Research Subcommittee on Design and Verification of Part Detailing of Reinforced Concrete Structures (357)

The shape and internal rebar arrangement (structural details) of concrete members are conventionally determined empirically, but there is now a need to clarify the grounds for making particular design choices. For example, as seismic resistance requirements have become more stringent in Japan, there is a growing problem with overcrowded rebar arrangements. Consequently, there is a desire to develop more rational rules and methods of confirming validity with a view to achieving more reliable construction procedures and productivity improvements. In pursuing such developments, there is also a possibility of achieving more rational joint members if methods are developed for checking the shape and rebar arrangements of joints, which are conventionally prescribed in the standard specifications.

Prescribed member shapes and rebar arrangements (structural details) should be based on mechanics and relevant experimental results. However, it is still the case that experience has been unconditionally accepted into construction standards and some rules can be said to constitute ‘tacit knowledge’ whose reasoning is difficult to explain. It is highly possible that such tacit knowledge is inhibiting the construction of concrete structures that are more rational and improvements in worker productivity.

The JSCE’s Research Subcommittee on Design and Verification for Part Detailing of Reinforced Concrete Structures (Committee 357) was established in 2018 with the aim of converting this tacit knowledge into ‘explicit knowledge’ that can be expressed explicitly in language and using formulas. That is, in engineering terms, the subcommittee’s purpose is converting specification-based regulations into verifiable ones. The subcommittee concluded its work in June 2020.

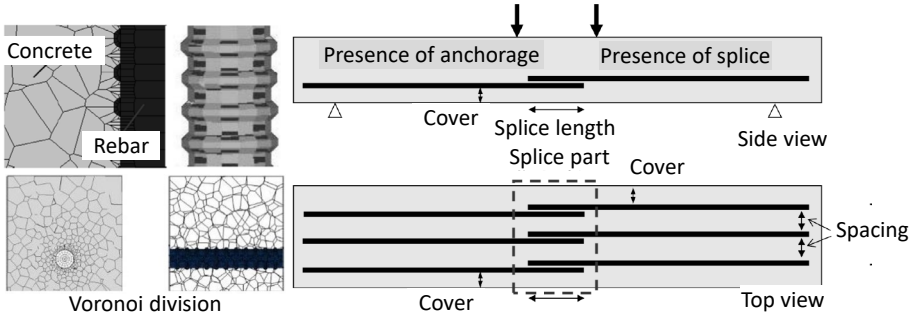
The term ‘Part detailing’ has not been generally used until now, so it has been newly defined and can be explained as "a concept including information on member shape, rebar arrangement details (structural details), and materials used". The subcommittee, consisting of 31 members including railway and road managers, consultants, general contractors, universities, and others, systematically collected current knowledge and methods regarding the detailing of members. It then produced a validity confirmation method for determining the structural performance of RC members, reliable construction procedures and rational structural details. By embodying the relationship between the performance of structures and their Part Detailing, this is expected to lead to rationalization and labor saving of design, construction and maintenance related to RC structures.

Prior to undertaking specific discussions, the subcommittee began with activities that involved sharing and discussing issues related to Part Detailing, and awareness of them. These summarized the doubts each subcommittee member had about the provisions of the current specifications and contemporary design practice with the purpose of determining why members are detailed in a certain way. Following this work, committee members formed four working groups (WGs): "Fundamentals of structural details", "Details of planar members", "Details of member joints" and "Application of high strength materials".

Upon completion of subcommittee 357’s activities in June 2020, the results were compiled as Concrete Engineering Series 126 "Research Subcommittee on Design and Verification for Part Detailing of Reinforced Concrete Structures” (on CD-ROM), and reported in the form of an online meeting in November 2020. An outline of the examinations carried out by each WG and their results is given below.

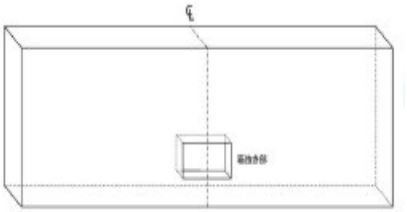
The WG on "Fundamentals of structural details" discussed the six main structural details of

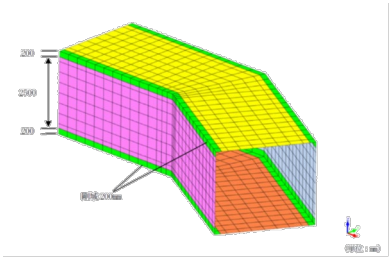
reinforcement in concrete members: concrete cover, spacing, placement, bent shape, anchorages and splices. The result was a summary of current issues, current regulations, grounds for formulation, transition to a new system and the characteristics required of the system. The WG also proposed a test method necessary for confirming the performance of structural details.



Proposals for verification tests and numerical analysis

The WG on "Details of planar members" developed a systematic arrangement of current understanding and current methods for the design of lateral rebars, splices (lap splices), and force distributing rebars in RC plane members. Consideration was given to revision of the JSCE standard specifications. Proposals were also developed for matters to be considered now and future issues. In addition, the WG collated knowledge on analysis methods and rebar arrangement methods for RC plane members with a bend and for reinforcement bars around openings.

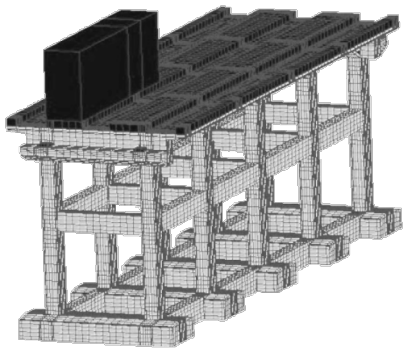


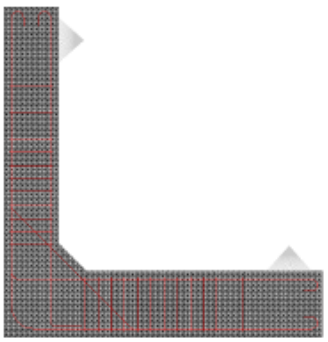


Model of culvert side-wall with opening

Analytical examination of box culvert with bend

The WG on "Details of member joints" investigated the guidelines for the design and verification of member joints, and examined the role of haunches, the effects of damage to member joints, and the role of rebars in member joints through numerical analysis. In addition, the WG made a proposal for rationalizing the rebar arrangement at member joint that achieves both workability and required structural performance.

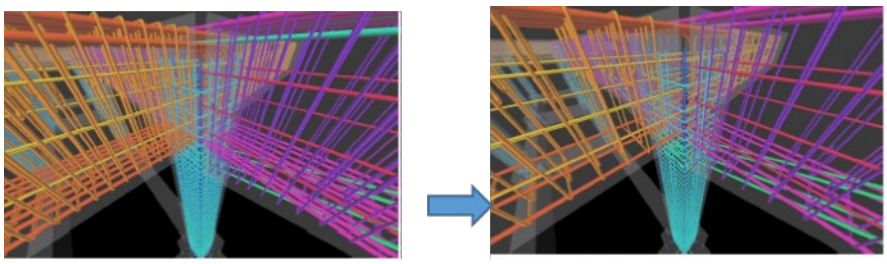




FEM of rigid-frame viaduct for railway

FEM for modeling the knee joint of RC culvert

The WG on "Application of high strength materials" studied the standards for using high-strength materials and examined analytically structural members for which the use of high-strength materials is difficult and the mechanical behavior of RC members with high-strength materials. Outstanding problems to be solved in the use of high-strength materials and possible paths toward solution were indicated by the WG.



(a) Normal strength concrete and rebars (b) High-strength concrete and rebars

Reduction in rebar density in a member with the same cross-sectional dimensions

As to the question of why structural members are detailed in certain ways, as discussed by the subcommittee as a whole, many engineers questioned the basis for the arrangement and quantity of core rebar, the necessity for a haunch in a box cross-section and other design features. Based on these discussions, the subcommittee has compiled valuable reference materials that will help engineers to understand what kind of questions are being raised in the field. The two years of activities enabled the subcommittee to gather many useful findings and suggestions, but there are some outstanding issues to consider. Further, for the newly obtained knowledge to be utilized when the specifications are revised, it is necessary to improve the background data and clarify mechanical mechanisms using numerical analysis.

Given this situation, it was decided that the subcommittee would begin a second term of two years in April 2021. In this second term, in addition continuing the examinations of the first term, five new studies will be conducted, including questions related to structure maintenance: (1) Experimental and analytical acquisition of data for rationalization of reinforcement details, (2) Investigation of the possibility of studying and verifying the mechanics of structural details by mesoscale analysis, (3) Improving the sophistication of design methods and verification methods for face members and member joints which are not based on linear structures, (4) Determination of requirements for utilizing high-strength rebars and high-performance cement-based materials, and (5) Handling of structural details where deterioration such as cracking has occurred.

Reference:

Concrete Engineering Series 126 "Research Subcommittee on Design and Verification for Specification of Reinforced Concrete Structures" (on CD-ROM), JSCE, November 2020.