Jurnal Informasi, Sains, dan Teknologi, 05 (02) 2022, E-ISSN :2829-2758 P-ISSN : 2828-7207

Identification of building reliability with a forensic audit of the Non Destructive Test method

Aco Wahyudi Efendi[1]

[1]Civil Engineering, Tridharma University of Balikpapan, Jl. AW. Syahranie No.7 Balikpapan, Indonesia

[*]Email: aw.efendi2018@gmail.com

ABSTRAK

Rekayasa forensik adalah analisis objek dan bangunan yang gagal berfungsi atau tidak berfungsi sebagaimana mestinya, yang mengakibatkan cedera pribadi atau kerusakan properti.
Analisis eksperimental dilakukan dalam penelitian ini dengan menggunakan alat non-destruktif pada elemen struktur gedung yang dievaluasi dan memberikan informasi berupa identifikasi kerusakan dari hasil audit forensik pada gedung OJK Samarinda yang direview.
Berdasarkan temuan studi dengan menggunakan teknik identifikasi kerusakan (audit forensik) dengan menggunakan instrumen NDT pada gedung perkantoran OJK, homogenitas beton pada elemen struktur balok dan kolom gedung adalah baik sampai sangat baik. Hal ini terlihat dari nilai kecepatan laju rambat ultrasonic yang terdapat pada beton bervariasi antara > 3000 m/s dan kuat tekan beton teridentifikasi lebih besar dari fc' 28 MPa, jumlah tulangan pada elemen balok dan kolom yang diperiksa melebihi kebutuhan tulangan pada elemen struktur balok dan kolom bangunan, pada retak yang terjadi pada elemen struktur balok dan kolom. Kerusakan komponen arsitektur ditemukan pada dinding bangunan..

Kata kunci: Beton; forensic; identifikasi; NDT; SANSPRO

ABSTRACT

Forensic engineering is the analysis of objects and buildings that fail to perform or do not work as intended, resulting in personal injury or property damage.
Experimental analysis was carried out in this study using non-destructive tools on the structural elements of the building being evaluated and providing information in the form of identification of damage from the results of forensic audits at the reviewed OJK Samarinda building.
According to the findings of study utilizing the damage identification technique (forensic audit) employing the NDT instrument in OJK office buildings, the homogeneity of the concrete in the structural elements of the building's beams and columns is good to very good. This is evident from the velocity values found in the concrete pieces. It varies between > 3000 m/s and When the compressive strength of concrete is greater than fc' 28 MPa, the amount of reinforcement in the beam and column elements examined exceeds the reinforcement requirement in the beam and column structural elements of the building, in terms of cracks that occur in the beam and column structural elements. The damage to the architectural components was discovered on the building's walls.

Keywords: *Concrete; forensics; identification; NDT; SANSPRO*

INTRODUCTION

Forensic engineering is the analysis of objects and buildings that fail to perform or do not work as intended, resulting in personal injury or property damage. Forensic Engineering deals with machine safety incidents and explosion fatalities. An academic subject that discusses legal difficulties in an engineering manner (J. H. Kim & Kim, 2013).

Forensic engineering is the analysis of goods and buildings that fail to perform or do not work as intended, resulting in personal injury or property damage. In order to investigate the explosion accident of the centrifugal casting machine in terms of forensic engineering, the computing simulation using FEM Software has been performed in this paper to investigate that the effect of the Check-Pin fracture by the flow phenomena and molten metal weight and the mechanical properties test of the accident Check-Pin has been performed using the instrumented indentation technique. Through these investigations, the risk of a safety accident in a centrifugal casting machine may be reduced by conducting a specialized and methodical study of the accident cause in terms of forensic engineering (E. S. Kim et al., 2011).

Experimental analysis was carried out in this study using non-destructive tools on the structural elements of the building being evaluated and providing information in the form of identification of damage from the results of forensic audits at the reviewed OJK Samarinda building. This study provides information on the reliability of building structural elements using the FEM SANSPRO V. 5.20 software.

RESEARCH METHODS

The work inspection method is illustrated in the flow chart depicted in Figure 1.

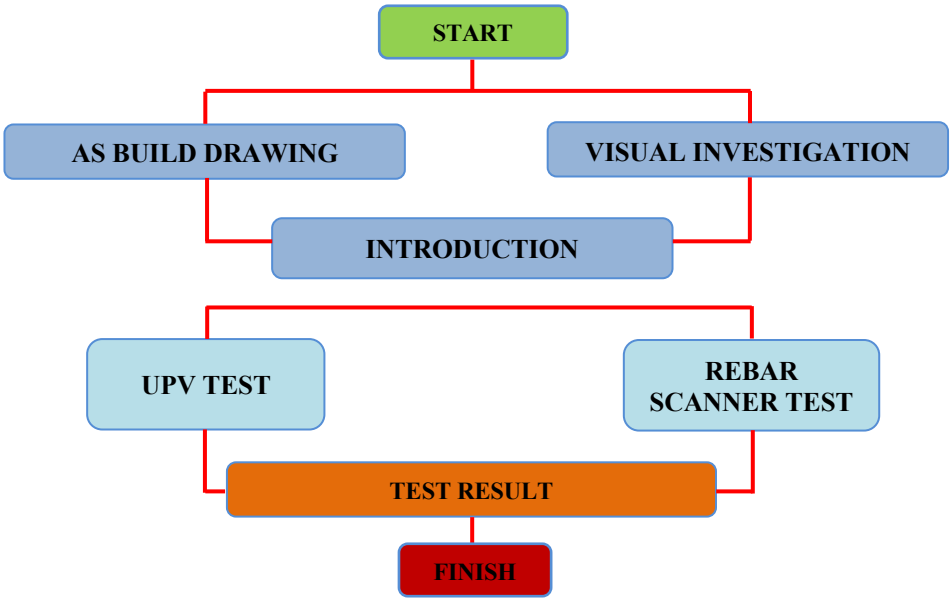


Figure 1 Investigation flow chart

The following are the broad scopes of the stages of research carried out:

1. Obtain the information required for this project, such as the As Built Drawing (Architecture and Structure) and load survey.

2. Conduct research on the quality and structural integrity of concrete by doing Ultrasonic Pulse Velocity testing on numerous random sections of concrete, both on concrete that shows signs of quality degradation and on concrete that is still in good condition, to assure concrete quality.
3. Analyzing the construction of the OJK building based on the test findings and taking into consideration the influence of the loads operating on the material quality conditions.
4. Conduct a structural study of the OJK Building based on the data findings (1) and the structural analysis results.
5. Based on the findings of the study, make suggestions for the actual protection and structural stability of the OJK Building, as well as efficient and effective methods of repair and/or strengthening, if necessary.

Building inspection is the activity of determining the dependability of a construction, its components, facility materials, and/or infrastructure and amenities over a specific time period in order to verify the building's correct operation. The non-destructive test (NDT) approach is utilized in conducting inspections of OJK buildings (A. W. Efendi, 2022a, 2022b).

Non Destructive Test Definition (NDT)

Non-destructive testing is a material testing technique that does not damage the test object. This test ensures that the material we are using is still safe and has not surpassed the damage tolerance level. Aside from the fact that NDT does not damage the test item, it is also more effective since it can be done immediately in the field rather than bringing the test object to the lab first, as is the case with testing the compressive strength of concrete in the lab.

NDT in the civil world is quickly expanding in wealthy countries like as the United States, Japan, and others (Dao & Lindt, 2013; Dou et al., 2022; McCormick et al., 2021).

Assessment method

Field testing, structural analysis, and strength analysis are the implementation steps carried out in this review. The following are the stages of the actions carried out:

1. Visual examination (Visual Check), both with the naked eye and with the use of a camera, to look for damage, particularly cracks. Other structural flaws such as porous, perforated, peeling, and so on are being investigated.

2. This action is performed specifically for components that transport loads, including vertical and horizontal stresses. The portrayal of crack patterns on the "Crack Pattern" structural components is the product of this work.
3. Examination of existing drawings, specifically "as built drawings. The purpose of this study is to gather the dimensions of reinforced concrete structures that have been put in the field, including the dimensions of the reinforcement. In addition, the compressive strength of the concrete and the tensile strength of the reinforcement must be determined. The collected findings are compared to the existing field conditions and utilized as input in the structure evaluation.
4. Non-destructive testing to determine the quality of materials. The Schmidt Rebound Hammer and Ultrasonic Pulse Velocity were utilized for concrete testing. A Rebar Scanner is used to determine the number and diameter of installed reinforcing steel. The breadth of a fracture in a concrete structure is measured.
5. Using the Meter tool, measure the geometry of the building structure. This activity consists of measuring the dimensions of reinforced concrete constructions that have been constructed in the field. If the as-built drawing is insufficient or confusing, actual measurements are taken in the field to gather reliable information about the present condition of the structure.
6. Structural analysis to determine the structural viability based on size and existing circumstances, and to calculate internal forces owing to various loading combinations. A computer with structural analysis software in the form of the FEM program is utilized as the tool.
7. The strength of the elements of the columns, beams, and floor slabs that serve as the framework for bearing the working loads is determined based on the findings of the structural analysis and study of the drawings.
8. Handling recommendations so that the building may operate physically and continue to be used, if necessary.

Method of finite elements

The finite element method (FEM) is a numerical approach for addressing issues in technical analysis. The finite element approach integrates various mathematical principles to generate

linear or nonlinear system equations. The number of equations formed is typically quite enormous, exceeding 20,000. As a result, unless a sufficient computer is employed, this strategy is of limited practical utility.

When a structure is exposed to forces such as stress, pressure, temperature, flow rate, and heat, strain (deformation) stress, temperature, pressure, and flow velocity are produced. The distribution of the ensuing effects (deformations) on an item is determined by the parameters of the force and stress system(Chen et al., 2021; D'Aniello, 2017; A. W. Efendi, 2022a; I. A. W. Efendi, 2022; Hong-quan et al., 2018; Ngan & Bocher, 2018; Okafor et al., 2020; Okello, 2018; Wang et al., 2022).

RESULTS AND DISCUSSION

NDT Test Results

Crack width testing

Crack pattern inspection is done at random, and testing is done on the section of the wall element where the cracks are visible. The three components tested are shown in Figure 3. Ultrasonic Pulse Velocity (UPV) testing was employed in this field. The following outcomes were produced as a result of the identification:

Table 1. Crack Observation Results
RESUME CRACK WIDTH TESTING-(SNI ASTM C597)

Elemen	Kode	Test Locations	Test Points Number	Width		
				Max	Min	Average
				(mm)	(mm)	(mm)
Wall	C1	Meeting room Lt. 2	3	1.39	0.92	1.21
Wall	C2	Meeting room Lt. 2	3	0.91	0.45	0.74
Wall	C3	Kabag Umum Room	3	0.32	0.09	0.19

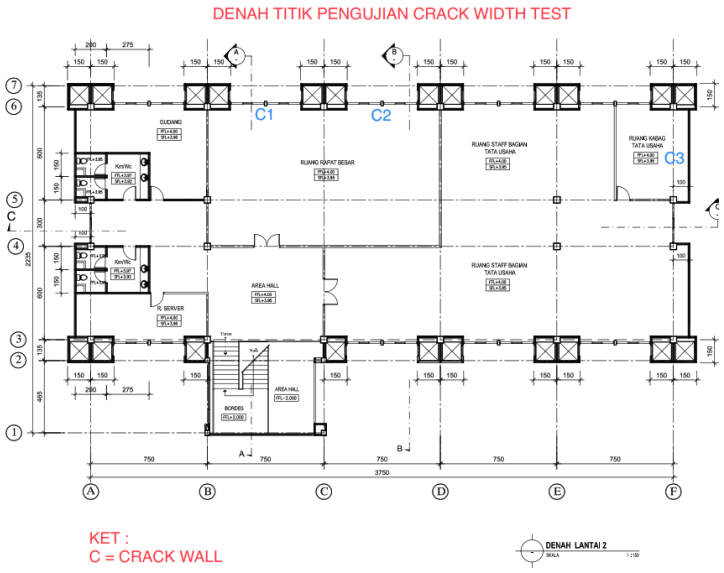


Figure 3. Plan of Crack Testing Locations

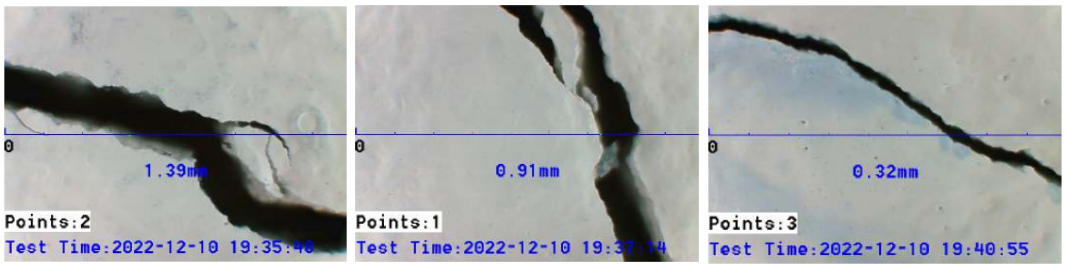


Figure 4. Photo of the scanned width of the crack

Figure 4 shows the width of the crack that occurs on wall C1 of 1.39 mm, wall C2 of 0.91 mm and wall C3 of 0.32 mm.

Ultrasonic pulse velocity test

The Ultrasonic Pulse Velocity Test is used to identify the compressive strength of concrete by measuring the speed of ultrasonic waves in the concrete, which is calculated using the formula: V=L/T, where L is the distance between the transmitter and receiver and T is the time traveled by the waves in the concrete.

Ultrasonic Pulse Velocity tests have been carried out on column elements, in the construction of the OJK Office building in East Kalimantan Province. Tests are carried out on 5 structural elements, which consist of 5 (five) column elements. Tests carried out in this field used an Ultrasonic Pulse Velocity (UPV) tool.

The results obtained from the test can be seen in Table 2.

Table 2. UPV Result
ULTRASONIC PULSE VELOCITY (SNI ASTM C597)

ID	Length (L)	Element ID	Velocity (m/s)	Quality of Concrete	Compressive Strength
	(mm)				MPa
Column	100	K1	3210.0	sufficient	28.00
Kolom	100	K2	3720.0	Good	33.00
Kolom	100	K3	4040.0	Good	37.00
Kolom	100	K4	4770.0	Very Good	44.00
Kolom	100	K5	3760.0	Good	34.00

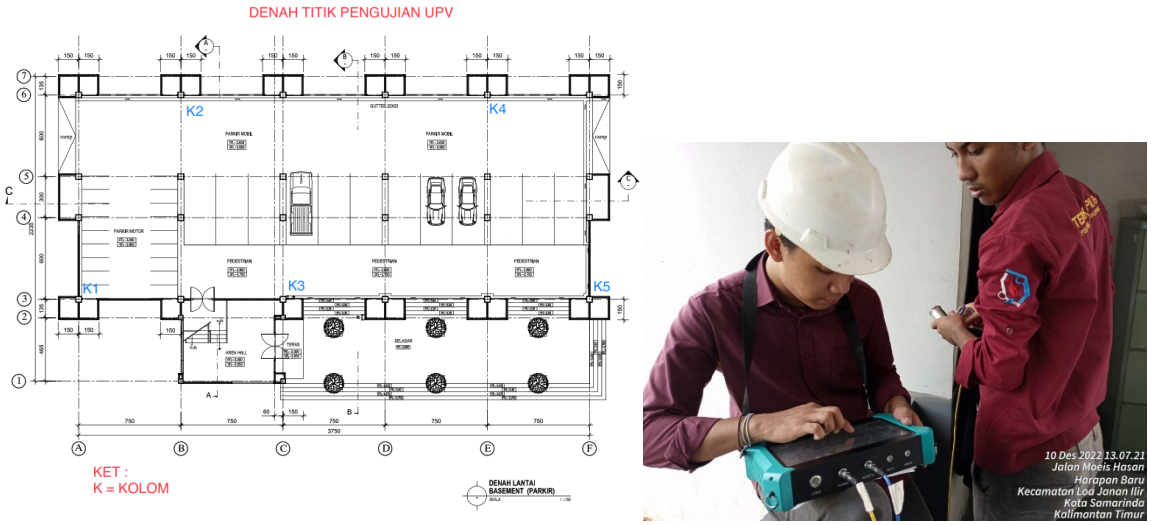


Figure 5 Location Plan of the UPV Test Points

Rebar scanner

The quality of reinforcement and the amount of reinforcement used in evaluating the strength of the structure is determined based on the "As Build Drawing", however, due to the thickness of the surface of the columns and beams and the possibility of damaging the structure, the amount of reinforcement is tested using a Rebar Scanner. The results of the number of reinforcement tests are shown in Table 3.

Table 3. Rebar Scanner Result

Instrument Type	IWIN RBL+		nstrument Numbe				rification Certific			
Detector	M. Yusuf				Certificate Number					
ember Nam	st Directio	mum Thick (mm)	mum Thick (mm)	rage Thick (mm)	dard devia (mm)	imum Diam (mm)	imum Diam (mm)	rage Diam (mm)	Total Dots	ualified	Dualified Ra
R1 (B1)	X	64	23	39.67	17.61	0	0	0.00	3	0	0.00%
R2 (B2)	X	38	35	36.33	1.29	0	0	0.00	3	0	0.00%
R3 (K3)	X	66	56	60.00	4.32	0	0	0.00	3	0	0.00%
R3 (K3)	X	64	29	43.50	12.98	0	0	0.00	4	0	0.00%
R4 (K2)	X	58	35	42.80	8.34	0	0	0.00	5	0	0.00%
R4 (K2)	X	27	26	26.50	0.71	0	0	0.00	4	0	0.00%
R5 (K1)	X	64	55	58.50	3.39	0	0	0.00	6	0	0.00%

Analysis of the existing building structure

The results of these inspections will be material parameter data on the structural elements of the building being reviewed, in the form of concrete strength quality values (fc') resulting from the velocity value approach on the concrete elements being reviewed, and the amount of reinforcement from scan results of concrete reinforcement.

The construction of the OJK building was analyzed using FEM software, specifically SANSPRO V. 5.20. (licence). The analysis is carried out by loading the structural elements and the live load from building usage, where the factored load is merely multiplied by one, with the service conditions, shown in figure 6.

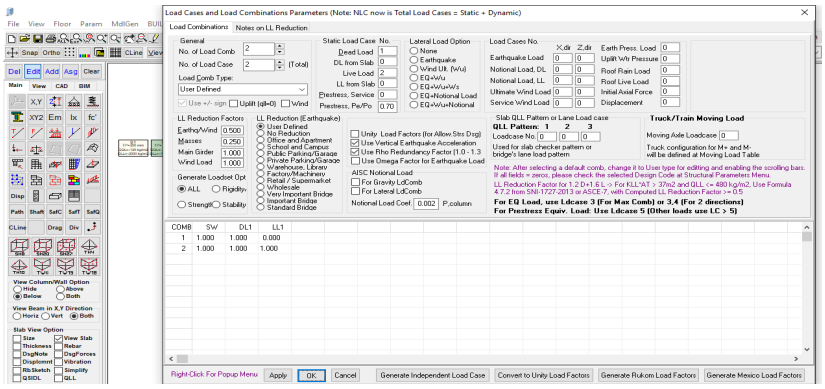


Figure 6. Load cases and load combination

Structural modeling is based on the as built drawing by adjusting the conditions of the building being built, shown in Figure 7.

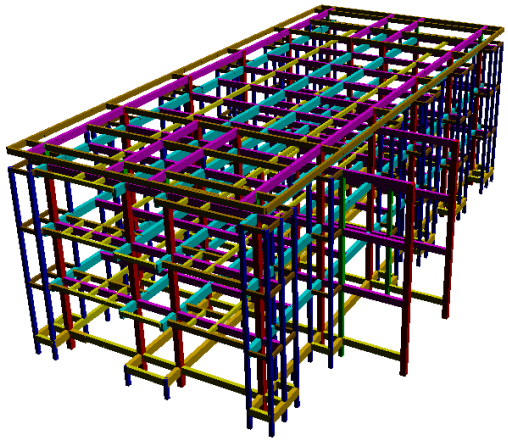
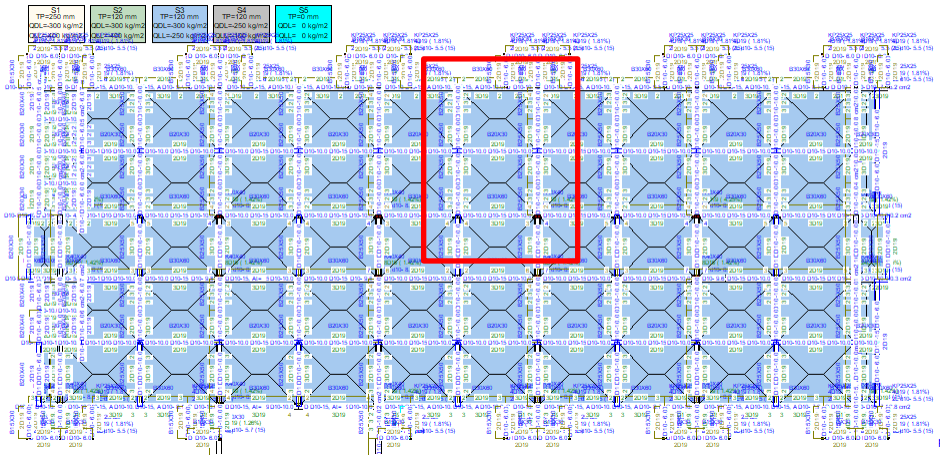


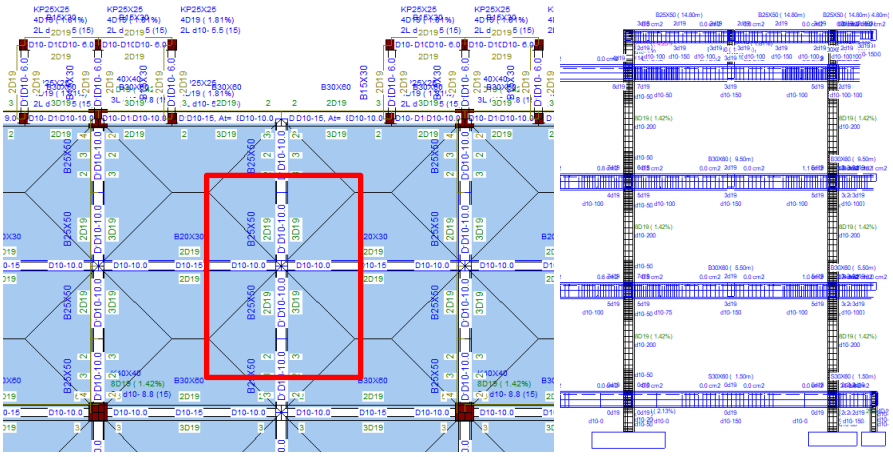
Figure 7. Structural modelling

The modeling results in the FEM software, i.e SANSPRO V. 5.20, and the analysis on the building's service conditions result in the building having a value of concrete strength quality (fc') from the NDT results and the number of reinforcement required from the FEM analysis on the rebar scanner results, as shown in Figure 8.

(a)



(b)



(c) (d)

Figure 7. analysis results (a) column (b) beam (c) amount of beam reinforcement (d) amount of column reinforcement

From Figure 9 it is explained that the results of the analysis carried out provide information on the need for reinforcement in these structural elements, where the amount of reinforcement in the beam on the support side requires 3 pieces of reinforcement with a diameter of 19 mm and in the column requires 8 pieces of reinforcement with a diameter of 19 mm which is the result of the rebar scanner on one side is 4 pieces on the X-axis side and 3 pieces on the Y-axis side, the total reinforcement in the existing building column is 14 pieces of reinforcement with a diameter of 19 mm which is more than the required reinforcement in the structural analysis that has been carried out.

CONCLUSION

From the results of research using the damage identification method (forensic audit) using the NDT instrument in OJK office buildings, the homogeneity of the concrete in the structural elements of the beams and columns of the building is in good to very good condition. This can be seen from the velocity values that occur in the concrete elements. it ranges from > 3000 m/s when it is correlated with the compressive strength of concrete is > fc' 28 MPa, the result of the amount of reinforcement in the beam and column elements examined exceeds the reinforcement requirement in the beam and column structural elements of the building, regarding the cracks that occur in The walls of this building identified damage to the architectural elements, not damage to the structural elements, and the width of the cracks

that occurred was < 3mm where minor damage was identified with sufficient repairs to be carried out using grouting or patching on the cracked architectural elements.

REFERENCE

Chen, X., Pan, L., Xu, L., & Shi, C. (2021). Three-Dimensional Vehicle–Curved Track Dynamic Model Based on FEM and DEM. *… Journal of Structural Stability and ….* https://doi.org/10.1142/S0219455421501790

D'Aniello, M. (2017). Finite element analyses on free from damage seismic resisting beam-to-column joints. In *COMPDYN 2017—Proceedings of the 6th International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering* (Vol. 1, pp. 802–814). https://doi.org/10.7712/120117.5458.17524

Dao, T. N., & Lindt, J. van de. (2013). Seismic performance of an innovative light-frame cold-formed steel frame for midrise construction. *Journal of Structural Engineering*. https://doi.org/10.1061/(ASCE)ST.1943-541X.0000683

Dou, P., Zou, L., Wu, T., Yu, M., Reddyhoff, T., & Peng, Z. (2022). Simultaneous measurement of thickness and sound velocity of porous coatings based on the ultrasonic complex reflection coefficient. *NDT & E International*, *131*, 102683. https://doi.org/10.1016/j.ndteint.2022.102683

Efendi, A. W. (2022a). ANALISIS PERKUATAN KOLOM PASCA KEBAKARAN PADA GEDUNG DPRD KALIMANTAN TIMUR. *JURNAL RIVET*. http://jurnal.unidha.ac.id/index.php/RIVT/article/view/412

Efendi, A. W. (2022b). Behavior Analysis of Building Structures After a Fire with FEA LISA V. 8. *Kurva S: Jurnal Keilmuan Dan Aplikasi Teknik ….* http://ejurnal.untag-smd.ac.id/index.php/TEKNIKD/article/view/6413

Efendi, I. A. W. (2022). Behavior Analysis of Forensic Audit Results at Pier 3 Mahakam Bridge. *PANRITA: Journal of Science, Technology, and ….* https://www.journal.dedikasi.org/pjsta/article/view/25

Hong-quan, L., Li-min, W., Sheng-yang, F., & ... (2018). INFLUENCE OF PVD-ENHANCING SOFT SOIL GROUND ON THE ADJACENT BRIDGE PILES–A 3D FEM ANALYSIS. *… Engineering Journal*. https://search.proquest.com/openview/88575286a6c9229984738779dc609fc7/1?pq-origsite=gscholar\&cbl=4665243

Kim, E. S., Kim, J. H., & Kim, M. G. (2011). Forensic engineering study on the explosion accident investigation of the centrifugal casting machine using ADINA FSI. *Journal of the Korean Society of Safety*. https://www.koreascience.or.kr/article/JAKO201121537465473.page

Kim, J. H., & Kim, E. S. (2013). Forensic Engineering Study on the Evaluation of the Structural Stability of the Mobile Crane Accident. *Journal of the Korean Society of Safety*. https://www.koreascience.or.kr/article/JAKO201330258590716.page

McCormick, R., Rosenblad, S. R., & ... (2021). Untapped Therapeutic Potential: Using Sandtray in Substance Abuse Treatment Groups. *Journal of Creativity in ….* https://doi.org/10.1080/15401383.2020.1789016

Ngan, N. H., & Bocher, P. (2018). Finite element analysis simulation of the effect of induction hardening on rolling contact fatigue. *Journal of Tribology*. https://asmedigitalcollection.asme.org/tribology/article-abstract/140/6/061404/383814

Okafor, V. C., Ogunoh, P. E., & Okechukwu, O. C. (2020). Finite Element Analysis of Fiber Cement Corrugated Roofing Sheet under Bending. *… Journal of Engineering and ….* https://ej-eng.org/index.php/ejeng/article/view/794

Okello, W. K. (2018). From self-authorship to self-definition: Remapping theoretical assumptions through Black feminism. *Journal of College Student Development*. https://muse.jhu.edu/article/703296/summary

Wang, Z. Y., Jin, Y. F., Yin, Z. Y., & ... (2022). A novel coupled NS-PFEM with stable nodal integration and polynomial pressure projection for geotechnical problems. *… Journal for Numerical and ….* https://doi.org/10.1002/nag.3417