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Standard Guide for Design of Earthen Wall Building Systems¹

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1. Scope

1.1 This standard provides guidance for earthen building systems, also called earthen construction, and addresses both technical requirements and considerations for sustainable development. Earthen building systems include adobe, rammed earth, cob, cast earth, and other earthen building technologies used as structural and non-structural wall systems.

NOTE 1—Other earthen building systems not specifically described in these guidelines, as well as domed, vaulted, and arched earthen structures as are common in many areas, can also make use of these guidelines when consistent with successful local building traditions or engineering judgment.

1.1.1 There are many decisions in the design and construction of a building that can contribute to the maintenance of ecosystem components and functions for future generations. One such decision is the selection of products for use in the building. This guide addresses sustainability issues related to the use of earthen wall building systems.

1.1.2 The considerations for sustainable development relative to earthen wall building systems are categorized as follows: materials (product feedstock), manufacturing process, operational performance (product installed), and indoor environmental quality (IEQ).

1.1.3 The technical requirements for earthen building systems are categorized as follows: design criteria, structural and non-structural systems, and structural and non-structural components.

1.2 Provisions of this guide do not apply to materials and products used in architectural cast stone (see Specification C1364).

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

¹ This guide is under the jurisdiction of ASTM Committee E60 on Sustainability and is the direct responsibility of Subcommittee E60.01 on Buildings and Construction.

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1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

C1364 Specification for Architectural Cast Stone
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
E631 Terminology of Building Constructions
E2114 Terminology for Sustainability

2.2 ASCE Standards:³

ANSI/ASCE 7 Minimum Design Loads for Buildings and Other Structures

2.3 New Zealand Standards:⁴

NZS 4297:1998 Engineering Design of Earth Buildings, 1998
NZS 4298:1998 Materials and Workmanship for Earth Buildings, 1998
NZS 4299:1998 New Zealand Standard, Earth Buildings not requiring Specific Design, 1998 (including amendment #1, December 1999)

3. Terminology

3.1 Definitions:

3.1.1 For terms related to building construction, refer to Terminology E631.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, <http://www.asce.org>.

⁴ Available from Standards New Zealand, Ministry of Business, Innovation & Employment, 15 Stout Street, Wellington 6011, <http://www.standards.govt.nz>.



3.1.2 For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114. Some of these terms are reprinted here for ease of use.

3.1.3 *alternative agricultural products, n*—bio-based industrial products (non-food, non-feed) manufactured from agricultural materials and animal by-products.

3.1.4 *ecosystem, n*—a community of biological organisms and their physical environment, functioning together as an interdependent unit within a defined area.

3.1.4.1 *Discussion*—For the purposes of this definition, humans, animals, plants, and microorganisms are individually all considered biological organisms.

3.1.5 *embodied energy, n*—the energy used through the life cycle of a material or product to extract, refine, process, fabricate, transport, install, commission, utilize, maintain, remove, and ultimately recycle or dispose of the substances comprising the item.

3.1.5.1 *Discussion*—The total energy which a product may be said to “contain” including all energy used in, inter alia, growing, extracting, transporting and manufacturing. The embodied energy of a structure or system includes the embodied energy of its components plus the energy used in construction.

3.1.6 *indoor environmental quality, IEQ, n*—the condition or state of the indoor environment.

3.1.6.1 *Discussion*—Aspects of IEQ include but are not limited to characteristics of the thermal, air, luminous and acoustic environment. Primary areas of concern in considering the IEQ usually relate to the health, comfort and productivity of the occupants within the indoor environment, but may also relate to potential damage to property, such as sensitive equipment or artifacts.

3.1.7 *renewable resource, n*—a resource that is grown, naturally replenished, or cleansed, at a rate which exceeds depletion of the usable supply of that resource.

3.1.7.1 *Discussion*—A renewable resource can be exhausted if improperly managed. However, a renewable resource can last indefinitely with proper stewardship. Examples include: trees in forests, grasses in grasslands, and fertile soil.

3.1.8 *sustainability, n*—the maintenance of ecosystem components and functions for future generations.

3.1.9 *sustainable development, n*—development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *adobe, n*—(1) (*building product*), unfired masonry units made of soil, water, and sometimes straw or other admixtures;

(2) (*product feedstock*), the soil/straw/admixtures mix that is used to make *adobe* (1), (here also called *earthen building mixtures* or *earthen material*);

(3) (*building product*), the earth plaster used for covering walls or ceilings, or both;

(4) (*structure*), the building that is built of *adobe* (1), (3); and

(5) (*building design*), an architectural style of earthen construction (see also 3.2.9).

3.2.1.1 *Discussion*—The word itself comes from an Arabic

word *atob*, which means muck or sticky glob or *atubah* “the brick.” In many other countries, the word “adobe” is meaningless, and it is more accurate to say “earthen-brick.” “Adobe architecture” also has different meanings in different places.

3.2.2 *asphalt emulsion, n*—a thick liquid made by combining by-products of crude oil distillation with water and proprietary surfactants.

3.2.3 *cast earth, n*—a construction system utilizing a slurry containing soil plus a chemical binder such as portland cement or calcined gypsum and water, which is sprayed against or poured into forms similar to those used for cast-in-place concrete; also called *poured earth*.

3.2.3.1 *Discussion*—In the sprayed system, modern shotcrete equipment is adapted to spray the wet earth mixture, which is usually stabilized earth.

3.2.4 *clay, n*—inorganic soil with particle sizes less than 0.002 mm [0.00008 in.] having the characteristics of high to very high dry strength and medium to high plasticity.

3.2.4.1 *Discussion*—This size definition for clay, along with those for silt, sand and gravel, is according to Practice D2487. Other standards in the world have slightly different size limitations.

3.2.5 *cob, n*—a construction system utilizing moist earthen material stacked without formwork and lightly tamped into place to form monolithic walls.

3.2.5.1 *Discussion*—Reinforcing is often provided with organic fibrous materials such as straw.

3.2.6 *earth, n*—granular material derived from rock, usually with air voids and often with organic content (humus) (also called *soil*).

3.2.7 *earth, stabilized, n*—earthen building mixtures to which admixtures are added during the manufacturing process to help limit water absorption, stabilize volume, increase strength, and increase durability (see also *stabilization*).

3.2.8 *earth, unstabilized, n*—earthen building mixtures that do not contain admixtures intended to help limit water absorption, stabilize volume, increase strength, and increase durability (see also *stabilization*).

3.2.9 *earthen construction, n*—construction in which walls and partitions are comprised primarily of earth.

3.2.9.1 *Discussion*—Roofs and other framing may be wholly or partly of wood or other materials. Common earthen construction systems go by many names, which sometimes connote minor variations. Some of those names are:

adobe, or mud brick, earthen brick, banco, butabu, brique de terre
cast earth, or poured earth, earthcrete, sprayed earth
cob, or zabur, puddled mud, puddled earth
extruded earth block
pressed brick, or compressed earth brick/block (CEB)
rammed earth, or pisé, tapial
sod, or turf, fale and divet
tire houses, also earth bags, earth tubes
wattle and daub, or quincha, jacal, barjareque, nyumba yo mata

3.2.10 *energy efficient, adj*—refers to a product that requires less energy to manufacture or uses less energy when operating in comparison with a benchmark for energy use, or both.