

# **Lessons learned. Renovation of seaplane hangars**

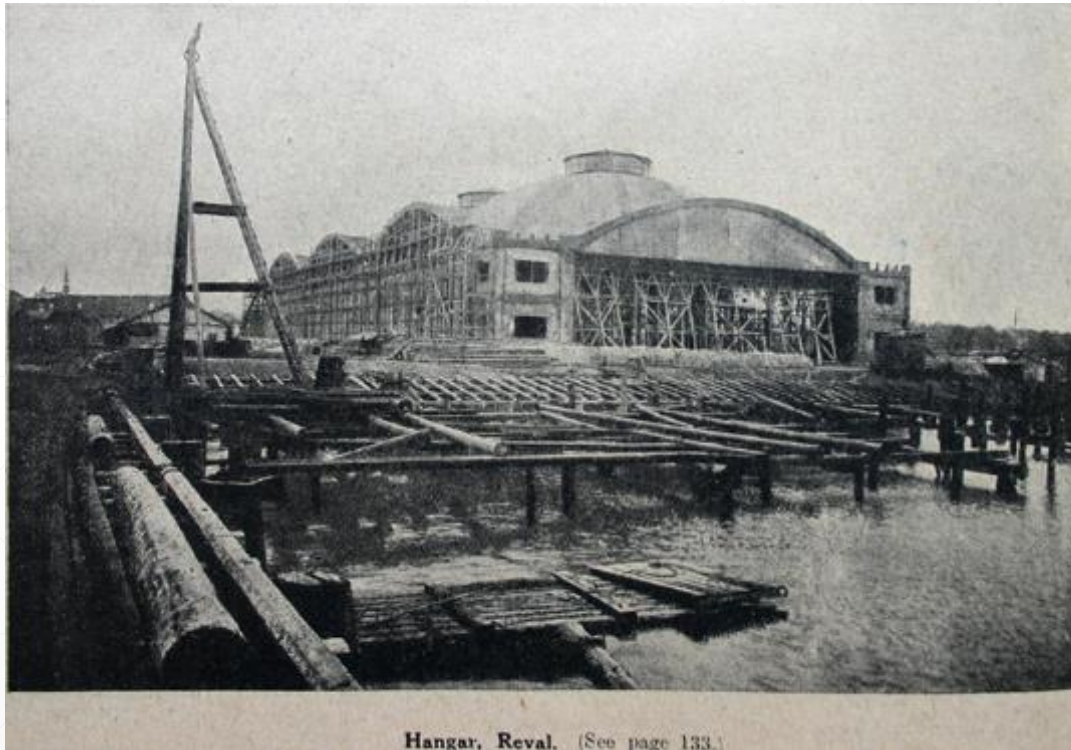
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Heiki Onton, Ph.D

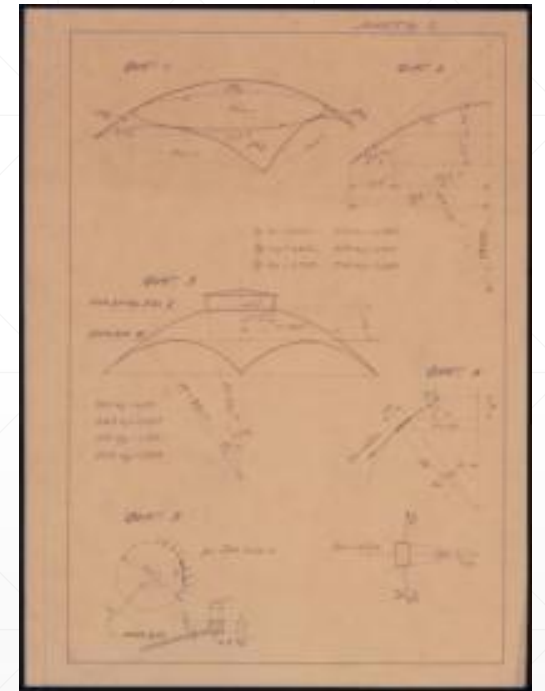
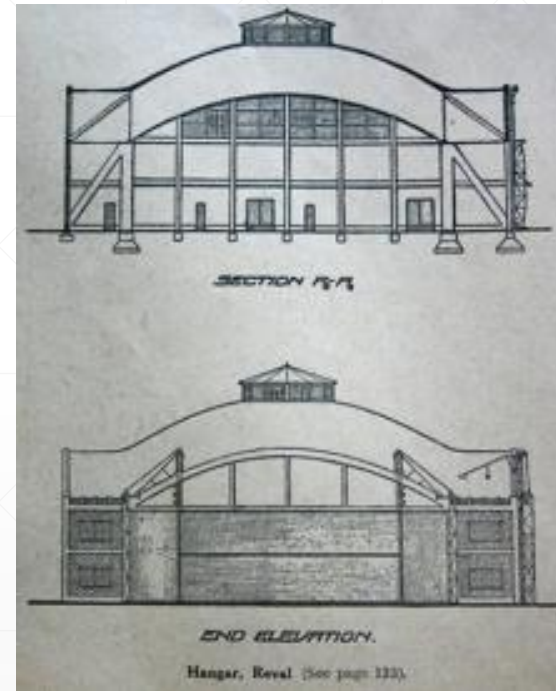
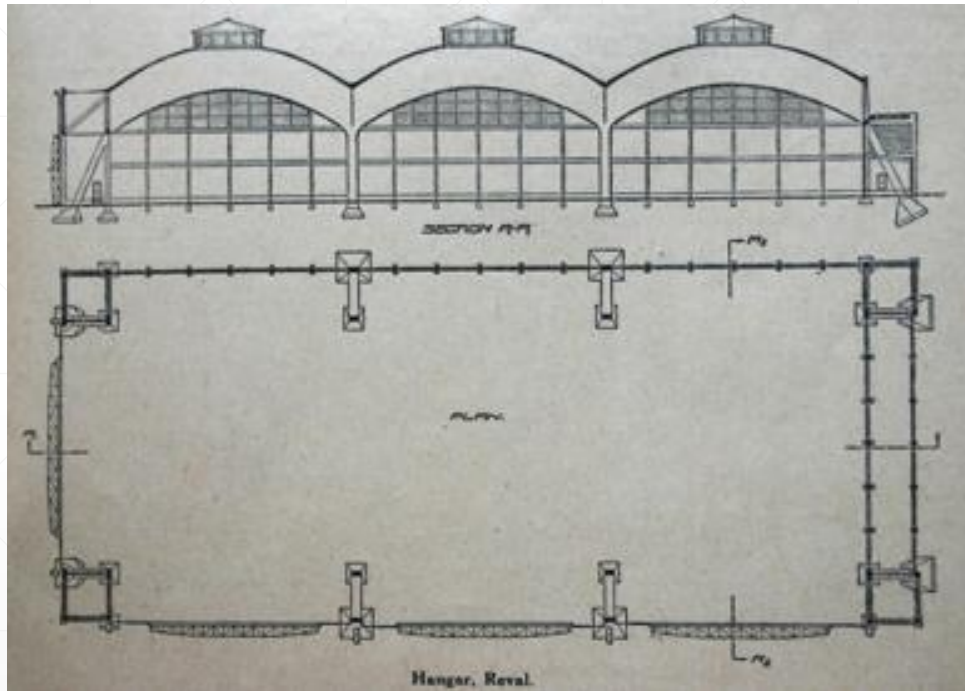
# History and objectives

- The Danish Christian & Nielsen designed the hangars that were built in 1916–1917.
  - The hangar is a part of Tallinn Seaplane harbour constructed for seaplanes in the area of the Peter the Great's Naval Fortress.
  - This is the first known steel concrete shell construction of this size in the world – 36.4 by 116 metres open roof space without any columns or intermediate supports.
  - The first and only renovation works were conducted in 2010-2012; the whole construction was in the edge of collapse.
  - Nowadays the Seaplane harbour is a maritime museum in Tallinn, opened in 2012.
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# The Tallinn seaplane hangars; designed and built in 1916-1917 by the Danish Christian & Nielsen



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# Assessment of Technical Condition of Structures



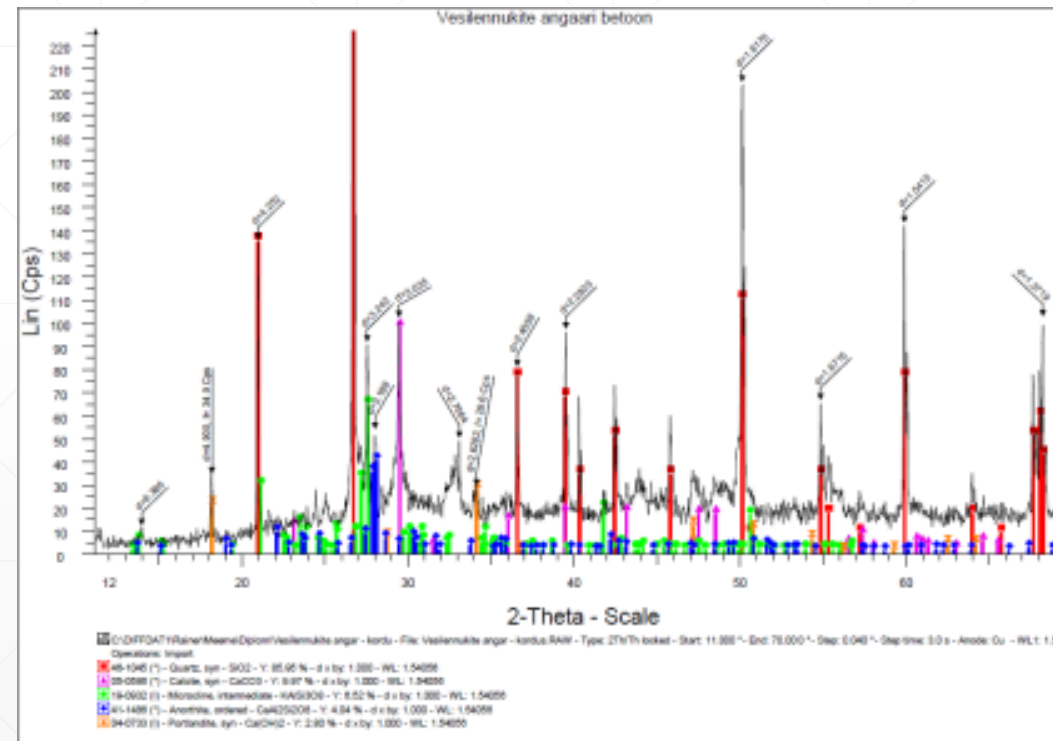
# Assessment of Technical Condition of Structures

- Methods used for structural conditions assessments:
    - Materials research concerning reinforced concrete - physical and chemical characteristics of concrete and reinforced steel;
    - The assessment and analysis of residual carrying capacity - the performance of the structures was analyzed by the finite element method (Robot Millenium, Staad/Pro); strength calculations were done according to the norms and standards in force.
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# Assessment of Technical Condition of Structures

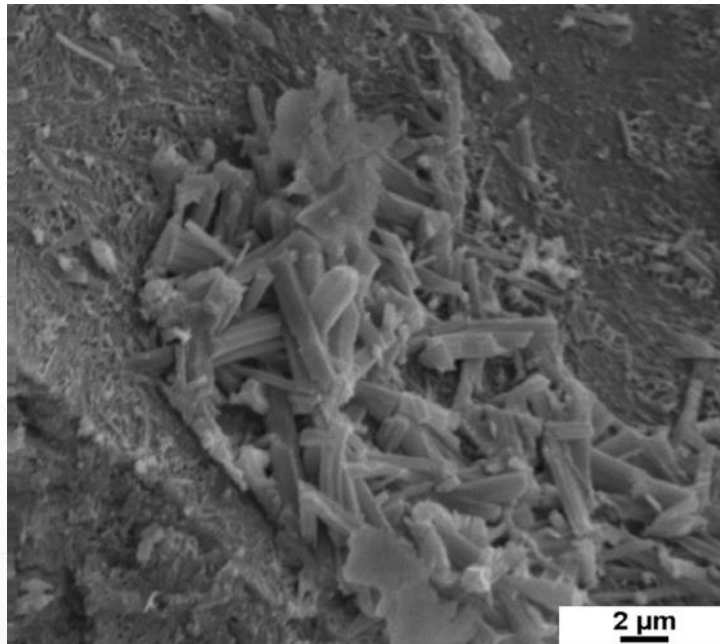
- Mineralogical composition of cement stone of concrete; the X-ray fraction analysis of cement stone



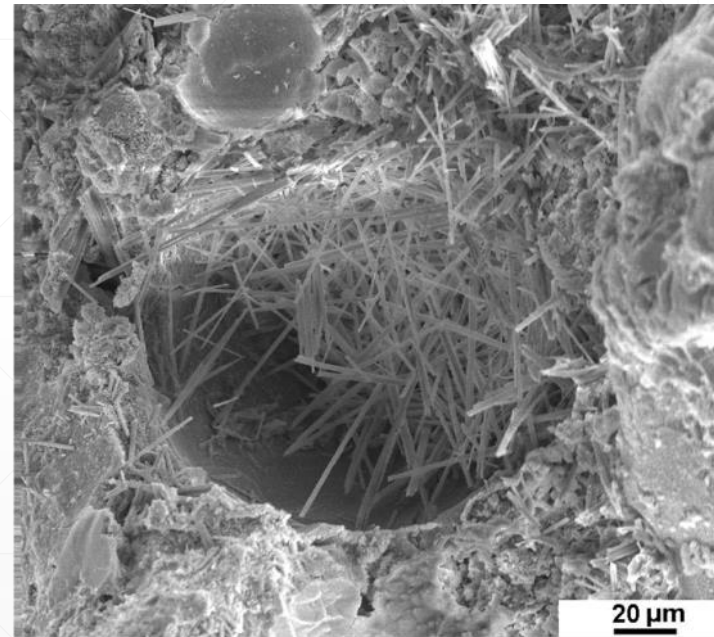


# Assessment of Technical Condition of Structures

- Morphology studies of concrete fracture, surface taken in the depth of 40-50 mm



Calcites



Porous concrete

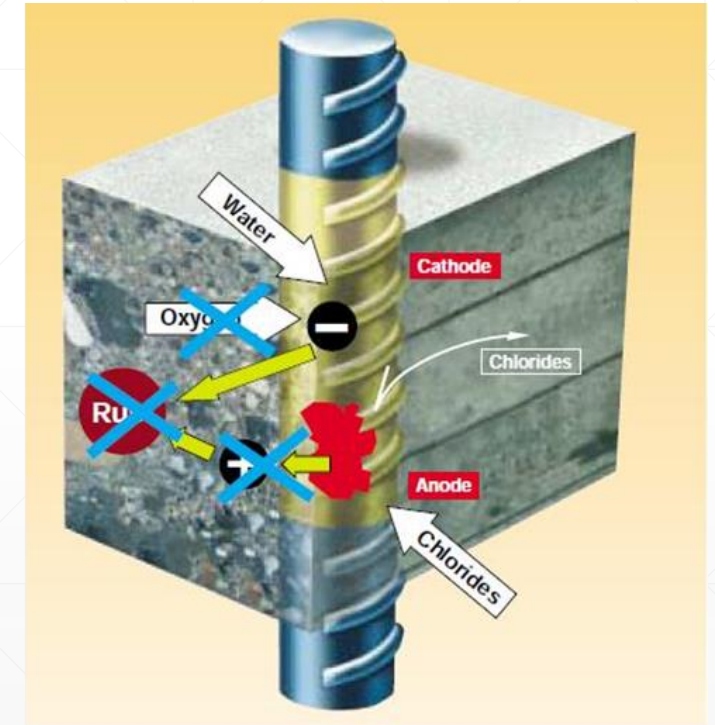
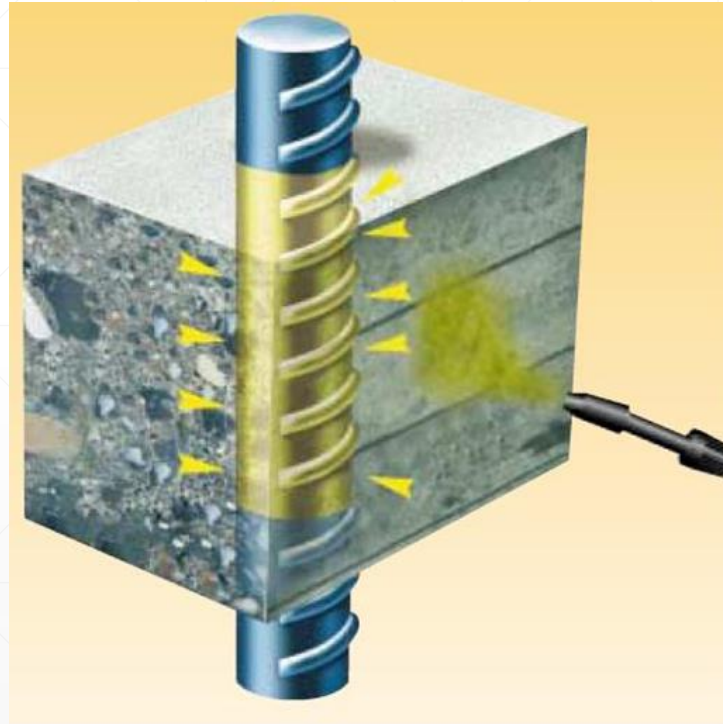
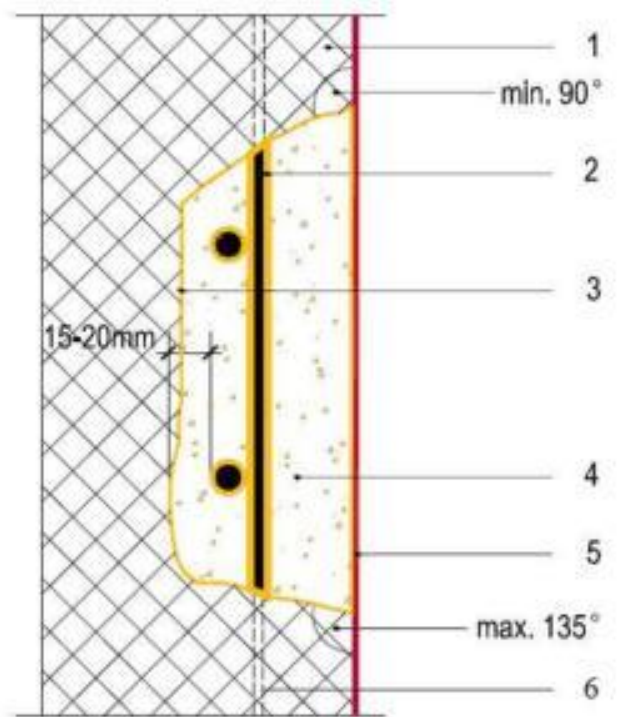
# Structural solutions of restoration works and their application on the site

- Temporary Supports to the deformed area of the spherical shell and beam structure



# Structural solutions of restoration works and their application on the site

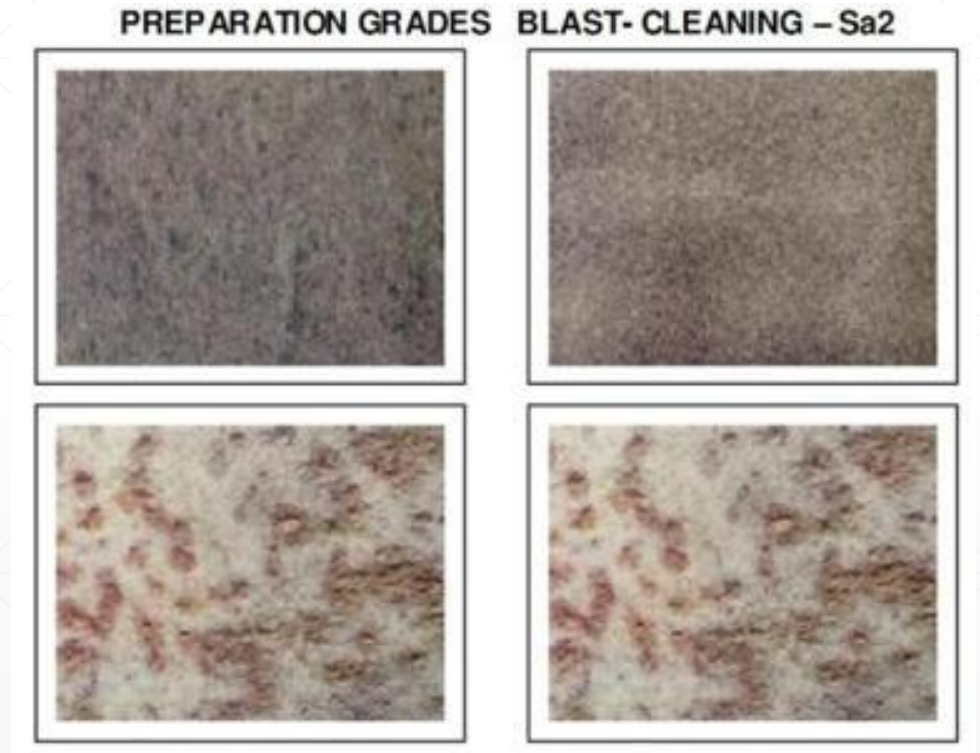
- Materials and technology used





# Structural solutions of restoration works and their application on the site

- Preparation of the reinforced steel bars





# Structural solutions of restoration works and their application on the site

- Preparation of the reinforced steel bars



# Structural solutions of restoration works and their application on the site

- Installation of reinforcement and sparyed concrete layer on the lower shell surface





# Structural solutions of restoration works and their application on the site

- Reinforcement and injection of cracks and deformed areas on the shell surface



# Structural solutions of restoration works and their application on the site

- Installing the thermal insulation and roof coverage





# Structural solutions of restoration works and their application on the site

- Lower surface of concrete shells before and after the renovation works



# The Seaplane hangars in Tallinn



# Lessons learned

- In terms of the carrying capacity of reinforced concrete structures, the geometry of structures, as well as physical-mechanical properties of the constituents of reinforced concrete as a composite material are the factors that the durability of structures depends on.
  - At the beginning of the 20th century, sufficiently good knowledge of how roof shell structures work had been acquired. That was confirmed by calculations made by help of the FEM method used today.
  - Structural restoration should take into consideration the following: preservation of the geometry of the structure according to that designed, physical-mechanical properties of reinforced concrete (strength, porosity, properties of steel), and the extent of damage.
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# Thank You!

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