Computational Fluid Dynamic Analysis Of An ADA Compliant Grate Progress Report for January – March, 2014

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When urban roads are resurfaced with concurrent repair and/or replacement of sections of curb and sidewalks, Americans with Disabilities Act (ADA) compliant pedestrian ramps at crosswalks may be required. Storm drains are often located near crosswalks, and may be in the crosswalk. In that case, an ADA compliant replacement grate would be required. Minnesota Department of Transportation (MnDOT) ADA Operations Unit identified a foundry with an available grate that meets ADA requirements, but no information on the hydraulic capacity of the grate for on-grade conditions is available.

The openings in ADA compliant grates are smaller than traditional grates and their hydraulic capacity is less. In order to maintain total street drainage capacity when ADA compliant grates are used the hydraulic capacity of ADA compliant designs must be determined. Computational Fluid Dynamics (CFD) analysis was used as an alternative to flume testing of the identified ADA compliant grate. Traditionally flume testing of grate capacity is done, however, flume conditions do not correspond directly to street conditions, and therefore procedures are needed to calculate capacities under full scale street design conditions. In addition, flume testing may require modification of a flume at a Federal Highway Administration (FHWA) laboratory or university flume and scheduling of time to run tests at that facility. CFD analysis of grates can be carried out at full scale for a variety of street slopes and water volume flow rates by modifying the model geometry.

Argonne National Laboratory's Transportation Research and Analysis Computing Center (TRACC) has been conducting CFD analysis of hydraulic problems for and in collaboration with the Turner-Fairbank Highway Research Center (TFHRC) since 2007. TRACC analysts conducted a brief feasibility study in 2013 and determined that grate hydraulic capacity could be determined using CFD. In January of 2014 a project using CFD analysis to determine the hydraulic performance of the ADA compliant grate, R-3210-Q from the Neenah grate catalog in comparison to a traditional vane grate, R-3210 from the Neenah grate catalog was begun. This report covers progress for the period from January through March, 2014.

MnDOT specified a set of 21 test conditions. These cases included 3 subsets with a gutter cross slope of 0.04 and width of 2 ft. The subsets had 8 ft. and 6 ft. wetted pavement width with 0.04 cross slope and 6 ft. wetted pavement width with 0.02 cross slope. Five longitudinal street slopes for each set were 0.003, 0.005, 0.01, 0.03, and 0.05. Additional cases with gutter cross slopes of 0.02 and 0.05 and longitudinal slope of 0.01 were also specified. Test cases for these additional conditions were planned for each of the 3 wetted pavement width and cross slope combinations giving six additional cases.

LSTC's LS-PrePost processor was used to create the grate geometry for the two grates to be analyzed. CD-adapco's STAR-CCM+ CFD software was used to create the different street geometries for the 21 cases. Most of the geometries were created during this quarter.

The physics models for a two phase free surface flow of water and air with appropriate boundary conditions were set up in STAR-CCM+ to do the analysis. The geometry was divided into 3 regions: the main street, the volume over the grate, and the grate and catch basin. A different set of meshing operations was created for each region to optimize the mesh for accuracy and computational efficiency.

STAR-CCM+ was used to run the cases and to collect desired result data via built in and user defined field functions and reports, such as the primary quantity of interest: the fraction of the flow intercepted by the grates. Approximately one third of the cases were run during the quarter.