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Improvement of Bridge Design in Relation to the Action of Water

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Summary

To enhance the quality of bridges, it is necessary to protect them against the action of water. Lessons learned from the pathology of existing bridges provide an excellent way for improving design. Sixteen defects have been identified, and for each of them a sheet has been published to present the description of the defect, the analysis of the causes, the consequence for the bridge and the proposed solution. This paper presents some of these sheets, concentrating on the points which are most important for the designer of a bridge.

Keywords: bridge ; design; water; waterproofing membrane; expansion joint; cornice; drainage; drip; durability; protection.

1. Introduction

Water is the principal enemy of civil engineering structures, being involved in most of the processes which affect their durability. The ingress of water into structures assists the penetration of aggressive agents, of which de-icing salts are among the most harmful. Water is responsible for corroding steel reinforcement and is involved in pathological processes such as carbonation, the alkali-silica reaction, sulphate attack and deterioration caused by freezing and thawing, etc.

To ensure that structures are durable and that maintenance can be performed without undue expense the action of water must be taken into account from the design phase. The experience which has been gained in recent decades from inspections and the pathology of existing bridges provides design engineers with essential information concerning the penetration of water into structures. The French Ministry of Public Works, more precisely the « Service d'Etudes Techniques des Routes et Autoroutes » and the « Laboratoire Central des Ponts et Chaussées », have published a set of 16 information sheets which are intended to improve the design and construction of bridges in relation to the action of water. These sheets are based on a large number of surveys conducted by the Regional Road Research Laboratories and on the views of specialists from the SETRA and the LCPC who are responsible for laying down technical principles. These sheets aim to assist designers, contractors, construction authorities and project managers.

2. Main points for the design of a bridge in relation to the action of water

2.1 The Necessity to install a waterproofing membrane

In the case of all new structures, including prefabricated underground culverts, all parts of the structure must be waterproof. This also applies to high performance or very high performance concrete bridges: although these materials are considerably more compact than ordinary concrete, cracking results when they are laid (in particular shrinkage cracking soon after laying) which provides routes for the penetration of aggressive agents.

2.2 The Necessity to extend the waterproofing membrane under footpaths

It is necessary to provide a waterproofing membrane over the entire deck, continuing under the footpaths and rising into a recess in the longitudinal beam which supports the cornice. In addition it is recommended not to anchor directly into the deck the longitudinal beams which provide support for the footpath kerbs or anchorage for the safety barriers as so doing will impair waterproofing.

2.3 The Selection and quality control of the waterproofing membrane

The waterproofing membrane must also be compatible with the type of structure, in particular one must be selected which adheres to the substrate and the bituminous mix in areas where vehicles brake. When such membranes are laid it is also necessary to comply with the correct procedure: the substrate must be prepared, climatic conditions must be taken into account, the laying procedure must be carefully followed. Lastly, particular care should be paid to all particular features (recesses, points of penetration, grids, downpipes, sealing of tendon anchors, etc.). In particular, waterproofing should terminate at its edges by rising to a recess.

2.4 Others points

When detailing, other important points should be considered :

- suitable waterproofing at expansion joints in pavements and footpaths
- improvement of the waterproofing of cornices
  - -- Preventing leakage between precast units
  - -- Ensuring Watertightness of cornice gutters
- taking care of the waterproofing adjacent to equipments
- installation of drips
- ensuring a good water drainage.

3. Conclusions

The installation of a waterproofing membrane on the entire structure is a fundamental factor in the protection of bridges from water. The collection and removal of water must not be viewed as a secondary detail of design, but as an important aspect of it. When the system of drainage devices is designed the path of water should be followed from when it reaches the structure until it enters the ditches or main drains designed to remove it.