Failure Analysis as a Base for Developing Quality Control Systems

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Bad Reichenhall Ice-Rink

Failure Analysis – Design Problems

Top View of the Roof Construction

Cross-Section of the Main Girder
Reasons for the failure of the construction:
1. No independent check of the design
2. No independent check of the execution on site
3. Construction of the roof outside the scope of the technical specifications
4. Deficits in the structural analysis: - finger-joints - tension in the centroid axis of the chords
5. Deficits in the cluing of the web-plates
6. Insufficient resistance of the urea-resin-based clue against humidity and temperature
Reasons for the failure of the construction:

1. No independent check of the design
2. No independent check of the execution on site:
   - eccentricities at panel-joints
   - connection between shell and foundation
3. Construction of the shell outside the scope of the technical specifications
4. Deficits in the structural analysis:
   - modelling of the corrugated steel panel shell
   - missing stiffening-ring at the top-end
   - safety factor for the action was taken to unity

Aerodynamic load according to DIN-FB 101

Aerodynamic load derived from measurements

Amplification-factor
Noise-Shield-Systems
Failure Analysis - Design Problems

Stress-time-history-function for one train-passage

Classification of stress-ranges for one train-passage

Micrograph of a damaged rivet-connection

Reasons for the failure of the construction:
1. No independent verification of the validity of the load-assumptions when leaving the scope of experience
2. Misjudgement of the quality of the action on noise-shield-systems:
   - dynamic character
   - amplification-factor
   - number and classification of stress-cycles
3. Construction principles based on a non-fatigue stress-concept
4. Fatigue-detail-categories and corresponding fatigue-strength-curve not available for relevant details:
   - connections of aluminium elements
   - bond of reinforcement under alternate loading
5. Incompatibility of materials within panel-connections
Welded node-point of a truss with complex geometry

Inside-view of the node-point

Reinforcement and Concreting

Node-points in Steel and Timber constructions

1. Recommendations for the Assessment of the Structural Quality of Building Constructions
   Co-ordination Committee - State Ministers - of the German Building Authorities
2. VDI 6200 Directive, Structural Safety of Buildings - Frequently Inspection
   Verein Deutscher Ingenieure
4. Life-Time-Monitoring concepts for building-constructions
5. Project-Book in analogy to the Bridge-Book DIN 1076:1999
6. References to the concepts of Earthquake-Engineering:
   - DIN 4149:2005, Buildings in German Earthquake Areas
Monitoring Intervals for Building Constructions
Life-Time-Monitoring Concepts

<table>
<thead>
<tr>
<th>Monitoring Stage</th>
<th>Time Corridor</th>
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<tbody>
<tr>
<td>Simple Review</td>
<td>Within intervals of 1 to 3 years by the owner</td>
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<tr>
<td>Inspection</td>
<td>Within 2 to 5 years by a specialist</td>
</tr>
<tr>
<td>General Check</td>
<td>Within 6 to 15 years by an appointed expert</td>
</tr>
</tbody>
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Qualification Criteria for Monitoring-Stages

<table>
<thead>
<tr>
<th>Monitoring Stage</th>
<th>Reviewer</th>
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</thead>
<tbody>
<tr>
<td>Simple Review</td>
<td>Owner of the building</td>
</tr>
<tr>
<td>Inspection</td>
<td>Engineer with in minimum five years of practice in design- ing buildings of the construction type concerned</td>
</tr>
<tr>
<td>General Check</td>
<td>Engineer with a special qualification for that purpose. An engineer with this level of qualification must have among others, a practice of in minimum ten years in designing structures. He has also to show, that he has designed structures of a complexity significant above the average. Prüfingenieure are qualified in their field of construction types for doing the General Check.</td>
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Thank You For Your Attention

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