What is DuCOM ?

DuCOM is a Finite-Element based computational program to evaluate various durability aspects of concrete. DuCOM stands for Durability Models of COncrete. The current version (2.21) traces the development of concrete hardening (hydration), structure formation and several associated phenomenons, from casting of concrete to a period of several months or even years. As such this tool can be utilized to study the effect of ingredient materials, environmental conditions as well as the size and shape of structure on the durability of concrete. The term durability considered here takes into account both the green concrete stage problems as well as matured concrete exposed to environment. This tool can be used to analytically trace the evolution of microstructure, strength and temperature with time for any arbitrary initial and boundary conditions. Since the main simulation program is based upon finite-element methods, it could be applied to analyze real life concrete structures of any shape, size or configuration. Furthermore, dynamic coupling of several phenomenons ensures that the effect of changing environmental conditions are easily integrated into the overall simulation scheme.

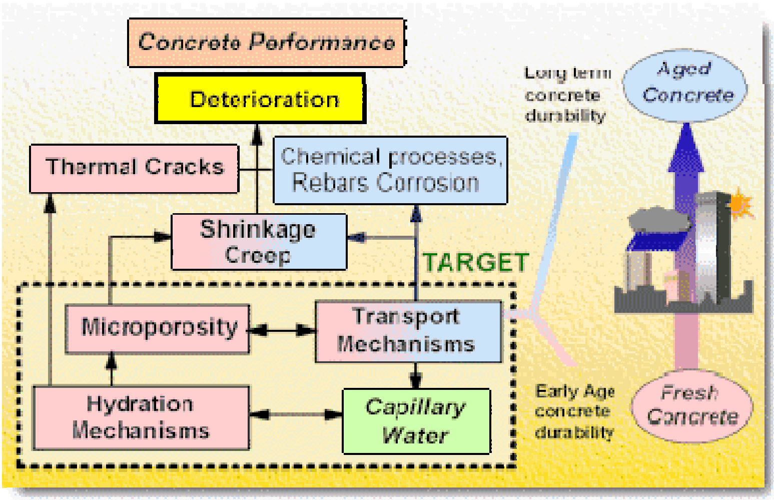
The simulation tool is primarily based on the study done in our laboratory during past few years on the physical mechanisms of hydration, micro-structure development and moisture transport coupled together in real time. The research is still in progress and certainly many more interesting developments are bound to appear.

DUCOM DEMO : http://concrete.t.u-tokyo.ac.jp/en/demos/ducom/index.html

Current status of DuCOM

It is well known that long-term durability of concrete in building and infrastructures can be achieved if material quality, concreting works, structural detailing and dimensioning would be appropriately performed. For systematically deciding plenty of articles related to structural concrete durability, performance based design is being discussed as one of the most promising schemes of durability design. On this frame, it is indispensable to accurately predict and/or verify behaviors of concrete materials and structures in time and space under external actions given as a design condition. It is also recognized that reproduced quality of concrete in structures and initial defects induced at early age are one of governing factors for long-term performance. Therefore, the ultimate objective to be attained through DuCOM is to seek for a so called life-span simulator of structural concrete based on the microscopic modeling of concrete in a manner which is similar to the established methods of structural analysis that are routinely being used in the field of structural concrete engineering. This requires a deep understanding of a number of physio-chemical processes that act upon concrete over its entire life-span. Obviously, this is a daunting task and requires stepwise integration of several key mechanisms related to both short and long term durability of concrete. The short term processes include temperature rise, various forms of shrinkage related to moisture in the concrete micro-structure; short-term creep etc. The long term processes basically include the transport of various external agents into concrete and creep. A vast amount of research data accumulated over the years and available to concrete community now, would aid in the understanding and integration of these processes into a comprehensive simulation tool.

The current level of computational models mainly address the issue of "Young concrete being matured after birth". The technology discussed is expected to be an initial input information for examining truly long-term durability and transient behaviors of structural concrete in future.



The current status of DuCOM in this scheme is shown by TARGET in the above figure. It is the early stages of concrete just after casting, when the foundation of concrete durability are laid. Therefore, at the current level of research, we have attempted to integrate the early stage hydration, microstructure formation and moisture transport processes of concrete in DuCOM. This has been achieved by individually considering the various physical laws that govern these processes and their interrelationships. The simulation method typically starts from the casting stage of concrete and computes several properties like, strength porosity microstructure etc., along with the temperature and pore moisture content history with time.

Future Directions

The primary thrust areas of research in our laboratory related to life span simulation modeling of concrete can be classified as below

- To understand and incorporate the long term diffusion and transport of ions (chloride etc.), gases (oxygen, carbon-dioxide etc.) and related problems like carbonation and corrosion into the general simulation framework of DuCOM
- To enhance the structure-formation and strength development simulation models and incorporate the creep and shrinkage problems with a more rational framework.
- Integrate durability simulation models like DuCOM with enhanced structural counterpart simulation tools like COM3 so that the serviceability and durability of a concrete structure can be evaluated from a global perspective. This would ensure that the valuable information related to material properties obtained from DuCOM could be directly used while analyzing the structural behavior of concrete

structures and vice-versa. On a primitive scale, this has been achieved at this stage by co-operative parallel executions of concrete structural analysis program like COM3 with material durability analysis program DuCOM on a real-time basis.

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