

Structural behaviour of bolted end-plated reinforced concrete beams

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Abstract

The paper reports a study on the flexural strength and deformation characteristics of concrete beams reinforced with threaded steel bars that were tensioned against steel plates bearing on the concrete ends by means of tightening nuts. Stressing of the beams was achieved when the nuts were turned until finger tight. Six beams were subjected to monotonic loading and 4–20 cycles of loading. Four control beams were also cast using normal non-tensioned bars. Cracking loads for the prestressed beams averaged 280% of the control beams. For the two series of beams, the ratio of cracking load P_{cr} to the failure load P_{ult} was almost the same, averaging 0.25 and 0.22 for the prestressed and control beams, respectively. Cyclic loading of the prestressed beams was characterized by complete crack closure on the removal of the applied load, but for the unstressed beams, cracks remained open throughout the full load cycles. Failure loads for the stressed beams averaged 244% of the unstressed beams, even though the span-to-depth ratio was larger for the former. Failure loads for the stressed beams averaged 219% of the theoretical failure load (based on an assumed unstressed beam). At failure the maximum crack width in the beams ranged from 0.03 to 0.2 mm for the prestressed beams, and 2.9–3.5 mm for the unstressed control beams.

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1. Introduction

Concrete is strong in compression but weak in tension, and has a modulus of rupture that generally varies from 7 to 16% of its compressive strength. Due to this low tensile capacity of concrete, flexural or tensile cracks develop in reinforced concrete members at their early stages of loading. The load-carrying capacities of reinforced concrete members are thus largely restrained so as to satisfy the requirements of serviceability limit states of cracking and deflection. This implies that the full strengths of concrete and steel cannot be exploited in ordinary reinforced concrete structures. In order to prevent or control crack development and reduce crack widths, internal compressive stresses are initially induced in the concrete by means of tensioned steel wires or tendons in prestressed concrete structures. The initial compressive stress can prevent crack formation by eliminating, or considerably reducing, the tensile stresses at the critical mid-span and support sections at service loads, thereby enhancing the bending, shear and

torsional capacities of the structure. The sections are then able to behave elastically, and almost the full capacity of the concrete in compression can efficiently be utilized across the entire depth of the concrete section when all loads act on the structure. This has made it possible to employ high tensile steel and high strength concrete which allow smaller and lighter members to be produced with increased loading capacities [1]. Modern uses of prestressed concrete include medium to long span bridges, high-rise buildings, water-retaining structures, long span roofs and railway sleepers. Prestressing operations, however, involve complex formwork and materials, specialized equipment, and tools that are highly expensive in poor developing countries.

The load-carrying capacity of structural concrete columns has been enhanced through the use of wraps/jackets/casings to create initial lateral compressive stresses. Experimental and theoretical work has been extensively conducted in this area using steel-based confinement mechanisms by a number of researchers [2–7].

The aim of the present study was to assess the structural potential of concrete beams reinforced with ordinary low to medium yield steel bars that were

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Table 1
Description of beams

Beam no.	Span/eff depth ratio	Concrete strength (N/mm ²)	Modulus of rupture (N/mm ²)	Area of prestressing steel bar, A _p mm ²	Area of unstressed steel, A _u (mm ²)	Total area of bottom steel A _t =A _p +A _u (mm ²)	% 100A _u bD	Area of top steel A _t ' (mm ²)	% 100A _u ' bD
P1	15.9	51.2	2.5	314	201	515	2.75	201	1.07
P2	15.9	62.4	3.0	314	201	515	2.75	201	1.07
P3	15.9	64.6	3.0	314	402	716	3.82	402	2.14
P4	15.9	63.9	3.0	314	402	716	3.82	402	2.14
P5	16.7	46.9	2.4	314	157	471	2.52	157	0.84
P6	16.7	47.8	2.4	314	157	471	2.52	157	0.84
P7	16.7	43.1	2.3	314	157	471	2.52	157	0.84
P8	16.7	51.1	2.5	314	157	471	2.52	157	0.84
P9	16.7	55.1	2.5	314	157	471	2.52	157	0.84
P10	16.7	46.9	2.4	314	157	471	2.52	157	0.84
C1	14.8	27.9	1.8	0	226	226	1.52	226	1.52
C2	14.8	30.5	1.9	0	226	226	1.52	226	1.52
C3	14.8	24.5	1.5	0	226	226	1.52	226	1.52
C4	14.8	28.0	1.8	0	226	226	1.52	226	1.52

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