Olson ENGINEERING

CROSSHOLE TOMOGRAPHY (CT)

METHOD BRIEF

APPLICATION

Crosshole Tomography (CT) testing is used to accurately characterize the size, location and severity of defects commonly found within newly placed drilled shafts, seal footings, and slurry or diaphragm walls. The CT method relies on propagation of ultrasonic waves between two or more access tubes or core holes to measure the velocity and signal strength of the propagated waves. This testing can be performed on any concrete foundation provided two or more access tubes – or coreholes capable of holding water – are present in the foundation. CT can also be used to image critical anomalies in underwater piers and foundations by strapping access tubes to the sides of the concrete structure.

The CT test is most commonly used when a defect has been identified by an initial test, such as Crosshole Sonic Logging (CSL), and requires further analysis. Unlike the CSL test where only horizontal data is collected, the CT test collects data at various angles (vertically and/or horizontally), thus providing the user with a more detailed understanding of the defect in question.

CT tests are typically performed on concrete, particularly concrete drilled shafts, and other materials which support transmission of ultrasonic waves, such as slurry, rock, grout, water-saturated media, and cemented radioactive wastes, or anywhere else a CSL test has already been completed.

STANDARDS

No standards for the United States currently exist.

FIELD INVESTIGATION

ACCESS

Access tubes must be installed before the construction of a drilled shaft for quality assurance purposes, unless coreholes are to be drilled in a forensic case. PVC or black steel tubes (U.S. schedule 40) are typically used, with steel tubes being strongly preferred. The tubes are 1.5 inches (steel tubes only) to 2 inches (38 to 50 mm) in inside diameter, and are typically tied to the inside of the rebar cage to ensure near-vertical positions of the tubes. The tubes must extend about 3 feet (1 m) above the top of the shaft to compensate for the water displaced by the source, receiver, and cables and to allow for easy access. Tubes must be bonded to the concrete for good test results. In order to minimize debonding of tubes, water should be added immediately prior to – or immediately after – concrete placement and the tubes should not be mechanically disturbed.

The concrete in the shaft should normally be allowed at least 1-2 days to cure and harden prior to testing. If PVC tubes are used, testing should be done within 10 days after the placement of concrete (this is due to possible tube-concrete debonding). If steel tubes are used, the testing can be done within 45 days after concrete placement as steel tubes bond better than PVC tubes over a longer time.

COLLECTION OF DATA

Tomography data is collected in a procedure similar to that for standard CSL testing, except that more data sets are collected with different source and receiver depths. Typically the receiver is first fixed at the lowest depth of interest (usually 3-5 meters below the suspected defect) or at the shaft bottom.The source is fixed above the receiver at a distance determined by the software after the desired offset angle has been entered. Both hydrophones are then pulled from this depth to a position 3-5 meters above the suspected defect. (or to the shaft top). Typically, the source is excited every 2 inches (6 cm) vertically and a measurement is taken. The source is then moved to the next offset height as determined by the WINCSL software based on the next offset angle and the hydrophones are again pulled up through the area of interest. This process is repeated until all the desired offset tests have been performed. Because CT tests require raising and lowering the hydrophones many times during a single test, recording data can be time consuming. Therefore, it is typical to only test tube pairs that help isolate the suspected defect. Olson Engineering uses the Olson Instruments Freedom Data PC with the Crosshole Sonic Logging System for collection and analysis of CT data.

DATA REDUCTION

PROCESSING TECHNIQUES

The collected data from the CT measurements between all tube pairs at all offset angles are saved as a single data file. The file is scanned in the CSL software to determine first wave arrival times and energy levels at all depths for each log. The CT logs within CSL show both the arrival time (or velocity) and signal energy vs. depth. These files are then imported into the GeoTomCG tomography software where a model file (2-D slice or 3-D volume plot) can be created. The tomography results can be displayed directly from GeoTomCG as 2-D slices or 3-D volumes and copied directly into reports, or the data can be optionally exported to 3-D modelling software to create a cleaner, smoothed 2-D or 3-D image.

INTERPRETATION OF DATA

In uniform, good quality concrete, the velocity values will be consistent. Any defects will show up in a 3-D plot as having slower velocities, thus allowing them to be easily pinpointed by removing the higher velocity (good quality) sections of the shaft from the plot. This visualization allows for easy determination of the volume and location of suspected defects.

EFFECTIVENESS

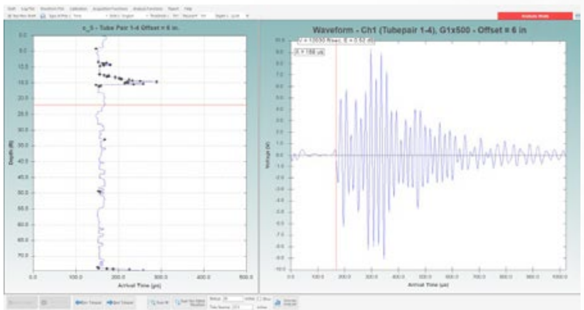
Access tubes must be installed prior to concrete placement in order to perform CSL tests. For existing shafts or other concrete members, coreholes or drill holes must be drilled to allow access for the source and receiver hydrophones. CSL is best used for quality assurance. Tubes must be bonded to the concrete for good test results. In order to minimize debonding of tubes, water should be added immediately prior to – or immediately after – concrete placement and the tubes should not be mechanically disturbed.

In areas where defects are identified by preliminary testing such as Crosshole Sonic Logging (CSL), the CT method proves to be a very useful tool in accurately characterizing defects. Using the data from these preliminary tests allows the CT method to achieve a far greater level of detail than any other method (such as coring) and thus allows the user to more accurately determine the volume of a suspected defect.

EXAMPLE RESULTS

CSL SOFTWARE – CT LOG

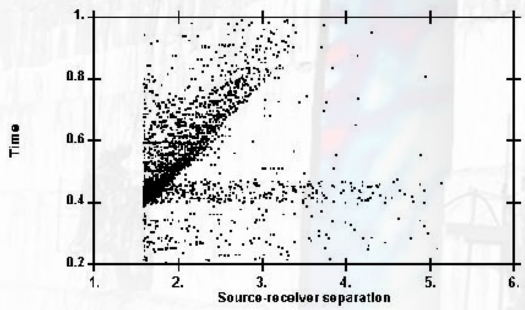
The figure below shows the data collected from one receiver depth. The record log shows first arrival times and signal amplitudes.



New WINCSL software tomogram example, 6 inch offset, 2 defects visible at 15 feet plus the bottom

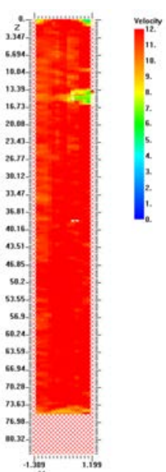
GEOTOMCG® DATA PLOT

The image below displays a time vs. source-receiver distance plot which allows the user to check the quality of the data.



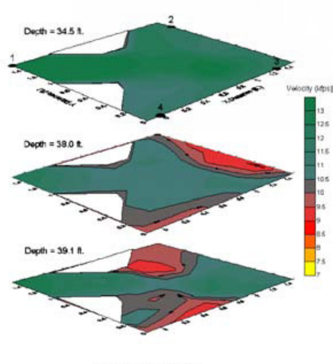
GEOTOMCG® 2-D SLICE

The image below displays a 2-D "slice" of data from a signal tube pair. Different colors show different velocities. Defect zones are depicted by lower velocity colors.



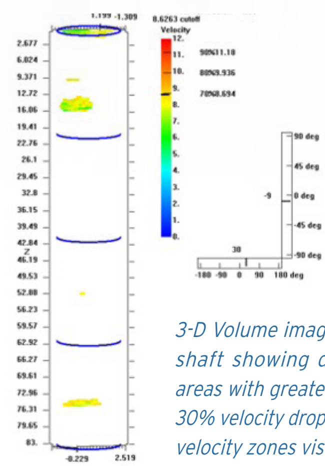
GEOTOMCG®-GENERATED DATA 2-D SLICE, AFTER IMPORT INTO EXTERNAL IMAGING SOFTWARE

Displays several 2-D horizontal slices of data. Note that red colors indicate areas of low velocity and – therefore – low strength.



3-D VISUALIZATION

The image below shows a 3-D visualization where the higher velocity sections of the shaft have been removed leaving only the lower velocity areas for easy viewing of defects.



3-D Volume image of a shaft showing defect areas with greater than 30% velocity drops. Low velocity zones visible at 15 feet and at the bottom

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