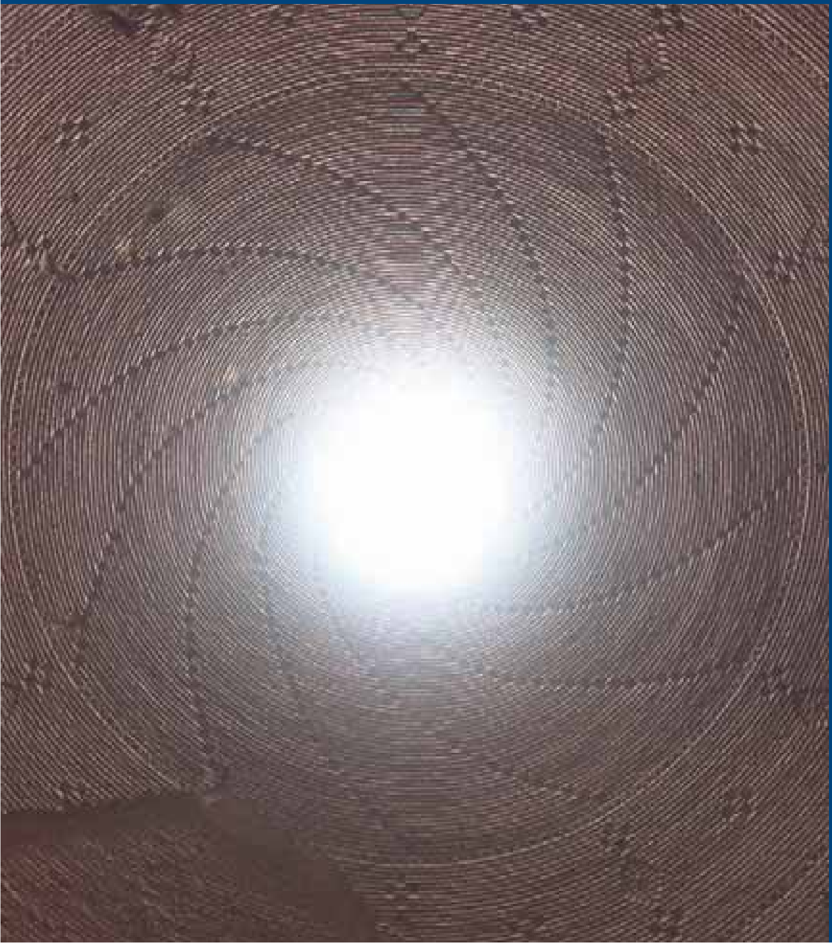
EARTH MASONRY

Design and construction guidelines

Tom Morton

Foreword by Rab Bennetts



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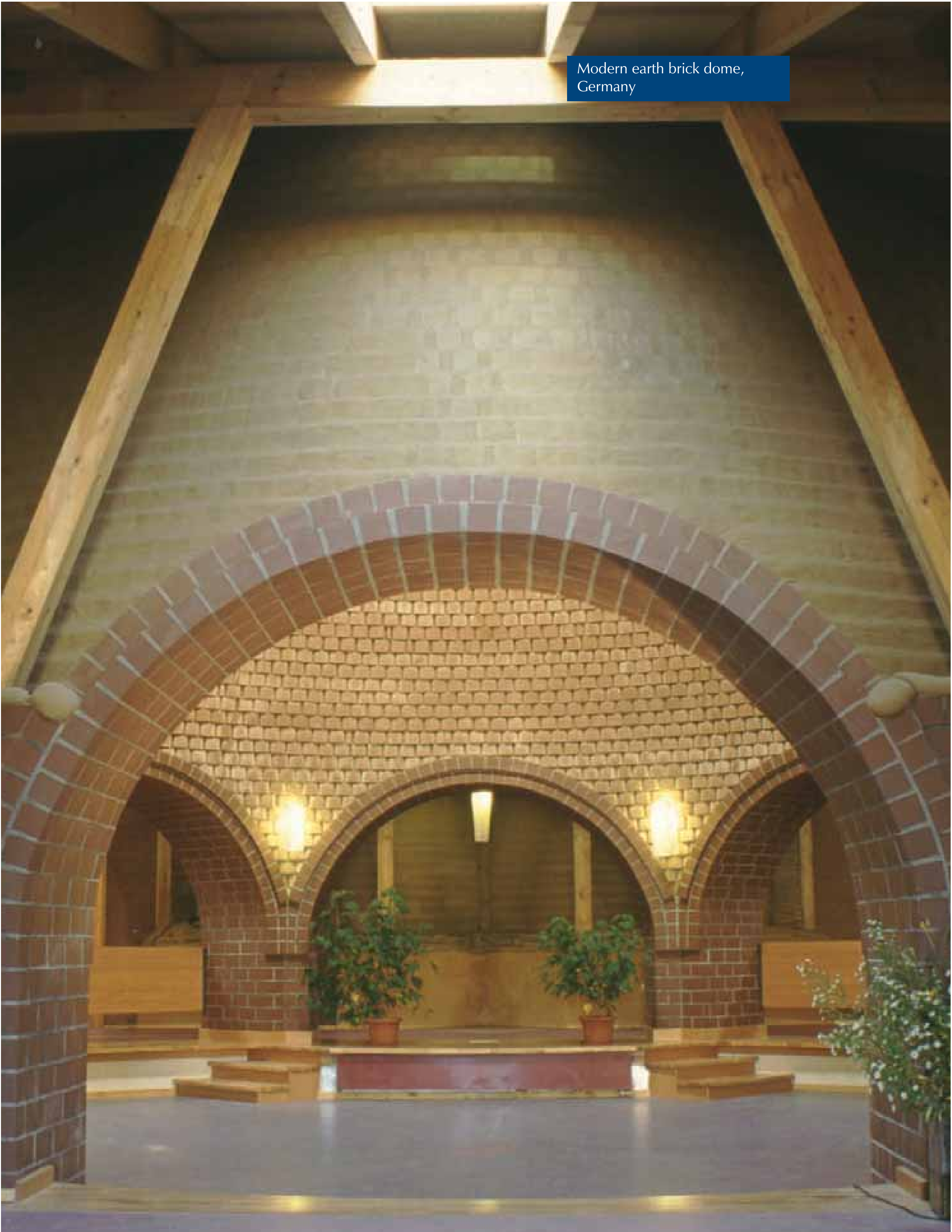

Modern earth brick dome, Germany

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FOREWORD

Rab Bennetts
Bennetts Associates

With public opinion finally endorsing the need for higher levels of sustainability, this book is a timely reminder that some all-but-forgotten forms of construction offer a signpost to the way ahead.

Earth masonry – unfired bricks, adobes and cob blocks that are free from cement additives – is one of those ancient technologies that all but died out in western society, but has remained alive and well in parts of the world untouched by industrialisation and conventional measures of prosperity. Now that the search is on for building techniques and materials that have far less impact on the environment than the bricks and blocks of modern construction, earth masonry has once again emerged as a sound and practical alternative.

Like rammed earth, recycled materials or planted roofs, earth masonry is not alone in being 'rediscovered' but the post-war dominance of products that rely on energy-intensive, relatively cheap manufacture means that our ability to use these low impact methods is hampered by a simple loss of traditional knowledge or the instinct required to avoid routine failures of performance. Even natural ventilation and passive solar control for larger buildings now have to be proven by computer analysis to gain acceptance in our risk-averse markets, because centuries of intuitive understanding has virtually disappeared.

The primary purpose of this book, then, is to fill in the considerable gaps in our understanding of earth masonry, with a factual account of issues such as density, moisture control, strength and construction details. But there is a secondary role for this book, which is to explore the cultural background to earth masonry, with a refreshing enthusiasm for the subject born of conviction for its potential, even for sizeable projects. The key to unlocking this potential is to think in local terms – the available raw materials, the labour force, the means of manufacture, distribution and of course the climate. As with much else in the search for sustainability, globalisation of the construction industry is being questioned as never before, not simply for its harmful environmental effects but also for its tendency to steamroller construction cultures across the world into uniformity. Earth masonry represents part of the fightback towards a more responsive, environmentally benign approach.

The Earth Store, The Genesis Project , Somerset College of Arts and Technology

PREFACE

Earth masonry is the one of the oldest and most widespread forms of construction. Even today a third of the human race is housed in earthen structures and these are most commonly built of earth brick.

Although technologically simple, earth masonry has the potential to produce a durable architecture of considerable artistic sophistication, and buildings that are appropriate to their climate and a wide range of uses. This is true in both vernacular and 'modern' contexts.

The development of earth building as a contemporary technique within industrialised construction over the last 20 years has demonstrated its potential to create healthy buildings at low environmental cost. Humidity control, low embodied carbon and near zero waste are key characteristics in the context of the development of a sustainable construction industry. In the UK, the use of earth masonry to form internal partitions is the key application to build a commercial market. But this is an unfamiliar material and in order to make a successful transition from a vernacular to an industrialised material, there is a need for guidance for those involved at all stages of the procurement, construction and use of buildings.

That is the purpose of this book, which follows a successful three-year Partners in Innovation (PII) project, Low Cost Earth Brick Construction: Monitoring and Evaluation, funded by the former UK Department of Trade and Industry (now the Department for Business Enterprise and Regulatory Reform).

Echoing comparable developments in other countries in recent years, the commercial potential of modern earth masonry has been recognised by the UK fired brick industry, whose future is increasingly uncertain as the cost of producing ceramic products rises along with the price of gas and growing concern for the environment. The potential of this well-established manufacturing sector to bring good quality, new unfired clay products quickly to a mass market signals that the future of earth masonry could be as important to global construction as it was in its past.

Globally, construction is changing in several important and competing ways. As vernacular materials are rapidly displaced by industrialised materials in the developing markets of China and India, it is increasingly clear that the world does not have the natural resources, energy or ability to absorb pollution that is needed to house the world in the steel and concrete which gave modern architecture its image of progress during the 20th century. In our era, a new generation of materials is being developed that can meet people's aspirations for physical development in a way that sustains and enhances the natural world which gave us life.

Unfired clay – a timeless construction material – has an important technical role to play in this exciting new phase in the development of architectural technology. What will be achieved over the next 25 years is unclear at this early stage, but what is certain is that the image of progress that architecture often bears will change alongside its technology, heralding the wider and essential role that architecture has always had in our cultural life.

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SCOPE AND STRUCTURE

These guidelines are intended to facilitate the use of earth masonry in common contemporary construction situations. They provide the necessary basic technical information needed by architects and engineers who do not have specialist knowledge of earth construction. Equally, they can act as a handbook for the self-builder or contractor.

In a field where there is a wide variety of materials and buildings, the guidance can only ever be general. Each material and design situation needs to be considered in its own right, and more specific expert guidance should be sought if the user is in doubt.

There is a range of possible sources of further advice. Manufacturers and distributors of proprietary materials should be able to advise on appropriate use of their products. There is also a loosely knit community of earth building experts in the UK, including architects, builders, engineers and surveyors. A list of useful contacts is given towards the end of the book. In addition, the references and further reading provide a list of relevant publications dealing with earth construction, including books giving a more detailed examination of some of the more technical aspects.

This book is written primarily from a UK perspective, though it is intended to be generally relevant in all countries. Comments on climate primarily relate to temperate climates, where rainfall and frost can be significant. It does not consider seismic design, which is outwith the experience of the author and which is described in other publications.

The book specifically addresses issues relating to the use of earth masonry in common commercial construction situations by non-expert professionals using proprietary materials, although it is also relevant to other forms of procurement and types of materials.

The book focuses on new-build applications, although earth masonry is sometimes used in conservation, especially of vernacular cob buildings. This is a specialist field, for which guidance is given in other publications.

This book does not describe in detail vernacular construction using earth masonry materials, such as cob block and clay lump. The guidance will be generally relevant to these uses, but such projects tend to follow well-established traditional conventions of construction, which do not require the same design process as non-specialist commercial new-build projects. Guidance on these traditional techniques can be sought from local earth building organisations.

This book does not include any detailed consideration of 'stabilised' earth materials. These have additives, such as cement or bitumen, which fundamentally alter the earth materials physical properties. Cement-stabilised earth bricks, for example, are better considered as weak concrete blocks. Such materials can have appropriate uses in earth masonry buildings, such as for a 'flood-proof' base course. Although often 'stronger' than unstabilised earth masonry, such stabilised materials do not possess the other, subtler, benefits of earth masonry. They are also adequately described in other publications, some of which are listed in the references and further reading.

The guidelines are structured to follow a typical project process where earth masonry will be used, identifying and assessing the issues relevant to each stage.

By its nature, this book gives a limited and simplified picture of a diverse subject into which there is much current research. The author welcomes any suggestions of corrections, omissions, comments or more interesting examples in the fascinating field of earth masonry.

GLOSSARY

Internationally, earth masonry techniques vary enormously according to climate, soil conditions, building typology, and traditional and modern construction practices. This rich diversity is an important resource in the wider context of design and has an equally rich and diverse descriptive language. For the purposes of this book, definitions are used that are most clear and relevant to the UK context.

Additives: Substances that are added to a base earth material to improve certain properties. These include benign additives, such as fibres and plant oils, as well as more powerful stabilisers such as cement.

Adobe: A term for wet moulded earth block used widely, especially in the Americas, of Spanish origin. The term is used to describe both the individual blocks, the wet material and the buildings from which they are made.

Brick: A small masonry unit, liftable with one hand.

Block: A large masonry unit, liftable with two hands.

Clay: The term 'clay' refers to a naturally occurring material composed primarily of fine-grained minerals, which is generally plastic at appropriate water contents and will harden when dried or fired. Although clay usually contains phyllosilicates, it may contain other materials that impart plasticity and harden when dried or fired (Reeves, et al, 2006). The term is commonly used to describe both the natural earth material of which clay minerals are usually only a minor constituent and the clay minerals constituent, which can either be defined by true mineralogy, or, more commonly in earth construction, by size grading (as described in Section 3.1.1).

Cob alt. clomn (Wales), mudwall (Scotland): A form of earth construction where wet clay earth is mixed with straw and built in consecutive layers to form a monolithic wall.

Dusting: Unbound fine clay material, lying on a surface.

Earth: Soil that can be built with, that is, soil without organic content, generally subsoil with some clay content.

Earth building: Constructional techniques utilising earth, usually sub-soil in combination with other natural materials.

Earth materials: Construction materials whose main ingredient is unfired earth. The material will degrade to mud when immersed in water.

Embodied energy: The total amount of energy used in bringing the material to its present state and location. It may also be thought of as the energy that could have been saved, had the product never been manufactured.

Environmental footprint: A catch-all term describing overall environmental impact.

Expansive: Materials that will swell significantly with uptake of water. In earth masonry, this includes clay minerals and organic fibres. There is great variation in the expansive activity of clay minerals.

Green brick: An unfired clay brick, specifically one whose composition is comparable to that of fired bricks, rather than being specially designed as an unfired product, which would be termed an earth brick.

Hygroscopic: The ability to absorb and release moisture from the surrounding environment.

Life cycle analysis: A method of assessing the total environmental impacts associated with a product's manufacture, use and disposal.

Moisture content: Water content expressed as a percentage of the mass of dry materials.

Moisture mass: The capacity of a material to store moisture in response to the surrounding environmental conditions.

Mud: Earth in liquid form.

Rammed earth: A form of earth construction where layers of earth are compacted, by hand or machine, to form a monolithic wall, in a process akin to making weak sedimentary rock.

Stabilisation: The process of binding together particles through the action of material other than clay, typically by the use a chemical binder, such as cement or lime. These can increase a materials durability and strength, but greatly increase embodied energy, waste and life cycle cost.

Standards: For the purpose of this book, standards are taken to mean documents giving authoritative guidance on the nature and suitable use of materials, such as those produced by bodies such as the British Standards Institution, as well as recognised codes of practice, specifications, etc. The 'Technical Standards', which are a specific part of the Building Control system, are always referred to as Technical Standards.

Subsoil: Soil that occurs below the organic horizon (topsoil) and above bedrock.

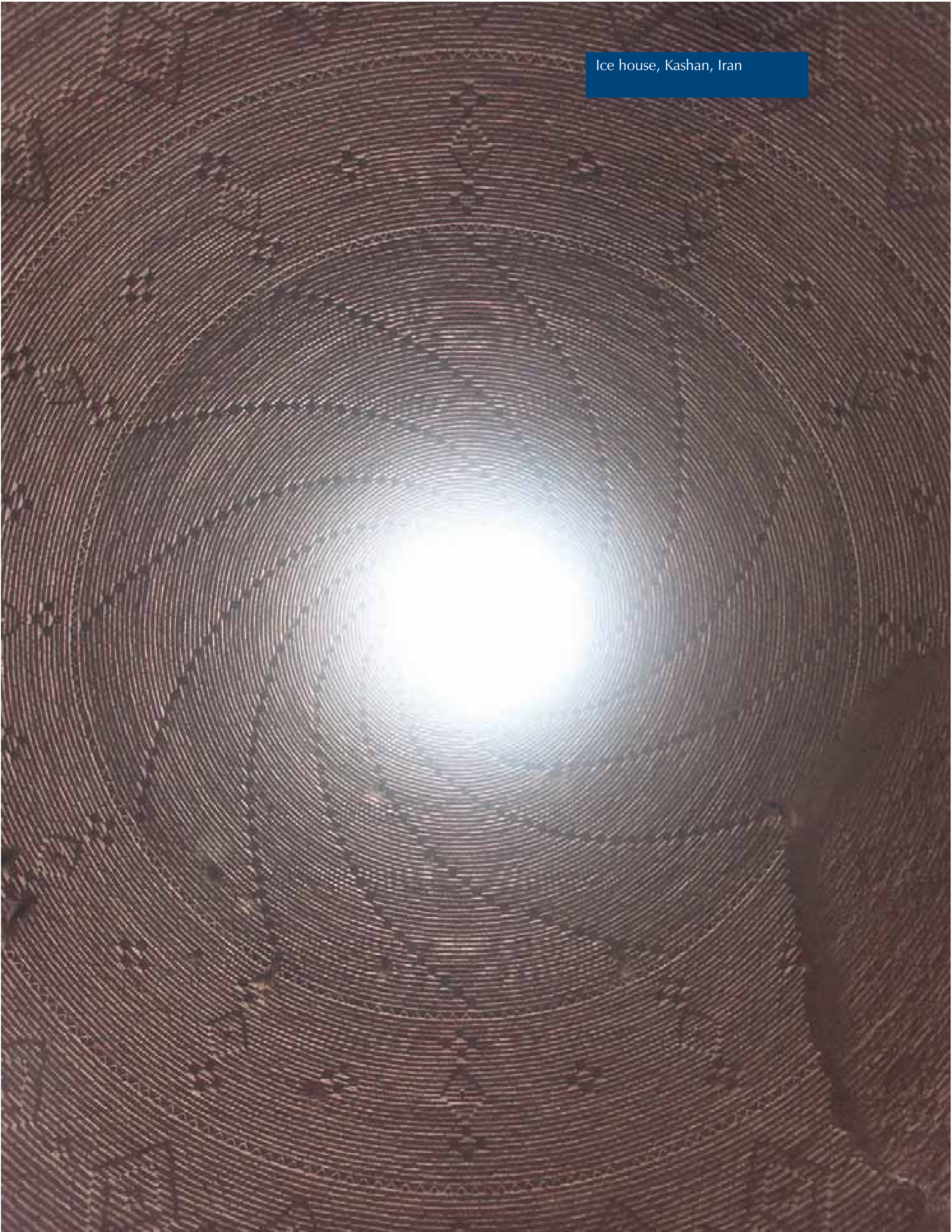
Sustainability: The concept of managing the use of natural resources such that the amount of the resource is not irretrievably depleted. Economic development taking place in this way is termed 'sustainable development', and has been defined as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. (The Brundtland Commission, United Nations, 1983).

Thermal mass: The capacity of a material to store heat in response to the surrounding environmental conditions.

Waste: Waste is defined in the Control of Pollution Act (1974) as including: (a) Any substance which constitutes a scrap metal or an effluent or other unwanted surplus substance arising from the application of any process; (b) Any substance or article, which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled.

Contemporary earth house, Germany

Bedroom, Mains of Branshogle, Stirlingshire



Ice house, Kashan, Iran

1 INTRODUCTION

This chapter defines earth masonry, describing its principal attractions as a contemporary construction material, giving an outline of its extensive history and indicating its practical limitations.

1.1 WHAT IS EARTH MASONRY?

- ***Earth***: a stable, dense, non-volatile inorganic substance found in the ground (The New Oxford Dictionary of English, 1998)
- ***Masonry***: the art of shaping, arranging and uniting stone, brick, building blocks, etc, to form walls and other parts of a building (Dictionary of Architecture & Construction, 1975).

Earth masonry is building with bricks of unfired earth, which are held together in a stable form, primarily by their clay content. The bricks are generally bonded together with a mortar that is usually also made from earth.

Earth masonry can form whole buildings or individual building elements, most commonly walls and vaults. It can also be used as infill to timber frames and in a variety of other less common applications. A diverse range of additives can be added to the earth to modify the brick's physical properties. Similarly, additives can be included in earth mortars, although other types of mortar can also be used and it is even possible to build without mortar at all.

For simplicity, the term earth brick is generally used in this book to cover masonry units of various geometries and materials, including ones commonly called earth blocks, adobes or mud bricks.

1.2 WHY USE EARTH MASONRY?

There are many good reasons to use earth masonry. The main ones are environmental sustainability, occupant health, building quality and cultural continuity. This section assesses these reasons in principle. How they could drive the development of a significant commercial market in the UK is outlined in section 7.1.