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Research Article

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Conformity Factors for Different Shapes and Sizes of Concrete Samples using their Relative Effective Length Ratio (Relr) Of

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Abstract A Novel method is developed in this paper for the determination of the conformity factors for different shapes and sizes of concrete samples with relationship to 150mm cube. Induced eccentricity in the samples tested is the determinant of the conformity factor. This eccentricity computed was from experimental data for various lengths to breadth ratio of test samples. The result of this study support the relationship between standard cylinder compressive strength and standard cube compressive strength in EN 206 and establishes new results for smaller sizes. Produced in this paper are Tables of factors to convert from any size to another, which hitherto may not have existed. The use of small size cubes and certification of designed concrete if encouraged will promote sustainability in concrete construction.

Keywords Concrete, Cube, Cylinder, Conformity, Strength, Sustainability

1. Introduction

In the course of re-validating the current code(s) method of the design of reinforced columns in a recent research, it was discovered, that there was a great disparity in strength results for a 150mm cube and a 50mm cube. This raised the enthusiasm to investigate this disparity. Literature shows that various researchers have studied the topic on effect of shape and size of test specimens for determination of concrete compressive strength as early as 1900.

Sizes and shapes of test specimens to determine the compressive strength of concrete are different for different countries. However, commonly used specimens are cylinders and cubes. Cylinders (Ø150mm×300 mm) are used in Australia, Canada, France, South Korea, the United States, and other countries whereas cubes (150 mm) are the standard specimens used in Germany, the United Kingdom, and many other European countries. Nigeria, Norway and several other countries, use both cylinders and cubes (i.e Ø150mm x 300mm cylinder and 150mm cubes). Gonnerman [1] Neville, [2,3] has reviewed research findings from extensive published literature and reported that the compressive strength of 100mm cubes are approximately 1.05 times those of 150mm cubes. There are few publications available on the strength comparison of 100mm and 150mm cubes. Published data were mostly on the comparison of the strength of concrete cylinders of different sizes. Gyengo; Murdock and Kesler and many other researchers were focused on some guidelines for translating the compressive strength of concrete determined from nonstandard specimens to that of standard specimens together with relationships between cylinder strength and cube strength for normal-strength concrete. Lessard found that the compressive strength of cylinders of 150mm diameter by 300mm was about 0.94 that of cylinders of 100mm diameter by 200mm height. Baalbaki et al repeated the experiment on a total of 126 cylinders and found that the strength of the cylinders of I50mm diameter was 0.93 that of cylinders of 100mm diameter. Mansur and Islam evaluated the interpretation of concrete strength for nonstandard specimens. However, their studies were limited to the interpretation of strengths between cylinders and cubes. CEB-FIP Model Code 1990 [10] also indicates that the ratio of the cube strength to cylinder strength with increasing compressive strength of concrete decreases progressively from 1.25 to 1.12 for the ratios corresponding to the cylinder compressive strengths of 40 and 80MPa, respectively.

BS EN 206 [4] adopts only 150mm diameter by 300mm length cylinders or 150mm cubes as standard specimens for determining compressive strength of concrete. Both BS EN 1992-1-1 [5] and BS EN 206 [4] provide for equivalent cube compressive strength corresponding to cylinder compressive strength. Generally, a factor of 1.2 is used to convert cylinder strength to cube strength for normal strength concrete NSC. However for high-strength concrete (HSC), the factor is gradually decreased from the value of 1.2 as the concrete strength increases. To help the question various researchers have agreed that end restraint due to the machine platen on cylinders create a complex system of stresses which usually reduce the value of compressive stresses. This they claim will result in cylinder and cube strengths obtained from the same batch of concrete to differ. It is the opinion of the authors that since the slenderness ratios of smaller cubes, 100mm, and 150 mm concrete cubes are both equal to unity, the only factor that can significantly affect the concrete strength is relative effective length ratio RELR. This paper is limited to the development of conformity factor to be used to convert cylinder strength to cube strength and vice versa for normal strength concrete NSC. The work shall be extended to producing factors to convert from one size to the other of same/different shape samples with different sizes. The paper is organized subsequently as follows: Theoretical Formulation, Relative Effective Length Ratio (RELR), Conformity formulation, Experimental Program, Results, discussion and conclusion of the work.

2.1. Theoretical Formulation

The compressive strength of concrete from all available information is a relative term. It is the strength of a 150mm cube or a 150mm diameter cylinder with a 300mm height depending on the country. Every other shapes and sizes from the same batch and age are compared to them and a conformity factor established. Cube of any size can be considered as a standard of comparison but in the final analysis, the result must be compared with that of a 150mm cube.

2.2. Relative Effective Length Ratio (RELR)

Test samples are considered as struts loaded in compression and therefore the critical load P_{cr} for a specimen is given as

$$P_{cr}=\lambda^2 P_E \qquad \text{Eq 1}$$

For any two samples of different shape and size from the same batch, the critical load must be the same. Therefore

$$\lambda_1^2 P_{E1} = \lambda_2^2 P_{E2} \qquad \text{Eq 2}$$

from where

$$\frac{\lambda_1^2}{\lambda_2^2} = \frac{P_{E2}}{P_{E1}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{P_{E2}}{P_{E1}}} \qquad \text{Eq 3}$$

If

$$P_E = \frac{EI\pi^2}{L^2} \qquad \text{Eq 4}$$

Then

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{I_2}{L_2^2}\frac{L_1^2}{I_1}} \qquad \text{Eq 5}$$

The RELR is the value given by equation 5 above.

2.3. Failure Load of Concrete Cubes and Prisms

The load recorded for the tested samples did not follow any of the known formula in literature i.e

$$P=\sigma A \quad \text{or} \quad P_E=\frac{EI\pi^2}{L^2} \qquad \text{Eq6}$$

It rather followed the pattern

$$\sigma = P/A + M/Z = P/A + Pe/Z = \frac{P}{A}(1+eA/Z) \qquad \text{Eq 7}$$

From where

P= $\sigma/(1/(A) + e/Z) = \sigma A/((1+eA/Z))$ Eq 8

2.4. Induced Eccentricity

Every term in Eq 8 is known except the induced eccentricity e. A and Z are the geometrical properties of the sample while P is the failure load of the sample recorded. σ is the compressive strength for a cube where e is always zero.

The induced eccentricity is given by

$$e = \left(\frac{\sigma}{P} + \frac{1}{A}\right) z \quad \text{Eq 9}$$

from the experimental results e is tabulated for Relative effective Length ratio from 1 to 20 for two mix designs in subsequent sections of this work.

2.5. Conformity formulation

Following simple strength of materials principle, direct compression strength of a particular grade of material must be a constant no matter the shape and size. Therefore for any number of different shapes or sizes of concrete specimen from the same batch

$$\frac{P_1}{A_1} = \frac{P_2}{A_2} = \frac{P_3}{A_3} = f_{CU} \quad \text{Eq 10}$$

$$\sigma_{1crushing} = \frac{P_1}{A_1}\left(1+\frac{eA_1}{Z_1}\right) \quad \text{Eq 11}$$

$$\sigma_{2crushing} = \frac{P_2}{A_2}\left(1+\frac{eA_2}{Z_2}\right) \quad \text{Eq 12}$$

Conformity factor is the ratio of $\sigma_{1crushing}$ to $\sigma_{2crushing}$

i.e

$$\frac{\sigma_{1crushing}}{\sigma_{2crushing}} = \frac{\frac{P_1}{A_1}\left(1+\frac{eA_1}{Z_1}\right)}{\frac{P_2}{A_2}\left(1+\frac{eA_2}{Z_2}\right)} = \frac{\left(1+\frac{eA_1}{Z_1}\right)}{\left(1+\frac{eA_2}{Z_2}\right)} \quad \text{Eq 13}$$

for relative effective length ratio RELR of unity, induced eccentricity e is zero. Since the smaller of the two samples will have RELR of unity, then the conformity factor is reduced to

$$\frac{\sigma_{1crushing}}{\sigma_{2crushing}} = \frac{\left(1+\frac{eA_1}{Z_1}\right)}{1} \quad \text{Eq 14}$$

The reciprocal of this will be the conformity factor if the larger sample becomes the standard reference specimen.

2.6. Experimental Program

In arriving at the e, concrete cubes and prisms of cross section 50mm x 50mm with heights measuring 50mm up to 1000mm were casted and tested in the laboratory for three (3) samples of each height for two different NSC 42.5KN/mm^2 and 32.5KN/mm^2. Standard size 150mm cubes were produced and tested as controls.

2.6.1. Materials

Crushed granite stones with maximum size of 12mm was used together with fine aggregate with a maximum size of 5 mm from Wilberforce Island. Portland cement type I (normal Portland cement) conforming to the requirement of BS EN 197-1 and clean water from a borehole tap were used.

2.6.2. Experimental Methods

Concrete was produced using batching by the modified volume method Orumu [6] as control for mix proportions of 1:1½:3 and water-cement ratio of 0.5. All specimens were produced by hand-mixing until a uniform mix was achieved. Preparation and filling of moulds, machine compaction of concrete, surface leveling and curing were all done according the requirement of BS EN 12390-2. The fresh concrete from the different mixes were tested for slump according to the requirement of BS EN 12350-2 . Three replicates of concrete cube specimens were made for each variable. The average values of the maximum loads at which each group of three specimens failed was found and the compressive strength determined accordance to the requirement of BS EN 12390-3.

2.6.2.1 Formworks

The formworks for the concrete column samples were prepared with plywood with varying minimum dimensions from 50 x 50 x 50 mm to a maximum dimension of 50 x 50 x 1000 mm. Figures 2.1 and 2.2 below shows the various formworks used to cast the concrete.

Figure 2.1: Photograph of formworks showing dimensions 50 x 50 x 200 mm and below

Figure 2.2: Photograph of formworks showing dimensions 50 x 50 x 50) mm and above

The concrete samples were casted into the formworks, was compacted with the vibrator for 60 seconds, and allowed to harden for 24 hours. The column samples were de-moulded and were cured for 7 and 28 days respectively. After the curing, the samples were weighed before crushing. Figure 2.3 is a photograph showing the crushing of one of the column sample.

Figure 2.3: a photograph showing the crushing of one of the column samples

3. Results

The values of the crushing loads were used to obtain the value of e, which was back substituted in Eq 14 to obtain conformity factors given in tables 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6 below5taeand which is given below

Table 3.1: Conformity factors for NCS of 32.5KN/mm^2 in terms of ratio

	Specimen width or diameter / 50mm							
Specimen height /50mm	**1**	**1.25**	**1.5**	**1.75**	**2**	**3**	**4**	**6**
1	1.00	1.19	1.37	1.56	1.75	1.83	1.91	2.21
1.25	0.84	1.00	1.16	1.32	1.47	1.54	1.61	1.86

1.5	0.73	0.86	1.00	1.14	1.27	1.33	1.39	1.61
1.75	0.64	0.76	0.88	1.00	1.12	1.17	1.22	1.41
2	0.57	0.68	0.79	0.89	1.00	1.05	1.09	1.26
2.25	0.57	0.67	0.78	0.88	0.99	1.03	1.08	1.25
2.5	0.56	0.66	0.77	0.87	0.98	1.02	1.07	1.24
2.75	0.55	0.66	0.76	0.86	0.97	1.01	1.05	1.22
3	0.55	0.65	0.75	0.85	0.96	1.00	1.04	1.21
3.25	0.54	0.64	0.74	0.84	0.95	0.99	1.03	1.20
3.5	0.53	0.64	0.74	0.84	0.94	0.98	1.02	1.18
3.75	0.53	0.63	0.73	0.83	0.93	0.97	1.01	1.17
4	0.52	0.62	0.72	0.82	0.92	0.96	1.00	1.16
4.25	0.51	0.60	0.69	0.79	0.88	0.92	0.96	1.12
4.5	0.49	0.58	0.67	0.76	0.85	0.89	0.93	1.08
4.75	0.49	0.58	0.67	0.76	0.85	0.89	0.93	1.08
5	0.49	0.58	0.67	0.76	0.85	0.89	0.93	1.07
6	0.45	0.54	0.62	0.71	0.79	0.83	0.86	1.00
8	0.36	0.42	0.49	0.56	0.62	0.65	0.68	0.79
10	0.29	0.34	0.39	0.45	0.50	0.52	0.55	0.63
12	0.25	0.29	0.34	0.39	0.43	0.45	0.47	0.55
14	0.20	0.24	0.27	0.31	0.35	0.37	0.38	0.44
16	0.19	0.23	0.26	0.30	0.33	0.35	0.36	0.42
18	0.17	0.20	0.23	0.26	0.29	0.30	0.32	0.37
20	0.14	0.17	0.19	0.22	0.25	0.26	0.27	0.31

Table 3.2: Conformity factors for NCS of 42.5KN/mm^2 in terms of ratio

	Specimen breadth/width or diameter Ratio							
Specimen height /50mm	**1**	**1.25**	**1.5**	**1.75**	**2**	**3**	**4**	**6**
1	1.00	1.04	1.09	1.13	1.17	1.30	1.91	1.64
1.25	0.96	1.00	1.04	1.08	1.12	1.24	1.61	1.57
1.5	0.92	0.96	1.00	1.04	1.08	1.19	1.39	1.51
1.75	0.89	0.92	0.96	1.00	1.04	1.15	1.22	1.45
2	0.85	0.89	0.93	0.96	1.00	1.10	1.09	1.40
2.25	0.83	0.87	0.90	0.94	0.97	1.08	1.08	1.36
2.5	0.81	0.85	0.88	0.92	0.95	1.05	1.07	1.33
2.75	0.79	0.82	0.86	0.89	0.93	1.02	1.05	1.30
3	0.77	0.81	0.84	0.87	0.91	1.00	1.04	1.27
3.25	0.75	0.79	0.82	0.85	0.88	0.98	1.03	1.24
3.5	0.74	0.77	0.80	0.83	0.86	0.95	1.02	1.21
3.75	0.72	0.75	0.78	0.81	0.85	0.93	1.01	1.18
4	0.71	0.74	0.77	0.80	0.83	0.91	1.00	1.16
4.25	0.69	0.72	0.75	0.78	0.81	0.90	0.96	1.14
4.5	0.68	0.71	0.74	0.77	0.80	0.88	0.93	1.11
4.75	0.67	0.69	0.72	0.75	0.78	0.86	0.93	1.09
5	0.65	0.68	0.71	0.74	0.77	0.85	0.93	1.07
6	0.61	0.64	0.66	0.69	0.71	0.79	0.86	1.00
8	0.48	0.50	0.52	0.54	0.56	0.62	0.68	0.79

10	0.38	0.40	0.42	0.43	0.45	0.50	0.55	0.63
12	0.33	0.35	0.36	0.38	0.39	0.43	0.47	0.55
14	0.27	0.28	0.29	0.30	0.32	0.35	0.38	0.44
16	0.26	0.27	0.28	0.29	0.30	0.33	0.36	0.42
18	0.22	0.23	0.24	0.25	0.26	0.29	0.32	0.37
20	0.19	0.20	0.21	0.21	0.22	0.24	0.27	0.31

Table 3.3: Conformity factors for average NCS of 42.5KN/mm^2 and 32.5KN/mm^2 in terms of ratio

	Specimen breadth/width or diameter / 50mm							
Specimen height /50mm	**1**	**1.25**	**1.5**	**1.75**	**2**	**3**	**4**	**6**
1	1	1.115	1.23	1.345	1.46	1.565	1.91	1.925
1.25	0.9	1	1.1	1.2	1.295	1.39	1.61	1.715
1.5	0.825	0.91	1	1.09	1.175	1.26	1.39	1.56
1.75	0.765	0.84	0.92	1	1.08	1.16	1.22	1.43
2	0.71	0.785	0.86	0.925	1	1.075	1.09	1.33
2.25	0.7	0.77	0.84	0.91	0.98	1.055	1.08	1.305
2.5	0.685	0.755	0.825	0.895	0.965	1.035	1.07	1.285
2.75	0.67	0.74	0.81	0.875	0.95	1.015	1.05	1.26
3	0.66	0.73	0.795	0.86	0.935	1	1.04	1.24
3.25	0.645	0.715	0.78	0.845	0.915	0.985	1.03	1.22
3.5	0.635	0.705	0.77	0.835	0.9	0.965	1.02	1.195
3.75	0.625	0.69	0.755	0.82	0.89	0.95	1.01	1.175
4	0.615	0.68	0.745	0.81	0.875	0.935	1	1.16
4.25	0.6	0.66	0.72	0.785	0.845	0.91	0.96	1.13
4.5	0.585	0.645	0.705	0.765	0.825	0.885	0.93	1.095
4.75	0.58	0.635	0.695	0.755	0.815	0.875	0.93	1.085
5	0.57	0.63	0.69	0.75	0.81	0.87	0.93	1.07
6	0.53	0.59	0.64	0.7	0.75	0.81	0.86	1
8	0.42	0.46	0.505	0.55	0.59	0.635	0.68	0.79
10	0.335	0.37	0.405	0.44	0.475	0.51	0.55	0.63
12	0.29	0.32	0.35	0.385	0.41	0.44	0.47	0.55
14	0.235	0.26	0.28	0.305	0.335	0.36	0.38	0.44
16	0.225	0.25	0.27	0.295	0.315	0.34	0.36	0.42
18	0.195	0.215	0.235	0.255	0.275	0.295	0.32	0.37
20	0.165	0.185	0.2	0.215	0.235	0.25	0.27	0.31

Table 3.4: Conformity factors for NCS of 32.5KN/mm^2 in terms of actual dimension

	Specimen breadth/width or diameter							
Specimen height	**b50**	**b62.5**	**b75**	**b87.5**	**b100**	**b150**	**b200**	**b300**
50	1.00	1.19	1.37	1.56	1.75	1.83	1.91	2.21
62.5	0.84	1.00	1.16	1.32	1.47	1.54	1.61	1.86
75	0.73	0.86	1.00	1.14	1.27	1.33	1.39	1.61

87.5	0.64	0.76	0.88	1.00	1.12	1.17	1.22	1.41
100	0.57	0.68	0.79	0.89	1.00	1.05	1.09	1.26
112.5	0.57	0.67	0.78	0.88	0.99	1.03	1.08	1.25
125	0.56	0.66	0.77	0.87	0.98	1.02	1.07	1.24
137.5	0.55	0.66	0.76	0.86	0.97	1.01	1.05	1.22
150	0.55	0.65	0.75	0.85	0.96	1.00	1.04	1.21
162.5	0.54	0.64	0.74	0.84	0.95	0.99	1.03	1.20
175	0.53	0.64	0.74	0.84	0.94	0.98	1.02	1.18
187.5	0.53	0.63	0.73	0.83	0.93	0.97	1.01	1.17
200	0.52	0.62	0.72	0.82	0.92	0.96	1.00	1.16
212.5	0.51	0.60	0.69	0.79	0.88	0.92	0.96	1.12
225	0.49	0.58	0.67	0.76	0.85	0.89	0.93	1.08
237.5	0.49	0.58	0.67	0.76	0.85	0.89	0.93	1.08
250	0.49	0.58	0.67	0.76	0.85	0.89	0.93	1.07
300	0.45	0.54	0.62	0.71	0.79	0.83	0.86	1.00
400	0.36	0.42	0.49	0.56	0.62	0.65	0.68	0.79
500	0.29	0.34	0.39	0.45	0.50	0.52	0.55	0.63
600	0.25	0.29	0.34	0.39	0.43	0.45	0.47	0.55
700	0.20	0.24	0.27	0.31	0.35	0.37	0.38	0.44
800	0.19	0.23	0.26	0.30	0.33	0.35	0.36	0.42
900	0.17	0.20	0.23	0.26	0.29	0.30	0.32	0.37
1000	0.14	0.17	0.19	0.22	0.25	0.26	0.27	0.31

Table 3.5: Conformity factors for NCS of 42.5KN/mm^2 in terms of actual dimension

	Specimen breadth or diameter							
Specimen height	**b50**	**b62.5**	**b75**	**b87.5**	**b100**	**b150**	**b200**	**b300**
50	1.00	1.04	1.09	1.13	1.17	1.30	1.91	1.64
62.5	0.96	1.00	1.04	1.08	1.12	1.24	1.61	1.57
75	0.92	0.96	1.00	1.04	1.08	1.19	1.39	1.51
87.5	0.89	0.92	0.96	1.00	1.04	1.15	1.22	1.45
100	0.85	0.89	0.93	0.96	1.00	1.10	1.09	1.40
112.5	0.83	0.87	0.90	0.94	0.97	1.08	1.08	1.36
125	0.81	0.85	0.88	0.92	0.95	1.05	1.07	1.33
137.5	0.79	0.82	0.86	0.89	0.93	1.02	1.05	1.30
150	0.77	0.81	0.84	0.87	0.91	1.00	1.04	1.27
162.5	0.75	0.79	0.82	0.85	0.88	0.98	1.03	1.24
175	0.74	0.77	0.80	0.83	0.86	0.95	1.02	1.21
187.5	0.72	0.75	0.78	0.81	0.85	0.93	1.01	1.18
200	0.71	0.74	0.77	0.80	0.83	0.91	1.00	1.16
212.5	0.69	0.72	0.75	0.78	0.81	0.90	0.96	1.14
225	0.68	0.71	0.74	0.77	0.80	0.88	0.93	1.11
237.5	0.67	0.69	0.72	0.75	0.78	0.86	0.93	1.09
250	0.65	0.68	0.71	0.74	0.77	0.85	0.93	1.07
300	0.61	0.64	0.66	0.69	0.71	0.79	0.86	1.00
400	0.48	0.50	0.52	0.54	0.56	0.62	0.68	0.79
500	0.38	0.40	0.42	0.43	0.45	0.50	0.55	0.63

600	0.33	0.35	0.36	0.38	0.39	0.43	0.47	0.55
700	0.27	0.28	0.29	0.30	0.32	0.35	0.38	0.44
800	0.26	0.27	0.28	0.29	0.30	0.33	0.36	0.42
900	0.22	0.23	0.24	0.25	0.26	0.29	0.32	0.37
1000	0.19	0.20	0.21	0.21	0.22	0.24	0.27	0.31

Table 3.6: Conformity factors for average NCS of 42.5KN/mm^2 and 32.5KN/mm^2 in actual dimension

Specimen height	b50	b62.5	b75	b87.5	b100	b150	b200	b300
50	1	1.115	1.23	1.345	1.46	1.565	1.91	1.925
62.5	0.9	1	1.1	1.2	1.295	1.39	1.61	1.715
75	0.825	0.91	1	1.09	1.175	1.26	1.39	1.56
87.5	0.765	0.84	0.92	1	1.08	1.16	1.22	1.43
100	0.71	0.785	0.86	0.925	1	1.075	1.09	1.33
112.5	0.7	0.77	0.84	0.91	0.98	1.055	1.08	1.305
125	0.685	0.755	0.825	0.895	0.965	1.035	1.07	1.285
137.5	0.67	0.74	0.81	0.875	0.95	1.015	1.05	1.26
150	0.66	0.73	0.795	0.86	0.935	1	1.04	1.24
162.5	0.645	0.715	0.78	0.845	0.915	0.985	1.03	1.22
175	0.635	0.705	0.77	0.835	0.9	0.965	1.02	1.195
187.5	0.625	0.69	0.755	0.82	0.89	0.95	1.01	1.175
200	0.615	0.68	0.745	0.81	0.875	0.935	1	1.16
212.5	0.6	0.66	0.72	0.785	0.845	0.91	0.96	1.13
225	0.585	0.645	0.705	0.765	0.825	0.885	0.93	1.095
237.5	0.58	0.635	0.695	0.755	0.815	0.875	0.93	1.085
250	0.57	0.63	0.69	0.75	0.81	0.87	0.93	1.07
300	0.53	0.59	0.64	0.7	0.75	0.81	0.86	1
400	0.42	0.46	0.505	0.55	0.59	0.635	0.68	0.79
500	0.335	0.37	0.405	0.44	0.475	0.51	0.55	0.63
600	0.29	0.32	0.35	0.385	0.41	0.44	0.47	0.55
700	0.235	0.26	0.28	0.305	0.335	0.36	0.38	0.44
800	0.225	0.25	0.27	0.295	0.315	0.34	0.36	0.42
900	0.195	0.215	0.235	0.255	0.275	0.295	0.32	0.37
1000	0.165	0.185	0.2	0.215	0.235	0.25	0.27	0.31

4. Discussion

Based on the theoretical formulation and experimental test data the six (6) tables above were generated and the use of them for conformity will be the core subject of this section with comparison to known available literature.

Example 1 If the compressive strength of a 150mm cube measured in the laboratory is 30 KN/mm^2 find the value of the same batch of concrete where a

i) prism of 150mm x 300mm, 150mm x 75mm is used.

ii) cube of 100mm, 75mm or 50mm is used.

iii) Cylinder 150mm diameter x 300mm height, 100mm diameter x 200mm height is used.

iv) Find the conformity factor from a Cylinder 150mm diameter x 300mm height to a Cylinder 100mm diameter x 200mm height

Solution. 1

Using the average tables 3.3 and 3.6 alone

From table 3.6 look out for the value where sample height meet sample width and read the value 0.81 and 1.26 which means we shall expect results of 24.3 KN/mm^2 and 37.8 KN/mm^2 respectively.

Using table 3.3 will produce exactly the same result; Here you will divide the Height by 50mm and the width by 50mm.

Solution 2

From table 3.6

Conformity factor for 150x100 is 1.075

Conformity factor for 100x150 is 0.935

Conformity factor for 150x150 is 1

Therefore

Conformity factor for 100x100 compared to 150mm cube =0.5 (1.075+1/0.935)=1.073

Similarly

Conformity factor for 100x75 compared to 150mm cube =0.5 (1.26+1/0.795)=1.259

And

Conformity factor for 100x50 compared to 150mm cube =0.5 (1.565+1/0.66)=1..435

Solution 3

Conformity factor for 150 x300 cylinder compared to 150mm cube =0.5 (0 .81+1/1.24)=0.808

And

Conformity factor for 100x200 cylinder compared to 100mm cube =0.5 (0.68+1/1.09)=0.7987

Conformity factor for 100x200 cylinder compared to 150mm cube =0.7987x1.073=0.856

Solution 4

The conformity factor for 150 x300 cylinder compared to 100x200 cylinder can be obtained as the ratio of the Conformity factor for 150 x300 cylinder compared to 150mm cube and the Conformity factor for 100x200 cylinder compared to 150mm cube. This gives a value of 0.94 (0.81/0.86).

Table 4.1: Comparison of results (all dimension in mm)

S/No	Assumed Standard sample	Non standard sample	Conformity factor from assumed standard to nonstandard by the Present method	Conformity factor from assumed standard to nonstandard by Other Authors
1	150x150 cube	100x100 cube	1.07	1.05 Neville
2	150x150 cube	75x75 cube	1.259	
3	150x150 cube	50x50 cube	1.435	
4	150x150 cube	150x300 prism	0.81	
5	150x150 cube	150x75 prism	1.26	
6	150x150 cube	150x300 cylinder	0.808	0.8 BS EN 206
7	150x150 cube	100x200 cylinder	0.856	
8	100x200 cylinder	150x300 cylinder	0.94	0.94 Gyengo, Murdock, Kesler

The results shown in table 4 above for the ratio of 150mm cylinders/150mm cubes are in agreement with those in Table 12 of BS EN 206 [4] with a nominal value of 0.80 for strength class up to C55/67. The other results also show agreement between the present method and previous authors. The method can be therefore be relied upon and tables 3.3 and 3.6 can be adopted for use.

5.0 Conclusion and recommendation

The common notion that concrete compressive strength is a unique material property has been re-established in this paper. The changes in compressive strength of concrete based on specimen sizes and shapes is due to their Relative Effective Length Ratio (RELR) rather than the fracture characteristics and the complex stress system between the bearing plates and the concrete cross sectional area they are in contact with.

The use of 100 mm or smaller cubes and cylinders has its advantages. The 100mm or smaller cubes and cylinders are easier to handle and will result in saving of materials, curing space, storage space and labor. The overall savings can be significant in financial terms. To simplify this, one will want to say here that the materials required to produce one 150mm cube of test sample, could produce 3.375 number 100mm cubes and 27 number 50mm cubes. The reluctance of engineers in using 100mm or smaller cubes for determining the compressive strength of concrete because of the perceived greater variability in their compressive strength over that of the 150mm cubes should be completely discouraged.
The Conformity tables developed in this paper may be used to revisit the existing design codes and methods of concrete columns and research should be focused on this.

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