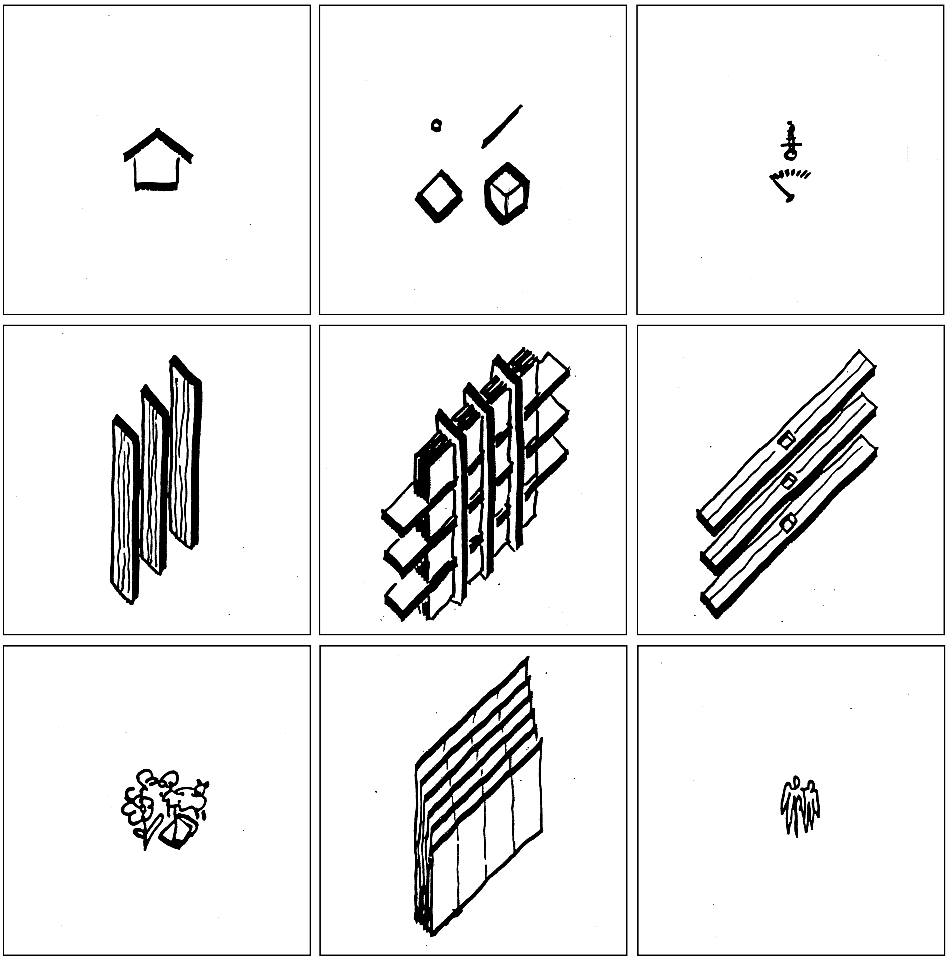
Part B
GUIDELINES



B1 MATERIALS AND ENERGY

Underlying issues

Matter and energy are two different expressions or manifestations of the same phenomenon. We cannot undertake building activity without using energy or material, and so we start with these two conditional factors (Fig. B1.1). We can also observe that material and energy are to a certain extent exchangeable in a building context, so that we have the concept of energy flow. In an environmental context we must make responsible decisions in relation to the materials and energy used throughout the entire life cycle of the building. It follows that we should recognise, respect and use materials and energy within an environmentally ethical framework. But finding guidance in this area is not particularly easy. We are awash with information related to sustainable construction, yet very little of this information

Fig. B1.1 Materials and energy pictogram. There are only a few main categories of building materials, deriving from (1) plants, (2) animals and (3) minerals, while energy can be seen as coming from (1) living beings, (2) fossil fuel, and, most important, (3) the sun – directly or indirectly.

will allow us to gain the specific knowledge we require. Take for example the challenge of adopting a whole-life approach, an area in which the theory is developing, but on a practical level it is very difficult to get the information about the environmental credentials of all materials and their related energy usage. So where do we start?

Not too long ago the choice of building materials was limited by the physical proximity of the site in relation to the materials and the availability of resources to work the raw materials. Processes tended to be very labour intensive and a lot of energy was required for acquiring and processing the material into a form suitable for building. Relative to their value, materials were expensive to transport long distances, and so choice was limited to local materials for the majority of the building stock, the exception being prestigious buildings. There was a certain economic, even ecological force at work simply through austerity. For many parts of the world this has changed. Now we can, and do, apply materials sourced from all over the globe, often at a cheaper capital cost than the materials available locally. The choice of raw materials and processed materials in the form of building products, components and systems is extensive. The 'cost' of this extended choice is to the environment in terms of pollution and in the worst cases the exploitation of people and societies through unethical practices. We should point out that we are not arguing for a Luddite approach to construction technology, rather we are trying to raise the specifier's awareness of the cost and consequences of the choices made.

A similar argument can be put for energy. In the majority of industrialised countries energy is cheap and there is little incentive to engage in energy-saving measures; instead we tend to rely on building codes and regulations to force us into designing and constructing buildings that have a more positive relationship to their immediate surroundings and exhibit positive rather than negative energy flows. From an environmental perspective building activity is expensive in terms of the energy consumed, but compared with the energy consumption of a building over its life this accounts for only 10–20% of all the energy consumed. Until we have moved to renewable energy sources our focus must be directed to minimising (or even eliminating) the use of energy from finite sources within our buildings. This is achievable in our new buildings, but it poses a considerable challenge for our existing building stock, which needs to be upgraded both in terms of the building envelope and the services within. We may need to implement more austere conditions with regard to the use of finite materials and finite energy sources.

Guidelines

It is useful to have a simple framework in which to work. Here we provide a very simple classification that may help to start us thinking about some of the fundamental issues from an ecological perspective (see material choice matrix, Fig. B1.4).

The main categories of building materials may be listed, starting with the most renewable materials and ending with the finite:

- plants;
- animals;
- minerals, including metals;
- mixed materials or composites.

We can also arrange materials in terms of the level of processing they experience, starting with the most natural and moving towards the most processed:

- materials that can be applied in their natural state, without or with very little processing;
- materials that are the product of handicraft and light industrial processes;
- materials that are the product of heavy industrial and energy-intensive processes;
- synthetic materials that are the result of a structural change in matter.

From this simple scale we can see that we need to try to select materials from the top of the scale and avoid those towards the bottom. It is also worth noting that experience has shown a marked increase in the risks to health from materials towards the bottom of the scale. In order to make choices we can use the material choice matrix (see Fig. B1.4).

Plant material

Biomass

The annual regrowth of biomass is a highly sustainable resource that is not exploited enough at present. The potential for new product development based on biomass is exciting and still to be exploited through the combination of new and old techniques. Some obvious examples (see Fig. B1.2) are:

- reed, straw and palm roof covering;
- pressed straw panels for walls and ceilings;
- straw bales for wall construction, flax for insulation, and so on;
- rice, grass and straw panels made by hand and/or machine;
- bamboo for load-bearing applications, e.g. scaffolding.

Wood

Wood can be shaped in many different ways with minimal waste. Assuming that we can source timber from forests that are managed in a responsible and sustainable manner, we have a material that can be used creatively, is load-bearing and has positive health benefits to building users.

Animal material

The use of animal material may be of the least importance quantitatively, but there is a strong tradition of using animal skins in construction (for example, tents and rugs) and bones for glue. Animal hair was at one time used as a reinforcement in mortar, is still woven for different types of fabric for use in buildings, and more recently has been reinvented for insulation (sheep's wool) (see Fig. B1.2).

Mineral material

Mineral materials are not renewable and so they should be used sparingly and also be designed for reuse and/or easy recovery when the building is disassembled or remodelled (see Fig. B1.3).

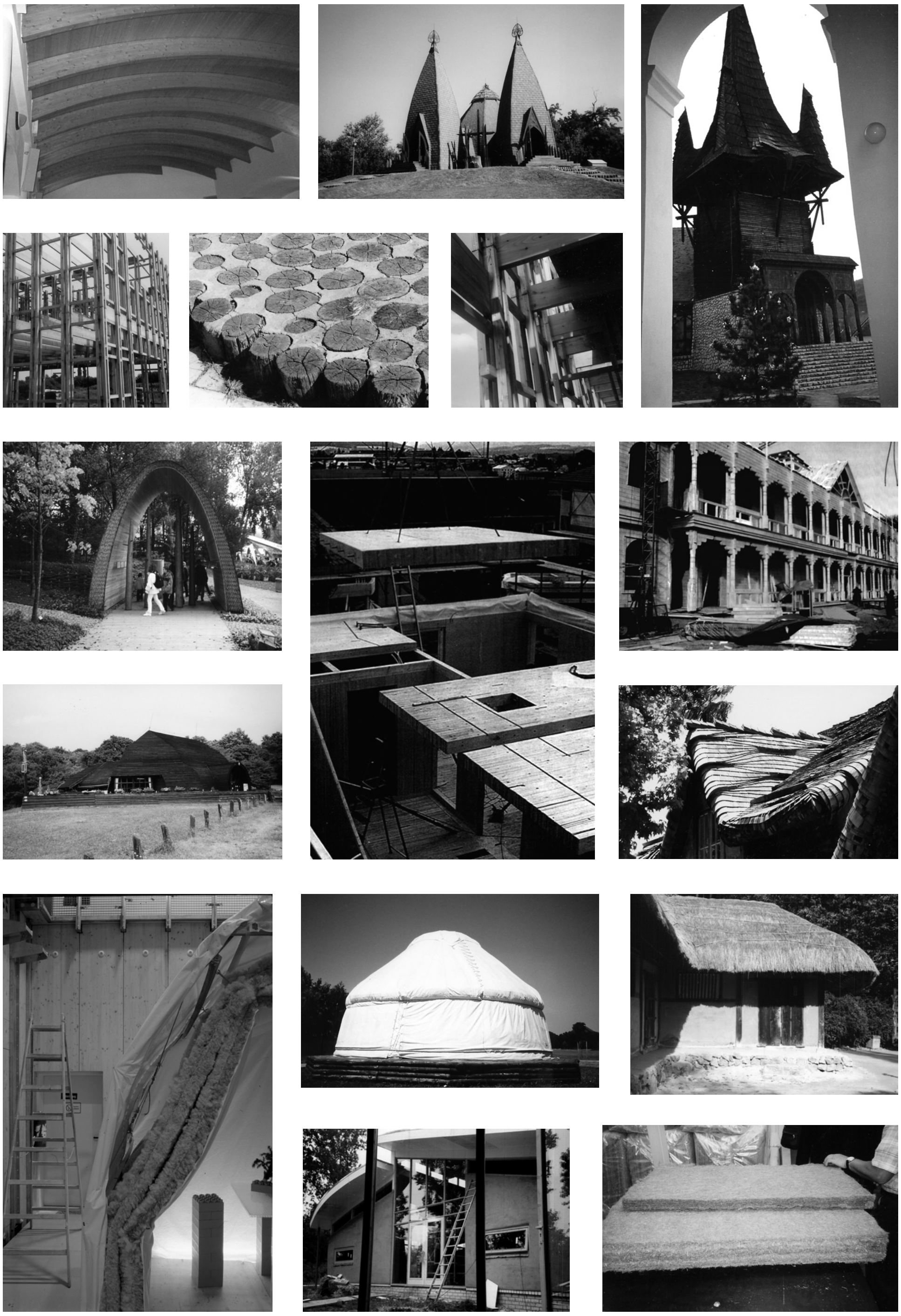


Fig. B1.2 Examples of organic material application considering sustainability: use of plant material (biomass), use of vegetation, use of timber/wood, use of animal material.

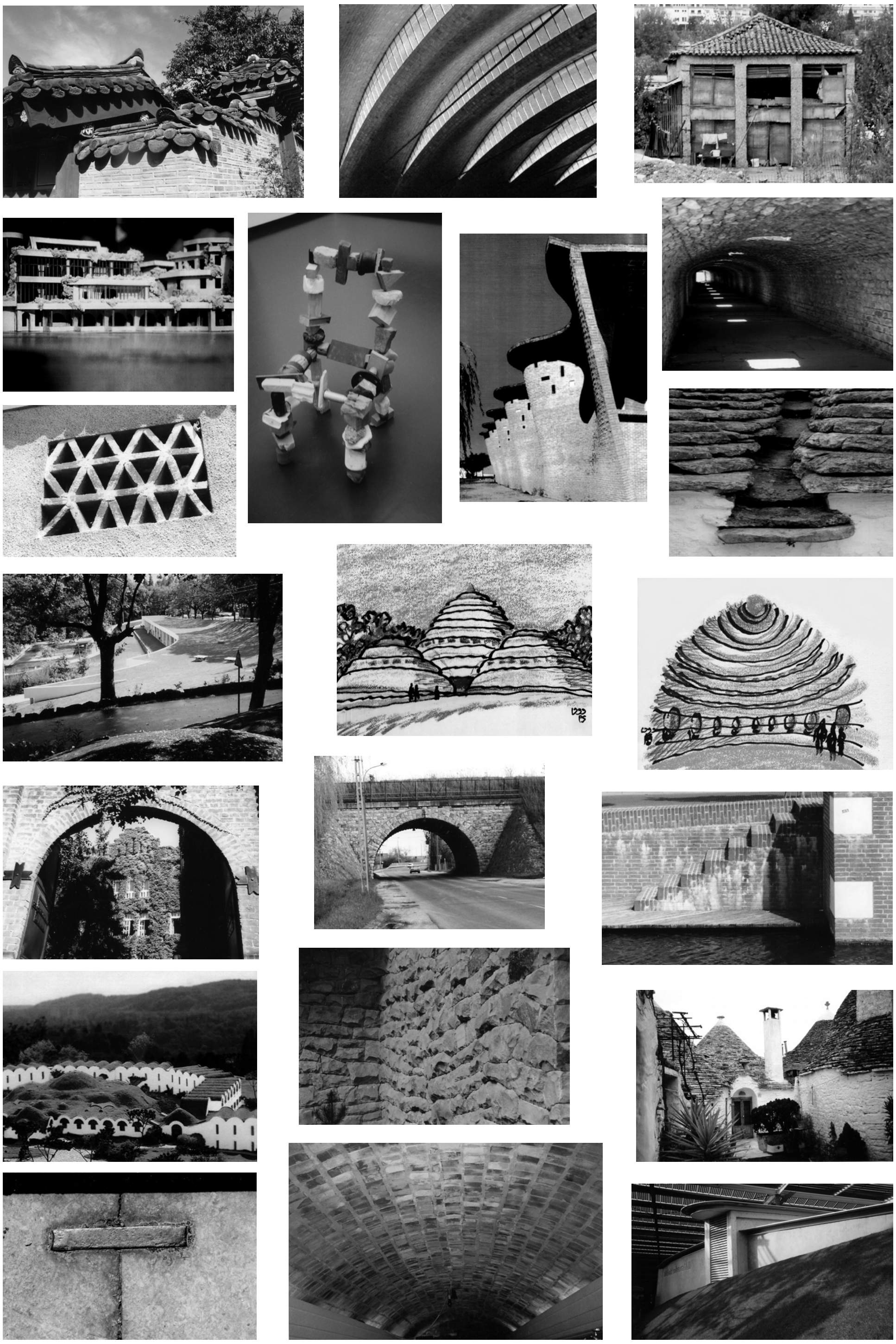


Fig. B1.3 Examples of inorganic material application considering sustainability: use of mineral material (clay, loam, mud, earth), use of mineral material (bricks), use of mineral material (stone), use of metals, derived from minerals, and recycled materials.

Earth

Clay, loam, mud or simply earth is the most fundamental of building materials. Mud bricks, earth sheltered housing are interesting approaches; there are creative options in conjunction with wood, and clay mixed with straw is another possibility.

Bricks

Burnt or fired bricks use a great deal of energy in their production, although they can be reused relatively easily if a lime mortar or a weak sand/cement mortar is used.

Stone

Stone takes a large amount of energy to process and good quality building stone is in short supply in many regions. Recycling is important. It is currently fashionable to use artificial stone, a cement-based product with stone particles giving the appearance of stone (best avoided, given the pollution created by cement production).

Glass

It would be unthinkable to build without glass, but its high embodied energy makes it necessary to recycle, and design buildings to exploit passive solar gain, thus helping to mitigate the energy used in production.

Metals

Given the high embodied energy associated with metals we need to use them wisely and always with a view to recycling and reuse.

Synthetic material

Synthetic materials are becoming more widely available in building and care is required in terms of their environmental and health impact. Avoidance where possible may be the most prudent course of action.

Being aware of the fundamental issues surrounding building material can aid the making of choices that improve health and wellbeing within them.

Energy

Energy is, in principle, a more simple issue to deal with. Finite resources must be avoided or at least minimised, both in production and in the use of the building. Renewable and clean sources must be utilised at all stages in production and use. The

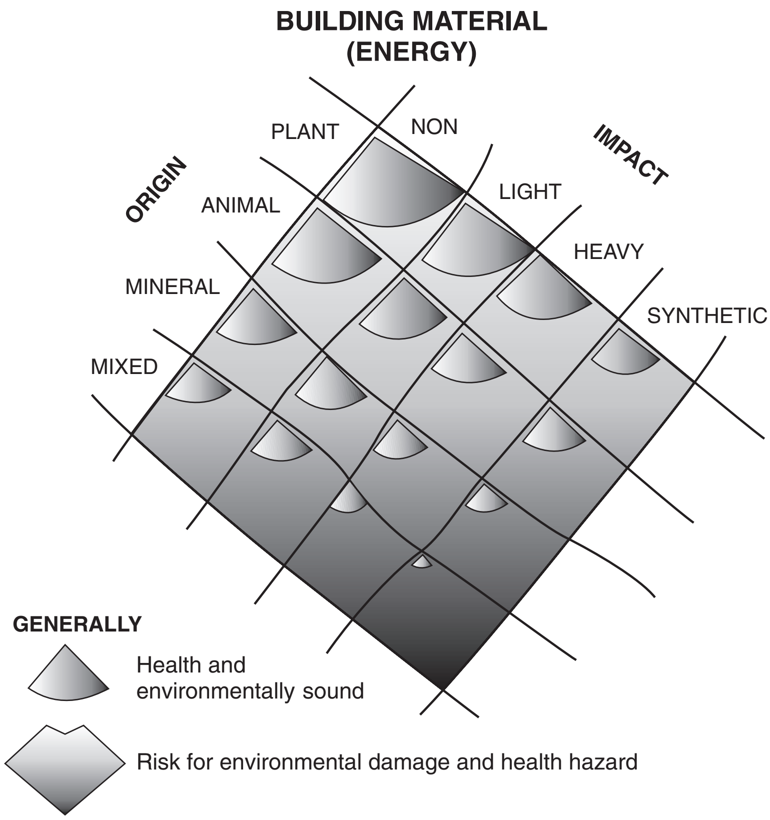


Fig. B1.4 Material choice matrix (MCM). Most buildings and building designs show a huge mixture of different building materials and components. The MCM can help to make a responsible choice between the many possibilities marketed to the decision-makers (designers and specifiers). The more we make a choice of a material in the lower part of the matrix, the greater the risk of environmental damage as well as health hazards. The more choices taken from the upper part of the matrix, the more chance we have generally to obtain healthy and environmentally sound results. Impact includes all treatment and handling (including energy content, transport, etc.) of a material, product component or building part from cradle to grave.

main problem here is that buildings tend to be placed in areas with existing infrastructure, and so the energy supplies are already in place and therefore determined by others. One way around this is to detail buildings to consume very little energy or no energy at all. To do this it is important to understand energy flow within buildings and the interactions of people with the building fabric and in turn with the external environment. At present we are preoccupied with reducing energy consumption (largely through better insulation), which is a relatively short-term problem. Once we switch fully to renewable resources (especially solar and wind power) the insulation values will be largely irrelevant and our detailing priorities will be different from what they are today.

Keywords

Design and service life
Durability
Energy
Environmental costs
Ethics
Health and wellbeing
Legislation
Pollution
Processing
Renewable