

1 **BETONBESTANDDELEN**

2 **BETON MAKEN**

3 **VERS BETON**

4 **VERHARD BETON**

3

VERS BETON

(zeer jong beton, jong beton... tot en met ontkisting)

a- VOORBEREIDING

3a1 bekisting

3a2 wapening

b- VERWERKING

3b1 mengen

3b2 transporteren

3b3 storten

3b4 verdichten

3b5 beschermen

c- EIGENSCHAPPEN VAN VERS BETON

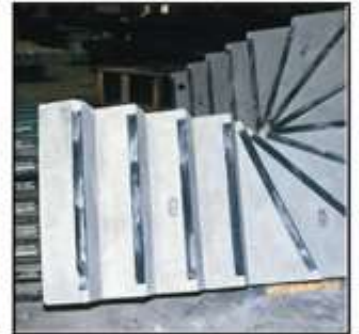
3c1 consistentie

3c2 stabiliteit

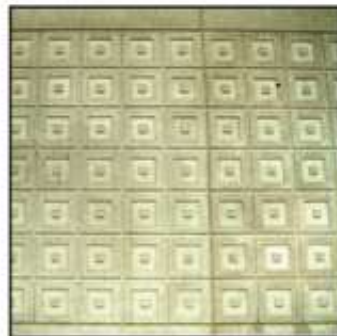
3c3 rijping

3a1 bekisting *soorten - uitzicht betonoppervlak*

glad

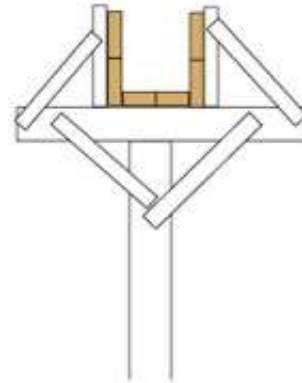
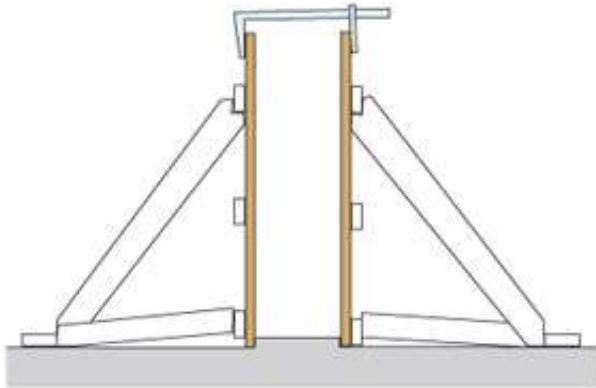


met structuur

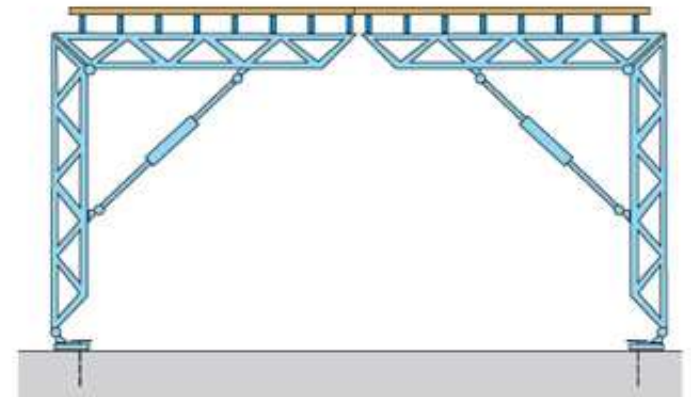
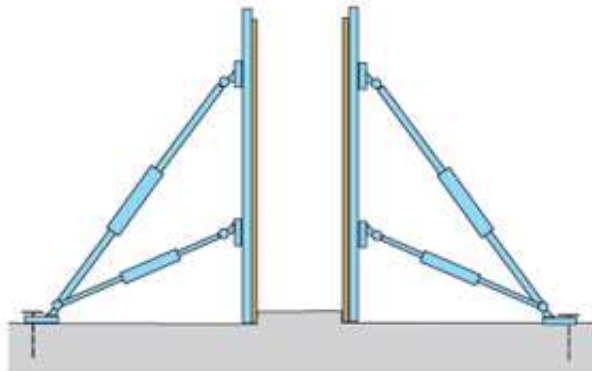
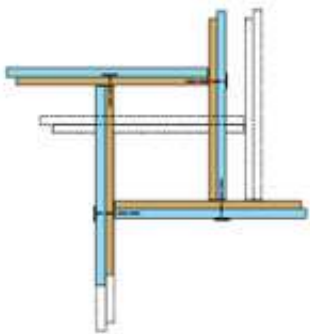


3a1 bekisting *soorten - op de bouwplaats*

traditionele bekistingen

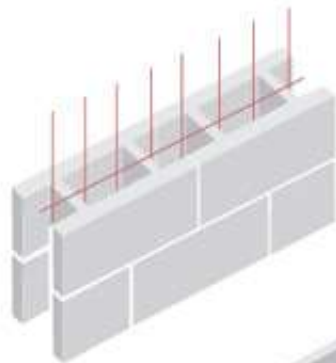


systeembekistingen



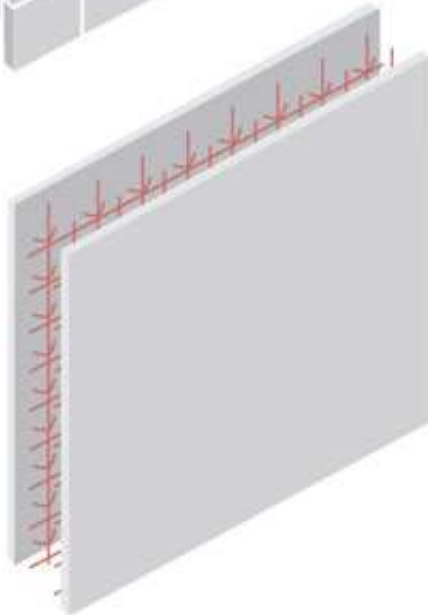
3a1 bekisting *soorten - op de bouwplaats*

blijvende ("verloren") bekistingen



holle blokken

*holle
bekistingswanden*



buizen



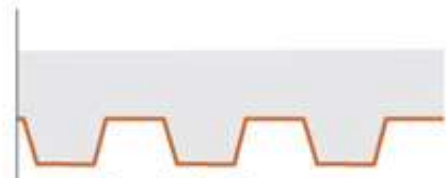
*balkjes / vulelementen
("potten")*



welfsels



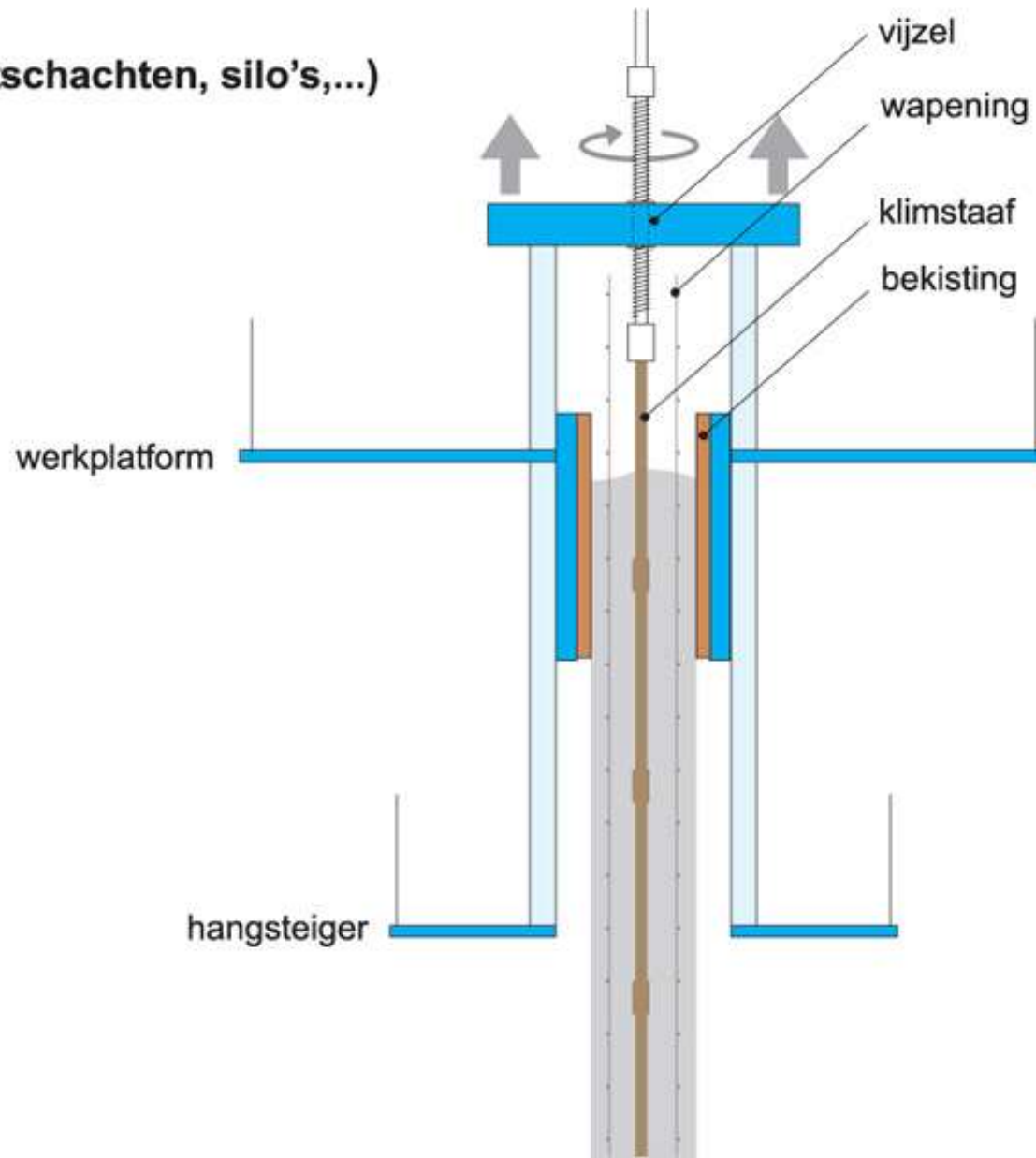
breedplaten



metaalplaten

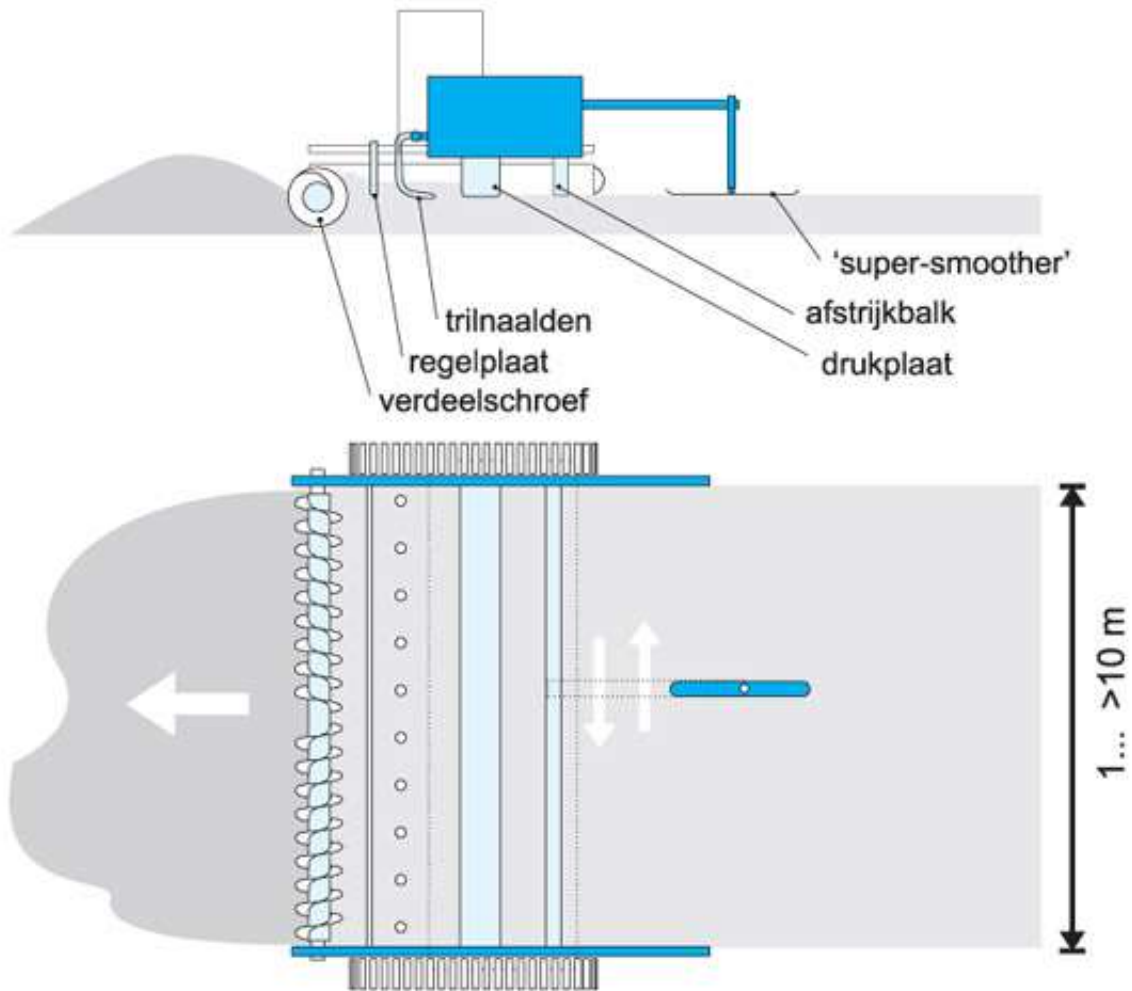
3a1 bekisting *soorten - op de bouwplaats*

glijbekistingen (liftschachten, silo's,...)

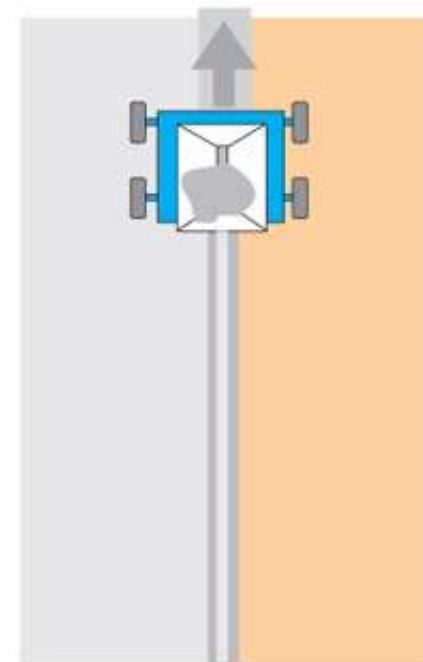
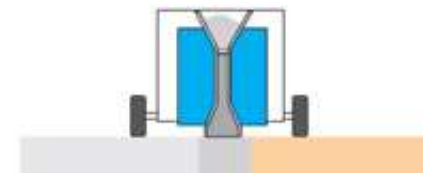


3a1 bekisting *soorten - op de bouwplaats*

glijbekistingen (wegenbouw)

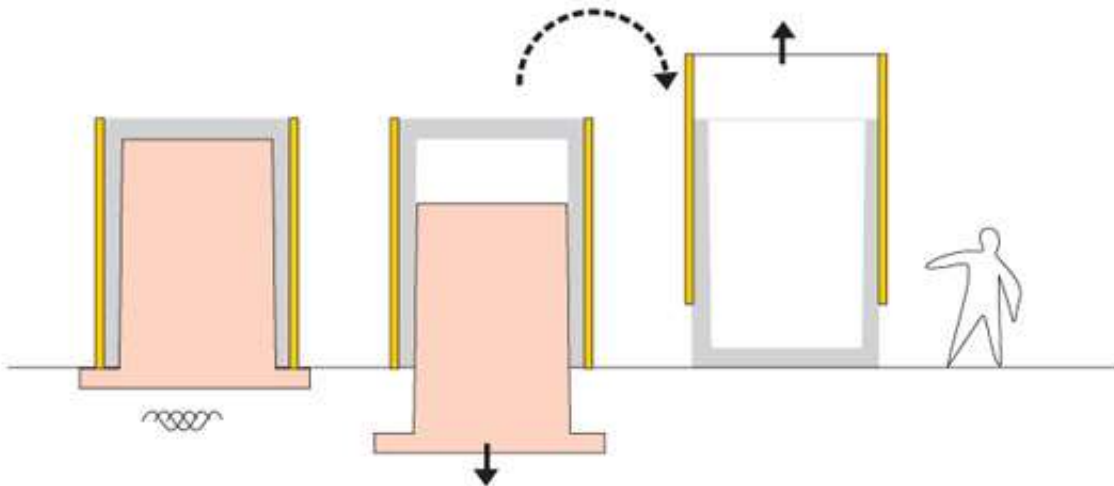
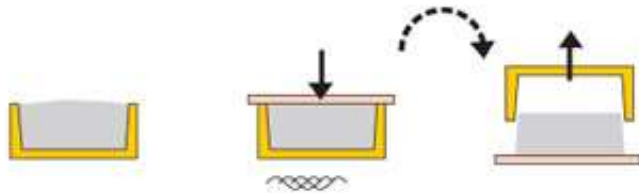


'slipform p



'new jersey'- profiel

3a1 bekisting *soorten - in de betonfabriek*



- consistentieklasse
- verdichting
- ontkisting

3a1 bekisting

courante gebreken

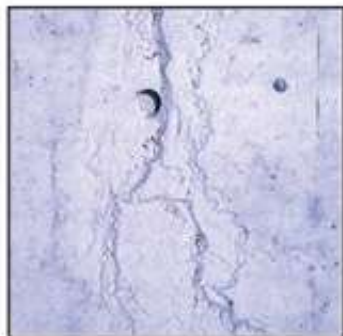
probleem:



tintverschillen

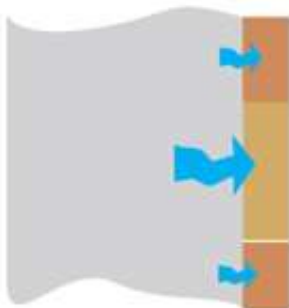


grindnesten



zandstrepen

oorzaak:



bekisting
meer absorberend
= lagere W/C-factor
= beton donkerder



lekkende
bekistingsnaad



storten op
ontmengd
beton

te vermijden door:

- homogeen bekistingsmateriaal
- bekisting nat maken vóór storten
- goede bekistingsmaterialen
- stijvere bekisting
- bekisting nat maken vóór storten
- juiste beton-samenstelling
- geschikte verdichtingstechniek

3a1 bekisting *courante gebreken*

probleem:



luchtballen

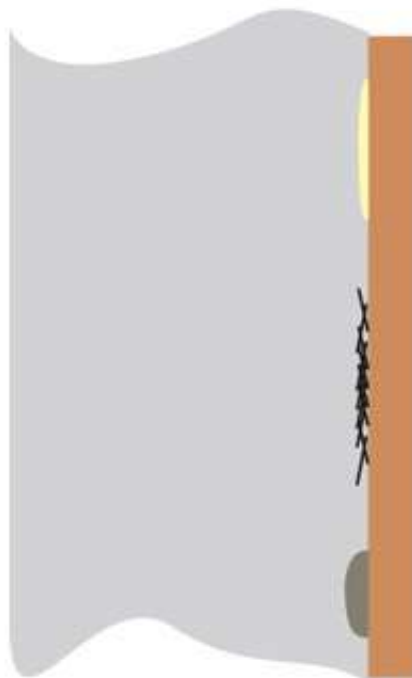


*tintverschillen,
oneffenheden,
onzuiverheden,
...*

oorzaak:



ontkistingsproduct
niet geschikt voor
gladde bekisting



ijs, rijm

vuil, roest

aarde...

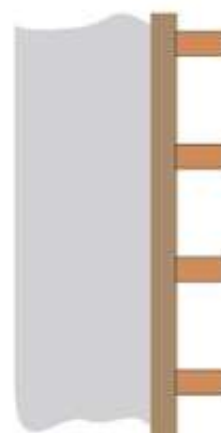
te vermijden door:

keuze ontkistingsproduct,
verdichtingstechniek

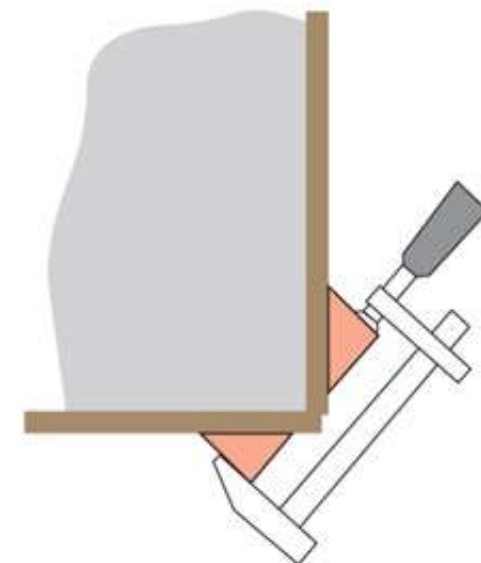
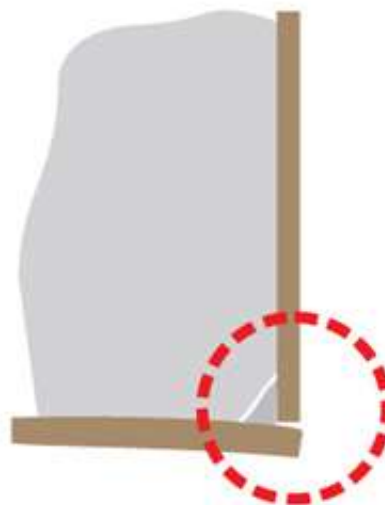
nazicht bekisting voor het
storten

3a1 bekisting *courante gebreken*

onvoldoende
stijve bekisting

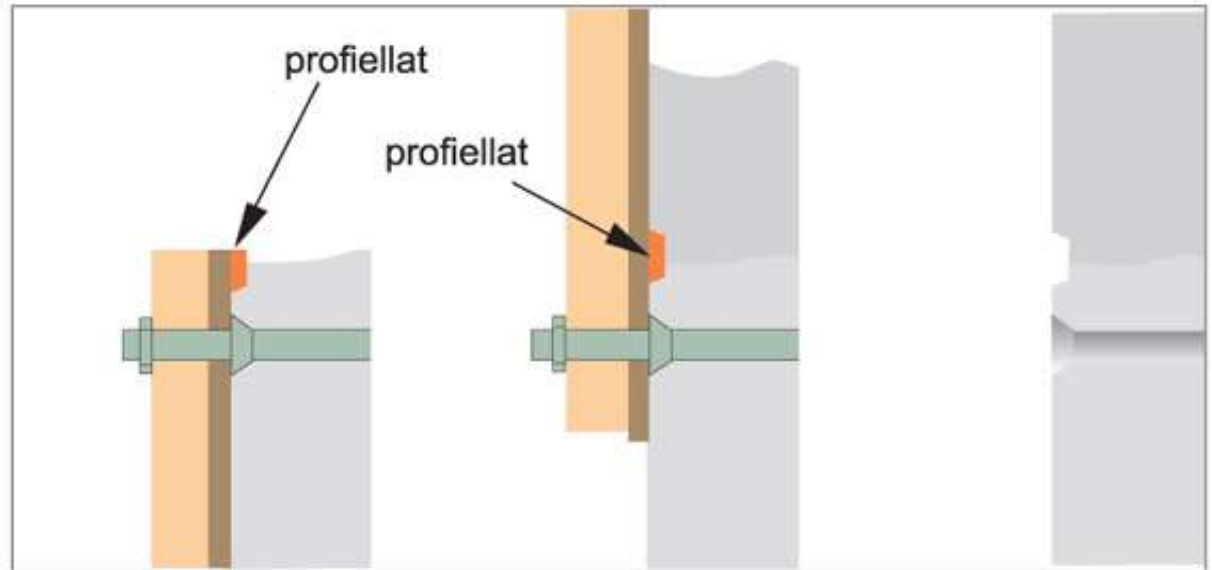
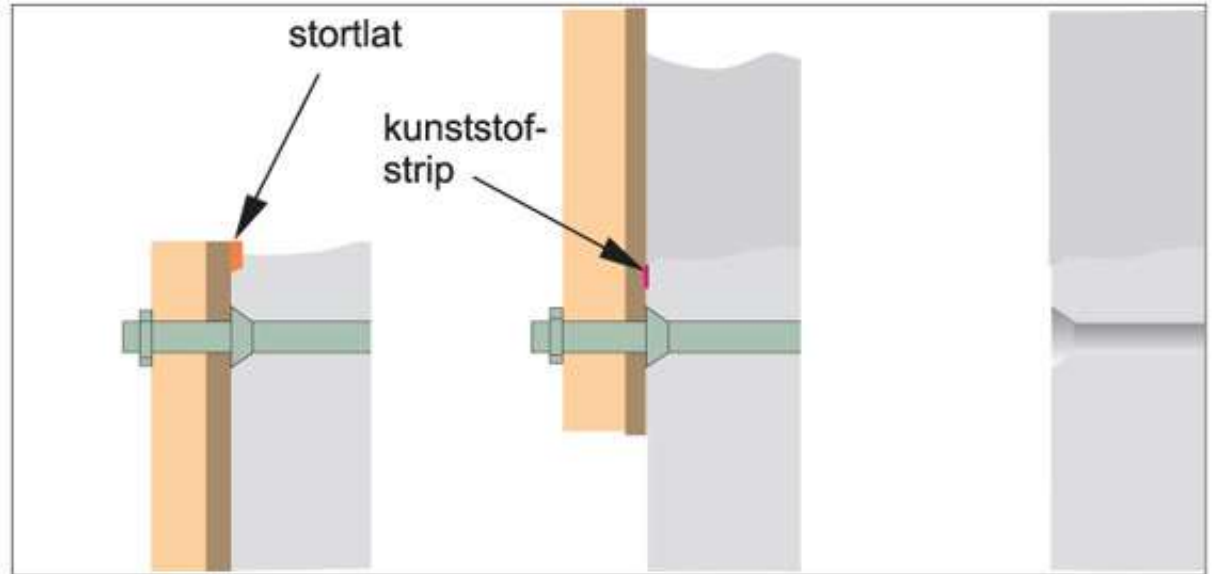
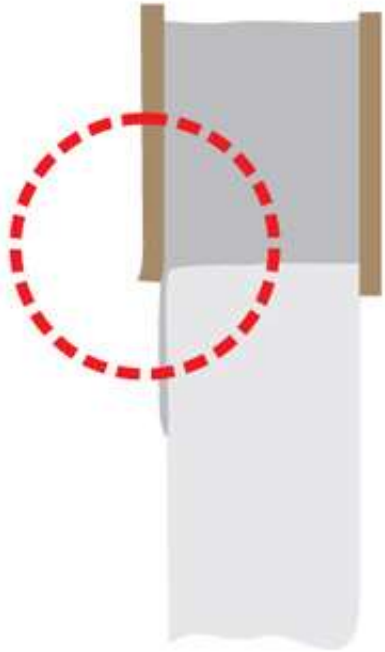


hoeken !



3a1 bekisting *courante gebreken*

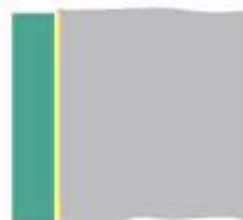
hernemingen (stortnaden)



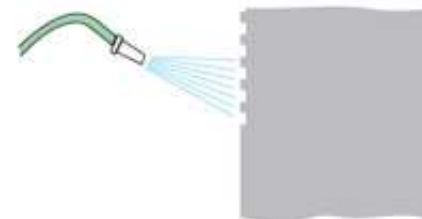
3a1 bekisting *ontkistingsproducten*

metaal, kunststof, multiplex, gebakeliseerd hout,...

● olie
(mineraal of plantaardig,
zuiver of in waterige emulsie)



● bindingsvertrager



● was (poriënvuller)



tijdens storten:
product moet aan bekisting hechten

3a1 bekisting *ontkistingsproducten*

ongeschaafd hout



bekisting nat maken



siliconen, rubber

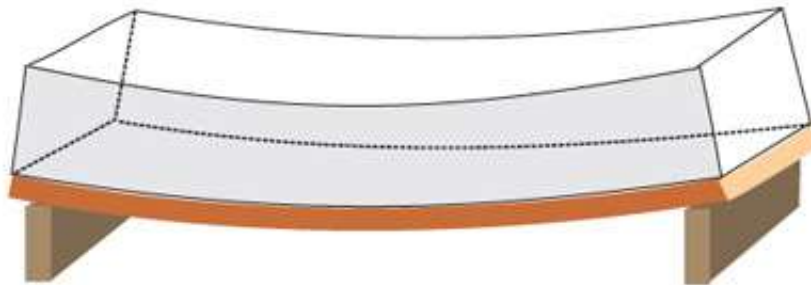
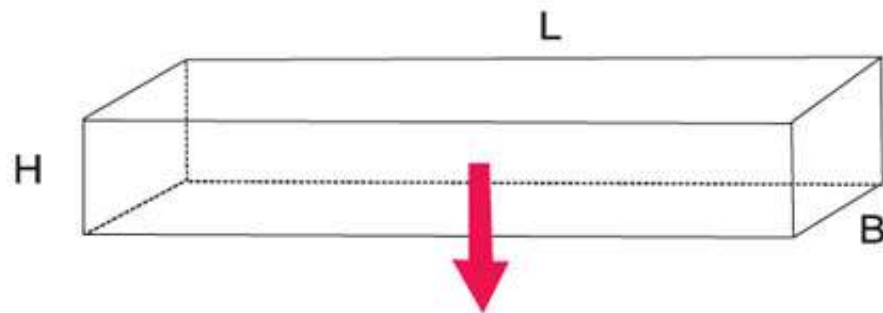
geen ontkistingsproduct
nodig



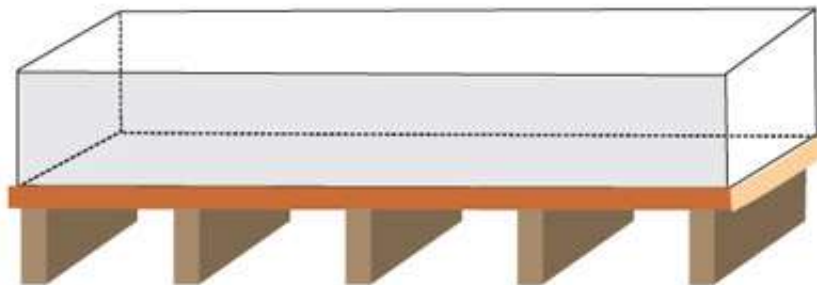
3a1

bekisting

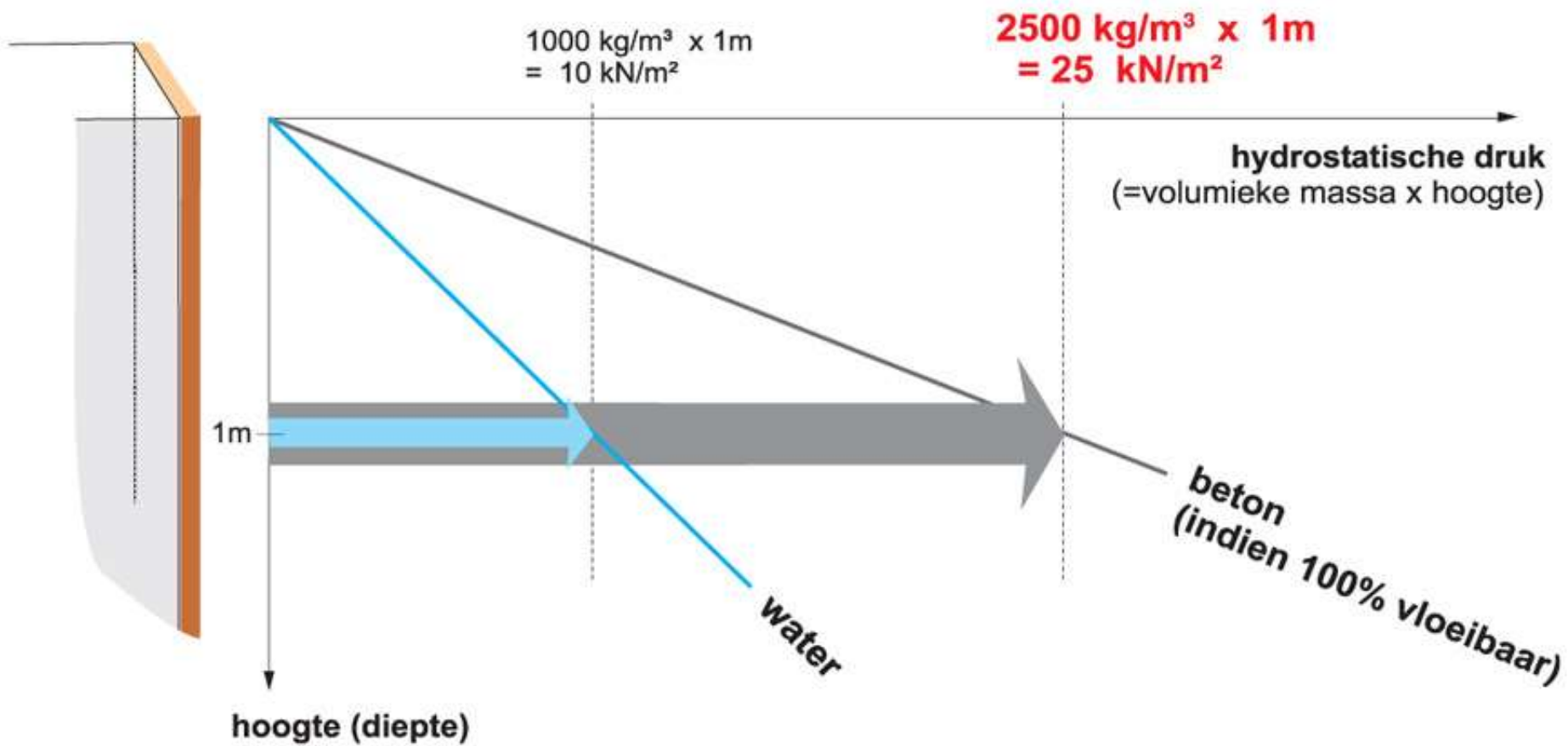
betonspeciedruk - VERTICAAL



$L \times B \times H \times 2500 \text{ kg/m}^3$!

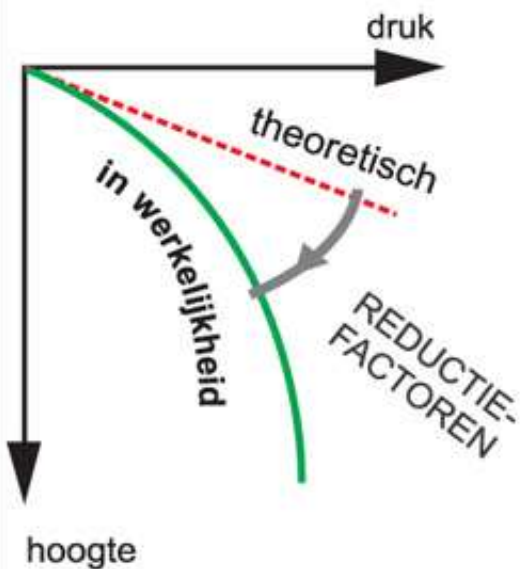


3a1 bekisting *betonspeciedruk - HORIZONTAAL*



3a1 bekisting

betonspeciedruk - HORIZONTALAAL



● CONSISTENTIE

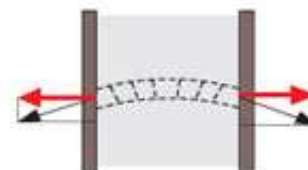
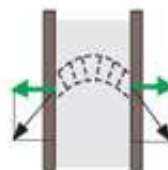
(lagere druk:)



(hogere druk:)



● GEWELFVORMING en 'SILO-EFFECT'



● WRIJVING (in functie van RUWHEID van de bekisting)



● STORT- en STIJGSNELHEID



liter/uur

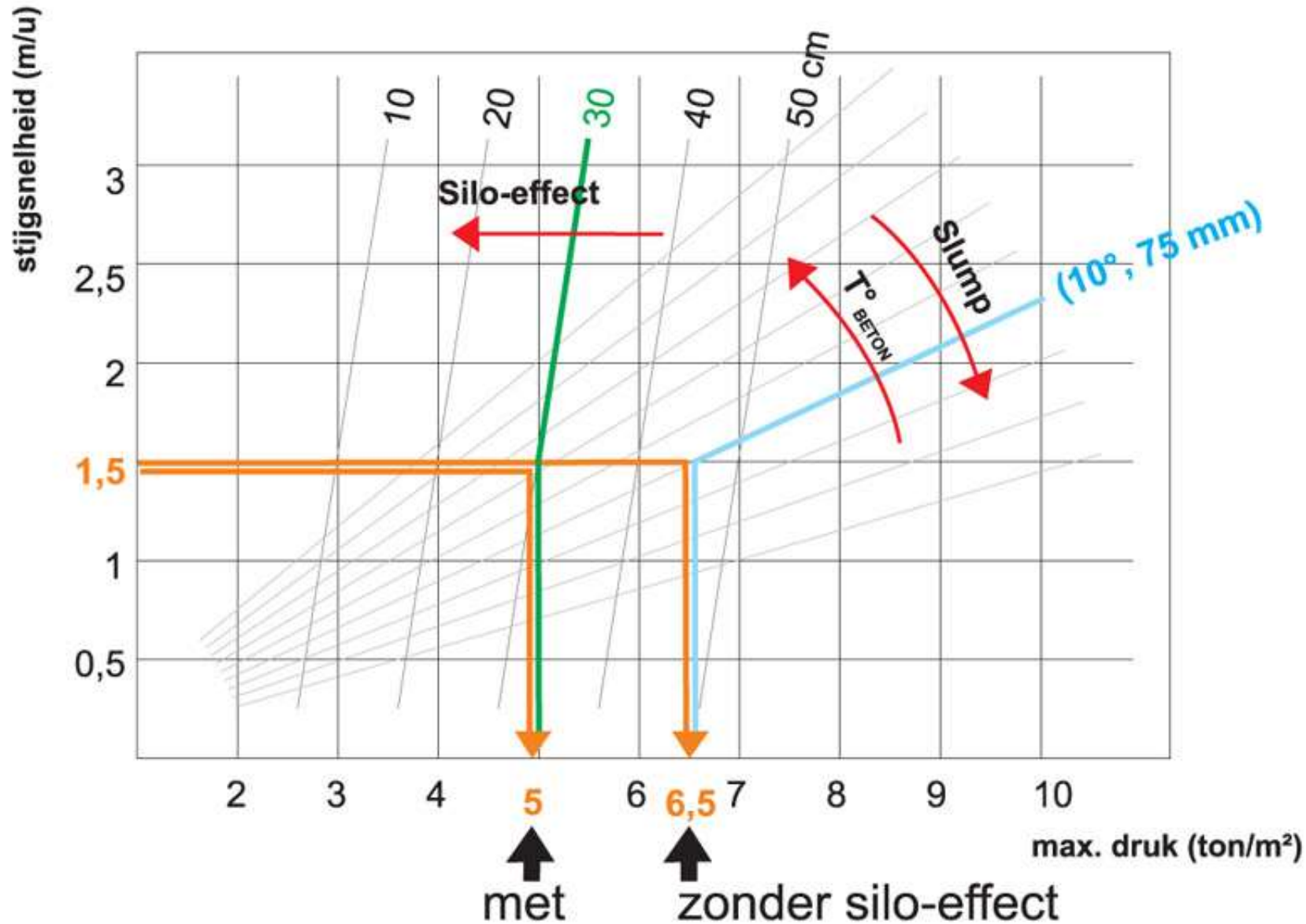


m³/min.

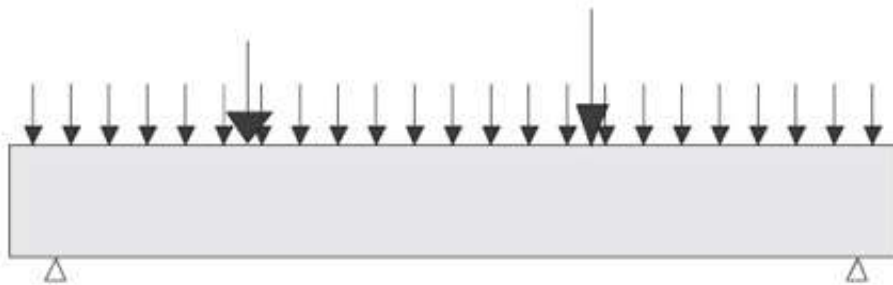
● OPSTIJVINGSTIJD (in functie van T°)



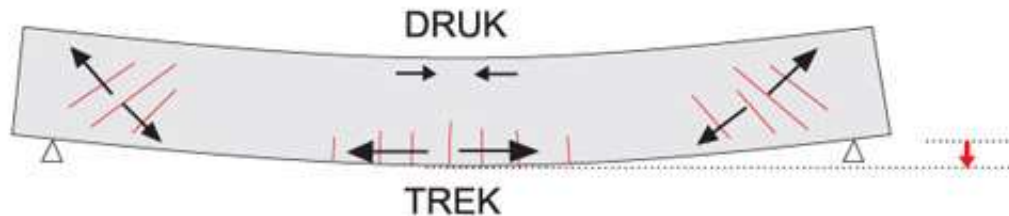
3a1 bekisting *betonspeciedruk - HORIZONTALAAL (voorbeeld)*



3a2 wapening *principe*



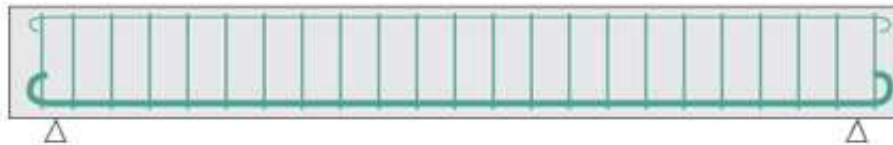
EIGENGEWICHT
NUTTIGE LAST
VEILIGHEIDSCOEFFICIENTEN



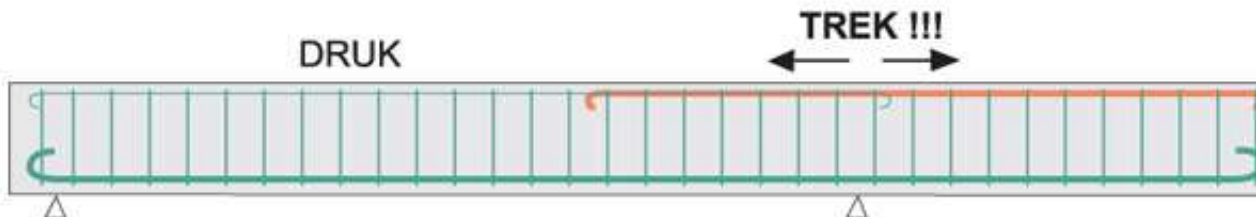
zonder wapening:
SCHEUREN
DOORBUIGING + breuk



WAPENING (THEORETISCH)
BETON = DRUK
WAPENING = TREK



WAPENING (in de PRAKTIJK)

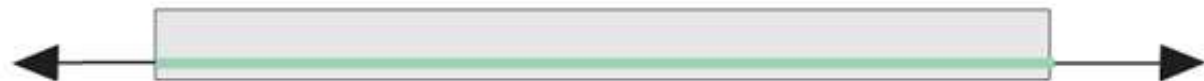


UITKRAGING,
BALKON...

3a2 wapening *voorspanning (door voorgerekte wapening)*



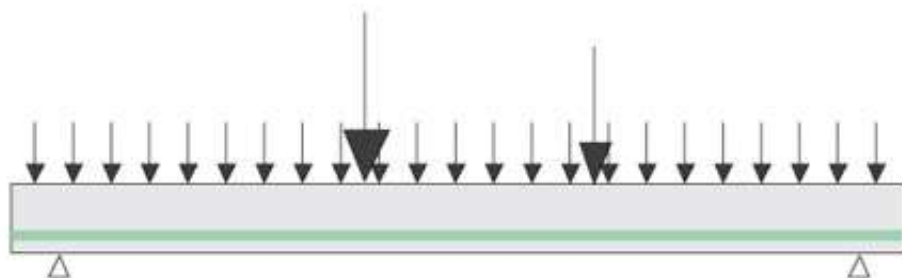
VOORSPANNEN
van de wapening



BETONNEREN



ONTKISTEN
ONDER SPANNING
BRENGEN van het beton



BELASTEN

3a2 wapening *vezels*

● staalvezels

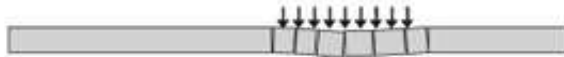
types (voorbeelden):



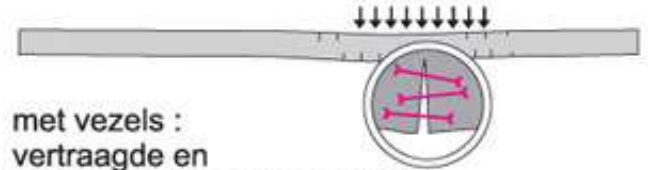
$L = 30 - 100 \text{ mm}$

$\varnothing = 0,1 - 1 \text{ mm}$

functie: verbeteren gedrag van verhard beton

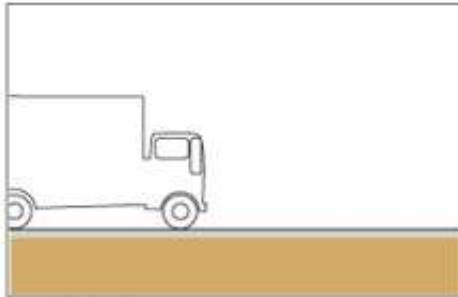


ongewapend: scheuren lopen door

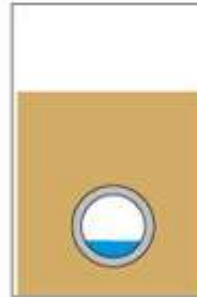


met vezels :
vertraagde en
gecontroleerde scheurvorming

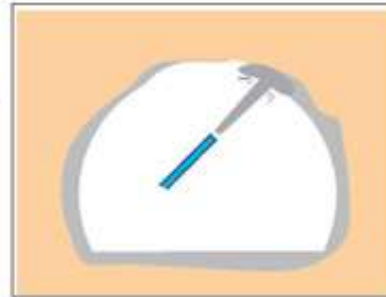
toepassingen (voorbeelden):



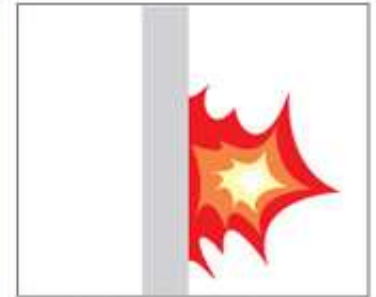
bedrijfsvloeren



buizen



tunnels
(spuitbeton)



explosiebestendige
constructies

dosering: $\sim 30 \text{ kg per m}^3 \text{ beton}$ ($\sim 30 \text{ vezels per } 10 \times 10 \text{ cm}^2 \text{ scheuroppervlak}$)



- enkel doeltreffend indien gelijkmatig verspreid in betonmassa

- verwerkbaarheid van het beton daalt $\Rightarrow$ betonsamenstelling aanpassen ($D_{\max} \downarrow$)

3a2 wapening vezels

• kunststofvezels (polypropyleen, nylon...)

types:

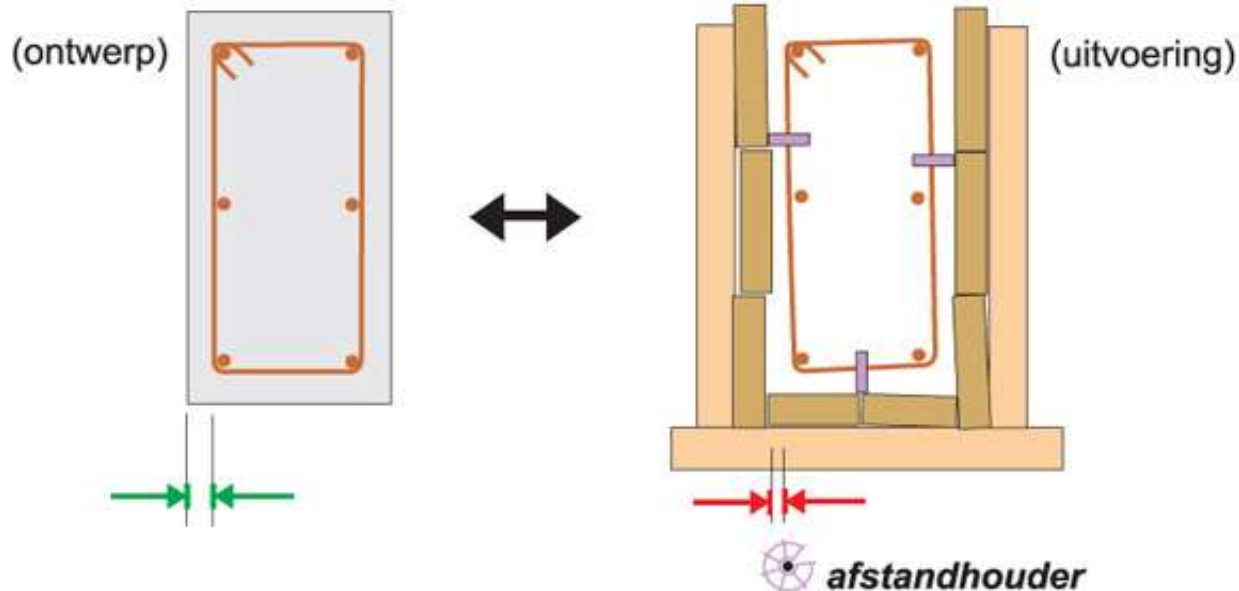


$L = 10 - 40 \text{ mm}$
 $\varnothing = 20 - 600 \text{ }\mu\text{m}$

	vers/jong beton	verhard beton
<i>functie:</i>	nemen trekspanningen op bij plastische krimp ⇒ minder scheurvorming ⇒ oppervlaktelaag van betere kwaliteit (beter bestand tegen vorst, agressieve stoffen...)	grotere brandweerstand zonder vezels: ingesloten stoom ⇒ afbrokkeling ("spalling") met vezels: vezels smelten ⇒ netwerk van kleine kanaaltjes ⇒ stoom kan ontsnappen hogesterktebeton (HSB) > 2,5 kg per m³ beton (monofilament-vezels)
<i>toepassing:</i>	- wegverhardingen - bedrijfsvloeren	
<i>dosering:</i>	0,6 - 1 kg per m³ beton (> 20 000 vezels per 10x10 cm² scheuoppervlak)	

3a2 wapening

corrosie - betondekking



milieuklasse	1	2a	2b	3, 3S	4a, 4b	5a	5b	5c
minimum betondekking (mm)	15	20	25	40	40	25	30	40
<i>indien voorgespannen beton</i>	25	30	35	50	50	35	40	50



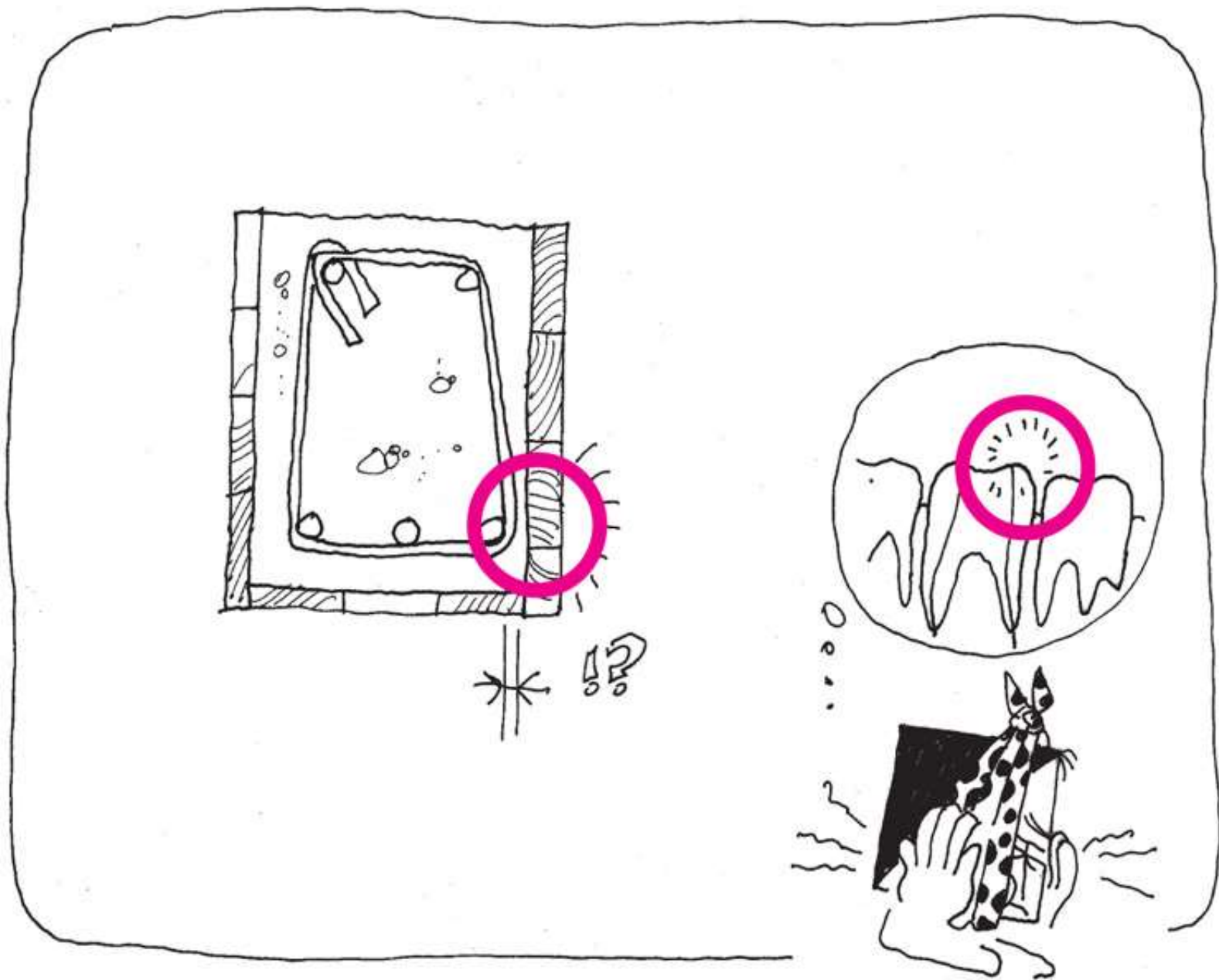
- niet van toepassing voor prefab beton
- voorzie toleranties: 5 à 10 mm !

minimum betondekking.....

2b1

corrosie.....

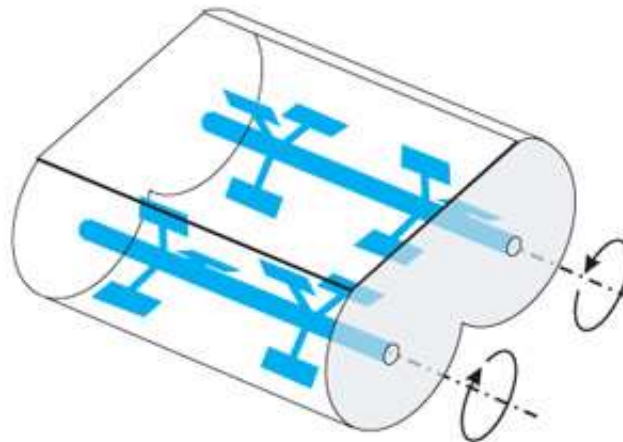
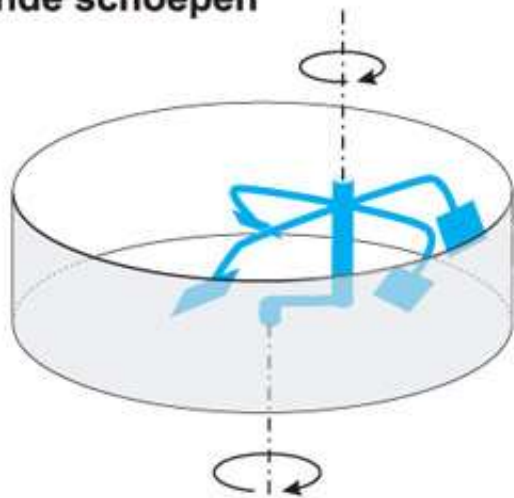
4b4



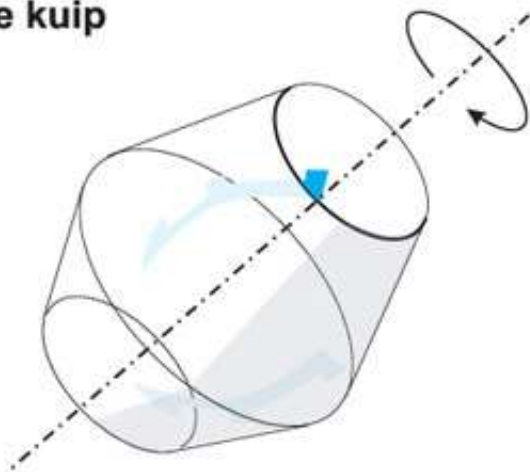
Onvoldoende betondekking: vaak een pijnpunt...

3b1 mengen *types mengers*

draaiende schoepen



draaiende kuip

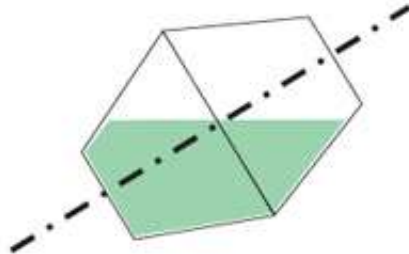


3b1

mengen

parameters / factoren

capaciteit

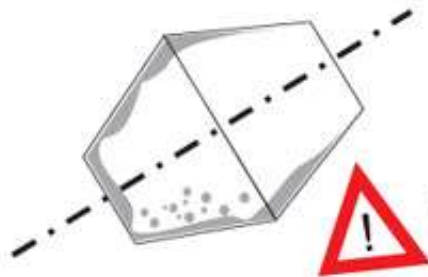


nuttige (~ 50% van de totale capaciteit)

mengtijd



volgorde



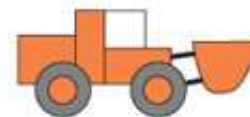
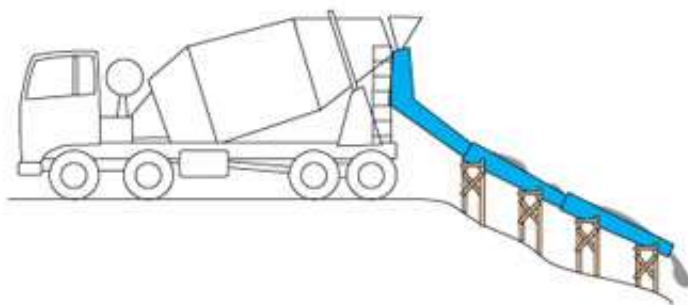
nooit cement eerst (klontervorming...)

3b2 transporteren *materieel*

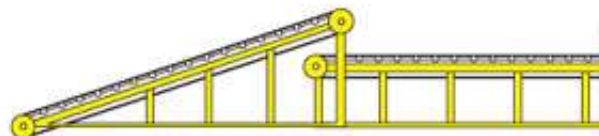
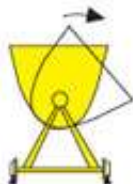
weg



bouw-
plaats



fabriek



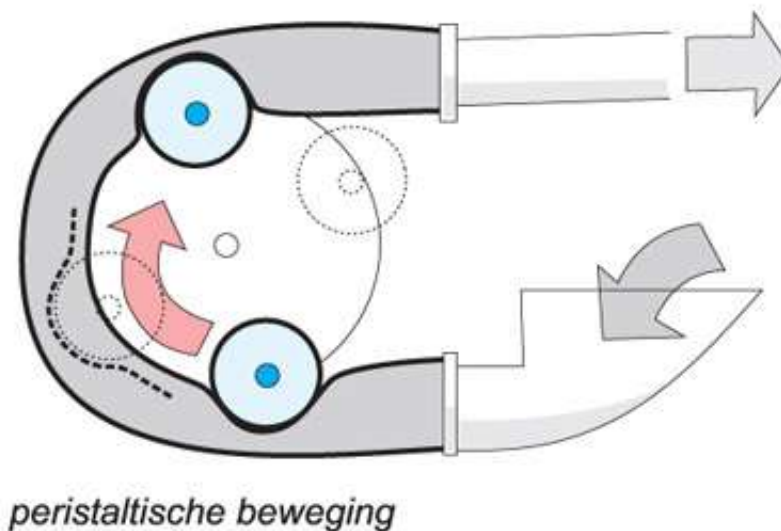
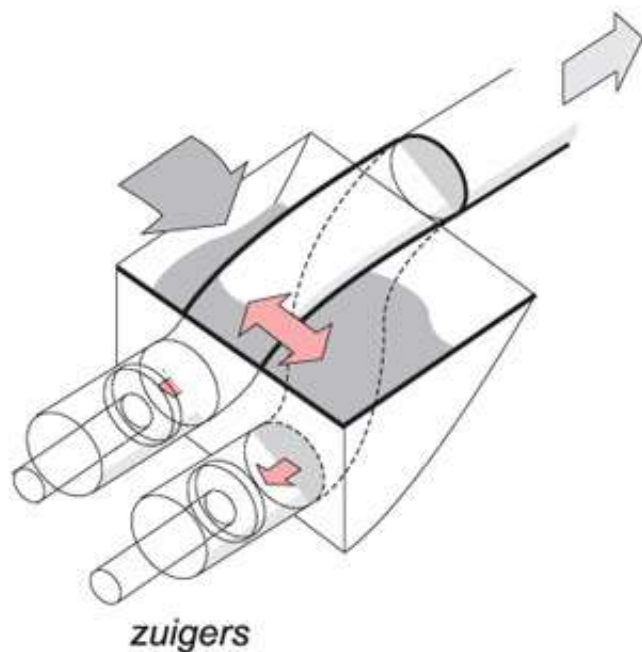
3b2 transporteren *materieel*

betonpompen

debiet = 20-80 m³/uur

L : tot 300 m

H: tot 100 m



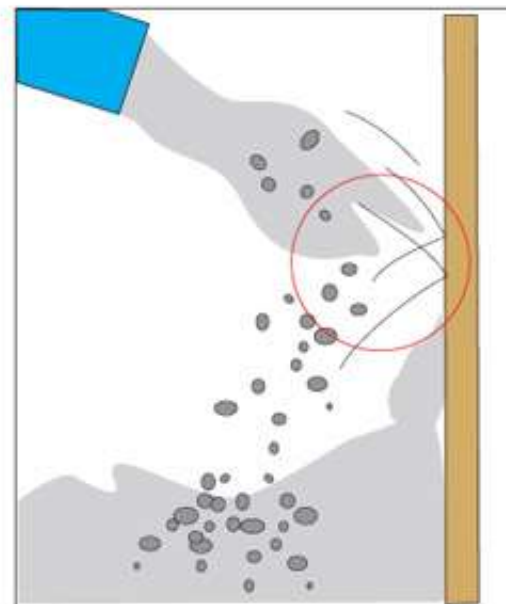
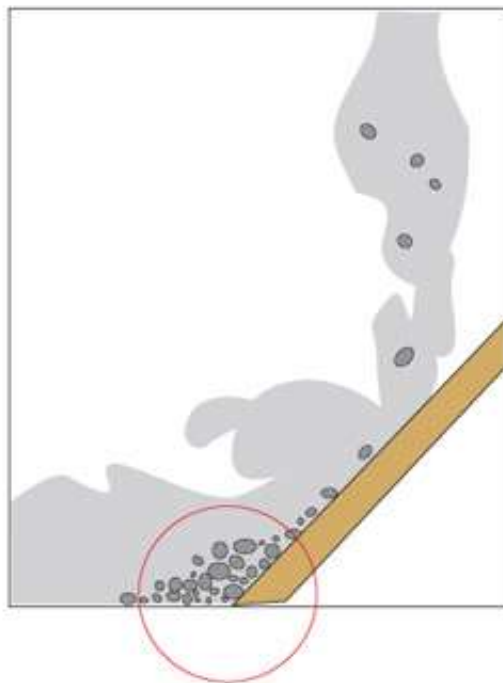
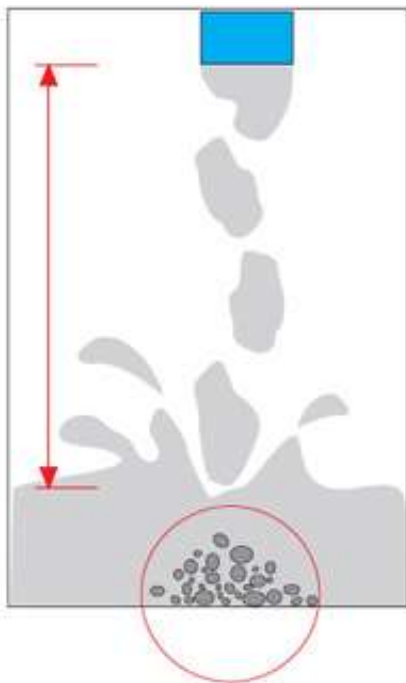
pompbeton =

- continue korrelverdeling
- voldoende fijne deeltjes

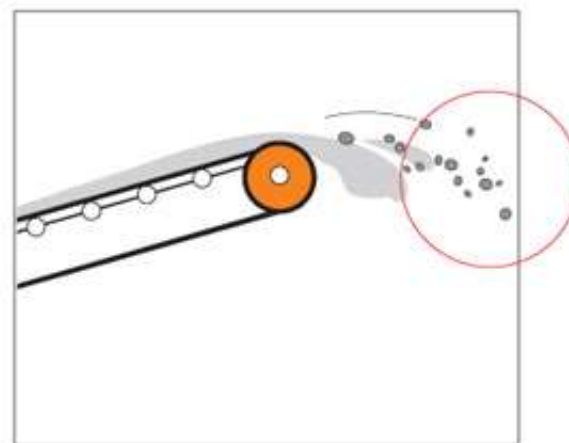
3b3

storten

courante fouten



 **ONTMENGING...**

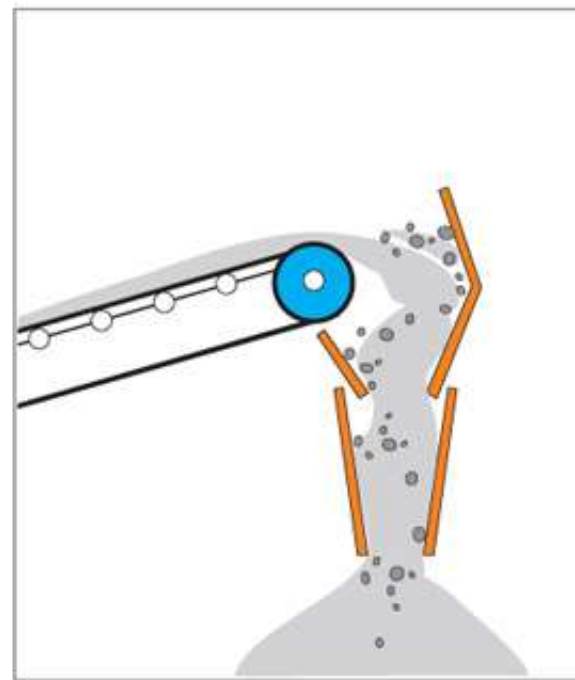
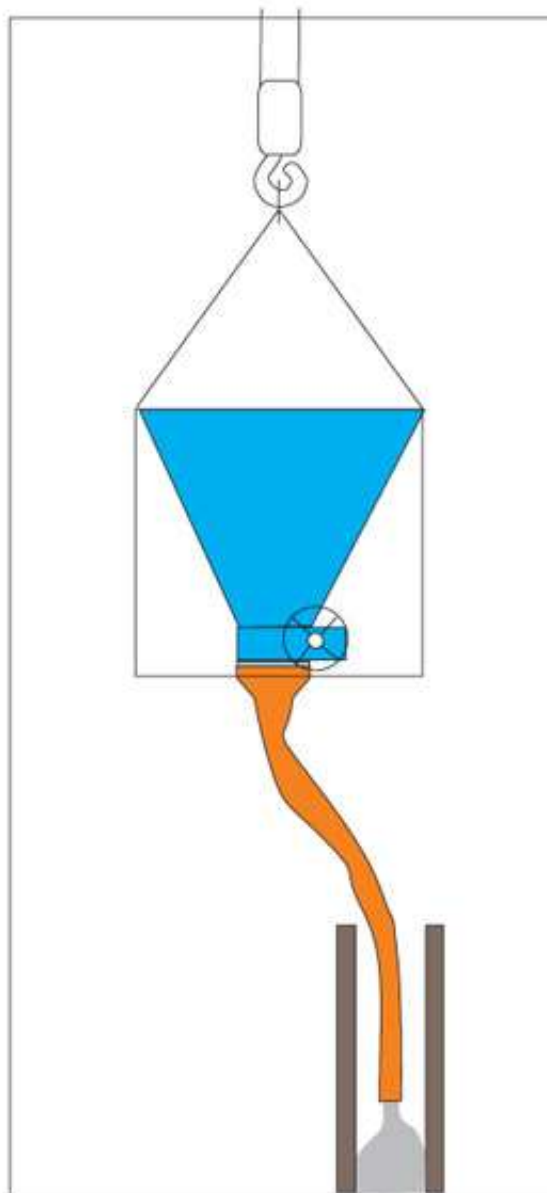
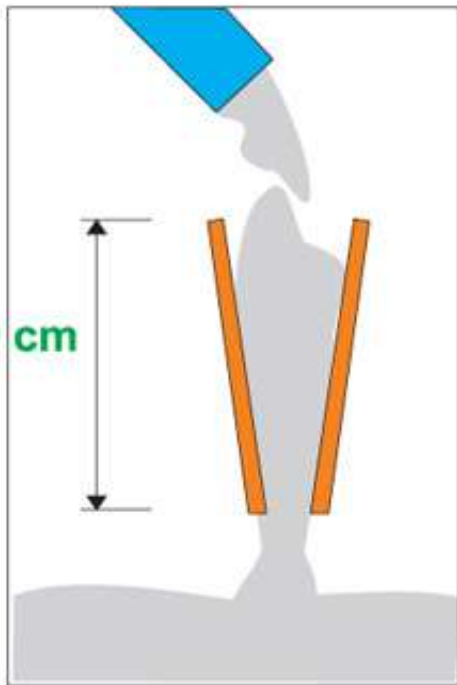


3b3

storten

hulpmiddelen

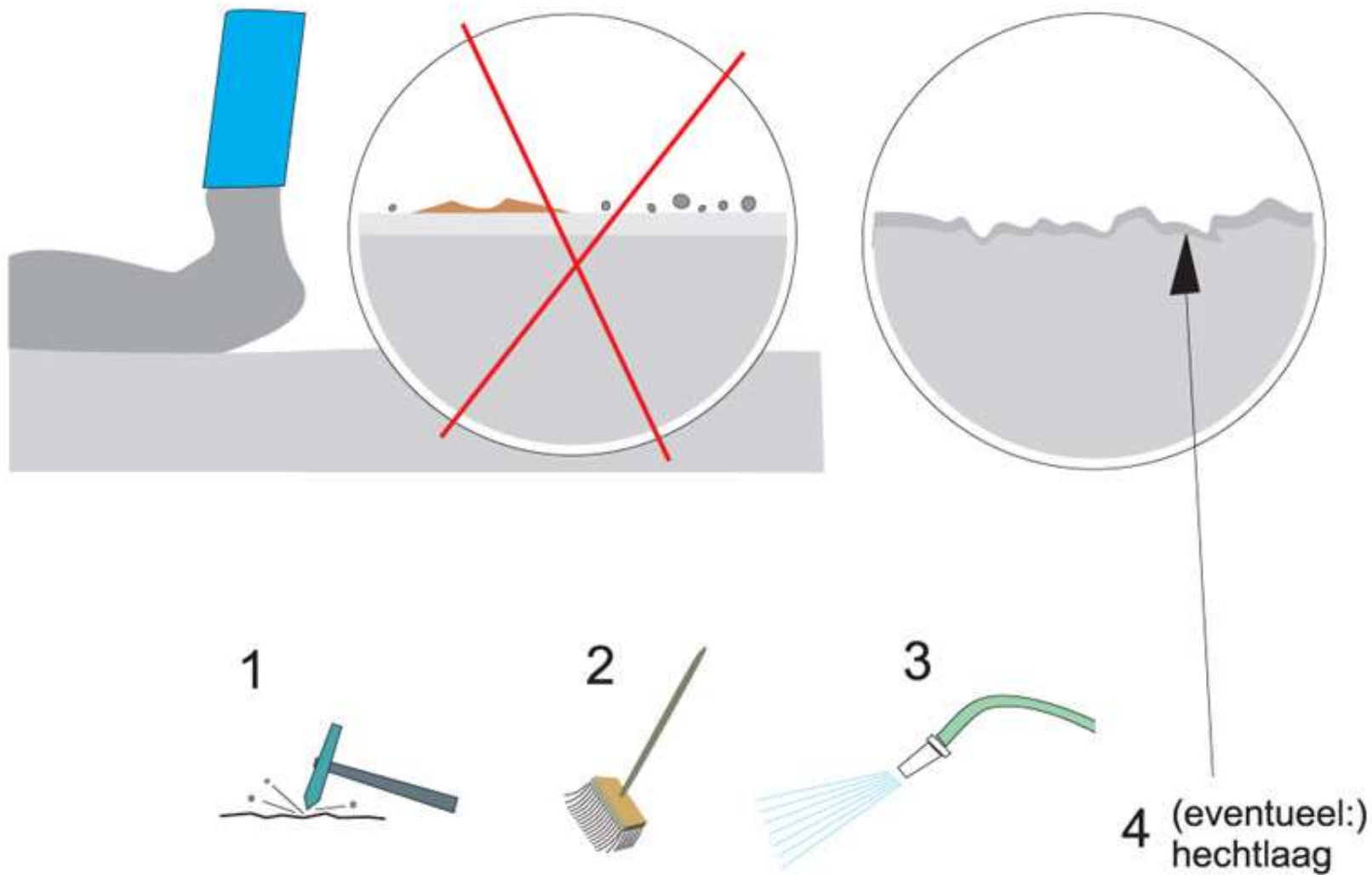
< 60 cm



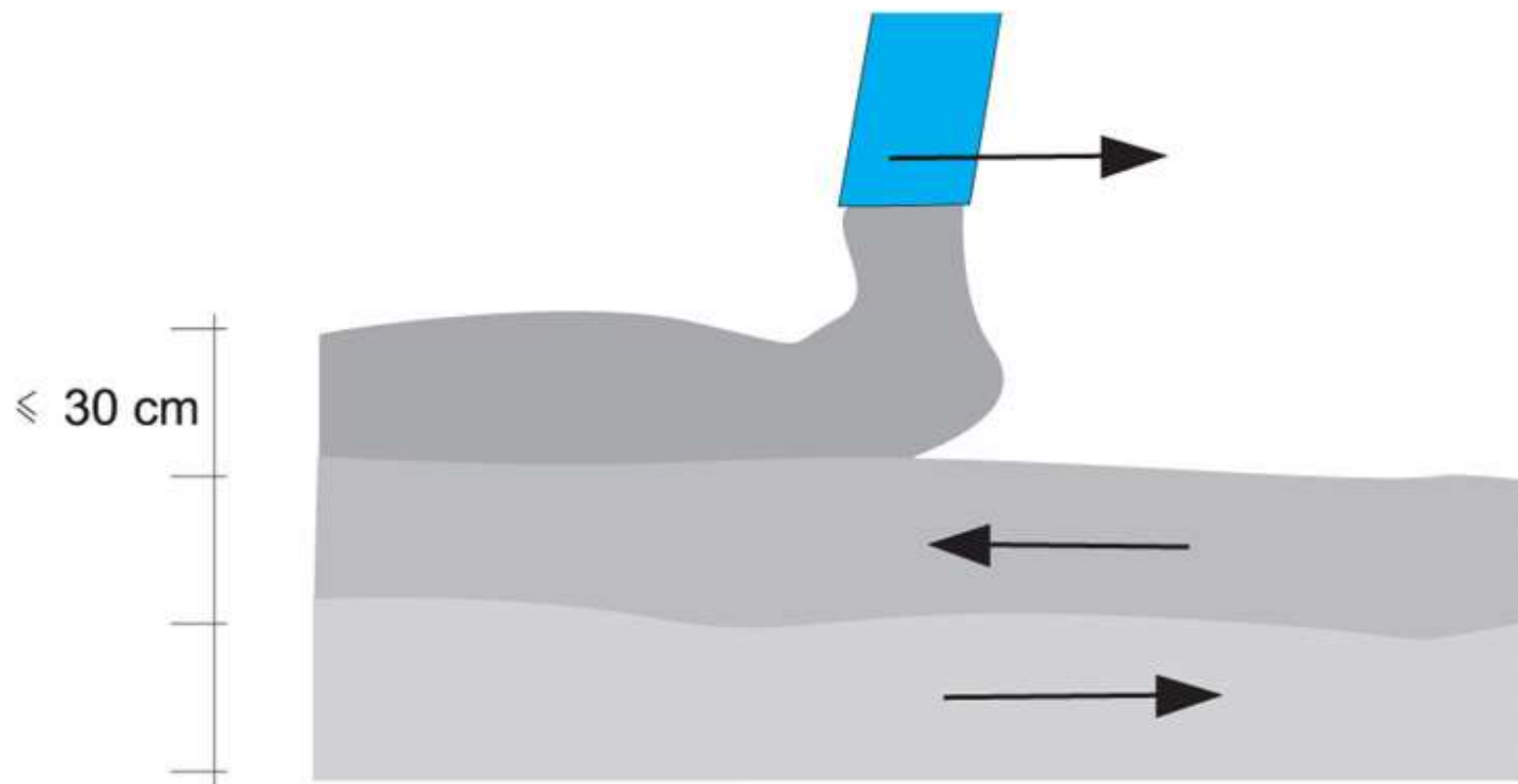
3b3

storten

voorbereiding



3b3 storten laagdikte



3b4 verdichten *doel*



onverdicht beton =

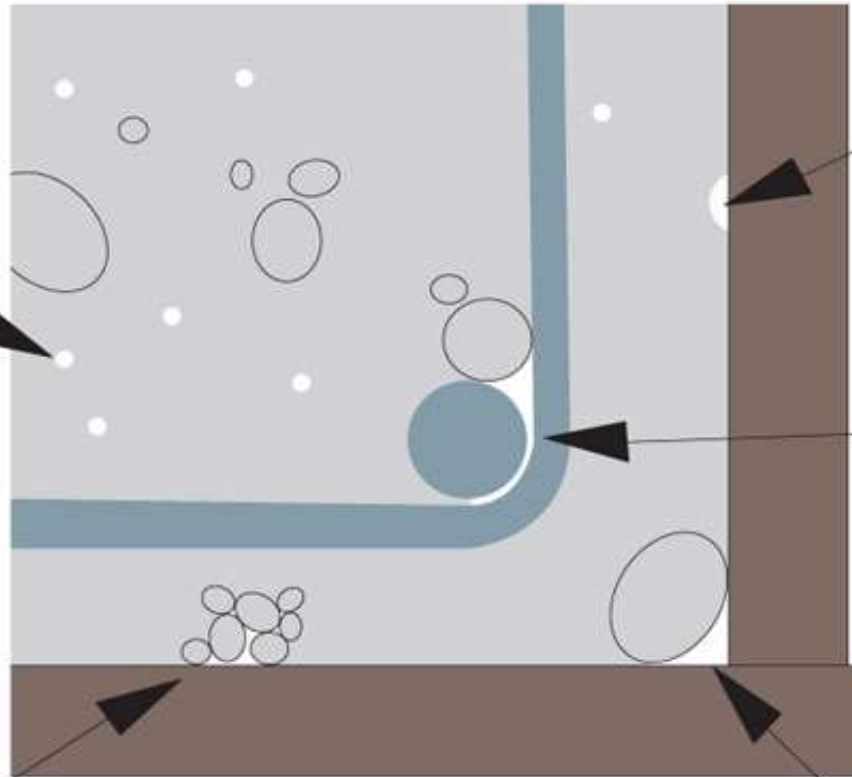
... 15 tot 20 % lucht

... luchtballen
op bekisting

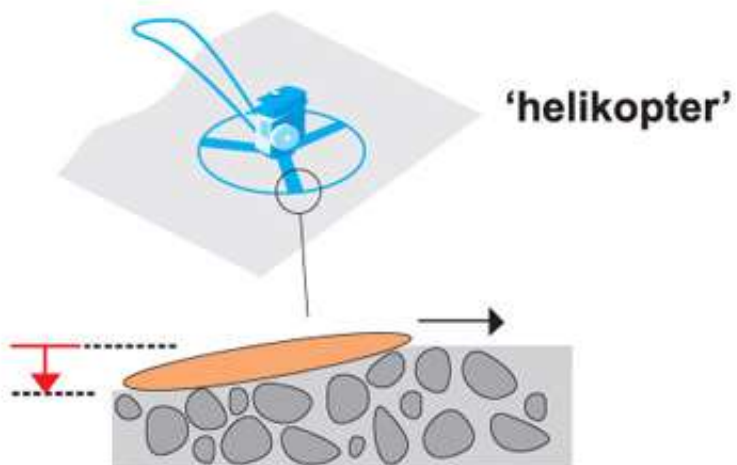
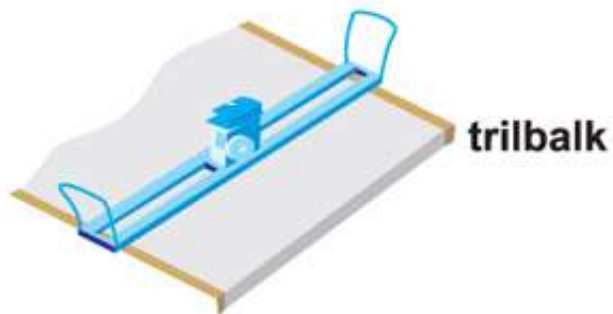
... wapening
niet omhuld

... granulaten
niet omhuld

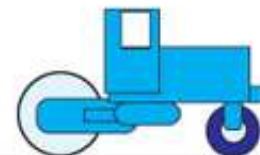
... hoeken
niet gevuld



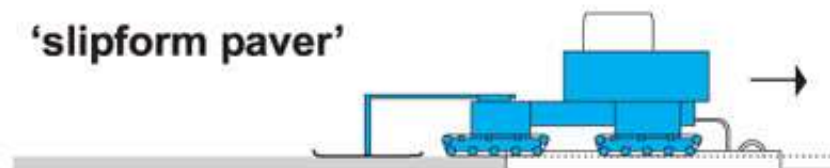
3b4 verdichten *materieel - op de bouwplaats*



wals



'slipform paver'

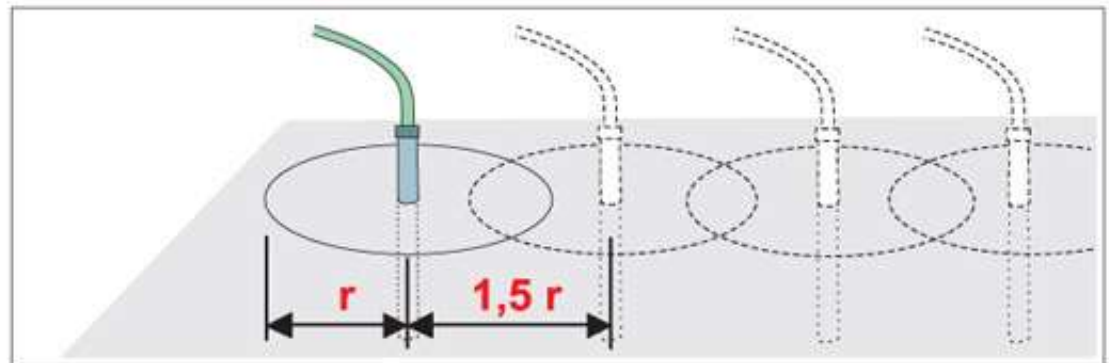
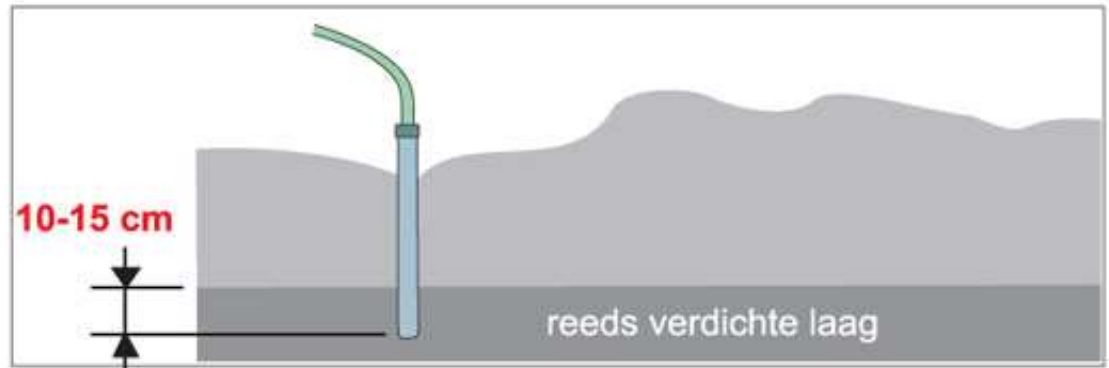
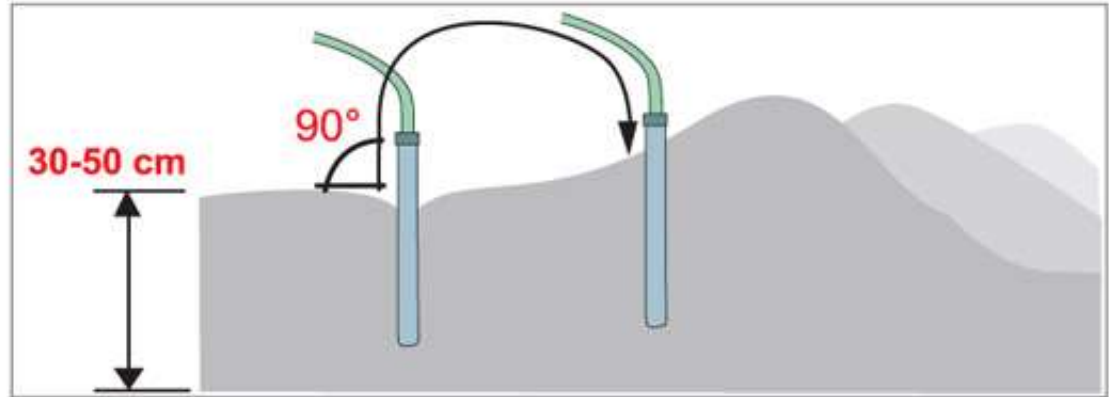
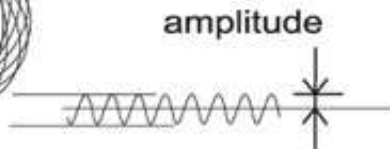


3b4 verdichten *materieel - op de bouwplaats / in de betonfabriek*

trilnaald

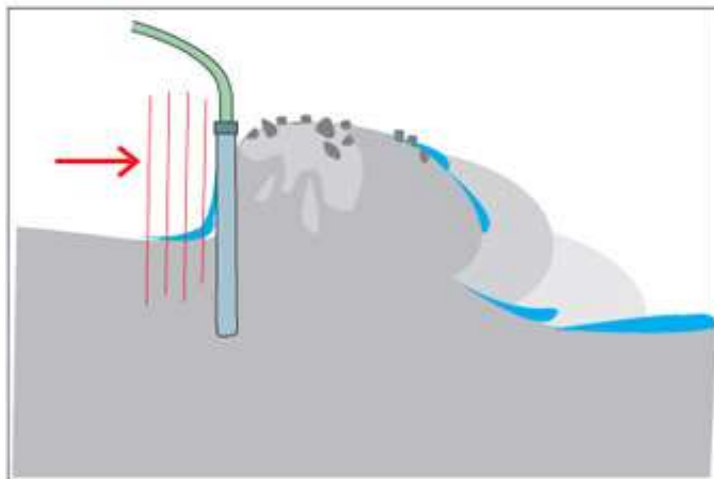


12.000 t/min
(= 200 Hz)

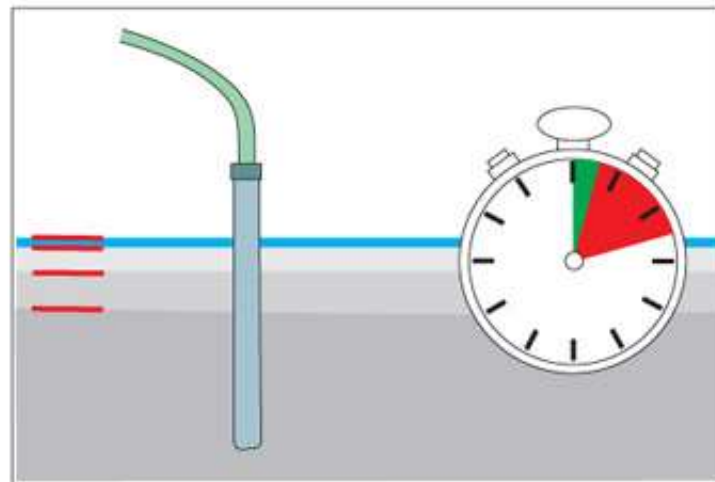


3b4 verdichten *materieel - op de bouwplaats / in de betonfabriek*

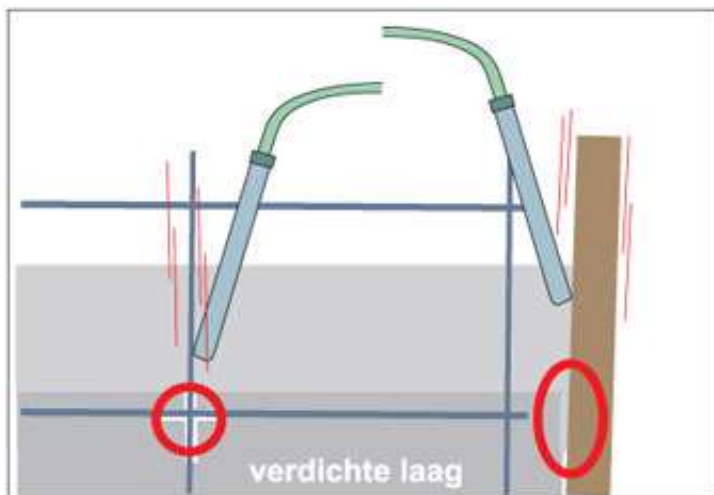
trilnaald



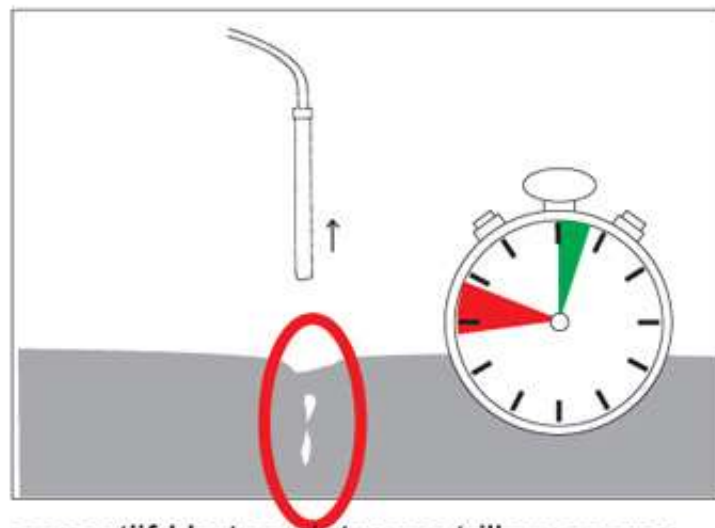
trilnaald niet gebruiken om beton open te spreiden...



te lang trillen = ontmenging...



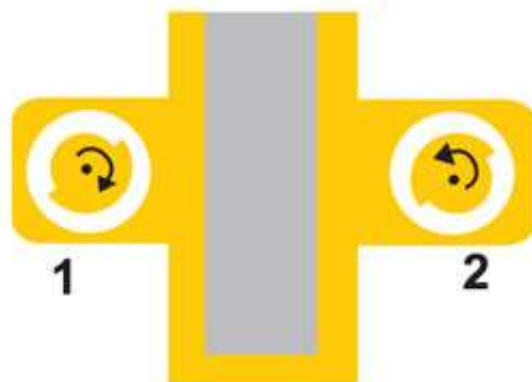
wapening niet trillen: geen goede hechting...
bekisting niet trillen: lekken...



opgestijfd beton niet meer trillen: sporen...

3b4 verdichten *materieel - in de betonfabriek*

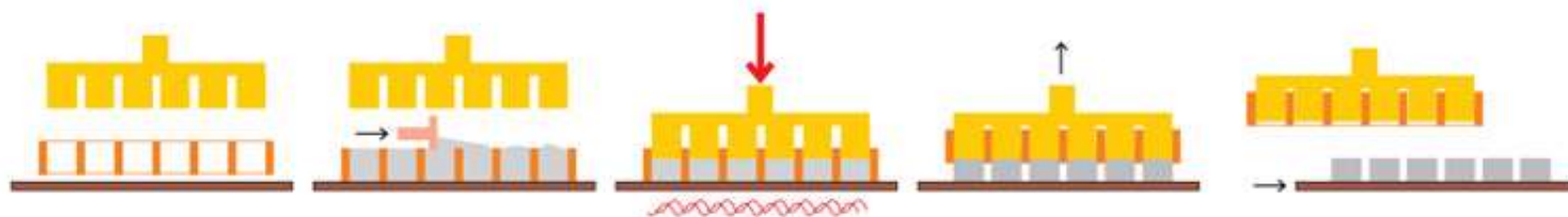
bekistingstrillers



schoktafels

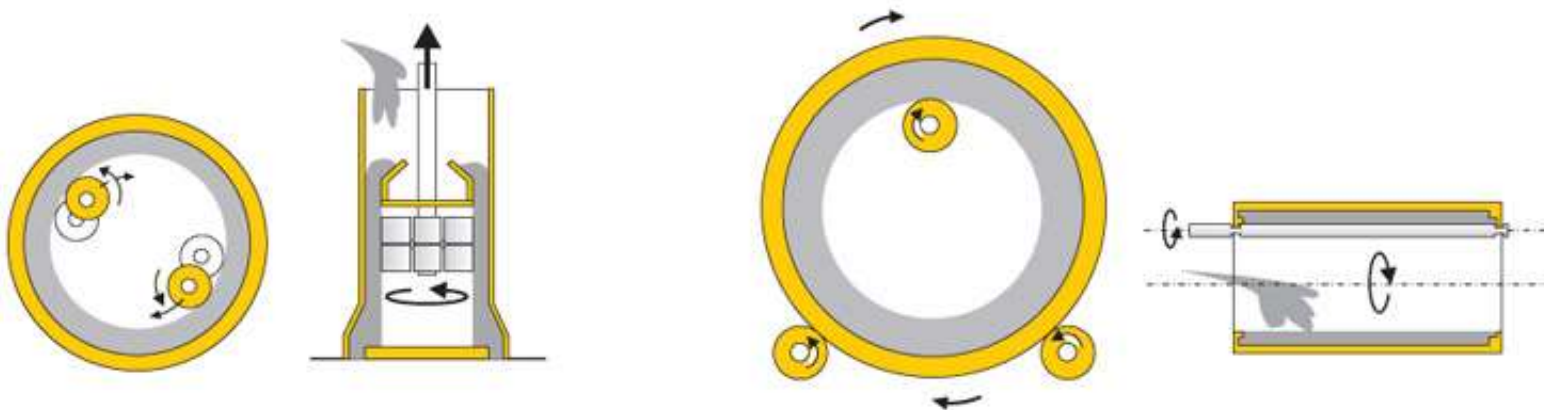


persen

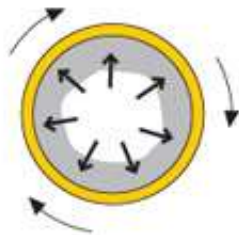


3b4 verdichten *materieel - in de betonfabriek*

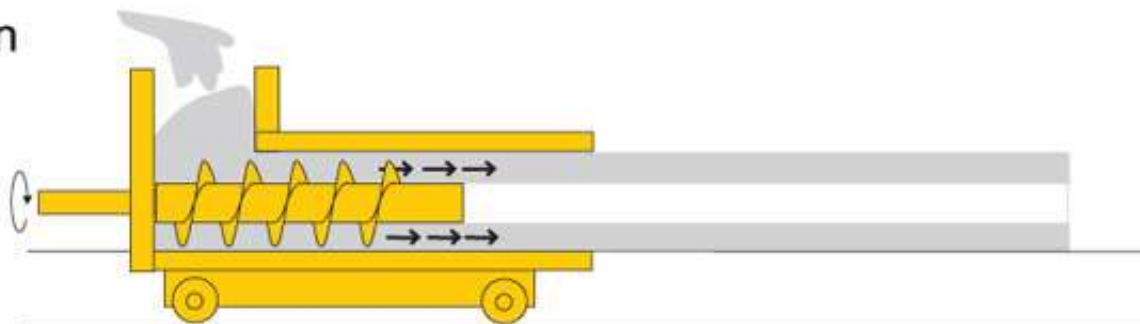
walsen



centrifugeren



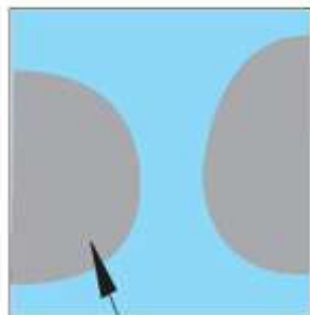
extruderen



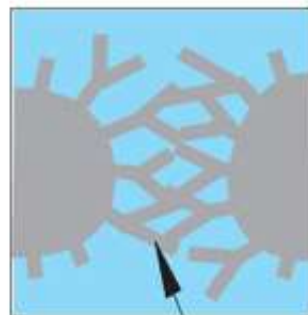
3b5 beschermen *tegen uitdroging*

zoniet...

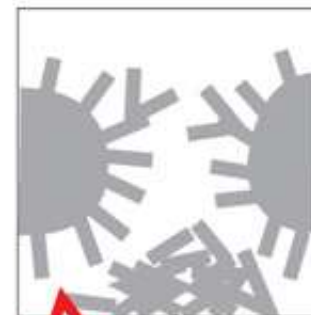
“verbranden”



cementkorrel

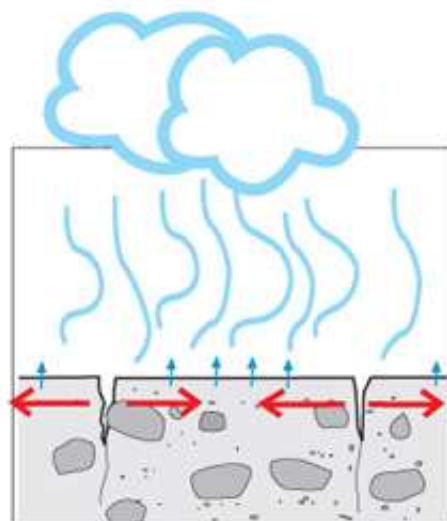


cementhydraten



hydratatie onderbroken
(niet recupereerbaar
door bevochtigen !)

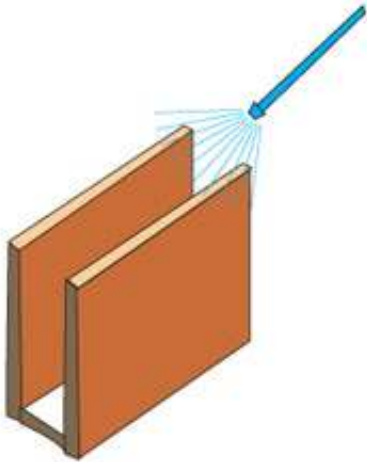
“plastische krimp”



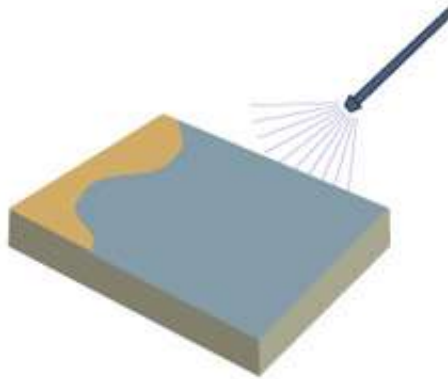
grote
trekspanningen
⇒ scheurvorming

3b5 **beschermen** *tegen uitdroging*

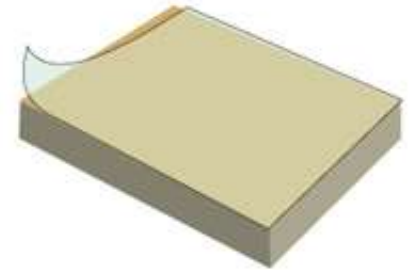
vóór betonneren:



bekisting nat maken



bitumen-emulsie



plastic folie



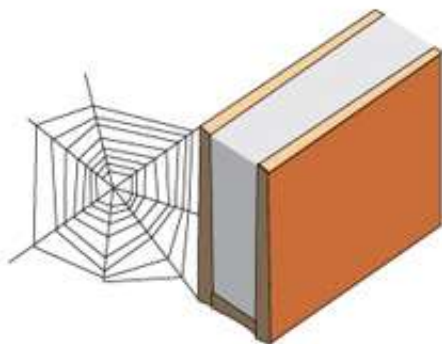
geen kleef met
onderlaag mogelijk

3b5

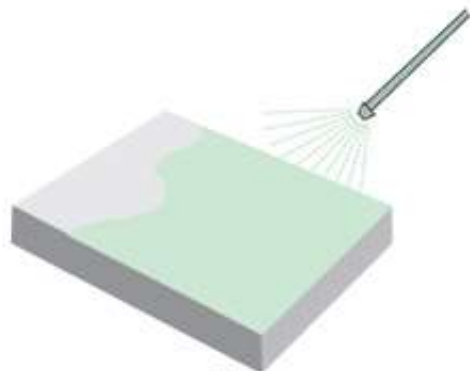
beschermen

tegen uitdroging

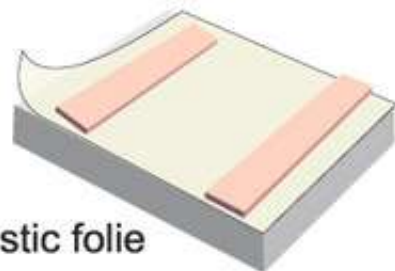
na betonneren:



niet te vroeg ontkisten



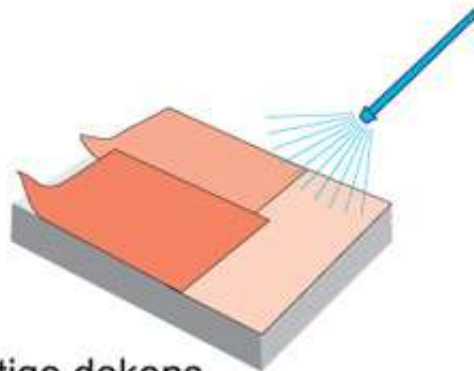
"curing compound"



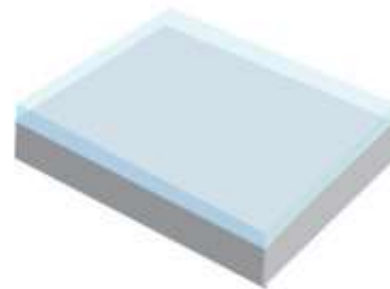
plastic folie



beschadiging
betonoppervlak
vermijden !



vochtige dekens



onder water zetten

3b5 beschermen *tegen uitdroging*

na betonneren:

*minimum beschermingsduur
(nabehandelings-)*

(in dagen, volgens NBN B15-001)

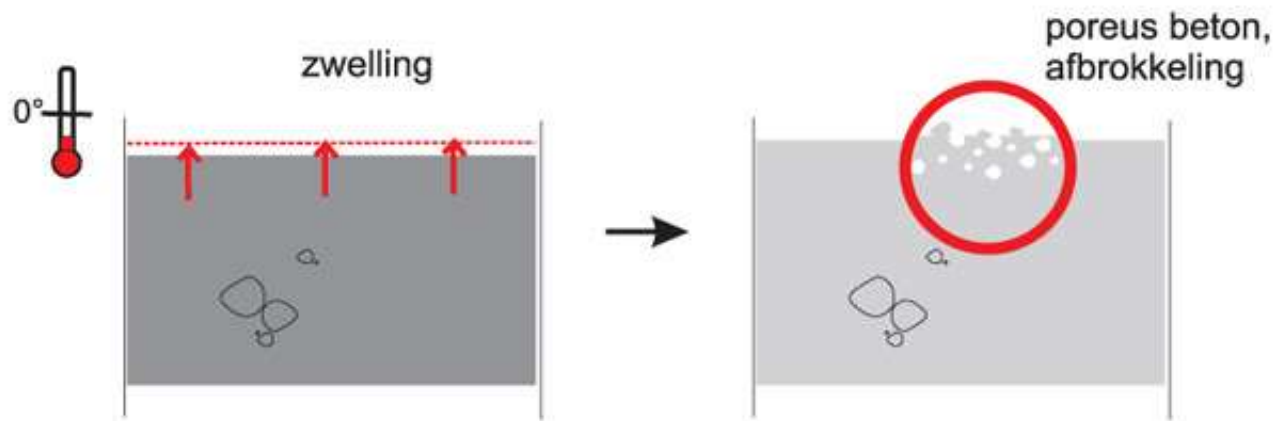
Sterkte-ontwikkeling Sterkteklasse cement W/C-factor	snel 42,5 - 52,5 < 0,5			matig 42,5 0,5 < W/C < 0,6			traag 32,5 - 42,5 > 0,6		
Betontemperatuur ≥ ... °C	5	10	15	5	10	15	5	10	15
 Geen zon R.V. ≥ 80 %	2	2	1	3	3	2	3	3	2
 Zon en/of matige wind (of R.V. ≥ 50 %)	4	3	2	6	4	3	8	5	4
 Zon en/of sterke wind (of R.V. < 50 %)	5	4	3	8	6	5	10	8	5



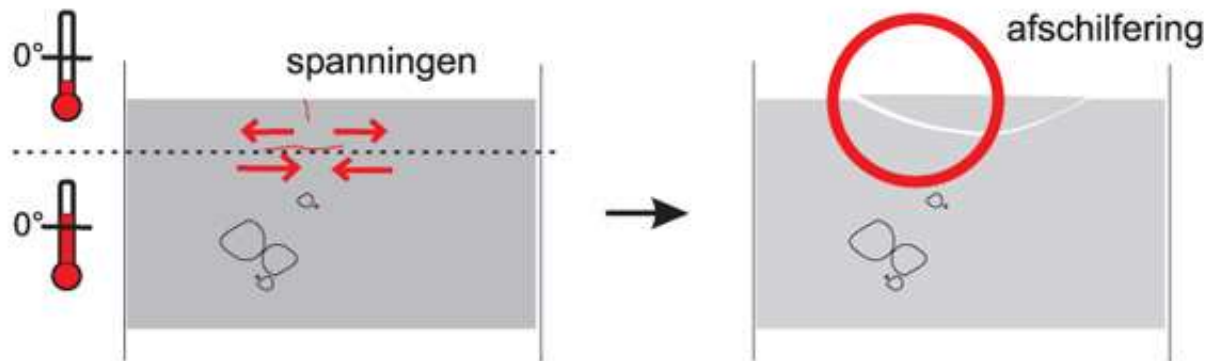
+ 2 dagen voor beton dat zal blootgesteld worden aan vorst, agressieve stoffen...

3b5 **beschermen** *tegen vorst*

vorst in
VERS beton



vorst in
JONG beton



vorst in verhard beton

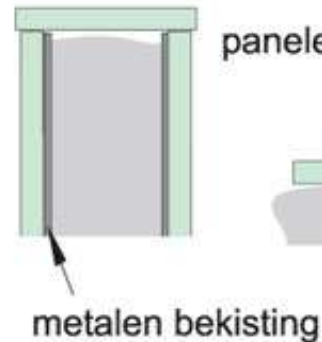
4b5

3b5 beschermen *tegen vorst*

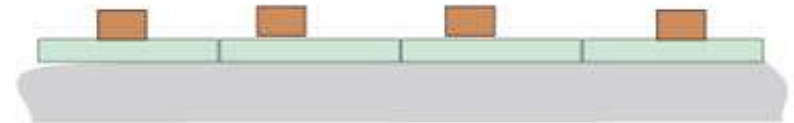
- afdekken



- afdekken + isoleren



panelen, dekens...



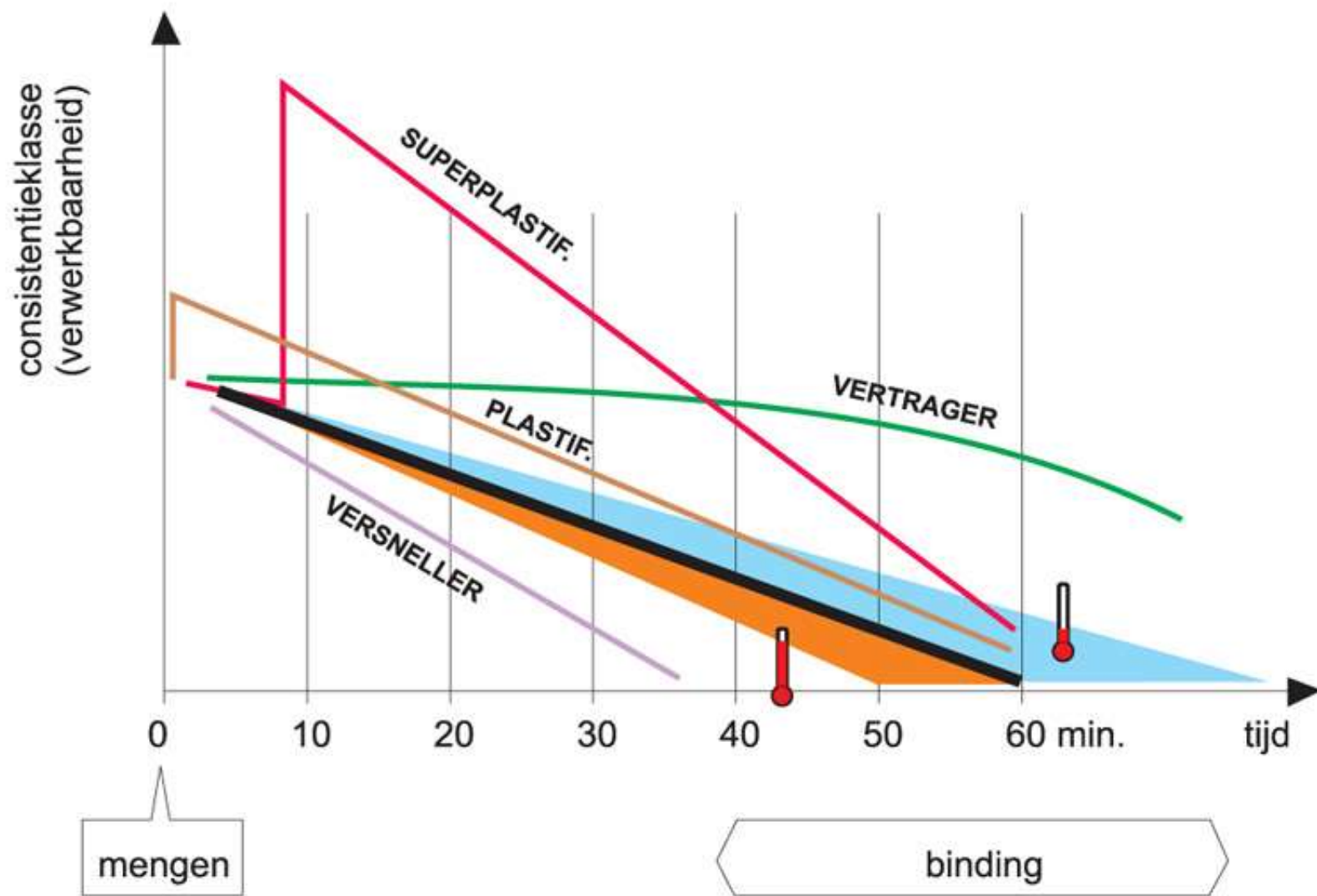
- cementkeuze: sterkteklasse 52.5 (R)

- hulpstoffen: bindingsversneller

1c

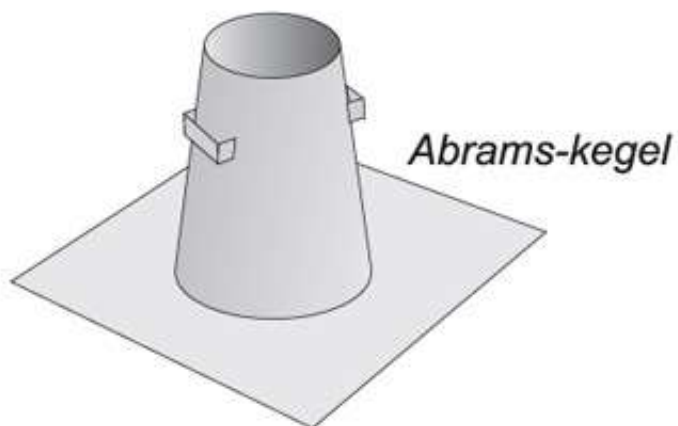
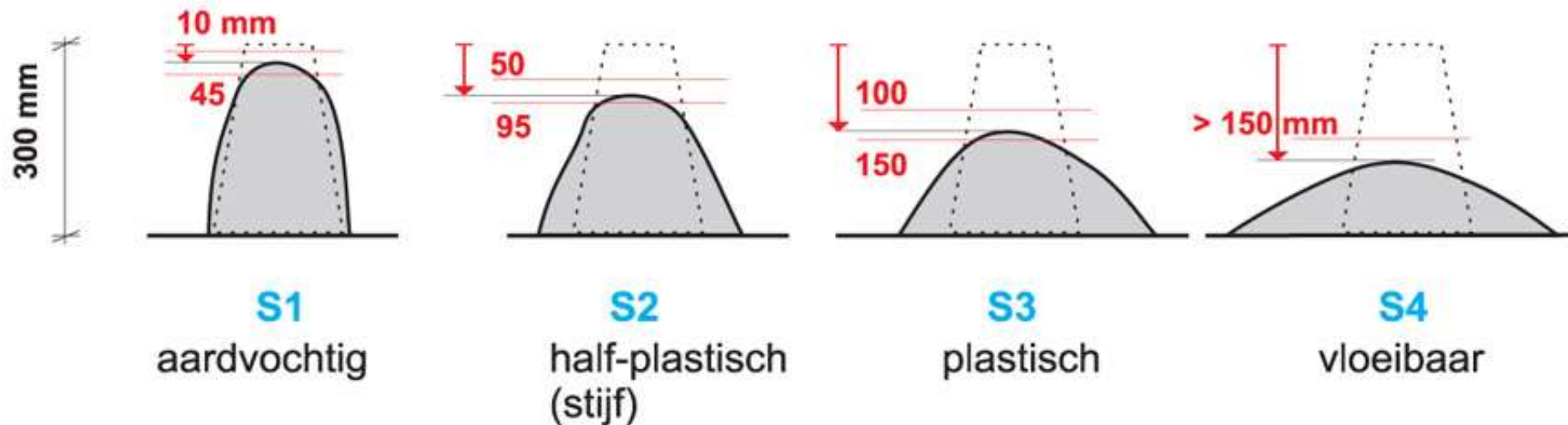
1e

3c1 consistentie *hoe beïnvloeden*



3c1 consistentie *klassen*

zetmaat ("slump")



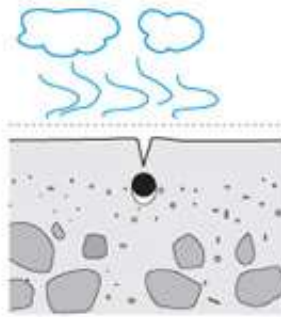
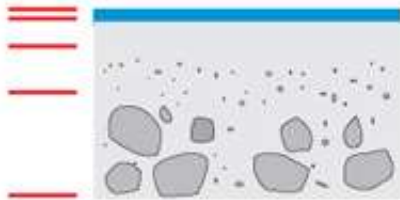
(zie ook:)

2b1

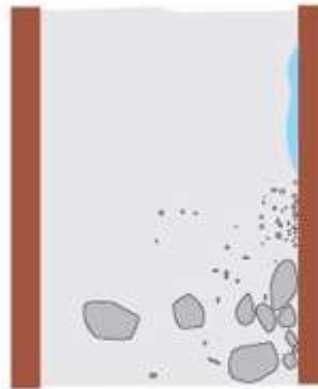
3c2 stabiliteit

↔ *ontmenging*

"sedimentatie"



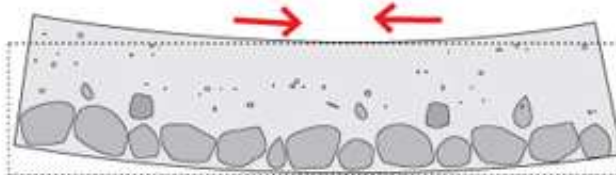
scheuren
(bv. boven wapening)



water- en zandstrepen

tintverschillen

grindnesten



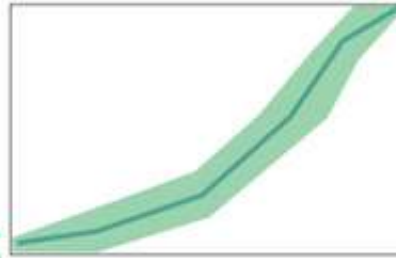
differentiële krimp
"schoteling" ("curling")
⇒ scheuren



3c2 stabiliteit *ontmenging vermijden*

- continue korrelverdeling

voldoende fijne deeltjes



- niet te hoge **W/C**-factor

- voldoende betondekking



- niet te lang trillen



andere factoren: betontemperatuur, cementtype, hulpstoffen

3c3

rijping

schatting van de drukweerstand

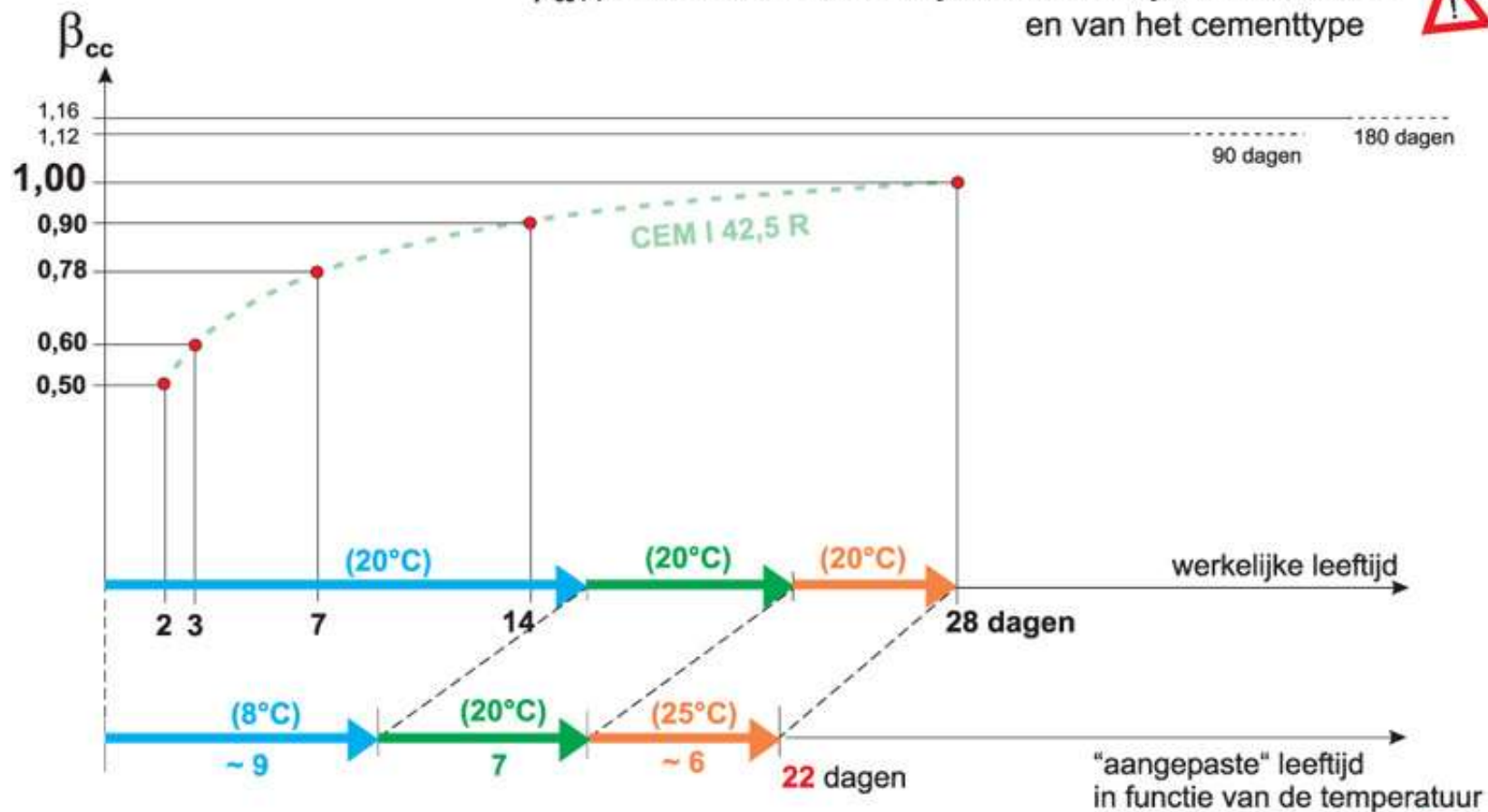
$$f_{cm}(t) = \beta_{cc}(t) \cdot f_{cm}$$

f_{cm} = gemiddelde drukweerstand na 28 dagen

$f_{cm}(t)$ = gemiddelde drukweerstand na t dagen

$\beta_{cc}(t)$ = coëfficiënt afhankelijk van de leeftijd van het beton
en van het cementtype

voorbeeld:



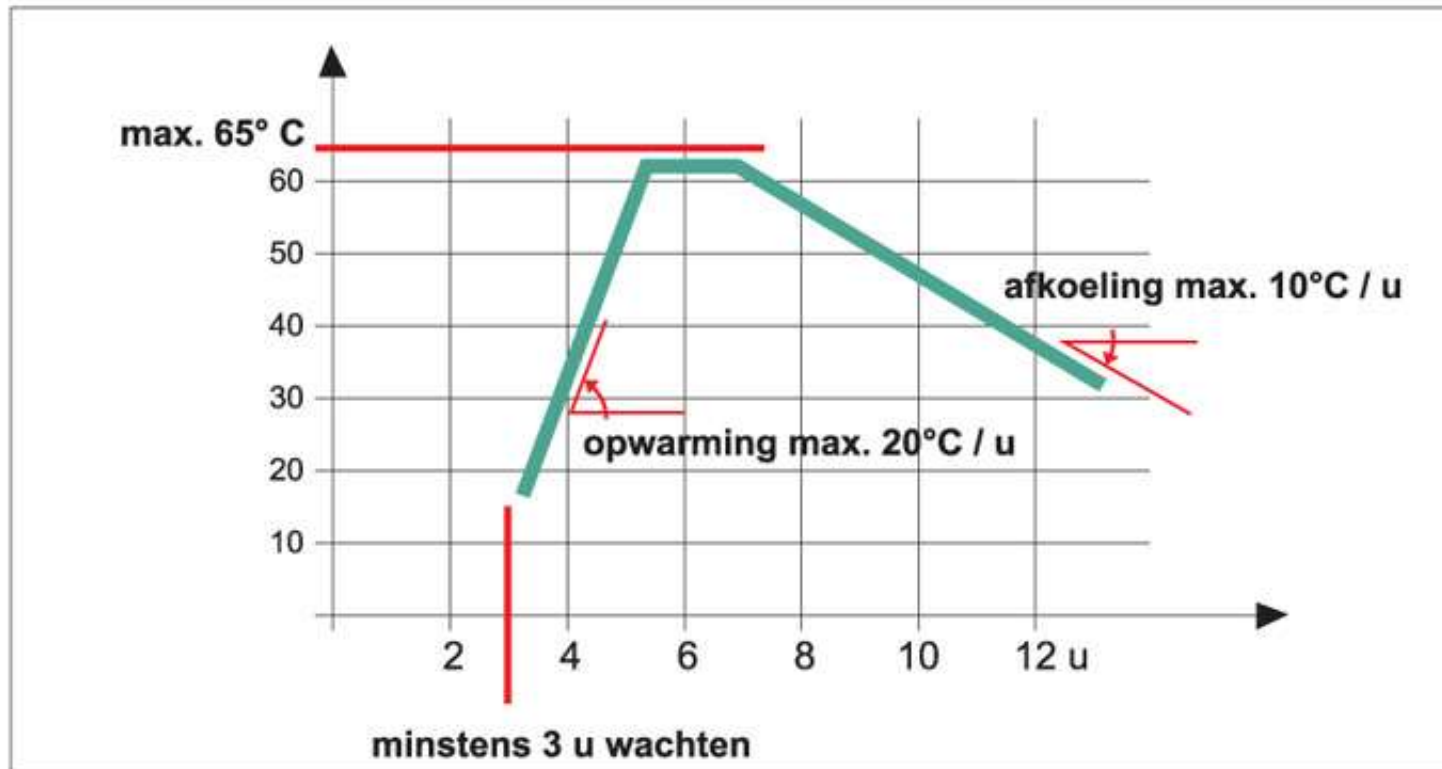
voor een periode van n_i dagen met temperatuur t_i geldt :

aangepast aantal dagen = $n_i \times \text{correctiefactor}$

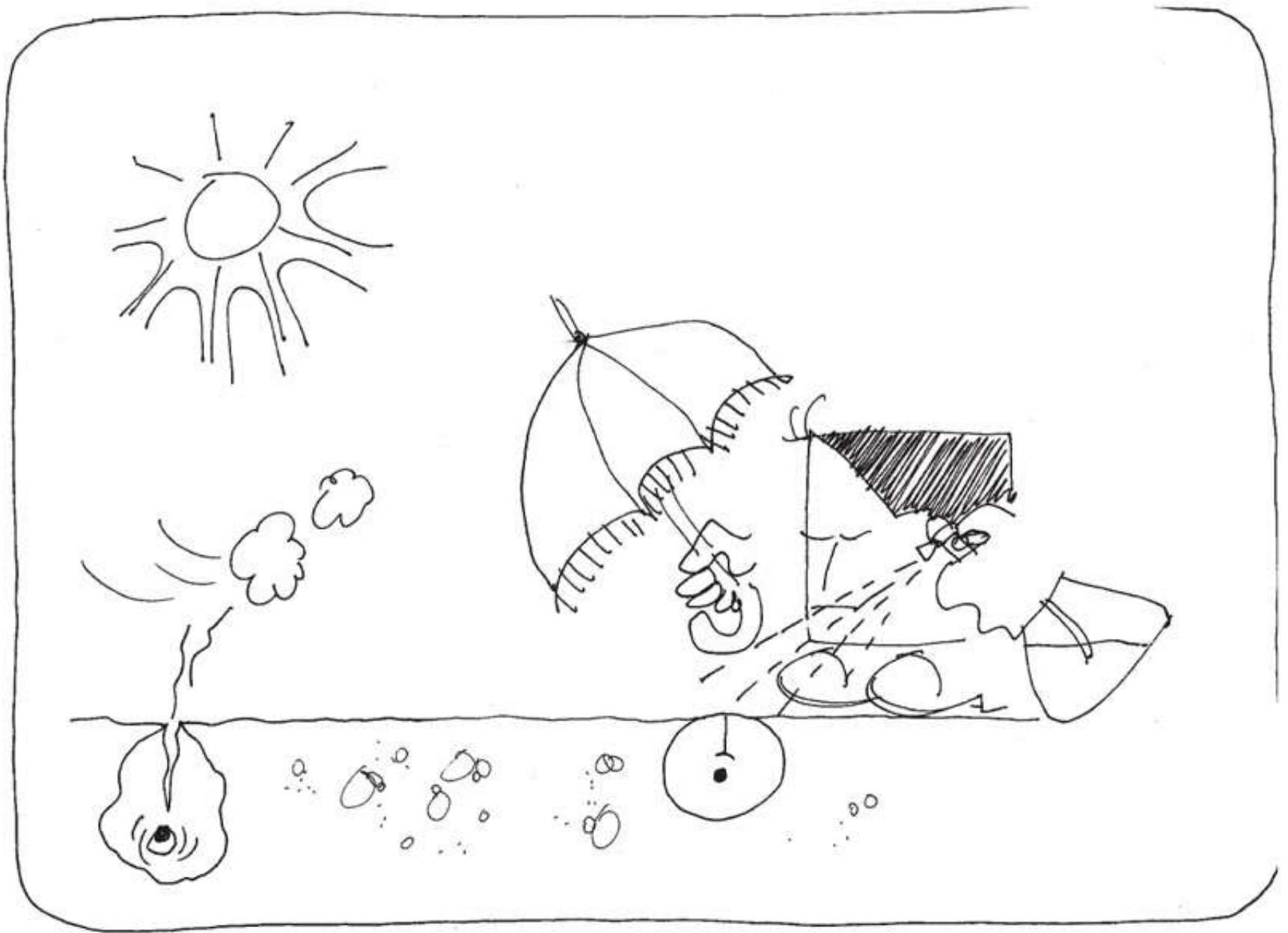
3c3 rijping *hoe versnellen*

t° ↗

- aanmaakwater opwarmen
- cement R gebruiken
- versneller gebruiken
- isolatie, stoom, autoclaaf



opgelet bij massieve constructies



Duurzaam beton... bescherming op jonge leeftijd is essentieel!

Normen & Technische Voorschriften:

NBN B15-001 : Beton - Prestaties, productie, verwerking en conformiteitscriteria

NBN B15-002 : Eurocode 2: Berekening van betonconstructies - Deel 1-1: Algemene regels en regels voor gebouwen

Technische Voorschriften (PTV) 21-601: geprefabriceerde elementen van sierbeton
Brussel : Probeton, 1999

ÖNORM B 2211: Beton und Stahlbetonarbeiten
Werkvertragsnorm, 07.86

Verdere informatie:

Krimp in jong verhardend beton
Dossier Cement, bulletin nr. 16
Brussel : FEBELCEM, 1998

Het uiterlijk van beton
Dossier Cement, bulletin nr. 22
Brussel : FEBELCEM, 2000

Schoon beton
Den Bosch : VNC, 1990

Schoon beton ... mooi werk. Leidraad voor projectspecificaties, uitvoering en beoordeling
's Hertogenbosch : ENCI, 2001

Tolerances on blemishes of concrete
CIB (Conseil International du Bâtiment), Report nr. 24, 1973

Elementen in architectonisch beton - Technische aanbevelingen
Brussel : FEBE, 1993

Memento van architectonisch beton
Brussel : FEBE, 2de uitgave, 1996

Betonoberfläche - Betonrandzone
DBV (Deutscher Beton-Verein), Sachstandbericht, 1996