ABSTRACT

In this study the wave characteristics (height and period of wave) were simulated by applying the Bretschneider spectrum and equations presented by Sverdrup-MunkBretschneider (SMB) by using the recorded data such as wind velocity and duration, differences between water and air temperature and the fetch length. It is essential for all offshore structures analysis to estimate the forces generated by the wave and current by developing a program for modeling wave and current forces on offshore structural members. Airy wave theory (linear theory) has been implemented in the present study, based on its attractiveness for engineering use. The Morison equation was used for converting the velocity and acceleration terms into resultant forces. For calibration and for comparison purposes, a developed program was checked against a well-known professional software package called Structural Analysis Computer System (SACS). Furthermore, a wide range still exists to improve the presented models as well as provides alternative to deterministic models. Therefore, this study investigates the possibility of utilizing the relatively current technique of artificial neural networks (ANN) for this purpose. Besides, the comparison of ANN models with the two characteristic prediction methods based on equations of SMB and Bretschneider equations showed a better performance for ANN models rather than SMB and Bretschneider equations. Different ANN architectures were used to by using sets of data with different parameters used in training process. The results confirm that a suitably trained network might supply acceptable outcomes in open wider areas, as well as when the sampling and predicting interval is enormous in order of magnitude of a week. Keywords: Bretschneider spectrum and equations, neural networks, offshore structures analysis, airy’s linear theory, structural analysis computer system.

1.2 Artificial Neural Network Much research attention has been centered on solving one problem: ―How does the human brain work?‖ Artificial Neural Networks have been used to try to solve this problem. (Hagan et al., 1995) report that, the preliminary research in neural networks field is back to 1943, by (McCulloch and Pitts, 1943) when they assumed a simple mathematical process 3 to give details about the way neurons are working biologically. This was apparently one of the first significant study on artificial neural networks (ANN) (Hagan et al., 1995). The technique of (ANNs) is an alternative possible methodology. Many investigations and works for more than five decades found that the biological neural system was must suitable way to apply ANNs in real world. ANN is helpful in many cases where the essential process of physical for prediction are still not completely understood and compatible in dynamical systems modeling that based on period of time. However, until 1980’s the ANNs it has not been applied on a large scale to the problems of the real world. Therefore, common application were not training by algorithms because of the lack of their sophisticated (Cha et al., 2006). According to (Huang et al., 2009), ANNs are one of the latest data-processing technologies available in the engineer’s toolbox. They serve as an important function in engineering applications. In particular for predicting the evolution of dynamical systems, modeling the memory and performing pattern recognition. In contrast to conventional approaches derived from engineering mechanisms, the only requirement for obtaining accurate predictions with ANN models is a reliable dataset to achieve suitable training database with accurate predictions for a variety of engineering problems (Cha et al., 2011). 1.3 Wave Forces on Offshore Structures Brief discussion on the theoretical aspect and simulation of the wave forces on offshore structural members has been presented. A computer program written in the FORTRAN language working under the Microsoft Power Station environment validated with a standard commercial package called Structural Analysis Computer System.

Artificial Neural Networks ANN was originally introduced as simplified models of brain-function. The human brain consists of billions of interconnected neurons. These are cells which have specialized members that allow the transmission of singles to neighboring neurons (Cha et al., 2011). The neural networks theoretical concepts can be found in many studies as well as books include, (Kosko, 1992). Network applications in civil engineering prediction such as (French et al., 1992), (Kasperkiewicz et al., 1995), (Grubert, 1995), (Thirumalaiah and Deo, 1998)and (Deo and Kumar, 2000), with many application that connected to prediction of rainfall, concrete strength and waves in onshore and offshore parts. Additionally, it has been applied ANN models in different engineering problems, for instance, the generation of wave equations that based on hydraulic data (Dibike et al., 1999), parameters of water quality prediction (Maier and Dandy, 1997), tidal prediction (Lee et al., 2002), prediction of shallow foundation settlement (Mohamed et al., 2002), dynamic amplification of the soil analysis prediction (Hurtado et al., 2001) and the prediction of concrete strength concrete (Rajasekaran et al., 2003). In this study, we will further apply ANNs to the prediction of the wave characteristics in the deep water conditions. 2.5.1 Artificial neural networks applications in engineering The last five decades have witnessed several applications of ANN in engineering prediction. These include heights and periods predicting (Deo et al., 2001), wave reflection (Zanuttigh and Meer, 2008), and water level prediction (Patrick et al., 2003). Some previous work related to Artificial Neural Networks application in the area of engineering 10 and science will be summarized under the headings: structural engineering, geotechnical engineering, water resources, and coastal engineering. Makarynskyy et al., (2004) discussed the ANN approach to the problem of improving the prediction of the wave. In this paper, they used two different approaches. First, they used the initial simulations of the wave parameters with leading times from 1 to 24 hours. Second, they allowed for merging the measurements and initial forecasts. These results showed that an ANN model can provide accurate simulation and demonstrated the ability of neural networks to improve the initial expectations, it is estimated in terms of the correlation coefficient, root mean squared error and scatter index. Deo et al., (2001) presented practical methodologies for designing better ANN architectures for wave prediction. It demonstrates an improved in the predictions result and the actual observations which represented in the improvement of the correlation coefficient (R²) of 68%. They concluded that smaller differences in the characteristics of the wind at this location coupled with the single location wave and wind measurements led to improvement in predictions. Lee et al., (2001) developed an ANN model to predict the behavior of stub-girder system in structural analysis. In this paper, they believed that it is difficult task to modeling stubgirder involving complex material behavior by traditional numerical modeling in computational. They concluded that, many of uncertainty and empirical problems within an approximate structural analysis can be solved successfully by the ANN models that require both an fast calculation with acceptable margin of error in structural engineering. Kim et al., (2001) presented how to utilize an accumulated database to evaluate particular tunnel sites and prediction of ground surface settlements due to tunneling using an ANN model. The ANN model based on past tunnel records that used as reliable database which leading to predicted the settlements of ground surface. They suggested that the ability to predict an accurate result is completely reliant on data quality and quantity that used in training ANNs. In water resources engineering, (French et al., 1992) used an ANN to predict rain- fall intensity. They used back-propagation network for the training, and they compared natural 11 rainfall history with an ANN predicted fields model. Their results indicated that the ANN is capable of learning the complex relationships describing the space-time evolution of rainfall that is inherent in a complex rainfall simulation model. Maier and Holger (2000) applied ANNs in prediction of water quality parameters. The authors reviewed the differences between ANNs and more traditional predicting methods, such as time series and physically based models, and applied the ANN model to predicting salinity in the River Murray at Mruuay Bridge, South Australia. They concluded that ANN models appear to be a useful tool for predicting salinity in rivers, even if they had difficult in determining the appropriate model inputs. Later, they investigated the relative performance of various training algorithms using feed-forward ANNs for salinity predicting. 2.6 Hydrodynamic Forces The hydrodynamic forces evaluation that acts on platform legs requires knowledge of vector of stress which includes gradients of the velocity and dynamic pressure. However, the fluid motion usually consider as steady, which means linearized, with no more boundaries. As a result, it is possible to relate the stress vector with the velocity of the rigid body relative to the fluid velocity in the far field by means of an integral equation of the first kind (Youngren and Acrivos, 2006). This approach was taken for the Stokes equation. In both cases, using the matching fundamental solution, at the first order integral equations system, valid at each point of the surface of the submerged rigid body, can be gained that link the stress vector with velocity of the rigid body. The numerical methods were developed numerical by the authors to calculate the stress vector and accordingly to gain a solution with details for the vector of stress which allows authors to calculate the hydrodynamic forces, Consisting of body forces and the stresses supposed to given by a potential, on the rigid body. The wave force theories concerning offshore platforms were not existed until Morison equation was presented in 1950; the wave forces on a vertical pipe were shown to be as illustrated in Fig. 2.2: 12 Figure 2.3: Hydrodynamic forces parameters on platform legs due to waves (Sadeghi, 2008) The coefficients of hydrodynamic forces including drag coefficient and inertia for various types of platforms such as square, rectangular or circular sections that will be subjected to hydrodynamic forces. The Morison formula is written below (Sadeghi, 2001): (2.2) (2.3) where, : Represents the drag force : Represents the inertia force The most important consideration in applying Morison’s equation is the selection of appropriate drag and inertia coefficients. However, there is considerable uncertainty in the 13 and values appropriate for the calculation of offshore structural members, with many values in publication. Some published studies reviewed by (Cassidy, 1999) in the literatures in his ―PhD diss‖. He evaluated that ranged between (0.6 - 1.2) depends on cylinder configuration. For ranged from (1.75 – 2.0) depends on cylinder configuration as well. Morison Equation is based on following assumptions: i. Flow is assumed unstable by the presence of the structure ii. Force calculation is empirical calibrate by experimental results iii. The right coefficients should be used rely on the shape of the structure body iv. Validity range shall be checked before use and generally, the validity suitable range for most jacket type structures is D/L less than 0.2. where, D : Represents the diameter of the structural member L : Represents the wave length The forces and moments due to waves that applied on structure member such as legs, piles and braces are important for process design of offshore platforms. Different amount of forces and moments applied on those members in each moment caused by a particle suspended in a fluid. From the combination of drag force ( ) and inertia force ( ), the total amount of forces and moments can be calculated, with respect to a force sign (Sadeghi, 2008).