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Acoustic Emission Monitoring on Real Structural Bridge

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Abstract *- This monitoring work presents the results of the field project, Acoustic Emission (AE) was used as a monitoring technique to detect and locate cracks and to monitor its propagation from the crosshead of the bridge. The advantage compared with other techniques is that the signal was generated in the material itself and will be recording the process of damage throughout the entire load without destroyed on the bridge structure. AE waves are high-frequency stress waves generated by the rapid release of redistribution energy from material localized sources, such as crack initiation and growth. The high sensitivity to crack growth to ability detect sources, passive nature and the possibility to perform real-time monitoring are some of the interesting features of the AE techniques. After the monitoring work, using AE wave signals including parameters such as AE amplitude, rise time, and average frequency, the crack pattern at the crosshead of the bridge will be identified according to the type of crack process, active crack, and crack classification.*

Keywords — *Acoustic Emission, AEwin, Bridges, Active cracks, AE amplitude*

I. INTRODUCTION

Accurate inspection of concrete durability has become a critical issue in recent years [1,2]. Concrete durability assessment is crucial to prevent any structural deterioration in the future [3]. Generally, to prevent structural failure, identifying cracks or defects within the concrete surface is essential [4]. Crack is a very important indicator in monitoring the status of an infrastructure [5]. Specifically, the accurate assessment of crack and delamination becomes a burden due to the structural design of a bridge. In this project, Acoustic Emission (AE) techniques will be applied to monitor the Bridge. In this work, the author's attention will be focused on assessing the structural integrity of the bridge.

The AE technique is being extensively applied in flaw detection, weld quality inspection, loose particle detection, aerospace and leakage location [6, 5, 7]. It is possible to classify the types of cracking by applying the AE technique. This technique is an effective tool for the evaluation of any system without destroying the material condition [8]. It also enables early crack detection as it has a very high sensitivity to crack growth [9]. At the moment, among the Non-Destructive Technique being investigated, AE is considered to be a good preference [10]. Acoustic Emission signals contain a lot of information on the damage mechanisms during the monitoring stage. AE sensors were used to acquire the AE parameter [11].

Fig. 1 Crosshead of the Bridge

In this project, will be monitored crosshead of the bridge at highway ELITE as shown in Figure 1. This is due to the process of implementation on early damage detection of the bridge [12]. The global monitoring is a real monitoring for large structure such as bridge and high rack building. This powerful tools of acoustic emission could detect the micro defects occurring even in hidden damage or hard to reach the area [10]. This technique is an effective tool for the evaluation of any system without destroying the structure condition [13].

II. EXPERIMENTAL OBJECTIVE

These projects aimed to determine the feasibility of AE techniques for detecting defects in crossheads of the bridge. The aim was addressed via fieldwork and the data was made available to PLUS Malaysia Berhad. The objectives of the work were;

i. Investigate the behavior crosshead of the bridge by recording the AE response.

ii. Investigate the effectiveness of applying the AE technique to monitoring the real bridge.

iii. Determine the reliability of the AE data to verify the results.

III. ACOUSTIC EMISSION TESTING

Acoustic Emission (AE) can be defined as pressure wave produced by mechanical deformation of the material and captured by AE sensors [21,22]. Since 1950, the AE technique has been extensively studied by the Kaiser [9,14,15]. In this project, AE technique are used to monitor the crosshead of the bridge. AE differs from other methods for investigating the material deformation process in three significant aspects. First of all, the detected energy comes from the structure itself, rather than being supply from external sources as in the ultrasonic testing. Another reason, AE could detect processes associated with decreased structural integrity. Most importantly, sensors located anywhere around the AE source are often able to detect and locate the emissions.

Acoustic Emission is classified as Passive Non-Destructive Techniques (NDT) that do not require signals to be release to detect damage. Instead, it waits for the signal to be recorded that the signal originated in the structure or material by the process of energy release and some damage occurs [10]. One of the advantages of AE, as it does not require continuous structural scanning or continuous data recording in search of possible defects. Vice versa also has disadvantages, when it is not any loaded on the structures there is not provide information. Therefore, the source must be active to be detected.

After that, the results presented in this paper were obtained using an AE SAMOS. Eight AE sensor of the type Wideband Differential (WD) sensor was used as shown in Figure 2. These transducers of 17.8 mm diameter by 16.5 mm high, it has a very good frequency response over the range of 100 – 900 kHz [20]. This WD sensor was well suited for structural health monitoring of large structures like a bridge, storage tanks, pipeline, etc. WD transducer comes along separately with the pre-amplifier. The 2/4/6 is a voltage pre-amplifier with switch-selectable gain ranges of 20, 40, and 60 decibels. The AE system can be checked by an analog signal. These emission signal of pencil lead breaks breaking has advantages of simplicity, economy, and repeatability. The function is to know the AE channel is smooth by the amplitude of the received pencil lead breaks breaking [23-25].

Fig. 2 WD - 100-900 kHz wideband differential AE sensor

Prior to the AE equipment set-up, the monitoring layout was prepared as shown in Figure 3. In this monitoring, six sensors were used to captured the AE wave. The AE equipment was set-up on the scaffold nearly the crosshead of the bridge, as shown in Figure 4. The loading from vehicles movement on the bridge could occur waveform within the structure, then captured by the AE sensor attached to the crosshead surface. After that, the raw signal is passed through a pre-amplifier for pre-amplification and then to the data acquisition system. The number of AE hits is then detected. Finally, the acquired data is digitised and fed into the AE computer for data storage, display, and analysis.

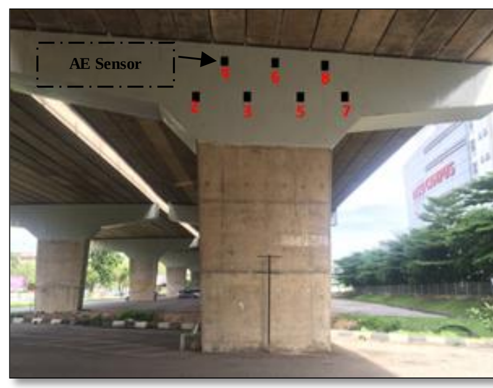

Fig. 3 AE Sensor layout at crosshead

Fig. 4 Experimental AE installation under bridge

Normally this real monitoring work will be evaluated from the effects of the traffic flow on the superstructure bridge and include under nominal loading. The duration of testing for each bridge is about 10 hours, 8 a.m to 6 p.m. The data will be recorded and evaluated with different loading parameters.

IV. RESULTS AND DISCUSSION

This subtopic describes the result and analysis from AE win that carried out during the real monitoring work and crack recognition in the crosshead of the bridge. The AE analysis for pier no 34A is shown in Figure 5 to Figure 8. Figure 5 shows graph hits versus channel, the hits emitted when stress occurred on the structure and was captured by AE sensors. According to the graph, a number of hits describing the AE activity that exceeds the threshold and causes a system channel to accumulate the data. These signals are generated when vehicles passing thru the bridge. Illustrated by the graph, AE sensor channel 6 increases rapidly due to the location of the sensor mounted at surface crosshead have high energy.

Figure 6 shows the results recorded during real monitoring, as could be seen from the graph demonstrate the results for energy versus time. Considering the observed distribution of AE energy, it is found that the energy becomes greater during peak hour as shown in Figure 6.

Figure 7, shows the signal strength value due to the x-axis position for pier no 34A. The highest signal value for this pier at channel 6 is about near 8x1011pVs and channel 5 above 6x1011pVs. The results indicated that the signal strength value did not show all the sensor highest due to the behavior of the structure.

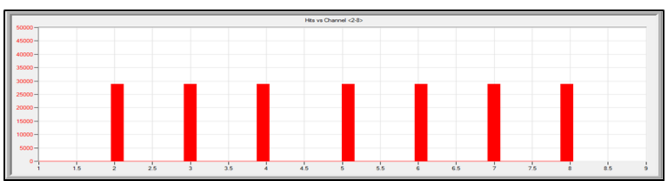

Fig. 5 Hits vs Channel

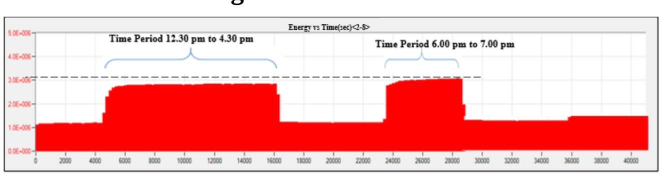

Fig. 6 Energy vs Time (sec)

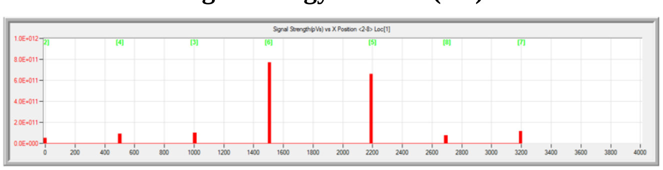

Fig. 7 Signal strength vs X Position

Figure 8 presents the amplitude versus time for pier no 34A. The highest amplitude shows the period time at 12.30 p.m., where the amplitude hits at 60 dB. Besides, the value of amplitude keeps increasing when the vehicle keeps moving on the structure, the values indicate the higher amplitude throughout the fracture process.

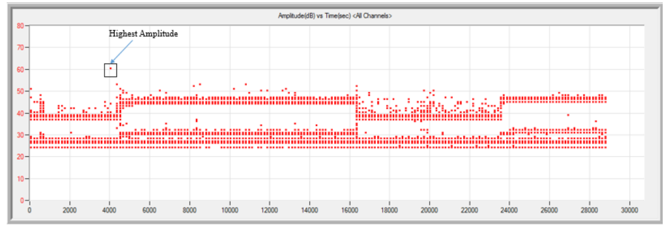

Fig. 8 Amplitude vs Time (sec)

V. CONCLUSIONS

Acoustic Emission (AE) techniques are useful for the evaluation of the integrity of reinforced concrete structures. It is proven successfully used for selecting bridges or their elements that need to be evaluated. AE is an active structural health monitoring technology without any damage to the original materials or structure. This project has investigated the role of AE and provided the analysis based on AE data parameter for global monitoring on the pier of the bridge in real site. AE signal analysis could be used to detect, locate, and evaluate these damage mechanisms. The signal strength in this analysis shows good results for the determination of hairline fractures with high signals collected in critical areas. The Absolute energy results indicate a more efficient for the determination damage process crosshead of the bridge. Then, from these results, it is shown assuring outcomes in the appraisal system to identify the degree of damage mechanism.

Finally, it can be concluded that the overall results of this project promise to determine the damage grading system at the crosshead of the bridge. Consequently, it is believed that the use of this evaluation system method was facilitates monitoring work for engineers and researchers to solve the problem of the bridge structural evaluation.

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