Experiments on mortar concerning the utilization of recycled concrete filler for concrete

2008.3

1. Materials employed

(1) Ordinary Portland cement (density: 3.16 g/cm^3) for cement material

(2) Sea sand (symbol: S), crushed sand (symbol: C), reproduction sand (symbol R) and standard sand (symbol: ST) for fine aggregate materials

(3) Fillers measuring 0.74-0.15 mm (symbol: FL), 0.74 mm under (Symbol: FS) and re-crushed FS (average particle diameter: 0.01 mm, symbol: FSC) as recycled fillers

(4) Nippon Paper Chemical's FlOWRIC SF500 for AE agent

Table-1 Physical properties of fine aggregates, etc.

Kinds	Density (g/cm^3)	Water absorption rate (%)	Actual performance rate (%)	FM	0.15 mm passing rate (%)
S	2.54	1.59	65.8	2.61	4.9
C	2.56	1.22	66.1	3.00	6.6
R	2.50	4.49	65.9	2.40	3.0
FL	2.49	—	—	—	—
FS	2.20	—	—	—	—

2. Mortar basic formulation

Table- 2 When using FL as a part of fine aggregate

Water (g)	Cement (g)	Fine aggregate (g)
225	450	1350

Table- 3 When using FS as a part of cement

Water (g)	Cement (g)	Fine aggregate* (g)
290	450	1350

*Standard sand

Table- 4 AE mortal using FL as a part of fine aggregate

Water (g)	Cement (g)	Fine aggregate (g)	AE agent (g)
225	450	1350	0.045

Table- 5 AE mortal using FL as a part of cement

Water (g)	Cement (g)	Fine aggregate* (g)	AE agent (g)
290	450	1350	0.045

*Standard sand

3. Mortar kneading and specimens

Materials were kept in the temperature control room at 20±2℃ from the day before and kneaded using a mortar mixer. The specimen measuring □40×40×160 mm, demolded the day after the molding, was used and cured underwater at 20±2℃.

4. Results and summary

4-1 Properties of mortar using the filler as a part of fine aggregate

Substitution of FL for fine aggregate does not have influence on the flow of mortar up to 5% substitution ratio. The flow decreases if usage exceeds 10%. Kinds of fine aggregates used do not make much difference in the trend curves (Fig. 1). However, the filling rate calculated by the ratio of the specimen's density to the theoretical density zeroing the air quantity shows almost no change up to 15% substitution ratio, while the filling rate is somewhat improved up to 15% substitution ratio in the case of crushed sand. Filling rate decreases at 20% (Fig. 2).

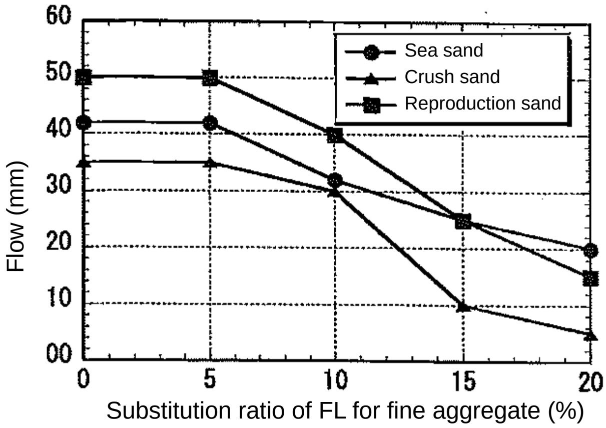

Fig. 1 Substitution ratio of FL for fine aggregate vs. mortar flow

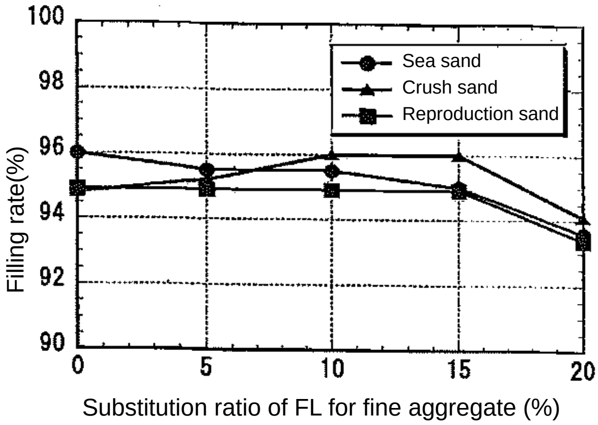

Fig. 2 Substitution ratio of FL for fine aggregate vs. mortar filling rate

Bending strength of mortar substituting FL for fine aggregate shows vertically no decrease in the strength up to 15% substitution ratio for crushes sand, and 10% for reconditioned sand. Sea sand shows a declining tendency in bending strength with the increase of substitution ratio. Interestingly, each of the fine aggregates shows the same strength at 20% substitution ratio. It is conceivable that the "weakest link theory" could be applicable (Fig. 3 and Fig. 4).

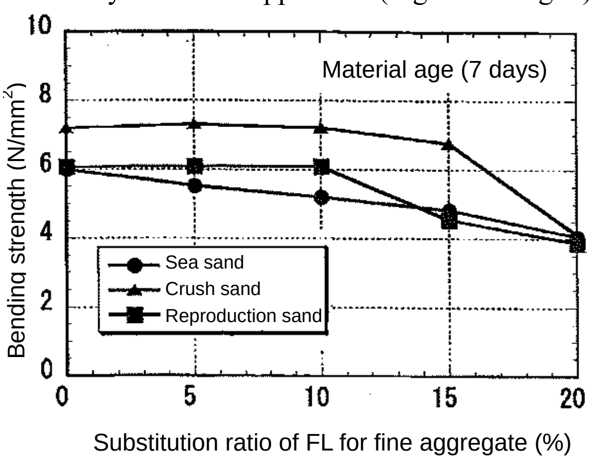

Fig. 3 Substitution ratio of FL for fine aggregate vs. bending strength (7 days)

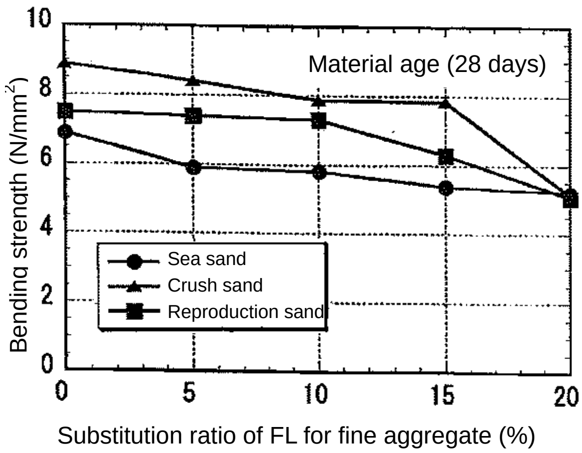

Fig. 4 Substitution ratio of FL for fine aggregate vs. bending strength (28 days)

The compression strength of the mortar substituting FL for fine aggregate does not show any change up to 10% substitution rate in any fine aggregates, but decreases when 15% is exceeded. At 20% substitution ratio, each of the fine aggregates shows almost the same strength in a way similar to the case of bending strength (Fig. 5 and Fig. 6).

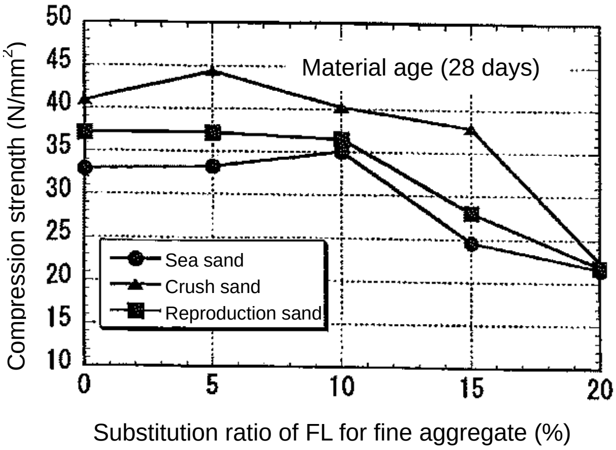

Fig. 6 Substitution ratio of FL for fine aggregate vs. compression strength (28 days)

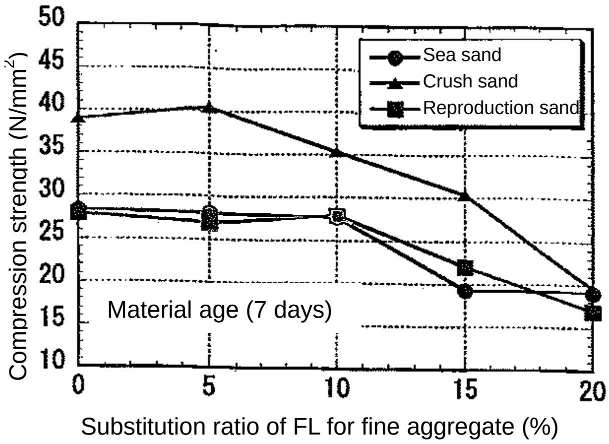

Fig. 5 Substitution ratio of FL for fine aggregate vs. compression strength (7 days)

4-2 Properties of mortar using filler as a part of cement

Substitution of FS or FSC for a part of cement is unlikely to have a significant influence on the flow and filling characteristics of mortar. However, water absorption in some degree is probable, since FS or FSC was used in a dry form (Fig. 7 and Fig. 8).

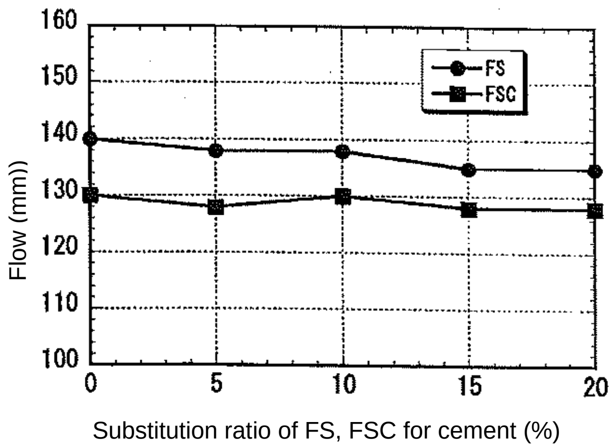

Fig. 7 Substitution ratio of FS, FSC vs. mortar flow

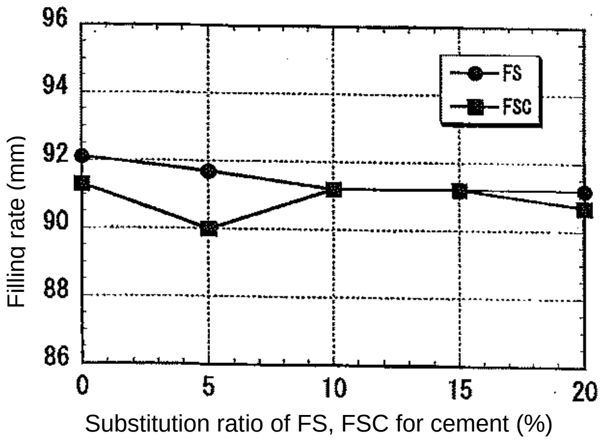

Fig.8 Substitution ratio of FS, FSC vs. mortar filling rate

Substitution of FSC for a part of cement is unlikely to have significant influence on the bending strength up to the substitution ratio not exceeding 15%. However, the strength declines drastically when 20 % is reached. On the other hand, the bending strength shows a declining tendency with the increase in substitution ratio in the case of FS (Fig. 9 and Fig. 10).

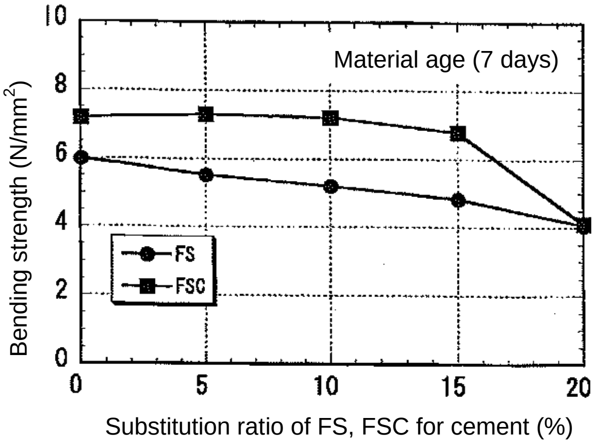

Fig. 9 Substitution ratio of FS, FSC vs. bending strength (7 days)

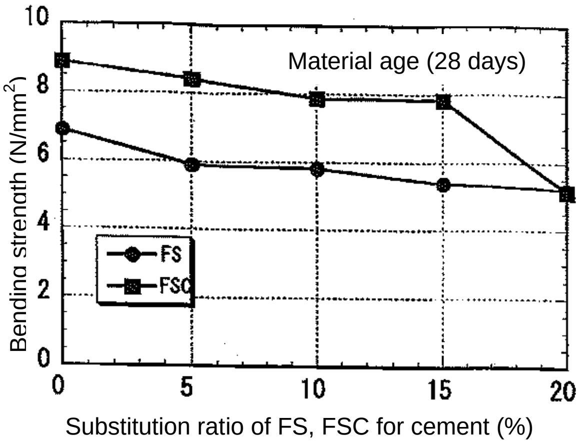

Fig. 10 Substitution ratio of FS, FSC vs. bending strength (28 days)

Substitution of FSC for a part of cement does not show a decline in the compression strength up to the limit of 5% substitution ratio, but the strength at the material age of 28 days shows a declining tendency if the limit is exceeded. The deterioration of strength is apparently insignificant in FSC under the same usage compared with that of FS (Fig. 11 and Fig. 12). The activity index calculated from the material age of 28 days marked 90 at FSC 10% and 87 at FSC 15%, which is thought indicative of the activation of unhydrated portions triggered by the re-crushing of FS (Fig. 13).

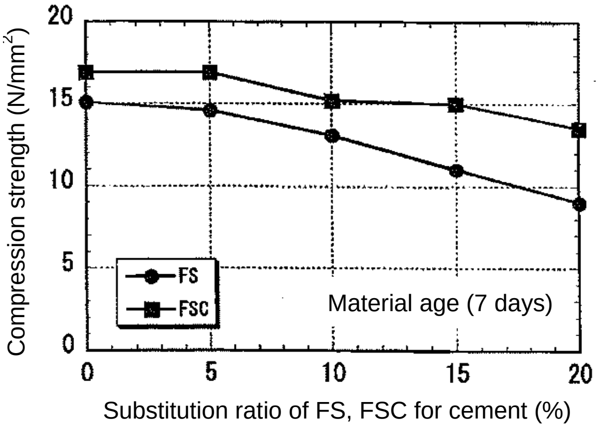

Fig. 11 Substitution ratio of FS, FSC vs. compression strength (7 days)

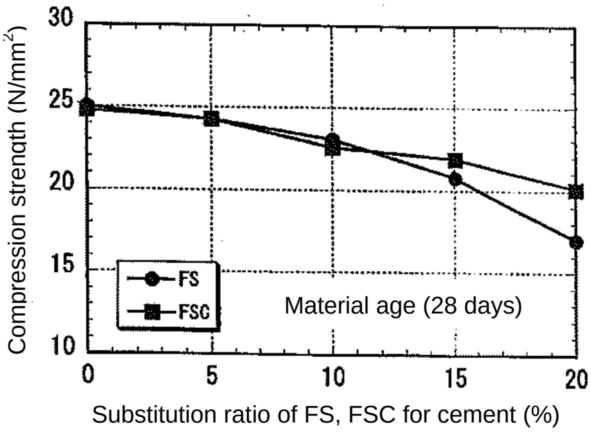

Fig. 12 Substitution ratio of FS, FSC vs. compression strength (28 days)

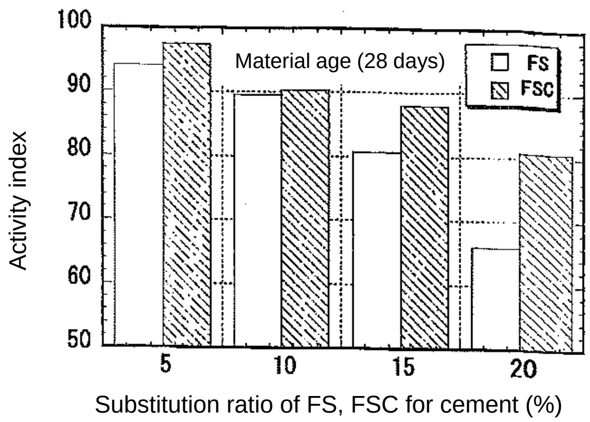

Fig. 13 Activity index of FS and FSC

4-3　Air quantity of AE mortar

Changes in the air quantity of AE mortar due to the substitution ratio of FL for fine aggregate are relatively small and almost unaffected by the substitution ratio in the case of sea sand and re-conditioned sand.　Crushed sand shows a tendency of air-entrainment resistance but the air quantity tends to increase with increase in FL substitution ratio.　On the other hand, air quantity does not show change due to the substitution of FS or FSC for cement　(Fig. 14 and Fig.15).

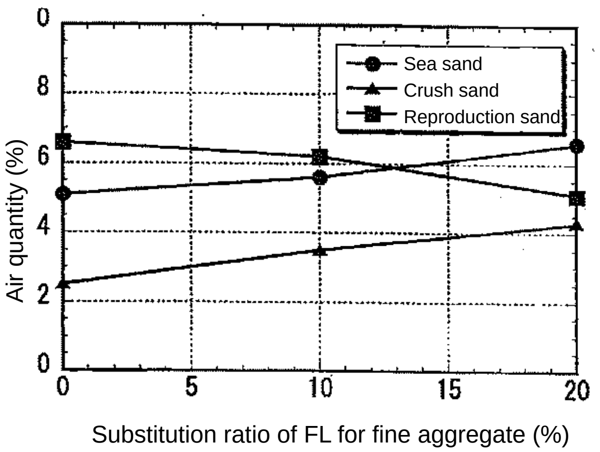

Fig. 14　Air quantity of mortar using FL as a part of fine aggregate

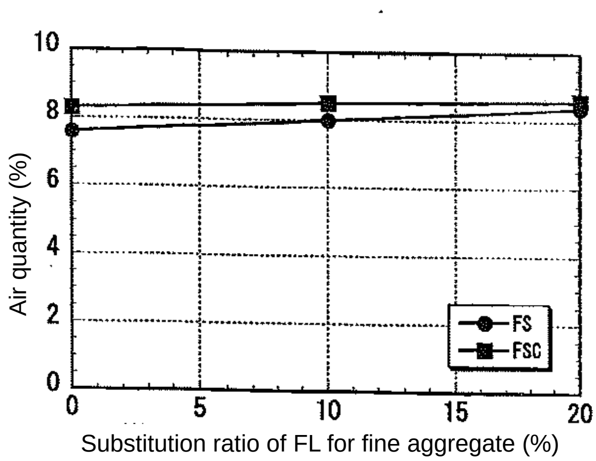

Fig. 15　Air quantity of mortar using FS and FSC as a part of cement