

The Characteristics and Application of Foamed Concrete

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Abstract: Foamed concrete is a kind of recycling, environmental protection, energy saving, lower and new energy-efficient building materials with incombustible. With the increasingly expanding of construction engineering, the building materials consumption constantly, resources continually reduced, foamed concrete has been widely increasingly concerned by governments at all levels and the social from all walks of life. This article mainly expounds the light, good heat insulation performance, sound proof and fire resistance superior seismic performance and durability of foamed concrete, the factors that affect its performance and briefly illustrate the application of foam concrete in our country that is foamed concrete products, backfill material, thermal insulation material, compensation foundation etc.

Keywords: Foaming agent; Foamed concrete; Performance; Application

1. Introduction

Building energy consumption accounts for about 30% of the national total energy consumption, residential energy conservation is urgent, but most of the palisade structure of the heating area of the thermal performance in China. With abroad under the condition of the thermal performance are different. Since the no. 65 document was issued by the ministry of public security, foamed concrete as a flame retardant, recycling, energy saving, environmental protection, low price of new type thermal insulation building materials, was got more and more whole society attention and recognition. And the foamed concrete industry get rapid development, and applied to various fields.

2. Definition and Composition

2.1. Definition

Foamed Concrete is lightweight porous building materials that Adding foam agent made from aqueous solution to silicon-based materials (fly ash, sand) calcareous materials (cement, lime) water and slurry composed of admixture, after mixture mixing, pouring forming and maintenance .The basic raw material is cement, water, foam, lime and fillers, aggregate and admixture[1].

2.2. Composition

cement: it is not only the important component of the concrete, but also an important part of the foamed concrete. It accounts for about 80% of the total quality, and directly affects its performance. Ordinary Portland cement, iron aluminate cement, fast hard sulfate aluminate cement concrete is the commonly used cement. Cement is the main gelled material to make the foamed concrete

get strength. The adding amount and the compressive strength after hydration decided the compressive strength of foamed concrete, The more the adding quantity, the higher the compressive strength of foamed concrete; The bigger the cement grade, the higher the compressive strength of foamed concrete. Foamed concrete appropriately USES more than 42.5 label of cement[2].

(1) The fly ash: it is the common mineral admixtures. The effect of ash composition can transform $\text{Ca}(\text{OH})_2$ to favorable C-S-H component. Morphological effect can improve bail aggregate gradation, liquidity, and it also can fill the gap in the aggregate to increase the density of foamed concrete. In addition, it also can improve the mix of caking property, reduce the early plastic shrinkage deformation of foamed concrete.

Sand: as the fine aggregate, it mainly fill the role in the foamed concrete to enhance the volume stability of concrete hardening bubble

(2) admixtures

In order to meet the fluidity, construction workability and some special properties of foamed concrete, appropriate admixture of different kind should be added in foamed concrete, Such as the addition of expansion agent to reduce the shrinkage crack; the addition of polyethylene fiber to improve the tensile strength, and the amount of the aggregate to reduce the shrinkage; the organic surface of the organic material surface impregnation polymerization improve the strength and reduce water absorption.

(3) Foaming agent

Foaming agent, also named foam beater, is the material that can promote the formation of the foam to form the structure of closed void or crosslinked hole. There are three kinds of foaming agent for making foamed concrete, the aluminum powder, the surface active agent and pro-

tein. The types of foaming agent can affect the stability porosity and uniform, hardening mechanics performance and frost resistance, and the quality of concrete is greatly affected.

3. The Performance

3.1. Light

The density of foamed concrete is small, and the density is 300-1800kg/cm³. The common density of foamed concrete is 300-1200kg/cm³, the density of ordinary concrete is 2200-2400kg/cm³. In recent years, the density of 160kg/cm³ ultra light foamed concrete has been applied in engineering construction. Due to the small density of the foamed concrete, using this kind of material in building internal and external wall, level, floor, columns, and other building structures, general can reduce the weight by about 25% of, some up to the total weight of the structure 30%-40%[3]. For structures, if use foamed concrete to instead of common concrete, it can improve the component bearing capacity. Therefore, Using foamed concrete in construction engineering has significant economic benefits.

3.2. Good heat insulation performance

Foamed concrete filled with bubbles and large enclosed, small, closed circular porosity. These pores can be in large degree of fixed air, so the thermal conductivity of the product is very low. Dry bulk density of 400-700kg/cm³ foamed concrete, its thermal conductivity is usually 0.09-0.17w/(K - M), adiabatic ability is 7 times of clay brick, 10 times of ordinary concrete[4].

3.3. Soundproof and fire resistance

Foamed concrete is a kind of porous structure material, containing the hole can make the acoustic wave gradually attenuate after the diffuse reflection of the final into heat energy, so as to achieve the effect of sound insulation. It can be used for building floors, highway Sound insulation board . It also can be used for the top floor of the underground building as a sound insulation material. Foamed concrete belongs to inorganic material and is not easy to burn, and can reach the standard of AI grade fire. The fire resistance limit can reach 2.7h, the sound insulation performance can reach 20db, the impact resistance can reach 100 times, it is a kind of high quality soundproof refractory[5].

3.4. Superior seismic performance

Foamed concrete is a special porous structure material with small density, light weight and low elastic modulus, under the earthquake load the earthquake force is small, and the transmission speed of the seismic load is slower than the ordinary concrete structures. According to the principle of vibration, the longer the self - shock period

of the structure , the faster the absorption of impact energy. Therefore, the foamed concrete has excellent shock absorption effect.

3.5. Durability

Compared with the ordinary concrete, foamed concrete has the function of buffer effect because of the large amount of air hole, so it has good freeze-thaw resistance and corrosion resistance and other properties.

3.6. Other properties

The construction of foamed concrete has better pump property, and it is especially suitable for large volume field pouring. It is also suitable for filling and pouring of underground goaf, such as trench filling and gap filling[6]. In addition, the foamed concrete can use industrial waste residue, the price is low and can reduce the construction

4. Performance Factors

4.1. The influence of additive

Qiao Huanhuan[7] studied the effect of additive types on the properties of foamed concrete, and the results show that: the addition of silica fume, can significantly improve the early strength of foamed concrete, but it will lead to the increase of water absorption, which is not conducive to the frost resistance; the incorporation of fly ash can improve the frost resistance of foamed concrete, adding with pulverized coal ash can make foamed concrete strength grow faster in the later stage, and reduce the rate of water absorption, but the impact of the freeze is not big. The compressive strength of foamed concrete mixed with fly ash is much lower than that of pure cement foamed concrete, while the use of chemical agent, fly ash foamed concrete strength significantly increased[8].

4.2. The influence of foaming agent

There are many kinds of material that can make the concrete produce foams, but not all this kind of material can be used in concrete as foaming agent. The foam agent can be used without the break of the foam and mortar (paste) mixing, with the enough stability, without producing adverse effect on the setting and hardening process of cementing materials . Different foam agent will produce different foam quantity, foam speed, foam size. Protein foaming agent widely used has the characteristics of foaming speed, small bubble, the bubble size uniform, , good foam stability and the long duration .as the foaming agent, It is the first selection of foamed concrete production[9].

(1) The influence of foam dosage

Li Junwei[10] studies show that with the increase of the amount of foam added , the dry density of block decreases

es, the resistance to folding and compressive strength decreases, and the thermal conductivity decreases. When the amount of foam added in a certain range, the uniform distribution aperture of the foamed concrete can be obtained. When the amount of foamed concrete is too large, the strength of the foamed concrete lose is not only serious, but also the various performance of the foamed concrete will fall sharply.

(2)The influence of foam stabilizing agent

Li Qing[11] study showed that incorporation amount of HPMC foam stabilizing agent, improve the slurry flowability and consistency at the same time, can also reduce the volume shrinkage of hardened, reasonable of HPMC content can also reduce the density of the foamed concrete hardening, and their dosage is 0.05% is appropriate.

4.3. The influence of aggregate

Zhang Leilei [12] on water ratio of material to study the effect of pore structure and properties of foamed concrete show that: foamed concrete, along with the increasing of the ratio of water to material , within 100 um pore ratio decreased, 100 - 200um pore ratio increased, the overall hole showed increasing trend, and reduce the deformation of the air-vent; foam concrete with water to feed ratio increases the compressive strength increased first and then decreased, the water material ratio has the suitable range, excessively increases or reduces the water material ratio will cause the intensity to drop.

4.4. The influence of the hole

(1) The impact on the mechanical properties

The median pore size change conference will cause the intensity to be small, and when the porosity is small, the size distribution has little effect on the strength. The shape factor has little effect on the intensity of it , the linear relationship between the average pore distance and the intensity has a great influence on the intensity.

(2) The impact on the durability

When to water vapor permeability and water absorption rate as the permeability of measure basis, the study found, large porosity does not necessarily bring higher water absorption, but the increase of the porosity can increase the amount of water vapor permeability. When the permeability of foamed concrete is characterized by water absorption and adsorption rate, it is found that the increase of the amount of foam as macro-pore, both will be reduced. By comparison, there is no uniform standard for the measurement of its permeability, and different standards will get different results.

Freeze thaw damage of foamed concrete except for freezing expansion damage. There is also a differential force between the saturated surface and the unsaturated interior makes the foam concrete damage. Studies show that when the density of concrete is small, namely more macro holes, freezing-thawing resisting circulation ability is

enhanced, and water absorption rate, penetration depth and the amount of water absorption of foam concrete have an impact on the frost resistance.

Foam concrete porous structure makes the foam concrete have good heat preservation and heat insulation performance. The thermal performance will be reduced with the increase of porosity in proportion.

4.5. The influence of the fiber

Shen Rongxi[13] found that the add of glass fiber has some restraint on the shrinkage of the foamed concrete, and this also helps to improve the intensity of it. After the addition of 0.9% fiber, the expansion of the crack is effectively delayed, and the damage of the foamed concrete is slowed down, thus the strength can improve. But it also affects the fluidity of the fiber, causing the uneven distribution of the foam in the slurry, affecting the distribution of the pore structure, it is easy to produce stress concentration after load, and is not conducive to strength. Therefore, the strength of the fiber will be decreased in other quantities.

5. Application

With the establishment of the resource-saving society and the implementation of residential energy saving policy, foamed concrete with its characteristics of lightweight thermal insulation, the energy saving and environmental protection ,in the field of building energy efficiency has been widely used.

5.1. Foamed concrete products

Foamed concrete block is not interlinked in the internal pores, and it has good insulation, water permeability and noise effect, in the foam concrete wall material is one of the biggest application. In the south of China, the grade 900-1200 kg/cm³ density is generally used.Foam concrete block is used as the frame structure infilled wall because of the good block heat insulation performance and the characteristics of light weight, high strength. In the northern region, foam concrete block is mainly used as wall thermal insulation layer.

5.2. Backfill material

Foamed concrete compared with ordinary concrete, the Construction of the backfill has the characteristics of easy construction, backfilling speed, full degree is high, the pipeline the buoyancy, integrated cost is low, and can meet the strength of the design requirements. When used as the retaining wall, as a lightweight backfill materials, it can reduce the other side of the wall of the lateral load, reduce the vertical load, also can be used to replace part of the soil slope, lose weight, increase the stability of embankment slope.

5.3. Thermal insulation material

Due to the good insulation of foamed concrete and convenient construction, it is applied to insulation engineering. This can be used as roof insulation, wallboard insulation, wall space insulation, floor heating insulation, etc.

5.4. Compensation foundation

Because of the uneven settlement of buildings, the large number of cracks generated. Due to the different weight of different parts of the building, the free differential settlement will be generated in the construction. So in the design process of building group, in the part of the low weight of the building, it is required to fill in the soft materials. It is required to make up for due to the weight of the settlement difference between the freedom of together.

5.5. Other applications

Foam concrete can be used to enhance the embankment slope stability, to replace part of the slope soil, reducing the weight of the slope, and reduces the effect on the slope stability of applied force; foamed concrete can also be used to build a playground and athletics track, use the permeable foamed concrete as lightweight foundation , which has strong drainage capacity, and covered with gravel or artificial turf; foam concrete can also be used for the pipeline backfill of sandwich component, poor concrete filling layer , roof slope, support the insulation of the firewall, tank bottom , sound insulation floor filling , tunnel liner backfill and isolation of power supply and water supply line.

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