Development of Seismic Hazard and Microzonification map in Venezuela

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FUNVISIS

Global Earthquake Model (GEM) Workshop to Launch the GEM Regional Programme in the Caribbean. Trinidad & Tobago 2\textsuperscript{nd} to 4\textsuperscript{th} May, 2011
Motivation

High seismic hazard at Caribbean – South America plate boundary zone
Seismicity in Venezuela 2000-2010

Mar Caribe

- magnitud > 5.0
- magnitud (4.0 - 4.9)
- magnitud (3.0 - 3.9)
- magnitud < 3.0
- magnitud 0.0
35 BB Seismic Stations equipped with Guralp sensor and digitizer (CMG-40T)

2 VBB Seismic Stations within the CTBTO umbrella, they are **AS117** (IRIS station with Streickessen sensor) and **AS118** (35 m Borehole station with GURALP sensor).

National network operated by FUNVISIS (governmental agency)
- Vault with reinforced concrete
- Concrete basement 1 mt deep to enhance optimum coupling sensor-ground.

- Broad-band sensor Guralp CMG-40T
- Three (3) components.
- 24 bits digitizer.
- Flat velocity response in the range (0.03 – 50.) Hz.
Some stations…

TEREPAIMA, EDO. LARA

JACURA, EDO. FALCÓN

BIRONGO, EDO. MIRANDA

LOS MONJES

GUANOCO, EDO. SUCRE
SATELITE DATAFLOW

Seismic station

Seismic station

Seismic station

Seismic station

VENESAT-1

FUNVISIS

NAQSSERVER DATABASE

3 Channel BroadBand
100 sps
24bit

Ku Band
10 Segment available for this network (5 in use)

1 main server & 2 backup server
40 short period seismic stations grouped en 5 local networks. Stations are equipped with the CMG-40T1.

Networks operated by local universities in cooperation with FUNVISIS: 1) Universidad de Los Andes (ULA), 2) Universidad de Oriente (UDO)

Networks operated by FUNVISIS in cooperation with local universities: 3) LUZ, 4) UCLA, 5) U-Carabobo

Local networks related to hydroelectric dams: 6) DESURCA, 7) EDELCA
Strong motion network
Typical strong motion station

140 Accelemetric Stations with Etna from Kinemetrics
The Seismological Service has an analyst in the Data Center at FUNVISIS 24 hours a day, everyday.

A weekly seismologist is on call, and a SMS message generated by the automatic location given by EARTHWORM reaches its cell-phone.

A report is posted on the WEB site and distributed to officials.

FUNVISIS President responsible for handling the media
Concerns and goals for the future

2011 - Upgrade the national seismological network:
back-up system with a second new receiver antenna for the whole network
15 new sites for the BB network
replacement of existing 5 BB sensors with new sensors
15 portable seismic stations
80 new accelerographic stations
10 GPS stations.

Joint regional seismological studies on the Caribbean plate integrating data and research efforts

Projects:
MAPS (Rice University, FUNVISIS, INGEOMINAS and VANDALS (FUNVISIS, UCV, ULA)

Training of seismologists: Geophysics at UCV and USB, Physics at ULA, UDO, UCV; no specific graduate study program
Seismological research: temporary networks

MAPS (Rice University, FUNVISIS, INGEOMINAS)

BOLIVAR (2003 – 2005) network in eastern Venezuela

MAPS (2010-2012) - proposal
Merida Andes Preija Santa Marta Seismological Network

MAPS (2010-2012)
75 BB stations covering Caribbean – South America plate interaction
Seismological research: geophysical studies

VANDALS (FUNVISIS, UCV, ULA)


Active seismic studies crossing Merida Andes

Gravity and magnetics, flexural modeling

Permanent deformations (paleoseismology, fission track, cinematics, etc.)

Petrology
Priorities for regional collaboration

Data exchange via Earthworm; experience in station evaluation and standardization of observatory practice is highly appreciated

Joint regional seismological studies on the Caribbean plate integrating data and research efforts, for example:
Common tomografic model for the Caribbean
Modeling of tsunami potential

Joint development of seismic hazard models (seismicity, active faults, seismogenic models) (GEM)

Revision of seismological catalogue

Standardization of building codes / incorporation of local studies (Seismic microzoning), closer interaction with structural engineers

New concepts and research regarding strong motion network (building instrumentation, experimental transfer functions, etc.)

Mitigation of seismic risk through educational efforts (public in general, schools) and retrofitting of existing buildings
- Caracas: zone of high seismic hazard (0.3 PGA at rock surface)
- Design spectra vary only due to soil classification for the upper 50 m
- No consideration of basin effects determined after the 1967 earthquake
3.5 Million inhabitants mainly distributed in high rise buildings in the valley, and informal buildings on deeply weathered steep slope areas

Strong increase in population, high demand of housing area
Use of Seismic Microzoning Information

New constructions
- Complement to the building code
  - Elaboration of Municipality Ordenances
    - Revision of building code
      - Input to urban planning

Existing building stock
- Risk studies
  - Reinforcement of structures
    - Public buildings
    - Private buildings
  - Emergency response

Municipalities
- Planned developments
- "Informal" city
- Insurance
- Slope stability

Vulnerability studies
Parametric evaluation of response spectra for groups of profiles using SHAKE
4 classes of sedimentary depth
3 classes of soil quality (Vs30)

Classification of geotechnical profile based on seismic information (variation for Vs30 and sedimentary depth)

Calibration of response spectra with geotechnical data from 4 deep drillholes

Smoothing of response spectra in order to define adjusted basic building code spectra
Local seismic hazard, 10% probability of exceedence in 50 years
= Return period (T) of 475 years

Macrozones: seismic hazard at bedrock, 0.21g, 0.24 g, 0.27 g and 0.3 g; Avila fault zone

Microzones limited by sediment thickness, Vs30, geomorphic units and damage distribution
Incorporation of 3D basin effects, adjusted basic spectra

SUELOS DUROS / DENSOS: $V_{S,30} > 325$ (m/s); $A_0 = 0.27$ g

Adjusted basic building code spectra for groups of profiles, stiff soils and for rock, without 3D basin effects (left), and with 3D basin effects (right); spectra for stiff soils from the seismic building code (dashed line) for reference.
Landslide hazard, triggered by earthquakes

High hazard areas:
1) Avila mountains in the north (National park area) and Guaire river canyon in the SE
2) Informal housing areas in the west and the east
3) Housing developments south of the valley
4) Future extension zones to the south
### Parametric study of building behaviour

**Exceedence probability of severe damage for a seismic scenario with “A0 ~ 0.28 g”**

**Reinforcement priorities:**

- **Buildings constructed previous to 1967**
- **Medium to high rise buildings located on deep deposits**
- **Importance of structural irregularities**

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*Violeta: elevada; Rojo: grande; Naranja: alarmante; Verde: tolerable; Azul: poco importante.*

Hernández, 2009
Application of the results of the seismic microzoning project

Existing buildings:
Need for study the distribution of buildings regarding to the respective microzones
Definition of priorities for reinforcement studies and political guidelines for their implementation

New buildings:
Application of response spectra for each microzone – incorporate results of seismic microzoning in new version of seismic building code (2009/2010)
Training of engineers; supervision mechanisms; definition of methodological standards for other cities
Risk management / seismic microzoning projects

Integrated risk management / seismic microzoning projects years 2005 - 2020

Projects

Years

- 2005-2011
- 2012-2015
- 2016-2020
Thanks for your attention