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**Visco-Elastic Behaviour**

Following the installation of the ICE prize winning RoadCem soil piling mats at Severn Trent Waters £45 million Cay Mills STW at Burton on Trent. PCT and Delft University of Technology, carried out simulation testing to explore and understand the dynamic force absorption properties observed on this project.

This visco-dynamic behaviour is a significant added value for construction design and shows that the stabilisation could bear high intensive dynamic forces such as the driving of piles through the RoadCem stabilisation. With no cracks occurring in the direct periphery of the piles nor in the complete PowerCem treated structure on site.





**“As proven in the laboratory it is hereby confirmed that RoadCem is leading to visco-elastic behaviour. Visco-elastic behaviour leads to absorption of energy in the material, without the occurrence of cracks”**

**Research set-up into Visco-Elastic Behaviour**

For the tests a single size sand (1780/m3) was used (fractions 0.5/1mm) in addition to 0.09% m/m RoadCem material in relation to sand, as well as 9.14% m/m OPC (CEM 1 42.5 N).

The OMC (optimum moisture content) at MPD (maximum proctor density) was 11% m/m.

The reference mixture was composed with 9,14 m/m OPC (CEM 1 42.5N) under equal conditions prepared without any RoadCem added.

The visco-elastic and ductility properties of RoadCem are found by conducting dynamic tests.

**Dynamic Testing**

These dynamic tests are carried out using non-destructive ultra-waves in order to determine the dynamic- elastic modulus. By means of destructive four-point bending tests in which repetitive loads at a fixed frequency are applied, a superior fatigue performance is confirmed.

By observing the longitudinal displacement mode after excitation, the dynamic modulus is obtained, as well as the dampening characteristics, which relate to the visco-elastic properties of the material being tested.

It is very clear that the pattern for cement treated stabilisation with added RoadCem (shown green) is showing a restrained vibration compared to the cement alone stabilised material (shown as red).



The above figure shows that vibration absorption with RoadCem shows a higher restrain and will be more resistant to impacts and foundation loadings.

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|  | 100 repetitions |  |  | 500 repetitions |  |  |  |  |  |  |  |  |  |  |  |  |
| **strain** |  | **dynamic modulus** |  | **strain** |  | **dynamic modulus** | **The graph clearly shows that the RoadCem stabilised soil behaves as a visco elastic material** |  |  |  |  |  |  |  |  |  |  |
| 60 |  | 5574 |  |  | 60 |  | 5103 |  |  |  |  |  |  |  |  |  |  |  |
| 70 |  | 5569 |  |  | 70 |  | 5087 |  |  |  |  |  |  |  |  |  |  |  |
| 80 |  | 5553 |  |  | 80 |  | 5182 |  |  |  |  |  |  |  |  |  |  |  |
| 90 |  | 5560 |  |  | 90 |  | 5136 |  |  |  |  |  |  |  |  |  |  |  |
| 100 |  | 5537 |  |  | 100 |  | 5135 |  |  |  |  |  |  |  |  |  |  |  |
| 110 |  | 5526 |  |  | 110 |  | 5116 |  |  |  |  |  |  |  |  |  |  |  |
| 120 |  | 5495 |  |  | 120 |  | 5121 |  |  |  |  |  |  |  |  |  |  |  |
| 130 |  | 5453 |  |  | 130 |  | 5115 |  |  |  |  |  |  |  |  |  |  |  |
| 140 |  | 5416 |  |  | 140 |  | 5086 |  |  |  |  |  |  |  |  |  |  |  |
| 150 |  | 5394 |  |  | 150 |  | 5040 |  |  |  |  |  |  |  |  |  |  |  |
| 160 |  | 5372 |  |  | 160 |  | 5001 |  |  |  |  |  |  |  |  |  |  |  |
| 170 |  | 5349 |  |  | 170 |  | 4982 |  |  |  |  |  |  |  |  |  |  |  |
| 180 |  | 5331 |  |  | 180 |  | 4963 |  |  |  |  |  |  |  |  |  |  |  |
| 190 |  | 5310 |  |  | 190 |  | 4912 |  |  |  |  |  |  |  |  |  |  |  |
| 200 |  | 5272 |  |  | 200 |  | 4880 | A traditional cement soil stabilisation without RoadCem will always behave as a rigid material. Rigid materials will normally break at a strain of 50-125 micro meter. Resulting in a steep decrease in Elastic modulus, when this breaking strain is reached.A visco elastic material such as a RoadCem soil concrete has a far higher breaking strain and the elastic modulus will reduce only gradually with an increase in value. |  |  |  |  |  |  |  |  |  |  |
| 210 |  | 5248 |  |  | 210 |  | 4867 |  |  |  |  |  |  |  |  |  |  |  |
| 220 |  | 5223 |  |  | 220 |  | 4825 |  |  |  |  |  |  |  |  |  |  |  |
| 230 |  | 5199 |  |  | 230 |  | 4799 |  |  |  |  |  |  |  |  |  |  |  |
| 240 |  | 5175 |  |  | 240 |  | 4752 |  |  |  |  |  |  |  |  |  |  |  |
| 250 |  | 5150 |  |  | 250 |  | 4717 |  |  |  |  |  |  |  |  |  |  |  |
| 260 |  | 5126 |  |  | 260 |  | 4678 |  |  |  |  |  |  |  |  |  |  |  |
| 270 |  | 5114 |  |  | 270 |  | 4626 |  |  |  |  |  |  |  |  |  |  |  |
| 280 |  | 5087 |  |  | 280 |  | 4578 |  |  |
| 290 |  | 5056 |  |  | 290 |  | 4527 |  |
| 300 |  | 5027 |  |  | 300 |  | 4485 |  |
| 310 |  | 5004 |  |  | 310 |  | 4438 |  |
| 318 |  | 4978 |  |  | 320 |  | 4374 |  |
| 329 |  | 4952 |  |  | 330 |  | 4342 |  |
| 338 |  | 4910 |  |  | 340 |  | 4265 |  |  |  |  |  |  |  |  |  |  |  |
| 345 |  | 4877 |  |  | 350 |  | 4209 |  |  |  |  |  |  |  |  |  |  |  |
| 359 |  | 4779 |  |  | 360 |  | 4131 |  |  |  |  |  |  |  |  |  |  |  |
| 367 |  | 4662 |  |  | 370 |  | 3999 |  |  |  |  |  |  |  |  |  |  |  |
| 377 |  | 4574 |  |  | 380 |  | 3873 |  |  |  |  |  |  |  |  |  |  |  |
| 388 |  | 4441 |  |  | 390 |  | 3579 |  |  |  |  |  |  |  |  |  |  |  |
| 396 |  | 3819 |  |  | 400 |  | 3014 |  |  |  |  |  |  |  |  |  |  |  |

 |  |  | 500 repetitions |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5574 |  |  | 60 |  | 5103 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5569 |  |  | 70 |  | 5087 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5553 |  |  | 80 |  | 5182 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5560 |  |  | 90 |  | 5136 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5537 |  |  | 100 |  | 5135 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5526 |  |  | 110 |  | 5116 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5495 |  |  | 120 |  | 5121 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5453 |  |  | 130 |  | 5115 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5416 |  |  | 140 |  | 5086 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5394 |  |  | 150 |  | 5040 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5372 |  |  | 160 |  | 5001 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5349 |  |  | 170 |  | 4982 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5331 |  |  | 180 |  | 4963 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5310 |  |  | 190 |  | 4912 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5272 |  |  | 200 |  | 4880 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5248 |  |  | 210 |  | 4867 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5223 |  |  | 220 |  | 4825 |  | A traditional cement soil stabilisation without RoadCem will always behave as a rigid material. Rigid materials will normally break at a strain of 50-125 micro meter. Resulting in a steep decrease in Elastic modulus, when this breaking strain is reached.A visco elastic material sucha s a RoadCem soil concrete has a far higher breaking strain and the elastic modulus will reduce only gradually with an increase in value. |  |  |  |  |  |  |  |  |  |  |
|  | 5199 |  |  | 230 |  | 4799 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5175 |  |  | 240 |  | 4752 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5150 |  |  | 250 |  | 4717 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5126 |  |  | 260 |  | 4678 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5114 |  |  | 270 |  | 4626 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 5087 |  |  | 280 |  | 4578 |  |

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|  | 5056 |  |  | 290 |  | 4527 |  |  |
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|  | 4978 |  |  | 320 |  | 4374 |  |  |
|  | 4952 |  |  | 330 |  | 4342 |  |  |
|  | 4910 |  |  | 340 |  | 4265 |  |  |  |  |  |  |  |  |  |  |  |  |