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Infrastructure Health Monitoring System (SHM) Development, a Necessity for Maintenance and Investigation

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Abstract-***Failure of Kutai Bridge already gives Indonesia civil engineer a blow in face. The failure which bring cause human accident make a new challenge to Indonesia civil engineer not to wait till failure but to safe before the construction failure. By the development in sensor and monitoring technology the idea become more realistic. Structure Healthy Monitoring (SHM) become new idea to detect, to monitor and to find out the reliability of structure. The development and research in Indonesia for SHM till now are presented and compared to other country. SHM research is needed to predict behavior of bridge by using data from monitoring to gain healthy condition.***

Keywords: Monitoring, Bridge, Structural Healthy Monitoring (SHM)

1. INTRODUCTION

Engineers of civil engineering are risk takers, this means design and build any construction are related with human life. Any mistake to the design and build will create a disaster. History already records an engineer fault in civil engineering that involve to human accident.

Civil engineering is different than engineering. Other could create a prototype to see it behavior and create a standard to avoid mistake. But in civil engineering every construction are different, have their own characteristic and have their own strength. Many factors create this condition from paper to field problem when that construction builds until other nature involve.

Even in Melchers [5] says that civil engineering failure that created a problem are smallest than other human activity (0.1 millions / years) depending to smoke activities risk which is 1000 millions / years. But still when a construction fails many people will watch and investigate more than dead by smoke. A civil construction failure happens in many ways. First due to a bad design by civil engineer consultant; a bad construction by civil contractor which create a bad composition of material strength. And the last is a deterioration of construction to nature or environment.

If construction is human being, we can consider the condition of it life that is related to all above. This might be a health condition for it. Different to human being, it does not grow by itself but it has a deterioration which always say as life time of construction.

Failure of construction before the life time will create a shock effect for all, especially for all civil engineer. lets just say our tragedy of Kutai Kartanegara Bridge. Failure of Kutai Bridge bring many things to Indonesia engineers. Investigation, history and strength of bridge are studied and calculated. The cause of the failure are considered and took by note so that there will be no other tragedy like it. This tragedy created a change in civil engineer to create and seek more ways to convince the other or next bridge will be safe for no more tragedy.

Beside of making better design and build effort, this will also bring a consideration about how to see a healthy condition of structure. Question like how healthy actually this construction or actually how much old this construction (which mean to life time design) and how much strength remain in construction are asked. The question above are needed to find out the reliability of the construction.

Reliability of construction which mean to it healthy are new part of civil engineering know as Structural Healthy Monitoring (SHM). This part idea are monitoring construction behavior from it build to deterioration of it. So by studying all data and condition related to construction, question above can be answered and can be used to predict maintenance and deterioration to construction. By ideas to safe and not to wait till failure, the changes of civil engineer idea may be different in the next period

From all construction, bridge might be started for SHM, this consideration come because bridge has a unique condition compare to other construction. Bridge are used every day by human but inspection are not often because not like a building, people use bridge but not related to fell it condition compare to building. Bridge is used every day by different load type, different composition of load and dynamic load occur in it. Other than that bridge are skeleton construction type, which mean SHM can be use directly to its main construction.

This idea is to change from how to detect, to monitor and to safe the structure with SHM come with development of technology. A century ago or at least fifty years ago, the idea to monitor might be not come across in civil engineer's mind. Technology of sensor and computer monitoring become a fast growing in electro engineering nowadays, by combining it to our basic concept of structure behavior, the idea from wait till to monitor

might become a solution for safety. This condition mean a challenge for all of civil engineers to be ready to this change specially for Indonesia engineer to use the monitoring system to the idea to safe before the construction fail.

This paper aim to explain of Indonesia SHM application compared to other countries, progress of SHM in bridge and next research for SHM which can be challenge to all of us to the next future of construction.

II. SHM DEVELOPMENT IN OTHER COUNTRY

Research for SHM are now become main idea in several countries, because the pattern of research are large and need integration of them. Figure 1 show main idea of SHM research.

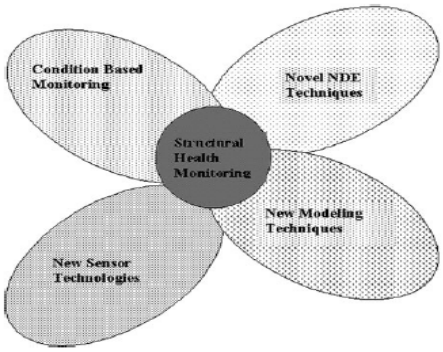

Fig.1 : Part of SHM Research [4].

According to data, research for SHM started from 1996 as define in table 1.

TABLE 1. SHM RESEARCH IN OTHER COUNTRY

Country	Year Start
Hungarian	2003
Swiss	1998
France	2000
China	1998
German	1996
Austria	1999
America	1998
Thailand	2001
Singapore	1997

Source : Helmut, 2009[2]

Research for SHM from other country consist of laboratory and field test using many sensor and many methods to define result of sensor. And there is still no agreement reached about standard for SHM data read.

Adrien Oth [1] from Luxenburg has proposed a method for deflection of bridge from their field experiment using vibration data. Meanwhile Zhu [8] from USA, propose a frequency to create a mode shape in FEM for the bridge. Another research comes from Resnik [6] in Germany which propose to use natural frequency as base standard of healthy.

Other type research of monitoring might come from other type of vibration data, Yukio [7] propose to use a robot detection method for monitoring and vehicle detection robot system just like in figure 2.

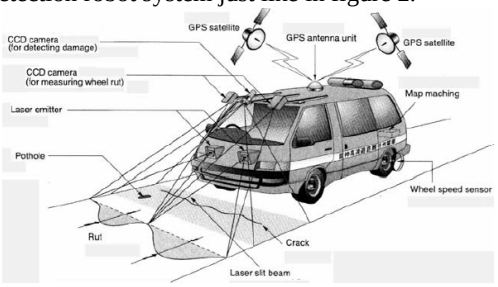

Fig. 2 : Vehicle Robot Sensor [7]

Meanwhile Korea's system for monitoring are called with SBBMS propose for deflection and temperature sensor to determine condition of bridge [3].

Research for SHM until 2012 are still trying to propose their method so that it can be used as standard of healthy bridge. Korea research are now harvest data from their major bridge , Sohae bridge, using sensor as figure 3 and 4.

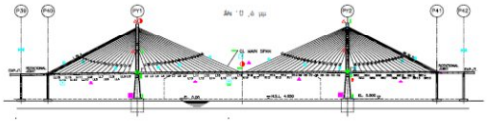

Figure 3 : Sensor in Sohae bridge

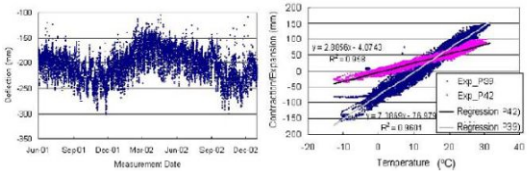

Fig. 4 : Sohae bridge harvest data

III. INDONESIA SHM DEVELOPMENT

Indonesia started SHM development by integrated SHM system in Suramadu bridge. Around 514 sensors are attached consist of vibration, corrosion, global positioning system, temperature and wind sensor. Suramadu sensors are using cable to transfer data. But the main idea getting a SHM attached not only to harvest data but also to read data from it. Which mean not only apparatus but human resource must be applied for SHM data. Research about SHM can be started when Suramadu Bridge SHM start their harvesting data, but with Kutai bridge failure need for human resource and cheap apparatus become more significant to do. Indonesia which is consist of many Islands with a lot of river which mean there are a lot of small, medium and long bridge need to be monitored.

IV. A RESEARCH FOR INDONESIA SHM

The need for Indonesia SHM research is cheap, can be transfer to control unit with long range, moveable apparatus and can be define a bridge healthy in control monitor system. This need refer to environment condition and resource of Indonesia.

Because of this need, SHM study group referring a condition of wireless sensor using GSM packet data to sent. Meanwhile from civil engineer need an algorithm for analysis data sent from wireless in second to define bridge healthy

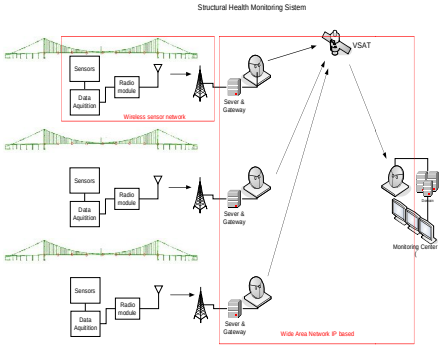

Fig. 5 : Indonesia SHM Model System

SHM study group define a vibration data harvest from accelerometer can be a start for define bridge behavior. Test will be done in laboratory scale using bridge model and full scale test in the field using wireless sensor apparatus which is still in prototype.

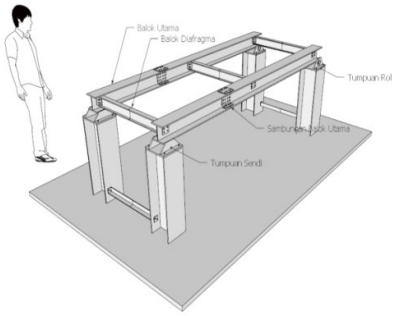

Fig. 6 : Laboratory scale bridge test

And test trust of bridge already started, as define in figure 5.

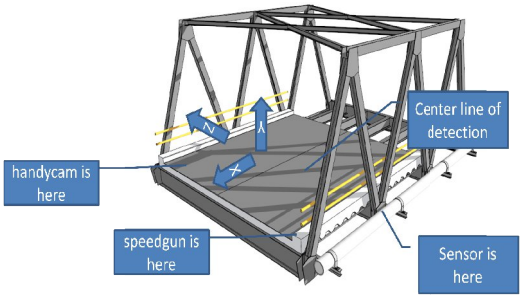

Fig. 7 : Trust scale test

Test in field harvest vibration data around 48 hours. This data are sort to create a type of define data to use. Filtering and whitening data using Fast ICA method.

TABLE 2. VEHICLE DATA COMPARRISON

No	Vehicle Type	Load	Speed km/ hours
1a	Truck With Wood As Load	Full	26
1b	Truck With Wood As Load	Full	20
2a	Concrete Mix Truck	Empty	24
2b	Concrete Mix Truck	Full	24
3a	Fuel Tank 10000	Full	29
3b	Fuel Tank 10000 litre 3 in row	Full	29

Comparisons using raw data are shown above

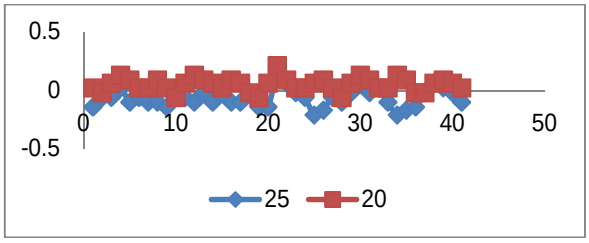

Fig. 8. Case 1 in raw vibration data

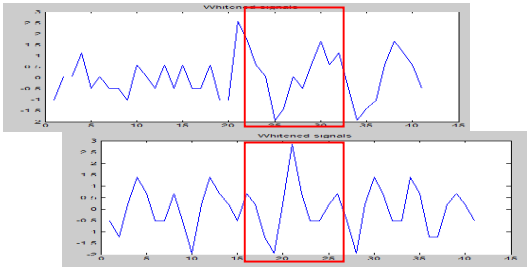

Fig. 9. Data Result Fast ICA no 1b, 1b

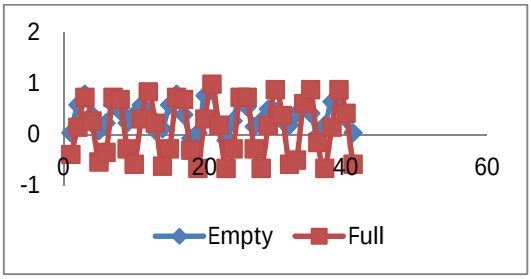

Fig. 10. Case 2 in raw vibration data

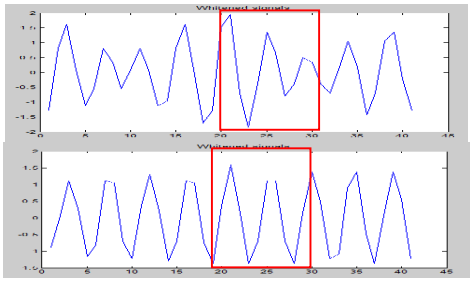

Fig. 11. Data Result Fast ICA no 2b

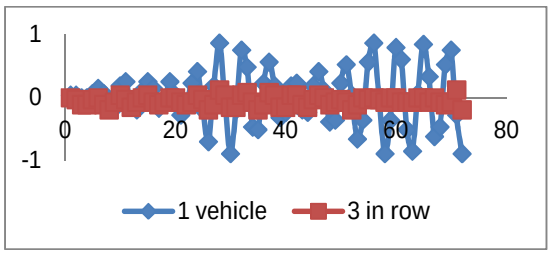

Fig. 12. Case 2 in Raw Vibration Data

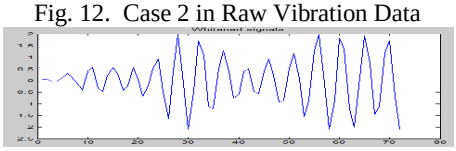

Fig. 13a Data Result Fast ICA no 3a

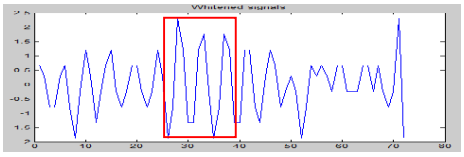

Fig. 13b Data Result Fast ICA no 3b

This comparison above show that vibration in bridge monitoring system need a database of load to create a standard frequency for define condition of bridge healthy. And the test must be done in real time to get a prediction of bridge healthy. Research of wireless sensor and wireless system to the bridge monitoring system are needed to gain more information about bridge behavior.

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