This is the submitted version of a paper presented at *XXIII Nordic Concrete Research Meeting*.

Citation for the original published paper:

**Schönbeck, P., Löfsjögård, M., Ansell, A. (2017)**
Requirements on concrete floor structures - a comparison of medical imaging facilities.
In: Marianne Tange Holst (ed.), *Nordic Concrete Research Publications*, 2017

N.B. When citing this work, cite the original published paper.

Permanent link to this version:
http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-217369
Requirements on concrete floor structures - a comparison of medical imaging facilities

Pia Schönbeck  
M.A., Ph.D. student  
KTH Royal Institute of Technology  
Division of Concrete Structures  
SE-100 44 STOCKHOLM, Sweden  
e-mail: pia.schonbeck@byv.kth.se

Malin Löfsjögård  
Ph.D., Adjunct Professor  
KTH Royal Institute of Technology  
Division of Concrete Structures  
SE-100 44 STOCKHOLM, Sweden  
e-mail: malin.lofsjogard@byv.kth.se

Anders Ansell  
Ph.D., Professor  
KTH Royal Institute of Technology  
Division of Concrete Structures  
SE-100 44 STOCKHOLM, Sweden  
e-mail: anders.ansell@byv.kth.se

ABSTRACT
Requirements management in construction projects have a tendency towards production-driven processes and definition of technical solutions. The stakeholders are involved by being asked to comment on defined products which can have consequences on the performance of the end-product. This comparison describes three projects within the Stockholm County where the scope to build new medical imaging facilities with the same requirements on the concrete floor structure. The result shows that the same requirements have resulted in different solutions which could have an impact on the performance of the buildings. Further research regarding tools for systematic requirements management is needed to ensure performance and sustainability of new buildings.

Key words: Execution, Modelling, Structural Design, Sustainability

1. INTRODUCTION
Stakeholder requirements are often non-specific and give room for subjective interpretation from the designers within construction projects. When technical solutions are presented to stakeholders, such as end-users, they have difficulties to understand if these fulfil their requirements in daily work. In the construction business there is a need for a more systematic management of requirements from stakeholders [1, 2]. In the projects there is a tendency
towards production-driven processes and definition of technical solutions. The stakeholders are involved by being asked to comment on pre-defined products or technical solutions instead of being an active part in the design process. To ensure good performance of the end-product in construction projects focus on requirements are more important than technical specifications the early design stages [2, 3]. Analyses of full life-cost and environmental impact are also necessary to achieve sustainability over time. During the life-time of a building the requirements will likely change which can make the building prematurely obsolete [4]. Processes and tools for requirements management in the construction process of healthcare facilities often vary from project to project. Therefore there is a need for flexibility in the structural systems to reach sustainable solutions, often dominated by prefabricated concrete elements. The need for a systematic tool that connects requirements and technical specifications is here discussed and demonstrated through comparing concrete floor structures in three medical imaging facilities.

3. REQUIREMENTS ON CONCRETE FLOOR STRUCTURES

The requirements on concrete floor structures for new medical imaging facilities with the same functions should be similar but technical solutions often differ. By structured requirements management the technical solutions could be made more similar and lead to sustainability of performance. Stockholm County Council have set requirements to accomplish standardization, flexibility for future functions and facilitate rebuilding based on four types of specifications [5]. The first two are minimum measurements and functionality criterions, as exemplified in Fig. 1. The third and fourth types are specified minimum load carrying capacities and serviceability requirements on e.g. deformations and dynamic behavior. For concrete floor structures the general requirements prescribes an overall load carrying capacity of 6 kN/m², a vibration damping capability to ensure performance of medical imaging equipment, practical possibilities to mount heavy equipment in the ceiling and a flexibility regarding placement of future openings due to rebuilding. To meet requirements the general technical solution recommended by the Stockholm County Council is in situ cast concrete floor slabs supported by beams. Anchor rails are recessed or mounted on the underside of the concrete floor structure to enable mounting of equipment in the ceiling.

![Figure 1 – Measurement requirements on structural systems for new healthcare facilities within the Stockholm County](image-url)
4. COMPARISON OF FLOOR STRUCTURE

Three medical imaging facilities in new healthcare buildings within the Stockholm County are compared. The three projects and the chosen concrete floor structures are briefly described in the following:

Project 1
A seven storey building with a gross area of approximately 28 500 m². One of the storeys is intended for a medical imagine facility. Prefabricated hollow core (HD/F) and massive concrete elements (D/DF) are used in the floor structure with a 100 mm overlay.

Project 2
An eight storey building with a gross area of approximately 19 000 m². One of the storeys is intended for a medical imagine facility. Prefabricated hollow core (380 HD/F) elements with 65 mm overlay and in situ cast concrete flooring are used in culverts.

Project 3
A four storey building with a gross area of approximately 28 000 m². One of the storeys is intended for a medical imagine facility. Prefabricated hollow core (380 HD/F) elements with 10-130 mm overlay depending on performance requirements. Massive concrete elements (220 RDF) with 210 mm overlay are used in some floor structures.

Medical imaging equipment installed in healthcare facilities is heavy and acquires structural damping of vibrations in order to achieve accuracy of measurements and image sharpness. These requirements are especially strict for magnetic resonance imaging (MRI) equipment. The data in this comparison is taken from technical specifications in system and/or construction plans of each project. In Tab. 1 there is a comparison of capacities for distributed loads, concentrated loads and multiplying factors for vibrations.

<table>
<thead>
<tr>
<th>Project</th>
<th>Distributed load (kN/m²)</th>
<th>Concentrated load – equipment (kN)</th>
<th>Concentrated load – transportation (kN)</th>
<th>Multiplying factors a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6,0</td>
<td>150</td>
<td>145</td>
<td>0,125 b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0,200 c)</td>
</tr>
<tr>
<td>2</td>
<td>6,0 b)</td>
<td>150</td>
<td>-</td>
<td>0,200</td>
</tr>
<tr>
<td></td>
<td>10,0 c)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>7,5</td>
<td>130</td>
<td>90</td>
<td>&lt; 0,250</td>
</tr>
</tbody>
</table>

a) according to British standard [6]  b) within concentrated load area  c) generally  d) for MRI

Eurocode standards EN 1990, EN 1991 and EN 1992 have been used for design of the structural frames and specification of distributed and concentrated loads. Multiplying factor for continuous vibrations is calculated according to British Standard [6], defined as:

\[
\text{Multiplying factor} = \frac{\text{root mean square acceleration} \times \text{frequency weighting of } W_g}{\text{base value}}
\]

Frequency weighting should be \( W_g \) and the base value is 0.005 m/s² [6].
5. CONCLUSIONS FROM THE COMPARISON
The three projects described in the comparison show that the performance of the concrete floor constructions differs. The capacity for distributed and concentrated loads varies which may limit future choice of new equipment. The ability to reduce vibrations is also different. Since the development of medical imaging equipment aims for more accurate measurements and image sharpness, its sensitivity to vibrations increases. If the requirements with respect to future medical imaging equipment must be changed and the flexibility of the floor structure is not enough, it could mean that some of the buildings in the comparison could become obsolete. Even though the requirements for most medical imagine facilities are similar, it was here shown that there are different technical solutions for the concrete floor performance. Reasons could here be non-specific requirements from the Stockholm County Council, open for interpretations. Stakeholders, such as end-users, often lack the technical knowledge to set requirements for e.g. the concrete floor structures.

6. FUTURE RESEARCH
The comparison shows that same requirements regarding concrete floor structure can lead to different technical solutions and performance of the building. Research regarding requirements management in construction projects often focus on converting demands from stakeholders to technical specifications. The software and product development business has done the opposite, requirement tools are based on technical information needed by developers. The tools often consist of questions that are easily understood by stakeholders and give correct information for formulation of accurate technical specifications [7]. Future research is needed to explore if a similar tool for the construction projects can be used to minimize the functionality discrepancy between requirements and the end-product. A tool for requirements management should be empirically validated to avoid subjectivity and bias.

REFERENCES