39. Confinement Structures, bracing and truss in land factories, brought to a simulation in software of finite elements

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Abstract: Study and assessment of containment structures, bracing and lattices used in factories earth, adobe type stabilized by the use of finite element software (Abaqus student version). The structures correspond to common types used in Spain for Europe and Ecuador, Perú, Paraguay and Bolivia in Latin America, and have been modified in manufacturing process, dosages and morphology of the material to improved rigidity, stability and energy dissipation of loads to walls of houses on one floor and transmitted to Cyclopean Concrete foundation. The used data in the simulation corresponds to the physical, mechanical, geometrical, adobe resistance characteristics found in characterization tests conducted in the Chapel "Tausa Vieja" in Cundinarmarca (Colombia) and its interaction with the structures of reinforced concrete without difficulty self-construction. The results will be a diagram of categories of structures for land factories and four simulated structural behavior models that include adobe walls in orthogonal cells of reinforced concrete.

Palabras clave: Confinement, bracing, truss, adobe, finite element analysis

1 Introducción

Habitierra in 1995 exposes: the potential of raw land as a building material has lost credibility and its properties, its wide possibilities have been forgotten and discrediting especially in developing country and rural areas, harnessing the prejudice of being considered the material very resistant to natural hazards, factors that depend more on how it is constructed that the material used for this: the stability of a construction system does not depend solely on the materials used, but as these are combined and the layout of the structure of the building as a function of the risks of location and type of soil, like the existence of insects as the "kissing bug" in the adobe buildings is due to the existence of cavities between the adobes that promote their habitat. This is a socio-cultural, institutional and / or employment policy of what has been described as an appropriate technology, provided within specific contexts barrier. (Serrano, 1995)

This study is a compilation and concretization of structural information factories of land, with a first model geometry and type of gear obtained from houses built with adobe walls and reed (Arundo donax) north of Peru, and the use results of tests conducted around the stabilization of the adobe in its structural characteristics come from the study of the chapel "Tausa Old" in Cundinamarca-Colombia with optimal resistance results characterize physics, chemistry and mechanically adobe blocks subtracted for research purposes (Juan Carlos Rivera, 2005). It should be noted that the condition of the land used for the site of origin, all framed in document Technical Standard Building Peru (E.0.80, 1999)

Then three additional models designed to the simulation including type of structural confinement, armed detail between the rig adobe with a reinforced concrete frame are described; to finish with a rating of geometric and constructive culling of more optical application system based on the results type.

The numerical model are performed specifically to submit to ABAQUIS software for finite elements selected because it has the attributes necessary to understand the behavior of structures under dynamic quite similar to reality, so a calibration for adobe blocks used. (Wilson Rodriguez, 2009)

2 Objectives

2.1 General

To determine the structural behavior of comparative models adobe rigging (EC) and mixed systems of reinforced concrete filled with adobe (EC_EA_EN) using three-dimensional models and numerical optimization of stiffness variations under load conditions

2.2 Specific

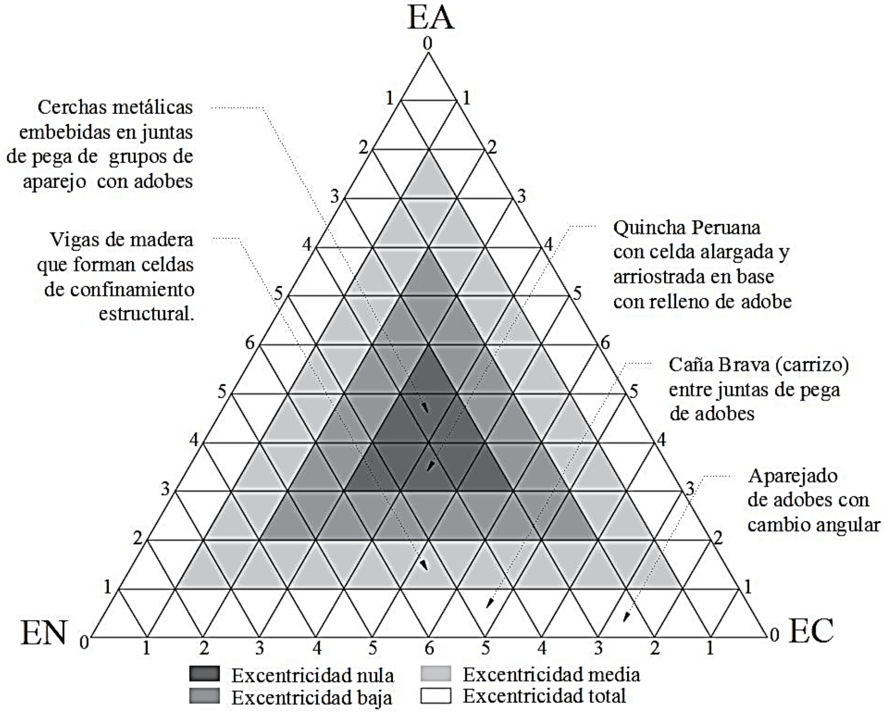
a) To describe the categories studied the types of structure for confinement, bracing and wall framing with the use of adobe
b) To design models using structural comparison confinement, bracing and lattices stabilized adobe and reinforced concrete
c) Simulation of three-dimensional models in finite element software ABAQUIS under load conditions and optimal construction specifications in the wall structure Adobe- Union

3 Hypothesis

Studying the behavior simulated in computer structural confinement systems, bracing and half in the construction of adobe walls in structural reinforced concrete frames on ideal foundations will be the basis for understanding the behavior of traditional homes on land on one level and select the system more efficient to withstand major movements produced by vertical loads and / or side.

4 Structure Types

Fig. 1.
Pyramid valuation to categorize structures in earth construction.



Interpretation: Fig.1 corresponds to the summary of the assessment of a total of eight systems, taking as its starting point a scheme of typologies (Minke, 2005) that involves rigidity, geometry, stability and energy dissipation as key factors when choosing a structural way. Thus we have:

Eccentricity structure null: When the structure has confine systems structural block confinement own adobe (EC), braced by diagonal (EA) and orthogonal lattices (EN). Possibly it is well on in-reinforced and decreases conditions of deformation or collapse.

Eccentricity structure low: Located slightly offset to 1 or 2 of the systems; this leads to think about normal behavior with one of the systems as a regulator of the others.

Eccentricity structure half: In this case the deviation is average and can host two of the three regulatory systems. Possibly the structural behavior is-better but the shape and geometry of the wall decreases plant-ing the fun of the entire envelope.

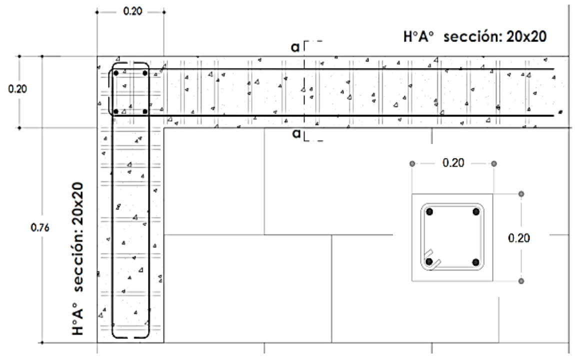
High Eccentricity structure: It is based on using particularly one of the three systems and resource factor is a favorable performance for certain charges and requests adherence design structure with adobe blocks.

5 Los Materiales

5.1 Reinforced concrete

The characterization of the models is done by adopting improved materials in a conventional structure with reinforced concrete with fc = 210 kg / cm2; a density of 2300-2400 kg / m3 and a strain at break of 370 kg / cm2. Steel reinforcement bars 12 and 14 mm circular section, with a variant in the connecting element of adobe wall with the HA will steel (rods) embedded in the column and / or on the beam, then enter on the board of the wall (See fig.)

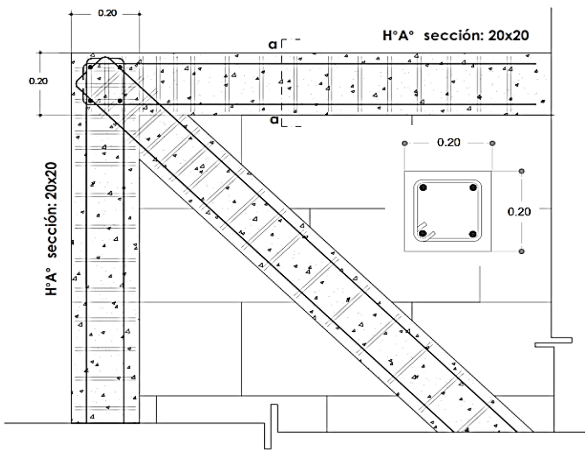
Fig. 2.
Detail of union upper beam with short column to model and joining M2A-beam column for M3A.



Short column

The connection between the diagonal brace in M4A model shown in Fig.3

Fig.3 Detail: Armed union with upper beam column and diagonal brace for model M4A.



5.2 Adobe

Adobe wall is formed by the rigged raw land units sundried (adobes), bonded with mud mortar also makes paste; They are shaped into rectangular formats and with addition of organic and inorganic elements with 38x18x8 cm dimensions, with compressive strength of 3,04 N / mm2 and 1.23 N / mm2, shear strength of 0,025 N / mm2 and units Poisson's ratio from 0.25 to 0.30 for rigging.

Tabla 1 C
Physical, chemical and mechanical Adobe (Juan Carlos Rivera, 2005)

Características Físicas*	**Unidad**	**Resultados**	**Características Químicas**	**Unidad**	**Resultados**
Humedad	%	3,3	Si	%	65,90
Contenido de materia orgánica	%	4,8	Al	%	15,88
Peso específico	Kg/m3	1770	Fe	%	4,75
pH	U	5	Ca	%	2,55
Límite de consistencia líquido	%	44	Na	%	0,57
Límite de consistencia plástico	%	25	K	%	2,83
Gravas	%	10	Mg	%	2,10
Arenas	%	18	**Características Mecánicas**	**Unidad**	**Resultados**
Finos (arcillas)	%	72	Resistencia a la compresión	MPa [N/mm^2]	3,04
			Resistencia a flexión-Módulo	MPa [N/mm^2]	0,41

* RIVERA J.C., MUÑOZ E.E., Caracterización Estructural de Materiales de Sistemas Constructivos en Tierra: El Adobe, Rev. Int. De Desastres naturales, Accidentes e Infraestructura Civil. Vol. 5 (2) 13 p.
Data taken with a sample of 17 specimens with adobes Old Chapel Tausa.

5.3 Reed (Arundo donax and Phragmites Australis)

The scientific name is Arundo donax (type of bamboo), and a second species of Phragmites Australis and is reed or reed which is preferably used in orthogonal systems mesh fabric coated with mud or known as bareque and in this case the longitudinal arrangement of the material is taken to form an inner matrix of the wall that can help stabilize for better distribution of loads with compressive strength of 14 and 18 N / mm2, modulus of elasticity: 18,400 N / mm2, resistance traction 4.18 N / mm2, shearing of 1.1. N / mm2, density 790 to 800 kg / m3 and 0.30 Poisson module.

Tabla 2 Strength and properties of materials (Rea Lozano, 2012)

	Caña Brava (Arundo dónax)	**Caña Brava (Phragmites)**	**Adobe**	**RC**
Density (Kg/m3)	790	160	1770	2300
Elasticity module (Kgf/m2)	18	18	65,0018	2,00 E+05
Young´s module	18	18	2,90E+13	2,00 E+05
Poisson ratio	0,30	0,30	0,25	0,18

REA LOZANO, Verónica, Uso de la Caña Guadua como material de construcción: Evaluación Medioambiental frente a Sistemas Constructivos Tradicionales, Universidad Politécnica de Madrid, 2012, pág. 23.

6 Models y methods using

Based on the combination of EA + EC + EN previously studied, with a geometric-based square structural and well provided for resistance to any seismic movement, is subjected to the analysis of simulation four models that have improved their rigidity structural. For the support frames and rings of confinement systems frame concrete is used in order to decrease its section to increase the filing function with the function of the filling with factories of land such as adobe and improved BTC. This includes a load approximately of covered tile and slabs of pine of 1457, 24 Kg. It begins with computer models and then three-dimensional ones are required by the software Abaqus used on students version.

6.1 M1A_EC+EN Model

It is formed by a wall of 2,98m high, 3,78m wide and a thickness of e=0, 38 with blocks of adobe type A1 which they measure 0, 38x0, 18x0, 08m. It includes two horizontal drills and parallel between joints horizontally and one spine upright between vertical joints inside of Spanish words "caña (cane) brava" (arundo donax). In the M1A model being this of a wall with adobe located bi-directionally, the software did not retain the information of more than 30 items and the wall contained a number of 2071 blocks, therefore we proceed to develop the same test using a macro model (Mersch, 2015) in which a block of adobe is taken and joint as one single element and the correspondence exists on the mortar.

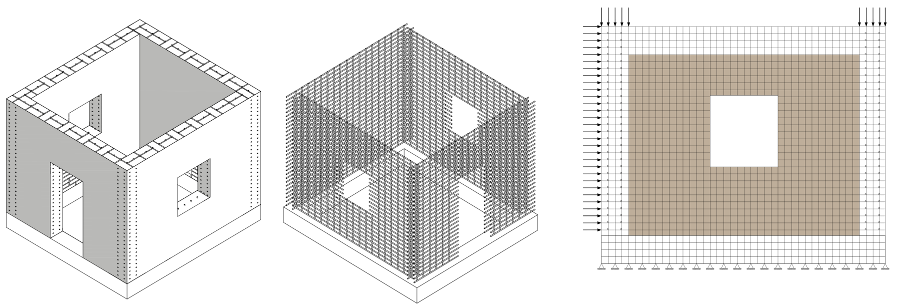


Fig.2 3D and numerical model of M1A system

6.2 M2A_EC+EA Model

Has the same measure of M1A, but with adobes in rig supported by a liner edge base (chain) “teeth” on the corners the same that is lined up with the adobe corner; and the same provision is created in the superior part of a beam with the “teeth” downwards. In the union of the corner we’ll find a vertical bar ¼ length at each end of the total height- 0,76m.

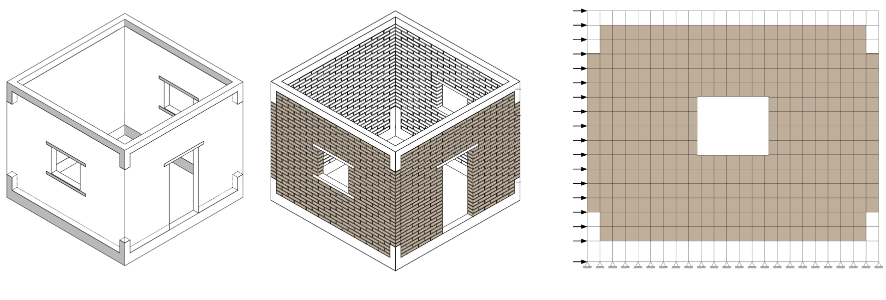


Fig. 3. 3D and numerical model of M2A system

6.3 M3A_EC+EN Model

Has the same measure of M1A, but now we take in account an octagonal frame with partitions between 0, 70 and 1,00m which contain adobe type A1. The section of grid elements are H☐A☐ from section= 0,07m.

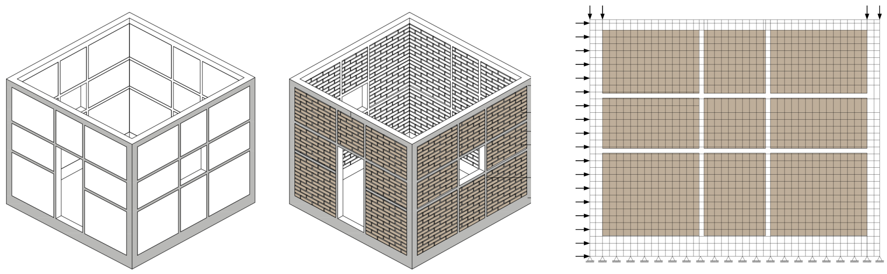


Fig. 4. 3D and numerical model of M3A system

6.4 Modelo M4A_EC+EA

Has the same measure of M1A, a bracing with diagonal elements of 0,08 a section, with beams and chains of RC= 0,20m; plus a lintel of compressive strength in the vain formed. The adobes are type A1 with cuts and increases of mortar by trapezoidal geometry. The corners have unions of rods with 0,76m.

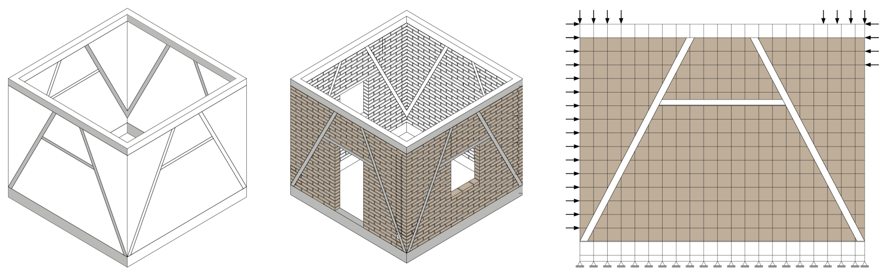


Fig. 5. 3D and numerical model of M4A system

7 Results

The graphic shows the area where the lateral load was applied (dark) which transmit efforts to contiguous blocks by pressing it together, but when this two meet with "caña brava" they manage to keep their position; apparently in this case the horizontal canes/cañas they seem dispensable to provide a new study to verify their inclusion in the mesh. (Fig.6).

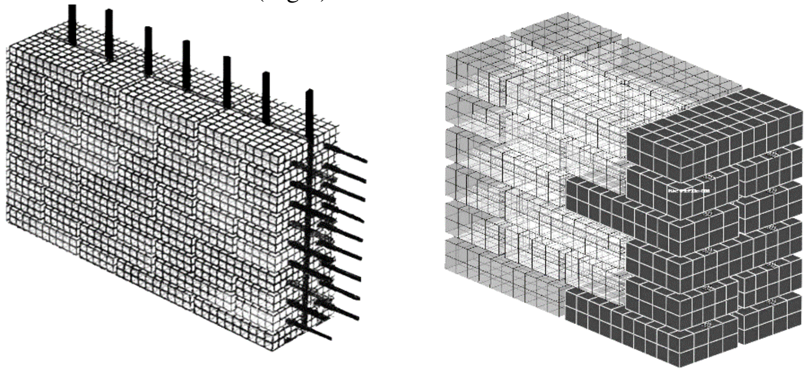


Fig.6 Position of the reed into the low wall of adobe adobe + rig

The M2A model the <“teeth”> are fundamental in the upper box in order to keep the geometry of the space and discover that the action is to distribute the load evenly in the superior part of the adobe walls, and also stops them from overfalling. The initial mesh was irregular to finding openings, but it was orthogonally calibrated. The model lacks of “teeth” this causes for the data to be inaccurate.(Fig.7)

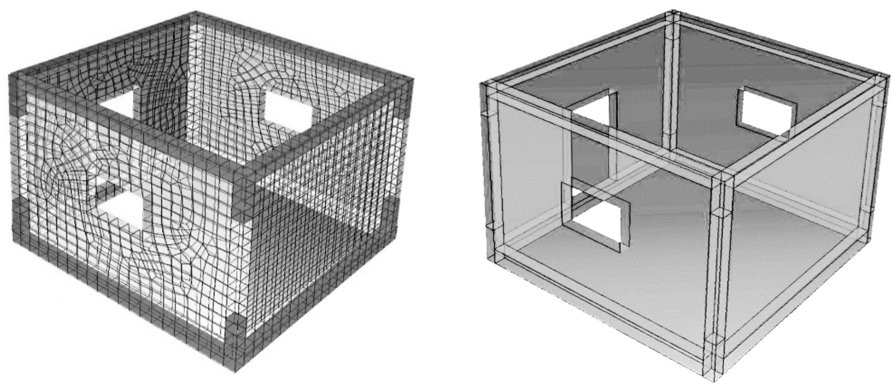


Fig. 7 Colouring partition wall Lattice adobe + RC

The M3A model shows the action of a whole network reinforce of concrete structure with filled in factory land, the program that uploads them on the upper and lateral loads are cancelled and this progressively decreases efficiently, although vulnerable sectors such as small walls on the lintels of openings is anticipated. (Fig8)

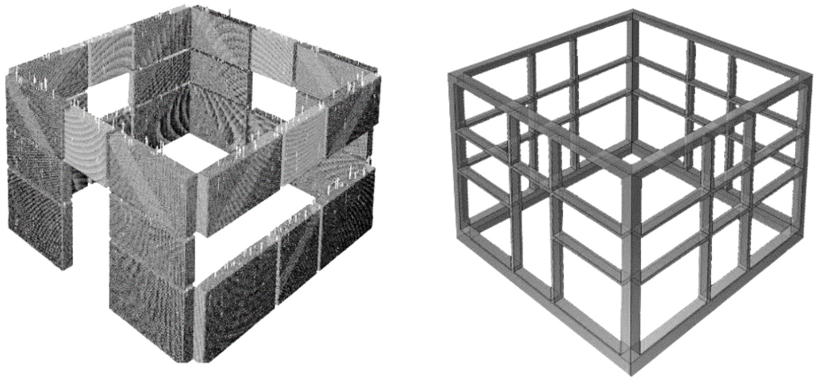


Fig. 8 Union of the upper and lower rings RC with adobe wall force vectors additional.

The M4A beam length and the level of chain vulnerability or NODE SURFACE just at the junctions of the diagonals with the lower corners and in the upper third of the beam. The trapezoidal mesh is determined so as it is a real way of perceiving the distribution of loads on a rig filled with conventional adobe (Fig.9)

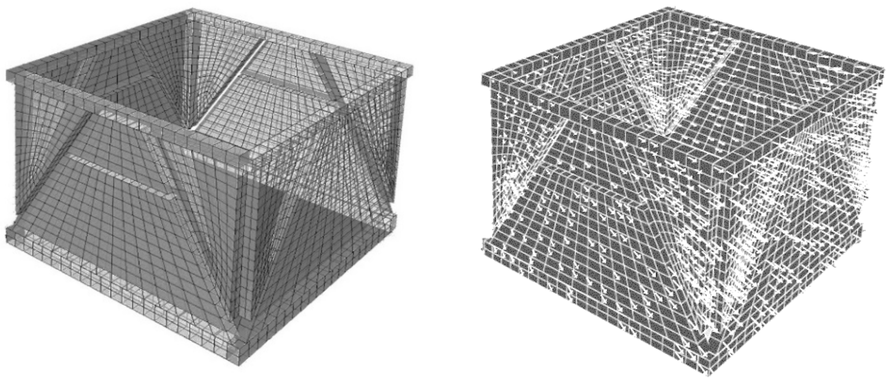


Fig. 9 The mesh junction points towards force vector.

7 Conclusion

The adobe wall contributed like as a support material once it is integrated into the material confinement or bracing, this allows us to inquire on the mixed systems or to improve the basic geometries of seism resistance as part of the structural design with the construction of land.

The data shown belong to the force vectors of resistance and resulting moments from vertical and side loads applied in each model.
The model which showed a higher resistance to loads covered (1,7 ton) as loads additional per floor was (35,0 ton) is M2A with jagged perimeter rings at the corners with steel reinforcements embedded in the wall of adobe and in the bidirectional frame from the M3A model which is very conventional.

8 References

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Acknowledgments

The authors are very thankful to the Polytechnic University of Madrid, Laboratory of Civil Engineering from “Universidad Tecnica Particular de Loja” and Dassault Systems for Abaqus Program (Student’s version).