EUROCODE 6-1-2
Design of masonry structures

Structural Fire Design

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• 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
- $\gamma_{\text{Global}}$, 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 $\lambda_a$

- 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)

\[ \lambda_a(T); \lambda_{a(20^\circ C)} = 1.0 \text{ W/m K} \]

\[ c_a(T); c_{a(20^\circ C)} = 1020 \text{ J/kg K} \]

\[ \rho(T); \rho(20^\circ C) = 1600-2000 \text{ kg/m}^3 \]
STRESS-STRAIN DIAGRAMS

- Figures D2 in Annex D
- Reliability? $\varepsilon_T$ 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-loadbearing 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 $\alpha = 1,0$ 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 $\geq 240$ 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 $\gamma$ values.
UTILISATION FACTOR

- Tests on slender clay masonry walls (t = 115 mm)
  - Test 1 ($\alpha_{\text{DIN}} = 1.0 = 27 \text{ kN/m}$)
  - Test 2 ($\alpha_{\text{DIN}} = 1.6$, $\alpha_{\text{EN}} = 0.8 = 45 \text{ kN/m}$)

- 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 ($\alpha_{\text{DIN}} = 1.0$, Deflection in mid-height 46 mm)
• Test 2 ($\alpha_{\text{DIN}} = 1.6$, 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 $\gamma$. 
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