ANCHORAGE ZONE OF POST-TENSIONING TENDONS - DESIGN OF REINFORCEMENT

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Abstract

Anchorage zones are examples of complicated 3D straining of concrete. Structure is affected by action of concentrated forces in case of bridge – prestressing and bearing forces. Designers mostly use recommendation of post-tensioning supplier and solutions based on elastic analysis. In some cases is proposed so much reinforcement in this zone that it is hard to proper concrete compaction. Sometimes it occurs.

Keywords: anchorage zone, post-tension, non-linear analysis

1 Introduction

When Mr. Freyssinet invented prestressed concrete it was a new material, which did not crack. Thus during the development the emphasis was on elastic methods of analysis and design. Elastic procedures were developed by Guyon and others. Designers were guided by a few general solutions which would be modified to specific situations.

More recently is prestressed concrete considered as material belongs to other type of concrete, e.g. reinforced concrete, i.e. with cracks. Modern access of designers is using strut-and-tie analysis. We can tell the structure, within limits, what to do. Nowadays designers can access to methods based on non-linear analysis.

This development deals with comparing common proposal from work experience with new proposal set from alternative solution and materials. Calculating will be done in software Atena 3D.

2 Structure

The anchorage zone will be examined in this development on example of bridge presented on figure 1. Foot and duct bridge has one span (L = 35.0 m) with tapered massive T cross-section, casting on rigid falsework. The ends of bridge are braced with a concrete block. Structure is supported with four bearings (two on each end of beam). Concrete belong to class C30/37.

Loading produce only dead load and prestressing (four bonded 17-strand cables). Designer proposes prestressing system VT – graded anchor VT 19 – 140/150 M, duct with inner diameter 90 mm, strand – pegged, diameter 15.7 mm, strength 1570/1770 MPa.

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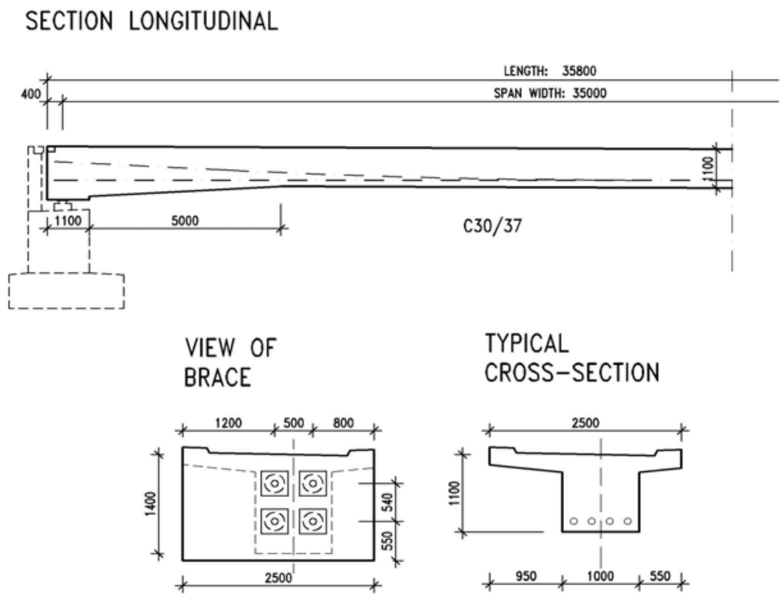

Fig. 1 Scheme of bridge

3 Anchorage zones

The anchorage zone consist of two areas, firstly local zone secondly general zone. The supplier of the post-tensioning system is usually responsible for the design of the anchorage device and the local zone immediately surrounding the device (spiral reinforcement). Design of the local zone is usually standardized for standard anchor spacing and side clearances.

The engineer of project is responsible for the design of the general zone which surrounds the local zone. This problem is different for each application. It depends mostly on the position of the tendons and overall member geometry.

For local zone is typical confinement of concrete in cross-section which increase loading capacity in the third direction. In addition local zone is attenuated by the ducts. On the other hand coverage of transverse splitting (tension) forces, which prestressing force produces, is general job in general zone.

4 Loading and bearing capacity

The general objective is obviously to provide a safe and serviceable structure. The question is “What are reasonable ultimate design loads for strength checks?” Net result would be load and resistance factors selected to provide some desired probability of failure. In this case one would get a factored design load greater than realizable strength of the tendons. On the other side using of partial safety factors in local section isn’t suitable for non-linear analysis.

4.1 Loading

Prestressing cables are usually strained to 80% of specified guaranteed ultimate tensile strength. It is possible to exceed the usual temporary jacking force but not by very much. The anchorage efficiency at the wedges will limit the realizable tendon force to about 95% of strength. This is accompanied by tendon elongations of at least 2% which is about 3 times greater then normal.

4.2 Design review

It is reasonable to use 80% of the characteristic concrete cylinder strength due to age of concrete in time of prestressing. Safe is secured by global factor according to code EN 1992-2 ($R_d = R (f_{ym}, f_{cm}, \ldots) / \gamma_R \;;\; \gamma_R = 1{,}27 \;;\; f_{cm} = 0.843 \,.\, f_{ck} \;;\; f_{ym} = 1{,}1 \,.\, f_{yk}$). In the calculations are supposed average values of material characteristics which are estimated from characteristic.

Adequate crack control is the usual serviceability criterion of interest for anchorage zones. The maximum permissible crack width depends upon the exposure conditions. For moderately aggressive environments (e.g. deicing agents in mists, where direct contact is prevented) a crack width of 0.2 mm is considered acceptable. This may be too conservative since inspections of existing structures with anchorage zones containing larger cracks.

For design, adequate crack control can be done by limiting the stress in the non-prestressed reinforcement from 200 to 240 MPa under typical load. This means that strain in the reinforcement is limited to 0.10 to 0.12%.

4.3 Alternative materials

Traditional solution of anchorage zones most often consist of reinforced concrete with steel bars. This development will deal several alternative way resolution our problem. As first we will test concrete reinforced only with spiral in local zone. Collapse of structure is expected. In next step we will find minimal required reinforcement in common arrange. Third concrete with spread reinforced will be proposed.

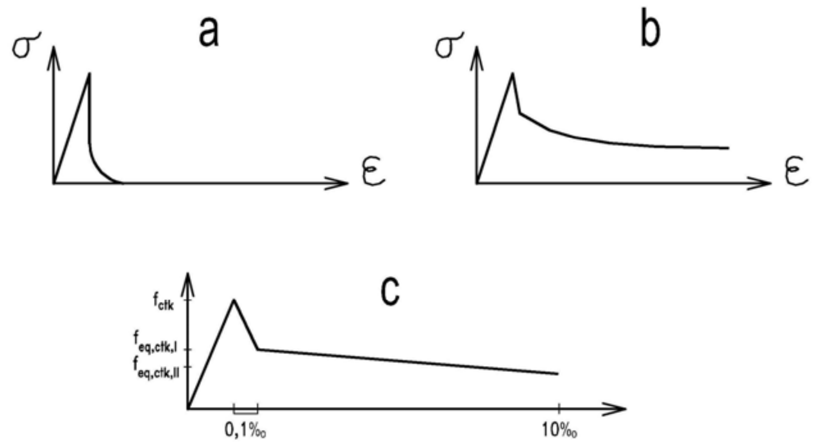

Fig. 2 Stress-strain diagram of brittle plain (a) and ductile fibre-concrete (b)(c)

Plain concrete with brittle dislocation will be replaced with fibre-concrete which is assumed as quasi-ductile material. When someone wants investigate behavior of structure, he needs necessary stress-strain diagram of all materials especially in case of non-linear research. Typical "working" diagram of fibre-concrete and comparing with plain concrete is shown on figure 2 (a)(b).

On figure 2 (c) is shown stress-strain diagram which will be used to predict behavior of anchorage area reinforced with fibre-concrete. Characteristic values we obtain after valid codes and recommendation specialists.

5 Conclusions

Object of this text is located on finding new un-common solution of performance anchorage zones. In this text are given general assumptions which are necessary every way. Solution will be calculated with modern method. If we obtain anything interesting by FEM analyze, model test can follow. Successful research can make propose of anchorage zones more transparent and effective.

References

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