Disclaimer

Use of this note is only to obtain general information regarding GE Solutions Consulting Ltd. and not for any other purpose.

Projects managed by GE Solutions Consulting Ltd. are not available to the general public. This note does not contain the information in consideration of construction projects, and that such information is only available to a limited group of persons and institutions meeting specified criteria.

This note has not been reviewed or approved by, filed with, or otherwise furnished to any governmental or similar authority, and is intended only to provide limited information to members of the public who have a legitimate interest in that information for reasons unrelated to particular construction projects.

This note presents the accumulated experience of GES however it should be noted that the natural spatial variation of the ground, both laterally and with depth, in addition to a multitude of other specific project variables, may cause deviation from the information herein.

The content of this note constitutes the proprietary intellectual property of GES and shall not directly or indirectly be copied, modified, recast, posted, published, displayed, redistributed, disclosed, made available in whole or in part to any third parties, have derivative works created from the content or otherwise have any commercial use of the content made without the prior written consent of GES.

A micro-study in sheet pile impacting

Background and ground conditions

The data presented here was extracted from a project undertaken in Newcastle-upon-Tyne. The works involved the installation of Arcelor Mittal PU32^{+1} and AZ48 sheet piles to depths of up to 15m.

The piles were pitched and driven to refusal with a rig-mounted vibratory hammer, typically refusing at a depth of 9-10m. Piles were then impacted to final toe level using impacting techniques which is the focus of this study.

The ground conditions comprised reworked glacial drift, considered to be made ground, composed of soft sandy gravelly CLAY with fragments of brick and concrete. Underlying this was competent glacial drift composed of firm to stiff sandy gravelly CLAY with infrequent cobbles and boulders and intermittent lenses of loose SAND. A plot of uncorrected standard penetration test results is presented in Figure 1 below.

Below the glacial materials were coal measures and it was envisaged that sheet pile refusal would be achieved at or near the top of this stratum. For further project details, contact our research team at info@ge-solutions.co.uk

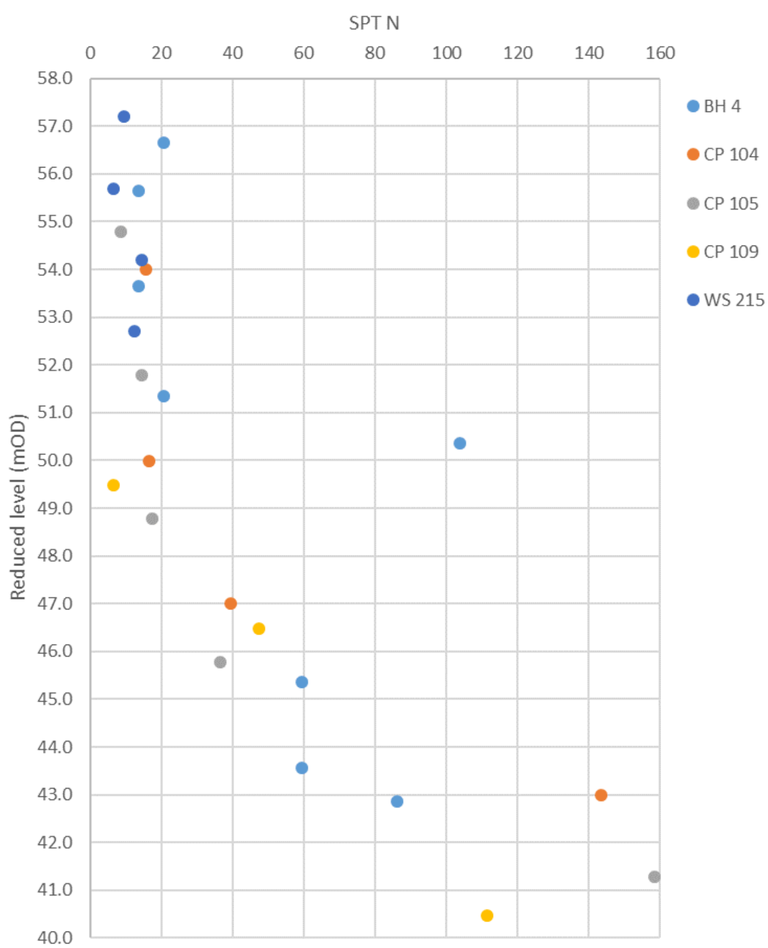

Figure 1 - Summary plot of uncorrected standard penetration test results

Adjusting the impact velocity

Impacting was undertaken with Dawson Construction Plant's HPH4500 hydraulic impact hammer as shown in Figure 2 below. The impact hammer is capable of an impact velocity of 5.05m/s equating to a maximum impact energy of 4,559kgm.

A particular focus of the study was in increasing the impact velocity in increments in order to examine the rate of penetration under varying impact force. In practical terms, incrementally increasing the impact velocity will result in less sheet pile damage.

Figure 2 - Impact hammer in the field driving $PU32^{+1}$ sheet piles

Normalising the impact velocity and comparison of N values

The results of the study are presented graphically below in Figure 3 for the impact velocity increments observed in the field of 25%, 35%, 75% and 100% of the maximum velocity. The number of blows per 100mm of penetration was estimated from site and, as expected, relationships for an increase in blow-count per unit depth can be readily established. The results approximate to an exponential function well.

Extending the observations and accounting for the applied impact force by multiplying the blow-count per 100mm penetration by the impact energy, it can be established that a good relationship is developed for the advance of the sheet pile. This is shown in Figure 4 below.

Accounting for the impact velocity, the following relationship is developed:

$$Nr.\, blows\ per\ 100mm\ peneration \approx \frac{e^{\left(\frac{Depth\ of\ sheet\ \ pile\ driven}{2.3}+2.8\right)}}{Impact\ energy\ (in\ kgm)}$$

Statistically, the data measured in the field for this project is defined by the relationship above with an R^2 value of 0.9022 which is a statistically good correlation of the data measured.

Another observation is that the uncorrected standard penetration test appears to be a reasonable proxy for the *impact energy * blow-count per 100mm*. Therefore, an alternative (but more tentative relationship) might be:

$$Uncorrected\ N = \ e^{\left(\frac{Depth\ of\ sheet\ \ pile\ driven}{2.3}+2.8\right)}$$

Some salient points should be noted here however, as follows:

1. The sheet piles had been driven to refusal (with approximately 9.5m embedded) in advance of impacting
2. The relationship appears to be less reliable at *impact energy * blow-count* values in excess of 200
3. Account of hydraulic hammer efficiency (a reduction factor of 0.8) has been assumed in relating the uncorrected standard penetration test results. This is a variable not expressly examined in this study

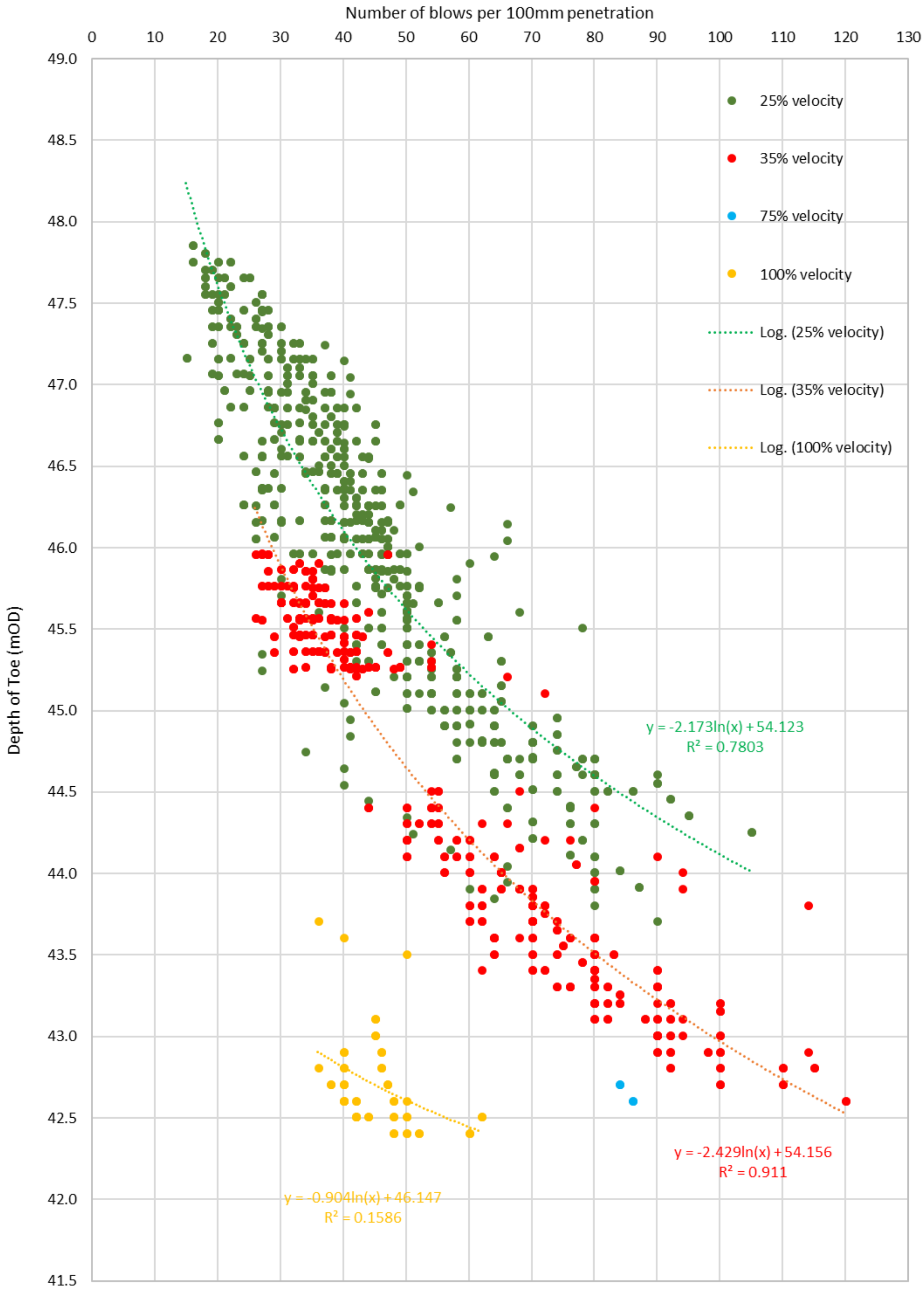

Figure 3 - Raw data from the impact study

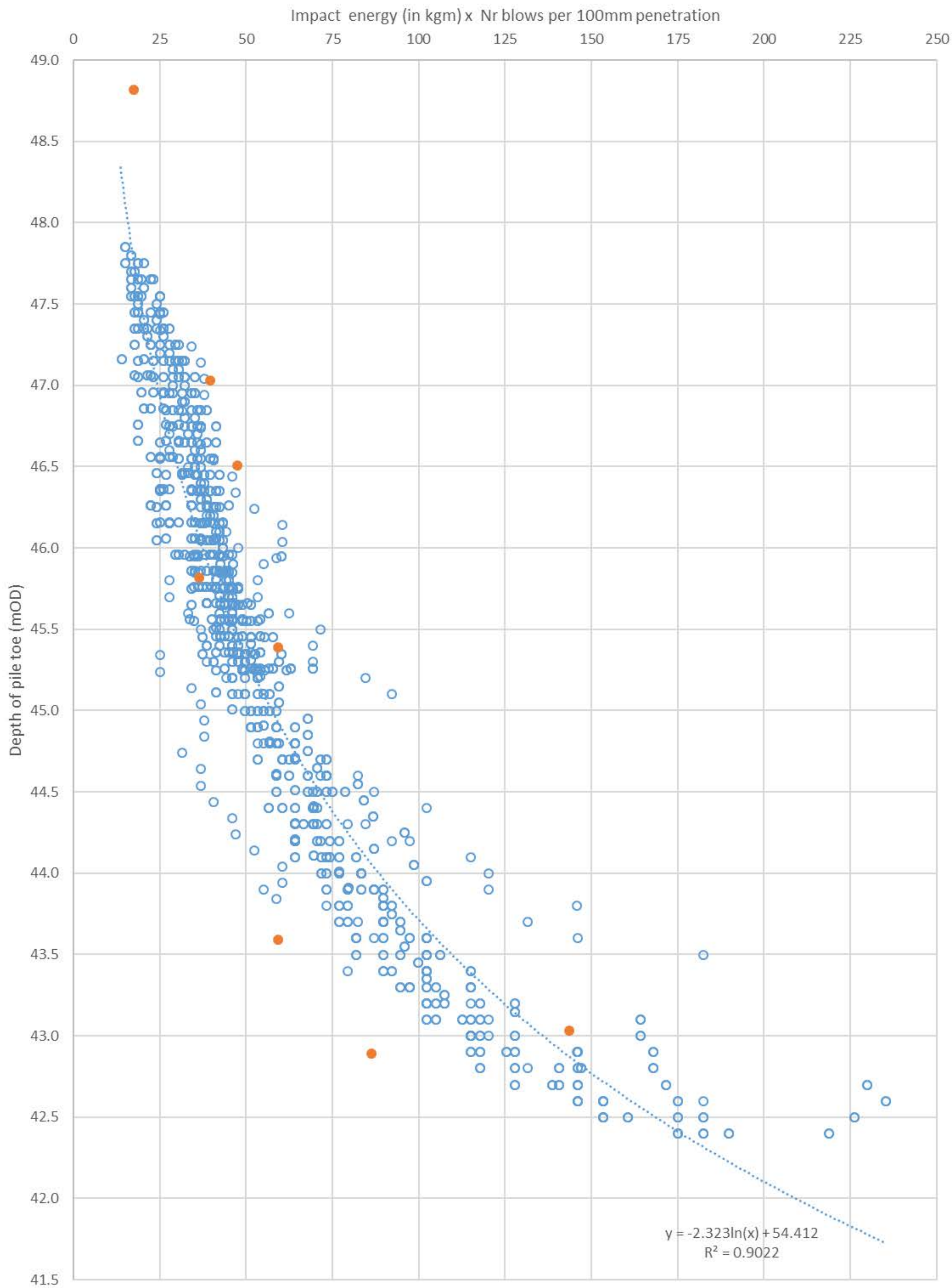

Figure 4 - Normalised data with SPT N overlay

Summary and limitations

A relationship is proposed between the penetration rate of sheet piles under impacting and impact velocity. The relationship correlates well on a statistical basis but there are many variables not expressly examined in the study including (but not limited to):

1. The study was undertaken in stiff glacial material which expresses increasing strength with depth and any correlations could not be considered reliable for other soil types or strength interpretations
2. The effect of sheet pile stiffness has not been examined
3. The effect of hammer efficiency has not been expressly examined and is worthy of further study
4. The results were obtained from a hydraulic impact hammer under field conditions. The relationship could not be considered reliable for other hammer types
5. As previously noted, the sheet piles had been driven to refusal (with approximately 9.5m embedded) in advance of impacting. Further examination of this dynamic is merited.
6. As previously noted, the relationship appears to be less reliable at *impact velocity * blow-count* values in excess of 200. However, it is conjectured that the stratigraphy transitioned to a different (solid) geology at this point and further study would be merited