

## A New Approach to Calculate Stress Concentration Factors: Artificial Neural Networks

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### ABSTRACT

As an alternative approach to calculate the Stress Concentration Factor(SCF) we propose the Artificial Neural Networks (ANN). Neural networks have the ability to learn, to generalize and, besides, the user does not need to know *a priori* a function between input and output data. The training set used in this research work was obtained by FE simulations of tubular joints, considering the 3D geometry of the weld fillet between chord and brace members. The procedure proposed represents an advance among the traditional SCF calculations for tubular joints, both because it takes into account the effects of the weld geometry in the SCF and also uses the Neural Network approach for the stress concentration factor computation.

**KEY WORDS:** tubular joints, SCF, neural networks.

### NOMENCLATURE

ANN = Artificial Neural Networks.  
D, d = chord and brace diameters.  
G = gap in the weld root between chord and brace.  
L = chord length.  
SCF = stress concentration factor.  
Sec = % of weld fillet length stem from crown hell.  
T, t = chord and brace thickness.  
 $W_{ij}$  = weight between neurons  $i$  and  $j$ .  
 $\alpha$  =  $2L/D$ .  
 $\beta$  =  $d/D$ .  
 $\gamma$  =  $D/2T$   
 $\tau$  =  $t/T$ .  
 $\theta$  = angle between brace and chord (*hell*).  
 $\alpha_s$  = weld fillet groove angle.  
 $\eta$  = learning rate.  
 $\delta_j$  = error value at neuron  $j$ .  
 $\theta_j$  = neuron  $j$  threshold.

### INTRODUCTION

Offshore structures consist primarily of steel tubular members with cylindrical hollow sections, which provide high strength to weight ratio, high buoyancy and low drag coefficients. The connections are performed by welding the end of brace members onto the external surface of the chord, giving rise to high stress gradient in the welding zone. In the aforementioned region, stress peak can achieve several times the nominal stresses of the brace members, which is commonly defined as stress concentration factor.

As can be seen in various research works (Kuang, 1975), (Gibstein, 1987) and (UEG, 1985), the procedures to evaluate the SCF are closely related, usually with two steps. In the first one, experimental tests and FE analysis provide SCF values by changing important geometric variables of the tubular joint. The second phase involves the definition of a parametric equation to estimate the SCF. The equation is defined by regression, which requires a function between input and output data and coefficients to be evaluated. In this sense, various parametric equations are available for the calculation of SCF, for example Gibstein (1987) and Kuang (1975), for several types of tubular joints and load conditions.

The existing equations, however, lack from homogeneity about the influence of each joint parameter, as well as there is disagreement in the obtained results. Moreover, the validity ranges of these equations in terms of geometric joint configuration are significantly different (Wardenier, 1982). Among the cause of such disparity, it is worth to mention the limited range of geometric parameters employed in the regression and the formulae *a priori* admitted to evaluate the SCF. Since the phenomenon is highly complex, the later is probably the leading source of unsuitable results in several joints.

In this work, we present another approach to evaluate the SCF. Likewise in the regression approach, a database is taken from FE analysis. However, the FE model adopted taking into account the weld geometry, which brings two advantages: the geometry of joint is better represented and the values of SCF do not need to be extrapolated, because the hot spot stress is attained in a straightforward manner. Besides, Artificial Neural Networks (ANN) are used instead of regression analysis. This is motivated by the needless of an expression to correlate input and output data.