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A STUDY ON INTENSITY DISTRIBUTION OF CONCRETE IN STRUCTURE WITH DIFFERENT BUILDING AGES

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Recently, seismic diagnosis and earthquake resistant reinforcement works of buildings built before the new earthquake resistant standards are conducted in various places. However, there is no uniformity in sampling methods, and it seems that there are occasional extreme variations in the determination of representative intensity of the building. In addition, the physical properties of structure concrete which factor of the above-mentioned variations are considered to reflect the horizontal and vertical distribution at the time of concrete placing. Therefore, this study, the core of the existing buildings to be disassembled was collected, and the distribution of physical properties of structure concrete was examined. All target buildings were reinforced concrete constructions, and cores were collected from pillars and waist walls. In addition, there are parts that were built at the time without the ready-mixed concrete plant (from 1960) and pump truck (from 1964). Experimental results of horizontal and vertical distributions of compressive intensity at the pillars and waist walls revealed that there was no greatest decrease in strength and there was not much difference between the maximum strength of the pillar and 300 mm from the vicinity of the pillar and about 300 mm from F. L. Therefore, from this study, it seems that the position of 300 mm from the pillar and F. L. is suitable for the measurement position which develops the representative intensity of the building.

Keywords: Strength, Carbonation depth, Demolition.

1 INTRODUCTION

In this study, the distribution of compressive strength and carbonation depth of concrete was collected from multiple demolition buildings, and the analysis was done considering the influence of the time background and the construction conditions.

Recently, seismic diagnosis and earthquake resistant reinforcement works of buildings built before the new earthquake resistant standards are conducted in various places. As a result, there are many cases of dismantling in various buildings. However, there is no uniformity in sampling methods, and it seems that there are occasional extreme variations in the determination of representative intensity of the building.

This is considered to be a cause of variation by the part of structure concrete. Also, the physical properties of structure concrete which factor of the above-mentioned variations are considered to reflect the horizontal and vertical distribution at the time of concrete placing. The vertical distribution has been studied in the past and the reason was clarified, the report on the horizontal distribution of the wall, which is most suitable to collect the core from a real building is limited.

Therefore, this study, the core of the existing building which was dismantled target was collected, and distribution of the physical properties of the concrete structure as a main issue, that was examined with the change of the building age and the building technology.

Moreover, it is difficult to collect the core usually to target the demolition building. Therefore, it is a feature of this research that can be taken from a pillar.

2 RESEARCH OVERVIEW

2.1 Buildings Surveyed

The specifications of the target buildings that are investigated in the present structural assessment are listed in Table 1. The structural components of all the buildings are made from reinforced concrete. The five building types are labeled A to E. The most common building-type A comprised three subgroups, which included four-, six-, and six-story buildings. The four-story buildings were built in 1952, 1953, 1954, 1955, 1958, 1960, whereas the first type of six-story buildings were built in 1966, 1967, and 1968; the remaining buildings were built in 1970 and 1979. Overall, eleven buildings of different age groups were studied. The buildings that were constructed at different times were built using different construction equipment and materials. Some of the buildings were built before the raw concrete factories were introduced in 1960, whereas some were built without pump trucks, which were introduced in 1965.

Table 1. The present structural assessment of the target buildings**.**

building \ details	building age	use	story
A-1～A-6	1952,1953,1954,1955,1958,1960	university	four-story
A-7～A-9	1966,1967,1968		six-story
A-10～A-11	1970,1979		six-story
B	1943	primary school	two-story
C	1933	primary school	two-story
D	1947	middle school	two-story
E	1971	cultural center	six-story

2.2 Survey Components

This study discusses five main aspects that are related to the structural analysis of these buildings, which are as follows:

1) Dimensions of the test specimen
2) A method for measuring the carbonation depth in the sample core
3) Effects of the distribution of carbonation depth and finishing
4) Horizontal and vertical distributions of the compressive strength and density in the lower half of the walls
5) A vertical distribution of the compressive strength in column and its relation to the wall strength

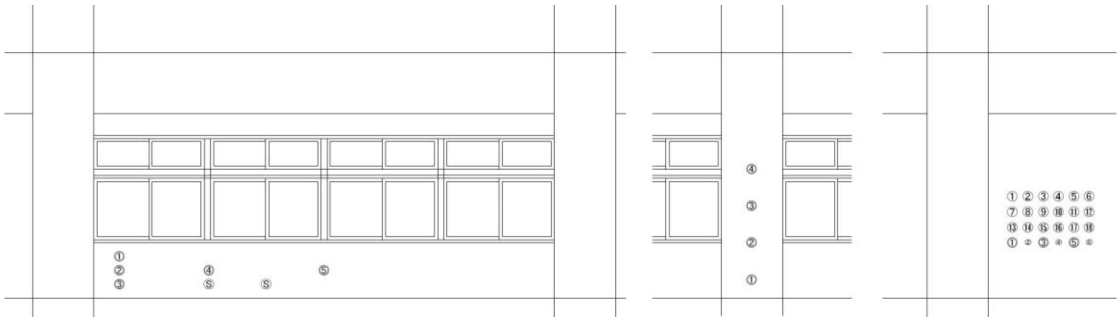

Figure 1. Core sampling position (from left, wainscot, pillar, no window wall).

2.3 Core Collection Position

Core positions are shown in Figure 1. Cores were collected from a spandrel, a column, and a windowless wall in each building. At the spandrel, points ①–③ were approximately 300 mm from the column. The heights of these positions from the floor line (FL) were ① 450, ② 300, and ③ 150 mm. ⑤ is located at the center of the span, whereas ④ is located midway between ①–③ and ⑤. Both ④ and ⑤ are horizontal with ②. Ⓢ is close to ④ and ⑤. On the column, ① is 300 mm from the FL, ② is 900 mm from the FL, ③ is 1500 mm from the FL, and ④ is 2100 mm from the FL. The measurements were recorded for ④ only if the wall was tall enough. At the windowless wall, ①–⑱ exhibit the locations of the cores that are used for storage, whereas ①–⑥ exhibit the locations of the cores used to measure the effect of the dimensions. ①, ⑦, ⑬, and ① are approximately 300 mm from the column. The height from the FL for all of these cores was approximately 1000–1500 mm. Although the standard core diameter was ϕ 75 mm, these cores were collected at ϕ 50mm because of the arrangement of the reinforcing bars in the concrete. More than 300 cores were collected in total, and approximately 150 samples were tested.

3 EXPERIMENTAL RESULTS AND CONSIDERATIONS

3.1 Dimensions of the Test Specimen

To examine the influence of the core diameter on the test results, I examined the correlation between the average measurements that were recorded using three cores of φ 50mm and φ 75mm that were obtained from five locations in the same windowless wall. The results are shown in Figure 2. The average values of the core test body of φ 50mm and φ 75mm were observed to differ if they were obtained from walls that were built at different times. However, this test confirmed that the core diameter did not exhibit much effect on the relevant measurements.

3.2 A Method for Measuring the Carbonation Depth in the Sample Core

To ensure adherence with the JIS3 standards, structural analysis must proceed using samples from five or more locations in the structure. However, it is difficult to evenly distribute the choice of locations for these five points across the different structural components of a building.

Thus, cores were taken from more than five points in this study, and the carbonation depth measurements were performed using a selection of measurement points. Further, the carbonation depth was measured from all the cores that were taken from the spandrel ②. The results are shown in Table 2. From the table, some differences can be observed between the variations and the number of measurements; however, the difference between the mean values is generally less than 0.30 mm. Based on this result, the measurement of the carbonation depth can be conducted using the average of the maximum value and based on eight other measurements.

Table 2. A study of the number of carbonation measurements.

Number of measurements	8-point (in) Average (mm)	Stdev (mm)	16-point (in) Average (mm)	Stdev (mm)	Difference (mm)	8-point (out) Average (mm)	Stdev (mm)	16-point (out) Average (mm)	Stdev (mm)	Difference (mm)
A-1 South	21.64	5.22	21.66	4.88	0.02	13.53	8.94	13.65	8.44	0.12
A-1 North	32.91	6.76	32.63	6.38	0.28	46.86	4.32	46.88	3.85	0.02
A-2 South	23.85	5.30	23.46	5.13	0.40	-				
A-2 North	18.31	8.62	17.61	8.96	0.70	0.53	1.15	0.42	0.90	0.11
A-3 South	0.97	0.70	0.54	0.69	0.43	0.97	0.22	1.21	0.24	0.24
A-3 North	1.36	0.91	1.26	0.77	0.10	1.76	1.67	1.91	1.44	0.15
A-4 South	37.75	24.77	36.87	23.35	0.88	1.65	0.89	1.66	0.79	0.00
A-4 North	46.27	3.58	46.32	3.31	0.05	1.27	0.68	1.09	0.69	0.18
A-5 South	3.40	0.95	3.45	0.96	0.05	-				
A-5 North	2.31	0.41	2.28	0.42	0.04	1.26	1.42	1.17	1.35	0.09
A-6 South	16.25	2.20	16.12	2.08	0.13	3.96	1.75	3.72	1.78	0.24
A-7 South	21.39	2.23	20.78	2.03	0.62	0.48	0.42	0.53	0.40	0.05
A-8 South	1.62	0.27	1.72	0.34	0.10	2.49	2.05	1.96	1.63	0.53
A-8 North	2.62	2.11	2.39	1.98	0.23	1.05	0.68	1.08	0.66	0.03
A-10 South	14.20	5.05	14.25	4.59	0.05	-				
A-11 South	13.62	2.40	13.42	2.07	0.20	-				
B	9.98	1.42	9.84	1.40	0.14	1.50	0.49	1.41	0.41	0.09
C	1.08	0.62	0.83	0.54	0.25	0.54	0.36	0.66	0.38	0.11
D	All sections are neutering									
E	43.75	6.20	43.85	5.98	0.10	2.69	0.65	2.12	0.60	0.57

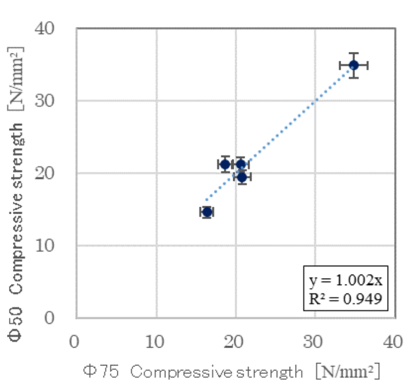

Figure 2. Effect of diameter difference.

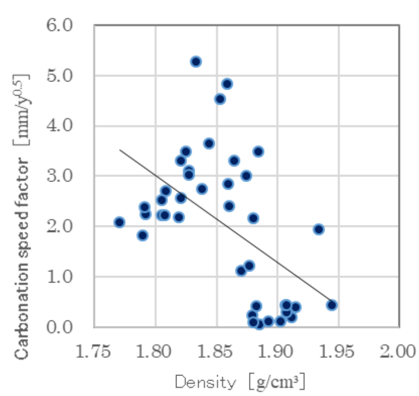

Figure 3. Relationship between finish density and carbonation speed factor.

3.3 Effects of the Distribution of Carbonation Depth and Finishing

As reported previously (Yanagibashi 2010), the carbonation depth of concrete is affected by four main factors. The carbonation speed is affected by ① the environmental conditions, ② the finishing material that is used on the concrete surface, ③ the quality of concrete, and ④ aging. This study focuses on the relation between the finishing material and the carbonation speed. The results are shown in Figure 3. The two values are not strongly correlated; however, a slight inverse correlation is apparent. If the finishing material is dense, carbonation proceeds somewhat slowly.

3.4 Horizontal and Vertical Distributions of the Compressive Strength and Density in the Lower Half of the Walls

Figures 4 and 5 depict the compressive strength distribution within the spandrel in the horizontal (②, ④, ⑤ in Figure 1) and vertical (①, ②, ③ in Figure 1) directions. Further, the strength is observed to vary in the horizontal direction in all the specimens. The strength is considered to be the highest at sampling position ② and begins to decrease as it approaches ⑤. Some variations were observed in the vertical direction with age; however, the compressive strength was generally observed to be the highest at ②, ①, and ③, whereas the strength at ③ tended to be lower. From this result, position ② is the optimal location from which a core sample that will most accurately represent the wall strength can be obtained.

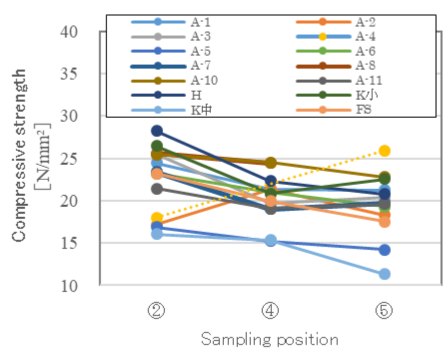

Figure 4. Horizontal distribution of compressive compressive strength (in spandrel).

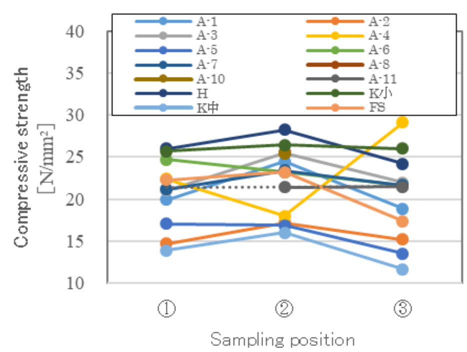

Figure 5. Vertical distribution of strength (in spandrel).

3.5 A Vertical Distribution of the Compressive Strength in Column and its Relation to the Wall Strength

The strength distribution in the vertical direction of the column was concentrated at the bottom of the pillars, which was similar to that observed in previous reports (JIS A 1107 2012). The concrete strength gradually decreased toward the top of the column, and the strength tended to increase at the boundaries of some components. This increased strength seems to be a result of compaction as the concrete was poured. Here, we investigated the core strength of the spandrel section ② at the same height as that of ①, which exhibited the highest strength in the column. It is shown in Figure 6. From this, it can be observed that the strength of the column is 1.6 times higher than the strength of the spandrel. However, the difference between the strengths of the spandrel and column is not statistically significant, and the two values exhibit a weak positive correlation. This trend indicates that the measurements of the difference in strength between the FL and the column are suitable for estimating the overall strength of the structure.

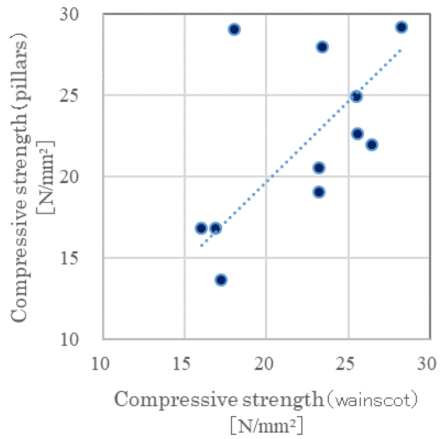

Figure 6. Relationship between compressive strength in column ① and spandrel ②.

4 CONCLUSIONS

This study investigated the distribution of physical properties by collecting cores from reinforced concrete buildings built in various ages. Summarizes the results obtained are shown below.

1) The compressive strength and density were confirmed by the horizontal and vertical distributions from the core sampling position.
2) The collected concrete core of approximately 300 mm from the F.L. of the wainscot and near the pillar (about 300 mm in this study) is seems to be suitable for the measurement position, which expresses the strength that represents the building.

Acknowledgements

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