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M. Kamal
Building Research Centre., Cairo., Egypt.

A. Abdel-Reheem
Assistant Professor., Civil Engineering Department., Faculty of Engineering., El-Mansoura University., Mansoura., Egypt.

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QUALITY CONTROL BETWEEN THEORY AND PRACTICEIN BUILDING INDUSTRY

Dr. M.M. Kamal
Building Research Centre
Cairo, Egypt.

Dr. A.H.A. Abdel Reheem
Civil Eng. Dept.
Mansoura Univ.

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الخلاصة :

تم التخطيط لهذا البحث لدراسة وتقييم بعض العناصر التى تؤثر فى جودة الخرسانة . تم اختبار عدد ستمائة مكعب خرسانى يمثلون مائة عينة تم اخذهم من عشرين موقع عمل مختلفه فى محافظة الدقهلية وتم اختبار مقاومتهم للضغط فى اعمار ٧ أيام و ٢٨ يوم . ثم حساب متوسط مقاومة الضغط للخرسانة و الانحراف المعيارى ومعامل الاختلاف للعينات المختلفة كما تم توقيع بعض العلاقات التى تساعد على تقييم جودة الخرسانة . ولقد دلت الدراسة على ان جودة الخرسانة تتوقف الى حد كبير على كفاءة العنصر البشرى ومقدار فهمه وتطبيقه لاصول ضبط الجودة . كما اوضحت الدراسة الحاجة الى زيادة العناية بضبط جودة الخرسانة على المستوى التطبيقى .

ABSTRACT

This research was conducted to investigate and assess some of the factors affecting the quality of concrete. Six hundred concrete cubes out of one hundred samples were taken from twenty different sites at different locations in El-Dakahlia governerate. They were tested in compression. Average compression strength values, the standard deviation and the coefficient of variation were computed and correlations were made.

The study indicated that the human factor is very significant and the quality control in general is deficient and needs to be reviewed.

INTRODUCTION

In the last few years failures in buildings due to the poor quality of concrete increased with high frequancy in Egypt Fig. (1). This fenomina was investigated by different research workers in different countries (1 - 6). In Egypt extensive research has been started either in the laboratory or in the field (7-9)

The present study was planned to investigate the quality of concrete in the governerate of El-Dakahlia. Six hundard concrete cubes out of one hundred samples were taken from twenty different sites and tested in compression. These samples were provided by the inspectors authorised for quality control in the different construction sites and tested at the Strength of Materials laboratory in El-Mansoura University.

EXPERIMENTAL WORK

Compression test was carried out on 600 concrete cubes representing mainly two groups. The first group consisted of fifty two sets each of six cubes taken from the same batch, cured in water and tested at 7 days age. The second group consisted of forty eight sets of six cubes each tested at 28 days age. Tests were carried out in accordance with the British Standard Specifications B.S. 1881.

For each set of concrete cubes tested in compression at 7 days age or 28 days age, the mean strength, the standard deviation and the coefficient of variation were computed and correlations were made.

To evaluate the concrete quality, certain procedure was carried out into the test results of the first group of cubes tested at 7 days age (312 cubes) as well as the second group of cubes tested at 28 days age (288 cubes). For each group the cubes were arranged in desending order according to their strength then devided into sets with equal class interval with a range of 30 Kg/cm². The average strength value of each set was calculated as well as the frequancy which is the number of cubes with strength lies within the boundries of each set.

Check sheets, histograms and Ogive comulative curves were plotted from which the mode and the median values were determined.

The standerd deviation for each set of cubes was evaluated according to the A.C.I. classification. An overall veiw was carried out to evaluate the general situation of the cubes tested at 7 days age as well as those tested at 28 dyas age.

An analytical relationship was determined between the compressive strength of the concrete cubes recived from the different construction sites of El-Dakahlia provence and tested at 7 days age and those tested at 28 days age.

ANALYSIS AND DISCUSSIONS

Tables (1 and 2) show the test results of the different sets for concrete cubes tested at 7 days age and for those tested at 28 days age, respectivelly. Generally speaking, it is clear that there is a great difference between the strength of the different cubes within the same set. However, table (1) shows that the average compressive strength of the 312 concrete cubes tested at 7 days age is 215.59 kg/cm², while, the average standard deviation is 54.12. The coeffecient of variation varied between 4.17 and 54.34. Table (2) shows that the average compressive strength of the 288 concrete cubes tested at 28 days age is 280.12 kg/cm², while, the average standard deviation is 64.21. The coefficient of variation varied between 6.73 to 30.44. These results indecate that good effort was done by the inspectors which led to concrete of reasonable average strength, however, these inspectors need more training on the quality control and inspection applications.

Tables (3 and 4) show the concrete compressive strength of the cubes tested at 7 days age and those tested at 28 days age respectively as arranged in desending order. Tables (5a and 5b) show the classification of concrete strength into sets with definite limits. However, the range of each set and the frequency of test results are also indicated. The check sheets and the histograms shown in Figs. (2 and 3) indicate that the highst frequency (the mode) of the 7 days and the 28 days concrete compressive strength are at 225 kg/cm² and 205 kg/cm², respectively.

Table (6) and Fig. (4) show that the median of the 7 days age test specimens is 217 kg/cm². However, table (7) and Fig. (5) show that the median of the 28 days age test specimens is 270 kg/cm².

The Egyptian Code of Practice stated that the strength of concrete used in reinforced concrete structures should not be less than 120 kg/cm². However, about 1.0 % of the tested cubes were of strength less than 120 kg/cm² at 28 days age. The Code of Practice stated also that the strength of the hand mixed concrete with 300 kg/m³ cement should not be less than 160 kg/cm². However, about 5 % of the tested cubes were of strength less than 160 kg/cm² at 28 days age.

Tables (8 and 9) show the evaluation of the different concrete mixes tested at 7 days and 28 days age respectively with respect to the standard deviation and taking the classification of the A.C.I. Code into consideration.

Table (10) and Fig. (6) show the evaluation of the whole status of the quality of concrete tested at 7 days age, while, table (11) and Fig. (7) show the evaluation of those cubes tested at 28 days age.

A summery of the whole situation as classified according to the A.C.I. Code is shown in Fig. (8).

The relationship between the 7 days and the 28 days concrete compressive strength is plotted in Fig. (9). Big agreement is found between the expression drived through a computer program for curve fitten ($f_{c28} = 1.3 f_{c7} - 15.049$ kg/cm²) and the imperical expression ($f_{c28} = 1.26\ f_{c7}$).

CONCLUSIONS

This research study led to the following conclusions:

1. In quality control the human factor is very significant, thus, the inspectors should be given extensive training courses in such field and its application in the laboratory and in the site.
2. More care should be taken for the quality control of concrete as a product.
3. The expression drived througth a computer program for curve fitting of the experimental test results obtained in this research is $f_{c28} = 1.3\ f_{c7} - 15.049$. This expression is in a good agreement with the imperical expression $f_{c28} = 1.26\ f_{c7}$ which relates the concrete compressive strength at the age of 28 days to that at 7 days age.

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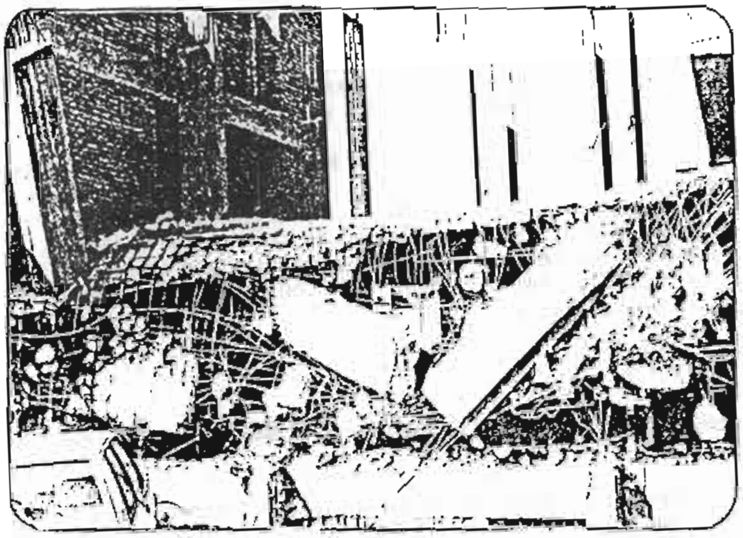


Fig. (1) Building Failure

Table (1)

7 Days Age Compressive Strength (kg/cm²)

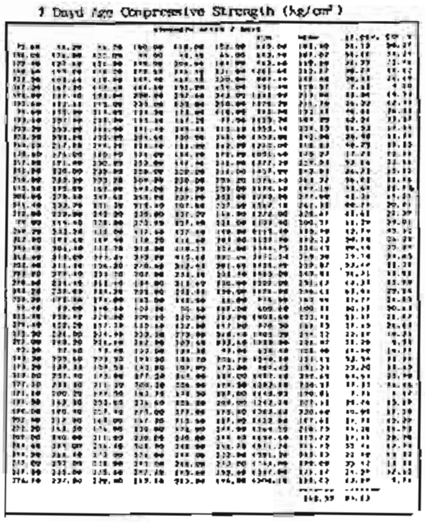


Table (2)

28 Days Age Compressive Strength (Kg/cm²)

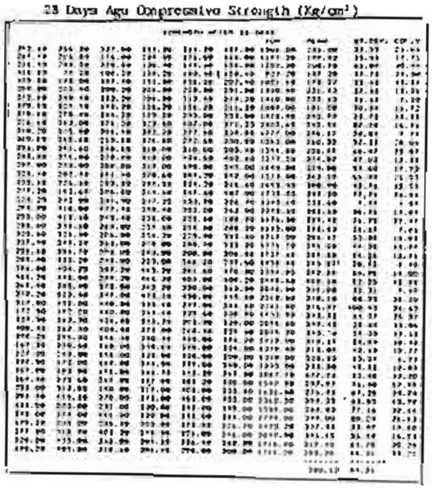
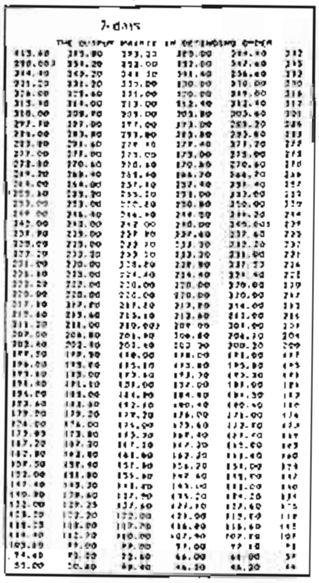


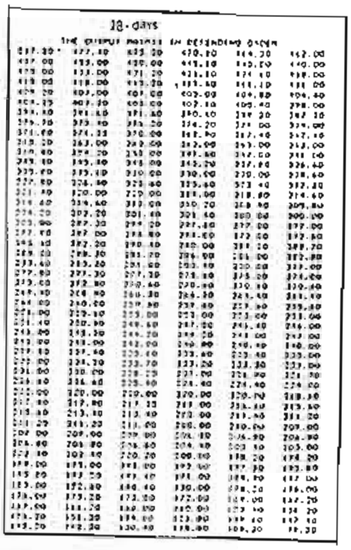
Table (3)



7-days

THE OUTPUT MATRIX IN DESCENDING ORDER

Table (4)



28-days

THE OUTPUT MATRIX IN DESCENDING ORDER

Table (5)

a- FREQUENCY TABLE
FOR 7 DAYS

NO. OF SETS	LIMITS OF SETS	AVERAGE OF SET	FREQUENCY
1	30-60	45	7
2	60-90	75	3
3	90-120	105	22
4	120-150	135	15
5	150-180	165	19
6	180-210	195	31
7	210-240	225	36
8	240-270	255	33
9	270-300	285	30
10	300-330	315	18
11	330-360	345	17
12	360-390	375	4
13	390-420	405	3

b- FREQUENCY TABLE
FOR 28 DAYS

NO. OF SETS	LIMITS OF SETS	AVERAGE OF SET	FREQUENCY
1	70-100	85	1
2	100-130	115	3
3	130-160	145	11
4	160-190	175	18
5	190-220	205	42
6	220-250	235	45
7	250-280	265	33
8	280-310	295	51
9	310-340	325	31
10	340-370	355	17
11	370-400	385	15
12	400-430	415	20
13	430-460	445	8
14	460-490	475	3
15	490-520	505	1

Table (6)

COMPRESSIVE STRENGTH 7 DAYS

NO. OF SET	MIN LIMIT OF SET KG/CM2	NO. OF READINGS ≥ MIN LIMIT OF SET	PERCENTAGE OF VALUE ≥ MIN LIMIT
13	420	312	100
13	390	309	99.04
12	310	303	97.76
11	312	288	92.31
10	300	270	86.54
9	330	240	76.92
8	240	205	65.76
7	160	147	47.13
6	200	96	30.77
5	150	57	18.27
4	120	32	10.26
3	90	19	2.3
2	60	2	1.24
1	30	0	0.0

Table (7)

COMPRESSIVE STRENGTH AFTER 28 DAYS

NO OF SET	MIN LIMIT OF SET KG/CM2	NO. OF READING LESS THAN MIN LIMIT OF SET	PERCENTAGE VALUE < MIN LIMIT
15	520	329	100
15	490	317	99.36
14	460	311	97.92
13	430	272	94.11
12	400	253	87.41
11	370	222	82.29
10	340	218	73.69
9	310	184	62.24
8	280	137	54.13
7	250	114	41.03
6	220	29	22.43
5	190	22	11.11
4	160	14	[illegible]
3	130	3	1.03
2	100	2	0.64
1	70	0.0	0.0

Table (8)

EVALUATION THE STRENGTH
AFTER 7-DAYS

No. of Test	Standard Deviation	Classification A.C.I
1	51.31	Poor
2	34.18	Poor
3	36.55	Good
4	28.14	Good
5	38.53	Good
6	7.13	Excellent
7	31.94	Very Good
8	24.33	Excellent
9	40.45	Good
10	53.55	Poor
11	51.52	Poor
12	28.19	Very Good
13	40.75	Good
14	17.71	Excellent
15	53.15	Poor
16	36.77	Good
17	56.53	Poor
18	45.65	Fair
19	42.36	Fair
20	60.75	Poor
21	63.61	Poor
22	66.70	Poor
23	83.54	Poor
24	50.76	Poor
25	60.44	Poor
26	74.70	Poor
27	53.49	Poor
28	31.71	Very Good
29	40.83	Poor
30	61.86	Poor
31	51.77	Poor
32	50.68	Poor
33	51.17	Poor
34	51.63	Poor
35	33.49	Very Good
36	18.78	Very Good
37	17.40	Excellent
38	57.56	Poor
39	28.70	Very Good
40	61.64	Poor
41	37.25	Good
42	7.91	Excellent
43	28.16	Very Good
44	40.08	Good
45	24.53	Excellent
46	46.20	Fair
47	53.07	Poor
48	55.46	Poor
49	32.40	Very Good
50	35.47	Good
51	37.59	Good
52	17.89	Excellent

Table (9)

EVALUATION THE STRENGTH
AFTER 28-DAYS

No. of Test	Standard Deviation	Classification A.C.I
1	52.83	Poor
2	35.85	Good
3	61.05	Poor
4	31.13	Good
5	23.40	Excellent
6	21.30	Excellent
7	41.53	Excellent
8	30.31	Very Good
9	35.17	Good
10	51.90	Poor
11	18.85	Very Good
12	51.23	Poor
13	65.47	Poor
14	47.07	Fair
15	51.60	Poor
16	56.45	Poor
17	43.74	Fair
18	72.31	Poor
19	9.33	Excellent
20	56.76	Poor
21	76.15	Poor
22	11.67	Excellent
23	53.89	Poor
24	44.30	Fair
25	51.16	Poor
26	29.42	Excellent
27	54.98	Poor
28	52.55	Poor
29	30.51	Very Good
30	80.55	Poor
31	100.13	Poor
32	64.31	Poor
33	38.64	Good
34	52.32	Poor
35	58.61	Poor
36	47.53	Good
37	23.51	Excellent
38	47.37	Fair
39	23.48	Excellent
40	45.10	Fair
41	61.20	Poor
42	63.09	Poor
43	77.16	Poor
44	85.24	Poor
45	33.15	Very Good
46	36.48	Poor
47	64.78	Poor
48	66.31	Poor

Table (10)

Table for 7-days

Evaluation	Tests	No. of Test	Percentage
Excellent	6-8-14-37-42-45-52	7	13.46
Very Good	7-12-28-35-36-39-43-49	8	15.38
Good	3 - 4 - 5 - 9 - 13 - 16-41-44-50-51	10	19.23
Fair	18 - 19 - 46	3	5.78
Poor	1-2-10-11-15-17-20-21-22-23-24-25-26-27-29-30-31-32-33-34-38-40-47 - 48	24	46.15

Table (11)

Table for 28-days

Evaluation	Tests	No. of Test	Percentage
Excellent	5-6-7-19-22-26-37-39	8	16.
Very Good	8 - 11 - 29 - 45	4	8
Good	2-4-9-33-36	5	10
Fair	14-17-24-38-40	5	10
Poor	1-3-10-12-13-15-16-18-20-21-23-25-27-28-30-31-32-34-35-41-42-43-44-46-47-48	26	54

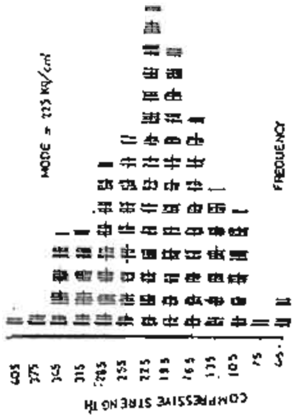


Fig. (2-a) Check Sheet for 7 Days

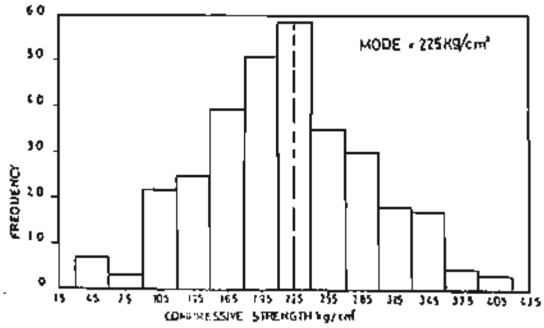


Fig. (2-b) Histogram for 7 Days

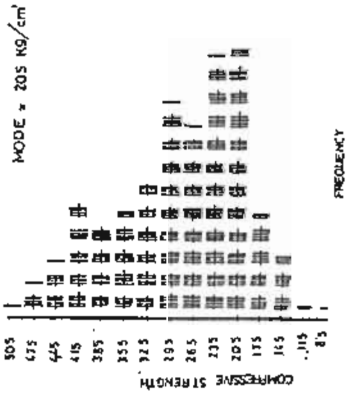


Fig. (3-a) Check Sheet for 28 Days

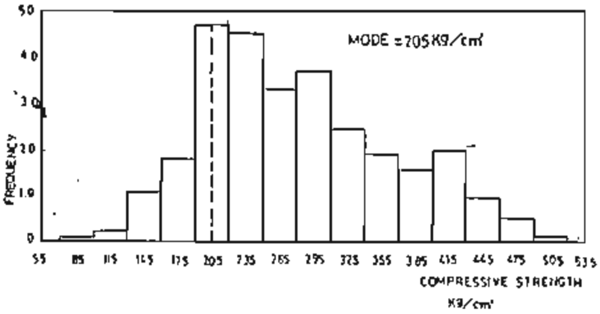


Fig. (3-b) Histogram for 28 Days

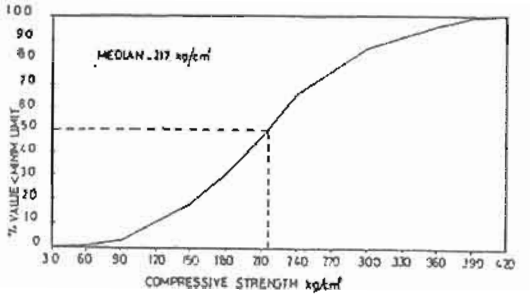


Fig. (4) Ogive Curve for 7 Days

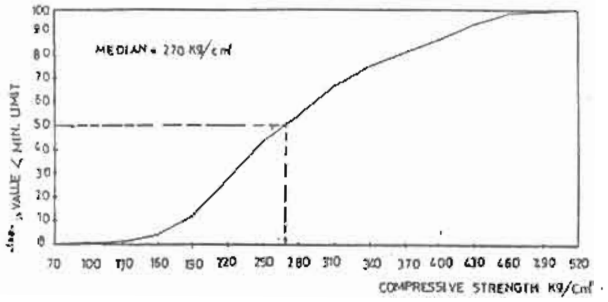


Fig. (5) Ogive Curve for 28 Days

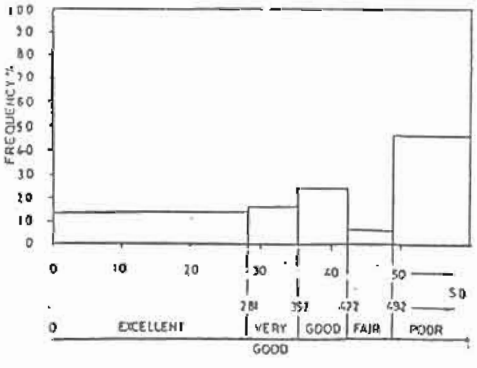


Fig. (6) Histogram for 7 Days

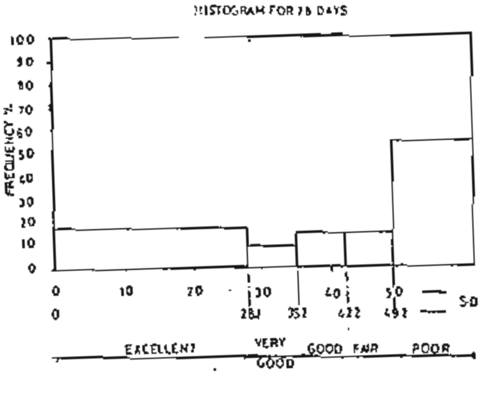
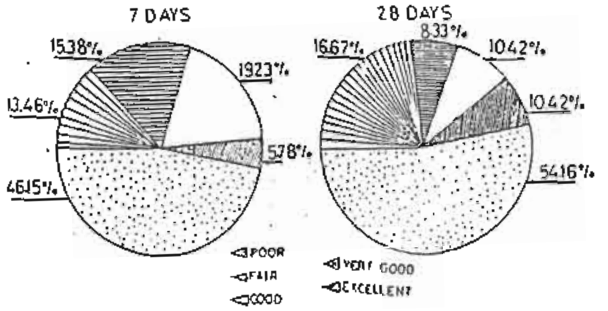


Fig. (7) Histogram for 28 Days

Fig. (8) CLASSIFICATION OF CONCRETE QUALITY ACCORDING TO ACI



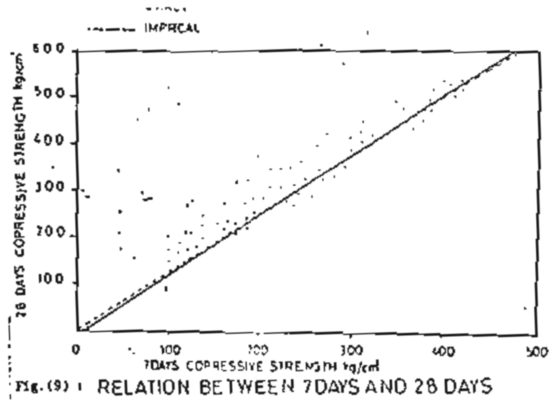


Fig. (9) : RELATION BETWEEN 7DAYS AND 28 DAYS