Introduction on Chinese National Key Research Project -Basic Research on Environmentally Friendly Contemporary concrete

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Outlines

1、Introduction

1、Introduction

4. Research team

What is 973 project ?

- 973 Program (The National Basic Research Program) is China's on-going national keystone basic research program
- Approved by the Chinese government in June 1997 and is organized and implemented by the Ministry of Science and Technology.
- To meet the nation's major strategic needs.
- To create an excellent scientific research environment and to scale the peak of the world's science

What is 973 project ?

- 973 Program emphases:
  - Agriculture
  - Energy
  - Information
  - Resource and Environment
  - Population and Health
  - Materials
  - Synthesis and Frontier Science

What is 973 project ?

- 973 Project application procedures:
  - Call for proposal
  - Proposal reviewed through internet
  - Interview by MOST consultant committee
  - Interview by high-level advisor committee
  - Decision by MOST

What is 973 project ?

- Basic requirements for 973 Project:
  - National needs
  - Scientific issues
  - Feasibility of research methodology
  - Strength of research team

Introduction

What is 973 project ?

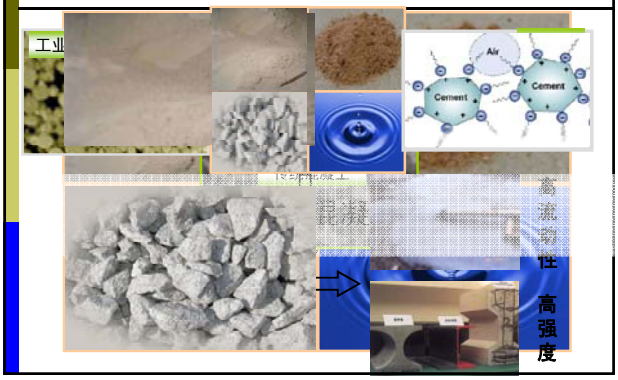
- The project of Basic Research of Environmentally Friendly Contemporary Concrete is the first one and only one for concrete field

Introduction

National Urgent Needs

Introduction

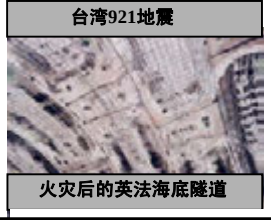
Traditional and contemporary concrete



Introduction

Problems in contemporary concrete-more brittle

台湾921地震



火灾后的英法海底隧道

5.12汶川大地震：梁柱节点混凝土崩裂现象普遍！

Introduction

Problems in contemporary concrete-less durable

In USA, real service life for design service life of 75 years only have 40 years。 According to statistics in 2004, 27.5% of bridges in US has durability problem

--FHA, USA， 2006

In China, the number of bridges in danger increased linearly from 2000 and reached 15000 in 2005。

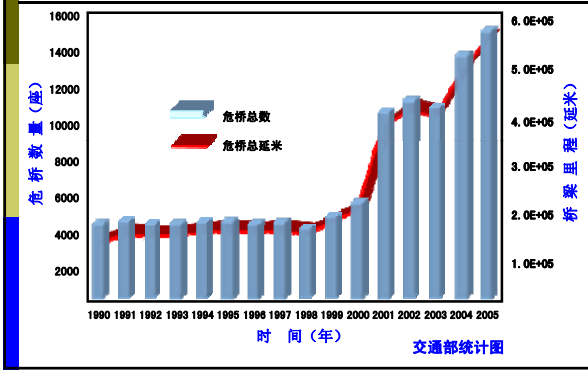
--Transportation Ministry, China， 2007

In China, the economic lose due to corrosion in RC structure was 1 trillion RMB per year。

-- CAE report 2002

Introduction

Bridges in danger



Introduction

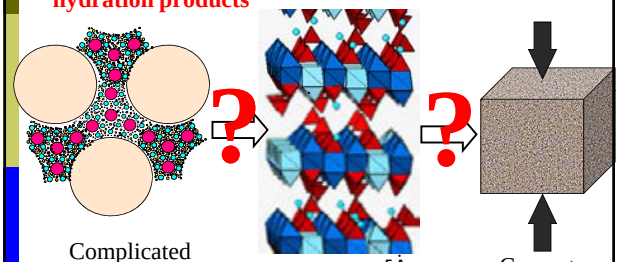
Challenge that contemporary concrete facing

- How to scientifically and effectively utilize industry waste，reduce cement content to minimum ⇨
  Save energy and reduce pollution
- Enhancing durability, prolong service life ⇨
  Most effective way to save energy and reduce pollution
- Improve the capability resisting natural disaster ⇨
  To ensure the safety of human being and properties

Introduction

Urgent issues need to be resolved

- Mechanism of formation of microstructure of hydration products

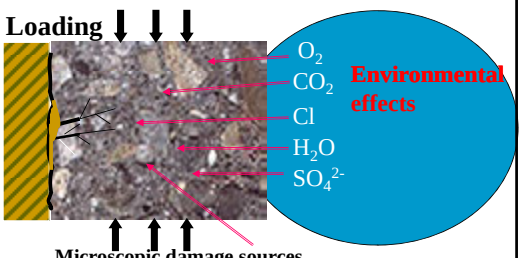


Complicated binding system　　Hydration products　　Concrete

Introduction

Urgent issues need to be resolved

- Mechanism of damage process



Introduction

Urgent issues need to be resolved

- Lack of study on unified design of loading carrying and durability

$\{R \geqq Q\} \cap \{D_{index} = f\,(p,t,T,H\ldots)\} \rightarrow ?$

2、Key scientific issues & research contents

Key scientific issues

Key scientific issues

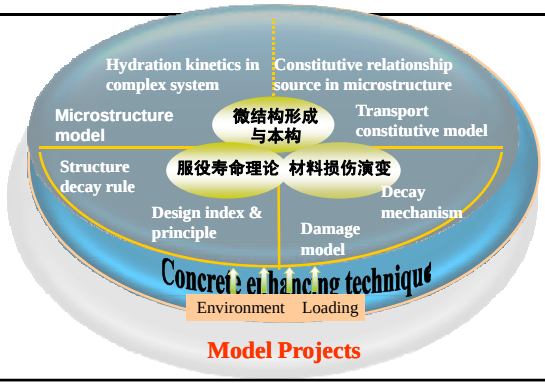
- How concrete performance decay
- How to unify loading bearing and durability
- How ingredient of binder interact
- How hydrate microstructure form
- How hydrate i…
- How loading and environment interact
- How micro damage source form and propagate
- …properties
- Scientifically predict service life

Microstructure & performance　⇔　Damage process

- Reveal the relationship between microstructure and properties
- Reveal damage mechanism under service environment
- Scientifically fully utilize waste , minimize cement content

Main research content

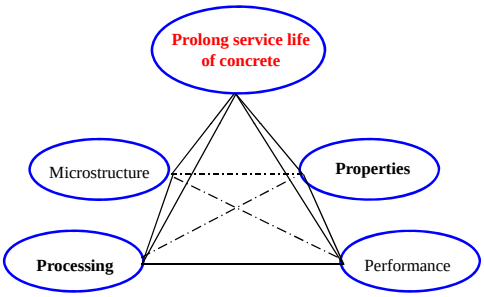
Main research contents



Model Projects

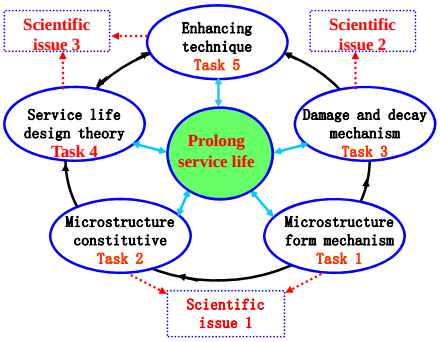
3、Research methodology

General consideration

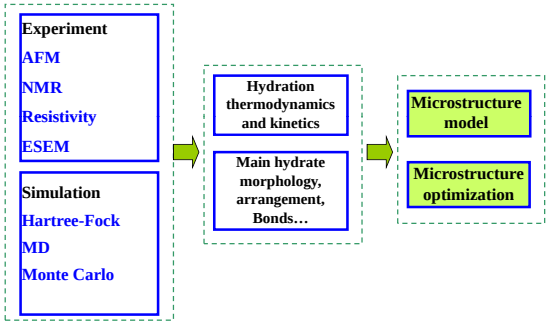


Methodology

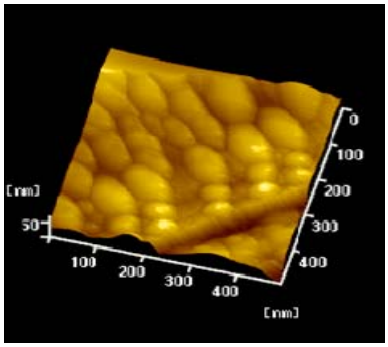
Task distribution



Task 1：Microstructure forming mechanism of paste in contemporary concrete

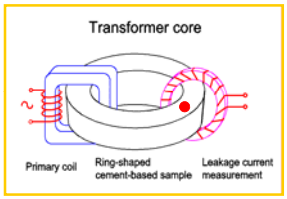


Atomic Force Microscopy



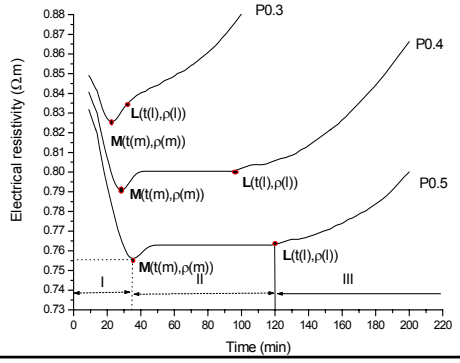
Non-contact resistivity measurment

US 663941, Nov. 2003

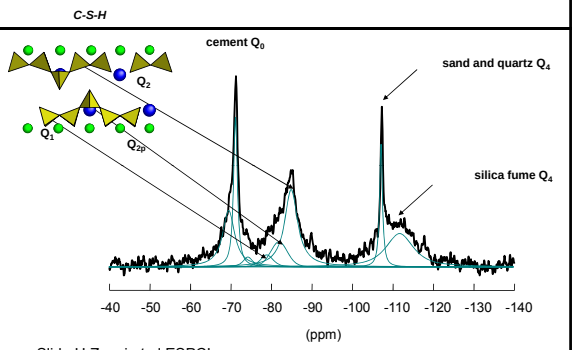


$$\rho = \frac{H}{2\pi}\left[-\frac{r1}{r2-r1}\ln\frac{r2}{r1} + \ln\frac{r3}{r2} + \frac{r4}{r4-r3}\ln\frac{r4}{r3}\right]\frac{V}{I}$$

Resistivity curve

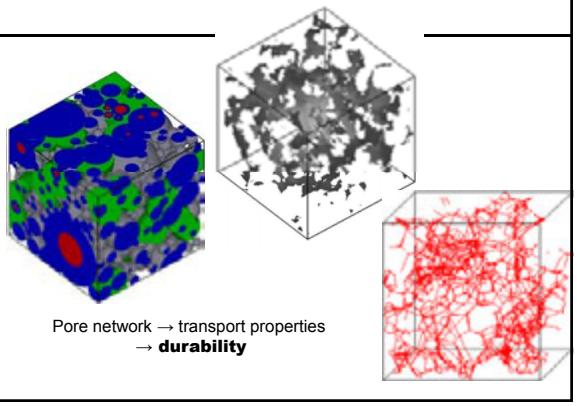


^{29}Si solid state NMR



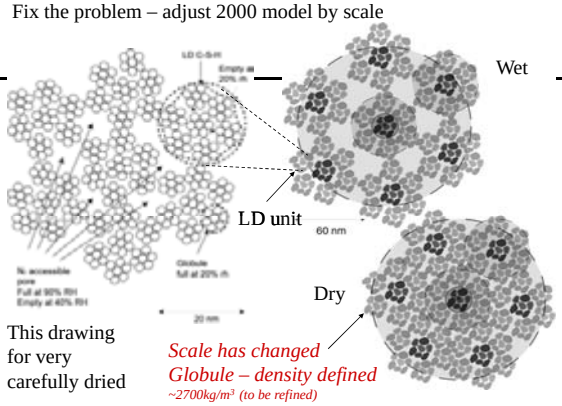
Slide H.Zanni et al ESPCI

Microstructural Modelling



Pore network → transport properties
→ **durability**

Fix the problem – adjust 2000 model by scale



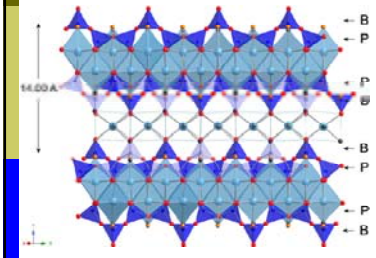
This drawing for very carefully dried

Scale has changed
Globule – density defined
~2700kg/m³ (to be refined)

Revised model

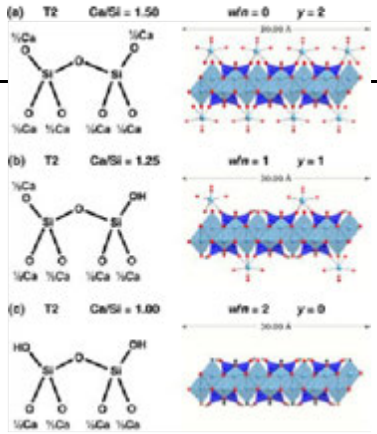
H. M. Jennings, J. J. Thomas, J. S. Gevrenov, G. Constantinides, and F.-J. Ulm, *Cem. Concr. Res.* (in press).

C-S-Hstructure



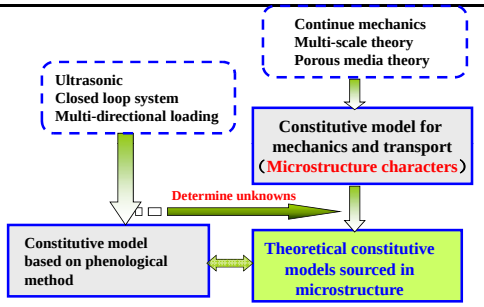
1.4 nm tobermorite projected along [210]

it has a central Ca-O sheet that has silicate chains on both sides, which are kinked with a periodicity of three tetrahedra; these chains are called dreierketten, or wollastonite-like chains. interlayer space occupied by H2O molecules and Ca2+ ions



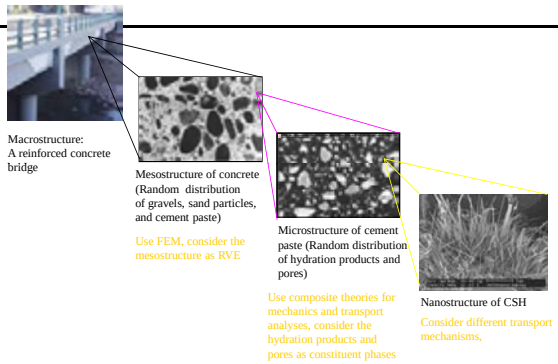
tobermorite-based dimer (n=1) that has the minimum (a), intermediate (b), and maximum (c) degree of protonation of the silicate chains

Task 2: Microstructure-sourced constitutive model



$$\sigma = f(\mu, \varepsilon, \varphi, P, ...)$$

Multi-scale Modeling: Nanometer to real structure



Macrostructure: A reinforced concrete bridge

Mesostructure of concrete (Random distribution of gravels, sand particles, and cement paste)

Use FEM, consider the mesostructure as RVE

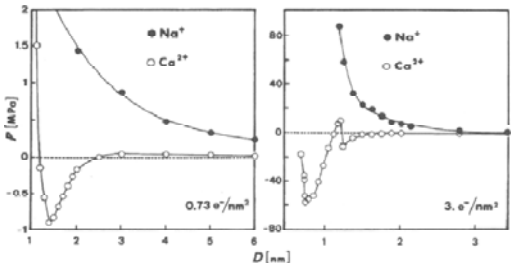
Microstructure of cement paste (Random distribution of hydration products and pores)

Use composite theories for mechanics and transport analyses, consider the hydration products and pores as constituent phases

Nanostructure of CSH

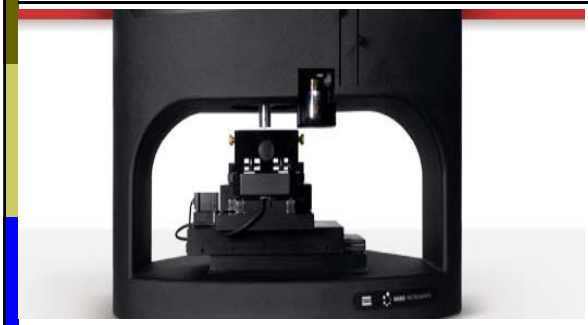
Consider different transport mechanisms,

Simulating C-S-H binding using Monte Carlo method- Pellenq et al.

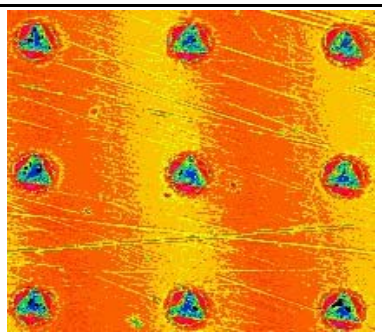


Primitive model calculation of the pressure between two negatively charged walls separated by sodium or calcium ions in water. The surface charge density is that of a smectite clay on the left and that of a Tobermorite-like *C-S-H* with all its OH groups ionized on the right.

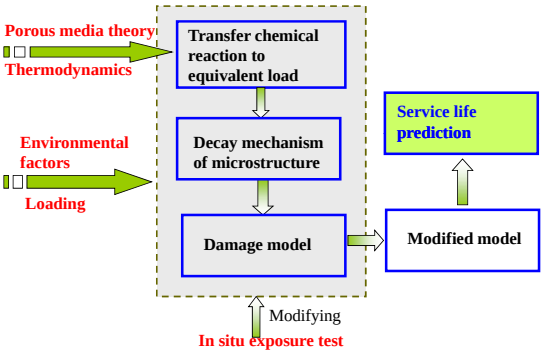
Nanohardness measurement



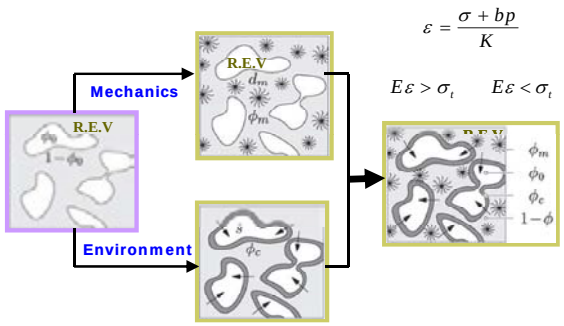
Nano-hardness



Task 3: Damage and decay mechanism under coupling of loading-environment



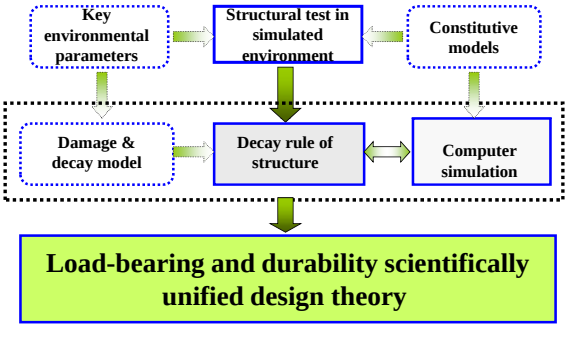
Porous media theory and thermodynamics



Exposure environmental test facility

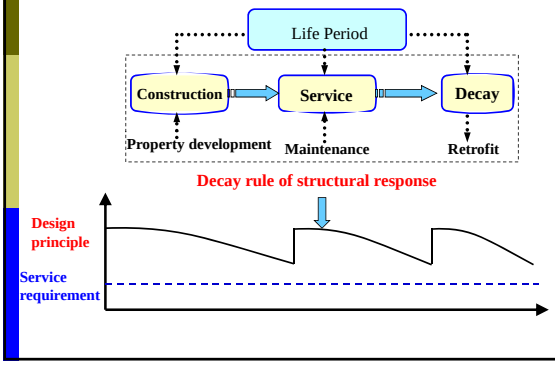
Methodology

Task 4: Load-bearing and durability unified design theory



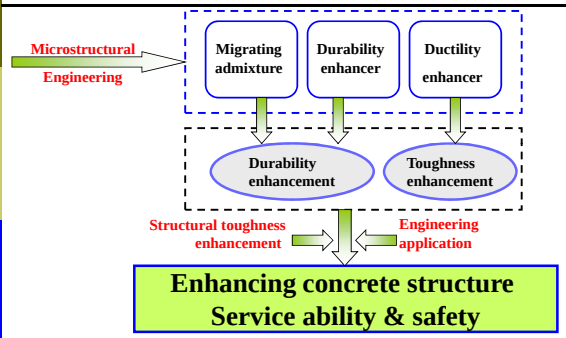
Methodology

Load-bearing and durability unified design theory

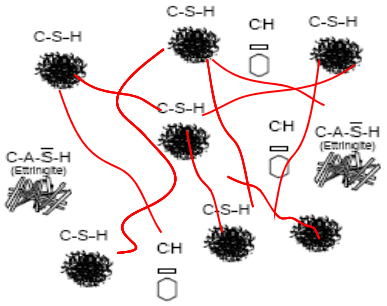


Methodology

Task 5: Concrete enhancing technique



Ductility enhancing admixture



4. Research team

Research team

General information

Hydration process & microstructure
Damage & decay mchanism
RC durability and service life
Micro-mechanics, fracture, and multi-scale theory
Innovative admixture development

Institutes：8	
Southeast University	Wuhan Universith of Technology
Zhejiang University	Hong Kong University of Sci. & Tech.
Tongji University	Jiangsu Institute of Building Research Ltd
Tsinghua University	Wuhan University

Manpower：55	
Academicians	CAE、and Canada Academy of Engineering
Changjiang Scolar	1
Jieqing	3
Professor	28
Associate Prof.	20

Research team

Chief Scientist：Zongjin Li

- BS. Zhejiang Uiv.（1982），PhD Northwestern Univ.(1993)
- Prof. HKUST
- Chairman or Co-chairman and Key note speaker for 20 international conferences
- Project manager for more than 35 projects with funding over 30 million HK dollars
- Awarded 2 US and 2 China patents
- Published two books and more than 230 papers

Thank you for your kind attention !