Steel Sheet Piling – recent developments and Codes of Practice

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Sheet Piling has, for many years, been adopted as the primary solution when constructing quay walls and berthing facilities in a marine environment. As the requirements of port operations have developed over time, with larger and deeper berths being constructed to accommodate larger vessels, so has the design and range of steel and sheet pile elements been developed to provide greater design capacity. In addition to the ongoing developments in the basic materials available, particularly in the UK and Europe, significant changes are being made to design methodology with the introduction of the Eurocodes. These are a suite of standards which are being adopted across Europe and will replace many national standards currently used for the design and construction of sheet pile walls. The Eurocodes consist of standards covering the basic materials used in construction and the design methods to be adopted, and are accompanied by a number of execution codes which detail how the construction should be undertaken. A summary of the Eurocode standards is given below:

EN 1990 Eurocode: Basis of structural design
EN 1991 Eurocode: Actions on structures
EN 1992 Eurocode: Design of concrete structures
EN 1993 Eurocode: Design of steel structures
EN 1994 Eurocode: Design of composite steel and concrete structures
EN 1995 Eurocode: Design of timber structures
EN 1996 Eurocode: Design of masonry structures
EN 1997 Eurocode: Geotechnical design
EN 1998 Eurocode: Design of structures for earthquake resistance
EN 1999 Eurocode: Design of aluminium and aluminium alloy structures

For steel sheet piling, the most significant elements of the Eurocodes are:

EN 1990 Eurocode: Basis of structural design
EN 1993 -5 Eurocode: Design of steel structures - Piling
EN 1997 -1 Eurocode: geotechnical design – General rule

Plus the accompanying execution code:

EN 12063 Execution of special geotechnical work – Sheet pile walls

The impact of the Eurocodes has also driven significant revision in the suite of British Standards covered by BS6349 – Maritime Works, which have been used for many years on an international basis.

Standards and Codes of Practise

The current BS6349 standards are not based upon the use of 'limit state design', and as this approach is the fundamental basis of the Eurocodes, significant changes to the design sections have been required to bring them in line with the European standards. Whilst this in itself should not have a significant effect upon the overall use of sheet piles within ports and harbours, there are a number of issues which can arise if the new codes are not fully understood and applied correctly. Examples of potential pitfalls or areas of uncertainty include:

Language – The Eurocodes have been produced on the basis of agreeing a consistent use of language to describe elements of the design process. For example, the Eurocodes aim to use the term 'Action' instead of 'Forces' or 'Loads' acting on structures. However, on closer examination of the documents, references can be found to 'Loads'. It appears that an 'Action' can be a 'Load' when it has its own mass!

Corrosion – The potential for corrosion and the rate at which it will occur is one of the primary considerations when selecting steel piles as the construction method for a new quay wall. A number of engineers have, when using the new design approach, been calculating much higher corrosion rates than if using previously established standards and documents. This obviously can cause concern and could result in the production of over specified and uneconomic designs. However, when

Figure 1. Typical steel combi-wall construction, Campbeltown Scotland.

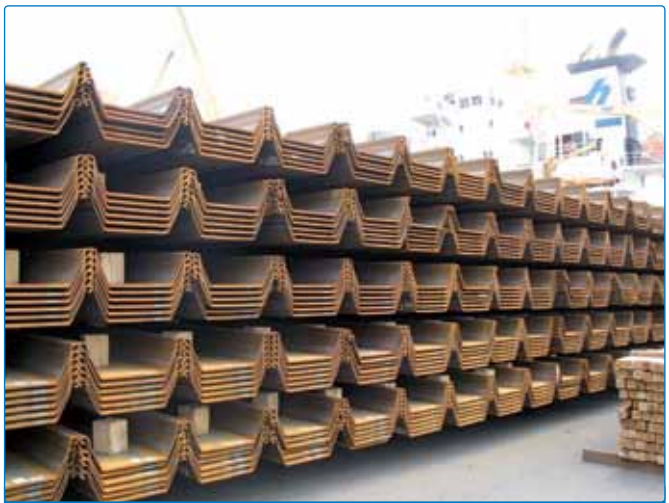

Figure 2. Shipment of Japanese sheet piles to the UK.

TABLE 1: COMPARISON OF DIFFERENT PILES

Pile Section	Elastic Section Modulus	Mass kg/m² of wall	Saving
Piles manufactured by Arcelor Mittal			
PU18 600mm wide U section	1,800	128	–
AU18 750mm wide U section	1,800	118	8%
AZ18 670mm wide Z section	1,800	118	8%
AZ18 -700, 700mm wide Z section	1,800	109	15%

interrogated, the reasons behind the increased corrosion calculations include the following:

- A difference in terminology between the standards such as: characteristic values, mean values and 95 percent probability values being taken from source documents, which were not produced on this basis.
- Selecting published corrosion rates from older documents and utilising within new design methods. Unless the basis of the measured rate is understood then there is no certainty that the rate selected corresponds to the requirements of the calculation. For example, the new codes deal with uniform corrosion and accelerated corrosion separately, however, many of the older published measurements and guidance were produced as single figures. If one of these is selected as a mean rate for uniform corrosion, then much higher design rates will be calculated.

It is therefore important to understand where data is derived from and on what basis it was measured in order to ensure that its use is compatible with the design method and terminology being used.

Sheet pile materials

Concurrent with the development in design methods and standards, there has been an improvement in the manufacture of steel sheet piles. There have been significant improvements made in the efficiency of sheet pile sections, particularly with the development of wider Z profile piles such as the Arcelor Mittal 700 series of AZ piles.

The differences between different pile profiles are more clearly defined within the Eurocodes, with U profile piles being affected significantly more in unfavourable conditions than Z profile sections. This will probably lead to a decline over time in markets where U sections have dominated, such as the UK, as the benefits of utilising Z profile piles are demonstrated. The principle reasons for the variance between U and Z shaped piles being adopted in wall designs are due to the fact that U section piles are connected together along the centre line of the pile wall. As the piles resist actions upon the wall, there is a greater potential for movement within the pile clutches of U section piles, which negatively affects the flexural strength of the piles. This potential is accommodated for within the Eurocodes through the introduction of two partial factors, which act as reduction factors on the capacity of U section piles within a design.

Therefore, there are design advantages for adopting Z profile piles as well as sound commercial reasons as demonstrated in Table 1, where piles with an equivalent capacity are compared against the weight of the section:

Conclusion

Steel sheet piles have been used for many years to construct quay walls within port environments, and visually, there has been very little change. However, there are constant changes and developments to both the manufacture and design of sheet piles leading to greater efficiency in the final wall construction. The design and commercial benefits of wider Z section piles is more easily demonstrated using the design process outlined within the Eurocodes and will lead to increased use over U section piles over the next few years.

Figure 3. Standard 600mm wide U section sheet piles.

ABOUT THE AUTHOR

Alec Courts is a Geotechnical Engineer with many years experience of piling and foundation systems. Having worked both nationally and internationally on marine projects, using a variety of geotechnical techniques, he was invited to become a member of CB502, the BSI committee responsible for revising and updating the BS6349 suite of standards, covering maritime works. He represents the Federation of Piling Specialists on these committees, this being the UK Industry body for Piling and Geotechnical Contracting Specialists.

ABOUT THE COMPANY

Radix Geoscience Ltd is a Geotechnical Consultancy specialising in piling, foundation systems and marine construction.

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