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Ultimate Strength of "T"-shaped Connection Sheet Piles for Cellular Sheet Pilings with Straight Web Steel Sheet Piles

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Synopsis :
In cellular sheet piling structures, connection sheet piles, required at the intersection of walls between are cells and circular cells, are subjected to the most severe stress and deformation conditions among structural components and so they may lead to fatal failures. For the purpose of studying ultimate strength of "T" connection sheet piles, which are used for almost all types of cellular cofferdams in Japan and developing new connection sheet piles with higher strength, a series of two directional simultaneous tensile tests were conducted by using several types of about one-meter-long prototype "T" connection sheet piles. For design purposes, test results obtained were illustrated as interaction curves of ultimate strength at connections concerning hoop tensions in circular cells and are cells for every structural details, and also estimation methods for ultimate strength of typical types of connections were discussed. Additional tensile tests were also conducted on three types of "T" connection sheet piles for newly developed straight web sheet piles with higher interlock strength than that of conventional ones.

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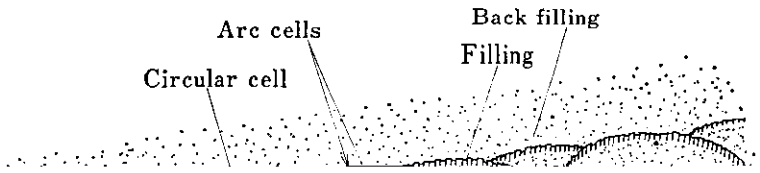
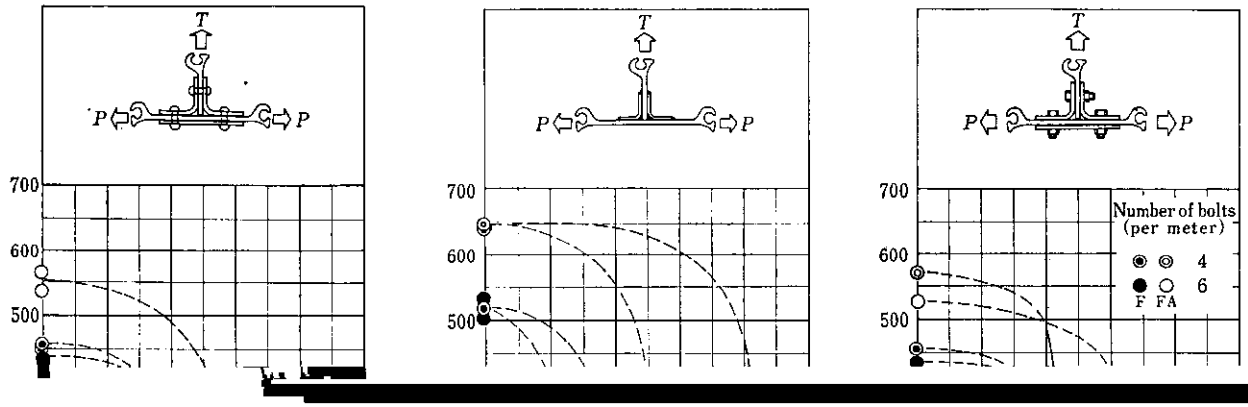

Arc cells
Back filling
Filling
Circular cell

Riveted type	Sheet pile		Splice plate		Rivet			Notation
	T	Steel	Plate	Steel	Dia	Steel	Pitch	

Table 1 [illegible]

Material			Yield strength (kgf/mm^2)	Tensile Strength (kgf/mm^2)	Elongation (%)
Steel sheet pile F	SY 30	t_w=9.5	44	60	21
	SM 50A		44	58	27


T
P
P
700
600
500
Number of bolts
(per meter)
4
6
F FA

rent increase. As a result, the bending strain [redacted] force of the entire structure. In the steel sheet pile

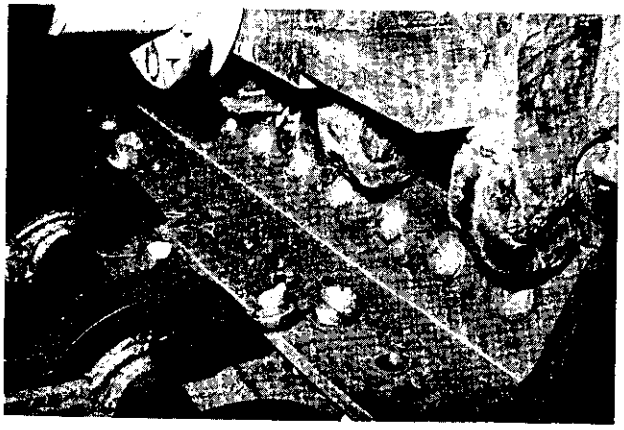


Photo 2 Typical failure mode of riveted "T" connection sheet piles subjected to tension

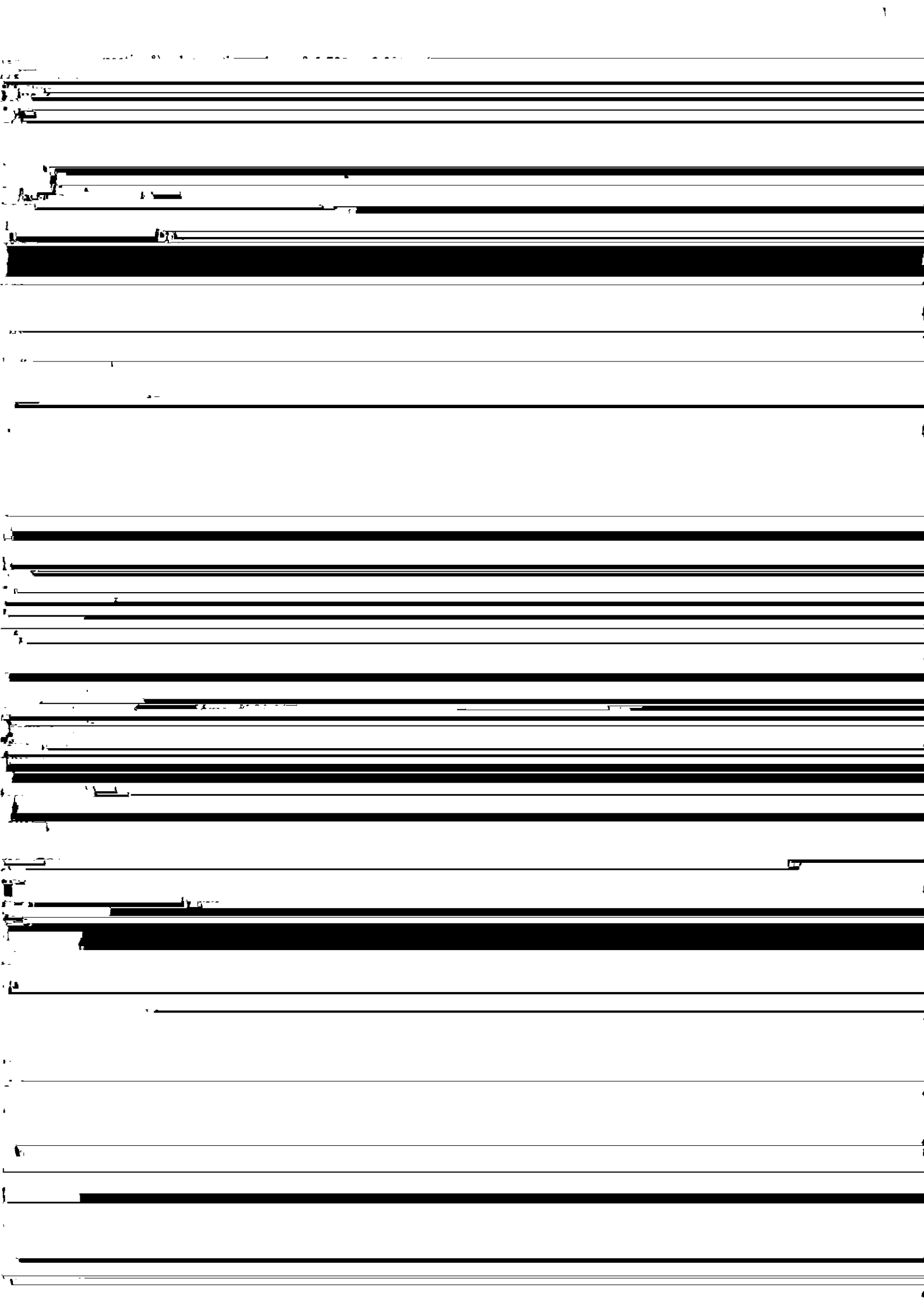
2.2.2 Failure modes

(1) Riveted connection type

For the riveted "T" connection, ultimate strength is governed entirely by the shear strength of arc-cell-side-rivets. **Photo 2** and **3** show the tested "T" connection sheet piles and its rivet after failure, respectively. In general when "T" connection sheet piles are designed to be rivet-connected, it is assumed that the circular-cell-side rivets are tensile rivets and arc-cell-side rivets are shearing or bearing ones, and the strength of the connections is checked by using a smaller value of the two types of rivets. **Table 2** shows all types of allowable stress applicable to riveted connections of steel sheet piles. When these values are used in designing "T" connection sheet piles in order to obtain the guaranteed interlock strength of 400 tf/m, it is found that strength is insufficient. And no valid design based on the allowable stress will become possible, even if tensile rivets on the circular cell side are driven in the minimum pitch, on the assumption that the allowable tensile strength of straight web steel sheet pile is 150 tf/m, and the

on the interlock strength of 400 tf/m specified in

The shearing strength of the rivet on the arc cell



failure is, in ideal terms, governed by the tensile strength of the arc-cell-side sheet piles or shearing strength of the fillet weld. In general, previous studies[9-11] reported that the bending deformability of weld was comparatively small. In the present test, the welded tee connection sheet piles reinforced with splice angles also generated a weld toe crack and fractured when load of about 50% tf/m (both for cases having 4 bolts/m and 6 bolts/m) and of 150 tf/m (4 bolts/m) were subjected,— developed base-material-side fracture as shown in **Photo 6** (shear fracture starting from bolt hole). The bolts after this testing showed great shear deformation, thereby indicating that the combination of material strength values in the present test lay on the border separating the failure mode Case

that $\alpha = 1/2$ in the high strength bolted tee connection sheet piles, taking into consideration its special structural characteristics that bending is unavoidably applied on the bolt head, its double shear strength T_{ss} is given by the following equation:

$$T_{ss} = \frac{}{} \times 2 \times \frac{\pi d^2}{} \times \tau_{}$$

be calculated as shown in **Table 3**. This table indicates that high strength bolted tee connection is much more effective than the riveted (SV41) "T" connection for preventing decrease in ultimate strength caused by hole exclusion on the circular cell side sheet piles and for reduction in the number of rivets or bolts.


85
85

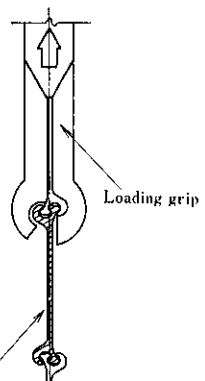
Table 4 Mechanical properties of tested materials for "T" connection sheet piles with minimum interlock

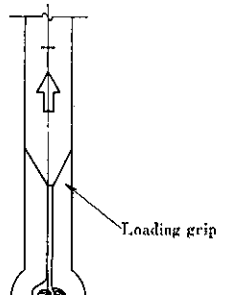
tension of 600 tf/m

Material			Yield strength (kgf/mm²)	Tensile strength (kgf/mm²)	Elongation (%)
Sheet pile FR	SY30	t_W=12.7	37	58	23
	SM50A		42.3	57.1	26
Splice plate	SM50A	t=14 16	42.9	55.6	25
Rivet	SV41	ϕ 25	28	43	34

3.1.2 Test method

The present test was primarily aimed at developing "T" connection sheet piles for the high interlock strength straight web steel sheet piles which can ensure a minimum tensile strength in the arc-cell-direction of 400 tf/m. Therefore, no 2-direction simultaneous tensile test was performed, but separate 2 single-direction tensile tests were performed by using separate tensile grips for tension in the arc-cell-direction and that in the circular-cell-direction as shown in **Fig. 9**. Dummy steel sheet piles were inserted between the tensile grip and "T" specimens which were made from the same lot as "T" sheet piles, so that failure at interlocks might occur when the connection strength of sheet piles is higher than the interlock strength.





3.2 Test Results

required arc-cell-direction tensile minimum strength of 400 tf/m has been satisfactorily obtained except the

bination type) which ought to have better weldability shpws lower ultimate length than that of SY30 which has been considered inferior in weldability. This may be attributable to the following reason: For the specimen consisted of SY30 a standard of visual

inspection for weld configurations was set up and

connection sheet piles for the high interlock straight web steel sheet piles can be obtained.

4 Conclusion

For the purpose of studying the ultimate strength

ated in the design specification of the Japan Port and Harbour Association[3], the F-type riveted "T" connection type (rivet dia.: 25 mm, pitch: 85 mm) was proved to have sufficient ultimate strength of

5) S. Kikukawa, K. Murata and A. Nishimura: "Secular Changes of Slip Resistance of Friction-type Bolted Joints in Structural Members", *Kawasaki Steel Technical Report*, **11** (1979) 4, pp. 127–135 (in Japanese)
6) T. Yagyu: *Kowan*, **57** (1980), 8, pp. 55–66