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RESEARCH ARTICLE

Acoustic of monolithic dome structures

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Abstract
Monolithic dome structures were built in the 1970s in Europe and America. These dome structures share common benefits of being cost-efficient, earth-friendly, extremely durable, and easily maintained. Monolithic shells are easily constructed and are extremely cost-effective. Monolithic domes respond efficiently to any climate, even to extremely cold or hot temperatures. In terms of utility savings, monolithic domes can cut electricity consumption by up to one-third, thereby saving 60–70% of total energy costs. Moreover, monolithic structures provide the highest survivability rates from destructions.
The interior of monolithic domes have perfect, concave shapes to ensure that sound travels through the dome and perfectly collected at different vocal points. These dome structures are utilized for domestic use because the scale allows the focal points to be positioned across daily life activities, thereby affecting the sonic comfort of the internal space. This study examines the various acoustic treatments and parametric configurations of monolithic dome sizes. A geometric relationship of acoustic treatment and dome radius is established to provide architects guidelines on the correct selection of absorption needed to maintain the acoustic comfort of these special spaces.

1. Introduction

Monolithic dome structures are enclosed by smooth concave surfaces built in one block. These structures are unsuitable for communication, presentation of speeches, and musical performances. Smooth concave surfaces purely reflect sound energy and do not diffuse this energy properly in space. In most cases, these structures will create focal points and dead spots with different geometrical configurations. Previous work outlined practical guidelines for the proper acoustic design of circular rooms and domes (Vercammen, 2012; Kuttruff, 2000; Cremer, 1982; Satoshi Inoue, 2009; Imaizumi, 1997), but the general application of common rules to different scales and uses cannot be easily achieved. a recent study (Dagmar REINHARDT, 2013)

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outlined remedial actions of sound by focusing on structural deflections of the original concave geometry of domes; however, this approach has limitations because of the structural construction process of monolithic domes.

Acoustical behavior cannot be easily standardized because of variation in the size, shape, and volume of concave domes. Therefore, correct treatments of internal surfaces should be applied to prevent the occurrence of unusual phenomenon in the room and assess remedial strategies against such phenomenon through an accurate acoustic assessment of space handling.

Monolithic dome structures are constructed for residential spaces. The acoustic phenomena arising from concave shapes will interfere with human activities because the focal points of acoustic energy have the same levels of occupancy. This study examines the acoustic behavior of residential monolithic dome structures and aims to standardize acoustic treatment strategies related to dome size. Acoustic examination is based on parametric analysis of the acoustic and geometric factors related to subjective evaluation. This study presents the results of acoustic evaluation to improve sound fields through the use of certain parameters.

2. Monolithic domes

A monolithic structure is a structure that is carved or cast from one piece to form a homogeneous structure. The term monolithic stems from "*monolith,*" which means a large piece of stone used to erect a structure or monument. The earliest forms of monolithic structures are integrals of a building unit. These domes were first constructed in Asia Minor through masonry in 4000 B.C. by cantilevering of stones. The igloo (Hall, 1865) is also an example of this structure, which was formed of compressed snow bricks melted together to form a homogeneous dome structure (Figs. 1-3).

Fig. 4 shows an image of a current monolithic structure, which is lightweight cast in a one piece and can be opened

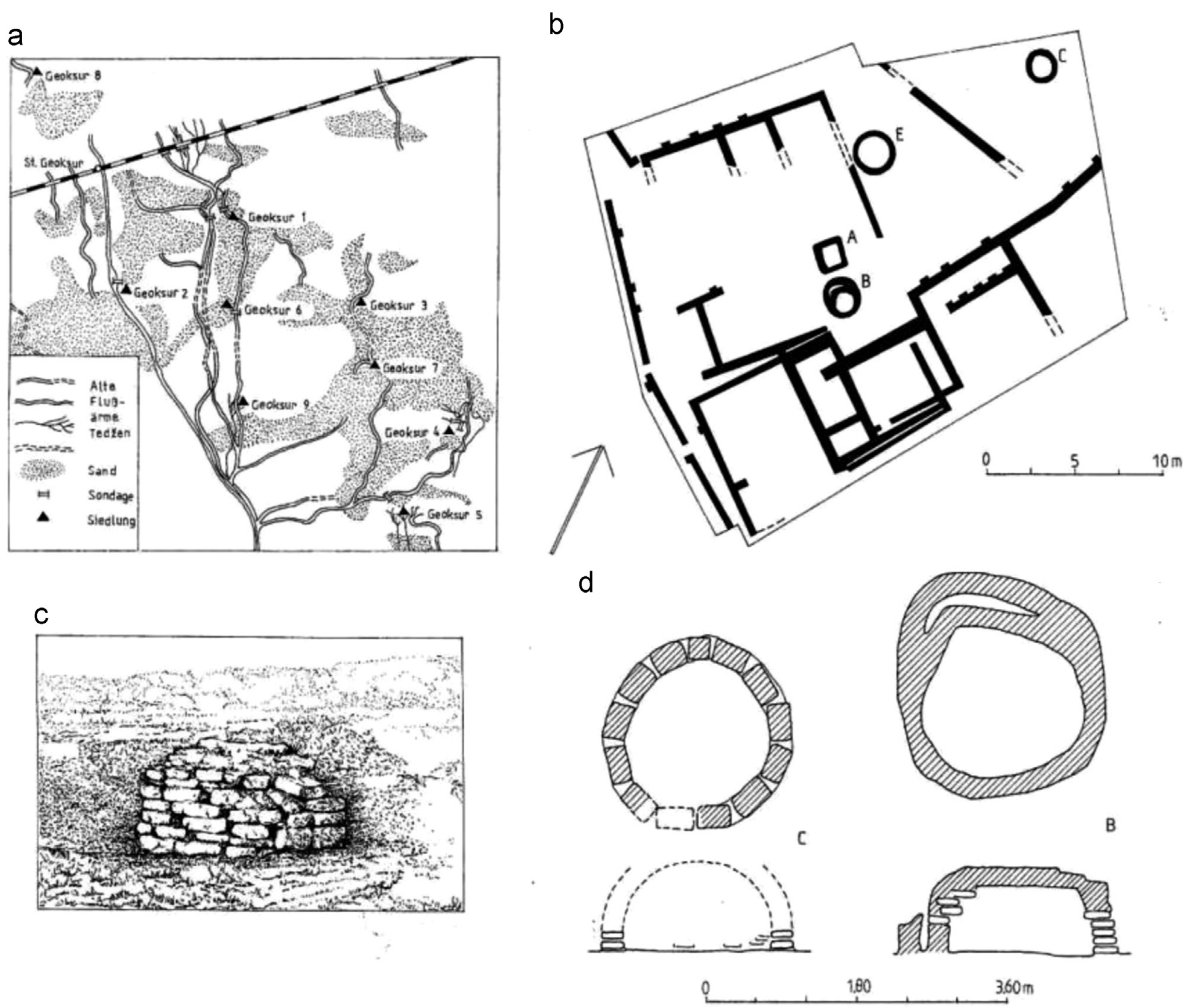

Fig. 1 Domes covering an oval plan in Asia Minor (Huerta, 2007).