**A Multi-levelStructural Assessment Proposal for Reinforced Concrete Bridge Deck Slabs**



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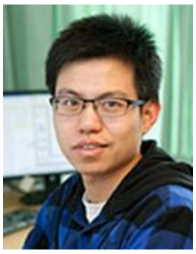
# A Multi-level Structural Assessment Proposal for Reinforced Concrete Bridge Deck Slabs

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## Abstract

This study proposes a multi-level assessment strategy for reinforced concrete bridge deck slabs. The proposed methods were used for the analysis of previously tested two-way slabs subjected to bending failure and a cantilever slab subjected to a shear type of failure, in both cases loaded with concentrated loads. The case studies show that the proposed assessment strategy and the analysis methods are feasible and give conservative estimates of the load-carrying capacity.



Keywords: Multi-level assessment, Reinforced concrete slabs, nonlinear FEA


## 1. Introduction

Bridge deck slabs are among the most exposed bridge parts and are often critical for the load-carrying capacity. Consequently, it is important to have appropriate methods for assessment of the load-carrying capacity and the response of bridge deck slabs. With such methods, higher load-carrying capacity can be detected in the assessment of existing bridge deck slabs. A step-level procedure for the structural assessment of existing bridges has been proposed with successively improved evaluation integrated with the decision process [1]. The aim of this paper is to propose an assessment strategy for the structural assessment of RC bridge deck slabs and to demonstrate and examine the proposal on two case studies.

## 2. A Multi-level Structural Assessment Strategy

The multi-level assessment strategy proposed in this paper for RC bridge deck slabs is based on the principle of successively improved evaluation in structural assessment [1]. For RC slabs, different levels of assessment can be recognized in Figure 1. Assessments of load-carrying capacity with associated responses can be conducted through the following levels and methods: (I) simplified analysis, (II) 3D linear shell (FE) analysis, (III) 3D nonlinear shell (FE) analysis, (IV) 3D nonlinear FE analysis with continuum elements and fully bonded reinforcement and (V) 3D non-linear FE analysis with continuum elements including the slip between reinforcement and concrete. This method differs from MC2010 [2] in that MC2010 focuses on resistance models for different failure modes while this approach focuses on the structural analysis of the slab; furthermore, this approach connects the structural analysis on different levels with resistance models on different levels from EC2 [3] or MC2010 [2].

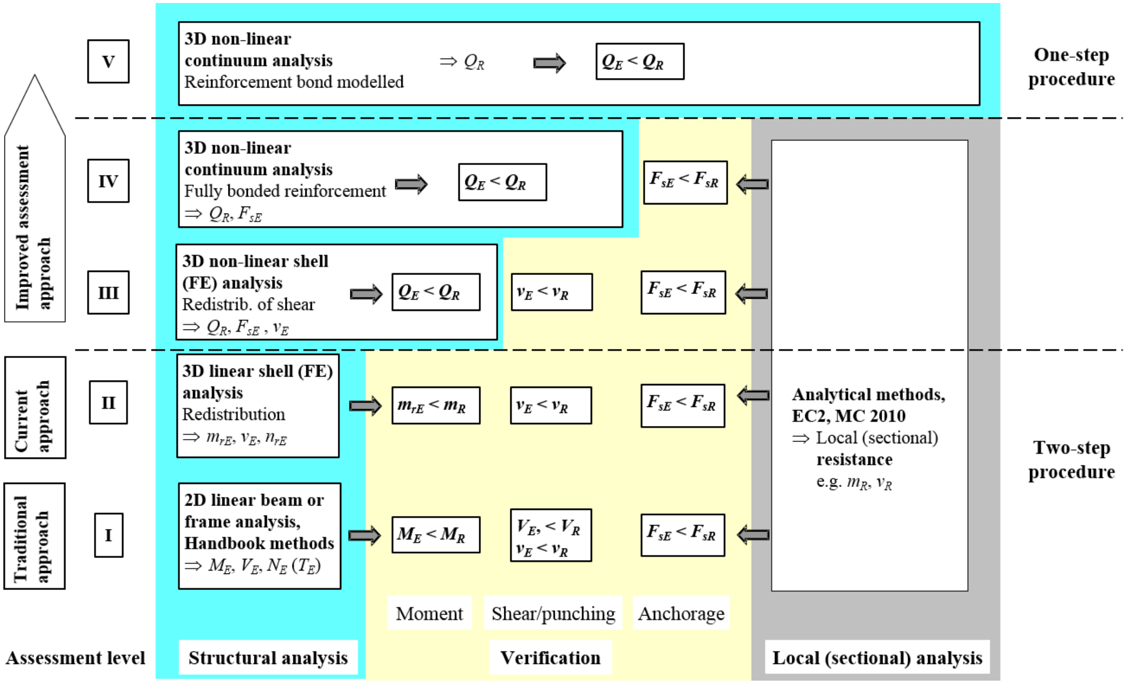


Figure 1. Scheme for multi-level assessment of reinforced concrete bridge deck slabs

## 3. Case studies

The proposed methods were used for the analysis of previously tested two-way slabs subjected to bending failure [4] (see Figure 2) and a cantilever slab subjected to a shear type of failure [5] (see Figure 3). Details can be found in Shu [6].

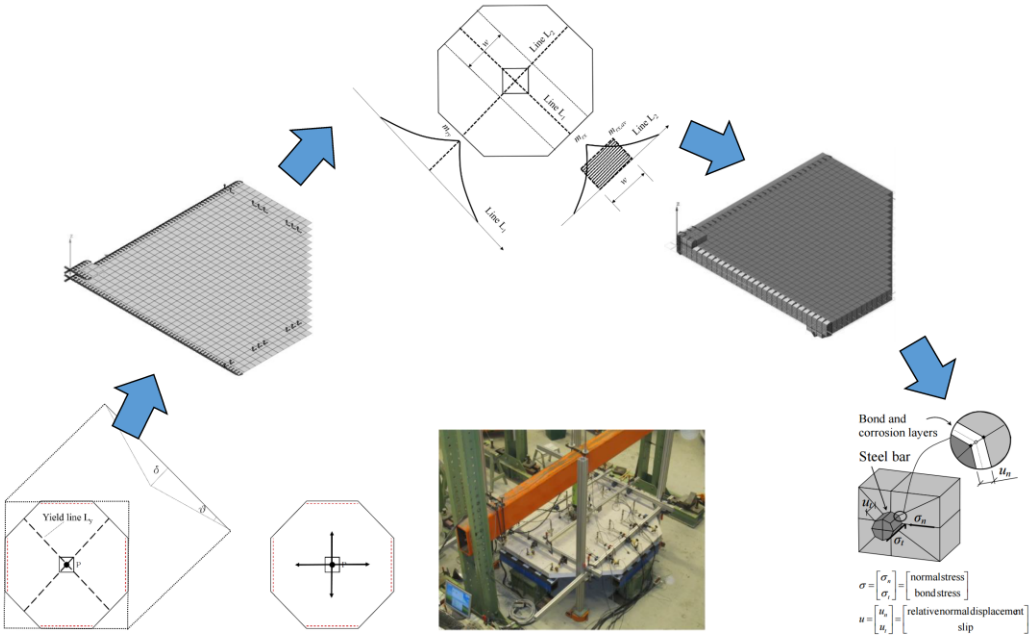


Figure 2. Case 1: application to two-way slabs subjected to bending failure

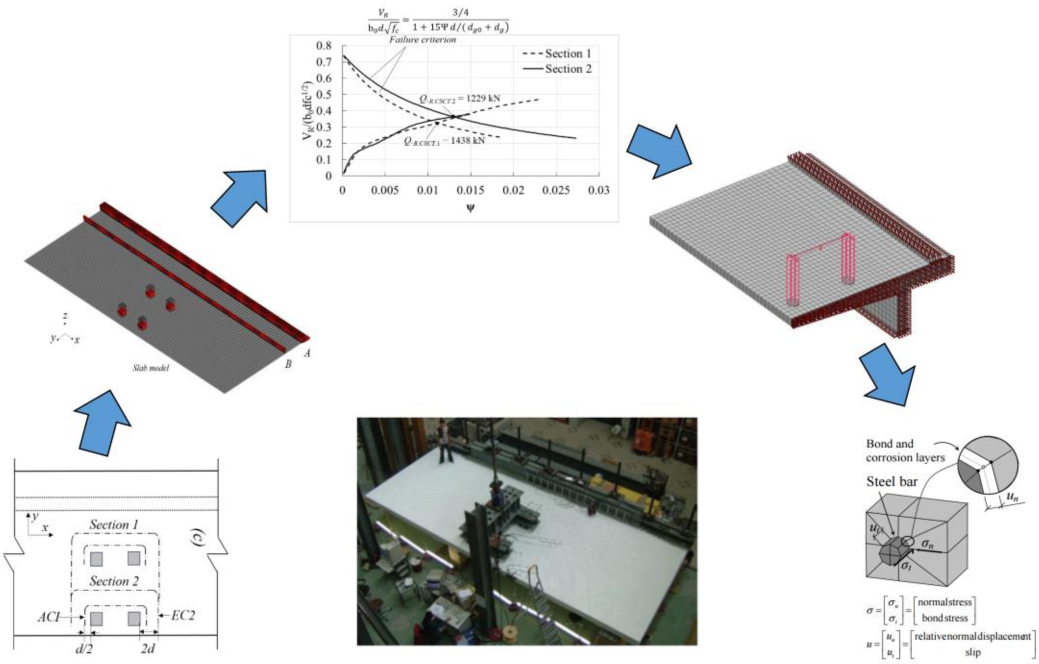


Figure 3. Case 2: application to a cantilever slab test

## 4. Results and Discussion

Table 1 presents the failure modes of the slabs occurred in the structural analyses at different levels of assessment.

Table 1. Failure mode at multi-level assessment of slabs

| Levels | Two-way slabs | | | Cantilever slab | | |
|---|---|---|---|---|---|---|
| | Bending | Shear (punching) | Anchorage | Bending | Shear (punching) | Anchorage |
| V | × | × | × | × | × | × |
| IV | × | × | ✓ | × | × | ✓ |
| III | × | ✓ | ✓ | × | ✓ | ✓ |
| II | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| I | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

✓: need to check with separate resistance model
×:reflected in the structural analysis
□:failure load determine load-carrying capacity

Figure 4 summarizes the load-carrying capacity from the analyses at the different assessment levels and from the experiments. It is obvious that generally the detectable load-carrying capacity increased for higher levels of assessment, but was always less than the experimental value. Similar results were also obtained by Belleti *et al.* [7]. However, this may not always be the case. For example, in case study 1, the load-carrying capacity obtained at level IV was higher than for level V.

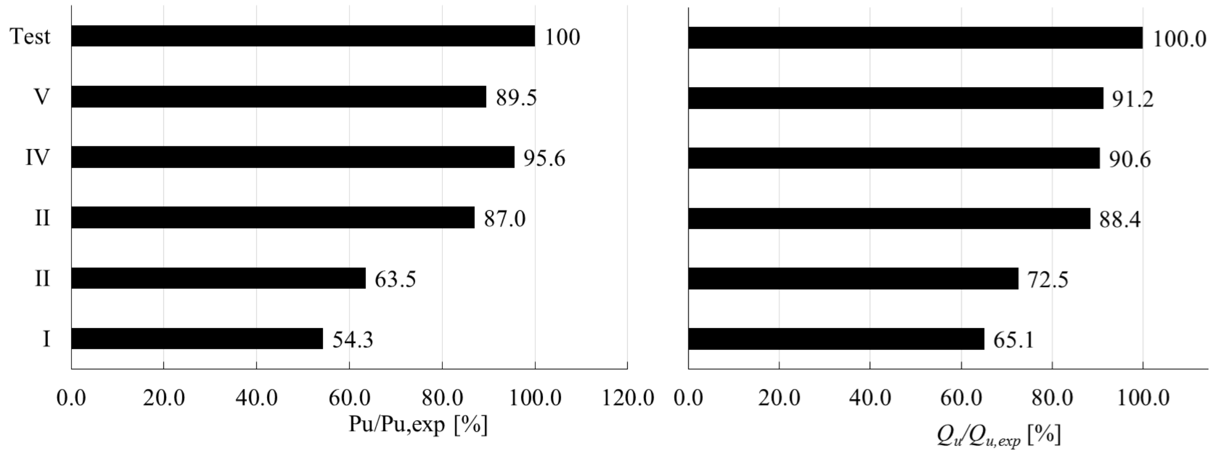


Figure 4: Load-carrying capacity of two-way slabs (left) and a cantilever slab (right) at different levels

## 5. Conclusions

The case studies show that the proposed assessment strategy and analysis methods are valid and give conservative estimates of the design capacity. Furthermore, the results show that, generally, more advanced methods are capable of demonstrating a load-carrying capacity closer to the reality.

However, when choosing if to proceed with assessment on more enhanced levels, it is necessary to consider the increased cost in terms of more working hours and computation time in relation to what might be gained by analysis on the higher level. The benefit of doing more advanced structural analysis must also be weighed against other methods to improve the assessment. When enhanced analysis is judged to be a favourable, the proposed multi-level assessment strategy can provide a structured approach to successively improved assessment.

## Acknowledgement

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