Knowledge-Based System For Predicting The Non-Conformed Quality Of Precast Concrete Products

Sasiwimol Promote*, Thatchavee Leelawat**

*(Department of Technology of Information System Management, Mahidol University, Thailand
**(Department of Civil and Environmental Engineering, Mahidol University, Thailand

Abstract

The study was aimed at developing web-based application for identifying the nonconformed quality of precast concrete products using knowledge-based system. Types of non-conformed precast concrete products were identified and their main reasons were then converted into logical processes using the syntax of if-then-else statements. The priorities of the causes for the nonconformity cases were additionally identified and the reinforcing data for the causes were also confirmed by statistical analysis using "Shewhart" quality control chart. The 150 concrete mixes obtained from the actual results of precast concrete production were used for validation of the system. The result of the nonconformity case was informed successfully with the main cause of the corresponding problem.

Keywords - Knowledge-based, nonconformity, precast concrete production, quality control, web-based application

I. Introduction

Knowledge is widely accepted to be one of the most important resources in every organization. Since it could significantly reduce the duration of decision-making for solving the consistent problems and, therefore, could increase the efficiency of works. Knowledge-based system could also be used for solving many instantaneous problems like expertise. The system firstly needs to identify the specific domain covering the scope of problem being interested. The well-equipped system needs to address even small fraction of the specific domain such as the identification of the distresses or diagnosis of failure in bridge structures [1]. The wider scope of the domain is specified, the more difficult system needs to be developed. Therefore, the most successful systems usually address only narrow scope of the specific domain [2].

The expertise then needs to indicate the main reasons of the specific domain. The technical knowledge adopted by the expertise needs to be converted into logical processes which are then used for supporting human decision-making as well as recommending the appropriate action for solving the problems. Berrais [2] commented that the user requirements, aspects of usability, capability of the program, hardware environment, and the intended functions of the knowledge-based system should be taken into consideration.

Many organizations have tried to develop and implement the knowledge by capturing, storing, and retrieving the related information [1, 3]. Liu [4] developed the quality prediction program for concrete manufacturing in order to acquire the qualitative knowledge during the production of concrete. Arıöz et al [5] developed the web-based quality control of ready mixed concrete. Their program was claimed to provide better communication and also simultaneously check the properties of materials and products. However, no initial warning system for nonconformity of the output products could be found from the search. Since their input and outputs were found to be compared only to the limitations of their relevant standards without identifying the causes and the priorities of the problems. The decision making of the relevant problems was found to rely only on the quality control managers. Without in-depth technical knowledge of the main area, it may not be easy for the quality control manager to detect the real problems.

This research was, therefore, aimed at extending the web-based quality control program from the previous researchers into the knowledge-based system for predicting the non-conformed quality of the precast concrete products using web-based application. The causes and the priorities of the problems were designed to keep warning at the early stage after the non-conformed quality of products was detected.

II. System Design And Development

The domain of the study has focused on the detection for the non-conformed quality of materials and precast concrete products. Therefore, the production manager of the precast concrete company was interviewed in order to collect information involving with the current process for the precast concrete production, types of non-conformed products, and the quality control reports of the precast concrete production. The production process of hollow-core concrete piles was selected in the study. The non-conformed products; such as longitudinal crack, unintended shape, discoloration and roughly internal surface of products, were reported (Fig 1). The main reasons for the non-conformed products were also partially endorsed. Typical example of the main reasons for the non-conformed product is shown in Fig 2.

Figure 1 Roughly internal surface of hollow-core concrete pile

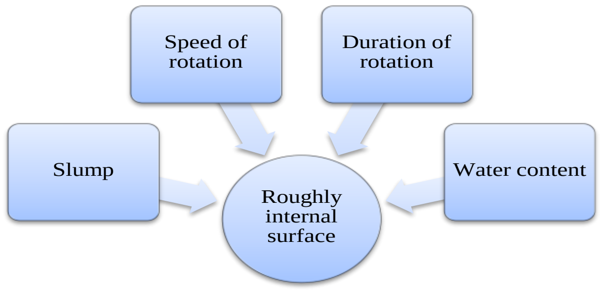

Figure 2 Main reasons for the non-conformed product

Causes and the priorities of the problems relating to the nonconformity of the products were reviewed further from technical research papers and textbooks. The summarized main reasons and their priorities of the problems adopted were converted into logical process using the syntax of if-then-else statements.

The system was then programmed using Microsoft Visual Studio .NET 2008. MySQL Community Server 5.1 was also used as a database platform. Databases and codes of material properties were conducted following the user requirements and also designed conforming to ACI 126.3 [6]. The data flow diagram for the development of database system used in the study is shown in Fig 3.

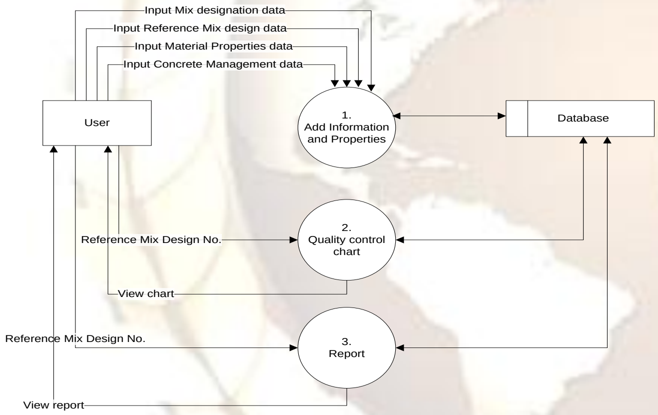

Figure 3 Data flow diagram developed in the study

2.1 Database Information

The mix designation for both referenced and tested concrete mixes, material properties and concrete management were used in the database. The entity relationship diagram was used for creating the flows of data and the relationship between data given in the database.

2.2 Quality Control Charts

The statistical analysis using "Shewhart" quality control chart was used for assisting the user to identify the nonconformity of each material and process. The control chart was plotted by collecting measurements from each characteristic of materials or process. The results of analysis were then plotted on the graphs which also showed the upper control limit (UCL) and lower control limit (LCL). The UCL and LCL lines were calculated from mean ± (3×S.D.) and mean ± (1.5×S.D) respectively.

2.3 Non-Conformed Reports

Factors influencing the nonconformity of precast concrete products specified previously were used for demonstrating the relationships between causes including their priorities and effects of the problems. Table 1 shows the typical causes of environmental condition including their priorities that could affect to the slump of precast concrete.

Table 1 Causes of environmental condition affecting the slump of precast concrete

Environmental Conditions	Priority	Reasons
Concrete temperature	High	Increasing temperature Slump decreased with increasing concrete temperature. Decreasing temperature Slump increased with decreasing concrete temperature.
Air temperature	Moderate	Increasing temperature Increasing air temperature could possibly increase temperatures of mixing ingredients. Increasing air temperature could possible change in water addition up to 6 liters per square meter.
Relative humidity	-	

Typical examples of conditions that were written in the model are given below:

If: Concrete temperature increases
Then: Slump of concrete will decrease and priority is high

If: Slump of concrete increases
Then: Roughly internal surface of product is possible and priority is high

If: Strength of concrete decreases
Then: Roughly internal surface of product is possible and priority is high

The report showed only the processing results of non-conformed properties which their values were found to exceed the upper or lower control limit of the "Shewhart" quality control analysis and the influencing factors specified previously indicated high or moderate priority.

3 RESULTS AND DISCUSSION

The model was validated by testing with 150 concrete mixes obtained from the actual results of hollow-core concrete piles. The user firstly needed to add the mix design information and the specified properties of referenced concrete mix. The user then added the tested results of mix proportions, material properties and concrete management used in the corresponding concrete mixes. The properties of tested concrete mixes were compared to the corresponding reference concrete mix (Fig 4).

Mix Design No.	Mix Description	Date	Design Slump	Actual Slump
STD001/2011	Precast 600x1200 Production Line 1	31/03/2011	5	4
STD002/2011	Precast 350x1200 Production Line 2	31/03/2011	5	4
STD003/2011	Precast 600x1100 Production Line 1	30/03/2011	5	4.5
STD004/2011	Precast 350x1200 Production Line 2	30/03/2011	5	5
STD005/2011	Precast 600x1200 Production Line 1	29/03/2011	5	5
STD006/2011	Precast 350x1200 Production Line 2	29/03/2011	5	5
STD007/2011	Precast 600x1100 Production Line 1	28/03/2011	5	4
STD008/2011	Precast 350x1200 Production Line 2	28/03/2011	5	4
STD009/2011	Precast 600x1300 Production Line 1	26/03/2011	5	5
STD010/2011	Precast 350x1100 Production Line 2	26/03/2011	5	4
STD011/2011	Precast 600x1300 Production Line 1	25/03/2011	5	5
STD012/2011	Precast 350x1100 Production Line 2	25/03/2011	5	4.5

Figure 4 Database of tested concrete mixes and their corresponding referenced concrete mix

Typical nonconformity report displaying the roughly internal surface of concrete pile is shown in Fig 5. It was found that the corresponding compressive strength results of concrete was slightly lower than the lower control limit of the "Shewhart" quality control chart (Fig 6) and the corresponding water content of the mix was slightly higher than the lower control limit of the "Shewhart" quality control chart (Fig 7).

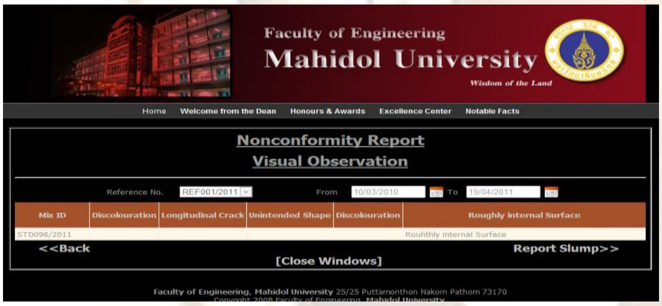

Figure 5 Nonconformity report of concrete mix investigated by visual observation

The water content of the STD 096 mix was also reported as the main factor influencing the roughly internal surface of the precast concrete pile using the syntax of if-then-else statements specified previously. The rotation speed and duration during the centrifugal process of the tested concrete mixes were not significantly different to those corresponding referenced concrete mix.

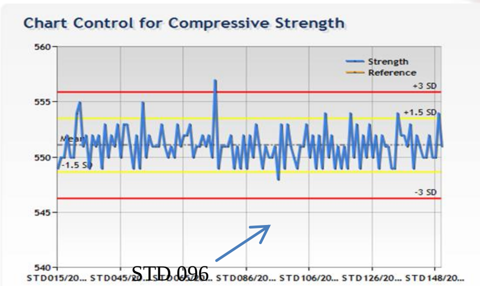

Figure 6 Quality control chart for the compressive strength

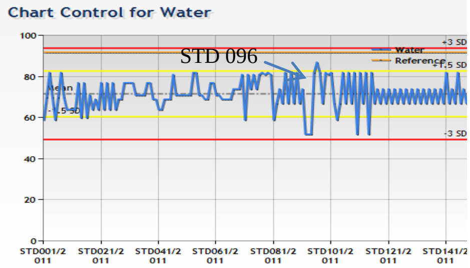

Figure 7 Quality control chart for the water content of concrete mix

III. Conclusion

The web-based application was successfully developed for predicting the non-conformed quality of precast concrete piles using knowledge-based system. The nonconformity case of the roughly internal surface of the precast concrete pile was detected following the report for the main cause of the problem. This could be conducted by the combination of the syntax of if-then-else statements and the statistical analysis using "Shewhart" quality control chart.

ACKNOWLEDGEMENTS

The author would like to thank the production manager of Taksin Concrete Public Company Limited for providing useful information for this research.

REFERENCES

[1] B DAVE, L KOSKELA, COLLABORATIVE KNOWLEDGE MANAGEMENT--A CONSTRUCTION CASE STUDY, *AUTOMATION IN CONSTRUCTION*, *18 (7)*, 2009, 894-902.

[2] A BERRAIS, KNOWLEDGE-BASED EXPERT SYSTEMS: USER INTERFACE IMPLICATIONS, *ADVANCES IN ENGINEERING SOFTWARE*, *28 (1)*, 1997, 31-41.

[3] L KAETZEL, J CLIFTON, EXPERT/KNOWLEDGE BASED SYSTEMS FOR MATERIALS IN THE CONSTRUCTION INDUSTRY: STATE-OF-THE-ART REPORT, *MATERIALS AND STRUCTURES*, *28 (3)*, 1995, 160-174.

[4] J LIU, QUALITY PREDICTION FOR CONCRETE MANUFACTURING, *AUTOMATION IN CONSTRUCTION*, *5 (6)*, 1997, 491-499.

[5] Ö ARIÖZ, G ARSLAN, M TUNCAN, S KIVRAK, WEB-BASED QUALITY CONTROL OF READY MIXED CONCRETE, *BUILDING AND ENVIRONMENT*, *42 (3)*, 2007, 1465-1470.

[6] ACI, GUIDE TO RECOMMENDED FORMAT FOR CONCRETE IN MATERIALS PROPERTY DATABASE, *ACI COMMITTEE 126.3*, (FARMINGTON HILLS: AMERICAN CONCRETE INSTITUTE, 1999) 1-50.