Modular design of cross flow channel through structural optimization

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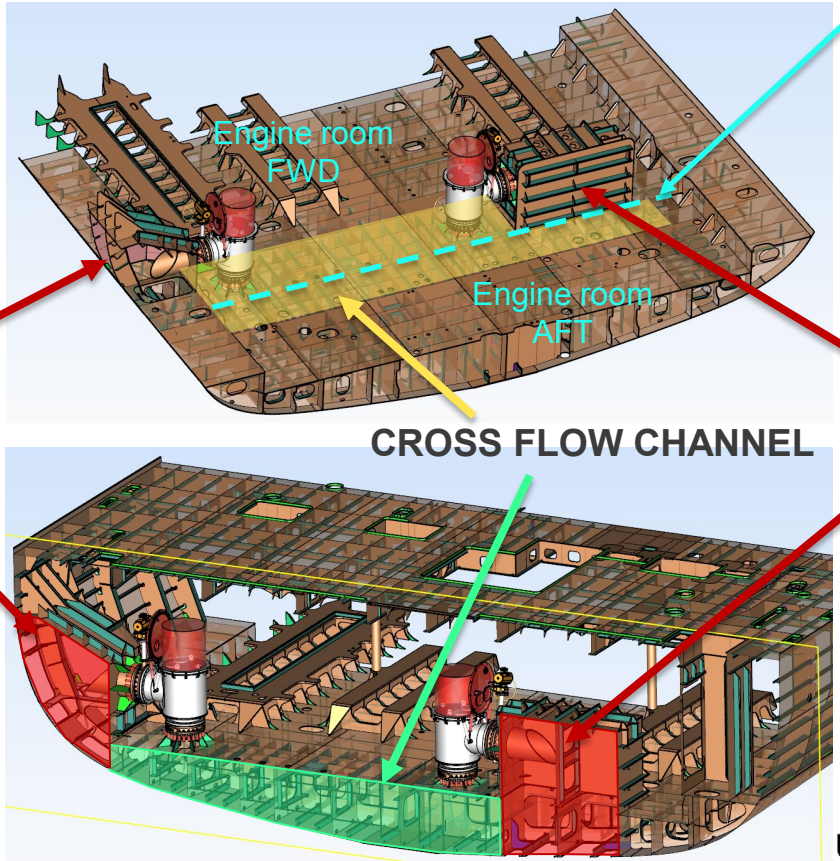
Motivation

- To study the modular design of complex double bottom structures, based on the cross flow channel.
- Taking advantage of modular construction, the structural optimization of the cross flow channel is done.
- The optimized structure shall be designed to be built as a module by identifying the general aspects to consider.

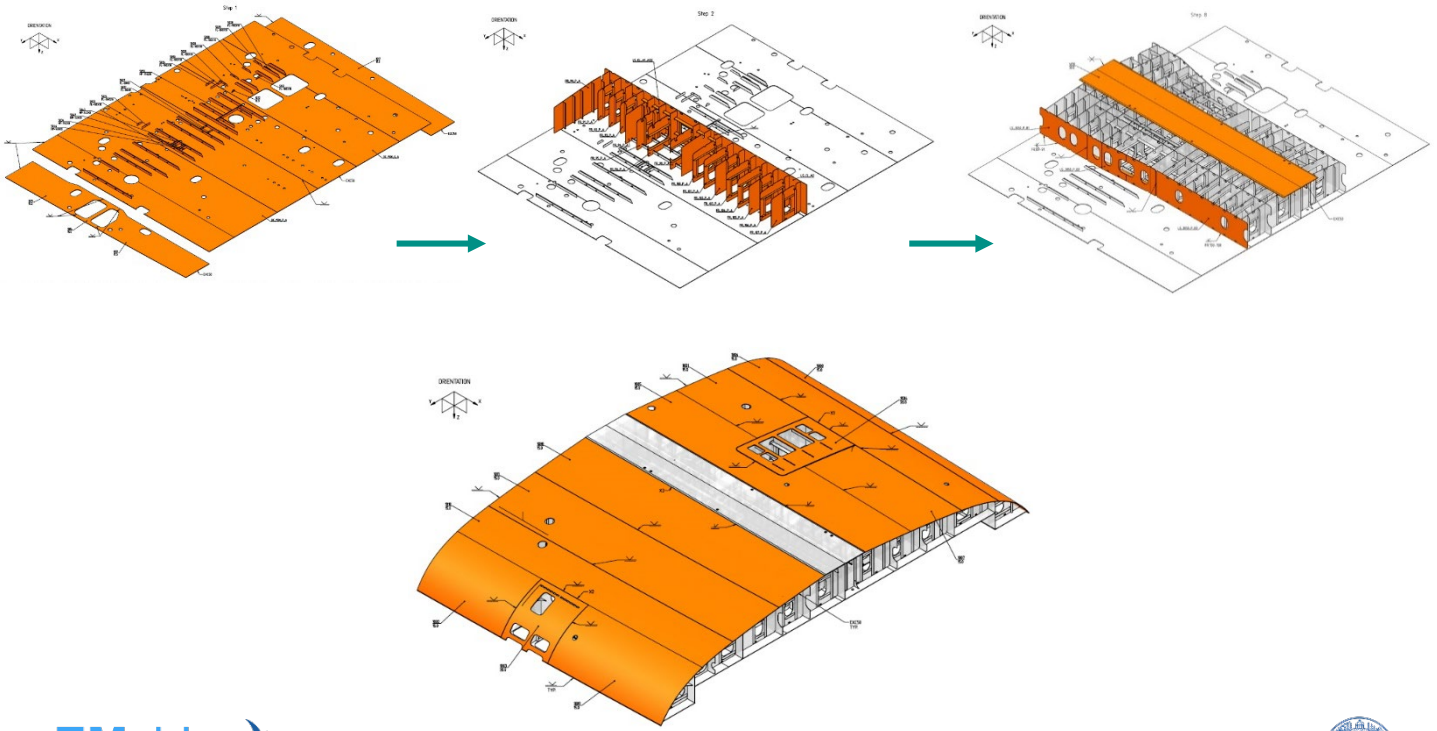
Cross flow channel

Example:



How it is built

Complete block is constructed at the block assembly



Problems associated

- Accessibility and reachability
  - Welding , Distortion straightening
  - Painting
  - Time waste due to Human errors
- Welding position
- Number of parts involved : 1600+
  - Storage issues
  - Missing parts/components
- Other issues
  - More idle time of workers
  - Less room for change of plans

- Unsafe working environment.

→ Modular construction

Requirements of a crossover

- Functional requirements:
  - Flow rate
  - Flow velocity (0.5~1.1 m/s)
    - Higher velocity → increased resistance
    - Lower velocity → easy marine growth
  - Avoid air bubbles/air cushions

- Operational requirements:
  - Avoid sharp corners → reduce mud/sludge
  - Enough space and access for inspection/maintenance
  - Suitable for anti-fouling

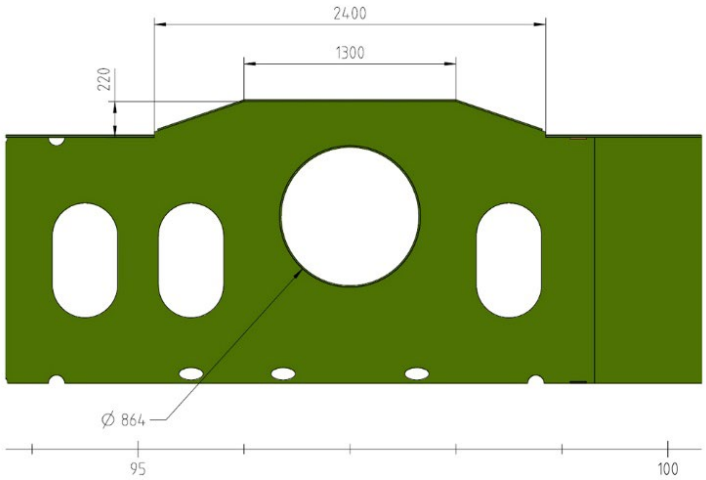
Pipe integrated in double bottom

- Required flow: 2000 m3/h on average.
- With 1 m/s → 844 mm diameter standard size pipe
  - ✓ Slightly over 2000 m3/h possible
  - ✓ Can give up to 2200 m3/h with 1.1 m/s
- Pipe thickness: 10 mm
- Pipe is provided with;
  - ➢ Cut-outs/connections for suction and intake
  - ➢ Blind flanges on either side for inspection

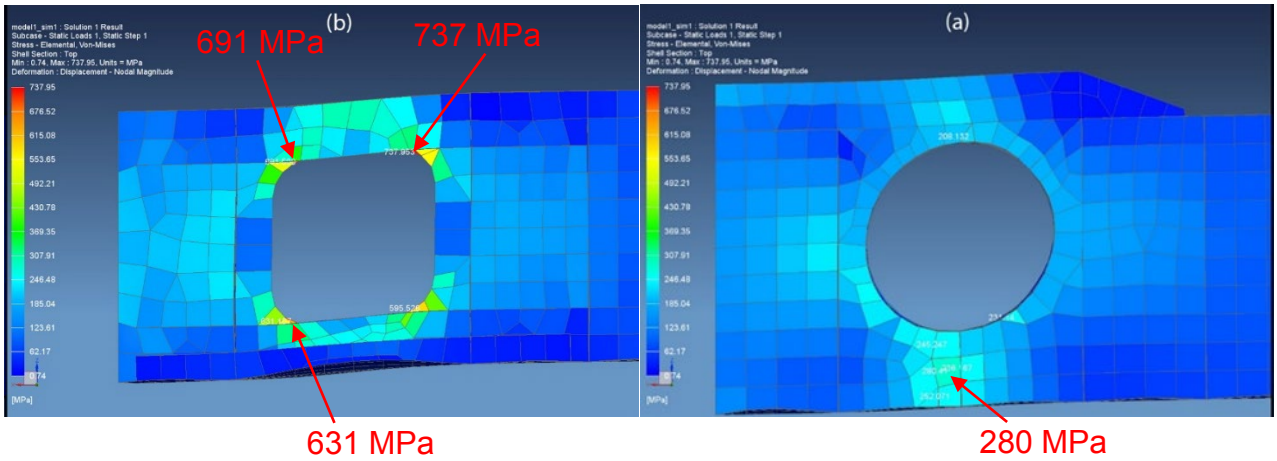
Structural Optimization: Girder

Girder openings & strength

- Height of openings < 60% of girder height, a rule of thumb.
- Integrating the pipe → increase height of girder locally: 220 mm



Girder strength – FE analysis

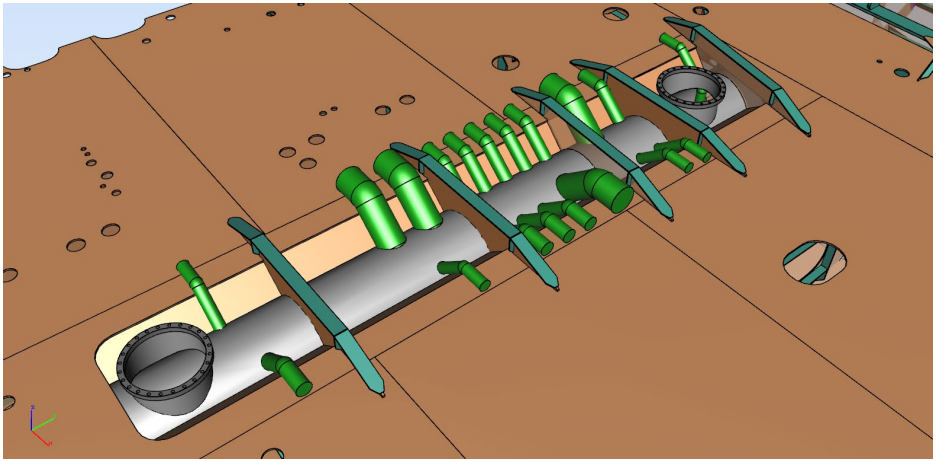


- ✓ Reduced stress concentration been achieved at opening
  - ➢ Comparatively satisfies and even better behaviour.

Only a comparison, needs further investigation!!

Structural Optimization: Deck

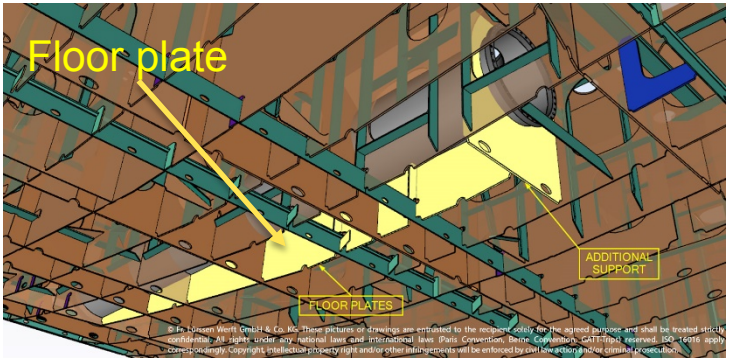
Open deck arrangement



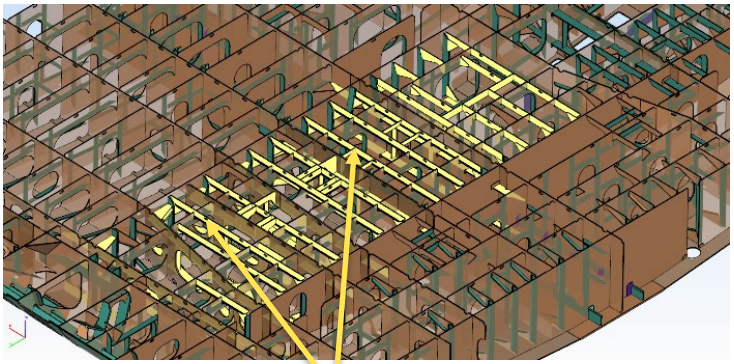
- Deck plates are knuckled to the pipe
- Pipe is open to the deck
  - To avoid tight spaces between pipe and deck plate
  - Direct installation of suction pipes

Other Structural optimizations

Addition of floor plate & support



Elimination of additional stiffening profiles



Benefits achieved

- Flow velocity and flow rate with small volume
- Reduced resistance/ air bubbles
- Reduced mud/sludge formation & marine growth
- Reduced surface area → Reduced anti-fouling
  - About 60% reduction in cost related
- Easy inspection and maintenance

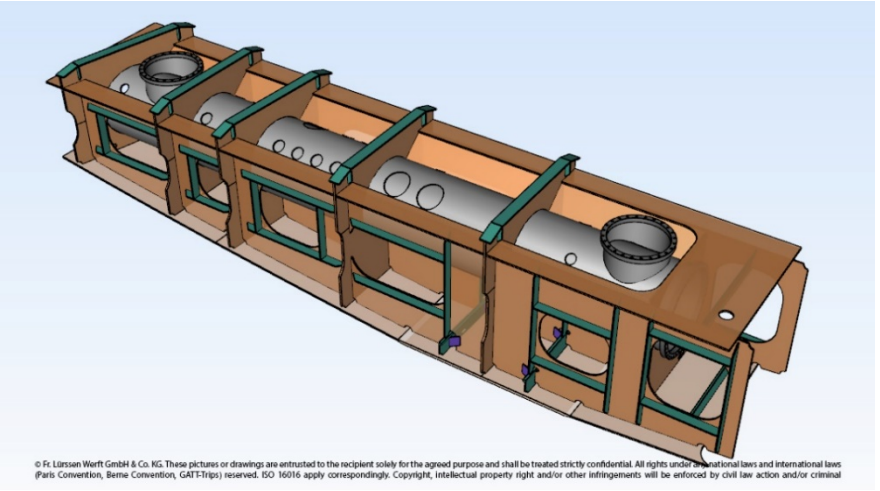
Cost analysis : 30% reduction in overall production cost

Modular Design

General aspects to consider

- Tolerances
- Size standards
- Accessibility & reachability
- Working position & condition
- Number of parts
- Available facility
- Special parts → Possible subcontracting

Module of the Cross flow channel



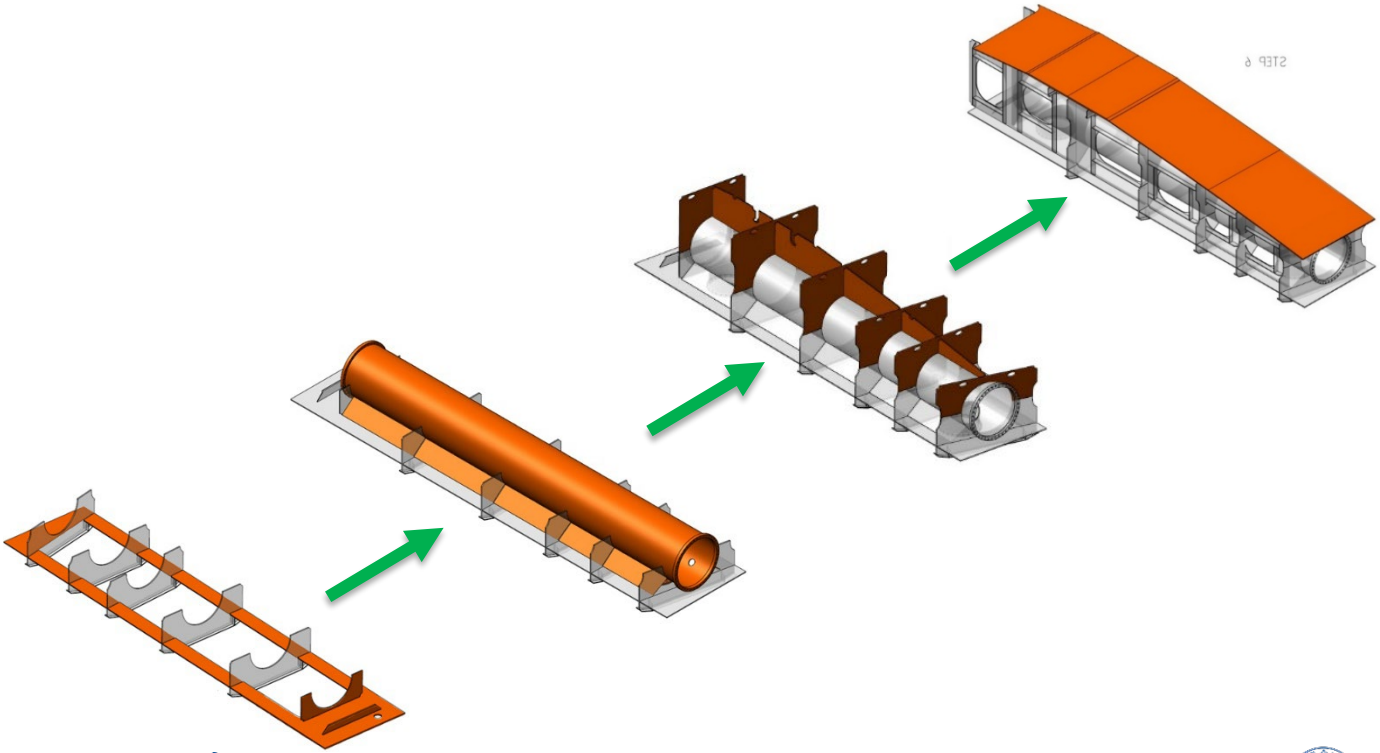
Length = 8.25m , Breadth = 1.7 m , Height (max) = 1.5 m

Number of parts = 137

Weight ≈ 8.5 tons

Construction of the Module

Steps followed



Advantages of modular construction

- Better accessibility/reachability
  - Reduced time wastage due to human errors
- Better working conditions
  - Downside welding
  - Safe environment
- Less number of components involved
- Easy to straighten welding distortions
- Less overall process time
  - Relocation of work into pre fabrication
  - Module can be built parallel to the block
- Possible pre-outfitting

Drawbacks

- Extra plate/profile cutting
- Module mounting
- Module handling and transportation

Conclusion

“Lessons learned”

- Modular design/construction enables more complex structures construct-able.
- A large pipe as ‘crossover’ can possibly be integrated in the double bottom.
- A well-planned, zone-oriented modular design process can shorten the duration time and bring down costs.