Quality Attainment of Concrete Structures Using Visual Evaluation

「目視評価法を活用したコンクリート構造物の品質確保の取組み」の概要




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1. Introduction

It has been realized that if defects in concrete surfaces occur at the time of construction, then the structure will fail to achieve its intended life cycle even if good construction quality has been ensured. Hence, the authors have promoted an initiative to develop a homogenous, robust, and integrated framework using visual inspection to ensure quality control during construction.

This paper presents an overview of a visual evaluation framework integrated with the plan–do–check–act (PDCA) cycle to implement quality control. The framework has been developed for general structures such as piers, abutments, culverts, and tunnel lining concrete. Furthermore, the proposed framework has been applied to a construction site, and it was realized that it promoted a harmonious working atmosphere at the site in addition to the development and improvement of technology.

2. Outline of Visual Evaluation Method

The proposed visual evaluation method involves assessing the quality of concrete surface finish after demolding to verify the suitability of the construction materials used and construction method applied. **Table-1** shows the visual evaluation criteria for general structures such as abutments, bridge piers, box culverts, and retaining walls. The general defects that occur during construction have been classified into five categories: (1) placement joints, (2) surface air bubbles, (3) settlement cracks, (4) leakage from formwork joints, and (5) sand streaks. These are the defects that have been accepted and approved in the past after the final construction inspection has been completed by the client. Until now, the surface quality after demolding was evaluated vaguely, but by classifying the defects into five criteria and evaluating each one, they can now be quantified. The classification of observed surfaces into categories and the subsequent grading of these defects into four levels using the proposed framework facilitates quantitative evaluation of surface finish and verifies the suitability of construction methods. The acquired information is then integrated with the PDCA cycle, leading to improved quality of construction for subsequent lifts.

Table-2 lists certain criteria with different levels of defects to be investigated during visual evaluation for the tunnel lining concrete that was developed for the construction of the Taro No. 6 Tunnel on the Fukuden Road. Six evaluation criteria were considered: (1) spalling, (2) surface air bubbles, (3) water splashes/sand streaks, (4) color unevenness, placement joint, (5) poor construction joints, and (6) leakage from the inspection window frame.

Table-1 Visual representation of different grades for each category of concrete surface defects

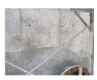
Criteria	4	3	2	1
Placement joints				
Surface air bubbles				
Settlement cracks				

Table-2 Quantification of certain surface defects for tunnel lining

Criteria	Point	4	3	2	1
Surface air bubbles		almost none	10 voids of 5 mm	10 voids of 10 mm	20 voids of 10 mm
Color unevenness, placement joint		almost none	1/10 of area	1/2 of area	more than 1/2 of area

The special features of the visual evaluation method are as follows.

· By classifying and quantifying the observed defects of the concrete surface finish after demolding the formwork into the aforementioned criteria, it is possible to see clearly the aspects of construction quality that had been overlooked until now.

· The proposed framework is easy to adopt and convenient to use because it does not require any special scaffolding or equipment and can be performed from a distance. Additionally, it can be carried out immediately after demolding and can be completed in a very short period of time of around 1 or 2 min.

· The quality of the entire inspection area can be evaluated.

· It can be conducted by many personnel simultaneously.

Effects of the Method

(1) Trial on Viaduct Piers

Using the proposed visual evaluation framework, efforts to enhance quality control and assessment by the contractor in collaboration with the client were improved. As a result of this framework, reasons for the defects were identified and new innovative construction methods were introduced to mitigate their occurrence. Solutions such as using a transparent mold, attaching a rubber hose to the concrete pumping pipe to reduce material segregation at the tip, post-mixing of admixture to improve properties of fresh concrete, and curing of concrete by covering it with a thin sheet were developed and implemented at the construction site. The improvement in construction quality using the proposed framework along with PDCA cycle can be confirmed from **Fig. 1**. As can be seen, although there were some surface air bubbles on the fifth lift, the concrete surface finish quality was improved to almost 4 points.

(2) Application to Tunnel Lining Concrete

A trial of the proposed framework to evaluate the quality of tunnel lining concrete was conducted in collaboration between the contractor and the first author. Certain criteria decided for the visual evaluation of concrete in this construction project are shown in **Table-2**. Following the integrated visual evaluation framework, construction methods were modified, for example, using pressure sensors to control the pressure during concrete pumping, using a pull-out vibrator to compact the concrete, and discharging the remaining air along with bleeding water in the back of the tunnel lining. **Figure 2** shows the inspection scores for color unevenness, placement joint and air bubbles at different parts of the tunnel lining concrete. Although the scores for both items were low for the initial stages of construction, the scores improved and were subsequently maintained following the application of the aforementioned improvements.

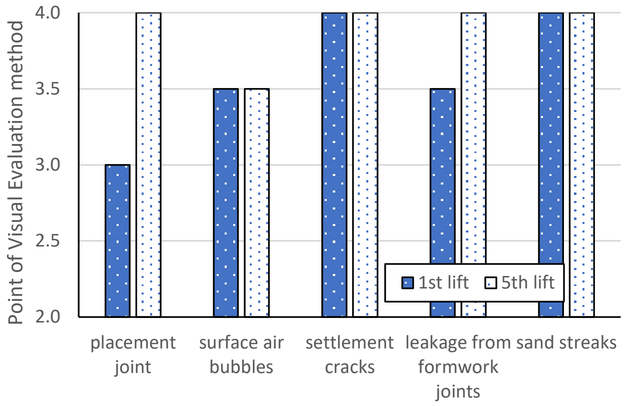


Fig. 1 Results of visual evaluation[1]

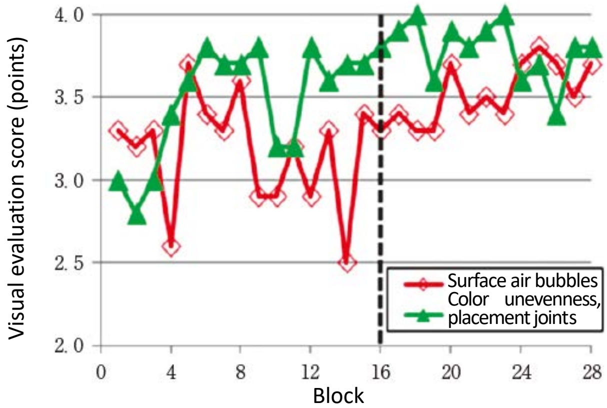


Fig. 2 Overview of sheet curing method[1]

3. Conclusion

This study presents the characteristics of the proposed visual evaluation framework and the results of its application for quality attainment and quality control. It was demonstrated that following the PDCA cycle to quantitatively evaluate the concrete surface finish quality clarifies the reasons for observed defects, helps in developing suitable countermeasures, and encourages ingenuity on the part of contractors, ultimately leading to quality improvement. Having realized the impact of concrete surface quality on structure durability, the proposed integrated framework has shown the potential to ensure appropriate quality control as the construction progresses.

Reference

[1] Hosoda, A. et al.: *Quality Attainment for Concrete Structures Using Visual Evaluation Method*, Concrete Journal, Vol. 54, No. 10, JCI, Tokyo, pp. 1005–1014, Oct. 2016 (in Japanese).