EUROCODE 6-1-2

Design of masonry structures

Structural Fire Design

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CONTENTS

- National determined parameters
- Statements on calculation methods
- Background on tabulated data
- Necessary steps towards an applicable harmonised standard

National determined parameters

- Emissivity of a masonry surface (“Actions”)
- Design values of material properties
- Member analysis
- Thermal elongation, specific heat capacity, Thermal conductivity
- Tabulated values of fire resistance
- γ_{Global}, constant c

Emissivity

- No values given in the main standard
- Some decisions from member states
- Austria: e_m = 0,9 to 0,95 in cold design, no values for fire design
- UK: nvg = no value given

DESIGN VALUES OF MATERIAL PROPERTIES $\gamma_{m,fi}$

- Recommended value for $\gamma_{m,fi}$ = 1,0
- UK: distinction between thermal and mechanical properties but: nvg
- Austria: use equation 6.10 from EN 1990:2003

Clarification necessary

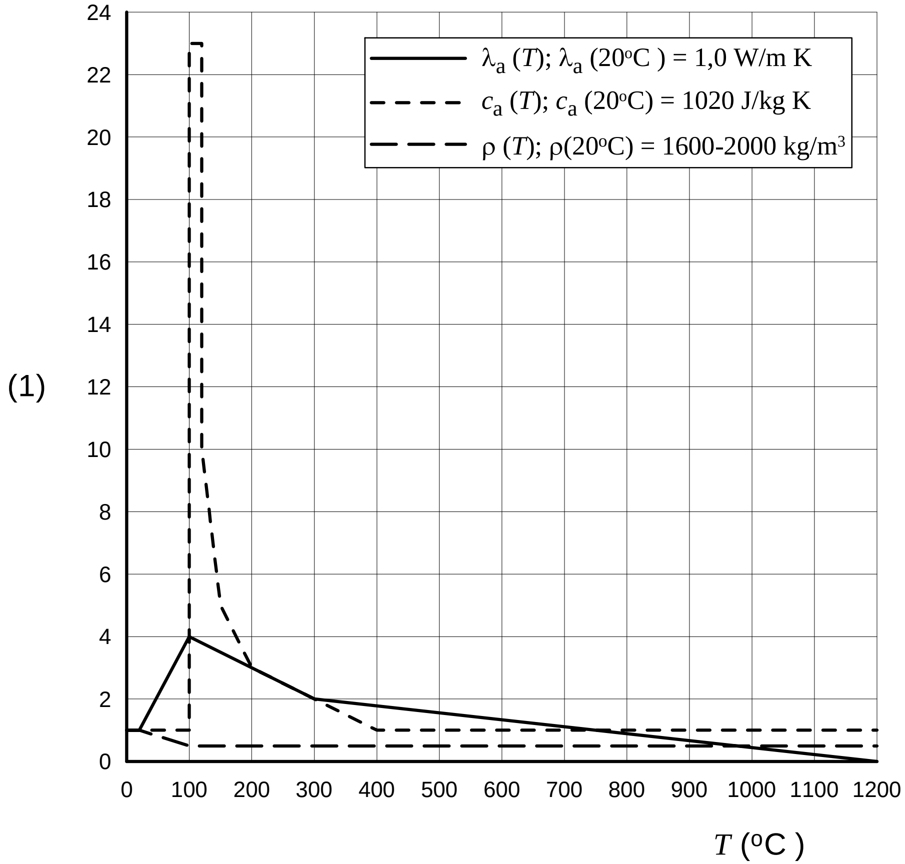
SPECIFIC HEAT CAPACITY c_a

- Annex D gives very specific values for certain materials in J/(kg K) obviously obtained in a very limited number of tests
- EN 1745 gives a default value of 1,0 kJ/(kg K) for 20°C for all types of masonry materials
- Austria takes values from Annex D
- UK says nvg
- Proposal to use 20°C values from EN 1745 and/or perform some basic research work on European level

THERMAL CONDUCTIVITY λ_a

- Annex D contains results from a very limited number of tests
- The diagrams show some strange effects
- Values should only be used for a very rough assessment
- Additional research is necessary

EN 1996-1-2 Diagram D.1(b)



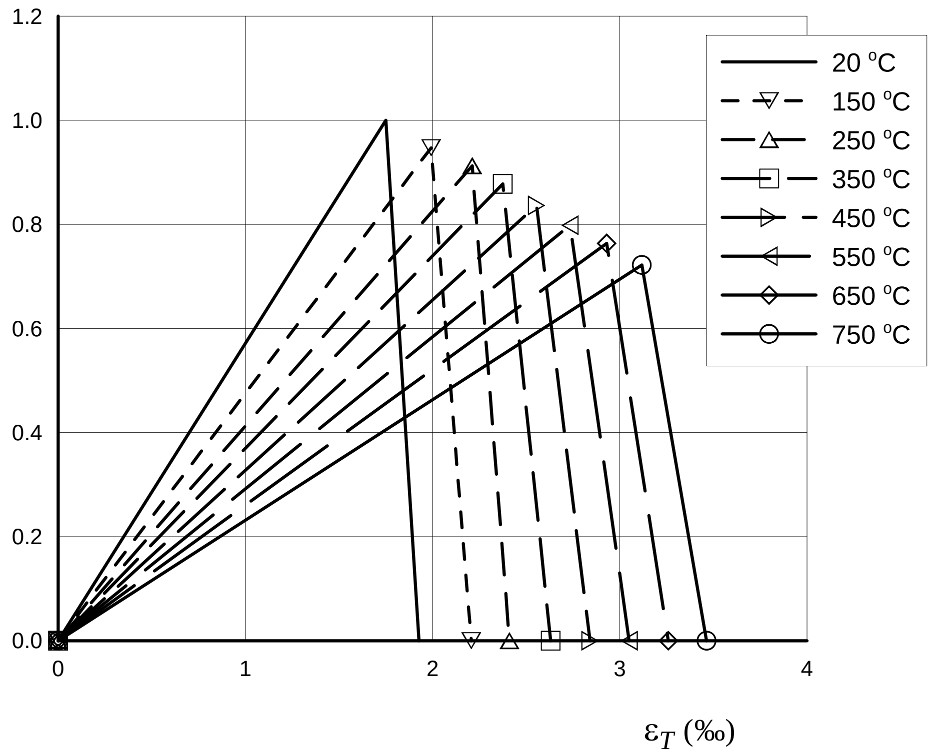
STRESS-STRAIN DIAGRAMS

- Figures D2 in Annex D
- Reliability?

  ε_T in the original report (1)

  14 mm/m for 20°C

- Elongation values beyond 750°C?



STATEMENT ON CALCULATION METHODS

- input parameters based on a very limited number of tests and therefore questionable
- Methods from concrete and timber design do not seem to be adoptable in all cases
- Application of calculation methods can not be recommended for the time being
- High relevance of tabulated data

TABULATED DATA (ANNEX B)

- Different values for

- Non-loadbering separating walls (Criterion EI)
- Loadbearing separating walls (Criterion REI)
- Loadbearing non-separating walls (Criterion R, Fire from all sides)
- Short loadbearing non-separating walls (Criterion R)
- fire walls (loadbearing or not, single or double leaf)

TABULATED DATA (ANNEX B)

- These different types react significantly different to fire

- Non-loadbearing walls show the highest resistance
- Loadbearing separating walls (fire from one side) may develop significant differences depending on the load level
- Loadbearing non-separating walls (fire from all sides) may perform better (lower deflection) or worse (deterioration from all sides) than separating walls

TABULATED DATA

- Recommendations for wall thicknesses meeting a specified criterion are given only in a note
- Differentiation for types of units, utilisation factor and applied surface finishes
- every member state is free to choose periods of fire resistance, materials and load levels according to its needs
- definitions may be based on existing data, experience or testing

BASIS FOR TABULATED DATA

- A number of tests on loadbearing masonry were available as basis for the recommendation, mainly from Belgium, Germany and the UK
- Definition of specified wall thicknesses problematic due to test method
- Tests were often not carried out until failure, but until a specific resistance was obtained

UTILISATION FACTOR

- Definition of utilisation factor
- Utilisation α = 1,0 is related to a vertical load derived from the simplified method in the former German standard DIN 1053-1 for the time being
- These loads can be significantly lower than the design values according to EN 1996-1-1
- DIN had significantly higher load reductions for slender walls

UTILISATION FACTOR

- Values for wall thicknesses ≥ 240 mm are comparable while EN increases the load on 115 mm walls by a factor of more than 2
- All these statements are based on the draft of the German NA with German f_k and German γ values

UTILISATION FACTOR

- Tests on slender clay masonry walls (t = 115 mm)

- Test 1 (α_{DIN} =1,0 = 27 kN/m)
- Test 2 (α_{DIN} =1,6, α_{EN} =0,8 = 45 kN/m)

- For both cases REI >150
  (German classification was REI 90, as is the proposal in EN 1996-1-2, Table N.B 1.2, lines 2.1.2 and 2.1.4 (100/140))

UTILISATION FACTOR

- Tests on slender clay masonry walls (t = 115 mm)

- Test 1 (α_{DIN} =1,0 Deflection in mid-height 46 mm)
- Test 2 (α_{DIN} =1,6, Deflection in mid-height 62 mm)

- A verification with simplified calculation methods would have failed in both cases

ALTERNATIVE: DEFINED LOAD LEVELS

- Requirements are normally related to certain types of buildings
- Tabulated data may be developed for certain characteristic load levels in these buildings

ALTERNATIVE: DEFINED LOAD LEVELS

- f.e. a wall in a 3-storey apartment building will no get more than +- 200 kN/m vertical load (or 300 kN/m in a 5-storey building)
- Available tests may be checked to derive tables for these levels to avoid the inevitable differences resulting from NDPs on f_k and γ.

HOW TO PROCEED IN THE FUTURE?

- Some countries are doing basic research and material tests to create a basis for their respective tables
- Austria, France, Germany, Italy, UK, and others?
- These research efforts should be coordinated or at least reported on European level
- A related research project on European level is absolutely necessary

CONCLUSIONS

- Fire design according to EN 1996-1-2 should be based on tabulated data
- The use of calculation methods is not recommended for the time being as most input parameters are questionable as well as the methods
- Joint research efforts are necessary to broaden the basis for the tabulated data and calculation methods