Application of Plastic Theory to Shear Strength Prediction of External Prestressed Concrete Beams

Yu Zhao
Ph.D. Candidate
Tongji University
Shanghai, China
06zhaoyu@tongji.edu.cn

Linh C. Hoang
Professor
Univ. of Southern Denmark, Odense, Denmark
lch@ib.sdu.dk

M.P. Nielsen
Professor Emeritus
Technical Univ. of Denmark and Alectia A/S, Denmark.
mpni@alectia.com

Summary

This paper investigates the applicability of plasticity based models for shear strength prediction of reinforced concrete members with external prestressing. Shear tests collected from the literature are compared with calculations according to the Variable Strut Inclination Method as well as the upper bound Crack Sliding Model. Reasonably agreements with test results have been found, espessically when the effectiveness factor proposed in the Eurocode 2 is used.

Keywords: Plastic theory; Variable Strut Inclination Method; External prestressing; Crack Sliding Model; Shear strength.

1. Introduction

External prestressing has in recent years been recognized as an effective method for construction of segmental concrete box girder bridges and for strengthening and rehabilitation of existing structures.

Experiments and analytical studies have been conducted on external prestressed concrete beams for many years. However, most of the studies deal with the flexural behaviour and in particularly the effects of the unbonded tendons. Only few analytical studies on the shear behaviour of such members have been published. Among these are the work of Tan and Naaman [1, 2], who proposed a strut-and-tie model. Still, consensus on how to evaluate the shear strength of externally prestressed members has not been reached.

This paper investigates the applicability of plasticity based models for shear strength prediction of reinforced members with external prestressing. Calculations based on the upper bound Crack Sliding Model are performed. In addition, comparison of tests and calculations based on the lower bound method adopted in the Eurocode 2 is also presented. This method, often referred to as the Variable Strut Inclination Method, firstly applies to conventionally reinforced concrete. The method has also been thoroughly verified for conventionally prestressed members. For members with external prestressing, however, similar verification has not been reported.

2. Comparison of tests and calculations

Comparison of test results with calculation based on The Crack Sliding Model is shown in Fig. 1. The initial prestressing force as well as the final prestressing force has been used. With the initial prestressing force, the mean value of $P_{u,test}/P_{u,cal}$ was found to be *1.13* with a standard deviation of *0.31*. When the final prestressing force is used, the mean value and the standard deviation were found to be *1.06* and *0.27*, respectively.

Fig. 2 shows the comparison of tests with calculations based on the Variable Strut Inclination Method. Here, the mean value and standard deviation were found to be *1.07* and *0.15*, respectively.

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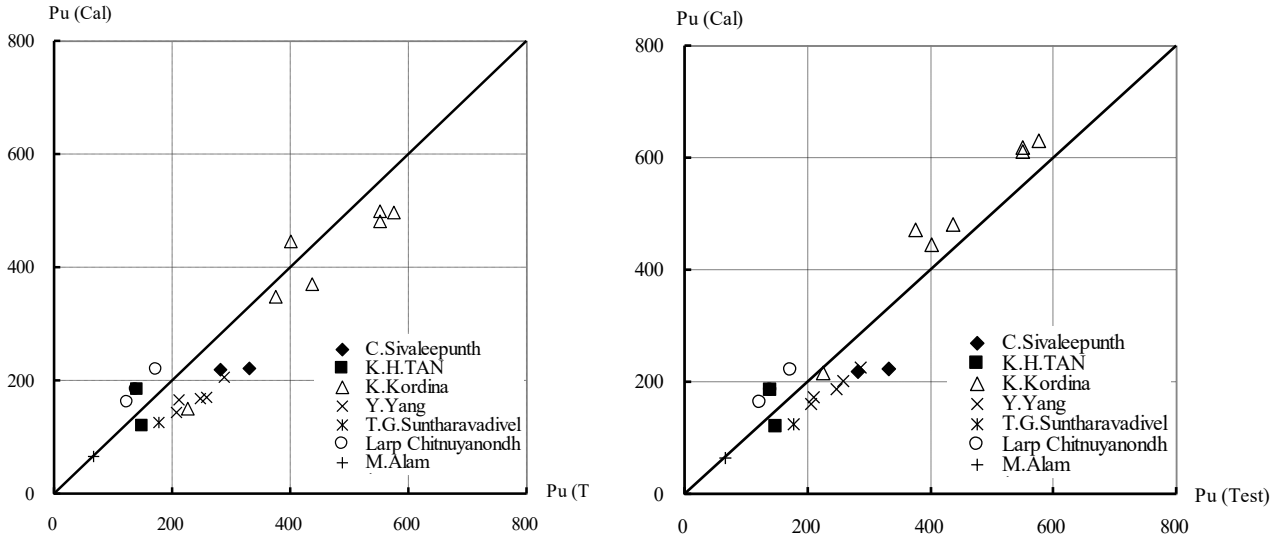

Fig. 1: Comparison of tests with calculations based on Crack Sliding Model, initial tendon force (left); final tendon force (right).

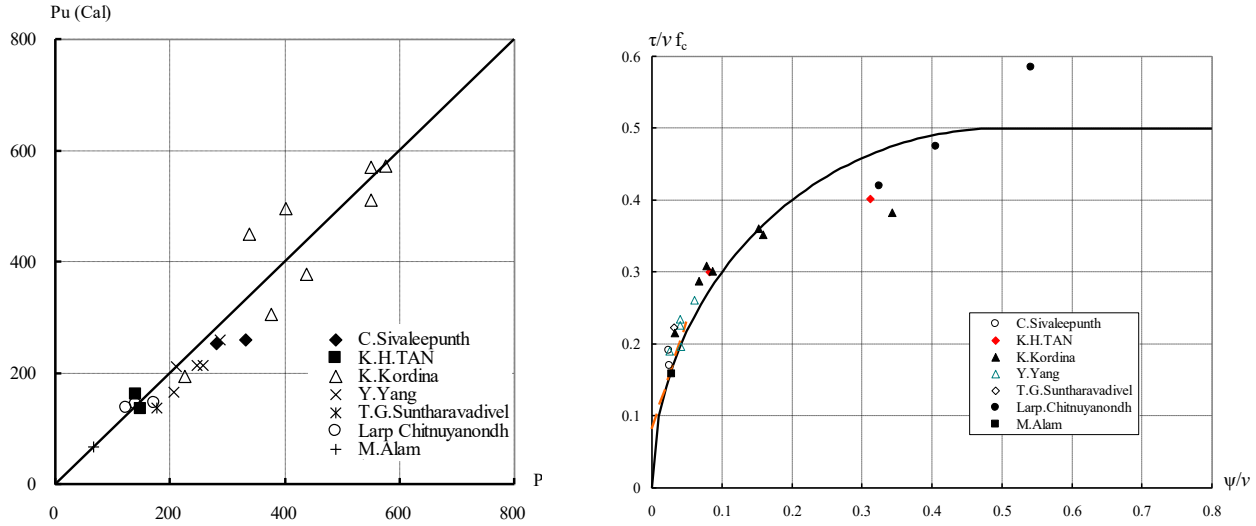

Fig.2: Comparison of tests with calculations based on the Variable Strut Inclination Method.

3. Conclusion

This study was carried out to investigate the applicability of plasticity based models for shear strength prediction of reinforced members with external prestressing. Shear tests collected from the literature have been compared with calculations according to the Variable Strut Inclination Method and the upper bound Crack Sliding Model. Reasonable agreements with test results have been found for both methods. For the Crack Sliding Model, relatively large standard deviations were found even though this model includes the effects of axial compression in a more theoretical manner