Anchorage of steel bars in Hennebique structures

A. Brencich*, M. Nebiacolombo†

* Dept. of Civil, Chemical and Environmental Engineering
University of Genoa - Polytechnic School
via Montallegro 1 – 16145 Genova

* e-mail: brencich@dicca.unige.it
† e-mail: nebiacolombo@outlook.it

ABSTRACT

The Hennebique system, obscure in its origins, is the most widely used patent for r.c. structures used in Europe till WWI. It makes use of large diameter bars for flexural reinforcement and, usually, of thin (2mm) steel plates (20-to-50mm wide) for shear reinforcement.

Several points of concern arise when the safety of such a structure has to be assessed: i) concrete composition is variable, being left to the contractor; ii) the only structural scheme used was the simply supported beam also in case of multi span continuous beams; iii) the design criteria for the bending moment and for the shear were unknown, being covered by the patent; iv) anchorage of the bars, consisting of fish-tail ends for the flexural bars and of partially bent plates for the stirrups, is uncertain due to lack of data; v) some design detailes (lcontinuity of ongitudinal bars in columns) are not known.

This paper deals with anchorage in the Hennebique r.c. system because no modern code provision may be applied to Hennebique structures while anchorage of the bars is not a minor issue in the safety of an r.c. structure.

A series of tests have been performed to outline the anchorage mechanisms of both bending and shear reinforcement. To this aim, 20 and 30mm bars, with fish-tails ends, and 30 and 50mm wide steel plates, with bended ends, have been casted inside concrete cubes. The bars and the plates were pulled out from the concrete in various confinement conditions (no confinement, 1-direction or 2-direction confinement). It has been demonstrated that the anchorage of the bars is inadequate since it fails always before the reinforcement gets to the yielding limit. Anchorage of fish-tailed bars and of shear reinforcement is due to the closure of the tails. Nevertheless, since the closure of the tails is associated with local crushing of concrete in the close surroundings of the anchorage, a significant dependence on the concrete strength has been identified, estimated as large as 40% of the anchorage strength. Lateral confinement of the anchorage, i.e. the location of the bars in a central node of the frame or in a lateral one, is responsible for noticeable increase in the anchorage strength but not as large as one could expect This is specifically true for large diameter bars.

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