Research on Concrete Appearance Quality Control Technology at Home and Abroad Present Situation

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Abstract: *In this paper, the common appearance quality problems of concrete were studied. Based on the factors that cause the appearance quality problems of concrete, the control points of common concrete appearance quality problems such as raw materials, mix ratio, formwork, demoulding agent, demoulding and maintenance are discussed. Combining with the past engineering experience and referring to the relevant technical specifications, the control measures of concrete appearance quality were put forward, which has certain reference value for guiding the construction on site.*

Keywords: *concrete; appearance quality; influencing factors; control measures*

1. Introduction

Concrete is made by mixing cement, coarse aggregate, fine aggregate and water in a certain proportion and then hardening. Because of its revolutionary and universal nature, as well as its unique firmness, ductility and plasticity, concrete is widely used in the field of modern architecture. With the development of economy and the improvement of aesthetic requirements of the public, people have higher and higher requirements on the appearance of concrete. The appearance defects of concrete will not only affect the appearance of the project, but also shorten the service life of the building. In the current concrete construction work, the construction standard is developing towards "the real inside and the beautiful outside", that is, both the solid inside and the beautiful outside, which has become the most important index of the concrete construction quality control. This paper analyzes the causes of the concrete appearance quality defects and the related control measures, and studies the concrete appearance quality control technology at home and abroad The status quo is described.

2. Study on the Detection of Concrete Appearance Quality Defects

2.1 research on concrete apparent crack detection

The appearance crack of concrete not only affects the appearance, but also affects the use and durability of the whole structure. When the crack develops from the surface to the inside to a certain width, it even endangers the safety of the structure [1]. Therefore, the appearance crack of concrete is a common concern. In order to ensure the user's psychological comfort, the appearance of concrete and the safety and durability of the structure, scholars at home and abroad have conducted in-depth research on the appearance cracks of concrete.

With the development of digital image processing technology, image analysis technology is gradually applied to the detection of concrete appearance quality defects. Geng Fei et al. [2] applied image analysis technology, and analyzed and calculated the characterization parameters of concrete apparent cracks through Delphi language. The test shows that the method can directly and conveniently carry out in-depth quantitative research on concrete cracks. Fu Jun et al. [3] applied the method of image segmentation based on neural network to the measurement of wall shallow cracks, which can overcome the shortcomings of traditional measurement methods, such as time-consuming, laborious, low accuracy, etc., and verified the accuracy of the measurement technology with engineering examples, with a wide range of application prospects.

Taiwan scholar PI Cheng Tung et al [4] developed a mobile manipulator imaging system for detecting bridge cracks, which can automatically detect bridge surface cracks. Korean scholar Hong gyoo Sohn et al [5] proposed a crack monitoring system to quantify the change of image cracks during monitoring, and the experiment shows that the system can successfully detect and accurately quantify the change of cracks. Based on the permeability model, Japanese scholar Tomoyuki Yamaguchi et al. [6] proposed a method to detect the surface cracks of concrete, which can not only ensure the detection accuracy of cracks, but also reduce the calculation burden. Jeong Ho Lee et al. [7] developed and designed an automatic bridge detector based on the robot vision system. The system can detect cracks in real time, which is superior to the traditional method. Naoki Tanaka et al. [8] used morphological operation method to extract pavement surface crack information, which has strong robustness for detection of fuzzy cracks in noisy pavement images. Yu S. et al [9] proposed a semi-automatic safety assessment system for detecting cracks in concrete structures, which is composed of a mobile robot system and a crack detection system. The accuracy of the

system depends on the environmental state. A. Ito et al. [10] used the comprehensive image processing technology to automatically extract the apparent micro cracks and their displacement features of concrete, so as to realize the automatic feature extraction and quantitative analysis of cracks.

Du Wenwei [11] combined with the propagation law of Rayleigh wave, put forward the calculation formula of the length and angle of the surface crack in concrete, and used the finite element method to analyze and verify the accuracy of the formula.

2.2 research on detection of other defects on concrete surface

In addition to cracks, the appearance quality defects of concrete include honeycomb, pitted surface, air hole, uneven color, staggered platform, exposed reinforcement, etc. In view of these quality defects, domestic and foreign scholars have carried out research. However, compared with the detection of concrete cracks, the research on honeycomb, pitted surface and color difference is relatively weak.

Zhou Xiangjun of Wuhan University of science and technology [12] uses image processing and neural network technology to detect and identify concrete apparent honeycomb, pockmarked surface, holes and other defects. Lu Jie et al. [13] used image Pro software to collect and process the image of as cast finish concrete, and detected and evaluated the color difference and bubbles of concrete.

Yinghong, Tan Zhiming et al [14] proposed a measurement method of staggered platform based on binocular vision imaging system. Firstly, the image of cement concrete pavement is collected by binocular camera, and then the seam position is located by digital image technology. Finally, according to the imaging characteristics of binocular camera, the dislocation calculation is carried out, and the result is basically consistent with that of ruler measurement. Sun Chaoyun et al. [15-16] collected the 3D information of the road surface based on the laser triangulation method, used the digital image processing technology to process the collected data, and designed the 3D detection system of laser staggered platform.

Suwwanakarn s et al [17] proposed a method to detect the holes on the concrete surface, which can ensure high accuracy, but the response rate is low, and the hole detection results are easy to be affected by cracks, peeling and other concrete defects. Liu B and Yang t [18] Based on the image analysis method, the holes on the concrete surface were detected, and the evaluation parameters of the holes on the concrete surface were given. Zhenhua Zhu et al [19] put forward a new method of air hole detection, which uses two indexes of accuracy and response rate to evaluate the detection effect, and two indexes of hole area ratio and hole number to evaluate the appearance quality of concrete. The research results of Tang Ming [20] show that the air content of concrete, fractal dimension of bubbles and electric flux have good correlation.

3. Research on the Causes of Common Appearance Defects of Concrete and Quality Control Measures

Wu Wei and Feng Qiaoling [21] mainly analyzed the causes of concrete surface cracks from the aspects of temperature change, volume shrinkage and improper construction operation, and provided practical control measures. Yang Hongjun [22] discussed the appearance quality and pouring temperature control method of mass concrete, which has reference significance for the pouring construction of mass concrete. Zhang Xiong et al. [23] believed that the traditional repair methods of concrete cracks are mainly post repair and regular repair, while bionic self-healing method is a new method that imitates the function of biological tissue to automatically secrete a certain substance in the injured part, so that the injured part can be healed. Qian Chunxiang [24] used microbial induced mineralization technology to repair concrete surface defects and micro cracks. Based on the mechanism of protective repair, passive repair and self repair, the research progress at home and abroad was discussed, and their advantages, existing problems and solutions were analyzed. Ren Lifu [25] used carbonic anhydrase microbial enzymatic reaction to induce mineralization and deposition of CaCO3 to repair microcracks on the surface of cement-based materials, and observed the microstructure of cement-based materials by X-ray diffraction and scanning electron microscopy. When the surface crack width is less than 100, the effect of microbial mulching is better; when the surface crack width is greater than 100, the effect of microbial mulching is limited or even disappeared. Jonkers et al. [26-27] systematically studied the compatibility of microorganisms with concrete. They developed a two-component self-healing system composed of bacteria, judged the negative effect of these microorganisms and corresponding organic components on concrete and the impact of mechanical properties, and explored the feasibility of self-healing cracks of such microorganisms in concrete.

Tanjunfeng [28] combined with the actual situation of the site, analyzed the causes and characteristics of the color difference on the concrete surface of the box girder, and provided effective prevention measures. Li Xiao Ke et al. [29] showed that the cement content, water cement ratio, sand ratio and fly ash content in turn affect the surface color and brightness of concrete, while the use of formwork tie rod can improve the brightness of concrete surface, and the mixed oil is a good choice that can not only consider the cost of separating agent but also improve the color difference.

Keler s et al. [30] effectively reduced the exposed reinforcement of concrete by using epoxy coating

reinforcement materials to act as the physical barrier between chloride and concrete electrolyte. Based on the analysis of various methods of eliminating bubbles, Meng h [31] discussed the mechanism of concrete bubbles and treatment measures, which provided reference for eliminating holes on concrete surface.

Donald Walker et al. Pointed out that diamond grinding method can effectively grind 4-6mm staggered platform, but when there is mud and void under the cement plate, it needs to be treated before grinding [32]. Xiao Yimin et al. [33] analyzed the causes of cement concrete pavement dislocation and gave treatment methods. Yang Qingguo et al [34] put forward the dislocation mechanism based on three basic failure forms, and verified the mechanism through field investigation, which has certain theoretical and practical significance. Xu Shaobo and Zhang Lin [35] analyzed the causes of concrete bubbles and color difference problems in construction and provided corresponding improvement measures.

Xiong Kaibing of Dalian University of technology [36] deeply analyzed the causes of various common appearance quality problems such as uneven concrete surface and slag inclusion, and put forward the construction technology and repair measures to prevent and reduce the appearance quality defects of concrete combined with the actual project. Jin Guifeng and Mo Yuhan [37-38] analyzed the common quality problems (mainly including cracks, honeycombs, pockmarks, etc.) in reinforced concrete engineering based on the actual situation, and put forward the corresponding quality control measures for the causes of these common quality problems. The research of Wang Zelin and Li Honghui [39-40] shows that fair faced concrete with uniform color, flat surface, no bubbles, no honeycomb and pockmarks and qualified appearance quality can be obtained by selecting appropriate raw materials and construction technology. Lengshuitao and Kong Yulin [41-42] proposed effective measures to control the appearance quality of concrete from the aspects of the improvement of construction mix proportion and construction technology through the analysis of the causes of common defects of concrete appearance quality, such as honeycomb, pockmarked surface and exposed reinforcement. Tan Yanwei et al [43] proposed to use thixotropic epoxy mortar combined with environmental protection and high-permeability epoxy leakage plugging grouting materials, which can effectively treat the defects of honeycomb pits, cracks and water leakage under various conditions, and solve the problems of low cohesion, insufficient strength or complex construction technology in the existing technology. Guk and fan G [44] in view of the quality defects of as cast finish concrete, such as holes, honeycombs, pockmarks, surface irregularities and cracks, put forward systematic treatment measures from the production, installation and construction management of formwork, effectively improving the appearance quality of as cast finish concrete.

Based on the above research, this paper summarizes several common concrete appearance quality problems and control measures:

1. Cracks: the apparent cracks of concrete mainly refer to the shrinkage cracks caused by the plastic shrinkage of concrete, most of which appear on the upper surface of the just poured concrete.

1) Causes: first, the amount of cement and water is too much, resulting in excessive shrinkage of concrete. Second, the concrete curing is affected by high wind or high temperature, which causes the concrete surface to lose water too fast and the concrete volume shrinks hard, resulting in cracks.

2) Control measures: first, select the type of cement suitable for the concrete strength, must select the same cement from the same manufacturer; the selection of water cement ratio should consider the environmental factors and the actual situation of the project; select the aggregate with small expansion coefficient, clean surface and good grading; select the compound admixture of water reduction and expansion. Second, the temperature and humidity shall be well controlled during the construction, and the construction shall not be carried out in windy weather. Third, select reasonable methods (pouring method, slotting method, bionic self-healing method, etc.) to repair the existing cracks.

2. Pockmarked surface: refers to the phenomenon that there are many small pits and pockmarks on the concrete surface, but there is no exposed reinforcement.

1) Causes: first, the sand rate is too large, the cement is too little, and the concrete liquidity is not enough. Second, rough formwork or improper use of mold release agent. Third, the concrete construction personnel did not spray water regularly, and the water distribution speed on the concrete surface accelerated, resulting in serious water shortage on the concrete surface and the formation of pockmarks.

2) Control measures: first, clean the formwork surface and spray water regularly. Second, seal the pores on the formwork surface with felt paper and putty, and brush a proper amount of release agent in the formwork.

3. Color difference: after formwork removal, the color band of concrete is different from the basic color of concrete, forming obvious color difference of concrete.

1) Causes: first, the quality of concrete raw materials is not stable. Second, the instability of water consumption. When the water cement ratio is large, the cement has high hydration degree and white color. And the color of water cement is bluer than that of hour.

Third, the uneven mixing of concrete mixture affects the uniformity change of concrete, which leads to the change of concrete color. Fourth, the formwork is not smooth or the influence of mold release agent. If there are dirt, dust, oil stain, etc. on the formwork, these substances are easy to adhere to the surface of concrete to produce color difference. Expiration of release agent, pollution and uneven painting will also affect the uneven distribution of concrete surface color. Fifthly, the interval between layers is too long.

2) Control measures: first, ensure the quality of raw materials is stable. Second, accurate mix design. Third, properly extend the mixing time. Fourth, ensure the quality of formwork and release agent. Fifth, reasonable construction organization design.

4. Honeycomb: the surface of the concrete structure is partially loose, with less mortar and more stones, and there are similar honeycomb like holes between the aggregates.

1) Causes: first, improper cutting or insufficient vibration. The blanking is too much or too high, the pouring is not carried out in sections and layers, the vibration is insufficient, and the honeycomb is formed due to missing vibration. Second, the mix proportion design is improper or the weighing is not allowed to cause less mortar and more stones. Third, the strength of the formwork is small, and there is a gap that leads to leakage of slurry or premature removal of formwork. Fourth, the small cross-section of structural members, the small spacing between steel bars or the large aggregate particle size cause the vibration not solid.

2) Control measures: first, the concrete shall be placed in layers to control the free fall height of the concrete. If the height exceeds 2m, chute, chute and other blanking methods can be adopted. Second, scientific and reasonable mix design, accurate measurement, control of mixing time. Third, check the formwork gap to ensure that the formwork gap is tight. The wood formwork shall be watered and wetted, and the steel formwork surface shall be cleaned and coated with release agent. Fourth, control the effective spacing of reinforcement and the maximum size of aggregate.

5. Air bubble: refers to the phenomenon that the air bubble in the concrete cannot be discharged and gather on the surface of the formwork.

1) Causes: first, the aggregate is not dense due to the unreasonable aggregate grading, forming voids and bubbles. Second, a proper amount of admixtures can fill the gap of aggregate and reduce the generation of bubbles, but too many mineral admixtures such as fly ash and silica fume will lead to the increase of the viscosity of concrete and the difficulty to discharge bubbles. Third, a large number of air entraining components in the admixture increase the air content in the concrete, but can not be effectively excluded. Fourth, the influence of water binder ratio. If the water binder ratio is too large, the content of free water in concrete will be too much, and the probability of forming bubbles will increase; if the water binder ratio is too small, the viscosity of concrete will be too high, it will make bubbles difficult to be discharged.

2) Control measures: first, pay attention to the factors that affect the quality of aggregate, such as grading, needle sheet content, etc. Second, add the admixture properly. Third, control the water binder ratio and air entraining agent content.

6. Exposed reinforcement: refers to the phenomenon that the reinforcement inside the concrete component is partially exposed on the structure surface.

1) Causes: first, during the concrete pouring, there are displacement and leakage of the cushion block, and the thickness of the reinforcement protective layer is not enough. Second, the reinforcement is too dense to fill the formwork with concrete slurry. Third, the concrete mix design is unreasonable, the mixture leakage, segregation, can not be well wrapped steel. Fourth, the displacement of the reinforcement occurs during the vibration.

2) Control measures: first, adjust the position of the pad before fixing and prevent the displacement of the pad. Second, where the reinforcement is arranged densely, the maximum particle size of aggregate shall be controlled so that the mixture can pass through the reinforcement and fill the formwork. Thirdly, mix proportion design should be carried out reasonably. Fourth, vibrate carefully to avoid the vibrating equipment touching the reinforcement.

7. Staggering: refers to the phenomenon that the surface of two concrete construction layers forms steps at the joint of formwork due to the dislocation of formwork.

1) Causes: first, setting out error is too large. Secondly, the rigidity of the formwork is not enough and displacement occurs.

2) Control measures: first, the setting out error shall be controlled within the specification requirements. Second, use the formwork with the required rigidity.

4. Research on the Evaluation System of Concrete Appearance Quality

Zhang Jianxiong [45] and others of Jiangsu Academy of construction Sciences proposed the evaluation framework of the appearance quality of as cast finish concrete by referring to the image processing and analysis technology, and comprehensively considered the appearance defects such as color difference, bubble and surface roughness.

Liu Chunyu of Wuhan University of science and technology [46] used the method of computer image

processing to process and identify the concrete appearance quality defects in a data and systematic way, forming the concrete appearance quality rating rules based on color image recognition.

Li Nan [47] of Wuhan University of science and technology combines image processing and pattern recognition technology based on engineering practice, discusses the evaluation method of concrete appearance quality based on image recognition, develops intelligent evaluation software, and forms a relatively systematic concrete appearance quality evaluation system.

Liu Haibao [48] of Qingdao University of science and technology put forward a set of methods and systems to evaluate the appearance quality of as cast finish concrete in full combination with the apparent color of concrete, the size and quantity of surface bubbles.

Ruixing w [49] used image processing analysis method to evaluate the appearance quality of concrete, and established the evaluation system of concrete appearance quality with Delphi 7.0 software. Liu B [50] proposed the evaluation parameters of concrete surface defects, and gave the evaluation system of concrete surface quality.

5. Summary

The appearance quality of concrete reflects the construction technology level of concrete raw materials, mix proportion, pouring, construction and formwork. To control the appearance quality of concrete can ensure the quality of concrete, prevent steel corrosion and enhance the overall durability of the building structure. Concrete appearance diseases are very common, but the research of domestic and foreign scholars is not deep enough. In the future research work, we need to solve the following problems:

(1) Many scholars at home and abroad have carried out a systematic analysis on the causes and prevention measures of concrete appearance diseases, but they have failed to start from the deep-seated influencing factors, explore the causes and put forward effective prevention measures.

(2) The reasons for the appearance defects of concrete can not be analyzed theoretically.

(3) From the domestic and foreign research results and engineering application practice, the perfect, scientific, reasonable and effective concrete appearance quality evaluation and monitoring system has not been established or is imperfect, unscientific, unreasonable, with general effect.

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