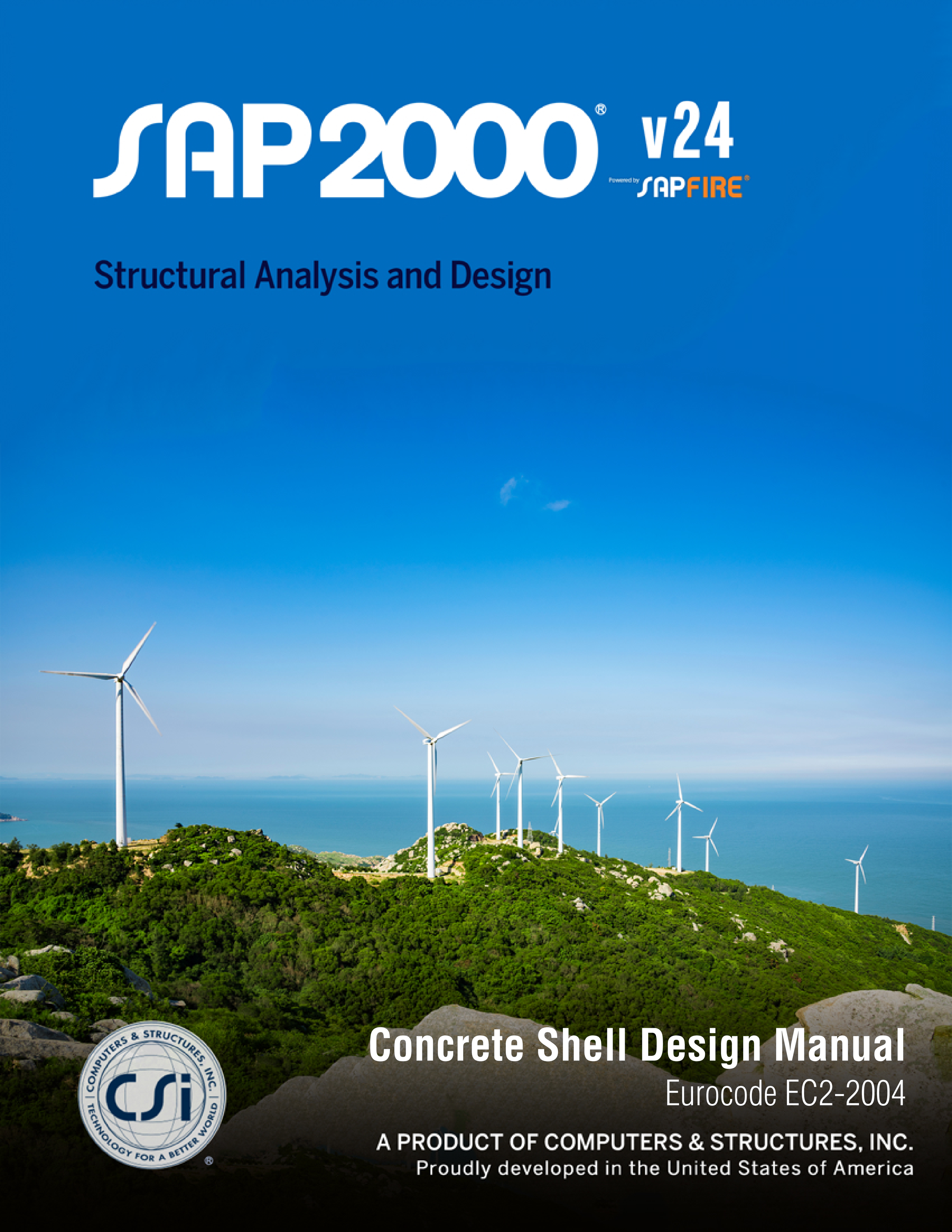

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## Structural Analysis and Design

# Concrete Shell Design Manual

## Eurocode EC2-2004

A PRODUCT OF COMPUTERS & STRUCTURES, INC.
Proudly developed in the United States of America

# Concrete Shell Design Manual

## Eurocode 2-2004

### For

SAP2000®

ISO SAP010122M54 Rev. 0
Proudly developed in the United States of America February 2022

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# Contents

# 1 Introduction

The design of concrete shell in accordance with the "Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings" (EN 1992-1-1, 2004) is seamlessly integrated within the program. Initiation of the design process, along with control of various design parameters, is accomplished using the Design menu. Automated design at the object level is available for any one of a number of user-selected design codes, as long as the structures have first been modeled and analyzed by the program. Model and analysis data, such as material properties and member forces, are recovered directly from the model database, and are used in the design process in accordance with the user defined or default design settings. As with all design applications, the user should carefully review all of the user options and default settings to ensure that the design process is consistent with the user's expectations.

The default implementation in the software is the CEN version of the code. Additional country specific National Annexes are also included. The Nationally Determined Parameters are noted in this manual with [*NDP*]. Changing the country in the Design Preferences will set the Nationally Determined Parameters for the selected country as defined in Appendix B.

It is important to read this entire manual before using the design algorithms to become familiar with any limitations of the algorithms or assumptions that have been made.

For referring to pertinent sections of the corresponding code, a unique prefix is assigned for each code.

- Reference to the EN 1992-1-1:2004 code is identified with the prefix "EC2."

## 1.1 Units

The EC2 design code is based on Newton, millimeter, and second units and, as such, so is this manual, unless noted otherwise. Any units, imperial, metric, or MKS may be used in the software in conjunction with Eurocode 2 design.

## 1.2 Concrete Shell Design

Concrete shell design consists of calculating the amount of reinforcement in the membrane layers required to resist bending moments and axial forces, and shear demand-over-capacity ratio at the nodes of the shell member. The design results at other locations within the shell elements are averaged from those at the nodes.

Program output can be presented graphically on the model and in tables for both input and output data. For each presentation method, the output is in a format that allows the engineer to quickly study the stress conditions that exist in the structure, and in the event the member is not adequate, aid the engineer in taking appropriate remedial measures.

# 2 Design Algorithms

This chapter provides an overview of the basic assumptions, design preconditions, and some of the design parameters that affect the design of concrete shell.

## 2.1 Design Capability

The program has the ability to design for the amount of reinforcement in the membrane layers required to resist bending moments and axial forces, and shear demand-over-capacity ratio at the nodes of the shell member**.** The design algorithm including iteration to determine the thickness of the outer layers and the optimum amount of reinforcement follows the procedure described in Brondum-Nielsen (1974), Colombo et al. (2014), and Craveiro et al. (2021).

# 3 Design Process

This chapter provides a detailed description of the algorithms used by the programs in the design/check of structures in accordance with “Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings” (EN 1992-1-1, 2004.)

## 3.1 Notations

The various notations used in this chapter are described herein.

| | |
|---|---|
| $a^t, a^b$ | Thickness of the top and bottom layers, respectively, mm |
| $A_{s1}^t, A_{s1}^b$ | Area of reinforcement per unit length of the top and bottom layers along direction 1, respectively, mm$^2$/mm |
| $A_{s2}^t, A_{s2}^b$ | Area of reinforcement per unit length of the top and bottom layers along direction 2, respectively, mm$^2$/mm |
| $f_c$ | Concrete compressive strength of the outer layer, N/mm$^2$ |
| $f_{cd}$ | Design value of concrete compressive strength, N/mm$^2$ |
| $f_{cd1}$ | Compressive strength of uncracked concrete, N/mm$^2$ |
| $f_{cd2}$ | Compressive strength of cracked concrete, N/mm$^2$ |
| $f_{ck}$ | Characteristic compressive cylinder strength of concrete at 28 days, N/mm$^2$ |
| $f_{yd}$ | Design yield strength of reinforcement, N/mm$^2$ |
| $f_{yk}$ | Characteristic yield strength of reinforcement, N/mm$^2$ |
| $h$ | Thickness of the shell element, mm |
| $h^t, h^b$ | Distance from the center of the shell element to the center of the top and bottom layers, respectively, mm |

| | |
|---|---|
| $h_{s1}^{t}, h_{s1}^{b}$ | Distance from the center of the shell element to the center of the reinforcement in the top and bottom layers along direction 1, respectively, mm |
| $h_{s2}^{t}, h_{s2}^{b}$ | Distance from the center of the shell element to the center of the reinforcement in the top and bottom layers along direction 2, respectively, mm |
| $N_{11}^{t}, N_{11}^{b}$ | Axial force component per unit length along direction 1 at the center of the top and bottom layers, respectively, N/mm |
| $N_{22}^{t}, N_{22}^{b}$ | Axial force component per unit length along direction 2 at the center of the top and bottom layers, respectively, N/mm |
| $N_{12}^{t}, N_{12}^{b}$ | Shear force component per unit length at the center of the top and bottom layers, respectively, N/mm |
| $N_{c}^{t}, N_{c}^{b}$ | Principal compressive force per unit length at the center of the top and bottom layers, respectively, N/mm |
| $N_{c1}^{t}, N_{c1}^{b}$ | Maximum principal force per unit length at the center of the top and bottom layers, respectively, N/mm |
| $N_{c2}^{t}, N_{c2}^{b}$ | Minimum principal force per unit length at the center of the top and bottom layers, respectively, N/mm |
| $N_{s11}^{t}, N_{s11}^{b}$ | Axial tensile force component per unit length along direction 1 at the center of the top and bottom layers to be resisted by the top and bottom reinforcement, respectively, N/mm |
| $N_{s22}^{t}, N_{s22}^{b}$ | Axial tensile force component per unit length along direction 2 at the center of the top and bottom layers to be resisted by the top and bottom reinforcement, respectively, N/mm |
| $N_{d11}^{t}, N_{d11}^{b}$ | Design axial force component per unit length along direction 1 at the reinforcement location and to be resisted by the top and bottom reinforcement, respectively, N/mm |
| $N_{d22}^{t}, N_{d22}^{b}$ | Design axial force component per unit length along direction 2 at the reinforcement location and to be resisted by the top and bottom reinforcement, respectively, N |
| $v_1, v_2$ | Shear stress demand per unit length on face 1 and 2, respectively, |
| $v_{c1}, v_{c2}$ | Shear stress capacity of concrete on face 1 and 2, respectively, |

| | |
|---|---|
| $\alpha_{CC}$ | Coefficient taking account of long-term effects on the compressive strength and of unfavorable effects resulting from the way the load is applied |
| $\varepsilon_{c3}$ | Strain at concrete compressive strength $f_{cd}$ |
| $\varepsilon_{yd}$ | Yield strain of reinforcement |
| $\theta$ | Angle between 1-direction and the principal tensile direction (perpendicular to the cracks) |
| $\gamma_C$ | Partial factor for concrete |
| $\gamma_S$ | Partial factor for reinforcement |

## 3.2 Three-Layer (Sandwich) Design Model

In general, shell elements are subjected to eight stress resultants. Those are the three membrane force components $N_{11}$, $N_{22}$, and $N_{12}$; the two flexural moment components $M_{11}$ and $M_{22}$ and the twisting moment $M_{12}$; and the two transverse shear force components $V_1$ and $V_2$ (Figure 3-1.) For the purpose of design, the shell is isolated as a unit element. It is further idealized as comprising two outer layers and an uncracked core – this is sometimes called a "sandwich model." The outer layers of the sandwich model are assumed to carry moments and membrane forces, while the transverse shear forces are assigned to the core as shown in Figure 3-2. The dimensions of the sandwich layers and the location of the reinforcement are illustrated in Figure 3-3. The design implementation in the software assumes there are no diagonal cracks in the core. In such a case, a state of pure shear develops within the core, and hence the transverse shear force at a section has no effect on the in-plane forces in the sandwich covers. Thus, no transverse reinforcement needs to be provided, and the in-plane reinforcement is not enhanced to account for transverse shear.

It is important to note that the design will not be performed for the case in which the sum of the concrete covers of the top and bottom reinforcement exceeds 95% of the shell section thickness. It is to avoid any problem associated with numerical difficulties in calculation of the forces in the reinforcement at its actual location.

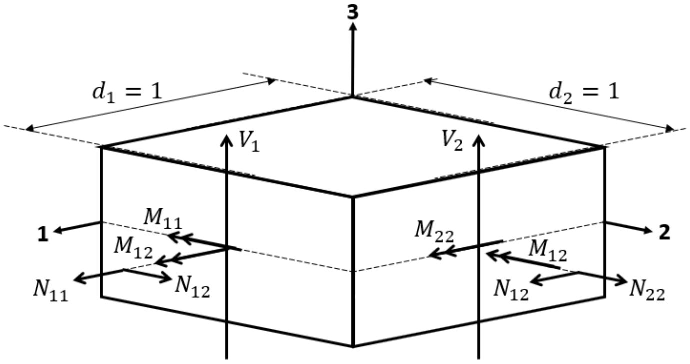


*Figure 3-1: Unit shell element and stress resultants*

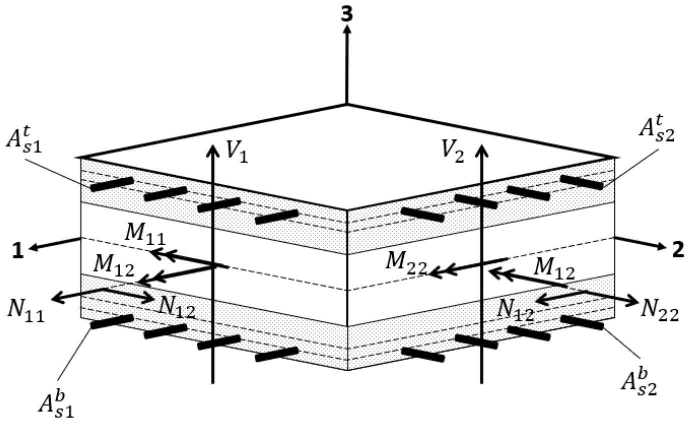


*Figure 3-2: Idealized sandwich model*

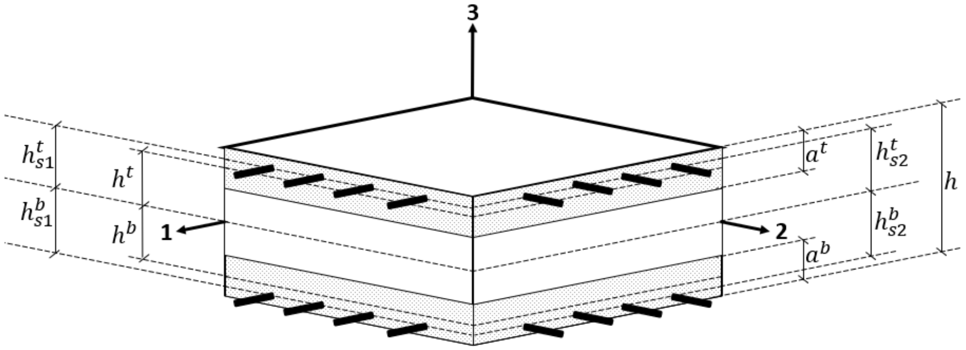


*Figure 3-3: Dimensions of the sandwich model*

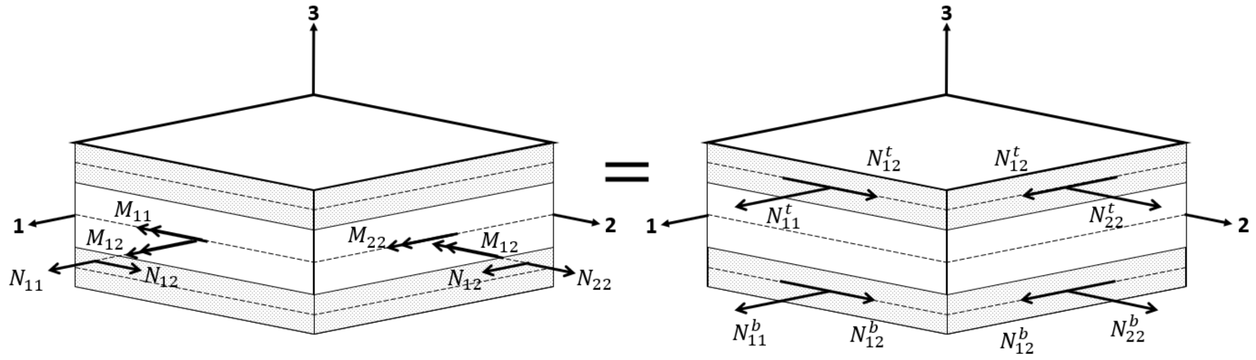


*Figure 3-4: Loads on the outer layers of the sandwich model*

### 3.2.1 Design for Axial Forces and Bending Moments

The membrane forces of the top and bottom layers of the sandwich with respect to the center of the layers as shown in Figure 3-4 are determined as follows:

$$\sum M_{center\ of\ the\ bottom\ layer} = 0 \rightarrow N_{11}^{t} = \frac{N_{11}h^{b} - M_{11}}{h^{t} + h^{b}}$$

$$\sum M_{center\ of\ the\ bottom\ layer} = 0 \rightarrow N_{22}^{t} = \frac{N_{22}h^{b} - M_{22}}{h^{t} + h^{b}}$$

$$\sum M_{center\ of\ the\ bottom\ layer} = 0 \rightarrow N_{12}^{t} = \frac{N_{12}h^{b} - M_{12}}{h^{t} + h^{b}}$$

$$\sum M_{center\ of\ the\ top\ layer} = 0 \rightarrow N_{11}^{b} = \frac{N_{11}h^{t} + M_{11}}{h^{t} + h^{b}}$$

$$\sum M_{center\ of\ the\ top\ layer} = 0 \rightarrow N_{22}^{b} = \frac{N_{22}h^{b} + M_{22}}{h^{t} + h^{b}}$$

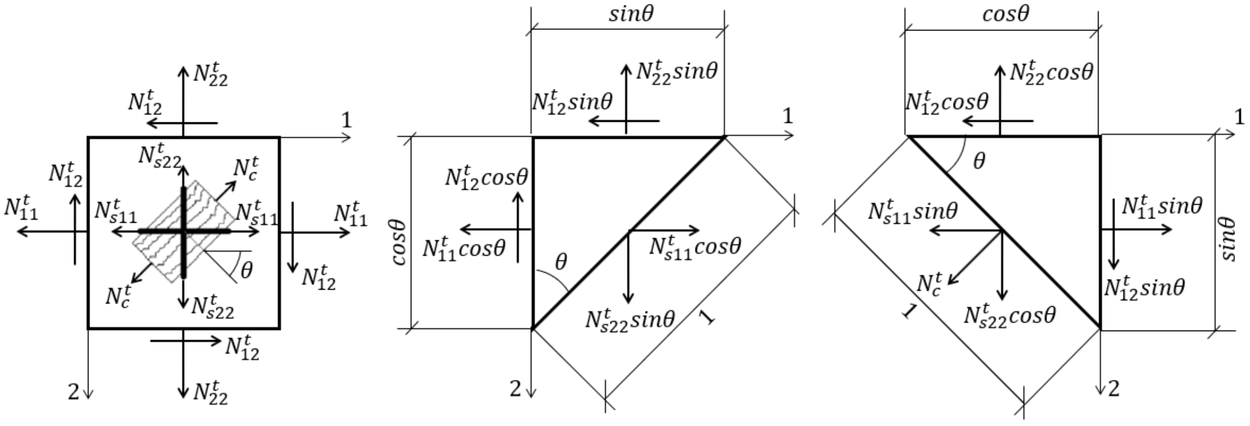
$$\sum M_{center\ of\ the\ top\ layer} = 0 \rightarrow N_{12}^{b} = \frac{N_{12}h^{b} + M_{12}}{h^{t} + h^{b}}$$

For the top (or bottom) membrane element as shown in Figure 3-5(a), the forces required to be resisted by the reinforcement ($N_{s11}^{t}$ and $N_{s22}^{t}$) and concrete ($N_{c}^{t}$) at the center of the layer are determined as follows:

In Figure 3-5(b): $\sum F_1 = 0 \rightarrow N_{s11}^{t} = N_{11}^{t} + N_{12}^{t} tan\theta$

$\sum F_2 = 0 \rightarrow N_{s22}^{t} = N_{22}^{t} + N_{12}^{t} cot\theta$

In Figure 3-5(c): $\sum F_1 = 0 \rightarrow N_{c}^{t} = -\frac{N_{12}^{t}}{sin\theta cos\theta}$



(a) (b) (c)

*Figure 3-5: Top layer: (a) forces per unit length; (b) section parallel to the crack; (c) section perpendicular to the crack*

For design case I in which the reinforcement is required in both directions, $\theta = 45°$ provides the most economical amount of reinforcement and results in:

$$N^t_{s11} = N^t_{11} + |N^t_{12}|$$
$$N^t_{s22} = N^t_{22} + |N^t_{12}|$$
$$N^t_{c} = -2|N^t_{12}|$$

If $N^t_{s11} < 0$ or $N^t_{11} < -|N^t_{12}|$, which is design case II, the reinforcement in direction 1 is not required. Assuming $N^t_{s11} = 0$:

$$tan\theta = -\frac{N^t_{11}}{N^t_{12}}$$
$$N^t_{s22} = N^t_{22} - \frac{(N^t_{12})^2}{N^t_{11}}$$
$$N^t_{c} = N^t_{11} + \frac{(N^t_{12})^2}{N^t_{11}}$$

If $N^t_{s22} < 0$ or $N^t_{22} < -|N^t_{12}|$, which is design case III, the reinforcement in direction 2 is not required. Assuming $N^t_{s22} = 0$:

$$tan\theta = -\frac{N^t_{12}}{N^t_{22}}$$
$$N^t_{s11} = N^t_{11} - \frac{(N^t_{12})^2}{N^t_{22}}$$
$$N^t_{c} = N^t_{22} + \frac{(N^t_{12})^2}{N^t_{22}}$$

If both $N^t_{s11} < 0$ and $N^t_{s22} < 0$, which is design case IV, the reinforcement in both direction is not required. In this case, the value of $N^t_c$ is the minimum principal force $N^t_{c2}$.

The principal forces are obtained by:

$$N^t_{c1} = \frac{N^t_{11} + N^t_{22}}{2} + \sqrt{\left(\frac{N^t_{11} - N^t_{22}}{2}\right)^2 + (N^t_{12})^2}$$
$$N^t_{c1} = \frac{N^t_{11} + N^t_{22}}{2} - \sqrt{\left(\frac{N^t_{11} - N^t_{22}}{2}\right)^2 + (N^t_{12})^2}$$

The forces $N^t_{s11}$ and $N^t_{s22}$ are calculated at the center of the layer. The forces in the reinforcement at its actual location is determined as illustrated in Figure 3-6:

Case (a) – reinforcement required in both top and bottom layer:

$$\sum M_{bottom\ reinforcement} = 0 \rightarrow N^t_{d11} = \frac{N^t_{s11}\left(h^t + h^b_{s1}\right) + N^b_{s11}\left(h^b_{s1} - h^b\right)}{\left(h^t_{s1} - h^b_{s1}\right)}$$
$$N^b_{d11} = N^t_{s11} + N^b_{s11} - N^t_{d11}$$

Case (b) – reinforcement required in top layer only:

$$\sum M_{center\ of\ the\ bottom\ layer} = 0 \rightarrow N^t_{d11} = \frac{N^t_{s11}\left(h^t + h^b\right)}{\left(h^t_{s1} + h^b\right)}$$
$$\Delta N^b_{11} = N^t_{s11} - N^t_{d11}$$

Case (c) – reinforcement required in bottom layer only:

$$\sum M_{center\ of\ the\ top\ layer} = 0 \rightarrow N_{d11}^{b} = \frac{N_{s11}^{b}\left(h^{t} + h^{b}\right)}{\left(h_{s1}^{b} + h^{t}\right)}$$

$$\Delta N_{11}^{t} = N_{s11}^{b} - N_{d11}^{b}$$

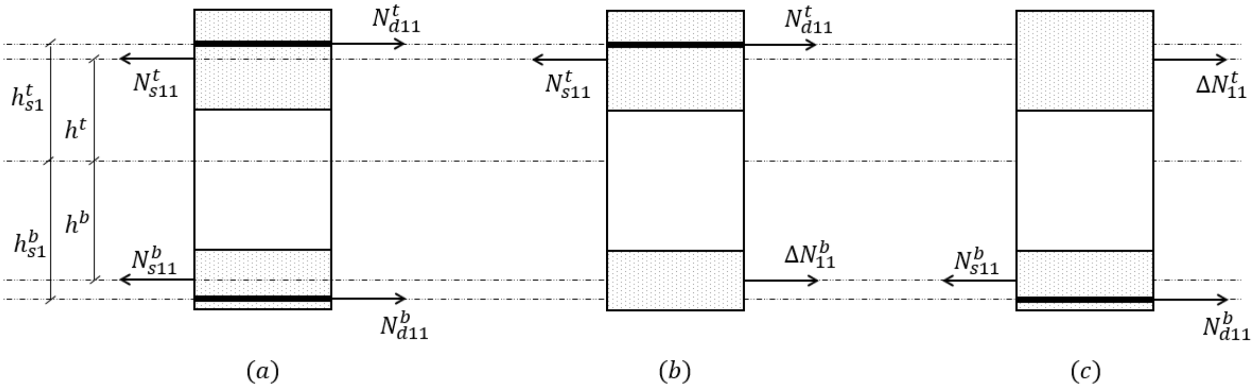


***Figure 3-6: Loads on the reinforcement for case in which the reinforcement is required in: (a) both top and bottom layers; (b) only top layer; (c) only bottom layer***

The forces in the reinforcement along direction 2 are determined similarly.

The required area of reinforcement per unit length and the design thickness of the top and bottom layers are then computed as:

$$A_{s1}^{t} = \frac{N_{d11}^{t}}{f_{yd}}$$

$$A_{s2}^{t} = \frac{N_{d22}^{t}}{f_{yd}}$$

$$a^{t} = \frac{N_{c}^{t}}{f_{c}}$$

$$A_{s1}^{b} = \frac{N_{d11}^{b}}{f_{yd}}$$

$$A_{s2}^{b} = \frac{N_{d22}^{b}}{f_{yd}}$$

$$a^{b} = \frac{N_{c}^{b}}{f_{c}}$$

where:

$$f_{yd} = \frac{f_{yk}}{\gamma_{S}}$$

$$f_{cd} = \alpha_{CC}\frac{f_{ck}}{\gamma_{C}}$$

$f_{yd}$ = design yield strength of reinforcement
$f_{yk}$ = characteristic yield strength of reinforcement
$\gamma_{S}$ = partial factor for reinforcement
$f_{cd}$ = design value of concrete compressive strength
$f_{ck}$ = characteristic compressive cylinder strength of concrete at 28 days
$\alpha_{CC}$ = coefficient taking account of long-term effects on the compressive strength and

of unfavorable effects resulting from the way the load is applied

$\gamma_C =$ partial factor for concrete

As the outer layer (top or bottom) of concrete is subjected to the set of forces $N_{11}$, $N_{22}$, and $N_{12}$, the concrete compressive strength, $f_c$, is computed as follows:

For uncracked concrete:

$$f_c = f_{cd1} = \begin{cases} \left(1 - \dfrac{f_{ck}}{250}\right) f_{cd} & f_{ck} \le 90\ MPa \\ 0.64 f_{cd} & f_{ck} > 90\ MPa \end{cases}$$

For cracked concrete:

$$f_c = f_{cd2} = \begin{cases} 0.6\left(1 - \dfrac{f_{ck}}{250}\right) f_{cd} & f_{ck} \le 90\ MPa \\ 0.384 f_{cd} & f_{ck} > 90\ MPa \end{cases}$$

For design cases I, II, and III, in which the concrete is assumed to be cracked, $f_c$ is interpolated between the values of $f_{cd1}$ and $f_{cd2}$ based on the model by Vecchio and Collins (1986) that the compressive strength of concrete decreases as the maximum tensile strain $\varepsilon_1$ increases:

$$f_c = \begin{cases} f_{cd2} & \beta < 0.6 \\ \dfrac{f_{cd1}}{0.8 - 0.34\left(\dfrac{\varepsilon_1}{\varepsilon_{cp}}\right)} & 0.6 \le \beta \le 1.0 \\ f_{cd1} & 1.0 < \beta \end{cases}$$

$$\beta = \frac{1.0}{0.8 - 0.34\left(\dfrac{\varepsilon_1}{\varepsilon_{cp}}\right)}$$

$$\varepsilon_1 = \begin{cases} 2\left(\varepsilon_{yd} - 0.5\varepsilon_{c3}\right) & Design\ case\ I \\ \dfrac{\varepsilon_{yd} - \varepsilon_{c3} cos^2\theta}{sin^2\theta} & Design\ case\ II \\ \dfrac{\varepsilon_{yd} - \varepsilon_{c3} sin^2\theta}{cos^2\theta} & Design\ case\ III \end{cases}$$

where:

$\varepsilon_{yd} =$ yield strain of reinforcement

$\varepsilon_{c3} =$ strain at concrete compressive strength $f_{cd}$

$\theta =$ angle between 1-direction and the principal tensile direction (perpendicular to the cracks)

For design case IV, in which the concrete is uncracked, the concrete compressive stress is taken as $f_c = f_{cd1}$

The entire procedure as described in this section assumes the values of the design thickness of the top and bottom layers are known to start the design, and at the end these thicknesses are determined again. An iteration is then implemented to ensure the initial and final thicknesses are matched. The steps of the iteration are as follows:

1. Assume both thicknesses of the top and bottom layers have the value of $0.2h$
2. Calculate the forces at the center of the top and bottom layers
3. Determine the design case for each layer

4. Compute the forces to be resisted by the reinforcement at the center of each layer in each direction and the compressive force to be resisted by concrete
5. Adjust the forces for reinforcement design at the actual location of the reinforcement in each direction and each layer. For the design case and the direction in which there is only one layer of reinforcement required, determine $\Delta N$ and update the forces in the other layer if $\Delta N > 0$. For this layer without the reinforcement, re-determine the design case and the compressive force to be resisted by concrete.
6. Calculate the thickness of the top and bottom layers. If the difference of these thicknesses and those assumed in step 1 is within specified tolerance, the required reinforcement is calculated, and the design is done. Otherwise, the newly assumed thickness is taken as the average of these thicknesses and the previously assumed thicknesses, and the procedure is repeated from steps 2 to 6.

### 3.2.2 Shear Check

The shear stress demand-over-capacity ratio check is also performed. Shear stress demand per unit length is calculated as follows:

$$v_1 = \frac{V_1}{h - a^t - a^b}$$

$$v_2 = \frac{V_2}{h - a^t - a^b}$$

And the concrete shear stress capacity is determined for each direction of shear as:

$$v_{c1} = C_{Rd,c}k(100\rho_{l1}f_{ck})^{1/3} + k_1\sigma_{cp1} \geq \left(v_{min} + k_1\sigma_{cp1}\right) \qquad \text{(EC2 Eq. 6.2.a \& 6.2.b)}$$

$$v_{c2} = C_{Rd,c}k(100\rho_{l2}f_{ck})^{1/3} + k_1\sigma_{cp2} \geq \left(v_{min} + k_1\sigma_{cp2}\right) \qquad \text{(EC2 Eq. 6.2.a \& 6.2.b)}$$

where:

$f_{ck} =$ concrete strength in MPa.

$k = 1 + \sqrt{\frac{200}{d}} \leq 2.0$ with $d$ in mm.

$$\rho_{l1} = \frac{\max\left(A_{s1}^t,\ A_{s1}^b\right)}{d} \leq 0.02$$

$$\rho_{l2} = \frac{\max\left(A_{s2}^t,\ A_{s2}^b\right)}{d} \leq 0.02$$

$$\sigma_{cp1} = \frac{N_{11}}{d} < 0.2f_{cd}$$

$$\sigma_{cp2} = \frac{N_{22}}{d} < 0.2f_{cd}$$

$$v_{min} = 0.035k^{3/2}f_{ck}^{1/2} \qquad \text{(EC2 Eq. 6.2.a)}$$

The values of $C_{Rd,c}$, $v_{min}$, and $k_1$ are found in National Annex as described in Appendix B.

The shear stress ratios are then determined as:

$$D/C_1 = \frac{v_1}{v_{c1}}$$

$$D/C_2 = \frac{v_2}{v_{c2}}$$

# APPENDICES

# Appendix A
# References

Brondum-Nielsen, T., (1974). *Optimum Design of Reinforced Concrete Shells and Slabs*, Technical University of Denmark, Department of Civil Engineering.

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# Appendix B
# Nationally Determined Parameters (NDPs)

This appendix provides a listing of the Nationally Determined Parameters (NDPs) used by default for the various country implementations. Several of these parameters can be modified through the design preferences.

**Table B-1 CEN Default NDPs**

| NDP | Clause | Value |
|---|---|---|
| $\gamma_C$ | 2.4.2.4(1) | 1.5 |
| $\gamma_S$ | 2.4.2.4(1) | 1.15 |
| $\alpha_{CC}$ | 3.1.6(1) | 1.0 |
| Max $f_{yk}$ | 3.2.2(3) | 600MPa |
| $C_{Rd,c}$ | 6.2.2(1) | $0.18/\gamma_C$ |
| $v_{min}$ | 6.2.2(1) | $0.035k^{3/2}f_{ck}^{1/2}$ |
| $k_1$ | 6.2.2(1) | 0.15 |
| $v_1$ | 6.2.3(3) | $0.6\left(1-\frac{f_{ck}}{250}\right)$ |

### Table B-2 United Kingdom NDPs

| NDP | Clause | Value |
|---|---|---|
| $\alpha_{cc}$ | 3.1.6(1) | 0.85 |

### Table B-3 Slovenia NDPs

All parameters for Slovenia concrete shell design are as those by CEN Default.

### Table B-4 Norway NDPs

| NDP | Clause | Value |
|---|---|---|
| $\alpha_{cc}$ | 3.1.6(1) | 0.85 |
| $k_1$ | 6.2.2(1) | 0.15 for compression<br>0.3 for tension |

### Table B-5 Singapore NDPs

| NDP | Clause | Value |
|---|---|---|
| $\alpha_{cc}$ | 3.1.6(1) | 0.85 |

### Table B-6 Sweden NDPs

All parameters for Sweden concrete shell design are as those by CEN Default.

### Table B-7 Finland NDPs

| NDP | Clause | Value |
|---|---|---|
| $\alpha_{cc}$ | 3.1.6(1) | 0.85 |
| Max $f_{yk}$ | 3.2.2(3) | 700MPa |

**Table B-8 Denmark NDPs**

| NDP | Clause | Value |
|---|---|---|
| $\gamma_C$ | 2.4.2.4(1) | 1.45 |
| $\gamma_S$ | 2.4.2.4(1) | 1.20 |
| Max $f_{yk}$ | 3.2.2(3) | 650MPa |

**Table B-9 Portugal NDPs**

| NDP | Clause | Value |
|---|---|---|
| Max $f_{yk}$ | 3.2.2(3) | 500MPa |

**Table B-10 Germany NDPs**

| NDP | Clause | Value |
|---|---|---|
| $\alpha_{CC}$ | 3.1.6(1) | 0.85 |
| Max $f_{yk}$ | 3.2.2(3) | 500MPa |
| $C_{Rd,c}$ | 6.2.2(1) | $0.15/\gamma_C$ |
| $v_{min}$ | 6.2.2(1) | $(0.0525/\gamma_C)k^{3/2}f_{ck}^{1/2}$ for $d \leq 600mm$<br>$(0.0375/\gamma_C)k^{3/2}f_{ck}^{1/2}$ for $d > 800mm$ |
| $k_1$ | 6.2.2(1) | 0.12 |
| $v_1$ | 6.2.3(3) | $0.75v_2$ where<br>$v_2 = (1.1 - \frac{f_{ck}}{500}) \leq 1.0$ |

**Table B-11 Poland NDPs**

| NDP | Clause | Value |
|---|---|---|
| $\gamma_C$ | 2.4.2.4(1) | 1.4 |

**Table B-12 Ireland NDPs**

| NDP | Clause | Value |
|---|---|---|
| $\alpha_{CC}$ | 3.1.6(1) | 0.85 |