Gilles’memory

Steel Fibre Reinforced Concretes: from Meso to Macro-Scale

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Why to use steel fibres?

- To improve the tensile behaviour of concretes: **Strength and Ductility**
  - *Only possible in very special Ultra-High Performances Concretes*

- To replace a partly or totally the rebars in concrete structures
  - *For all concrete structures*
Meso-Scale

Behaviour of one or several fibres embedded in a concrete matrix

Optimisation of the fibre geometry and dimensions in function of the compactness of the matrix

PHD thesis of Gilles, 9 Janvier 1992, Université de Sherbrooke, Canada
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cadre rigide de la presse

cellule de charge

casque de fixation

échantillon

bagues de fixation

casque de fixation

vérin
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PHD thesis of Gilles

Diagram showing the relationship between displacement (mm) and force for different E/C ratios (0.3, 0.5, 0.7) with a note indicating a length of 2 waves and an angle of 90 degrees.
What is the fibres acting through a macrocrack?

- Friction between the fibres and the matrix: importance of the length and the diameter of the fibre

- Plastification of the fibres: importance of the geometry (existence of hooks at the fibres ends, undulations…)

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General rules of optimization of SFRC

More compact the matrix is, shorter and thinner the fibres have to be
The mechanical behaviour of the fibre/matrix interface depends on the percentage of fibres.

The mechanical behaviour of the composite is strongly dependent on the preferential orientations of fibres.

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Macro-Scale

Determination of the post-cracking behaviour in tension of SFRC

Direct approach: uniaxial tensile test on notched specimens
Macro-Scale

Post-cracking behaviour in tension of SFRC

Design of SFRC structures based on the cracked section equilibrium approach

The first french recommandations for designing SFRC structures (AFREM, 1998)

Gilles Chanvillard, Pascal Casanova, Pierre Rossi
After 1998


- Creation of the International Conference BEFIB on Fibre-Reinforced Concretes (2000, Lyon, Co-Chairman: Gilles Chanvillard and Pierre Rossi)

The next one (5th edition), in September 2016, in Vancouver (Canada)
New challenges

- **Sustainable Development**: necessity to optimize the quantity of concrete used for a given constructive function (conception of hyperstatic structures)

- **Durability** of the structures: better knowledge and mastering of the cracking of concrete structures in service conditions

  Traditional design approaches are not enough efficient

  Development of finite elements models
Specifications for an efficient FE Model for SFRC Structures

- **Concrete (the matrix) is an heterogeneous material**: random spatial distribution of the tensile strength

- **Concrete (the matrix) rupture in tension is a scale effect process**: the average tensile strength and the standard deviation increases when the volume of material stressed decreases

- **Post-cracking behaviour of the SFRC (the composite) is less scattered** when the volume of material stressed in tension increases
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Discret probabilistic cracking model

I. Cracking of concrete
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Discret probabilistic cracking model

II. Post-Cracking of SFRC

![Diagram showing stress-strain relationship for SFRC with post-cracking behavior.]

- $\sigma$: Stress
- $RT$: Tensile resistance
- $K'_n$: Crack propagation resistance
- $(1 - D)K'_n$: Reduced crack propagation resistance
- $\delta_0$: Initial crack opening
- $\delta_c$: Crack closure

Equation: $(1 - D)K'_n$
Discret probabilistic cracking model

Example of application - I

\[ h = 300 \text{ mm} \]
Discret probabilistic cracking model

Example of application - I
Discret probabilistic cracking model

Example of application - I
Discret probabilistic cracking model

Example of application - II
Discret probabilistic cracking model

Example of application - II

$E_{\text{ground}} = 10 \text{ MPa}$

$E_{\text{ground}} = 40 \text{ MPa}$
Gilles

My Friend

Thank you for accompanying me during a large part of my professional life
It was a pleasure and an honor to meet you