TuEngr Group

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

PAPER ID: 10A17M

INSPECTION AND STRENGTHENING IMPROVEMENT OF RC BEAM AND LOAD TEST OF RC SLAB: CASE STUDY OF SOCIAL SCIENCE COMPLEX BUILDING#2 (SC2) THAMMASAT UNIVERSITY, RANGSIT CAMPUS, THAILAND

Saharat Buddhawanna [a*], Boonsap Witchayangkoon [a], Passaworn Boonyavinij [a]

[a] *Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, THAILAND.*

ARTICLEINFO

Article history:
Received 11 March 2019
Received in revised form 24 July 2019
Accepted 08 August 2019
Available online 30 September 2019

Keywords:
Structural inspection; Structural strengthening; Structural improvement; Reinforced concrete; Reinforced beam; Structure load test; Concrete slab repair; Beam deflection repair; Beam strengthening.

ABSTRACT

This study focuses on the strengthening improvement of reinforced concrete (RC) beams and slab using the Social Science Complex Building (SC2), Thammasat University, Rangsit Campus, Thailand, as the case study. The optimal strengthening design for RC beams in the case study building is recommended. The main focused issue is to reduce the deflections of the beams. There are three strengthening improvement methods that are compared each other. Once completing the design, this study finds that the first, the second, and the third methods have the maximum deflection at 3.57 cm, 3.35 cm, 3.51 cm, respectively. The second method offers the smallest deflection; however, the third method requires the smallest repair amount of strengthening reinforcing steels. When compare to ACI standard, it is clear that the maximum deflections all three methods are within the acceptable standard. Therefore, the third method is considered the most optimal design method.

1. INTRODUCTION

Thammasat University has a Social Science Complex Building project (SC2) in Thammasat University, Rangsit Campus, Khlong Nueng Sub-district Klong Luang Distinct Pathumthani province Which is 2 reinforced concrete buildings, Building A which has the floor plan as shown in Figure 1 and Building B.

From the initial examination, the cracks found in the structure of the building, ie, cracks in the 4 floor structure, 4 positions, cracks at the 3rd floor, large oval and oval rooms, cracks at the 1st and 2nd floors and cracks at the second floor beam, therefore, requires additional design in the improvement and reinforcement of the beam structure and the fourth floor as shown in Figure 2. The authors, therefore, conducted a study to examine, evaluate, improve the strength of the structure of the building, case studies that found problems from cracks and deflections of beam and floor structures.

*Corresponding author (S. Buddhawanna). Tel: +66-25643001 Ext.3248. Email: bsaharat@engr.tu.ac.th ©2019 International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 10 No.17 ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8 Paper ID: 10A17M http://TUENGR.COM/V10A/10A17M.pdf DOI: 10.14456/ITJEMAST.2019.239

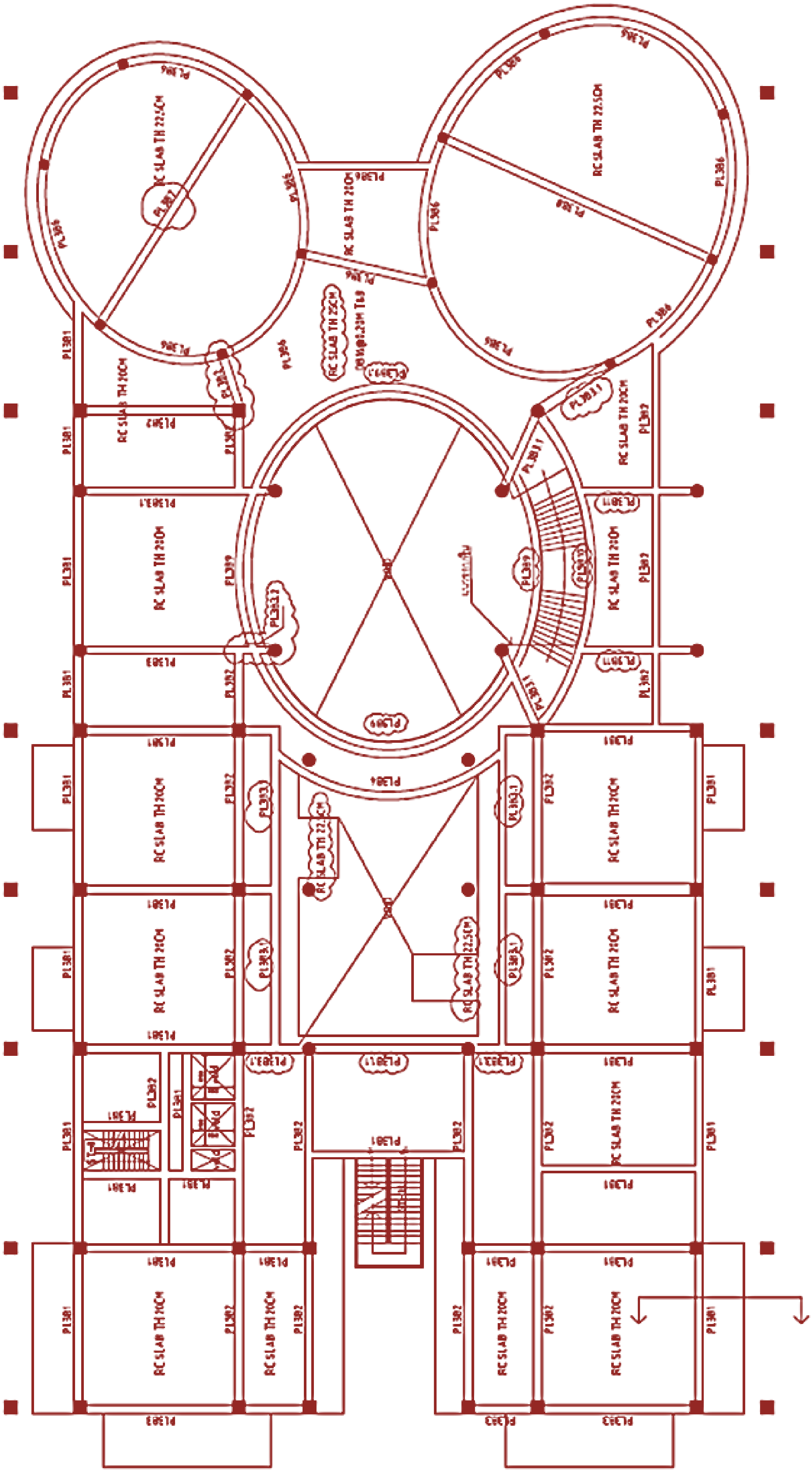


Figure 1: Floor Plan of the 3rd Floor, SC2 Building at Thammasat University.

2. LITERATURE REVIEW

There are possible reasons that parts of buildings get cracks during the construction phases or soon after the completion. Structural engineers look for a way to repair the cracked structures.

Buddhawanna (2015) evaluated structural strength by nondestructive evaluation (NDE) and load test of RC slab structure of the hospital reinforced concrete (RC) building of Thammasat University. With huge deck slabs deflections seen by the naked eyes, a load test was conducted to assess the structural strength of the problematic deck slabs. The slab deflections were compared with the ACI 318/318R allowable deflections.

To enhance structural behaviors (Atichat et al, 2017), there are many possible repair methods such as strengthening of RC slab via concrete overlay (Sirimontree et al., 2018), strengthening of RC column via ferrocement jacketing (Sirimontree et al., 2015), applying corrugated steel sheet and concrete topping (Montha et al., 2018), or using external prestressing force (Phuwadolpaisarn, 2013). Degradation behaviors of the structure may also possibly be predicted by computer simulation (Chueachom & Sirimontree, 2015).

This study, however, uses a basic method for the repair of the crack structures. The in-situ load test is used as an evaluation method. From three methods, we can compare weights, moments of inertia, and beam deflections, in order to choose an optimal method.

3. METHODOLOGY

3.1 BEAMS STRENGTHENING

The optimal strengthening design for RC beams in the case study building will be calculated and found. The main focused issue is to reduce the deflections of the beams in the large oval room and the small oval room in the 2nd and 3rd floors (Figure 1). After the improvement, the improved beams will be able to carry more weight from floor finishing and their deflection will be in the allowable range. The responsible engineer has designed the reinforcements by using channel steel with two 10 mm steel plate (reinforcement first method). In order to compare and find the optimal reinforcement design method, two additional and comparing designs have been made in the study: the second method using only steel plates for strengthening and the third method using two angle steels with two 10 mm steel plate. Both the second and third methods are based upon the assumption that the beam deflections must less than the allowable deflection. The Moment of Inertia is used in the creation of the reinforcement design. (Beer, et.al., 1992).

Figure 2: Cracks in Beam

2.1.1 THE FIRST STRENGTHENING METHOD

The first strengthening method is designed using two-channel steels spliced on both sides of the repair beam and at the bottom it is attached by two-10mm thick steel plates as shown in Figure 3.

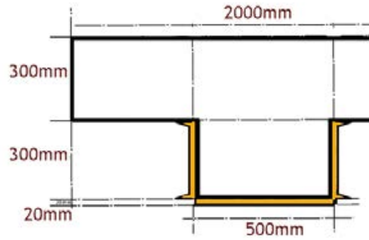


Figure 3: The first strengthening method.

2.1.2 THE SECOND STRENGTHENING METHOD

The second strengthening method is designed using two 100x100x10 mm steel angles spliced on both sides of the beam and welded with double-10mm thick steel plates at the bottom of the beam as shown in Figure 4.

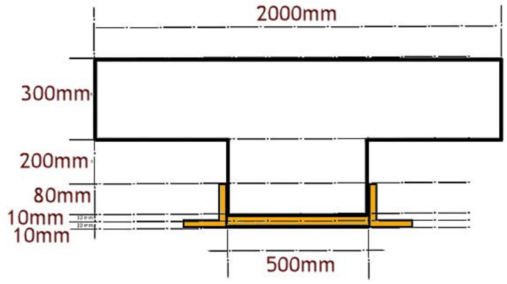


Figure 4: The second strengthening method.

2.1.3 THE THIRD STRENGTHENING METHOD

The third strengthening method is designed using two 80mm width and 1cm thick steel plates covered on both sides of the beam and attached by two-10mm thick steel plate at the bottom as shown in Figure 5.

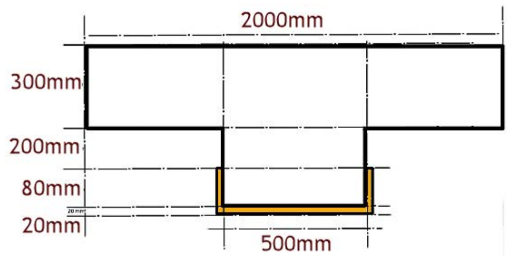


Figure 5: The third strengthening method.

2.2 LOAD TEST

2.2.1 STEEL DETAILING AND LOAD TEST DETAIL

The load test for this case study building is prepared on the 4^{th}-floor slab that has cross-section as Figure 6 and the grid lines location is shown in Figure 7. The locations of displacement transducers (that are points A, B, C, D, and E) are shown in Figure 8.

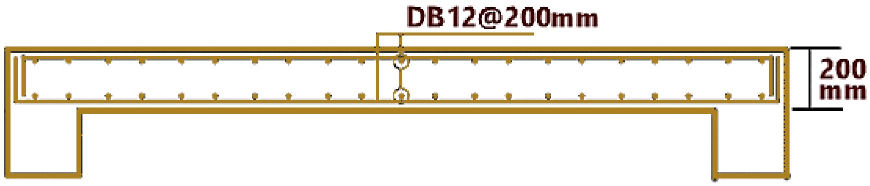


Figure 6: Cross Section of the 4th Floor Slab for Load Test.

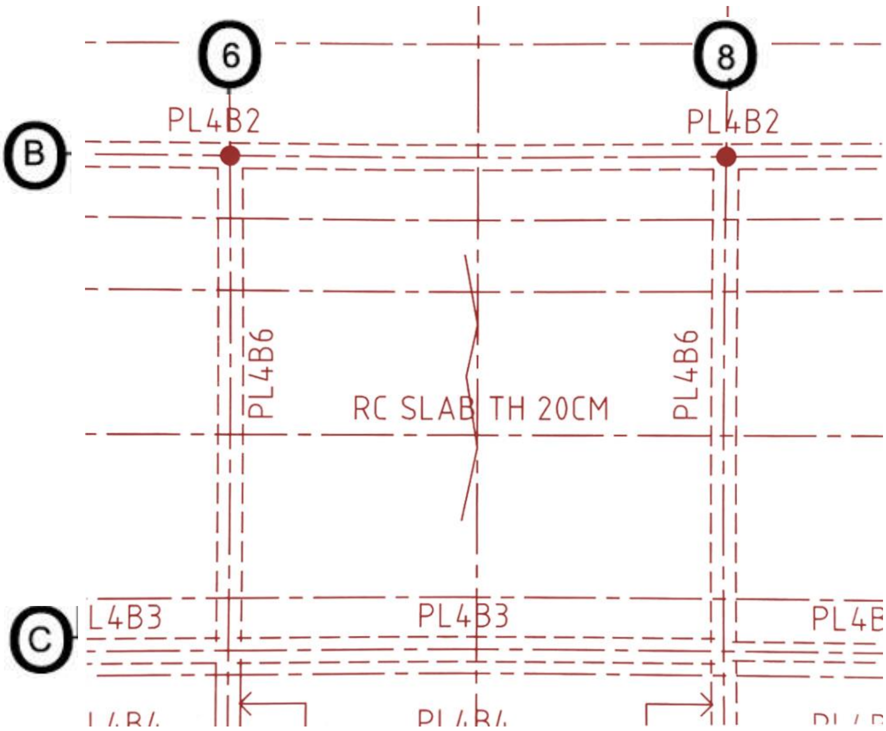


Figure 7: Load Tested Slab.

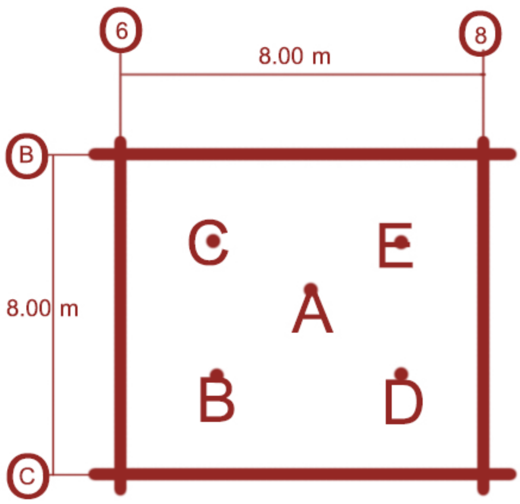


Figure 8: Installation of locations of displacement transducers.

4. RESULTS

4.1 COMPARISON OF BEAM STRENGTHENING METHODS

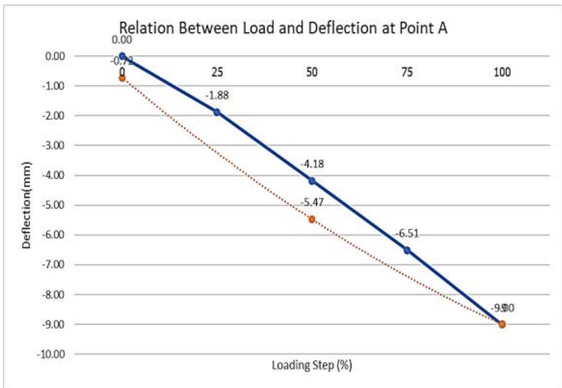
After the computation, we find that the weight of strengthening steels, the moment of inertia of the beam with strengthening steels, and strengthened beam deflection for each method can be compared as shown in Table 1.

Table 1: Weight, moments of inertia, and deflection comparison of all three strengthening methods

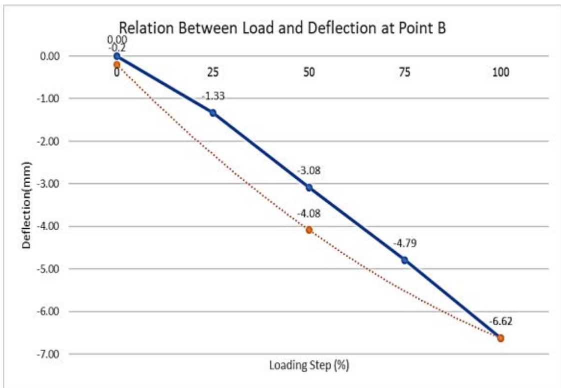
Method	Weight (kgf/m)	Moment of inertia (cm^4)	Deflection (mm)
1	76.2	1,836,056.2	35.7
2	29.8	1,811,902.8	33.5
3	18.8	1,696,065.6	35.1

4.2 LOAD TEST (ACI, 2008)

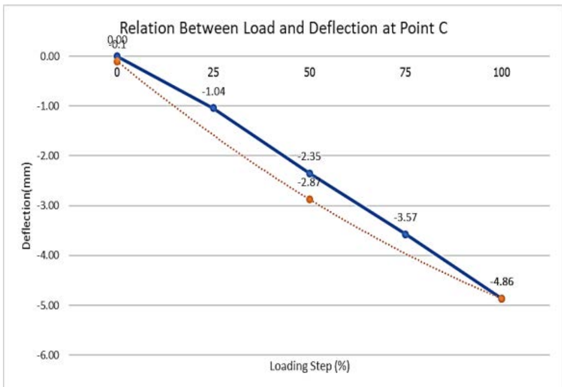
From the slap load test, the loads and deflections of the tested slab are shown in Figure 12.



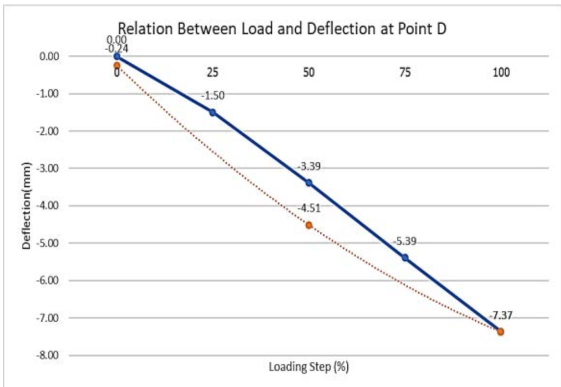
Point A



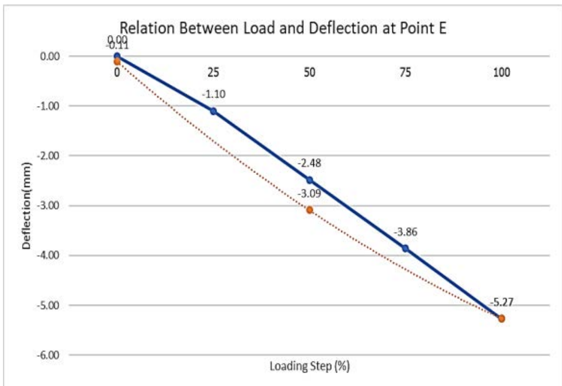
Point B



Point C



Point D



Point E

Figure 12: Relationship between loading step (%) and slap defection at points A, B, C, D, and E.

5. DISCUSSION

This study finds that the first method has the maximum deflection at 3.57 cm whilst the second method has the maximum deflection at 3.35 cm, which was the smallest deflection value. And reinforcement of the third method has the maximum deflection at 3.51 cm. It is also discovered that there is the smallest amount of steel required for the third method. When considered, it is clear to see that all three types have the maximum deflection value in the acceptable standard. Therefore, the third design is the most optimal design method.

6. CONCLUSION

This study presents a simple way to beam strengthening methods. From three basic beam strengthening methods, the result focuses on weight, moment of inertia, and deflection for each method. The second method givens the smallest deflection, while the third method requires the smallest repair amount of reinforcing steels. When compare to ACI (2008) standard, all three methods the maximum deflections are less than the acceptable standard, thus either method can be utilized, and the third design is the most optimal design method.

7. DATA AND MATERIAL AVAILABILITY

This study already includes all the information about this study.

8. REFERENCES

American Concrete Institute (ACI), Building Code Requirements for Reinforced Concrete, American Concrete Institute, January 2008.

Atichat, A., Sirimontree, S., & Witchayangkoon, B. (2017). Behaviors of Concrete Beam to Column Connections under Static Load Using Finite Element Method. *International Transaction Journal of Engineering Management & Applied Sciences & Technologies*, 8(2), 57-67.

Buddhawanna, S., Witchayangkoona, B., & Panmekiat, S. (2015). Structural Strength Evaluation by NDE and Load Test of RC Slab Structure, Case Study: RC Deck Slab of Primary Hospital Building, Faculty of Medicine, Thammasat University, Thailand. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*. 6(1), 13-20. http://tuengr.com/V06/013M.pdf

Ferdinand P. Beer, E. Russell Johnson, John T. Dewolf, David F. Mazurek, Mechanical of Materials, Second Edition, 1992.

Montha, A., Sirimontree, S., & Witchayangkoon, B. (2018). Behaviors of The Composite Slab Composed of Corrugated Steel Sheet and Concrete Topping using Nonlinear Finite Element Analysis. *International Transaction Journal of Engineering Management & Applied Sciences & Technologies*, 9(2), 75-84.

Sirimontree, S., Witchayangkoon, B., Lertpocasombut, K., & Sornchomkaew, P. (2018). Strengthening of Reinforced Concrete Slab by Concrete Overlay. *MANZAR-THE SCIENTIFIC JOURNAL OF LANDSCAPE*, *10*(44), 60-67.

Sirimontree, S., Witchayangkoon, B., & Lertpocasombut, K. (2015). Strengthening of reinforced concrete column via ferrocement jacketing. *American Transactions on Engineering and Applied Sciences*, *4*(1), 39-47.

Phuwadolpaisarn, T., Sirimontree, S., & Witchayangkoon, B. (2013). Relations between Structural Damage and Level of External Prestressing Force on the Flexural Behavior of Post-Tensioned Prestressed Concrete Beams. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, *4*(4), 241-251.

Chueachom, K., & Sirimontree, S. (2015). Prediction of Flexural and Degradation Behaviors of Full Scale Prestressed Concrete Girder by Finite Element Method. *American Transactions on Engineering and Applied Sciences*, 4(3), 201-212.

Dr. Saharat Buddhawanna is an Assistant Professor of Structural Engineering, Thammasat School of Engineering, Thammasat University, Thailand. He received a Bachelor's Degree in Agricultural and Civil Engineering and a Master's Degree in Structural Engineering from Khonkaen University (KKU), Khonkaen, Thailand. Dr.Buddhawanna has graduated Master and Ph.D. degrees in Civil Engineering concentrated on Structural Engineering field from University of Colorado (UCD), Denver, and Colorado State University (CSU), Fort Collins, Colorado, USA. His research involves non-destructive testing of structures.

Dr. Boonsap Witchayangkoon is an Associate Professor at Department of Civil Engineering, Thammasat School of Engineering, Thammasat University. He received his B.Eng. from the King Mongkut's University of Technology Thonburi with Honors. He received his Ph.D. study in Spatial Information Science & Engineering from University of Maine, USA. Dr. Witchayangkoon's current interests involve Applications of Emerging Technologies to Engineering.

Passaworn Boonyavinij is a Master's Degree student at Department of Civil Engineering, Thammasat School of Engineering, Thammasat University. He received his B.Eng. from Kasetsart University. His research involves Non-destructive Testing of Structures.