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# Plasticiteit en grensspanningshypothesen

## GEWAPEND BETON 3D

Betonspanning is totale spanning min staalspanning.

$$\begin{bmatrix} \sigma_{xx} - \rho_x f_y & \sigma_{xy} & \sigma_{xz} \\ \sigma_{xy} & \sigma_{yy} - \rho_y f_y & \sigma_{yz} \\ \sigma_{xz} & \sigma_{yz} & \sigma_{zz} - \rho_z f_y \end{bmatrix}$$

- $\rho$ is wapeningspercentage in de x-, y- of z-richting.
- Aangenomen is dat de wapening vloeit.
- Als drukwapening dan vervang – door +.

Betonhoofdspanningen mogen niet groter dan 0 zijn omdat het beton misschien gescheurd is (krimpscheuren)

$$\sigma_1,\ \sigma_2,\ \sigma_3 \leq 0$$

Bezwijken op druk treedt niet op als

$$\frac{\sigma_1}{f_t} - \frac{\sigma_3}{f'_c} \leq 1$$

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## Twee manieren:

1. Wij kiezen de wapening en de computer berekent de unity checks.

2. De computer berekent de minimaal benodigde wapeningspercentages en wij kiezen wapening die daaraan voldoet.

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## Methode 1

Zie oude tentamens.

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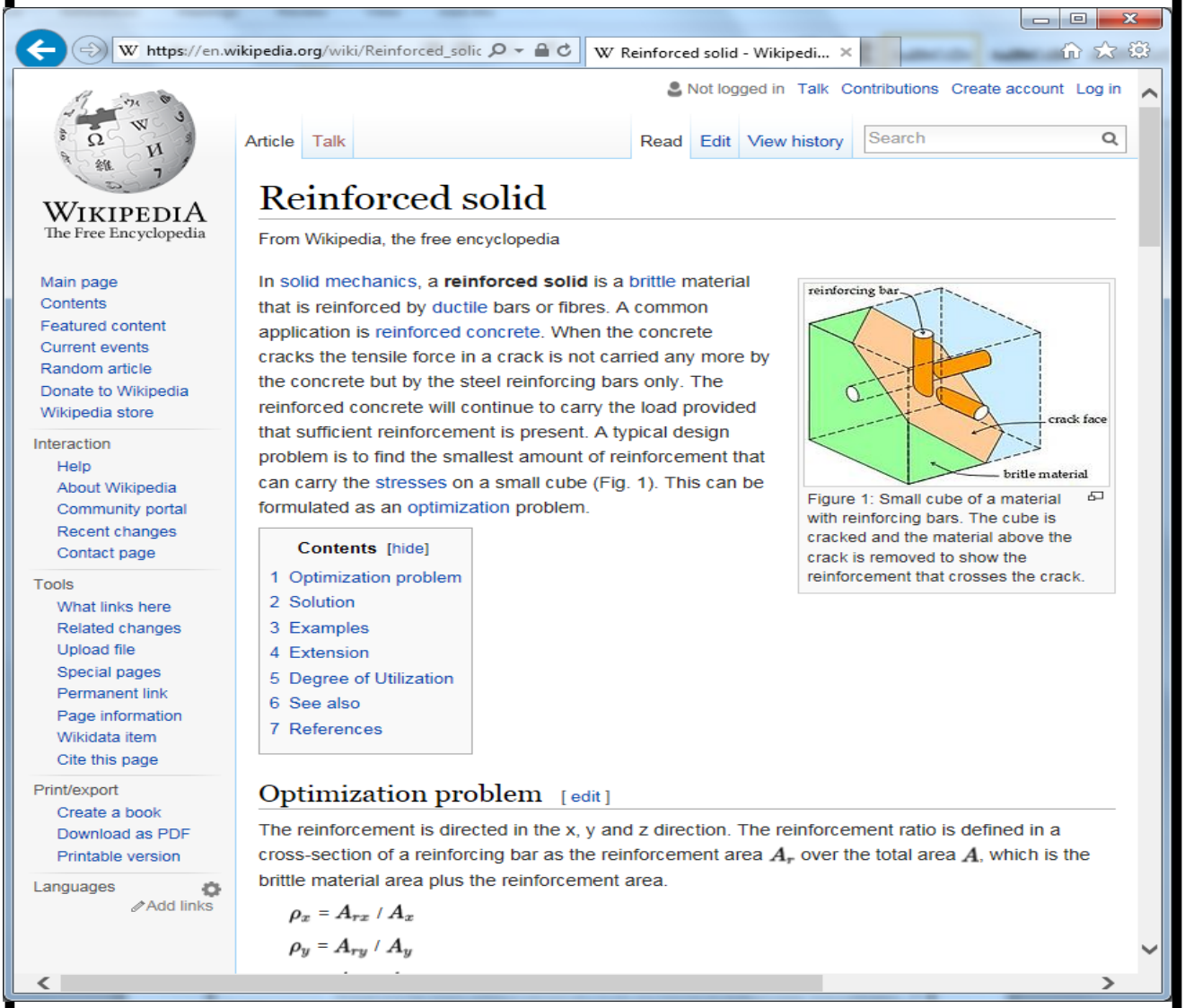
## Methode 2



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# Reinforced solid

From Wikipedia, the free encyclopedia

In solid mechanics, a **reinforced solid** is a brittle material that is reinforced by ductile bars or fibres. A common application is reinforced concrete. When the concrete cracks the tensile force in a crack is not carried any more by the concrete but by the steel reinforcing bars only. The reinforced concrete will continue to carry the load provided that sufficient reinforcement is present. A typical design problem is to find the smallest amount of reinforcement that can carry the stresses on a small cube (Fig. 1). This can be formulated as an optimization problem.




Figure 1: Small cube of a material with reinforcing bars. The cube is cracked and the material above the crack is removed to show the reinforcement that crosses the crack.

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## Optimization problem [ edit ]

The reinforcement is directed in the x, y and z direction. The reinforcement ratio is defined in a cross-section of a reinforcing bar as the reinforcement area $A_r$ over the total area $A$, which is the brittle material area plus the reinforcement area.

$$\rho_x = A_{rx} / A_x$$

$$\rho_y = A_{ry} / A_y$$

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| | Condition | $\rho_x f_y$ | $\rho_y f_y$ | $\rho_z f_y$ |
|---|---|---|---|---|
| 1 | $I_1 \le 0,\ I_2 \ge 0,\ I_3 \le 0$ | 0 | 0 | 0 |
| 2 | $\sigma_{yy}\sigma_{zz} - \sigma_{yz}^2 > 0$<br>$I_1(\sigma_{yy}\sigma_{zz} - \sigma_{yz}^2) - I_3 \le 0$<br>$I_2(\sigma_{yy}\sigma_{zz} - \sigma_{yz}^2) - I_3(\sigma_{yy} + \sigma_{zz}) \ge 0$ | $\frac{I_3}{\sigma_{yy}\sigma_{zz} - \sigma_{yz}^2}$ | 0 | 0 |
| 3 | $\sigma_{xx}\sigma_{zz} - \sigma_{xz}^2 > 0$<br>$I_1(\sigma_{xx}\sigma_{zz} - \sigma_{xz}^2) - I_3 \le 0$<br>$I_2(\sigma_{xx}\sigma_{zz} - \sigma_{xz}^2) - I_3(\sigma_{xx} + \sigma_{zz}) \ge 0$ | 0 | $\frac{I_3}{\sigma_{xx}\sigma_{zz} - \sigma_{xz}^2}$ | 0 |
| 4 | $\sigma_{xx}\sigma_{yy} - \sigma_{xy}^2 > 0$<br>$I_1(\sigma_{xx}\sigma_{yy} - \sigma_{xy}^2) - I_3 \le 0$<br>$I_2(\sigma_{xx}\sigma_{yy} - \sigma_{xy}^2) - I_3(\sigma_{xx} + \sigma_{yy}) \ge 0$ | 0 | 0 | $\frac{I_3}{\sigma_{xx}\sigma_{yy} - \sigma_{xy}^2}$ |
| 5 | $\sigma_{xx} < 0$ | 0 | $\sigma_{yy} - \frac{\sigma_{xy}^2}{\sigma_{xx}} + \lvert\sigma_{yz} - \frac{\sigma_{xz}\sigma_{xy}}{\sigma_{xx}}\rvert$ | $\sigma_{zz} - \frac{\sigma_{xz}^2}{\sigma_{xx}} + \lvert\sigma_{yz} - \frac{\sigma_{xz}\sigma_{xy}}{\sigma_{xx}}\rvert$ |
| 6 | $\sigma_{yy} < 0$ | $\sigma_{xx} - \frac{\sigma_{xy}^2}{\sigma_{yy}} + \lvert\sigma_{xz} - \frac{\sigma_{yz}\sigma_{xy}}{\sigma_{yy}}\rvert$ | 0 | $\sigma_{zz} - \frac{\sigma_{yz}^2}{\sigma_{yy}} + \lvert\sigma_{xz} - \frac{\sigma_{yz}\sigma_{xy}}{\sigma_{yy}}\rvert$ |
| 7 | $\sigma_{zz} < 0$ | $\sigma_{xx} - \frac{\sigma_{xz}^2}{\sigma_{zz}} + \lvert\sigma_{xy} - \frac{\sigma_{yz}\sigma_{xz}}{\sigma_{zz}}\rvert$ | $\sigma_{yy} - \frac{\sigma_{yz}^2}{\sigma_{zz}} + \lvert\sigma_{xy} - \frac{\sigma_{xz}\sigma_{yz}}{\sigma_{zz}}\rvert$ | 0 |
| 8 | $\sigma_{yz} + \sigma_{xz} + \sigma_{xy} \ge 0$<br>$\sigma_{xz}\sigma_{xy} + \sigma_{yz}\sigma_{xy} + \sigma_{yz}\sigma_{xz} \ge 0$ | $\sigma_{xx} + \sigma_{xz} + \sigma_{xy}$ | $\sigma_{yy} + \sigma_{yz} + \sigma_{xy}$ | $\sigma_{zz} + \sigma_{yz} + \sigma_{xz}$ |
| 9 | $-\sigma_{yz} - \sigma_{xz} + \sigma_{xy} \ge 0$<br>$-\sigma_{xz}\sigma_{xy} - \sigma_{yz}\sigma_{xy} + \sigma_{yz}\sigma_{xz} \ge 0$ | $\sigma_{xx} - \sigma_{xz} + \sigma_{xy}$ | $\sigma_{yy} - \sigma_{yz} + \sigma_{xy}$ | $\sigma_{zz} - \sigma_{yz} - \sigma_{xz}$ |
| 10 | $\sigma_{yz} - \sigma_{xz} - \sigma_{xy} \ge 0$<br>$\sigma_{xz}\sigma_{xy} - \sigma_{yz}\sigma_{xy} - \sigma_{yz}\sigma_{xz} \ge 0$ | $\sigma_{xx} - \sigma_{xz} - \sigma_{xy}$ | $\sigma_{yy} + \sigma_{yz} - \sigma_{xy}$ | $\sigma_{zz} + \sigma_{yz} - \sigma_{xz}$ |
| 11 | $-\sigma_{yz} + \sigma_{xz} - \sigma_{xy} \ge 0$<br>$-\sigma_{xz}\sigma_{xy} + \sigma_{yz}\sigma_{xy} - \sigma_{yz}\sigma_{xz} \ge 0$ | $\sigma_{xx} + \sigma_{xz} - \sigma_{xy}$ | $\sigma_{yy} - \sigma_{yz} - \sigma_{xy}$ | $\sigma_{zz} - \sigma_{yz} + \sigma_{xz}$ |
| 12 | $\sigma_{xy}\sigma_{xz}\sigma_{yz} < 0$ | $\sigma_{xx} - \frac{\sigma_{xz}\sigma_{xy}}{\sigma_{yz}}$ | $\sigma_{yy} - \frac{\sigma_{yz}\sigma_{xy}}{\sigma_{xz}}$ | $\sigma_{zz} - \frac{\sigma_{yz}\sigma_{xz}}{\sigma_{xy}}$ |