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Technical Note

Effects of modeling strategy on computational wind pressure distribution around the cooling tower's

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1. Introduction

The wind load is always the dominant load in design of the NDCT due to its large size, complex geometry and thin wall. Hence, evaluation of the Wind Induced Pressure Field (WIPF) around NDCT structures is one of the major concerns of the structural engineers. The design guide-lines provide straight forward suggestion for estimation of WIPF around the NDCT with standard shape, (VGB Guideline 2005).

Computational Fluid Dynamics (CFD) methods have become efficient tools for computer simulation of WIPF around NDCT structures (Bergstrom *et al.* 1993, Al-Waked *et al.* 2002, Liu *et al.* 2006, Sabbagh-Yazdi *et al.* 2007). Following the concept of equivalent sand roughness for the wall function, the Surface Wind Ribs (SWR) which significantly affect the formation of WIPF on external surface of NDCT, are modeled by the authors using an innovative relation (which utilizes height and spacing of wind ribs) for modeling the effects of wind ribs (Goudarzi and Sabbagh-Yazdi 2008).

In this paper, the effects of NDCT geometry features on formation of pressure field around a NDCT are investigated. First, the effects of inside flow modeling on the external surface wind induced pressure are investigated. Then, the effects of adding circumferential footing structures to the external WIPF distribution are numerically examined. Numerical experiments are performed on a full scale NDCT and conclusions are made by comparison between computed internal and external pressure distributions and the VGB suggestions.

2. Numerical investigations on full scale NDCT

For investigating the effects of modeling circulating flow inside the NDCT on the internal and external wind pressure, a full scale NDCT designed for KAZERUN power plant in Iran is chosen (Goudarzi and Sabbagh-Yazdi 2008). The atmospheric pressure ($P=0$) is considered at outflow boundary and vertical distribution of horizontal component of wind velocity imposed at inflow

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boundary is considered as *41.2(Z/10)*$^{0.11}$.

2.1 Effects of inside NDCT flow modeling

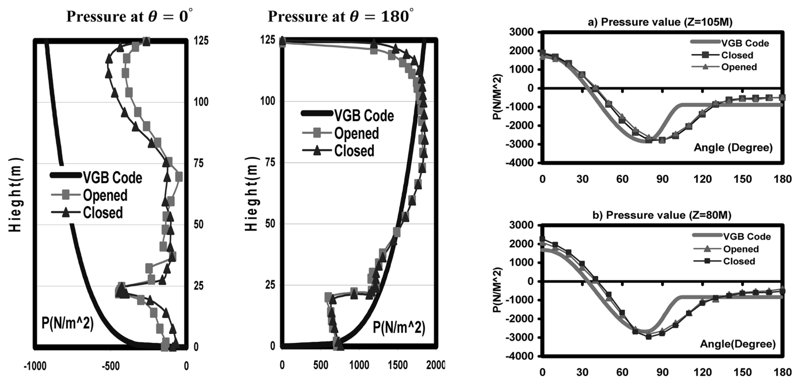
Interior part of the NDCT is a region that requires fine elements due to formation of circulating flow field. Reduction of flow region by omitting the parts of flow domain with minor influence on NDCT external WIPF may provide computational savings. In order to examine the effects of interior part on external WIPF, the geometry of the computational domain is modeled under two conditions. First, complete flow domain is formed by meshing both external and internal cavity of a full scale NDCT. Second, internal space of NDCT is omitted (by specifying a slip condition across the NDCT outlet. In the second modeling condition, the trapped flow inside the NDCT is neglected for the sake of computational efficiency (by reduction 33% on number of elements).

Fig. 1 presents the comparison between the circumferential and vertical distributions of computed WIPF for two models with WIPF predicted by VGB guidelines. As can be seen in Fig. 1, the computed external WIPF in most parts of NDCT shell are in close agreements with VGB guidelines. Computed circumferential WIPF distributions have also similar trend in both models. Both models represent the identical positive computed WIPF at upstream stagnation point ($\theta \approx 0$) and approximately constant value of negative computed WIPF on downstream part of the NDCT ($120 < \theta < 180$). The maximum negative WIPF occur on both lateral sides of NDCT ($70 < \theta < 90$).

It can be stated that modeling inside the NDCT has negligible effects on the external WIPF. Despite of considerable differences between the computed velocity fields behind the NDCT ($\theta = 180$), Fig. 2, there are minor differences on computed WIPF resulted from two modeling strategies. In Fig. 3, the computed WIPF distributions on internal surface of NDCT follow the constant internal WIPF value suggested by VGB for various elevations at most of internal parts of the NDCT. However, some differences on top elevations of NDCT at downstream zone are formed on those parts of the internal shell which are exposed to the upstream external wind flow. This effect leads to increasing the WIPF (reducing the internal negative pressure).

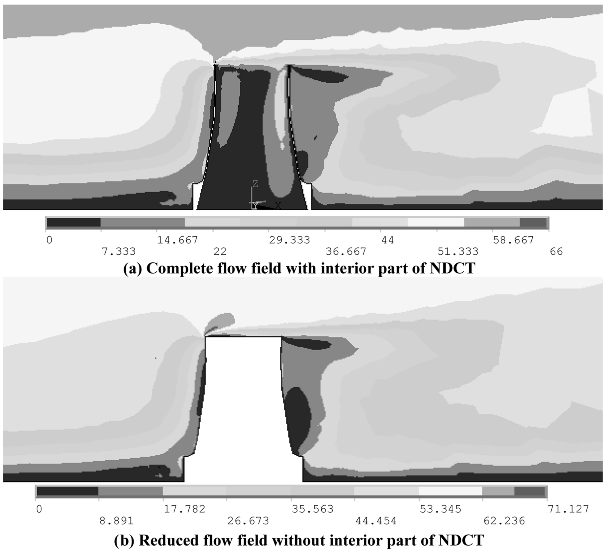
2.2 Effects of footing structure of NDCT

To evaluate the effect of the footing structure on WIPF, two modeling strategies are considered.



(a) Vertical distribution (b) Circumferential distribution

Fig. 1 Computed pressure of full scale NDCT for both closed and opened top conditions



(a) Complete flow field with interior part of NDCT

(b) Reduced flow field without interior part of NDCT

Fig. 2 Two dimensional color-coded computed velocity contours on a full NDCT external surface

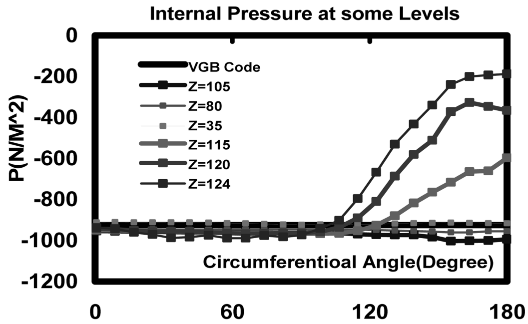
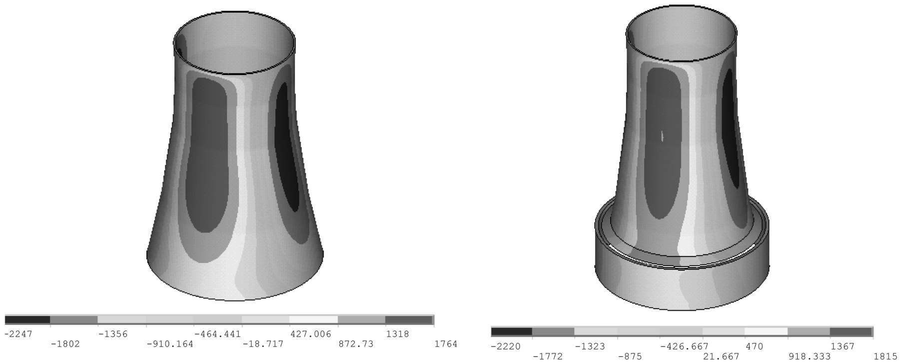


Fig. 3 Circumferential distribution of internal computed pressure at some levels of NDCT

First, the geometrical characteristics of a full scale standard NDCT (for which the design load of design guide line suggestions of NDCT can be applied) are considered by omitting the footing attachments. Second, the physical features of the footing structure are specified to construct the digital geometry of a NDCT shell with major geometrical difference with standard NDCT shape. For the sake of computational savings, internal domain of the NDCT is not modeled in both models.

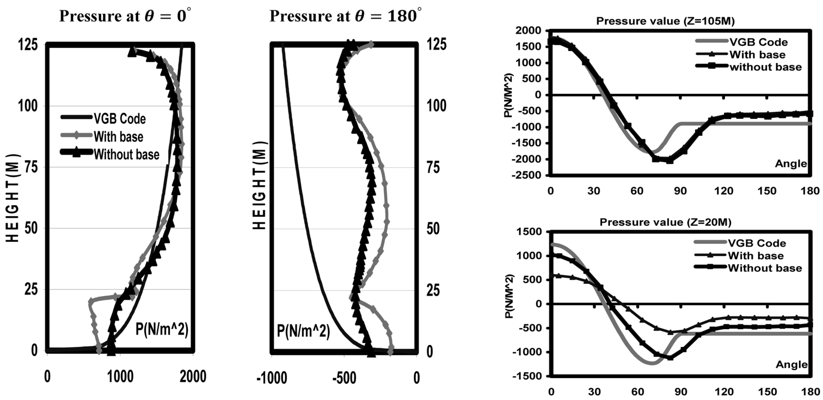
For both models, the 3D computed WIPF around the NDCT are presented in Fig. 4. Comparisons of the circumferential WIPF diagrams with VGB for both cases present similar trends at throat level (Fig. 5(b)) and identical positive WIPF are computed at upstream stagnation point ($\theta = 0$) and constant values of negative pressure are obtained at downstream part of the NDCT ($110 < \theta < 180$) shell. For the footing levels, the circumferential WIPF presents different trends for the two models (Fig. 5(b)).

Far from the footing structure, the vertical profiles of WIPF follow the VGB guideline in the vertical levels for the two models (Fig. 5(a)). However, the computed negative WIPF behind the NDCT are approximately 40% less than the VGB guideline for both models. At the level of the footing structure some disturbances are appeared and due to different vortex flow regions behind the NDCT ($\theta = 180$), the differences between computed WIPF of the two modeling strategies are not negligible.



(a)Without base structure (b)With base structure

Fig. 4 Three dimensional color coded map of pressure on external surface of NDCT



(a) Vertical distribution (b) Circumferential distribution

Fig. 5 Computed pressure of full scale NDCT for both with and without base structure

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