ISC-PRIME VERSUS WIND-TUNNEL OBSERVATIONS FOR MULTI-TIERED, SLOPED, POROUS STRUCTURES

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1. INTRODUCTION

This paper evaluates the validity of ISC-PRIME for modeling multi-tiered, sloped, porous structures. ISC-PRIME was proposed for use to model a pair of such structures that were to be located near two proposed combustion turbines. The local agency questioned the use of BPIP determined building dimensions as inputs to the model due to the complexity of the surrounding structures. Hence, wind-tunnel testing was conducted to determine the equivalent building dimensions for ISC-PRIME input. During the course of the study, building dimensions were defined using both the BPIP analysis program and wind-tunnel determined "equivalent building dimensions" (EBD). ISC-PRIME was then run for 36 wind directions and one wind speed using both sets of building dimensions as input. The predicted concentrations were compared with wind-tunnel measurements obtained using a scale model of the facility.

2. WIND-TUNNEL DATABASE

A series of 36 wind-tunnel tests (i.e., 10 degree wind vector increments) were conducted to obtain profiles of maximum ground level concentrations versus downwind distance due to emissions from a 45.7 m stack with the site structures in place. Figure 1 shows one of the multi-tiered, porous, sloped site structures. Eight additional tests were conducted to obtain maximum ground level concentrations versus downwind distance for buildings with height/width/length ratios of 1:2:1 (i.e., the "equivalent buildings") with the significant site structures removed. The simulated source parameters and building dimensions for all tests are provided in Table 1.

3. BUILDING DIMENSION INPUTS

Building dimensions for input into the ISC-PRIME model were determined using both BPIP and the EBD method. Figure 1 shows the simplification of the multi-tiered, sloped, porous, structure used as input for the BPIP program. EBD were determined by plotting the maximum observed C/Q in each receptor row versus downwind distance for the site structures as well as each equivalent building. Based on an EPA approved criterion, an equivalent building was selected for each of the 36 wind vectors. Figure 2 shows the variation in the building height specification, H_b, versus wind vector for the various methods.

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4. MODEL EVALUATION

The ISC-PRIME model was run using building parameters generated using both the BPIP program (ISC-PRIME/BPIP) and the EBD technique (ISC-PRIME/EBD). Figure 3 shows the relative performance of ISC-PRIME using the two building dimension generation methods. All of the maximum predicted concentrations are within a factor of two of those observed in the wind tunnel. In general, ISC-PRIME/BPIP tends to over-predict when compared to both ISC-PRIME/EBD and the wind-tunnel observations.

Figure 4 shows the maximum concentrations versus wind vector, normalized by the observed concentration for that wind vector, for each method. Again, ISC-PRIME/BPIP tends to over-predict for most wind vectors. This over-prediction is amplified for several wind vectors, including 30 degrees and approximately 290 through 350 degrees. The models slightly under-predict the maximum observed concentration for wind vectors 100 through 180 degrees. This is likely due to the orientation of the two complex structures. There are no significant structures upwind of the stack, but the "wing" of the complex structure may be acting as a "trip" that increases the vertical dispersion of the plume.

In practice, a selected number of maximum concentrations (i.e., the 50 greatest concentrations) are used to evaluate model performance. Figure 5 shows the maximum predicted and observed concentrations in increasing rank order. This figure shows that an environmental impact assessment using ISC-PRIME/BPIP for complex structures such as the multi-tiered, sloped, porous structure evaluated here, may needlessly over-predict the maximum concentrations actually produced by the facility.

5. CONCLUSIONS

The results of this study show that the ISC-PRIME model using BPIP generated building dimensions tends to over-predict concentrations for complex structures such as the multi-tiered, sloped, porous structure evaluated. When "Equivalent Building Dimensions" (EBD) are used, the ISC-PRIME model performed exceptionally well in predicting the overall maximum concentrations for the complex structure evaluated.

In general, this study shows that the ISC-PRIME model performs exceptionally well for complex structures if the building parameters are first determined using the EBD method. If BPIP generated dimensions are used, the model tends to over-predict the maximum concentration for this particular structure. However, this study was limited in scope and additional testing is needed before general conclusions can be drawn.

References and additional discussion can be found in the detailed paper at:
http://www.cppwind.com/papers/primeebd.pdf.

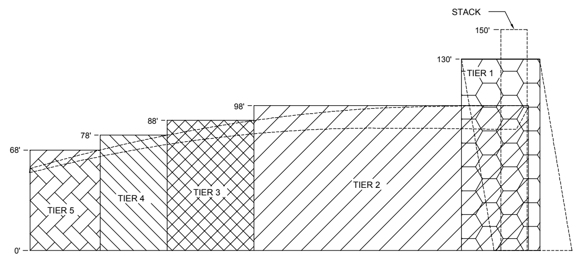

Figure 1. Simplification of the multi-tiered, porous, sloped structure for input into the BPIP program.

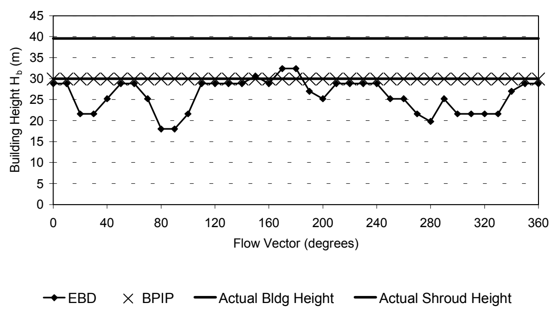

Figure 2. Building Height, H_b, predicted using the EBD technique, the BPIP program and the actual heights versus wind vector.

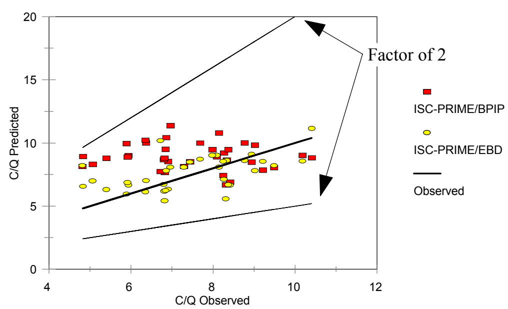

Figure 3. Maximum predicted concentrations versus those observed in the wind tunnel.

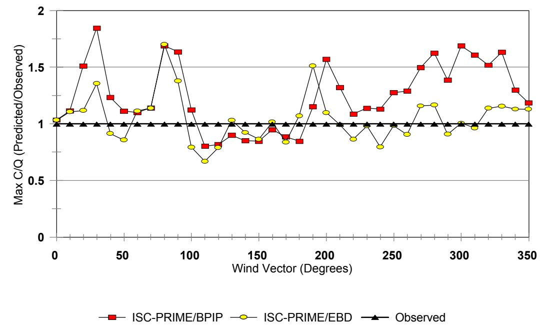

Figure 4. Maximum predicted and observed C/Q normalized by the C/Q observed in the wind tunnel versus wind vector.

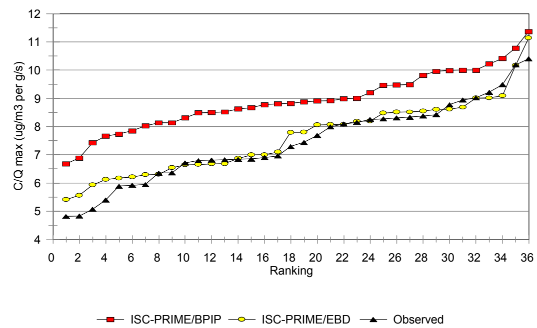

Figure 5. Maximum predicted and observed concentrations in increasing rank order.

Table 1. Model Inputs

Exhaust Stack Parameters

Exit Diameter	5.49 m
Stack Height	45.7 m
Exit Temperature	294.4 K
Volume Flow Rate	872.9 m^3/s
Exit Velocity	36.875 m/s

Ambient Parameters

Wind vector	Varies
Stack Height Wind Speed	28.91 m/s
Approach Roughness	Urban
Ambient Temperature	291.5 m/s