

# Flexural behaviour of externally prestressed beams. Part II: Experimental investigation

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## Abstract

In Part I of this paper, a simple “pseudo-section analysis” method which accounts for second-order effects in a simply supported, externally prestressed beam subjected to two symmetrically applied concentrated loads was developed. In this paper, an experimental investigation of the flexural behaviour is reported. A total of nine simply supported prototype beams were tested to evaluate the effect of span-to-depth ratio and second-order effects. It was found that span-to-depth ratio has no significant effect on the flexural behaviour of the beams. For beams with span-to-depth ratio of up to 22.5, a single deviator provided at midspan section is effective in minimising second-order effects, that is, maintaining higher load-carrying capacity and ensuring ductility at the ultimate limit state for the beams. However, second-order effects prevailed in a longer beam with larger span-to-depth ratio of 30.0 despite the provision of a single deviator at midspan. This type of long beams would require at least two deviators placed at one-third span sections, hence reducing the deviator spacing in order to minimise second-order effects so that the beams would achieve the desired flexural performance with regard to beam strength and ductility. Theoretical predictions of the load–deformation responses using the proposed analytical model were found to agree well with the test results in this study and experimental data of other investigations. © 2005 Elsevier Ltd. All rights reserved.

**Keywords:** Analysis; Beam; External prestressing; Flexure; Strength; Second-order effects

## 1. Introduction

Experimental studies on flexural behaviour of externally prestressed beams are scarce based on a literature survey carried out by the authors in Part I of this paper. Most of the theoretical investigations reported that the span-to-depth ratio of the beams has a significant effect on the flexural behaviour, particularly on external tendon stress [1–3]. In a separate investigation [4], span-to-depth ratio was found to be insignificant in the external tendon stress of the beams if second-order effects are minimised. Therefore, more experimental data is required to address this issue. Another aspect of the flexural behaviour which is lacking in experimental data is the variation in external tendon depth, or normally termed as second-order effects.

The investigation reported herein aims at providing more experimental data on the behaviour of externally prestressed

beams, particularly on the effects of span-to-depth ratio and number of deviators or second-order effects. The test results were also used for the validation of the analytical model proposed in Part I of this paper.

## 2. Test program

Nine prototype concrete *T*-beams with cross-sectional dimensions and reinforcement details shown schematically in Fig. 1, were prepared (see also Table 1). In all beams, the internal longitudinal reinforcement consisted of two T16 bottom bars and four R8 top bars, with average laboratory tested yield strengths,  $f_y$  and  $f'_y$ , of 530 MPa and 338 MPa respectively. The beams were reinforced with R6 or R8 mild steel stirrups throughout their lengths, with average laboratory tested yield strengths of 320 MPa and 338 MPa respectively. The design cube strength of the concrete used was 38 MPa at 28 days. No deviator was provided in beams T-0A and T-0B. In beams ST-1, ST-2, ST-3, ST-4 and ST-5, a 100 mm wide

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