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**Technical specification for application of phosphorous slag
powder concrete**

磷渣混凝土应用技术规程

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Technical specification for application of phosphorous slag powder concrete

1 General provisions

1.0.1 This Specification is formulated to standardize the application of phosphorus slag powder concrete, make full use of industrial waste, save resources, protect the environment, achieve advanced technology, economic rationality, ensure project quality.

1.0.2 This Specification is applicable to the mix proportion design, construction, quality inspection, acceptance of phosphorus slag powder concrete.

1.0.3 In addition to complying with this Specification, the application of phosphorus slag powder concrete shall also comply with the provisions of the current relevant national standards.

2 Terms and symbols

2.1 Terms

2.1.1 Granulated electric furnace phosphorus slag powder

The molten material with calcium silicate as the main component, which is obtained when yellow phosphorus is produced by electric furnace method, is quenched into granules and ground into powder, referred to as phosphorus slag powder.

2.1.2 Phosphorous slag powder concrete

Concrete which uses phosphorus slag powder as the main admixture.

2.1.3 Cementitious material

The general term for cement and mineral admixtures in concrete.

2.1.4 Percentage of phosphorous slag powder

The percentage of phosphorous slag powder mass in the total mass of cementitious materials.

2.2 Symbols

m_b - Total amount of cementitious materials in each cubic meter of concrete;

m_c - Cement content in each cubic meter of concrete with mineral admixtures;

m_{fp} - Phosphorus slag powder content in each cubic meter of concrete;

β_t - Percentage of cement replaced by phosphorus slag powder.

3 Raw materials

3.0.1 Portland cement and ordinary Portland cement should be used for cement. Slag Portland cement, pozzolanic Portland cement, fly ash Portland cement, composite Portland cement may also be used. Cement shall comply with the provisions of the current national standard "Common Portland cement" GB 175. When other types of cement are used, they shall meet the requirements of the corresponding standards.

3.0.2 Coarse aggregate and fine aggregate shall comply with the provisions of the current industry standard "Standard for technical requirements and test method of sand and crushed stone (or gravel) for ordinary concrete" JGJ 52.

3.0.3 Phosphorus slag powder shall comply with the provisions of the current industry standard "Granulated electric furnace phosphorous slag powder used for concrete" JG/T 317.

3.0.4 The performance index of granulated blast furnace slag powder shall comply with the provisions of the current national standard "Ground granulated blast furnace slag used for cement and concrete" GB/T 18046; the performance index of fly ash shall comply with the provisions of the current national standard "Fly ash used for cement and concrete" GB/T 1596; the performance index of silica fume shall comply with the provisions of the current national standard "Silica fume for cement mortar and concrete" GB/T 27690. When other admixtures are used, the performance index shall also comply with the provisions of the current relevant national standards and shall be verified by tests.

3.0.5 Admixtures shall comply with the provisions of the current national standards "Concrete admixtures" GB 8076 and "Code for concrete admixture application" GB 50119. When other admixtures are used, they shall be verified by tests and the performance shall meet the provisions of the current relevant standards.

3.0.6 The water used for concrete mixing shall comply with the provisions of the current industry standard "Standard of water for concrete" JGJ 63.

4 Phosphorus slag powder concrete performance

4.1 Technical requirements of mixtures

4.1.1 Phosphorus slag powder concrete mixtures shall have good fluidity, cohesiveness, water retention; they shall not segregate or bleed.

4.1.2 The performance of phosphorus slag powder concrete mixtures shall meet the requirements of engineering design and construction. The consistency grading and allowable deviation of concrete mixtures shall comply with the provisions of the current national standard “Standard for quality control of concrete” GB 50164. The test method of concrete mixture performance shall comply with the provisions of the current national standard “Standard for test method of performance on ordinary fresh concrete” GB/T 50080.

4.1.3 The slump loss of concrete mixtures over time shall not affect the normal construction of concrete. The slump loss of pumped phosphorus slag powder concrete over time should not be greater than 30 mm/h.

4.1.4 The setting time of phosphorus slag powder concrete mixtures shall meet the requirements of engineering construction and concrete performance.

4.1.5 The total alkali content of phosphorus slag powder concrete mixture shall comply with the provisions of the current national standard “Technical code for prevention of alkali-aggregate reaction in concrete” GB/T 50733. The alkali content should be measured and calculated in accordance with the provisions of the current industry standard “Specification for mix proportion design of ordinary concrete” JGJ 55. The alkali content of phosphorus slag powder can be taken as 1/2 of the measured value.

4.1.6 The maximum water-soluble chloride ion content of phosphorus slag powder concrete mixture shall comply with the requirements of Table 4.1.6. The water-soluble chloride ion content of phosphorus slag powder concrete mixture should be measured according to the rapid determination method of chloride ion content of concrete mixture in the current industry standard “Testing code of concrete for port and waterwork engineering” JTJ 270.

$$m_c = m_b(1 - \beta_f) \quad (5.2.2)$$

Where:

m_c - The amount of cement per cubic meter of mineral admixture concrete (kg/m^3);

m_b - The total amount of cementitious materials per cubic meter of concrete (kg/m^3);

β_f - The percentage of cement replaced by phosphorus slag powder (%).

5.2.3 The amount of phosphorus slag powder per cubic meter of concrete, m_{fp} , can be calculated as follows:

$$m_{fp} = m_b \cdot \beta_f \quad (5.2.3)$$

Where:

m_{fp} - The amount of phosphorus slag powder per cubic meter of concrete (kg/m^3);

m_b - The total amount of cementitious materials per cubic meter of concrete (kg/m^3);

β_f - The percentage of cement replaced by phosphorus slag powder (%).

5.2.4 The minimum amount of cementitious materials and the maximum water-cement ratio shall comply with the provisions of the current industry standard “Specification for mix proportion design of ordinary concrete” JGJ 55.

5.2.5 The amount of admixture shall be calculated as a percentage of the total amount of cementitious materials.

5.2.6 The construction mix proportion of phosphorus slag powder concrete shall be adjusted according to the provisions of the current industry standard “Specification for mix proportion design of ordinary concrete” JGJ 55; it is used after verification.

6 Production and construction of phosphorus slag powder concrete

6.1 General requirements

6.1.1 Before construction, the construction unit shall prepare a technical plan for the construction of phosphorus slag powder concrete, based on design requirements, engineering properties, structural characteristics, environmental conditions, etc.

6.4 Transporting of fresh concrete

6.4.1 The transportation of phosphorus slag powder concrete shall comply with the relevant provisions of the current national standards “Standard for quality control of concrete” GB 50164, “Code for construction of concrete structures” GB 50666, “Ready-mixed concrete” GB/T 14902.

6.4.2 For phosphorus slag powder concrete constructed by pumping, the transportation shall be able to ensure continuous pumping of concrete and shall comply with the relevant provisions of the current industry standard “Technical specification for construction of concrete pumping” JGJ/T 10.

6.4.3 When phosphorus slag powder concrete is transported to the pouring site, segregation or stratification shall not occur.

6.4.4 For concrete transported by mixer trucks, when the slump loss is large and cannot meet the construction requirements, an appropriate water reducer with the same composition as the original mix proportion can be added to the tank of the truck. The amount of water reducer added shall be confirmed by test in advance and recorded. After the water reducer is added, the concrete mixer truck shall rotate quickly to mix evenly; it shall be pumped or poured only after the required working performance is achieved.

6.5 Casting of concrete

6.5.1 The pouring of phosphorus slag powder concrete shall comply with the relevant provisions of the current national standards “Standard for quality control of concrete” GB 50164 and “Code for construction of concrete structures” GB 50666.

6.5.2 Vibration shall ensure that the concrete is dense and uniform; it shall avoid under-vibration, over-vibration, missed vibration.

6.5.3 During summer construction, the temperature of phosphorus slag powder concrete mixture entering the formwork shall not exceed 35 °C; it should choose nighttime pouring of concrete. When the on-site temperature is higher than 35 °C, the metal formwork should be watered to cool it down; no water shall be left; shielding measures can be taken to prevent the metal formwork from exposed to sunlight.

6.5.4 During winter construction, the temperature of phosphorus slag powder concrete mixture entering the formwork shall not be lower than 5 °C; corresponding thermal insulation measures shall be taken.

6.5.5 When the wind speed is greater than 5.0 m/s, windproof measures shall be taken when pouring phosphorus slag powder concrete.

6.5.6 When pouring structures with larger vertical dimensions, they shall be poured in layers; the thickness of each layer should be controlled within 300 mm ~ 350 mm.

6.5.7 When pouring phosphorus slag powder concrete, the material shall be evenly distributed in the plane; the material shall not be driven by a vibrating rod.

6.5.8 When vibrating phosphorus slag powder concrete, collision with the formwork, steel bars and embedded parts shall be avoided.

6.5.9 During the pouring process of phosphorus slag powder concrete, the stability of the formwork support and the tightness of the joints shall be observed; no concrete leakage shall occur.

6.5.10 After the phosphorus slag powder concrete is vibrated and compacted, it shall be smoothed and pressed by a finishing machine or manually for multiple times before final setting; moisturizing maintenance shall be carried out after smoothing. Moisturizing maintenance can be carried out by sprinkling water, covering, spraying curing agent, etc.

6.5.11 After the phosphorus slag powder concrete components are formed, it is not allowed to walk on the concrete before the compressive strength reaches 1.2 MPa.

6.6 Curing of concrete

6.6.1 The curing of phosphorus slag powder concrete shall be carried out in accordance with the relevant provisions of the current national standards “Standard for quality control of concrete” GB 50164 and “Code for construction of concrete structures” GB 50666.

6.6.2 The curing of phosphorus slag powder concrete components or products shall comply with the following provisions:

- 1 When steam curing or damp heat curing is used, the curing time and curing system shall meet the requirements of concrete and product performance;
- 2 When steam curing is used, it shall be divided into four stages: standing, heating, constant temperature, cooling. The standing time after concrete forming should not be less than 1 h; the heating rate should not exceed 25 °C/h; the cooling rate should not exceed 20 °C/h; the maximum temperature and constant temperature shall be less than or equal to 75 °C. Before concrete components or products are taken out of the pool or the curing measures are removed, the temperature measurement shall be carried out; when the components are taken out of the pool or the curing measures are removed, the temperature difference between the surface and the outside shall not be greater than 20 °C;
- 3 When wet natural curing is used, it shall comply with the provisions of Article

ignition loss, chloride ion content, stability;

- 2 The inspection items of other raw materials shall be implemented in accordance with the relevant current national standards.

7.1.4 The inspection rules for raw materials shall comply with the following provisions:

- 1 Phosphorus slag powder shall not exceed 200 t per inspection batch; bulk cement shall not exceed 500 t per inspection batch; bagged cement shall not exceed 200 t per inspection batch; fly ash and slag powder and other mineral admixtures shall not exceed 200 t per inspection batch; aggregate shall not exceed 400 m³ or 600 t per inspection batch; admixture shall not exceed 50 t per inspection batch;
- 2 When the source of phosphorus slag powder is stable and has passed three consecutive inspections, the inspection batch size can be doubled.

7.1.5 The sampling of raw materials shall comply with the following provisions:

- 1 The sampling of phosphorus slag powder shall be carried out in accordance with the provisions of the current industry standard “Granulated electric furnace phosphorous slag powder used for concrete” JG/T 317;
- 2 The sampling of other raw materials shall be carried out in accordance with the current relevant national standards.

7.1.6 The quality of phosphorus slag powder and other raw materials shall comply with the provisions of Chapter 3 of this Specification.

7.2 Property inspection of concrete mixture

7.2.1 The raw material metering system of phosphorus slag powder concrete shall be used only after verification; the concrete production unit shall conduct self-inspection once a month. The raw material metering deviation shall be checked once per shift; the raw material metering deviation shall comply with the provisions of Article 6.2.2 of this Specification.

7.2.2 During the production and construction process, the phosphorus slag powder concrete mixture shall be sampled and tested; the working performance of the phosphorus slag powder concrete mixture shall be sampled and tested at the mixing site and the pouring site, respectively; the water-soluble chloride ion content shall be sampled and tested at the pouring site.

7.2.3 The working performance of the phosphorus slag powder concrete mixture shall be checked not less than 1 time per 100 m³, meanwhile not less than 2 times per work shift; the number of inspections may be increased if necessary. The water-soluble chloride ion content of phosphorus slag powder concrete of the same project and the

same mix proportion shall be tested at least 1 time.

7.2.4 The performance of the phosphorus slag powder concrete mixture shall comply with the provisions of Article 4.1 of this Specification.

7.2.5 When the performance of phosphorus slag powder concrete mixture is abnormal, the cause shall be found and the mix proportion shall be adjusted according to the actual situation.

7.3 Property inspection of hardened concrete

7.3.1 The strength inspection of phosphorus slag powder concrete shall comply with the provisions of Article 4.2.2 of this Specification; other mechanical performance tests shall comply with the engineering requirements and the provisions of the current relevant national standards.

7.3.2 The inspection and evaluation of the long-term performance and durability of phosphorus slag powder concrete shall comply with the provisions of the current industry standard “Standard for inspection and assessment of concrete durability” JGJ/T 193.

7.3.3 The mechanical properties, long-term properties, durability of phosphorus slag powder concrete shall comply with the provisions of Articles 4.2 and 4.3 of this Specification, respectively.

7.4 Acceptance of concrete engineering

7.4.1 The quality acceptance of phosphorus slag powder concrete engineering shall comply with the provisions of the current national standard “Code for acceptance of constructional quality of concrete structures” GB 50204.

7.4.2 The acceptance of phosphorus slag powder concrete projects shall comply with the provisions of this Specification, on the long-term performance and durability of concrete.

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