

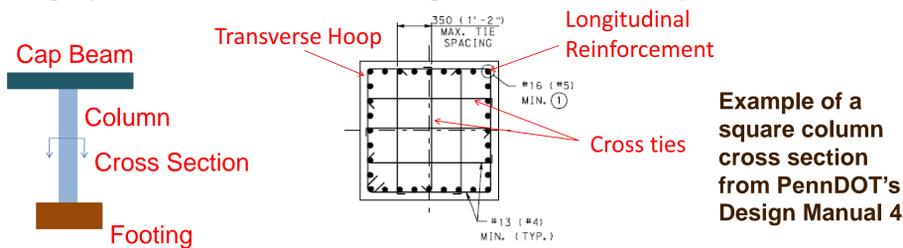


Evaluation of Transverse Reinforcement Requirements for Reinforced Concrete Bridge Piers in Seismic Regions

By: *Jordan Warncke, Clay Naito (P.E., Ph. D.), Ian Hodgson (S.E.)*
Department of Civil and Environmental Engineering

Background

- Bridge piers consist of a footing, column, and cap beam

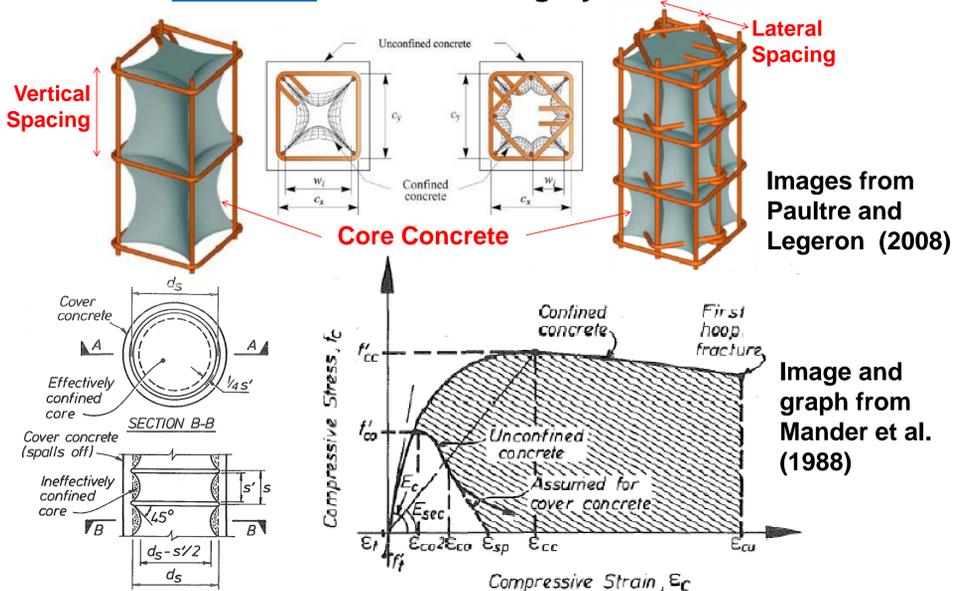


- The seismic design of bridge columns requires that a **plastic hinge region** is located at the top and bottom of columns



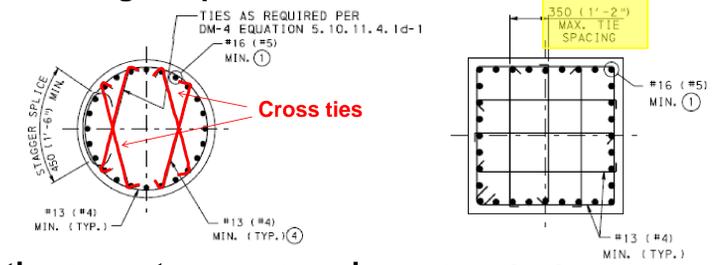
- Importance of Transverse Reinforcement

- **Hoops** – Prevent buckling of the longitudinal reinforcement
- **Cross ties** – Maintain integrity of core concrete



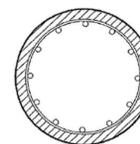
Results and Discussion

- PennDOT design requirements from BD629M:



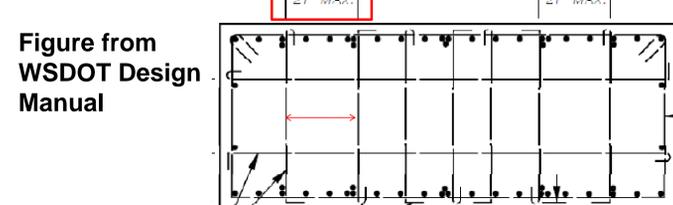
- Cross ties are not necessary when a circular hoop is used

Image from Priestley et al. (1996)



• ACI 318-08 states: R7.10.5 "...Where longitudinal bars are arranged in a circular pattern, only **one circular tie** per specified spacing is required."

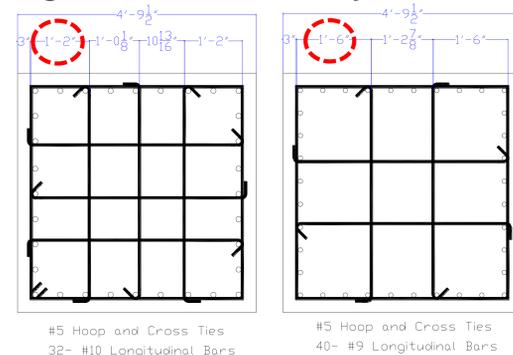
- Washington State DOT Manual allows a lateral spacing of 18.0" to 21.0" for cross ties



- According to ACI 318-08 and AASHTO LRFD Specifications, the lateral spacing of cross ties should not exceed 14.0"

- Theoretical calculations were done to examine if an 18.0" spacing would be structurally stable

14" Spacing
 $P_o \approx 13950 \text{ K}$
 $P_2 \approx 17000 \text{ K}$



18" Spacing
 $P_o \approx 13900 \text{ K}$
 $P_2 \approx 15900 \text{ K}$

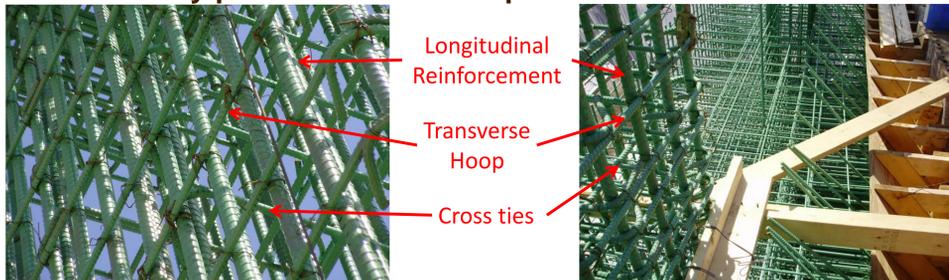
- AASHTO Specifications (C5.10.11.4.1d) require that "**the axial load carried by the column after spalling of the concrete cover (P_2) will at least equal the load carried before spalling (P_o)**"

- PennDOT's Design Manual 4 had a reference error which allowed a vertical spacing of 6.0" which diverted from AASHTO's required 4.0" maximum spacing

Objectives

- PennDOT wanted to extend the 14.0" lateral spacing of cross ties to 18.0" or 21.0" in an attempt to decrease the amount of steel necessary for construction

- Densely packed steel makes placement of concrete difficult



- Pictures taken of the pier reinforcement from the Gay St. Bridge, PA

Procedure

- Perform an extensive literature review of research conducted on the seismic performance of reinforced concrete bridge piers
- Review current state DOT guidelines regarding the use of cross ties
- Develop recommendations for the use of cross ties in reinforced concrete bridge piers for PennDOT
- Modify PennDOT Design Manual 4 and Bridge Drawings (BD629M)

Conclusions and Recommendations

- Cross-ties in circular columns should be removed
- Vertical spacing of transverse reinforcement should be changed to 4.0" maximum
- The lateral spacing of transverse reinforcement should remain at 14.0" maximum until further testing is conducted
- It is highly recommended that solely spiral reinforcement be used
- This research was developed into ATLSS Report No 09-06 and the recommendations are in the process of being implemented into PennDOT's Design Manual 4 and BD629M

Acknowledgments

I would like to thank Tom Macioce and Chad Knavel from PennDOT for funding this research, and Dr. Clay Naito and Ian Hodgson for their support and aid throughout working on this project.