IPHA PRODUCTION SEMINAR 2016

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Production cycle of hollow core slabs (excl. casting)

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INTERNATIONAL PRESTRESSED HOLLOWCORE ASSOCIATION

in cooperation with

Pujol

Introduction

Olli Korander

- Involved in precast business since 1978
  - Designer
  - R&D engineer
  - R&D director
    - R&D, productivity, transfer of knowledge, safety
  - Managing director in Consolis Technology
  - Member of Consolis Executive Committee
  - Board member in several Consolis companies
  - Retired 2012 from Consolis
  - Board member in international organisations (BIBM, IPHA)
  - Board member in Finnish standardisation organisation (Sfs)
  - Actively involved in fib and national associations

  - Board member in Polarmatic Oy

Main topics

- **The main factors in production process evaluation**
- **Some other aspects in technology selections**
- **Level of mechanization and automation**
- **Production Process**
  1. Bed cleaning and strand pulling
  2. Pre-stressing
  3. Measuring and marking
  4. Hole cutting
  5. Drainage holes
  6. Covering and curing
  7. Sawing
  8. **LOGISTICS and HANDLING**
- **Some future possibilities in production**

- **<u>Opinions based on 35 + years experience</u>**

Importance of business environment

- **Market need**
  - Products, product mix, specialised business/ multi-product business…
  - Services
- **What is the life cycle position of the product in the market**
- **Used business model**
  - Different offering (Full building / sub-systems / single components)
  - Cost driven / Added value driven
- **Planning and management principles**
  - Used management/ process control tools (ERP)
  - Used engineering principle and methods
    - Individual slabs / Floor design
    - Engineering tools (Modeling, calculations, drawings, input to ERP)
  - Used production planning principle
  - Used assembly planning principle
- **Logistics**

➔ **INDUSTRIALISED CONSTRUCTION as a TARGET**

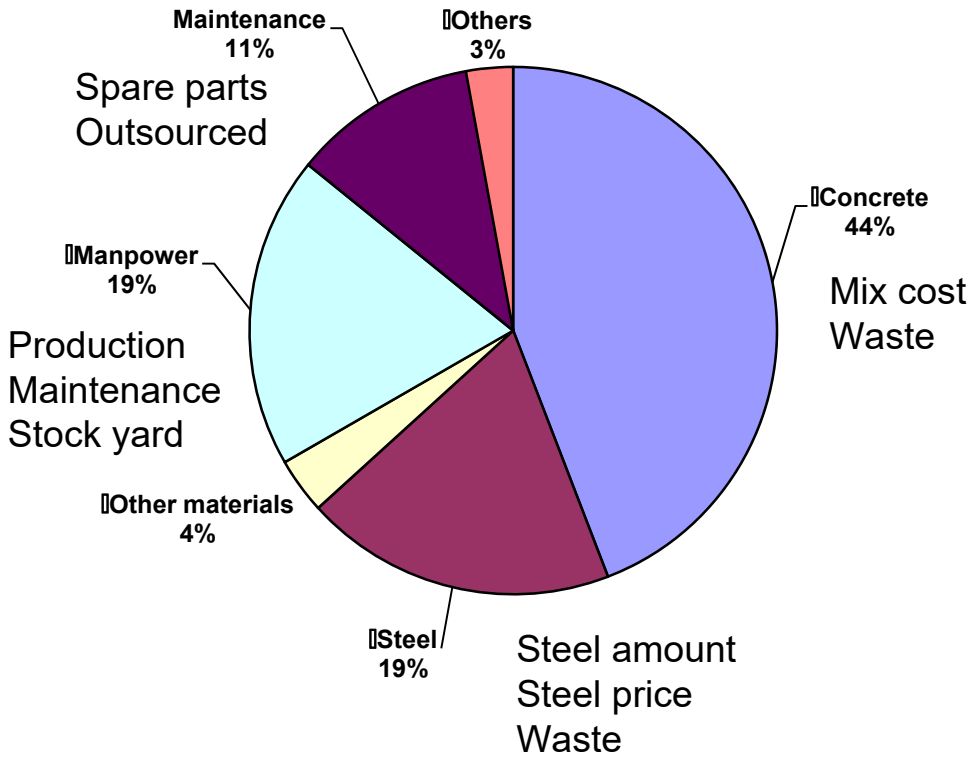
Features of industrialised construction

- **Work is transferred from site to factory conditions**
- **Efficient production methods are used**
  - Mechanization
  - Automation
  - Better quality control
- **Efficient use of raw materials**
  - Less raw materials
  - Less waste
  - Sustainability
- **Modern design methods are used**
- **Site work more effective**
  - Mainly assembly of components
- **Less noise, dust to the neighborhood during construction**
- **More attractive job for competent and talented labor**
- **Safe site work**

Process factors in technology selection

- **Safety**
- **PRODUCTION as a PROCESS**
- **Costs**
  - Manpower
  - Use of raw materials
  - Investment
- **Productivity**
  - Through put time
  - Unit time / m, m^2, m^3
  - Down time
- **Quality**
  - Visual quality
  - Technical quality
- **Waste**
  - **Concrete**
  - **Steel**

Example:
HOLLOW-CORE SLAB
DIRECT PRODUCTION COSTS



Process factors in technology selection (cont.)

- **Used casting technology**
- **Factory lay-out, specialised/multi product factory**
- **Product mix**
  - Cross-sections
  - Average size, max length, weight
  - Product types
    - "Normal slabs"
    - Amount of "special slabs" (narrow, angle cuts, openings)
    - Insulated slabs
    - "Added value" slabs (for insulation, heating, cooling)
    - Hollow core as a wall, foundation etc.
- **Capacity need / actual utilisation**
  - m^2/m^2
- **Process cycle need / possibilities**
  - Casting speed
  - Curing / hardening time

Productivity areas

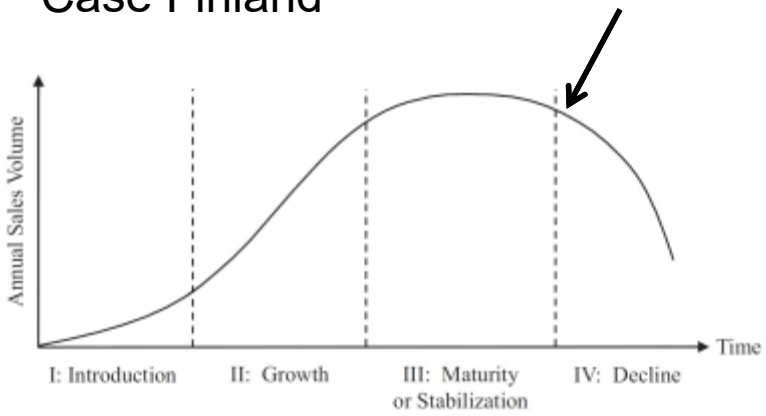
- **Manpower; typically main emphasis**
- **Materials**
  - Concrete mix design
  - Concrete / steel waste
  - Other waste
- **Process**
  - New methods and process control tools
  - Production planning principles
  - Process waste
  - Maintenance
  - Down time / preventive maintenance
  - Production machinery power (electricity, gas, diesel)
- **Design methods and tools**
- **Quality**
- **Safety**
- **Capital**
  - Capacity utilisation
- **Others**
  - Role of administration

Level of mechanization and automation

- **Size of the factory**
  - Flexibility according to market needs
  - Specialised/ multi-product
- **Available input data for automation**
  - Internal / external design
- **Level in industry**
  - Do we have industrial culture?
- **Level of personnel**
  - Do we get best people?
- **Evolution or revolution**
  - Investments mainly in old factories
- **Benefits of automation**
  - What are the benefits?
  - Do we get more flexibility?

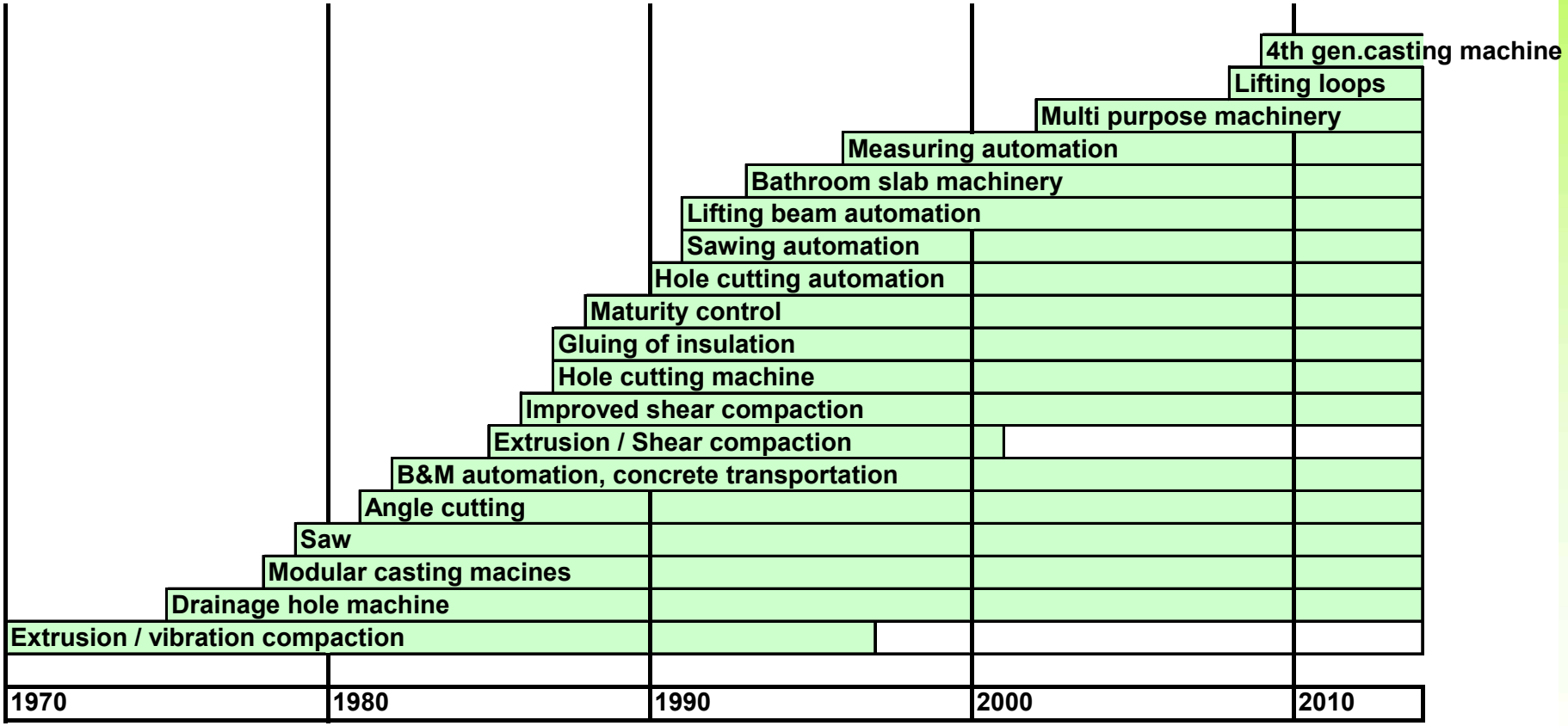
Hollow-core slab, product evolution

Case Finland



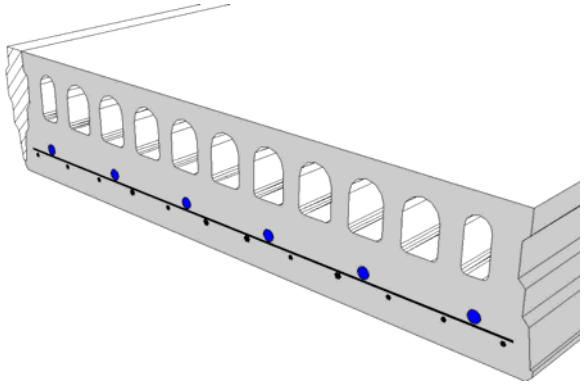
Hollow-core slab, production evolution

Case Finland



Cost driven products

Added value products



Production Process

1. Bed cleaning and strand pulling
2. Pre-stressing
3. Measuring and marking
4. Hole cutting
5. Drainage holes
6. Covering and curing
7. Sawing
8. **LOGISTICS and HANDLING**

1. Bed cleaning and strand pulling

- **Manual / mechanised**
- **Cleaning / waste handling**
- **Oiling**
  - Oil quality
  - Amount
  - Even oil surfaces
  - Strand pulling
    - Individual strands
    - All strands
  - Oiling of the strands / strand slippage

Cleaning and strand pulling, equipment

2. Pre-stressing

- **Safety**
  - Cleaning of grips
  - Pre-stressing procedure and safety
- **Anchor structure**
  - What is the usable length of the bed
  - Capacity utilisation
- **Control of pre-stressing**
  - Power / elongation or both
- **Single or bundle pre-stressing**
  - Size of the factory
  - Normally differences minor
  - Even pre-stressing easy to test
- **Waste**
  - Starting length (> 1 m)
  - Ending length (min 1 m-xx m)
  - Use of continuous strands

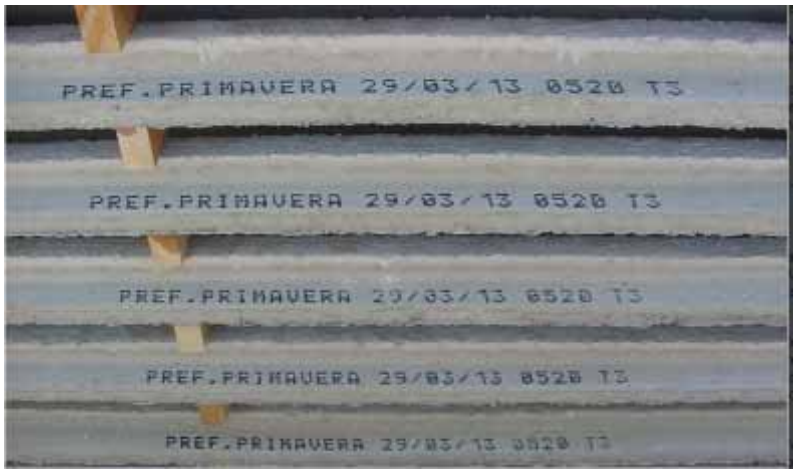
Pre-stressing, equipment

Use of continuous strands

- **Steel waste**
- **Bed utilisation / production planning principle**
- **Steel strength / grips**
  - Is it allowed?
  - A lot of tests done
- **Steel stock value**

3. Measuring and marking

- **Manual**
  - Tolerances
- **Automated**
  - Tolerances
  - Measuring principle
    - Laser
    - Pulse
  - Ink jet



- **<u>Is input data available in right format for all products?</u>**
  - Different formats in design and machinery, standards?
- **Labeling, on the slab/ other labels**

- **Height measurement, control/ concrete waste?**
  - Use of tolerances; production in minus area
  - Example 270 mm slab
    - 2 mm extra height = 1,4 % waste

Automatic measuring, equipment

4. Hole cutting

- Manual
- Mechanised
- Automatic

Fresh concrete

- Shovel principle
- Vacuum principle
- Excavating principle

Hardened concrete

- Diamond tools, drilling, chain saw
- Water jet cutting?

Important topics

- Tolerance and outlook requirements
- Re-use of concrete

Hole cutting, equipment

5. Drainage holes

- **Are they needed?**
  - In most cases yes, especially in cold climate
  - Water in voids is a very expensive claim
  - Sales contract topic, who is responsible
- **Drilling from the top**
  - Fresh concrete
  - Quality of holes
- **Drilling from the bottom**
  - Hardened concrete
  - Quality of holes
- **Different drilling methods**
  - Normal drills
  - Hammering
  - Water jet

6. Sawing

- **Normal sawing**
- **Angle cuts**
- **Longitudinal sawing**

- **Fresh sawing**
  - Quality of sawing
  - Tolerances

- **Sawing of hardened concrete**
  - Manually operated
  - Fully automated, measuring principle
  - Dust and slurry handling
  - Availability of input data in right format

Sawing, cont.

Important topics

- **Sawing speed**
- **Sawing quality, tolerances**
- **Sawing costs / blade quality**
- **Noise level**
  - Noise protection
  - Blade structure
- **Quartz dust**
  - Aggregate minerals
  - Saw machine structure

Sawing, equipment

7. Curing and maturity control

Why important?

- To control the rate and extent of moisture loss from concrete during cement hydration
- On-line control of concrete temperature, control of heating
- Calculation of final strength
- Forecast of hardening time
- Tracking of curing process needed in some projects
- Variations in raw materials; aggregates, cement
- Less waste (strand slippage)
- Lower energy consumption, short pay-back time

=> OPTIMISED and CONTROLLED PROCESS CYCLE

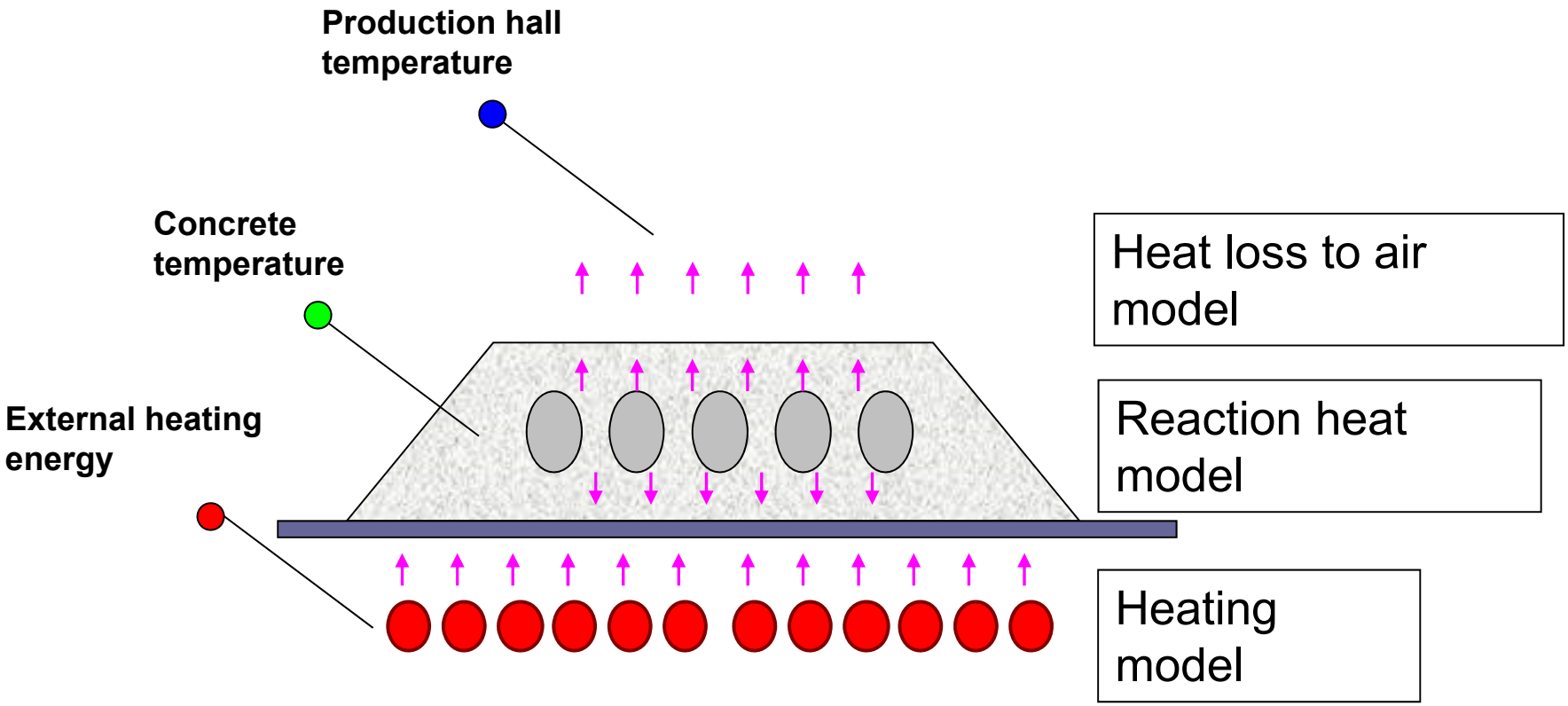
Curing and maturity control

Methods of curing concrete

- **Minimise moisture loss from the concrete, by covering it with a relatively impermeable membrane.**

- **Prevent moisture loss by continuously wetting the exposed surface of the concrete.**
- **Keep the surface moist and, raise the temperature of the concrete => increasing the rate of strength gain.**

Maturity control principle



8. Logistics and handling

- **Handling in the factory**
- **Handling in the stock yard**
- **Assembly at the building site**

- **Main aspects in lifting**
  - Safety in all phases/ local regulation
  - Speed
  - Amount of special slabs (narrow slabs, large openings etc.)
  - Storage system
  - Transportation contract
  - Transportation method and assembly order and method

- **Lifting options**
  - Individual slabs
  - Bundle lifting
  - Long lifting

Logistics and handling, production hall

Cranes

Clamps / lifting beams

Collection wagons / cars

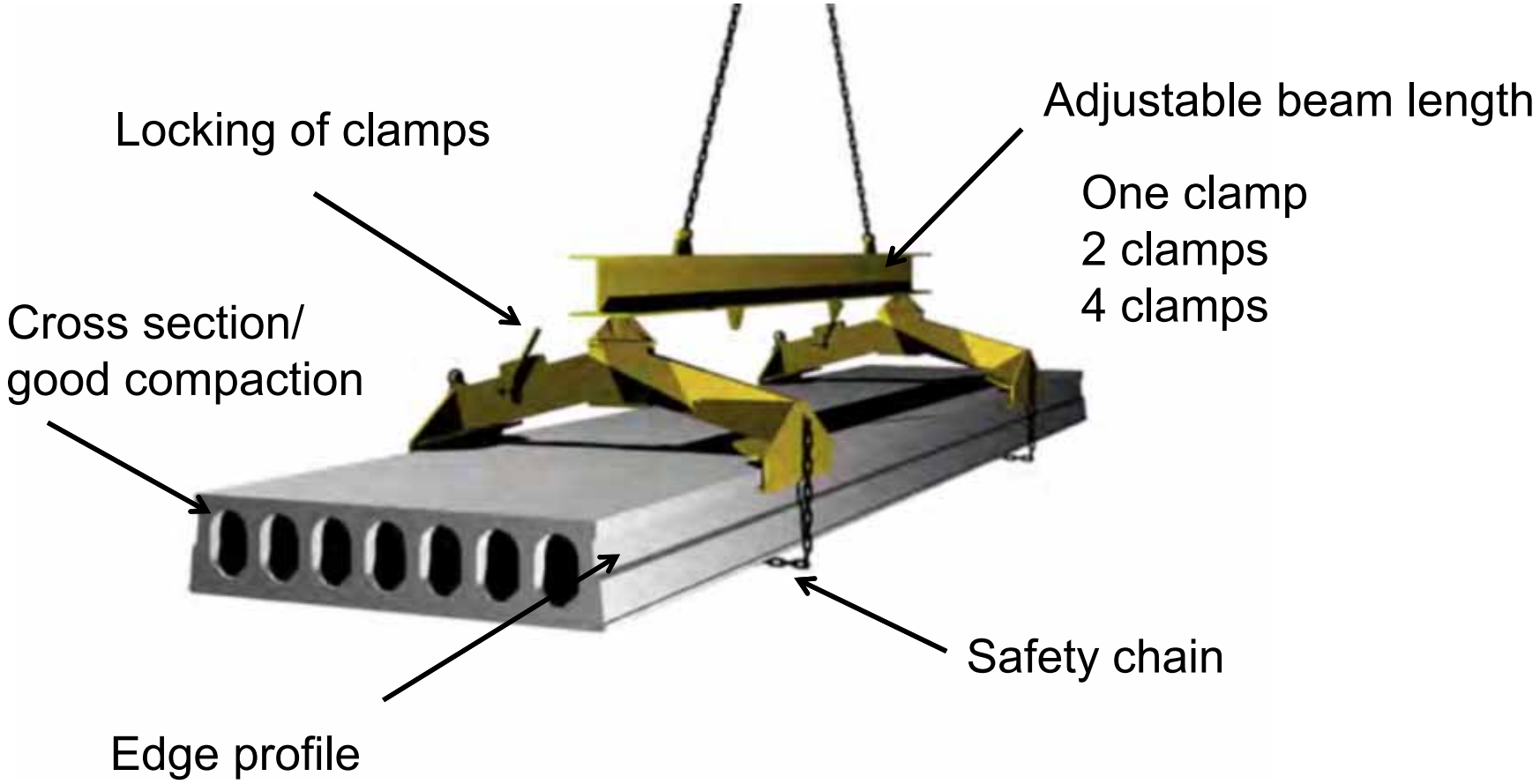
Lifting hooks / lifting beams

Logistics and handling, production hall

- **Clamps / hooks**
  - Total production cycle time
  - Manual / mechanised hook assembly
  - Extra concrete for hook casting
  - Handling of special slabs (narrow, large openings)
  - Calculation principle and calculated safety

- **De-molding is the first quality control test**
- **Load bearing capacity of both methods is based on concrete tensile strength**
  - Design principle of hooks, bonding under the strand or not
- **Planning principle is very important, sorting in the hall or stock yard**

Logistics and handling, clamps



Logistics and handling, lifting hooks and anchors

Lifting hooks, equipment

Logistics and handling, storage

- **In coming products**
  - Assembly order
  - Load size
  - Available storage area

- **Out going products**
  - Transportation contracts
  - Who is doing loading?
  - Assembly order

Logistics and handling, storage

Single slabs

Bundle handling

Ready loads

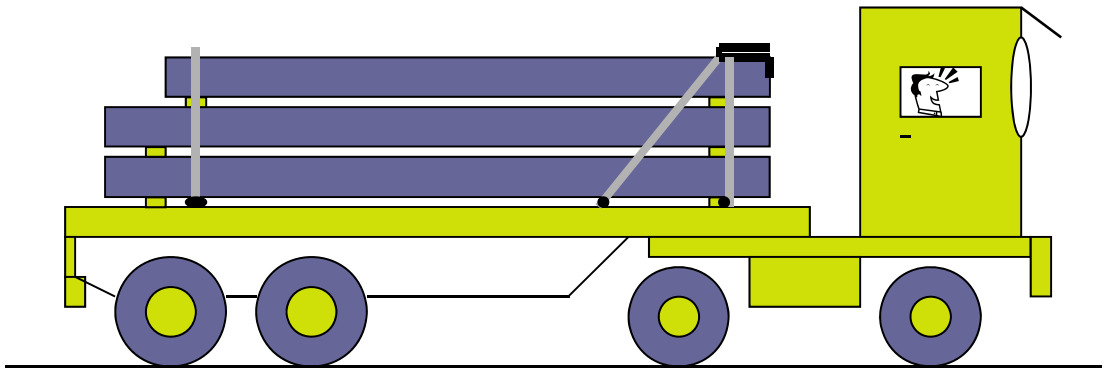
Crane on the lorry

Logistics and handling, at site

Fixing of the load

Hollow-core slabs

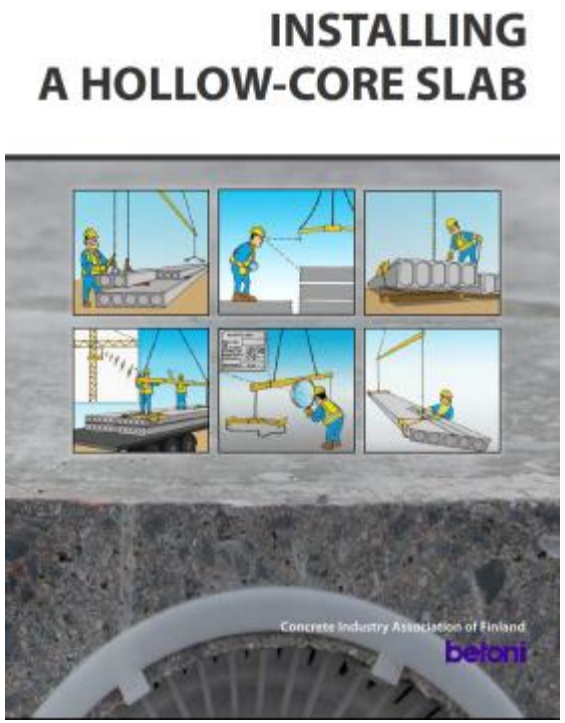
- **Notice the location of stacking timbers**
- **Fixing behind stacking timber, not from the side of cantilever**



Logistics and handling, at site

Logistics and handling, at site

- **Safety**
  - Safety rules
- **Assembly instructions**
  - Easy to understand
- **Assembly speed**
  - Crane speed / lifting height
  - Adjusting of the slabs
  - Extra castings of hooks



Clamps / hooks

	Clamps	Hooks
Safety	++	++
Unit cost	+++	+
Handling speed	++	+++
Special slabs	+	+++
Local regulation		
Extra site work	+++	++

Future of pre-cast industry…..

- **Evolution will continue**
- **Larger factories, more flexible production?**
- **Co-operation with other players and materials**
- **Environmental challenges are real**
- **Examples from other industries**
- **Industrialization of total building process**
  - Focus on productivity
  - Design the key area
  - Pre-fabrication as a main tool
  - Automation and mechanization
- **More emphasis on material technology**
  - Cost, quality / outlook, sustainability

- **MORE INNOVATIONS NEEDED**

Future possibilities in hollow core production

- **Fully automated factories**
  - Larger units?
  - Technology is available
- **Automation of individual steps**
  - Heavy work
  - Better quality
- **Simulation as production planning tool**
- **Faster production cycle / hardening**
- **Preventive maintenance**
- **New production concepts**
  - Now fixed product, moving machinery
  - Moving product, fixed work stations
- **New technologies**
  - Water jet, laser
  - RFID, machine vision