Fifth International Conference on Sustainable Construction Materials and Technologies. http://www.claisse.info/Proceedings.htm

UT INSPECTION PRACTICE FOR ANCHOR BOLTS

Ali Abdullah Al-Shehry

Engineering Division; Sea Water Injection Department; Saudi Arabian Oil Company. O. Box 11656 Dhahran 31311 Saudi Arabia, Email<shehaa2h@aramco.com>

ABSTRACT

Ultrasonic testing method is presented that can detect the sheared embedded steel anchor bolts. Results are compared to the conventional method of inspecting the embedded anchor bolts. The ultrasonic testing technique detects the embedded broken anchor bolts without the need to chip the concrete foundation. The transducer of the UT device sends waves that can travel through the cross section to the end of the embedded steel anchor bolts, and return along the same path, revealing the actual length of the anchor bolts. This new UT technique has an impact on reducing the time of the inspection, saving on annual costs, makes the job more efficient and safer, and maintains the durability of aging structures. The most significant findings are related to the inspection cost and time saving. The advantage of inspecting the embedded steel anchor bolts with ultrasonic testing is in the avoidance of the chipping the concrete foundation, and providing the required results almost instantly, with significant cost-savings.

Keywords: UT, anchor bolts, ultrasonic, inspection, transducer

INTRODUCTION

Anchor bolts are utilized secure vessels, large equipment, tanks etc to concrete foundations. During installation anchor bolts are tightened according to the required torque specification to secure the equipment from movement. Inspection of aging structure component such as anchor bolts isn't always easy. Corrosion inspection of structural anchor bolts can be quite challenging. The reason is that access to these buried elements is often very difficult [fprimec 2017]. Concrete and steel are not infallible, and continued maintenance and observation are crucial to ensure the safety and integrity of our facilities. Inspecting concrete structures by conventional methods are costly and requires a high degree of specialization in concrete. The visible part of the bolt is usually in poor quality, and mechanical tests such as pull-out is not an option [fprimec 2017].

Qurayyah seawater treatment plant (SWID) which is the largest water treatment plant in the world was built in 1970s and located on the gulf coast at Saudi Arabia. This plant has a lot of aging structures which need to be inspected frequently, to maintain the durability and safety of important assets. The major two factors that affect the durability of those structures are the hot weather and high humidity which cause corrosion of embedded steel and anchor bolts. Corrosion of embedded anchor bolts is a serious concern as it can cause cracks in structural foundations which adversely affects the plant assets. The progressive nature of corrosion reaction, when combined with structural loads (i.e. dynamic loads, vibrating machinery, etc) can result in catastrophic events. [fprimec 2017]. Therefore, regular inspection and assessment of these bolts is necessary.

According to previous studies to be representative of various visual inspection tasks. Findings indicate that inspection accuracy decreases with reductions in defect rate. The percentage of true

defects detected significantly decreased and the percentage of false reports significantly increased [APA 2016]. Visual inspection is not an accurate technique to inspect an embedded anchor bolt. Moreover, using the conventional method to inspect the anchor bolts are required where the concrete structure has to be chipped in order to expose the embedded anchor bolts, however, even this technique is not easy if you have a numerous anchor bolts that have to be inspected.

There is therefore an urgent need for an alternatives and new technique to inspect these anchor bolts to assure the reliability of the facility structures. Thus, SWID inspection unit worked along with the corporate inspection department to find a new method to inspect the anchor bolts. Many researches have been conducted and finally a decision was taken to utilize this new ultrasonic testing application to inspect the embedded anchor bolts. To inspect the length of the bolt and the location of the defect can be indicated by using Ultrasonic testing technology [Chinese Journal of Rock Mechanics and Engineering 2007].

The physical principle of UT is that an acoustic wave passing through a material will be a fully or partially reflected by discontinuities in the material or a boundary of the material. Acoustic waves are introduced into the material using an ultrasonic transducer placed on the surface. The transducer launches an acoustic wave that passes through the material and is reflected by discontinuities in the material or a boundary of the material. After the waves has passed through the material, an ultrasonic transducer is used to detect and display the resulting waveform. The waveform is analyzed from discontinuities in the anchor bolts and shows if there are any deficiencies in the anchor bolts.

This paper presents a case study utilizing the ultrasonic testing technology to inspect the existing embedded anchor bolts of the concrete structures. A detailed field inspection was carried out involving visual inspection, concrete chipping and exposing the anchor bolts to assess the new UT technique.

METHODOLOGY

Visual inspection of the existing embedded anchor was performed at the subject facility to detect the deficiencies in the anchor bolts of aging structures. Figure 1. shows typical external view of the embedded anchor bolts and the concrete foundation. Neither no signs of cracks on the concrete foundation nor signs of corrosion on the embedded anchor bolts were found.

It can be seen from the figure that the anchor bolts and the foundation are in a good condition, however after performing the conventional method of inspecting the embedded anchor bolts by chipping the concrete structure to assure that it is in a good condition, the anchor blot were found broken as shown in figures 2 and 3.

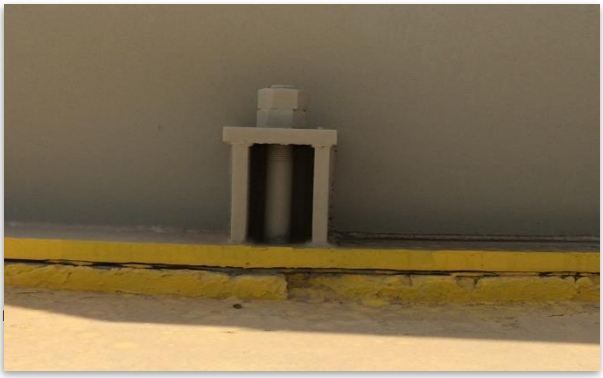

Figure 1. typical external view of the embedded anchor bolts and the concrete foundation

Figure 2. view of the broken anchor bolt and the chipped foundation

Figure 3. view of the broken anchor bolt

It was difficult to perform the conventional method and exposing all the embed anchor bolts where 448 anchor bolts have to be exposed at the subject facility. Thus, ultrasonic testing technique was performed to determine the condition of the embedded anchor bolts as shown in figure 4.

Figure 4. view of performing the UT technology

Data is acquired by using a hand-held, battery-operated ultrasonic flaw detector as shown in figure 5. Non-destructive UT is implemented using straight-beam configuration. Therefore, the range highlighted in figure 5. was increased to the total length of the existing anchor bolt which was 1165 mm. Figure 6. shows the UT small probe called ultrasonic transducer that was used in order to launch longitudinal wave to the surface of the anchor bolts that being tested.

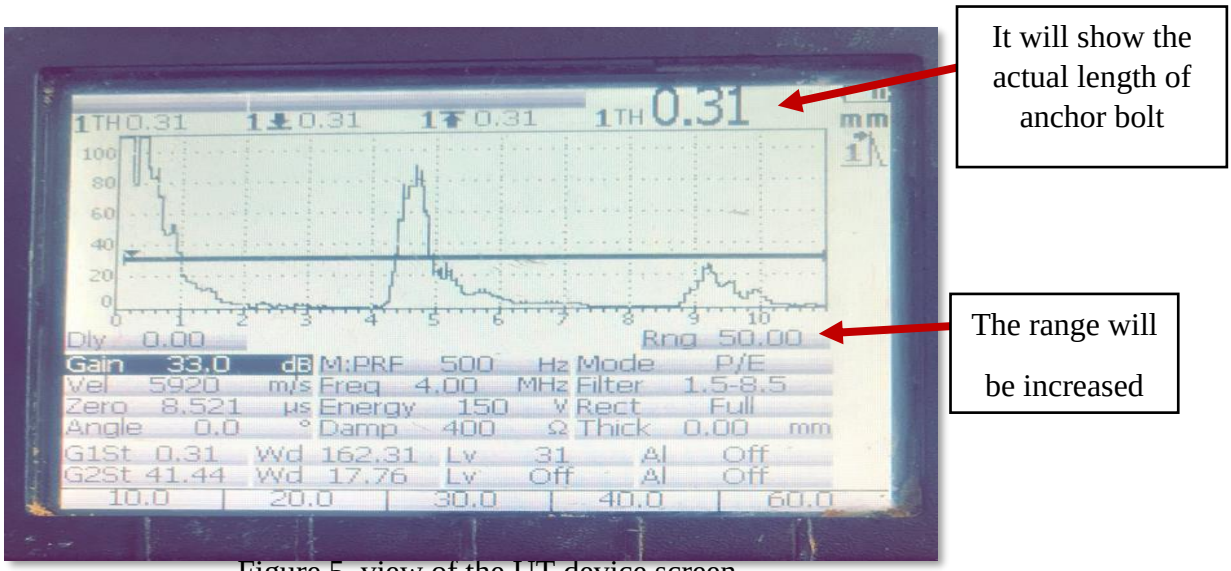

Figure 5. view of the UT device screen

Figure 6. views of the UT probe transducer

To assess the ultrasonic testing technology, an actual demonstration was performed in the field to compare the existing anchor bolts condition with UT readings where four (4) anchor bolts were exposed. As an example, the length of anchor bolt 2 of the Deaerator 1 is 419 mm as identified by UT devise as shown in table 1. After that, the same anchor bolt was extracted and measured. The filed verification and the ultrasonic testing readings were found same 419mm while the original length of the anchor bolt should be 1165 mm. which was an indication that the anchor bolt was broken.

RESULTS AND DISCUSSION

A comprehensive ultrasonic testing was applied in order to survey all embedded anchor bolts of the subject facility as shown in table 1. The UT survey results clearly show that 142 of the anchor bolts out 448 were suspected to be broken. For the anchor bolts of the Deaerator from 15 to 28, the UT survey revealed that the anchor bolts were found in a good condition.

Another significant finding of this inspection test was that all the defected anchor bolts are located in Deaerator Column 1 up to Deaerator Column 14 which were constructed in the late '70s.On the other hand, the survey of the anchor bolts of Deaerator Column 15 to 18 that were built in 2005 were found healthy. This result agrees with other previous similar studies. According to experimental research published in (Chinese Journal of Rock Mechanics and Engineering 2007) ,Ultrasonic site inspection is performed for an anchor bolt with 18 mm diameter and 2 m length. The inspection results show that the wave's technology is available for the nondestructive testing of full-length- bolts. This agreement confirms that the technology can be used effectively to detect broken anchor bolts. However, the current survey cannot identify the difference line between the corroded anchor bolts and the broken bolts. For the future, a comprehensive study along with field demonstration should be conducted in order to identify corrosion of the embedded anchor bolt in the early stages and not after the fact.

Table 1. UT results for the anchor bolts of the Deaerator from 1 to 14

Anchor Bolt #	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14
	Depth in (mm)													
1	ok	ok	ok	424	New	ok	ok	370	New	New	320	445	442	447
2	419	ok	ok	428	New	ok	ok	419	369	New	425	447	445	457

3	372	ok	ok	416	New	ok	ok	428	423	423	425	380	455	449
4	351	ok	ok	430	ok	ok	365	421	426	441	387	448	448	443
5	432	ok	ok	425	419	ok	388	427	New	424	425	441	448	441
6	ok	428	ok	410	442	ok	360	346	354	419	420	442	446	446
7	ok	381	ok	422	417	ok	370	343	New	362	385	446	446	450
8	ok	379	ok	417	424	ok	377	422	424	New	415	450	452	381
9	ok	426	ok	429	429	420	425	425	428	396	480	442	447	449
10	428	436	ok	419	377	430	ok	426	368	Ok	424	443	449	390
12	419	361	ok	424	367	ok	ok	360	360	374	424	447	442	442
13	419	423	ok	391	New	ok	ok	426	428	419	361	447	449	450
14	ok	424	427	ok	New	ok	ok	377	422	387	402	446	451	384
15	ok	New	ok	New	New	ok	ok	New	New	417	424	445	443	447
16	ok	425	ok	New	New	ok	ok	New	New	New	423	447	445	440
Total	**7**	**9**	**1**	**12**	**7**	**2**	**6**	**14**	**10**	**10**	**16**	**16**	**16**	**16**
Total number of Anchor bolts (suspected to be broken per UT results) #										**142**				

CONCLUSION

The main conclusions from the present case study can be drawn as follows:

- Utilizing ultrasonic technology helps in simplifying the inspection process and reducing the time for inspection.
- UT provides the required results almost instantly, with significant cost-savings where no civil works are required. SWID being able to save around $314,000 by using UT rather than the conventional method of inspecting the anchor bolts
- Maintain the safety and durability of the subject facility by performing the UT technique.

ACKNOWLEDGEMENTS

The support provided by the Inspection Department, Saudi Aramco and Inspection Unit, Engineering Division, Sea Water Injection Department, Saudi Aramco are gratefully acknowledged.

REFERENCES

American Society of Nondestructive Testing (ASNT) Handbook, 3rd Edition, Volume 7, Ultrasonic Testing (ET), 2005.

American Psychological Association (APA), Harris, Douglas H., Effect of defect rate on inspection accuracy, Journal of Applied Psychology, Vol 52(5), Oct 1968, 377-379.

AWS, Bridge Welding Code, AWS D1.5, American Welding Society, Miami, FL, 2010.

Moore, M., Phares, B, and Washer, G., Guidelines for Ultrasonic Inspection of Hanger Pins, FHWA, ed., USDOT, Washingon, D.C., 99, 2004

Ultrasonic Testing of Anchor Bolts, Posted on February 16, 2017 ,FPrimeC solution Inc.2017

WU Bin, SUN Yaxin, HE Cunfu, WANG Xiuyan, LIU Zenghua and ZHANG Qin, Application of High Frequency Ultrasonic Guided Waves to Inspection Of Full-Length-Bonding Bolt, (College of Mechanical Engineering and Applied Electronics Technology, Beijing University of Technology), Beijing 100022, China., Chinese Journal of Rock Mechanics and Engineering, 2007.