The Abu Dhabi Strong Motion Network, UAE

M. Ciudad-Real, D. A. Skolnik, M. Franke, M. Gardine, M. El-Idrissi
Kinematics, Inc., Open Systems & Services Department, Pasadena - California, USA

Z. Milutinovic
GECO & University "Ss. Cyril and Methodius", Institute of Earthquake Engineering and Engineering Seismology, Skopje, Republic of Macedonia

H. Almulla, A. Almarri, A. Megahed
Abu Dhabi Municipality, Spatial Data Division - Town Planning Sector, Abu Dhabi, UAE
1. Introduction
2. Equipment
3. Network Disposition
4. Station Design & Installation
5. Ground Motion Estimation
INTRODUCTION

“To assure sustainable development of the Emirate of Abu Dhabi, and cultivate a disaster-free living environment for its citizens, the Abu Dhabi Municipality initiated the Project”:

ASSESSMENT OF SEISMIC HAZARD AND RISK IN EMIRATE OF ABU DHABI

PROJECT OBJECTIVE: To quantify and assess the seismic hazard and risk that exists for the Emirate of Abu Dhabi.
### PROJECT OUTCOMES

- Enhanced planning and policy tools for rapid response during seismic induced state of emergencies
- Engineering data and information for enhanced design and protection of an evolving infrastructure
- A scientific understanding into the dynamic structure underneath the Emirate

<table>
<thead>
<tr>
<th>TK</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Seismic Zoning</td>
</tr>
<tr>
<td>02</td>
<td>Site Amplification &amp; Microzonation</td>
</tr>
<tr>
<td>03</td>
<td>Liquefaction Susceptibility Study</td>
</tr>
<tr>
<td>04</td>
<td>Seismic Design Parameters</td>
</tr>
<tr>
<td>05</td>
<td>Risk Analysis of Lifelines</td>
</tr>
<tr>
<td>06</td>
<td>Risk Analysis of Critical Structures</td>
</tr>
<tr>
<td>07</td>
<td>Permanent Accelerograph Network</td>
</tr>
<tr>
<td>08</td>
<td>Seismic Monitoring Network</td>
</tr>
<tr>
<td>09</td>
<td>Ground Shaking Map</td>
</tr>
<tr>
<td>10</td>
<td>Structural Health Monitoring</td>
</tr>
<tr>
<td>11</td>
<td>3D Seismic Simulation Model</td>
</tr>
<tr>
<td>12</td>
<td>Risk Analysis of Tall Buildings</td>
</tr>
<tr>
<td>13</td>
<td>Loss Estimation</td>
</tr>
<tr>
<td>14</td>
<td>Data Management Centers</td>
</tr>
<tr>
<td>15</td>
<td>GIS Seismic Database</td>
</tr>
<tr>
<td>16</td>
<td>Coordinated Activities</td>
</tr>
<tr>
<td>17</td>
<td>Promotion &amp; Public Awareness</td>
</tr>
<tr>
<td>18</td>
<td>Training</td>
</tr>
<tr>
<td>19</td>
<td>Build, Operate, and Transfer (BOT)</td>
</tr>
<tr>
<td>20</td>
<td>Maintenance</td>
</tr>
</tbody>
</table>
Objectives

– Furnishing and Installing a 50-Station Strong Motion Network
– Ground Strong Motion Maps “shakemaps”
– Areas in the Abu Dhabi Emirate:
  - Abu Dhabi Municipality (ADM), Al Ain Municipality (AAM) and Western Region Municipality (WRM)
  - ADM - Plan Abu Dhabi 2030: Urban Structure Framework Plan
  - AAM - Al Ain Urban and Regional Structure Plan 2015
  - WRM - Designated Urban Areas in Western Region Municipality
Description

– 50 Free-Field Strong Motion Stations

– Selection Based on:
  ▪ Seismic Hazard Zoning
  ▪ Microzoning Distribution Patterns
  ▪ Site Geotechnical Characteristics
  ▪ Distribution of Built Environment
  ▪ Reclaimed Areas under Development

– Compliance with Consortium of Organizations for Strong Motion Observation Systems - COSMOS Guidelines
INTRODUCTION

Task Deliverables

– Provision of Equipment
– Disposition of Strong Motion Network
– Installation of Strong Motion Network
– Site Characterization and Site Response Analysis of Accelerograph Sites (Lab work & Studies)
• Digitizer/Recorder: Basalt 4X
• Sensor: SB EpiSensor Accelerometer
  ES-T EpiSensor Accelerometer
• Enclosure Design
• Power System
  – Solar Panel (80W)
  – Intelligent Solar Battery Charger
  – 42Ah Battery
• Communication Layout
  – Wireless 3G Network (Raven XE)
  – Redundant Links to 2 Data Centers
• Site Selection of about 20-25 sites per Municipality
• Final Selection of 50 sites in compliance with the COSMOS guidelines
• Final Network Disposition
## General Distribution

<table>
<thead>
<tr>
<th>Municipality Network</th>
<th>SMRF OG</th>
<th>SMRF SB</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abu Dhabi</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Al Ain</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Western Region</td>
<td>7</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Lifelines (Distributed among all three Municipalities)</td>
<td>10</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>

SMRF - Strong Motion Reference  
OG - Open Ground  
SB - Small Building
Site Selection Highlights

- Pre-selection of sites to be surveyed
- Survey Form - COSMOS Guidelines for Installation of Advanced National Seismic System Strong-Motion Reference Stations
- More than 100 sites visited and surveyed
- 73 Proposed Sites
- 50 Preferred Sites
- 23 Alternative Sites
<table>
<thead>
<tr>
<th>Site ID</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Location or Name</td>
<td>Capital Garden</td>
</tr>
<tr>
<td>Region / Sub-Region</td>
<td>Abu Dhabi / Abu Dhabi Island</td>
</tr>
<tr>
<td>Distribution Code</td>
<td>OG</td>
</tr>
<tr>
<td>Station Location</td>
<td>South corner near existing utility cabinet</td>
</tr>
<tr>
<td>GPS Latitude Longitude</td>
<td>N24.49107 E54.36313</td>
</tr>
<tr>
<td>Zone / Sector / Plot</td>
<td>435 / 4274 / 414363</td>
</tr>
<tr>
<td>Date of Inspection</td>
<td>26 Jan 2011 &amp; 19 Feb 2011</td>
</tr>
<tr>
<td>Field Notes</td>
<td>Parking lot available. Fenced garden. Possibility of keeping the station inside the garden and using adjacent parking lot for drilling for site characterization. See additional pictures of the site</td>
</tr>
</tbody>
</table>
WESTERN REGION

• Preferred
• Alternative
Open Ground Station Design
Small Building Station Design

- NEMA Enclosure
- Data Logger
- Surface Sensor
Al Khaznah Municipality, AA
Sultan Bin Zayed 32 & Delma 13, AD
Capital Park
Abu Dhabi
Al Towaya Park
Al Ain
Khalidiya Public Park
Abu Dhabi
Al Zakher Park
Al Ain
Al Basra Park
Al Ain
Heritage Park
Abu Dhabi
Zalamat Park
Abu Dhabi
Falaj Hazaa Park
Al Ain
Ghantout Polo Club
Abu Dhabi
Al Foah Park
Al Ain
Al Mraijeb Park
Al Ain
Al Maquam Park for Women & Children, AA
AD Golf Club, Al Raha Beach, AD
Hamim, WRM
Saadiyat Island
Abu Dhabi
Al Salam Camp
Abu Dhabi
Razeen Police Station
Abu Dhabi
Khalifa Port
Abu Dhabi

No photo allowed
Communication Layout
Software for:

– Automatic processing & graphic rendering of spatial distribution of earthquake induced ground shaking in different formats
– Information dissemination & displayed via Web-pages
– Antelope module provided by Kinemetrics allows for near real-time data acquisition and interface with USGS *ShakeMap* program
Why ShakeMap?

– Location & magnitude alone not adequate to determine possible areas of damage
– ShakeMap incorporates attenuation relations, geologic data, and recorded data
– Provides easy-to-digest visuals showing areas of peak ground motion (PGV, PGA, PSA) for non-seismologists
– The defacto standard
ShakeMap Automation within Antelope

– Antelope real-time system will calculate locations and magnitudes
– Antelope downloads segmented strong-motion data automatically and measures ground-motion metrics for available weak- and strong-motion sites
– Starting the ShakeMap system for a suitable origin
GROUND MOTION ESTIMATION

ShakeMap Results
Thank You!