Comprehensive utilization study of waste red brick in urban reconstruction

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Abstract. With the progress of the society and the promotion of "three old reconstruction", the output of waste red brick and other construction wastes increases year by year. If not used properly, waste red brick will produce potential harm. For solid waste, the treatment principle is "three": reduction, harmless and resources. Waste red brick is a spatial-temporal displacement of resources, with a wide range of applications, listed as follows: production of building materials, recovery or utilization of the useful components, road and dam, production of agricultural fertilizer and soil improvement, goaf backfill, soil reclamation, and in daily life reuse, etc. The chemical composition of waste red brick includes SiO$_2$, Al$_2$O$_3$ and various other metal oxides. Because of the composition of SiO$_2$ and various metal oxides, waste red brick has been widely used.

1. Introduction
Promoting the construction of the Guangdong-hong Kong-macao greater bay area is a new measure to promote the formation of a new pattern of all-round opening-up in the new era. In February 2019, the CPC central committee and the state council issued the "outline of development plan for the Guangdong-hong Kong-macao greater bay area" [1]. In September, the Guangdong provincial people's government issued the "guiding opinions of the Guangdong provincial people's government on deepening reform and accelerating the upgrading of the" three old "areas to promote high-quality development", making breakthroughs in the upgrading of the "three old areas". With the acceleration of the urbanization process in the greater bay area and the promotion of the renovation of old towns, old factories and old villages, a large amount of construction waste needs to be dealt with urgently [2]. In recent years, our country construction wastes such as waste red brick production increased year by year. According to statistics, by the end of 2016, our country building waste production amount is about 2.4 billion tons of [3], a large number of construction wastes not only occupy the land resources, but also potentially dangerous [4-5], so the construction waste recycling has been the focus of many studies. Construction waste resource utilization way can be divided for sorting and general backfilling, as the basis of building and road materials, reduction of cement and asphalt, [6], and give priority to with buildings and road base material. However, since the product performance cannot be compared with the product performance of natural raw materials [8-11], the utilization of resources is restricted, and new resource-based application methods of construction wastes such as waste red brick need to be developed.
2. Resource-based application of waste red brick

2.1. Principles for the treatment of solid waste
Pollution control of industrial solid waste, like other environmental problems, has undergone a development process from simple treatment to comprehensive management. In the early stage, all countries in the world paid attention to terminal management, and put forward the "three" principles of resource utilization, reduction and innocency [12]. After many lessons, there was a growing awareness of the importance of source control and the emergence of "cradle-to-grave" management control systems (seen in Figure 1).

![Cradle-to-grave management and control system for solid waste](Resource recovery)

At present, the basic solution for achieving a worldwide consensus is to avoid the so-called "3C principle" of Clean generation, Cycle utilization and Control. According to the above principles, the process of solid waste from generation to disposal can be divided into five continuous or discontinuous steps: (1) waste generation; (2) recycling within the system; (3) comprehensive utilization outside the system; (4) harmless/stable treatment; (5) final disposal and monitoring. Corresponding to the utilization and treatment of solid waste in the above links (2) ~ (5), the industrial solid waste treatment and disposal system combining centralization and dispersion is generally adopted in various regions.

2.2. Comprehensive application of waste red brick
In recent years, China has made great progress in the recycling of industrial solid waste, such as chemical alkali residue recovery technology, phosphogypsum sulphuric acid co-production of cement technology, gangue hard plastic and semi-hard plastic extrusion brick technology, coal gangue and coal slime mixed firing power generation, pure burning of blast furnace gas power generation level and so on. In general, the recycling approaches of waste red brick are mainly concentrated in [13]:

(1) Production of building materials: Its advantages are: (1) Slag consumption, less investment, quick effect, high product quality, good market prospects; (2) Low energy consumption, save raw materials, do not produce secondary pollution; (3) Can produce a variety of products, good performance, such as used as cement raw materials and ingredients, admixture, retarding agent, wall materials, concrete mixture and aggregate, aerated concrete, mortar, block, decorative materials, insulation materials, slag cotton, lightweight aggregate, cast stone, glass, and so on. (4) Doped to fire will waste red brick, produce a variety of specifications refractory brick, it is a stable performance of acid and alkali resistant, fire prevention performance is good, high strength, good durability, small density, low water absorption of high-performance artificial light aggregate, widely used in light aggregate concrete and lightweight aggregate concrete structure, bridge structure and wall materials and other fields, can greatly reduce the weight of the building, can greatly reduce the use amount of steel buildings. The heat insulation performance of the heat preservation brick that makes with waste red brick is the 3 ~ 4 times of common ceramic tile, can save air conditioning charge for the building, the wall body material that prepares with waste red brick at the same time, flame-retardant performance is good replace the building heat preservation material that commonly used on the market at present fireproof...
performance is poor, smoke toxicity is high, can improve high-rise building fire control safety effectively.

(2) To recycle or utilize the useful components, develop new products and replace some industrial raw materials, such as using waste red bricks to make flower POTS, craft pen inserts, etc., which can play the purpose of saving raw materials, reducing energy consumption and improving economic benefits.

(3) Road and dam construction: Less investment, large consumption, mature technology, easy to promote. For example, the construction of a 1km highway can consume tens of thousands of tons of fly ash. Some places can be backfilled and covered with soil, and cultivated land, woodland or residential construction can be opened up.

(4) Production of agricultural fertilizer and soil improvement: Waste red brick contains high content of silicon, calcium and various trace elements, some also contain phosphorus and other useful components. Therefore, waste red brick can be used as agricultural fertilizer after processing and modification. Some waste red brick because its composition is appropriate, can be used as soil ameliorant or microelement fertilizer, in order to effectively improve the aggregate structure of the soil, improve the porosity of the soil, permeability, permeability, promote crop yield.

(5) Goaf backfilling and earth-covering: The use of waste red brick from a wide range of sources for underground goaf backfilling, cost less, simple operation, can prevent land subsidence collapse and cracking, reduce the occurrence of geological disasters. The backfill area, after years of cultivation, planted vegetables, fruits, grain can obtain a good harvest, and the tailings pond is covered by green plants, improve the local air humidity, the concentration of dust in the air greatly reduced.

(6) Reuse of waste red brick in daily life
Because red bricks are made at high temperatures, there are no germs or microbes in them, compared to ordinary stones. Very few, if any. Plus it also has a certain adsorption capacity, can effectively soil carried by the bacteria are adsorbed away. (a) Waste red brick can be used to make waste red wine conversion cabinets with better performance than wooden wine cabinets. After wooden wine ark for a long time, the likelihood is affected by outside environment, suffer from damp, moldy, brick builds by laying bricks does not have this trouble; Wine generally needs to be placed in the cool cool place with a lower temperature, brick wine cabinet itself has the effect of cooling, so conducive to storing wine. (b) Waste red brick masonry as a bookshelf: You can use waste red brick to add a brick bookshelf for yourself, you can choose embedded type, not occupying space, but also more integrated with the space wall. Make a bookshelf with waste red brick additionally, can match with integral style more, restore ancient ways for example style, the bookshelf that builds by building bricks has the effect of a kind of make the finishing point so, adornment effect may be better than woodiness bookshelf. (c) Waste red brick masonry as a pass, give full play to the original function of red brick as a wall, generally the most common pass is wrapped with plasterboard, in fact, as long as the use of waste red brick masonry arch pass: It will make people feel bright again, with personality, so that its decorative effect will not be bad. (d) Waste red brick masonry as a partition wall: If the indoor area is limited, there is no porch to speak of, then you can masonry a very narrow wall as a partition wall, so as not to block the line of sight, create a sense of oppression, but also achieve functional partition. (e) Waste red brick masonry as a shelf to form an open storage area, the storage space in the home instantly increased. (f) Waste red brick clever use in the restaurant: As the base of the table exists, and then in the red brick base above a glass table, such a personality table is completed, do not need to go to the market to buy a table. (g) Waste red brick is used skillfully in the kitchen: Use red brick on the one side of island, have the effect of ornament, create the feeling that mixes on the style thereby, add different adornment effect to the kitchen. (h) The waste red brick can be skillfully used in the courtyard and the porch, and a low protective wall can be built at the edge to solve the problem of hidden safety problems.
2.3. Composition analysis of waste red brick
Waste red brick can be used effectively in wastewater treatment because of its large specific surface area and porosity. Firstly, the composition of the waste red brick is analyzed and determined, so that the waste red brick can be modified in different ways according to the nature of the waste water, and then the waste water can be treated appropriately. The chemical composition of waste red brick is shown in Table 1.

| Composition | Content (%) | Composition | Content (%) |
|-------------|-------------|-------------|-------------|
| SiO₂        | 64.21       | MnO         | 0.148       |
| Al₂O₃       | 18.2        | BaO         | 0.064       |
| Fe₂O₃       | 6.579       | ZrO₂        | 0.0528      |
| CaO         | 2.63        | SrO         | 0.0346      |
| K₂O         | 2.55        | ZnO         | 0.0247      |
| MgO         | 1.73        | Cr₂O₃       | 0.023       |
| Na₂O        | 1.5         | Rb₂O        | 0.0136      |
| P₂O₅        | 1.08        | CuO         | 0.0105      |
| TiO₂        | 0.975       | NiO         | 0.008       |
| SO₃         | 0.197       |             |             |

It can be seen that in the composition of waste red brick, the main is SiO₂, which occupies 63.12 percent of the total mass content of waste red brick, followed by Al₂O₃, and then various metal oxides. It is because of the SiO₂ and various metal composition of waste red brick that it produces the above various uses.

2.4. Application of waste red brick in water treatment
Waste red brick has a certain hardness, suitable for water treatment as a filter medium; The waste red brick has a large porosity and a certain specific surface area, so it can be used as an adsorbent to filter and retain the suspended substances in the water and adsorb the dissolved substances into the pores of the waste red brick. The physical properties of waste red brick are similar to those of waste ceramic. As filter medium and adsorbent, it is a new application field of waste red brick.

3. Conclusion
With the development of the economy and the promotion of construction measures such as "three old renovation", the output of construction waste such as waste red brick is increasing year by year. If waste red brick is not used properly, this kind of solid waste will produce potential harmfulness. For solid waste, the treatment principle is "three": reduction, harmless and resources. Waste red brick is a spatial-temporal misplacement of resources, with a wide range of applications: production of building materials, recovery or utilization of useful components, road and dam construction, production of agricultural fertilizer and soil improvement, goaf backfill, soil reclamation, and in daily life reuse, etc. Because of the SiO₂ of waste red brick, Al₂O₃ and the composition of various metal oxides, waste red bricks have been produced as above in wide use.

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References
[1] 《Outline of development plan for the guangdong-hong kong-macao greater bay area》. http://www.xinhuanet.com/gangao/zt/ldzt/ldzter3/index.htm, 2020-3-01.
[2] 《Guiding opinions of Guangdong provincial people's government on deepening reform and accelerating the promotion of "Three Old" reconstruction to promote high-quality development》. https://www.sohu.com/a/339252977_479496, 2020-3-01.

[3] Lan C, Lu J L, Chen J, et al. Status Quo and Development Analysis of Resource Utilization of Construction Waste in China [J]. Eady-Mixed Concrete, 2017, (9): 23-25.

[4] Zhan L W, Zhang Y L. Analysis of Resource-based Treatment of Construction Solid Waste Pollution [J]. Resources Economization & Environment Protection, 2016, (1): 93.

[5] Xie T, Gao X F, Huang S, et al. Pollution Transformation of Heavy Metal Polluted CDW in Acid Rain [J]. Shandong Chemical Industry, 2015,44(6):157-160+164.

[6] Leng F G, He G X, Zhang R Y, et al. Status and Development Trend of Construction Waste Resource at Home and Abroad [J]. Environmental Sanitation Engineering, 2009,17(1): 33-35.

[7] Sun L R. Research on properties of recycled fine powder and its effects to recycled products [D]. Beijing: Beijing Institute of Civil Engineering and Architecture, 2012.

[8] Wang J Y. Influence of Recycled Aggregate Defects on the Durability of Recycled Aggregate Concrete [D]. Beijing: Beijing Jiaotong University, 2013.

[9] Li T. Influence of Recycled Aggregate Defects on the Mechanical Properties of Recycled Aggregate Concrete [D]. Beijing: Beijing Jiaotong University, 2013.

[10] Pérez I, Pasandín A R, Medina L. Hot mix asphalt using C & D waste as coarse aggregates [J]. Materials & Design, 2012, (36): 840-846.

[11] Pasandín A R, Pérez I. Laboratory evaluation of hot-mix asphalt containing construction and demolition waste [J]. Construction & Building Materials, 2014, 52(2): 284-293.

[12] Zhao Yucai. Solid waste treatment and recycling (3rd edition) [J]. Beijing: chemical industry press, 2019.07.

[13] Long H R, Luo H, Zhou Y. Study on the production of glazed tiles from waste red bricks [J]. Foshan ceramics, 2019, 270 (1): 27-29.