Objectives

• What is new about EC7 Ultimate Limit State Design?

• How does EC7 ULS design appear?
  – From the point of view of a user

• How can we best use EC7 ULS methods?
What has changed?

• Much of EC7 is little different from previous practice, e.g.:
  – SLS calculations with partial factors unity
  – SI practice

• The main change is in ULS design:
  – Formalises definition of ULS
  – Terminology:
    action, effect, resistance
  – Use of partial factors
Attributes of a New Design Code

• Comprehensiveness

• Ease of Use

• Consistency
  – Internal
  – With previous codes
  – With physical reality

• Leads to reliable and economic design

Some Perceptions

From Bond & Harris:
• Negative
  – “a cross between ‘the European Scream’ and the reaction of the ostrich”
  – Codification for codification’s sake
  – Too high a cost

• Positive
  – Opinions improved once people had had experience of EC7
Some Identified Problems

- Is passive pressure a resistance or a favourable action? (Bond & Harris)

- What strength should one use at ULS?

- Should water pressures be factored? (Brian Simpson)

- The single source principle – what does it mean? (CIRIA)

- Bond and Harris:
  - “The book deliberately presents ...... a completely different running order from the Eurocodes so they can be explained more clearly” (My italics)

Example of Obscurity

- John Atkinson gave training sessions for Coffey

- He missed out the Model Factor ($\gamma_{R,d}$) for Pile Design by calculation

- After I drew his attention to it, it took him 20 minutes to find the reference in EC7, Even though he knew it must be there
**Consistency with Physical Reality**

**Statics**

Newton’s Laws

1. If a body is at rest, the sum of the forces acting on it must be zero

2. (Dynamics)

3. To every Action there is always opposed an equal Reaction

**ULS Design**

- For Limit State EQU:

  \[ E_{\text{dst};d} \leq E_{\text{stb};d} \]

- For Limit State GEO

  \[ E_d \leq R_d \]

- How does the inequality affect consistency with Newton’s Laws?
**ULS Design**

- For Limit State EQU:

\[ E_{dst;d} \leq E_{stb;d} \]

- How does the inequality affect consistency with Newton’s Laws?

**ULS in Practice**

- Pile Design

\[ R_d = Q_s + Q_b \]

- The resistances are not forces, they are capacities (maximum possible forces)
ULS in Practice

- Piping with upward water flow
- What is the safety factor?
- It depends on how you define it

- Total Stresses:
  - $FS = \gamma_b h_2 / \gamma_w h_1$

- Effective Stresses:
  - $FS = (\gamma_b h_2 - \gamma_w h_2) / (\gamma_w h_1 - \gamma_w h_2)$

- e.g. For $h_1 = 3$ m, $h_2 = 2$ m
  - $FS_T = 40/30 = 1.3$
  - $FS_E = 20/10 = 2$

ULS in Practice

- Cantilever Wall Design

- Problem of definition of safety factor was addressed during development of CIRIA 104
- We are used to using partial factors for strength
- The resistances depend on the actions
  and the actions depend upon the resistances
Problems with ULS Calculations

• Resistances are sometimes treated as forces, when in fact they are capacities
  – i.e resistances and actions interact

• This applies to any ULS calculation, (e.g. Global safety factors)
  not just EC7 (with partial factors)
  – We are used to this with global safety factors
    (e.g. Hydraulic uplift, cantilever walls, slopes)

  – Partial factors can make the problem more complex,
    but not intrinsically different

• A safety factor is still what you define it to be

Comparison of Global and Partial Safety Factor Methods

• Global safety factors are simpler,
  and therefore easier to get a feel for
  – For any particular problem
    and depending on how they are defined

• Partial factors allow better assessment of uncertainty
  (variation?) of real physical factors
  (e.g. Variable loadings, material strengths)
  – But how do the code factors relate to real variation?
    Have they just been chosen to fit previous codes?

• Thinking about partial factors has enabled better
  identification of inconsistencies in previous practice
Can we Simplify ULS in EC7?

- Reduce to two sheets of A4:

- All except piles & anchors:
  DA1:C1 \( A1 + M1 + R1 \)
  DA1:C2 \( A2 + M2 + R1 \)

- Piles and anchors:
  DA1:C1 \( A1 + M1 + R1 \)
  DA1:C2 \( A2 + M1 \) or \( M2 + R2 \)
  + Model Factor

- And write down what you have done!

Conclusions

- Partial Factors constitute the main new feature of EC7 ULS calculations

- ULS calculations have intrinsic difficulties

- We are used to them in global factor methods, but not yet in partial factor methods

- EC7 calculations can be made more straightforward
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