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REDUCTION OF EARTHQUAKE LOSSES IN THE EXTENDED MEDITERRANEAN REGION - RELEMR -

Seismicity and Earthquake Engineering in the Extended Mediterranean Region

Workshop Report

Lisbon, Portugal

26 – 29 October 2009

Contact: b.rouhban@unesco.org

Foreword

In many countries of the Mediterranean Basin, disasters caused by natural and environmental hazards continue to exact a heavy toll in terms of the loss of human lives and the destruction of economic and social infrastructure. With population growth in the coastal areas of countries concerned, expanding public and private infrastructure, and continuing trends towards urbanization and industrialization, the risks from great disasters are expected to increase over the coming years and decades.

Among the numerous natural disasters that the countries of the Mediterranean have experienced, earthquakes have historically had great impacts. It is necessary to mobilize scientific knowledge and technological know-how to assess earthquake hazards in the Extended Mediterranean Region (EMR) and to strengthen disaster mitigation measures. To this end, regional collaboration needs to be encouraged. Since 1993, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United States Geological Survey (USGS) have been cooperating with EMR scientific and engineering organizations under the programme: Reduction of Earthquake Losses in the Extended (formerly Eastern) Mediterranean Region (RELEMR). The Programme benefits from the collaboration of the International Seismological Centre (ISC) and other entities. The purpose of the Programme is to provide a platform for examining regional approaches to improve seismic data and earthquake risk mitigation. A number of collaborative activities have taken place under this initiative. These activities have included twenty-nine workshops that have been held since the start of the Programme in 1993. Participants from countries in the region extending from Northern Africa to the Middle East were invited to attend.

A workshop was convened in Lisbon, Portugal, on 26-29 October 2009.The present report provides an overview of the outcome of this workshop. This workshop and its follow-up should be seen in the context of the implementation by the countries concerned of the Hyogo Framework for Action 2005-2015, which was adopted at the World Conference on Disaster Reduction held in Kobe, Japan, in January 2005 and convened within the United Nations International Strategy for Disaster Reduction.

UNESCO thanks the USGS, the Universidade de Lisboa and the Luso-American Foundation for their cooperation in the implementation of the workshop and for the production of this report. The commitment and hospitality of the Universidade de Lisboa and the Luso-American Foundation have made the meeting a successful event. UNESCO wishes to express its gratitude to all those who have contributed to the success of the workshop. UNESCO is especially grateful to Helena Arouca, Livia Moreira and Luis Matias for their careful attention before, throughout, and after the workshop.

January 2010

Badaoui Rouhban
Director
Section for Disaster Reduction
Natural Sciences Sector
UNESCO, Paris

*The content of this report does not necessarily reflect the views of UNESCO.

Seismicity and Earthquake Engineering in the Extended Mediterranean Region

Lisbon, Portugal
26 – 29 October 2009

Executive Summary

In recent years, there were several major, damaging earthquakes in the extended Mediterranean region (EMR). In the interest of reducing earthquake risk in the EMR, UNESCO, the USGS, and the Universidade de Lisboa convened a workshop at the Luso-American Foundation in Lisbon, Portugal, 26 – 29 October 2009, on *Seismicity and Earthquake Engineering in the Extended Mediterranean Region*. Participants from Northern Africa to the far Middle East were invited to attend. Seventy-six (76) participants from the following countries attended the Lisbon-2009 workshop: Algeria, Austria, Cyprus, Egypt, France, the Islamic Republic of Iran, Israel, Italy, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Portugal, Saudi Arabia, Spain, Sudan, Syria, the Palestinian Authority, Tunisia, Turkey, United Kingdom, United States, and Yemen. This report provides an overview of the outcome of this workshop.

The workshop was opened by representatives of the Luso-American Foundation, the Universidade de Lisboa, the National Commission of Portugal for UNESCO, USGS and UNESCO.

Keynote addresses were presented by: Carlos Oliveira: *The new generation of seismic simulators and applications in Portugal,* and M.J. Jimenez and M. Garcia-Fernandez: *Assessing seismic hazard in the Iberian Peninsula: Few issues and some risk.* In addition to the two keynote addresses, forty-seven (47) papers were presented on topics including: Seismicity, earthquake engineering, seismic hazard and risk mitigation including seismic hazard assessment and seismic zonation, the protection of historic buildings, loss-estimation studies, accelerometer networks and strong ground motion, seismo-volcanic investigations of earthquake swarms, earthquake catalogs, the relationship between recorded earthquakes and shear zone mineralization, and strategies for data sharing.

Douglas Bausch, U.S. Federal Emergency Management Agency (FEMA), presented five hours of lectures on the *Technical Methodology and Applications of the HAZUS-MH Earthquake Loss Estimation Model.* The technical methodology for each major component of the HAZUS earthquake model was reviewed, including ground motion, ground deformation, development of the buildings and infrastructure inventory, engineering fragility functions, analysis parameters, economic and social loss approach, as well as results and uncertainties. Instruction on modifying this information with local data, and how engineering parameters can be adjusted to represent the building stock characteristic of the extended Mediterranean region was also provided.

A one-day fieldtrip was held to illustrate Lisbon before and after the 1755 earthquake and the effect the earthquake had on the evolution of urban and building technologies. The changes were clearly in response to the destruction and new architectural, technical, social and economic structures were developed in order to survive future earthquakes.

Introduction

The Mediterranean region, because of its geological structure, seismicity, active tectonics, topography and climate, has been frequently subjected to natural disasters resulting in great losses of life and property. Field studies and investigations of disasters indicate that large portions of the land surface, population, infrastructure, and industry of the region have been subjected to earthquakes in the past or will be subjected to earthquakes in the future.

In the Eastern Mediterranean Region, these earthquakes are associated with the northward movement of the Arabian plate. The 1,000 km long western boundary of the Arabian plate is a complex plate boundary, extending from zones of sea-floor spreading in the Red Sea to zones of plate convergence in Turkey, and lies along the line of the Gulf of Aqaba, the Dead Sea rift, the Bekaa Valley and the Ghab depression. The sense of motion along the Dead Sea transform fault system is left lateral, with the eastern side moving northward relative to the western side. Total displacement is estimated at about 107 km since Oligocene time, with an annual rate of about 0.5 cm. over the last 7 to 10 million years.

On 22 November 1995, an M_w 7.2 earthquake occurred in the central Gulf of Aqaba region causing damage in nearby communities in Jordan, Egypt, Israel, and Saudi Arabia and was felt for more than 700 km. An aftershock sequence lasted for more than one year with numerous shocks exceeding M_s 5.0. The size of the main shock and some of the aftershocks demonstrates the threat that earthquakes pose to the EMR. These events occurred during RELEMR's (Reduction of Earthquake Losses in the Eastern Mediterranean Region) second Joint Seismic Observing Period (JSOP-II) and therefore we had the ability to accurately locate the earthquake sequence by integrating data from all the national networks in the region. This permitted greatly improved accuracy in epicenter and magnitude determinations. In October 1997, a workshop was hosted by the Cyprus Geological Survey Department to locate the main shock and approximately ten aftershocks.

In the western Mediterranean region, which includes portions of Greece, Italy, Portugal, Spain and northern Africa, seismicity is widely distributed and there are many earthquake hazards. Modern interpretations of this seismicity suggest the existence of seven micro-plates, with seismic activity concentrated at the micro-plate boundaries, which coincide with the Alps, Apennines, and Hellenic arc. Among the most notable recent (1996) seismic events was the M 6.8 earthquake in the historic city of Assisi in the Italian Apennines which destroyed numerous cultural artifacts, including important frescoes.

In 2003, the Extended Mediterranean Region (EMR) experienced devastating earthquakes in Boumerdes, Algeria, and Bam, Iran. Both countries experienced extensive economic losses in addition to the loss of lives and injuries.

Since 1993, the USGS and UNESCO have been cooperating with Eastern Mediterranean Region earth science organizations under the RELEMR program. Countries from the Western Mediterranean Region have participated since 1995. The International Seismological Centre (ISC), the European-Mediterranean Seismological Center (EMSC), Lawrence Livermore National Laboratory (LLNL) and Observatories and Research Facilities of European Seismology (ORFEUS) have also cooperated in the program.

The Lisbon – 2009 Workshop

Background

In recent years, there were several major, damaging earthquakes in the extended Mediterranean region (EMR). In the interest of reducing earthquake risk in the EMR, UNESCO, the USGS, and the Universidade de Lisboa convened a workshop at the Luso-American Foundation in Lisbon, Portugal, 26 – 29 October 2009, on *Seismicity and Earthquake Engineering in the Extended Mediterranean Region*. Participants from organizations in countries extending from Morocco in the west to Iran in the east were invited to attend. The list of participants is given in Annex A.

This workshop continued efforts addressed in similar RELEMR workshops in Amman, Jordan, 4-7 May 1998; in Istanbul, Turkey, 14-17 October 1998, 29 May – 2 June 2000 and 25-27 October 2000, Nicosia, Cyprus, 3-7 May 1999and 10-13 September 2003; and in Kumbergaz, Turkey, 29 May – 2 June 2000 and 25-27 October 2000; Santa Susanna, Spain, 20-25 May 2001; Larnaca, Cyprus, 19 – 22 March 2002; Antakya, Turkey, 11 – 14 December 2002; Nicosia, Cyprus, 2003; Aqaba, Jordan, 18 – 28 January 2004; Ankara, Turkey, 26 – 29 January 2005; Valletta, Malta, 24 – 27 April 2006; Barcelona, Spain, 19 – 21 December 2006; Madrid, Spain, 26 – 29 November 2007, and Istanbul, Turkey, 27 – 29 May 2008. The goals of RELEMR workshops are to foster data exchange among countries in the region, to conduct joint activities and experiments that would improve the quality of seismic data, to improve hazard assessments in the Mediterranean region, to improve the dissemination of earthquake engineering data, and ultimately to improve the seismic provisions of building codes in the region. In Amman, working groups were formed on 1) seismic calibration and 2) the development of a RELEMR seismic hazard map. The 1998 workshop in Istanbul was organized along these themes. The Cyprus-1999 workshop added sessions on the role of auxiliary station operators and their responsibilities and the interaction with their earthquake-reporting activities. The first Istanbul-2000 workshop was dedicated to seismic calibration using the Dead Sea explosions and selected natural events while the second Istanbul-2000 workshop was dedicated to large earthquakes in the region. The Spain 2001 workshop focused on Earthquake Hazard Assessment Practice and Velocity Models and Reference Events in the Mediterranean Region and this workshop focused on seismicity and hazard assessment in the Mediterranean region. The program for this workshop is presented in Annex B.

Seventy-six (76) participants from the following countries attended the Lisbon-2009 workshop: Algeria, Austria, Cyprus, Egypt, France, Iran, Israel, Italy, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Portugal, Saudi Arabia, Spain, Sudan, Syria, the Palestinian Authority, Tunisia, Turkey, United Kingdom, United States, and Yemen. The list of participants is given in Annex A.

Workshop Proceedings

In earlier workshop reports, detailed notes on the presentations were included. In this workshop, all of the papers were presented using PowerPoint™ and are included on the DVD that accompanies this report, and therefore, as in all reports since 1999, no detailed notes are included in this report.

Opening Remarks

In the Opening Session, welcoming remarks were made by:

- Dr. Jorge Miguel Alberto de Miranda, University of Lisbon
- Representatives of Portuguese Government's earthquake agencies
- Dr. Michael Foose, USGS
- Dr. Badaoui Rouhban, UNESCO
- Ambassador Fernando Andresen Guimarães, President of UNESCO's National Commission
- Dr. Rui Machete, President of the Executive Council of the Luso-American Foundation
- Eng. Vitor Vieira, Director of the City Hall Civil Protection Department

Presentations

Keynote addresses were presented by: Carlos Oliveira: *The new generation of seismic simulators and applications in Portugal,* and M.J. Jimenez and M. Garcia-Fernandez: *Assessing seismic hazard in the Iberian Peninsula: Few issues and some risk.*

In addition to the two keynote addresses and the HAZUS-MH presentation (described below), forty-seven (47) papers were presented on topics including:

- The Global Earthquake Model
- Civil and scientific applications of international monitoring data
- Re-production of the Entire ISC Dataset (1960-2009)
- Protection of historic buildings against seismic hazards
- Seismic fragility and vulnerability of historic buildings
- Seismic hazard and risk mitigation
- Awareness of seismic risk
- Quasi-static testing of stone-concrete bearing walls and in-filled reinforced concrete frames
- Seismic zonation
- Seismic hazard assessment
- HAZUS and other loss-estimation studies
- Onshore versus offshore controls of seismic hazards
- Establishment of national seismograph networks
- Data processing and archiving
- Accelerometric networks and strong ground motion
- Seismicity along plate boundaries
- Seismo-volcanic investigation of earthquake swarms
- Implementation of tsunami warning systems
- Local and duration magnitude scales
- Spectral attenuation of strong motions
- Geodetic constraints on plate motion and intra-plate deformation:
- Volcanic and seismic activity in western Saudi Arabia
- Regional seismicity
- Seismic data acquisition
- Oilfields as a source of seismic hazard
- Earthquake catalogs

- Microtremor measurement for seismic hazard assessment in urban areas
- Vulnerability index of masonry buildings
- New earthquake parameters from old bulletins and seismograms
- Wave propagation modeling in viscoelastic media
- Topographic effects in seismic hazard assessment
- Vibration modes, frequency and damping of structures
- Relationship between recorded earthquakes and shear zone mineralization
- Open source software for seismic processing
- Strategies for data sharing

HAZUS Presentation

Douglas Bausch, U.S. Federal Emergency Management Agency (FEMA), presented five hours of lectures on the *Technical Methodology and Applications of the HAZUS-MH Earthquake Loss Estimation Model.*

The technical methodology for each major component of the HAZUS earthquake model was reviewed, including ground motion, ground deformation, development of the buildings and infrastructure inventory, engineering fragility functions, analysis parameters, economic and social loss approach, as well as results and uncertainties. Instruction on modifying this information with local data, and how engineering parameters can be adjusted to represent the building stock characteristic of the extended Mediterranean region was also provided. The presentation focused on a broad variety of applications. The HAZUS software contains many databases that apply to the United States (for example, the building types). The removal of U.S.-focused databases and the addition databases more appropriate to other countries was also discussed.

Fieldtrip

Up until the nineteenth century, the most important changes in the urbanization and spatial organization of Lisbon took place after the occurrence of strong earthquakes. The changes were clearly in response to the destruction and new architectural, technical, social and economic structures were developed in order to survive future earthquakes.

A one-day fieldtrip was held on Wednesday, 28 October 2009 to illustrate Lisbon before and after the 1755 earthquake and the effect the earthquake had on the evolution of urban and building technologies.

For a more complete description of the field trip, see the Guidebook and Addendum for the field trip that is included on the DVD.

Written Communication

Prior to the Lisbon 2009 RELEMR meeting Dr. Rémy Bossu, Secretary General, European-Mediterranean Seismological Center, sent seven recommendations for the improvement of RELEMR meetings to UNESCO. These recommendations were presented to the participants and discussed during the closing session. The results of those discussions are summarized in Annex C.

Closing Session

At the end of the Closing Session, participants gave thanks to UNESCO, the USGS, the Universidade de Lisboa and the Luso-American Foundation for their cooperation in the implementation of the workshop. The commitment and hospitality of the Universidade de Lisboa and the Luso-American Foundation made the meeting a successful event. Participants also gave their appreciation to all of the organizers of the fieldtrip and especially to Helena Arouca, Livia Moreira and Luis Matias for their careful attention before, throughout, and after the workshop.

Results and Conclusions

Seventy-six (76) participants from the following countries attended the Lisbon-2009 workshop: Algeria, Austria, Cyprus, Egypt, France, I.R. Iran, Israel, Italy, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Portugal, Saudi Arabia, Spain, Sudan, Syria, the Palestinian Authority, Tunisia, Turkey, United Kingdom, United States, and Yemen.

Keynote addresses were presented by: Carlos Oliveira: *The new generation of seismic simulators and applications in Portugal,* and M.J. Jimenez and M. Garcia-Fernandez: *Assessing seismic hazard in the Iberian Peninsula: Few issues and some risk.* In addition to the two keynote addresses, forty-seven (47) papers were presented on topics including: Seismicity, earthquake engineering, seismic hazard and risk mitigation including seismic hazard assessment and seismic zonation, the protection of historic buildings, loss-estimation studies, accelerometric networks and strong ground motion, seismo-volcanic investigations of earthquake swarms, earthquake catalogs, the relationship between recorded earthquakes and shear zone mineralization, and strategies for data sharing.

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Annex A

Seismicity and Earthquake Engineering in the Extended Mediterranean Region

Lisbon, Portugal
26 – 29 October 2009

List of Participants

Algeria

Mehdi Boukri
Researcher and Head of "Vulnerability and Seismic Risk in Urban Areas" Research and Study Team
National Centre for Applied Research on Earthquake Engineering (CGS),
Algiers, Algeria
Tel : 213 21 49 55 39
Fax : 213 21 49 55 36
Mobile : 213 661 284 004
E-mail: mboukri@cgs-dz.org;
mehdi.boukri@gmail.com

Djillali Benouar
Professor & Consultant
Director, Built Environment Res. Lab.(LBE)
University of Bab Ezzouar (USTHB)
Faculty of Civil Engineering,
BP 32 El-Alia/ Bab Ezzouar,
Algiers 16111, Algeria
Tel : +213 21 247 914
Mobile: +213 771 842 428
E-mail: dbenouar@yahoo.com;
dbenouar@gmail.com

Mohamed Hamdache
Chercheur. CRAAG
BP63 Bouzaréah
Algiers,
Algeria
Tel: +21 90 44 54/55
Fax: +21 90 44 58
E-mail: mhamdache@hotmail.com

Austria

Jeffrey Given
International Data Centre
Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization
Provisional Technical Secretariat
Vienna International Centre
P.O. Box 1200
A-1400 Vienna, Austria
E-mail: jeffrey.given@ctbto.org

Cyprus

Eleni Georgiou Morisseau
Director
Geological Survey Department
1415 Nicosia,
Cyprus
Tel: +357 224 09213
Fax: +357 223 16873
E-mail: director@gsd.moa.gov.cy

Kyriacos Solomi
Senior Geological Officer,
Head of Seismology Section
Geological Survey Department
1415 Nicosia,
Cyprus
Tel: +357 224 09265
Mob: +357 994 85235
Fax: +357 223 16873
E-mail: ksolomi@gsd.moa.gov.cy

Egypt

El-Sayed Mohamed Salem
Egyptian Geological Survey and Mining Authority
3 Salah Salem Road
Abbasiya, Cairo 11517, Egypt
Tel.: 20 2 682 8013
E-mail: sayedsalem2000@hotmail.com

France

Ahmed Mebarki
Full Professeur, Civil Engineering
University Paris-Est Marne-la-Vallée,
Laboratory Modelisation et Simulation Multi Echelle, MSME FRE 3160 CNRS
5 Bd Descartes, Cité Descartes
77454 Marne la Vallée, Cedex 2, France
Tel: +33 160 95 77 87
+33 160 95 85 03
Fax: +33 160 95 77 99
E-mail: Ahmed.Mebarki@univ-paris-est.fr

Iran (Islamic Republic of)

Mohsen Ghafory-Ashtiany
Distinguished Professor of International Institute of Earthquake Engineering and Seismology (IIEES)
Director, Executive Committee, International Association of Earthquake Engineering (IAEE)
Chairman, IASPEI Commission on Earthquake Hazard, Risk and Strong Ground Motion
Member of the UN-ISDR Science and Technical Commission
CEO of Hazard and Risk Management Consultants (HRMC)
No. 3, 2nd St., Hashtroodi St., Velenjak;
Tehran, 19836-73351; I.R.Iran
Tel: (0098-21) 22294050
Fax: (0098-21) 22428280
Website: www.ashtiany.com
E-mail: mohsen.ashtiany@gmail.com,
ashtiany@iiees.ac.ir

Mehdi ZARE
Associate Professor of Engineering Seismology
Vice President for Research and Technology
Head, National Center for Earthquake Prediction
International Institute of Earthquake Engineering and Seismology (IIEES),
P.O.Box: 19395/3913,
Tehran, Iran
Tel.: 98 21 2283 1234
Fax: 98 21 2280 3656
E-mail: mzare@iiees.ac.ir,
mehdi_zare@yahoo.fr

Noorbakhsh Mirzaei
Seismologist
Institute of Geophysics
Tehran University
Tehran, Iran
E-mail: nmirzaii@ut.ac.ir

Israel

Avi Shapira
Chairman
National Earthquake Preparedness Committee
Minister of National Infrastructures
Jerusalem, Israel
Tel: +02-5316033
Fax: 02-5316063
E-mail: avis@mni.gov.il

Rami Hofstetter
Director, Seismology Division
Geophysical Institute of Israel
P.O. Box 182
6 Habaal Shem-Tov
North Industrial Zone
Lod 71100, Israel
Tel.: 972 8 978 5854
Fax: 972 8 925 5211
E-mail: rami@seis.mni.gov.il

Tal Vexsler
Geophysicist
National Data Center (NDC)
Tel-Aviv, Israel
E-mail: tal@ndc.soreq-ndc.gov.il

Tsafrir Levi
Geological Survey of Israel
30 Malkhei Israel Street
95501, Jerusalem, Israel
E-mail: tsafrir@gsi.gov.il

Veronic Avirav
Seismology Division
Geophysical Institute of Israel
P.O. Box 182
6 Habaal Shem-Tov
North Industrial Zone
Lod 71100, Israel
Tel.: 972 8 978 0000
Fax: 972 8 925 5211
E-mail: veronic@seis.mni.gov.il

Yuli Zaslavsky
Seismology Division
Geophysical Institute of Israel
P.O. Box 182
6 Habaal Shem-Tov
North Industrial Zone
Lod 71100, Israel
Tel.: 972 8 978 0000
Fax: 972 8 925 5211
E-mail: yuli@seis.mni.gov.il

Italy

Rui Pinho
Secretary General
GEM Foundation
c/o EUCENTRE, Via Ferrata 1,
27100 Pavia, Italy
Tel: +39-0382-516911
Fax: +39-0382-529131
website: www.globalquakemodel.org
E-mail: rui.pinho@globalquakemodel.org

Jordan

Darwish Jaser
Director
Geologist
Natural Resources Authority
Jordan Seismological Observatory
P.O. Box 7
Amman, Jordan
Tel.: 962 6 550 4403
Fax: 962 6 550 4403
Email: jaser@nra.gov.jo

Mohammad Dawud Fandi Naser
Natural Resources Authority
Jordan Seismological Observatory
P. O. Box 7
11118 Amman
Jordan
Tel: 962 6 5504410
Fax: 962 6 5504410
Mobile: + 962 777 397807, + 962 777 395171
E-mail: mfandi@nra.gov.jo,
mnaser@hotmail.com

Tareq Al-Hadid
Director, Building Research Center (BRC)
Royal Scientific Society (RSS)
P.O Box 1438, Al-Jubaiha,
Jordan
Tel: +962 6 534 4701
Fax: +962 6 534 7399
website: www.rss.gov.jo
E-mail: tareqh@rss.gov.jo

Dr. Hanan Al-Nimry
Assistant Professor of Structural Engineering
Department of Civil Engineering,
Faculty of Engineering
Jordan University of Science and Technology
P.O Box 3030
Irbid 22110, Jordan
Tel: +962 2 720 1000 Ext. 22110
Fax: +962 2 720 1074
E-mail: hsnimry@just.edu.jo

Kuwait

Abdullah Al-Enezi
Research Associate
Kuwait Institute for Scientific Research
P.O. Box 24885 Safat
13109 Kuwait
Tel.: 965 489 9080
Fax: 965 489 9079
E-mail: aenezi@safat.kisr.edu.kw

Lebanon

Ramy El-Khoury
Rafik El-Khoury & Partners
Consulting - Engineers
Head Office
Solar Building
Facing Bourj Hammoud Stadium P.O.Box 11-9256
P.O.Box 11-9256
Beirut, Lebanon
Tel: +961-1-493150/1
Fax: + 961-1-488250/1/2
E-mail: ramy.elkhoury@rafikelkhoury.com

Libya (Socialist People's Libyan Arab Jamahiriya)

Abdunnur Ben Suleman
Scientific Advisor of the LNSN
Head of Geophysics Department
Al Fateh University
Faculty of Science
P.O.BOX 13044
Tripoli,
Socialist People's Libyan Arab Jamahiriya
Mobile: +218 9250 25390
E-Mail: abdunnurs@yahoo.com

Malta

Pauline Galea
Seismic Monitoring and Research Unit
Department of Physics
Faculty of Science
University of Malta
Msida MSD2080, Malta
Tel.: 356 2340 3034
Fax: 356 21332728
E-mail: pauline.galea@um.edu.mt

Morocco

Mohamed Menzhi
Laboratoire de Géophysique
Centre National de Recherches
Scientifiques et Techniques
Rabat,
Morocco
E-mail: menzhi@cnrst.ma

Nacer Jabour
Laboratoire de Géophysique
Centre National de Recherches
Scientifiques et Techniques
Rabat,
Morocco
E-mail: jabour@cnrst.ma

Oman

Issa El-Hussain
Director, Earthquake Monitoring Center
Sultan Qaboos University
P.O.Box 50, Al-Khoudh
PC 123
Muscat,
Oman
Tel: +968 2414 2642
Fax: +968 2441 3137
E-mail: elhussain@squ.edu.om

Palestinian Authority

Mutaz A. Al-Qutob
Head of the Department of
Environment and Earth Studies
Faculty of Science and Technology
Al-Quds University
West Bank,
Palestine
E-mail: mkutob@science.alquds.edu

Iman Amad
An-Najah National University
Nablus,West Bank
Palestine
P.O.Box:7,707
E-mail: eamad@najah.edu

Hatem F. AL-Wahsh
An-Najah National University
Nablus, West Bank
Palestine
P.O.Box:7,707
Tel: +972-022760871
Mob: +972-0599368477
E-mail: Hatem_wahsh@najah.edu

Jalal Al Dabbeek
ESSEC Director
Earth Sciences and Seismic
Engineering Center
Nablus,West Bank
Palestine
Tel: +970 92344121
Fax: +970 92345982
Mobile: + 970 599336061
E-mail: seiscen@najah.edu

Portugal

Alfredo Campos Costa
LNEC
Lisbon, Portugal
Tel: +351 21 844 37 97
Fax: +351 21 844 30 35
E-mail: alf@lnec.pt

Carlos Sousa Oliveira
Department of Civil Engineering and
Architecture
IST, Thecnical University of Lisbon
Av Rovisco Pais, 1, 1049-001
Lisbon, Portugal
E-mail: csoliv@civil.ist.utl.pt

Eduardo Cansado Carvalho
GAPRES-SA
Lisbon, Portugal
E-mail: eccarvalho@gapres.pt

Isabel Pais
Conselho Nacional de Planeamento Civil
de Emergencia
Lisbon, Portugal
E-mail: ipais@cnpce.gov.pt

Joao Fonseca
Researcher, ICIST
Assistant Professor,
Physics Department, IST
Av Rovisco Pais, 1, 1049-001
Lisbon, Portugal.
Tel: +351 218417535
Fax +351218419078
website: fisica.ist.utl.pt/~sismo/jfonseca
E-mail: jfonseca@ist.utl.pt

Jorge Miguel Miranda
IDL
Campo Grande, Edifício C8
1749 - 016
Lisbon, Portugal
E-mail: jmiranda@fc.ul.pt

Josep Batlló
CGUL-IDL
Campo Grande, Edifício C8
1749 - 016 Lisbon,
Portugal
E-mail: jobatllo@fc.ul.pt

Luis Matias
IDL - Instituto D. Luís
Campo Grande, Edifício C8, piso 3
1749 - 016
Lisbon, Portugal
E-mail: lmmatias@fc.ul.pt

Maria Ana Baptista
ISEL, Intituto D. Luiz, Portugal
Instituto D Luiz, Fac Ciencias, C8, 3º -
Campo Grande, 1700
Lisboa, Portugal
Tel: +315 21 7500809
website: www.igidl.ul.pt/baptista.htm
E-mail: mabaptista@dec.isel.ipl.pt

Mario Manuel Paisana dos Santos Lopes
IST
Av Rovisco Pais, 1, 1049-001
Lisbon, Portugal
Tel: 351 218418208
Email: mlopes@civil.ist.utl.pt

Mourad Bezzeghoud
Departamento de Física
Centro de Geofísica de Évora
Escola de Ciências e Tecnologia
Universidade de Évora
Rua Romão Ramalho, 59
7002-554 Évora,
Portugal
Tel: +351 266 740 800
(ext. 5413)
Fax: +351 266 745 394
E-mail: mourad@uevora.pt

Paula Teves Costa
IDL & FCUL
Campo Grande, Edifício C8
1749 – 016 Lisbon,
Portugal
E-mail: ptcosta@fc.ul.pt

Rita Bento
Associate Professor
Department of Civil Engineering and Architecture
IST, Thecnical University of Lisbon
Av Rovisco Pais, 1, 1049-001
Lisbon,
Portugal
Tel: +351 21 8418 210
Fax: +351 21 8418 200
E-mail: rbento@civil.ist.utl.pt

Susana Custódio
Instituto Geofísico da Universidade de Coimbra
Av. Dr. Dias da Silva,
3000-134 Coimbra,
Portugal
Tel: +351-239-793-420/7
+351-265-552-260
Fax: +351-239-793-428
website: www.crustal.ucsb.edu/~susana
E-mail: susanacustodio@dct.uc.pt
susana@crustal.ucsb.edu

Saudi Arabia

Hani M. Zahran
Saudi Geological Survey
P.O.Box 53828,
Jeddah 21543,
Saudi Arabia
E-mail: Zahran.HM@sgs.org.sa

Talal Ali Mokhtar
Supervisor of Geological Phenomena Studies Unit
Dept of Geophysics
Faculty of Earth Sciences
King Abdulaziz University
PO Box 80206,
Jeddah 21589,
Saudi Arabia
Tel: +966 26952312, +966 26291948
E-mail: tmokhtar@kau.edu.sa,
talal.mokhtar@gmail.com

Yahya Mohammad Tarabulsi
Geophysicist
Saudi Geological Survey (SGS)
P.O.Box 53828,
Jeddah 21543,
Saudi Arabia
Tel: +96626195000
Mobile: +966505550962
Fax: + 96626199924
E-mail: tarabulsi.ym@sgs.org.sa

Abdullah M. Al-Amri
Professor
King Saud University,
Department of Geology
P.O. Box 2455
Riyadh 11451, Saudi Arabia
Tel.: 966 1 467 6198
Fax: 966 1 467 3662
Mobile: 966 50 548 1215
website : www.a-alamri.com
E-mail: amsamri@ksu.edu.sa;
amri444@yahoo.com

Mohammed Fnais
Assistant Vice Rector for Graduate Studies and Scientific Research
King Saud University
Riyadh 11451,
Saudi Arabia
E-mail: m_fnais@yahoo.com

Spain

María José Jiménez
Spanish Council for Scientific Research
Museo Nacional Ciencias Naturales
Dept. Volcanology & Geophysics
C/ José Gutiérrez Abascal, 2
E-28006 Madrid, Spain
Tel.: 34 91 411 1328 ext. 1160
Fax: 34 915 644740/645078
Email: mjjimenez@mncn.csic.es

Mariano García-Fernández
Spanish Council for Scientific Research
Museo Nacional Ciencias Naturales
Dept. Volcanology & Geophysics
c/Jose Gutierrez Abascal, 2
28006 Madrid, Spain
Tel.: 34 91 411 1328 ext. 1160
Fax: 34 915 644740/645078
Email: mgarcia@mncn.csic.es

Jenni Jenni
Spanish Council for Scientific Research
Museum of Natural History
Dept. Volcanology & Geophysics
C/ José Gutiérrez Abascal, 2
E-28006 Madrid, Spain
E-mail: jenni@mncn.csic.es

Sudan

Nada Bushra El Tahir Ahmed
PhD student
Penn State University
Pennsylvania, USA.
444 Deike building, University, campus UP,
Tel: +1 814 441 8722
E-mail: nbe2@psu.du,
nada_ahmed99@hotmail.com

Syrian Arab Republic

Rayan Yassminh
National Earthquake Center
Ministry of Petroleum and Mineral Resources
Damascus,
Syrian Arab Republic
E-mail: yassa@scs-net.org;
yassminh2006@yahoo.com

Ryad Darawcheh
Department of Geology
Syrian Atomic Energy Commission
Damascus
Syrian Arab Republic
E-mail: rdarawcheh@yahoo.com

Tunisia

Najla Bouden Romdhane
Professor,
Scientific Senior Councilor
Minister of Higher Education, Scientific Research and Technology of Tunisia
Tel: +216 71 800 724
Mobile: +216 97 193 407
E-mail: najlaromdhane@hotmail.fr

Ahmed Ksentini
Earthquake engineer
Department of civil engineering
Ecole nationale d'ingénieurs de Tunis
BP37, campus universitaire
1002 Tunis belvédère, Tunisia
Tel : +216 22 631 912
Fax: +216 71 872 729
E-mail: ahmedksentini@yahoo.fr

Turkey

Cuneyt Tuzun
Bogazici University
Kandilli Observatory
Earthquake Research Institute
Department of Earthquake Engineering
34684 Cengelkoy,
Istanbul, Turkey
Tel: +90 216 516 33 60
Fax: +90 216 308 01 63
E-mail: cuneyt.tuzun@boun.edu.tr,
ctuzun@gmail.com

Cem Yenidogan
Bogazici University
Kandilli Observatory
Earthquake Research Institute
Department of Earthquake Engineering (KOERI)
34684 Cengelkoy,
Istanbul, Turkey
Tel: +90 216 516 33 67
Mobile: +90 532 206 65 53
E-mail: cem.yenidogan@boun.edu.tr,
cem.yenidogan@gmail.com

Niyazi Türkelli
Professor, Department of Geophysics
Kandilli Observatory
Earthquake Research Institute
Bogazici University
34684 Cengelkoy
Istanbul, Turkey
Tel: +90 216 3082711
Mobile: +90 532 4408185
E-mail: turkelli@boun.edu.tr

United Arab Emirates

Yousuf Abdulrahman Al Marzooqi
Head of Geodesy and Hydrographic Survey Section
P.O.Box: 67, Dubai Municipality
United Arab Emirates
Tel: +971 50 5509595
Fax: +971 4 2234910
E-mail: yamarzooqi@dm.gov.ae;
almarzooqi@www.m1.ae
website: www.dm.gov.ae
www.seismo.geodesy.ae

Abdallah Shanableh
Chairman, Department of Civil and Environmental Engineering
University of Sharjah
P.O.Box 27272
Sharjah,
United Arab Emirates
Tel: +971 (0)6 5050904
Fax: +971 (0)6 5585173
website: www.sharjah.ac.ae/
E-mail: shanableh@sharjah.ac.ae

United Kingdom

Dmitry A. Storchak
Director
International Seismological Centre (ISC)
United Kingdom
Tel: +44 (0) 1635 861022
website: www.isc.ac.uk
E-mail: dmitry@isc.ac.uk

United States of America

Douglas Bausch
Senior Physical Scientist
FEMA Region VIII, Denver Federal Center
Bldg. 710, P.O. Box 25267,
Denver, CO 80225
United States of America
Tel: + 1 (303) 235-4859
Fax: + 1 (303) 235-4849
Mobile: + 1 (303) 263-0949
E-mail: Douglas.Bausch@dhs.gov

Arthur Rodgers
Lawrence Livermore National Laboratory
7000 East Avenue, L-046
Livermore, CA 94551
United States of America
Tel: +1-925-423-5018
Fax: +1-925-423-4077
E-mail: rodgers7@llnl.gov

Keith Nakanishi
Consultant
1644 Frankfurt Way
Livermore, CA 94550
United States of America
Tel: +1-925-455-1380
E-mail: keith.nakanishi@gmail.com

Rengin Gök
Lawrence Livermore National Laboratory
7000 East Avenue, L-231
Livermore, CA 94551
United States of America
Tel: 925-423-1563
Fax: 925-422-3118
E-mail: gok1@llnl.gov

Michael P. Foose
Regional Specialist for Africa and the Middle East
International Programs
U.S. Geological Survey
National Center, MS 917
12201 Sunrise Valley Drive
Reston, VA 20192-0002
United States of America
Tel: + 1- 703-648-6055
Fax: + 1 -703-648-6075
E-mail: mfoose@usgs.gov

Yemen

Jamal M. Sholan
Director
National Seismological Observatory
Center
Al-Gamarik Street
P.O. Box 87175
Dhamar, Republic of Yemen
Tel: 967 6 509 609
Fax: 967 6 509605
E-mail: sholan20@hotmail.com

UNESCO

Badaoui Rouhban
Director
Section for Disaster Reduction
UNESCO
1 rue Miollis, B. 3.21
75732 Paris Cedex 15, France
Tel: + 33 1 45 68 41 20
Fax: + 33 1 45 68 58 21
E-mail: b.rouhban@unesco.org

Frederick O. Simon
Consultant
11813 Stuart Mill Road
Oakton, Virginia 22124
United States of America
Tel: +1 703 620 2772
Fax: +1 703 620 3043
E-mail: fredericksimon@msn.com

Jair Torres
Consultant
Section for Disaster Reduction
Natural Science Sector
UNESCO
1, rue Miollis, B3.23
75732 Paris Cedex 15,
France
Tel: +33 (0)1 45 68 41 22
Fax: +33 (0)1 45 68 58 21
E-mail: j.torres@unesco.org

Annex B

Seismicity and Earthquake Engineering in the Extended Mediterranean Region

Luso-American Foundation
Lisbon, Portugal

26 - 29 October 2009

Agenda

Sunday, 25 October 2009

6:00 – 24:00 Participants arrive in Lisbon

Monday, 26 October 2009

9:00 – 9:30 Registration

9:30 – 10.30 Opening Ceremony: Chair: H.E Mr. Fernando Andresen Guimarães
Dr. Jorge Miguel Alberto de Miranda, University of Lisbon
Representatives of Portuguese Government's earthquake agencies
Dr. Michael Foose, USGS
Dr. Badaoui Rouhban, UNESCO
Ambassador Fernando Andresen Guimarães, President of UNESCO's National Commission
Dr. Rui Machete, President of the Executive Council of the Luso-American Foundation
Eng. Vitor Vieira, Director of the City Hall Civil Protection Department

10:30 – 11:00 Coffee/tea break

11:00 – 11:15 Logistical announcements

11:15 – 13:00 Keynote Addresses: Chair: Dr. Jorge Miguel Alberto de Miranda
Carlos Oliveira: *The new generation of seismic simulators and applications in Portugal*
M.J. Jimenez and M. Garcia-Fernandez: *Assessing seismic hazard in the Iberian Peninsula: Few issues and some risk*

13:00 – 14:30 Lunch

14:30 – 16:00 Contributed Papers:
Rui Pinho: *The Global Earthquake Model: Calculating and communicating earthquake risk*
Iman Amad: *Protection of Historic Buildings against Seismic Hazards: The Case of Palestine*

Kadder Abu-Daqqah, Samer Barakat and Abdallah Shanableh: *Seismic Fragility of Buildings in Sharjah, United Arab Emirates*
Nada Ahmed: *Seismic hazard mitigation in Sudan*
Jalal Al-Dabbeek and Hussein Ahmad: *The Extent of Awareness of Seismic Risk among Palestinian Cities*
Mehdi Boukri: *Seismic risk assessment of current buildings of Algiers city*

16:00 – 16:30 Coffee/tea break

16:30 – 18:00 Douglas Bausch, FEMA: *Technical Methodology and Applications of the HAZUS-MH Earthquake Loss Estimation Model – Part I*

The technical methodology will be reviewed for each major component of the earthquake model including ground motion, ground deformation, development of the buildings and infrastructure inventory, engineering fragility functions, analysis parameters, economic and social loss approach, as well as results and uncertainties. Instruction on modifying this information with local data, and how engineering parameters can be adjusted to represent the building stock characteristic of the extended Mediterranean region will be provided. The presentation will focus on a broad variety of applications. The HAZUS software contains many databases that are focused on the USA (for example, the building types). Doug will also discuss how participants can remove the USA-focused databases and insert databases more appropriate to their country.

18:00 – 19:00 Contributed Papers:
Rita Nogueira Leite Pereira Bento: *Seismic Vulnerability Assessment of Old Buildings*
Hanan S. Al-Nimry: *Quasi-Static Testing of Stone-Concrete Bearing Walls and Infilled RC Frames*
Lassina Zerbo: *Civil and Scientific Applications of International Monitoring Data*
Eduardo Cansado Carvalho: *Seismic zonation and seismic action in the Portuguese National Annex to Eurocode 8*

<u>Tuesday, 27 October 2009</u>

9:00 – 10:30 Douglas Bausch, FEMA: *Technical Methodology and Applications of the HAZUS-MH Earthquake Loss Estimation Model – Part II*

10:30 – 11:00 Coffee/tea break

11:00 – 13:00 Douglas Bausch, FEMA: *Technical Methodology and Applications of the HAZUS-MH Earthquake Loss Estimation Model – Part III*

13:00 – 14:30 Lunch

14:00 – 16:00 Contributed papers:
Tsafrir Levi, Barak Taveron, Oded. Kats, David Segal, Yakov Bar-Lavi, Shacham, Romach: *Earthquake loss estimates in Israel: Insight from a new implementation of HAZUS software*
Douglas Bausch: *Application of HAZUS-MH to Loss Estimation in the U.S.A.*
Mustafa Erdik, Karin Sesetyan, Mine Demircioglu, Ufuk Hancilar, Can Zulfikar, Eser Durukal, Yaver Kamer, Cem Yenidogan, Cuneyt Tuzun, Zehra

Cagnan, Ebru Harmandar: *Rapid earthquake hazard and loss assessment for the Euro- Mediterranean region*
Alfredo Campos Costa: *Seismic loss estimation in Portugal; methods and results*
João F. Fonseca: *Onshore versus offshore: what controls the seismic hazard in Greater Lisbon?*
Djillali Benouar: *Reducing Earthquake Vulnerability in Built Cultural Heritage in the Maghreb Region by Re-Discovering and Re-Evaluating Local Seismic Cultures*

16:00 – 16:30 Coffee/tea break

16:30 – 19:00 Contributed papers:
Abdunnur Ben Suleman and Hadi Ghashut: Establishment of the Libyan National Seismograph Network: *An effort aimed at assessing and mitigating natural disaster risks on national and regional scales*
Dmitry A. Storchak*: Re-production of the Entire ISC Dataset (1960-2009)*
Niyazi Türkelli and Mehmet Yilmazer: *Data Processing and Archiving System at Kandilli Observatory and Earthquake Research Institute (KOERI)*
Kyriacos Solomi: *The Cyprus Seismic Network: The accelerometric network and strong ground motion*
Mourad Bezzeghoud: *Seismicity along the Western Eurasia-Africa plate boundary*
Abdullah M. Al-Amri and Mohammed S. Fnais: *Seismo-Volcanic Investigation of 2009 Swarms at Harrat Lunayyir (Ash Shaqah), Western Saudi Arabia*
Susana Custódio: *Parkfield Earthquakes: Characteristic or Complementary?*
Maria Ana Baptista: *On the implementation of the PtTWS (Portuguese tsunami warning system)*
Noorbakhsh Mirzaei: *Iranian Seismological Network, present status and future plan*

20:00 – Workshop Dinner hosted by Instituto Dom Luiz and the Luso-American Foundation

Wednesday, 28 October 2009

Fieldtrip—See Annex D (or attached documents)

Thursday, 29 October 2009

9:00 – 10:30 Contributed Papers
R.Yassmineh, S. Bagh and M. Daoud: *Local and Duration Magnitude Scales for Syria*
Mehdi Zare: *Contribution to the Spectral Attenuation of Strong Motions in Iran*
Reilinger, R., And Mcclusky, S., Arrajehi, A., Mahmoud, S., Rayan, A., Ogubazghi, G. Sholan, J.: *Geodetic constraints on Arabia plate motion and intra-plate deformation: Implications for regional geodynamics*
Hani Zahran and Salah El-Hadidy Yousef: *The 2009 volcanic and seismic activity in Harrat Al-Shaqah (Lunayyir), western Saudi Arabia*
Jabour Nacer and Menzhi Mohammed: *The seismicity in the region of Agadir, southwest Morocco*
Veronique Avirav: *Seismic Data Acquisition (SDA), the Israel Seismic Network: A tool for permanent and portable seismic measurements (software presentation)*

10:30 – 11:00 Coffee/tea break

11:00 – 13:00 Contributed Papers

Ahmed Ksentini and Najla Bouden-Romdhane: FEMA-HAZUS software exporting study for the seismic risk evaluation on the new and old cities of Tunis

Talal A. Mokhtar: Revised Seismic Microzonation of the City of Makkah, Saudi Arabia

Abdullah Al-Enezi and Reda Abdul Fatah: Oilfields in Kuwait: A Source of Seismic Hazard

M. Hamdache, J.A. Peláez, A. Talbi, M.A. Ureña and M.T. García¬ Hernández: A main earthquake catalog in Northern Algeria from 856 to 2008

Zaslavsky, Y., Shapira, A., Hofstetter, A., Ataev, G., Gorstein, M., Aksinenko, T. Kalmanovich, M. and Perelman, N.: Microtremor Measurement for Seismic Hazard Assessment in urban areas: Examples from Israel

Mehdi Boukri: *Vulnerability index of Algiers masonry buildings*

Josep Batló: *New earthquake parameters from old bulletins and seismograms*

A. Dhemaied, N. Bouden-Romdhane, F. Rejiba, C. Camerlynck, L. Bodet, and R. Guérin: *Wave propagation modeling in viscoelastic media: Application to sedimentary basin of Tunis*

13:00 – 14:30 Lunch

14:30 – 16:00 Contributed Papers

Hofstetter, R., Zaslavsky, Y., and Perelman, N.: *Investigation of topographic effects and seismic hazard assessment: Hadassa En Kerem hospital*

Tareq Al Hadeed: *Microzonation of Aqaba*

Naser, M. F. and Darweesh, J.: *Vibration Modes, Frequency and Damping of the Al-Mujib Bridge*

El-Sayed Mohamed Salem: *The relationship between recorded earthquakes and shear zone mineralization in central and south Eastern Desert of Egypt*

Keith K. Nakanishi, Arthur Rodgers, Jr., and Rengin Gok: *Open source software for seismic processing*

Keith K. Nakanishi: *Strategies for Data Sharing*

16:00 – 16:30 Coffee/tea break

16:30 – 18:00 Closing session

<u>Friday, 30 October 2009</u>

Participants depart Lisbon

Annex C

SUMMARY AND DISCUSSIONS
RECOMMENDATIONS FOR RELEMR PREPARED BY DR. REMY BOSSU

Prior to the Lisbon 2009 RELEMR meeting Dr. Rémy Bossu, Secretary General, European-Mediterranean Seismological Center, sent seven recommendations for the improvement of RELEMR meetings to UNESCO. These recommendations were presented (by PowerPoint) to the participants and discussed during the closing session. This Annex summarizes those discussions.

1. Exchange of real-time waveform data for the creation of virtual networks in order to improve national seismological monitoring. Is a demonstration in the western Mediterranean region useful and desirable?

Comments:

- This is possible but the problems are greater than communications. Many issues need to be resolved before efficient data exchange can be done, and much planning will be required. For example, one needs to decide what magnitude earthquakes are reported and the mechanics of online data transferred need to be resolved.
- There is a need for real-time exchange; it is important especially for Oman and Iran in order to monitor Makran. Data formats are a big obstacle and RELEMR should address formatting and help with data conversion.
- It is important to have real-time access to data.
- We need to address the obstacles and how RELEMR can help?

2. RELEMR should provide a quick estimate of earthquake impacts. It might be possible to make estimates based on past earthquakes (magnitude, localization, number of casualties).

Comments:

- The USGS Prompt Assessment of Global Earthquakes for Response (PAGER) addresses these aspects. The PAGER system provides estimates of the number of people and the names of cities exposed to severe shaking following significant earthquakes worldwide. It is operational and there is no cost.
- NERIES is a system that can also do building damage estimation. Kandilli Observatory is doing this but it is still under development and the methodology is now being calibrated. Kandilli plans to share the technology with anyone who asks.
- Kandilli needs cooperation from everyone so that calibration can be done. Databases must be available.
- A proposal was made for a discussion on how to deal with PAGER information.

3. Ask participants to send their questions regarding operational maintenance of networks (share of experiences, practices and knowledge, software and tools available). EMSC receives this kind of requests and RELEMR could also collect this type of inventory of needs. These questions should be sent prior to the meeting.

Comments:

- No comments were offered.

4. Ask participants to make a presentation of the recent developments of their networks. Examples, what are Morocco and Tunisia doing to upgrade their networks. What is the status of networks in Algeria and Libya? If RELEMR organizes this kind of session, it is important that we have the right speakers.

Comments:

- This depends on the case-by-case basis. It depends on the added value of presentations and on the interest of concerned scientists to do so.

5. Implementation of a tsunami warning system in the Mediterranean: Present situation and its consequences for the seismological networks. This should be presented from the seismologists' point of view because seismologists from Maghreb and Middle East countries hardly participated in the IOC meetings.

Comments:

- It may be useful to have a status report from IOC. This should be organized through UNESCO.
- This is way beyond the scope and funding of RELEMR.

6. Inform and discuss initiatives in order to explore the feasibility for coordination. For instance, EMSC, ORFEUS, and NERIES have organized a coordination meeting on the accelerometric data that will be held in Ankara in November with EuroMed and global participation (United States, Japan).

Comments:

- We need to know what is being done and what are the results?
- No one present had attended an EMSC coordination meeting.

7. Discussion with the participants in order to identify regional needs. It might be interesting to give participants questionnaire during RELEMR meetings to identify these needs and then to discuss the results of the questionnaire at the meeting.

Comments:

- Many participants felt this would be useful and would be willing to fill in questionnaire.
- To an important degree, RELEMR has repeatedly done this. For example, the recent focus at RELEMR meetings on HAZUS and the participation of Mr. Doug Bausch are the result of asking RELEMR participants what change in meeting focus is desired and their response that more training on HAZUS is needed.
- Joint projects should be considered.

The organizers agreed to consider these comments in the organization of future RELEMR meetings.

Annex D

Fieldtrip

The guidebook for the field trip is presented as two separate documents on the DVD (or attached):

1. LISBON BEFORE AND AFTER THE 1755 EARTHQUAKE: Effects on the urban and building technologies evolution

2. Field Trip – Notes on the building visited at Recolhimento Street, S. Jorge Castle area

Annex E

Abstracts

Assessing seismic hazard in the Iberian Peninsula: few issues and some risk

M.J. Jiménez and M. García-Fernández
CSIC-Madrid

Located in the extreme southwest of Europe, the Iberian Peninsula is the westernmost of the three Mediterranean European peninsulas - Iberian, Italian and Balkan - and it includes Portugal, Spain, Andorra and Gibraltar.

From the Earth Sciences perspective and earthquake threads, the Iberian Peninsula constitutes a unit; from political perspective the Iberian Peninsula incorporates four political borders of four different countries. From scientific or technical viewpoint the main issues regarding seismicity and assessment of seismic hazard for Iberia can be addressed as a whole, while issues regarding seismic risk and seismic risk mitigation, in that they include seismic resistant design, land use management, city planning, earthquake insurance, public education, legislation, or rapid emergency response cannot.

Regional seismicity is diffuse in connection with present day crustal deformation in the Iberian Peninsula and adjacent regions (the Maghreb and offshore regions in the Mediterranean and the Atlantic) which corresponds to the convergence along this part of the African-Eurasian plate boundary. Seismic activity does not clearly delineate the present day European-African plate boundary and it extends well into intraplate settings in north-western and central Iberia. In general, seismicity in the area is characterized by the occurrence of low to moderate earthquakes; the strongest ones located within the adjacent regions, i.e. offshore in the Atlantic and in the Maghreb.

A general overview on the main issues regarding the assessment of seismic hazard in the Iberian Peninsula (seismicity, seismotectonic framework, historical and instrumental observations of seismicity, earthquake catalogue, seismic sources, ground motion models) and on the results of seismic hazard studies performed in the past three decades shows how these have been taken in account to different extents in different times in national seismic codes specially in the case of Spain and the need for the at present ongoing trans-boundary cooperation funded under the framework of several international or regional initiatives.

In recent years a number of studies on seismic risk assessment at different scales in Spain have been carried out. Most of these recent results have been obtained linked to applications for mandatory Emergency Planning Regulations for different Spanish regions and few of them at local/urban scale have not. The details on the approaches and resolutions when compared show the urgent need for the periodical updating and harmonization of data and procedures in the applied risk assessment. This holds not only at national level in relation to the existing practice in the rest of Iberian countries, but also and even most important at the regional and local scales in Spain to check for consistency of results and methods at neighbouring regions within the country.

The Global Earthquake Model: Calculating and Communicating Earthquake Risk

Rui Pinho
Secretary General, GEM Foundation, Pavia, Italy

Over half a million people died in the last decade due to earthquakes and tsunamis, most of these in the developing world, where the risk is increasing due to rapid population growth and urbanization. Yet in many earthquake-prone regions no risk models exist, and even where models do exist, they are inaccessible. Better risk awareness can reduce the toll that earthquakes take by leading to improved planning, construction, emergency response, and greater access to insurance.

Responding to a call from the Global Science Forum of the Organization for Economic Cooperation and Development (OECD), the Global Earthquake Model will provide an authoritative standard for calculating and communicating earthquake hazard and risk by developing needed global datasets, building open-source tools, and engaging scientists and engineers and users around the world.

The overall aim of GEM is to produce software and tools that help to reduce earthquake deaths, destruction, dislocation, and monetary losses. GEM will provide a basis for comparing earthquake risks across regions and across borders. GEM tools will be usable at the community, national and international level for uniform earthquake risk evaluation and as a defensible basis for risk mitigation plans. GEM results will be disseminated widely and openly. GEM will be inclusive, it will be politcally, scientifically, and commerically independent, and GEM will build technical capacity and promote awareness raising activities.

GEM is thus a public-private partnership that serves a humanitarian imperative while offering a key to sustainable development, and promotes a larger involvement of the insurance and financial sectors. GEM will take 5 years to build its first working model, though the engagement of the scientific research community worldwide and the deployment of a number of independently-driven Regional Programmes.

Protection of Historic Buildings against Seismic Hazards:The Case of Palestine

Iman Amad
An-Najah National University, Nablus West Bank, Palestinian Territories

This presentation focuses on protection of the traditional historic buildings of Palestine against earthquakes. It investigates vulnerability of traditional stone buildings in historic cores of Palestinian cities and villages. The paper focuses on some examples in Nablus and Kore village where important historic buildings exist. The historic buildings in the two settings had survived major earthquakes however they suffered some destruction and had been weakened as a result, in addition to abandonment, neglect and lack of maintenance.

The presentation stresses issues related to consolidation of historic buildings as an important procedure in conservation. Protection against earthquakes should be considered fundamental in the process of conservation and protection of the built cultural heritage. Understanding traditional construction techniques, traditional building material and the vulnerability of traditional structures help structural engineers to arrive into appropriate solutions for dealing with traditional buildings consolidation and protection.

Strengthening historic buildings against seismic risks should be carried out without compromising the quality of important historic structures. Cultural heritage protection laws which are absent in the meantime in Palestine should seriously consider this matter in order to secure historic buildings against potential seismic hazards and to ensure their survival to future generations.

Seismic Fragility of Buildings in Sharjah, United Arab Emirates

Kadder Abu-Daqqah, Samer Barakat and Abdallah Shanableh
Department of Civil and Environmental Engineering
University of Sharjah, Sharjah, United Arab Emirates

In this study, a database of buildings in Sharjah City, United Arab Emirates, was established and the buildings were classified according to their use, types and heights. The city was then divided into sub-areas, with each area assigned a representative building type that averaged the characteristics of buildings in the area. As a result, 13 model buildings were used to represent Sharjah city buildings. The model buildings were designed using applicable design codes then subjected to a suite of scaled ground motions recorded by the Iranian Strong Motion Network (ISMN). The responses of the 13 model buildings were represented by suitable fragility curves relating the probability of reaching or exceeding one of four damage sates; slight, moderate, extensive, and complete to the peak ground acceleration (PGA). Estimates of potential human losses were also made using the ATC-13 injury and death rates.

Seismic Hazard Mitigation in Sudan

Nada Bushra Ahmed
Sudan Seismic Network, Khartoum, Sudan

Though Sudan is characterized by low seismic activity, several large earthquakes have been recorded, which resulted in loss of life and damage to properties. The largest of these was probably the largest earthquake in Africa in the 20th century. It occurred on 20 May 1990 (Ms=7.1-7.4) near Juba in the southern part of Sudan. Other earthquakes whose effects caused major damage and even deaths, include the Suakin graben earthquakes (Ms = 5.8) of 12 May 1938, located in the Western margin of the Red Sea, the Jebel Dumpier event located in Central Kordofan (Ms = 5.6), which occurred on 9th October 1966, and the Khartoum event (Ms = 5.5) of August 1993. In 2001, the Sudan Geological Research Authority (GRAS) established a three station seismic network to monitor earthquake activity in the region. The network is, for practical reasons, distributed around Khartoum and local, regional and distant earthquakes are recorded. Most of the local events are found to be correlated with the fault NW of Khartoum, which is thought to be the epicenter of the Khartoum earthquakes of August 1993. The SSN is also able to detect and locate events from large distances.

The southern part of Sudan is most susceptible to earthquake effects and preventive measures are necessary. The relatively stable central parts of the country, however can also produce occasional earthquakes of moderate magnitude that can give rise to damaging intensities, thus, we recommend the determination of the response spectra for the cities and towns in this region, in particular that of Juba. Such results would be of importance in building anti-seismic structures.

The Extent of Awareness of Seismic Risk among Palestinian Cities

Jalal Al-Dabbeek & Hussein Ahmad
Center of Earth Sciences & Seismic Engineering
An-Najah National University, Nablus West Bank, Palestinian Territories

This study is based on a field survey carried out by the center for Opinion Polls and survey studies and the center of earth sciences and seismology at An- Najah National University. A sample representing the west bank and the Gaza strip was taken; the descriptive and analytical approaches were used to reach to the results.

The study shows that there is an acceptable level of seismic awareness among West Bank and Gazan citizens and that they are ready to accept adopting some procedures including an increase in costs 3-5% in case buildings are designed and constructed according to seismic resistant plans. Members of a sample also believed that municipalities and Engineers' Association should accept responsibilities to monitor the adoption of seismic design in the construction of buildings. The study also shows a discrepancy in awareness between the citizens of Gaza and those of the West Bank. Discrepancies also apply to governorates and are influenced by social and economic variables.

The study also includes some recommendations to increase seismic awareness among citizens and to reduce the risk of earthquakes.

Seismic Risk Assessment of Current Buildings of Algiers City

Mehdi Boukri
Head of "Vulnerability and Seismic Risk in Urban Areas" Research and Study Team
National Centre for Applied Research on Earthquake Engineering, Algiers, Algeria

Algiers, capital of Algeria, because of bigger concentrations of economic infrastructures and population, requires a particular attention to protect it, to an acceptable level, against the negative consequences of seismic event, a phenomenon that threatens it to the highest degree, and that can hit at any time.

The authorities of the city aware of this risk and in order to have the necessary elements that let them to know and estimate the potential losses in advance, with an acceptable error, and to take the necessary countermeasures, initiated a seismic vulnerability and risk assessment of Algiers city. The main goal being to put in evidence the zones or districts that are more exposed to the seismic risk, and so, to be able to localize the places of intervention and the appropriate means before the event occurrence, and reduce its negative impact on population and socio-economic assets.

The results of this seismic vulnerability and risk study obtained using the RADIUS method, assuming an earthquake of magnitude 6.5 generated by the Bouzareah Fault at 10H00 in the morning, are synthesized in tables and maps where are represented the losses and damages (in terms of buildings and human lives) in the city limited to 26 districts.
These will allow the concerned authorities to take arrangements to put the necessary tools in place (emergency plan, politics of prevention, etc.) to reduce these potential losses and damages.

Technical Methodology and Applications of the HAZUS-MH Earthquake Loss Estimation Model

Douglas Bausch
FEMA, United States of America

The technical methodology will be reviewed for each major component of the earthquake model including ground motion, ground deformation, development of the buildings and infrastructure inventory, engineering fragility functions, analysis parameters, economic and social loss approach, as well as results and uncertainties. Instruction on modifying this information with local data, and how engineering parameters can be adjusted to represent the building stock characteristic of the extended Mediterranean region will be provided. The presentation will focus on a broad variety of applications.

The HAZUS software contains many databases that are focused on the USA (for example, the building types). Doug will also discuss how participants can remove the USA-focused databases and insert databases more appropriate to their country.

Seismic Vulnerability Assessment of Old Buildings

Rita Bento
IST, Portugal

Portugal, alike southern Europe, has not adequately dealt with the vulnerabilities associated to risks such as the seismic risk, that occur suddenly but in a sharply manner, at an unpredictable time, location and severity. Lisbon, as an early settlement of populations, has witnessed along the centuries to a significant number of large events that have been narrated and are known to us nowadays. However, given that the time distance between events surpasses that of several generations, earthquake catastrophes tend to be forgotten... just until another one strikes. Conversely, given its centuries of History, the capital has a patrimonial value in old constructions, still standing in our days, of great importance and continuous need for preservation. Some of these constructions were built with anti-seismic concerns (for instance the Pombalino buildings) while other old constructions have been designed to withstand gravity loads alone, presenting a vulnerable group at seismic risk (a recognised example would be the Gaioleiros buildings).

The response of this type of structures to strong earthquakes is still an open research subject. The analysis of the existing old masonry buildings in the light of the present seismic codes would lead to the conclusion that they are highly vulnerable to severe earthquakes; nevertheless, they behaved relatively well during past earthquakes, albeit with large variability of performances. Such discrepancies demonstrate the weakness of the available methods in accurately predicting the real behaviour of these types of buildings under destructive earthquakes. By the use of modern design techniques it is possible to apply many retrofitting schemes for the desired level of strengthening, in most cases with questionable accuracy. Moreover the level of interventions is significantly limited due to functionality and architectural reasons. Furthermore, many of these buildings belong to the historical heritage or their initial structural system should be maintained or emphasized, thus limiting the level of applicable interventions.

Nowadays, the vulnerability that the seismic hazard poses to old masonry structures and possible retrofitting solutions are a main concern. Additional developments concerning the derivation of fragility curves are still required for particular, less common, building typologies, namely old masonry constructions. A main goal for future research work will be to derive fragility curves for the masonry constructions encountered in Lisbon, which will be a significant contribution to the state of the art. For that it is required to characterize, from a structural point of view, these constructions, including, among others, their typologies, materials, dynamic characteristics, stage of conservation. Having all the elements essential to characterize the constructions, one needs to assess their seismic behaviour and decisions have to be made regarding the type of theoretical and numerical and experimental tools that are available and best suited for each case. Finally, one has to know how to use these tools to assess the performance of these structures under different severity levels of the seismic action, in other words, to assess the seismic vulnerability.

For this the mechanical approach should be chosen given the specificness of the constructions analysed conjugated with their importance. For that simplified non-linear static methods and, in particular cases, non-linear dynamic analysis should be performed so as to validate the previous. The numerical tools to be used could be state-of-the-art macro-element software. This has proved to be a very good cost-effective tool, in terms of reliability and time consumption, to analyse this type of structures, and especially when compared to refined non-linear finite element analyses. The research work developed until now has been limited to the use of finite element analyses and some of work previously performed will be presented.

Quasi-Static Testing of Stone-Concrete Bearing Walls and Infilled RC Frames

Hanan S. Al-Nimry
Dept. of Civil Engineering, Jordan University of Science and Technology

The effect of stone-concrete wall panels on the seismic response of two different construction practices in Jordan is examined using quasi-static experimentation. The two investigated construction practices represent an older local practice (prior to 1985) in which the stone-concrete walls are used as bearing walls, and a newer practice wherein the walls act as infills in a gravity load-designed RC frame. In addition to the type of construction, test parameters included the presence of window openings, level of axial loads and presence of dowels between the infill wall and the bounding frames. Eight test specimens were constructed at one-third scale and tested under reversed cyclic lateral loading and constant axial loads. Details of test specimens, test setup, applied load histories, and test results are presented. Test results show that the increase in axial load enhanced the lateral resistance of the bearing wall system by a small margin but enhanced greatly its ductility and energy dissipation capacity. Again, the effect of axial load was not pronounced in the case of gravity load-designed RC frames infilled with stone-concrete wall panels. However, better performance in terms of ductility and energy dissipation of the frame-infill system was detected in the presence of openings as compared to higher lateral resistance and stiffness (yet lower ductility and energy dissipation) in the absence of openings. The inclusion of dowels at the base of the wall increased the stiffness and energy dissipation of the frame-wall system but didn't affect its lateral resistance. An increase in the lateral resistance of about 30% was attained with dowels at the base and between the infill wall and bounding columns.

Civil and Scientific Applications of International Monitoring System Data

Lassina Zerbo
International Data Centre, Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, Vienna, Austria

When completed, the International Monitoring System (IMS) of the Preparatory Commission for the Comprehensive Nuclear test Ban Treaty Organization will be a global network of 321 stations; 50 primary seismic, 120 auxiliary seismic, 11 hydroacoustic, 60 infrasound, and 80 radionuclide. Currently, 240 of the IMS stations are in operations. The primary seismic, hydroacoustic, and infrasound stations send their data in real-time to the International Data Centre (IDC) in Vienna, Austria. Data from the auxiliary seismic stations are available to the IDC upon request, and data from radionuclide stations are sent to the IDC when counting has completed. Upon request, the IDC forwards these data to the states signatories to the Treaty as soon as they are received. It also processes the data and produces products derived from the data. While the primary purpose of the data is to monitor compliance with the CTBT, civil and scientific applications benefit from the timely, high quality data from the IMS. Several tsunami warning centres use IMS seismic and hydroacoustic data in their operations, and IMS data could also be used to study earth structure, supplement seismic hazard analyses, assist in tracking radioactive dispersion from accidents, etc.

Earthquake loss estimates in Israel: Insight from a new implementation of HAZUS software.

Tsafrir Levi[1], Barak Taveron[2], Oded. Kats[1], David Segal[3], Yakov Bar-Lavi[4], Shacham, Romach[4]

[1] Geological Survey of Israel, Jerusalem, Israel
[2] Israel Electric Corporations, Haifa, Israel
[3] Earthquake Engineer
[4] Survey of Israel, Israel

Israel is situated along the Dead Sea Transform (DST), one of the most active fault system in the Levant. Based on paleoseismological studies, historical accounts and modern recordings, the DST is the source of the strongest and most destructive earthquakes in the region. Given the cyclic nature of strong earthquakes, a major earthquake (Mw≈6-7) in the region is inevitable. Moreover, studies show that several of the DST segments have not been ruptured for a long period, suggesting the inter-seismic, quiescent term, may reach to its end.

Emergency agencies and decision makers in Israel are expected to face the consequence of a large earthquake in the near future. Hence, a governmental earthquake hazard reduction programs is implemented in Israel in the last ten years. A reference-earthquake loss estimation scenario that will be a base for planning of emergency and hazard reduction actions is a key element of this program. In this work we develop a few preliminary reference-earthquake loss estimation scenarios and different synthetic earthquake scenarios in Israel by applying the US HAZUS software.

As a first step, a relevant data base was collected and built into HAZUS structure files. The data base covering all Israel includes: demographic data, building quality data and geotechnical maps. Then, different synthetic earthquake scenarios were simulated by using a few earthquake magnitudes and epicenter sites, different building type distributions and different seismic code levels. The results show that for Mw=6.5 earthquake close to Sea of Galilee the number of buildings expected to be completely damaged is tens to hundreds depending on the seismic code and the building type that is used in the simulations. Accordingly, the number of the people that are expected to be fatally injured is tens to hundreds of people.

The results of the earthquake loss simulations strongly suggested that the HAZUS platform has all the advantages of being a useful tool for modern loss estimations in Israel. Further using of the HAZUS platform will provide Israeli decision-makers and authorities handling emergencies with indications as to what type of losses may take place, an idea of the scope of the losses, and suggested priority in improving building codes to those places that are expected to be mostly affected by the earthquake. Development of capacity and fragility curves for the Israeli building types, extension of the demographic data inventory, and collection and arrangement of the data on the essential facilities, the utility systems and the hazard material facilities will further improve the earthquake losses and damages estimations.

Rapid Earthquake Hazard and Loss Assessment for Euro- Mediterranean Region

Mustafa Erdik, Karin Sesetyan, Mine Demircioglu, Ufuk Hancilar, Can Zulfikar, Eser Durukal, Yaver Kamer, Cem Yenidogan, Cuneyt Tuzun, Zehra Cagnan, Ebru Harmandar.
Bogazici University, Istanbul Turkey

For almost-real time estimation of the ground shaking and losses after a major earthquake in the Euro-Mediterranean region the JRA-3 component of the EU FP6 Project entitled "Network of Research Infrastructures for European Seismology, NERIES" foresees:

1. Finding of the most likely location of the source of the earthquake using regional seismotectonic data base, supported, if and when possible, by the estimation of fault rupture parameters from rapid inversion of data from on-line regional broadband stations.

2. Estimation of the spatial distribution of selected ground motion parameters at engineering bedrock through region specific ground motion attenuation relationships and/or actual physical simulation of ground motion.

3. Estimation of the spatial distribution of site-specific ground selected motion parameters using regional geology (or urban geotechnical information) data-base using appropriate amplification models.

4. Estimation of the losses and uncertainties at various orders of sophistication (buildings, casualties)

The multi-level methodology developed for real time estimation of losses is capable of incorporating regional variability and sources of uncertainty stemming from ground motion predictions, fault finiteness, site modifications, inventory of physical and social elements subjected to earthquake hazard and the associated vulnerability relationships. This methodology was coded into a software called "ELER".

The earthquake rapid loss estimation methodology developed will be discussed and elaborated with example applications of ELER.

Onshore versus offshore: what controls the seismic hazard in the Greater Lisbon?

Joao F B D Fonseca and Susana P Vilanova
ICIST, Instituto Superior Técnico, Lisbon Portugal

The perception of a particular hazard by the population is critically influenced by the return period. Events that recur with intervals longer than a lifetime can only be perceived by the population as a significant threat if they are extreme. However, when a certain threshold is exceeded the dimension of the event can supersede the effect of its long return period. This is clearly the case of the offshore Lisbon 1755 earthquake, with an indelible presence in Portuguese history, architecture and urbanism. Smaller but still destructive earthquakes with epicentre onshore within 50 km from Lisbon, such as the M~7 1531 earthquake or the M6.3 1909 earthquake, both in the Lower Tagus Valley, or the M7.1 1858 earthquake near Setubal did not register well in the collective memory. Recent research indicates that, due to to their shorter return period, such smaller events dominate the seismic hazard in the Greater Lisbon. This is in contrast with the long held viewpoint that the offshore scenario is the leading contributor. However, the latter view is still present in very recent publications.

In this paper, we argue that risk awareness can be influenced in more subtle ways by the cultural background of the exposed population, researchers included. In the Portuguese case, there seems to be a systematic tendency to equate the source of geologic risks, whenever that is possible, with the distant offshore. We use accidents induced by geotechnical problems or coastal cliff instability to illustrate this tendency. We propose that the Portuguese are collectively well equipped to absorb ocean-related risks – a by-product of a history rich in sea-faring adventure – whereas a rational attitude towards solid Earth geological hazards seems to be still hampered by long- lasting taboos inherited from centuries of a religion-dominated educational system. The persistence in the scientific literature of seismic hazard models dominated by the distant offshore scenario (Sousa and Campos-Costa, 2009) is discussed under the light of the cultural factors described above, while presenting the strengths and weaknesses of the different hazard assessments.

Reducing Earthquake Vulnerability in Built Cultural Heritage in the Maghreb Region by Re-Discovering and Re-Evaluating Local Seismic Cultures

Djillali Benouar
Built Environment Res. Lab. (LBE), University of Bab Ezzouar (USTHB)
Faculty of Civil Engineering, Alger, Algeria

Historical monuments and sites are present in every country in the Maghreb countries as in all the other countries of the Mediterranean basin. They are important not only for their physical structures but also for their traditional seismic preventives techniques used in their built and that today could be replicated and could be preserved.

The historical cities in the Maghreb countries were built between the XVIIIth and XIXth centuries, Algiers (Algeria) and Tunis (Tunisia) seem to constitute a homogeneous block influenced mainly by the Ottomans. However, other large cities in North Africa not influenced by the Ottomans, as Fes (Morocco) present similar structural, functional and constructive characteristics as old cities in North Africa, which may help to study the various problems related to these factors. These historical cities are located in a seismic active zone in North Africa which extends from Agadir (Morocco) through the north of Algeria to the Golf of Gabes (Tunisia). Many more historical cities with similar characteristics are found in Libya, Egypt, Syria, Lebanon, Turkey, Greece, Italy, France, Spain and Portugal.

If these historical cities survived all the numerous destructive seismic events that had stricken them; this implies that in the past there was a certain awareness of the seismic risk and thus the development of an ancient seismic preventive technology during the reconstruction of structures. This has probably engendered a local seismic culture characterized by local preventive measures. Concerning the Casbah (old nuclei of Algiers built in XVIth century) which was seriously damaged during the 1716 earthquake, it was reported that the Dey (Governor) in that time decided to impose preventive techniques that he decreed and which some of them have been re-discovered today.

Establishment of the Libyan national seismograph network: An efforts aimed at assessing and mitigating natural disaster risks on the National and regional scale

Abdunnur Ben Suleman and Hadi Ghashut
Libyan Center for Remote Sensing and Space Science

The Libyan National Seismograph Network (LNSN) is a multi-dimensional project on earthquake monitoring and research studies that have been established with UNESCO aimed in assessing and monitoring natural disaster risks. The LNSN consists of an up-to-date 15 broadband digital national network, utilizing state of the art VSAT communication technology, and a Central Processing Center, located in the City of Ghariyan. Libya, located at the northern extreme of the African continent, has yielded a complex crustal structure that is composed of a series of basins and uplifts. The present day deformation of Libya is the result of the Eurasia-Africa continental collision. The recorded number of earthquakes in Libya, before the establishment of the LNSN, was not representative of the actual total number. This scientific fact was fully proven after the establishment of LNSN operated since November of the year 2005. This study aims to explain in detail the LNSN and its main objectives both on the local and regional scales. We also aim to discuss the first catalogue of Libyan earthquakes and to explain the new picture of the seismicity and seismic hazard of Libya. The newly compiled Libyan catalogue represents the main source of data through which we analytically reanalyze earthquake activity of Libya with the aim of improving the earthquake hazard assessment of the Country. Different sources were used in the compilation process within a geographical window limited by the 190 N and 340 N parallels and the 80 E and 260 E meridians.

The LNSN network was designed to monitor local, regional and teleseismic activities, as well as to provide high quality data for research projects in regional and global seismology. At first glance the seismic activity map, based on the present seismic catalogue, shows dominant trends of seismicity with most seismic activity concentrated along the northern coastal areas. Areas of noticeable seismic activity are recognized among which four major seismic trends were quite noticeable. A first trend is a NW-SE direction coinciding with the eastern boarder of the Hun Graben. A second trend is also a NW-SE direction in the offshore area and might be a continuation of this trend. The other two trends were located in the western Gulf of Sirt and Cyrenaica platform. The rest of seismicity is diffuse either offshore or in land, with no good correlation with well-mapped faults.

Re-production of the Entire ISC Dataset (1960-2009)

Dmitry A. Storchak
International Seismological Centre (ISC), United Kingdom

Consistency and uniformity of the long period data sets is a major constrain on developments at any data centre. Nevertheless there are times when technological advances are unavoidable. At the ISC we recently started using AK135 velocity model and preparing to introduce a different more advance location algorithm soon. To make sure that newly produced seismic bulletin data are consistent with those in the past we are planning a massive project of re-producing the entire ISC Bulletin since 1960 till 2009. We shall:

- Re-compute ISC hypocentres to guarantee consistency of locations and error using new standard earthquake locator, ak135 velocity model in place of Jeffreys-Bullen, uniform threshold algorithm that decides if an event warrants an ISC location, uniform set of seismic phases (IASPEI) and uniform set of error estimates;
- Re-compute event magnitudes using consistent treatment of amplitude measurement outliers, removing magnitude estimates based on too few measurements, providing previously unavailable magnitude error estimates and an account of which stations contributed towards the ISC network magnitude in each case;
- Collect, introduce and process essential additional datasets that have not been available at the time of original ISC Bulletin production;
- Fill known gaps in agency's bulletin reports in the past;
- Rectify known errors, inconsistencies and spurious events, identify and mark data from networks with erroneous time stamp, re-assign event type flags to provide consistency between reports of different agencies.

We invite comments, error reports, suggestions and missing bulletin datasets from those interested to help the ISC in this vital development.

Data Processing and Archiving System at Kandilli Observatory and Earthquake Research Institute (KOERI)

Niyazi Türkelli and Mehmet Yilmazer
Bogazici University, Kandilli Observatory and Earthquake Research Institute, Istanbul, Turkey.

Anatolia and its surroundings is a tectonically complex region resulting from the collision of Arabian and Eurasian plates in the east, slab roll back along the Hellenic arc, and escape of the Anatolian plate along two transform faults, the North Anatolian Fault and East Anatolian Fault Zones. The entire region, because of the relatively high rates of deformation, has been subjected large devastating earthquakes, associated with fault zones, in the past and will be subjected to earthquakes in the future.

During the last decade, many of the permanent seismic networks in the region have been modernized, number of stations increased and their data became available to the whole scientific community. Data from these networks have led to improve event and source parameter determination and to derive a better picture of crust and upper mantle structure in the region.

The earthquake monitoring and seismic data acquisition infrastructure at Kandilli Observatory and Earthquake Research Institute (KOERI) provides data to monitor real time seismicity as a public service and gives opportunity to scientists to access high-quality digital seismic waveform database in SAC and Miniseed formats.

The Cyprus Seismic Network the Accelerometric Network and Strong Ground Motion

Kyriacos Solomi
Geological Survey Department, Nicosia, Cyprus

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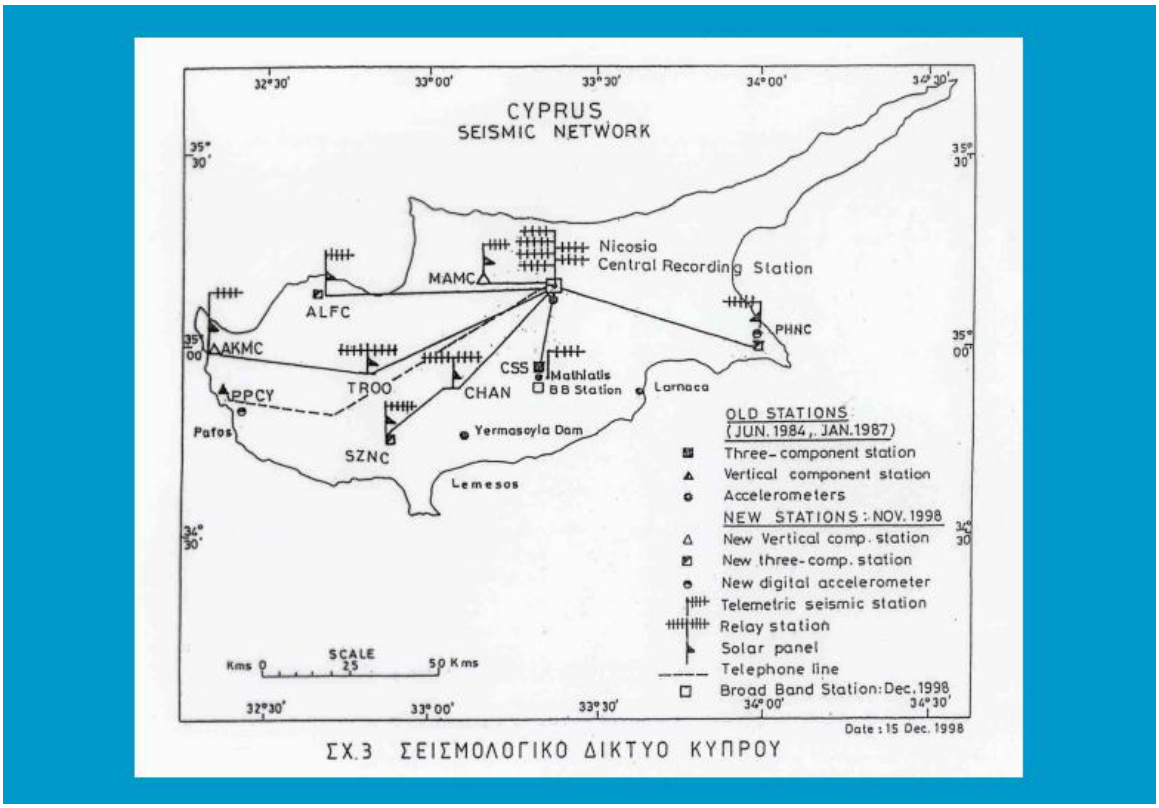


Seismicity along the Western Eurasia-Africa Plate Boundary

Mourad Bezzeghoud
Departamento de Física & Centro de Geofísica de Évora
Universidade de Évora, Portugal

The western part of the Eurasia-Africa plate boundary, with different tectonic features, extends from the Azores Islands to the Strait of Gibraltar. The interaction between Iberia and Africa results in a complex region located in the western part of the Eurasian-African plate boundary. This region corresponds to the transition from an oceanic boundary, to a continental boundary where Iberia and Africa collide. The change in the seismicity along the Azores-Gibraltar-Algeria Plate boundary zone confirms that the present plate movement is transtensional in the Azores, dextral along the Gloria transform and convergent between the SW Atlantic margin and the Ibero-Maghrebian zone. The convergence rate decreases west (Azores plateau) to east (Ibero-Maghrebian zone). The plate boundary is very well delimited in the oceanic part, from the Azores Islands along the Azores-Gibraltar fault to approximately 12ºW (west of the Strait of Gibraltar). From 12ºW to 3.5ºE, including the Iberia-African region and extending to the western part of Algeria, the boundary is more diffuse and forms a wider area of deformation (Buforn et al., 2004; Borges et al., 2007; Bezzeghoud et al., 2008). This is also reflected by the occurrence of historical and instrumental large earthquakes, in particular by the recent earthquakes occurred in the Azores Islands, off coast of South-Western Portugal and in Ibero-Maghrebian zone. In this study we discuss the segmentation and complexity of this plate boundary using seismicity and focal mechanisms of large earthquakes occurred in this region. Some strong earthquakes occurred in the studied area will be addressed.

Seismo-Volcanic Investigation of 2009 Swarms at Harrat Lunayyir (Ash Shaqah), Western Saudi Arabia

Abdullah M. Al-Amri & Mohammed S. Fnais
Dept. of Geology, King Saud University, Riyadh, Saudi Arabia

On 18th of April 2009 A.D., a swarm of earthquakes began in the eastern side of the Cenozoic lava field of Harrat Lunayyir and in the vicinity of the town of Al-Ays. Satellite imageries and aeromagnetic features of Harrat Lunayyir lava field were verified by comparison and integration from findings obtained from seismic data and from existing geologic and geographic information. A seismic sub-network was deployed around the volcanic area and local seismicity was undergo data processing and waveform modeling.

Analysis of the seismicity data in conjunction with aeromagnetic and geologic information indicates that the seismicity is shallow and the correlation of the epicentral distribution with the major tectonic features is, in general, quite good. The recent seismic activity indicates a cyclic pattern of events consisting of seismic minima which may represent episodes of accumulation of energy, and seismic maxima which represent the release of energy that can be accumulated to cause larger events in the future.

Analysis of available broadband seismic data indicates that focal mechanism solutions are normal faulting with two major structural trends of NE-SW and NW-SE which is consistent with the opening of the Red Sea and with broad-scale tectonics of the Arabian-African rifting as well as in good agreement with linear surface cracking observed in the affected areas.

Parkfield Earthquakes: Identical or Complementary?

Susana Custódio
Instituto Geofísico da Universidade de Coimbra

The idea that the Parkfield section of the San Andreas Fault, California, fails in identical consecutive earthquakes has been around since 1979. In order to test whether Parkfield earthquakes are characteristic we compare the spatial distribution of co-seismic slip distribution of the two most recent M w 6 events. We model the 1966 and 2004 Parkfield earthquakes from near-fault strong motion seismograms. The rupture models, as well as independent observations, indicate that slip during the 1966 and 2004 Parkfield earthquakes occurred in different regions of the fault. This result implies that regions of a fault that are frictionally locked may remain locked even during a main shock (moderate-size earthquake). In this scenario, large earthquakes occur when all the locked regions of a fault are "synchronized" and ready to slip at the same time.

Portuguese Tsunami Warning System

Maria Ana Baptista
University of Lisbon, Instituto Dom Luiz, Lisbon, Portugal

After the Sumatra tsunami of December 2004 the IOC-UNESCO decided to implement a global tsunami warning system in 4 broad areas: the Indian Ocean, the Pacific Ocean, the Caribbean and the North East Atlantic, Mediterranean and connected seas (NEAM).

The Pt TWS (Portuguese Tsunami warning system) is the central core for tsunami warning in the North East Atlantic area. The implementation of this system constitutes the natural response to the perception of tsunami hazard in the area.

The implementation of the PtTWS comprises. The sea level detection network: coastal tide stations and future ocean bottom tsunameters; the seismic detection network that includes up to now 35 broadband stations and the TAT – tsunami analysis tool.

The PtTWS (Portuguese tsunami warning system) is part of the NEA – North East Atlantic tsunami warning system.

Seismic Hazard Driven Seismological Research in Iran

Mohsen Ghafory-Ashtiany, M. Mokhtari and M. Tatar
International Institute of Earthquake Engineering and seismology (IIEES), Tehran, Iran

Iran as one of the very well known seismic active zone located between two Arabian and Eurasian plates with more than 140 strong earthquakes with magnitude of 7.5 or more in the past centuries, causing extensive human and economic losses. From 1990, specially after Manjil earthquake, to ensure the sustainable development of Iran a multidisciplinary risk reduction strategy with the objective of saving human lives and resources have been initiated. The implementation of this program had significant effect on Iran risk reduction. Seismological research with the objective of more reliable hazard assessment has been the main core of the scientific research needed for risk reduction.

International Institute of Earthquake Engineering and seismology (IIEES) as the main developer of "Iran Earthquake Research Strategy" with the consideration of the insufficient understanding and estimation of seismicity and seismic hazard of Iran have initiated a long term seismological research program with the following objectives:

- Real time Seismic Monitoring: Expansion of Seismic and GPS Networks.
- Understanding and modeling the Kinematic Characteristic of Iran.
- Mapping and Identifying the major active faults of Iran and major cities.
- Investigation of active tectonic of Alborz, Zagros and the transitional zone.
- Paleo-seismological study of main active faults.
- Microseismic and Crustal studies of Iran, specially active regions.
- Geodetic studies of Active area using GPS measurements.
- Revisiting the past major earthquakes.
- Research on mid-term and long-term earthquake prediction.
- Processing and detail analysis of the strong motion data recorded in Iran.
- Development of PGA and spectral value attenuation relationship for Iran.
- Development of detail seismic hazard zoning map of Tehran and major cities

The general outcome and use of the above mentioned projects in the area of seismology are: Better definition of crustal velocity structural beneath the Iranian plateau which resulted in better earthquakes location; Improve quality of the seismic source parameters (magnitude, location, etc.); Understanding the mechanism and rate of deformation; Determination of the seismogenic layer in active regions; Determination of the geometry and mechanism of the active faults; and finally more reliable assessments of active faults and sources and their seismicity.

To complete the process of reliable seismic hazard assessments, the development of the dense Strong Ground Motion network by BHRC of Iran and processing the rich Acceleration data bank was a major step. Following points are some of the outcomes: Developing reliable SGM attenuation relation; Reliable assessment of seismic hazard of Iran; Seismic hazard micro-zonation of major urban areas; Providing reliable design spectra for building codes; Expanding the research activities related to SGM; Providing inputs for developing of seismically compatible urban area planning; and Providing reliable input data for aseismic design of structures.

The paper provides an overview to the results of these extensive and comprehensive studies.

Local and Duration Magnitude Scales for Syria

R. Yassmineha, S. Bagha and M. Daouda
National Earthquake Center - Damascus – Syria

In the present work, we develop local and coda duration magnitude scales for Syria based on vertical and three-components short-period records of the Syrian National Seismological Network (SNSN). This study is motivated by the possibility of applying the computed scales to local earthquakes, as this region has been continuously monitored by 28 short period stations since the mid-1995s. Today, a significant number of earthquakes have been recorded by the network, allowing the calibration of the local magnitude scales by using local earthquakes recorded by the network in the period 1995-2008.

The magnitude scale $ML = \log A + \log(R/100) + 0.0089(R - 100) + 3 - S$ is derived for the network with the requirement that the correction S of station WRDH is zero. This scale is based on 2338 maximum amplitudes (273 earthquakes) computed from horizontal synthesized Wood-Anderson seismograms, in the range $0 \leq ML \leq 3.2$. The local magnitudes predicted by the new scale are used to calibrate magnitude scale based on total duration of the seismic events.

Finally, the reliability of the obtained magnitude scales and station corrections is assessed using Bootstrap analysis.

Contribution to the Spectral Attenuation of Strong Motions in Iran

Mehdi Zare
Associate Professor on Engineering Seismology,
International Institute of Earthquake Engineering and Seismology (IIEES), Tehran, I.R. Iran

The attenuation of strong ground motions are studied in the recent years in Iran. The Iranian strong motion data comprises a databank of more than 7000 three component accelerograms. In this article it is intended to introduce an overview on the performed studies since 15 years ago, and a focus on the spectral attenuation laws recently developed for Iran. These studies performed using Iranian strong motions database, and mainly using 2000 well recorded three components data (analog and digital). The teleseismic source parameters were available, or calculated by the records, for these 2000 accelerograms. Different methods of one-step and two-step regressions are applied, and the main focus in this article in on the one-step regression method. The spectral values of the recorded strong motions in Iran are used to derive the empirical attenuation laws for different response spectral ordinates at different site conditions. The empirical relationships are established for the spectral acceleration as the function of moment magnitude, hypocentral distances, and constant parameter representing the site conditions. The data set are recorded in 1975-2007. The attenuation coefficients are in general accordance with the different attenuation coefficients established for Iran. However, the spectral values, obtained here, are greater in comparison with those gained by the previous studies (1999 and 2006). The difference might be due to the selecting greater motions, recorded in the distances nearer to the seismic source. This may show the importance of specific near-source attenuation studies for Iran in the future steps as well as the attempt for developing the next-generation attenuation of strong motions for the country. The feasibility study for such models is started in Iran.

Geodetic Constraints on Arabia Plate Motion and Intra-Plate Deformation: Implications for Regional Geodynamics

Reilinger, R. [1], And Mcclusky, S., [1]; Arrajehi, A. [2], Mahmoud, S. [3], Rayan, A. [3]; Ogubazghi, G. [4] Sholan, J. [5]

[1] Department of Earth, Atmospheric, and Planetary Sciences, MIT, Cambridge, USA
[2] King Abdulaziz City For Science And Technology, Riyadh, Ksa;
[3] National Research Institute Of Astronomy And Geophysics, Helwan, Cairo, Egypt
[4],Asmara University, Asmara, Eritrea
[5], Seismological Observatory Center, Dhamar, Yemen

We are using the Global Positioning System GPS to monitor and quantify patterns and rates of tectonic and magmatic deformation associated with active rifting of the continental lithosphere and the transition to sea floor spreading in the Red Sea. Broad-scale motions of the Nubian and Arabian plates indicate coherent plate motion with internal deformation below the current resolution of our measurements 1 mm yr. The GPS-determined Euler vector for Arabia-Nubia is indistinguishable from the geologic Euler vector determined from marine magnetic anomalies, and Arabia-Eurasia relative motion from GPS is equal within uncertainties to relative motion determined from plate reconstructions. These observations indicate that Arabia plate motion has remained constant (±10%) during the past ~25 Ma when Arabia separated from Nubia. GPS survey profiles extending from the Red Sea coast in KSA show no resolvable motion relative to the Arabian Plate. This and the approximate agreement between broad-scale GPS rates of extension i.e., determined from relative plate motions and those determined from magnetic anomalies along the Red Sea rift imply that spreading in the central Red Sea is primarily confined to the central rift plus minus 10 hundred percent. In the southern Red Sea, GPS results are beginning to define the motion of the Danakil micro plate. We investigate and report on a model involving CCW rotation of the Danakil microplate relative to Nubia and magmatic inflation below the Afar Triple Junction that is consistent with available geodetic constraints. Extrapolating the GPS velocities back in time indicates that the Red Sea rift initiated around 25 Ma BP more or less simultaneously from the Gulf of Suez to the Afar Triple Junction, and that rifting transferred from the Gulf of Suez to predominantly left lateral strike slip faulting along the Gulf of Aqaba and Dead Sea fault system around 11 Ma BP.

The 2009 volcanic and seismic activity in Harrat Al-Shaqah (Lunayyir), western Saudi Arabia.

Hani Zahran and Salah El-Hadidy Yousef
Saudi Geological Survey, Jeddah, Saudi Arabia

Harrat Al-Shaqah is one of the recent volcanic provinces in western Saudi Arabia, (also known as Harrat Lunayyir). Recently, it has suffered from an intense earthquake swarm due to magmatic intrusion activity. Numerous small to moderate-size earthquakes in May-July 2009 have been recorded by Saudi National Seismic Network (SNSN) operated by Saudi Geological Survey (SGS). More than 27,000 earthquakes have occurred, of which 207 were felt in and around Harrat Al-Ahaqah, up to distances of more than 210 km. The most intense activity was on 17-19 May when a ML 5.39 earthquake occurred.

The Saudi Geological Survey has studied in detail several phenomena associated with this magmatic activity, including surface fractures, radon and CO2 measurements, geothermal activity, geodetic measurements, and the spatial and temporal distribution of the recorded earthquakes, the estimation of a one dimensional velocity model using recorded events and fault plane solutions of the largest recorded earthquakes, in addition to analyzing satellite radar interferograms (InSAR) data.

Satellite radar interferograms (InSAR) spanning the activity in mid-May exhibit strong deformation that extends across a large area, showing over a meter of WSW-ENE extension. In addition, the data show clear signs of surface faulting and a graben-like subsidence in the middle of the deformed area. The subsidence exceeds 50 cm and is in good agreement with geologic field observations that have been done by the SGS.

Fault plane solutions for the largest events that have been recorded at Harrat Al-Shaqah show pure normal faulting in most cases and normal faulting with a small strike-slip component in some other events. The regional stress field deduced from the focal mechanisms of selected events indicates NE – SW tension, which is in a good agreement with the dike modeling and observed geological features associated with the recent earthquake activity in Harrat Al-Shaqah.

It is concluded that the deformation appears to be caused by a near-vertical dike intrusion with a NW-SE orientation. The dike caused faulting on graben-forming normal faults. The shallowest part of the dike appears to have reached within about 5 km of the surface, right below where the graben is the narrowest and under an area with a number of cinder cones from previous volcanic events. The dike appears to have continued to grow after the initial strong phase of activity in mid-May, as a deformation interferogram spanning the time period from the end of May until early July shows a similar deformation pattern, although with a much smaller amplitude. This continuing activity is also manifested in several earthquakes with magnitude larger than 4 that took place from late May until early July.

The Seismicity in the Region of Agadir, South West of Morocco

Jabour Nacer & Menzhi Mohammed
National Geophysical Institute, CNRST, Rabat, Morocco

The Maghreb-Iberia and adjacent oceanic areas are characterized by a diffused seismicity due to the convergence of the African and Eurasian plates and are continuously being shaped by their collision. The region of Agadir is situated on the southern limit of the continental deformed Atlas region of Morocco.

Even if this region is some what far from the schematic plates boundary, it is close to their relative pole of rotation hence showing a particular type of seismic behavior. This region is pronouncing a sequential seismic pulsing from surficial layers. This seismic activity is analyzed with regard to seismicity models used for the characterization of seismogenetic zones.

Although the occurrence of the 1960 February 29th damaging earthquake in Agadir, M=5.9, seismicity catalogues contain few indications about the foreshocks and aftershocks of the 1960 earthquake with approximately the same geographical coordinates until 1967 where the epicenters started to shift off shore and into the interior of the continent owing to the installation of new seismic stations, this shift is interpreted in terms of seismicity migration of the instability fronts.

The spatial distribution of the seismic activity can be used to draw the contours of a seismic gap centred on the city of Agadir. This seismic gap corresponds to the seismogenetic zone that produced the earthquake of 1960.

In this study, we attempted to identify the different phases of a seismic cycle that can fit the seismicity of the region considering of course the geological setting and the historical seismicity.

The analysis of the focal mechanisms available for this region is more ambiguous. The most amazing observation is the change of the stress field for the 1960 earthquake and its back deviation for a predictable direction for the rest of events, which may suggest that a major earthquake in the region of Agadir is just a secondary effect of the major plates convergence.

Finally, this study may emphasize some new factors to any scheme for the assessment of the seismic hazard in the Agadir region with regard to the seismic cycles observation.

Seismic Data Acquisition (SDA), the Israel Seismic Network: a tool for permanent and portable seismic measurements

Veronic Avirav and Avi Shapira
Geophysical Inst. of Israel, Lod, Israel

GII-SDA system was designed by the GII Seismology Division for seismic data acquisition on personal computers. The program was written by Veronic Avirav, in Pascal Language, under the guidance of Dr. Avi Shapira. The system is a modified version of the Israel Seismic Data Acquisition Network (ISDA) (Shapira and Avirav, 1990), which was also developed by the GII Seismology Division and adapted for use on PCs. New options have been added to the PC-SDA system for work on various special projects. The system can use up to six different algorithms when logging a seismic event, i.e., seismic events are registered using a triggering system. GII-SDA can operate several triggering systems in parallel, provided each system is specified by the corresponding algorithm, the channels included and the parameters required to operate the respective algorithm. GII-SDA is synchronized to international time (UTC) through a GPS satellite receiving system and dedicated software. The system is synchronized automatically at predetermined intervals (generally 3 to 10 minutes). Seismic channels are sampled using an A/D unit adapted to use with a PC. The Seismology Division operates two types of GII-SDA system using PCMCIA card: 1) 8 channels differential input or 16 channels single ended input; 2) 16 bits per sample, 64 channels.

FEMA-HAZUS software exporting study for the seismic risk evaluation on the new and old cities of Tunis.

Najla Bouden Romdhane[1] and Ahmed Ksentini[2]
[1] Ecole Nationale d'Ingénieurs de Tunis
[2] Institut Supérieur des Sciences Appliquées et Technologiques de Gabès, Tunisia

The seismic risk estimation can be made using earthquake damage models. In this case, the Federal Emergency Management Agency (FEMA-US) methodology is adopted for the new and old city (medina) of Tunis district. Hazus Software based on geographical information system GIS was used in order to calculate, map and display earthquake direct loss data for buildings.

In this work, hazard curves (PGA and spectral acceleration for short and long periods) were combined on GIS with local buildings data such as number of stories, age, geometry…, to analyze vulnerability of exposures. In order to best describe building response, capacity curves for push over analysis proposed by Hazus were revised to fit the Tunisian local building scheme. For this task, representative plans and drafts of each class of buildings were introduced under CSI-SAP 2000 program. Push over analysis was made for every building with different number of stories using ATC-40 for concrete buildings and FEMA 273 for steel buildings to define lateral loads and plastic hinges localization. Capacity curves are then plotted to compare them with Hazus proposed curves. Also the occupancy and building type relation was modified in order to represent the Tunisian building scheme under Hazus. The seismic scenario was then run under local ground motion calculated with the probabilistic method and using new capacity curves for each class of building (concrete, steel and masonry). Estimated potential earthquake losses are finally plotted under GIS to define zones at risk and to plan for risk mitigation.

Revised Seismic Microzonation of the City of Makkah, Kingdom of Saudi Arabia

M. A. El-Difrawy and T. A. Mokhtar
Geological Phenomena Studies Unit, Faculty of Earth Sciences, King Abdulaziz University, Jeddah, Saudi Arabia

A detailed, homogeneous, high quality database for shear wave velocities (Vs) of the soils of the city of Makkah down to a depth of 30 meters (Vs30) was built to be used in NEHRP-IBC soil classification, seismic microzonation, and in related geotechnical investigations. The very special nature of the city of Makkah, with cultural activities going on day and night, required applying the unconventional, relatively new, but well established, refraction microtremor (RM) technique which is a passive, non-invasive technique that is expedient, accurate, and urban friendly. This technique uses, as its energy source, ambient vibrations (microtremors) that travel through the ground mainly in the form of Rayleigh waves. These dispersive waves are analyzed to extract phase velocities that can be modeled into shear wave velocity profiles down to various depth levels, sometimes reaching 100m.

The ~95km2 area chosen for detailed soil investigation encompasses almost all of the city of Makkah and is inhabited, built-up, and mostly occupied by soft Quaternary deposits overlying basement rocks. RM measurements were carried at 1206 sites with inter-site spacing ranging from few tens of meters to ~400 meters. The RM-based Vs depth profiles were then input to a one-dimensional (1D) spectral soil response modeling routine to obtain the fundamental resonance frequency and corresponding maximum relative amplification. We also carried measurements at selected sites using the microtremor spectral ratio (H/V) technique, with the aim of comparing field observed soil responses with those obtained by 1D modeling to infer the absence or potential presence of two- (2D) or three-dimensional (3D) soil response effects.

Based on the RM-modeled average Vs (Vs30), we produced a 1:25,000 NEHRP-IBC-complying soil zonation map for the city of Makkah. The soil map indicated that the soils of the inhabited wadis of Makkah fall within the NEHRP-IBC "B" and "C" soil classes, with the most southwestern part of the investigated area being closer to soil class "D". The sites measured within the Al Utaibiyyah District, the scene of the 1426H localized seismic phenomenon, revealed the unexpected finding that the district, located over exposed basement rocks, is underlain by a thick weak soil down to a depth exceeding 30m.

Based on the 1D-modeled soil responses, we also produced 1:25,000 fundamental resonance frequency and corresponding maximum relative amplification maps. The maps indicated that parts of the wadis in Makkah had fundamental resonance frequencies between ~4-10Hz and could amplify bedrock ground motion as much as 8. This indicated that the 1-5 storey building stock in Makkah are vulnerable to hazardous resonant shaking from local and near earthquakes that could be generated by potentially active seismogenic zones less than 30Km northeast of the Holy Mosque. This explained the response of buildings to shallow, local, high frequency seismic event of Al Utaibiyyah District. It also explained the noticeable shaking the low-rise buildings of the city underwent during the small magnitude event (~ 3.6) that occurred 30Km northeast of the city center at AlSharai'a area, and pointed to the potential hazard that vibrations from construction explosions and heavy construction machinery might inflect. Further, comparisons between H/V field measurements and RM-based 1D soil response models indicated that 2D and even 3D soil response effects might be important in the wadis of Makkah due to basin and topographic effects. Accounting for these effects can be achieved by a complete, elastic, 3D seismic wavefield simulation which is now possible with the advent of low-cost, high-performance computing facilities.

Oilfields in Kuwait Source of Seismic Hazard

Abdullah Al-Enezi and Reda Abdul Fatah
Kuwait Institute for Scientific Research

Kuwait is one of the main oil producers worldwide. It is planning for significant expansion of its crude oil and gas production capacity and aims to increase its output at most of its oil fields. . In Kuwait, earthquake activity has been observed within the oilfields since September, 1976. Establishment of Kuwait National Seismic Network (KNSN) in March, 1997 by Kuwait Institute for Scientific Research (KISR), allowed for more seismic events detection. The monitoring of seismic activities its very useful for The assessment of seismic hazard. In short term, hazard assessment will inform responsible such as policy makers engineers in the oiolfields, governments, civil defense official and urban planners the degree of hazards posed by earthquakes.

In this study, we have begun to improve seismic hazard assessment in Kuwait. The project used existing catalog and waveform data to estimate seismic hazard assessment parameters and improve understanding of seismic events in Kuwait. The Kuwait National Seismic Network (KNSN) in Kuwait Institute for Scientific Research (KISR) recorded about 900 local earthquakes from March 1997 to July. 2009. A large portion of these earthquakes was located within the oil fields. In particular, in Sabiriyah, Raudhatain and Bahra oil fields in the north and in Minagish, Umm Gudair, Wafra, Abduliyah and Dharif oil fields in the south. The magnitude (ML) of these earthquakes ranges from 0.3 to 4.8 and occurred at depth ranging from 3.3 to 28 km (Fig. 1).

A preliminary seismic velocity model for the crust and upper mantle was identified in the first phase of the project. This model is useful to improve local and regional earthquake locations and depths. The resulting model shows low velocities near the surface, consistent with known sedimentary structure. The Moho is likely to be transitional from between 30-40 km. The large velocity increase around 15 km depth is likely to be an artifact.

Deterministic seismic hazard map shows that Kuwait has maximum PGA value 60 gal, while the seismic hazard map for 2 % probabilities of exceedance in a 50 year shows that the maximum PGA value 20 gal. The potential sources of hazard in Kuwait is the southwest near by the Minagish and Umm Qudair fields (Fig 2).

Figure 1. Seismic Event recorded by Kuwait National Seismic Network (KNSN) for the period 1997-2009.

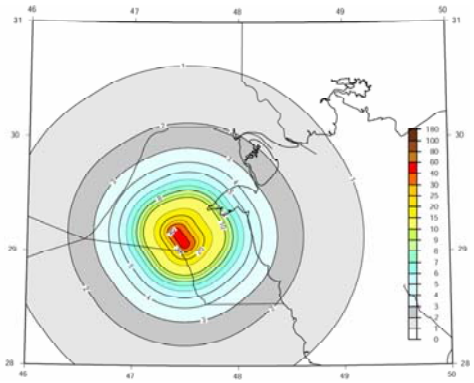
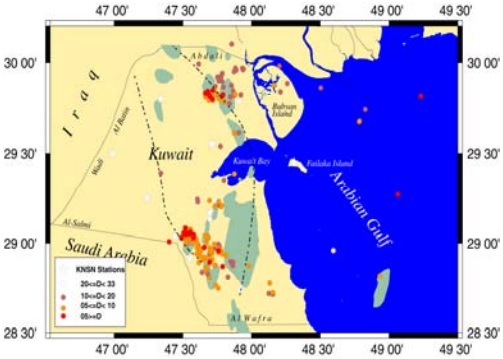


Figure 2. Deterministic seismic hazard map for a magnitude 6.5 Minagish earthquake: Peak ground accelerations (PGA).



A main earthquake catalog in Northern Algeria from 856 to 2008

M. Hamdache [1], J.A. Peláez [2], A. Talbi [1], M.A. Ureña [3] and M.T. García-Hernández [2]
[1] Departement Etudes et Surveillance Sismique, CRAAG, Bouzareah, Algiers, Algeria
[2] Dpt. of Physics, University of Jaén, Campus de Las Lagunillas, Jaén, Spain
[3] Dpt. of Cartographic Engineering, Geodesy and Photogrammetry, University of Jaén, Campus de Las Lagunillas, Jaén, Spain

A homogeneous and reliable earthquake catalog is highly desirable to conduct seismic hazard studies. In this work a great effort has been invested in the compilation of a main earthquake catalog for Northern Algeria and surrounding area, as complete and homogeneous as possible, with the aim of updating probabilistic seismic hazard values in this area.

Our goal was to catalog all known events from every available published source for the area between 3ºW to 10ºE and 32ºN to 38ºN, including North-westernmost Morocco, North-easternmost Tunisia and South-easternmost Spain.

We have obtained an uniform catalog using the moment magnitude scale. To compile it, several empirical relationships between reported magnitude, macroseismic intensity and moment magnitude have been used. Finally, all the dependent events have been removed using the Gadner and Knopoff declustering procedure with appropriate values for time and space windows. By removing events with magnitude less than 2.0, the final database covers the time span since 856 to 2008, including more than 4000 events.

The Poissonian character has been analyzed for different threshold magnitudes to derive the appropriate time period with constant activity rate. The completeness period and the threshold magnitude of completeness have also been studied in depth.

Microtremor Measurement for Seismic Hazard Assessment in urban areas: Examples from Israel

Zaslavsky, Y.,[1], Shapira, A.,[2], Hofstetter, A., [1], Ataev, G., [1], Gorstein, M. , [1], Aksinenko, T. [1], Kalmanovich, M. [1], and Perelman, N. [1].

[1] Seismology Division, Geophysical Institute of Israel, Lod Israel.
[2] Earthquakes Preparedness Committee, Ministry of National Infrastructure, Jerusalem, Israel

Ground motion amplifications due to soft soils, common in urban areas, are a major contributor to increasing damage and number of casualties. The great variability in the subsurface conditions across a town/city and the relatively high costs associated with obtaining the appropriate information about the subsurface, strongly limit proper hazard assessments. Direct information from strong motion recordings in urban areas is usually unavailable. Such is the situation in Israel which has population centers in close proximity to the seismically active Dead Sea Fault system, capable of generating earthquakes with magnitude as high as 7.5.

Heavily limited with relevant local recordings of strong ground motions, we adhere to the use of simplified modelling of the earthquake processes. More precisely, we generate synthetic spectra of the expected ground notions by implementing the so called Stochastic Approach (e.g. Boore, 2000), in which we integrate analytical models to determine the nonlinear response of the site under investigation that requires modelling of subsurface. Then, Monte-Carlo simulations are used to obtain the uniform hazard, site-specific acceleration spectrum.

Over the years, we have conducted site investigations in several thousands of sites across Israel. These investigations demonstrate the usefulness of using horizontal-to-vertical (H/V) spectra of ambient noise measurements to identify sites with high potential for being vulnerable to amplification effects and characterize the sites with respect to their expected resonance frequencies and the corresponding H/V levels. This information, together with any available geological, geotechnical and geophysical information, helps building a reliable model of the subsurface, which is then integrated in the processes of the seismic hazard assessment.

At the final stage of the hazard assessment process, we divide the study region into zones of similar hazard characteristics, which are used for earthquake scenarios and better represent the design acceleration spectra for safer buildings.

Vulnerability Index of Algiers Masonry Buildings

Mehdi Boukri
Head of "Vulnerability and Seismic Risk in Urban Areas" Research and Study Team
National Centre for Applied Research on Earthquake Engineering, Algiers, Algeria

In Algeria, the seismic risk threat the large cities, and more particularly the Algiers Metropolitan City which contains a very old urban nuclei mainly made up of masonry buildings (stone and/or brick). The expertises carried out on this kind of structures showed the low resistance of this type of construction towards seismic action. The study of the seismic vulnerability of masonry buildings is thus of topicality and constitutes a fundamental stage for the reduction of the losses due to earthquakes in this city. This vulnerability can be reduced if preventive measures are taken. In this work, we will present an estimate of the vulnerability degree of Algiers masonry buildings by using the “Vulnerability Index Method”. This one will allow us to evaluate the seismic vulnerability of these buildings then to carry out their classification according to their seismic quality.

New Earthquake Parameters from Old Bulletins and Seismograms

J. Batlló[1], D. Stich[2], M. P. Teves Costa[1,3] and R. Macià [4]

[1] Universidade de Lisboa, CGUL-IDL, Lisboa, Portugal
[2] FCUL-DEGGE, Lisboa, Portugal
[3] Instituto Andaluz de Geofísica, UGR, Granada, Spain
[4] Dept. Matemàtica Aplicada II, UPC, Barcelona, Spain

The Iberian Peninsula and other parts of the Euro-Mediterranean region are areas of moderate seismicity. As a consequence, modern digital recordings of earthquakes that are comparable in magnitude to those that have occurred historically are not always available, and that would not permit an in-depth analysis of the seismic sources, fundamental for a range of subsequent studies; hazard and risk assessment among them. An alternative to this situation is the recovery, analysis and study of old analogue records of past earthquakes. Such approach significantly enlarges our period of observation and new and valuable information on the events of our interest can be retrieved. Such kind of analysis implies the development of techniques and methodologies to handle the sequence from the old analog records to the analysis of the waveforms with the available modern digital tools. The results obtained in the last years for some of the most important earthquakes occurred in the Iberian Peninsula on the first half of the XX century are presented. Also, the implication of these results for the regional seismicity understanding and new developments are pointed.

Wave propagation modeling in viscoelastic media: application to sedimentary basin of Tunis

A. Dhemaied [1,2], N. Bouden-Romdhane [1] F. Rejiba [2], C. Camerlynck [2], L. Bodet [3], R. Guérin [2]

[1] URIG, Ecole Nationale d'Ingénieurs de Tunis, Tunisie
[2] UMR 7619 Sisyphe, Université Pierre et Marie Curie-Paris6, France
[3] UMR 6112, Université du Maine, France

We develop a finite difference time domain code to simulate wave propagation in two dimensional viscoelastic media. It is an essential tool to understand the kinecmatic and dynamic propreties of seismic waves propagating through models of the crust. Furthermore, knowledge of a sedimentary basin response plays an important role in the study of seismic effects. This work joins within the general framework of the studies led for the evaluation of the seismic risk of the city of Tunis. The code is planed for both seismological and engineering applications. The method used is based on the first-order velocity stress formulation of the 2D P-SV wave equation. The anelasticity is introduced using a Generalized Maxwell Body (GMB) with L-Maxwell Bodies, and we achieve a constant quality factor Q between 2 and 25 Hz. A crucial step for the numerical validation is to evaluate both numerical dispersion and physical dispersion due to anelasticity and layered structure. For numerical modeling of seismic wave propagation in unbounded media, we implement and validate the convolutional perfectly matched layer (CPML) for a dispersive background. We then compare the results performed by our code with (i) analytical, (ii) canonical solutions (weathered-layer model, 90 degree corner model) and (iii) experimental results acquired on small scale aluminium device. Finally, we present preliminary results performed on the sedimentary basin of Tunis.

Thus, the implemented code reveals itself as a robust tool to predict wave propagation in earth materials.

Investigation of topographic effects and seismic hazard assessment: Hadassa En Kerem hospital

Hofstetter, R., Zaslavsky, Y., and Perelman, N.
Seismology Division, Geophysical Institute of Israel, Lod, Israel.

Topographic amplifications may occur on hills and steep slopes. These effects may be significant in terms of damage due to local and regional earthquakes, depending on the resonance frequencies of the ridge site relative to the natural frequencies of the buildings on the site, especially, when geological complexities may be also involved.

Field experiments were performed in order to obtain data needed to study the effect of topography on seismic motion. Three digital recording seismic stations were deployed at the crest and base of Hadassah hill.

Twenty-seven local and two regional earthquakes with magnitude varying from 2.1 up to 4.1 at epicenter distances of 40-450 km were recorded at the period between April 16, and June 29, 2008. The earthquake waveforms data were analyzed using two different approaches: 1) horizontal-to-vertical (H/V) S-wave spectral ratio (receiver function); and 2) S-wave spectral ratio for two horizontal components of motion with respect to reference site.

Average H/V spectral ratios are computed from S-wave window for Stations 1 and 2 located on the top of Hadassah hill exhibit peaks near 1.3 and 2.0 Hz with amplitudes reaching 3 and 6, respectively. These are interpreted as resonance frequencies attributed to the effect of topography. The comparison between the results obtained from the H/V and the reference site methods, suggest that both the methods are able to point out the same fundamental frequencies of the hill.

The empirical transfer function obtained from average receiver function was simulated analytically by a linear model, which, in turn, was integrated into the Stochastic Estimation of Seismic Hazard procedure (Shapira and van Eck, 1993, Natural Hazard, 8, 201-215). The seismic hazard is defined in terms of Uniform Hazard Acceleration Response Spectrum for a probability of exceedence of 10% during an exposure time of 50 years and a damping ratio of 5 %. These probabilistic criteria are identical to the requirements set for the Israel Standard 413. The shape of the spectra obtained for Hadassah En Kerem Hospital differs significantly from those prescribed by IS-413, as the latter underestimates the accelerations in the period range from 0.3 to 2.0 sec.

The widely accepted opinion, that structures built directly on a hard rock site are less vulnerable to damaging ground motion than those built on sedimentary deposits, could be a misleading generalization. In some cases, the effect of topography on seismic motion can be larger than the effects of surface geology.

Aqaba Microzonation study, Jordan

Tareq Al-Hadid
Building Research Center (BRC), Royal Scientific Society (RSS) Al-Jubaiha, Jordan

Aqaba is the sole port of Jordan with a major importance to Jordan as a port as well as being an industrial center and a hub for a quickly developing tourist industry. Due to its economic importance the Jordanian Government set Aqaba as a Special Economic Zone.

Therefore, stemming from the objective of saving lives in the event of an earthquake, it was decided to carry out a microzonation study for the city in order that the results of the study would be utilized by structural engineers to design and construct safer buildings. An accurate evaluation of the site responses across Aqaba city to seismic ground motion is very important for urban developments, safer design of buildings and to the mitigation of the earthquake risk.

This paper include the results of a complicated geological structure with many faults, ambient vibration measurements, design response spectra for the studied area and microzonation map for Aqaba city.

It is important to mentioned that the maximum spectral acceleration in the northern area, is equal to1.12 g for deep and shallow alluvium sand deposits. Whereas, the maximum spectral acceleration in the southern area is equal to 0.98g for alluvium sand and beach deposits, and 0.7 g in Pleistocene gravel.

Vibration Modes, Frequency and Damping of the Al-Mujib Bridge

Naser, M. F. [1] and Darweesh, J. [2]
[1] Natural Resources Authority (NRA), Jordan Seismological Observatory (JSO), Amman – Jordan
[2] Natural Resources Authority (NRA), Director General Assistant for Geological Survey, Amman - Jordan

Recently built Al-Mujib bridge exposed Jun. 12, 2001 to enlargement of shaking that caused serious damages to all four span basement joints and partially failure of southern span. Special attention was made through on site recording of the bridge free oscillation in purpose to evaluate bridge dynamic characteristics as well as the surface geology of the Mujib delta. Data were obtained in two stages, few days following the Al-Mujib bridge incidence, and later on after the bridge being initially repaired and opened for light usual traffic prior to the installation of span – foundation rubber joints. First stage records were processed, analyzed and interpreted at the LGIT laboratory of Fourier University in Grenoble – France. Second stage records were processed, analyzed and interpreted at the JSO laboratory using improved and more reliable SEISPECT software. Damping factors of both bridge longitudinal and transverse directions were calculated using half-width band method (Dunand F. 2001). Analysis of both stages of bridge records nearly gave same results of bridge fundamental modes (1.80 – 1.92 Hz) and damping factors that varied from 0.06 to 0.13. Comparison between noisy and quit records revealed that only south pile records shows clear elongations with maximum recorded transverse elongation of 20% relative to both mid - span and north pile records. Much less elongation relative to the elongation attributed to transverse vibrations also found on both longitudinal and vertical records obtained next to the southern pile.

Records of both northern and southern Al Mujib delta were obtained at tow locations, at approximately 300 m away to the north and southward from the bridge structure. Analytical results of both delta ground records shows that each delta have different vibration characteristics and the response of both delta to wave amplification found different. Southern delta dominant mode found at 1.68 Hz while the northern delta dominant mode found at 1.37 Hz. Based on the analytical results of both ground and bridge records, it seems that the bridge southern pile fundamental mode decreases to the amount of 1.81Hz that lie within the frequency domain of southern delta dominant mode of 1.68 Hz when ever bridge subjected to high amplitude of vibration caused by heavy traffics.

The relationship between recorded earthquakes and shear zone mineralization in central and south Eastern Desert of Egypt

El-Sayed Mohamed Salem
Egyptian Geological Survey

There are many types of mineral deposits in central and south Eastern Desert of Egypt. This article deals with the shear zone mineralization. Since the establishment of the Egyptian Geological Survey in 1896, the exploration for mineral occurrences are in most cases associated with the location of veins, veinlets and lenses occupying pre-existing fractures. It is the first time and an empirical trial in Egypt to note the relationship among recorded earthquakes, geological features related to earthquakes and mineralized zones, the relationship between mineralization and seismicity is an indirect relation, it is hoped to help with the location of mineral occurrences because they are controlled by structural trends. Recorded earthquakes play important role in the evaluation of the weak areas of the crust; the release of stress is concentrated at active regions and located along zones of lowest strength, especially ancient highly tectonic areas.

The results revealed that the area was affected by several tectonic movements. The distribution of earthquakes through the period 1900-2008 was represented by two categories the first is cluster of earthquakes with low rank of mineralization and the second is scattered earthquakes reflecting the existence of shear mineralization which located along paleo-tectonic trends, it was the environment of high permeability zones, where fluid flux intruded the paleo-fractures. The scattered recent recorded earthquakes indicate the probability of occurrence of gold deposits, the identification of paleo-aftershocks area is very important because it is expected area for mineral deposits of shear type. The best occurrences for mineralization are concentrated at the end, bend, intersection of faults and ancient tension sites. The highly paleo-tectonic areas are responsible of attenuation and distortion of seismic waves in southern portion of Eastern Desert of Egypt during the recording of earthquakes. The geological features related to ancient earthquakes such as paleo-liquefaction, potential active faults and paleo-landslides show the probability of occurrences of shear mineralization is higher.

The technique of exploration of gold deposits in Egypt according to the response of the area to the distribution of earthquakes leaves the door open for additional field observations and more seismic data.

Open source software for seismic processing

Keith K. Nakanishi, [1], Arthur Rodgers, Jr. [2], Rengin Gok [2],
[1] Independent consultant
[2] Lawrence Livermore National Laboratory, Livermore, CA, USA

There is widespread availability of software appropriate for seismic analysis available for downloading from the worldwide web as well as data. The software is, for the most part, either freeware or shareware and, more importantly, open-source, which make source code available and easily modified to make it appropriate for your application. In addition to processing software, computer operating systems, particularly Linux are also available as well as a number of data resources.

There has been excellent progress in computer operating systems for desktop computers and the latest distributions of Linux offer different graphics user interfaces (such as Gnome and KDE), Open Office (an integrated package incorporating a word processor, spreadsheet, presentation, and data base), and a wide variety of compilers, typically C/C++, Java, and gfortran. Most distributions have advanced installers which allow preparing your desktop computer for multiple boot, installing the operating system and configuration/update based on your hardware configuration. Typically networking is required for the setup and setting up of the graphics interface requires the most attention.

Most seismic analysis packages can be installed on either Windows or Linux operating systems. In Windows, this can be done natively, such as utilized by Seisan, or through Cygwin, which is the route taken by Dr. Bob Herrmann's CPS package, or SAC. There are Linux packages, such as Ubuntu, which allow installation within Windows, similar to what is done with Cygwin.

This presentation will be in three parts. The first is on the Linux and Windows/Cygwin systems. The second part of the presentation will discuss data processing packages that are openly available. The third part will review the availability of seismic data over the internet.

Proposal for a Website for RELEMR Seismic Waveform Data Exchange

Keith K. Nakanishi
Independent consultant

UNESCO's Reduction of Earthquake Losses in the Extended Mediterranean Region (RELEMR) program improves the understanding of earthquakes and seismic hazards in the region. Recently, a RELEMR meeting on "Data Exchange and Analysis for Earthquakes in the Dead Sea Rift and the Zagros Mountains" was held in Istanbul, Turkey, May 27-29, 2008. The purpose of this meeting was to analyze contributed waveform data from institutions operating seismic networks in the region. A set of 24 earthquakes in the region was determined and data were requested in advance of the meeting. Participation was excellent, involving contributions from over ten networks.

During the discussion session on the last day, an idea emerged for a website to facilitate exchange of seismic data. The purpose of this website would be to allow participating RELEMR institutions exchange seismic waveform data for future events. This document describes a proposal for such a website and summarizes the administrative and technical issues facing such an enterprise. Because of several substantial challenges, a measured (step-wise) approach is suggested. A framework for the discussion of building and maintaining website is presented.

Technical Details

A RELEMR Data Exchange Website (RDEW) is proposed to serve as a virtual data library for RELEMR participants to exchange seismic waveform data for events of interest in the region. This will serve as a centralized location, accessible from everywhere where RELEMR participants can contribute and obtain data. It is expected that events will be selected by some process to be decided by the RELEMR community, probably satisfying some criteria (e.g. location, magnitude). Participants will be informed that an event has occurred satisfying the exchange criteria. A separate webpage within the RDEW will be created by the website host(s) for this event, allowing participants to contribute and access data specifically for this event.

The RDEW will have to have the following properties:

1) The website must be hosted at a site where it may be accessed by all participating countries.

2) The website must be hosted at a site where the internet bandwidth is sufficient to transfer large files (up to 100 Megabytes). Note that limitations in bandwidth on the client side cannot be addressed. We may discover that efforts must be made to make data files smaller to facilitate access.

3) The website must have a password protected area that is accessible only to RELEMR participating institutions.

4) The website must allow both upload and download operations, so participants can upload data from their institutions and download data from other institutions.

5) The data must be available on-line so that it can be accessed through the website. If due to storage or other issues, the data is stored off-line, a provision must be made to make the off-line data available in a reasonable amount of time.

Administrative Details

There are at least two broad administrative details to resolve: 1) determination of criteria for selecting events for which to share data; and 2) institutional permissions for data exchange.

The criteria for selecting events for which to share data must be considered in terms of the consequences. The criteria can involve set rules based on location (latitude, longitude, depth) and magnitude from an acceptable near real-time catalog (such as the EMSC or USGS-PDE), or by a consensus of participants (e.g. voting). If a broad selection criteria are set (say events with magnitudes, M, greater than 4.0, then there will be many events to consider and this will place a significant workload burden on the website host(s) as well as the participants. If the criteria are set too stringent, say events with M>5.5, there will be few events. It will probably come done to a hybrid solution where events above a certain magnitude in the region will be considered and voted on by the participating institutions. For smaller events, institutions can nominate events for consideration by the group. Note that participating institutions could elect not to contribute data for events that are too distant and/or small to provide useful signals at their network. All data should be reviewed for quality control purposes by participating institutions before uploading.

It is known that participating institutions have different policies on data sharing and exchange. Each institution will have to follow guidelines and obtain permission for the proposed RDEW activity. It was discussed at the Istanbul workshop that data exchange would be easier for some institutions if UNESCO provided a formal request to each institutes's director. This will likely place an undue burden on UNSECO. We propose that the issue of data exchange permissions be taken up at a future RELEMR meeting. In order to defer this issue until resolved by participants and test the technical capability of the website, we propose that after the website is created participants upload their data from one of the events exchanged at the Istanbul workshop because permission to share these data with RELEMR participants was previously obtained.

A trial website should be made which would allow data upload and download with password protection to test the concept for RELEMR organizations. The feasibility of this proposal can then be evaluated and a decision can be made by the RELEMR participants to proceed with the website.

RELEMR PROGRAMME
Reducing Earthquake Losses in the Extended Mediterranean Region

WORKSHOP
ON SEISMICITY AND EARTHQUAKE ENGINEERING IN THE EXTENDED MEDITERRANEAN REGION

Luso-American Foundation, 26-29 October 2009

LISBON BEFORE AND AFTER THE 1755 EARTHQUAKE
Effects on the urban and building technologies evolution

- Guidebook for the field trip -

Lisbon Patriarcal after the 1755 Earthquake

Lisbon's Reconstruction Plan after the 1755 Earthquake (Eugénio dos Santos)

Isabel Pais

FIELD TRIP ORGANIZATION TEAM

From Lisbon City Council (Câmara Municipal de Lisboa - CML):

Ana Cristina Leite (Historian), Head of Division (Divisão Museus e Palácios)

Ana Esteves (Engineer), Director of the Mouraria Project Unit (Unidade de Projecto da Mouraria)

Ana Paula Cunha (Architect), Director of the Baixa-Chiado Project Unit (Unidade de Projecto da Baixa Chiado)

Clara Vieira (Architect), Baixa-Chiado Project Unit (Unidade de Projecto da Baixa-Chiado)

Eva Leitão (Archaeologist), Divisão Museus e Palácios

Joaquim Mendonça Dias (Sociologist), Departamento de Reabilitação e Gestão de Unidades de Projecto

Jorge Catarino Tavares (Architect), Municipal Director, Direcção Municipal de Conservação e Reabilitação Urbana

Luís Braga (Architect), Mouraria Project Unit (Unidade de Projecto da Mouraria)

Luís Ruivo (Architect), Director of the Alfama Project Unit (Unidade de Projecto de Alfama)

Mafalda Enes Dias (Historian), Baixa-Chiado Project Unit (Unidade de Projecto da Baixa Chiado)

Margarida Bastos (Historian), Divisão Museus e Palácios

Nuno Brito (Architect), Alfama Project Unit (Unidade de Projecto de Alfama)

Nuno Morais (Architect), Director, Departamento de Reabilitação e Gestão de Unidades de Projecto

Nuno Correia (Engineer), Alfama Project Unit (Unidade de Projecto de Alfama)

Paulo Silva (Architect), Departamento do Património Imobiliário

Pedro Monteiro (Engineer), Baixa-Chiado Project Unit (Unidade de Projecto da Baixa Chiado)

Rodrigo Banha da Silva (Archaeologist), Roman Theatre Museum and Archeological Centre (Núcleo Museológico do Teatro Romano), Divisão Museus e Palácios

Rui Matos (Historian), Alfama Project Unit (Unidade de Projecto de Alfama)

From the Empresa de Gestão de Equipamentos e Animação Cultural (EGEAC):

Teresa Oliveira, Marta Sá, Inês Noivo, St George Castle Museum Centre (Núcleo Museológico do Castelo de São Jorge)

From the MILLENNIUM BCP FOUNDATION (FUNDAÇÃO MILLENNIUM BCP):

Isabel Cravinho, Ana Martins Ferreira, Fátima Dias, and archaeologists who will guide the visit to Correeiros Street Archaeological Site (Núcleo Arqueológico da Rua dos Correeiros)

From Instituto Superior Técnico, Technical University of Lisbon:

Mário Lopes, Professor and Engineer

From the National Council for Civil Emergency Planning (Conselho Nacional de Planeamento Civil de Emergência):

Isabel Pais, Geographer and Senior Expert on Risks and Security

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MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

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8. REFERENCES

LISBON BEFORE AND AFTER THE 1755 EARTHQUAKE
Effects on the Urban and Building Technologies Evolution

- Guidebook for the Field Trip -

Isabel Pais
National Council for Civil Emergency Planning
(Conselho Nacional de Planeamento Civil de Emergência)
Adviser of the Vice-President

1. INTRODUCTION

It is well known that several strong earthquakes have affected Lisbon in the past. Some of them caused severe damage and were responsible for important changes in Lisbon's urban structure and evolution.

In fact, up until the nineteenth century, the most important changes in the urbanisation and spatial organisation of Lisbon took place after the occurrence of strong earthquakes. They were clearly related to the need to respond to destruction, either by repairing the damages, or by developing new ways of planning and conceiving the city, in order to provide it with new architectural, technical, social and economic structures, able to survive similar seismic situations in the future.

At various junctures, the city was reorganised according to new planning principles and measures. The periods during which these measures were taken were always characterised by specific historical circumstances. For example, periods of strong population growth and territorial expansion were very important for the formulation of these measures. But, in this city, whose architectural and urban history has always been influenced by powerful physical phenomena, the earthquake played the role of providing immediate and timely motivations for fundamental responses in what concerns political action and urban culture.

Fig.1. Plan of Lisbon in the 16th century (Braunio)

Between the Portuguese Middle Ages (the twelfth century) and the end of the Modern Era (the end of the eighteenth century), we can identify four particular phases in the history of urbanism in Lisbon (whether through the reorganisation of the existing spaces or the creation of new developments). Chronologically, these phases are located in the twelfth, fourteenth, sixteenth and eighteenth centuries. (Fig.1 and Fig. 2)

Any journey through the old parts of Lisbon brings one into contact with numerous traces of this city that was always rebuilt at the same place, and later on, expanded outward from that point. Apart from

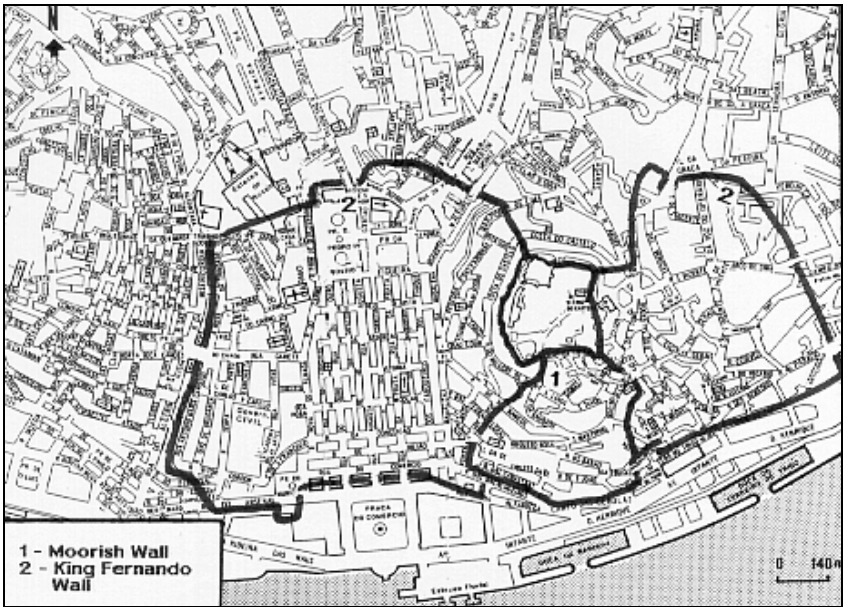
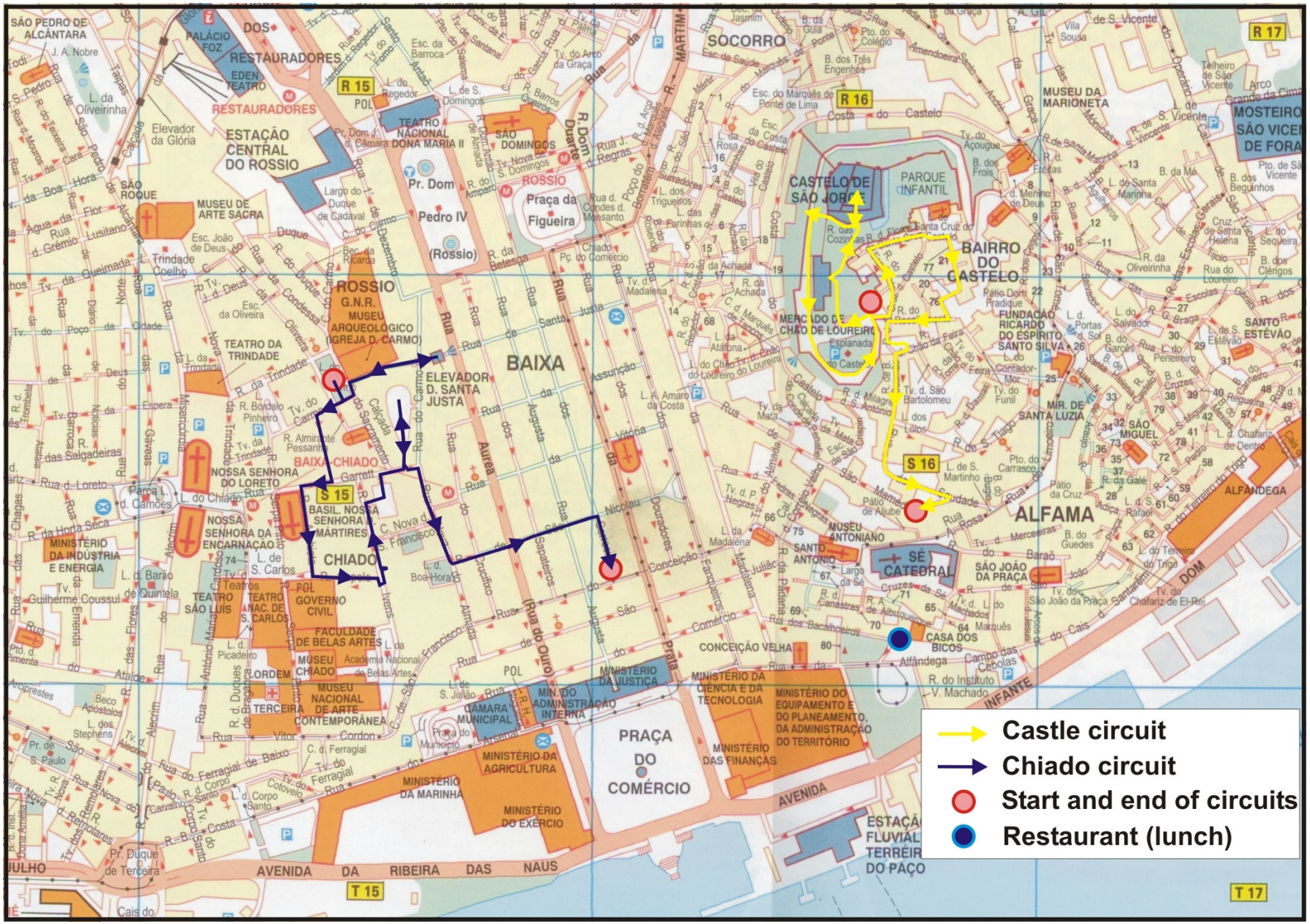


Fig.2. The Moorish and King Fernando walls in today's plan of Lisbon

Some impressive monumental testimonies, the city preserves reminders of countless places and urban spaces that were incorporated, and some times reformulated into new constructions.

For that reason, we still can find today several vestiges both of the effects of the most damaging earthquakes that hit Lisbon and of the most remarkable phases of the city's urbanisation process, as well as the relationship between these two facts. Some of these vestiges date back from the Roman period or even before, while the most impressive date back from Pombal's time.

The **present field trip** was specially organised for the participants of the **Workshop on Seismicity and Earthquake Engineering on the Extended Mediterranean Region**, **RELEMR Programme** (Reducing Earthquake Losses in the Extended Mediterranean Region Programme) in order to help identifying and characterising these vestiges in the field.


Castle circuit
Chiado circuit
Start and end of circuits
Restaurant (lunch)
BAIXA
ALFAMA
CHIADO
ROSSIO
SOCORRO
BAIRRO DO CASTELO
CASTELO DE SÃO JORGE
PARQUE INFANTIL
MERCADO DE CHÃO DE LOUREIRO
SÉ CATEDRAL
CASA DOS BICOS
ESTAÇÃO CENTRAL DO ROSSIO
ELEVADOR D. SANTA JUSTA
MUSEU ARQUEOLÓGICO (IGREJA D. CARMO)
MUSEU DE ARTE SACRA
MUSEU DA MARIONETA
MUSEU ANTONIANO
MUSEU NACIONAL DE ARTE CONTEMPORÂNEA
MUSEU CHIADO
FACULDADE DE BELAS ARTES
TEATRO NACIONAL DONA MARIA II
TEATRO DA TRINDADE
TEATRO SÃO LUÍS
TEATRO NAC. DE S. CARLOS
GOVERNO CIVIL
MINISTÉRIO DA INDÚSTRIA E ENERGIA
MINISTÉRIO DA JUSTIÇA
MINISTÉRIO DA CIÊNCIA E DA TECNOLOGIA
MINISTÉRIO DO EQUIPAMENTO E DO PLANEAMENTO, DA ADMINISTRAÇÃO DO TERRITÓRIO
MINISTÉRIO DAS FINANÇAS
MINISTÉRIO DA AGRICULTURA
MINISTÉRIO DA MARINHA
MINISTÉRIO DO EXÉRCIO
PRAÇA DO COMÉRCIO
ESTAÇÃO FLUVIAL TERREIRO DO PAÇO
AVENIDA DA RIBEIRA DAS NAUS
AVENIDA INFANTE DOM
ALFANDEGA
SÃO JOÃO DA PRAÇA
SANTO ANTÓNIO
SÃO MIGUEL
SANTO ESTÊVÃO
MOSTEIRO SÃO VICENTE DE FORA
CONCEIÇÃO VELHA
CAMARA MUNICIPAL
MIN. DO ADMINISTRAÇÃO INTERNA
R 15
R 16
R 17
S 15
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T 17

2. FIELD TRIP ITINERARIES:

Along the 2 circuits, geothecnical works done in special foundations as well as the rehabilitation and structural reinforcement of buildings will be addressed, such as the consolidation and stabilisation of slopes, the use of holding walls, anchorage, micro-piles and architraves.
Special attention will be drawn to buildings in which anti-seismic techniques were used such as vaults and the "gaiola" (cage) structure.

CASTLE CIRCUIT

From St. George Castle to the Roman Theatre Museum and Archaeological Centre (Núcleo Arqueológico do Museu do Teatro Romano)

Visit to the residential area of St. George Castle (Castelo de S. Jorge);

Recolhimento Street Building: visit to the Building in Recolhimento Street, 26-36, dated from the end of the 19th Century, which presents cage ("gaiola") structure characteristics used on that time. It has 5 floors, 20 dwellings and 1021,23 square meters gross area and most of its flats are rented.

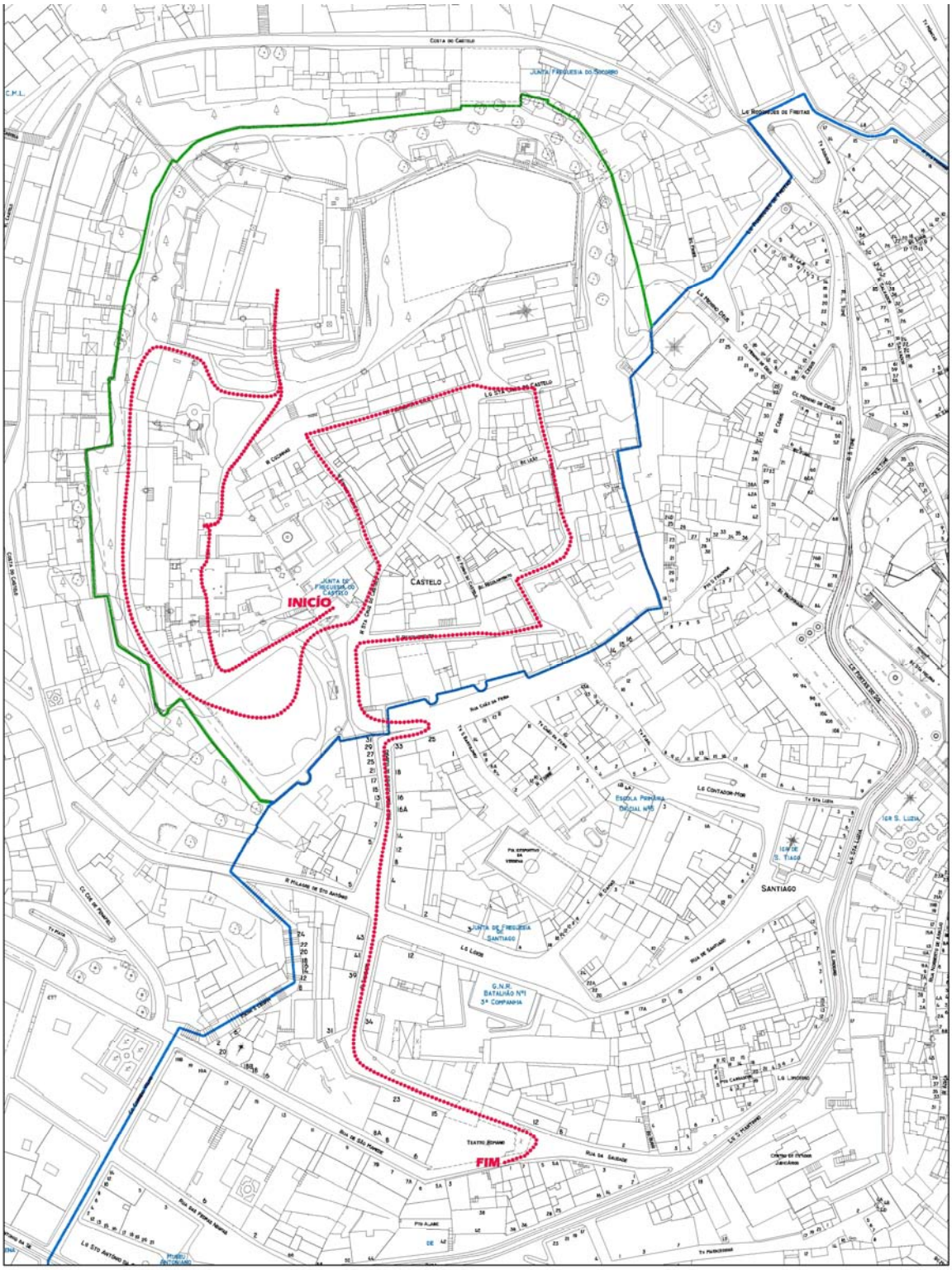
Castle Museum Centre (Núcleo Museológico do Castelo de S. Jorge): visit to the Castle fortified area and to the Castle Museum Centre where an exhibition of archaeological objects found during the excavations which took place in various sites at the top of the Castle Hill allowing us to understand the culture and lifestyles of the city during the Iron Age (6th Century B.C.), the Islamic Period, the Medieval Ages up to the 18th Century is shown.

Chão da Feira Square, Bartolomeu de Gusmão Street, Lóios Square, Saudade Street
(going down the Castle Hill)

Roman Theatre Museum and Archaeological Centre (Núcleo Arqueológico do Museu do Teatro Romano): a museum created to exhibit archaeological findings of different ages collected during the excavations carries out in the ruins of the Lisbon Roman Theatre, located in S. Mamede Street.

The Theatre was built in the 1st Century B.C., during Emperor August times and rebuilt in the year 57 A.D. Holding 3000 to 5000 spectators, it was one of the most significant buildings of Olisipo (Roman designation for Lisbon).

See map in Annex with the Castle Circuit



Tour from the Castle to the Roman Theatre

PERCURSO DO CASTELO AO TEATRO ROMANO

Alfama Project Unit
Unidade de Projecto de Alfama

Unidade de Projecto do Castelo
Castle Project Unit

SEM ESCALA / without scale

Outubro de 2009

Início / Starting point
Fim / Ending point

Lisboa
CÂMARA MUNICIPAL

Direcção Municipal de Conservação e Reabilitação Urbana
UNIDADE DE PROJECTO DE ALFAMA

CHIADO CIRCUIT

From Carmo Square (Largo do Carmo) to the Correeiros Street Archaeological Site (Núcleo Arqueológico da Rua dos Correeiros)

Carmo Square: observation of Carmo Convent and explanation on its resistance to the 1755 Earthquake, the function of foothills of the Gothic Architecture, the reinforcement cuttings made during the underground works, the holding works and reinforcement works. Observation of Architect Siza Vieira building of Carmo Street 63-77.

Carmo Lane (Travessa do Carmo): visit to the "Chiado's Block" ("Quarteirão do Chiado"), by Garrett Street 54 to see the restoration/renovation works of Architect Gonçalo Byrne.

Garrett, Anchieta and Capelo Streets, Courtyard A (Pátio A): observation of the reinforcement and sustenance methods of the holding walls.

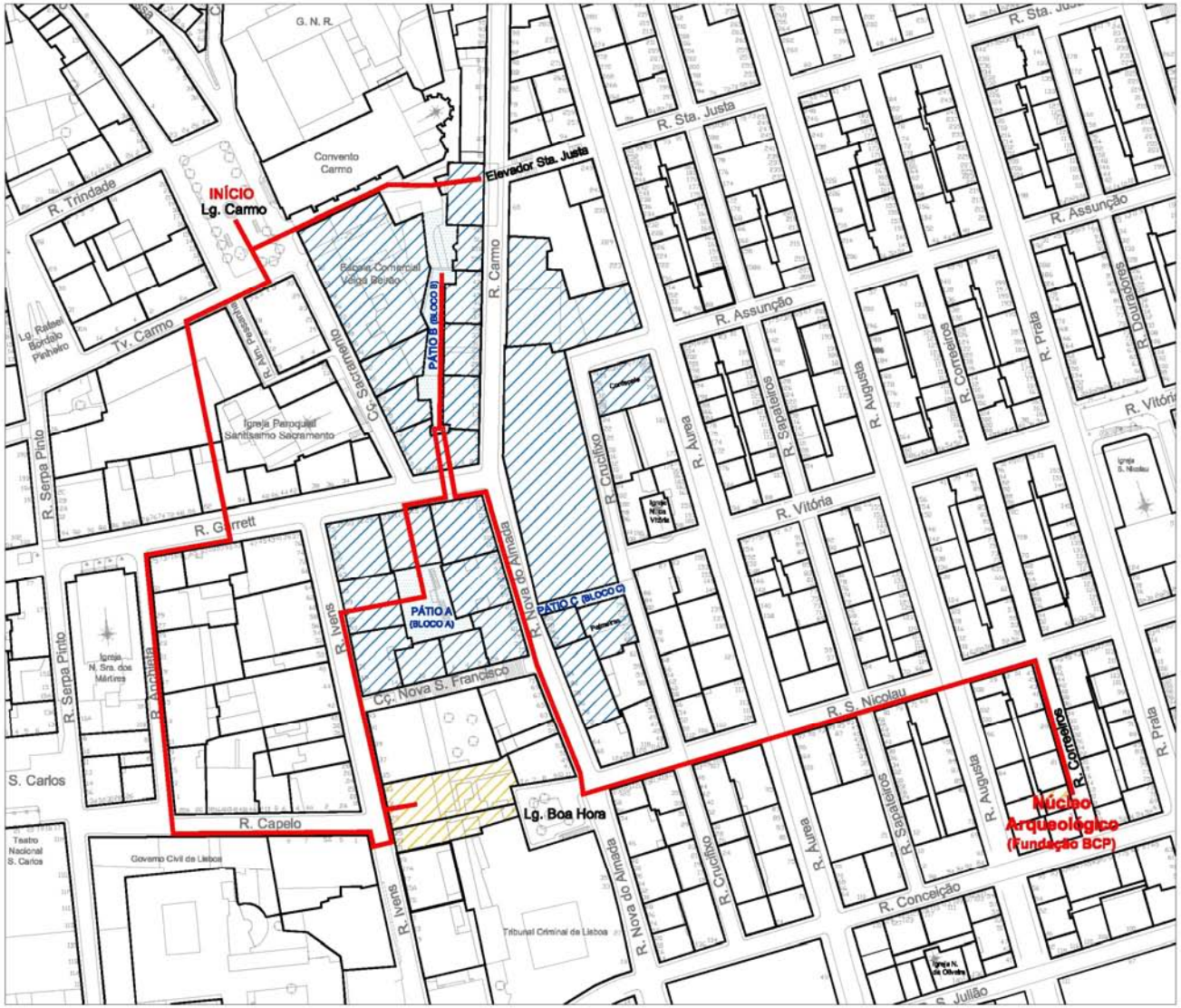
Ivens Streeet : visit to the Ivens Street 25-33 Building. The works under way link 2 previous Pombaline buildings in just one for high standard residential occupation. Although the interior had already been modified, the "Gaiola" (cage) structure, the wooden floors, ceilings and staircases as well as other characteristics of Pombal times building technologies can still be clearly observed.

Rua Garrett Street 10: "Courtyard B" ("Pátio B"), of Architect Siza Vieira.

Nova do Almada and S. Nicolau Streets
(going down the hill)

Correeiros Street: visit to the Correeiros Street Archaeological Site (Núcleo Arqueológico do Millennium BCP, a private museum owned by the bank Millenium BCP, where archaeological findings under the "Baixa Pombalina" (Pombaline Baixa or Downtown) displaying vestiges from different ages, specially from the Roman Times can be seen. Also the basis of the 18th Century "Gaiola" (cage) structure used to resist earthquakes can be clearly observed.

See map in Annex with the Chiado Circuit



Percurso do Largo do Carmo ao Núcleo Arqueológico da Rua dos Correeiros

Tour from the Carmo Square to the Rua dos Correeiros Archaeological Site

Legend

Início / Starting point (Carmo Square)

Percurso / Route

Without scale / Sem Escala

Câmara Municipal de Lisboa
Direcção Municipal de Conservação e Reabilitação Urbana
Unidade de Projecto da Baixa-Chiado

Outubro 2009

GROUP A PROGRAMME

Morning Period:

09:30 - Meeting-point: Largo da Casa do Governador ao Castelo.

- Wellcome to the participants by Architect Nuno Morais, Director (Departamento de Reabilitação Urbana e Gestão das Unidades de Projecto), Lisbon City Council.
- Visit to the Castle residential área and to the Rua do Recolhimento Building guided by Dr. Rui Matos, Architect Nuno Brito and Eng. Nuno Correia, Alfama Project Unit (Unidade de Projecto de Alfama), Lisbon City Council.

11:00 – Visit to the St. George Castle Museum Centre (Núcleo Museológico do Castelo de S. Jorge), guided by Dr Inês Noivo, EGEAC.

12:15 – Visit to the Roman Theatre Museum and Archaeological Centre, oriented by Dr. Rodrigo Banha da Silva, Divisão de Museus e Palácios, Lisbon City Council.

- Lunch -

Afternoon period:

14:30 – Meeting-point: Carmo Square.

- Visit to the area surrounding the Carmo Convent, oriented by Dr Margarida Bastos and Dr Eva Leitão, Divisão de Museus e Palácios, Lisbon City Council.
- Visit to the Chiado-Pombaline Baixa area and to the Ivens Street Building, guided by Architect Clara Vieira, Dr Mafalfa Enes Dias and Eng. Pedro Monteiro, Baixa-Chiado Project Unit (Unidade Projecto Baixa-Chiado), Lisbon City Council.

17:00 – Visit to the Correeiros Street Archaeological Site (Núcleo Arqueológico da Rua dos Correeiros, Millennium BCP, guided by the archaeologists of the Millennium BCP Foundation.

18:00 – End of the visit

GROUP B PROGRAMME

Morning Period:

09:30 – Meeting-point: Carmo Square.

- Wellcome to the participants by Architect Jorge Catarino Tavares, Municipal Director (Direcção Municipal de Conservação e Reabilitação Urbana), Lisbon City Council.
- Visit to the area surrounding the Carmo Convent, oriented by Dr Margarida Bastos and Dr Eva Leitão, Divisão de Museus e Palácios, Lisbon City Council.
- Visit to the Chiado-Pombaline Baixa/Downtown area and to the Ivens Street Building, guided by Architect Clara Vieira, Dr Mafalfa Enes Dias and Eng. Pedro Monteiro, Baixa-Chiado Project Unit (Unidade Projecto Baixa-Chiado), Lisbon City Council.

12:00 – Visit to the Correeiros Street Archaeological Site (Núcleo Arqueológico da Rua dos Correeiros, Millennium BCP, guided by the archaeologists of the Millennium BCP Foundation.

- Lunch -

Afternoon period:

14:30 - Meeting-point: Largo da Casa do Governador ao Castelo.

- Wellcome to the participants by Architect Nuno Morais, Director (Departamento de Reabilitação Urbana e Gestão das Unidades de Projecto), Lisbon City Council.
- Visit to the Castle residential área and to the Rua do Recolhimento Building guided by Dr. Rui Matos, Architect Nuno Brito and Eng. Nuno Correia, Alfama Project Unit (Unidade de Projecto de Alfama), Lisbon City Council.

15:30 – Visit to the St. George Castle Museum Centre (Núcleo Museológico do Castelo de S. Jorge), guided by Dr Inês Noivo, EGEAC.

16:30 – Visit to the Roman Theatre Museum and Archaeological Centre, oriented by Dr. Rodrigo Banha da Silva, Divisão de Museus e Palácios, Lisbon City Council.

18:00 – End of the visit

3. The Urban Growth of Lisbon

See next page:

Paper: **"The Urban Growth of Lisbon"**

Author: Teresa Barata Salgueiro

Professor, Departamento de Geografia, Universidade de Lisboa (GeographY Department, Lisbon University)

Publication: Proceedings of the *"Fifth European Intensive Course on Applied Geomorphology – Mediterranean and Urban Areas"*, ERASMUS ICP 91/96-I-1226/07, June 1996, Lisbon.

THE URBAN DEVELOPMENT OF LISBON

TERESA BARATA SALGUEIRO

Teresa Barata Salgueiro - Centro de Estudos Geográficos and Departamento de Geografia, Universidade de Lisboa

Abstract

After reviewing the growth stages of Lisbon area, we look at the main features of the city townscape: the layout and the contemporary changes of its functional structure.

Key words: trade, growth stages, plan, functional areas

1. INTRODUCTION

The metropolitan area of Lisbon comprises 18 municipalities in a territory of 3,128 km^2 which in 1991 had a population of 2.5 million, almost one quarter of the country's total.

With its obscure origins buried in pre-historical times, the site of Lisbon was frequently visited by several Mediterranean seafaring peoples, and in the Roman age it was already an important town. Its importance grew with the formation of Portugal, and in the mid-13th century it became the political and economic capital of the kingdom.

Lisbon's fortunes have been indeniable linked to its geographical position and the conditions of its port. Lisbon's position can be assessed in both national and international terms. In national terms, one must foreground its location by the Tagus River, in the median line of the country, on a good estuary harbour. The Tagus is the most important river in the Iberian Peninsula, navigable nearly up to the border with Spain, and it ensured the command of a vast hinterland. Furthermore, the city has the advantage of a wide harbour, suitably protected from the Southwest winds, located in the Atlantic finisterre, close enough to the mouth of the river to be almost regarded as a seaport but slightly withdrawn within the estuary, the better to protect itself. In the 16th and 17th century the embouchure of the river was fortified with an ensemble of towers, among which the Tower of Belém stands out for its beauty, and fortresseses, some of which strengthened watch structures built much earlier. The general location and conditions of the port enabled the city to organise the cabotage navigation, which in medieval times was particularly intense, and therefore maintain permanent relations with the western littoral and the meridional borderland of the country, as well as harbour foreign merchantships and engage in the adventures of the ocean sea.

In international terms, the availability of a haven in the exposed Atlantic coast proved decisive in the commercial development and increasing wealth of Lisbon: the fleets sailing along the coast, in a movement considerably boosted by the Crusades, found here a safe resting place.

Administration and trade have always been prominent among the urban functions, and from the Middle Ages onwards the presence of foreign merchants in Lisbon has been recorded. In the 13th century the main planned street was occupied by this class and accordingly known as Rua dos Mercadores (or Nova dos Ferros). It was however in the 16th century that Lisbon became the great emporium of the rare products which flooded the European markets, when its control of the maritime route for the products of the East precipitated the decline of the Italian cities.

The development of the city reflects the growth peaks in its external trade, as indeed does the development of the country as a whole: expansion and aggrandisement occurred when a new commercial front was opened, dormancy set in with every recession period.

The importance of trade, and of the port sustaining it, in the life of the city is attested to by the continued expansion of the populated area along the banks of the River Tagus, by the

Salgueiro T. B. (1996) - The urban development of Lisbon. *In: A. B. Ferreira & G. T. Vieira (eds.), Fifth European Intensive Course on Applied Geomorphology - Mediterranean and Urban Areas, Departamento de Geografia, Universidade de Lisboa, 45-52.*

transference in the 16th century of the royal palace from the Alcazar, in the Castle, to the Ribeira (waterfront) - where the palace was installed above the Casa da Índia warehouses, thus bringing to light the king's behaviour as a great merchant -, and by the presence of foreign merchants and the importance of native traders as well. To honour them the main city square was named Praça do Comércio in the Pombalean reconstruction, in acknowledgement of their contribution as a class to the reconstruction works.

The Lisbon harbour, which on several occasions received significant improvements, has retained down to the present day its role as the main gate for the coming in and going out of commodities. Mention must be made of the amelioration works carried out in the late 19th century (1860, 1887), as from them bank corrections were made through lands conquered from the river, and embankments on which the railway and later the new highway were built. In recent years, changes in transoceanic navigation modes and in commodity transport, on the one hand, and the division and assignment of functions to the ports of Setúbal and Sines, on the other, have rendered some of the harbour facilities obsolete and made it possible to put to other uses harbour sites and buildings that had been abandoned. The restructuring and planning schemes developed for the North bank, from the Sacavém to Algés, delimitate the areas which remain bound to port activities and make others available for recreation and construction purposes. Some of the Alcântara warehouses have already been converted into restaurants, cafés and the like, but it is in the eastern part of the city, upstream from Cabo Ruivo, that the major changes are expected in the short term, with the 1998 International Exhibition taking place there.

2. FROM TOWN TO METROPOLIS

Lisbon's site combines the defensible crest of a hill with the easy relational life facilitated by the port, a dual quality very common in Mediterranean cities. The town was originally situated on the top of the hill (Fig. 1) corresponding to the present Castelo ward, which is still surrounded by walls. In this place the seat of public administration and the military garrison remained very long. But the population growth and the importance of economic activities and relational life favoured the expansion towards the river, and the pre-Portuguese town was already widely developing down the South slope, where an outskirt formed outside the town walls - the present Alfama neighbourhood.

The mid-Middle Ages witnessed the growth of the town to the lower area, gradually drained, and towards the hills, where churches, convents and monasteries gave rise to autonomous settlement nuclei. The considerable increase in the urban area led King Fernando I in the mid-14th century to provide the city with a new, accordingly named Fernandean wall, which however also enclosed important rustic tracts. The city had a grossly rectangular shape, elongated riverwise, and highlighted the importance of the westward expansion. By the end of the 19th century this traditional growth direction was abandoned for the expansion to the North (Fig. 1). While in 1852 Lisbon had an area of 12.2 km^2, with a maximum length of 5.6 km in the E-W direction as against 3.3 km in the North-South direction, in 1885, with an area of approximately 84 km^2, the North-South length already amounted to 12.2 km and the E-W length did not exceed 8.5 km.

In the last quarter of the 19th century, in a process of expansion carried out in several phases, the foundations of the modern agglomeration were laid. Firstly, the traditional growth direction through the riverside strip was discontinued, and growth was inflected to the North, a movement which was initiated with the opening of Avenida da Liberdade in 1879 and then of Avenida Almirante Reis. Both layouts followed the course of the two main valleys converging on the Baixa (downtown Lisbon), duplicated the old rural routes of access to the city by land, which in part are still preserved, and guided the new urban expansions of the late 19th century; seventy years later, we trace along them the migration of tertiary activities in their own search for new expansion room.

In a second stage the occupancy of the Avenidas Novas plateaux was consolidated. Meanwhile both the street designs and the urban

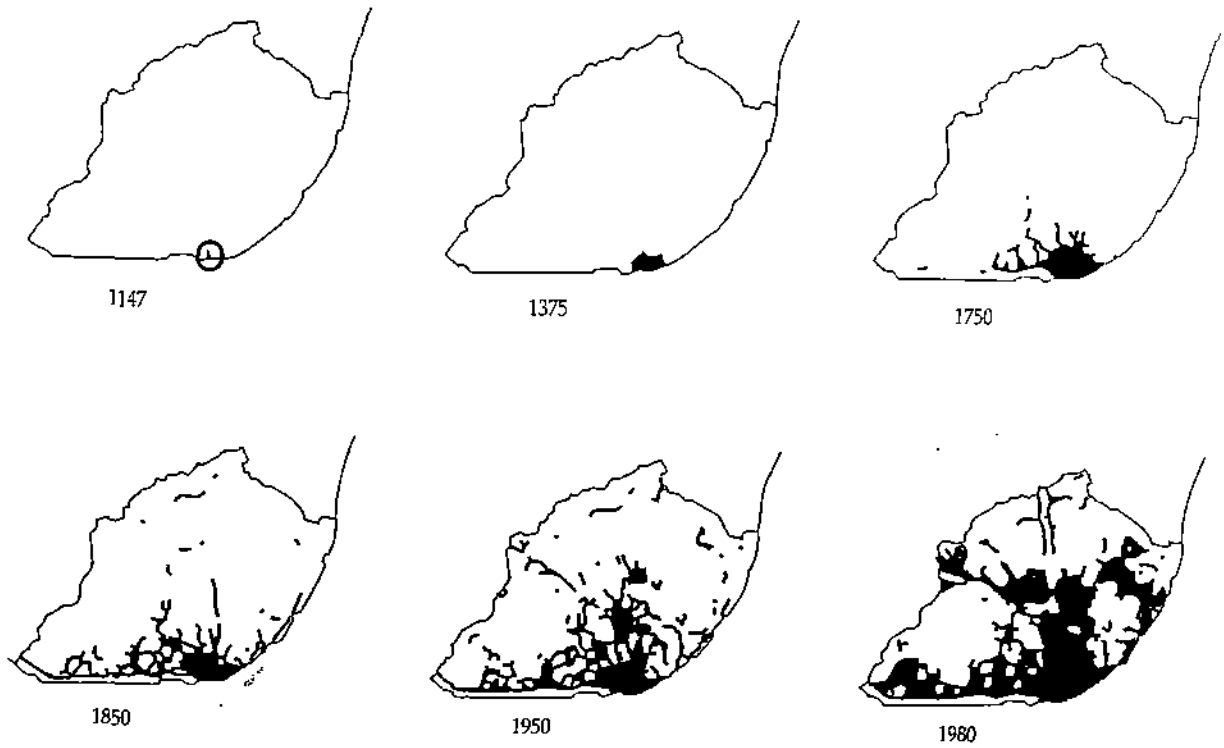


Fig. 1 - Lisbon growth (*Atlas de Lisboa*, 1993).

life were adapted to the new social division of labour and the new social class structures. In parallel with the bourgeois districts in French-inspired avenues, working-class districts entered the picture, together with housing for other low-income groups.

The growth of the city was largely determined by migrants arriving from rural areas, a process which was particularly accelerated after World War II and pushed the urban zone beyond the administrative boundaries of the city. This was facilitated by the existence in the urban ring of significant areas which for many years remained unoccupied. Some of those tracts of land, either municipal or church property, provided the ground for the shantytowns which proliferated in the 50s and 60s.

By their situation and shape, the first suburbs reflected the transportation facilities that gave rise to them. The tram and the first bus lines to and from the main city gates help to explain the early development of city-gate centres such as Algés, Venda Nova, and Moscavide. The train has led to a radial suburban growth, with towns formed around the railway stations succeeding one another along the tracks, in the North bank of the Tagus River, where an industrial axis following the river and the close railway line was consolidated. On the South bank, on the other hand, urban centres grew around the quays which ensured the fastest connections with Lisbon (Cacilhas, Trafaria, Barreiro, Seixal), and manufacturing towns developed also in close connection with the water transport which supported them (Barreiro, Montijo).

Later on, the development of road transport filled the gaps left by the former construction axes, and urbanisation advanced like an oil spill, extensively and rapidly. The crossing of the Tagus, and the fact that the public road transport system rendered the South bank less accessible, account for the delay of the urban growth on this bank, which became the scene of demographic explosions after 1966, when the Tagus Bridge was inaugurated (Table 1).

The more recent effort to build motorways with fast lanes and highways has led to the enlargement of the territory in which metropolisation process takes place, bringing Lisbon and Setúbal closer each other and creating

Table 1 - The Population in the Metropolitan Lisbon.

Year	Total Population	North Bank (%)	South Bank (%)	City (%)
1950	1,312,500	22.4	17.8	59.7
1960	1,524,195	28.2	19.1	52.6
1970	1,839,741	36.4	21.8	41.8
1981	2,502,044	44.3	23.4	32.3
1991	2,542,653	48.9	24.4	26.7

a metropolitan reality at the least bipolar. It also facilitates the greater dispersion of peripheral settlements, the increase of second homes, and the diversification of periurban territories occupancy.

3. MORPHOLOGY

From the morphological point of view the city of Lisbon is a heterogeneous city in which the following stand out:

- *the old nucleus*, presenting relatively irregular pattern in Alfama and the hills of Castelo, Graça, and Sant'Ana, in which the antiquity of the occupancy, the Muslim influence, and the slope topography combine as explaining factors;
- *the grid pattern*, the product of planned actions, in which pattern and street width vary according to the epoch in which they were built (Fig. 2). In the 16th century, by the west gate of the city of that time, the Bairro Alto (High neighbourhood) was built. It was the first district with a regular grid plan in the city but its buildings height would significantly rise with the densification process of the following centuries.

In the second half of the 18th century, the reconstruction of the lower part of the city, destroyed by a violent earthquake on November 1, 1755, would adopt a hierarchical grid plan, elongated in the north-south direction and finished by quadrangular squares. The monumental square dedicated to merchants, with the statue of the king on horseback as its central focus, opened on to the river and functioned as the city's genuine reception room for travellers arrived by sea. To the North the new lay-out was finished by two squares, of which one would become the site of the central market (Praça da Figueira) and the other served as antechamber to the Passeio Público (Public Promenade). The destruction of this garden, one hundred years later, made it possible to open the Avenida da

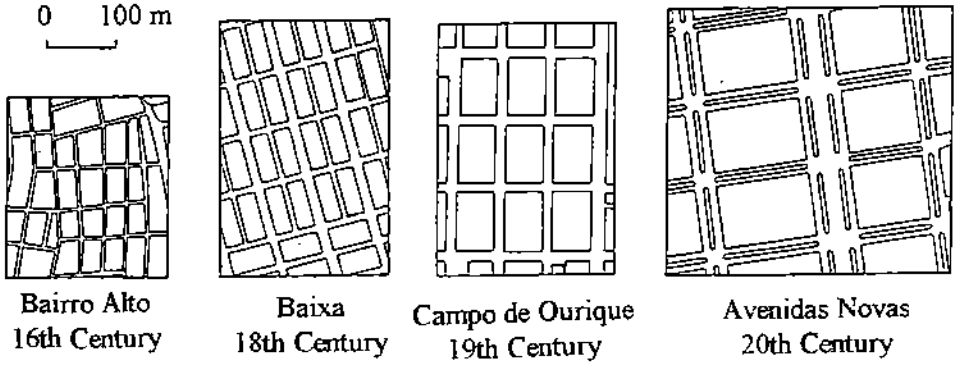


Fig. 2 - Examples of grid pattern in Lisbon (*Salgueiro*, 1994).

Liberdade with its adjacent orthogonal patterns. From there followed the extensive plan of the Avenidas Novas, a true nineteenth-century expansion scheme which supported the bourgeois development of the city and the real estate business up to the 40s of the present century.

Dating from the end of the 19th and the first half of the 20th century, other examples of grid plans, more localised and less central, deserve attention (Campo de Ourique, Estefânia, Alto de Santo Amaro, Actores neighbourhood, Colónias neighbourhood). The first experiments in vicinity units and traffic separation are to be found in the Alvalade allotment (1945).

- *The patterns resulting from the application of the principles of the Athens Charter and modern urbanism* were belatedly applied. The break with the concept of the corridor-street was instantiated in Avenida dos Estados Unidos and Avenida Infante Santo, but those ideas were fully developed only in the municipal plan for Olivais (1958/60), and in the one for Chelas (1962/66) as well, followed by Telheiras (plan of 1973/75), already directed by a different conception, corresponding to the occupancy of the outmost peripheral ring of the administrative city.

- *The suburban nuclei* also bring to light the period of their growth, the buildings predominating in them having been constructed in the last 30 to 40 years.

In the urban periphery permanent dwellings, on the whole in multi-storey apartment buildings, are combined with second houses, either in seaside resorts or in the rural areas of the countryside, involving one- or multi-storey typologies.

The major tourist areas (Costa do Estoril, Costa da Caparica, Sesimbra) continued for most of the current century to supply accommodation in one-family dwellings, but the demographic pressure after 1960 prompted the appearance, even in such places, of large high-rise buildings, often occupied by permanent residences.

The 60s and 70s witnessed the mushrooming of illegal housing districts and allotments in the urban periphery. Such parcels of farming land being unlicensed for urban development by the Council authorities, and unprovided with sanitary infrastructures (water supply, sewage disposal), they were consequently sold at prices far below those of the legal market, and construction for housing purposes was undertaken there without municipal supervision. Such districts, poorly situated and lacking housing facilities, presented the only accommodation possibility for a significant fraction of the working population in a period when the housing market was highly speculative. As a matter of fact, the rural-urban migration and the restructuring of the central-city ensured an unfailing demand increase. As public investment in the housing sector was insignificant, the market was completely controlled by private enterprises and became markedly speculative. In the latter half of the 70s took place a pronounced growth in the illegal districts of permanent accommodation, and illegal constructions for second homes also made their appearance in chosen littoral tracts outside the Lisbon metropolitan area. This kind of construction was undertaken in order to dodge the public administration bureaucracy and to secure the one-family typology which was practically nonexistent in the legal market, except for the luxury segment.

4. THE FUNCTIONAL STRUCTURE

In functional terms, only a few aspects are highlighted in which changes were more conspicuous. For a long time, the central business district occupied the Baixa. In the 60s it began to migrate Northwards through Avenida da Liberdade and Avenida Almirante Reis, and after the mid-70s it became located in the Avenidas Novas area, which in the last years has undergone a profound morpho-functional change as housing buildings were replaced by office buildings. Even buildings classified for their architectonic quality were replaced, and the luxury villas of the beginning of the century were demolished to make way for modern, not seldom

uncharacteristic, office buildings with some shops and restaurants. Today the Marquês de Pombal-Avenidas Novas area is the central business district and the major concentration of business and producer services is to be found there.

Part of the national and local government departments have remained in the Comércio and Município Squares, but the Prime Minister's official residence and many Ministries have for some years now been scattered over the town. The Lisbon City Hall has some of its services scattered in several buildings and plans to concentrate them all in the building under construction in Campo Grande.

The finance centre, formerly located next to the administrative one, is being (re)-constituted further northward at the edge of the Avenidas tertiary centre in modern buildings (along the Avenida de Berna-Avenida João XXI axis, extended to Avenida das Forças Armadas by the recent relocation of the Stock Exchange in this avenue), although the central offices and representation buildings of the older banks still remain in the Southern downtown sector.

Parallel with the consolidation of the new tertiary centre, new business districts have developed, as a rule the upshot of major real estate undertakings and often for mixed purposes, in both the city and its periphery (Amoreiras, Centro dos Olivais, Lisbon Towers, Colombo, among others), in an agglomeration with a complex structure in which several commerce and services centres emerge, and compete with, and complete one another. The decentralisation of producer services towards the periphery has privileged the Oeiras borough, contiguous with Lisbon and very easily accessible, either in a relatively spontaneous and dispersed fashion or through affiliation with the modern office parks.

The commercial structure has also changed. With the commercial revolution which took place after 1985, supply has increased and diversified in relation to the emergence of new retailing outlets (superstores, shopping centres, franchising). In the highest level of retailing hierarchy two alternative poles have emerged, as the same time as an evolution in the characteristics of the Baixa has ocurred. One higher order center is chiefly made up of street-shops (the Av. Guerra Junqueiro-Av. de Roma axis), and the other is a shopping-centre, Amoreiras, in the fringe of the core. In these three poles are to be found the higher level shops and the most significant franchising shops.

In the suburban area, the retailing of the central districts in the most important towns has been strengthened and modernised, in general combining street-shop outlets and shopping arcades, besides the appearance of one large regional shopping centre, the CascaiShopping, with its 60,000 m^2 of gross commercial area, the true crowning piece of the retail trade decentralisation.

The leisure facilities essentially occupy the Bairro Alto/Av. 24 de Julho area, which has expansion potentialities through the appropriation of the waterfront strip, as is already the case downstream, and will certainly be the case upstream from Cais do Sodré, in connection with the International Exposition. Other facilities, such as cinemas and gamesparlours, tend to appear in the largest shopping centres in response to the growing tendency to combine trade and leisure in consumer practices.

Whereas tertiary jobs show some signs of decentralisation, in manufacturing that phenomenon took place much earlier and a deindustrialisation is now under way. In the 80s the Lisbon metropolitan area lost 40,000 blue-collar jobs.

The industrial equipment in basic sectors began in the 40s, thereby displacing the traditional wood, cork, canned goods, and textile industries. Besides a few other localisations of minor concentration, Lisbon had two major industrial areas characterised by the presence of heavy industry plants providing a large number of jobs, the Vila Franca axis and the Setúbal Peninsula. The former began in the oil refineries still within the city and stretched to the municipal town of Vila Franca, comprising cement, food, and chemical plants. In the Setúbal peninsula mention must be made of the activity of the district town itself, based as it traditionally was on fish processing industries and later revitalised by the metalworking and the shipbuilding factories, and also of the activity along the left Tagus bank (Almada, Seixal, Barreiro, Montijo), where side by side with meat-processing and cork industries there developed the chemical, iron and

steel, and shipbuilding industries in a modern complex with characteristics of the so-called Fordist organisation. The foundations of that structure were challenged in the 70s, the shipbuilding industry was dismantled, and the Setúbal Peninsula was hit by a crisis from which many today hope it may recover through the Ford-VW project (located in Palmela, by the A-2, or South motorway), because not only of its direct employment capability but also of the indirect job creation it could generate.

Housing constitutes a fine mosaic of realities ranging from old, decayed buildings in the historical centre to luxury accommodation, through shanties, with hardly room enough for one family, and the great diversity of flats in a strongly segmented market.

The strong demographic growth in the metropolitan area, the absence of housing policies and several institutional blockages contributed to cause not a few bottlenecks in a market dominated up to the 70s by private enterprise and by the leasing market. The situation has in the meantime significantly changed, since there have been a greater public intervention in the sector and an increased diversity of measures aimed at promoting owner occupied houses, building infrastructures in several districts, legalising unlicensed constructions and rehabilitating decayed buildings.

In the face of the need to replace much of the existing accommodation and the new trends in the family structure, the fact that demographic growth in the metropolitan area is beginning to slow down has not yet produced any decrease in housing demand. In the lower-grade housing districts a process of population replacement has occurred, as many Africans and other foreigners have occupied the accommodation left vacant by the nationals who in the meantime have managed to find better living conditions, and the Geography of Poverty has accordingly been changing over the last few years.

Social exclusion cases have dramatically risen and, as in other countries, they are not confined to housing conditions, for they go hand in hand with increasing unemployment rates and job insecurity, with population ageing - the elderly with very low pensions being particularly vulnerable -, and with growing drug addiction.

To wind up my argument by way of conclusion, I would like to emphasise that the Lisbon metropolitan area has on the whole grown unplanned. In part because planning was nonexistent, but mainly because there has been no political will to develop planning. For too long no urban policy has been adopted in articulation with economic development and sectorial coordination. Planning has thus been downgraded to a mere technical instrument. That omission, combined with unexacting demands in terms of quality, accounts for the innumerous problems the metropolitan area has to contend with, among which must be included the location of great infrastructures and facilities (the airport, the bridge, manufacturing districts, large hypermarkets), housing and transport conditions, the poor quality of both constructed and open spaces. The result of all these converging factors is low standards in the quality of life and low profitability in some investments.

Such build-up of problems has rendered the management of the metropolitan territory a burdensome legacy. Over the two last decades a remarkable change has been operated through the construction of roads, parking lots and public parks and gardens, the creation or enlargement of pedestrian areas, the rehabilitation of old buildings while preserving the social fabric, in parallel with the supply of standing residences in buildings redeveloped for gentrifiers both in the city and in its periphery. The necessity of the international affirmation of the city has also been taken into account: after being named Europe's 1994 cultural capital, Lisbon is now preparing for the 1998 International Exhibition. It is to be expected that such an event, over and above its own importance, will energise the whole eastern zone, now occupied by several small factories and under-utilised, relatively obsolete warehouses.

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4. SAINT GEORGE'S CASTLE (CASTELO DE S. JORGE)

4.1 BRIEF GEOLOGICAL CHARACTERISATION OF THE CASTLE HILL*

Paula Azevedo and Gabriel de Almeida, Geologists
Lisbon City Council

Stratigraphy and Lithology

The characterised area corresponds to the intervention area of the Local Office of Alfama and Castle Hill, namely to the parishes of S. Miguel, Sto. Estêvão, Sé and a part of S. Vicente de Fora.

The substrate of this area is composed of Miocene formations, covered by Quaternary (Holocene) superficial deposits, including alluviums and reclaimed lands, filling natural or artificial depressions (Fig. 3).

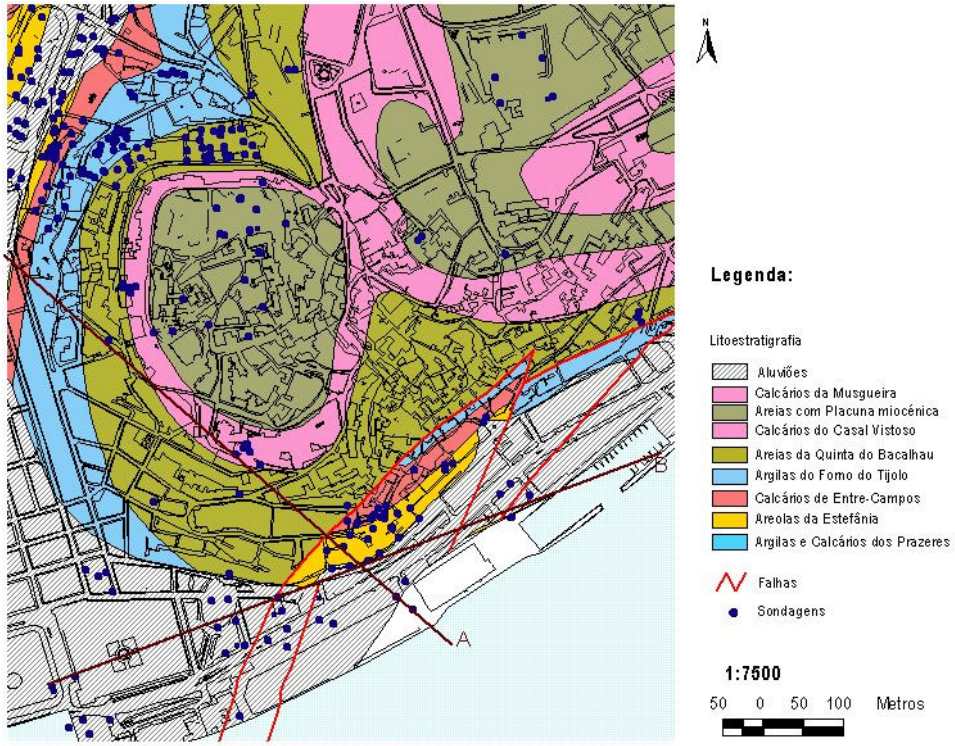

Fig. 3 – Extract of Lisbon's Geological Map

The Lisbon Miocene Series corresponds to a continuous sedimentation process, occurred over 16 Millions of years in the Tejo-Sado Cainozoic Basin estuary. Materials corresponding to different sedimentation environments with alternate marine and continental facies present significant lateral variations.

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* *Translation into English: Isabel Pais and Isabel Moitinho de Almeida*

The geological mapping of this area, based on the lithostratigraphical units, includes, according to their age (from the most recent to the oldest), several formations characterised as follows:

Alluviums (a)

There are two types of alluviums:

(i) River Tagus alluvia. Composed by very heterogeneous lenticular sandy mud and muddy sands, with different organic matter content. The thickness, in the deepest zones near the margin, can be greater than 30 metres.

(ii) Alluvia from the small valleys crossing the town, usually with very small thickness. Sands, sandy gravels and sandy clays, depending on the eroded materials, compose these deposits.

Reclaimed lands and slope debris (A)

Reclaimed Lands are often the result of human occupancy. They are composed of very heterogeneous deposits, mainly of clay, sand or clay and sand. They can contain blocks of different size.

The slope debris includes soils dragged over the surface of the slopes or caused by deeper slope movements. They have a heterogeneous composition, as well as different thickness.

Musgueira e Casal Vistoso sands and limestones ($M^2_{V\,a1,a2,\,a3}$)

This unit is formed of sands interlayered with calcareous sandstones and limestones, sometimes very fossiliferous.

Limestones and calcareous sandstone beds prevail on the top and on the basis of the complex, while in the intermediate zone clayey sands are predominant, sometimes lenticular shaped and containing vegetal fossils.

Quinta do Bacalhau sands (M^2_{IVb})

This unit is composed by a series of sandy layers, partially ferruginous, red coloured and also by white coloured and more homogeneous sands, making the transition to more compact and fossiliferous limestone.

The complete series has a thickness of 34-35 m.

Forno do Tijolo clays (M^2_{IVa})

The name of this unit comes from the name of the place where they were intensively explored for brick production, in the Southern bank of Tagus River.

This complex is composed of clays, marls and sandstones layers with dark colours with narrow interlayer of calcareous sandstones very fossiliferous and light coloured.

Entrecampos limestones (M^2_{III})

Also called *Banco Real* limestone, this formation is mainly composed of fragments of shells and moulds, linked by carbonated cement. It also includes marly sandstone, as well as micaceous limestone.

The facies changes lateral and vertically. On the top, the limestones are more compact and sandy, making the transition to the next unit.

This unit may have a thickness of 12-17 m.

Estefânea sands (M^1_{II})

This complex is composed of fine, silty, micaceous sands, with bright colours, sandy clays and sandstone, interlayered with more resistant beds, composed of sandstone and limestone, sometimes very fossiliferous.

The total thickness varies between 24 and 36 m.

Prazeres clay and limestone (M^1_I)

This formation is composed of overconsolidated clays and silts, grey or green coloured, containing randomly layers of light calcareous sandstone. The basis of the unit is characterised by the presence of black layers and conglomeratic sandstone.

Geomorphology

Lisbon's Geomorphology is characterised by the presence of several hills, one of them being the Castle Hill.

The Castle Hill and the surrounding area have a very uneven relief, which morphology depends on the geological formations resistance and geological structure.

The highest slope values correspond mainly to the more resistant Miocene layers (limestone). The lowest slope values correspond to the alluvium deposits.

Tectonics

From a geological point of view, the Castle Hill Miocene layers have a monocline structure, SW-NE oriented, with a slight inclination towards SE. The Geological Map of Fig. 3, as well as sections A and B (Fig. 4) show that in this zone the geological formations are crossed by a set of vertical faults E-W and NE-SW oriented. This set of faults is responsible for some thermal springs on this area.

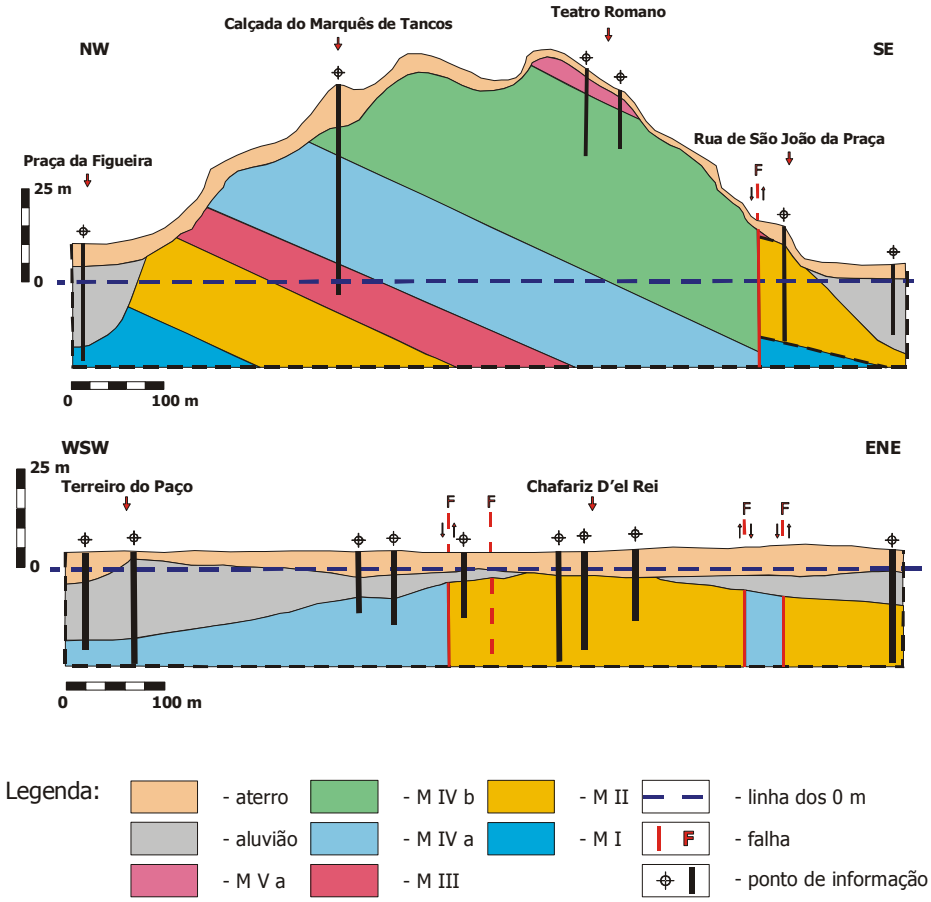

Fig. 4 – Section A – NW-SE direction (elevation factor 4x)
Section B – WSW-ENE direction (elevation factor 4x)

4.2 SAINT GEORGE'S CASTLE (CASTELO DE S. JORGE): INTRODUCTION

According to the roman texts, the Castle of Lisbon had its origins during the Iron Age. In the eighth century, the Moors conquered Lisbon and built an impressive defence system, composed of two lines of walls: the Alcáçova, up on the hill and where the governor's Palace stood, and the city walls, known nowadays as the Cerca Moura (Moorish Wall).

The first king of Portugal Afonso Henriques conquered the city from the Moors in 1147, with the help of north European crusaders. He used the Moorish defence system. In the thirteenth century, King Dinis rebuilt the hill Palace, that was to be abandoned by King Manuel, in the sixteenth century, who built a new Palace by the river in Terreiro do Paço, close to the ships of the overseas discoveries.

Long before the eighteenth century, the hill Palace was already in ruins, and finally collapsed during the earthquake of 1755. It was never rebuilt.

The site of the Castle was used for military purposes until 1938. The remains of the Royal Palace and of the "Castelejo" or Fortress completely vanished under successive military buildings for garrison quarters and prisons. In October 1938, a difficult restoration work began in the Castle, whose main objective was to bring it back to its former structure, using the still standing materials and those revealed by the diggings, and by the demolishing and the pulling down of buildings. Actually, the whole area of the Castle was cleared of meaningless constructions and two years later, military headquarters and prisons had gone. The esplanades were cleared and the bailey around the old fortress lowered to its original level.

4.3 THE INTEGRATED CASTLE PROJECT

Contribution of Lisbon City Council Technicians
(Direcção Municipal de Conservação e Reabilitação Urbana, CML)

4.3.1 HISTORICAL DATA

St. George's Castle has a unique location, on top of one of the seven hills of the city of Lisbon, overlooking the other hills, the valleys and the river.

It is goes back to the dawn of the city of Lisbon, whose origin predates the founding of the Portuguese nation in the middle of the 12th century.

Thus the richness of the heritage, architecture and archaeology in the Castle can be appreciated. Many historical periods are represented, including the Iron Age, the Roman and Islamic occupations, the middle ages, the Pombaline period and the modern buildings.

The history of St. George's Castle is, therefore, the history of Lisbon. Even when events did not take place inside its walls, the Castle was their witness.

The most striking event was probably the earthquake of 1755, whose devastation caused enormous changes, not only in terms of the political, economic and social consequences but also in the morphology of the city, which benefited from the greatest urban planning and re-conversion activity of the time.

Unfortunately, this structured intervention, whose planning was strictly complied with, did not extend to the Castle area, which had also been completely destroyed.

This lack of interest was due to the fact that the political power had left the Castle about two centuries earlier, taking with it the richest families as well.

The rebuilding of the Castle district houses was, therefore, carried out by the local inhabitants themselves, using materials from the destroyed buildings and based on badly compacted debris. In the Monumental Zone, the old barracks were reconstructed. The barracks had been in use since the annexation of Portugal by the Spanish crown during the 16th and 17th centuries. The invading French troops used these barracks at the start of the 19th century, and the Portuguese army occupied them until the middle of 20th century.

It was at that time that the first major action was taken in the Castle, since the time of the great earthquake.

As part of the spirit of nationalism that directed the politics of those times, a restoration plan was defined for those monuments, mainly palaces and castles, considered to be most symbolic of Portuguese nationhood. This process culminated in the organisation of the Exposition of the Portuguese World, held in Lisbon in 1940.

It was in this context that significant work was carried out in the Monumental Zone of St George's Castle, namely, the walls, the highest point of the castle ("Castelejo") and the Alcaçova palace. This work was done between 1938 and 1940, and the current appearance of the Monumental Zone dates from that time.

However, no work was done on the residential area and the buildings that make up this district of the city have not undergone any significant intervention since their rebuilding in the second half of the 18th century.

This is due to the fact that the local residents have always been poor, comprising elements of a migratory community originating from different rural zones of Portugal. Since the end of the 19th century, people have taken up residence in this district and worked in shipping and fishing activities. As was the case for most of the population of the neighbouring district of Alfama, these were the main occupations of the people who lived between the docks and the Castle, in addition to the services provided to the military units stationed in the barracks.

St. George's Castle is made up of two distinct zones: the Monumental Zone and the Residential Centre, occupying a total area of about 5 hectares.

The Monumental Zone is composed of the "Castelejo", the Alcáçova palace and the most visible parts of the walls, which provide a superb viewing point over the city and the river. For this reason, this is the most popular touristic zone and makes the castle one of the most visited monuments in Lisbon.
The residential centre corresponds to the civil parish. The urban structure is identical to that existing before the earthquake and so its streets, alleys and squares still have their medieval characteristics.

The buildings, for the reasons referred to earlier, are constructions that, in spite of the architectural, historical and heritage value, are poorly built along popular architectural lines.

In general, these are buildings made basically of stonework. The outside walls are structural walls while the interior ones are merely partitions. The outside walls of the buildings are whitewashed while the interiors are plastered.

The slabs between floors are structured with wooden beams, with floorboards and "saia-camisa" (skirt-shirt) type ceilings.

In this area there are about a hundred buildings, housing approximately four hundred families and a few shops, as follows:

- Total number of properties – 91
- Number of residential homes – 392
- Number of places used for commerce and services – 38
- Total resident population – 692

4.3.2 PROBLEMS IDENTIFIED IN THE DISTRICT

The problems that affect this district are, in general, common to the other historical districts of the city. They are caused by the social and building degradation.
The resident population is generally elderly, of low socio-cultural level, with large family groups and, consequently, very limited economic resources.

A large part of the population is retired and most the active population work outside the parish. Consequently commercial activities, principally handicrafts, have been stagnant, as well as the group organisations of the district (the Castle Sports Group and the Excursion Group). This had a marked effect on the community.

Indeed, this type of group organisation, commonly present in this type of district, is generally the driving and uniting force of the resident population, both for the young and elderly people. They serve as meeting points and encourage the active participation of the residents in leisure, cultural and sporting activities, as well as festive gatherings (dances, traditional celebrations), excursions, cultural visits, exhibitions, etc.

With regard to the buildings, they are in very poor condition. The precariousness of the very small homes causes poor safety and health conditions.

Most of the houses have a large number of structural problems (some are in imminent risk of collapsing) and serious dampness problems (caused by rain water coming through degraded roofs, and by badly maintained water pipes and drain pipe joints). This has serious consequences for the weakening of mortar and rotting of woodwork (ends of roof beams and structural support of front and partition walls).

In addition, it should be mentioned that some of the houses do not even have a kitchen or a bathroom and have deficient ventilation systems.

In fact, the social and building characterisation of this district is very similar to those of the other historical districts of the city. However, the Castle parish has a unique

feature: it is completely walled in, with just one entrance, at the top of a hill, making it a kind of village inside the city.

This characteristic has made the population of the Castle District a truly unique community, with their own codes, hierarchies and relationships. This community is very proud of their “village” and therefore, very participative.

Fig. 5

Fig. 6

4.3.3 PROPOSED SOLUTIONS

Taking into consideration the various aspects referred to above, the objectives of the Work Group for the Integrated Castle Project, as well as the intervention strategy for solving the existing problems, were defined according to the following guidelines:

- Rehabilitation and re-conversion of the Monumental Structures and Archaeological Remains, the Residential Centre, the Commerce, Services and Industry, the infra-structural elements and the Public Areas.
- Improvement of the socio-cultural and tourist related aspects of the parish, providing the residents with better life conditions; re-vitalising the traditional commerce, principally workshop and artisan activities; creating new cultural and leisure infrastructure elements to bring benefits to the local population and to improve attractiveness for tourists.
- With regard to the buildings, the restoration of all the buildings that need such work is planned (whether these are private or owned by the municipality). The buildings will be made safe and rendered comfortable, functional and healthy both for residential, commercial and other purposes. Whenever possible, the original building materials and systems will be used (Fig. 5 and 6).

In the public areas the objective is to re-establish the functional relationship between the tourist and residential zones, that is, the Castle of the tourists and the Castle of the local residents.

Taking advantage of the need to install or reinstall the basic sanitation facilities, the intervention has been extended to all the underground utilities: supply of water and natural gas, electricity, telephone lines and cable TV.

This major intervention work includes the resurfacing of the roads and squares of the parish, remodelling them for pedestrian and leisure use, and improving access for local residents, tourists and emergency services. The commercial area of Rua Santa Cruz, Largo de Santa Cruz and Caminho do Menino de Deus (work done by DGEM) is a good example of this type of intervention.

St George's Castle will, then, have a renovated and welcoming group of buildings, composed mainly of residences, but where there will also be the following additional features:

- The commercial area of Rua de Santa Cruz, where establishments such as restaurants and cafes, a dairy outlet, a drugstore, etc., will be re-activated. The road will end at the Largo de Santa Cruz, which will be re-modelled to provide leisure areas and esplanades for the restaurants that will operate there.
- The opening of the Dom Fradique gate, discovered in the wall above the Chão da Feira, and the creation of a small square in Rua do Recolhimento, will enable the commercial centre to be given fresh life, as in addition to the existing grocer's shop and installations of the forge, there will be three handicraft shops, a tea room and a cafe.
- Also in Rua do Recolhimento a car park will be made for Castle residents, with a capacity of about thirty vehicles.

In addition, to these features there will also be a private hotel, operating in the Palacete das Cozinhas, called the Casa do Governador. This will include a multi-purpose room for meetings and exhibitions and a shopping area; the City Interpretation Centre, which operates in the Casa Ogival; a periscope installed in the Torre de Ulisses, which will allow a 360º view over the city and surroundings; the Pátio dos Corvos, that will operate as an open-air multi-purpose area; the restaurant "Casa do Leão", belonging to ENATUR; the cafeteria / snack-bar / esplanade; the Palacete/Pátio da Pascácia, where the Castle Excursion Group will be based and which will have multi-purpose rooms for cultural and recreational purposes and a restaurant area with an esplanade; the installations of the Castle Sporting Group and two museums, one with grain-stores from the Islamic period and the other in the Praça Nova, where urban structures from the Roman and Islamic periods can be seen; the Caminho da Ronda (work carried out by the Direcção-Geral dos Monumentos Nacionais) that will function as a viewpoint over the southern and eastern areas of the city, and where there will be areas with seating and for leisure.

We are confident that the programme described for the Integrated Castle Project will be of great help in solving the problems that exist in that District.

4.3.4 FINANCING PROGRAMMES

The intervention of the Integrated Castle Project is structured in five phases. Each of the phases has a major contract project, involving several buildings in the same street or in nearby zones. This will enable most of the population to keep on living in the parish during the work, avoiding disruptions in family, neighbourhood and community relations.

The work began in 1997. At present time, 90% of the Project has been concluded. Meanwhile the Castle Project Unit which was responsible for the co-ordination and development of this Project has been integrated in the Alfama Project Unit.

All the Castle District rehabilitation work has been very complex and, for various reasons, it has not been possible to meet the initially established deadlines.

Indeed, when the work began it was found that the buildings were more seriously degraded than they appeared to and was described in the diagnostic reports. It would only have been possible to discover this if drilling had been done beforehand. However, this was impossible given that most of the houses were small and occupied by families with many members.

Thus the interventions have had to go much deeper than originally planned, requiring the strengthening of the structures and, sometimes, the re-laying of wall foundations. The opening of drainage sumps on the ground floors has required excavations to be made and this in turn has required the presence of archaeologists to analyse any possible archaeological remains found, as it is defines in the protocol between the Câmara Municipal de Lisboa (CML) and the Instituto Português do Património Arquitectónico e Arqueológico. This enables us to comply with the current legislation that obliges job owners to communicate all underground work where archaeological remains are likely to be found. This is another aspect that causes delays in the work.

In addition to these factors, other restrictions were the shortage of construction companies with experience of rehabilitation, the low skill levels of the workers and the actual construction methods. Whenever possible, the same 18th century type of materials and methods were used: masonry, mortars, lime cement, pigments, frontages, latticed partitions, floors, ceilings, etc.

The carrying out of the work has been possible through the support of several financing programmes, namely:

- PROCOM (community fund for re-vitalising urban commerce), with which the costs of the improvement and renovation work on commercial installations and equipment and vocational training of the agents involved are jointly financed;
- PROCOM/URBCOM (community fund for the re-qualification of public areas), with which not only simple re-surfacing work, but also the re-modelling of these spaces and the installation of new pieces of urban furniture are jointly financed;
- FUNDO DE TURISMO (community fund granted by the Secretaria de Estado da Cultura), with which the exterior work on facades and roofs carried out on the various buildings are jointly financed;
- RECRIA/REHABITA (joint funding systems operated through the Instituto de Gestão e Alienação do Património Habitacional do Estado (IGAPHE) and the Câmara Municipal de Lisboa), with which the work carried out on privately owned buildings is jointly financed up to 65% of the total cost (in the proportion of 60% from IGAPHE and 40% from the CML), with the remainder being the responsibility of the owners. This also covers the financing for the acquisition by CML of the buildings used for re-housing.
- LEI DO MECENATO, this allows sponsorship by companies. For example, CIN supplied construction materials and CEPSA sponsored the preparation of the architectural projects.

Through these financing schemes, owners benefit from joint funding by grants; they are not responsible for the provisional re-housing of tenants during the work period as this is done by the Câmara Municipal de Lisboa; they do not pay the expenses resulting from the administrative aspects of the work; they do not pay the expenses of the preparation of the projects; and they benefit from economies of scale since the work on each building is done as part of a much larger volume of general work.

On the other hand, they allow: (i) not to increase the rent to more than the social rent value whenever ordinary improvement and/or conservation work is done; (ii) to solve, in terms of the current legislation, irregular occupation situations; (iii) to pay to the CML the cost of the work minus the jointly financed amount, in no more than 10 years.

4.4 CASTLE MUSEUM CENTRE (NÚCLEO MUSEOLÓGICO DO CASTELO DE S. JORGE):

Established in the rooms built on the site of Paço Real da Alcáçova (Citadel Royal Palace), the Arch Room, the Column Room and the Cistern Room, the Castle Museum Centre an exhibition of archaeological objects found during the excavations which took place in various sites at the top of the Castle Hill is shown. These findings allow us to understand the culture and lifestyles of the city during the Iron Age (6th Century B.C.), the Islamic Period, the Medieval Ages up to the 18th Century.

5. ALFAMA

Alfama was built on the eastern slope of the Castle hill, overlooking the river, and it has managed to keep its traditional historical characteristics throughout the centuries. This quarter includes today the parishes of São Miguel, St° Estevão, Sé, Santiago, Castelo as well as part of São Vicente.

Both its geographical location and topography account for Alfama's unique characteristics. Despite a close relationship with the river nearby, it was able to keep some interiority and a considerable privacy, favoured by the twelfth century Muslim urban model. On the other hand, successive flows of a great variety of people gradually allowed for a heterogeneous but rather pleasant social tissue.

Alfama's typically medieval image is well known and has become a symbol of Lisbon itself. The labyrinth-like structure and the network of narrow streets and lanes, cobblestone stairs and small squares reflect both the cultural heritage of the Muslim urban model and an empirical knowledge of space occupation and organisation.

5.1 ALFAMA - A MUSLIM RESIDENTIAL AREA

The first urban settlements were built on the eastern slope of the Castle hill a long time ago. In spite of the exiguity of space and the irregular topography, the area was rather attractive since it faced south and had plenty of water. In the second century, during the Roman occupation, the discovery of thermal springs with healing potential led to the building of leisure resorts, thermal facilities and fountains, attracting the inhabitants of Olisipo[*].

[*] Roman name for Lisbon

During the Muslim occupation, between the eighth and the twelfth century, the thermal industry flourished and some aristocrat families built their residences in the area. The quality of the water or of the place itself are apparently in the origin of the name "Alfama". According to tradition, the toponym "Al-hama" means "hot spring", "good water" or simply "beautiful place".

There were several paths that run along the riverbank and the city wall towards the city. Alfama´s inhabitants used to go in and out of the Muslim medina through the ancient wall that surrounded the city, using two doors later called Portas de São Pedro and **Portas do Sol**.

5.2 MEDIEVAL ALFAMA

When King Afonso Henriques conquered Lisbon from the Moors in 1147, Alfama was abandoned. During the siege the local inhabitants moved to the medina while the Christian troops and the crusaders took strategic positions along the riverbank and near the southeastern gate of the Moorish Wall. The Christians used precisely Porta de São Pedro to occupy part of the walled city.

Following its incorporation in the kingdom of Portugal, the city was subject to a new administrative and territorial organisation and adapted to the Christian social patterns. Temples were built according to the ancient religious structure of the Visigoth age and parishes were created inside the walled Christian city, while rural communities developed gradually in the outskirts.

The Old University (Escolas Gerais) was established in the thirteenth century (around 1240) and remained in Lisbon until 1537, when it moved definitely to Coimbra. There is still a street named after the University (Rua das Escolas Gerais), exactly in its former site.

The development of the medieval quarter of Alfama followed the Muslim urban model with its organic and irregular labyrinth-like structure. Three main streets (Adiça, along the wall, São Pedro and São Miguel) could be already identified in the network of narrow streets, stairs and small squares. They were all oriented towards a church, according to the traditional pattern, ending in squares that were also centres of social contact and commerce.

Largo do Chafariz dos Cavalos, by the river, was the most important and liveliest public space in town. It was later called Chafariz de Dentro when it became part of the city, after the King Fernando Wall was built in the fourteenth century. Local people and travellers used the square for leisure and water supply. The regular market and periodical fairs usually took place there as well, expanding to Rua de São Pedro and to the seashore.

The population grew considerably in the thirteenth and fourteenth centuries, especially with the arrival of Christians, Moors and Jews, as well as mixed Christian-Muslim families. Although there was a high number of craftsmen and sailors, the trade of agricultural products and handicraft was the main economic activity. Activities related to the river and the sea were also relevant, as well as those related to the thermal industry.

A significant Jewish community settled in Alfama in the fourteenth century. Their main activity was commerce. They had their own legal statute and most of them lived in **Rua da Judiaria (Jewish Street)** and in the surrounding area. Alfama remained a favourite quarter for the Jewish population for a long time, even after King Manuel abolished the Jewish ghettos. There are still a number of signs of the Jewish presence in Alfama, such as the above-mentioned Rua da Judiaria.

Meanwhile the city had grown considerably down the slopes of the Castle hill. During the political crisis of 1373-1375, the threat of a Castilian invasion led to the conclusion that the Moorish Wall had lost most of its usefulness, both as an urban limit and from a strategic point of view. The King Fernando Wall was built during those critical years, enclosing and unifying a group of new and heterogeneous urban areas of relevant historical value. Vestiges of the wall and its gates are still visible today in the Castle hill.

5.3 ALFAMA IN THE SIXTEENTH CENTURY

The development of the rivershore area towards the east was particularly remarkable in the fifteenth and sixteenth centuries, during the Portuguese maritime discoveries. The new Royal Residence of King Manuel in Terreiro do Paço, by the river, led to the renewal of old traditional equipment and a number of buildings related both to internal and external trade appeared in that area - shipyards, an armoury (Tercenas Novas), a biscuit factory intended to supply both the population and the vessels and a huge Renaissance-style cereal warehouse (Terreiro do Trigo). The docks were rectified and a new water supply system and was made possible through the improvement of already existing fountains (Chafariz).

- CHAFARIZ (FOUNTAIN) D'EL-REI *

This wonderful building with marble pillars and arcades was equipped with six taps and its utilisation for domestic and ship supply was subject to regulation. Three further taps were added in the eighteenth century and the upper part was built and decorated in the nineteenth century (Fig. 6).

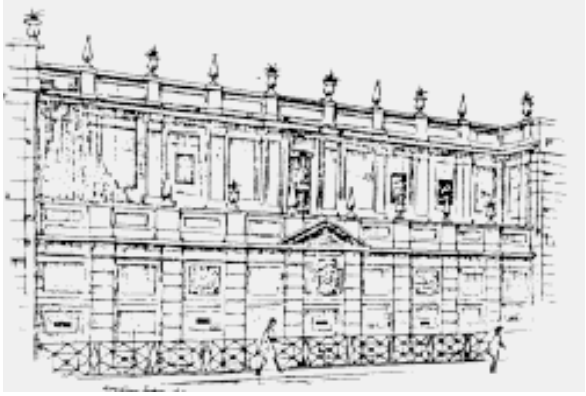

Fig. 6 Chafariz d'El-Rei

- CHAFARIZ DE DENTRO *

It was apparently built in 1285. It was improved in the sixteenth century, when a number of horse-like bronze taps (to match the fountain's name Cavalos, meaning horses) were added.

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* In the area next to Solar dos Bicos Restaurant

- ALCAÇARIAS *

It has also disappeared. It was built in a small square, today called Largo das Alcaçarias, between Chafariz d'El-Rei and Chafariz de Dentro, and people used it to wash clothes, leather and wool.

New houses were built in the wall itself, leading to significant changes in the warehouse area between the market (Mercado da Ribeira, today Campo das Cebolas) and Chafariz de Dentro. These houses had usually two or three floors. Their owners were well-off merchants belonging to a bourgeoisie, which had slowly developed with the maritime activities and also a few foreign merchants. The wall gradually disappeared as the new houses were built. The «Ribeira terraces», a group of houses with galleries and terraces overlooking the river, became famous.

The wall had a considerable number of gates opening to the rivershore. Some of them became part of buildings, while others were replaced by Pombal-style houses or more recent buildings. Some important buildings in this area were severely damaged by the earthquake of 1755 and were rebuilt afterwards:

- CASA DAS VARANDAS (TERRACE HOUSE) *

It was built in the sixteenth century and rebuilt after the earthquake. The upper floors, with large terraces, were added in the nineteenth century and built in the fashionable style of that period (Fig. 7).

Fig. 7 Casa das Varandas

Although the urban structure of Alfama had already been defined in the medieval period, it was completed in the sixteenth century, when a considerable number of houses was built along the main streets (São Pedro, São Miguel, Judiaria and Regueira), all in the characteristic style of the sixteenth and seventeenth centuries - projected façades, solid stone external angles and narrow gables.

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* In the area next to Solar dos Bicos Restaurant

- CASA DOS BICOS *

It was first built in 1521-1523 and the Albuquerque family owned it. The façade still exists, richly decorated with stones in the shape of pyramids like the Diamond House in Ferrara, which was built approximately in the same period. Two of the doors were built, however, in the Portuguese King Manuel-style. It had originally four floors, two of which were destroyed by the earthquake of 1755 (Fig. 8).

Fig. 8 Casa dos Bicos rebuilt after the 1755 earthquake

The building was slightly changed and some modern elements were added in 1983, when it was used for the 17th Exhibition of Art, Science and Culture. It has become a cultural space ever since, and it is frequently used as an exhibition hall (Fig.9).

Fig. 9 Casa dos Bicos today

* In the area next to Solar dos Bicos Restaurant

5.4 THE EARTHQUAKE OF 1755 AND ITS CONSEQUENCES

The earthquake and the fire that followed destroyed a considerable part of Alfama, including several churches, monasteries, palaces and private homes.

The reconstruction of Alfama did not follow a specific plan. The Public Housing Department (Casa do Risco das Obras Públicas) gave only sporadic support. There was never a general plan of urbanisation for the eastern part of the city and although some ideas were discussed their implementation kept being postponed. There was nevertheless a reconstruction plan for the seashore area, which included the demolition of some remaining wall vestiges and the definition and alignment of façades.

The old Terreiro do Trigo was replaced by the imposing Celeiro Público, built in Pombal-style with the same function of its predecessor.

The palaces and churches (in particular the churches of São Miguel and Santa Luzia) were rebuilt in the sober fashionable style of the period.

In the years that followed there was a strong population flow towards less affected areas. In 1758 Alfama had 4 979 inhabitants; in 1780 only 2 480 people lived there.

In the end of the eighteenth century and during the nineteenth century the population increased again, due to the rehabilitation of the thermal industry in Alfama and later to the development of industry and construction, which attracted people to Lisbon.

5.5 UNIDADE DE PROJECTO DE ALFAMA (ALFAMA PROJECT UNIT)

The former Alfama Technical Office (*Gabinete Técnico de Alfama*) was established in a time of deep concern about the future of the old part of Lisbon. The problem of house deterioration, in a few areas in particular, became so urgent that it was necessary to create a special department to centralise and implement actions of urban rehabilitation.

After a first experimental phase, during which immediate action was taken to tackle the most urgent cases, the *Gabinete Técnico de Alfama* was integrated in the municipal services and given larger responsibilities. Its action, initially restricted to Alfama, was extended to a larger area.

Later on called Local Office of Alfama and Castle Hill *(Gabinete Local de Alfama e Colina do Castelo)*, it is now the Alfama Project Unit.

Like the others Project Units of Lisbon City Council, It employs architects, engineers, sociologists and lawyers, in a multidisciplinary, which goes far beyond the initial case-by-case approach. Technical, social and economic factors as well as specific problems of each area are now taken into account in the urban rehabilitation projects.

The Unit carries out the following main types of action in Alfama:

- <u>municipal buildings</u> - their recuperation allowed for the definition of a specific model to be applied in similar cases; it also provided temporary or definitive shelter for low-income families.

- <u>Compulsory action in private buildings</u> - as a first step, the municipality notifies the owner, urging him to take the necessary action; if he fails to do so, it takes over the administrative responsibility and repairs the building at the owner's expenses.

- <u>private action programmes</u> - the owners and/or the private sector are responsible for the recuperation of their buildings. In most cases (for example, the RECRIA programme) both the Government and the municipality give considerable financial support while encouraging private investment at the same time. The amount of public support is calculated on the basis of rent values, so that low-rent buildings get higher subventions. The results of this type of action have been very positive so far. It has decisively contributed to a global

improvement of buildings and private homes, also in what concerns security, public health and comfort. On the other hand, a growing number of owners have been adopting this programme to repair their buildings. The municipality also supervises the works and gives all necessary advice, including in cases where the owner supports total repairing costs.

- Urban Regeneration Integrated Projects - The increased knowledge and consolidation of the districts and the establishment of a more solid plan of action made it necessary to complement the municipality's Urbanisation Plans for the central historic area (Alfama, Mouraria; Bairro Alto/Bica, Madragoa) with special integrated plans for specific areas with given characteristics. For the purpose, five centres were selected, one for each district: Teatro Taborda, in Mouraria; Chafariz de Dentro, in Alfama; Palácio Marim/Olhão, no Bairro Alto and Convento das Bernardas, in Madragoa). Castelo was added to these centres afterwards.

  The urban rehabilitation philosophy is based, on the one hand, on the principle of maintaining the inhabitants and attracting young people and, on the other hand, in the autodinamisation of the quarters, improving housing conditions, as well as of the public urban areas and its accessibilities, by creating social and cultural equipment, also preserving the historic and architectonic patrimony.

  Apart from the isolated interventions in buildings, the Alfama Project Unit carries out integrated projects, taking place in groups of buildings, blocks and street fronts, especially in areas that are potential invigorating poles for the surrounding districts. Specific financial supports and special agreements with private owners allow the municipality to play the role of the owners, concerning work planning and execution.

  The Units are also responsible by urban management and perform a remarkable role in the relationship with the inhabitants, the promoters, the local administrative authorities and the other municipal departments, which have direct intervention in public areas (green areas, infrastructures, etc.).

6. LISBON CATHEDRAL (SÉ DE LISBOA)

The Cathedral (Sé) is Lisbon's oldest and most important church. It is devoted to Saint Mary. Its architectural and artistic characteristics reflect many significant moments of Portugal's history and culture.

The construction of the Sé began in 1147, right after King Afonso Henriques conquered Lisbon from the Moors. Some Visigoth carved stones were also found in the walls of the church during the rebuilding periods that followed its destruction by the earthquake of 1755. In fact, the stones may prove the existence of a former Visigoth temple, but they also could have been brought from other places and used there to build the new church (Fig. 10).

Fig. 10 The Sé in the 16th century (Braunio Plan)

The Cathedral was severely damaged by several earthquakes, particularly by those that occurred in 1344, 1531 and 1755. It was therefore reconstructed and repaired frequently, which led to a pleasant coexistence of styles still visible today. The building of the Cathedral occurred mainly in two periods: the Romanic (late 17th century) and the gothic (13th and 14th centuries).

The building's façade looks like a fortress. It has two solid square bell-towers with battlement and window slits. On the top of each tower we can see a gothic window. In the middle of the façade, the main door of the church is composed of four archivolts in Romanic style. Above the door, a rosette is to be seen. The cloisters date from the 13th century, but they have been rebuilt and modified several times.

Until 1755, the Sé had a clerestory, a prominent structure above the church transept. It collapsed completely during the earthquake and was never rebuilt. The last recuperation dates from 1940.

7. LISBON OF POMBAL

7.1 THE BAIXA (DOWNTOWN)

7.1.1 BEFORE THE EARTHQUAKE

The city destroyed by the earthquake in 1755 had been built along the right bank of the Tagus, from Pedrouços and Belém to Xabregas, with a growing urban concentration towards the centre. The most densely populated area of the city began in São Paulo, up to São Pedro de Alcantara and Alto da Graça, then down again to Santa Apolónia in the east, including the old quarters of the Castle and Alfama, perched high up the hill, and to the lower part of the city or **"Baixa"**, which had been built on a former arm of the Tagus.

The only available document showing the topography of Lisbon before the earthquake of 1755 is the plan drawn by Joao Nunes Tinoco in 1650, since the more accurate plan drawn by Manuel da Maia in 1719, showing the destroyed city, is lost (Fig. 11). A thorough analysis of Tinoco's plan shows that between 1650 and 1755 there were very few changes in the topography of the area which was most severely damaged by the cataclysm. In 1755 it still looked like a labyrinth, with a typically medieval, densely concentrated urban image, squeezed between the Castle hill in the east and São Francisco hill in the west, but already opening towards the two squares - Terreiro do

Paço and Rossio - which will survive the earthquake. A few imposing buildings rose amidst the labyrinth of houses and streets: the old Paços de Alcáçova, a former Royal Residence abandoned in the beginning of the sixteenth century, and the Royal Residence Paço da Ribeira, facing the river in Terreiro do Paço, built during King Manuel's reign and further improved in the following reigns. Its high dome, designed by Terzi, dominated the most important axis of the city. It was surrounded by the most important. public buildings: the customhouse, the House of India, the shipyards and, on the east side, the Misericórdia Church, with its King Manuel-style door, Casa dos Bicos with its bewildering facade, the Bragança Residence and Ribeira Velha, the main fish and vegetable market. A magnificent group of buildings, in particular the Royal Hospital de Todos-os-Santos and São Domingos Monastery ennobled Rossío. On the north side of this square, the Estaus Palace became the headquarters of the Inquisition Court during the reign of King Joao III.

Fig. 11 Plan of Lisbon by J. N. Tinoco (1650)

A number of important buildings appeared during the reign of King Joao V, as the city expanded towards the west: Palace of Necessidades, Palace of Belém, the Patriarcal Church, the Opera House (opened in 1755 and immediately destroyed by the earthquake), Ludovici Palace in São Pedro de Alcantara and several beautiful fountains, some of which still exist today. The Aqueduct of Aguas Livres, a remarkable engineering work, was finished in 1744, but it did not change the city's general appearance, as it was away from the centre. It is still the most magnificent urban edification in today's Lisbon.

The structure of the traditional quarters remained unchanged, except for Bairro Alto, built during the sixteenth and seventeenth centuries. Its Renaissance plan announced already the orthogonal design of Illuminist cities, including Lisbon of Pombal.

The city about to be severely damaged by the earthquake of 1755 and the subsequent fire had a basically medieval structure. It had grown chaotically and had been subject to various and rich influences, while incorporating artistic and architectural treasures of considerable value.

7.1.2 THE EARTHQUAKE OF 1755

On the first of November 1755, All Saints Day, at exactly forty past nine in the morning, when most of the population was in church, a series of increasingly strong earthquakes destroyed with a deafening roar and in a suffocating cloud of dust the noblest area of a city that centuries of history had made famous all over Europe. The earthquake had an unusual intensity (VII to X in the modified Mercalli scale) and magnitude (8.75 to 9 in

the Richter scale). It was followed by a violent and unexpected tsunami and a dreadful fire that lasted four days and destroyed what had been left by the earthquake.

The central downtown area of "Baixa", as well as São Francisco hill up to Chagas and Carmo and a considerable part of the eastern area, including the Cathedral (Sé) and São Mamede, were almost completely destroyed. Other areas of the city were also severely damaged. According to available data 10 000 to 30 000 of the 250 000 inhabitants were killed (Fig.12).

Fig. 12. The Earthquake of 1755

It is possible to imagine what this cataclysm must have been like by going through some very lively, detailed and sometimes rather fanciful descriptions and drawings done by eye-witnesses, most of them foreigners.

In the turmoil that followed the earthquake, a lot of frightened people were killed as they tried desperately to escape, while the survivors fled from the burning city centre towards the seashore, where they ended up being swallowed by the gigantic waves of the tsunami. Some people fled to the inland, seeking shelter in less affected areas such as squares, monasteries and gardens. They camped there, in tents made of canopies used in the procession of Corpo de Deus and tissues taken from the city's warehouses. They also fled to Cotovia and São Bento hills and to Belém. Lisbon was almost totally abandoned by its inhabitants. It was left to tramps and thieves and became a city of misery and desolation.

The royal family was in Belém when the earthquake happened. They decided to stay there, in a wooden palace designed by Carlos Mardel and situated in Alto da Ajuda, thus leaving the city centre for good.

7.1.3 REBUILDING THE CITY

Sebastiao José de Carvalho e Melo, Marquis of Pombal and Prime Minister of King José I, was given the great responsibility of taking urgent and efficient measures to mitigate the situation. He began his work immediately, for both his political career and the future of the nation were at stake.

On the very day of the earthquake and on the following days Pombal took several preventive measures with a view to ensuring food supply and fixing prices. Thieves and

speculators who had tried to take advantage of the situation were punished. A series of protective measures to avoid population flow towards the outskirts followed, encouraging people to return and camp in the city. Wooden houses were imported from the Netherlands and became very popular among the Lisbon upper class.

Legal measures were taken to prevent illegal construction outside the city as well as to forbid the construction of stone houses in the city, for there were no official propriety registers. These laws were strictly enforced so that all houses illegally built in the following months were demolished in February 1756. On November 29 and December 3 two important decrees were published. The first stipulated the official register of every destroyed quarter while the second announced the publishing, at the earliest possible date, of reconstruction plans for every quarter.

Pombal had a difficult task ahead. But he was not alone, nor is he the only one to get all the credits for the gigantic work done. He relied on the help of a team of determined politicians (for example, Duke of Lafoes, who coordinated the reconstruction work) and efficient technicians (Manuel da Maia, Eugénio dos Santos, Carlos Mardel, Joao Pedro Ludovici, José Poppe, Gualter da Fonseca and many others).

There was a time of hesitation and doubt concerning the future of Lisbon. While some favoured the construction of a whole new city in a safer area like Belém or Campo de Ourique, strong economic arguments led both King José I and Pombal to decide in favour of rebuilding the city on its original site, in particular the central and most severely damaged area.

Absolute priority was given to the downtown area of "Baixa", the economic and commercial centre of the city. The preliminary alignment work started in December.

Six proposals were presented to Manuel da Maia. These proposals ranged from an ambitious plan to demolish what was left and to build a whole new city to the simple reconstruction of the destroyed area exactly as it was before.

The selected project, by Eugénio dos Santos, was based on one of Manuel da Maia's ideas. It was approved by the Decree of June 12, 1756, and its implementation began immediately (Fig. 13). For the first time in six Christian centuries Lisbon had a systematic plan of construction and an effective programme of implementation.

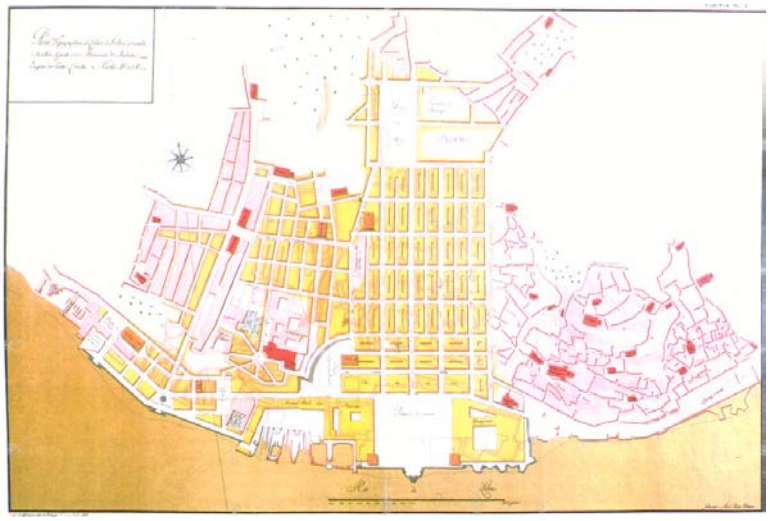

Fig.13 Plan for the Reconstruction of Lisbon by Eugénio dos Santos

Eugénio dos Santos' plan covers the central downtown area of the city and, with less accuracy due to the irregular topography, São Francisco and Castle hills, the last one never accomplished, as well as the western seashore area until São Paulo.

The two traditional squares of Rossio and Terreiro do Paço were aligned and linked by a network of longitudinal and transversal streets forming right angles. These streets were organised according to a hierarchy and their importance was defined by their wideness, quality of pavement and sewage as well as the number of innovative urban elements. The rubble was used to level the ground. Three "noble" streets (Áurea, Augusta and Bela da Raínha or Prata) have their origin in Terreiro do Paço, facing the river. Two of them end in Rossio while the third ends in another parallel square, Praça da Figueira, built on the site of the old Royal Hospital (transferred to the Monastery of Sant'Antão and later called São José Hospital). A regular market was held there for many years. Two other parallel streets, Nova da Princesa (Fanqueiros) and Madalena, have approximately the same length as their neighbour streets. Between each one of the three "noble" streets there are three narrower streets. One of them, Rua Nova d'El-Rei (Rua do Comércio), was built on the site of old and famous Rua Nova dos Ferros and geometrically aligned with the others. All these streets define longitudinal and transversal blocks, thus creating a rather dynamic and lively urban network.

The reconstruction plan of Rossio was designed by Carlos Mardel. The reconstruction of Terreiro do Paço was assigned to Eugénio dos Santos. It became the noblest place in the newly-rebuilt city centre: regular arcades, a triumphal arch (which was finished only a century later) leading to the inner city, Spanish-style turrets and a statue of King José I riding his horse - this masterpiece by the sculptor Machado de Castro, built in 1775, was the first relevant monument of Lisbon. All these elements formed a "Place Royal" of international taste; in opposition to its new name Praia do Comerica (Commerce Square), which reflected the social, political and ideological intentions of Pommel’s Illumines.

Although priority was given to the central downtown area, Pombal's plan of reconstruction was very ambitious and contained more or less detailed urbanisation projects for other areas of the city.

This systematic large-scale programme reflects the ambitious intention of Pombal to give Lisbon a rational urbanisation plan with a view to controlling its growth after the earthquake. It proved too excessive in view of the limited capacities of that time, and eventually it was abandoned. It was nevertheless a first global approach to the problem of urban growth.

Manuel da Maia's plan also included projects for the city's new buildings, signed by Eugénio dos Santos. These projects followed Manuel da Maia's guidelines concerning size, number of floors and balconies, as well as the new concept of chimney-boards built on the sidewalls and rising above the roof. The new houses should have two floors, so as to achieve a balance between the building's dimension and the size of the streets, thus avoiding major damages in case of an earthquake. As the two-floor project did not meet the demands of owners and economic groups, it was replaced in 1758-59 by a new one, also signed by Eugénio dos Santos. According to this new project, houses should have three floors; the first with large windows and a long balcony, the second and third with bay windows and a mansard with windows opening out on the roof. The ground floor was used for commercial purposes. The facade decoration of

the "Pombal building" varied according to the hierarchical importance and broadness of the streets (Fig. 14 and Fig. 15).

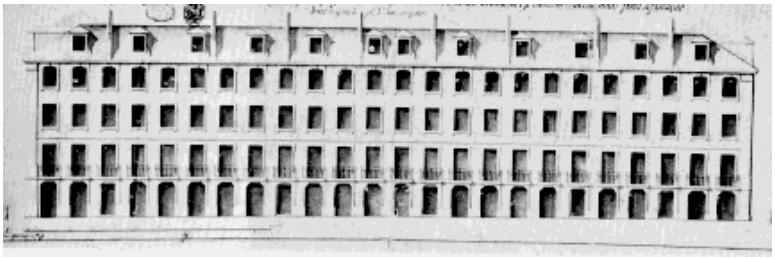

Fig. 14 Building Façades in the Main Streets by Eugénio dos Santos

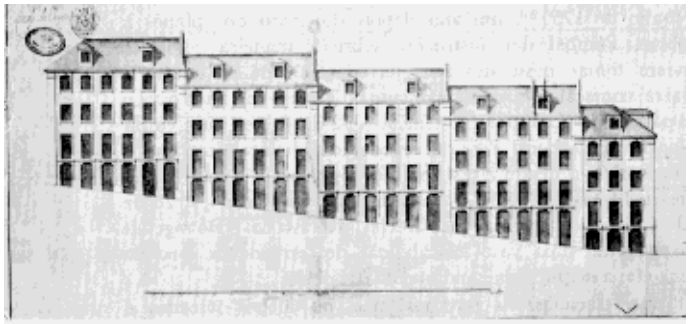

Fig. 15 Building Façades in Steep Streets by Eugénio dos Santos

This model reflects, also in the interiors, an attempt to obtain a harmonisation of patterns and will be adopted later in other areas of the city. A pleasant balance was achieved between a certain monotony of the streets and the proportion and relative position of the blocks. Architecture was therefore determined by urbanism and based on rational principles of both practical and symbolic nature. This is after all the basic philosophy of a modern city.

According to Eugénio dos Santos, this new concept should serve a "city of tradesmen": it should be economical and strong; aesthetical concerns were secondary. This concept was subject to criticism, but it also reflected a positive approach to Pombal's policy, based on middle-class support.

Shops and workshops were distributed by the new streets according to a specific occupation or craft (goldsmiths, silversmiths, shoemakers, saddlers, gilders, haberdashers, drapers), grouped in independent guilds similar to those of the Middle Ages.

The Government and Court of Justice, the economical departments, the Stock Exchange and the Customhouse were established in Praça do Comércio, as well as a building occasionally used as a residence by the King.

In Rossio, Carlos Mardel's subtle and elegant design, based on German-style roofs, contrasted with the monotony of the nearby streets, built according to the traditional Portuguese system.

In the central downtown area (Baixa Pombalina), a traditional commercial quarter, there was no place for noble residences, most of which were built in the new quarters.

Only a few of them were palaces. Their owners belonged to a prosperous bourgeoisie, who preferred to adopt the sober design of Pombal-style buildings.

Sobriety was also the outstanding characteristic of churches built or rebuilt during this period, in spite of the availability of financial resources (expenses were supported by the religious orders) and a larger freedom of concept. Most of them looked rather discrete and monotonous. They usually had a triangular gable and some had two symmetrical towers, like São Paulo and Santo Estêvao. The interior was also austere: the "azulejos" (tiles) and carvings were simple and often replaced by stone or plaster.

7.1.4 CONCLUSION

Pombal's plan of reconstruction was meant to face a special situation - the destruction of Lisbon caused by the earthquake of 1755. It was based on very strict principles of functionality and economy both of time and money. It introduced important technical innovations and developed advanced public health and urban theories. Although some of them were never applied, it is worth recalling a few important innovations:

1. The reconstruction of Lisbon set up a mass production system long before the industrial revolution took place in Portugal. The uniformity of construction led to the adoption of models, which were made according to previously programmed dimensions and structures. It was therefore possible to produce a considerable number of parts that could be used almost everywhere. This also applied to the Pombal-style "azulejo", which followed the seventeenth century model and was subject to mass-production as well.

2. The need to develop safety systems to prevent major damages in case of an earthquake led to the adoption of a few devices in the new buildings, namely the "gaiola" or cage (a structure similar to a cage) and the chimney-board (Fig. 16 and 17).

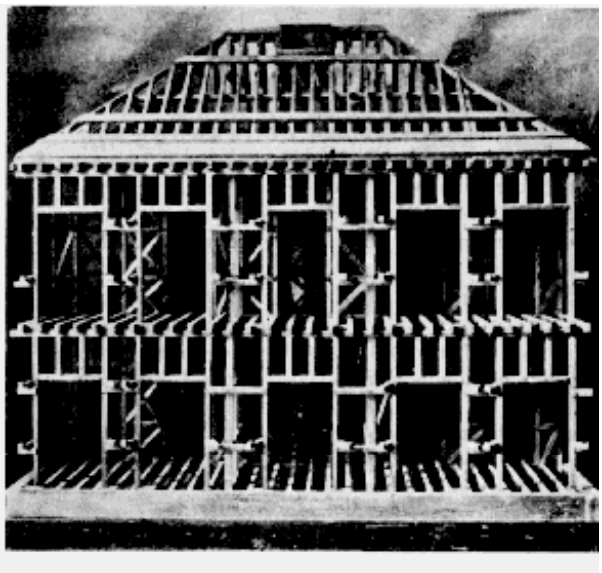

Fig. 16 The “Gaiola”: the Basic Structure of Pombal-style Buildings

The "gaiola" is a flexible wooden structure built on beams and girders (10x13 cm or 15x13 cm), able to support both the roof and the floors in case of an earthquake and to prevent masonry from collapsing. The “gaiola” was set up on site and filled afterwards with masonry. The chimney-board system was also an important technical innovation. It

first appears in the downtown area or "Baixa", in projects by Eugénio dos Santos. Chimney-boards were usually built on the sidewalls of every building, rising above the roof. In case of a fire, it would be therefore easier to prevent it from spreading to the neighbour buildings.

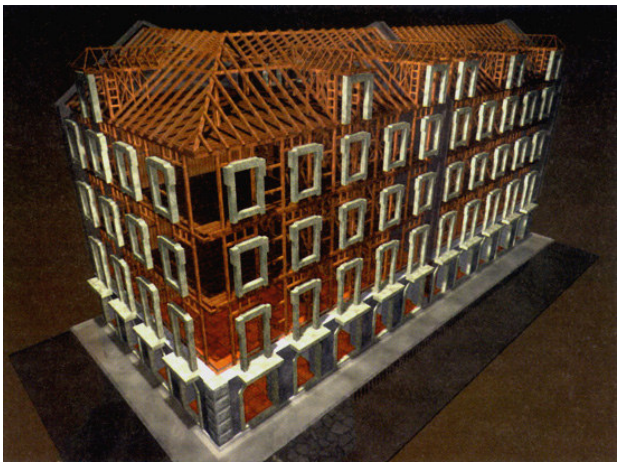

Fig. 17 Another view of the "Gaiola"

3. There were also some proposals by Manuel da Maia and Eugénio dos Santos concerning public health, namely a sewage system along every main street. As this system was too expensive and not very practical, the hygienic conditions in the city remained very poor throughout the eighteenth century. The same happened inside the buildings, where toilets were inexistent. Manuel da Maia also proposed to establish a new water supply system all over the city (including a water delivery project), but in practical terms only a few fountains were added (Fig. 18).

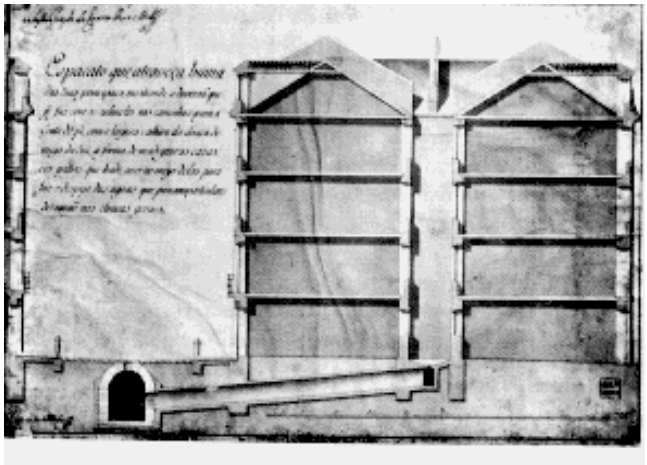

Fig. 18 Sewage System (detail)

There were nevertheless some improvements. The alignment of streets and buildings in Baixa according to Pombal's directives solved the problem of regular floods in the lower part of the city. The construction of several large and airy streets and two beautiful new squares, one of them by the river, as well as a long alley surrounded by gardens (Passeio Público), designed by Reinaldo Manuel dos Santos and built in 1764, helped improve the overall public health conditions in the city.

Although only part of the initial reconstruction plan was implemented, its technical innovations as well as a number of original, efficient and bold solutions made it one of the most important and best executed programmes of modern times.

7.2 THE BAIXA-CHIADO PROJECT UNIT

The Chiado Reconstruction Office (*Gabinete de Reconstrução do Chiado*) was created after the Chiado Great Fire of 25th August 1988. Between 1991 e 2002 this Office centralised and supported the reconstruction and the licensing processes of the buildings included in Architect Siza Vieira's Detailed Plan for the Destroyed Area.

In 2002 the Baixa-Chiado Project Unit (*Unidade de Projecto da Baixa-Chiado*) was created occupying a space between the areas of intervention of Mouraria, Alfama, Bairro Alto and Bica Project Units.

The area of Baixa-Chiado Unit includes the Pombaline Baixa (Downtown), classified as "Public Interest Set of Buildings" ("*Imóvel de Interesse Público*") and Chiado. Pombaline Baixa and a part of Chiado have a process under way to be designated as "Pombaline Lisbon" ("Lisboa Pombalina"). The Pombaline Baixa Detailed Plan, also including a part of Chiado.,is now in the final phase of the public consultation process.

7.3 CORREEIROS STREET ARCHAEOLOGICAL SITE (NÚCLEO ARQUEOLÓGICO DO MILLENNIUM BCP

Correeiros Street Archaeological Site (Núcleo Arqueológico do Millennium BCP is a private museum owned by the bank Millenium BCP, where archaeological findings under the "Baixa Pombalina" (Pombaline Baixa or Downtown) displaying vestiges from different ages, specially from the Roman Times can be seen. Also the basis of the 18th Century "Gaiola" (cage) structure used to resist earthquakes can be clearly observed.

RELEMR WORKSHOP, Lisbon 26-29 October 2009

Field Trip – Notes on the building visited at Recolhimento Street, S. Jorge Castle area

The intervention carried out in the building located at Recolhimento Street n.º 28 to 36 in the S. Jorge Castle Residential Area, aimed at providing the best property habitation conditions and security, seeking to remove dissonant elements that have changed the original composition of the facade, also reshaping the geometry and material of the roof.

This is an old building from the late nineteenth century, which has the characteristics of buildings with the implementation of the "Gaioleiros" structure (Wooden structure with "Saint-Andrew" crosses filled with bricks).

It has a total of five floors, twenty apartments and a total floor area of 1021.23 m^2.

The main facade of the building is covered with tiles that have been maintained, as also all the decorative elements typical of the time of construction, including the cast iron rails, platband and the capstone configuration.

In order to provide better living conditions to the top floor apartments, the geometry of the roof was changed and was transformed in a garret ("mansard").

Although all the framework for windows and doors is new, it was designed to respect the spirit of the existing framework. In terms of the facade, the architecture limited itself to eliminate the dissonant aspects to be found (aluminium windows, blinds, etc.), re-framing the windows framed in wood.

All the infrastructures were reinstalled for water, gas, electricity, telephones, cable television, as well the sewerage.

The existing building is structurally composed of masonry walls of mortared stone in its outer contour and inside the building in frontal walls of wood filled with brick masonry and wooden beams for floors and roof.

Due to the fact that the city of Lisbon is in the seismic zone A, as defined in the zoning regulation and Security Measures Structures of Buildings and Bridges – RSA, the joint connections between the wooden structural beams for floors and roof have auxiliary metal pieces. These reinforced connections provide an improvement to the behaviour of the building against earthquakes.

The stability, studied the building as one, and tried to comply with the original construction techniques used in the building.

In the sequence of the structural changes made, and with the dual purpose of rehabilitating maintaining the original construction processes, improving in particular by giving them better resistance to earthquakes by the interconnection between the structural elements, such as:

Full replacement of the roof, which was rebuilt in wood structure, made compatible with the design proposed by the architecture. The wooden beams were laid out like sticks connected with metal pieces, vertical beams slightly inclined (constituting the walls of the attic) supported on the exterior walls.

On the top of the exterior walls, was made a reinforced concrete lintel all the way around, connected by bolts for the purpose of joining them.

Elimination of the covering materials in kitchens and bathrooms with full replacement of the wooden beams as principal elements and secondary elements such as billets and floor coverings. In this mentioned areas the solution found was the application of "viroc" boards (cement and wood mixture compose), which in turn were fixed with screws to the wooden beams.

Along the walls of the periphery on its inner side, a metal beam in "U" shape (UNP160) will be introduced, which is connected with metal pieces in the outer walls and joined by metal "cables". That has the function of connecting wood flooring to exterior masonry walls, in order to ensure and improve the resistance of the building against earthquakes.

Fig. 2

Fig. 3

Fig. 4

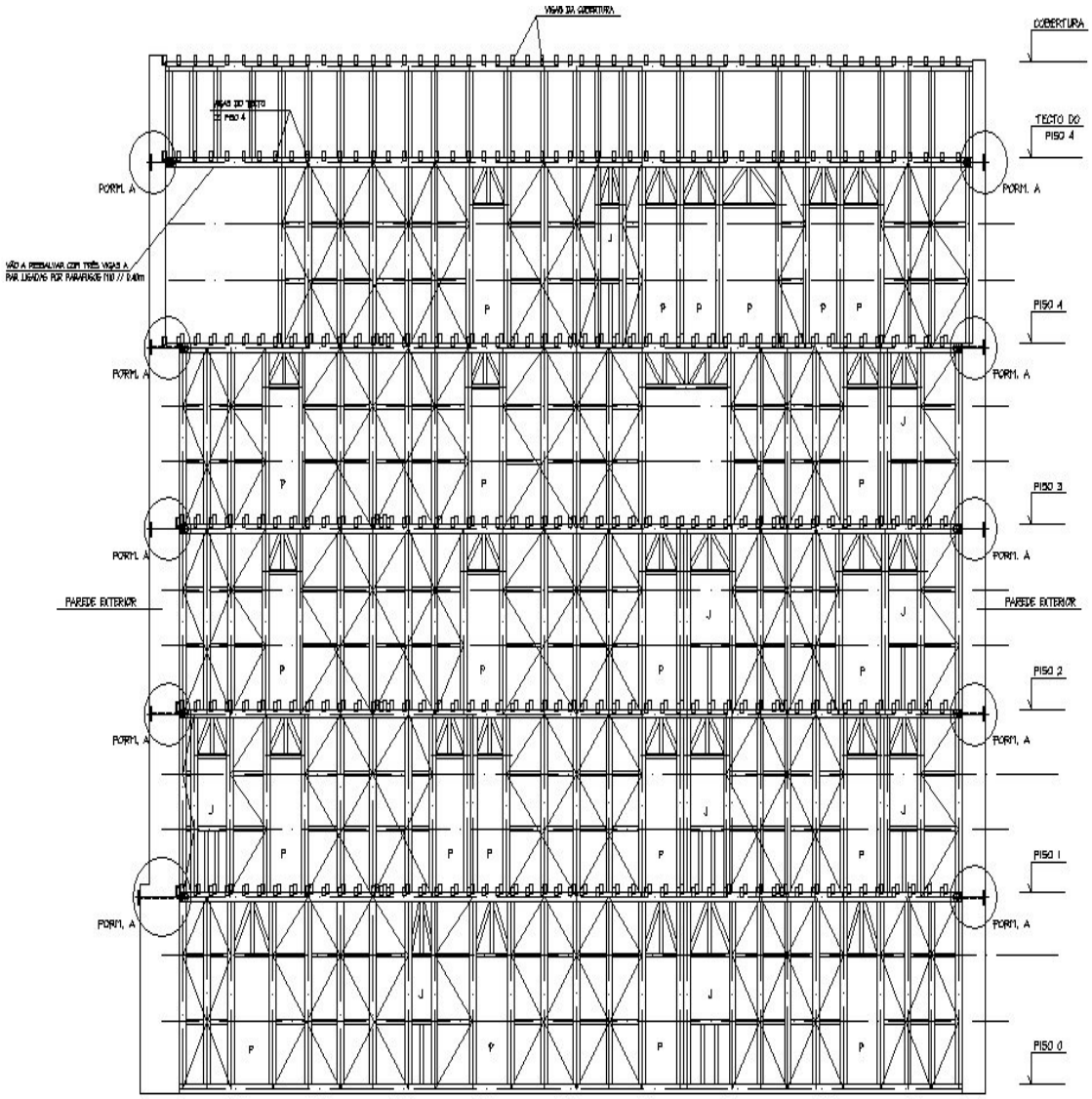
VIGAS DA COBERTURA
COBERTURA
VIGAS DO TECTO
DO PISO 4
TECTO DO
PISO 4
PORM. A
VÃO A REBALSAR COM TRÊS VIGAS A
PAR LIGADAS POR PARAFUSOS M10 // 0.40m
PISO 4
PISO 3
PISO 2
PISO 1
PISO 0
PAREDE EXTERIOR
J
P

Fig. 1

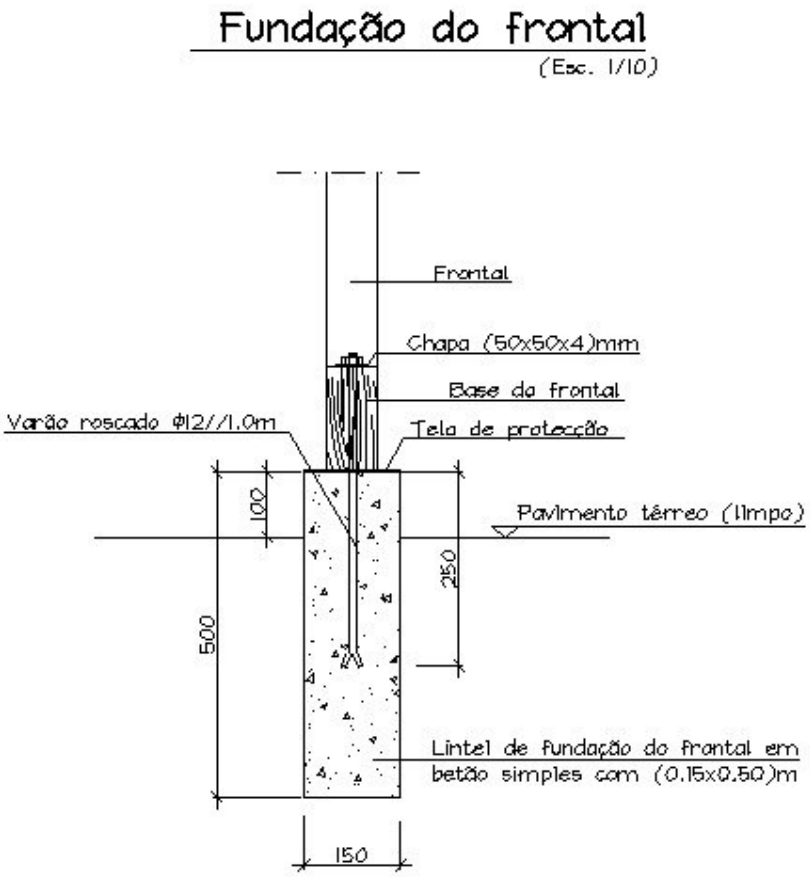
Fundação do frontal
(Esc. 1/10)
Frontal
Chapa (50x50x4)mm
Base do frontal
Varão roscado Φ12//1.0m
Tela de protecção
Pavimento térreo (limpo)
100
250
500
Lintel de fundação do frontal em
betão simples com (0.15x0.50)m
150

Fig. 5

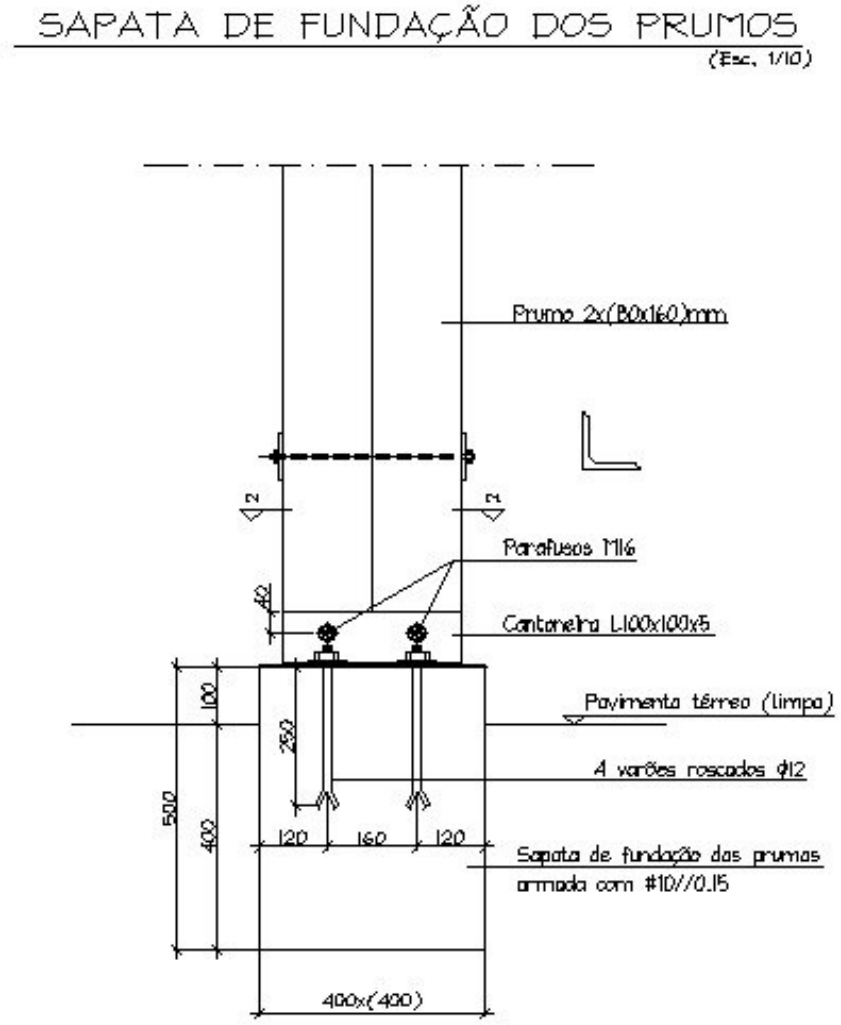
SAPATA DE FUNDAÇÃO DOS PRUMOS
(Esc. 1/10)
Prumo 2x(80x160)mm
Parafusos M16
Cantoneira L100x100x5
Pavimento térreo (limpo)
4 varões roscados ϕ12
Sapata de fundação dos prumos
armada com #10//0.15
400x(400)
120
250
500
400
120
160
120

Fig. 6

Fig. 7

Fig. 8

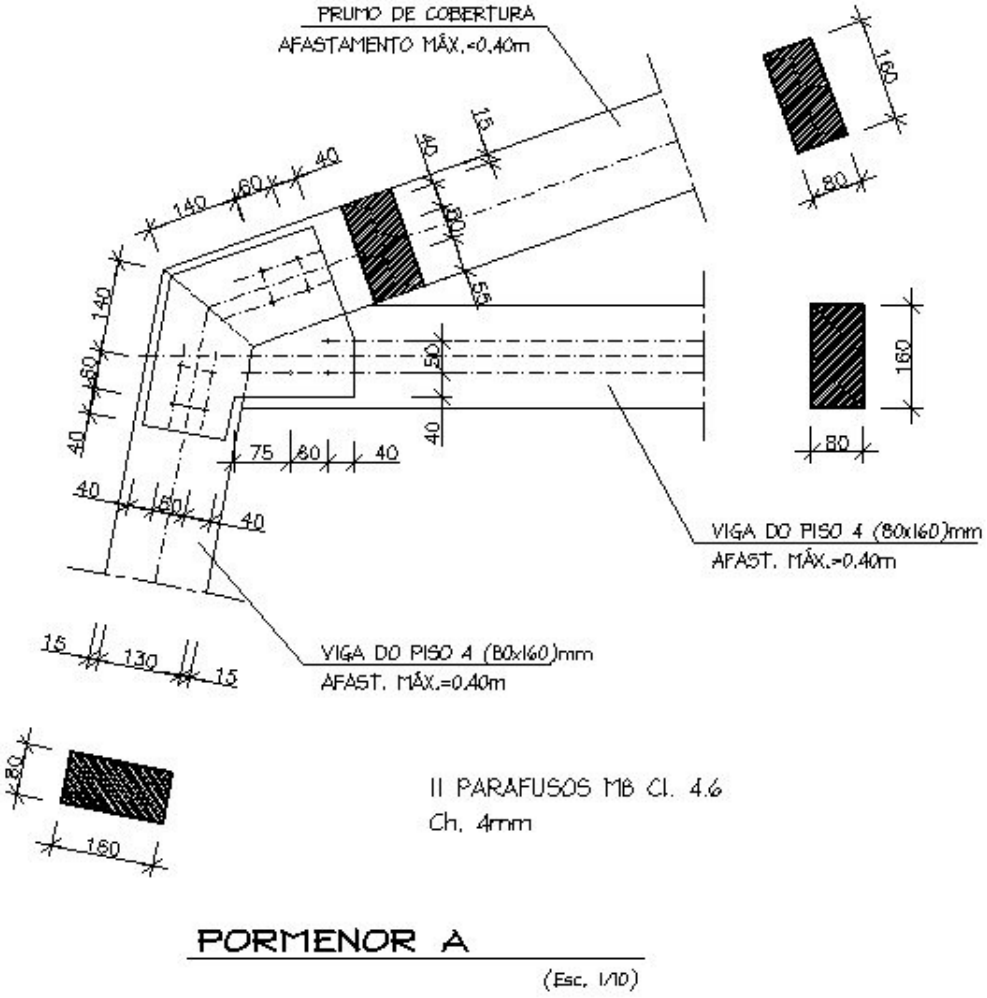
PRUMO DE COBERTURA
AFASTAMENTO MÁX.<0.40m
VIGA DO PISO 4 (80x160)mm
AFAST. MÁX.>0.40m
VIGA DO PISO 4 (80x160)mm
AFAST. MÁX.=0.40m
11 PARAFUSOS M8 Cl. 4.6
Ch. 4mm
PORMENOR A
(Esc. 1/10)

Fig. 9

Fig. 10

Fig. 11

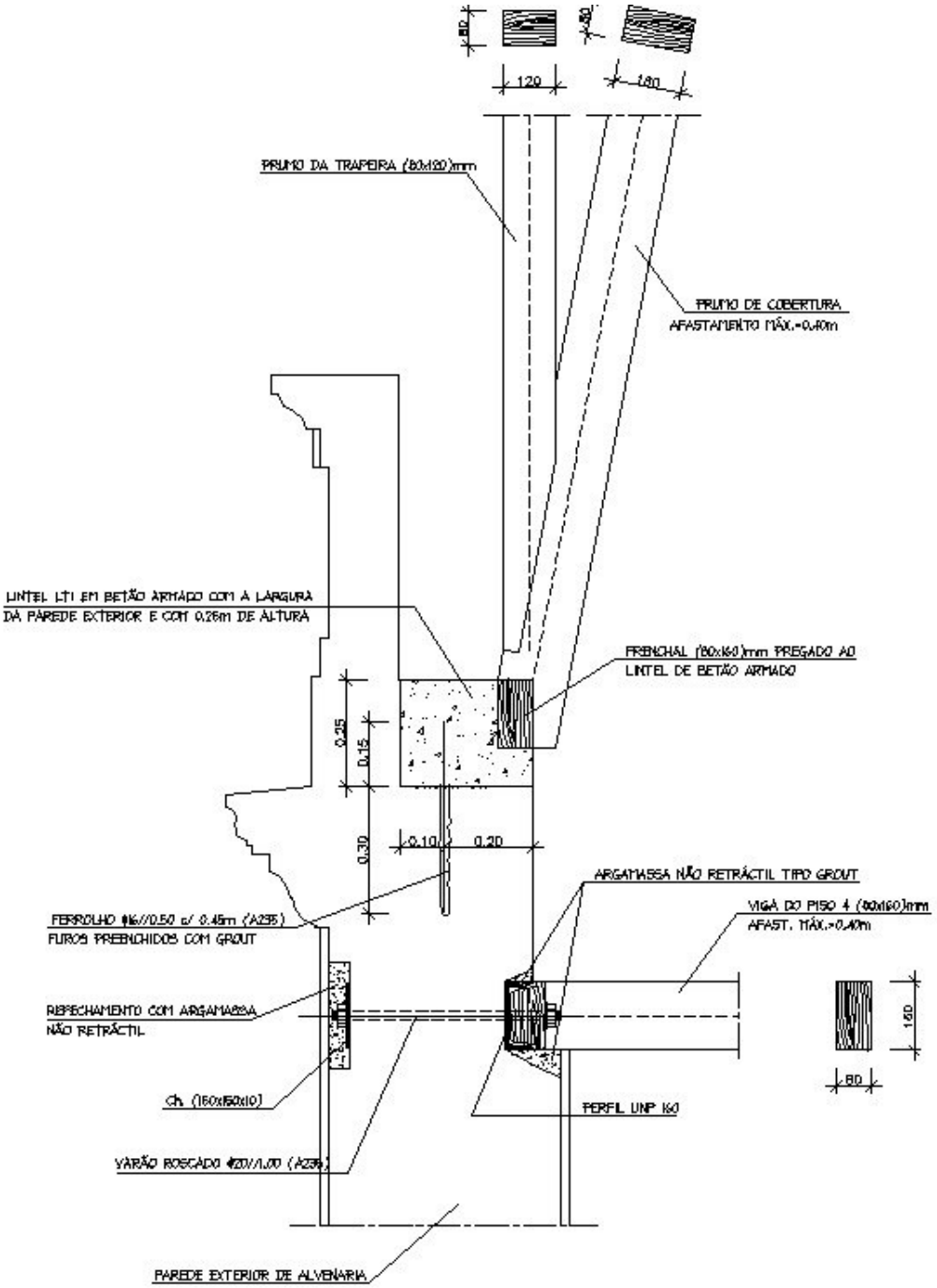
PRUMO DA TRAPEIRA (80x120)mm
PRUMO DE COBERTURA
AFASTAMENTO MÁX.=0.40m
LINTEL LT1 EM BETÃO ARMADO COM A LARGURA
DA PAREDE EXTERIOR E COM 0.26m DE ALTURA
FRENCHAL (80x160)mm PREGADO AO
LINTEL DE BETÃO ARMADO
ARGAMASSA NÃO RETRÁCTIL TIPO GROUT
VIGA DO PISO 4 (80x160)mm
AFAST. MÁX.=0.40m
FERROLHO Φ16//0.50 c/ 0.45m (A235)
FUROS PREENCHIDOS COM GROUT
REPECHAMENTO COM ARGAMASSA
NÃO RETRÁCTIL
Ch. (150x150x10)
PERFIL UNP 160
VARÃO ROSCADO Φ20//1.00 (A235)
PAREDE EXTERIOR DE ALVENARIA

Fig. 12

Fig. 13

Fig. 14

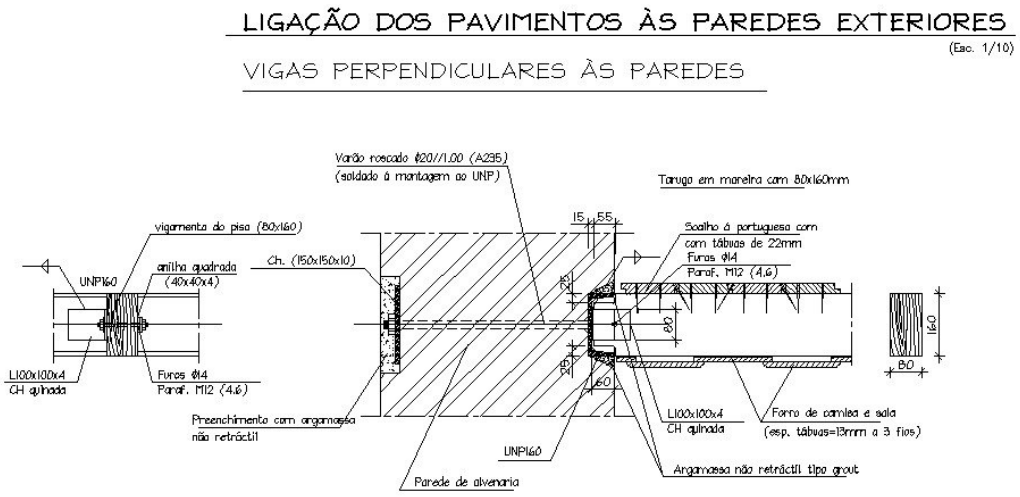
LIGAÇÃO DOS PAVIMENTOS ÀS PAREDES EXTERIORES
(Esc. 1/10)
VIGAS PERPENDICULARES ÀS PAREDES
Varão roscado Ø20//1.00 (A235)
(soldado à montagem ao UNP)
Taruga em madeira com 80x160mm
vigamento do piso (80x160)
anilha quadrada
(40x40x4)
Ch. (150x150x10)
UNP160
L100x100x4
CH quinada
Furos Ø14
Parafs. M12 (4.6)
Preenchimento com argamassa
não retráctil
Parede de alvenaria
UNP160
L100x100x4
CH quinada
Argamassa não retráctil tipo grout
Soalho à portuguesa com
com tábuas de 22mm
Furos Ø14
Parafs. M12 (4.6)
Forro de camlea e sala
(esp. tábuas=13mm a 3 fios)
15
55
25
80
25
60
160
80

Fig. 15

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RELEMR WORKSHOP, Lisbon 26-29 October 2009

Field Trip – Notes on the building visited at Recolhimento Street, S. Jorge Castle area

The intervention carried out in the building located at Recolhimento Street n.º 28 to 36 in the S. Jorge Castle Residential Area, aimed at providing the best property habitation conditions and security, seeking to remove dissonant elements that have changed the original composition of the facade, also reshaping the geometry and material of the roof.

This is an old building from the late nineteenth century, which has the characteristics of buildings with the implementation of the "Gaioleiros" structure (Wooden structure with "Saint-Andrew" crosses filled with bricks).

It has a total of five floors, twenty apartments and a total floor area of 1021.23 m^2.

The main facade of the building is covered with tiles that have been maintained, as also all the decorative elements typical of the time of construction, including the cast iron rails, platband and the capstone configuration.

In order to provide better living conditions to the top floor apartments, the geometry of the roof was changed and was transformed in a garret ("mansard").

Although all the framework for windows and doors is new, it was designed to respect the spirit of the existing framework. In terms of the facade, the architecture limited itself to eliminate the dissonant aspects to be found (aluminium windows, blinds, etc.), re-framing the windows framed in wood.

All the infrastructures were reinstalled for water, gas, electricity, telephones, cable television, as well the sewerage.

The existing building is structurally composed of masonry walls of mortared stone in its outer contour and inside the building in frontal walls of wood filled with brick masonry and wooden beams for floors and roof.

Due to the fact that the city of Lisbon is in the seismic zone A, as defined in the zoning regulation and Security Measures Structures of Buildings and Bridges – RSA, the joint connections between the wooden structural beams for floors and roof have auxiliary metal pieces. These reinforced connections provide an improvement to the behaviour of the building against earthquakes.

The stability, studied the building as one, and tried to comply with the original construction techniques used in the building.

In the sequence of the structural changes made, and with the dual purpose of rehabilitating maintaining the original construction processes, improving in particular by giving them better resistance to earthquakes by the interconnection between the structural elements, such as:

Full replacement of the roof, which was rebuilt in wood structure, made compatible with the design proposed by the architecture. The wooden beams were laid out like sticks connected with metal pieces, vertical beams slightly inclined (constituting the walls of the attic) supported on the exterior walls.

On the top of the exterior walls, was made a reinforced concrete lintel all the way around, connected by bolts for the purpose of joining them.

Elimination of the covering materials in kitchens and bathrooms with full replacement of the wooden beams as principal elements and secondary elements such as billets and floor coverings. In this mentioned areas the solution found was the application of "viroc" boards (cement and wood mixture compose), which in turn were fixed with screws to the wooden beams.

Along the walls of the periphery on its inner side, a metal beam in "U" shape (UNP160) will be introduced, which is connected with metal pieces in the outer walls and joined by metal "cables". That has the function of connecting wood flooring to exterior masonry walls, in order to ensure and improve the resistance of the building against earthquakes.

Fig. 2

Fig. 3

Fig. 4

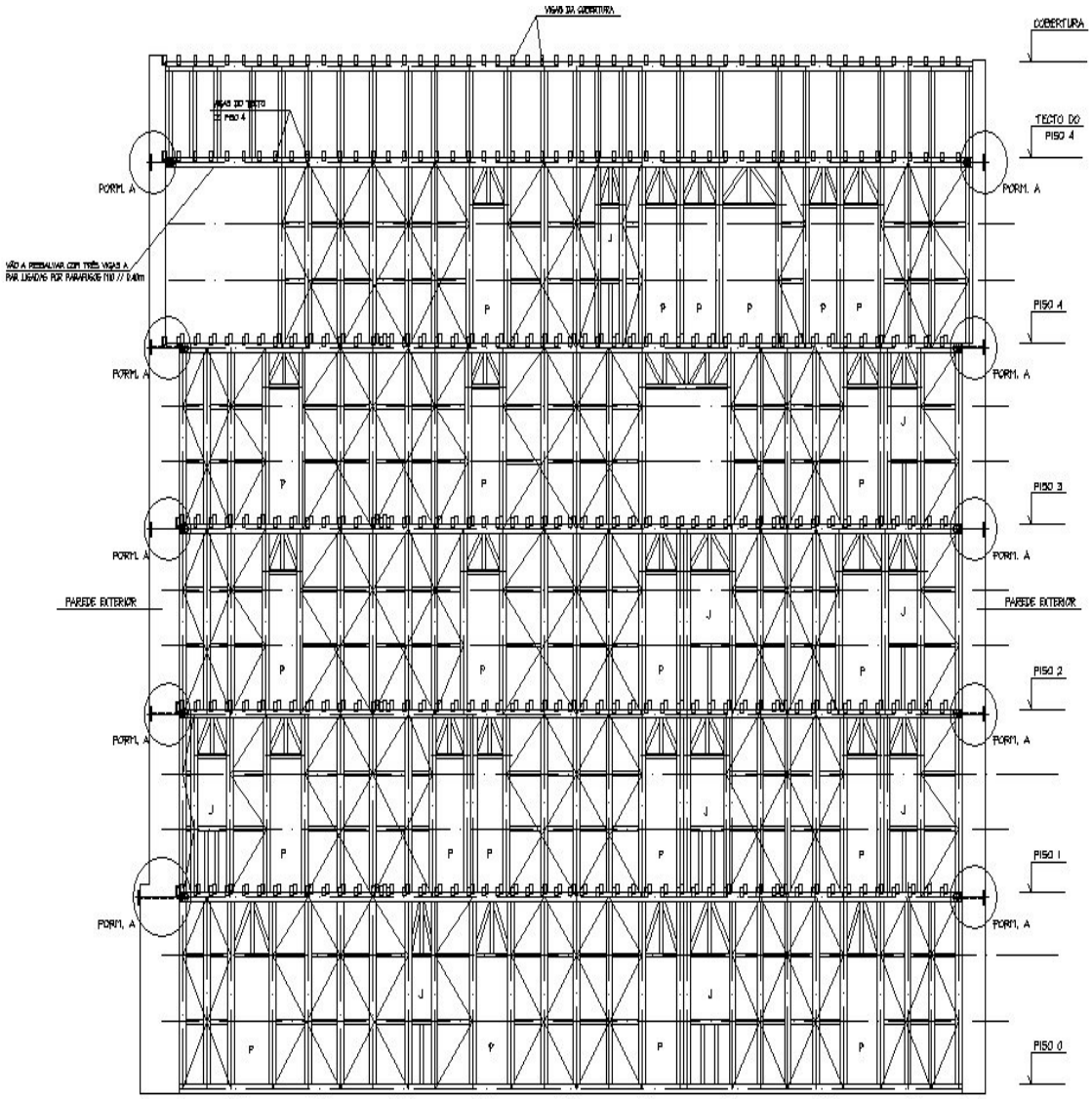
VIGAS DA COBERTURA
COBERTURA
VIGAS DO TECTO
DO PISO 4
TECTO DO
PISO 4
PORM. A
VÃO A REBALSAR COM TRÊS VIGAS A
PAR LIGADAS POR PARAFUSOS M10 // 0.40m
PISO 4
PISO 3
PISO 2
PISO 1
PISO 0
PAREDE EXTERIOR
J
P

Fig. 1

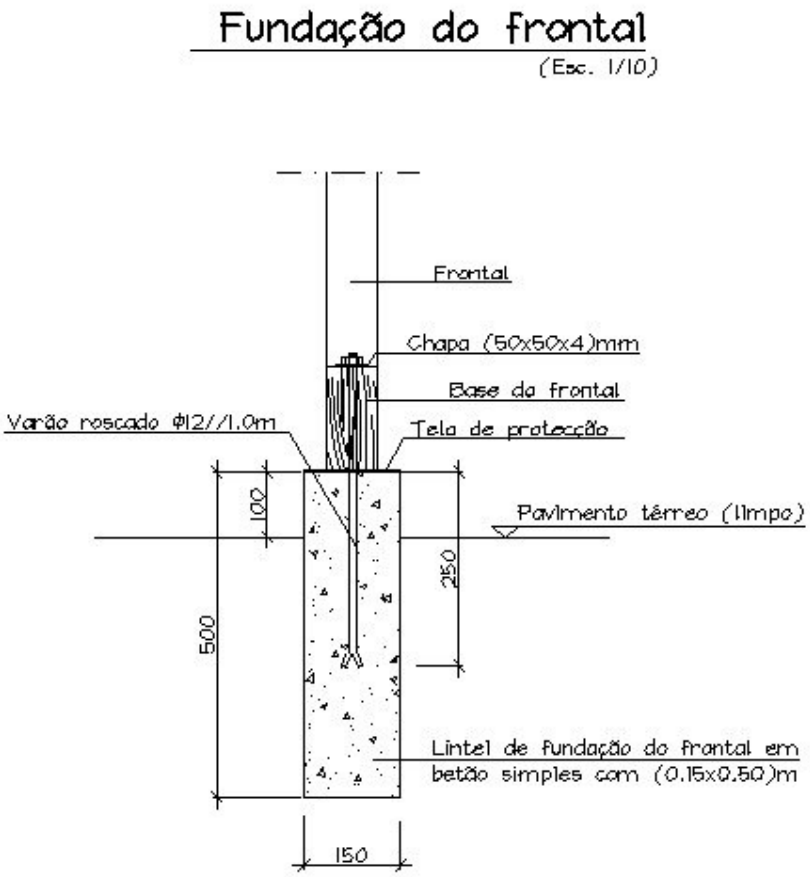
Fundação do frontal
(Esc. 1/10)
Frontal
Chapa (50x50x4)mm
Base do frontal
Varão roscado Φ12//1.0m
Tela de protecção
Pavimento térreo (limpo)
100
250
500
Lintel de fundação do frontal em
betão simples com (0.15x0.50)m
150

Fig. 5

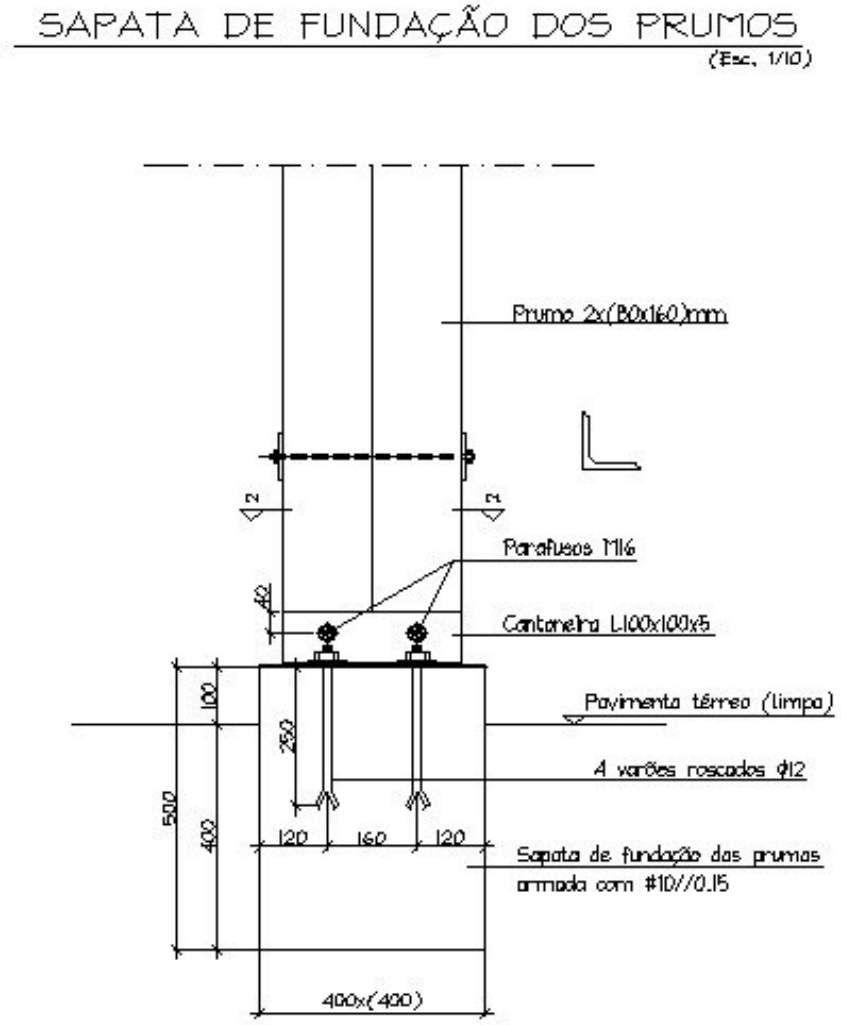
SAPATA DE FUNDAÇÃO DOS PRUMOS
(Esc. 1/10)
Prumo 2x(80x160)mm
Parafusos M16
Cantoneira L100x100x5
Pavimento térreo (limpo)
4 varões roscados ϕ12
Sapata de fundação dos prumos
armada com #10//0.15
400x(400)
120
250
500
400
120
160
120

Fig. 6

Fig. 7

Fig. 8

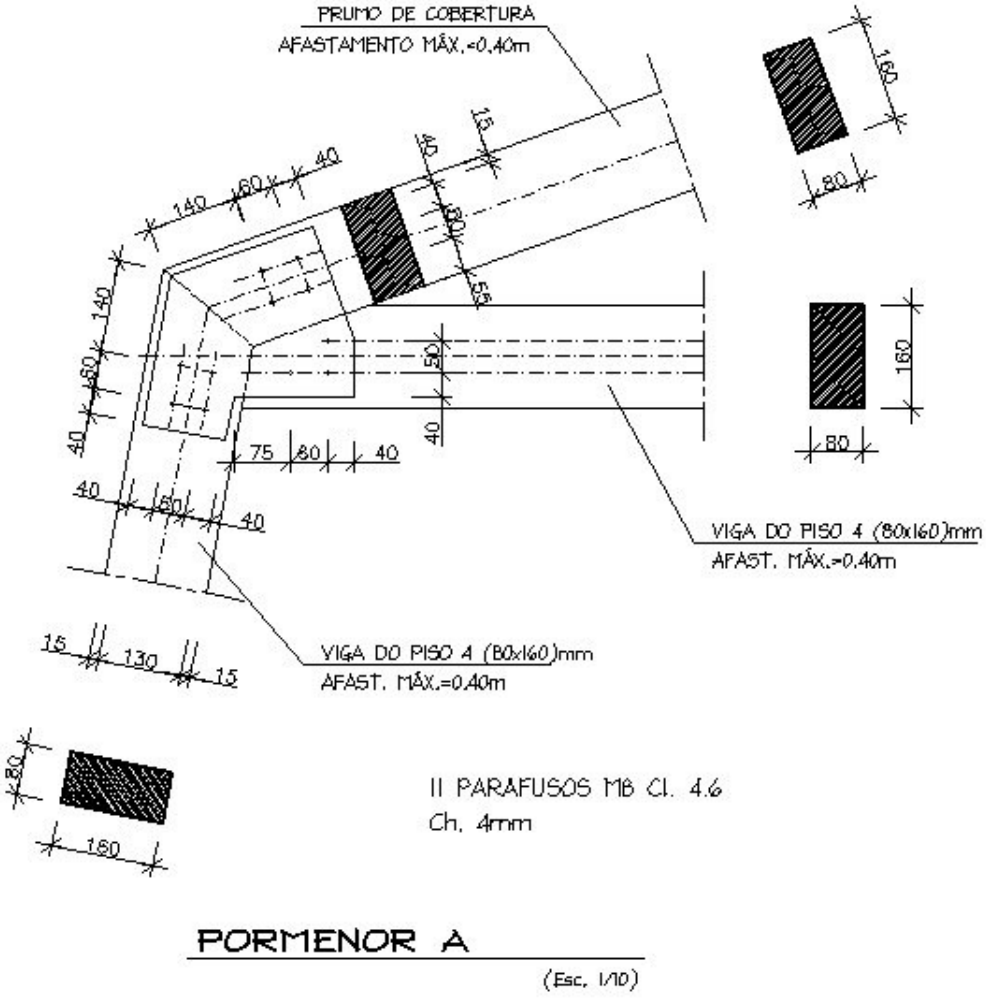
PRUMO DE COBERTURA
AFASTAMENTO MÁX.<0.40m
VIGA DO PISO 4 (80x160)mm
AFAST. MÁX.>0.40m
VIGA DO PISO 4 (80x160)mm
AFAST. MÁX.=0.40m
11 PARAFUSOS M8 Cl. 4.6
Ch. 4mm
PORMENOR A
(Esc. 1/10)

Fig. 9

Fig. 10

Fig. 11

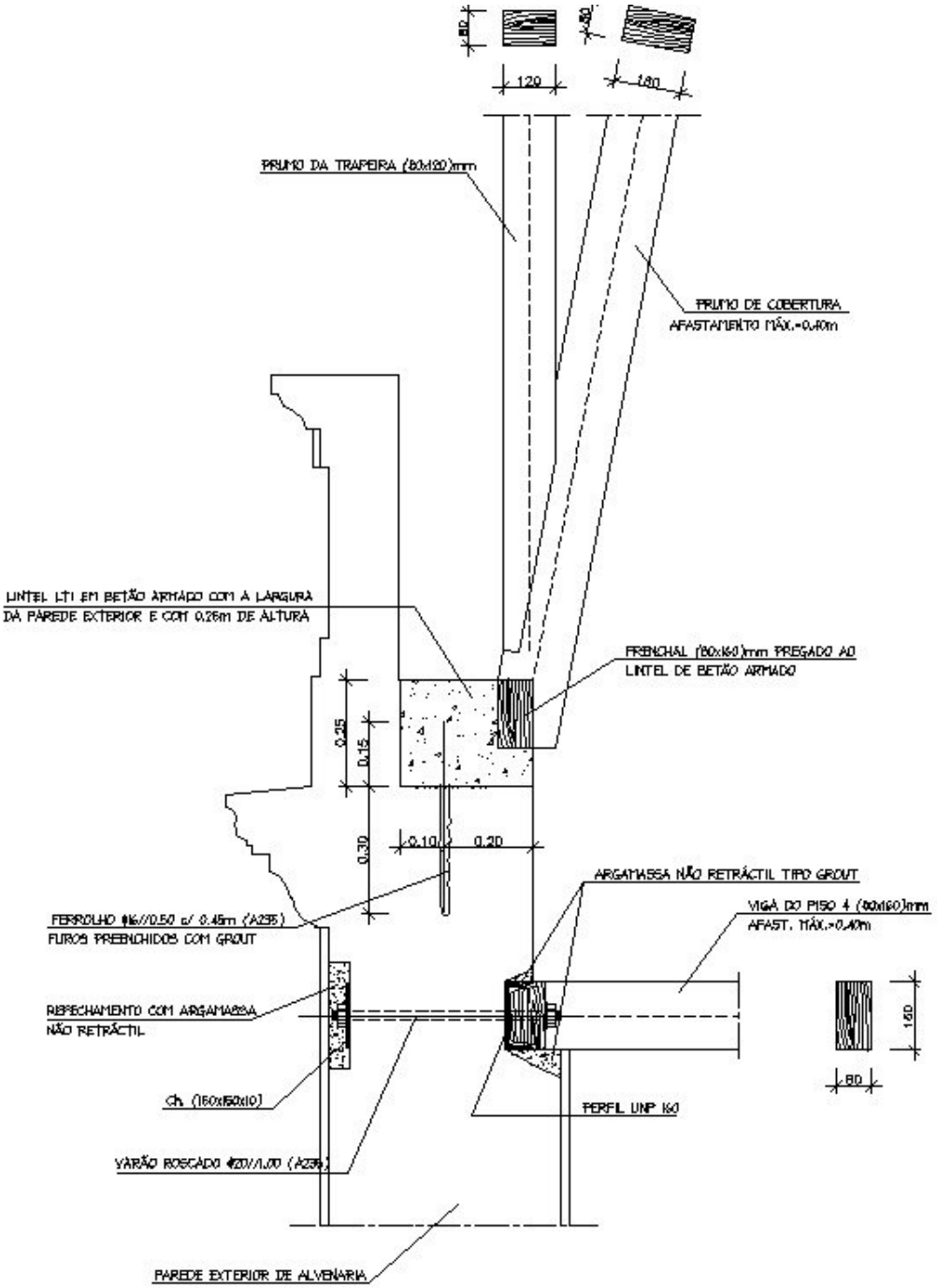
PRUMO DA TRAPEIRA (80x120)mm
PRUMO DE COBERTURA
AFASTAMENTO MÁX.=0.40m
LINTEL LT1 EM BETÃO ARMADO COM A LARGURA
DA PAREDE EXTERIOR E COM 0.26m DE ALTURA
FRENCHAL (80x160)mm PREGADO AO
LINTEL DE BETÃO ARMADO
ARGAMASSA NÃO RETRÁCTIL TIPO GROUT
VIGA DO PISO 4 (80x160)mm
AFAST. MÁX.=0.40m
FERROLHO Φ16//0.50 c/ 0.45m (A235)
FUROS PREENCHIDOS COM GROUT
REPECHAMENTO COM ARGAMASSA
NÃO RETRÁCTIL
Ch. (150x150x10)
PERFIL UNP 160
VARÃO ROSCADO Φ20//1.00 (A235)
PAREDE EXTERIOR DE ALVENARIA

Fig. 12

Fig. 13

Fig. 14

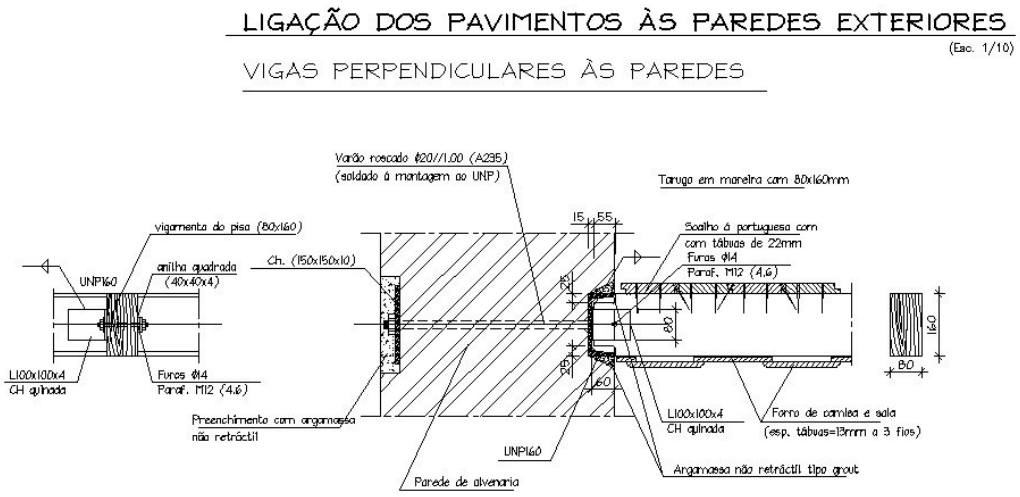
LIGAÇÃO DOS PAVIMENTOS ÀS PAREDES EXTERIORES
(Esc. 1/10)
VIGAS PERPENDICULARES ÀS PAREDES
Varão roscado Ø20//1.00 (A235)
(soldado à montagem ao UNP)
Taruga em madeira com 80x160mm
vigamento do piso (80x160)
anilha quadrada
(40x40x4)
Ch. (150x150x10)
UNP160
L100x100x4
CH quinada
Furos Ø14
Parafs. M12 (4.6)
Preenchimento com argamassa
não retráctil
Parede de alvenaria
UNP160
L100x100x4
CH quinada
Argamassa não retráctil tipo grout
Soalho à portuguesa com
com tábuas de 22mm
Furos Ø14
Parafs. M12 (4.6)
Forro de camlea e sala
(esp. tábuas=13mm a 3 fios)
15
55
25
80
25
60
160
80

Fig. 15