論 文

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SHEAR RESISTANCE OF VARIOUS CONNECTIONS USED FOR PRECAST CONCRETE LOAD-BEARING SHEAR WALL PANELS

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1. INTRODUCTION

Because of the little possibility to have an earthquake in the north American area, precast high-rise structures have become very popular due to the high quality control of the prefabricated panels that can be achieved in the manufacturing plant and the savings in construction time. The precast concrete panels are assembled and tied together at the construction site with a minimum of interference from the weather conditions. The behavior of connections used in wall panel construction greatly influences the structural integrity of the entire structure.

This paper discusses the results of two phases of experimental work undertaken to examine the behavior of six connection configurations that are typically used for precast concrete load-bearing shear wall panels. The first phase (1) included four types of connections: a reinforcement and dry-packed connections with two types of mechanical shear connectors, in addition to the continuity bars. The second phase (2) included two different types of dry-packed multiple shear key configurations. All the connections were subjected to monotonic shear load up to failure. The results of the experimental program were used to calibrate a mathematical model introduced to predict the strength of these connections.

2. EXPERIMENTAL PROGRAM

The experimental program was designed to study the behavior of various connections under monotonic loading. The variables included in this study were the dry pack and panel concrete strengths, the continuity bars and mechanical shear connectors, the pre-load level normal to the connection and the geometry of the connection.

A total of thirteen specimens were tested. The overall dimensions of the precast panels used are shown in Fig.1. The various connection configurations tested in this study are:

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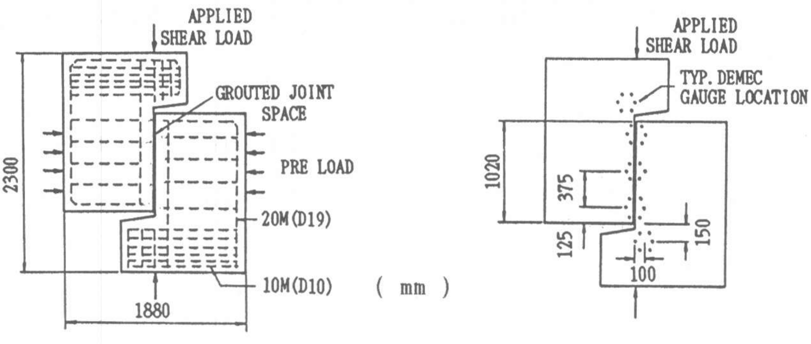


Fig. 1 Overall specimen dimensions
and demec gauge location

Type I: Dry pack grout only.
Type II: Dry pack grout and 25M (D25) continuity bars.
Type III: Dry pack grout, 25M (D25) continuity bars and shear connector Type A.
Type IV: Dry pack grout, 25M (D25) continuity bars and shear connector Type B.
Type V: Large size dry-packed multiple shear keys.
Type VI: Small size dry-packed multiple shear keys.

The configurations of the above connections are shown in fig.2.

Two levels of pre-load, applied normal to the connection, equivalent to 2 and 4 MPa, were used to simulate the dead load effect of a building. The overall test parameters, including material properties, are given in Table 1.

A system of demec points, as shown in Fig.1, was attached on each side of the connection to measure the average strain of the concrete. LVDT's were also used to monitor the deformation parallel to the joint. Each specimen was aligned vertically in the testing machine, as shown in Fig.3. A post-tensioning scheme, consisting of eight Dywidag bars, was used to apply a pre-load normal to the connection. An independent post-tensioning scheme was also used at the end of the panels to prevent premature failure of the individual panels. The testing machine was used to apply shear load in increments of 100 KN.

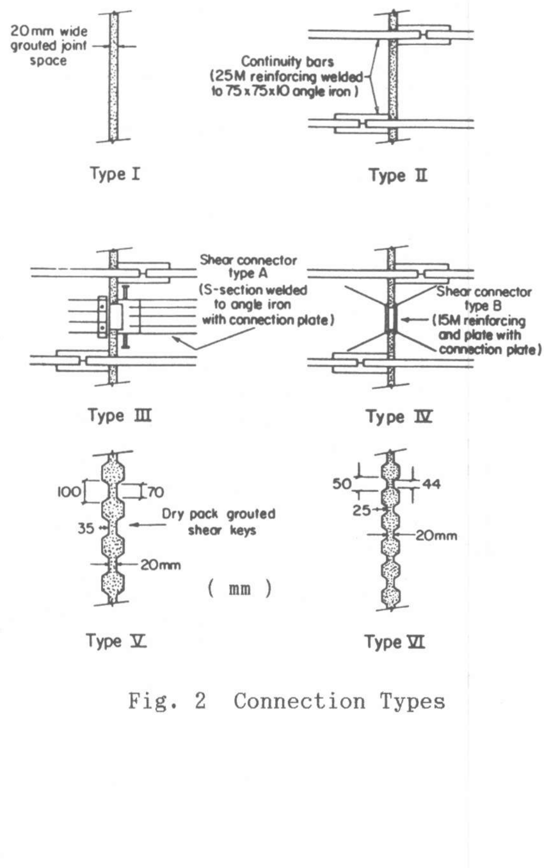


Fig. 2 Connection Types

Table 1 Overall test parameters

	Dry pack configuration	Load normal to connection MPa	Type of connection	Specimen mark	f'_c MPa	f'_g MPa
Phase I	Plain surface	2	I	SP11	31.9	46.4
			II	SP12	32.3	49.7
			III	SP13	43.5	56.6
			IV	SP14	46.5	66.5
		4	I	SP21	41.5	56.6
			II	SP22	34.5	67.6
			III	SP23	49.3	56.9
			IV	SP24	52.8	60.2
Phase II	Multiple shear key	2	V	ILK2	47.5	37.0
			VI	1SK2	47.5	36.9
		4	V	2LK4	44.1	36.2
			VI	2SK4	37.2	38.7
	Plain surface	2	I	1NK4	49.5	38.5

Note: f'_g is the cube compressive strength of the dry pack grout

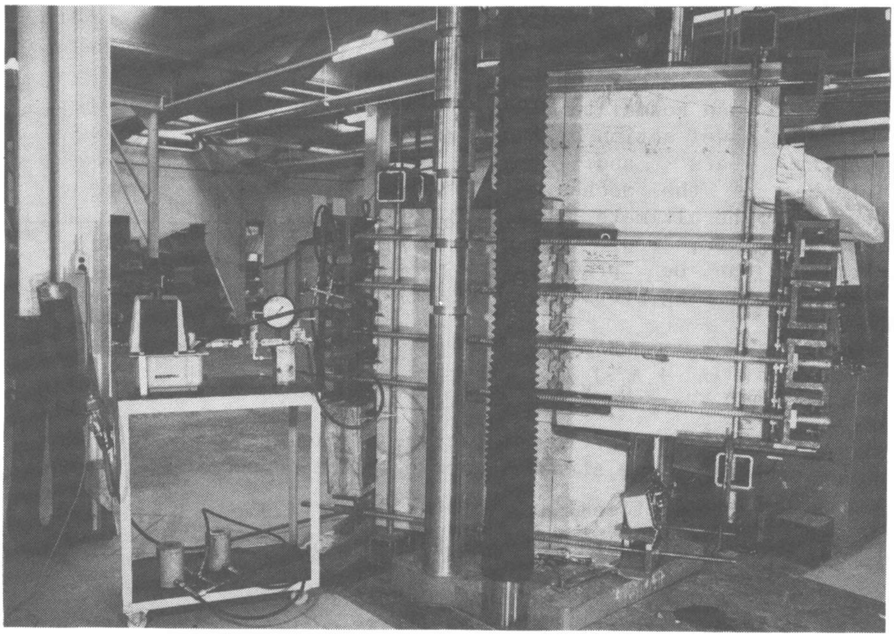
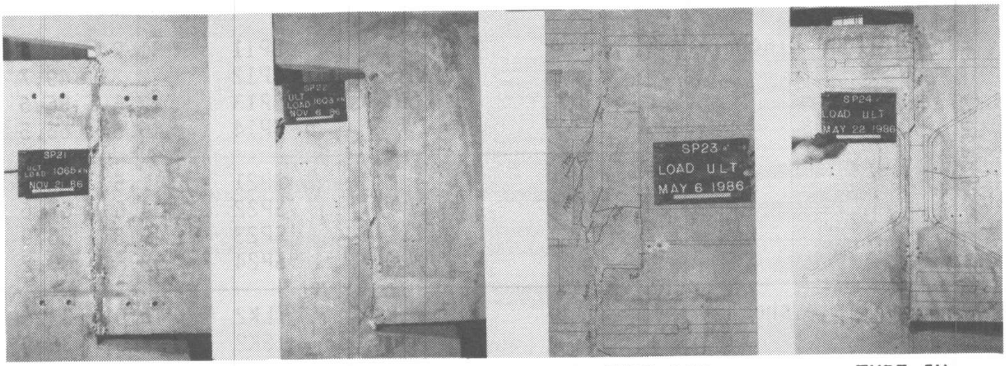


Fig. 3 Test set-up

3. TEST RESULTS AND DISCUSSION

Typical failure patterns of the various connections tested in phase I of this study, type I, II, III and V, are shown in Fig.4. Typical load-slip curves of the connections tested in phases I and II, under a pre-load level of 4 MPa, are shown in Figs. 5 and 6, respectively.



TYPE I TYPE II TYPE III TYPE IV

Fig. 4 Typical crack patterns (phase I)

The test results of phase I indicate that regardless of the mechanical connectors used, the cracking strength of the connections depends mainly on the bond strength at the dry pack concrete interface. the residual shear capacity of the connection is related to the level of the load normal to the joint, the dowel action of the continuity bars and the resistance of the mechanical connectors. The ultimate shear resistance, Vu, of these connections can be predicted using the following proposed model:

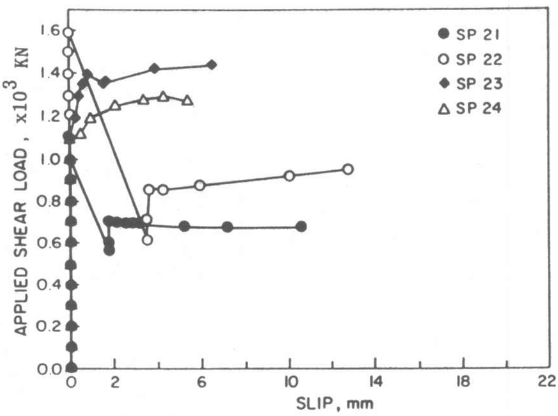


Fig. 5 Load-slip curve at the 4 MPa pre-load level (phase I)

$$V_u = \mu \cdot \sigma_n \cdot A_c + A_b \cdot f_y / \sqrt{3} + V_w$$

where μ = friction coefficient factor, 0.7 is proposed

σ_n = compressive stresses normal to the connection

A_c = cross-sectional area of the connection

f_y = yield strength of the continuity bars

A_b = area of the continuity bars

V_w = shear strength of the fillet weld for Types III and IV (= (effective throat of weld)*(weld length)*$f_y/\sqrt{3}$)

The predicted ultimate shear resistance based on the proposed model was found to be in good agreement with the measured values, as shown in Fig.7.

The test results of phase II, indicate that using multiple shear keys will enhance the ultimate shear capacity by as much as 60 percent in comparison to the plain surface connections at the same level of pre-load. The behavior of these connections suggests that the shear capacity depends mainly on the strength of the weaker material within the vicinity of the connection and the level of the load normal to the connection. The difference in multiple shear key configurations used in this study had no measurable effect on the ultimate shear load capacity of the connection.

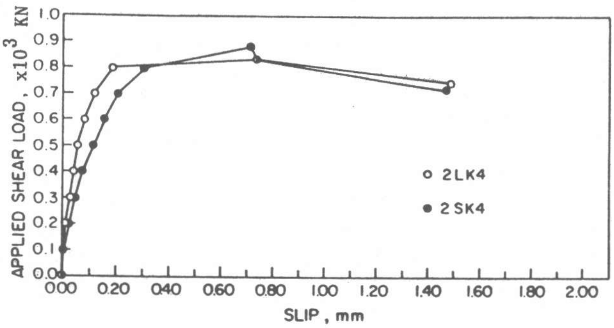


Fig. 6 Load-slip curve at the 4 MPa pre-load level (phase II)

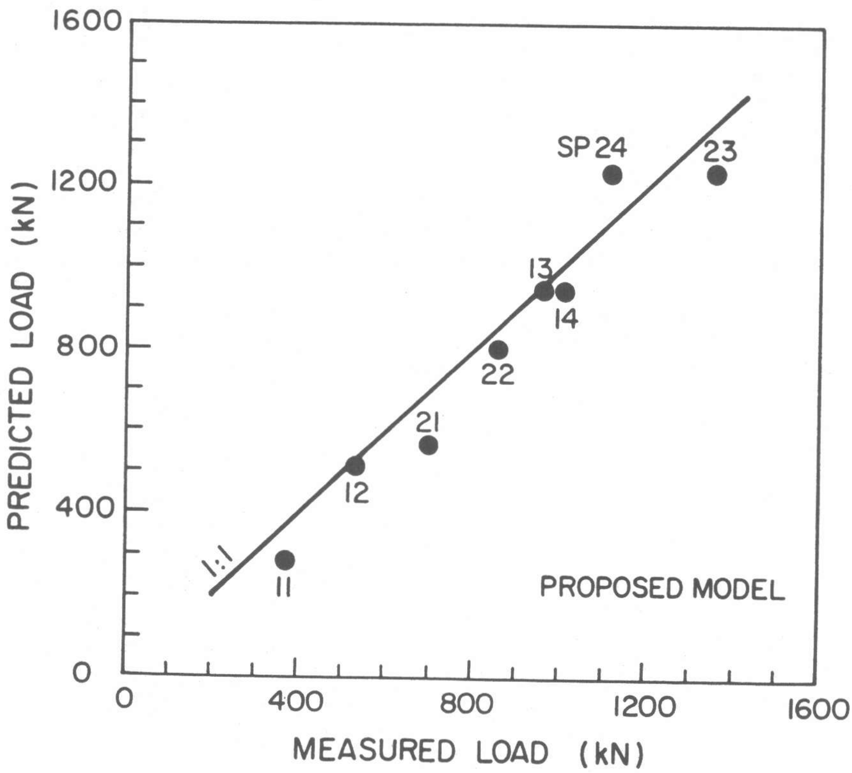


Fig. 7 Comparison between predicted and ultimate shear load for the phase I connections

It should be noted that the strength of the dry pack grout used in phase II is considerably lower than the grout strength used in phase I.

4. CONCLUSION

The behavior of the various connections typically used for precast concrete shear wall panels is determined. Based on the test results, it was found that the behavior is mainly dependent on the following basic parameters:

(1) The tensile strength of the weaker material within the connection.
(2) The bond strength of the dry pack grout.
(3) The load level normal to the connection.
(4) Dowel action of the continuity bars and the shear strength of the mechanical shear connectors.
(5) The presence of the multiple shear keys.

The proposed mathematical model introduced for the plain surface dry-pack connections was found to be in good agreement with the measured values.

ACKNOWLEDGMENTS

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