

**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.

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Extraction and manufacture	
<b>Impact of extraction</b>	Removal of earth has visual impacts, and there is the potential for damage to local ecosystems during extraction.  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 <i>Materials and workmanship for earth buildings</i> .
<b>Energy use</b>	Only a very small amount of energy is needed to manufacture earth building materials. Embodied energy is quoted <sup>1</sup> as 0.15 MJ/kg for straw stabilised adobe  Energy use will increase where materials must be transported to site.
<b>By-products/emissions</b>	Earth is inert. .  Lower density earthen materials with high amounts of organic fibre have negative CO <sub>2</sub> emissions (absorb CO <sub>2</sub> ) and those containing cement have positive CO <sub>2</sub> emissions (emit CO <sub>2</sub> ). CO <sub>2</sub> emissions for adobe with straw are: -12 g/kg; or -20 kg/m <sup>3</sup>
Sourcing	
<b>Material sources</b>	Earth or earth bricks can be obtained locally – including on the building site – if the earth is suitable for use.
<b>Availability</b>	Availability varies – depends on suitability.
<b>Cost</b>	Material costs are low but a significant amount of labour is required.
<b>Transport to site</b>	Transport costs are high if raw or finished materials need to be transported.
Construction/installation	
<b>Health and safety during construction/installation</b>	There is a risk of sunburn during construction.
<b>Ease of construction</b>	Materials can sometimes be sourced on site. Earth building takes a relatively low skill level.
<b>Adaptability</b>	Earth buildings can be readily cut and repaired.
Performance	
<b>Health and safety during life of building</b>	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.
<b>Structural capability</b>	Earth buildings must comply with NZS 4298 <i>Materials and workmanship for earth buildings</i> .

<b>Expected durability</b> (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.
<b>Maintenance rating</b>	Earth is relatively high maintenance because of the importance of protecting it from moisture.
<b>Moisture resistance</b>	Resistance to moisture is good when used in accordance with the New Zealand earth building standards. Adherence to NZS4299:1998 <i>Earth buildings not requiring specific design</i> and NZS4298:1998 <i>Materials and workmanship for earth buildings</i> 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.
<b>Rot, mould and corrosion</b>	Earth may be attacked by burrowing insects. Material will disintegrate when wet.
<b>Thermal performance</b>	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.
<b>Sound insulation</b>	The high mass of earth walls gives good sound deadening/insulation.
<b>Fire performance</b>	Earth won't burn.
<b>Waste disposal/recycling/re-use</b>	
<b>Re-use</b>	Earth building materials can be re-used.
<b>Recycling</b>	Earth building materials can be recycled provided they do not contain cement.
<b>Waste disposal</b>	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.)