

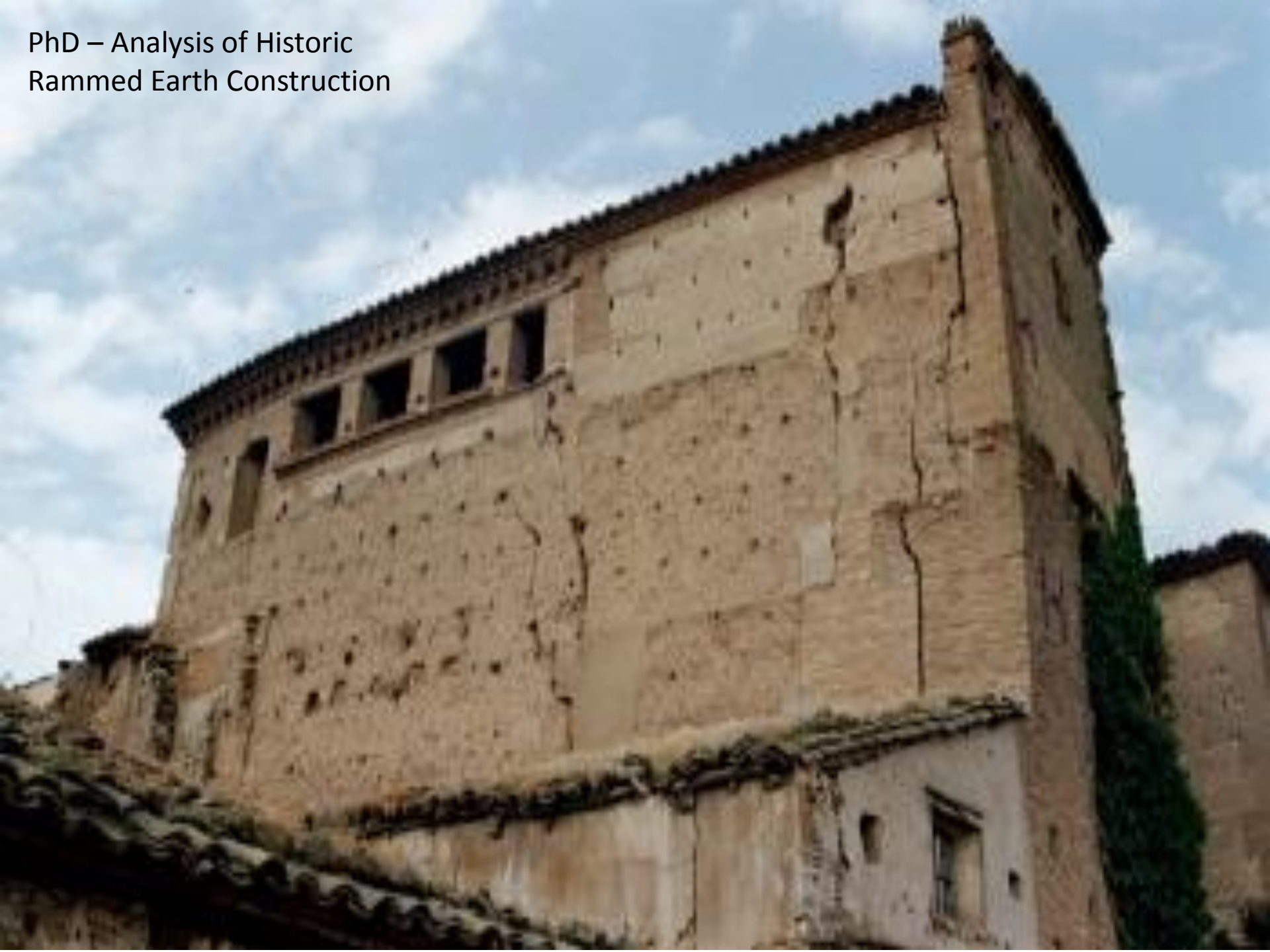
A history of innovation in earth building

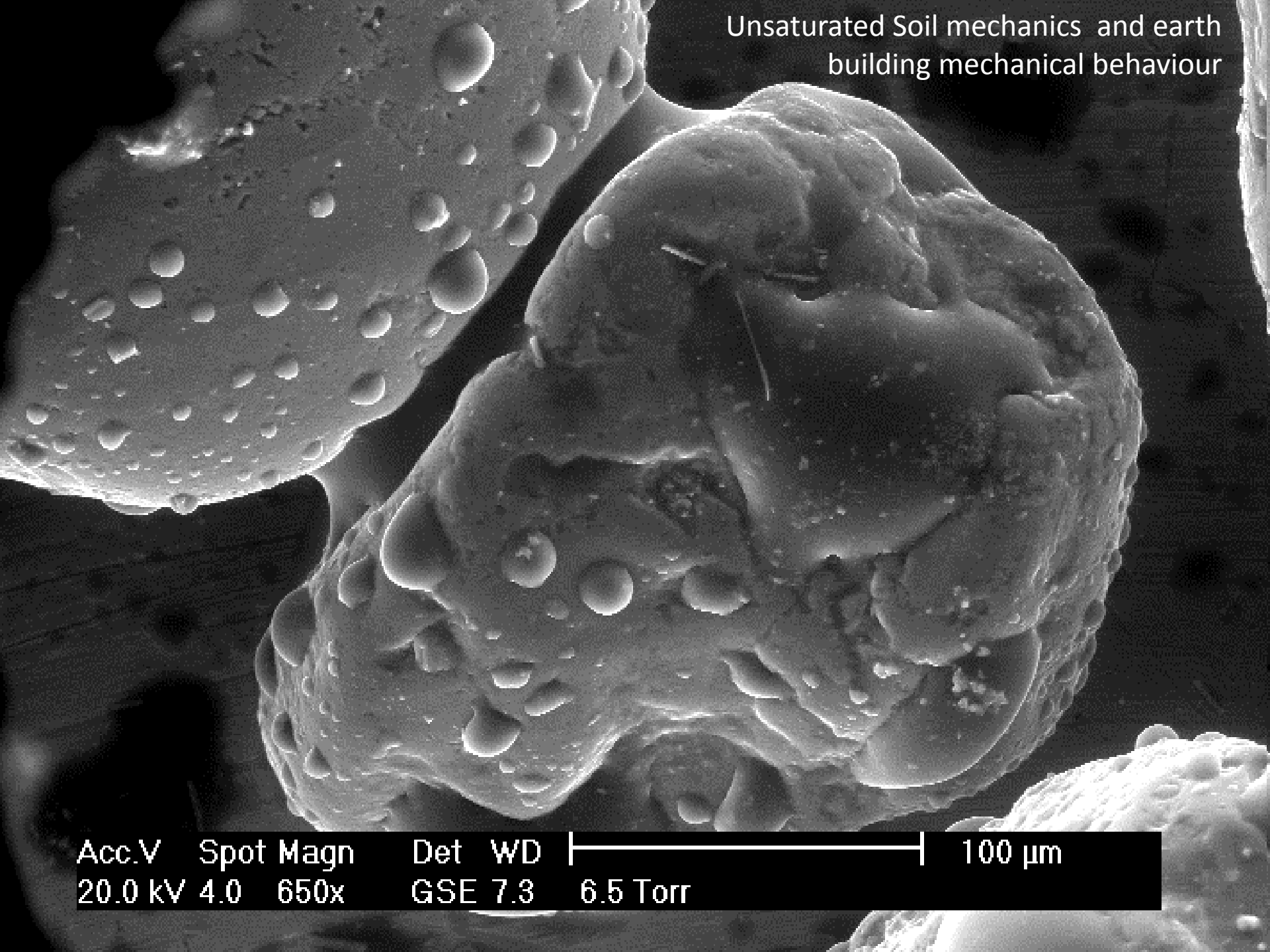
Paul Jaquin





PhD – Analysis of Historic
Rammed Earth Construction





Acc.V	Spot	Magn	Det	WD		100 μ m
20.0 kV	4.0	650x	GSE	7.3		

6.5 Torr





Structural Engineer UK



ModCell
Straw bale panel
Fire test

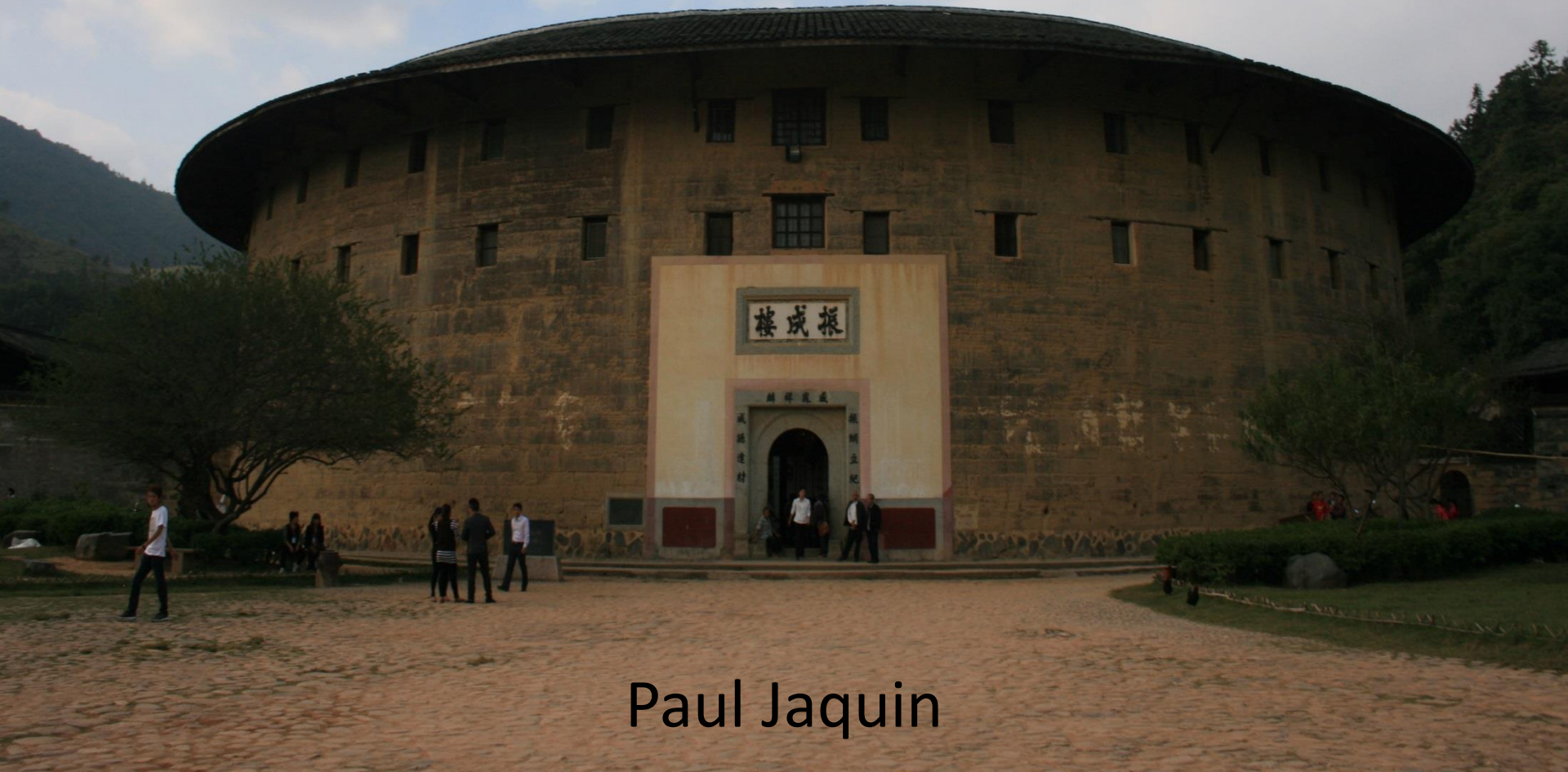


Structural and Geotechnical Engineer
Land Development and Exploration
Warkworth
New Zealand

Part of NZ government team to
Nepal in August- October 2015
Assisting with earthquake
assessments and teaching



A history of innovation in earth building



Paul Jaquin

- Historic
 - Mix additives
 - Building strengthening
 - Process improvement
- Now
- Future
- Not technical
- Not comprehensive



9,000 BC

Jericho



Mix additives

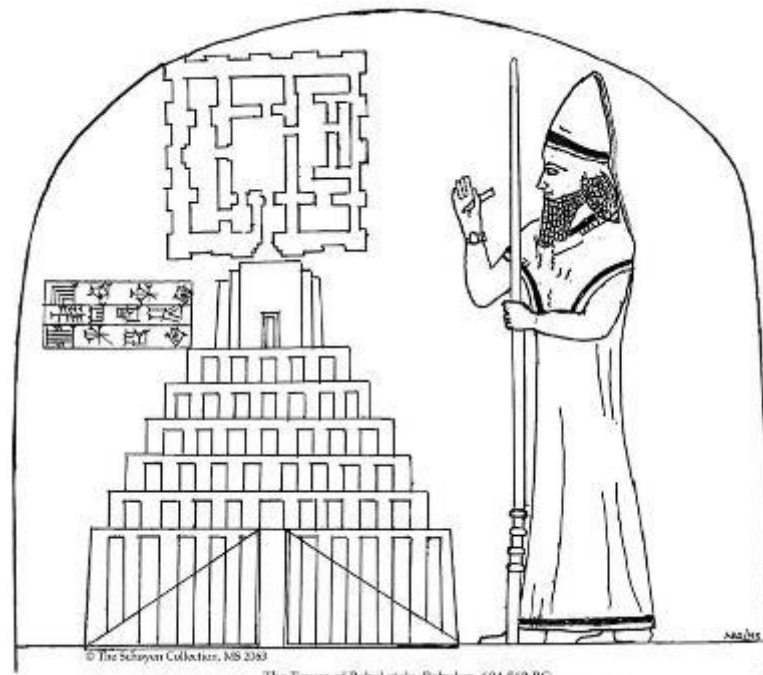
Straw

Development of agriculture.
Incorporated into the walls
Pre - pottery

Evidence for food storage and predomestication granaries
11,000 years ago in the Jordan Valley, Ian Kuijta, and Bill
Finlayson

Etemenanki

2000BC



The Tower of Babel stele. Babylon, 604-562 BC.
Reconstruction by Martin Schøyen after an original drawing by Andrew George

Nebuchadnezzar am I ...The base I filled in to make a high terrace, I built their structure with **bitumen and baked brick** throughout. I completed it raising its top to the heaven...

“Now the whole world had one language and a common speech. As people moved eastward, they found a plain in and settled there. They said to each other, “Come, **let’s make bricks and bake them** thoroughly.” They used brick instead of stone, and **tar for mortar.**”



MS 2063
The Tower of Babel stele. Babylon, 604-562 BC.
The only contemporary illustration of The Tower of Babel

Schøyen Collection

Unfired
Straw
Bricks

1200BC



British Museum, number EA6020

Hakka Tolou, Fujian
Paddy field water





Chicken Bones?

Blood?

Milk?

All act as coagulants, binding together better

Lime

Greeks, Romans



Natural hydraulic lime – Limestone containing clay

Artificial hydraulic lime - Add clay, pozzolans



Pantheon, Rome

126 AD

Natural Pozzolanic concrete



Spain

967 AD



Rammed earth
Lime

- **Historic**
 - Mix additives
 - Building strengthening
 - Process improvement
- Now
- Future



Timber ring beam
Horizontally
Seismic?



Carmona, Spain

Physical additions

Timber horizontal members
Seismic protection?



Physical additions

Timber horizontal members





Tamarind sheets between rammed earth lifts

- **Historic**
 - Mix additives
 - Building strengthening
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- Now
- Future



Joseph Needham
Science and Civilisation in China, 1971



Concepción del Bermejo, Argentina

1585



Srinagar,
India, 1850



Morocco 2008



Innovation in formwork

Nepal 2008

Not really



- **Historic**
 - Mix additives
 - Building strengthening
 - Process improvement
- **Now**
- **Future**



Block press machines



Limestone dust
Reduced variability



Watershed Block

Low cement
Geopolymer
Extruded
Still a block



Prefabrication

Offsite construction

Reduce manual handling



Lightweight formwork



Pinnacle of earth plastering?

Nepal National Library
Constructed as Singa Durbar Palace 1908

- Clay
- Brick dust
- Rice husk
- Honey
- Lime

3 layers of plaster with different constituents
Different to the mortars
Different internal and external plaster mix



- **Historic**
 - Mix additives
 - Building strengthening
 - Process improvement

Now

- **Future**



Biomimicry



What exactly do Swallows do?

Biomimicry

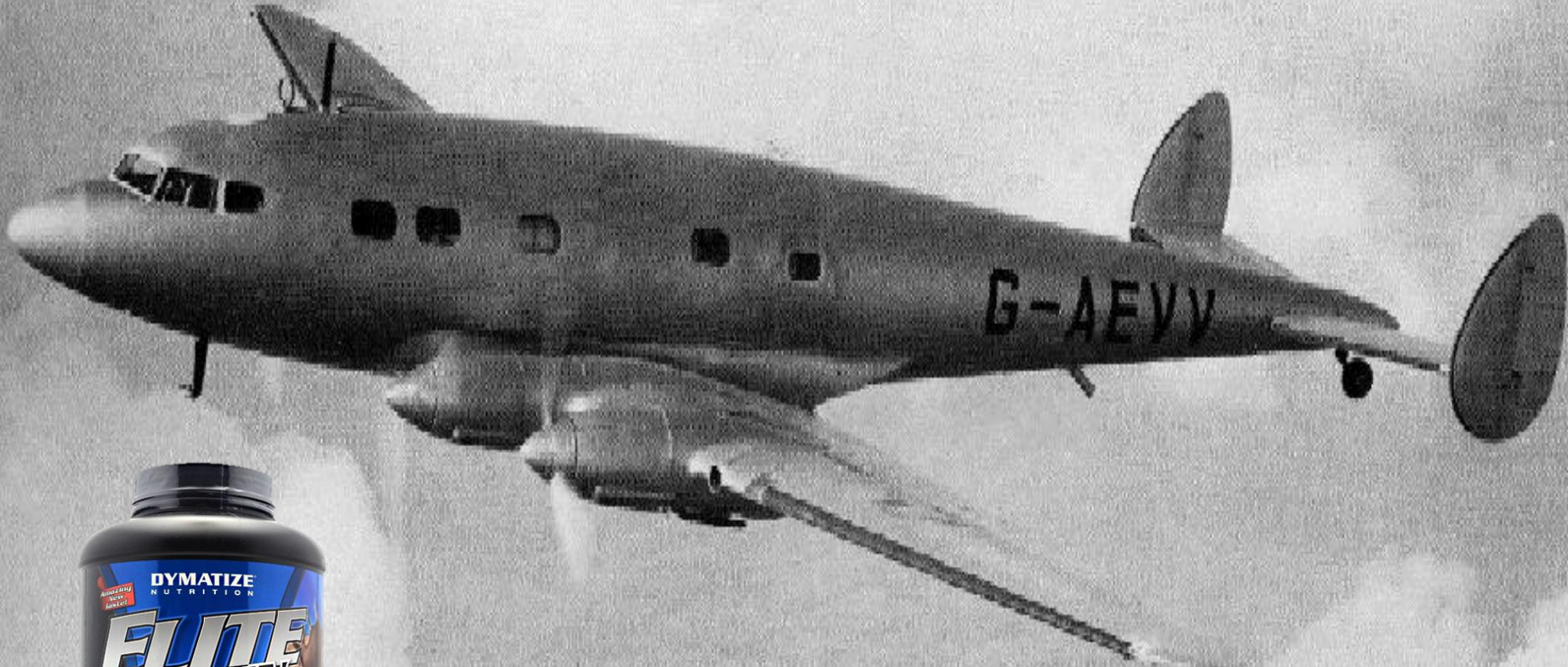


What exactly do Termites do?

Starch in rice/straw?



Use milk derived glues



Grow Coccolithophores



1.0µm

3D Printed clay



Ronald Rael
Emerging Objects



Traditional
Natural
Sustainable

Building

Needs constant innovation



Djenne Mosque, Mali

413. Afrique Occidentale - SOUDAN - DJENNÉ - Ruines de l'ancienne Mosquée



Collection Générale Fortier, Dakar

Djenne Mosque, Mali 1893

HISTORIC
RAMMED
EARTH



