A Study on the Influence of the Number of Re-crushing with regard to the Physical Properties of Recycled Coarse Aggregates

再生粗骨材의 物理的 特性에 미치는 再破碎回數의 影響에 관한 硏究

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要 約

本 硏究는 現在 一般的으로 製造되고 있는 再生粗骨材를 改良型 죠오크러셔(modified-jaw crusher)를 利用하여 다시 1-3次 破碎를 행함으로써 再生骨材의 品質이 어느 정도 改良될 수 있는가를 實驗的으로 究明하여 再生骨材의 實用化를 위한 하나의 方法을 提案하고자 하는 것이다.

實驗結果, 再破碎處理를 행하지 않은 경우의 再生粗骨材의 吸水率은 5-7% 정도이나 再破碎를 함에 따라 吸水率은 현저하게 낮아져, 3차례의 再破碎를 행한 경우 吸水率이 2% 以內로 나타나 再生粗骨材의 品質을 確保하기 위하여는 再破碎가 매우 有用한 方法임을 알 수 있었다. 또한 吸水率의 分布도 처음에는 2個의 範疇를 가지고 넓게 散布하게 되나 再破碎가 進行될 수록 再生粗骨材중에 付着되어 있던 모르타粉이 점차 떨어져 나감에 따라 品質의 散布가 상당히 낮아지는 結果를 얻었다. 그러나 이와같은 再破碎에는 많은 經濟的 負擔이 發生하게 되므로 骨材의 品質과 經濟的 效率을 考慮하여 適正한 再破碎回數가 決定되어야 할 것으로 思料된다.

1. INTRODUCTION

In general, when old concrete is crushed, a certain amount of mortar or cement paste from the original concrete remains attached to stone particles in recycled aggregates.

However, it is possible to improve the quality of recycled coarse aggregates in accordance with the removal of that mortar or cement paste by repetition of re-crushing.

The purpose of this study is to demonstrate the supposition that several re-crushings are available to improve the physical properties of recycled coarse aggregates.

2. TEST PROGRAM AND METHOD

The recycled coarse aggregates tested in this study were produced from recycling plants for construction waste in Japan. The process of re-crushing in that plant is illustrated in the flow diagram which is shown in fig.1.

The types of recycled coarse aggregates and measure items are shown in table 1.

Table 1. Types of aggregates and measure items

Division	Symbols of agg.	Production area of agg.	Size of agg.	Measure items
Series K	K0, K1 K2, K3	Kitaaoi Mt. in Tokyo	10-20 mm	· Surface dry specific gravity · Oven dry specific gravity · Percentage of water absorption
Series F	F0, F1 F2, F3	Huchyu in Tokyo	5-10 mm	

Note) Symbols of agg. are classified according to re-crushing times. (K0 and F0 are conventional recycled aggregates)

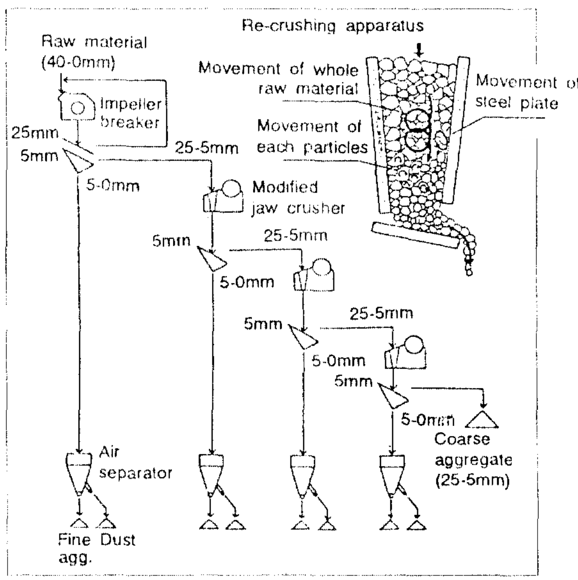

Fig.1 Re-crushing process of recycled aggregates

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Note) This study was carried out at Building Research Institute in Japan in the period of Winter Institute(95.1.10-2.24)

Each of the sample ores of recycled coarse aggregates, which were produced by crushing of original concrete having a compressive design strength of 180 kgf/㎠, were selected 25 particles by a random sampling method respectively.

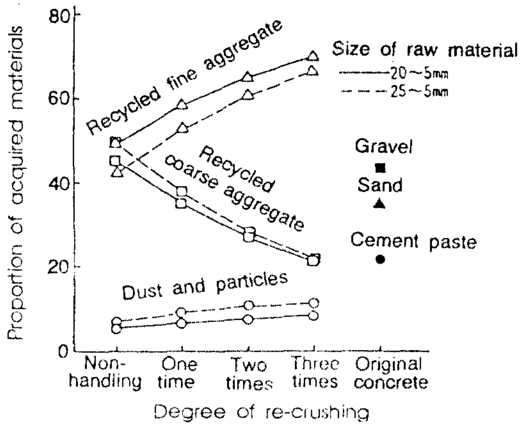
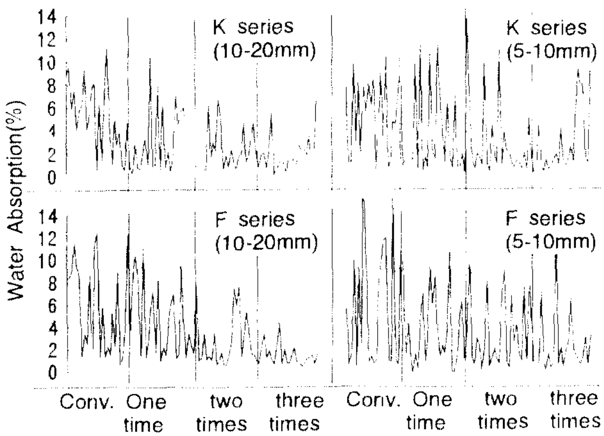


Fig.2 Distribution ratios of each materials obtained according to the degree of re crushing[1]



* Sample ores measured is 25 in each degree respectively

Fig. 3 Distribution of Water absorption by types of aggregates and re crushing times

Fundamental physical properties of recycled aggregates, which were surface dry specific gravities and water absorption ratios of aggregates, were examined in conformity to JIS A 1110.

3. RESULTS AND DISCUSSION

First of all, fig.2 shows the amount of obtained coarse aggregates decreases in proportion to reiteration of re-crushing times. Like this, the decrease in the amount of coarse aggregates led to a debatable problem without regard to improvement in the quality of recycled coarse aggregates.

The test results in this study are summarized in table 2 which also include the test results on the natural river gravels and crushed stones for comparison.

Table 2 shows water absorption ratios and specific gravities tested with the two series of recycled coarse aggregates. And the aggregates are divided into conventional recycled aggregates (K0, F0) and re-crushed aggregates (K1-K3, F1-F3) which were breaked up one time, two times and three times by a modified jaw crusher.

Firstly, the average of specific gravities in recycled coarse aggregates which were re-crushed by one time, two times, and three times in surface dry condition ranged from 2.46 to 2.63 for 5-10mm materials and from 2.53 to 2.63 for 10-20mm materials, see table 2. On the other hand the corresponding average of specific gravities of conventional recycled coarse aggregates ranged from 2.43 to 2.47 for 5-10mm materials and from 2.40 to 2.41 for 10-20mm materials.

The rate of increase in specific gravity between conventional recycled aggregates and re-crushed

Table 2. Test results on the physical properties of recycled coarse aggregates

Measure Items	Size of coarse agg.	Division	Series K of recycled agg.				Series F of recycled agg.				River gravel	Crush-ed stone
			K0	K1	K2	K3	F0	F1	F2	F3		
Specific gravity in surface dried condition	10-20 mm	Average	2.430	2.540	2.579	2.632	2.468	2.529	2.582	2.554	2.525	2.650
		Std. Dev.	0.160	0.156	0.101	0.112	0.142	0.164	0.118	0.133	0.104	0.016
	5-10 mm	Average	2.398	2.463	2.591	2.625	2.409	2.508	2.519	2.543	2.505	2.622
		Std. Dev.	0.237	0.147	0.156	0.064	0.217	0.155	0.163	0.142	0.130	0.021
The Ratio of Water absorption (%)	10-20 mm	Average	5.309	2.922	2.488	1.874	4.067	3.192	2.044	2.251	3.231	0.526
		Std. Dev.	2.950	2.805	1.919	1.573	2.583	3.340	2.175	2.273	1.768	0.093
	5-10 mm	Average	5.723	4.579	2.689	1.394	6.010	3.801	3.649	2.654	3.394	0.681
		Std. Dev.	4.061	3.289	2.294	0.925	5.223	2.903	3.130	2.645	2.093	0.213

aggregates was 3.5% for once re-crushing, 5.8% for twice re-crushing, and 6.7% for thrice re-crushing on an average.

The specific gravities of crushed stones, however, varied between 2.6 and 2.7, and the specific gravities of corresponding natural river gravels ranged from 2.3 to 2.7.

It may be concluded that the specific gravities of recycled coarse aggregates are somewhat lower than the specific gravities of crushed stones and natural river gravels due to a relatively low density of the old mortar which is attached to original aggregate particles.

On the other hand from a relation between the percentage of water absorption and re-crushing times, it was found that water absorption was far more improved in comparison with the results obtained in specific gravity from the point of view of a increase rate.

Especially, in case of re-crushed state by three times, the water absorptions in recycled coarse aggregates were considerably improved. The water absorptions were distributed around 2% for 10-20 mm particles. Corresponding water absorptions for 5-10mm particles ranged from 1.4% to 2.7% on an average, see table 2.

Then the water absorptions were around 5% for 10-20mm recycled coarse aggregates which were not re-crushed by a modified-jaw crusher, independent of the quality of original waste concretes. Corresponding water absorptions for 5-10mm recycled coarse aggregates were around 6%.

Therefore the water absorption of recycled aggregate which is re-crushed results in by far lower than that of not re-crushed aggregates. This is because the old particles of mortar or cement paste attached to aggregates were broken off in proportion to the reiteration of re-crushing times.

According to 'the japanese standard for the use of recycled aggregate and recycled aggregate concrete, recycled aggregate should not be used for concrete production when water absorption is more than 7% for coarse aggregate and more than 13% for fine aggregate.

It would appear from what is said above that most recycled aggregates would meet such requirements.

However, in fig.4 is shown the distribution of water absorption ratios by type of the recycled coarse aggregates.

When recycled coarse aggregates are not re-crushed by a modified-jaw crusher, the water absorptions in coarse aggregates are approximately dispersed two scopes. This depends upon whether mortar or cement paste is attached to recycled coarse aggregates or not. But the dispersion of water absorptions in recycled coarse aggregates is dwindled in proportion to the addition of re-crushing frequency.

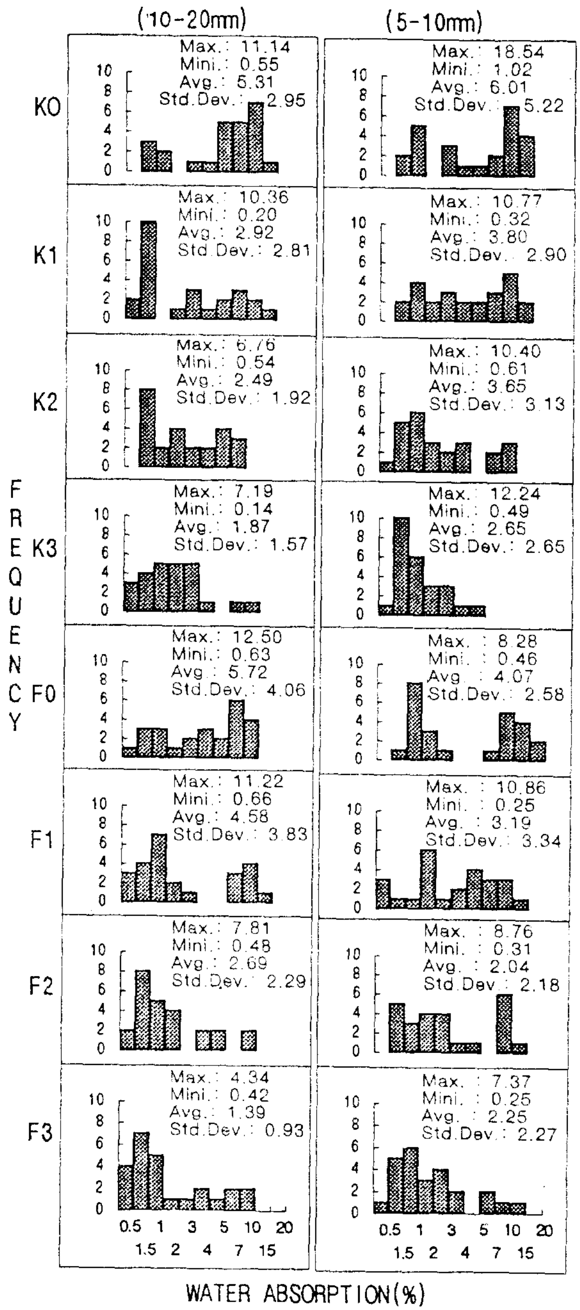


Fig. 4 Histogram of water absorptions by types of recycled aggregates

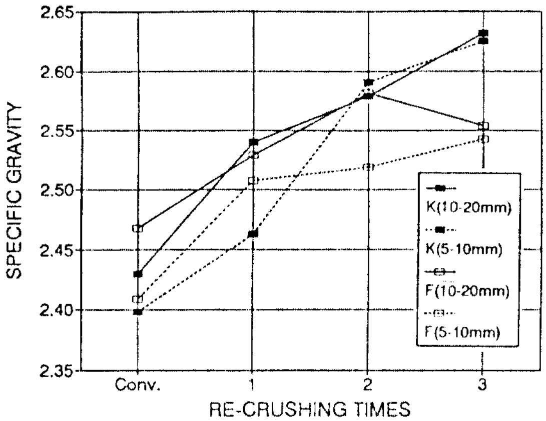


Fig.5 Relationship between Specific gravities and re crushing times

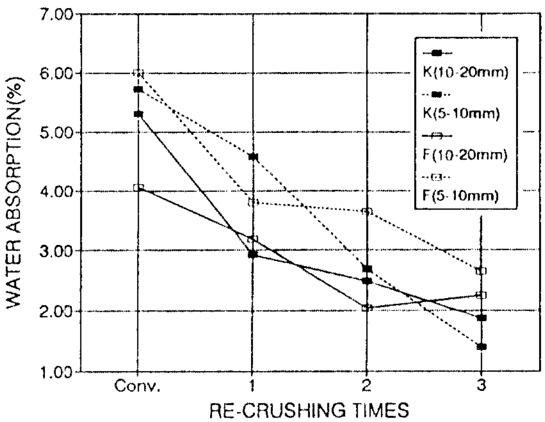


Fig.6 Relationship between water absorptions and re crushing times

Table 3. Comparison ratios of physical properties by repetition of re crushing

Physical property	Seri-es	Size of agg(㎜)	Re-crushing times 0	1	2	3
Specific gravity	K	10-20	100	104.5	106.1	108.3
		5-10	100	102.7	108.1	109.5
	F	10-20	100	102.5	104.6	103.5
		5-10	100	104.1	104.6	105.6
	aver-age	10-20	100	103.5	105.4	105.9
		5-10	100	103.4	106.4	107.6
Ratio of water absorp-tion	K	10-20	100	55.0	46.7	35.3
		5-10	100	88.0	47.0	24.4
	F	10-20	100	77.9	50.3	55.3
		5-10	100	63.2	60.7	44.2
	aver-age	10-20	100	66.5	48.5	45.3
		5-10	100	75.6	53.9	34.3

And according to table 3, comparative decrease ratios in water absorption between conventional state and thrice re-crushed state was 65.7% for 5-10mm aggregates and 54.7% for 10-20mm aggregates. That is, the decrease in absorptions of 5-10mm aggregates results in larger variations than that of 10-20mm aggregates. This is probably bacause 5-10mm aggregates retained more old mortar or cement paste particles.

Also the degree of increase in quality for each test, as determined in both specific gravity and water absorption ratio, tended to be weakened in accordance with the reiteration of re-crushing times. Especially, in the side of the degree of quality improvement in each re-crushing step, when those were re-crushed by one time the variation ratios in the specific gravities and water absorptions of recycled aggregates are substantially greater than those were re-crushed by two times or three times.

4. CONCLUSIONS

The results of this study are summerized as follows;

1) The physical properties, that is, water absorptions and specific gravities, of recycled coarse aggregates are significantly affected by the reiteration of re-crushing times. Therefore in order to obtain recycled aggregates in high quality, several re-crushings are positively necessary.

2) In the side of the size of aggregate, it may be concluded that the improvement in physical properties of 5-10mm aggregates is somewhat higher than those of 10-20mm aggregates

3) In advance, it is possible to apply recycled coarse aggregates for structural materials considering that water absorptions are decreased around 30% and specific gravities are increased around 3.5% in case of one time re-crushing.

4) In an economic point of view, it is nearly impossible to re-crush and rehandle the recycled aggregates over and over again. Accordingly it is important that the number of re-crushing times has to be determined taken into account the economical efficiency. From this study twice re-crushings were probably most efficient not only in the side of quality but in the side of economical efficiency.

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