Condition Evaluation of Concrete Through UPV Using MATLAB

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Abstract- *Testing of ultrasonic pulse velocity (UPV) is one of the most popular and actual non-destructive techniques used in the estimation of the concrete properties in structures. In this thesis, an approach has been proposed for the evaluation the condition of concrete structures related to UPV which significantly influenced by concrete compressive strength, concrete cover, surface hardness and density of concrete mix prepared. The present study is performed by using the experimental data obtained from testing many casted concrete cubes and existing structures. Cubes have been casted using plain cement based on performed concrete mix design as per IS code.*

In the last MATLAB fitting tool has been used to develop two different models. In the first model combined effect of concrete cover and surface hardness has been determined on the condition of existing concrete structures.
In the second model effect of initial characteristics such as compressive strength and density has been detected over the UPV of the concrete cubes.

This present approach enables engineers to detect the condition of concrete structures through the initially developed properties. Also, condition of the existing reinforced concrete structures can be obtained using UPV values. In addition, it can be used as a non-destructive procedure for health monitoring of structural elements.

Keywords- Compressive strength, Durability, Service life, Non destructive testing.

I. INTRODUCTION

Concrete has been used as a construction material for several years. Structural design of concrete structures traditionally focuses over the compressive strength and construction. However, the field experience in the last decades has established that concrete structures degrade with age. Henceforth, a steady weakening in material properties is observed, and this explains into degradation in the presentation and life of a structure. Repair and rehabilitation of degrading concrete structures is needed at regular interval to preserve the performance. Due to be deficient in performance of building structures in past decades, there is an increasing curiosity in the field of harm assessment and preservation of concrete structures.

Deprivation and weakening of structures initiated by physical and chemical damage results in the reduce in performance with age, physical injury occurs due to fire, contraction and expansion stresses, whereas chemical damage occurs due to harsh environment. Lack of robustness of concrete structures or beginning of cracking has been caused mainly due to harsh environment.

II. OBJECTIVES OF PRESENT STUDY

In the present research a series of experiments had been performed

1. To propose a method for determining the condition of concrete by measuring UPV.
2. To propose a correlation between UPV and different properties of concrete cubes and existing concrete structures.

III. LITERATURE REVIEW

Many studies have been conducted in order to inspect the benefits of utilizing pozzolanic materials in constituting and improving the properties of concrete.

Amini et al. (2016) developed models for predicting the compressive strength of concrete, without considering the past maintenance record of building. Performed ultrasonic pulse velocity (UPV) and rebound hammer (RH) tests over several cylindrical samples of concrete.

Several destructive and non-destructive tests had been conducted by Pucinotti (2015) on a significant historic building in Reggio Calabria. It has been observed from results that due change in the in-situ mechanical properties of the concrete; it is needed to calibrate the strength determined by non-destructive testing of concrete.

An experimental study has been conducted by Malek and Kaouther (2014) for assessing the compressive strength of concrete through destructive and non-destructive testing at 7, 14 and 28 days. For destructive testing compression test and for non destructive testing rebound hammer tests have been conducted. Effect of several parameters on the modulus of elasticity has been investigated through pulse velocity test. These parameters are the age of concrete and the water/ cement ratio.

The compressive strength of several concrete mixes produced using lightweight aggregate has been evaluated using the non-destructive ultrasonic pulse velocity method by Bogas et al. (2013). In this study almost 84 separate compositions have been tested after 3 and 180 days of curing, compressive strengths of these samples is ranging about 30 to 80 MPa.

In an experimental study performed by Jain et al. (2013) evaluated the effects of concrete ingredients, proportion of concrete mix, and variables related to workmanship on the Rebound Number and Ultrasonic Pulse Velocity of concrete. In this study combined use of both the NDT techniques had been determined.

Hajjeh (2012) performed several destructive and non-destructive tests several laboratory casted concrete cubes. Regression investigation is carried out and several relationships were determined and correlated between non-destructive testing method which is Schmidt rebound hammer test and concrete destructive compression test. Schmidt hammer has been applied in both vertical and horizontal positions. The standard concrete cubes had been made with a range of mix proportions that yielded standard cubes crushing strengths

IV. EXPERIMENTAL RESULTS

During the in-situ testing twenty five concrete structures were tested and parameters such as age, compressive strength and ultrasonic pulse velocity were determined. The values obtained for above parameters are summarized in table below.

Table 3.4 – In-situ data

S. No	Structure	Strength (MPa)	Corrected strength (Mpa)	Concrete Cover (mm)	UPV (m/sec)
1	Building 1	20	21.92	30	4200
2	Building 2	20	21.92	30	4025
3	Building 3	19	20.92	40	3904
4	Building 4	17	18.92	30	3986
5	Building 5	16	17.92	35	3800
6	Building 6	16	17.92	35	3740
7	Building 7	16	17.92	33	3624
8	Building 8	14	15.92	40	3560
9	Building 9	14	15.92	32	3508
10	Building 10	23	24.92	35	3400
11	Building 11	13	14.92	40	3310
12	Building 12	22	23.92	40	3260
13	Building 13	12	13.92	50	3200
14	Building 14	12	13.92	35	3255
15	Building 15	12	13.92	30	3145
16	Building 16	21	22.92	32	3180
17	Building 17	13	14.92	45	3020
18	Building 18	14	15.92	32	3120
19	Building 19	22	23.92	42	3000
20	Building 20	23	24.92	40	2980
21	Building 21	16	17.92	36	3085
22	Building 22	17	18.92	40	2940
23	Building 23	13	14.92	42	2860
24	Building 24	18	19.92	42	2820
25	Building 25	19	20.92	42	2746

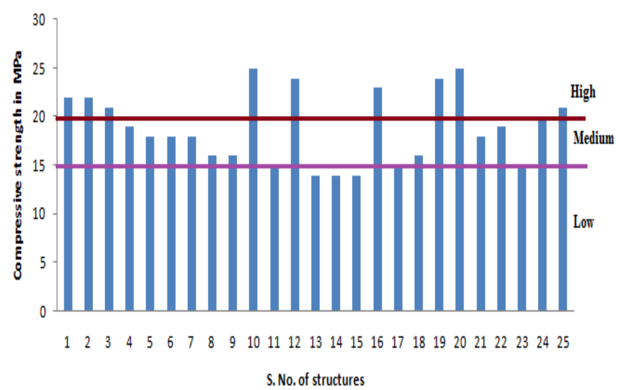
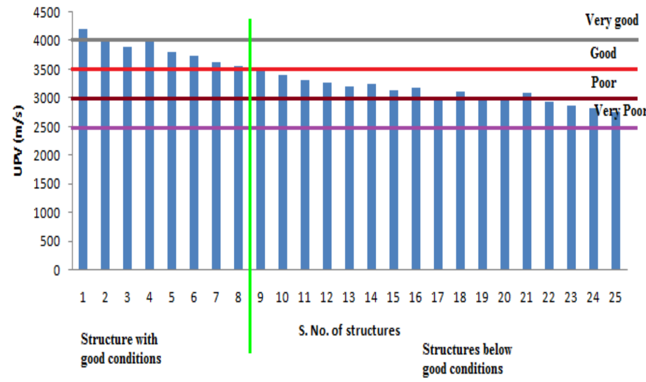


Fig. 3.11 – compressive strength of structures



UPV of all the structures has been presented in fig. 3.12.

Data obtained from crushing strength and UPV tests over prepared concrete cubes were presented here. Data obtained from testing of cubes has been presented in figure given below

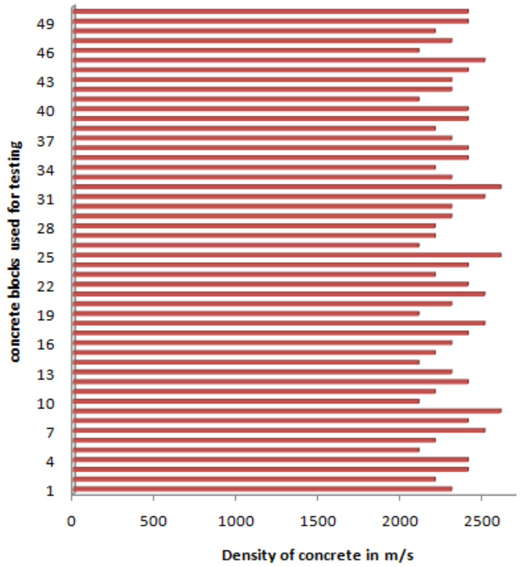


Fig. 3.14 – Values of concrete density determined in laboratory

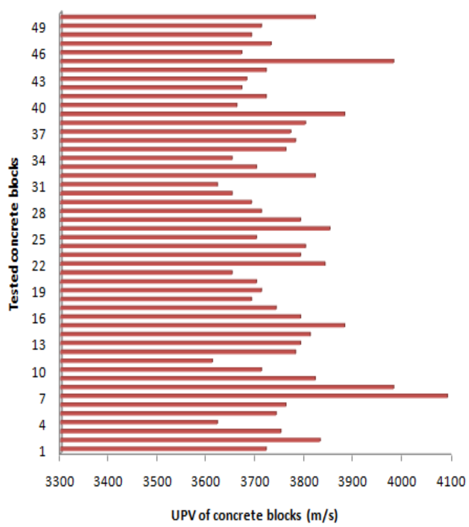


Fig. 3.15 – Values of UPV of concretes

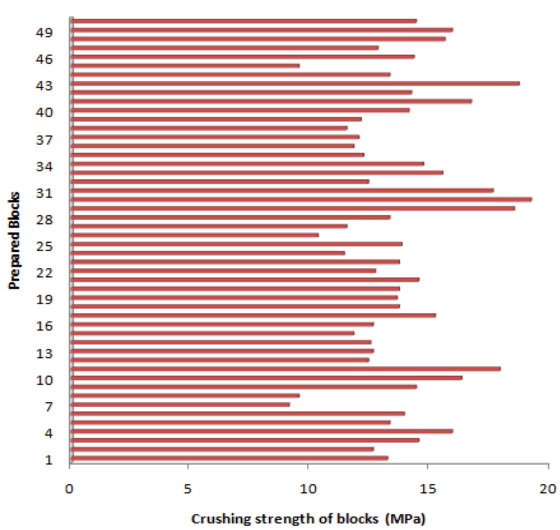


Fig. 3.16 – Crushing strength of concrete blocks

Relation between strength, density and UPV

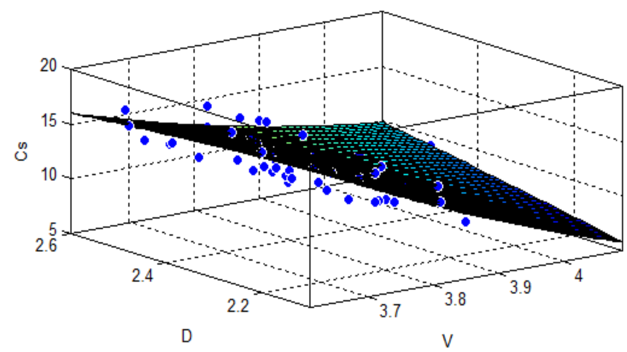


Fig. 4.1 – Surface plot Cs vs V and D

Fig. 4.1 presents a surface plot to obtain the value of Cs on the basis of UPV and Density of concrete. Following eqn. 4.1 presents the relation between theses parameters –

Cs (V,D) **= p00 + p10*V + p01*D + p20*V^2 + p11*V*D + p02*D^2** (4.1)

p00 = 488
p10 = -178.2
p01 = -84.88
p20 = 13.15
p11 = 24.69
p02 = -1.673

Cs (V,D) **= 488 -178.2 *V -84.88*D + 13.15*V^2 + 24.69*V*D -1.673 *D^2** (4.2)

Following figures presents the goodness of proposed models

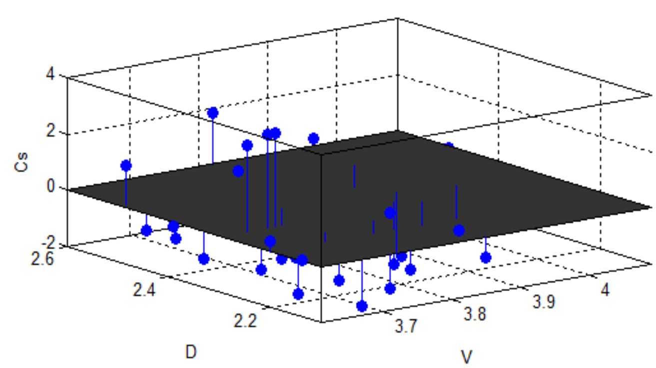


Fig. 4.2 – Error residuals between experimental and models values of compressive strength

Figure 4.3 shows the contours of Cs values with respect to values of V and D –

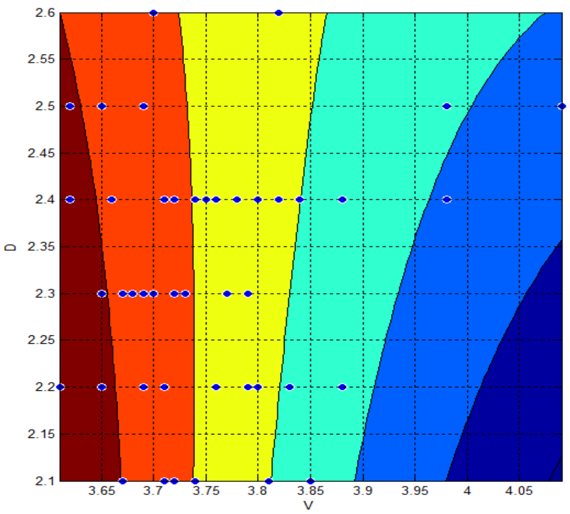


Fig. 4.3 – Contour of values of Cs

V. DISCUSSIONS AND CONCLUSIONS

1. This study indicates the ability of the MATLAB surface fitting tool as a good technique for model the concrete compressive strength, UPV and density relationship.
2. The model performs sufficiently in the estimation of UPV or condition of concrete.
3. Analyzing the results obtained at the end of the study has shown that by using crushing strength and density data with MATLAB is a suitable method to predict the condition of concrete specimens.
4. The prediction made using proposed model shows a high degree of consistency with experimentally evaluated condition of concrete specimens by UPV. Thus, the present study suggests an alternative approach of predicting condition of concrete structures against other in-situ methods.
5. In this research, next to the crushing strength to estimate the condition, density parameter has also been taken into consideration. When the density, which can be easily determined, has been taken into account, it has been useful for more accurate prediction of concrete condition.
6. This current study employed data set which is composed of limited pairs of input and output vectors. Therefore, it would be reasonable to propose a further works using more data sets from various areas could be needed to generalize the conclusions in this study.

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