Pile Cushions:

A Make or Break Proposition

By Steve Whitty, Specialty Piling Systems, Inc.

Pile cushions are one of those details often overlooked or misunderstood in the execution of a piling project. Pile cushions are a type of pile-driving cushion and differ from hammer cushions. However, like hammer cushions, they represent a small item in the overall scheme of things. They are consumables, just like fuel, oil and other items necessary to the execution of the work but not incorporated in the finished project. They have an anomalous function in that they are provided to "cushion" a blow and protect parts of the system, but are required to "transmit" as much of the driving energy as possible to the pile. Pile cushions are not necessary to almost every project as are hammer cushions, but they are essential when driving concrete piles and, although they are a minor cost item when compared to the cost of the pile, the total cushion expense on many projects can be substantial.

The question is, "What are pile cushions and why are they important or required"? As the name implies, pile cushions are provided and necessary to protect the pile during driving; plain and simple, or so it would seem. The fact is that pile cushions perform a rather more complex task than they appear from first glance.

When concrete was first used as a pile material, the piles were conventionally reinforced and cast. The length of the individual pile sections was limited by the reinforcing steel content to short lengths that could be supported in the horizontal as a beam (such as when the pile was lifted from the form, transported to the job site or picked from the ground and tilted to the vertical in preparation for driving). In these early days of conventional reinforcing, the piles were rather simple in design and usually driven with simple equipment such as drop hammers. It was obvious that a drive cap would be required to avoid striking the pile top directly by the cast iron or steel hammer and that some sort of material was required to avoid damage to the pile top from spalling. This was accomplished by the use of pieces of wood planks on top of the pile, inserted into the drive cap. Often times, other materials such as a tight coil of rope would be used. With the increased use of mechanically operated hammers imparting greater energy to the pile top, this issue became more critical and the usual remedy to problems was to increase the thickness of the cushion material or to use hardwood blocks.

As the name implies, pile cushions are provided and necessary to protect the pile during driving; plain and simple, or so it would seem.

When pre-stressing was introduced for the manufacture of piles, pile lengths were able to be extended considerably. During manufacture, transport and handling, "residual compressive forces" due to pre-stressing of the strand, provides rigidity which allows for lengths longer than for conventionally reinforced piles. Over time, additional advancements were introduced. Stronger cement mixes, larger and stronger stressing strand, and differing aggregates all contributed to the strength, increased length, and cross section of the piles. It was not long after that these longer and larger piles were being driven with bigger hammers and differences in the characteristics of the piles became apparent. Certainly, the longer lengths required additional attention during handling and this was readily apparent because it was observable while the pile was above ground. However, with more piles of longer lengths being driven, it was noted that increasing numbers of piles were cracking or breaking during driving and not just at the tops.

Without going into a lot of history, it is sufficient to say the problems were studied and a better understanding of how the pre-stressed, pre-cast concrete piles reacted during driving was provided. Instruments employed to monitor piles during driving confirmed much about how piles behaved in differing scenarios, i.e. differing soil types and differing hammer types and energies. As a result, it was discovered that the piles are not as rigid as once thought and, in fact, are rather elastic. The effect of the pre-stressing causes the pile to be compressed throughout its length. During driving, especially when piles drive through a rather stiff soil layer and into a soft to very soft strata, the piles have a tendency to "drive the tip portion away from the body of the pile" in a similar fashion as a croquet ball is driven away from its touching neighbor when the neighboring ball is struck by the mallet. The problems occur when there is relatively little resistance at the tip, causing the tensile forces to exceed the residual compressive forces due to pre-stressing. The residual compressive forces in the pile are acted against by the energy of the hammer blow being transmitted through the pile toward the tip, and reflected back toward the top as tensile forces. This is where the pile cushion is called upon to

do its job. It acts to dampen the intensity of the forces generated by the hammer blow while allowing the transfer of as much energy as possible to drive the pile, pushing it into the ground, rather than having the tip tend to pull away from the rest of the pile.

Identifying the problems that can occur in driving pre-stressed concrete piles has resulted in different materials being tried as pile cushions. Different combinations of wood and wood products have been the most popular materials tried with some manufactured products showing some promise. Presently, the pile-driving industry predominantly uses plywood materials although some contractors use manufactured products with success. Regardless of the material employed, there are certain characteristics during use common to all cushions. Considering the job that the cushion performs, it is essential to understand that a fresh cushion is better able to do its job than one that has been used for a while. After being pounded by the hammer for some time, the cushion tends to become compacted and its ability to cushion the blows is diminished. In the case of the wood and plywood cushions, this can be carried to the extreme and they start to retain heat energy, not only robbing the systems of driving energy but also producing heat in sufficient amounts to cause the cushion to char or burn. At this point, the cushion is not able to cushion the blow, and continued use can expose the pile to damage. For this reason, a fresh cushion should be used for each pile at the start of driving. Also, when a pile is stopped during driving (to change cushions or other reasons) it is subjected to "freeze" or "set up" in the soil, frequently making it difficult to start the pile moving again when driving resumes. In addition, this mandates that the driving rig be checked closely for alignment with the partially driven pile before driving resumes to avoid bending and possible breaking of the pile.

In addition to thickness, another consideration when selecting pile cushions is that the cushions are properly fitted to the pile and drive cap. A misaligned cushion can cause the hammer blow to be transmitted unevenly to the end-face of the pile, possibly causing harmful high stresses to one side of the pile and, consequently, spalling of the end. Just as it is a requirement that the pile ends be provided smooth and square to the axis of the pile, it is necessary to have the cushion sit tightly and in intimate contact with the end of the pile, allowing for the uniform transmission of the energy to the pile.

When selecting cushions, consideration must be given to the pile length and the soils anticipated to be encountered. A preferred way to select the proper cushion is to get this information when running a wave equation analysis of the pile, hammer and soil system. Modern practice dictates that a consistent, predictable cushion be provided. Plywood cushions are frequently specified with

multiple layers of plywood of alternating grain orientation generally having consistent properties. Cylinder piles can be driven using cushions made with layers of segmented arcs of plywood with the arc sections overlapping in each successive layer. Specially constructed cushions can be provided for pile ends with exposed reinforcing or for improved performance in hard or unusual driving situations.

Presoaking cushions in water before use, as some have tried, does not make them perform better. Cushions are porous and absorb water which cannot be compressed by the hammer blow. Rather, the soaked cushions tend to come apart or delaminate, disintegrate quicker and are more susceptible to the ravages of heat.

Regardless of the material used, the things to consider about cushions for a successful concrete pile installation are to have a proper fitting cushion; use a cushion of the appropriate thickness; start each pile with a fresh cushion; change cushions when they no longer are able to provide adequate cushioning. Most importantly, remember that the cushion is much cheaper than a pile, even a broken pile! Pile cushions really can literally make or break a concrete pile job.

Several PDCA supplier members provide pile cushions and can be a good source of information about pile cushions and their applications. For additional information, visit the PDCA Web site at www.piledrivers.org and search for suppliers of pile cushions in the "Member Search" section. ▼

Steve Whitty is a PDCA board member and can be reached at (985) 643-0690 or swhittysps@earthlink.net.

Apology

Piledriver magazine wishes to apologize to Steve Whitty and Herb Engler for neglecting to include their bylines on their article entitled, "Does Size Really Matter? In Hammer Cushions, Little Things Count!" in the summer 2004 issue. We sincerely hope this has not caused an inconvenience.