Research on recycling and key technologies of construction waste

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Abstract. Under the background of China's rapid economic development and accelerated urbanization process, the construction industry has been fully developed. However, due to the characteristics of extensive production in the construction industry, a large amount of construction waste is generated. This paper relies on the centralized resettlement project of Zhanjie Town in Gongyi City. Through the research on the key technologies such as the reuse of pile head, the reuse of steel bar head and the recycling of construction waste in engineering practice, the practical methods of construction waste recycling are analyzed, so as to better carry out the recycling of construction waste.

1 Introduction

With the acceleration of industrialization and urbanization, various reconstruction and expansion projects and new construction projects continue to advance, the building materials industry has developed rapidly. However, a large amount of construction waste has also been generated, which has caused great pressure on the urban ecological environment and seriously restricted the sustainable development of the city. Affected by factors such as resource endowment, energy structure, and development stage, China 's bulk solid waste will still face severe challenges of high production intensity, insufficient utilization, and low added value of comprehensive utilization products in the future. At present, the cumulative stock of bulk solid waste is about 60 billion tons, and the annual stock of new piles is nearly 3 billion tons. The content of construction waste in the proportion of urban waste accounts for about 30 % to 40 % of the total waste[1-4]. In addition, the current disposal method of construction waste in China is still dominated by landfill, and the disposal method of construction waste is shown in Fig. 1.

How to effectively deal with construction waste is an urgent problem to be solved in the construction industry. Many experts have carried out a lot of research on this[5-8]. Based on the centralized resettlement project of Zhanjie Town, Gongyi City, this paper analyzes the key technologies of construction waste recycling by studying the key technologies of pile head reuse, steel bar head reuse, construction waste recycling, arrangement design of aerated concrete blocks in the secondary structure, mechanical cutting management application, earthwork balance to reduce earthwork transportation, wood extension, mechanical and electrical pipeline slotting management in the secondary structure, so as to provide a new scheme for the research of construction waste recycling technology.

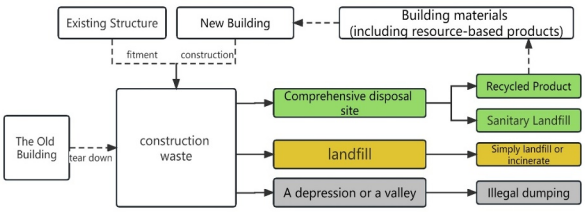

Fig. 1. Construction waste disposal methods in China

2 RESEARCH ON KEY TECHNOLOGIES OF GREEN BUILDING

2.1. Reuse of concrete cast-in-place pile cutting off pile head

Captions should be typed in 9-point Times. They should be centred above the tables and flush left beneath the figures.

At present, the concrete cast-in-place pile is basically cut off the pile head by traditional manual breaking or manual assisted small machinery breaking. Generally, after the concrete cast-in-place pile is cut off the pile head, the pile head will generally become construction waste. For the reuse of the cut-off pile head, we have done the following measures:

1) It is planned to jointly study the construction technology of construction waste reuse by providing construction waste and local mechanism brick enterprises. Because the concrete pile head is common and more, we can effectively collect and combine the local brick making enterprises or unit brick suppliers to effectively reprocess the collected pile head and make it into reusable building bricks, as shown in Fig. 2. In this

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way, it not only reduces the emission of construction waste, but also reduces some construction costs.

2) It is planned to put in a crusher to crush the concrete pile head for the construction of road subgrade in the field. For some concrete pile heads, we can break themselves, use the broken residue for the construction of some roads in the field, enhance the hardness of the road, reduce the amount of lime soil input, and reduce the construction cost.

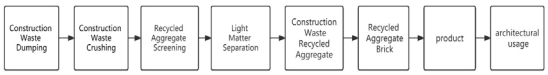

Fig. 2. Reuse of construction waste

2.2 Reuse of steel bar head

At present, there is a widespread situation of serious loss caused by unfavorable management and control of steel bar engineering. There is a situation of preferring long to short and discarding at will. Only the whole material is used on site, and the phenomenon of short material as waste treatment occurs frequently, resulting in excessive loss of steel bar. How to reduce the loss of steel bars has become an important aspect of testing the management level of the site. Therefore, the reuse technology of steel bar head has become the key to the green construction of construction waste recycling. The following adjustments have been made to the collection and classification of different steel head, and the classification results are shown in Table 1.

Table 1. Use of different rebar classifications.

Classification of different steel waste	Usage
φ < 12mm Reinforcement waste	construction column, ring beam or making test block cage
φ=12mm Reinforcement waste	secondary structure construction column planting bar and column steel bar positioning hoop
φ16-20mm Long 50cm-70cm steel waste	make ground anchor
1140mm Reinforcement waste	U-type edge banding for foundation raft (750mm)

Through Table1, it can be seen that : 1) The short head of steel bar less than Φ12 can be used on structural columns and ring beams, and can also be used to make test blocks and raise cages. 2) The underground storage room is 2.9 m high and the diameter of the wall reinforcement is 12 mm. The remaining 1140 mm material head after the 9m raw material is cut off the wall bar can be used as the U-shaped edge sealing of the foundation raft (750mm). The design diameter of the edge-sealing steel bar is 10 mm, and the design is communicated to change the raft edge-sealing steel bar to a diameter of 12 mm, which can make full use of the waste. 3) The diameter of 12 mm steel bar material head is used as secondary structure construction column planting bar, also can be used to do the column steel bar positioning hoop. 4) Φ16-Φ20, about 50cm-70cm long steel bar short head can be used to make ground anchor.

2.3 Concrete construction waste recycling

With the vigorous development of the construction industry, the demand for building materials in China has increased dramatically. In the raw materials of concrete, aggregate accounts for about 75 % of the total amount of concrete, and the source of aggregate is mainly quarrying, processing to form sand and gravel, or directly digging sand, pebbles and gravel in the river. This destroys the natural environment and is not conducive to the sustainable development of the construction industry, so the recycling of concrete is the top priority. Based on the idea of cost saving, waste reduction and green environmental protection, we collect scattered concrete and concrete waste recycling.

1) The site can be used as a prefabricated plate for the post-pouring belt of the basement exterior wall.

2) Prefabricate the beam in advance according to the requirements of the drawings, prefabricated blocks for masonry.

3) Prefabricate the concrete cover of sump and outdoor pipe well in advance according to the requirements of the drawings.

4) for on-site construction roads and material sites.

2.4 Arrangement design and mechanical cutting of aerated concrete blocks in secondary structure

During the construction of the secondary structure, the level of the workers ' masters is different, and many of them use the axe to cut the aerated block, resulting in a large number of block damage, which not only wastes materials but also produces construction waste.

Before construction, BIM is used to optimize the arrangement of blocks, and the optimal arrangement scheme is designed, as shown in Fig. 3. According to the size of the wall width and the size of the block, the swing block is arranged according to the block design, and the swing block can be cut into the required size when the whole block is not enough, but it should not be less than 1 / 3 of the length of the block. When the thickness of the horizontal mortar joint of the lowest skin is greater than 20 mm, the fine stone concrete leveling layer is applied. When the masonry is built, it is full of extrusion, the upper and lower T-shaped staggered joints, the lap length should not be less than 1 / 3 of the block length, and the corners bite each other. After optimizing the arrangement of the block, then arrange someone to cut it according to the design drawing.

The project department invested 5 gas block cutting machines. According to the layout diagram and layout scheme, the block processing material list is listed, and the special person is arranged to cut the block centrally, and then put into use. It can not only save materials to avoid unnecessary waste of block damage, but also save time and cost.

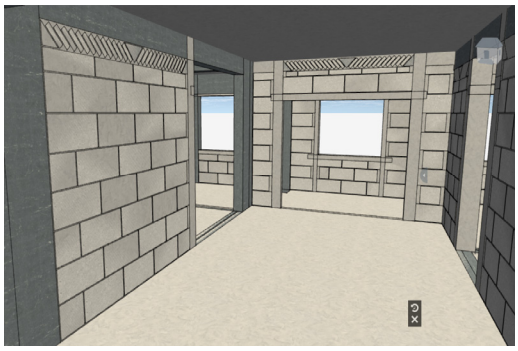

Fig. 3. Secondary structure aerated concrete block layout design

2.5 Short wood square lengthened

In the process of engineering construction, a large number of square woods are truncated and become construction waste, which not only occupies the construction space, increases the engineering cost, but also easily causes personnel to be injured, causes fire, and brings potential safety hazards to the construction site. How to deal with the waste wood and reuse it is of great significance to reduce the project cost, save wood resources and protect the environment.

The technology of lengthening and reusing short timber is beneficial to the safe construction on site, reducing the accumulation on site, ensuring the normal construction, saving wood, reducing the project cost and reducing the waste of resources. The short wooden square is processed by using the short wooden square comb tooth tenon docking technology, and the processing flow is shown in Fig. 4.

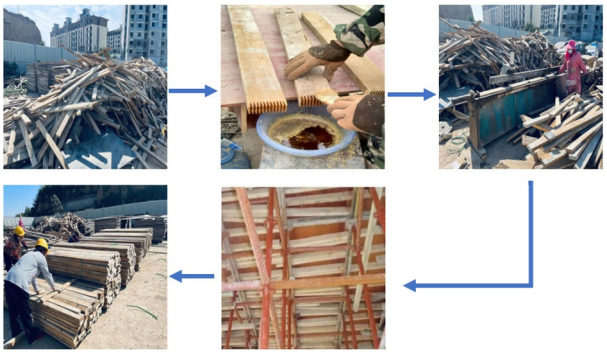

Fig. 4. The short wood square is lengthened and reused

In order to study the related mechanical properties of the long wood cube, the mechanical properties test of the wood cube was designed and carried out, including the stiffness test and the failure test. The size of the wood cube specimen is shown in the Table 2.

Table 2. Test specimen size.

Numbering	Type	Length/mm	Sectional Dimension /mm²
1	Complete squared timber	2900	35×83
2	Complete squared timber	2900	35×83
3	Complete squared timber	2950	35×83
4	Spliced square wood	2710	35×83
5	Spliced square wood	2700	35×83
6	Spliced square wood	2650	35×83

Taking the shortest length of the wooden square as the reference, the test span of 6 wooden squares is 2.6 m, and the concentrated load is applied at the middle position of the wooden square with a jack. The load is stopped when the middle position of the wooden square is pressurized to a deflection of 3 cm, and the force and deformation of the wooden square during the loading process are recorded. The stiffness test arrangement is shown in Fig. 5. The test loading is shown in Fig. 6.

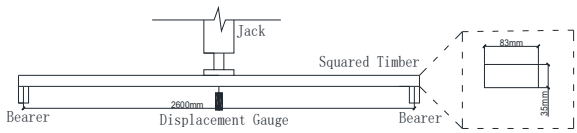

Fig. 5. Stiffness test diagram

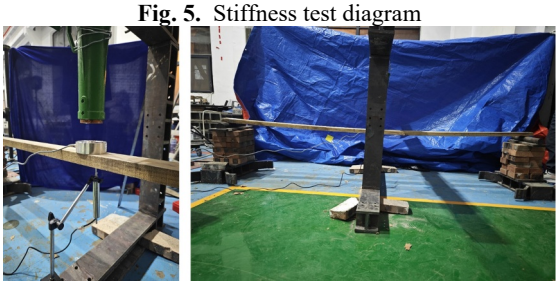

Fig. 6. Loading process of wooden square stiffness test

Table 3. Stiffness test loading results.

Numbering	Type	Span /m	mid-span deflection/mm	Ultimate load/kN
1	Complete squared timber	2600	3	0.196
2	Complete squared timber	2600	3	0.407
3	Complete squared timber	2600	3	0.433
4	Spliced square wood	2600	3	0.193
5	Spliced square wood	2600	3	0.255
6	Spliced square wood	2600	3	0.226

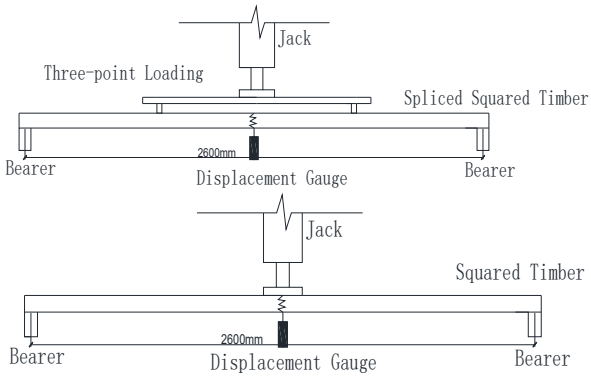

Fig. 7. Three-point and mid-span loading test diagram

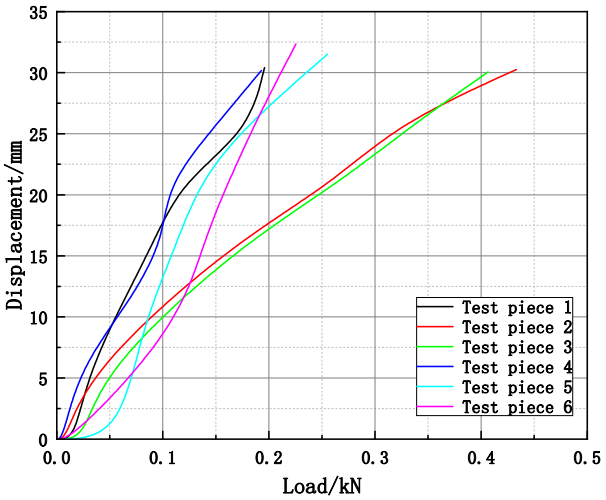

Fig. 8. Load-displacement curves of different numbered wood cubes

The strength failure test of wooden blocks is divided into two groups. The first group of experiments used a distribution beam to apply a load at three points and disposed of the extension inside the distribution beam. The second group of test jacks applied a concentrated load at the extension of the wooden block until the block was damaged. Two sets of experiments were conducted as control experiments. Load diagram as shown in Fig.7. The wood failure diagram is shown in Fig. 9 and Fig. 10.

According to Table 4., it can be seen that during the three-point loading failure test, the wooden block failed at the three-point point point. When the failure occurred, the shear force (V) of the extended wooden block was 1.4kN, the bending moment (M) was 1.064kN·m, and the shear force of the intact wooden block was 1.24kN, the bending moment was 0.942kN·m. It can be seen that when the extended wooden block failed, it can reach or even exceed the load that the intact wooden block can withstand, indicating that the splicing strength meets the requirements. In the mid span loading failure test, the wooden beam was damaged at the mid span position. When the extended wooden beam was damaged, the bending moment was 0.523kN·m and the shear force was 0.475kN. When the complete wooden beam was damaged, the bending moment was 0.495kN·m and the shear force was 0.45kN. It can be seen that the corresponding internal force of the extended wooden beam was greater than that of the complete wooden beam when the structure was damaged, indicating that the splicing strength meets the requirements.

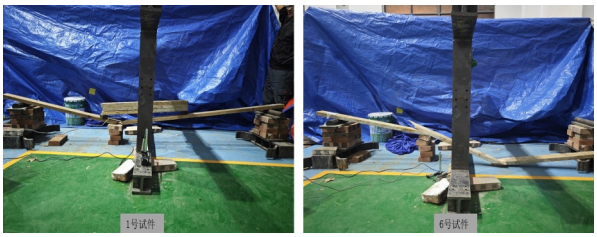

Fig. 9. Three-point loading wood failure diagram

Fig. 10. Three-point loading wood failure diagram

Table 4. Strength test results

Test piece number	Test piece type	loading method	S/mm	Fmax/kN	V/kN	M/kN·m
1	Complete squared timber	Three-point loading	2600	1.24	1.24	0.942
2	Complete squared timber	Middle loading	2600	0.9	0.45	0.495
4	Spliced square wood	Middle loading	2600	0.95	0.475	0.523
6	Spliced square wood	Three-point loading	2600	1.4	1.4	1.064

According to Table 3. and Table 4., it can be seen that in the stiffness test, the six groups of timber specimens did not crack when they were pressurized to 3cm in the mid-span bending under the span of 2.6m. At this time, the external load was 0.193-0.407kN, and the difference was large, indicating that the timber was subjected to the same deformation. The load difference is large and the stiffness difference is large. This conclusion can also be inferred from Fig. 8. In the failure test, the two groups of three-point failure test wood cubes were destroyed at the three-point point, and the splice at the mid-span of the long wood cube was not cracked. When destroyed, the bending moment and shear force of the long wood cube were slightly larger than those of the complete wood cube, indicating that the bearing capacity of the long wood cube is not lower than that of the complete wood cube ; the two groups of bending moment mid-span loading failure tests were all destroyed in the middle. When the failure occurred, the bending moment and shear force of the lengthened timber were slightly larger than those of the complete timber, indicating that the bearing capacity of the lengthened timber was not lower than that of the complete timber.

2.6 Slotting of electromechanical pipeline in secondary structure

In the pre-embedded construction of the secondary structure at the present stage, the general practice is '

masonry first, then slotting '. There are many problems in the construction, such as large workload of slotting and burying, more construction waste, cumbersome repair work, and reduced structural safety.

The project plan adopts the non-slotting process, effectively reduces construction waste and repair work, and achieves the effect of improving construction efficiency, ensuring construction quality, saving resources and green construction. Masonry wall wire tubes should be reserved, embedded or mechanically slotted and opened, and manual construction is strictly prohibited. The wall groove is filled with cement mortar and is flat with the masonry wall. The vertical electric pipeline of small hollow block wall should be buried in the small block hole with the wall masonry, and filled with cement mortar or fine stone concrete after installation. The wall groove is filled with cement mortar and is flat with the masonry wall. The masonry trench can only be slotted vertically or obliquely, so as to ensure that the installation position of each line box is centered when the line is straight, so as to ensure the perfect process ; the line box and the box installation position should not be too large, so as not to cause an increase in the amount of secondary holes.

3 Conclusion

Green development is an important connotation of urban renewal ; the recycling of construction waste provides important technical support for the green transformation and renewal of urban buildings. Green construction emphasizes the cross-stage integration of the whole process of construction to achieve efficient allocation of resources and efficient use of energy. The use of green construction technology to promote the development of construction waste recycling is conducive to promoting resource conservation and environmental protection in the construction industry, improving the level of green construction and management of the general contractor of the project, promoting the greening of the building and energy conservation and emission reduction in the construction industry, and contributing to the peak of carbon and carbon neutralization and achieving sustainable development of the construction industry.[9,10]. Based on the actual engineering project, this paper studies the recycling of waste pile head, steel head and concrete construction waste in the construction process, as well as the layout design of aerated concrete blocks in the secondary structure, the slotting of electromechanical pipelines, the external transportation of earthwork, and the extension of wood. The seven key technologies provide a new solution for the recycling of construction waste and a new idea for the further development of construction waste recycling.

References

1. Qian Z , Yang X , Xu Z.(2021)et al.Research on Key Construction Technology of Building Engineering Under the Background of Big Data[J].Journal of Physics: Conference Series,1802(3):032003 (9pp) .
2. Li L , Shen X , Liu J.(2023)et al.The Feasibility Analysis of Recycled Aggregates from Construction and Demolition Waste for Permeable Pavement[J].KSCE journal of civil engineering.
3. Jing-Rui Y.(2019)Research on Key Construction Technology of Prefabricated Concrete Structure of Building Construction[J].Construction & Design for Engineering.
4. Chao L.(2019)Research on Key Construction Technology of Fair-faced Concrete[J].Building Technology Development.
5. Qiang G , Tie-Long L.(2019)Research on Key Points and Quality Control of Building Roof Waterproofing Construction Technology[J].Building Technology Development.
6. (2023)RecyclingAKTlv & TiefbauLlVE to showcase solutions for recycling old wood and mineral construction waste[J].World of mining-surface & underground.
7. Xing G.(2017)Research on Key Technology of High Construction of Building[J].architecture knowledge.
8. Zhi-Yong W.(2014)Research on construction technology of high-rise housing building[J].Shanxi Architecture.
9. Bandehlou A K , Parvishi A , Kheradranjbar A M.(2023)Study of Construction Debris Waste and the Role of Recycling to Protect the Environment[J].
10. Chao-xian, Deng M C , Zhang X J.(2019)et al.Discussion on the Recycling of Construction Waste in Fengxi New City Sponge City Construction[C]