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DAMAGE IDENTIFICATION SEGAH BRIDGE PIER DUE TO SHIP IMPACT

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Abstract

Identification of damage or often referred to as on-site structural forensic testing, using visual observation methods and testing of existing materials using the Non Destructive Test method, in addition to check condition the geometry of the bridge after a ship hit. Conducted to determine the extent of damage to the Segah Bridge P2 pier after it was struck by a pontoon vessel carrying coal material across the Segah Bridge. To conduct this research, in addition to collecting data from the visual survey and some field testing, the results were analyzed using LISA FEA to determine the behaviors and stresses encountered during the incident. This investigation was conducted by collecting data from the on-site visual inspection followed by an inspection using the NDT tool to determine the material condition of the elements of the struck bridge, namely the P2 pierhead of the Segah Bridge. After collecting data, it proceeds by performing a microstructural analysis using the FEA software, namely LISA FEA V.8. From the results of the research and data processing, it can be seen that the damage behavior resulting from the numerical analysis using LISA FEA is very similar to the conditions in the field, which of course is obtained from very detailed and measurable parameters and data collection, so that the behavior corresponds to the actual state.

Keywords: *Bridge, Damage, Impact, LISA FEA*

Abstrak

Identifikasi kerusakan atau sering disebut dengan structural forensik testing, menggunakan metode observasi visual dan pengujian material yang ada menggunakan metode Non Destructive Test, selain untuk memeriksa geometri jembatan setelah ditabrak kapal. Dilakukan untuk mengetahui tingkat kerusakan dermaga P2 Jembatan Segah setelah ditabrak kapal ponton yang membawa material batubara melintasi Jembatan Segah. Untuk melakukan penelitian ini, selain mengumpulkan data dari survei visual dan beberapa pengujian lapangan, hasilnya dianalisis menggunakan LISA FEA untuk mengetahui perilaku dan tekanan yang dihadapi selama kejadian. Penyelidikan ini dilakukan dengan mengumpulkan data dari inspeksi visual di lapangan yang dilanjutkan dengan inspeksi menggunakan alat NDT untuk mengetahui kondisi material elemen jembatan yang tertimpa yaitu pierhead P2 Jembatan Segah. Setelah data terkumpul, dilanjutkan dengan melakukan analisis mikrostruktur menggunakan software FEA yaitu LISA FEA V.8. Dari hasil penelitian dan pengolahan data dapat diketahui bahwa perilaku kerusakan yang dihasilkan dari analisis numerik menggunakan LISA FEA sangat mirip dengan kondisi di lapangan, yang tentunya diperoleh dari parameter dan pendataan yang sangat detail dan terukur. , sehingga perilaku sesuai dengan keadaan sebenarnya..

Kata kunci: *Gaya, Jembatan, Kerusakan, LISA FEA.*

1. INTRODUCTION

The Segah Bridge is a connecting bridge between the Tanjung Redeb Regency and Bulungan Province where this bridge is the only means of connecting the two regions.
Identification of damage or often referred to as on-site structural forensic testing, using visual observation methods and testing of existing materials using the Non Destructive Test (NDT) method, in addition to protecting the geometry of the bridge after a ship hit.
This survey was conducted to determine the extent of damage to the Segah Bridge P2 pier after it was struck by a pontoon vessel carrying coal material across the Segah Bridge.

To conduct this research, in addition to collecting data from the visual survey and some field testing, the results were analyzed using LISA FEA to determine the behaviors and stresses encountered during the incident.

Figure 1 View of the Segah Bridge

2. RESEARCH METHODS

This investigation was conducted by collecting data from the on-site visual inspection followed by an inspection using the NDT tool to determine the material condition of the elements of the struck bridge, namely the P2 pierhead of the Segah Bridge.
After collecting data, it proceeds by performing a microstructural analysis using the FEA software, namely LISA FEA V.8, by entering parameter values according to the results of the previous NDT study and identifying and validating the behavior occurring through the In-field damage results showing damage modeling results analyzed by field scale.

2.1 Types of concrete damage

Damage occurring to the structure in general can be classified into three categories, namely:

1. Cracks are cracks in concrete along a relatively long and narrow line. These cracks can be caused by a number of reasons including: Rapid evaporation of water in the concrete mix occurs due to hot, dry or windy weather. Cracks caused by this condition are called plastic cracks.
2. Cavity is a relatively deep and wide hole in the concrete. Cavities in the concrete can have various causes, among other things, compaction with a vibrator is not good because the distance between the formwork and the reinforcement or the distance between the reinforcement is too small and the mortar cannot fill. the voids between the coarse aggregates are correct.
3. Scaling/spalling/erosion is uniform surface delamination that can be caused by a variety of things including: Repeated freezing and thawing that results in surface delamination. This state is referred to as scaling.

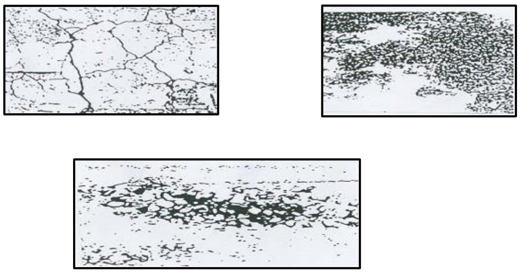


Figure 2 Types of damage that occur in concrete materials

Another type of damage that often occurs in structural elements of civil buildings are steel-concrete connections; The bond strength is affected by the surface roughness of the steel and the quality of the concrete around the rebar. Failure of the bond leads to a reduction in the bearing capacity of structural members to service loads, an increase in deformation and even collapse of the structure [1].

2.2 Non-Destructive Testing (NDT)

Non-destructive testing or non-destructive testing is a technique for testing materials without damaging the test object. This test is performed to ensure that the material we use is still safe and has not exceeded the damage tolerance limit. The NDT method is more practical than DT, in addition NDT does not damage the test object and because NDT is more effective because it can be performed directly in the field without having to bring the test object to the laboratory. Firstly, testing the compressive strength of concrete in the laboratory.

NDT in the civilian world is growing rapidly in developed countries like America, Japan and others. One of the fundamental considerations of professionals in the development of NDT is the complexity of the damage that can occur to a structure, which is impossible or very difficult to do with the DT method (Destructive Testing) and carries a high risk of damaging the Structure. Material that can affect other structures [2].

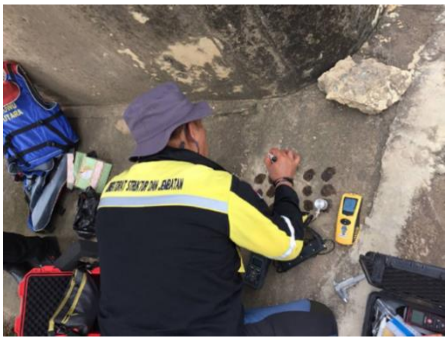


Figure 3. NDT testing at the scene of the incident, namely Pier P2 Segah Bridge

2.3 Finite Element Method

The finite element method (FEM) is a numerical method for solving technical analysis problems. The finite element method combines several mathematical concepts to generate equations of a linear or nonlinear system. The number of equations generated is usually very large, reaching more than 20,000 equations. Therefore, this method is of little practical value unless a suitable computer is used [3].

When a structure is subjected to forces such as stress, pressure, temperature, flow rate, and heat, the result is strain (deformation), stress, temperature, pressure, and flow rate. The nature of the distribution of the resulting action (deformation) on a body depends on the properties of the force and stress system itself. In the finite element method you can find the distribution of this effect, expressed as displacement.

The finite element method uses an element discretization approach to solve the problem of finding displacements of vertices/connections/lattices and structural forces. The discrete element equations are related to the matrix method for structural analysis and the results obtained are identical to those of classical analysis for structures. The discretization can be done with one-dimensional elements (line elements), two-dimensional (plane elements) or three-dimensional (volume/continuum elements). This approach uses a continuum element to determine a solution that is closer to the truth [4].

2.4 LISA FEA

LISA, a popular finite element analysis application, was used to estimate the temperature rise for three different models of heat exchangers. The three types of models are, in order of their simplicity and ease of construction, the line element model, the shell model, and the solid model [5].

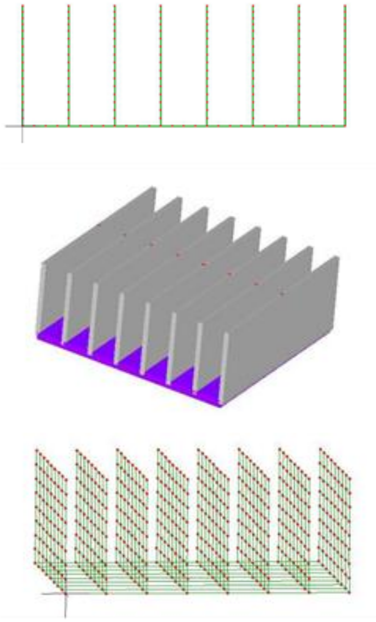


Figure 4. Element model on LISA FEA

For line element models only, the convection coefficient of the baseplate surface needs to be determined as half the value used elsewhere since we cannot exclude convection from assembling the baseplate surface with the face selection tool. It's just a matter of common sense.

For the other two models, it's easy to exclude the mounting surface from convection - we just don't select that surface. An internal heat generator is used in each case, and the volume of the entire floor slab is assumed to be the heat source. Care should be taken when applying boundary conditions to a line element model. LISA selects all faces of the line elements when the "face" selection is made (i.e. both "ends" of the line and all "sides" of the line) [5].

2.5 Analysis method

Static calculations to evaluate the structural feasibility based on existing sizes and conditions to determine the internal forces due to different load combinations. A computer equipped with statics software in the form of a microstructure analysis program with LISA V.8 serves as a tool. In this phase of performance, static calculations are performed in the field based on as-built drawings and the results of geometry test data. Based on the results of the static analysis and the picture check, the strength of the pile head and dolphin elements was examined.

2.6 Impact Load from Ship

The ship's impact load is determined by several factors, including the weight of the ship and the speed of the ship's collision. The magnitude of the ship's impact force depends on the ship's collision energy. Vessel impact energy is calculated in accordance with BS 6349-4 [6].

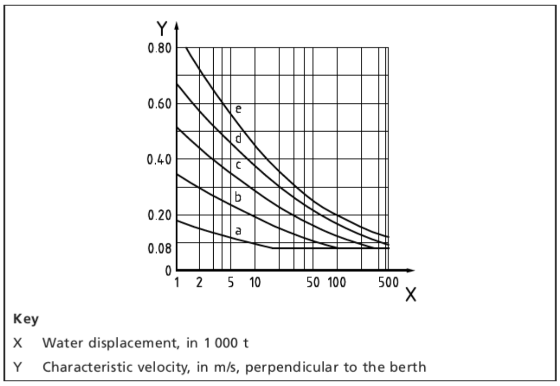


Figure 5. Mash Rate Design Curve (BS 6349-4)

The application energy is calculated using the equation in BS 6349-4.

$$E_C = 0.5 C_M M_D (V_B)^2 C_E C_S C_C$$

$$E_D = E_C \times BEF \quad (1)$$

Where:

EC = ship collision energy under normal conditions, kNm
ED = ship collision energy abnormal state, kNm
BEF = Berthing Energy Factor (1.5 – 2.0 based on BS 6349-4)
MD = ship displacement, ton
VB = ship collision velocity, m/s
CE = coefficient of eccentricity
CM = hydrodynamic mass coefficient
CS = fineness coefficient
CC = configuration coefficient of the pillar structure.

The calculation of the ship's impact energy is shown in the table below [6].

Table 1 Calculation of lying energy

DATA		General Cargo	Barge	Barge	
Deadweight tonnage	DWT	20,000	11,000	6,500	ton
Displacement tonnage	M_D	28,000	15,400	9,100	ton
Length of Overall	LOA	166.00	100.580	99.00	m
Length Between Perpendicular	LBP	158.00	95.55	94.05	m
Draft	D	10.00	4.51	5.30	m
Breadth	B	24.80	30.48	19.00	m
Berthing velocity	V_B	**0.200**	**0.250**	**0.300**	m/sec
Berthing angle	θ	6.00	6.00	6.00	deg
Impact from bow	x	39.50	23.89	23.51	m
Impact to centre of mass	R	41.40	28.34	25.36	m
Radius of gyration	K	38.31	31.26	27.10	m
Eccentricity coefficient	C_E	0.55	0.72	0.64	
Block coefficient	C_B	0.70	1.14	0.94	
Hydrodynamic mass coefficient	C_M	1.81	1.30	1.56	
Softness coefficient	C_S	1.00	1.00	1.00	
Berth configuration coefficient	C_C	1.00	1.00	1.00	
Berthing Energy Factor	BEF	1.50	1.75	1.75	
Design Energy - Normal Cond.	E_C	552.78	450.57	405.74	kN.m
Design Energy - Abnormal Cond.	E_D	829.17	788.50	710.05	kN.m

The maximum application energy is 829.170 Nm. Based on the Basic Design Document, the magnitude of the ship's impact force applied to the structural modeling is as follows:

- Impact / impact force on pillar 4: 829.170 N x 110% : 912.087 N
- Dolphin and Pier Available material: reinforced concrete fc' 20 MPa
- Modulus of elasticity: 2,102e+10 N/m2
- Poison Ratio: 0.2
- Concrete density: 24.000 N/m3
- Occurring impact/collision force: 950.000 N
- Friction: 0.2*impact force=190.000 N

3. Results and discussion

Based on the results of the on-site inspection and intelligence gathering, the bridge was hit by a pontoon boat being towed by a tugboat as it was crossing the Segah Tanjung Redeb bridge. In classifying the pontoon, it is carried by the current until the tug can no longer control the position of the pontoon in the shipping lane causing it to plunge into Dolphin Safety until it collapses and the pontoon hits the downstream face of the pier head P2 and it gives a very strong friction that causes the surface of the concrete to fall off and break, thick as a concrete pavement.

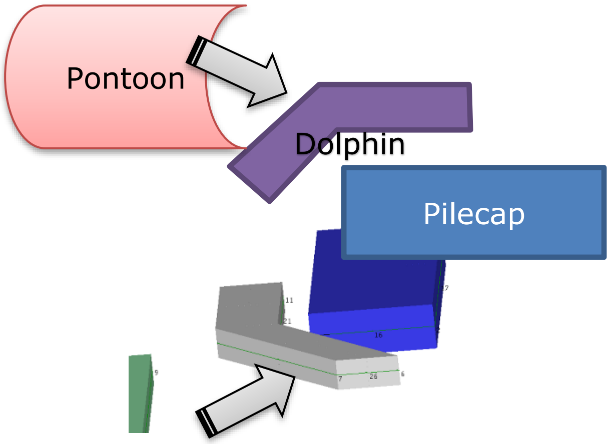
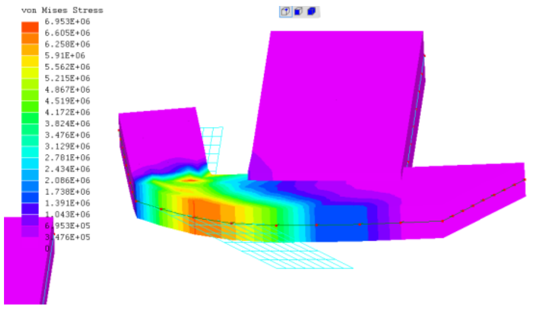
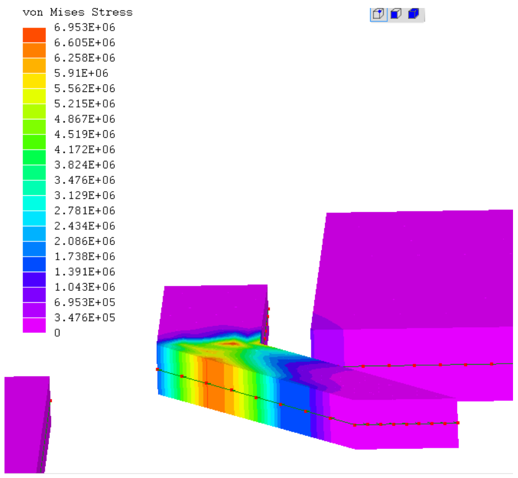


Figure 6. Chronology when the pontoon loses control of the tug

From the results of non-destructive testing in the field, the concrete quality values ranged from 22 to 30 MPa, these results were entered as parameters of the material of each checked element, namely the P2 pier and the dolphin. Then model the elements to be checked with LISA FEA.

From the results of collecting impact load data and the material parameters of the tested elements, it appears that the behavior is the same as under the actual field conditions, as shown in Figure 1





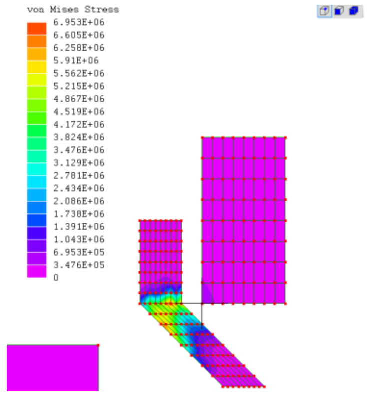


Figure 7. Element modeling and stress results occurring due to ship collisions and friction occurring after the dolphin collapses.

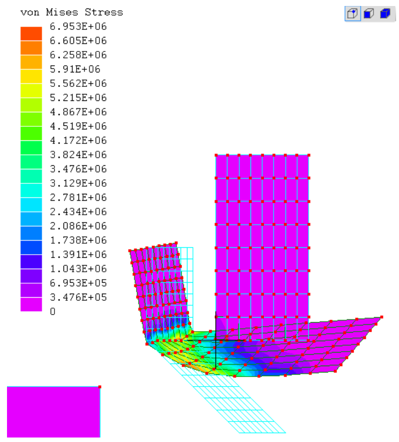


Figure 8 Damage to pile cap elements based on numerical..

The results of the analysis show that the stress occurring in the dolphin is 6.95 x 106 N/m2, while the strength of the pillar material is 0.8 fc' = 0.8 x 20 MPa = 1.6 x 107 N/m2 amounts to.

The material is still able to withstand collisions from the ship, it is only assumed that the condition of the pile is unfavorable to friction, so that the position of the dolphin collapses, as shown in Figure 8. At the end of the pile cap, the stress due to ship friction after hitting the Dolpih is 7,29,106 N/m2, causing cracks on the surface as thick as a concrete slab exposing the rebar as shown in Figure 9 shown.

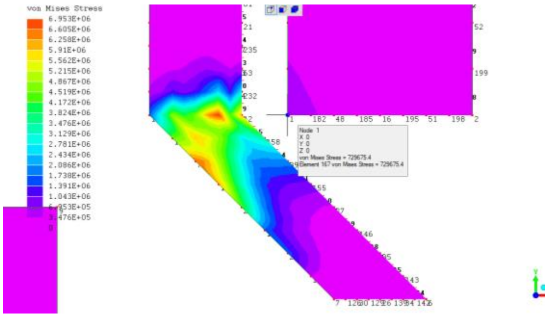


Figure 9 Damage to pile cap elements based on numerical analysis with LISA FEA and loading of the pile cap by ship friction

It can be seen that the damage state of existing elements in the field agrees with the results of the numerical analysis using LISA FEA V.8. in case of concrete cover thickness chip damage/fractures on the face of the pile cap, so that the reinforcement of the element is exposed and this is very dangerous for the steel material, which cannot withstand large temperature differences.

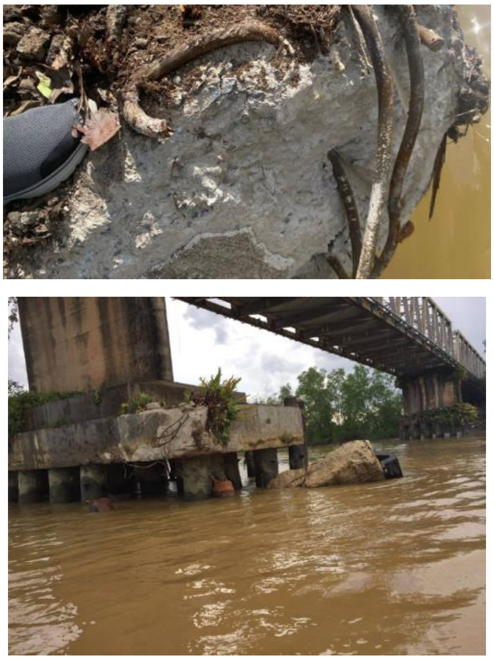


Figure 10 State of damage to existing elements in the field

4. Conclusion

From the results of the research and data processing, it can be seen that the damage behavior resulting from the numerical analysis using LISA FEA is very similar to the conditions in the field, which of course is obtained from very detailed and measurable parameters and data collection, so that the behavior corresponds to the actual state.

References

[1] A. Efendi, "Investigasi dan Assesment Audit Building pada Gedung D Komplek Kantor DPRD Provinsi Kalimantan Timur," CV. Quantum Consultant, Balikpapan, 2020.

[2] ASTM, Standard Test Method for Pulse Velocity Through Concrete C597-09., America: ASTM, 2009.

[3] H. Suryanto, "Aplikasi Metode Elemen Hingga Untuk Analisa Struktur Statik Linier Dengan Program Msc/Nastran," State University of Malang, Malang, 1999.

[4] L. J. Segerling, Applied Finite Element Analysis., Singapore: John Willey & Sons, 1984.

[5] C. R. Couch, "Comparative analysis of a heat sink using three different finite element models and validated experimentally.," Consulting Engineer, RF and Microwave Components and Systems, USA, 2013.

[6] B. S. 6349, Code of Practice for Maritime Structures, ritish: The British Standards Institution, 2000.

[7] A. W. Efendi, "nalisis Metode Pelaksanaan Retrofitting Pada Bangunan CSF Kariangau Balikpapan," *Jurnal Penelitian Teknika Universitas Tridharma Balikpapan,* 2017.

[8] A. W. Efendi, Laporan Hasil Investigasi Rona Lapisan Tanah pada Situs Gunung Selendang Sanga-Sanga, Samarinda: CLTQ&BANTEK Universitas Tridharma Balikpapan, 2016.

[9] A. W. Efendi, "Audit Forensik Bangunan Gedung Balai Wilayah Sungai Provinsi Kalimantan Timur," CV. Quantum Consultant, Balikpapan, 2020.

[10] S. N. A W Efendi, Analisis Perubahan Jarak Blok Angkur Jembatan Gantung Terhadap Gaya Yang Terjadi, Balikpapan: Research, Universitas Tridharma Balikpapan, 2019.

[11] H. M. N. S. A W Efendi, "Laporan Akhir Kegiatan Jasa Studi Land Subsidence PLTGU PRO POMU," PT. ARCSINDO KARYA UTAMA, Jakarta, 2020.

[12] A. C805, Standard Test Method for Rebound Number of Hardened Concrete, America: ASTM.

[13] A. C1383, Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method., America: ASTM.

[14] A. 3. Building Code Requirements for Structural Concrete, ASTM C597 – 09 Standard Test Method for Pulse Velocity Through Concrete, USA: ACI 318 Building Code Requirements for Structural Concrete, 2009.

[15] SNI-6880, Spedifikasi Beton Struktural, Jakarta: SNI, 2016.

[16] B. S. N. SNI, Persyaratan Beton Struktural untuk Bangunan Gedung SNI 2814:2013., Jakarta: Hanafi, M.B., 2013.

[17] B. S. Nasional, Beban Minimum Untuk Perancangan Bangunan Gedung dan Struktur Lain SNI 1727: 2013., Jakarta: Badan Standarisasi Nasional, 2013.

[18] B. S. Nasioanal, Tata Cara Perencanaan Ketahanan Gempa Untuk Struktur Bangunan Gedung dan Non Gedung SNI 1726:2012, Jakarta: Badan Standarisasi Nasioanal, 2021.