Archaeology of buildings and seismic risk
Methodological practice and case studies from Italy

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
WHY ARCHAEOLOGY OF BUILDINGS AND SEISMIC RISK?
The ministerial regulation in Italy issued by MIBACT in 2010-2011

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
By the Guidelines, Ch. 4.
The path of knowledge includes:

“...For the purpose of correctly identifying the system and its stress, it is important to reconstruct the whole constructive history of cultural building, the construction process and the subsequent modifications of the complex during the time. In particular, the succession of the various parts of the factory will be highlighted in order to identify the areas of possible discontinuities and material disomogeneities, both in plan and in elevation (added bodies, overhangs, horizons substitutions, etc.). The history of the building can also be used as one of the tools for checking and verifying the building's response to particular natural or man-made events and any resulting transformations. Therefore, the events, especially the most significant and traumatic events, and the corresponding effects, documented (written or iconographic sources), or by means of a direct analytical survey of the artefact must be identified...”
BUILDING ACTIVITY

TAKE OVER OF DATAS BY THE CONSTRUCTIVE ACTIONS

DOCUMENTATION OF THE STRATIGRAPHICAL INTERFACES AND RELATIVE CHRONOLOGY (PHYSICAL AND CHRONOLOGICAL RELATIONS)

INTEGRATION WITH DATAS FOUND IN OTHER TYPE OF SOURCES

MATERIALS, WORKERS AND COMMITTENCE

TYPOLOGY OF THE BUILDING’S TECHNIQUES

DOCUMENTATION OF THE BUILDING HISTORY

USE OF INFORMATIONS

HISTORICAL MODEL

DEVELOPMENT OF A URBAN CENTER
CIRCULATION OF WORKERS
BUILDING MODELS
CHRONOTYPHOLOGY OF BUILDING TECHNIQUES
ATLAS OF BUILDING TECHNIQUES
MENSIOCRONOLOGY OF BUILDING MATERIALS
DOCUMENTATION OF THE WORKING TOOLS
ETC....

TECHNICAL MODEL

PRESCRIPTION FOR THE STRUCTURAL PLAN
DETERMNIATION OF THE MECHANICAL HISTORY OF THE BUILDING
OPERATIONS OF CONSERVATION AND RESTORING
DETERMANTION OF THE MATERIALS DECAY ETC.....
Mugello (Toscana, Italy) – XVI century
Roggiano (Calabria, Italy) – XX century
THE PROJECT

Archaeology of Buildings and Seismic Risk in Mugello

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
Research goals:

- Structuring an archaeoseismological operational practices for the analysis of historical buildings in seismic risk areas
- Develop historical and technical data in relation to the construction and reconstruction of the seismic history of an area (not only single buildings)
- Validate the application of archaeological analysis in relation to the requirements of the Guidelines of MIBAC
- Evaluate the contribution of an archaeoseismological approach to archeology and for all professions that deal with seismic risk
- Produce innovative elements on the basis of direct analysis on buildings (vulnerability, restoration, etc.).

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
STEP 1

SEISMOLOGICAL INTRODUCTION OF THE CONTEXT

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
<table>
<thead>
<tr>
<th>Year</th>
<th>Location/Region</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1148</td>
<td>Firenze Sud (VII grado)</td>
<td></td>
</tr>
<tr>
<td>1194</td>
<td>Galeata (FI) (VII grado)</td>
<td></td>
</tr>
<tr>
<td>1453</td>
<td>Firenze (--)</td>
<td></td>
</tr>
<tr>
<td>1463</td>
<td>Firenze Sud (VII grado)</td>
<td></td>
</tr>
<tr>
<td>1542</td>
<td>Scarperia (IX grado)</td>
<td></td>
</tr>
<tr>
<td>1554</td>
<td>Firenze Sud (VII grado)</td>
<td></td>
</tr>
<tr>
<td>1597</td>
<td>Scarperia (VII-VIII grado)</td>
<td></td>
</tr>
<tr>
<td>1611</td>
<td>Scarperia (VII grado)</td>
<td></td>
</tr>
<tr>
<td>1762</td>
<td>Mugello-Firenze (VII grado)</td>
<td></td>
</tr>
<tr>
<td>1770</td>
<td>Incisa V. d'Arno (VIII grado)</td>
<td></td>
</tr>
<tr>
<td>1812</td>
<td>San Casciano (VIII grado)</td>
<td></td>
</tr>
<tr>
<td>1835</td>
<td>Borgo S. Lorenzo (VI grado)</td>
<td></td>
</tr>
<tr>
<td>1864</td>
<td>Mugello (VII grado)</td>
<td></td>
</tr>
<tr>
<td>1895</td>
<td>San Casciano (VIII grado)</td>
<td></td>
</tr>
<tr>
<td>1919</td>
<td>B.go S. Lorenzo-Vicchio (X grado)</td>
<td></td>
</tr>
<tr>
<td>1929</td>
<td>Mugello (VI-VII grado)</td>
<td></td>
</tr>
</tbody>
</table>

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
STEP 2

RECOGNITION OF THE AREA AND IDENTIFICATION OF REPRESENTATIVE BUILDINGS

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
RECOGNITION OF THE AREA
STEP 3

3D SURVEY
PHOTOGRAMMETRIC AND MICRO-PHOTOGRAMMETRIC 3D SURVEY

Church of Sant’Agata (FI)
Ortophoto and Digital Elevation Model were used for the identification and recording of the building’s deformations

Church of San Michele a Ronta (FI)
D.E.M. and profile sections record the deformations of the surfaces with a high accuracy (about 1-2 mm)
The monitoring of cracks through the micro-photogrammetry

In collaboration with:

Church of San Gavino Adimari (FI)
Digital Elevation Models e Surface sections

T0: SEPTEMBER 2011

T1: SEPTEMBER 2012
The comparison of the profile sections

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
STEP 4

STRATIGRAPHICAL ANALYSIS AND IDENTIFICATION OF SEISMIC EFFECTS AND ANTI-SEISMIC BUILDING TECHNIQUES

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
STRATIGRAPHIC READING AND IDENTIFICATION OF INSTABILITY

Church of Sant’ Agata (FI)
Church of Sant’Agata (FI)
Church of Sant’ Agata (FI)
Some examples of anti-seismic building’s techniques: the chains
Some examples of anti-seismic building's techniques: the chains and the pilasters
STEP 5

ANALYSIS OF THE DIRECT AND INDIRECT SOURCES

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
Epigraphy dated 1263 that shows the construction of the bell tower of the church

Church of San Lorenzo a Borgo S. Lorenzo (FI)
Capitani di Parte Guelfa, end of the XVI century

Vasari-Stradano, 1563-65

Stradano, 1557-58

City of Scarperia (FI)
Pievano Nozzolini, 1609

Church of Sant’Agata (FI)
Church of San Cassiano in Padule (FI) after the earthquake of 1919
STEP 6

INTEGRATION BETWEEN HISTORICAL SOURCES AND STRATIGRAPHICAL ANALYSIS

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it
PERIODIZATION OF THE DAMAGES CAUSED BY EARTHQUAKES

1542

1542

1542 - 1611

n.d.

1542 - 1611

1542-1895

n.d.

1542-1611
PERIODIZATION OF THE CRACK PATTERN

Prev. 1542 (half of the XIII century?)
1542-1611
1919

Church of San Francesco a Borgo S. Lorenzo (FI)
Schematic reconstruction of damage mechanisms by earthquakes from 1542 to 1611 on church of Sant'Agata del Mugello (FI).

In particular, the kinematic mechanisms found are the following: out-of-plane of the façade and of the lateral wall; detachment of the portico; collapse of corners and part of the roof; collapse of the higher part of the bell tower; vertical cracks on the west elevation of the bell tower.
RESULTS
MATERIALS FOR THE ATLAS OF THE MUGELLO BUILDING’S TECHNIQUES

XI – XIII secolo

XII secolo

XIII secolo

XVIII – XIX secolo

XIX-XX secolo
SUPPLY AND USE OF BUILDING MATERIAL FROM THE X TO THE XVII CENTURY

X-XII CENTURY

XIII-XIV CENTURY

XV CENTURY

XVI-XVII CENTURY
THE IDENTIFICATION OF A POSSIBLE EARTHQUAKE OF THE HALF OF THE XIII CENTURY

ETRURIAN FAULT SYSTEM

- Buildings not constructed
- Buildings with seismic damages
- Buildings without seismic damages
Bibliography about the project in Mugello

Ph.D. Andrea Arrighetti – andrea.arrighetti@unisi.it