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Original Contribution

THE DETERMINATION OF CONCRETE COMPRESSIVE STRENGTH OF READY-MADE CONCRETE POWERED INTO THE SAME BUILDING BY DIFFERENT READY-MADE CONCRETE FIRM WITH CONCRETE TESTING HAMMER (SCHMIDT HAMMER)

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ABSTRACT

In this study, a concrete which is poured on the same structure by different ready concrete firms in concrete test pulling experiment and concrete durability. For this, ready concrete samples are taken, which are poured on the second floor by Set Ready Concrete firm and the Third floor Polat Ready Concrete firm, from a construction which is being contioned in Karapürçek, Ankara 21767 city block, 5 parcel. It is considered that pouring periods of the ready concretes shouldn't be less than 90 days. The construction is formed with columns and joists. Experiments points are found in the columns which will represent all construction. After necessary preparations are completed at column levels. Average back response numbers are found belong to the surfaces with a test pulling. Combining the datas taken from both floors and using the statistic methods, the comprehension of the durability of the ready concretes poured by ready concrete firms is done. As a result, Set Ready Concert firm's concrete durability is higher than Polat Ready Concrete firm's concrete durability.

Key Words: *concrete durability, concrete test pulling experiment*

INTRODUCTION

In parallel with technological developments, some factors such as the desire to live in more attractive environments and the high migration rates from rural to urban areas have resulted in a considerable increase in the number of buildings, which is still continuing with a rapid pace[1].

Due to this rapid increase, ready-mixed concrete has gained more attention in concrete production to save on cost, time, and workmanship in buildings. Furthermore, more careful construction of buildings has been on the rise as a result of earthquakes, the recent nightmare of people. While building strength was previously measured only with concrete samples obtained from large and significant construction projects, now with ready-mixed concrete available, concrete quality is determined before use even in the construction of small buildings.

Non-destructive concrete test methods have been developed to assess the actual in situ concrete strength by taking care not to extend a period 90 days after the concrete is cast. 28-day compressive strengths of standard samples cannot be used to determine whether a concrete form has acquired sufficient strength for a safe removal. Before the 28th day, non-destructive tests can be used to determine whether compressive strength of concrete is sufficient for formwork removal (AKMAN, 1965).

LITERATURE REVIEW

This section relates to the review of literature on assessment of concrete compressive strength using the Schmidt Hammer. The Schmidt hardness value increases rapidly first in parallel with cement hydration, but

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decelerates later (OZTURK, 1994).

The experiment sample should be firmly fixed so that it will not move. Otherwise, Schmidt number assumes smaller values. Test points should not be close to element detachments and should be placed with a distance of at least 2cm from each other (FACAOARU, 1972). It leads to grossly inaccurate results in concretes older than 90 days and low-dose concretes (OZTURK, 1994).

Very small results are obtained when large aggregate grains are present just beneath concrete surfaces and there are very high air voids. Therefore, five or ten readings are required in experimental areas of 20x20cm (YURDAKUL, 1988). The Schmidt hardness value which depends on cement hydration development increases with time and concrete age (OZTURK, 1994).

In an N-type Schmidt Hammer, a spring-loaded mass is raised to a certain energy level by stretching the spring and is then released and impacted against a steel end leaning against the surface of the concrete to measure the rebound of this mass. The amount of rebound is assumed to depend on the hardness of the surface against which the end part leans (AKMAN and GÜNER, 1984).

MATERIALS AND METHODS

Material

C16 ready-mixed concretes of Set and Polat Ready-Mixed Concrete Manufacturers to be used in the project were used as study material. As for the Schmidt hammer, an N-type test hammer was selected, a model of the group of linear rebounding hammers.

- Selection of Test Points

The optimum measurement surface is concrete surfaces cast in vertical molds (SANGARI, 1991). Care was taken to identify a sufficient number of test points on the building columns to represent the entire building. Concrete form joints and measurements on hollow or visible aggregates were avoided. Some of most strained areas and critical points for strength were selected. Element parts like corners, sides, and joints were avoided when selecting the test points. A distance of at least 2cm was maintained between two test points (YUKSEL, 1995).

- Preparation of Experimental Surfaces

Before conducting any measurements on the surface, cement slurry adhered to the surface and loose materials were cleaned off with carborundum stone. This cleaning procedure was continued until normal concrete tissue was reached (YUKSEL, 1995).

For the Schmidt Hammer, test surfaces were smoothened with an area of 20x20cm, enough to make 5 or 10 beatings.

Method

Conduction of Experiments

The surface was made ready for the test and beatings were made with the Schmidt Hammer.

For the Schmidt Hammer; after an N-model Schmidt hammer was calibrated for Schmidt hammer readings, readings were taken with the hammer at a right angle (0°) to the surface. Ten beatings were made on each surface and readings with a deviation of more than five units in their means were cancelled and new readings were taken. More than one beating was not made on the same point and no beatings were made on aggregate pieces and voids in concrete (YUKSEL, 1995). Thus, a total of 80 beatings were made on 8 columns. On the basis of the means of beatings on each side, mean rebound numbers for each surface are given in Table 1.

Scope and Method of the Experiment

To arrive at a conclusion by experimentation in this study, limitations and conditions should be determined (HICKS, 1985).

System: Compressive strengths of different ready-mixed concretes
Limitation: A single-factor, two-level experiment on 8 columns
Cause: Applying compression on the surface
Effect: Rebound number obtained from different concretes under compression
Detector: A device that shows rebound numbers obtained as a result of the experiment
Results: Compressive strength values obtained as a result of the experiment
Evaluation: Representation of the obtained compressive strengths in a table.

Table 1. Mean values for the Schmidt Hammer beatings are given.

Number of beatings	Set Ready-Mixed Concrete (Rebound Numbers)				Polat Ready-Mixed Concrete (Rebound Numbers)			
	Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 1**	**Column 2**	**Column 3**	**Column 4**
1	30	32	35	30	28	29	29	31
2	30	35	34	31	28	29	31	28
3	33	36	30	30	29	28	29	30
4	28	29	29	30	28	30	28	27
5	31	32	34	30	28	29	28	27
6	32	29	30	31	29	28	28	26
7	30	32	30	29	28	30	28	26
8	30	29	30	29	28	29	32	29
9	29	30	42	30	26	30	30	29
10	30	31	32	32	28	30	27	28
Arith. Means	**30.3**	**31.5**	**32.6**	**30.2**	**28**	**29.2**	**29**	**28.1**

Table 2. *Presents the compressive strengths corresponding to rebound numbers.*

Ready-Mixed Concrete	**I –SET CONCRETE**	**II- POLAT CONCRETE**
Compressive Strength	**(N / mm²)**	**(N / mm²)**
Column 1	24.2	20.5
Column 2	26.0	22.4
Column 3	28.2	22.0
Column 4	24.1	20.8

EXPERIMENTAL RESULTS and EVALUATION

The aim was to compare the concrete compression strengths of two different ready-mixed concretes cast in the same building using a Schmidt Hammer. Only two different ready-mixed concretes were tested. The test was a single-factor experiment with two specific levels. It was determined that four observations would suffice for each of the ready-mixed concretes and eight rows of columns would be randomly selected for the test. The obtained data were organized as in Table 1. Figure 1 shows the distribution graphs of these data.

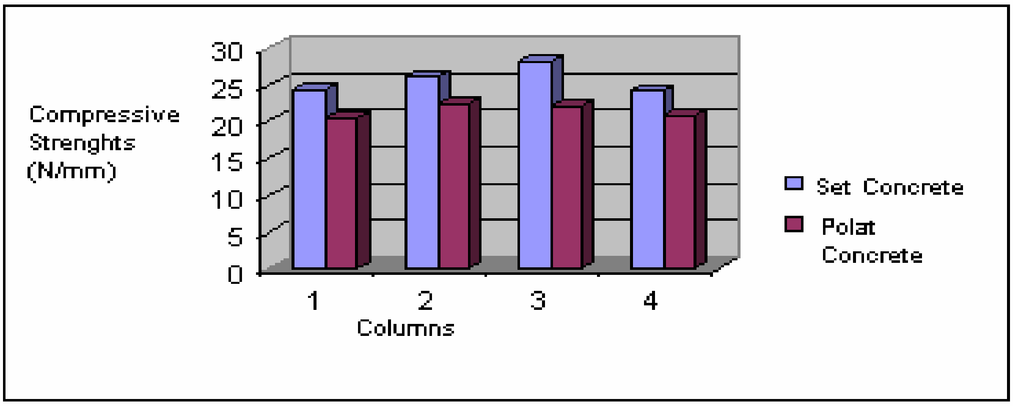

Figure 1. Distribution graphs of test data

Table 3. Compression values obtained by a Schmidt Hammer for columns cast with different ready-mixed concretes.

Ready-Mixed Concrete	I –SET CONCRETE	II- POLAT CONCRETE
Compressive Strength	(N / mm²)	(N / mm²)
Column 1	24.2	20.5
Column 2	26.0	22.4
Column 3	28.2	22.0
Column 4	24.1	20.8

Hypothesis

The test was performed in accordance with the criteria specified in TS 3114.
For the testing method;

The compressive strength values of C16 ready-mixed concrete cast by Set Ready-Mixed Concrete Firm are smaller than those of C16 ready-mixed concrete cast by Polat Ready-Mixed Concrete Firm.

The compressive strength values of C16 ready-mixed concrete cast by Polat Ready-Mixed Concrete Firm are smaller than those of C16 ready-mixed concrete cast by Set Ready-Mixed Concrete Firm.

One-Way Variance Analysis

CONCLUSION

To compare and make these obtained values meaningful, one-way variance analysis was performed and the accuracy of the proposed hypotheses was investigated, and a mathematical equation model was developed as follows:

$$Y_{ij} = \mu + \tau_j + \varepsilon_{ij}$$
$$i = 1,2,3,4 \quad j = 1,2$$

Table 4 presents the compressive strength values obtained from the columns at the end of the test.

Table 4. Mass array for one-way variance analysis (VA).

	I –SET CONCRETE	II- POLAT CONCRETE
	(N / mm²)	(N / mm²)
	24.2	20.5
	26.0	22.4
	28.2	22.0
	24.1	20.8
Mass Mean (μ)	25.63	21.43

The model equation can also be written as follows:

$$Y_{ij} = \mu + (\mu._j - \mu) + (Y_{ij} + \mu._j)$$

Thus,

$$Y_{ij} - \mu = (\mu._j - \mu) + (Y_{ij} + \mu._j)$$

As the means are unknown here, test means and general means can be estimated by randomly extracting samples from each mass. Table 5 shows the Sample Array for One-Way Variance analysis.

Where $T._j$, is the total number of observations in test j., n_j is the number of observations in test j., and $Y._j$ is the mean of the observations in test j. T.. is the general total of all observations and Y.. is the mean of all observations (CELIK, 2000).

Table 5. Sample array for one-way variance analysis.

	I –SET CONCRETE (N/mm²)	II- POLAT CONCRETE (N/mm²)	
	24.2	20.5	
	26.0	22.4	
	28.2	22.0	
	24.1	20.8	
Total	102.5	85.7	T.. = 188.2
Number of Observations	4	4	N = 8
Means	25.63	21.43	Y = 23.53

Calculations are made easier by extracting 24 from the data (HICKS, 1985). Table 6 presents the coded data calculated by extracting 24 from the compressive strength values.

Table 6. *Coded data for the concrete columns applied with the Schmidt Hammer.*

	I –SET CONCRETE (N/mm²)	II- POLAT CONCRETE (N/mm²)	
	+ 0.2	-3.5	
	+ 2.0	-1.6	
	+ 4.2	-2.0	
	+ 0.1	-3.2	
$T_{\cdot j}$	+ 6.5	-10.3	T.. = -3.8
N_j	4	4	N = 8
$\sum_{j=1}^{nj} Y^2_{ij}$	21.69	29.05	$\sum_{j=1}^{k}\sum_{i=1}^{nj} Y_{ij}^2 = 50.74$

By the help of Table 6, general sum of squares is calculated as:

$$KT_{General} = \sum_{j=1}^{k}\sum_{i=1}^{nj} Y_{ij}^2 - \frac{T^2_{..}}{N} = 50.74 - \frac{(-3.8)^2}{8} = 48.94$$

And between-test sum of squares is computed as follows:

$$KT_{Test} = \sum_{j=1}^{k} \frac{T^2_{ij}}{n_j} - \frac{T^2_{..}}{N} = \frac{(6.5)^2}{4} + \frac{(-10.3)^2}{4} - \frac{(-3.8)^2}{8} = 35.27$$

Thus,

The sum of error squares is found as:

$KT_{Error} = KT_{General} - KT_{Test} = 48.94 - 35.27 = 13.67$

These calculated values are shown in the Variance Analysis Table in Table 7.

Table 7. *Variance Analysis Table.*

Source	Sd	KT	KO
Between-test τ_j	1	35.27	35.27
Within-test or error ε_{ij}	6	13.67	2.28
General	**7**	**48.94**	

The "F test" was selected to test the accuracy of the experiments. Thus, with the computation method, the "F" value was found as follows:

$$F_{1,6} = \frac{K.O.\ (\text{Test})}{K.O.\ (\text{Error})} = \frac{35,27}{2,28} = 15,47$$

Given the significance level of α = 0.05, from distribution table "F", it is calculated that $F_{(1,6)}$ = 5.99. Then, since $F_{(Calculation)} > F_{(Table)}$, the hypothesis is rejected and the related significance graph is as shown in Figure 2.

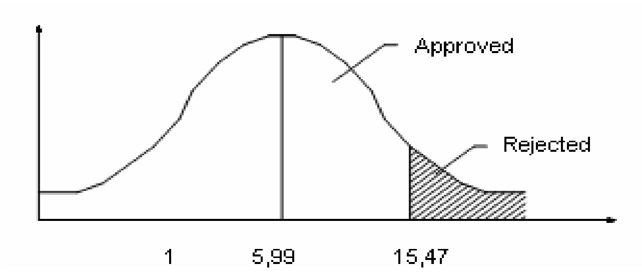

Figure 2. *F test graph (α = 0.05 significance graph).*

There is a significant difference between the calculated "F" value and the "F" value calculated from the table.

Orthogonal Contrasts

Orthogonal contrasts should be created between the compressive strengths of C16 ready-mixed concretes of Set and Polat Ready-Mixed Concrete firms to check the variance analysis.

Since the degree of freedom between the ready-mixed concrete firms is 1, one orthogonal contrast can be created for ready-mixed concretes. Thus,

$$C_m = \sum_{J=1}^{7} Cjm.T.j \quad \text{and} \quad \sum_{J=1}^{7} Cjm = 0$$

and the orthogonal contrast is created as C = $T_1 - T_2$. Coefficients of this contrast are shown in Table 8.

Table 8. *Table of orthogonal coefficients.*

Schmidt Hammer	T_1	T_2
C	+ 1	- 1

The result is calculated by placing the values in the given equation.

It is calculated that C = (1)(6.5) + (-1)(-10.3) = 16.8

On the basis of these data, if the related sum of squares is calculated using the following equation

$$KTC_m = \frac{C^2{}_m}{n\sum_{j=1}^{k} C^2{}_{jm}} \;;$$

Then,

$$KTC = \frac{(16,8)^2}{4(1)} = 70,56 \quad .$$

As the "F" test gave $F_{(Calculation)} > F_{(Table)}$ at a significance level of α=0.05, the hypothesis has been rejected. The means of the compressive strength values for concretes cast by different ready-mixed concrete firms differ at a significance level of α=0.05.

CONCLUSION AND SUGGESTIONS

In the present study, as a result of the experiments conducted using the Schmidt Hammer on C16 ready-mixed concretes cast in the same building by Set and Polat Ready-Mixed Concrete Firms, differences were found between the concrete compressive strengths. In a study in 1994 that compared the classical and ultrasound methods in assessing concrete strength, ÖZTÜRK argued that depending on cement hydration development, Schmidt Hardness value increased with time and concrete age. The data obtained in the study revealed a difference in compressive strengths of concretes cast with 25 days difference due to cement hydration. Nevertheless, the difference of seasonal temperatures between the earlier-cast ready-mixed concrete and that cast later was found to be a factor that affects compressive strength. Therefore, the compressive strength of the concrete cast later will increase in time.

In today's construction industry, ready-mixed concretes preferred for time and economical reasons are subjected to the required quality control procedures before they are cast in buildings; therefore, no significant difference is observed among the compressive strengths of concretes cast by ready-mixed concrete firms.

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