

# Des bâtiments en construction mixte acier-béton: Une alternative pour les entreprises générales de construction?!

## Nachhaltige Gebäudelösungen in Stahl- und Verbundbauweise - eine Alternative für Generalunternehmer und Bauunternehmen?!

Univ.-Doz. Dr.-Ing. M. Schäfer



# Application of steel and composite structures

Multi-Storey Buildings

Hall Construction

High Rising Buildings

Industrial Buildings

Parking's

Bridges

Pylons, Towers

Chimney

Bunker, Tanks

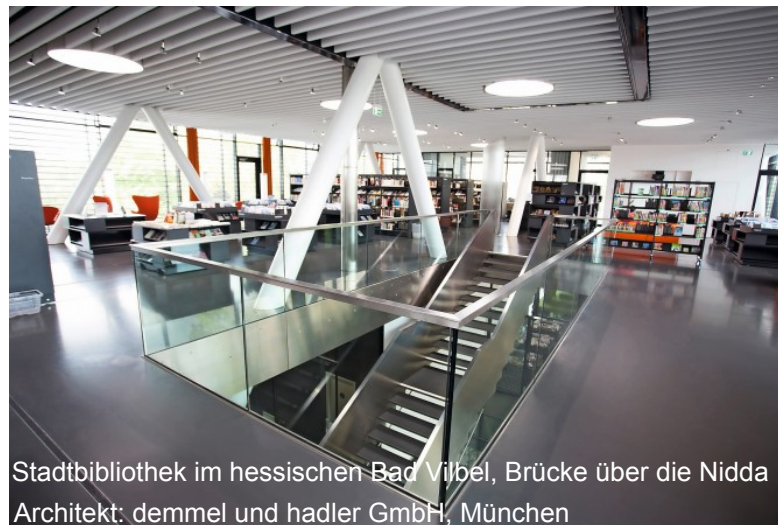
Scaffolds and Formwork

Cranes and conveying plants





Hubschrauberlandeplattform Universitätsklinikum Aachen  
Architekt: OX2architekten



Stadtbibliothek im hessischen Bad Vilbel, Brücke über die Nidda  
Architekt: demmel und hadler GmbH, München

## Advantages ... for architecture

- variety conceptions and forms
- innovative building structures
- elegant, transparent, lightweight and filigree structures
- small cross-sections
- optimal use in existing buildings
- good combinations with other materials such as concrete, glass and membranes, wood
- many options for installations



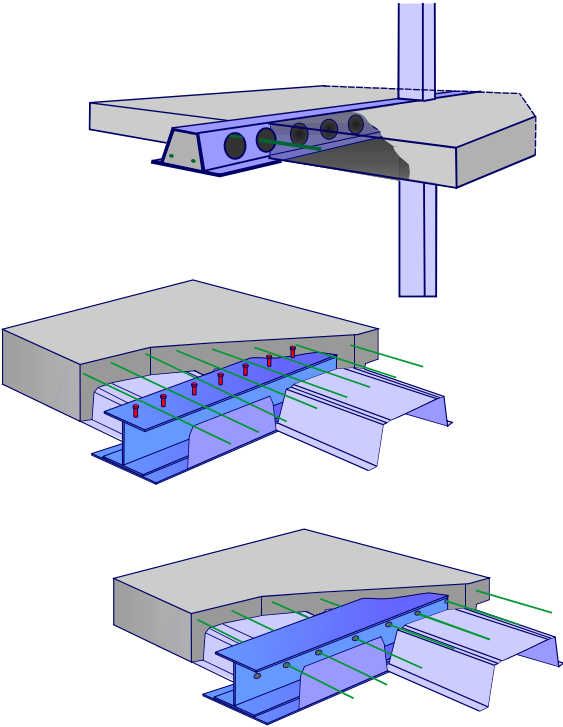


- Are Steel and Composite solutions also still interesting for functional (“ordinary”) multi-storey office buildings?
- What does this mean for the general contractor or contractor and at least for the investor?

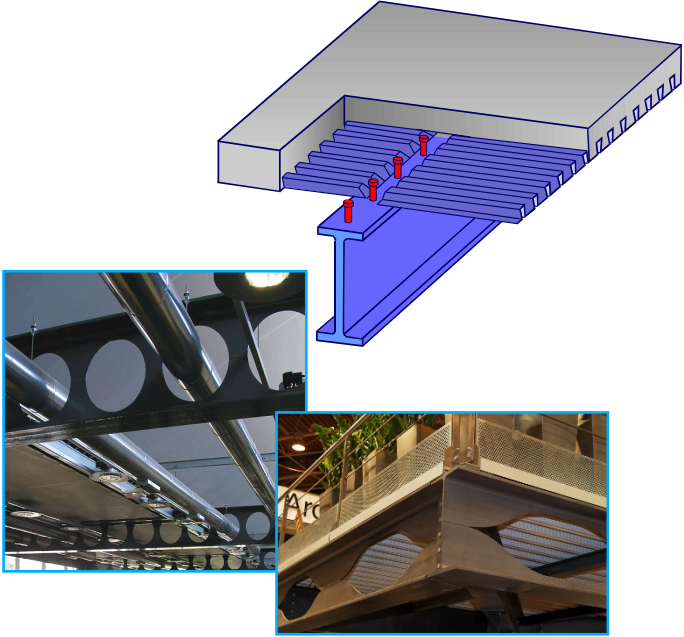


# standard-solutions in steel and composite

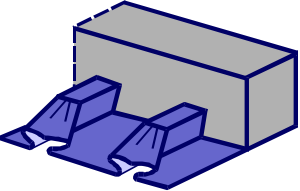
slim-floor beams



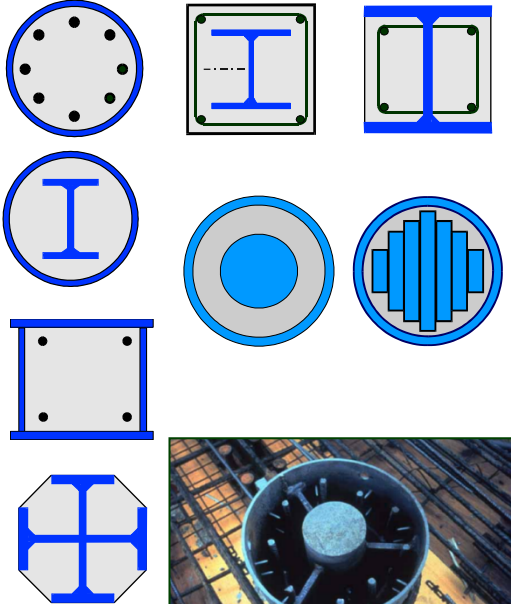
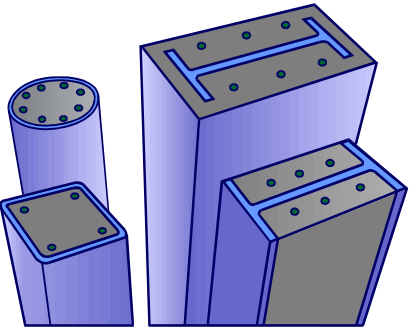
composite girders



composite slabs

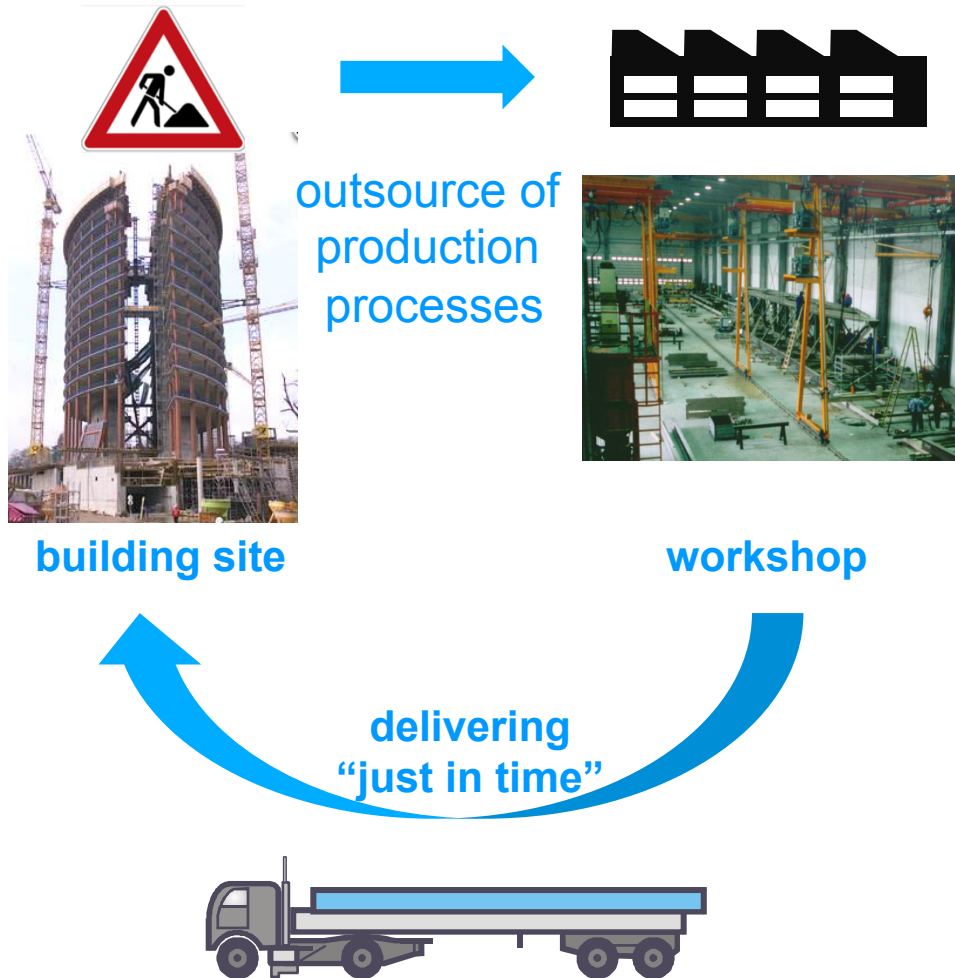


steel & composite columns



LUXEMBOURG

# steel and composite structures what does it mean for organization of building site



## • Advantages ... for production

- industrial production in workshop
- higher quality standards  
⇒ industrial standards
- production on basis of electronically controlled systems (CNC)
- better dimensional accuracy
- better conditions for welding process
- better operational safety
- independent of weather
- better waste management

# steel and composite structures what does it mean for organization of building site



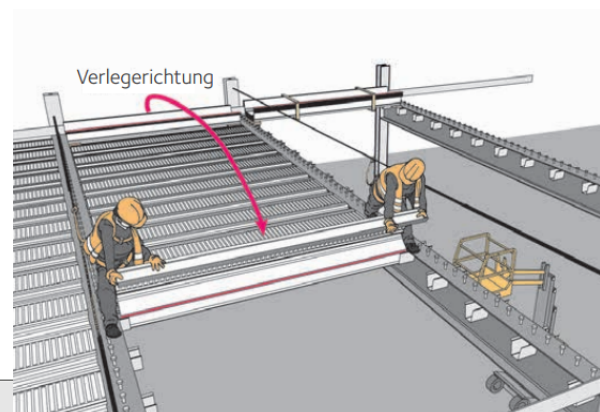
Example metal decking sheets:

- 850-1500m<sup>2</sup> of sheet by one lorry
- placing by hand
- low crane utilization
- function as formwork and reinforcement



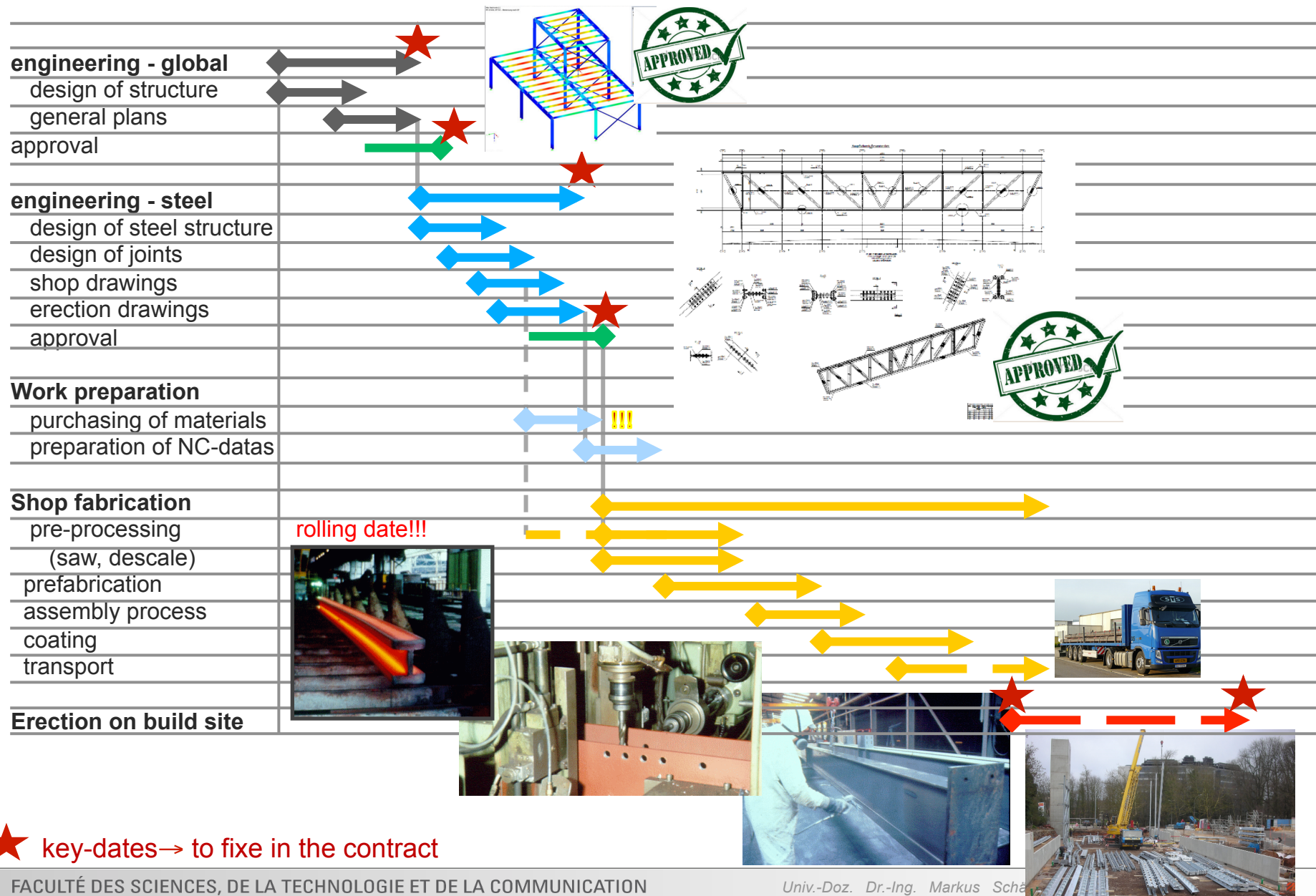
## • Advantages ... for construction site

- efficient time and cost management with just-in-time processes
- industrialized construction process for construction on site by using of “prefabricated” steel components
- less noise/waste on building site
- short construction period
- small site equipment (!)
- better coordination of logistics



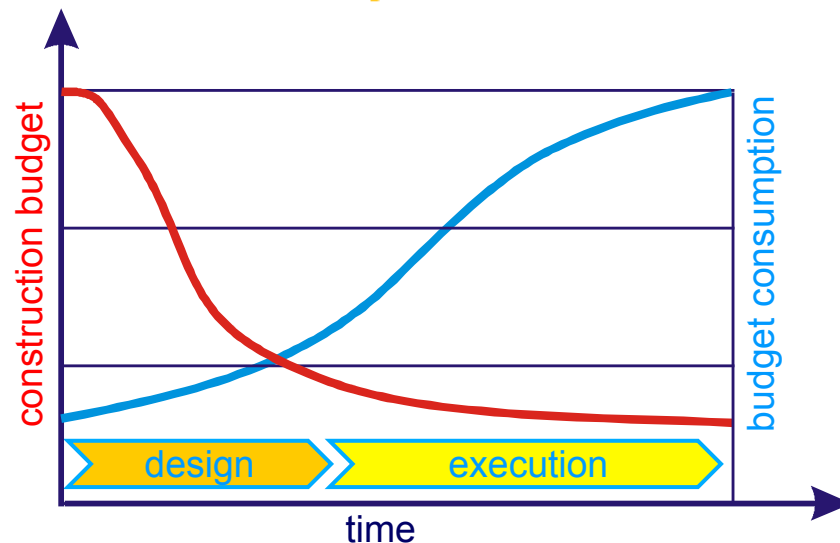
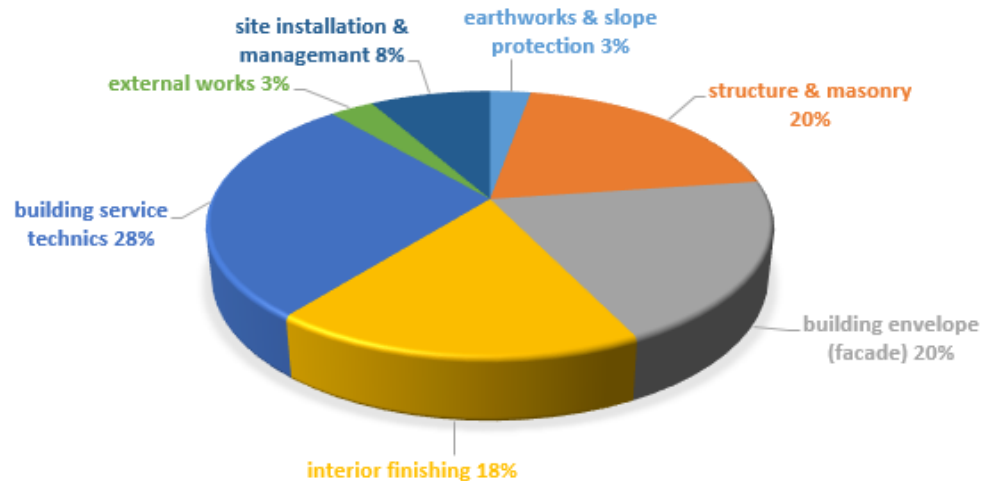


# Required preparation and planning phases for steel composite structures



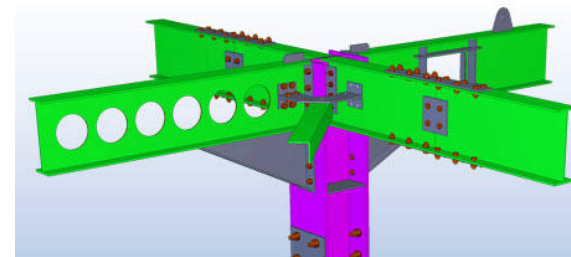
★ key-dates → to fixe in the contract

## COST ALLOCATION OF CONSTRUCTION COSTS FOR OFFICE BUILDINGS



### • Advantages ... of early design state

- Agreement with architect and building installation engineers
  - Solve of conflicts and problems for divers interfaces in an early state
  - Planning reliability
  - Time for optimization and preparation
  - Including of 3-D drawings and BIM models
- ⇒ Reduction of construction costs!

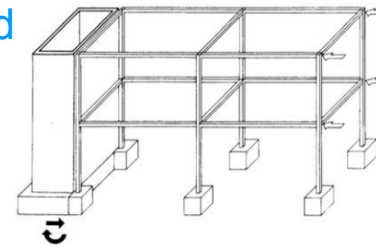


# Constraints in multi-storey buildings situation on construction site

## ● Economic multi-storeys = mixed systems of concrete + steel composite elements

foundation  
stiffening walls  
slabs (semi-precast or composite)  
columns (concrete or composite)

reinforced  
concrete



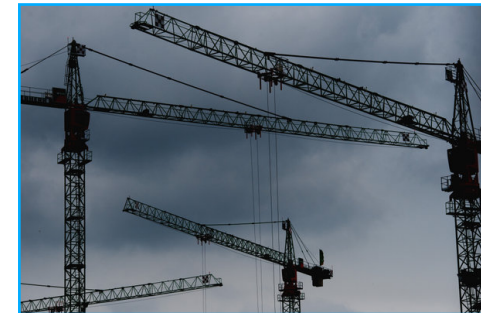
girders  
slabs (composite slabs)  
columns (steel or composite)

steel /  
composite



## ● Problems on building site for mixed structures

- ☹ Often two different contractors for concrete and steel work
- ☹ Coordination of an additional subcontractors
- ☹ Interface concrete work and steel work
- ☹ Coordination of logistics with several subcontractors
- ☹ Reliability of construction schedules
- ☹ **Availability of construction crane!**
- ☹ Connection steel to concrete
- ☹ Connection often to labor intensive



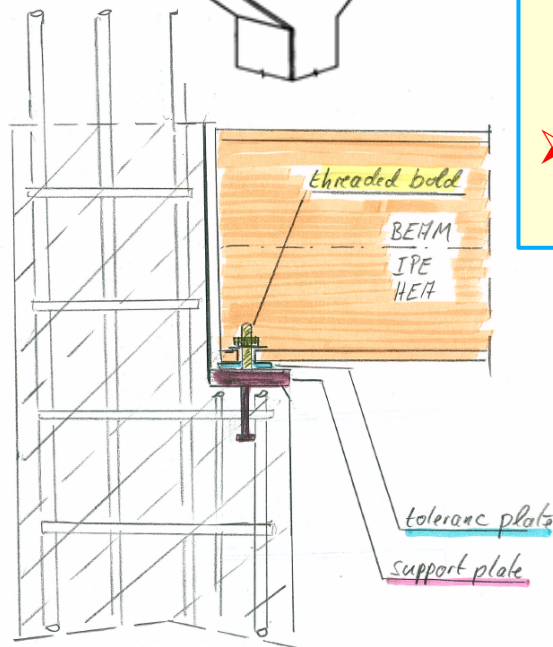
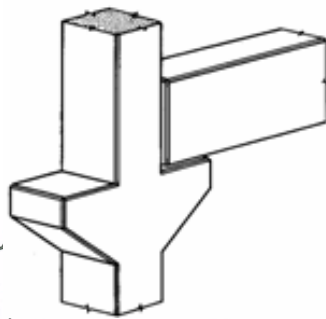


# optimization and simplification of steel-composite structures for multi-story buildings

## ● Hypothese:

**STEEL COMPOSITE STRUCTURE = PRE-FABRICATED STRUCTURE**

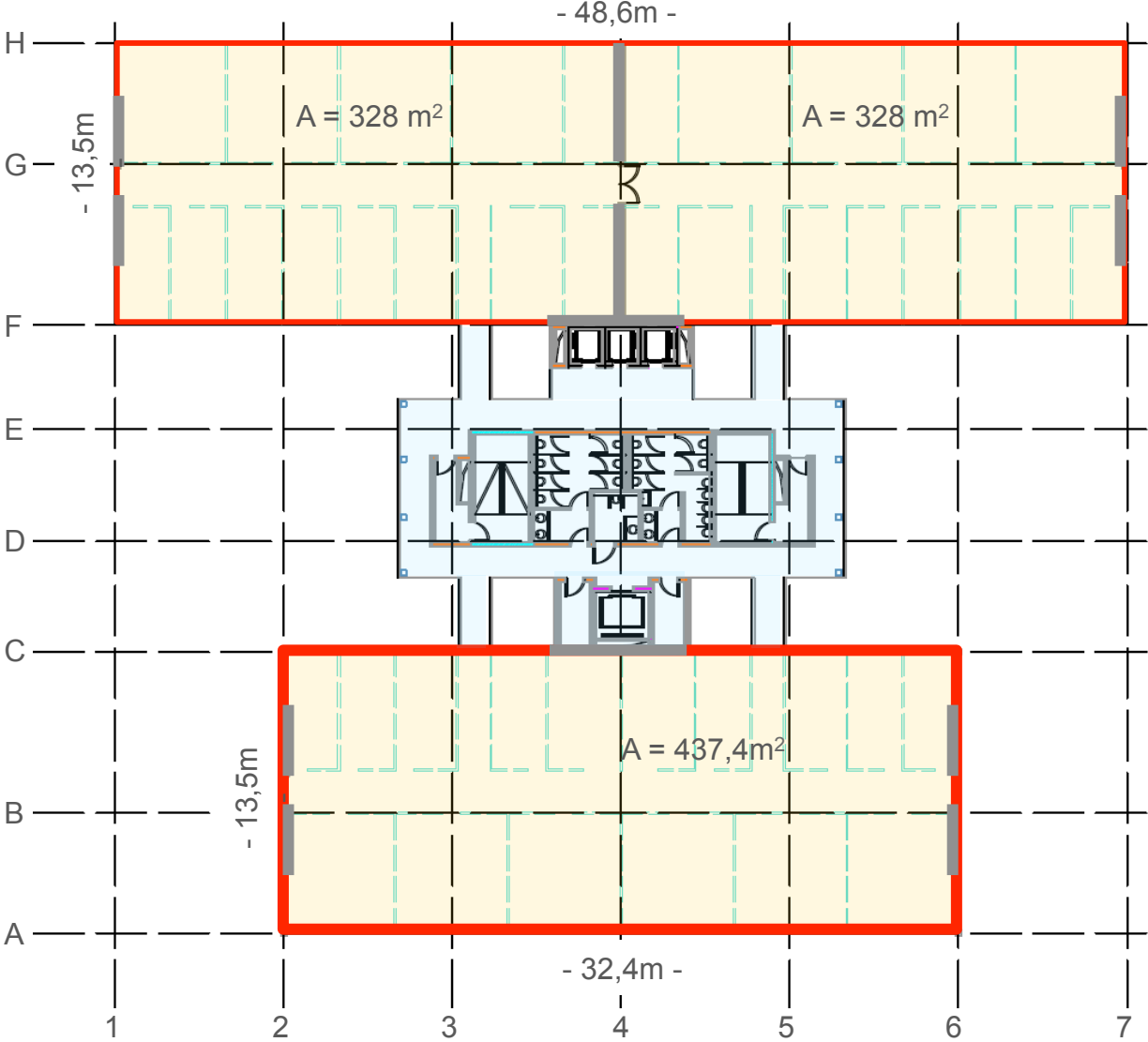
## ● Solution:



- simplification of interface between steel and concrete
- simplified connections between steel and concrete elements
  - plug-in connection (LEGO)
  - support consoles
  - easy compensation of tolerances
- simple placing of beams by construction crane without much bolting or any welding!



# example of a standard office building

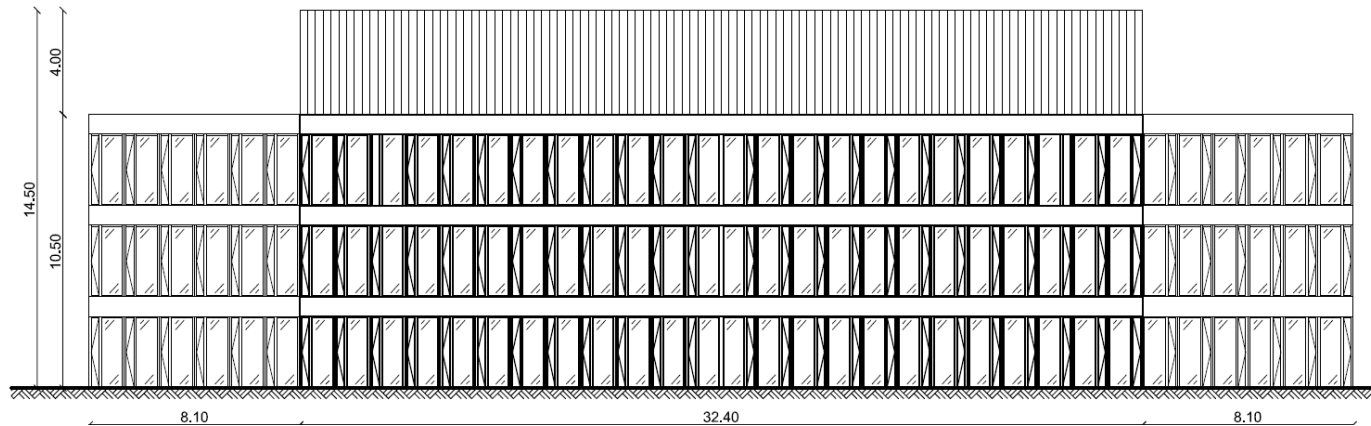


**Surface:**  
A = 1093,4m<sup>2</sup>  
A = 250m<sup>2</sup>

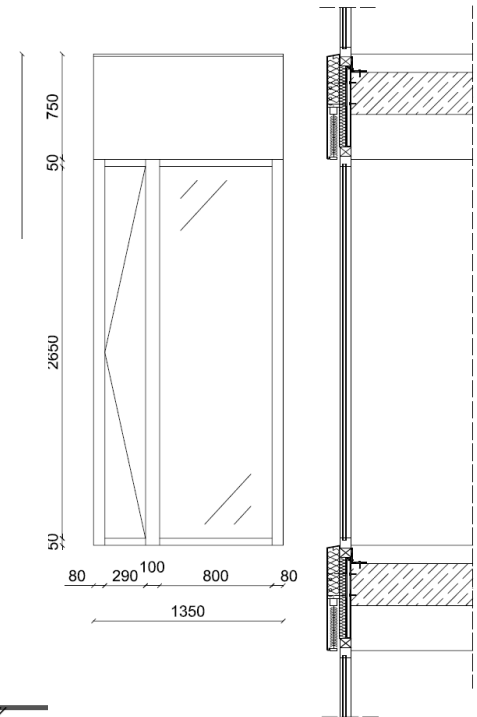
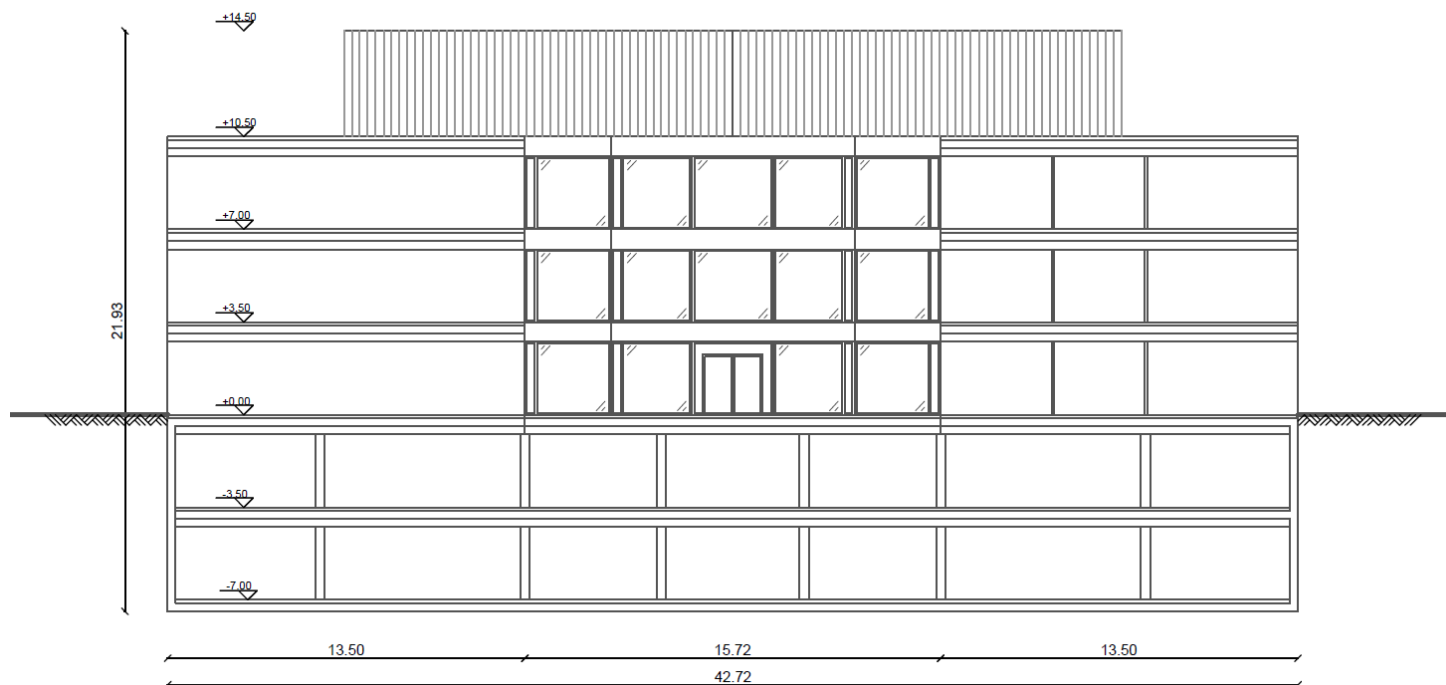
3 Levels:  
A = 4030,2m<sup>2</sup>



# example of a standard office building



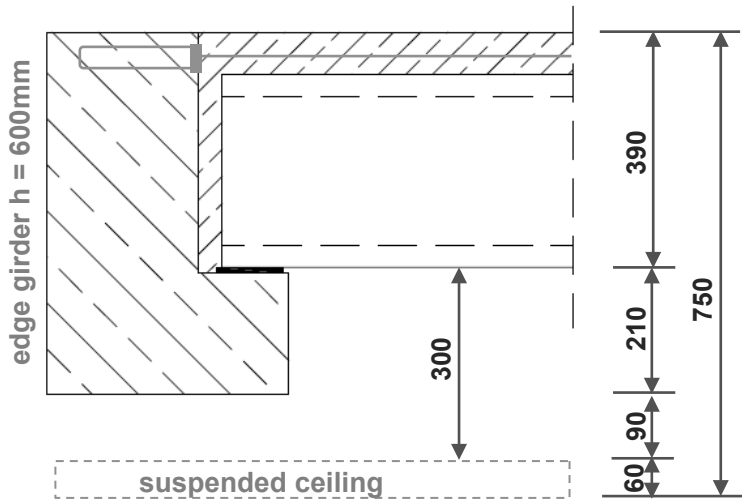
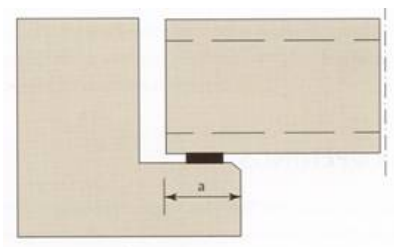
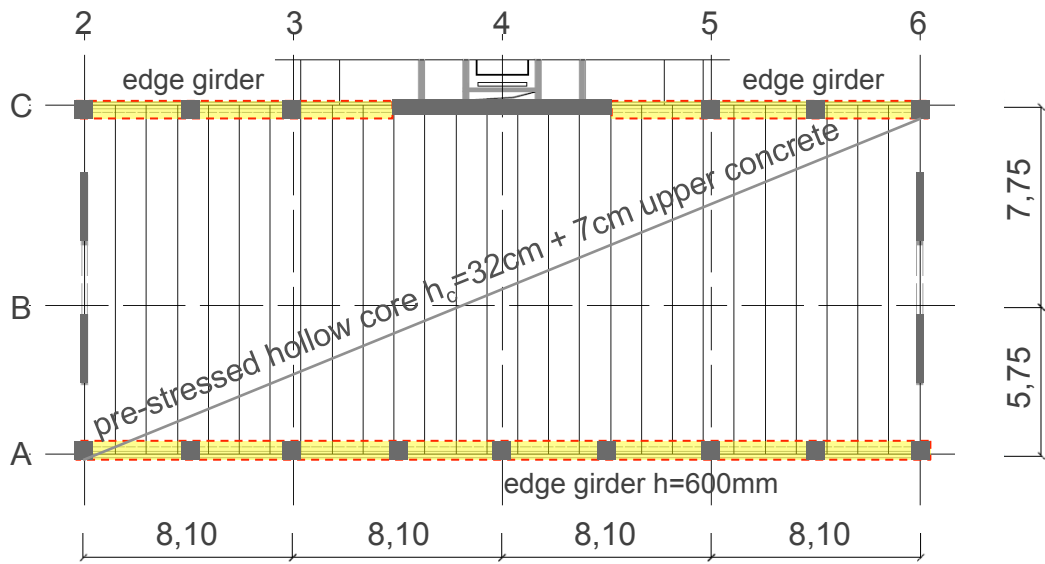
Schnitt I-I



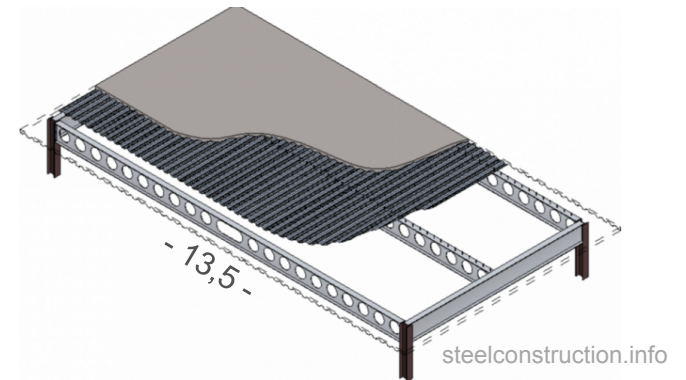
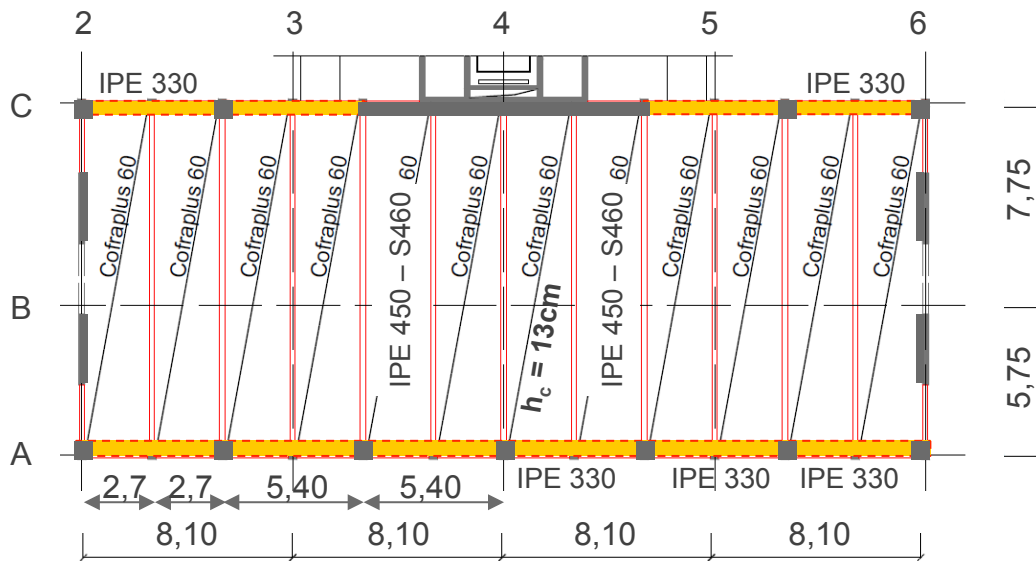


# solution with pre-stressed hollow core slab – without internal columns

axe raster 13,50m/4,05m



# solution with composite cellular beams – without internal columns axe raster 13,50m/4,05m



## geometry:

$$L = 13.500\text{mm}$$

$$h_{\text{tot}} = 640\text{mm}$$

$$h_c = 130\text{mm}$$

## serviceability limit state

$$f_o = 4,0 \text{ Hz}$$

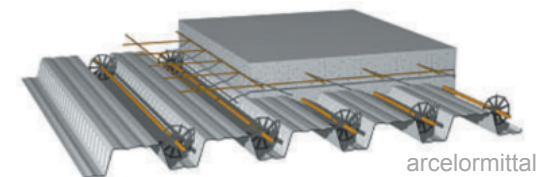
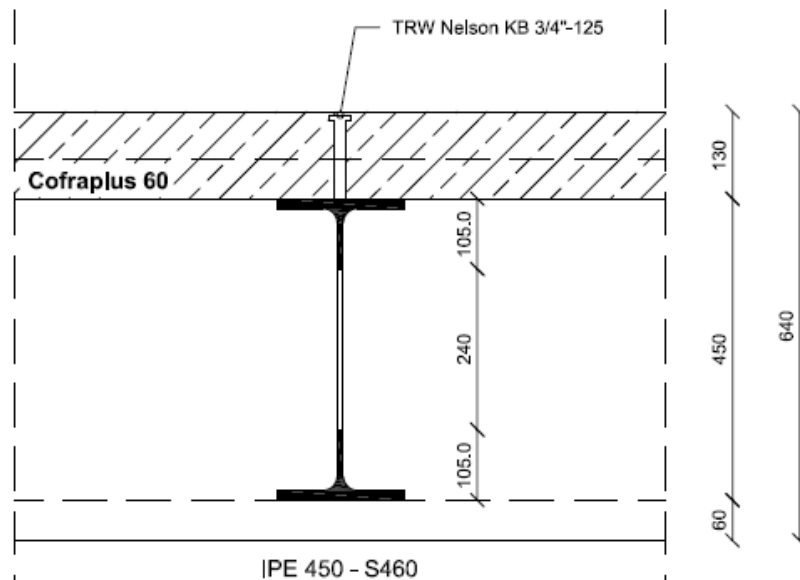
$$f_{o,q} = 3,8 \text{ Hz (0,2q)}$$

$$w = < L/500$$

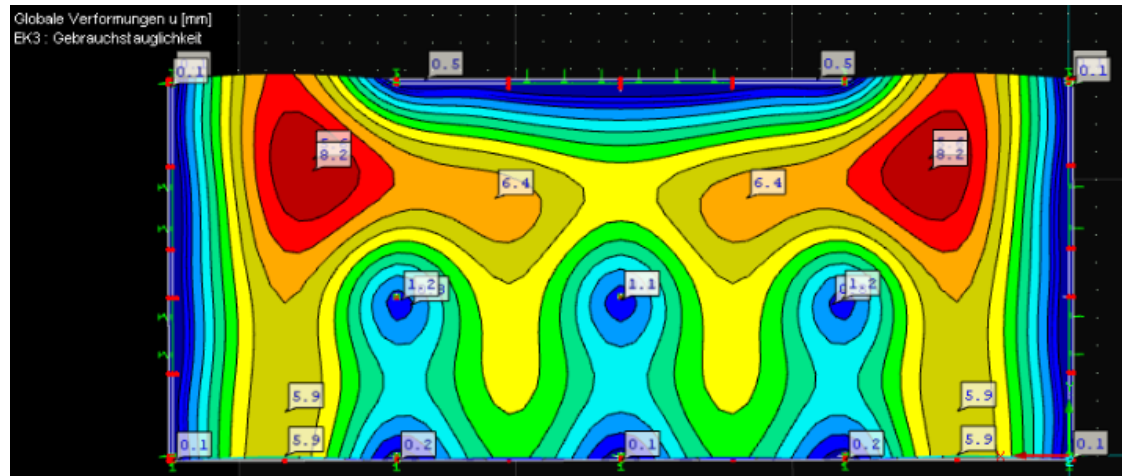
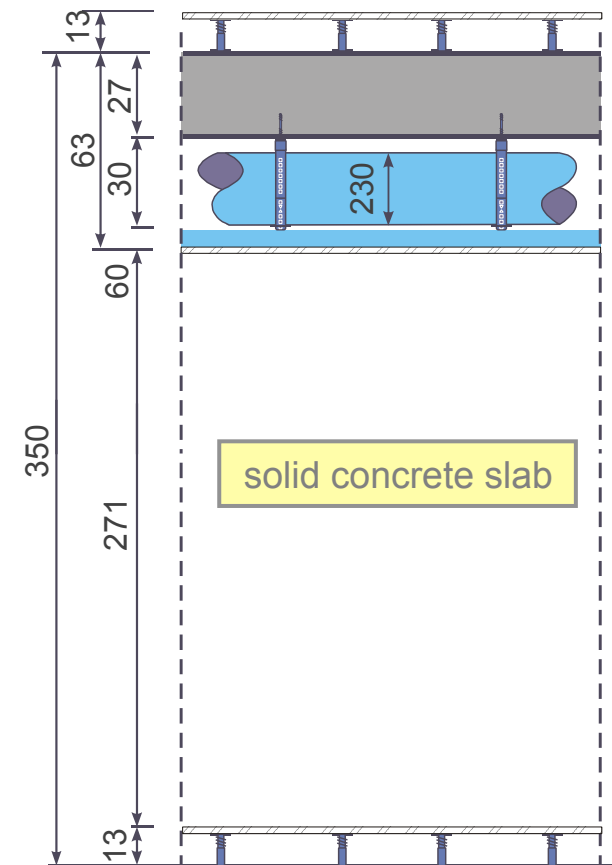
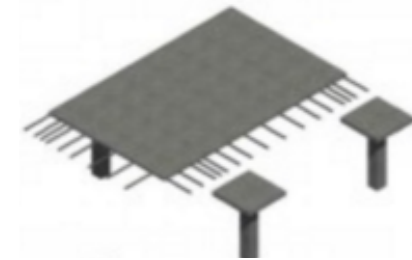
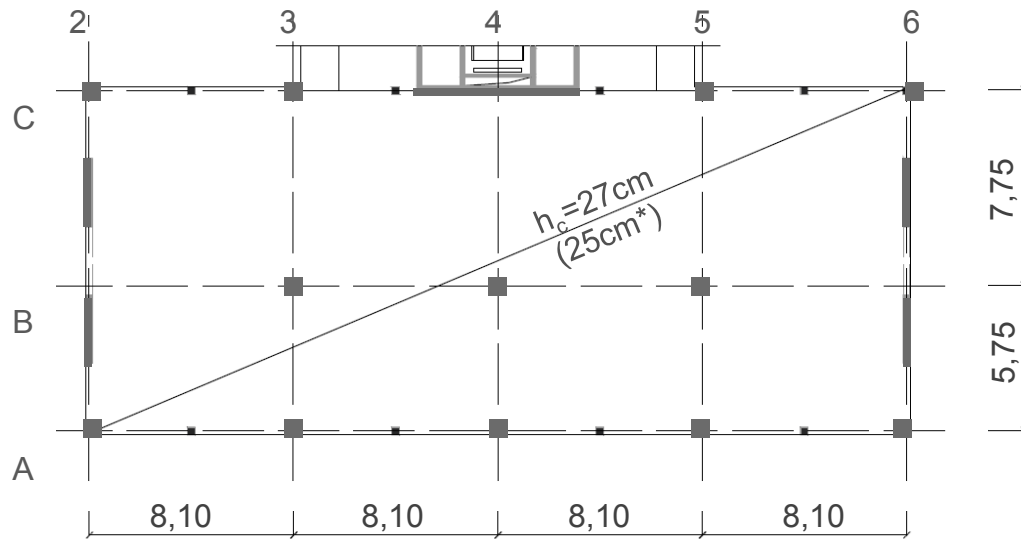
## fire:

$$\theta_{\text{crit.}} = 617 \text{ C}^\circ$$

$$\text{steel ratio: } 30,6 \text{ kg/m}^2$$

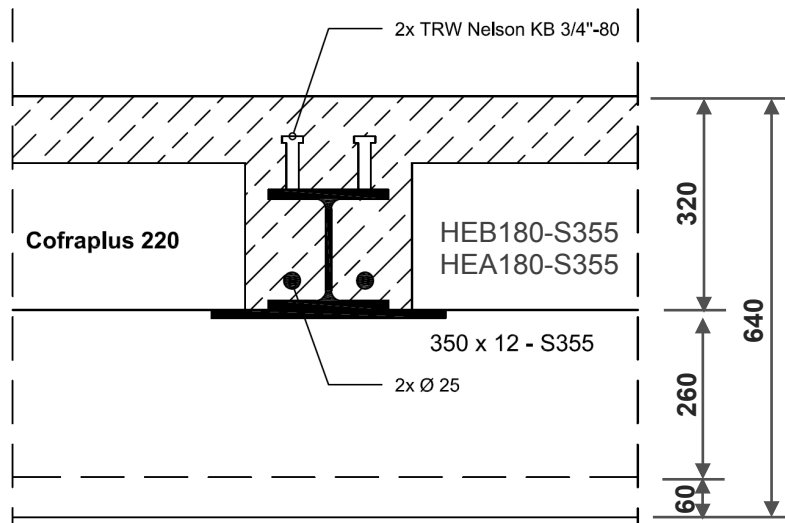
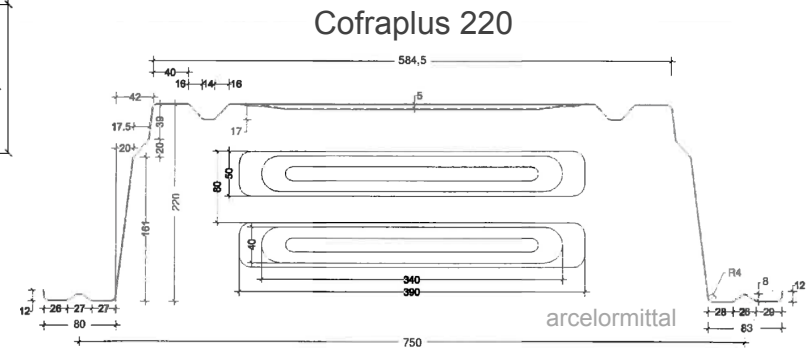
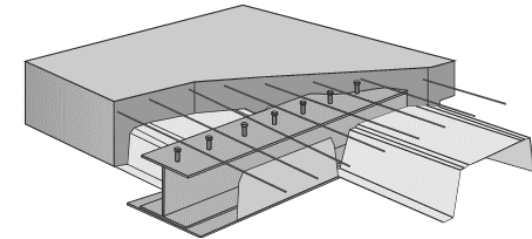
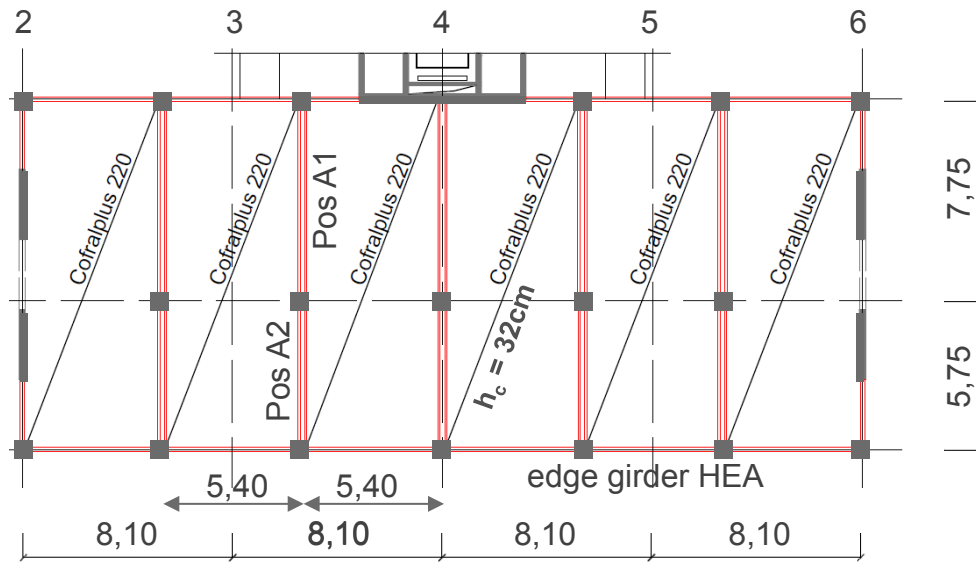


## solution with solid concrete slab axe raster 8,10m/7,75m/5,75m





# solution with slim-floor beams and Cofraplus 220 slab



## geometry:

$$L = 7.750/5.750\text{mm}$$

$$h_{\text{tot}} = 640\text{mm}$$

$$h_c = 32\text{mm}$$

## serviceability limit state

$$f_o = 4,7/7,3 \text{ Hz}$$

$$f_{o,q} = 4,5/7,0 \text{ Hz (0,2q)}$$

$$w = < L/500$$

## fire:

R60

$$\text{steel ratio: } 18,2 \text{ kg/m}^2$$

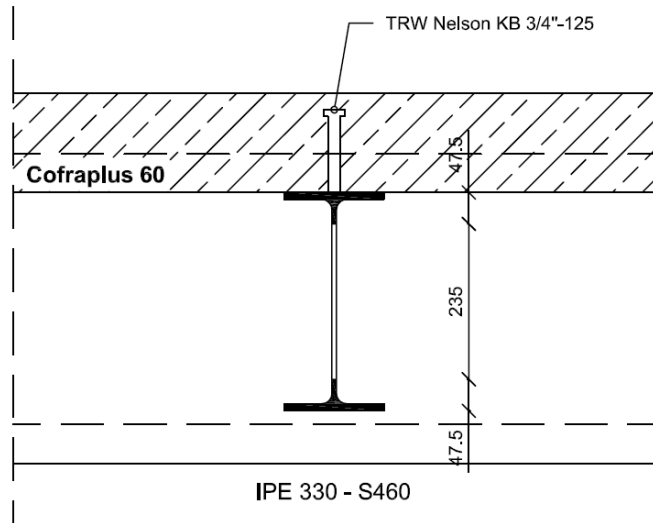
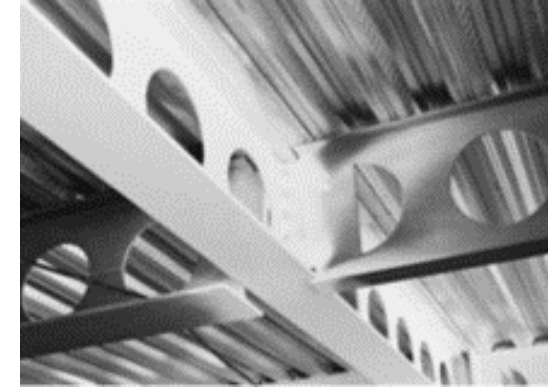
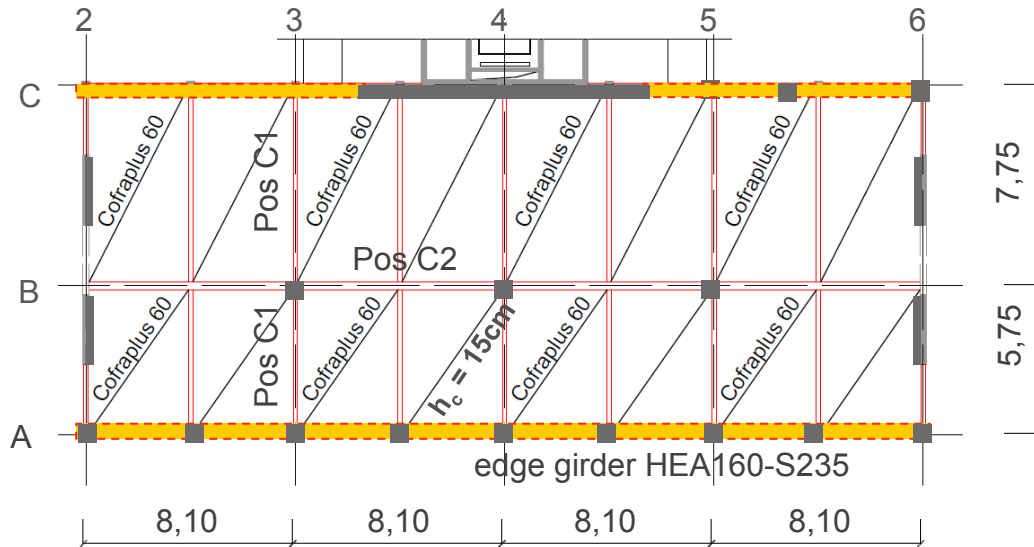
## Comflor 210



dutchengineering

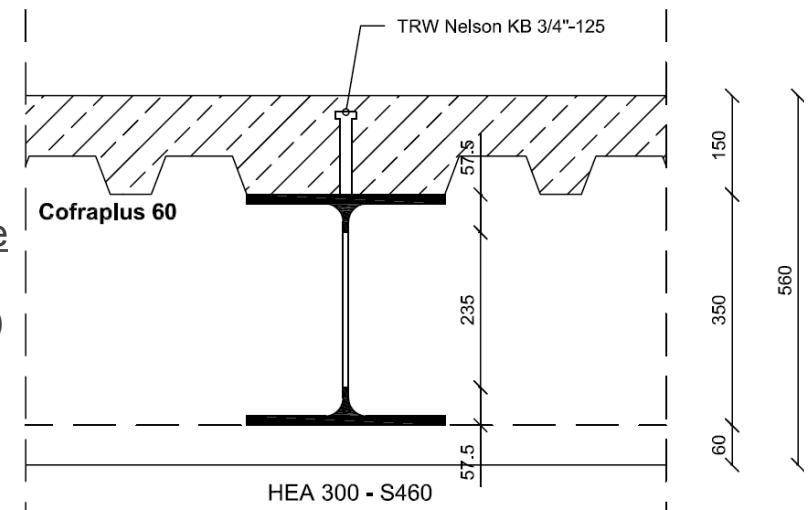


# solution with primary and secondary composite cellular beam axe raster 8,10m/7,75m/5,75m

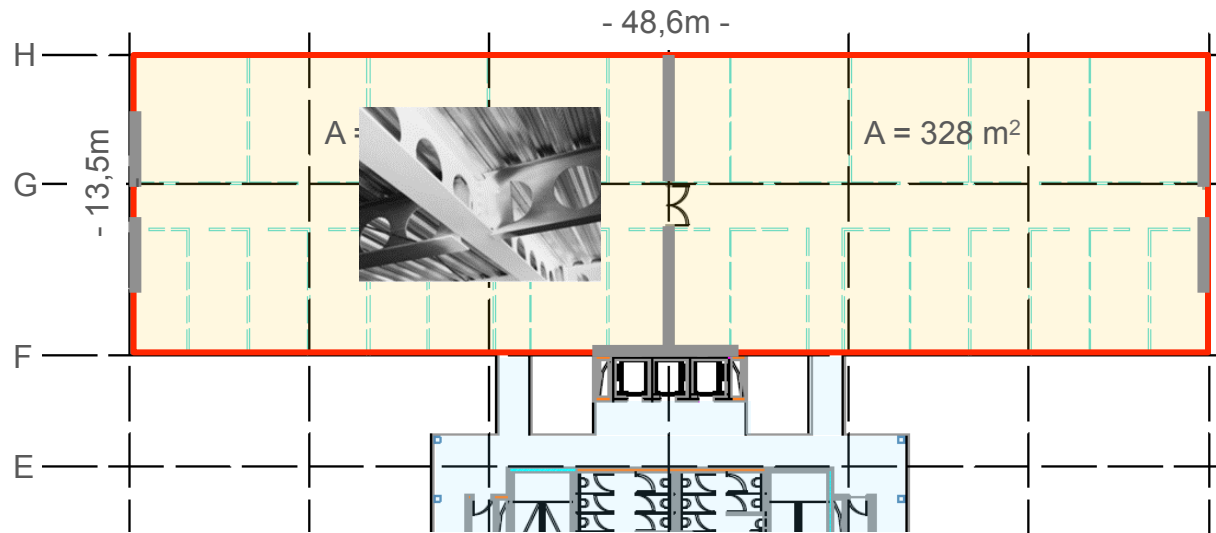


**geometry:**  
 $L = 7,75/5,75/8,1m$   
 $h_{tot} = 560mm$   
 $h_c = 150mm$   
**serviceability limit state**  
 $f_o = 5,4/4,9Hz$   
 $f_{o,q} = 5,0/4,6Hz (0,2q)$   
 $w = < L/500$   
**fire:**  
 $\theta_{crit.} = 592/583C^\circ$

steel ratio: 23,5 kg/m<sup>2</sup>



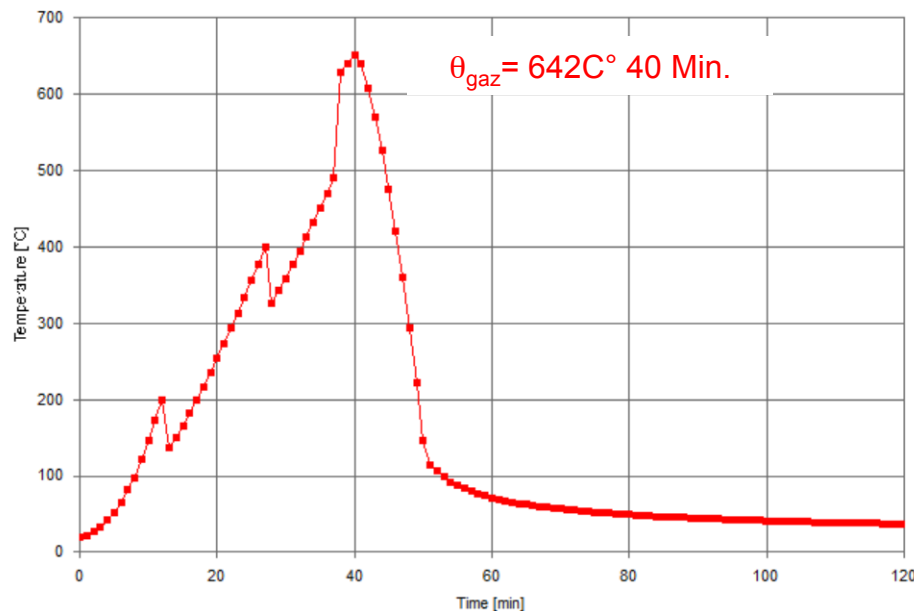
# Fire protection of steel sections? fire design by natural fire



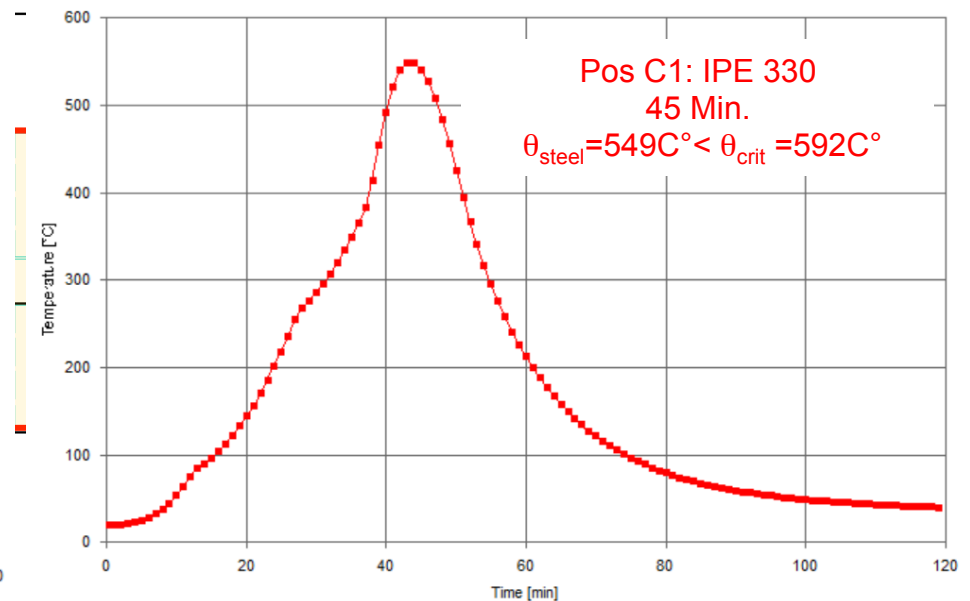
## Fire Installations:

- Automatic Water Extinguishing system
- Independent Water Supplies
- Automatic Fire Detection by Heat and Smoke
- Safe Access Routes
- Fire Fighting Devices
- Smoke Exhaust System

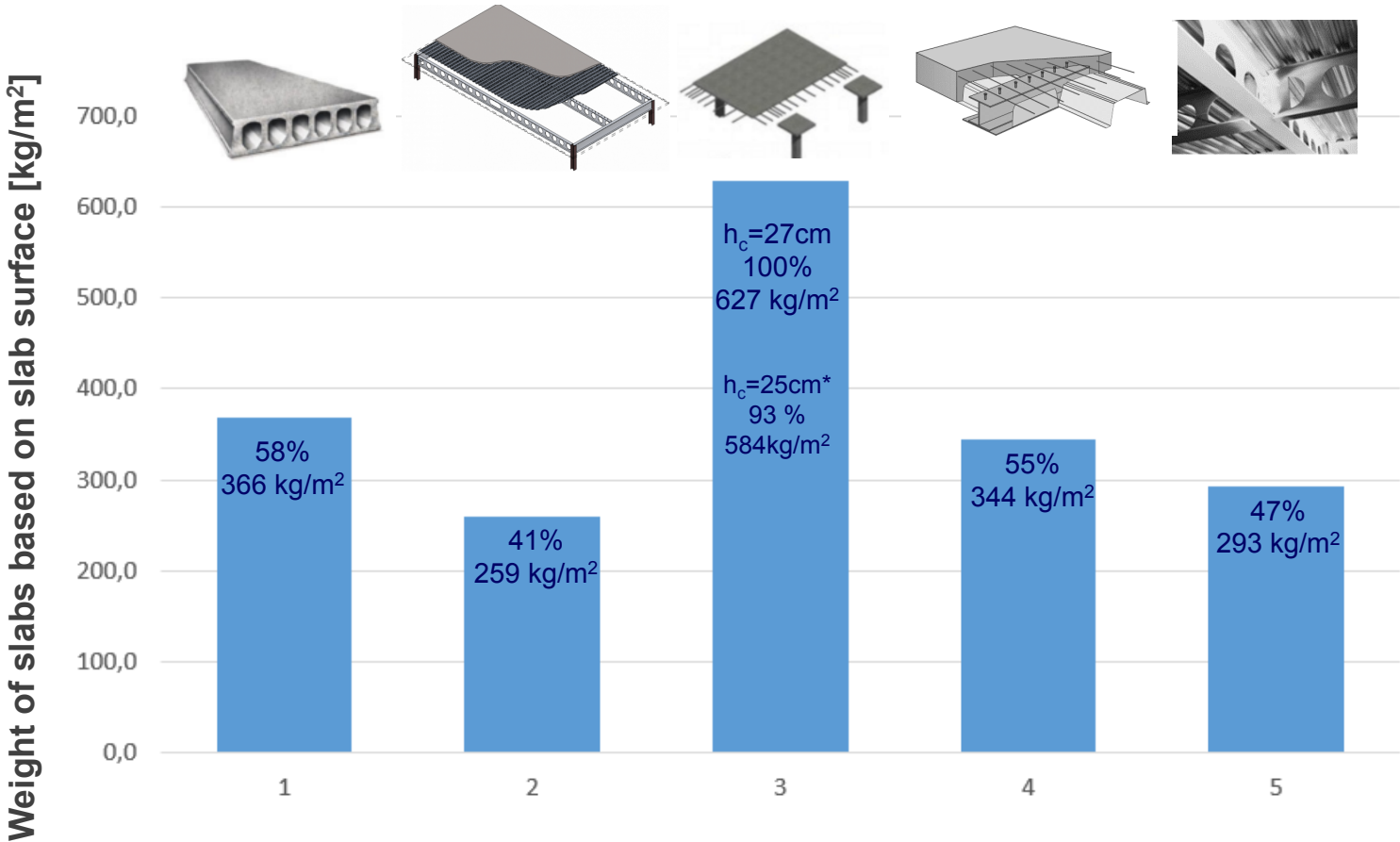
Gas Temperature



Steel Temperature

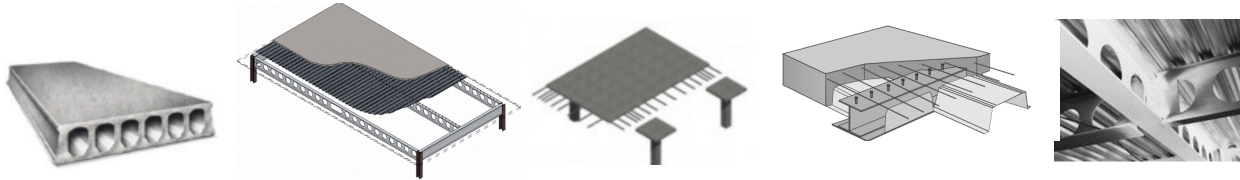


# comparison of structure weight superstructure

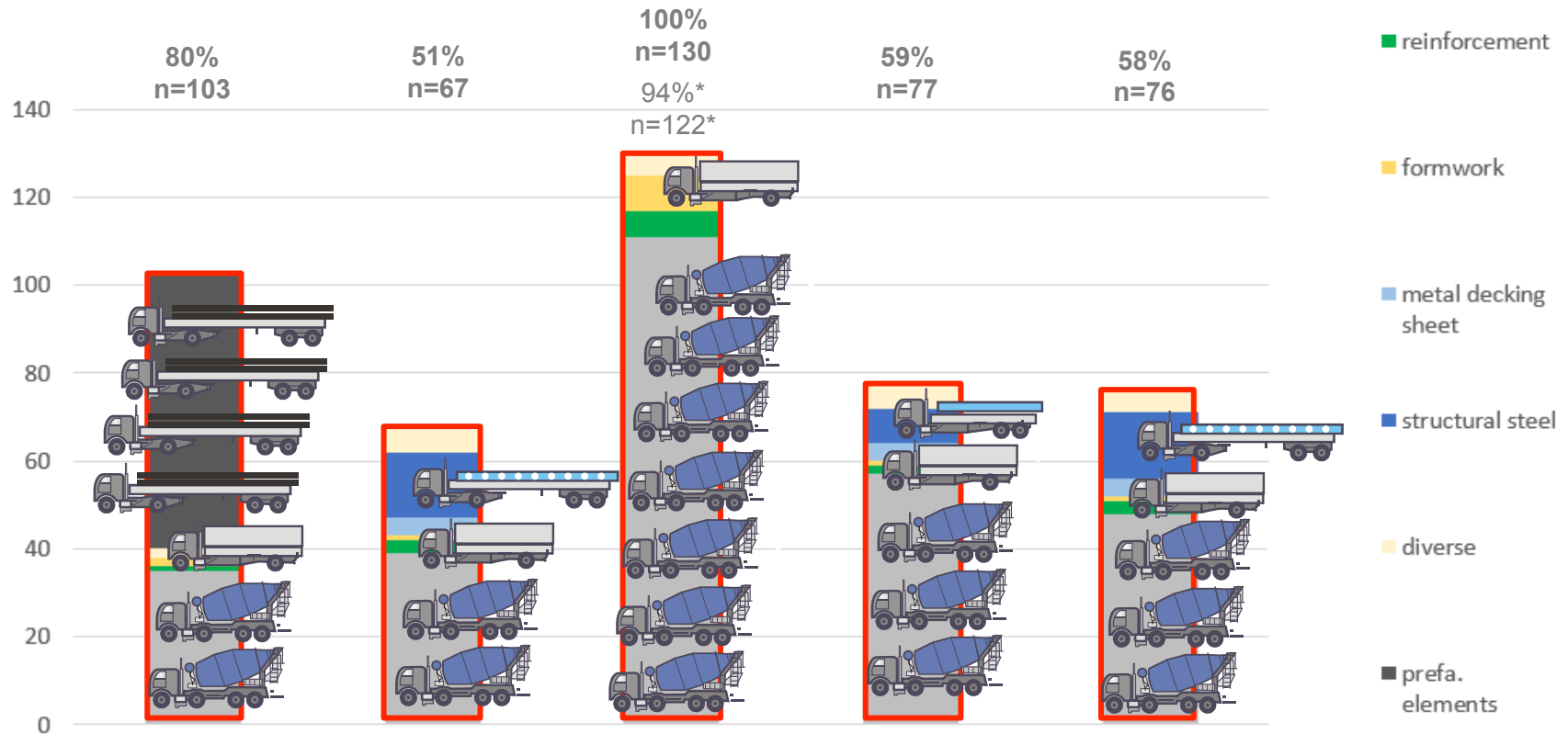




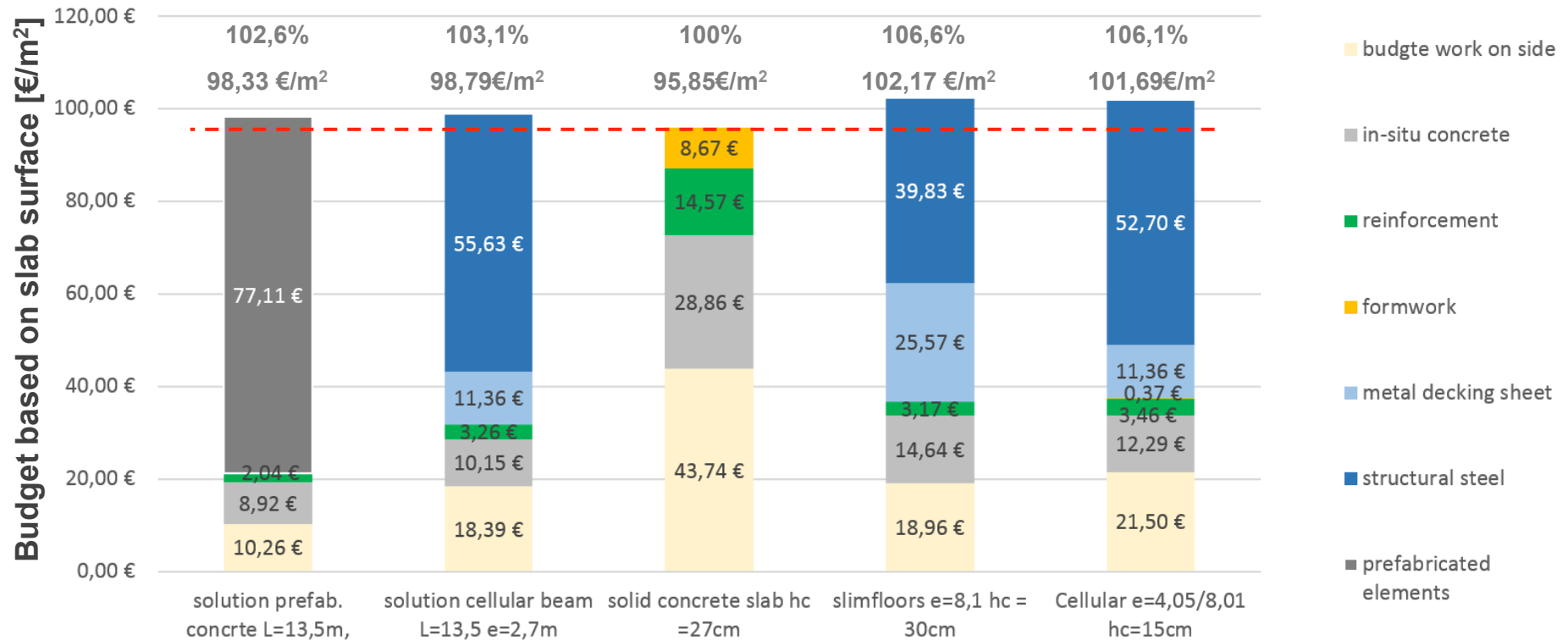
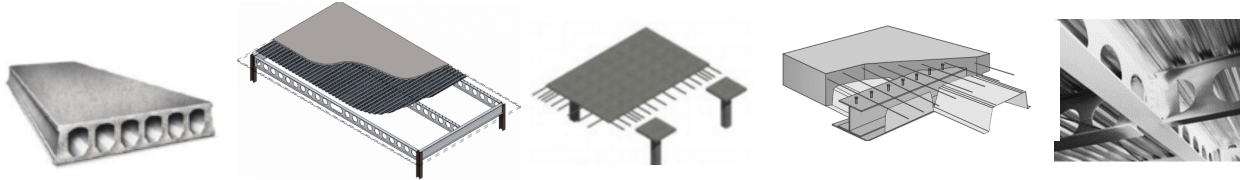
# comparison of building site logistics site traffic for structural work – superstructure/slabs



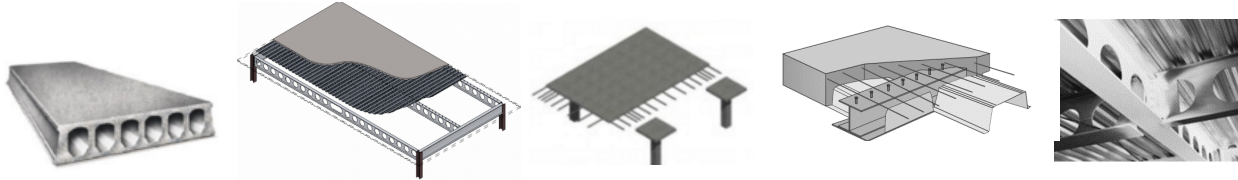
Site traffic for slabs - superstructure



# comparison of construction budget for slab systems of superstructure



# influence of structure on facade



Slab height:  $h_{tot} = 0,75m$

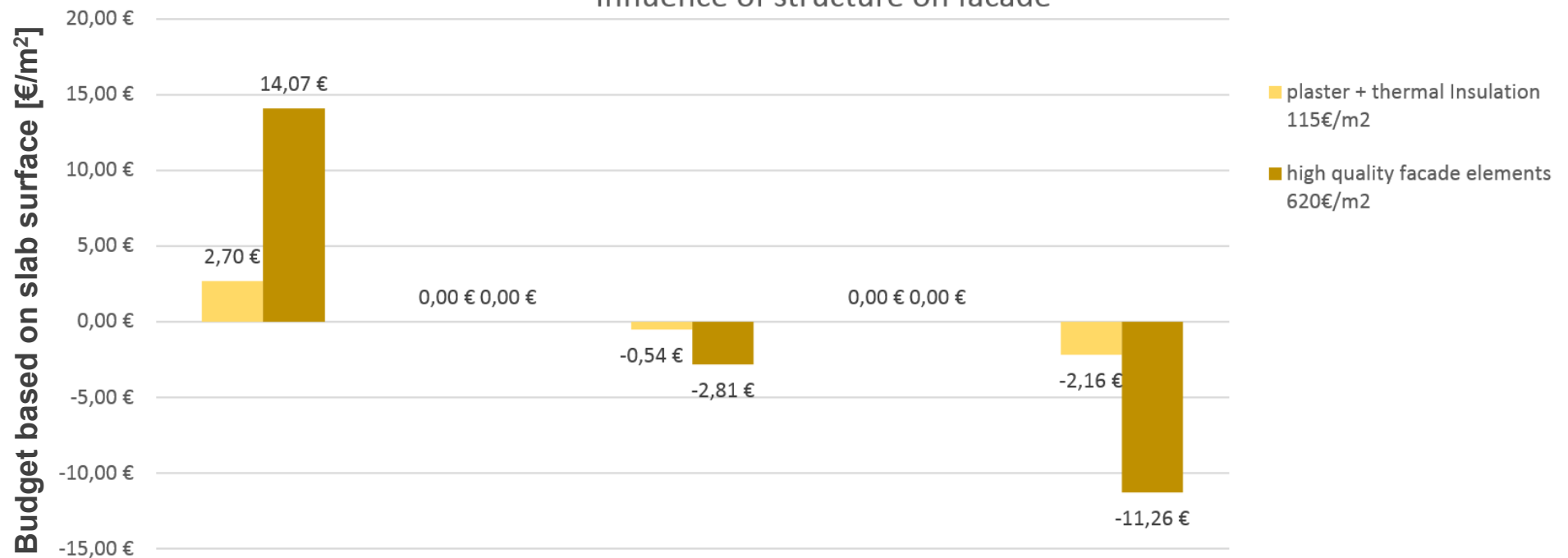
$h_{tot} = 0,64m$

$h_{tot} = 0,63m$

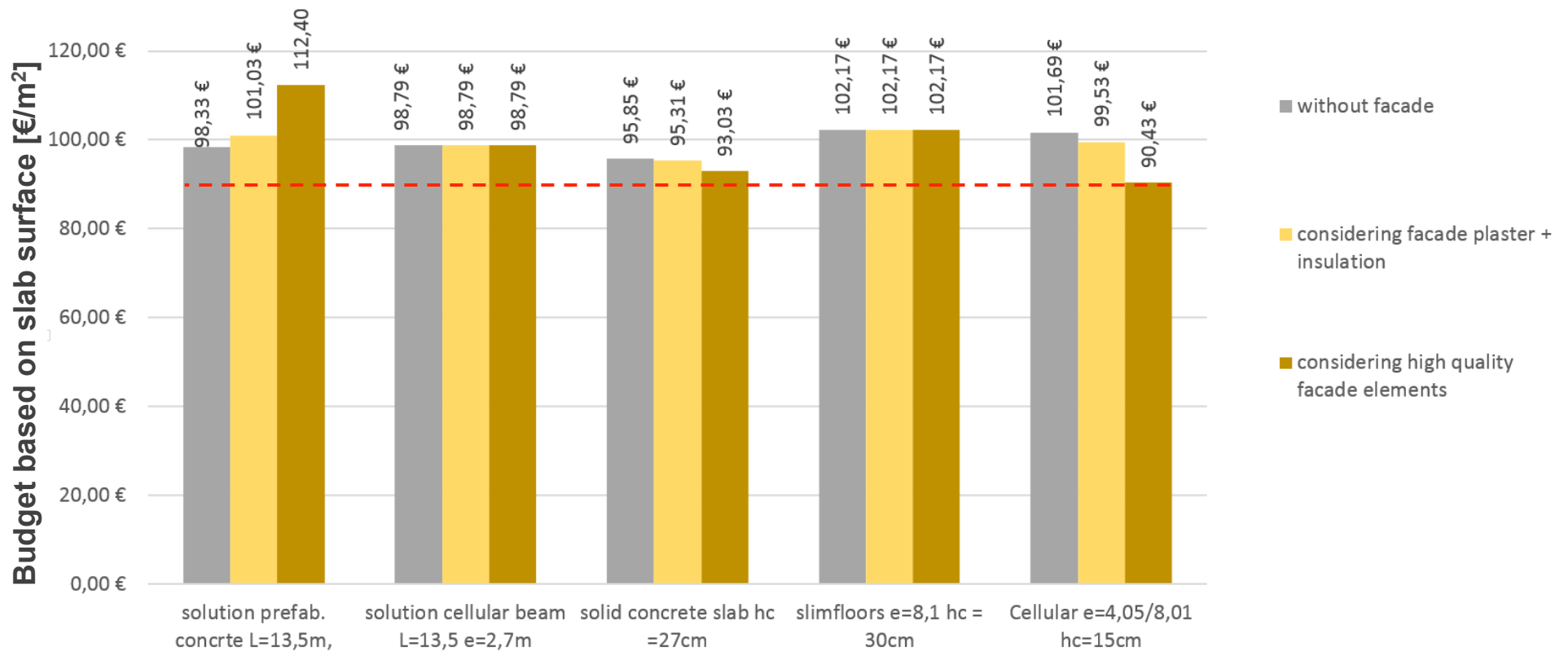
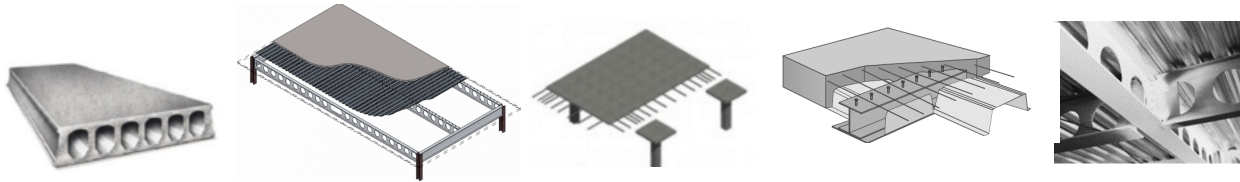
$h_{tot} = 0,64m$

$h_{tot} = 0,56m$

Influence of structure on facade



# comparison of construction budget for slab systems considering the influence of structure on facade



balance by façade budget of 348€/m<sup>2</sup>





## advantages by the steel/composite construction method for the building owner and construction company

high degree of industrial  
prefabrication

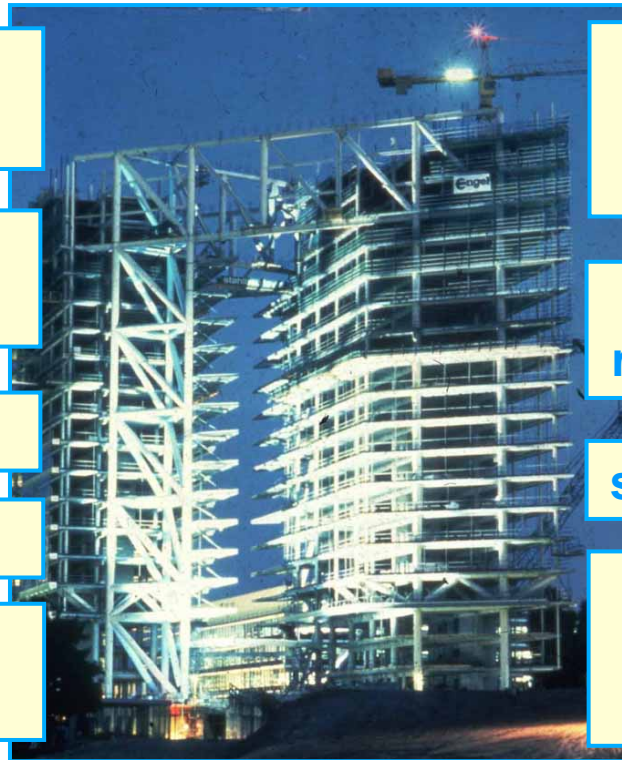
high load capacity of the  
composite components

reduction of construction  
self-weight

integrated fire protection

weather independence

small site installation  
reduce of site-traffic



high flexibility of use by  
large spans and small  
component dimensions

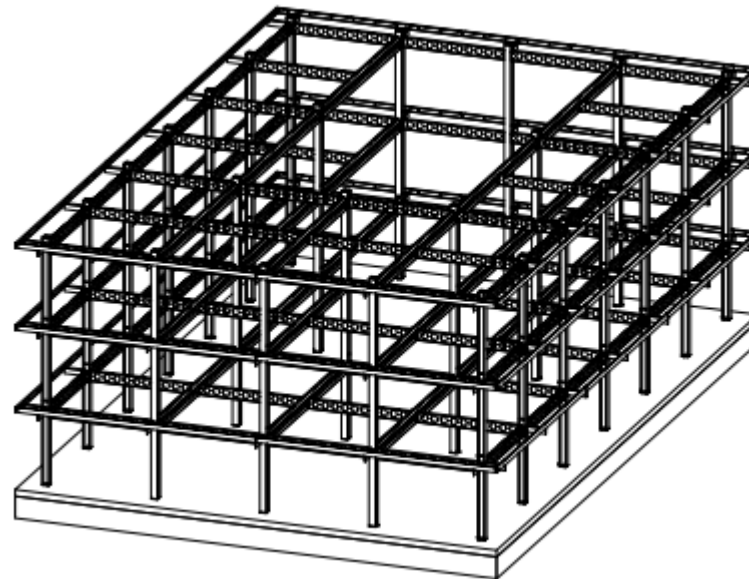
short construction times,  
reducing the cost of capital

saving of natural recourses

reinforcement measures  
are simple to realize in  
case of later use changes

high dimensional accuracy,  
unrestricted interior fittings  
and installation works

sustainable structures with  
possibilities of recycling +  
re-use with financial returns



**merci de votre attention!!!**