Journal of Materials and Construction Vol 15 No.01 (2025)

Journal of Materials and Construction
ISSN 2734-9438
Website: www. jomc.vn

Evaluation of compressive strength degradation of concrete using a model based on survey data

Nguyen Thanh Hung[1], Cao Nu Kim Anh[1], Dao Duy Kien[1*]

[1]Department of Civil Engineering, University of Technology and Education Ho Chi Minh City

KEYWORDS

Concrete
Destructive method
Reinforced concrete
Linear regression
Compressive strength

ABSTRACT

The studies of the reduction in compressive strength of concrete structures built before 1975 through survey data at the construction site. The survey results were conducted on structures (columns, beams, floors) at different floors, and the specimens were tested to determine compressive strength (Ri, Rhttb, Rmin) according to the TCXDVN 239:2006 standard. Using the parabolic model to evaluate the influence of concrete strength at the floor positions, the results showed that the model was consistent with the data ($R^2 = 1$). On the other hand, the survey data also showed that the concrete strength of the columns was lower than that of the beams and floors and tended to increase with the height of the floors. This study clarified that the compressive strength of concrete in construction tends to decrease between floors, columns, beams, and floors, thereby providing appropriate solutions to upgrade the construction to ensure the structural safety of the construction when in use.

1. Introduction

Concrete is widely used mainly in construction works due to its outstanding mechanical properties [1, 7]. In particular, the compressive strength of concrete is one of the important factors directly affecting the load-bearing capacity and safety of the structure [6, 8, 9]. Therefore, determining the correct compressive strength of concrete is very important, especially when evaluating the quality of construction or the structure's durability in cases of quality deterioration [11, 12, 13].

Methods for testing the compressive strength of concrete are divided into two groups: destructive and non-destructive [2, 7, 10, 14]. Destructive methods, such as drilling and compressing specimens, provide direct and highly accurate results [6, 8]. However, they are expensive, time-consuming, and can affect the structure [2]. In contrast, non-destructive methods, using rebound hammers and ultrasound, provide results without affecting the structure, although the accuracy is not high [2, 10, 12, 14].

Many studies on the assessment of concrete strength, such as Carino et al. (1981), found that the concrete strength in the upper floors of a building can be 3 % to 14 % lower than that in the middle floors [1]. Hola and Schabowicz (2019) reviewed the techniques of non-destructive methods and their role in detecting strength variations without affecting the structure [2]. Studies by De Stefano et al. (2013), Viti et al. (2016), and Mariani et al. (2016) analyzed the influence of concrete strength variations on the behavior of structures [3, 4, 5]. Standards TCVN 12252:2020, TCVN 3118:2022, TCVN 9334:2012, TCXDVN 239:2006, and EN 13791:2020 provide detailed instructions on determining the strength of concrete [8, 9, 10, 11, 14].

In Vietnam, there are studies by Tran Thi Ngoc Hoa et al. (2024) and Le Van Manh (2022) applying destructive and non-destructive methods to assess the compressive strength of concrete [12, 13]. This article studies concrete's decrease in compressive strength at 68 Nguyen Trai, My Long Ward, Long Xuyen City, An Giang Province, built before 1975, through data surveyed according to TCXDVN 239:2006 standard [14].

The results of using the parabolic model to evaluate the influence of concrete strength at the floor position show that the model is consistent with the data. On the other hand, the survey data also shows that the concrete strength of the column is lower than the strength of the beam and floor and tends to increase with the floor height.

Through this study, it has been clarified that the compressive strength of the project's concrete tends to decrease between floors, columns, beams, and floors, thereby providing appropriate solutions to upgrade the project to ensure the structural safety of the project when in use.

2. Survey data collection

2.1. Project introduction

Figure 1. Survey recorded concrete cracking and steel rusting.

*Corresponding author: kiendd@hcmute.edu.vn

Received 09/05/2025, explanation 14/05/2025, accepted 15/05/2025
Link DOI: https://doi.org/10.54772/jomc.v15i01.967

The project at 68 Nguyen Trai, My Long Ward, Long Xuyen City, An Giang Province was built before 1975 (Figure 1), including ground floor, 1st floor, 2nd floor, 3rd floor (rooftop), reinforced concrete frame structure, corrugated iron roof, construction area of about 166 m^2 x 4 = 664 m^2. During the use, there were renovations and repairs to suit the function of the project, currently the project has degraded after a period of use (Figure 1).

2.2. Survey methods and equipment

This study uses a destructive method to determine the compressive strength of concrete by drilling to obtain specimens (Figure 2). Using a concrete drilling device Model DK-6NF, Doo Hyeon with a maximum drill diameter of 152 mm, a drilling depth of 400 mm to drill to obtain specimens and a concrete compression device 2000 kN with Model: C089-02 Matest to test to determine the compressive strength of drilled specimens.

Figure 2. Drilling concrete specimens at the site.

2.3. Take concrete specimens to evaluate strength

According to TCXDVN 239:2006 [14], to conduct concrete sampling to determine the compressive strength of concrete, in figure 2 shows the work of using a drill to drill and take concrete specimens of a combination of three specimens, the core after being taken from the structure is flattened at both ends of the drilled specimen, classifying the drilled specimens according to each structure. Drilled specimens of the foundation (03 groups of specimens, 1 group = 02 specimens), beam (03 groups of specimens, 1 group = 02 specimens), ground floor column (01 group of specimens, 1 group = 03 specimens), 1st floor column (01 group of specimens, 1 group = 03 specimens), 2nd floor column (01 group of specimens, 1 group = 03 specimens), ground floor beam - floor (02 groups of specimens, 1 group = 03 specimens), 1st floor beam - floor (02 groups of specimens, 1 group = 03 specimens), 2nd floor beam - floor (02 groups of specimens, 1 group = 03 specimens).

2.4. Test to check compressive strength of concrete

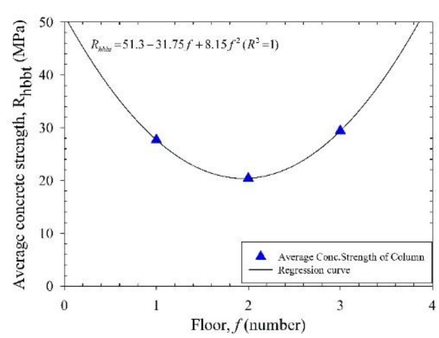
After the drilled specimens were processed and classified according to structure, the specimens were put into the concrete compression equipment Model: C089-02 Matest to determine the compressive strength of the concrete, the results were recorded as shown in Table 1.

3. Analysis of compressive strength of concrete

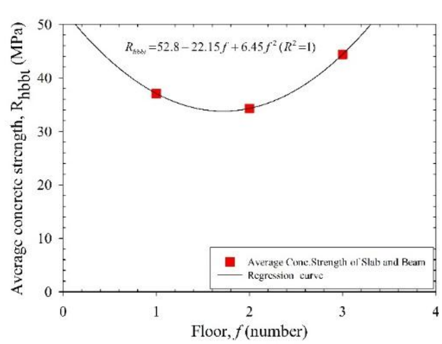
The analysis of the average compressive strength of concrete columns and floor beams according to height obtained results clearly shows the parabolic distribution trend, shown in detail in Figure 3. The data shows that the concrete strength of the first floor column is 26.35 % and 30.6 % lower than that of the columns on the ground floor and the second floor, respectively. However, similarly, the concrete strength of the floor beam does not change much, the concrete strength of the first floor beam is only 7.5 % and 22.7 % lower when compared to the ground floor and the second floor, respectively.

The concrete strength of the column throughout the ground floor to the second floor ranges from 20.4 Mpa to 29.4 Mpa, equivalent to concrete B20 to B25 or concrete Mac 200-300. Meanwhile, the concrete strength of the floor beam is equivalent to concrete B30 to B35 or concrete Mac 300-350. This shows that the initial design strength of columns and floor beams is also different, the concrete strength of columns is much lower than that of floor beams.

To describe and be able to evaluate the impact of environmental factors on the reduction of concrete strength of columns, floor beams, as well as the phenomenon of creep, concrete corrosion based on the results obtained from the field visually from Figure 3. The parabolic function y = a + bx + cx2 can be completely applied with a compatibility of 100 % through the variance index and standard deviation of 1, from the statistical analysis of the data set.



a) Column



b) Slab and Beam

Figure 3. Relationship between average concrete strength and level of floor.

Table 1. Compressive strength of concrete.

No	Component name	Symbol specimen	Field compressive strength R_i (Mpa)	Field compressive strength R_{httb} (Mpa)	R_{min} (Mpa)
1	Foundation	2/B' (1)	26.9	31.0	26.9
		2/B' (2)	35.1		
2	Foundation beam	2-3/B'(1)	30.7	28.1	25.4
		2-3/B'(2)	25.4		
3	Column of 1st floor	2/D	28.8	27.7	25.3
		3/D	29.1		
		3/B'	25.3		
4	Column of 2nd floor	5/A	17.4	20.4	17.4
		2/C	22.1		
		2/D	21.7		
5	Column of 3rd floor	1/B	31.1	29.4	23.9
		2/D	33.2		
		5/A	23.9		
6	Slab and Beam of 1st floor	2-3/A-B	30.1	37.1	30.1
		3-4/A-B	33.5		
		5-6/A-B	47.6		
7	Slab and Beam of 2nd floor	1-2/C-D	34.6	34.3	33.7
		3-4/C-D	33.7		
		5-6/C-D	34.5		
8	Slab and Beam 3rd floor	2-3/A-B	49.9	44.4	41.6
		3-4/A-B	41.6		
		1-2/C-D	41.8		

4. Results and discussion

The project was built before 1975, the survey results were conducted on the components (columns, beams, floors) at different floors, with specimens taken directly on the components according to TCXDVN 239:2006. After more than 50 years of use, the compressive strength of the concrete through the survey showed that the remaining concrete strength was quite high, but there was a difference between columns, beams, floors and between floors.

However, the survey data showed that the remaining strength was quite high, but in Figure 1 it was shown that the project had corrosion of the steel reinforcement, so the project was experiencing a decline in the load-bearing capacity of the structure. In particular, the compressive strength of the concrete for columns was lower than that of beams and floors, which shows that the decline in concrete strength has a great impact on the environment in Long Xuyen City, An Giang Province, especially vertical structures.

5. Conclusion

- The result indicated that the compressive strength of concrete for works after more than 50 years of use is still quite high, but there is a difference between floors and for columns compared to beams and floors.

- The survey data shows that the concrete strength of the first floor columns is 26.35 % and 30.6 % lower than the columns on the ground floor and the second floor, respectively. However, similarly, the concrete strength of the floor beams does not change much, the concrete strength of the first floor beams is only 7.5 % and 22.7 % lower when compared to the ground floor and the second floor, respectively.

- To evaluate the impact of environmental factors on the reduction of compressive strength of concrete columns and floor beams from the results obtained from the field visually from Figure 3, the parabolic function y = a + bx + cx2 can be completely applied with a compatibility of 100 % through the variance index and standard deviation of 1, showing that the selected model has high reliability.

Acknowledgments

This work belongs to the project in 2025 funded by Ho Chi Minh City University of Technology and Education, Vietnam.

References

[1]. Carino, N. J., Clifton, J. R., & Frohnsdorff, G. J. (1981). Evaluation of strength variation due to height of concrete members. *Cement and Concrete Research*, 11(4), 621-632.

[2]. Hola, J., & Schabowicz, K. (2019). Non-destructive evaluation of concrete strength: A review. *Materials*, 12(9), 1502.

[3]. De Stefano, M., Tanganelli, M., & Viti, S. (2013). Effect of the variability in plan of concrete mechanical properties on the seismic response of existing RC framed structures. *Bulletin of Earthquake Engineering*, 11, 1049-1060.

[4]. Viti, S., Tanganelli, M., & De Stefano, M. (2016). The Concrete Strength Variability as Source of Irregularity for RC Existing Buildings. *Seismic Behaviour and Design of Irregular and Complex Civil Structures II*, pp. 149-158.

[5]. Mariani, V., Tanganelli, M., Viti, S., & De Stefano, M. (2016). Combined effects of axial load and concrete strength variation on the seismic performance of existing RC buildings. *Bulletin of Earthquake Engineering*, 14, 805-819.

[6]. Inel, M., Ün, H., & Senel, S. M. (2008). Experimental evaluation of concrete strength in existing buildings. *Magazine of Concrete Research*, 60(4), 279-289.

[7]. Malhotra, V. M., & Carino, N. J. (2004). *Handbook on Nondestructive Testing of Concrete* (2nd ed.). CRC Press.

[8]. TCVN 12252:2020 - Bê tông - Phương pháp xác định cường độ bê tông trên mẫu lấy từ kết cấu.

[9]. TCVN 3118:2022 - Bê tông - Phương pháp xác định cường độ chịu nén.

[10]. TCVN 9334:2012 - Bê tông nặng - Phương pháp xác định cường độ nén bằng súng bật nảy.

[11]. EN 13791:2020 - Assessment of in-situ compressive strength in structures and precast concrete components.

[12]. Trần Thị Ngọc Hoa, Lâm Thanh Quang Khải, Võ Trương Hoàng Sang (2024). Cường độ chịu nén của bê tông trong kết cấu chịu uốn bằng phương pháp phá hủy và phương pháp không phá hủy, Tạp chí Xây dựng, Số 2.2024, Trang 96-100.

[13]. Lê Văn Mạnh (2022). Nghiên cứu xác định cường độ chịu nén hiện trường của bê tông tường chắn theo tiêu chuẩn EN 13791:2020, Tạp chí Khoa học Kiến trúc - Xây dựng, Trang 70-74.

[14]. TCXDVN 239:2006 - Bê tông - Hướng dẫn kiểm tra cường độ bê tông trong kết cấu công trình.