

Static and dynamic testing of driven piles in Poland

Jaroslaw Rybak

Wroclaw University of Technology, Wyb. Wyspianskiego 27, 50-370 Wroclaw, Poland

Dariusz Sobala

Rzeszow University of Technology, ul. Wincentego Pola 2, 35-959 Rzeszow, Poland

Grzegorz Tkaczynski

AARSLEFF Sp. z o.o., Lambady 6, 02-820 Warsaw, Poland

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ABSTRACT: The current possibility of obtaining financial resources from the European Union funds results in the increase of road investments in Poland. At the same time, Poland (together with Ukraine) is preparing for the organisation of EURO 2012. Fast development of motorway and land road network, connected with simultaneous construction of ring roads for many towns, brings about the necessity of erecting a large amount of engineering objects – bridges and viaducts. The majority of those objects are founded on foundation piles. The construction of piles underneath the erected objects is preceded by the obligatory testing determined by the code of practice, and thus leads to the prolonging of the works execution. As it is in the whole EU, static testing constitutes the basic bearing capacity testing due to local regulations (Polish code of practice) and, as follows, contract specifications. High-strain dynamic testing (CASE, CAPWAP, DLT, PDA) and integrity testing (PIT, SIT) used to be carried out as the additional control procedures, which provides the quality, and not quantity, assessment. However: last years dynamic testing became in Poland an accepted method of pile capacity assessment. Kinetic bearing capacity testing (STATNAMIC, DYNATEST) is not frequently used.

1 INTRODUCTION

It must be mentioned here, that the binding Polish codes of practice, regulating the pile and pile foundation designing and the execution of works, date back to the early '80s of the previous century.

That is a blessing as much as a curse. On the one hand, the whole generations of engineers “speak the same language”. On the other hand, however, a wide range of new piling and testing technologies is neither described nor defined in the code of practice, which results in the impossibility of referring directly to Polish standards.

The works leading to updating the codes and the implementation of EU standards (Eurocode 7 and execution guidelines) to local conditions are still being carried out.

The design of the load test is an integral part of the piling design. The execution of the load capacity test is typically included in the piling contract, and the responsibility for organising the test rests with the piling contractor.

The load capacity testing takes place under the supervision of the investor's representative, as well as independent specialists. The interpretation of the results is carried out by independent institutions (often associated with Universities).

2 CONTROL TESTS OF PILE LOAD CAPACITY

Static load tests are the fundamental tests of bearing capacity of precast concrete piles in Poland. The tests are carried out with the help of the “inverted beam method”, including the use of anchor piles. If necessary, it is also possible to take advantage of the ballast made of concrete pavement slabs or the precast concrete piles which have already been brought to the building site and are to be driven at some later stage of works.



Figure 1. An example of static load testing.

Load capacity testing usually cover 1-2% of the contracted piles. As a rule (in accordance with Polish Code of Practice), two first piles out of 100 (driven in given geotechnical conditions) are put to load test, and then one pile out of each succeeding hundred of piles. If the average precast concrete pile length is about 12 m, less than 2 piles for each 1000 running metres must be tested.

Dynamic tests (see Fig. 2, 3, 4) have been used in Poland to estimate the driven pile bearing capacity ever since the year 1996. Since 2005 the results of dynamic testing are accepted according to the code PN-EN 12699. However, the correlation methods between static and dynamic testing are still not described in Polish codes of practice and contractors have to rely on their experience.

Dynamic load tests are performed mainly with the use of the equipment and software of PDI company (Pile Dynamics Inc.), see Fig 2. The measuring unit consists of a digital device recording electronic output signal from the pairs of extensometer sensors (strain transducers) and acceleration sensors. The frequency of sampling amounts to 5000Hz.

The results are sorted out in PDA and CAPWAP programmes.



Fig. 2. The recorder able to transfer data to PC.



Fig. 3. PC combined recorder.

Extensometers (strain transducers) and acceleration sensors are attached to the side surface of the testing pile at the distance of about $2 \cdot A$ from its head.

Typically, for $0,30 \times 0,30$ m or $0,40 \times 0,40$ m piles, the distance is 0.60 or 0.80 m. The testing is performed with the use of a pile driver whose hammer weighs 5 to 8 tons.

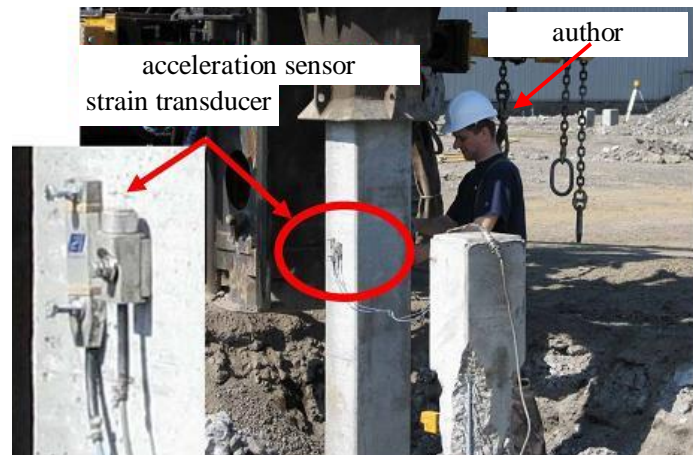


Figure 4. An example of dynamic pile testing equipment.

Independently of static and dynamic load tests, for each pile the driving resistance is recorded. This recording consists in counting and the analysis of blows in course of pre-cast concrete pile driving process. Such pile driving analyses (on the basis of the Sorensen and Hansen's formula) are frequently carried out and are especially helpful for the contractor and the supervisor on the building site. Those methods provide fast and reliable information about the conformity of actual geotechnical conditions with the previously assumed data.

3 MARKET GROWTH OF PILE WORK

Time pressure in the execution of pile foundations, combined with high reliability requirements, causes the situation in which some piling technologies are favoured over the others. In Polish conditions last decades stood for the period of the definite domination of "large diameter pile monoculture", when large diameter bored piles were designed even to support the smallest footbridge. Last decade, we also deal with the renaissance of the pre-cast concrete piles, which did not appear until the mid-eighties of the 20th century.

However Polish building market is very competitive, pre-cast concrete piles become more and more present in civil engineering. Some of the modern pile drivers have relatively small dimensions and weight, and, as such, enable piling on hardly accessible sites. The application of pre-cast concrete piles allows for eliminating the use heavy piling rigs, the transport of which may be expensive and technically complicated. In the case of prefabricated piles, only a small amount of equipment is necessary on site. Basically, only the pile driver is indispensable (see Fig. 5, 6), after the piles have been unloaded with the help of travelling crane.

It is not insignificant that the piling process may be carried out very fast. Depending on the soil conditions it is possible to drive 200-350 running metres of piles per day, using a single pile driver.



Fig. 5. Building site (Highway A-2).



Fig. 6. Building site (AUCHAN Commercial Centre).

The pile driver mast may be inclined in the wide range of angles. However, for the sake of the machine stability, if the pile length exceeds 12 m, the possible inclination of the mast is limited to 30 deg. The designing of inclined piles allows to reduce the dimensions of pile capping beam, as well as to transfer significant part of horizontal forces (Fig.7).



Fig. 7. Driving in of the 15-meter long pile, inclined by 27 deg.

Most commonly used pile driver masts are up to 22 meters long. That permits to drive 18-meter long pile. Usually, the length of a single pile is limited by transport regulations to 15 m. When it is necessary to drive in longer piles, they must be assembled from sections joined with steel joints. The longest driven piles in Poland reached the length of 45 m.

The total amount (length) of precast concrete piles driven in Poland increased significantly of 33% within the last two years. That came from the absorption of EC funds and dynamic development of public investments, especially in highway engineering sector.

4 CONTRIBUTION OF DYNAMIC TESTS

The growing insistence on the accelerating of the investment process highlights the importance of the role of dynamic testing. That is true both for the quality and the quantity control and evaluation of precast concrete pile bearing capacity. One may note the increase in the amount of performed tests, as well as the growing number of dynamic test contribution in the general number of the precast concrete pile testing (see Fig. 8, 9).

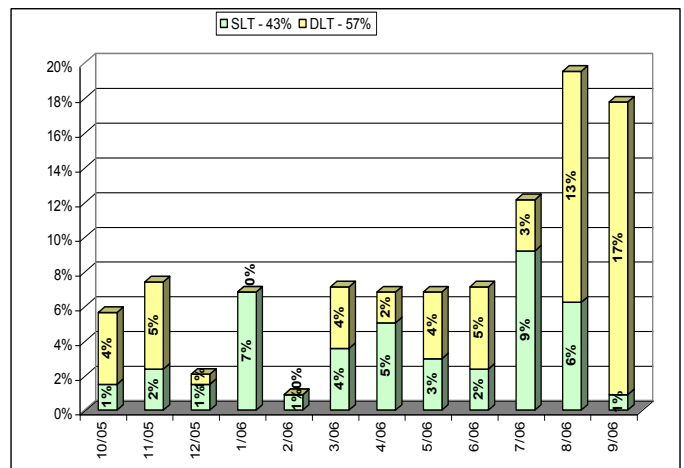


Fig. 8. Static and dynamic testing 2005/2006.

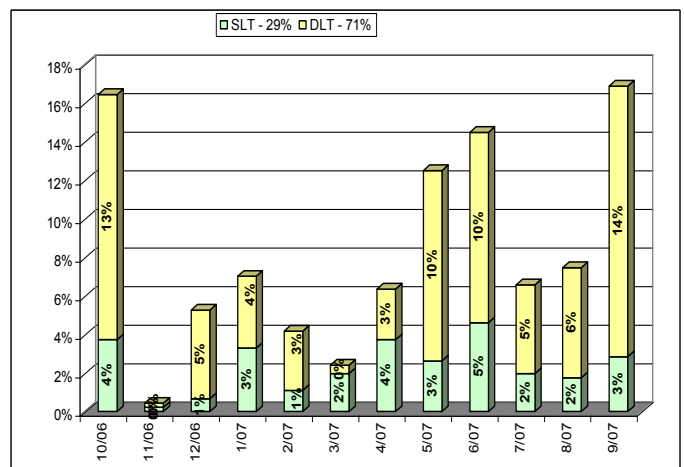


Fig. 9. Static and dynamic testing 2006/2007.

It is noteworthy that, because of the Polish climatic conditions, which are not particularly favourable in winter for pile work contractors, one can observe the decrease of load testing in winter season (see Fig. 8, 9).

The frequency of test performance, counted as the relation of the amount of tests to the total length of driven piles, remains on the constant level of more than 2,5 tests for each 1000 m of driven piles. That means a considerable increment of the amount of pile being tested in relation to the requirements defined in Polish Code of Practice. That increase is connected with the wide implementation of precast concrete piles dynamic testing. The charts below (Fig. 10, 11) present the statistics showing the number of tests in the subsequent months of the last years in relation to the length of the driven piles.

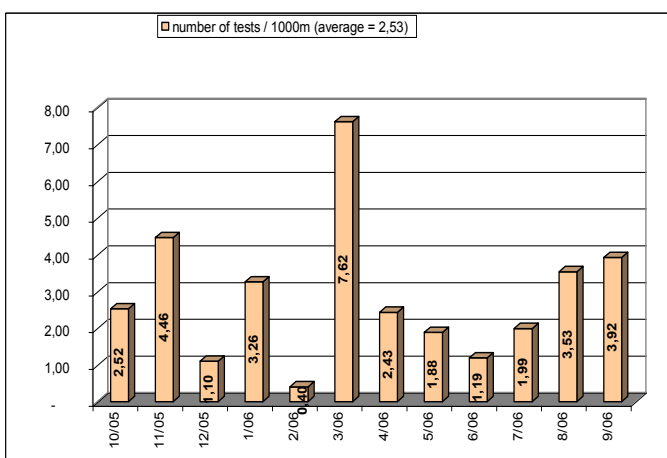


Fig. 8. The number of static and dynamic testing in relation to the amount of running metres of piles driven in 2005/2006.

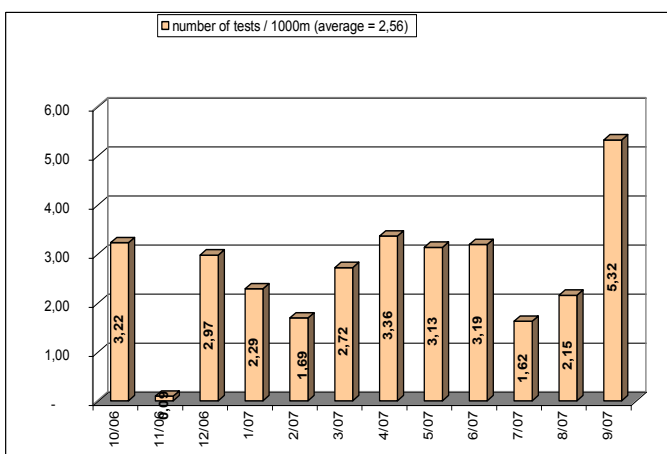


Fig. 8. Static and dynamic testing in relation to the number of running meters of piles driven in 2006/2007.

The commitment of academic centres is a very important factor that influences the dissemination of dynamic testing. A substantial part of the tests (especially the ones that are carried out within the framework of the public sector commissions) is performed under the scientific supervision of Gdansk University of Technology or Wroclaw University of Technology.

5 CONCLUSIONS

The testing of precast concrete piles bearing capacity tests are the basic tool for the control of design assumptions. They are also indispensable from the point of view of the investment process. In previous years one may notice the growth of the portion of dynamic tests carried out with the use of CASE and CAPWAP methods. Even though the static load tests remain (and will remain) the elementary reference test, the engineers responsible for the pile work quality share the conviction that the possibility of performing a large number of bearing capacity tests in a short time and at relatively low cost compensates for the potential inaccuracies in the evaluation of pile limiting bearing capacity. An additional factor that makes the engineers accept dynamic methods of load capacity testing is the fact that they are able to control all the piles whose driving resistance, when analysed, is dubious from the point of view of their load capacity.

Another reason, for which the amount of dynamic tests is increasing is the possibility of receiving the information on the pile load capacity change in time. While the repetition of the static test is rare (practically impossible), dynamic tests are often repeated. That happens in the situations when the piles initially do not reveal the required load capacity or when significant discrepancies between the values of driving resistance are observed.

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