Finite Element Modeling of Concrete Based on Quantitative Computed Tomography (QCT)

Arash Razmjoo
Amir Poursaeed

Follow this and additional works at: https://tigerprints.clemson.edu/grads_symposium

Recommended Citation
Razmjoo, Arash and Poursaeed, Amir, "Finite Element Modeling of Concrete Based on Quantitative Computed Tomography (QCT)" (2013). Graduate Research and Discovery Symposium (GRADS). 49.
https://tigerprints.clemson.edu/grads_symposium/49

This Poster is brought to you for free and open access by the Research and Innovation Month at TigerPrints. It has been accepted for inclusion in Graduate Research and Discovery Symposium (GRADS) by an authorized administrator of TigerPrints. For more information, please contact kokeefe@clemson.edu.
Finite Element Modeling of Concrete Based on Quantitative Computed Tomography (QCT)

Arash Razmjoo 1, and Amir Poursaee 2

1 Research Assistant and PhD candidate (arakazmijoo@caleemson.edu), 2 Assistant Professor (amire@caleemson.edu)

INTRODUCTION

Models have been used before to predict the mechanical and transport behavior of concrete. In most of these studies, aggregates were considered either circle or sphere. The impact of the aggregates geometry and in-homogeneities in concrete structure is ignored.

As shown in Figure 1, a rectangular 100 by 10 mm plane concrete body with its surface exposed to a chloride containing medium, which aggregates modeled as circular shape. The X-ray attenuation mathematical model while running through a homogeneous object with constant attenuation is following by Beer’s law: $I(x) = I_0 e^{-\mu x}$.

OBJECTIVES

The objective of this study is to develop a novel method for accurate prediction of the mechanical behavior of concrete using quantitative computed tomography (QCT)-based finite element analysis. Concrete cylinders were cast and cured for 28 days. The QCT scans were carried out on the samples using a clinical CT scanner. An image processing method was applied to detect aggregates, paste content and the air voids. The distribution of each phase then calculated in each image slice (2D) and in the bulk material (3D). The processed QCT images were directly converted into voxel-based 3D FE models for linear and nonlinear analyses. The FE models were generated by conversion of each voxel into a 8-node solid brick element. The void content of the cylinders (2D and 3D) was determined. In addition, the aggregates content was estimated using the image analysis. In both cases, the results obtained by the image analysis and the actual measurement and ASTM method are in very good agreement.

SAMPLE PREPARATION

Table 1. Mixture Proportion

<table>
<thead>
<tr>
<th>Materials</th>
<th>Specific Gravity</th>
<th>Amount (Lbs/yd$^3$)</th>
<th>Volume ($\text{ft}^3$/yd$^3$)</th>
<th>Batch Volume ($\text{ft}^3$)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (Type I)</td>
<td>3.13</td>
<td>913.84</td>
<td>4.65</td>
<td>4.65</td>
<td>100%</td>
</tr>
<tr>
<td>Water</td>
<td>1</td>
<td>383.81</td>
<td>6.15</td>
<td>6.15</td>
<td>20%</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>2.46</td>
<td>1036.15</td>
<td>6.75</td>
<td>6.75</td>
<td>25%</td>
</tr>
<tr>
<td>Course Aggregate</td>
<td>2.48</td>
<td>1462.41</td>
<td>9.45</td>
<td>9.45</td>
<td>35%</td>
</tr>
</tbody>
</table>

RESULTS AND CONCLUSIONS

All processed images assembled slice by slice to make a three-dimensional model. Using this sectional view, aggregate and void distribution inside concrete could be investigated in order to find if there are any defects or segregation. One of the QCT scans is shown in Figure 17. It illustrates a 3-D model indicating aggregates in light gray, cement matrix in dark gray and air voids in red color inside it.

FINITE ELEMENT MODELING

QCT-based finite element models of concrete specimens have been created by voxel-based method. In this method, the geometry is obtained directly from the images without using any surfaces or solid bodies and the finite element mesh is developed by assigning hexahedral elements that each encloses a predefined cubic volume of image voxels. Element sizes on the order of 0.25mm x 0.25mm x 1 mm have been used for the voxel-based method.