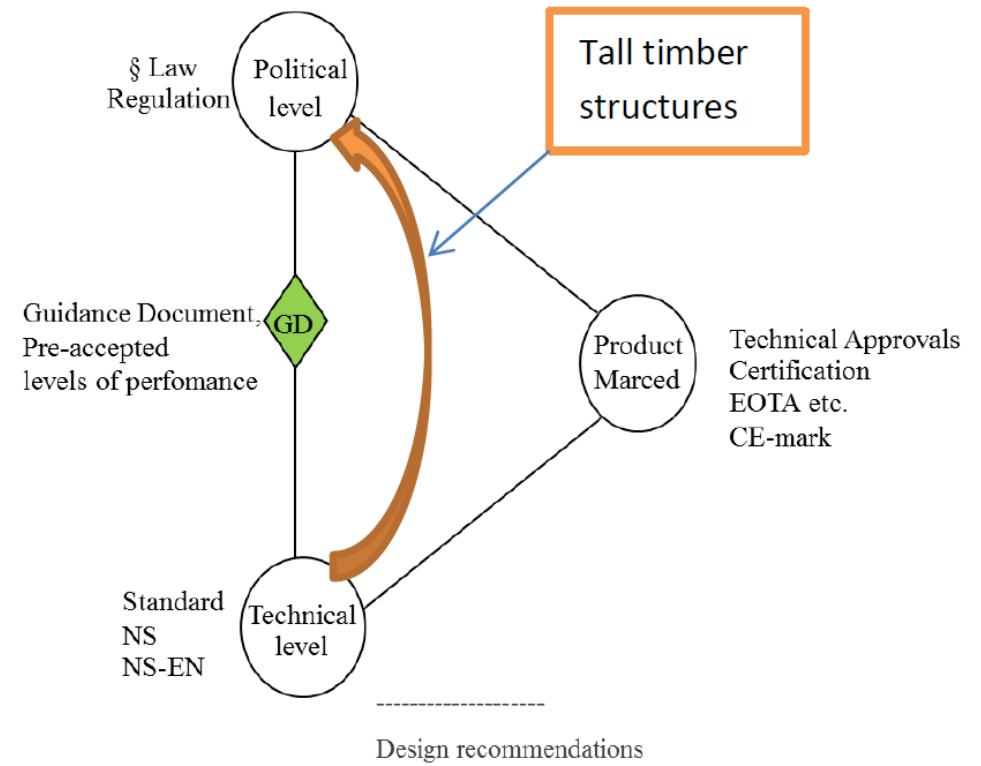


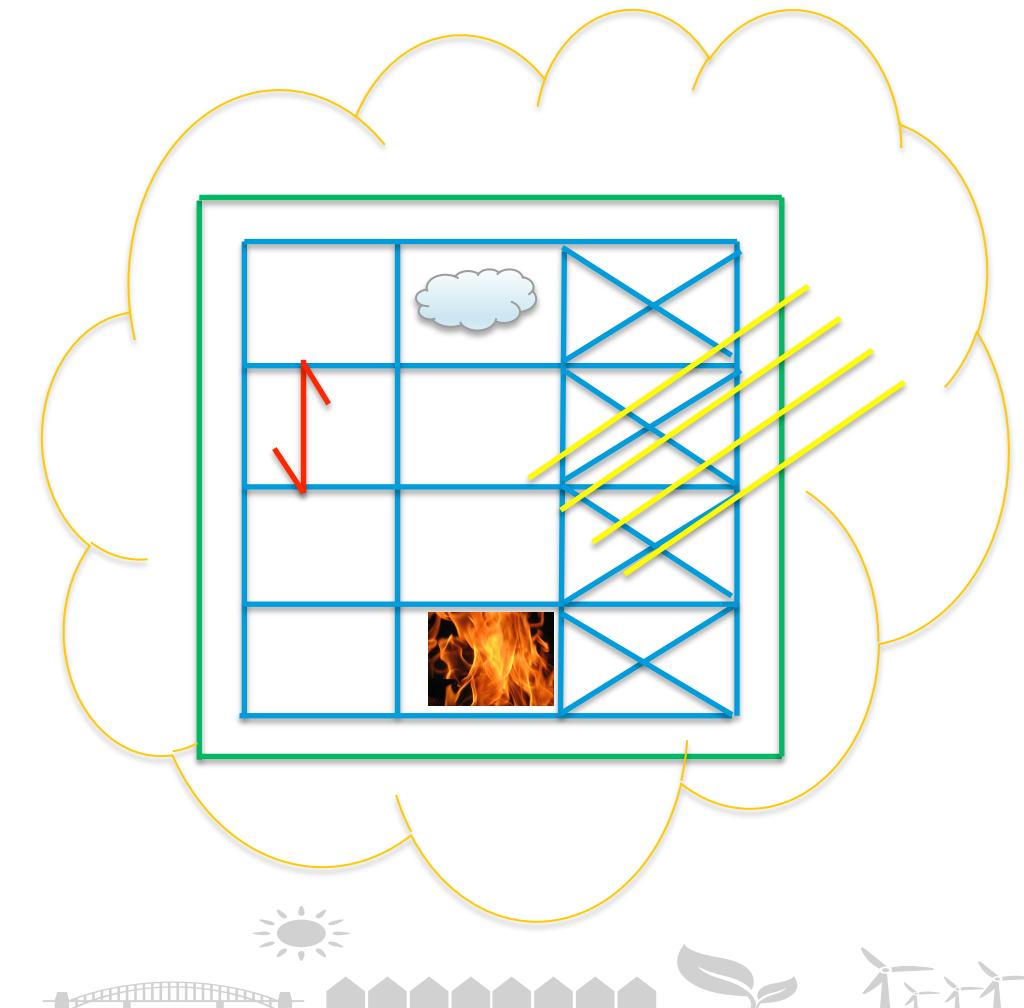
TREARKITEKTUR den 6. nasjonale konferansen 2018

Innledning om høye trebygg og brannsikkerhet

Professor II dr.ing Nils E. Forsén, Multiconsult/AHO



Funksjonsbaserte byggeregler



§

- Sikkerhet; konstruksjonssikkerhet og brannsikkerhet
- Inneklima – i videste forstand
- **Krav dagslys, krav til rom mv**
- Miljøkrav, herunder energibruk
- Arkitektur i et helhetlig perspektiv, plankrav

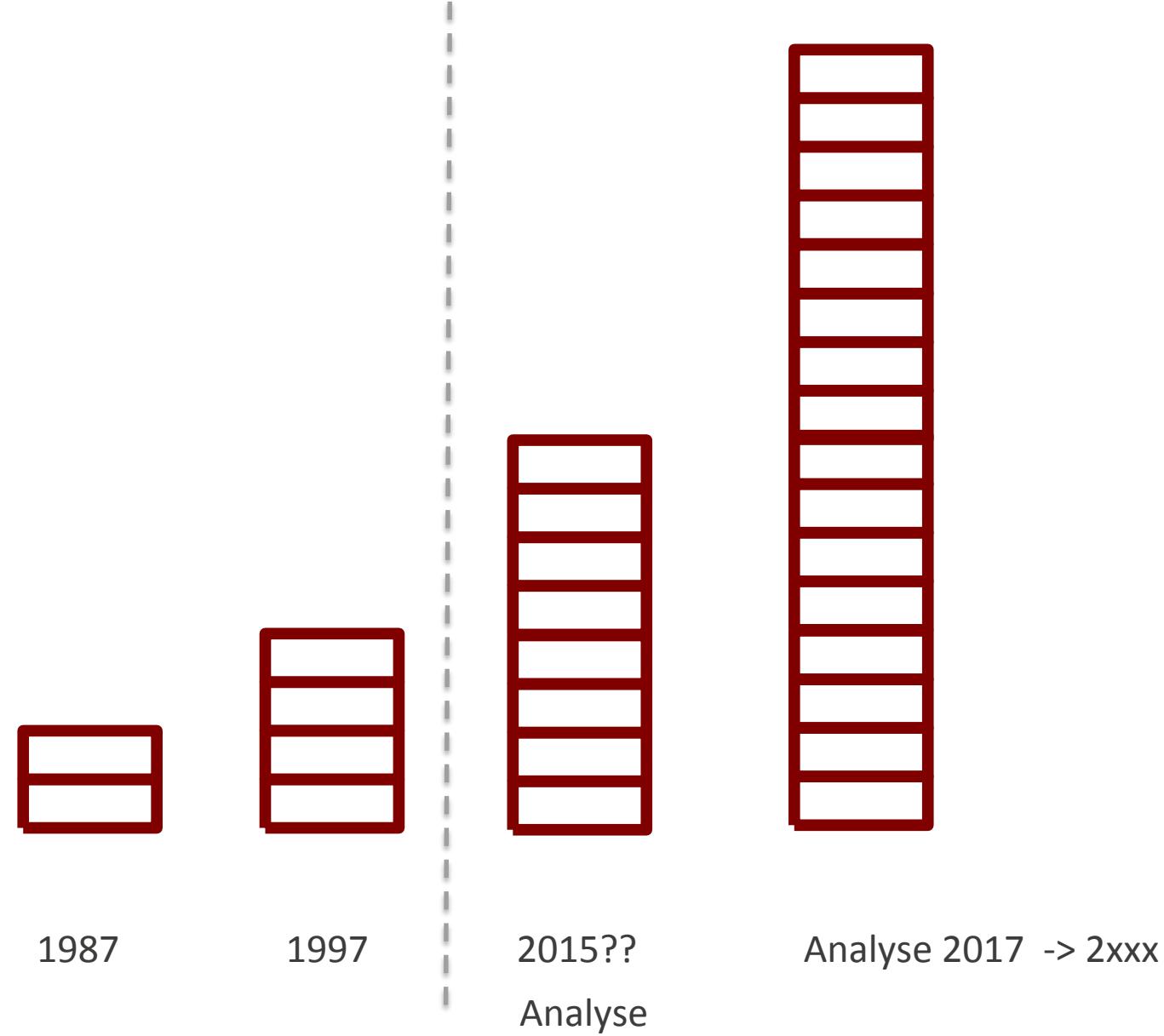
Gruppering av aktører - prosjektering

- Sikkerhet; konstruksjonssikkerhet og brannsikkerhet
- Inneklima – i videste forstand
- Krav dagslys, krav til rom mv
- Miljøkrav, herunder energibruk
- Arkitektur i et helhetlig perspektiv, , plankrav
- RIB, RIG, RIBr, RIE, Slukkeinstallasjoner
- RIV, ARK, RIA
- ARK
- ARK, RIBfy, RIV
- ARK



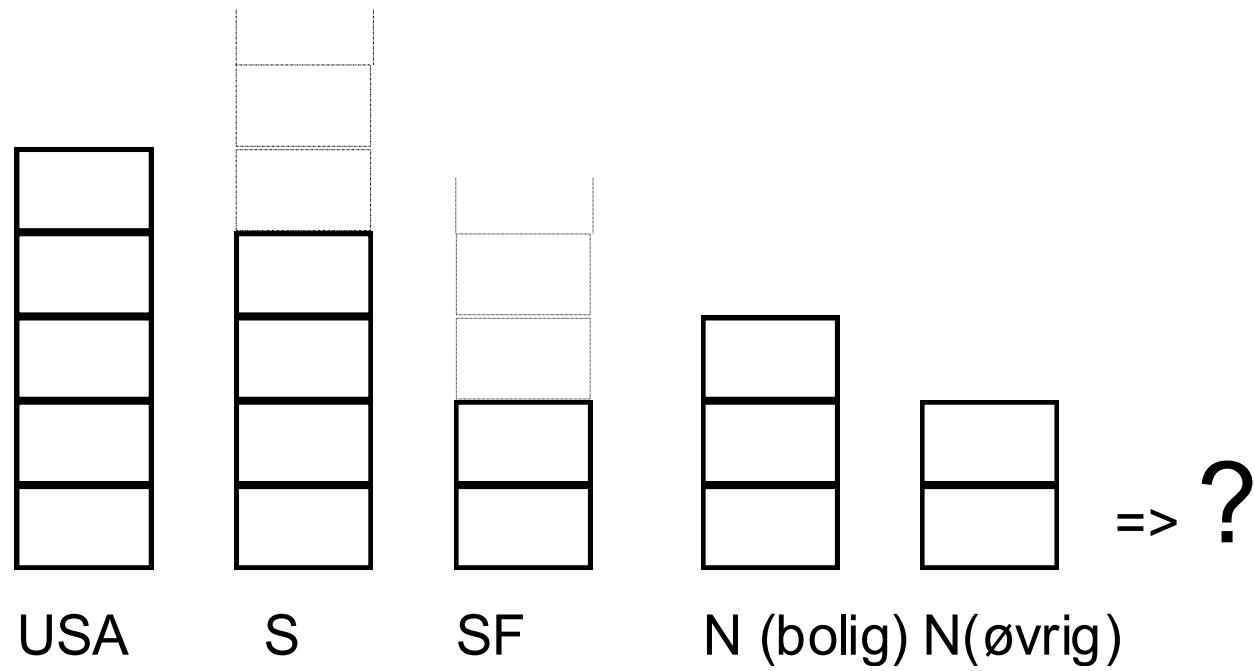
I perspektiv

multiconsult.no



Tilbakeblikk: Trehus - maks etasjetall=?

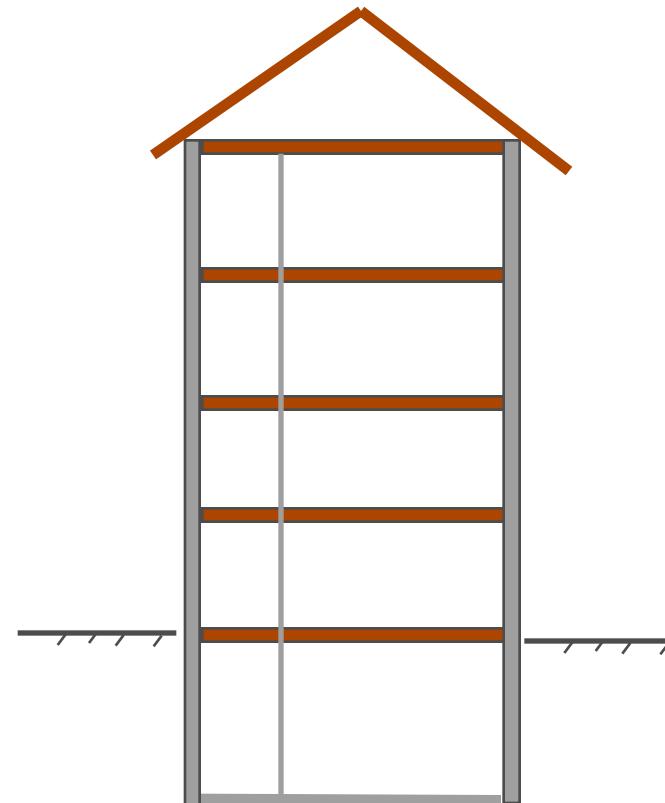
Situasjonen i 1994:



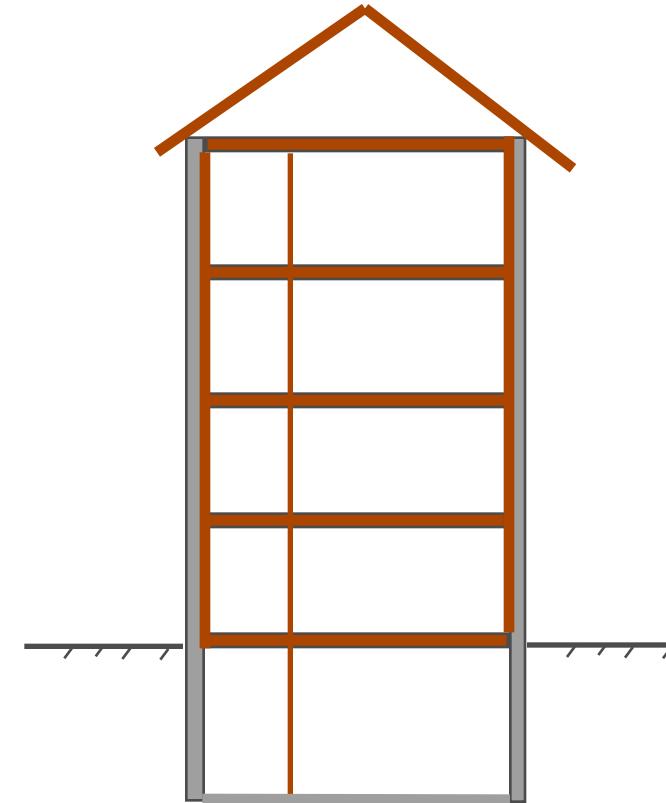
Tilbakeblikk; 4 etg bolighus i Norge

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OSLO 1844-1940



BERGEN 1800-tallet

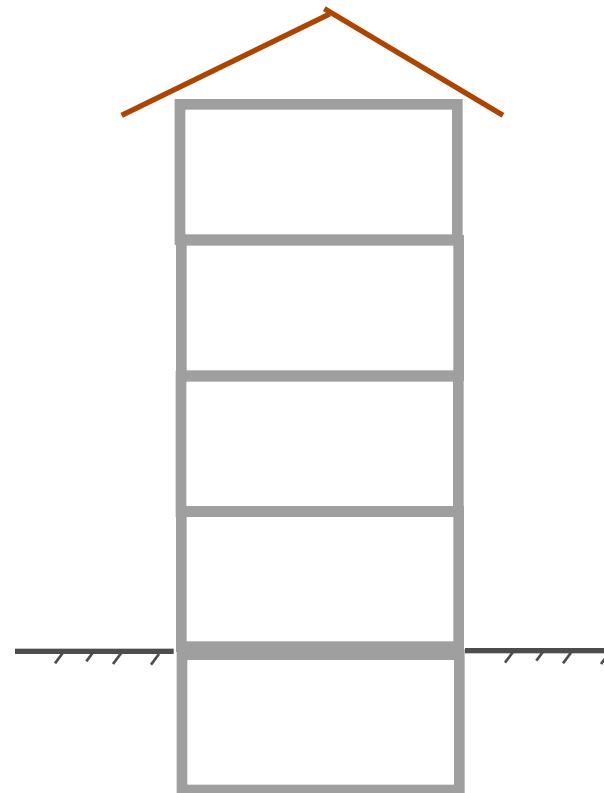


-  Mur
-  Tre

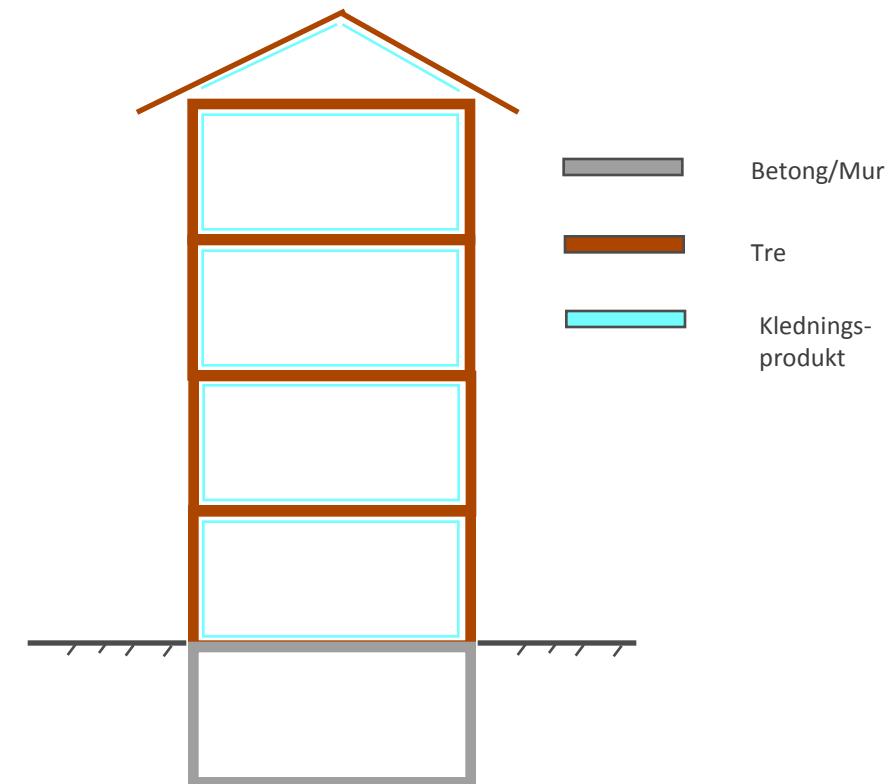
Tilbakeblikk; 4 etg bolighus i Norge

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1930/40-1997-



Trondheim 1997-



So many conferences.....

Multiconsult

*The 4th Forum Wood Building Nordic in Växjö,
September 24--25 – 2015
Fire resistance – **are we done now?***

*Recent development in Norway
Nils E. Forsén*

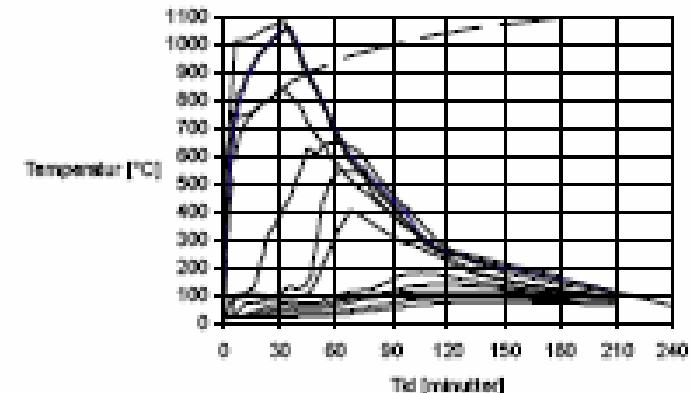
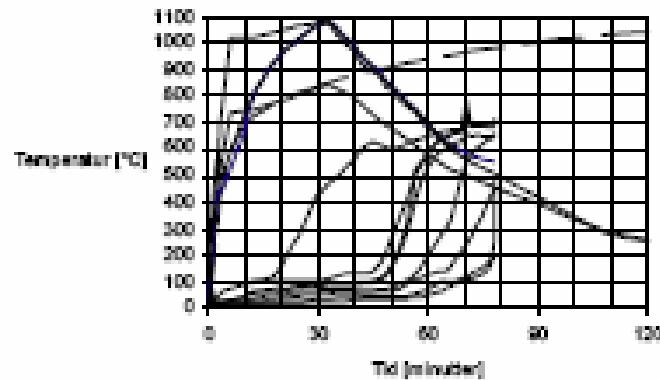
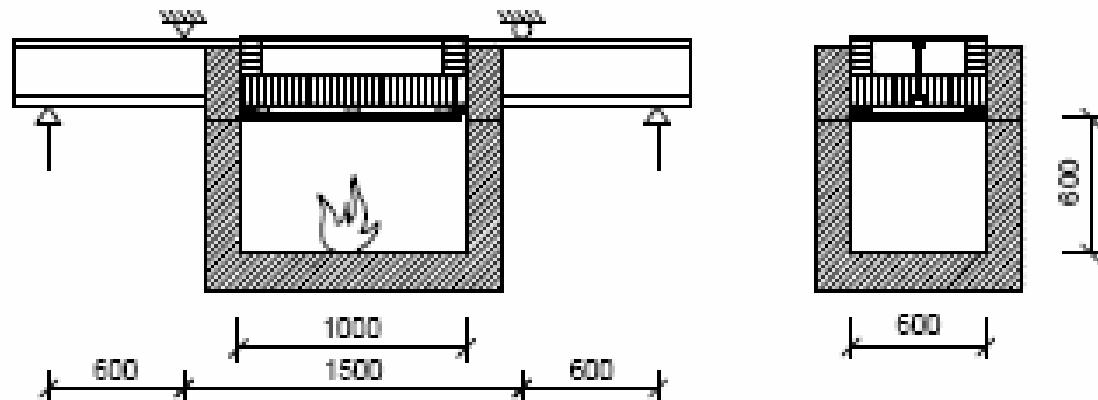


Brandcellstyp	$k_f = \frac{(\sqrt{\lambda\rho c})_A}{\sqrt{\lambda\rho c}}$
A: (Standardbrandcellen) Omslutande konstruktioner av ett material med en termisk tröghet $\sqrt{\lambda\rho c} = 1160 \text{ W s}^{1/2} \text{ m}^{-2} \text{ }^{\circ}\text{C}^{-1}$. Förenklat motsvarar ett sådant material ett genomsnitt av tegel, betong och gashetong	1.0
B: Omslutande konstruktioner av betong	0.85
C: Omslutande konstruktioner av gasbetong med densiteten $\rho = 500 \text{ kg m}^{-3}$	3.0
D: Omslutande konstruktioner i en omfattning av 50% betong och 50% gasbetong med densiteten $\rho = 500 \text{ kg m}^{-3}$	1.50
E: Omslutande konstruktioner i en omfattning av 50% gasbetong med densiteten $\rho = 500 \text{ kg m}^{-3}$, 33% betong och 17% sammansatt konstruktion bestående av inifrån 13 mm gipsplatta med densiteten $\rho = 790 \text{ kg m}^{-3}$, 100 mm mineralull med densiteten $\rho = 50 \text{ kg m}^{-3}$ samt tegel med densiteten $\rho = 1800 \text{ kg m}^{-3}$	1.50
F: Omslutande konstruktioner i en omfattning av 80% stålplåt och 20% betong. Brandcellen motsvarar en lagerlokal eller liknande med oisolierade tak och väggar av stålplåt och med golv av betong	1.00
G: Omslutande konstruktioner i en omfattning av 20% betong och 80% sammansatt konstruktion, bestående av dubbel gipsplatta, 2·13 mm, med densiteten $\rho = 790 \text{ kg m}^{-3}$, 100 mm luftspalt samt dubbel gipsplatta, 2·13 mm, med densiteten $\rho = 790 \text{ kg m}^{-3}$	1.45
H: Omslutande konstruktioner, bestående av stålplåt på ömse sidor om 100 mm mineralull med densiteten $\rho = 50 \text{ kg m}^{-3}$	3.0

Tabell 2.2 Kvoten mellan termisk tröghet för brandcellstyp A och för andra brandcellstyper

Er R90 R90
uansett?
Hvor mye fuel
skal til for å holde
ISO 834 –
kurven?
Betong har mye
større termisk
tetthet enn tre –
og krever mer
fuel

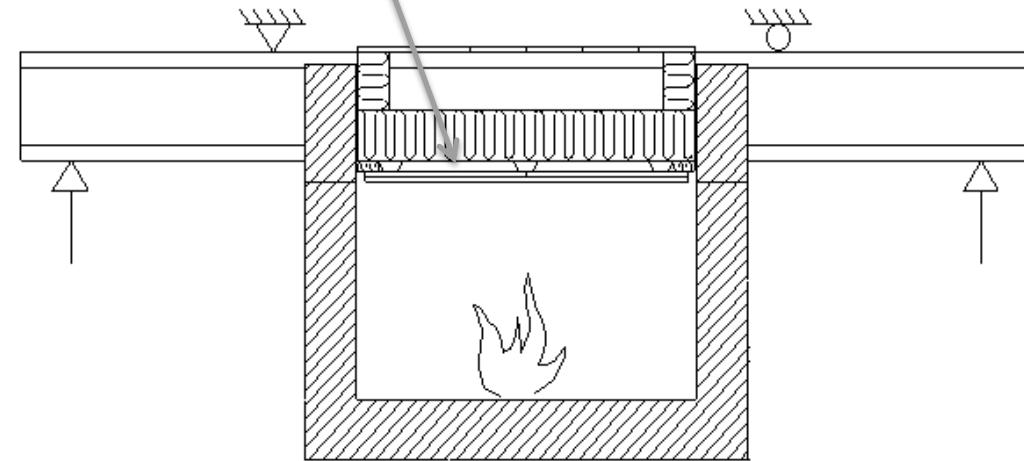
Tilbakeblikk – 23 år: In comparison: Timber frame/parametric fire (Nordic Wood 1995) superslender/light timber beam



Wood construction behaviour in natural/parametric fires. Paper presented at the 4th International Fire and Materials Conference, Washington DC, November 1995 [1995]

Koenig, J.
Noren, J.
Forsen, N.E.

Conclusion 3 layers required – an uneconomical and impractical design to withstand a total fire

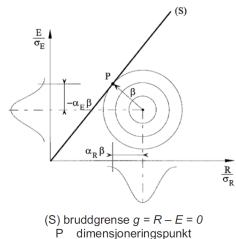


Think tanks

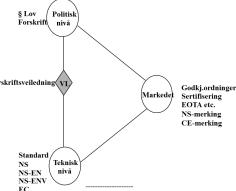
History, empirical



Rd>Ed, reliability



System of requirements



New interpretations

Number of stories in timber allowed in Nordic building codes:

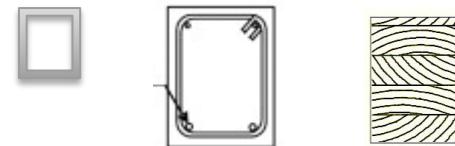
	Up to 1993	1994	1997	1999	2004	2007?
Sverige	2	∞	∞	∞	∞	∞
Norge	3	3	∞	∞	∞	∞
Finland	2	2	4*	4*	4*	∞?
Denmark	1-2	1-2	1-2	4	∞	∞

* sprinklers required

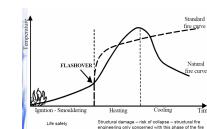
New experiences



Main structural systems



Modeled fire



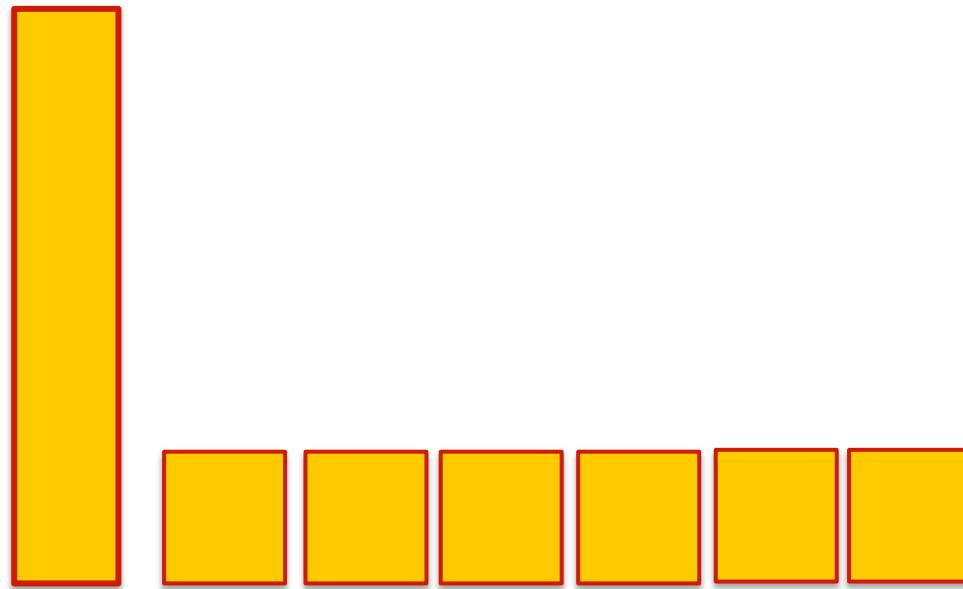
Design procedure
Fire engineering –
structural engineering

The road ahead



Urban Development – Timber!

- How tall?
- How dense?
- How large?
- Which use?



System of safety for protection of lives and values

- Sprinklers
- Access for fire brigade
- Fire compartments with limited sizes (redundancy)?
- Structural fire resistance
- - and other fire safety requirements
- Main threat: Fire out of control!

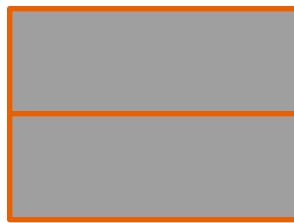


kW (MW)

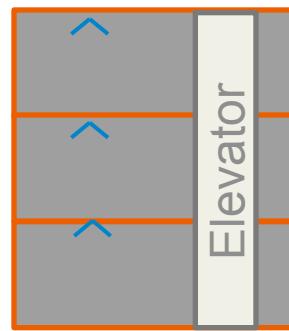
MW



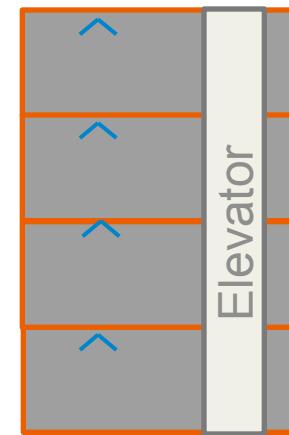
Universal design: Elevator required, when 3 storeys or more (dwellings) → Sprinkler



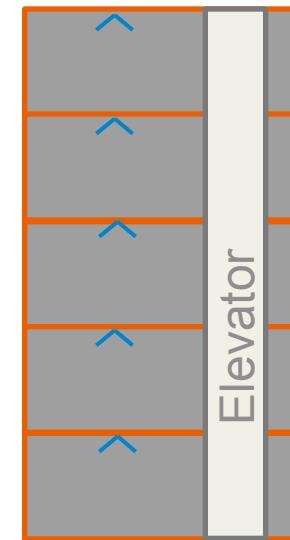
Fire class 1



Fire class 2



Fire class 2

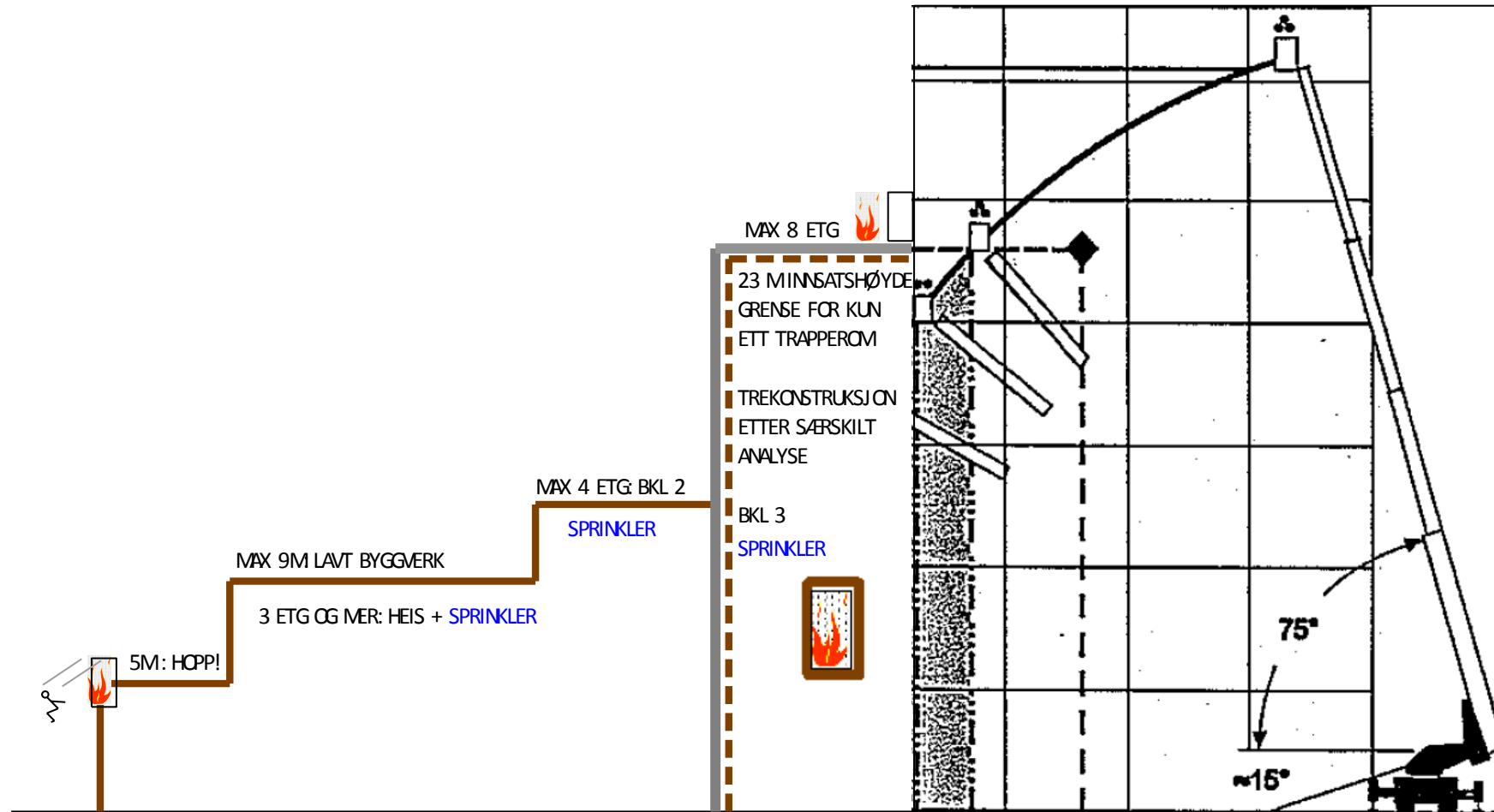


Fire class 3,



GD: Non-combustible

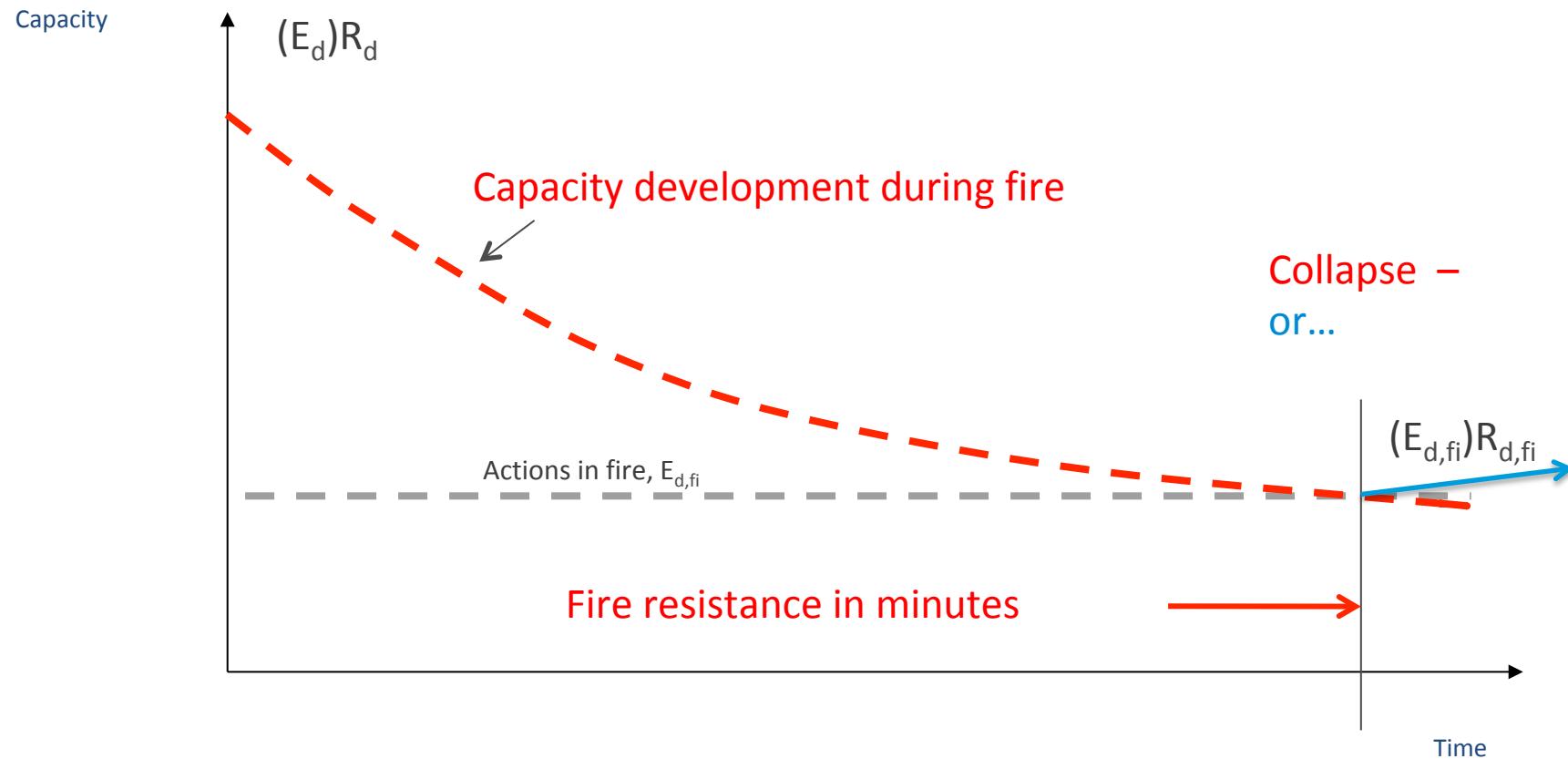
Essential height limits - dwellings – RKL 4



$$R_{d,fi} > E_{d,fi}$$



Structural response – in principle



The distinction between function, performance and verification should be noted:

- Function: The overall function of the main structural system, i.e. avoid collapse
- Performance: Measured or calculated fire resistance and material performance according to standard
- Verification: Use of methods according to standards to verify the performance, **or function**



Norwegian regulation TEK 10 § 11.3 (4)

- For the two higher building classes (3 and 4) the requirement is that the main structural system of the building *shall be designed to maintain a sufficient structural resistance throughout a complete fire development, appropriately modeled.* .



Pre-accepted levels of performance

- E.g. R90, non-combustible
- Experienced and intended safety level: Resistance against collapse of tall buildings due to fire alone



Important tasks to clarify between disciplines:

- Structural engineer: Define main structural system
- Structural fire design— Tools: Eurocodes 1, 5
- Fire engineer: Define combustible structure as a deviation from Guidance Document and give input to a parametric fire model
- Assess the fire safety strategy in regard to a possible probabilistic down-scaling of the fire energy, refer Eurocode 1 (not pre-accepted in Norway)



Possible development in pre-acceptance for tall timber buildings in a future Norwegian GD?

For apartment buildings up to 8 storeys (23m to highest floor) provided:

- Fire compartments moderate in size
- Sprinklers with high reliability
- Standard fire resistance R90.



Conclusions

- A significant market potential for 3-4 storey timber buildings has been there for the past 19 years, the fire regulations represent no obstacle
- For apartment buildings of 5-8 storeys, an opening in the GD for increased use of timber is possible, given that automatic extinguishing systems are required and that limitations in fire compartment sizes will be defined
- Beyond this, more spectacular concepts can always be put into life, provided that a comprehensive risk analysis is performed and controlled/approved



A close-up photograph of a fire, showing intense orange and yellow flames. The fire fills most of the frame, with bright sparks visible against a dark background.

Thank you – build safely – enough,,,,,