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Ultimate Strength of Bonding of Composite Beams

Résistance des assemblages de poutres en acier et béton

Tragwiderstand des Verbundes in Verbundträgern

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A total of 14 specimens of steel-concrete jointed beams was tested to investigate the ultimate strength of the joint which connects a steel beam with a concrete beam longitudinally. The aim of this study is to clarify the basic behavior of the jointed beam and to find simple conceptual models by which the ultimate strength of the joint can be evaluated. For this purpose the joint was designed as simple as possible as shown in Fig.1. A steel plate welded to the end of a steel H-beam is jointed to a reinforced concrete beam of rectangular cross-section by two prestressing bars.

Five specimens were tested under pure bending (4 points loading), six specimens under bending with shear (3 points loading) and three specimens under pure shear. All the results are summarized in Table 1.

The ultimate bending strength of all the bending test specimens were governed by crushing of the concrete at the upper fiber adjacent to the end plate where the normal compressive stresses transmitted from the upper flange plate of the steel beam concentrate(see Fig.2). It was found that increase in the end plate thickness and installation of connecting bars contribute to decrease the stress concentration at the end plate surface and increase the ultimate bending strength of the jointed beam.

It was also shown that the ultimate bending strength of the jointed beam with an end plate of sufficient thickness (36 mm for our tests) can be predicted fairly well by the formula based on the usual stress block models shown in Fig.3.

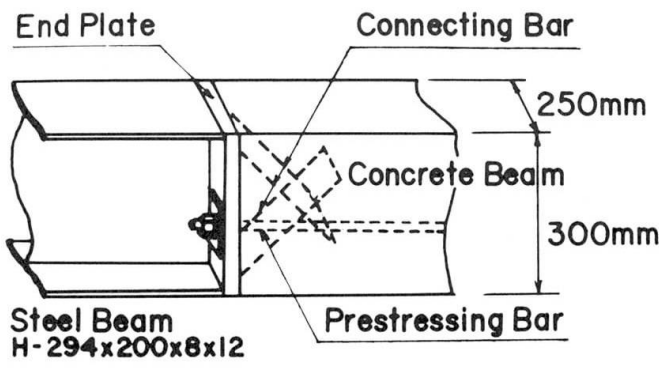

Fig.1 Steel-concrete jointed beam

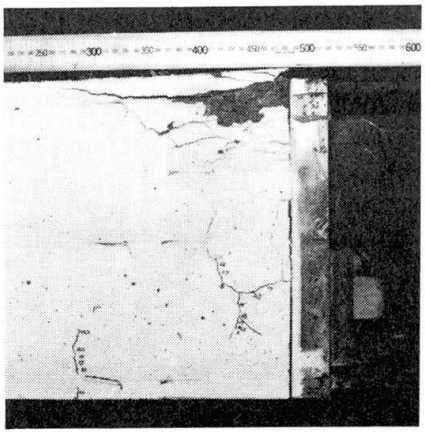

Fig.2 Ultimate state of the bending test specimen

Table 1 Test Results

Loading Condition	Name of Specimen	Span a (m)	Thickness of End Plate(mm)	Diameter of Connection Bar(mm)	$M_{u,test}$ (kN·m)	$M_{u,theory}$ (kN·m)	Test Theory	Remarks
Pure Bending	JB-8	1.0	8	None	90.8	152.5	0.60	Full Prestressing
	JB-8-16	1.0	8	16	107.9	174.4	0.62	〃
	JB-36	1.0	36	None	137.3	147.9	0.93	〃
	JB-36-16	1.0	36	16	161.9	170.9	0.95	〃
	CB	1.0	Reference PC Beam		161.3	151.9	1.06	〃
Bending with Shear	JSB-2	0.6	36	None	150.1	138.4	1.08	〃
	JSB-2-6	0.6	36	6	148.6	141.4	1.05	〃
	CSB-2	0.6	Reference PC Beam		167.8	133.1	1.26	〃
	JSB-3	0.9	36	None	141.4	140.6	1.01	〃
	JSB-3-6	0.9	36	6	142.1	142.2	1.00	〃
	CSB-3	0.9	Reference PC Beam		149.2	135.1	1.10	〃
Pure Shear					$V_{u,test}$ (kN)	$V_{u,theory}$ (kN)		
	JS-6	0.6	36	6	465.8	424.3	1.10	〃
	JSR	0.6	36	None	279.6	312.7	0.89	30% Prestressing
	JSR-6	0.6	36	6	367.9	333.6	1.10	〃

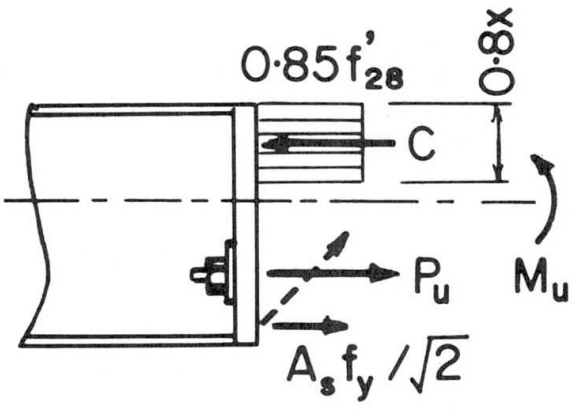

Fig.3 Theoretical model for estimating bending strength

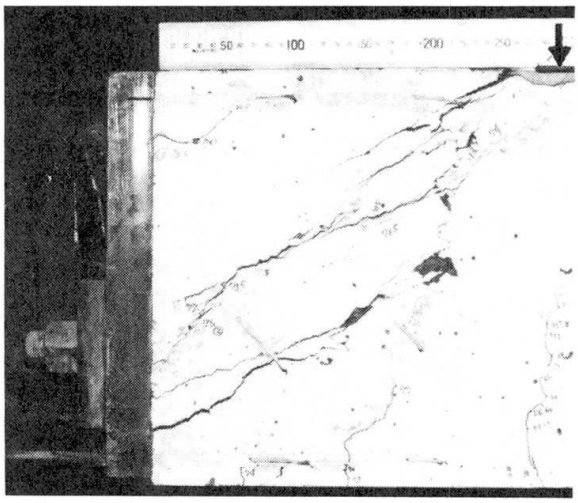

Fig.4 Ultimate state of the shear test specimen

In the tests under pure shear, the ultimate shear strength of the jointed beam was governed by the inclined shear cracks which run between the end of the prestressing bars and the loading point (see Fig.4). It was found that the experimental load for the initiation of the shear cracks can be predicted fairly well by the theoretical value which is evaluated from the criterion that the shear crack initiates when the principal tensile stress attains the tensile strength of the concrete.

The ultimate shear strength of the jointed beam is affected by the magnitude of the prestressing force. It was also found that the ultimate shear strength of the joint can be determined by the sum of the shear resistance of the concrete and the yield strength of stirrups and connecting bars. Further study is needed to clarify the mechanism of the ultimate shear resistance of the concrete, but the magnitude of the shear resistance of the concrete can be approximated by the shear force under which the principal tensile stress computed from average normal stress and average shear stress for the effective depth of the beam attains the tensile strength of the concrete.