J. of Korean Inst. of Resources Recycling
Vol. 16, No. 5, 2007, 13-18

≫ 研究論文 ≪

폐콘크리트에서 重液選別을 이용한 再生骨材의 選別†

李明奎 · 權基五 · 간빌렉 · ✝姜憲贊

東亞大學校 資源工學科

Separation of Recycled Aggregates from Waste Concrete by Heavy Medium Separation†

Myung-Gyu Lee, Ki-O Kwon, Ganbileg Gayabazar and ✝Heon-Chan Kang

Department of Resources Engineering, Dong-A University

요 약

폐콘크리트를 재활용하기 위하여 파쇄과정과 입도조절과정을 거쳐서 생산된 재생골재에는 모르타르나 시멘트페이스트가 많이 부착되어 있어 밀도가 낮고 흡수율이 높아 구조용 골재로 사용할 수 없는 실정이다. 그러나 생산된 재생골재 내에는 많은 양의 콘크리트용 재생골재가 포함되어 있으며 이들을 비중선별방법 중 중액선별을 통해 선별하여 콘크리트용 1종 재생골재를 약 45%정도를 생산할 수 있었다.

주제어 : 재생골재, 중액선별, 현탁액

Abstract

The recycled aggregates produced from waste concrete by crushing and granularity adjusting processes only can't be used for structural aggregates because they display low density and high abrasion rate by including lots of mortar and cement paste. However, the recycled aggregates include a lot of aggregates for concrete. Using the heavy medium separation method that is one of the specific gravity separation methods, about 45% of the waste concrete could be converted to the recycled aggregates.

Key words : recycled aggregates, heavy medium separation, suspension

1. Introduction

Due to the supply shortage of aggregates as a result of the exhaustion of natural aggregates, the recycled aggregates have become famous as the alternative.[1] But most of the recycled aggregates produced from waste concrete by crushing and granularity adjusting processes are inferior to the natural aggregates, because the recycled aggregates have lots of mortar and cement paste.[1,2] Thus they have rarely been used for concrete and have only been used as low-grade materials for filing purposes.

But the recycled aggregates for concrete that hold the least amount of mortar is mixed in produced recycled aggregates.[2,3] If they can be separated, recycled aggregates containing small amounts of mortar can be used for concrete and the rest of low grade recycled aggregates (excluding aggregates qualified for concrete) can be used for filling purpose, or for concrete after heat and abrasion treatments.

So this study was progressed about the separation method of recycled aggregates from waste concrete with minimum quantity of sludge discharging and saving energy.

† 2007년 8월 3일 접수, 2007년 10월 8일 수리
✝ E-mail: hckang@daunet.donga.ac.kr

2. Materials and Method of Experiments

2.1. Materials for Experiment

40 mm and 25 mm recycled aggregates from company S was used in this study.

Tetrabromoethane having a specific gravity of 2.96 and suspension(using Fe_3O_4 which has a specific gravity of 4.8) were used for heavy medium separation.

2.2. Method of Experiment

In order to understand the physical properties of 40 mm and 25 mm recycled aggregates produced by crushing and granularity adjusting processes, density and absorption rate were measured according to KS F 2503 (Testing Method for Density and Absorption of Coarse Aggregates - Korean Industrial Standards). Afterwards, heavy medium separation was tested by using tetrabromoethane. And based on the test result, our own heavy medium separation system was built.

Also the effect of heavy medium separation in changing of specific gravity of suspension was studied by measuring the physical property of recycled aggregates separated when specific gravity of suspension was lowered to ranges 2.65 and 2.40 at intervals of 0.05.

3. Result and Investigation

3.1. Characteristics of Recycled Aggregates

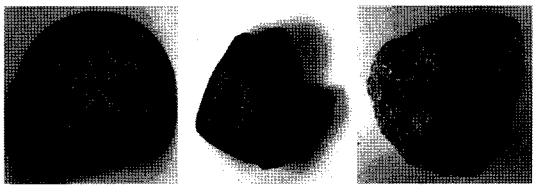
Due to the prevention of natural environmental destruction and the opposition of aggregates gathering by the residents in the area, gathering of natural aggregates has become increasingly difficult. So the phenomenon of serious supply shortage has occurred and the recycled aggregates will be used for the substitution of natural aggregates.

However the recycled aggregates which is produced by several stages of crushing, removing of foreign substances and granularity adjusting processes have low density and high absorption rate because of mortar and cement paste. Thus it can rarely be used for material of concrete and can only be used for filling material.

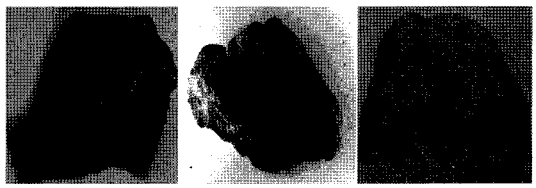
However, as shown in Fig. 1, several aggregates that hold mortar in the range of nearly 0% to nearly 100% are mixed in recycled aggregates before separation. Therefore the recycled aggregates were classified by naked eyes and measured the density and the absorption rate by KS F 2503 then the result was displayed in table 1.

Table 1 shows the measured density and absorption rate of 40 mm and 25 mm aggregates from company S. The samples were numbered from 1 to 9 according to the mortar quantity.

The absolute-dry density and absorption rate of 40



a) Mortar 0% (natural aggregate) b) Mortar 50% c)Waste cement brick



d) Mortar 0% (crushed aggregate) e) Mortar 50% f) Mortar 100%

Fig. 1. Classification of recycled aggregates by the mortar content.

Table 1. Density and absorption rate of classified recycled aggregates by the mortar content

	Surface-dry density (g/cm^3)	Absolute-dry density (g/cm^3)	Real density (g/cm^3)	absorption rate (%)
Total	2.37	2.21	2.62	6.90
1	2.69	2.64	2.79	2.05
2	2.63	2.57	2.74	2.37
3	2.62	2.56	2.74	2.60
4	2.59	2.50	2.73	3.27
5	2.53	2.43	2.70	4.21
6	2.48	2.35	2.69	5.35
7	2.43	2.29	2.65	5.88
8	2.32	2.14	2.60	8.24
9	2.16	1.98	2.42	9.26

mm and 25 mm aggregates yield 2.21 g/cm^3 and 6.90 % before separation. These characteristics do not satisfy with Korean recycled aggregates for concrete and JASS 5 regulation Grade 1 which are more than 2.5 g/cm^3 in absolute-dry density and less than 3% in absorption rate. Also they do not satisfy with Grade 3 standard of recycled aggregates which are more than 2.2 g/cm^3 in absolute-dry density and less than 7.00% in absorption rate. Thus they are proved to be unsuitable low-grade recycled aggregates for concrete.

However, as shown in Table 1, it was confirmed that after separation, three samples from No. 1 to No. 3 comply with Grade 1 standard (more than 2.5 g/cm^3 in absolute-dry density and less than 3% in absorption rate) and two samples numbered 4 and 5 satisfy Grade 2 standard (more than 2.2 g/cm^3 in absolute-dry density and less than 5% in absorption rate) while No. 6 and 7 samples are within Grade 3 standard (more than 2.2 g/cm^3 in absolute-dry density and less than 7% in absorption rate).

And it is confirmed that the increase of mortar content in aggregates causes to decrease density and to increase absorption rate.

3.2. Specific Gravity Separation

3.2.1 Heavy Medium Separation

The recycled aggregates which are produced by several stages of general crushing, removing of foreign substances and granularity adjusting processes have a lot of mortar and cement paste and are proved to be inferior to natural aggregates. However, it is different by the crusher type and crushing process, but they have lots of recycled aggregates for concrete. Thus in order to separate recycled aggregates for concrete, we have applied heavy medium separation in the specific gravity separation.

First of all, the recycled aggregates were separated by the mortar and cement paste with the naked eye as Table 1, Fig. 2 shows the change in density due to the increasing mortar content.

Generally the increase of mortar and cement paste causes the decrease in density and the increase in absorption rate in recycled aggregates as shown in Fig. 2. So the possibility of separation was confirmed by heavy medium separation in specific gravity separation which is the difference of density, increasing the

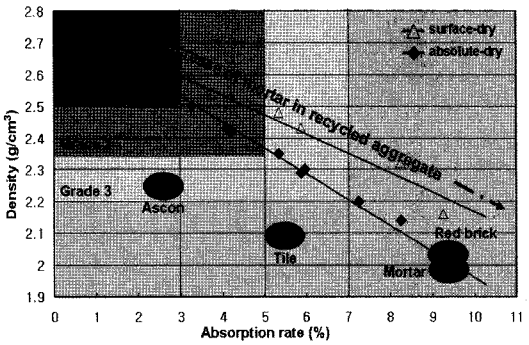
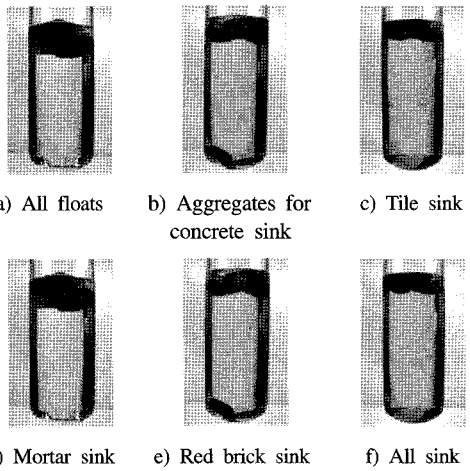


Fig. 2. Change in density due to the changing mortar content on recycled aggregates.



a) All floats b) Aggregates for concrete sink c) Tile sink

d) Mortar sink e) Red brick sink f) All sink

Fig. 3. Separation experiment of recycled aggregate for concrete, mortar, red brick, ascon and tile.

mortar content.

Fig. 3 shows the movement of aggregates when tetrabromoethane in the test tube contained recycled aggregates for concrete, red brick, ascon and tile is diluted with methyl alcohol.

As shown in Fig. 3, recycled aggregates for concrete sank to the bottom of a test tube when specific gravity was changed from 2.96 to 2.50. And tile(2.30), mortar(2.25), red brick(2.20) and ascon(2.10) were continued to sink in order of specific gravity.

So it was confirmed that only recycled aggregates for concrete can be separated by sinking them and floating the other things, using heavy medium separation which has a specific gravity of 2.5.

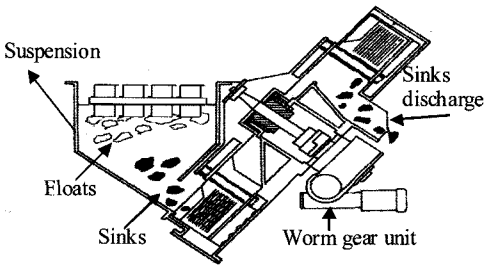


Fig. 4. The construction of heavy medium separation device.

3.2.2. Heavy Medium Separation Using Suspension

The possibility of separating the recycled aggregates for concrete by using heavy medium separation is proved in previous experiment. But if tetrabromoethane which is expensive is used by heavy medium separation in the field, it can depreciate economical efficiency. Therefore study was executed with the heavy medium separation using suspension which is able to apply in the field.

The experiment was executed with the heavy medium separation using suspension, changing specific gravity with Fe_3O_4 which has a specific gravity of 4.8 and water, in the heavy medium separation device as shown in Fig 4.

When specific gravity of suspension is diluted to ranges 2.65 and 2.40 at intervals of 0.05, the 40 mm and 25 mm recycled aggregates 100kg per unit whose absolute-dry density and absorption rate are 2.21 g/cm^3 and 6.90% from company S are separated into floating aggregates on the suspension and sinking aggregates under the suspension. Absolute-dry density, absorption rate, solid volume percentage and abrasion rate in property of separated aggregates were measured by KS(Korean Industrial Standards) and sinking rate of aggregates was confirmed.

Even if the specific gravity of suspension is lowered to 2.40, the sinking aggregates from Fig. 5 and Fig. 6 satisfy the standard of the recycled aggregate for concrete(more than 2.5 g/cm^3 in absolute-dry density and less than 3% in absorption rate), proving to be high quality. On the other hand, the floating aggregates show tendency to decrease density and to increase absorption rate when specific gravity of suspension is lowered continually.

The change of abrasion rate as a result of the

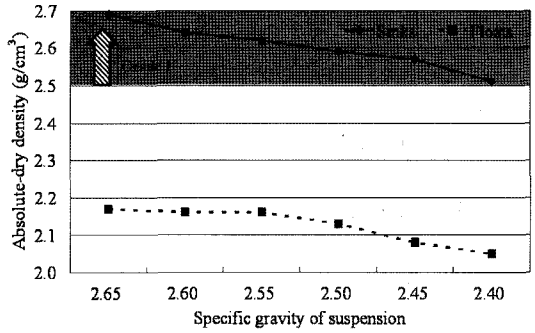


Fig. 5. Change in absolute-dry density as a result of the changing specific gravity of suspension.

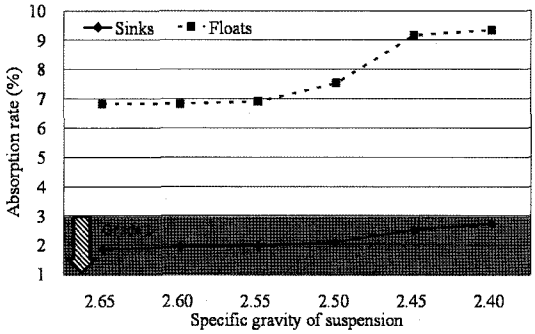


Fig. 6. Change in absorption rate as a result of the changing specific gravity of suspension.

changing specific gravity of suspension was measured according to KS F 2508(Method of Test for Abrasion of Coarse Aggregates by Use of The Los Angeles Machine). And the results are shown in Fig. 7.

The standards of recycled aggregates for concrete regulate less than 40% in abrasion rate. The sinking aggregates in Fig. 7 display 20.4% in abrasion rate even with the lowest specific gravity such as 2.40. But the floating aggregates tend to increase in abrasion rate from 40.3% to 47.5%.

Until now, when specific gravity of suspension is diluted to ranges 2.65 and 2.40 at intervals of 0.05, the sinking aggregates have satisfied with all of the property in the standard of recycled aggregates for concrete: absolute-dry density, absorption rate, abrasion rate.

Meanwhile, the quantity of sinking aggregates was measured when specific gravity of suspension is diluted to ranges 2.65 and 2.40, due to certify the quantity of sinking aggregates which is separated

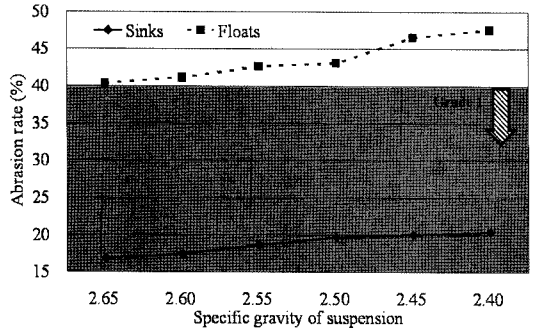


Fig. 7. Change of wear rate as a result of the changing specific gravity of suspension.

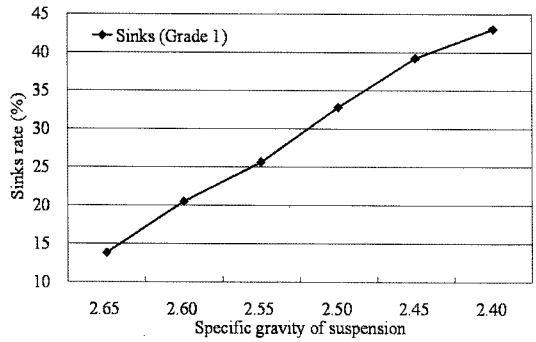


Fig. 8. Change in quantity of sinking aggregates as a result of the changing specific gravity of suspension.

with heavy medium separation system.

Fig. 8 shows the change of sinking rate as a result of the changing specific gravity of suspension. It shows 13.84% of sinking rate with specific gravity of 2.65 in the beginning and shows 43.07% of sinking rate with specific gravity of 2.40. The quantity of sinking aggregates increase as specific gravity of suspension is lowered.

Based on the generalization of the above outcome, it is estimated that recycled aggregates, satisfying with the standard of recycled aggregates for concrete(Grade 1), can be separated 43% from 40 mm and 25 mm recycled aggregates. In case of floating aggregates not mentioned, they can use for road construction, due to satisfying the Grade 2 of standard.

4. Conclusion

As a result of using heavy medium separation method to separate the recycled aggregates for concrete from the low grade recycled aggregates which have lots of mortar and cement paste, the following conclusion can be drawn:

(1) Several aggregates that hold mortar in the range of nearly 0% to nearly 100% are mixed with recycled aggregates before separation. And it is confirmed that the increase of mortar content in aggregates causes to decrease density and to increase absorption rate.

(2) It is confirmed that only recycled aggregates for concrete can be separated by sinking them and floating the other things(tile, red brick, mortar and ascon), using heavy medium separation whose specific gravity is about 2.50.

(3) The sinking aggregates tend to decrease density and to increase absorption rate when specific gravity of suspension is lowered from 2.65 to 2.40. But the every sinking aggregate satisfy with the standard of recycled aggregates for concrete.

(4) When the specific gravity of suspension is lowered from 2.65 to 2.40, the sinking aggregates display below 20% of wear rate, therefore satisfying the standard of recycled aggregates for concrete.

(5) When the specific gravity of suspension is lowered from 2.65 to 2.40, the separated sinking aggregates tend to increase quantity and when the specific gravity of suspension is 2.40, approximately 43% of recycled aggregates can be separated for Grade 1 recycled aggregates for concrete.

References

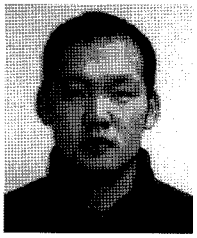
1. Sea-Hyun Lee, 2001: 재생골재의 재활용 활성화 방안, Journal of Korean Society of Road Engineers 3(1), pp. 93-102.
2. Kyoung-Rok Kong, Sung-Yul An, Heon-Chan Kang, 2004: The Characteristic Study by Particle size and Distribution of Recycled Aggregates, Proceedings of The Korean Institute of Resources Recycling 23, pp.133-137.
3. Kyoung-Rok Kong, Heon-Chan Kang, 2004: A Study on Application of Recycled Aggregate for Concrete, 東亞大學校 附設 環境問題硏究所 硏究報告 第26卷 pp.1-9.

李 明 奎

• 동아대학교 자원공학과 석사과정

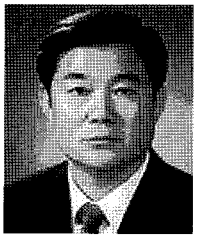
權 基 五

• 동아대학교 자원공학과 석사과정



간 빌 렉

• 동아대학교 자원공학과 박사과정



姜 憲 贊

• 동아대학교 자원공학과 교수