

# Analysis of the Influence of Recycled Aggregate Reference Ratio on the Performance of Recycled Permeable Cement

Fan Yang

Liaoning Jianzhu Vocational College, Liaoning, 111000

**Keywords:** Recycled aggregate; Concrete; Mechanical properties

**Abstract:** Urbanization and natural disasters have produced a large amount of construction waste. With the development of science and technology, recycled concrete, as a reusable construction waste, has attracted more and more attention. At present, the urbanization process is accelerating, and with the influence of natural disasters such as earthquakes, the amount of construction waste is increasing. China advocates sustainable development and resource reuse, and the reuse of recycled concrete begins to enter people's field of vision and get more and more attention. In order to protect the natural ecological environment and save the earth's resources, it is necessary to effectively utilize solid waste as a resource, so as to achieve the goal of sustainable utilization of building resources. In order to master the characteristics of recycled concrete, it is necessary to study the material properties of recycled concrete. In this paper, how to mix recycled aggregate concrete reasonably to ensure that the mechanical properties of recycled concrete meet the engineering requirements is discussed, so as to achieve the purpose of optimizing the application effect of recycled concrete.

## 1. Introduction

Permeable cement concrete road has attracted much attention because of its random uneven anti-sliding structure, good structure permeability, and the ability to absorb heat and noise. It is of great help to alleviate urban flood control, adjust urban climate, reduce urban heat island effect and improve traffic safety [1]. Permeable cement concrete road has attracted much attention because of its random uneven anti-sliding structure, good structure permeability, and ability to absorb heat and noise. It is of great help to alleviate urban flood control, adjust urban climate, reduce urban heat island effect and improve traffic safety [2]. The resource treatment of construction waste can be used as a new resource, which can not only solve the problem of waste concrete treatment, but also save a lot of primary aggregate to achieve the purpose of green energy saving [3]. Because permeable cement concrete has porous structure, pores weaken the effective bearing area of aggregates, and coarse aggregates are basically in point contact, which makes the mechanical properties and durability of permeable cement concrete obviously different from ordinary concrete [4]. Compared with natural coarse aggregate, recycled coarse aggregate has more edges and corners, rough surface and higher mud content. The amount of needle-like particles in both aggregates is similar, but the bulk density and apparent density of recycled coarse aggregate are lower than those of natural aggregate. This characteristic will result in lower density, and then increase the mass loss rate and water absorption rate [5].

With the increasing level of China's economic development and the rapid development of urbanization, large-scale infrastructure construction will lead to a large amount of construction waste [6]. Because permeable cement concrete has porous structure, pores weaken the effective bearing area of aggregates, and coarse aggregates are basically in point contact, which makes the mechanical properties and durability of permeable cement concrete obviously different from ordinary concrete [7]. Therefore, it is of great significance to carry out research on influencing factors and application of permeable cement concrete. In order to protect the natural ecological environment and save the earth's resources, it is necessary to effectively utilize solid waste as a resource, so that the building resources can achieve the purpose of sustainable utilization [8]. There are many factors affecting the strength of recycled concrete, such as the replacement rate of

recycled aggregate, water-binder ratio, aggregate gradation, admixture, crushing process, old mortar content, etc. [9]. Therefore, in order to master the characteristics of recycled concrete, it is necessary to study the material properties of recycled concrete. In this paper, how to mix recycled aggregate concrete reasonably to ensure that the mechanical properties of recycled concrete meet the engineering requirements is discussed, so as to achieve the purpose of optimizing the application effect of recycled concrete.

## 2. Concrete proportioning and compressive properties

The water-cement ratio will have a great influence on the strength and permeability of recycled aggregate pervious concrete. When the amount of recycled aggregate and cement is fixed, there will be an optimal water-cement ratio, and the compressive strength of permeable concrete will reach the maximum. If the water-cement ratio is greater than this value, the concrete will have strong fluidity, and segregation will easily occur during transportation and pouring. Uneven internal distribution of the poured concrete will affect the compressive strength and permeability of concrete. In the process of configuration, the matching design is based on ordinary concrete, and the calculation of saturated surface absorption rate of recycled coarse aggregate is based on the increase of water consumption of recycled coarse aggregate, which is added as water-side stirring. The water-cement ratio is designed according to the ordinary concrete mix proportion design method, and the increase of water consumption of recycled coarse aggregate is calculated as the water absorption of saturated dry surface state of recycled coarse aggregate, and is added as added water during mixing. When the water-cement ratio is the same, the change of compressive strength of recycled concrete depends on the replacement rate of recycled coarse aggregate. When the water-cement ratio reaches 0.5 and 0.6, there will be a negative correlation between compressive strength and replacement rate of recycled concrete aggregate [10].

Recycled aggregate particles can't be completely and uniformly wrapped by cement slurry, which makes the workability of concrete poor and the corresponding compressive strength also decreases. A good concrete mix ratio should meet the technical requirements of concrete. For example, Table 1 is the cement index to be controlled.

Table 1 Cement index data

Cement index	Fineness	Initial setting time	Compressive strength	Standard consistency water
Ordinary silicon hydrochloric acid cement	50um	160	40.5	26.5

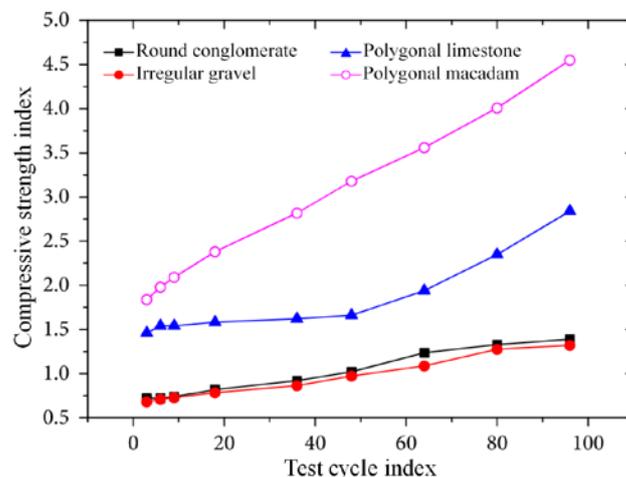


Figure 1 The relationship between compressive strength and age of concrete prepared with different aggregates

According to the grading characteristics of recycled aggregate, recycled aggregate pervious concrete belongs to skeleton pore structure. This kind of structure generally uses more coarse aggregate, which mainly depends on the internal friction resistance between them and the cohesive force of cement cementitious materials to form a certain strength. The relationship between compressive strength and age of concrete prepared with different aggregates is shown in Figure 1.

With the country's vigorous promotion of sponge city, permeable concrete will be widely used in the construction of light roads, squares and residential areas. With the deepening of urbanization and old city reconstruction, the country's demand for concrete is increasing, resulting in fewer and fewer natural stones to be mined. The shape of recycled aggregate surface and the arrangement of aggregate are very irregular, so the distribution of contact points is also irregular, which makes the direction of force transmission complicated and produces serious stress concentration at the contact points. Only by fully understanding the strength formation mechanism of recycled aggregate pervious concrete, can the mechanical properties of recycled aggregate pervious concrete be improved and the influence of structural defects on the performance of pervious concrete be minimized.

### 3. Application of recycled aggregate concrete

Compared with ordinary concrete, recycled aggregate pervious concrete has a special gradation. Discontinuous or single graded recycled aggregate will make recycled aggregate pervious concrete specimen contain a lot of pores and have good pervious performance. The larger the water-binder ratio, the smaller the compressive strength. This is because the larger the water-binder ratio, the worse the compactness of permeable cement concrete, and the thinner the thickness of cement paste on the aggregate surface, the lower the strength, resulting in the lower bond strength between aggregates and the lower the strength of permeable cement concrete. For slurry with specific composition, the maximum thickness that can be coated on the surface of specific aggregate is limited, that is, there is a maximum coating thickness. In the process of mix proportion design of permeable concrete, if the thickness of the designed slurry coating is greater than the maximum coating thickness, the fresh concrete is prone to slurry flow, which leads to uneven composition and pore blockage [11]. When the fluidity of fresh-mixed slurry does not reach the optimal fluidity range, the lower half of the formed fresh-mixed concrete has poor compactness and more actual pores than theoretical ones due to the lack of tamping and fluidity of samples. In the upper part, the porosity is less than the theoretical porosity due to the tamping and vibration of the plate vibrator, which leads to the overall permeability coefficient tending to the upper part, that is, lower than the optimal value.

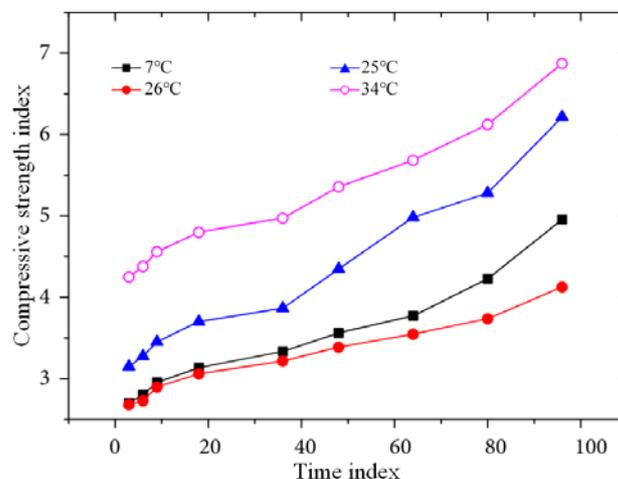


Figure 2 The effect of curing temperature on concrete strength

Under proper process and proportion, the pervious concrete with excellent performance can be prepared by optimizing aggregate particle size distribution. The influencing factors and failure mechanism of the durability of permeable concrete are complex, and the difficulty of passing water

or other harmful liquids in concrete is related, so the important index to evaluate the durability of concrete is permeability. The ambient temperature and humidity of concrete have an important influence on its strength development. The influence of curing temperature on concrete strength is shown in Figure 2.

The interface transition zone reduces the occlusal action between cement slurry and aggregate interface, so concrete failure mostly occurs between cement slurry and aggregate. With the increasing load, concrete cracks and eventually fails. The mass loss rate of concrete under different cycle times is shown in Table 2.

Table 2 The mass loss rate of concrete under different cycles

Cycles	5 times	10 times	20 times	40 times	60 times	80 times	100 times
Loss rate	0.04	0.08	0.12	0.16	0.14	0.16	0.19

In general, discontinuous gradation and single grain gradation are beneficial to water permeability, and continuous gradation is beneficial to mechanical properties. Compressive strength and permeability are two important indexes of permeable concrete, and the particle size distribution of recycled aggregate is the key factor to ensure these two indexes. If the particle size of recycled aggregate is too large, there are a lot of pores in the concrete skeleton. When the amount of cement used is the same, the water permeability is better and the strength is lower. On the contrary, although the strength is high, the water permeability is poor. Generally, pervious concrete contains no or a small amount of fine aggregate, and the aggregate surface is coated with a layer of cement paste, which is cemented into a whole. As a skeleton void structure, the strength of permeable concrete depends on the engagement force formed by the interlocking of aggregates and the number, area and strength of contact points in the structure. Mixing recycled coarse aggregate in concrete can improve the pore structure of concrete. Recycled aggregate has a light weight, so adding recycled aggregate into concrete can reduce the dead weight of concrete to a certain extent, and its application in building structures can improve the seismic resistance of structures.

#### 4. Conclusions

A large amount of construction concrete waste will inevitably cause environmental pollution and waste of resources, which will affect the further promotion of China's sustainable development strategy. Therefore, we should strengthen the recycling of waste, save energy and improve the utilization rate of resources. On the basis of summarizing the properties of recycled coarse aggregate, this paper makes an experimental analysis on the mixing ratio and compressive properties of concrete. Under proper process and proportion, the pervious concrete with excellent performance can be prepared by optimizing aggregate particle size distribution. Compared with natural aggregate, the bulk density and apparent density of recycled aggregate are smaller, and the density of recycled permeable concrete prepared by single and double gradation is higher by single gradation. Recycled aggregate has a light weight, so adding recycled aggregate into concrete can reduce the dead weight of concrete to a certain extent, and its application in building structures can improve the seismic resistance of structures. The application of recycled aggregate concrete improves the utilization rate of resources, improves environmental problems and reduces environmental pollution. In the application of recycled aggregate concrete, the proportion design should be carried out reasonably according to its performance to improve the mechanical properties. When the water-cement ratio is consistent, the basic law is that the lower the regeneration substitution rate, the greater the compressive strength, the higher the regeneration substitution rate and the lower the compressive strength.

#### References

[1] Medeiros-Junior R A, Balestra C E, Lima M G. Applicability of recycled aggregates in concrete piles for soft soil improvement[J]. Waste Manag Res, 2017, 35(1):56-64.

- [2] Mubashir V P, Vyshak R M, Athul K E, et al. Pervious Concrete Block with Recycled Aggregate[J]. International Journal of Civil Engineering, 2018, 5(5):37-44.
- [3] Tian Xiaohe. Research on Water Permeability and Mechanical Properties of Recycled Aggregate[J]. World of Transportation, 2017, 426(12):152-153.
- [4] Chen Shoukai, Li Binglin, Jiang Haifeng, et al. Analysis of the influence of water-binder ratio on the performance of recycled aggregate permeable concrete[J]. Hydropower, 2019, 045(010):122-128.
- [5] Liu Zhifeng, Shi Dandan, Zhou Binbin, et al. Research progress of permeable concrete and the influence of waste aggregates on its mechanical properties[J]. Concrete and Cement Products, 2018, 272(12):11-17.
- [6] Yang Fenglin, Zhao Yasong, Gao Jianming. Research on the influence of the mix parameters of recycled clay brick aggregate concrete on performance[J]. Concrete and Cement Products, 2019, 274(02):67-70.
- [7] Wang Junqiang. Experimental study on shrinkage and frost resistance of recycled aggregate permeable concrete[J]. Industrial Construction, 2016, 46(02):103-106.
- [8] Zhao Ying, Chen Boyang, Yang Zhen, et al. The influence of recycled aggregate powder on the properties of cement mortar[J]. China High-tech, 2019, 52(16):27-30.
- [9] Li Peng. Study on the performance of polymer modified recycled aggregate permeable bricks[J]. New Building Materials, 2018, 045(002):137-140.
- [10] Yue Gongbing, Li Qiuyi, Gao Song. The effect of the quality and replacement rate of recycled fine aggregates on the frost resistance of concrete[J]. Journal of Natural Disasters, 2015, 024(005): 223-228.
- [11] Wang Haichao, Chen Chen, Zhao Qianqian, et al. Experimental study on the performance of enhanced recycled aggregates[J]. Concrete and Cement Products, 2016, 240(04): 25-27.