The Getty Conservation Institute

THE GETTY

MUSEUM

RESEARCH INSTITUTE

FOUNDATION

CONSERVATION INSTITUTE

THE GETTY CONSERVATION INSTITUTE

COLLECTIONS

SCIENCE

BUILDINGS AND SITES

BUILDINGS AND SITES

CONSERVING MODERN ARCHITECTURE INITIATIVE

RECORDING AND DOCUMENTATION

HISTORIC CITEIS AND URBAN SETTLEMENTS

ARCHAEOLOGICAL SITES CONSERVATION AND MANAGEMENT

BUILDINGS AND SITES

CONSERVATION PRINCIPLES AND METHODS

DECORATED SURFACES

BUILDING MATERIALS

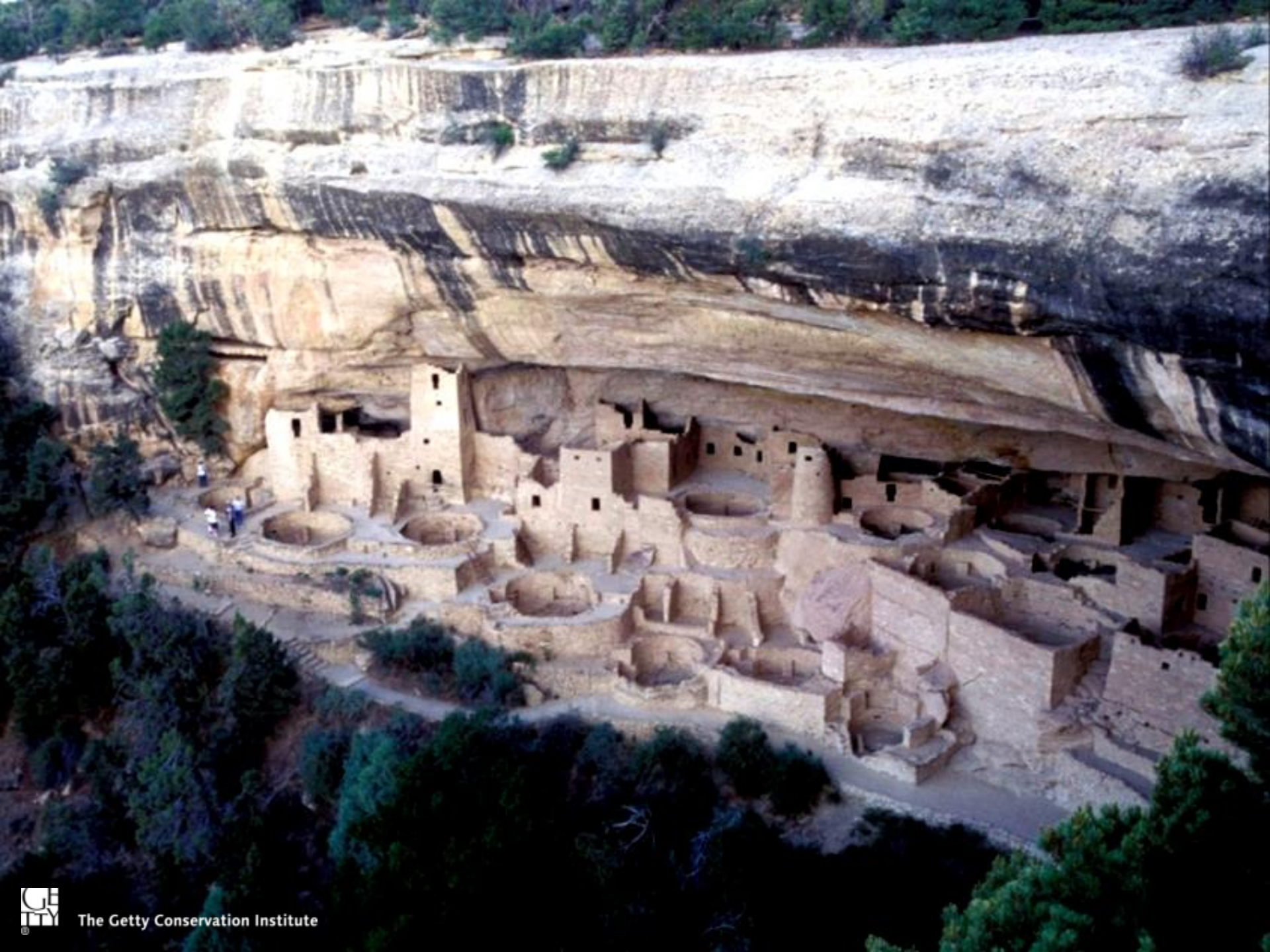
The Getty Conservation Institute

THE EARTHEN ARCHITECTURE INITIATIVE

Building and Sites Department

The Getty Conservation Institute

The Getty Conservation Institute



The Getty Conservation Institute

The Getty Conservation Institute

懷遠樓

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

The Getty Conservation Institute

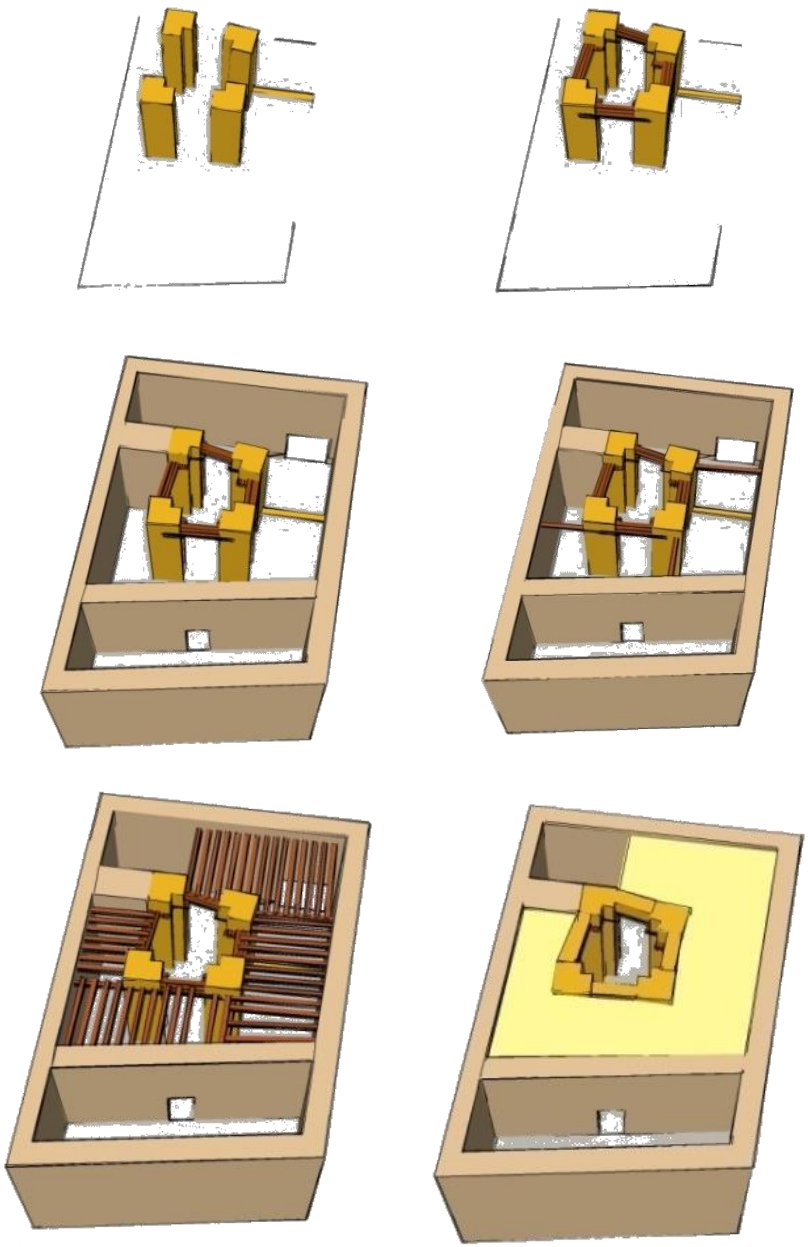
The Getty Conservation Institute

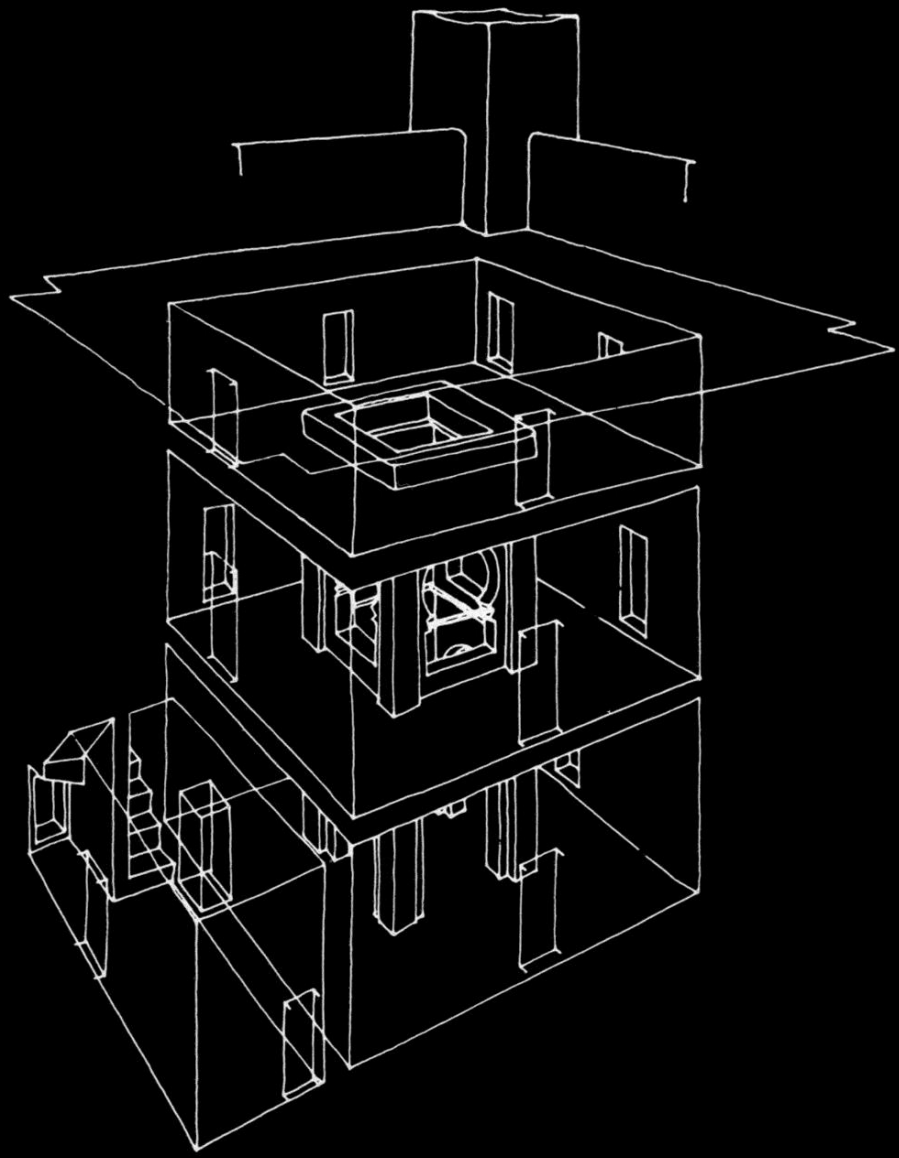
The Getty Conservation Institute

23% [2 BILLIONS OF PEOPLE (UN)] OF THE WORLD POPULATION LIVE IN EARTHEN BUILDINGS.

The Getty Conservation Institute

13% of the UNESCO World Heritage Sites are earthen sites.
62% of the sites of the World Heritage Sites in danger are made of earth.
26 of 100 sites of the WMF Watch list are made of earth.
The Getty Conservation Institute





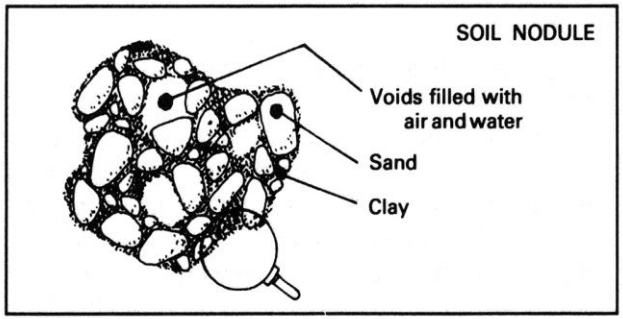
The Getty Conservation Institute

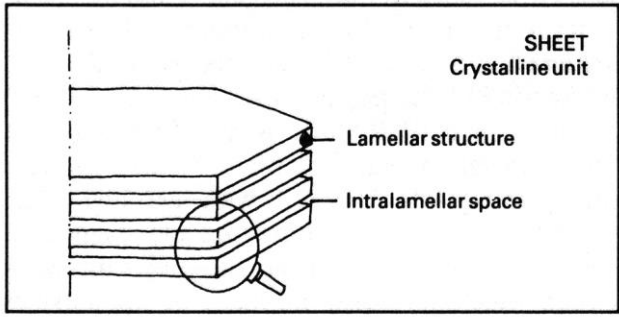
The Getty Conservation Institute

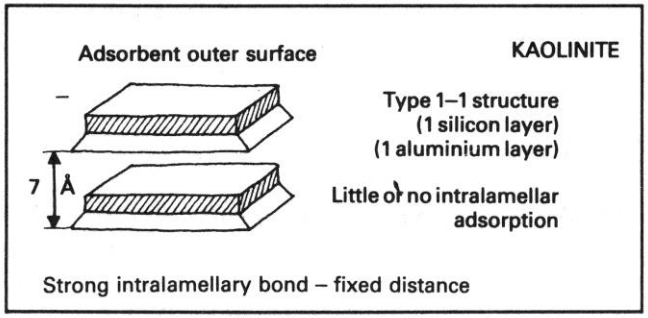
"A soil consists of an assemblage of discrete particles of various shapes and sizes. The types , the relative proportions of these particles and the forces between them give the soil a particular character and behavior."

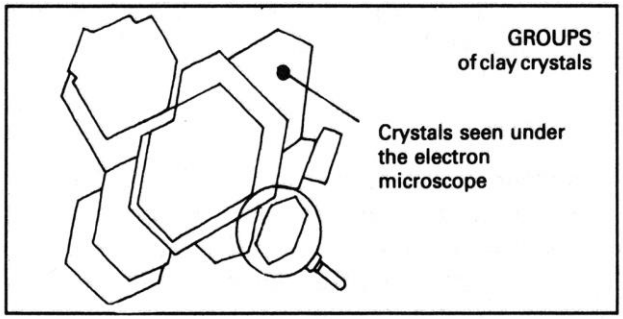
Teutonico, J.M.
"A laboratory manual for architectural conservators" p. 73

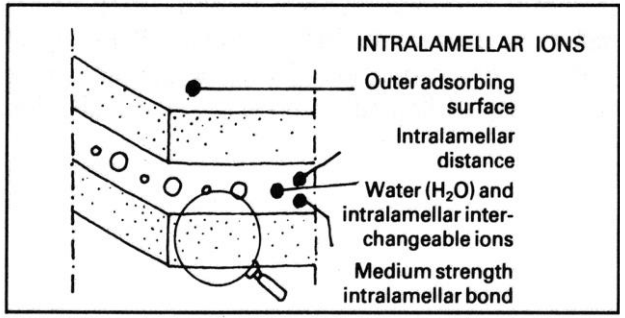
The Getty Conservation Institute

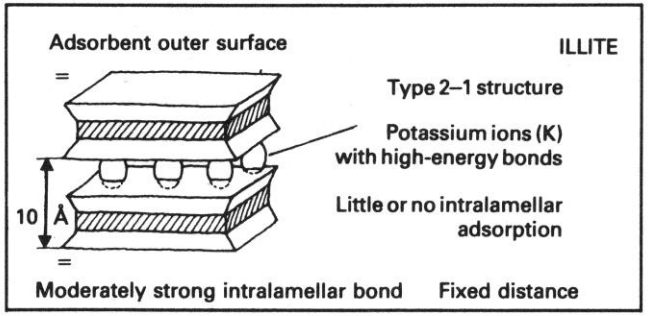

SOIL NODULE
Voids filled with air and water
Sand
Clay

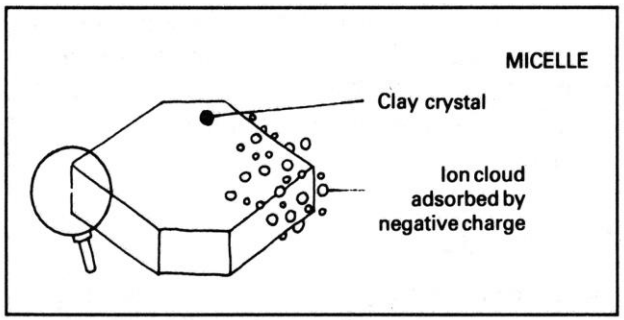

SHEET
Crystalline unit
Lamellar structure
Intralamellar space

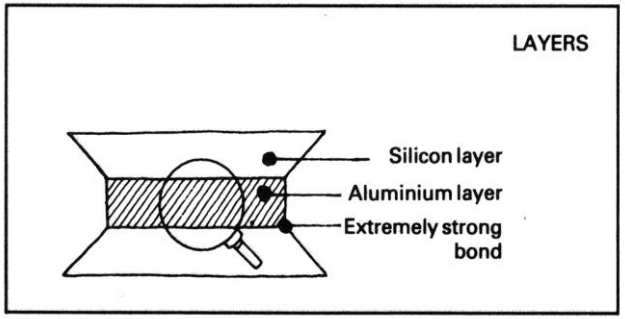

Adsorbent outer surface
KAOLINITE
7 Å
Type 1–1 structure
(1 silicon layer)
(1 aluminium layer)
Little or no intralamellar adsorption
Strong intralamellary bond – fixed distance

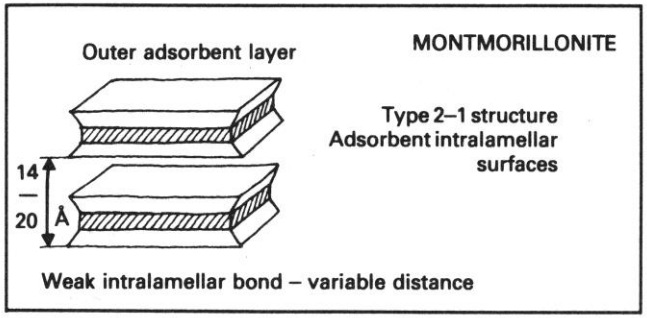

GROUPS
of clay crystals
Crystals seen under the electron microscope

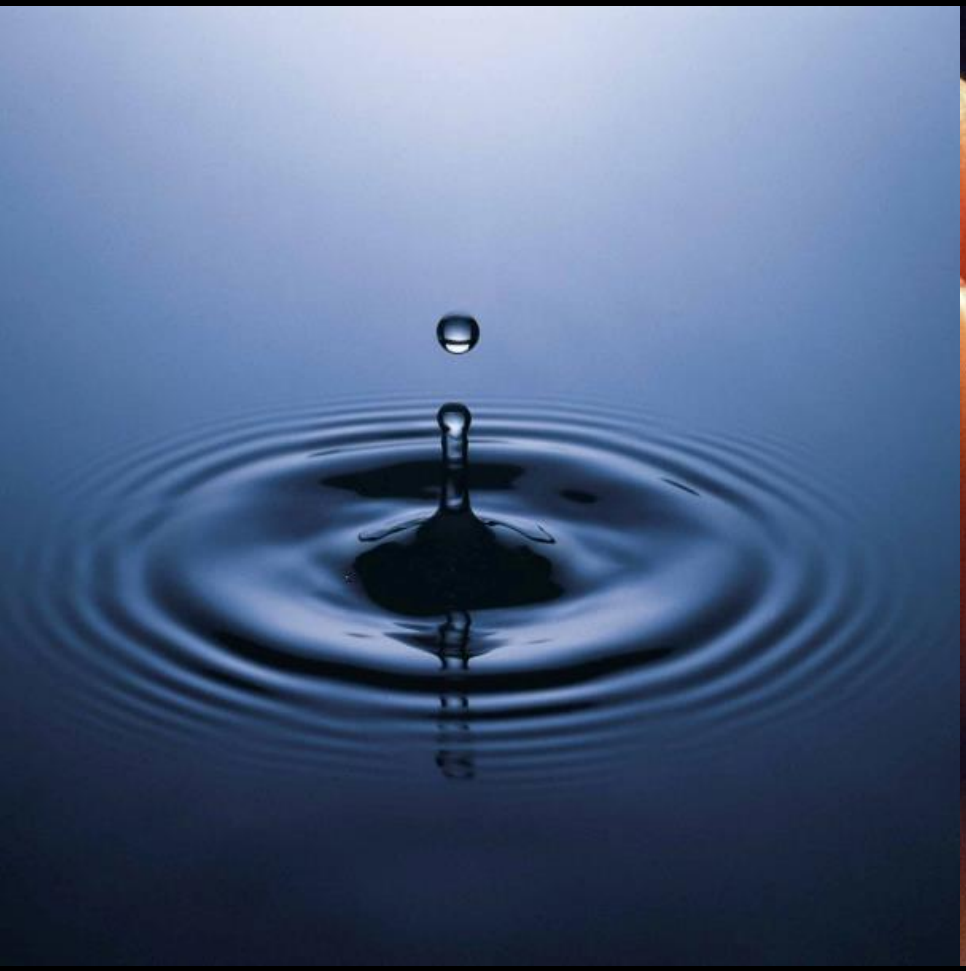

INTRALAMELLAR IONS
Outer adsorbing surface
Intralamellar distance
Water (H_2O) and intralamellar inter-changeable ions
Medium strength intralamellar bond

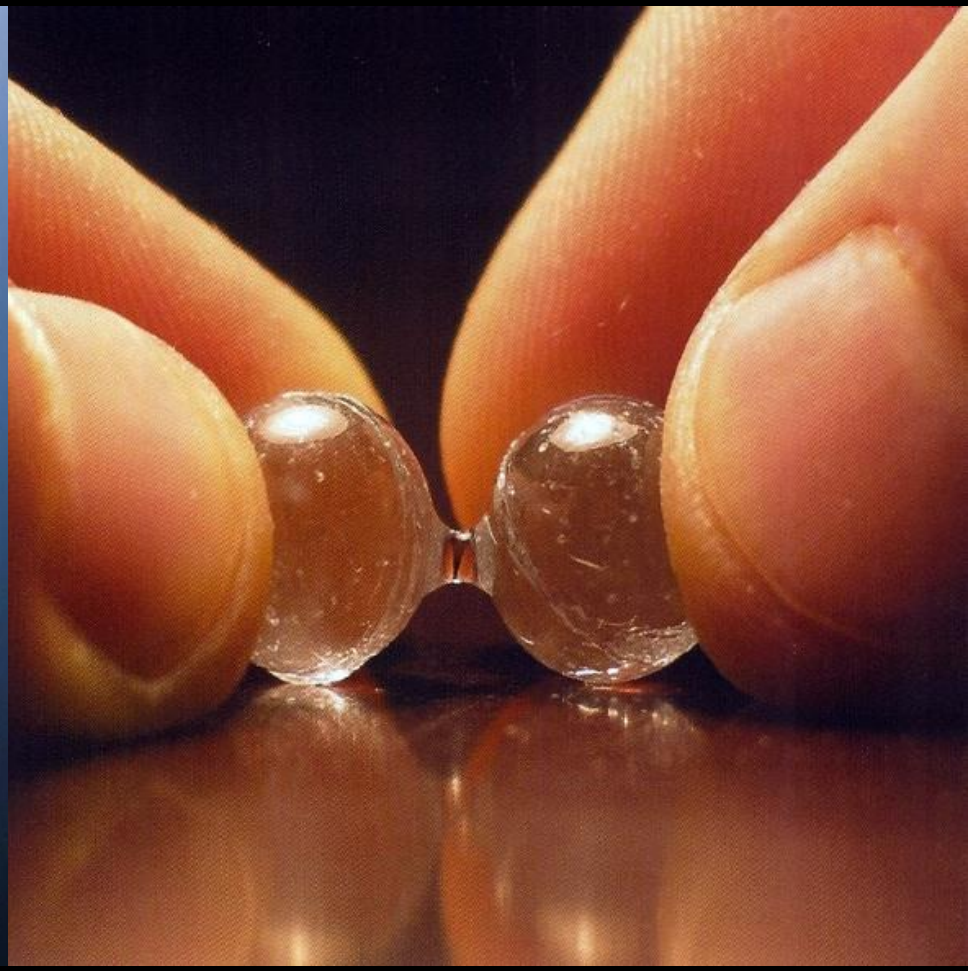

Adsorbent outer surface
ILLITE
10 Å
Type 2–1 structure
Potassium ions (K) with high-energy bonds
Little or no intralamellar adsorption
Moderately strong intralamellar bond
Fixed distance


MICELLE
Clay crystal
Ion cloud adsorbed by negative charge

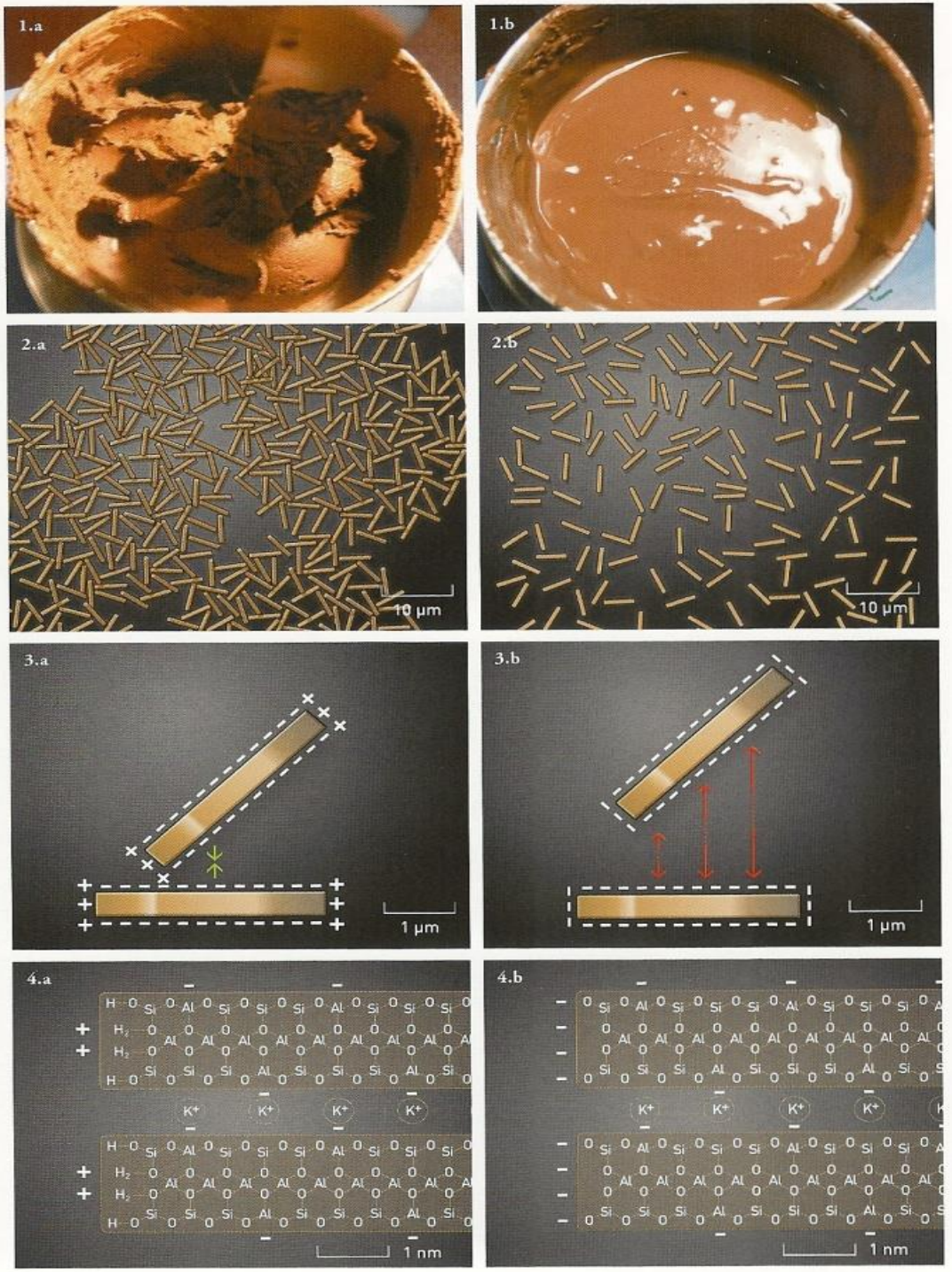

LAYERS
Silicon layer
Aluminium layer
Extremely strong bond


Outer adsorbent layer
MONTMORILLONITE
14 — 20 Å
Type 2–1 structure
Adsorbent intralamellar surfaces
Weak intralamellar bond – variable distance





Van der Waals forces



CRATERRE

The Getty Conservation Institute

EARTHEN COMPONENTS

SOILS – CHARACTERIZATION: LABORATORY FIELD TESTING

Characterization	Test	Standard
Composition	Granulometry	ASTM D 422-63; BS1377
Stability	Sedimentation	ASTM C940-81, NF P18-369
Type of clay	X-Ray Diffraction	
	Scanning Electro Macroscopic	
Soluble salts content: Carbonates, chlorides, sulfates, nitrates	Ion Chromatography	NORMAL 13/83
Acidicity	pH	

Atterberg Limits

Shrinkage Limit | **Plastic Limit** | **Liquid Limit**

Solid state | Semi-Solid state | Plastic state | Fluid state

Increasing water content

EARTHEN COMPONENTS

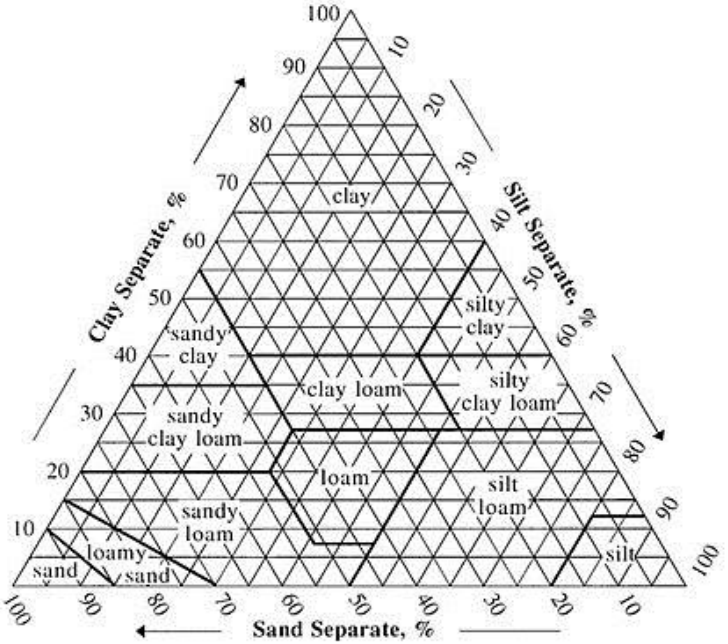
SOILS – BEHAVIORAL PROPERTIES

Properties description	Test	Standard
This measures the amount of water necessary for a grout to gain cohesion (plasticity) and the amount that will cause the grout to behave as a liquid.	Plastic and liquid limits	ASTM D 4318 – 84 [131]
The rate of uptake of water into the grout through capillary action.	Water abosorption by total inmersion	ASTM D6780 - 05
Velocidad de absorción de agua del material por capilaridad	Capillary action	NORMAL 11/85 RILEM II-6
The ability of the grout to allow water vapor to move through its pores	Water Vapor Transmission	ASTM E 96 RILEM II-2 NORMAL 21/85
The loss of volume that occurs when a soil goes from a wet to dry state	Shrinkage	ASTM C 1148-92a Linear: ASTM C 490 Volume: ASTM C 474
Evaluate the ability of the material to flow	Sand columns test Stability Fluidity	NF P-18-891 Stability NF P-18-359 Fluidity NF P-18-358

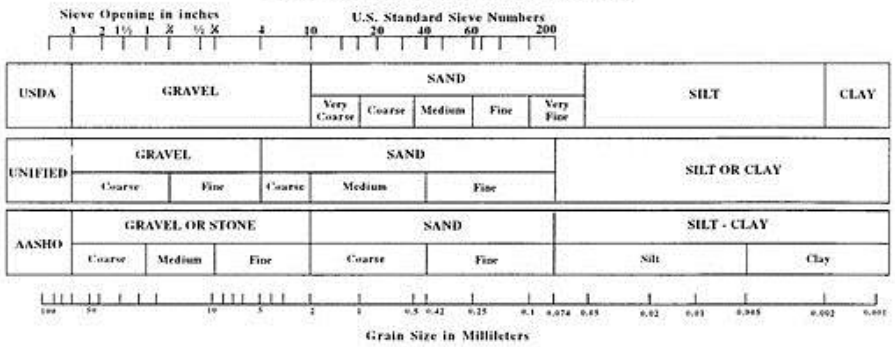
EARTHEN COMPONENTS

SOILS – BEHAVIORAL PROPERTIES

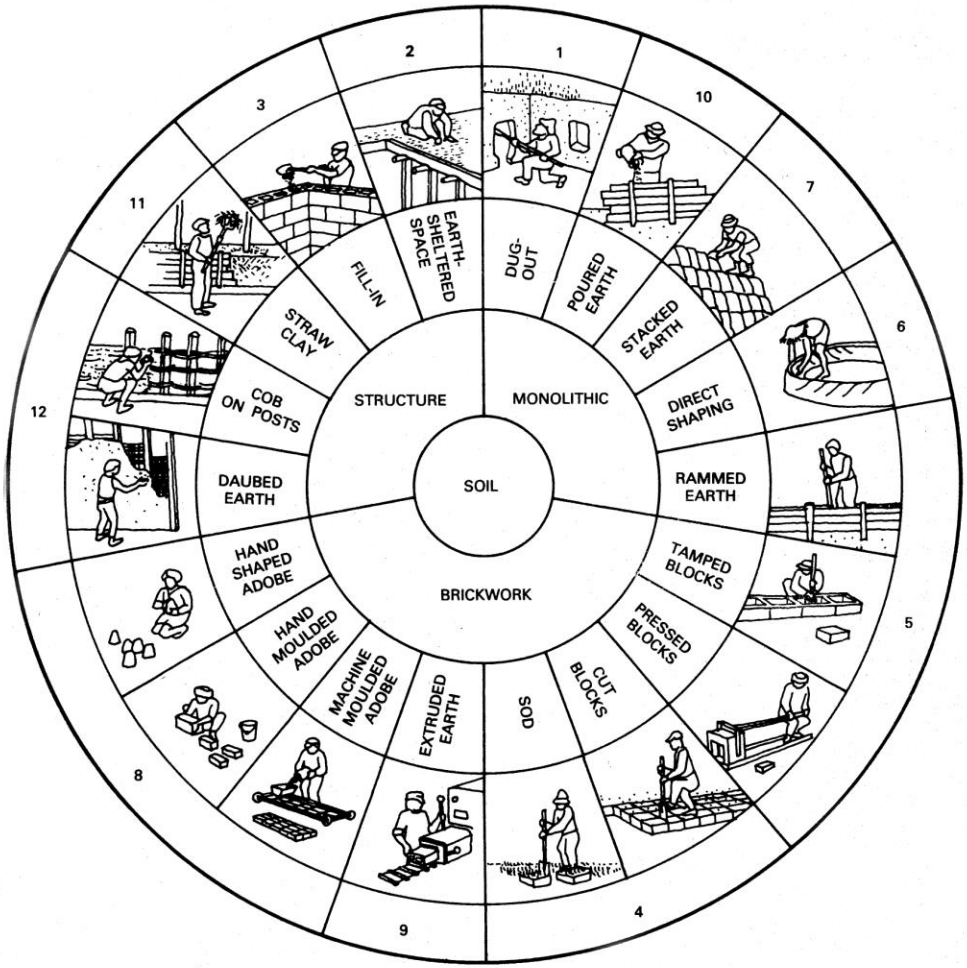
Properties description	Test	Standard
Way of measuring the resistance of materials to tensile and compression forces	Compression strength	ASTM C109 / C109M – 08 ASTM C942 - 99(2004)
	Tensile compression strength	ASTM C496 / C496M
	Flexural compression strength	BS 4551:1980 EN 196-1
Tensile bond strength (indirect, mortar)	Mortar resistance to tension and its adhesion to the substrate	ASTM C 496 ASTM E 518-03
Shear bond strength (indirect, mortar)	Resistance of mortar and its adhesion to the substrate to shear forces	ASTM D 3931 ASTM D 905 ASTM C 1019



COMPARISON OF PARTICLE SIZE SCALES



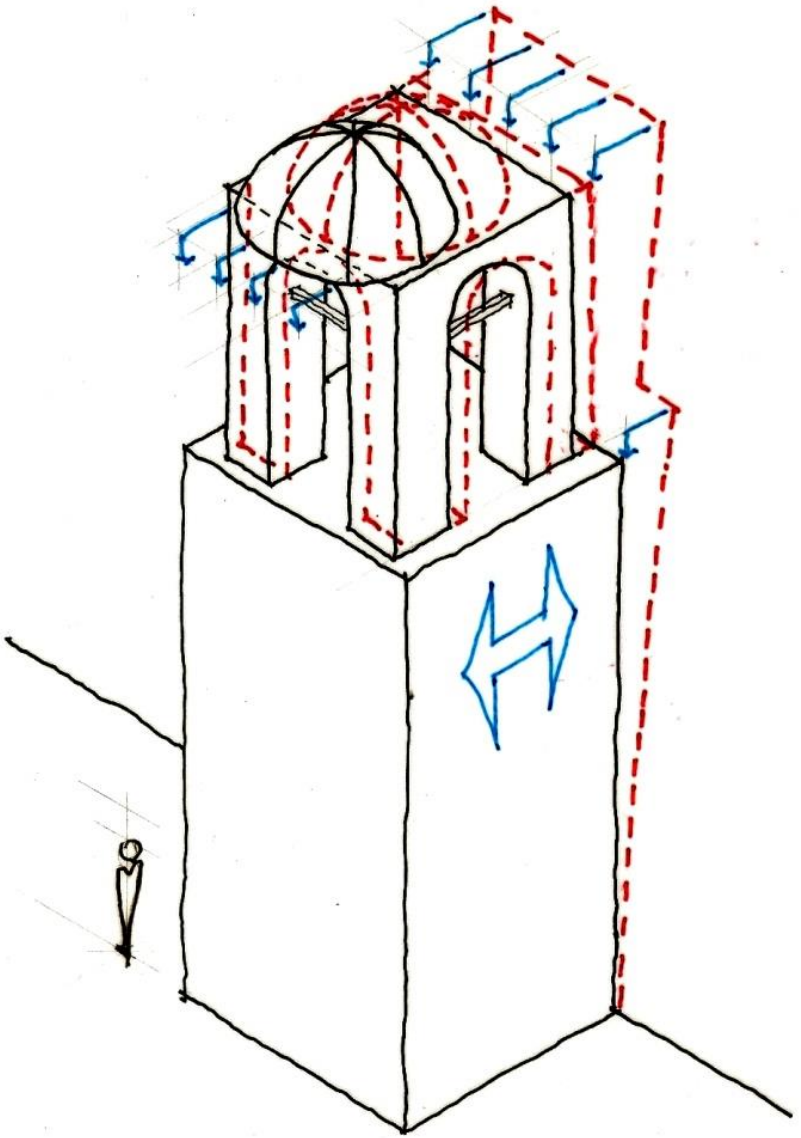
USCS

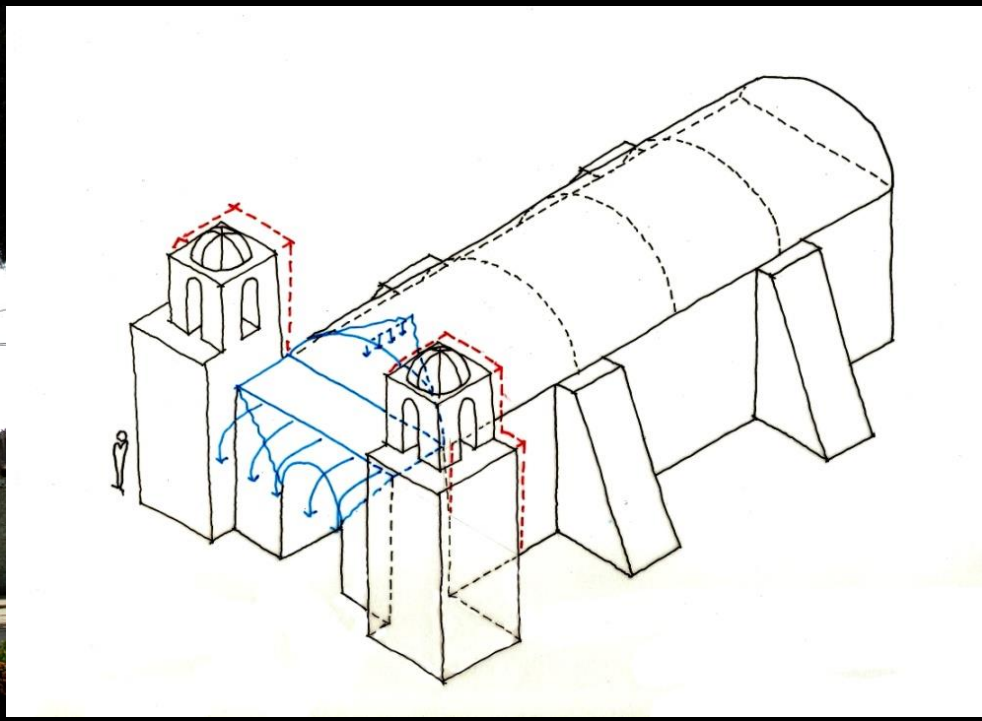


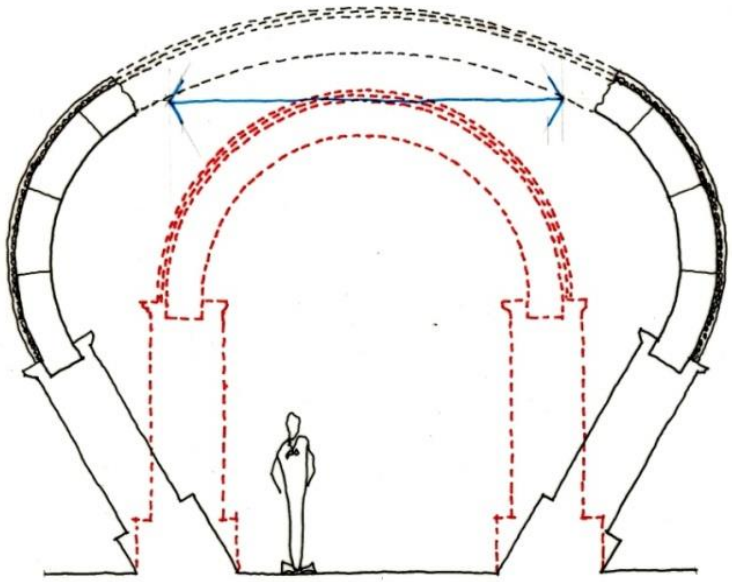
CRATERRE

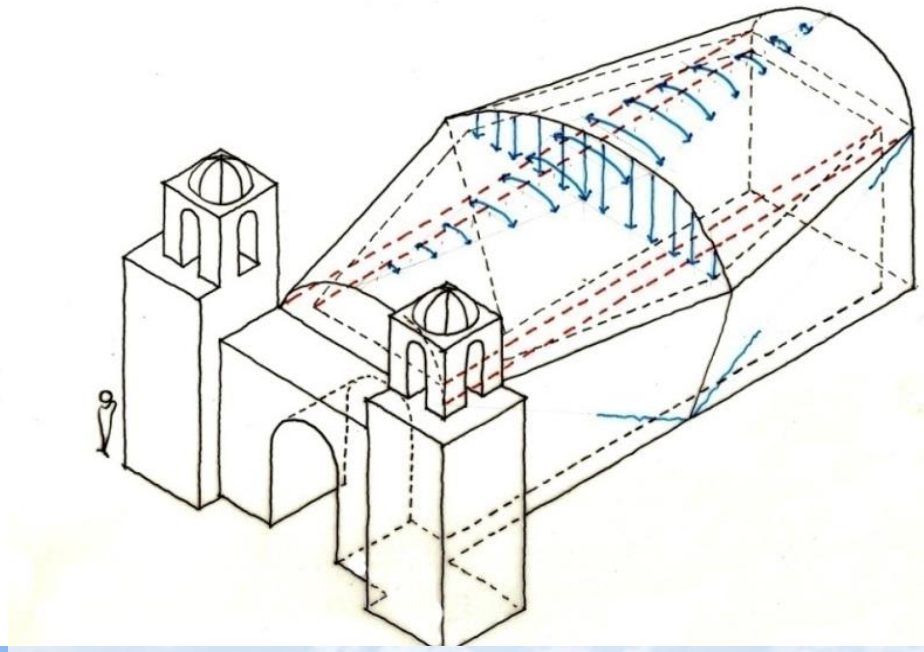
(C) DigitalGlobe

The Getty Conservation Institute









The Getty Conservation Institute

EARTHEN ARCHITECTURE INITIATIVE

TEAM

PROJECTS

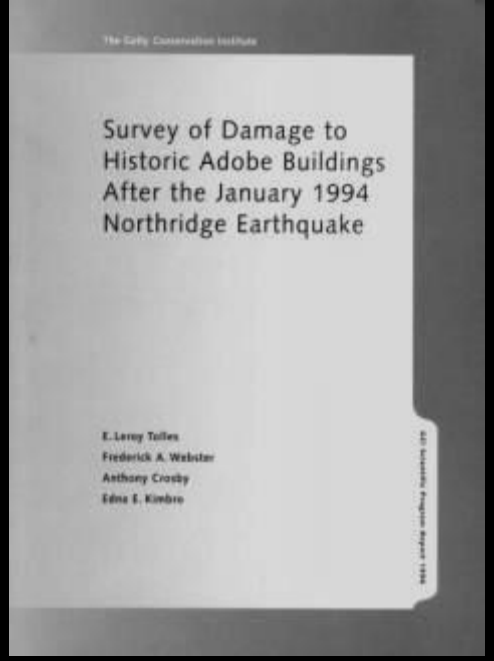
SEISMIC RETROFITTING
PERU

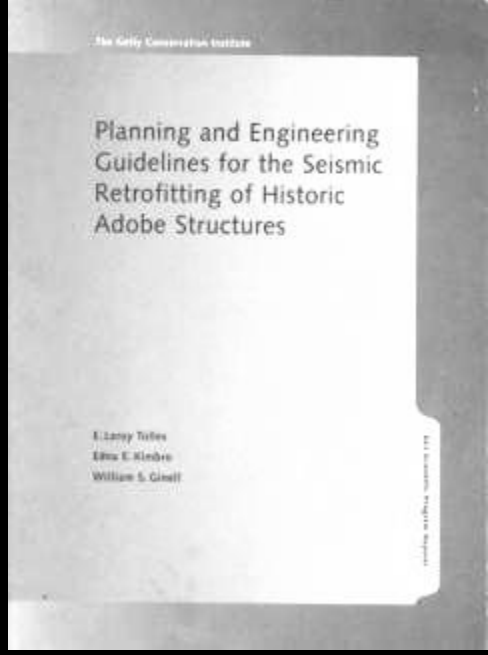
CONSERVATION AND REHABILITATION PLAN FOR KASBAH TOURIRT
MOROCCO

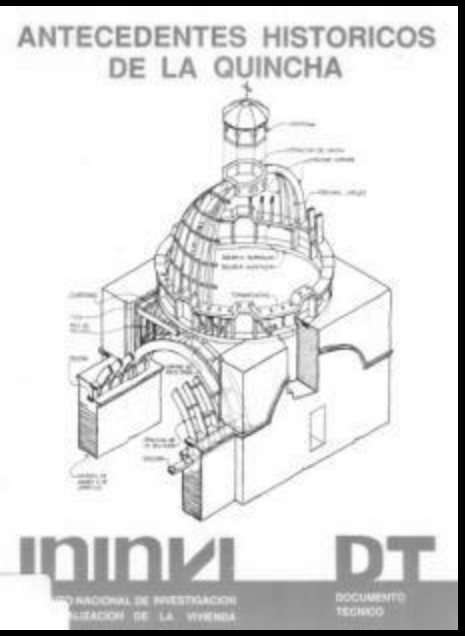
THE SEISMIC RETROFITTING PROJECT

The Earthen Architecture Initiative

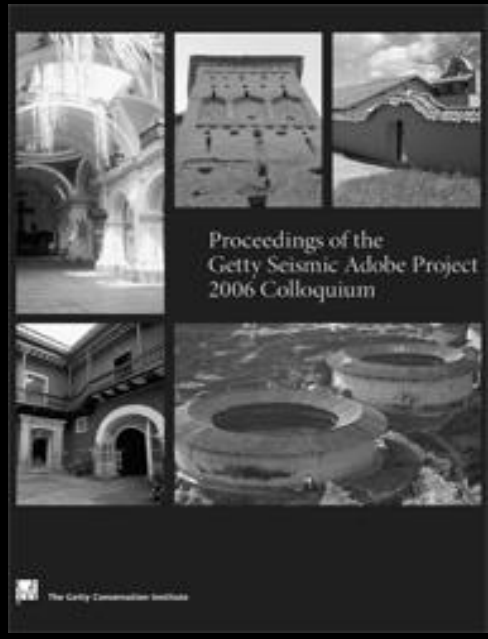
The Getty Conservation Institute


The Getty Conservation Institute
Survey of Damage to Historic Adobe Buildings After the January 1994 Northridge Earthquake
E. Leroy Tolles
Frederick A. Webster
Anthony Crosby
Edna E. Kimbro


The Getty Conservation Institute
Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures
E. Leroy Tolles
Edna E. Kimbro
William S. Ginell


ANTECEDENTES HISTORICOS DE LA QUINCHA
DOCUMENTO TECNICO

Getty Seismic Adobe Project 2006 Colloquium
Rancho Los Cerritos
12 April 2006


Proceedings of the Getty Seismic Adobe Project 2006 Colloquium
The Getty Conservation Institute

The Peruvian Case

1470? – Inca Tupac Yupanqui (1471-1493), *Crónicas*

1512 – Cusco, Inca Huayna Capac, *Comentarios Reales, Garcilaso de la Vega (1609)*

1545?/1553 – First registered earthquake in Lima,
Sinopsis de temblores y volcanes del Perú, José Toribio Polo (1899)

1586 – First registered earthquake in Cusco,
Letter to the Conde del Villar viceroyal Levillier,(1925) and others

1655 – Registered damages on specific sites (earth),
Terremotos. Manuel de Odriozola (1863)

March 31 1650 Earthquake in Cusco, Painting of Alonso de Moroy y Cortés, Cathedral of Cusco

1699:
Don Melchor Portocarrero Laso de la Vega, Conde de la Monclova, created a "bando" (first norm) that orders replacing adobe or brick second story building materials by "quincha".
Lima, 20 de Julio de 1699 (Cabildos de Lima. Tomo 33).

1746 :
Viceroy D. José A. Manso de Velasco—later known as Conde de Superunda—asked the mathematician D. Luis Gaudin to study the buildings' damage and to develop technical recommendations to improve their resistance to seismic events.

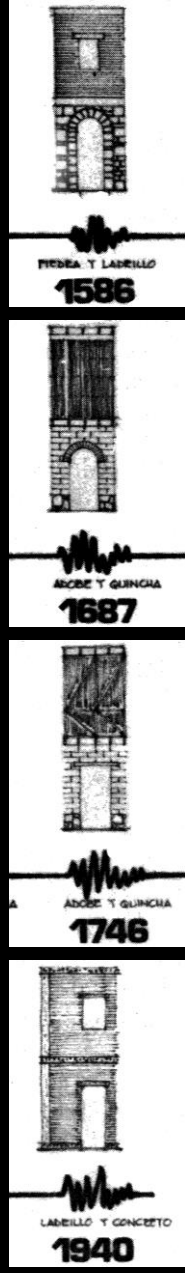
Gaudin, who had taken the chair of mathematics at San Marcos University in Lima in 1744, happened to be a supporter of building codes. He presented his report to the cabildo advocating: i) the use of mud, cane and adobe instead of lime, brick or stone as construction materials; ii) the use of quincha for wall partitions, iii) an increase in width of adobe masonry walls, iv) the addition of buttresses to lateral adobe church walls, v) the lowering of the height of church towers, vi) the limitation of construction of bow windows and vii) assuring adequate plazas and public space to serve as refuge in case of disasters, among other recommendations.

Bromley and Barbagelata, Evolución Urbana de la Ciudad de Lima, 71.

The Getty Conservation Institute

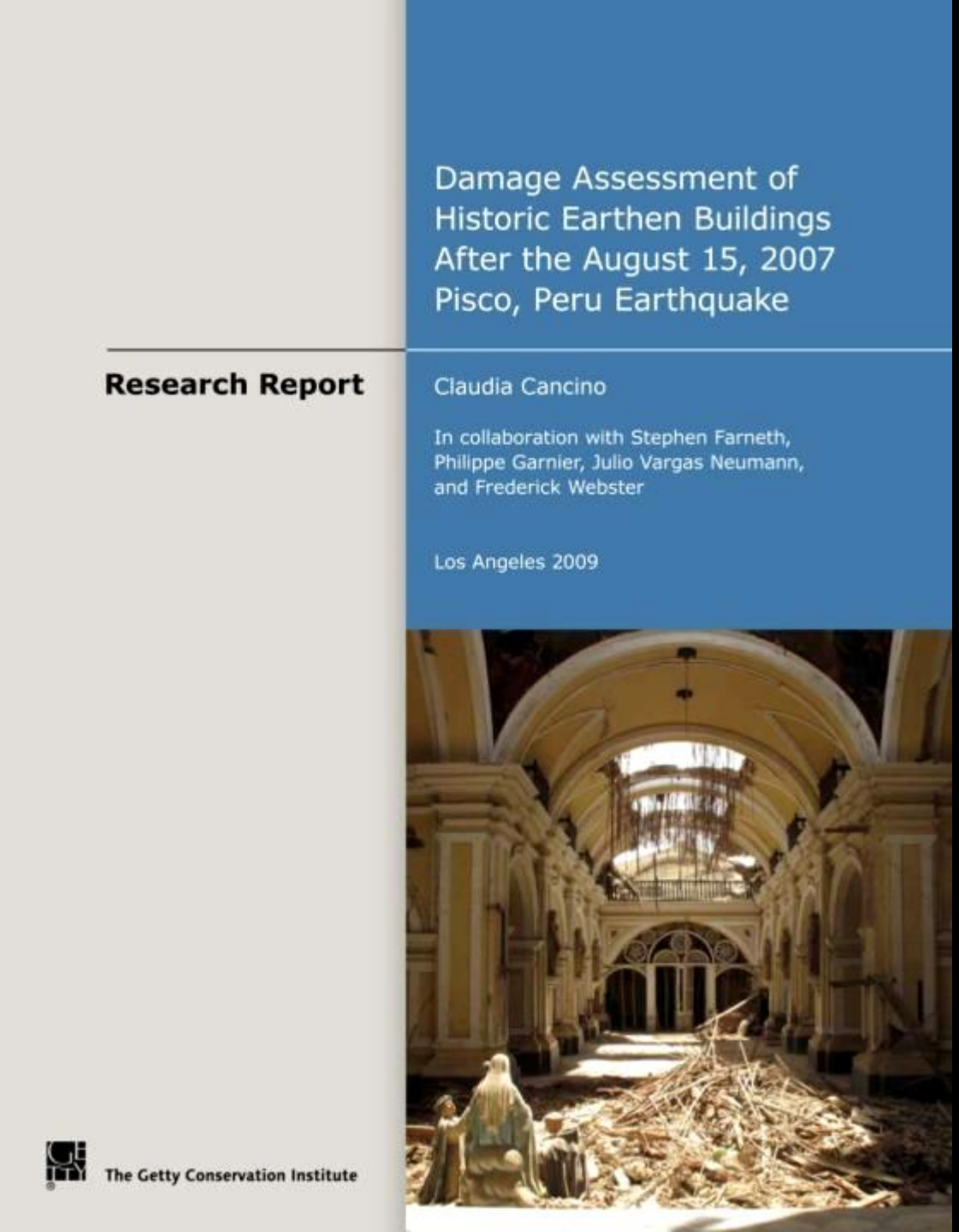
The Getty Conservation Institute

Year	Date	Location	M_W	Fatalities
1821	July, 10	Camana	8.2	162
1868	August, 13	Arica	9.0	25000
1908	December, 12	Off the coast of central Peru	8.2	
1913	November, 4	Abancay		150
1940	May, 24	Callao	8.2	249
1942	August, 8	Off the coast of central Peru	8.2	30
1943	January 30	Yanaoca		200
1946	November, 10	Ancash	7.3	1400
1947	November, 1	Satipo	7.3	233
1948	May, 11	Moquegua	7.4	70
1950	May, 21	Cusco	6.0	83
1953	December, 12	Tumbes	7.4	7
1958	January, 15	Arequipa	7.3	28
1960	January, 13	Arequipa	7.5	57
1966	October, 17	Near the coast of central Peru	8.1	125
1968	June, 19	Moyobamba	6.9	46
1969	October, 1	Comas region, Chile	6.4	136
1970	May, 31	Chimbote	7.9	50000
1974	October, 3	Near the coast of central Peru	8.1	78000
2001	June, 23	Near the coast of Peru	8.4	138
2001	July, 7	Near the coast of Peru	7.6	1
2005	September, 26	Northern Peru	7.5	5
2006	October, 20	Near the coast of central Peru	6.7	
2007	August, 15	Near the coast of central Peru	8.0	514



Quito
Ecuador
Guayaquil
Tumbes
Iquitos
Talara
Paita
Jaén
Tarapoto
Chiclayo
Cajamarca
Pucallpa
Acre
Huánuco
Perú
Huancayo
Ayacucho
Cuzco
Chincha Alta
Ica
Abancay
Juliaca
Arequipa
La Paz
Moquegua
Tacna

LIMA
HUANCAY
ICA
LEYENDA



CHAPTER 1: BACKGROUND INFORMATION
Introduction and scope of work

CHAPTER 2: THE PISCO EARTHQUAKE
Description of the Pisco Earthquake
Geological description of the affected region
Effects: Liquefaction and Landslides

CHAPTER 3: EARTHEN ARCHITECTURAL HERITAGE IN PERU
Ancient Peruvian Cultures
The Spanish Viceroyalty
The Republican Period
The Peruvian Building Code and Seismic Earthen Construction Research

CHAPTER 4: EARTHEN ARCHITECTURAL HERITAGE IN THE AFFECTED AREA
Damage Assessment Typologies:
- Quincha Deterioration Mechanism
- Dome / Vault Failure :
  - *Shift or Total Collapse of Domes*
  - *Partial or Total Vault Collapse*
  - *Out-of-Plane Collapse*
- Damage to Columns and Pillars
- Plaster Detachment

Conclusions
- Influence of Building Typologies
- Impact of the Lack of Maintenance on the Structure
- Modes of Failure

Recommendations

- Design low tech seismic retrofitting techniques using appropriate materials and local expertise for Peruvian historic building prototypes that have potential for wider application in South America.
- Test and model the scientific data that demonstrates the validity of the techniques.
- Obtain the national recognition, approval and promotion of the techniques.
- Develop a methodology to assess earthen historic sites as a tool for decision making regarding their maintenance and interventions.
- Develop site assessments and techniques implementation guidelines with emphasis on maintenance program.
- Development of a model implementation conservation project that demonstrates the implementation of the techniques.

PROJECT PARTNERS AND TEAM MEMBERS

The Getty Conservation Institute

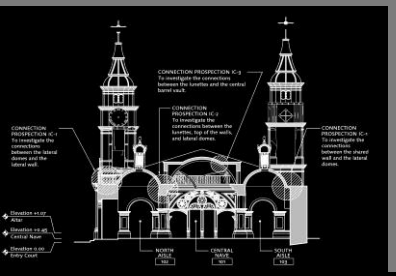
PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

Universidade do Minho

PERÚ Ministerio de Cultura

PEER REVIEW GROUP

PHASE I: RESEARCH



FEASIBILITY | PROTOTYPES | PEER REVIEW GROUP

SURVEY AND GRAPHICS | NDT: THERMO-IMAGING | PROSPECTIONS

CONSTRUCTION ASSESSMENT

PHASE II: ANALYSIS, TESTING AND DESIGN

PEER REVIEW MEETING

UNDERSTANDING MODES OF FAILURE

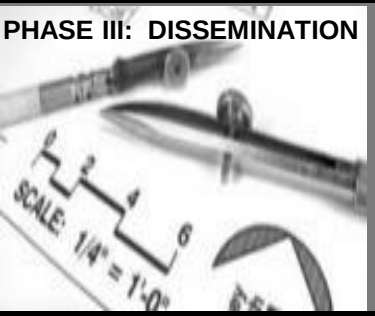
SEISMIC PERF. OF SIMI..STRUCTURES | STATIC AND DYNAMIC TESTS | NUMERICAL MODELING

SEISMIC RISK ASSESSMENT - ORIGINAL

TRADITIONAL RETROF.TECHNIQUES | RETROFITTING TECHNIQUES | HIGH-TECH RETROF.TECHNIQUES

SEISMIC RISK ASSESSMENT - RETROFITED

PHASE III: DISSEMINATION



PEER REVIEW GROUP

WORKHOPS

TECHNICAL GUIDELINES | MANUALS FOR IMPLEMENTATION

PHASE IV: IMPLEMENTATION

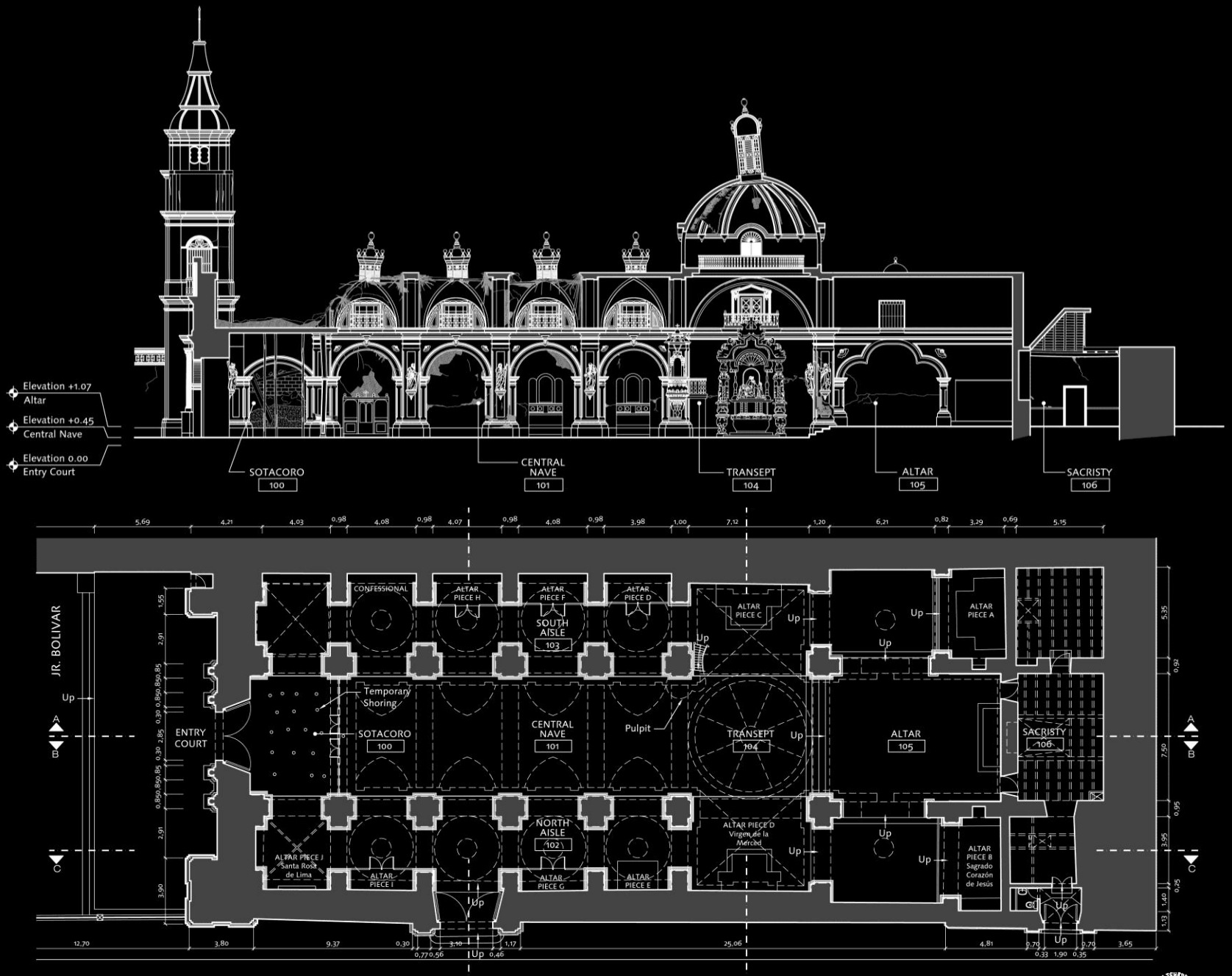
MODEL CONSERVATION PROJECT

The Getty Conservation Institute

BUILDING	Original structure (no interventions)	Historic value	Significance	Accessibility (owner)	Security (save for project staff)	Representatively of pathologies	Easy access and working eviron.	Available historic and arch. Info.	Visibility	TOTAL
Hospicio Ruiz Dávila, Lima	6	7	8	1	4	6	6	4	4	46
Quinta Heren, Lima	8	8	8	8	4	7	5	5	5	58
Hacienda San Juan Grande	5	7	6	2	2	6	6	4	5	43
Hotel El Comercio, Lima	6	8	8	10	8	8	8	9	6	71
Catedral de Ica, Ica	9	7	7	6	9	10	8	6	8	70
Iglesia de San Antonio, Mala	5	5	8	9	7	9	4	4	3	54
Iglesia de San Juan, Ica	8	5	8	9	7	9	4	4	3	57
Iglesia de San Luis, Cañete	4	5	8	10	7	9	4	4	3	54
Iglesia del Sant. de Yauca, Ica	7	5	8	8	7	9	4	4	3	55
Iglesia deAndahuaylillas, Cusco	7	10	8	7	7	3	5	7	10	64
Iglesia de Canincunca, Cusco	6	9	8	7	7	3	4	6	8	58
Iglesia de Marcapata, Cusco	10	8	8	8	6	8	2	6	8	64
Iglesia de Kuchi Wasi, Cusco	10	8	7	8	6	5	2	6	7	59
Iglesia de Kuño Tambo, Cusco	10	8	8	10	8	9	3	6	8	70
Iglesia de of Rondocan, Cusco	7	8	8	9	8	6	2	6	5	59
Casona Garrido Mendivil, Cusco	6	8	6	5	8	5	9	7	6	60
Casa Arones, Cusco	8	8	9	10	8	9	10	8	6	76
Casa Alonso del Toro, Cusco	6	8	6	4	4	5	8	7	6	54
Casa Serapio Calderón, Cusco	7	8	6	4	3	6	8	7	6	55
Casa Concha, Cusco	5	9	7	8	8	4	8	8	8	65

The Getty Conservation Institute

PONTIFICIA
UNIVERSIDAD
CATÓLICA
DEL PERÚ



The Getty Conservation Institute

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

Building: : Iglesia Santiago Apostol KuñoTambo

Address: Comunidad Campesina KuñoTambo, Distrito Rondocan, Provincia Acomayo, Cusco

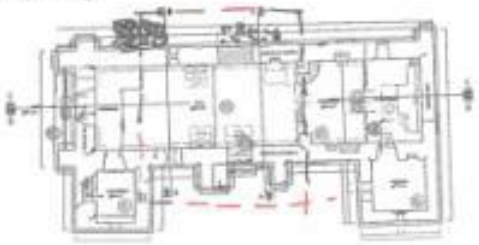
Sector: C

Sector type :

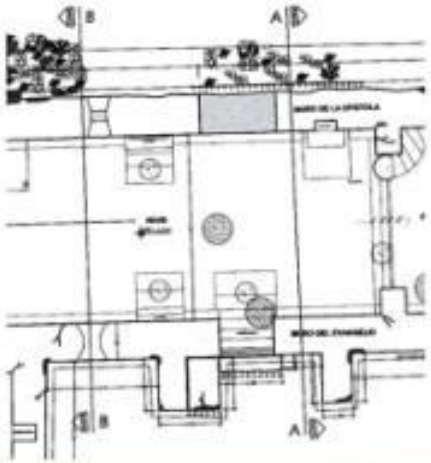
☐ Courtyard / ☐ Tower / ☐ Group of rooms / ☒ Individual Room / ☐ Roof

Level: ☒ First floor / ☐ Second floor / ☐ Third floor

I. Location of sector in building:



II. Floor plan of sector:



VII. Conditions impacting seismic performance of sector:

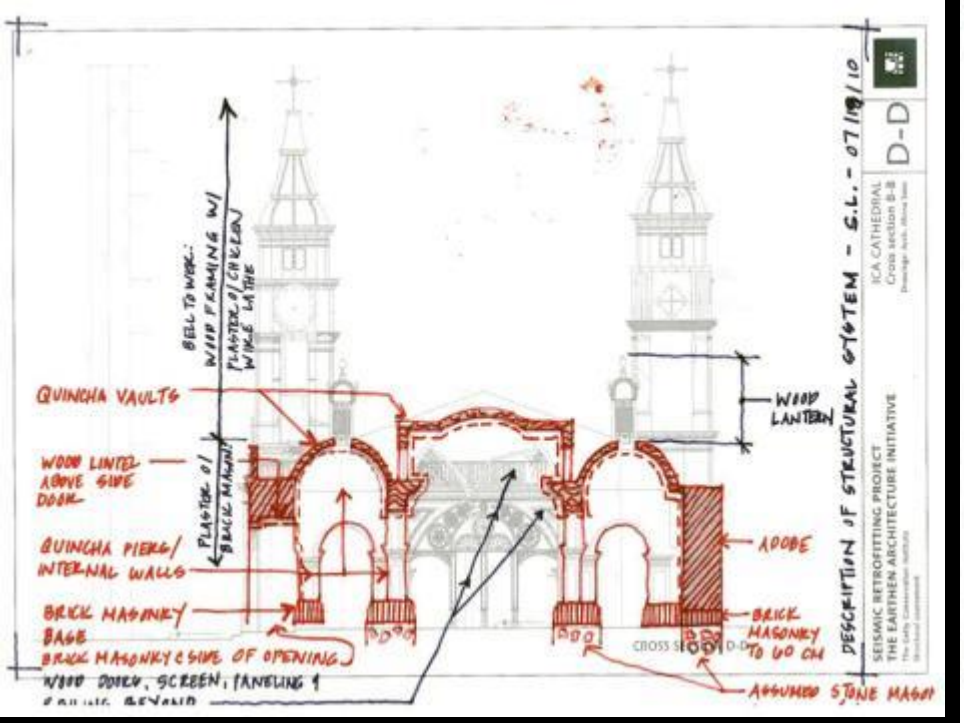
General impression: ☐ Stable ☐ Instable

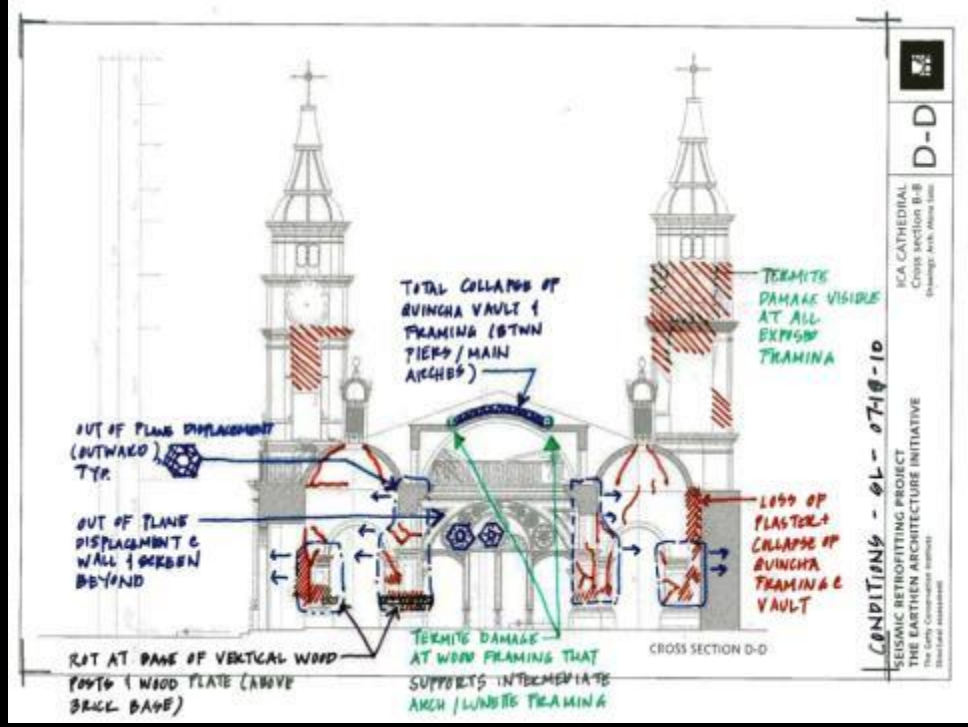
Adobe/Quincha walls

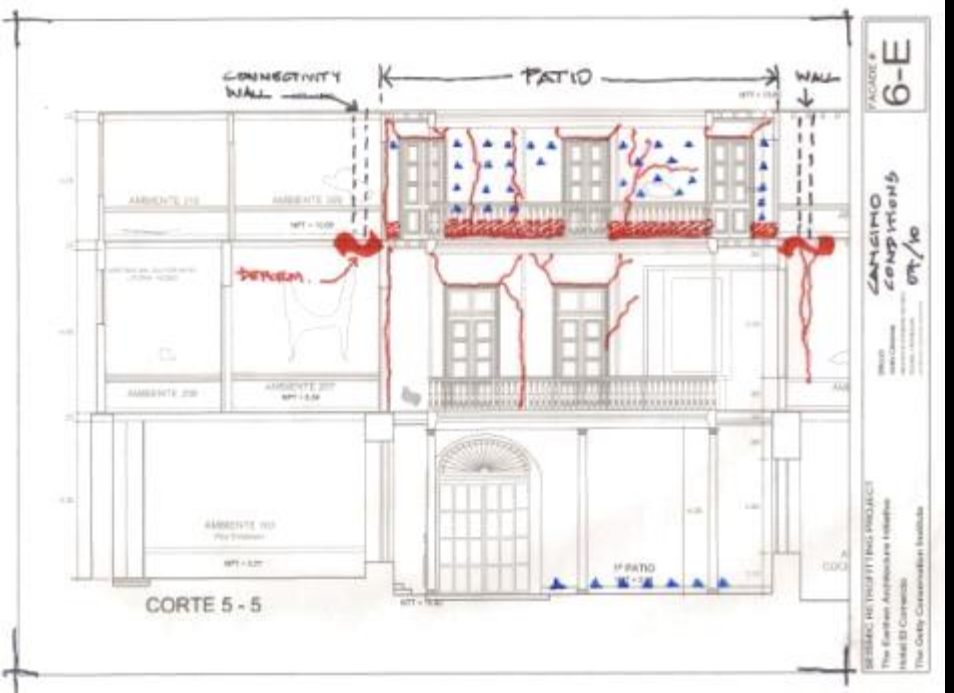
Conditions:	In relation to the longer wall	Location	Graphic at plan
Total wall collapse	☐ Yes ☒ No	☐ All walls ☐ ½ of walls ☐ 3/4 of walls ☐ ¼ of walls	
Partial wall collapse (no consider plaster)	☐ Yes ☒ No	☐ At the center ☐ At the corners ☐ Upper section	
Settlement of walls:	☐ Yes ☒ No	☐ Center ☐ Edges	
Corner damage: (The "V" thing, incipient corner collapse)	☐ Yes ☒ No	☐ All height ☐ Upper	
Out of plane displacement: ☒ Yes ☐ No	☐ Inward ☒ Outward ☐ Bowing	☐ Lower ☒ Upper ☐ Middle	
	☐ Horizontal	☐ Lower ☐ Upper ☐ Center	
	☒ Vertical	☐ Lower ☒ Upper ☐ Center ☒ Coming out of openings ☒ At corners	
Structural cracking: ☒ Yes ☐ No	☒ Flexural	☐ Wall to wall ☐ Wall to mid-wall	
	☐ Diagonal	☐ Top to bottom ☐ Top to mid-height ☐ Bottom to mid-height	
	☐ X-Shaped	☐ Top to bottom ☐ Top to mid-height ☐ Bottom to mid-height	

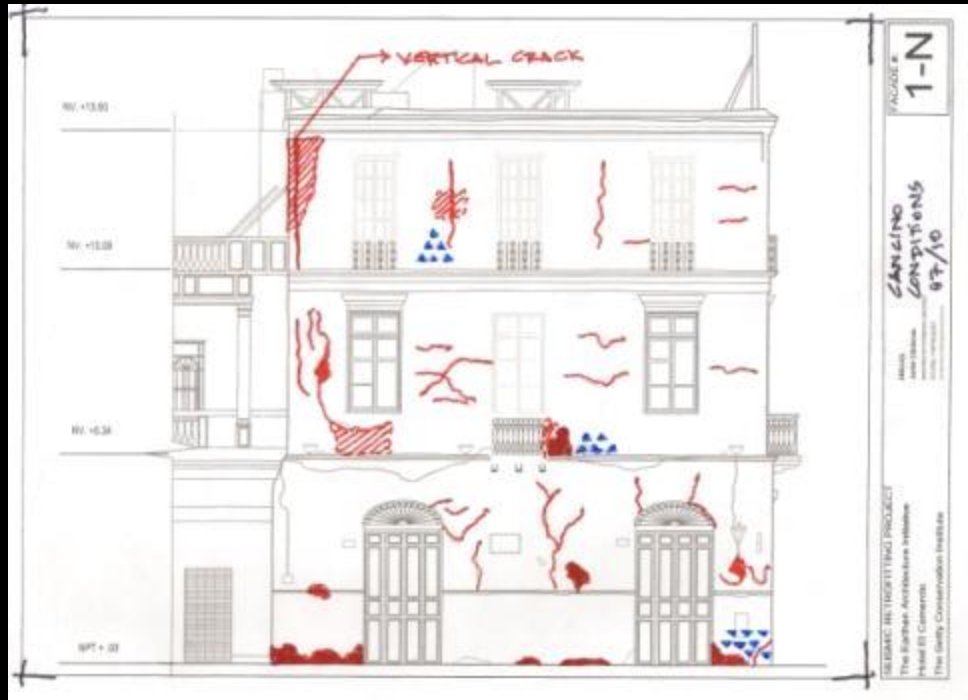
NOTE: SEE THERMAL CAMERA IMAGE IN FILE

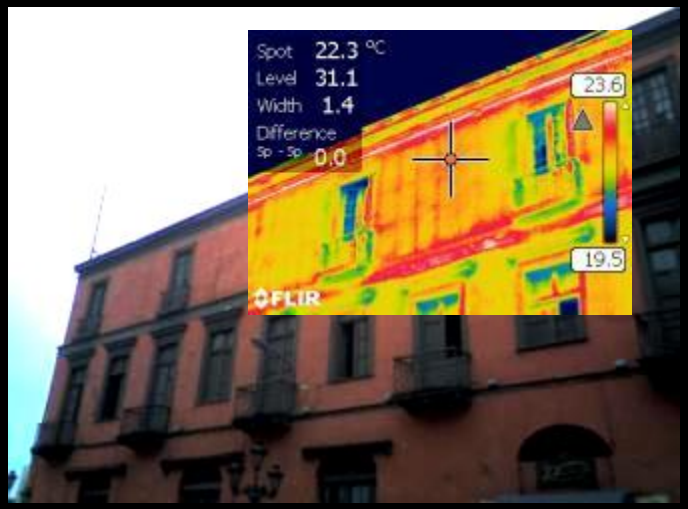
FOLLOWING OPENINGS ARE PHOTO REVIEWED FORM


QUINCHA VAULTS
WOOD LINTEL ABOVE SIDE DOOR
QUINCHA PIERS/ INTERNAL WALLS
BRICK MASONRY BASE
BRICK MASONRY & SIDE OF OPENING
WOOD DOORS, SCREEN, PANELING &
BELL TOWER: WOOD FRAMING W/ PLASTER O/ CHICKEN WIRE LATHE
PLASTER O/ BRICK MASONRY
WOOD LANTERN
ADOBE
BRICK MASONRY TO 60 CM
ASSUMED STONE MASON
CROSS SECTION D-D
DESCRIPTION OF STRUCTURAL SYSTEM - S.L. - 07/19/10
ICA CATHEDRAL
Cross section B-B
D-D
SEISMIC RETROFITTING PROJECT
THE EARTHEN ARCHITECTURE INITIATIVE


TOTAL COLLAPSE OF QUINCHA VAULT & FRAMING (BTWN PIERS / MAIN ARCHES)
TERMITE DAMAGE VISIBLE AT ALL EXPOSED FRAMING
OUT OF PLANE DISPLACEMENT (OUTWARD) TYP.
OUT OF PLANE DISPLACEMENT & WALL & SCREEN BEYOND
LOSS OF PLASTER + COLLAPSE OF QUINCHA FRAMING & VAULT
ROT AT BASE OF VERTICAL WOOD POSTS & WOOD PLATE (ABOVE BRICK BASE)
TERMITE DAMAGE AT WOOD FRAMING THAT SUPPORTS INTERMEDIATE ARCH / LUNETTE FRAMING
CROSS SECTION D-D
CONDITIONS - GL - 07-19-10
ICA CATHEDRAL
Cross section B-B
D-D
SEISMIC RETROFITTING PROJECT
THE EARTHEN ARCHITECTURE INITIATIVE


CONNECTIVITY WALL
PATIO
WALL
DEFORM.
CORTE 5 - 5
FACADE #
6-E
CANCINO CONDITIONS 07/10
SEISMIC RETROFITTING PROJECT

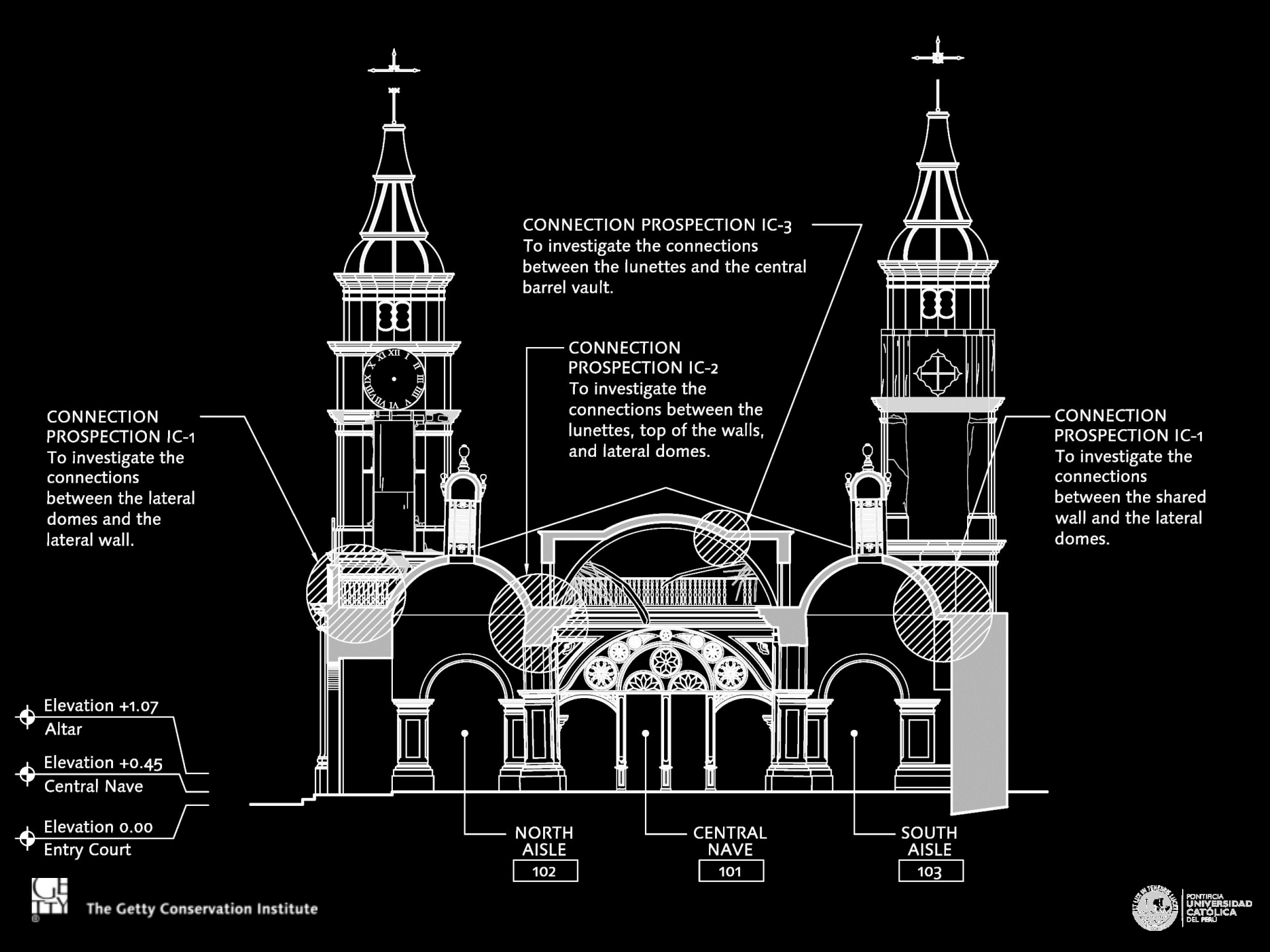

VERTICAL CRACK
FACADE #
1-N
CANCINO CONDITIONS 07/10
SEISMIC RETROFITTING PROJECT


Spot 22.3 °C
Level 31.1
Width 1.4
Difference
Sp - Sp 0.0
23.6
19.5
FLIR

FLIR

Level 32.6
20.4
10.5
FLIR

Level 32.6
20.4
10.5
FLIR

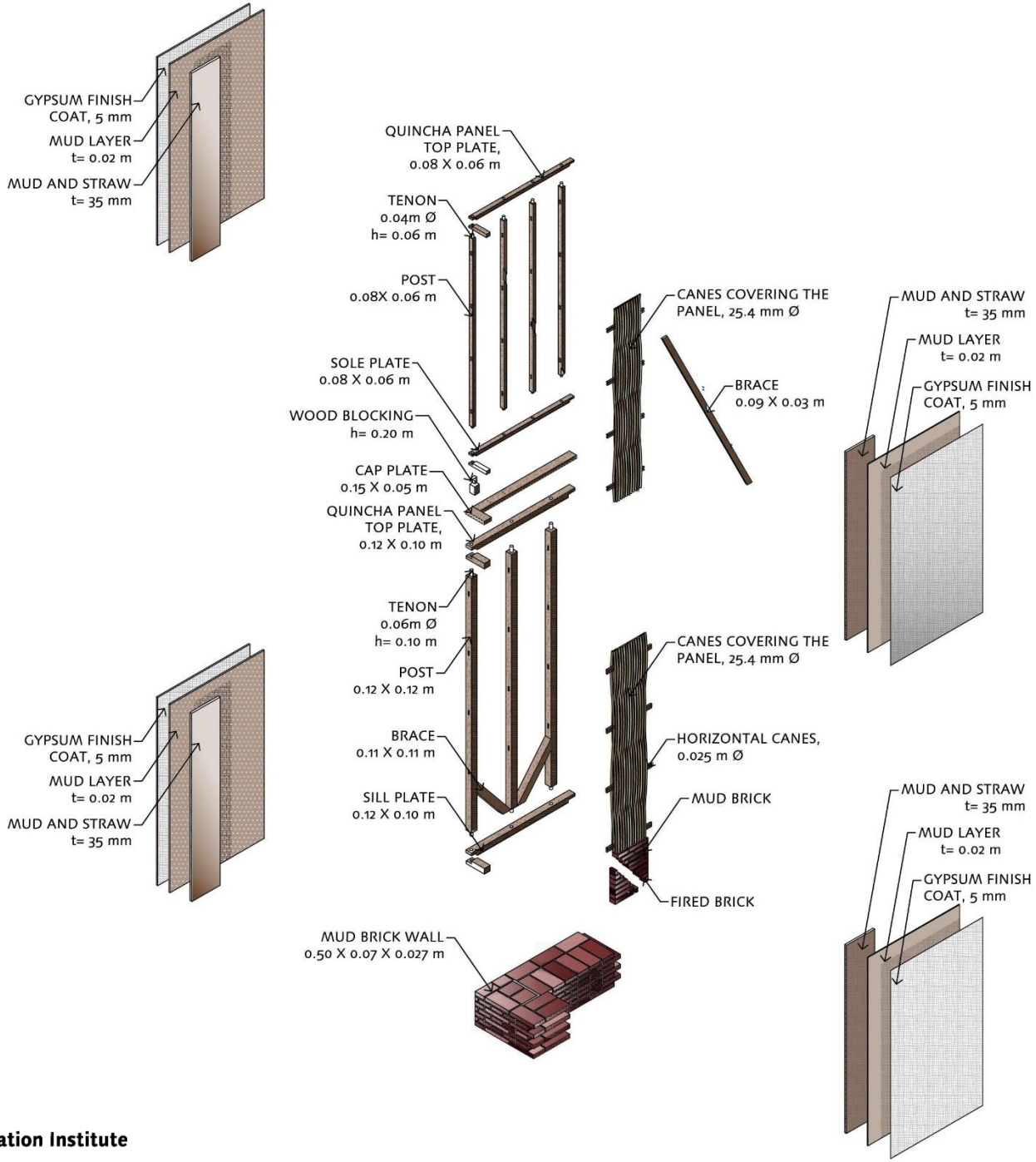


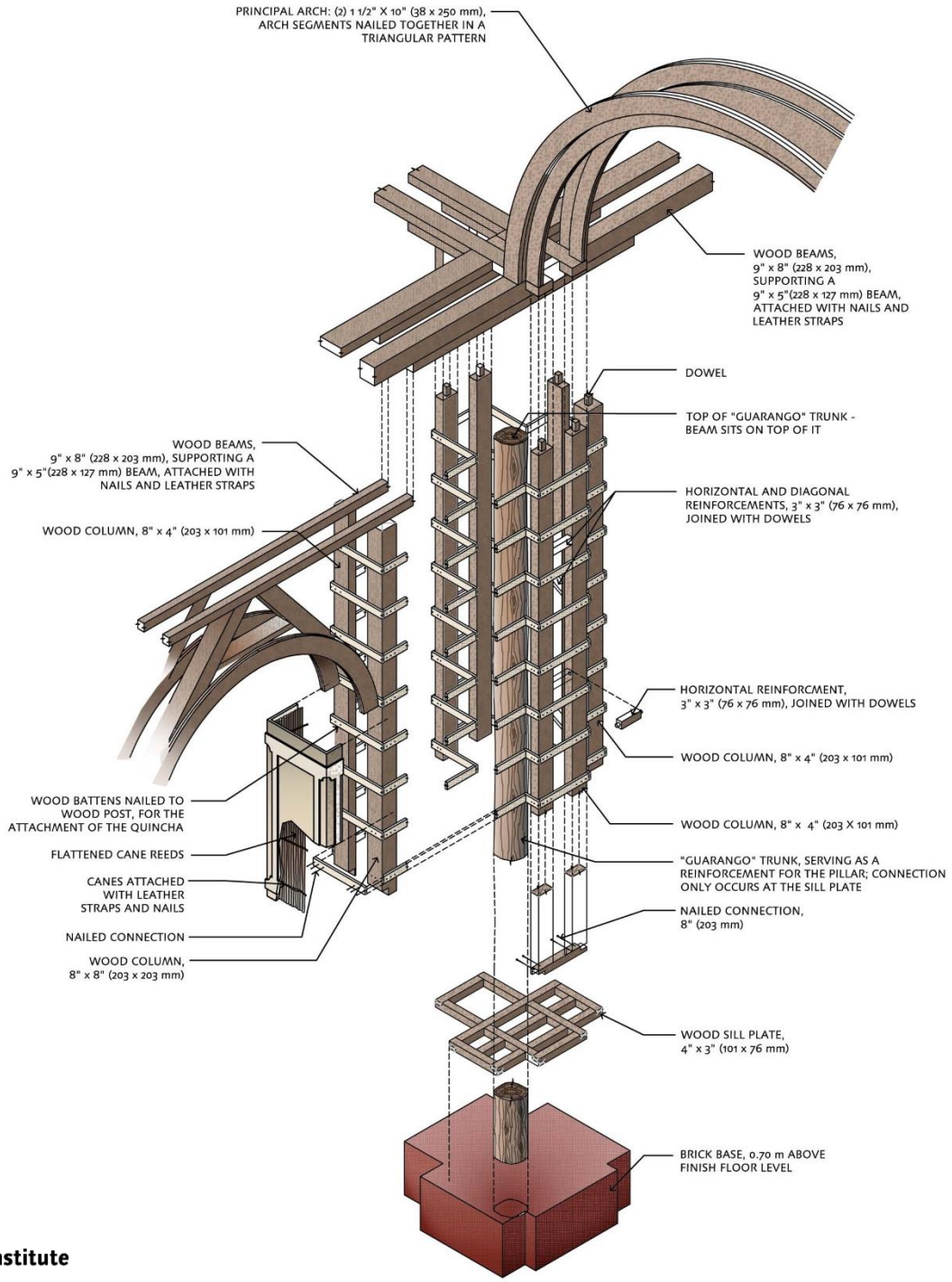
The Getty Conservation Institute

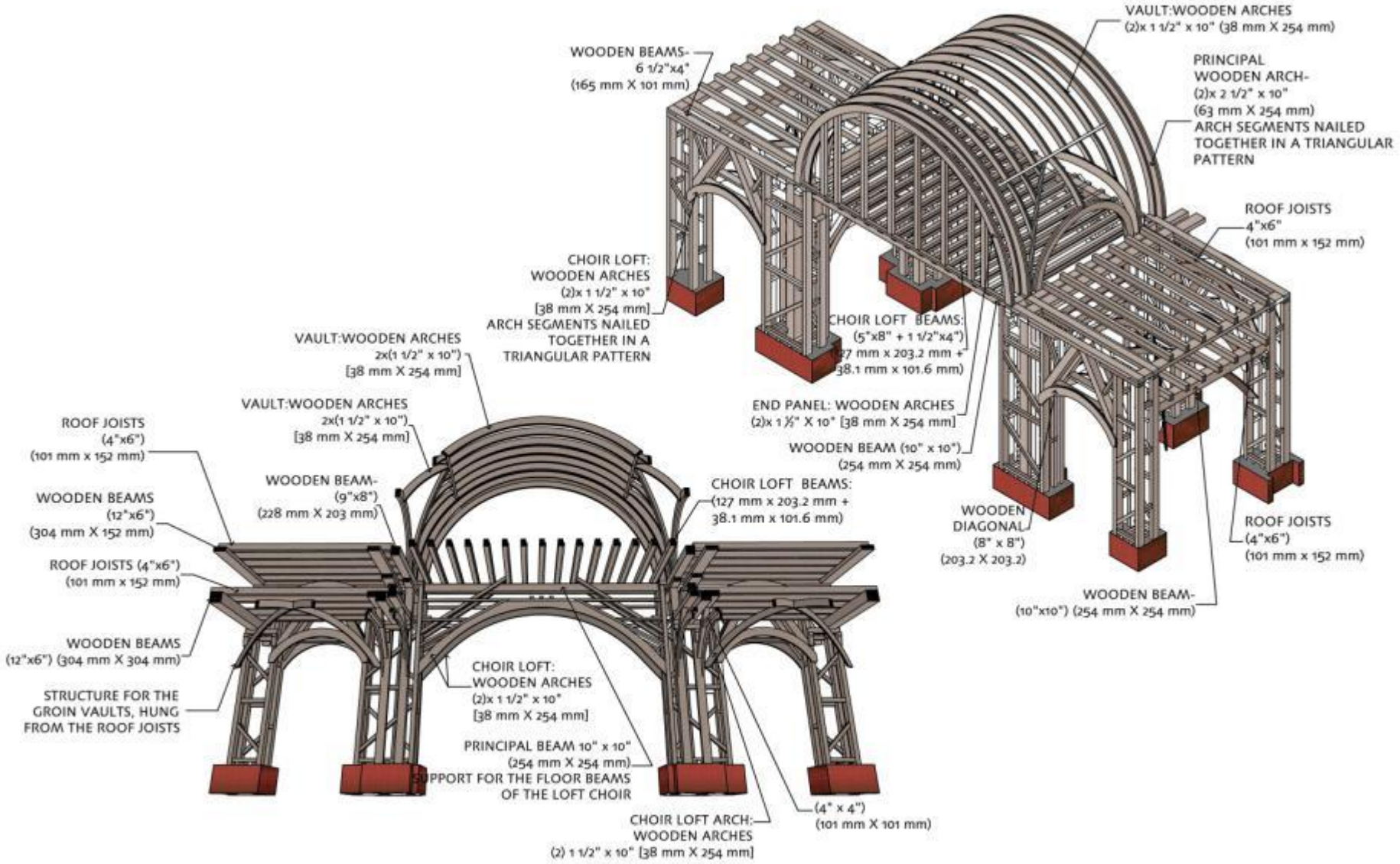
PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

The Getty Conservation Institute

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ


GYPSUM FINISH COAT, 5 mm
MUD LAYER t= 0.02 m
MUD AND STRAW t= 35 mm
QUINCHA PANEL TOP PLATE, 0.08 X 0.06 m
TENON 0.04m Ø h= 0.06 m
POST 0.08X 0.06 m
SOLE PLATE 0.08 X 0.06 m
WOOD BLOCKING h= 0.20 m
CAP PLATE 0.15 X 0.05 m
QUINCHA PANEL TOP PLATE, 0.12 X 0.10 m
TENON 0.06m Ø h= 0.10 m
POST 0.12 X 0.12 m
BRACE 0.11 X 0.11 m
SILL PLATE 0.12 X 0.10 m
CANES COVERING THE PANEL, 25.4 mm Ø
BRACE 0.09 X 0.03 m
MUD AND STRAW t= 35 mm
MUD LAYER t= 0.02 m
GYPSUM FINISH COAT, 5 mm
CANES COVERING THE PANEL, 25.4 mm Ø
HORIZONTAL CANES, 0.025 m Ø
MUD BRICK
FIRED BRICK
MUD BRICK WALL 0.50 X 0.07 X 0.027 m
GYPSUM FINISH COAT, 5 mm
MUD LAYER t= 0.02 m
MUD AND STRAW t= 35 mm
MUD AND STRAW t= 35 mm
MUD LAYER t= 0.02 m
GYPSUM FINISH COAT, 5 mm


PRINCIPAL ARCH: (2) 1 1/2" X 10" (38 x 250 mm), ARCH SEGMENTS NAILED TOGETHER IN A TRIANGULAR PATTERN
WOOD BEAMS, 9" x 8" (228 x 203 mm), SUPPORTING A 9" x 5"(228 x 127 mm) BEAM, ATTACHED WITH NAILS AND LEATHER STRAPS
DOWEL
TOP OF "GUARANGO" TRUNK - BEAM SITS ON TOP OF IT
WOOD BEAMS, 9" x 8" (228 x 203 mm), SUPPORTING A 9" x 5"(228 x 127 mm) BEAM, ATTACHED WITH NAILS AND LEATHER STRAPS
HORIZONTAL AND DIAGONAL REINFORCEMENTS, 3" x 3" (76 x 76 mm), JOINED WITH DOWELS
WOOD COLUMN, 8" x 4" (203 x 101 mm)
HORIZONTAL REINFORCMENT, 3" x 3" (76 x 76 mm), JOINED WITH DOWELS
WOOD COLUMN, 8" x 4" (203 x 101 mm)
WOOD BATTENS NAILED TO WOOD POST, FOR THE ATTACHMENT OF THE QUINCHA
WOOD COLUMN, 8" x 4" (203 X 101 mm)
FLATTENED CANE REEDS
"GUARANGO" TRUNK, SERVING AS A REINFORCEMENT FOR THE PILLAR; CONNECTION ONLY OCCURS AT THE SILL PLATE
CANES ATTACHED WITH LEATHER STRAPS AND NAILS
NAILED CONNECTION, 8" (203 mm)
NAILED CONNECTION
WOOD COLUMN, 8" x 8" (203 x 203 mm)
WOOD SILL PLATE, 4" x 3" (101 x 76 mm)
BRICK BASE, 0.70 m ABOVE FINISH FLOOR LEVEL



CHOIR LOFT STRUCTURE

SCALE 1:75

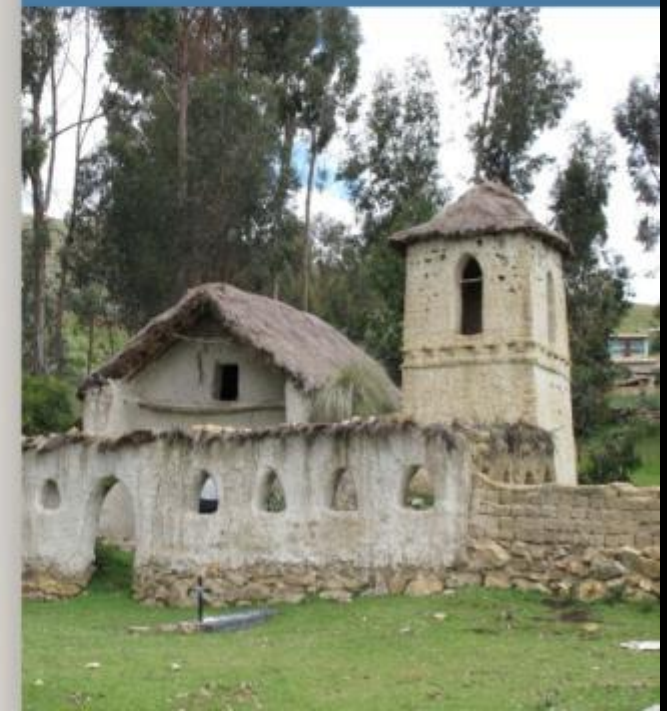
Research Report

Seismic Retrofitting Project: Assessment of Prototype Buildings

Claudia Cancino and Sara Lardinois

In collaboration with Dina D'Ayala, Carina Fonseca, Daniel Torrealva, and Erika Vicente

Los Angeles, August 2012



The Getty Conservation Institute

CHAPTER 1 : Background

CHAPTER 2: Methodology
- Post-Earthquake Assessment Following the 2007 Pisco Earthquake
- Selection of Prototype Buildings
- Assessment Methodology
  - Condition Survey
    - Survey sectors and forms
    - Non-destruction investigations
    - Prospections
  - Standards and Terminology

CHAPTER 3 , 4, 5 AND 6: ASSESSMENT
Hotel El Comercio, Ica Cathedral, Kuño Tambo and Casa Arones
- Summary
- Historical Background, Context, and Significance
- Architectural Description
- Geological and Environmental Description
  - Geological description and seismic history
  - Regional climate
- Structural Description
  - Survey sectors
  - Foundations and base course
  - Walls, Floors and Roof
- Irregularities, Alterations, Damages, and Decay
- Preliminary Findings

CHAPTER 7 : Conclusions and glossary

Appendix A: Architectural Drawings
Appendix B: Prospection Drawings

The Getty Conservation Institute

The Getty Conservation Institute

West Elevation

East Elevation

Ceiling

South Elevation

The Getty Conservation Institute

The Getty Conservation Institute

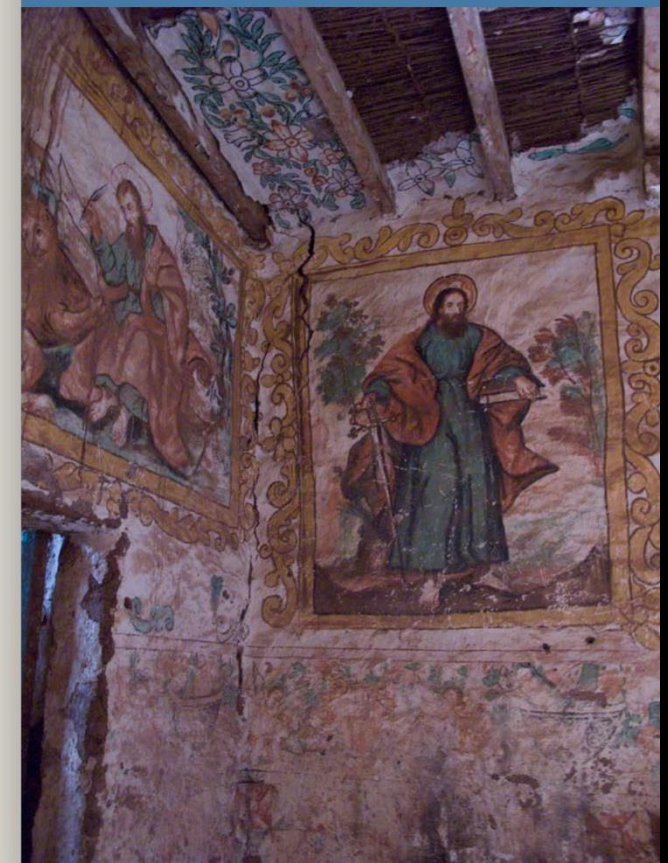
The Getty Conservation Institute

Proyecto de Estabilización Sismorresistente:
Metodología para la protección de pinturas murales previo a la intervención estructural en edificaciones históricas de tierra

Informe de investigación

Claudia Cancino, Clemencia Vernaza, Hugo Rivera, Humberto Gutierrez y Rotney Abril

Los Angeles 2016



The Getty Conservation Institute

The Getty
Conservation Institute

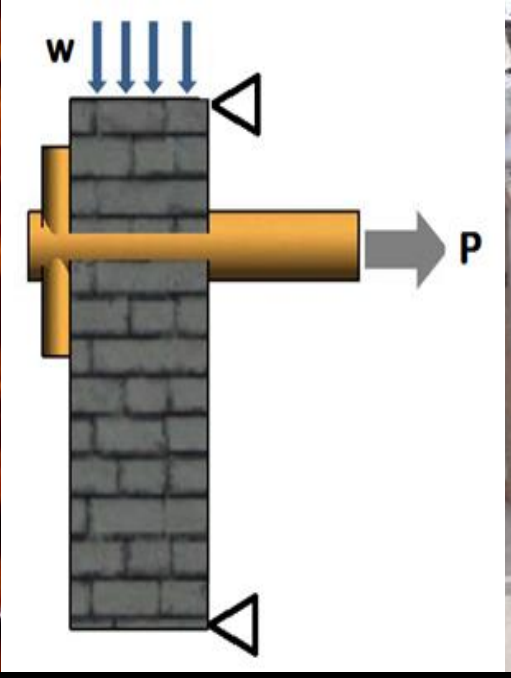
PROPERTIES	TEST	# DE ESPECIMENS	# OF TESTS
MECANICAL	GRANULOMETRY	1	4
	COMPRESSSION	5	4
	AXIAL COMPRESSSION	3	4
	DIAGNONAL COMPRESSION	3	4
STRUCTURAL	PULL-OUTS (BEANS)	9	1
	CORNERS KEYS	9	1

#	DIMENTIONS (cm)	AREA (cm2)	LOAD	COMPRESSION (Mpa)	
				UNIT	MEDIA
1	13.3 X 13.0 X 14.3	1729	14.61	0.84	0.7133
2	13.6 X 13.8 X 14.7	1877	12.23	0.65	
3	13.4 X 13.2 X 14.5	1769	8.51	0.48	
4	13.5 X 13.5 X 14.6	1823	15.90	0.87	

#	DIMENTIONS (cm)	AREA (cm2)	AXIAL COMPRESSION			YOUNG MODULUS (Mpa)
			LOAD (KN)	PRESS(Mpa)	MEDIA PRESS (Mpa)	
1	20.3 X 11.7 X 42.7	237.51	26.49	1.115	1.10	225.25
2	20.3 X 11.7 X 42.7	237.51	26.38	1.111		
3	20.3 X 11.7 X 42.7	237.51	25.45	1.072		

#	DIMENTIONS (cm)	AREA (cm2)	DIAGONAL COMPRESSION			MÓDULO DE ELASTICIDAD EN CORTE (G Mpa)
			LOAD(KN)	PRESS (Mpa)	MEDIA PRESS (Mpa)	
1	52.6 X 52.7 X 11.8	878.61	3.66	0.042	0.044	423.43
2	53.0 X 53.0 X 11.6	869.46	4.41	0.051		
3	52.5 X 52.5 X 11.5	853.83	3.31	0.039		

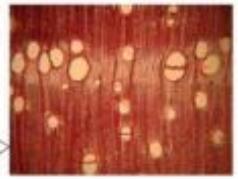
The Getty Conservation Institute
PONTIFICIA UNIVERSIDAD CATOLICA DEL PERU

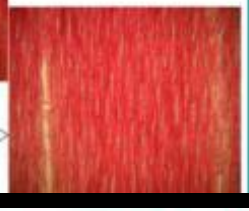


#	ESP. (cm)	VERTICAL LOAD (Kg/ml)	MÁX. LOAD (KN)	MEDIA (KN)	DEVIATION (KN)	DISPERSSION %
M1	26	180	16.04	16.7	0.72	4.283
M2	26	180	17.46			
M3	26	0	16.60			
M4	54	360	34.28	32.73	3.97	12.145
M5	54	360	35.69			
M6	54	0	28.21			
M7	83	0	41.83	47.86	5.43	11.338
M8	83	540	49.40			
M9	83	540	52.35			

Cedrela odorata L. / Meliaceae

CEDRO





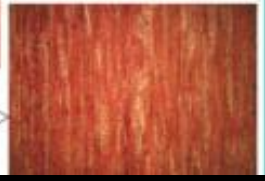
Prosopis sp. / Fabaceae

HUARANGO, ALGARROBO

Entandrophragma sp. / Meliaceae

CAOBA AFRICANA , SAPELLI

ESPECIE NO IDENTIFICADA



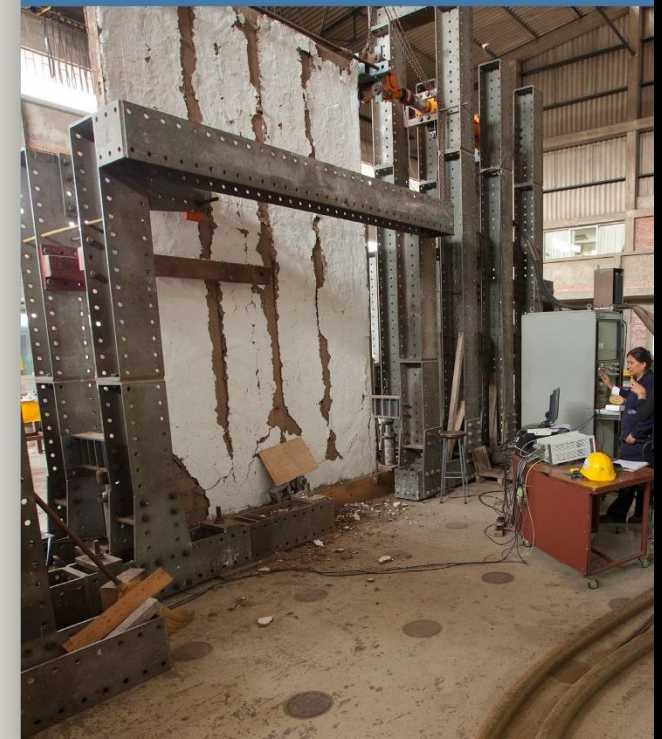
Seismic Retrofitting Project: Quincha, Adobe, Timber and Brick Experimental Testing

Research Report

Daniel Torrealva Dávila and Erika Vicente

In collaboration with
Claudia Cancino

Lima and Los Angeles 2015



Pontificia Universidad Católica del Perú

The Getty Conservation Institute

Project Participants

CHAPTER 1 - Background
1.1 Introduction
1.2 Institutional Background and Project Partners
1.3 Seismic Retrofitting Project: This publication

CHAPTER 2 - Historic earthen building typologies in Peru
2.1 Residential typologies in the coast: Hotel Comercio
2.2 Ecclesiastical buildings in the coast: Ica Cathedral
2.3 Residential typologies in the Andes: Casa Arones
2.4 Ecclesiastical buildings in the Andes: Kuño Tambo Church

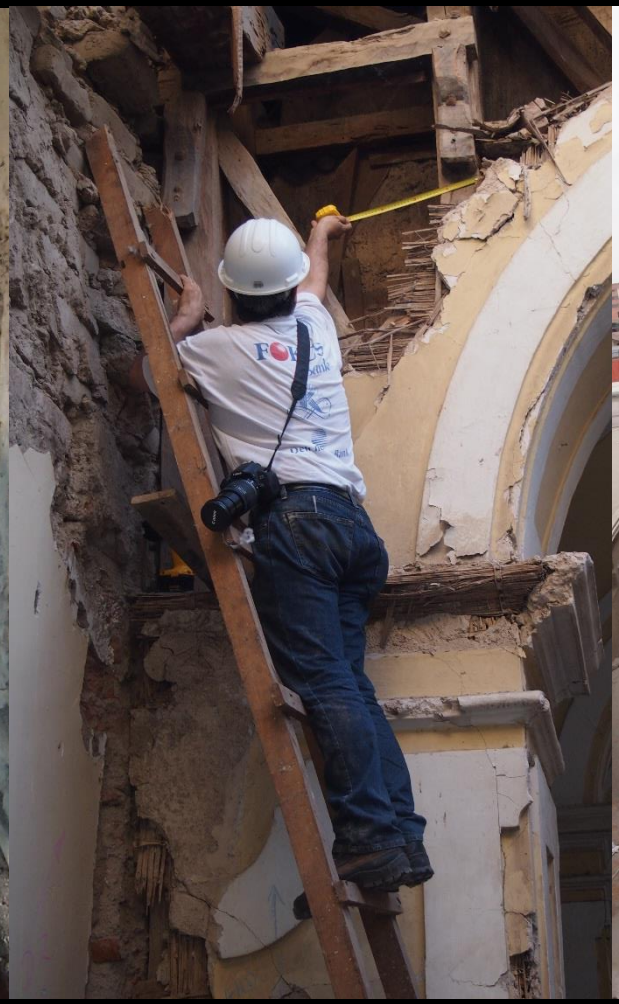
CHAPTER 3, 4, 5 & 6 - Material properties of adobe and brick masonry; timber elements, timber joints
3.1 Source of the material
3.2 Construction/preparation of specimens
3.3 Experimental program: Test set up, standards and instrumentation
3.4 Experimental results and discussion
3.5 Failure modes
3.6 Conclusions

CHAPTER 7 - Testing of traditional reinforcing techniques: Tie beans and corner keys
7.1 Source of the material
7.2 Structural function
7.3 Construction/preparation of specimens
7.4 Experimental program and material testing: Test set up, standards and instrumentation
7.5 Experimental results and discussion
7.6 Failure modes
7.7 Conclusions

CHAPTER 8 - Conclusions

Bibliography

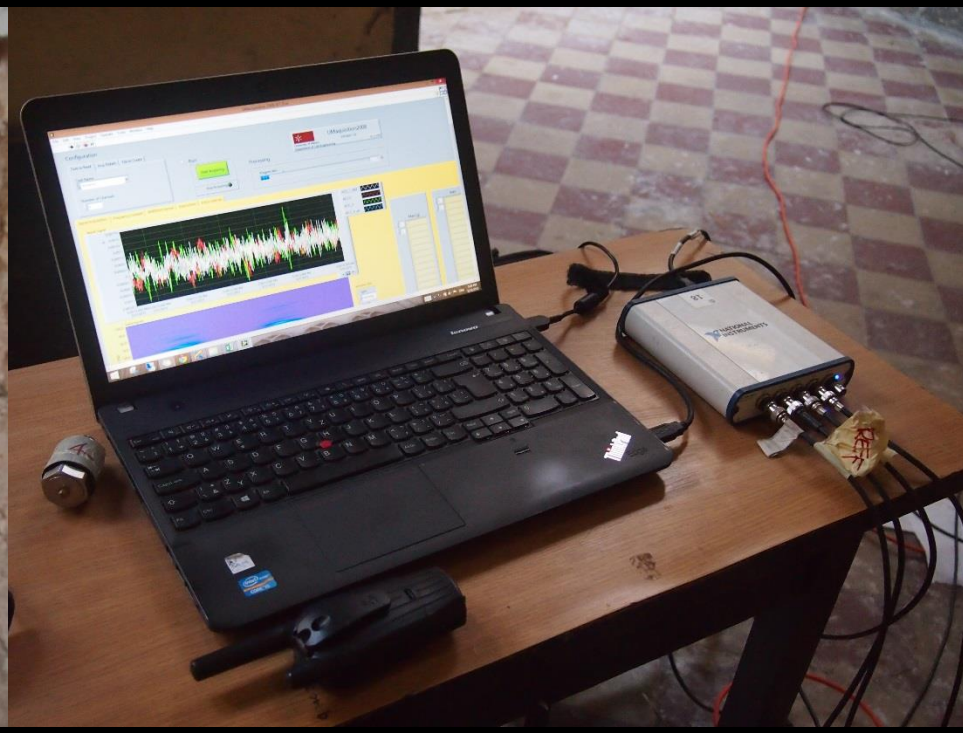
The Getty
Conservation Institute



The Getty Conservation Institute

Universidade do Minho

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

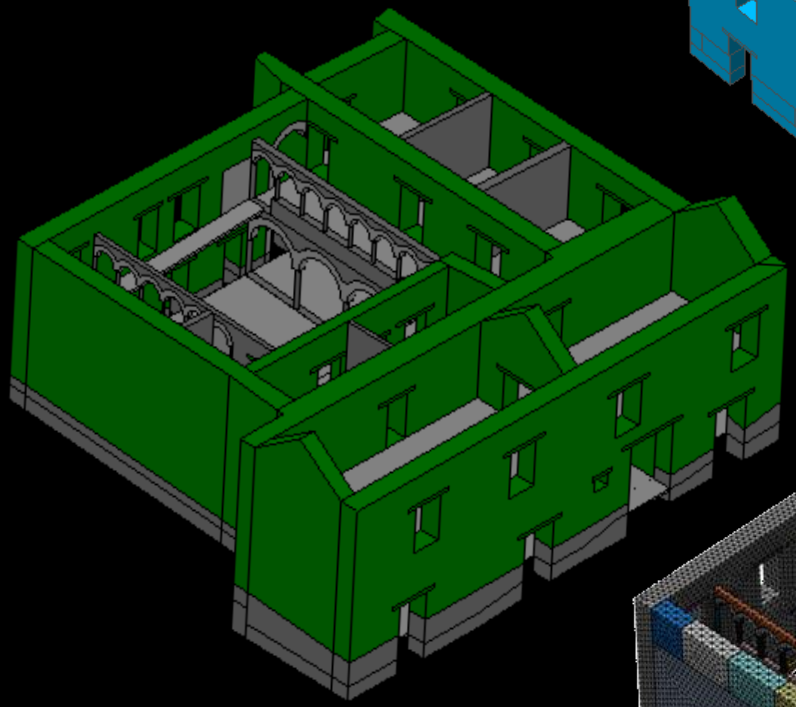


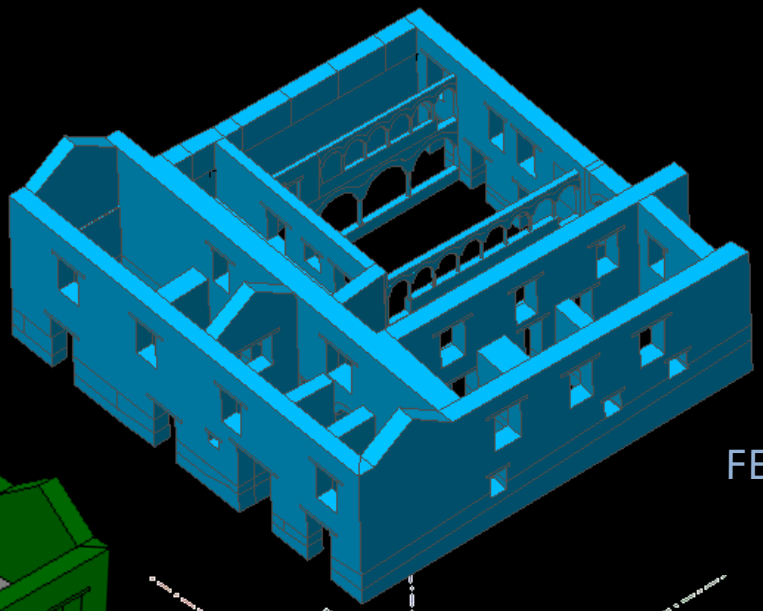
The Getty Conservation Institute

Universidade do Minho

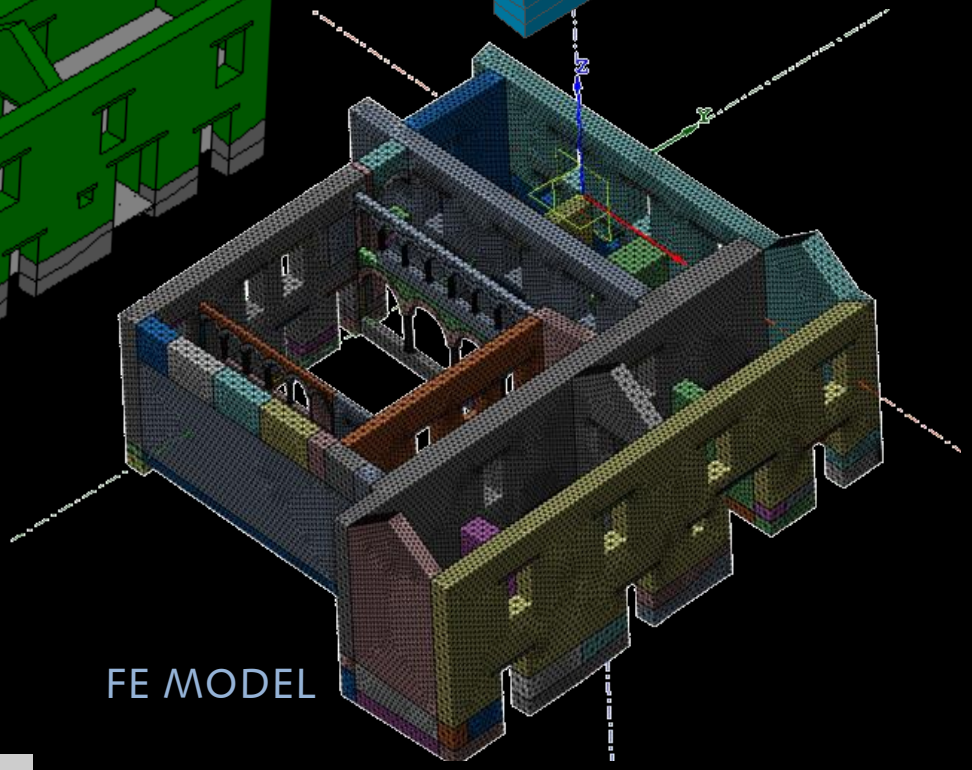
PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

3-D MODEL





FE MODEL



FE MODEL

The Getty Conservation Institute

Universidade do Minho

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

UNIVERSIDAD PERUANA DE CIENCIAS APLICADAS

Arq. Mirna Soto, Arq. José García Bryce

CONFERENCIA EPISCOPAL PERUANA

Mons. Héctor Vera Colona, Mons. Juan Antonio Ugarte, Mons. Ricardo García;

Arq. Violeta Paliza, Arq. Mirta Velezmoro

CENTRO GUAMÁN POMA DE AYALA

Lic. José María Gómez García, Arq. Enrique Estrada

UNIVERSIDAD CATÓLICA SEDES SAPIENTIAE

Mons. Lino Panizza Richero,

Gran Canciller de la Universidad Católica Sedes Sapientiae, Secretario General de la Conferencia Episcopal

Dr. Gian Battista Bolis, Secretario General