

BENDING/STRAIGHTENING CONCRETE REINFORCING STEEL: REVIEW OF WSDOT'S SPECIFICATIONS AND PROPOSED MODIFICATIONS

Introduction. Reinforcing bars partially embedded in concrete and protruding from it are frequently subject to bending and straightening in the field. Often it is necessary to bend the protruding bars to provide clearance for construction operations. Furthermore, field bending and/or straightening is required because of incorrect fabrication or accidental bending. Whatever the cause, the success rate of bending/straightening bars in the field has been unpredictable, and cracking of the bars has been reported. Even in the absence of cracking, there has been concern over the effects of bending/straightening on the engineering properties of concrete reinforcing bars.

Presently, the Washington State Department of Transportation (WSDOT) recommends two different procedures for field bending/straightening reinforcing bars. These are cold-bending and hot-bending. Cold-bending means bending bars whose temperature is close to ambient temperature. Hot-bending means bending bars that are heated to elevated temperatures to reduce their yield strength while bending. Generally, hot-bending increases the rate of success of the bending/straightening when large bars are involved.

Research Approach. WSDOT initiated this research project to review its present specification guidelines for field bending/straightening reinforcing bars and to recommend modifications to those guidelines so that it can increase the success rate of field bending/straightening and minimize possible changes in the engineering properties of reinforcing steel. After the available relevant data were collected, they were analyzed and the results were compared to WSDOT's current specification guidelines. Accordingly, recommendations for improvement of those guidelines were made. Finally, a second research phase consisting of laboratory tests was suggested to verify and/or modify the recommendations of this study.

Conclusions and Recommendations. The study recommended that the WSDOT's required bend diameter/bar diameter ratios for cold-bending and hot-bending be increased for certain bar sizes. This recommendation was based on both the expected strain capacity of ASTM A615 grade 60 reinforcing steel and the expected embrittlement caused by strain aging of such steel. The most effective temperature range for hot-bending was found to be 1400 to 1500°F. That temperature range assures that temperatures in the center of the bar are above a range of 400 to 700°F, since temperatures between 400 and 700°F can cause brittle fracture during the operation. However, the WSDOT required temperature range of 1100 to 1300°F was not increased because of concerns about controlling the temperature in the field and about overheating and degrading the steel. For hot-bending, guidelines for the heating period were provided to prevent excessive heating periods from causing strain age embrittlement of the metal. Also, recommendations were made concerning the bend diameter and use of non-strain aging steel to assure the development of seismic hinges when reinforcing bars to be bent in the locations designed for such hinges.

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