the public. These system can support them with information about what to do before, during and after the earthquake and can instruct them on how business continuity can be maintained, to be advised how safety can be best applied. Dubai Municipality performed these strategic projects to take all necessary measures for

Fig. (2): Photos of UAE Evacuations from 16-04-2013 Earthquake near Iran-Pakistan Border

Dubai Smart SHM Systems

By 2015-2016DM Survey Department startedthe installation of Smart structural health monitoring systems (SHM) on the strategic and high rise buildings; BurjKhlaifa(Highest Skyscrapers in the world) and Burj Rashid Tower (DWTC, Dubai Financial Market). These SHM systems at both buildings are monitoring continuously the dynamic behavior of the structures and in case of an earthquake or strong wind storm will provide the managers automatically with a SAFE report with Green, Yellow, Red structure status light. These alerting colors are determined based on a detailed performance study of the building under different shaking levels. This report will be used by onsite managers to take immediate decision on evacuation and/or safe re-entry.

By 2017-2018 DM installed another two smart SHM on Dubai Police Forensic Science and Criminology Building and Dubai Municipality main building. All of these smart SHM systems are supported by a robust two-way communication between the building mangers and the people who reside, work, and live ensuring the safety of Dubai residents and minimize the negative impacts, fear and stopping of the work in case of any felt earthquakes.

The Smart SHM systems composed mainly of three elements;

- A monitoring system: It is a permanent real-time structural monitoring and alarm systems to acquire, process and deliver the required data and information during seismic and strong wind induced shaking.
- Building Evaluation: It allows understanding of the current engineering capacity of selected building structural and non-structural systems to withstand seismic and strong wind induced shaking
- Communication Platform: it enables 2-way communication with occupants, facilitating situational awareness and information dissemination through a smart application (DB-safe/ Oasisplus for Dubai) and a web site operated by the facility management.

The strategic building safety levelsare determined from the building evaluation study and adjusted to the monitoring system to provide three colored alarms in the board of the security team. Also, an instantaneous email and SMS with the building response status can be sent to the officials to the support their decision.Besides, the systems support occupants with valuable data that showed any significant shaking above levels of human discomfort, how the building is influenced, how they can respond and the emergency plan with clear evacuation routes in a smart way within very limited time on their smart phones.

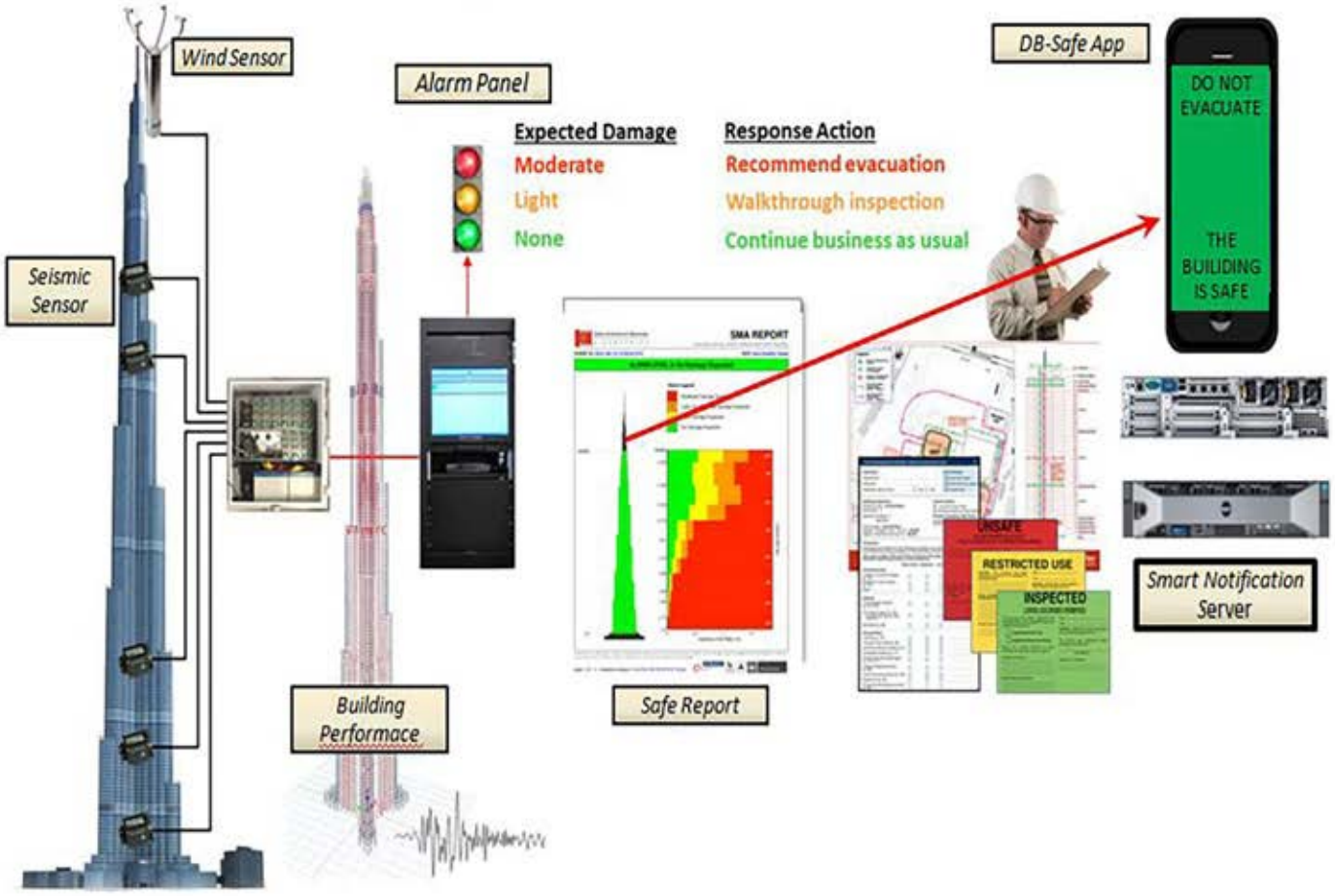

Fig. (3): Smart Seismic SHM system at BK.

DB-safe/ Oasisplus for Dubai application:

DB-SAFE (Dubai Building Safety After an Earthquake) is an application that uses the output from seismic devices as well as seismic-oriented websites, on-line reporting, and external data sources to effectively modify the behavior of building occupants before, during, and after seismic events. The solution will leverage modern, advanced mobile technologies. This application provides real time information to public (Fig. 4) and building occupants on what to do before, during and after the earthquake. Also, provides building's occupant with personalized emergency exit in case of evacuation (Fig. 5). In tall and ultra-tall buildings, the App can help to protect access to critical services. The App can help for doing scenario drill and enhancing the emergency response documentation and training protocol for existing and future buildings. Finally, The App can be used as a tool for tenants to call for help or report hazards, essentially crowd-sourcing onsite safety inspection.

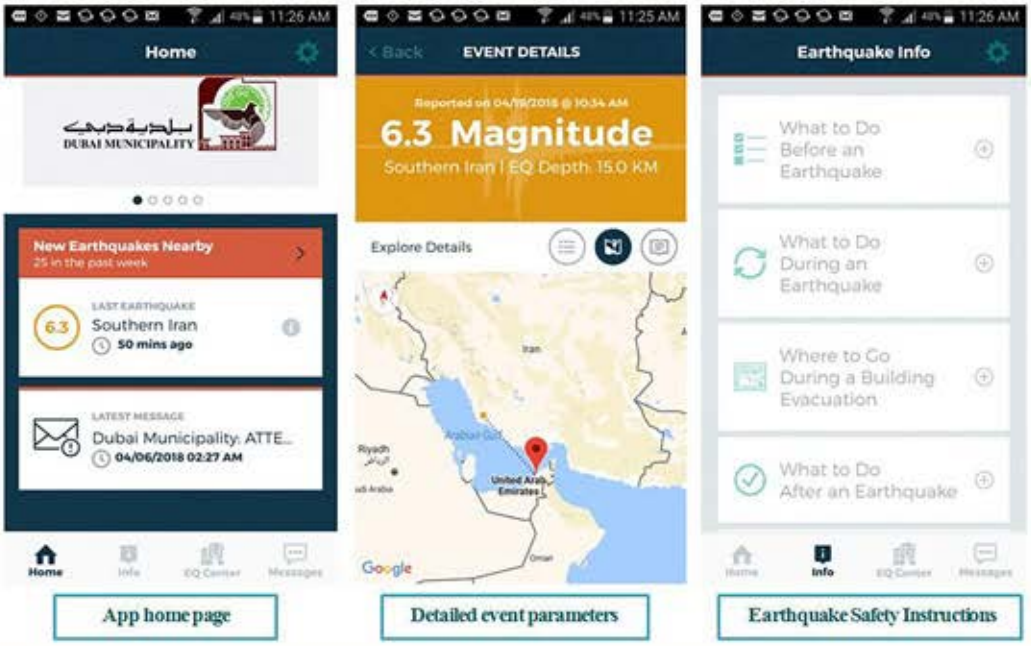

Fig. (4): App features for Dubai and Gulf countries public residence.

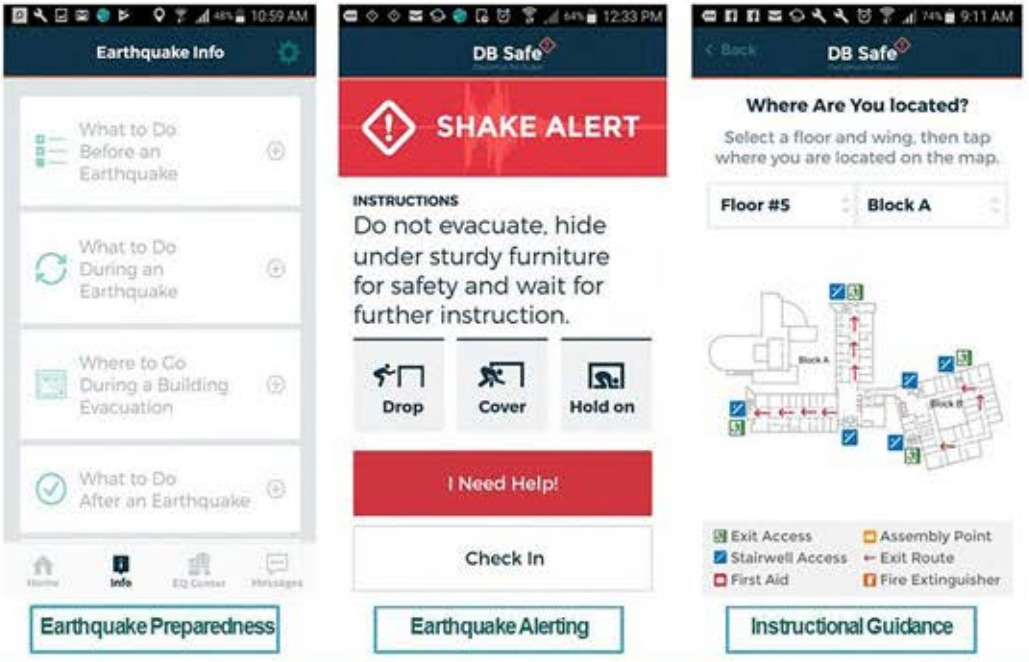

Fig. (5): App features for the equipped strategic buildings

A summarized of the general benefits of smart SHM systems:

1. Facility managers: Enhanced ability to carry out response actions appropriate to automatically generated and straightforward event information.
2. Building occupants: Improved confidence in facility management's ability to handle emergencies due to extreme events.
3. BuildingOwners:Savemoneybyavoiding business interruption from unnecessary evacuations and/or extended periods of downtimes (i.e. faster re-entry).
4. DM/Policy Makers: Improve safety mandates for the public and showcases city's progress towards resilience and growth.