SLIC – Structural Lifecycle Industry Collaboration is a Joint Industry Project with the participation of 10 Offshore Wind Operators, the UK Department for Energy and Climate Change and The Crown Estate. It has the technical support of Cranfield University, Siemens WP and all major Offshore Wind Class Societies DNV, Germanischer Lloyd and Lloyd’s Register.

The design of steel offshore foundation structures has been based largely on Oil & Gas standards and guidance which was migrated across, and served as the basis for the creation of offshore wind standards. Much of the original research is now several decades old, and was based on characteristics that were representative of typical Oil & Gas offshore structures, but differ fundamentally in terms of load regimes, structural characteristics and environment typical offshore wind substructures.

In this intervening period, materials, fabrication technologies, inspection and design techniques have evolved significantly and it is considered that fatigue tests on contemporary materials using representative manufacturing techniques, and exposed to relevant environments and loading would yield important information to support informed decisions concerning existing structures and future developments in terms of design savings, construction, and operation.

The need exists to re-address these issues in order to build a knowledge-base and methodologies that reflect the conditions in which current structures operate, and enable the design of new structures to be optimized accordingly.

Methods

For girth welded joints, the S/N curves currently used have been developed from tests conducted on pipeline steels over several decades by different investigators on specimens derived from relatively small diameter, thin walled components with variable degrees of reporting and uncertain specimen and testing quality control. All these test programmes were to satisfy concerns for Oil & Gas industry issues and to date no comprehensive fatigue test programme has been conducted for offshore wind monopile structures.

It is simply not practicable to conduct full-scale fatigue tests on girth welded monopile sections due to the extremely large loads required. Instead, an approach was developed during the Pre-testing Phase to preserve the important characteristics of the components whilst at the same time testing under conditions that match those of the real structures as much as possible, reproducing the following characteristics:

- Material and Welding Procedure;
- Section Thickness and relative scale of tolerances;
- Loading Mode;
- Crack Characteristics (e.g. surface breaking).

The Pre-testing Phase enabled the development of the techniques best suited to test the large scale specimens required to capture the characteristics seen as fundamentally representative. Figure 1 shows a number of the tests carried out to establish and optimize testing parameters, methodologies and test equipment.

In order to achieve the required specimen geometries and quality steel plate was obtained from the main offshore suppliers and fabricated using standard offshore wind methodologies by EEW, Bladt and SIF to ensure consistency with offshore fabrication standards.

Figure 1 – Pre-testing Phase activities and methodology development

Results

The Main-testing Phase is currently ongoing with full results expected towards the end of 2015. Ongoing tests are shown in figure 3 with respect to the C1 existing curve and figure 4 shows figuratively what a full plot would look like once full testing is completed. Once full results are obtained analysis will be carried out to obtain the respective standard deviation bands and establish S/N curves that would be representative of the offshore wind characteristics.

Figure 3 – Plot showing ongoing tests with reference to existing curves

Figure 4 – Illustration showing mean D curve and standard deviation bands for a figurative corresponding set of results

Conclusions

At this stage it is possible to establish that the work carried out during the Pre-testing Phase was successful in establishing methodologies that enable the testing of large scale specimens and crack initiation to occur at the test area to enable successful test results to be derived from representative specimens.

Currently it is expected that the full results will be available at the end of 2015 to complement the existing body of knowledge.

References