## Earth

Earth building methods include:

- structural walls of rammed earth or pisé, where the earth is progressively compacted into removable formwork
- earth bricks (adobe) as a veneer tied back to a structural frame of timber or steel
- rammed earth or earth brick as an infill to a structural timber post and beam structure
- structural walls of earth bricks (adobe) – though this is uncommon.

There are three New Zealand standards covering earth building. Updated versions of each were published in February 2020:

- NZS 4297:2020 – Engineering design of earth buildings
- NZS 4298:2020 – Materials and workmanship for earth buildings
- NZS 4299:2020 – Earth building not requiring specific design.

BRANZ has also published a bulletin on the topic, BU667 Earth buildings.



| Extraction and manufacture | |
|---|---|
| **Impact of extraction** | Removal of earth has visual impacts, and there is the potential for damage to local ecosystems during extraction.<br>Cement and/or organic matter can be used as a binder. Waste from manufacturing or installation can also be used. Earth used for building must comply with NZS 4298 Materials and workmanship for earth buildings. |
| **Energy use** | Only a very small amount of energy is needed to manufacture earth building materials. Embodied energy is quoted[1] as 0.15 MJ/kg for straw stabilised adobe<br>Energy use will increase where materials must be transported to site. |
| **By-products/emissions** | Earth is inert. .<br>Lower density earthen materials with high amounts of organic fibre have negative $CO_2$ emissions (absorb $CO_2$) and those containing cement have positive $CO_2$ emissions (emit $CO_2$). $CO_2$ emissions for adobe with straw are: -12 g/kg; or -20 kg/m$^3$ |
| **Sourcing** | |
| **Material sources** | Earth or earth bricks can be obtained locally – including on the building site – if the earth is suitable for use. |
| **Availability** | Availability varies – depends on suitability. |
| **Cost** | Material costs are low but a significant amount of labour is required. |
| **Transport to site** | Transport costs are high if raw or finished materials need to be transported. |
| **Construction/installation** | |
| **Health and safety during construction/installation** | There is a risk of sunburn during construction. |
| **Ease of construction** | Materials can sometimes be sourced on site. Earth building takes a relatively low skill level. |
| **Adaptability** | Earth buildings can be readily cut and repaired. |

| Performance | |
|---|---|
| **Health and safety during life of building** | Earth is inert, non-toxic and not generally prone to off-gassing of volatile materials. There is potential for off-gassing from earth mixes that contain bitumen. Earth may have to be sealed to prevent dusting or have an earth plaster finish. |
| **Structural capability** | Earth buildings must comply with NZS 4298 *Materials and workmanship for earth buildings*. |
| **Expected durability** (assuming correct installation and maintenance) | 80+ years – but this depends significantly on the climate, building design, construction and finish applied. To be durable, earth must be protected from moisture. |
| **Maintenance rating** | Earth is relatively high maintenance because of the importance of protecting it from moisture. |
| **Moisture resistance** | Resistance to moisture is good when used in accordance with the New Zealand earth building standards. Adherence to NZS4299:1998 *Earth buildings not requiring specific design* and NZS4298:1998 *Materials and workmanship for earth buildings* gives compliance with Building Code clauses B2, E1, E2 and E3. Earth may be susceptible to excessive rain wetting or rising damp. Natural earth materials moderate interior humidity. |
| **Rot, mould and corrosion** | Earth may be attacked by burrowing insects.<br>Material will disintegrate when wet. |
| **Thermal performance** | Lower density earthen mixes have higher R-values. The R-value of higher density earth is low. Earth walls, floors or internal earth brick veneers provide useful thermal mass if they are exposed to the interior and/or to direct sunlight through windows/doors. |
| **Sound insulation** | The high mass of earth walls gives good sound deadening/insulation. |
| **Fire performance** | Earth won't burn. |
| **Waste disposal/recycling/re-use** | |
| **Re-use** | Earth building materials can be re-used. |
| **Recycling** | Earth building materials can be recycled provided they do not contain cement. |
| **Waste disposal** | Earth is biodegradable and non-toxic when no additives such as bitumen are used. |

1. Embodied energy figures taken from work © J. Andrew Alcorn, 2010. (Alcorn, J. Andrew, *Global Sustainability and the New Zealand House,* a thesis submitted to Victoria University of Wellington in fulfilment of the requirements for the degree of Doctor of Philosophy in Architecture, Wellington, 2010.)