

# DIN EN 1993-1-6: 2010-12(E)

## Eurocode\_3: Design of steel structures\_- Part\_1-6: Strength and stability of shell structures (includes Corrigendum AC:2009)

---

| Contents  | Page      |
|---|-----------|
| <b>Foreword</b>   | <b>4</b>  |
| <b>1. General</b>   | <b>5</b>  |
| 1.1 Scope   | 5         |
| 1.2 Normative references                                  | 6         |
| 1.3 Terms and definitions                                 | 7         |
| 1.4 Symbols   | 12        |
| 1.5 Sign conventions                                      | 16        |
| <b>2 Basis of design and modelling</b>                    | <b>16</b> |
| 2.1 General   | 16        |
| 2.2 Types of analysis                                     | 16        |
| 2.3 Shell boundary conditions                             | 18        |
| <b>3 Materials and geometry</b>                           | <b>19</b> |
| 3.1 Material properties                                   | 19        |
| 3.2 Design values of geometrical data                     | 19        |
| 3.3 Geometrical tolerances and geometrical imperfections  | 19        |
| <b>4 Ultimate limit states in steel shells</b>            | <b>20</b> |
| 4.1 Ultimate limit states to be considered                | 20        |
| 4.2 Design concepts for the limit states design of shells | 21        |
| <b>5 Stress resultants and stresses in shells</b>         | <b>24</b> |
| 5.1 Stress resultants in the shell                        | 24        |
| 5.2 Modelling of the shell for analysis                   | 24        |
| 5.3 Types of analysis                                     | 27        |
| <b>6 Plastic limit state (LS1)</b>                        | <b>27</b> |
| 6.1 Design values of actions                              | 27        |
| 6.2 Stress design   | 27        |
| 6.3 Design by global numerical MNA or GMNA analysis       | 28        |
| 6.4 Direct design   | 29        |
| <b>7 Cyclic plasticity limit state (LS2)</b>              | <b>29</b> |
| 7.1 Design values of actions                              | 29        |
| 7.2 Stress design   | 30        |
| 7.3 Design by global numerical MNA or GMNA analysis       | 30        |
| 7.4 Direct design   | 31        |

|          |   |           |
|----------|---|-----------|
| <b>8</b> | <b>Buckling limit state (LS3)</b>   | <b>31</b> |
| 8.1      | Design values of actions  | 31        |
| 8.2      | Special definitions and symbols   | 31        |
| 8.3      | Buckling-relevant boundary conditions   | 32        |
| 8.4      | Buckling-relevant geometrical tolerances  | 32        |
| 8.5      | Stress design   | 39        |
| 8.6      | Design by global numerical analysis using MNA and LBA analyses  | 41        |
| 8.7      | Design by global numerical analysis using GMNIA analysis  | 44        |
| <b>9</b> | <b>Fatigue limit state (LS4)</b>  | <b>49</b> |
| 9.1      | Design values of actions  | 49        |
| 9.2      | Stress design   | 49        |
| 9.3      | Design by global numerical LA or GNA analysis   | 50        |
|          | <b>ANNEX A (normative)</b>  | <b>51</b> |
|          | <b>Membrane theory stresses in shells</b>   | <b>51</b> |
| A.1      | General   | 51        |
| A.2      | Unstiffened cylindrical shells  | 52        |
| A.3      | Unstiffened conical shells  | 53        |
| A.4      | Unstiffened spherical shells  | 54        |
|          | <b>ANNEX B (normative)</b>  | <b>55</b> |
|          | <b>Additional expressions for plastic collapse resistances</b>  | <b>55</b> |
| B.1      | General   | 55        |
| B.2      | Unstiffened cylindrical shells  | 56        |
| B.3      | Ring stiffened cylindrical shells   | 58        |
| B.4      | Junctions between shells  | 60        |
| B.5      | Circular plates with axisymmetric boundary conditions   | 63        |
|          | <b>ANNEX C (normative)</b>  | <b>64</b> |
|          | <b>Expressions for linear elastic membrane and bending stresses</b>   | <b>64</b> |
| C.1      | General   | 64        |
| C.2      | Clamped base unstiffened cylindrical shells   | 65        |
| C.3      | Pinned base unstiffened cylindrical shells  | 67        |
| C.4      | Internal conditions in unstiffened cylindrical shells   | 69        |
| C.5      | Ring stiffener on cylindrical shell   | 70        |
| C.6      | Circular plates with axisymmetric boundary conditions   | 72        |
|          | <b>ANNEX D (normative)</b>  | <b>74</b> |
|          | <b>Expressions for buckling stress <span style="border: 1px solid black; padding: 0 2px;">AC</span> Deleted text <span style="border: 1px solid black; padding: 0 2px;">AC</span></b> | <b>74</b> |
| D.1      | Unstiffened cylindrical shells of constant wall thickness   | 74        |
| D.2      | Unstiffened cylindrical shells of stepwise variable wall thickness  | 84        |
| D.3      | Unstiffened lap jointed cylindrical shells  | 89        |
| D.4      | Unstiffened complete and truncated conical shells   | 91        |