Stabilised Rammed Earth - Physical Properties and Compliance with UK Building Regulations

Stabilised rammed earth (SRE) can successfully be used to conform to the Building Regulations (2000) for England & Wales as an acceptable alternative form of low-rise masonry construction in public and residential buildings. Recommendations for how this can be achieved are given through the case study by the Planning Department of Chesterfield Borough Council (refer: Hall, Damms & Djerbib, 2004)

Regulation 7 – Materials and Workmanship

At present there are no officially recognised codes of practice for rammed earth construction in the United Kingdom. The fitness of SRE materials is currently established under:

f) Tests and calculations, and
g) Past experience

Suitability & classification of soil materials is established in accordance with:

- *BS 1377-2: 1990 - Soils for Civil Engineering Purposes - Part 2: Classification Tests*, British Standards Institute, London
- *BS 1377-4: 1990 - Soils for Civil Engineering Purposes - Part 4: Compaction Related Tests*, British Standards Institute, London

A series of 100mm SRE cube samples are produced in a laboratory using the prescribed mix design in accordance with the guidelines prescribed in:

- Hall M & Djerbib Y, 2004_b, "Rammed Earth Sample Production: Context, Recommendations and Consistency", *Construction and Building Materials*, 18 [4] pp.281-286
  N.B. Based upon BS 1881 for concrete materials

The curing shrinkage and estimated construction tolerances are calculated based upon:

- *BS EN 772-16: 2000 Methods of Test for Masonry Units - Part 16: Determination of Dimensions*, British Standards Institute, London

Cube samples are tested for compressive strength in accordance with the guidelines prescribed in:

- Hall M & Djerbib Y, 2004_b, "Rammed Earth Sample Production: Context, Recommendations and Consistency", *Construction and Building Materials*, 18 [4] pp.281-286

Cube samples can also be tested for other physical properties depending upon the application, e.g. moisture absorption, acoustic, thermal etc

Approved Document A - Structural Stability

For the purposes of assessment under Part A (structural stability) of the Building Regulations, SRE walls can simply be treated as a high density mass walling element.

Test Specimens

All SRE test specimens are characterised and produced as 100mm cube samples using the methodologies proposed by Hall M & Djerbib Y, 2004, "Rammed Earth Sample Production: Context, Recommendations and Consistency", *Construction and Building Materials*, 18 [4] pp.281-286

Compressive strength

Minimum characteristic unconfined compressive strength (f'_{cu}) = $\geq$ 3.5 N/mm^2
Typical range of f'_{cu} ≈ 3.5 N/mm^2 to 12 N/mm^2
N.B The f'_{cu} can be increased by altering the soil grading, the cement content, the ramming and the curing procedures.

Density

Typical dry density (ρ_d) ≈ 2000 to 2100 kg/m^3 (at 98% of Proctor compaction)
Tested in accordance with *BS 1377-4: 1990 - Soils for Civil Engineering Purposes - Part 4: Compaction Related Tests*

Fixing capacity

300mm Hilti C10 epoxy holds 2,000kg pull, Amdel Report No. M1034/87

For further details of compliance please refer to:

- Hall M, Damms P & Djerbib Y, 2004, "Stabilised Rammed Earth (SRE) and the Building Regulations (2000): Part A – Structural Stability", *Building Engineer*, 79 [6] pp. 18-21

Approved Document B - Fire Safety

SRE is classified as a 'non-combustible material'
Fire-resistance rating= 4 hours

- *Tests performed by CSIRO Report No. 1839*

Approved Document C4 - Resistance to Weather and Ground Moisture

SRE walls are constructed using standard practices for DPC & DPM installation

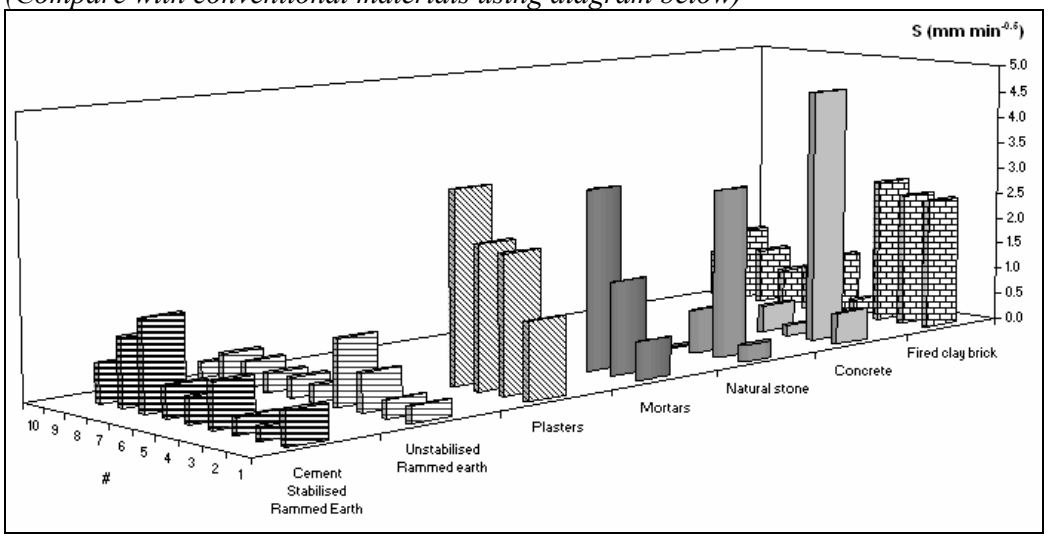
Experimental testing has revealed that SRE easily conforms to the Building Regulations in this country;

- Hall M & Djerbib Y, 2004, "Moisture Ingress in Rammed Earth: Part 2 – The Effect of Particle-Size Distribution on the Absorption of Static Pressure-Driven Water", *Construction and Building Materials*

Water Absorption Properties

Pressure-driven moisture absorption:
Initial surface absorption after 10 min (6% cement content) ≈ 1.90 to 9.95 ml/m^2 sec

Capillary absorption:
Typical Sorptivity (S) value ≈ 0.251 to 1.631 mm $min^{-0.5}$
Initial rate of suction (6% cement content) ≈ 0.29 to 1.47 kg/m^2 min
(Compare with conventional materials using diagram below)



Picture: adapted from Hall M & Djerbib Y, 2004, "Moisture Ingress in Rammed Earth: Part 3 – The Sorptivity and the Surface Inflow Velocity", *Construction and Building Materials*

Durability Properties

Durability of SRE materials is determined using the 'accelerated erosion test' (AET) in accordance with

- Standards New Zealand, 1998, *NZS 4298: 1998 Materials and Workmanship for Earth Buildings*, Wellington, New Zealand
- AET value for SRE = 0.0 mm/min

Tests performed by Materials Consultants Aust. Pty. Ltd. Report No. 202/87

Please note: *Unstabilised rammed earth walls* may not be compliant under Building Regulations. Both Regulation 7 and Approved Document C categorically state that external masonry walls on a building must:

- ✗ Not be damaged by rain or snow
- ✗ Resist the passage of rain (or snow) to the inside of the building
- ✗ Not transmit moisture due to rain (or snow) to another part of the building that might be damaged

Approved Document E - Resistance to the Passage of Sound

In order to demonstrate compliance "*laboratory values for new internal walls and floors within: dwelling-houses, flats and rooms for residential purposes, whether purpose built or formed by material change of use*" must have a minimum R_w of 40 dB (R_w = weighted sound reduction index)

Example: an SRE wall;
Assuming a wall thickness of 300mm the typical R_w of the wall = 58.3 dB

Approved Document L1 - Conservation of Fuel and Power in Dwellings

SRE buildings can be assessed either using the target U-value method, the Carbon Index method or the elemental method. The walls can be constructed in 3 different Part L-compliant configurations:

1. Solid SRE wall with external insulated cladding + render
2. Solid SRE wall with internal dry lining
3. Cavity SRE wall with solid-foam cavity insulation

Example:

For a cavity SRE wall with 175mm SRE inner & outer leaves incorporating polyisocyanurate solid cavity insulation and stainless steel wall ties;

Calculated U-value = 0.335 W/m^2 K (for 50mm thick insulation)

Or, = 0.245 W/m^2 K (for 75mm thick insulation)

SRE walls also have very high thermal capacitance (i.e. "thermal mass")

Typical value for a 300mm wall = 1673 KL/m^3K

Approximate thermal time lag = 6 - 8 hours