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THE DETERMINATION OF SURFACE HARDNESS OF READY-MIXED CONCRETE APPLICATIONS IN EDIRNE BY USE OF SCHMIDT HAMMER

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Abstract: *Within this study, the applications of ready-mixed concrete in Edirne are examined in terms of surface hardness and compressive strength. The measurements, done on the load-bearing elements of buildings with schmidt hammer, are then analysed in comparison with the values taken from concrete-mixing plants. When measurements done by using schmidt hammer in situ are compared with the press compressive strength values taken from concrete-mixing plants, it is seen that the compressive strength values found from the building elements are rather below the values of compression that are taken from the concrete-mixing plants. The inadequacies of concrete curing and compacting in the sites are accepted as the factors that lead to this result. On the other side, the strength losses, which result from the inadequacies of concrete curing, compacting and other technical issues, are determined.*
Keywords: *Conrete plant, non-destructive test, ready-mixed concrete, strength, schmidt hammer,*

Introductıon

Ready-mixed concrete is the fresh concrete which includes the components of cement, natural or artificial aggregate, water and chemical additive if needed; which is measured in the concrete mixing plant and which is delivered to the constructions after the process of measuring and mixing water occurs at the concrete-mixing plant or within the transit mixer. By programming the components of ready-mixed concrete with the help of computers, production is made at the desired level of quality. Since ready-mixed concrete can be produced in a large amount and in a very short time, it offers a greater possibility to save on labour and time than conventional (traditional) concrete offers and it provides a contemporary work possibility (Kamışlı, 1997).

The properties such as adequate strength to the earthquake, ductile behaviour and limited lateral shaking to the sides are sought for the buildings. Reinforced concrete has a distinct place to ensure that these conditions are provided. When the building is designed, detailed and applied appropriately to the regulations, it is seen that concrete and reinforced concrete are the most important elements (Ersoy, 2004).

In Turkey, where 92% of its land and 95% of its population are under the various degrees of earthquake effect, the social and economic losses resulting from the earthquakes make it necessary to take serious precautions (Kibici, 2005). Between 1900 and 2003, a number of 182 damaging earthquakes occurred and as a result a number of 100.000 people were dead in Turkey (www.bayindirlik.gov.tr, 2008). As a result of the earthquakes that occurred on the 17th of August and on the 12th of November in 1999, over a number of 15.000 people were lost, 30.000 people were injured and 70% of the buildings collapsed (Çetiner, 2005).

In Edirne, a destructive earthqukae, which was recorded as the “Edirne Earthquake”, occurred on 18 June 1953. “During the earthquake 270 buildings had serious damages and 5300 buildings had slight damages. The domes of the historical mosques, which were builded in the 15th and 16th centuries, cracked in Edirne and in the neighbouring villages” (www.jmo.org.tr, 2008). The earthquake risk is low in Edirne, where is located in the 4th seismic region. However, the buildings that have been constructed on the poor ground by using unqualified concrete, will be under threat, since a possible earthquke in Istanbul is likely to be felt in Edirne.

The buildings are provided dimensions after the calculations that are done considering the dead weight effects and live weight effects. The reinforced concrete building elements should have adequate strength to load effects. Knowing the strength values is very important in terms of controlling and evaluating the buildings (Yazıcı ve Ark., 2006).

It is generally accepted that ready-mixed concrete applications are better in order to have the desired strength. It can be said that; Turkish ready-mixed concrete sector has the latest technological equipment, as well as an experienced workforce. The ready-mixed concrete industry in Turkey is able to produce the desired grade of concrete. (Özkul ve Ark., 1999).

Within this study, the quality of the concrete, which is produced by the ready-mixed concrete plants in the city center of Edirne, is investigated by the method of measuring surface hardness. The direction and the effect grade of the strength are determined by obtaining measures from the ready-mixed concrete plants and from the buildings.

In the city center of Edirne, there are two concrete-mixing plant firms, which are named A and B. The firm A began to work in 1993, and the firm B began to work in 2006 in the city center of Edirne. In these concrete mixing plants, production is made through the wet system. The grade of the desired concrete is communicated to the control room-with computer. Cement and aggregate, which has the required diameter and weight, are automatically taken by the system and then they are filled into the transit mixers that readily wait in the filling place. Both of the firms have the instruments that can measure the dampness of the aggregate and the workability of the mortar. In the Table 1., the education levels of personnel according to their positions in the concrete-mixing plant firms in Edirne have been analysed in comparison with the education levels of personnel in the concrete-mixing plant firms in Bursa and Elazığ.

Table 1. Personnel Positions In Concrete Firms

PERSONNEL POSITION	FIRMS IN EDIRNE (Number of Personnel+Education)		FIRMS IN BURSA (Number of Personnel+Education)*			FIRMS IN ELAZIG (Number of Personnel+Education)**	
	A	B	A	B	C	A	B
Chairman (General Manager)	1PE	1U	1U	1U	1U	1U	1U
Assistant General Manager	1HS	1U	-	-	-	1U	-
Managing Director	1CL	-	4U	1U	1U	-	1CL
Technical Manager	1HS	-	1U	8U	13U	1U	-
Engineer	-	-	8U	17U	27U	1U	-
Site(Production, Division) Chief	-	1U	4U	6U	14U	1U+1U	1U
Chargehand	-	-	11CL +5HS	15U+ 12IVHS +25HS	20CL	1PE+3CL	1PE +1CL
Technician	-	-	5HS+ 12HS	100IVHS	13HS+ 144HS	4PE+1CL	-
Responsible for Laboratory	1U	1HS	-	-	-	-	-
Secretary (Officer)	-	-	1HS	2HS	15HS	-	3THS
Operator(For Loader, Plant, Band, Pump)	1HS+3PE+ 1PE+1HS+ 1PE+2PE	1HS+1HS+ 2HS	22HS	-	25HS	-	1PE
Worker (Driver, Welder, Helper, Cook, Tier Repairer, Watchman, etc.)	15PE+2HS +2PE+1HS +1PE+1PE +1PE	-	320PE	312PE	561PE	5PE	5PE
Other (Accounting, Marketing, Purchasing,Technical Superviser, Controller, etc.)	1U+1CL+ 2HS+1U+ 3PE	3CL+ 1CL+ 1CL+5PE	-	-	-	2HS	-

Quality-Controll	TS EN 206–1 Certificate TS 706 EN 12620 Certificate BS OHSAS 18001 ISO 9001	TS EN 206–1 Certificate ISO 9001	-	-	-	-	-
Notation	PE= Primary Education, HS=High School, Industrial Vocational High School: IVHS, College=CL, Technical High School=THS, University=U						

* (Oymael ve Yeğinobalı, 1993), ** (Aksoy ve Oymael, 2000).

Experimental Findings and Discussion

The compressive strength of the reinforced concrete bearing elements of buildings are measured on the buildings which locate on the east, west, south and north sides and in the middle of the city center of Edirne. These selected buildings are accepted to represent the buildings in the city center of Edirne. In order to increase the validity and reliability of the measures obtained by schmidt test method, each 10 hits of the schmidt hammer on the reinforced concrete building element are accepted to be one measure value. Depending on the survey method and technique of the building materials, it is accepted that the average of three samples make one compressive strength value; therefore 30 schmidt hits are suggested on a column or on a beam for every building. This means that in general 90 test hits were made on each building. The number of the schmidt test hits on totally 103 buildings (231 building elements) is 6930. The biggest and the smallest values founded by the schmidt test hits are eliminated. The values taken from the schmidt instrument are turned into equivalent cube strength by using computer softwares (Arıoğlu, 2008).

The press compressive strength values of the 15cm sized cube samples of the concrete, that was sent by the firms to the constructions, have been found from the firm records and the difference betwen the compressive strength values of these samples and the application compressive strength values of the buildings is represented. Furthermore, whether the frequency of sampling from the produced concrete fits TS EN 206-1 (Table 2) (TSE, 2002), is investigated. Within the survey, each grade of concrete is evaluated within its own circumstances and the concrete is examined in 3 groups, that are C20, C25 and C30. The values of concrete compressive strength found within the survey universe are presented in Table 3,4 and 5.

Table 2. The Frequency of Minimum Sampling for Accreditation

Production	**Frequncy of Minimum Sampling**		
	The first 50 m^3 of production	Production after first 50 m^3 [a]	
		Concrete having production controll certificate	Concrete having not production controll certificate
Starting (Until 35 experiment results are obtained).	3 samples	One per 200 m^3 or two per a weekly production.	One per 150 m^3 or two per a daily production.
Continuosly [b] (After 35 experiment results are obtained)		One per 400 m^3 or one per a weekly production.	

[a] Sampling procedure should extend the whole production and shouldn't be more than 1 for each 25 m^3 concrete volume.
[b] If the standard deviation of 15 experiment results is over 1.37σ, the frequency of sampling should be increased to the frequency that is needed for starting production, until the later results of 35 experiments are obtained.

Table 3. C20 Concrete Columns Compressive Strength

Building Numbers	C20	The Readings of Schmidt Test Hammer										Means. (R)	Equivalent Cube Strength Means (N/mm²)	Plant Cube Strength Means (N/mm²)
1	1.Floor	31	35	32	28	36	40	37	34	34	37	34.4	30.6	29.2
		34	37	35	37	39	31	35	34	35	40	35.7		
		30	36	33	37	39	31	35	34	35	40	35.0		
2	1.Floor	28	32	38	35	39	35	36	40	37	37	35.7	32.0	28.1
		38	31	33	34	36	41	39	43	33	39	36.7		
		36	38	32	39	35	37	41	37	32	29	35.6		
3	1. Floor	31	32	38	35	38	38	34	33	35	33	34.7	30.3	28.3
		32	32	31	33	41	33	36	37	31	34	34.0		
		36	36	37	34	36	32	38	37	30	42	35.8		
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		.	.	.	.	.	.	.	.	.	.	.		
		.	.	.	.	.	.	.	.	.	.	.		
(n) 55	1.Floor	31	29	29	30	31	29	30	30	27	29	29.4	22.4	28.9
		28	27	30	29	26	27	29	30	31	30	28.7		
		32	30	33	31	29	28	28	29	31	19	28.9		

Table 4. C25 Concrete Columns Compressive Strength

Building Numbers	C 25	The Readings of Schmidt Test Hammer										Means. (R)	Equivalent Cube Strength Means (N/mm²)	Plant Cube Strength Means (N/mm²)
1	1.Floor	35	38	33	33	35	35	28	36	40	40	35.3	30.2	33.6
		32	36	35	32	28	35	32	33	39	36	33.8		
		34	35	36	35	39	30	35	36	34	39	35.3		
2	1.Floor	31	34	33	34	38	34	31	36	34	37	34.2	30.5	37.7
		32	36	37	38	35	41	39	36	35	37	36.6		
		33	36	34	33	38	34	35	28	35	36	34.2		
3	1.Floor	38	36	35	37	39	37	33	34	36	37	36.2	31.9	33.6
		36	38	37	31	42	35	30	34	42	31	35.6		
		38	38	34	35	39	36	34	34	35	37	36.0		
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		.	.	.	.	.	.	.	.	.	.	.		
		.	.	.	.	.	.	.	.	.	.	.		
(n) 44	1.Floor	32	28	38	32	36	32	26	31	30	32	31.7	25.5	32.5
		30	27	31	37	30	32	30	30	31	30	30.7		
		36	33	33	34	33	27	29	32	33	29	31.9		

Table 5. C30 Concrete Columns Compressive Strength

Building Numbers	C 30	The Readings of Schmidt Test Hammer										Means. (R)	Equivalent Cube Strength Means (N/mm^2)	Plant Cube Strength Means (N/mm^2)
1	1.Floor	32	34	36	30	36	30	36	42	39	40	35.5	30.9	40.9
		30	34	36	35	37	36	32	34	33	34	34.1		
		34	38	37	39	34	42	36	32	34	37	36.3		
2	1.Floor	38	42	40	38	38	42	43	39	41	41	40.2	33.2	36.0
		37	37	34	38	43	40	28	37	35	32	36.1		
		35	35	36	37	32	37	33	39	31	26	34.1		
3	Basement	38	37	31	37	35	38	35	36	36	38	36.1	32.4	36.7
		37	40	34	40	36	36	35	35	38	39	37.0		
		38	38	37	38	39	38	39	42	41	43	39.3		
	1.Floor	36	38	34	35	39	30	35	34	39	33	35.3		
		38	34	39	39	36	34	38	39	40	35	37.2		
		31	38	36	31	40	33	39	28	35	33	34.4		
	2.Floor	35	33	32	33	35	35	32	32	32	33	33.2		
		31	35	42	39	35	42	35	33	38	37	36.7		
		38	36	38	39	34	37	34	38	41	37	37.2		
4	1.Floor	33	37	38	35	38	40	41	36	34	31	36.3	30.2	37.0
		34	38	36	34	30	31	37	37	34	33	34.4		
		32	34	32	33	39	33	33	35	36	30	33.7		

Σ hit numbers : 231 x 30 = 6930 Numbers.

With the help of computer softwares, the statistical solutions such as arithmetic mean, standart deviation and variation coefficient are calculated on the basis of compressive strength values found in terms of equivalent cube strength (Table 6). In order to determine the adequacy of the concrete, the quality of the concrete is examined depending on the variaton coefficient (Table 7) (Çelik ve Eren, 1993).

RESULTS AND SUGGESTIONS

Within this study, the press strength values of concrete that are taken from the concrete-mixing plants in Edirne are compared with the schmidt strength values that are found by the measurements done on the building elements. Within the study, three different groups of concrete strength - which are C20, C25 and C30 and in addition the conventional concrete C22.5 are sampled.

It is seen that the press strength values of the C20 group concrete, that is taken from the concrete mixing plants, are higher than the schmidt strength values. While 7% of the values of press compressive strength of the C20 group concrete, taken from the concrete mixing plants, is lower than the C20, this percentage is 24% for schmidt strength. This judgement is valid for C25 and C30 grade concrete groups. As these percentages are compared with the conventional C22.5 concrete grade, the situation becomes worse for the conventional concrete. The percentage of conventional concrete to remain lower than the grade strength according to C22,5 is 100%, and the percentage of conventional concrete to remain lower than the C16 grade concrete strength is 27% (Table 6). It means that, the press strength values of the concrete samples taken from concrete mixing plants are higher than the compressive strength values of concrete used in the buildings. This percentage is too high to be compared with the conventional concrete. The reasons of this result can be the weaknesses of the methods and techniques of compacting ready-mixed concrete, the inadequate curing of the samples and the absence of other conditions, as well as the inadequacies resulting from the workers.

Table 6. Statistical Analyses of Concrete Compressive Strength Values

	Schmidt Test Hammer Compressive Strengths on the Building (N/mm^2)							
.chmidt Strength	Concrete Grade	Building Numbers	Element Numbers	Arithmetic Mean (N/mm^2)	Standard Deviation (N/mm^2)	Variation Coefficient (%)	Characteristic Strength (N/mm^2)	Under Grade Concrete Strength Rate (%)
	C20	55	372	26.5	4.1	15.5	21.3	24
	C25	44	303	29.2	3.7	12.6	24.5	64
	C30	4	18	31.9	1.4	4.4	30.1	1
16	**Compressive Strengths at the Concrete-Mixing Plant (N/mm^2)**							
Press Strength	Concrete Grade	Building Numbers	Cube Numbers	Arithmetic Mean (N/mm^2)	Standard Deviation (N/mm^2))	Variation Coefficient (%)	Characteristic Strength (N/mm^2)	Under Grade Concrete Strength Rate (%)
	C20	55	55	29.1	1.8	6,2	26.8	7
	C25	44	44	32.1	2.2	6,8	29.3	13
	C30	4	4	37.7	1.9	5	35.3	0.5
	Conventional Concrete Press Compressive Strengths (N/mm^2)							
Press Strength.	*C22.5	-	-	12.0	42.0	33	66.0	74
	**C16	153	459	19.6	42.5	21	14.6	**27

***** Concrete grade strength values are values of 1997 for C22.5 concrete. (Sezer, 1997).
** The percentage of remaining below C16 is 27%.

Table 7. Concrete Quality Varying Due to the Variation Coefficient[13].

Work Grade	Excellent	Good	Medium	Poor
Common Construction Concrete	< 10%	10-15%	15-20%	> 20%
Labarotary Concrete	< 5%	5-7%	7-10%	> 10%

The variations of the compressive strenght values of C20, C25 and C30 concrete according to the sample numbers are given in Figure 1, Figure 2 and Figure 3. It is seen that the press strength values of each concrete group is very variable. Here, it is seen that the concrete, that has the same characteristic, may have a different performance at different buildings. As it can be seen from the tablaeus and figures, the biggest concrete grade is C30. The number of data and buildings that are constructed by using concrete, which is higher than C30, isn't enough. It means that, concrete, having a higher strength than C30, is not usually preferred to be used in the construction of buildings in the city center of Edirne.

In order to be a basis to determine the quality control levels during the application of concrete in the constructions; the percentages of concrete quality, which varies depending on the variation coefficients, are given in Table 7. According to these limits, it is seen that the variation analysis values of press compressive strength of C20 grade concrete is 6.2%, the variation values of schmidt strength is 15.5%, and the variation values of press strength of conventional concrete is 21-23%. It means that the press strength values of concrete samples, that are taken from the concrete mixing plants, are controlled nearly twice better than the schmidt strength values that are found from the buildings. Because, the variation coefficient of press strength values taken from the concrete mixing plant is 6.2%, which is below the perfect limit 10%. The level of controlling the qualities of ready-mixed concrete is also parallel with C25 and C30 grade concrete. Conventional concrete is too weak to be involved in such a comparison.

Within the process of concrete production, it is a necessity to decrease the risks, when the high costs of unqualified production is considered. The buildings, which can affect human life and society, are so variably characterized that it is an obligation to obey the standarts and regulations, technical spesifications and to do controlls in order to improve these variable characteristics.

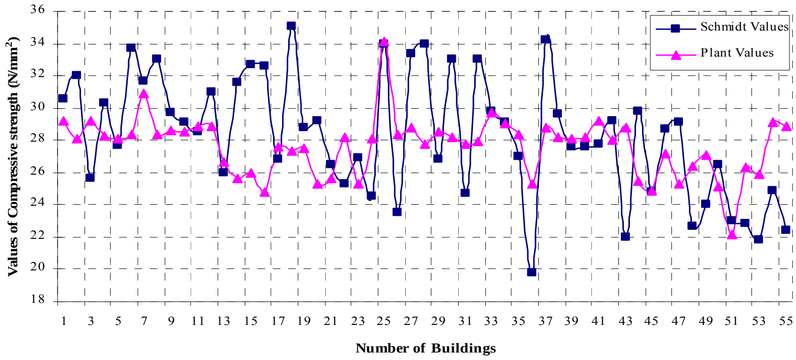

Figure 1. Compressive Strength Values of Buildings (C20)

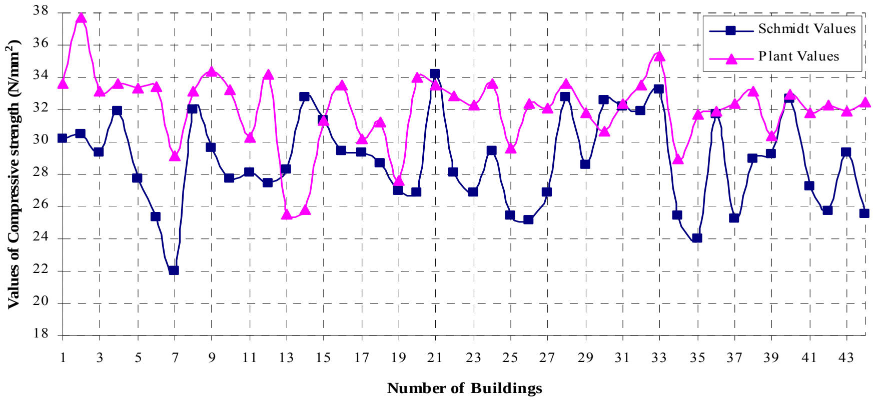

Figure 2. Compressive Strength Values of Buildings (C25)

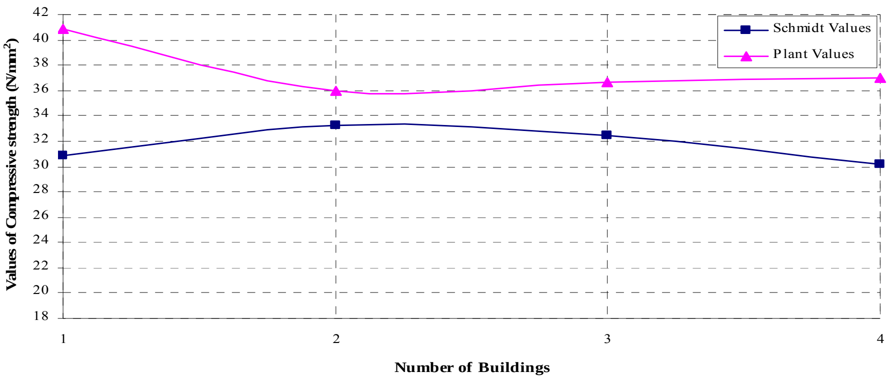

Figure 3. Compressive Strength Values of Buildings (C30)

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