Prediction of Compressive Strength of Concrete by Non-destructive Inspection based on Case Studies in Developing Countries

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1. Introduction

Evaluating the in situ concrete strength in a structure during its service life is important to prevent loss of lives during natural hazards. Developing countries in south Asia, like Bangladesh and Sri Lanka are exposed to the threat of earthquake and tsunami. Moreover, buildings have been demolished without occurrence of earthquake due to poor quality of concrete in Bangladesh. This phenomenon can be attributed to the fact of constructing an immense number of buildings after the Liberation war in 1971 without formulation of building standard law (Bangladesh National Building Code, BNBC) before 1993. Extensively detailed investigation for all existing buildings to identify the vulnerable ones is impractical. The easiest method to recognize the strength of concrete in concrete members is with non-destructive test methods (NDTs). This study is focused on two types of NDTs which are a rebound hammer (Type L) and a scratching test. To develop calibration curves the actual strength of the specific concrete and results of the NDTs are required. The aim of the study was to establish a prediction method of concrete strength based on NDTs results in developing countries , especially the combination of the NDTs is investigated.

2. NDT Methods

2.1. Rebound Hammer

Silver Schmidt (Type L) manufactured by Proceq Co. Ltd. is used for this study. This hammer consists of a spring-loaded piston which is released when the plunger is pressed against a surface. The hammer represents the impact penetration resistance (i.e. the hardness) of the surface. This is shown as rebound quotient Q on the digital screen accompanied in the instrument. The impact energy is 0.735 N·m with a measuring range of 5-100 MPa. This is suitable for measuring low strength concrete.

2.2. Scratching Test

Scratching test is hardness checking method which is developed by Japan Society for Finishing's Technology, by using test device certified by Japan Floor Coating Industry Association. Scratching is done by pushing the two pins of the device on the painted surface of concrete. The pins apply 1 kg and 0.5 kg forces. The grooves made on the surface of the concrete is measured by the various scale available with the device for measuring the surface hardness.

3. Experimental Procedure and Field Surveys

The target of this study was finding low strength concrete and establish a methodology for evaluating such type of concrete. In Bangladesh, commonly crushed brick chips are used as coarse aggregate. On the other hand, it is common practice to use crushed stones as coarse aggregate in Sri Lanka. Keeping in mind the variability of aggregate, laboratory specimens was made at Tohoku University laboratory. They are brick aggregate (high strength and low strength), stone aggregate, recycled aggregate, lightweight aggregate. In order to represent Bangladesh condition of very low strength concrete high water cement ratios were used and limestone powder was used as a filler powder. In addition, a two-story concrete frame of very low strength concrete using brick chips as coarse aggregate was manufactured at the University of Tokyo. The first story concrete slab was representative of normal strength concrete and the columns (15cm X 15cm) in the 1st and 2nd story was thin enough representing worst local condition. Cylinders were tested for compressive strength for laboratory specimens. Moreover, field surveys in Bangladesh and Sri Lanka were carried out and core test specimens for compression test were drilled from the same portion subjected to NDTs.

4. Results

Figures 1 and 2 represents the results of rebound hammer and scratching test. The derived regression curves provide good R^2 values but the data points show great scatter. Compressive strength obtained from this curve sometimes show over estimation of strength. Therefore, a different curve is required to avoid the misunderstanding of strength on site.

Figure 4 shows the relationship between the two NDTs. The

Estimation of concrete strength using non-destructive test methods based on field survey in developing countries

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right part of the curve represents higher R values whereas the left part represents lower R values. In the right region brick chips samples provide unique trend, for example scratch width is wider than expected. Similar trend is also followed by BD field data points. The data points on the right side is plotted in Figure 4 which provides a calibration equation for rebound hammer.

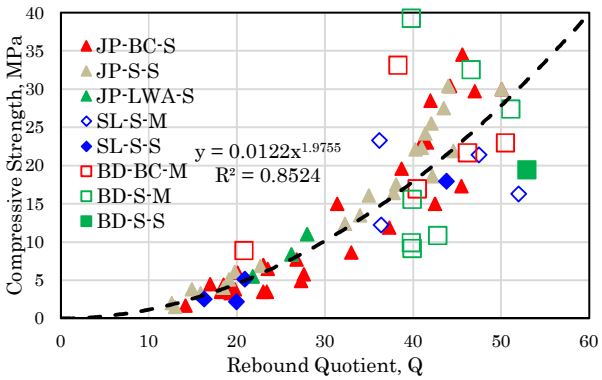

Fig 1. Results of Schmidt Hammer

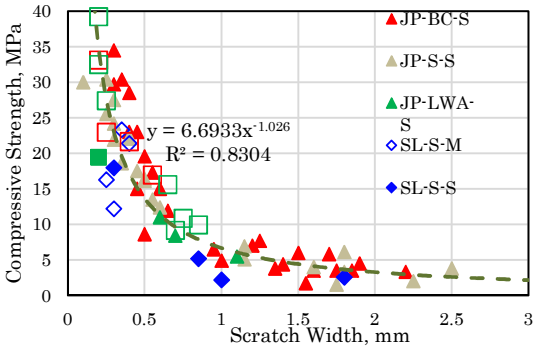

Fig 2. Results of Scratching Test

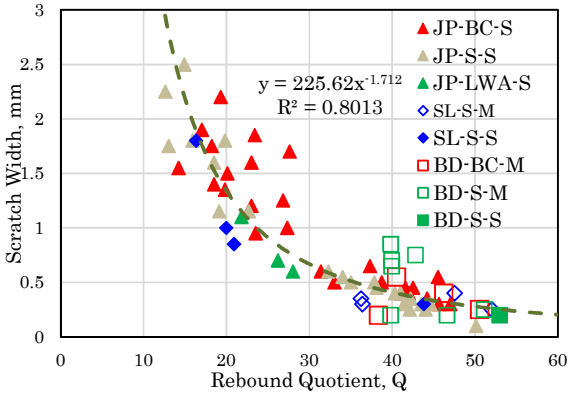

Fig 3. Relationship between two NDT methods

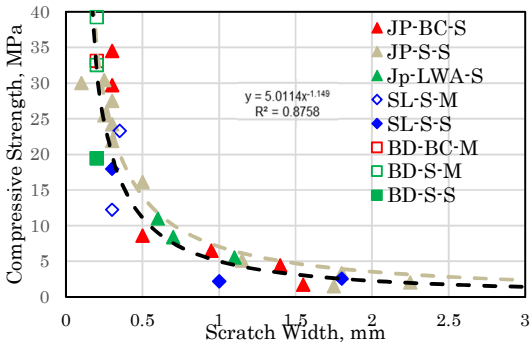

Fig 4. New regression curve of scratching test

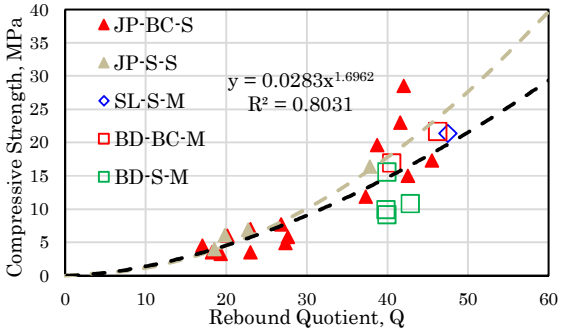

Fig 5. New regression curve of rebound hammer

In addition, the data on the left part is used to derive a calibration equation for scratching device shown in Figure 5. Three field data show lower compressive strength than expected by the established calibration equation. Therefore, while evaluating concrete strength it is necessary to obtain compressive strength from both devices. The device providing lower value of compressive strength from calibration equations obtained can be used as representative value.

5. Conclusion

This study is focused on the derivation of an easy procedure to evaluate low strength concrete in developing countries. Regardless of the difference in the materials used in concrete a method combining two NDTs, rebound hammer and scratching test, is established. Combination of two methods gives reliable prediction of strength rather than a single method. The lower value of the two methods obtained should be the representative value of compressive strength on site.

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