Use of Construction Wastes to Produce Recycling Aggregate through Cold-bonding Technique

Chih Ta Tsai
Assistant Research Fellow
SERC, NCKU
Tainan, Taiwan
chihta.tsai@gmail.com

Chih Ta Tsai, born 1973, received his civil engineering degree from National Taiwan University of Science and Technology, R.O.C.

Chien Chih Chang
Research Assistant
SERC, NCKU
Tainan, Taiwan
celebrate9@gmail.com

Chien Chih Chang, born 1979, received his civil engineering degree from National Taiwan University of Science and Technology, R.O.C.

Gordon Tung Chin Kung
Assistant Research Fellow
SERC, NCKU
Tainan, Taiwan
tckung@mail.ncku.edu.tw

Gordon Tung Chin Kung, born 1973, received his civil engineering degree from National Taiwan University of Science and Technology, R.O.C.

Juu En Chang
Professor & Acting Director
SERC, NCKU
Tainan, Taiwan
juuen@mail.ncku.edu.tw

Juu En Chang, born 1951, received his civil and environmental engineering degree from Tohoku University, Japan.

Summary

This study employs construction wastes as the main materials to develop the recycling aggregate, which meets the specifications of green building materials, using the cold-bonding technique instead of sintering method in light of the issues of reduction of waste, energy, and CO_2 footprint. Specifically, the cold-bonding technique incorporates the principles of the cement chemistry and composite material to develop the recycling aggregate. The results show that the specific gravity of cold-bonding recycling aggregate is in the range of 1.73 to 1.81; the absorption capacity is 14.9 to 16.7%; the bulk density (unit weight) is 1103 to 1176 kg/m^3; the voids is 35.0 to 36.6%; the particle cylindrical crushing strength ranges is 12.09 to 19.36 MPa. The developed cold-bonding recycling aggregate could increase the reuse and recycling of construction wastes, reduce the energy consumption and CO_2 footprint, and diminish the impact on the environment and future generations.

Keywords: aggregate; recycling resource; construction wastes; green building materials; cold bonding technique.

Table 1: Categories of construction wastes in Taiwan

Code	Properties of construction wastes
B1	Rocks, gravels, crushed rocks, or sand
B2-1	Blended soil, gravels, and sand (soil <30 % by vol.)
B2-2	Blended soil, gravels, and sand (30 %<soil<50 % by vol.)
B2-3	Blended soil, gravels, and sand (soil>50 % by vol.)
B3	Silt
B4	Clay
B5	Brick and concrete blocks
B6	Sediment or soil contains >30% moisture by wt.
B7	Bentonite from continuous walls construction

The attention of shortage of the primitive aggregate has been received in Taiwan. In the recent years, the requirement of the primitive aggregate in Taiwan depends heavily upon the supply from other countries, in which approximate 40% of requirement of the primitive aggregate in Taiwan every year comes from mainland China. Although the natural resource in Taiwan is rather lack, the recycling resource is quite plentiful (e.g., construction wastes and reservoir sediments). According to the evaluation by the Construction and Planning Agency Ministry of the Interior,

https://doi.org/10.2749/222137809796088710
Distributed by structurae

R.O.C., the construction wastes of about 40 millions m^3 is generated every year. The construction wastes are generally sorted as 10 categories (i.e. B1 to B7) as shown in Table 1, in which the reuse rate of B2-3, B3, B4, B6, and B7 categories is extremely low due to their poor properties.Based on the purposes of green building materials (reduction of waste and CO_2 footprint, energy conservation, lightening of material, and so on) and in the committeemen of the Kyoto Protocol for reducing the Green House Gas (e.g., CO_2), it is a critical issue for building and construction department to treat the construction waste properly and encourage the recycling of construction resources. In this study employs the cold bonding method, which incorporates the principles of the cement chemistry and composite material, instead of the conventional sintering method to develop the recycling aggregates using the above-mentioned construction wastes.

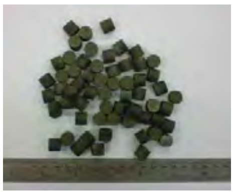
Table 2: Mixture of cold-bonding recycling aggregate, kg/m^3

w/cm	Cement	Slag	Fly ash	Construction wastes	Glass fiber	SP+ Water
0.20	200	20	280	1388 (B2-3)	39.4	100
0.20	200	20	280	1309 (B3)	39.4	100
0.20	200	20	280	1272 (B4)	39.4	100

The mixture proportions of cement-based composites for producing the cold-bonding recycling aggregates were designed by DMDA in this study as shown in Table 2.The water-to-c ementitious ratio mixture proportion is 0.2 and 2.0% by volume glass fibers were added.
The immediately squeeze out method cannot be adopted to form the cold-bonding recycling aggregates. Finally the press ingot method was developed and successfully formed the cold-bonding recycling aggregates as shown in Fig. 1.

D=24 mm

D=18 mm



D=12 mm

D=8 mm

D=5 mm

Fig. 1: Recycling cold-bonding aggregates

The specific gravity of cold-bonding recycling aggregate is in the range of 1.73 to 1.81; the absorption capacity is 14.9 to 16.7%; the bulk density (unit weight) is 1103 to 1176 kg/m^3; the voids is 35.o to 36.6%; the particle cylindrical crushing strength ranges is 12.09 to 19.36 MPa as shown in Table 3. Although the properties of the cold-bonding recycling aggregates with three various construction wastes are is not much different, the cold-bonding recycling aggregate with B2-3 construction waste has better performance. The properties of B2-3 construction waste are belong to sand, but the B3 and B4 construction wastes are belong to silt and clay, respectively.

Table 3: Properties of cold-bonding recycling aggregates

Property		Construction wastes B2-3	B3	B4
Specific gravity (OD)		1.81	1.73	1.80
Specific gravity (SSD)		2.08	2.02	2.08
Absorption (%)		14.9	16.7	15.5
Unit weight (kg/m^3)	D_{max}=25 mm	1176	1103	1141
	D_{max}=19 mm	1172	1114	1158
Voids (%)	D_{max}=25 mm	35.0	36.3	36.6
	D_{max}=19 mm	35.3	35.6	35.7
Particle cylindrical crushing strength (MPa)	D_{max}=25 mm	19.36	12.09	14.54
	D_{max}=19 mm	18.51	12.56	14.92

The recycling aggregate produced by using cold-bonding technique can reduce about 65% CO_2 footprint than using sintering technique. The prime cost of sintering recycling aggregate is 4 to 5 times higher than cold-bonding recycling aggregate. Even if the prime cost of cold-bonding recycling aggregate is lower than the primitive aggregate in Taiwan. The article cylindrical crushing strength of cold-bonding recycling aggregate is 2 times higher than sintering recycling aggregate.