Development of CFT without fire protection using high performance materials

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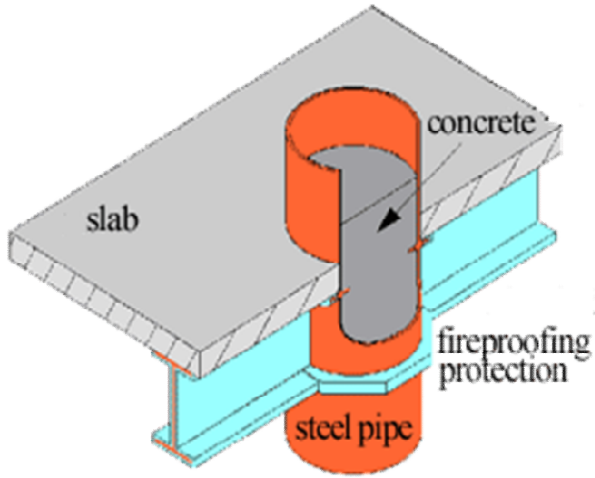
Background

- What is CFT ?

  : Structure system with Concrete Filled steel Tube

  – Combine the benefits of two materials

Section			
	RC	SRC	CFT



- Development of CFT using High strength materials

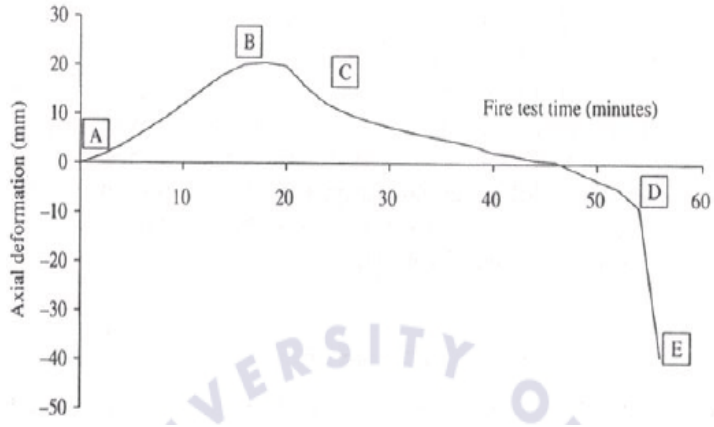
  : 800 MPa Steel + 100 MPa Concrete

  – usable space ↑ Structural weight ↓ CO_2 emission ↓

Background

- Fire resistant performance

  A~B : Steel Tube support the load
  B~C : Load Transfer
  C~D : Concrete support the load
  D~E : Failure



(Building Codes normally requires 3 hour fire protections)

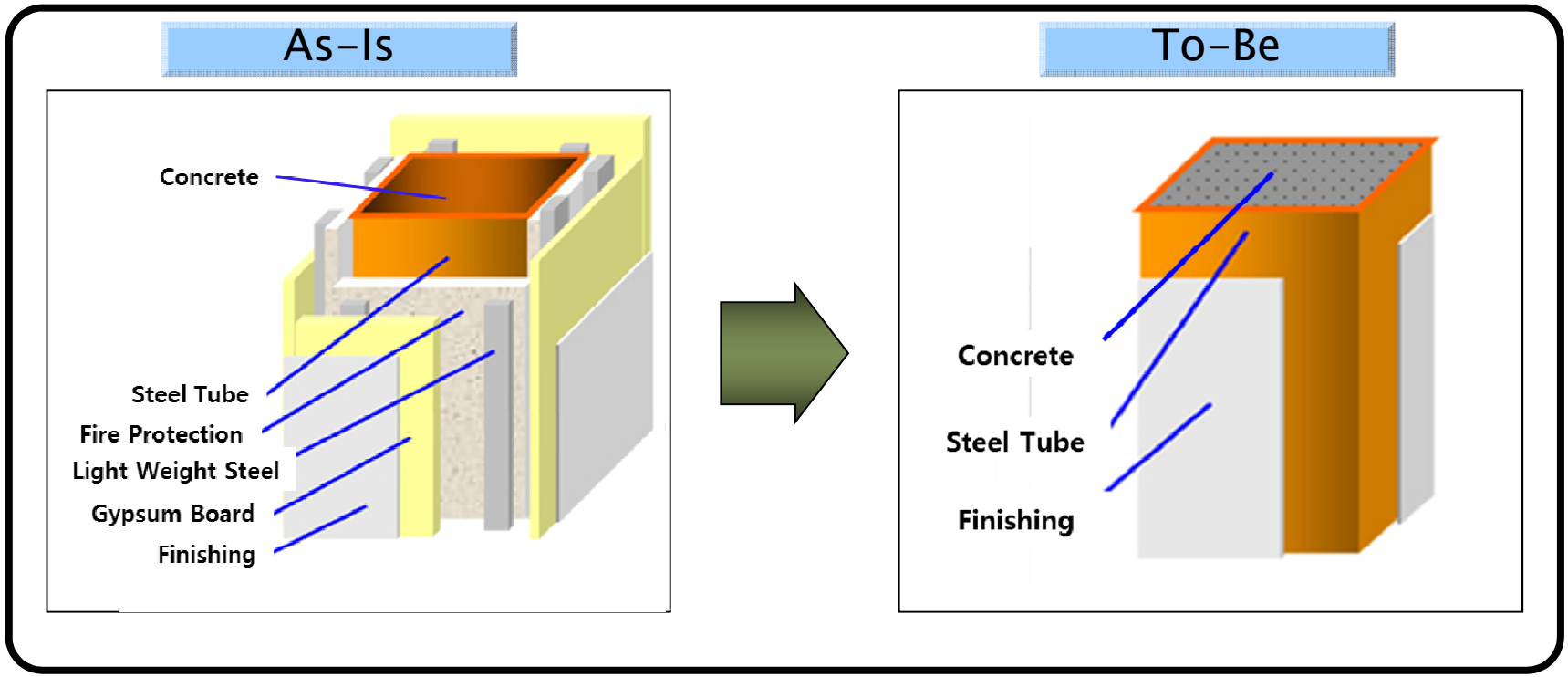
- Method for Fire resistance of CFT

: External fire protection like spray, mortar, paint or fire board
– Problem in Workability, Quality control and Construction time

Fire resistant CFT without external fire protection is possible?

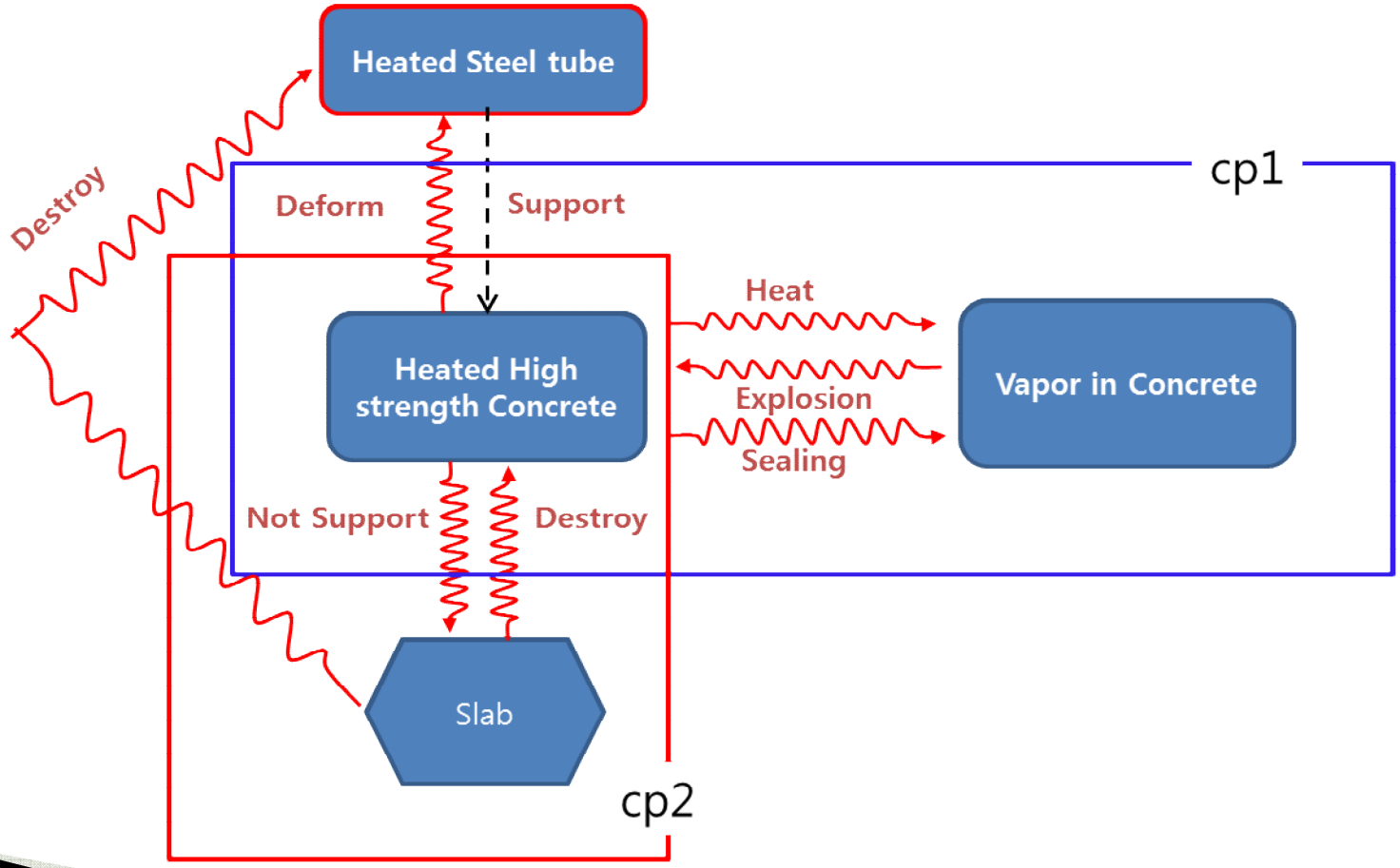
Define

- Wanted Result



Solve

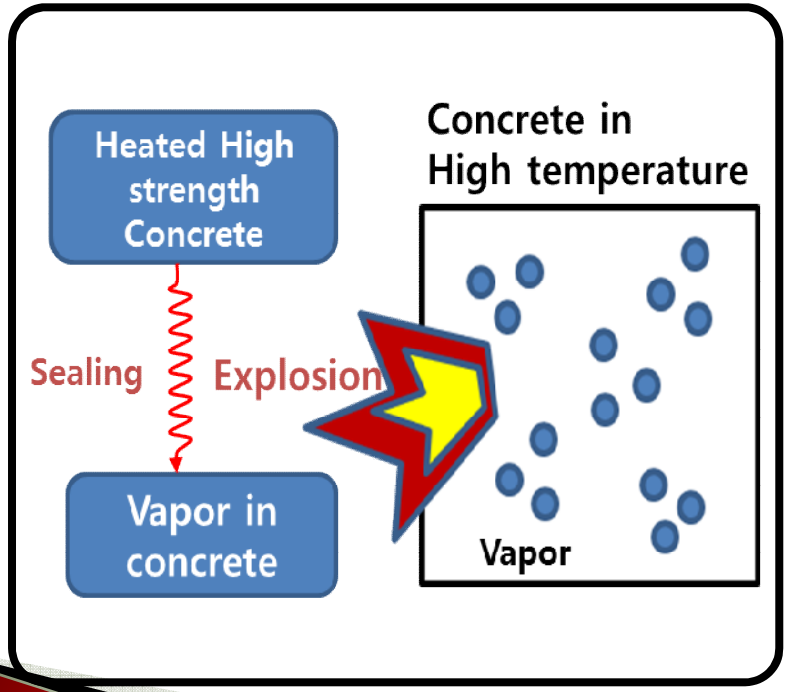
- Function Diagram



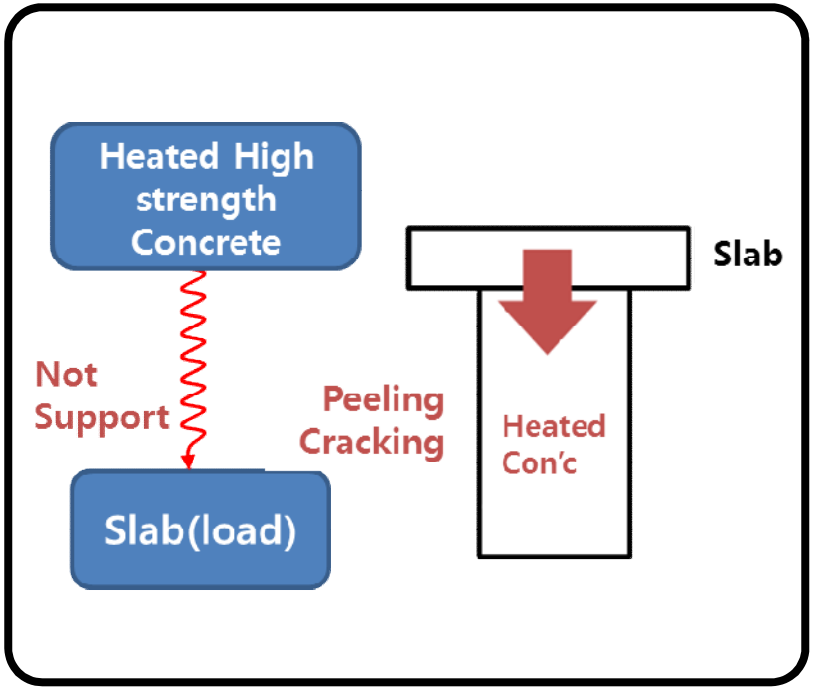
Solve

- Core Problem

CP1. Explosion due to heated vapor pressure in high strength concrete



CP2. Concrete gradually loses loading capacity due to the crack at fire

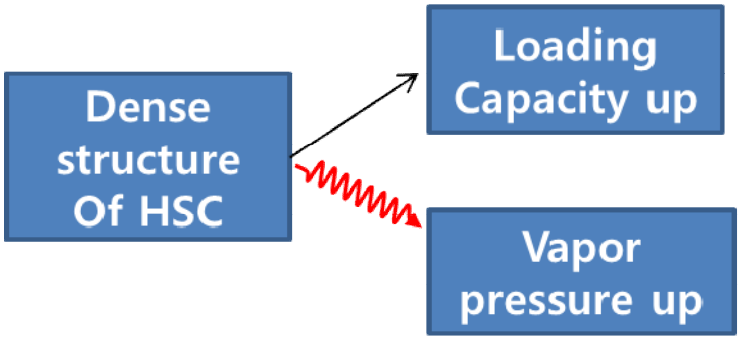


Solve

Core Problem 1

: Reducing the vapor pressure due to dense structure of high strength Con'c

➢ Contradiction



➢ IDEA Generation

<Principles of invention>

16. Partila or Excessive
- reduce dense structure by changing slica fume to slag powder

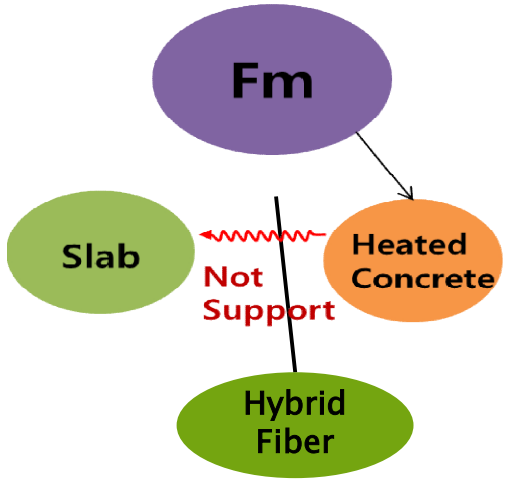
Blast furance Slag Powder(BFS) have lower fineness but can make the high strength by pozzolan effect

Solve

Core Problem 2

: In fire, crack is occurred and concrete gradually loses the loading capacity

➢ Functional model



➢ Conceptual Solution

Idea 1. Cheap Short Life (AS-IS)

- Nylon fiber melted in the Heated concrete make pass for vapor

Idea 2. Preliminary Counter Action

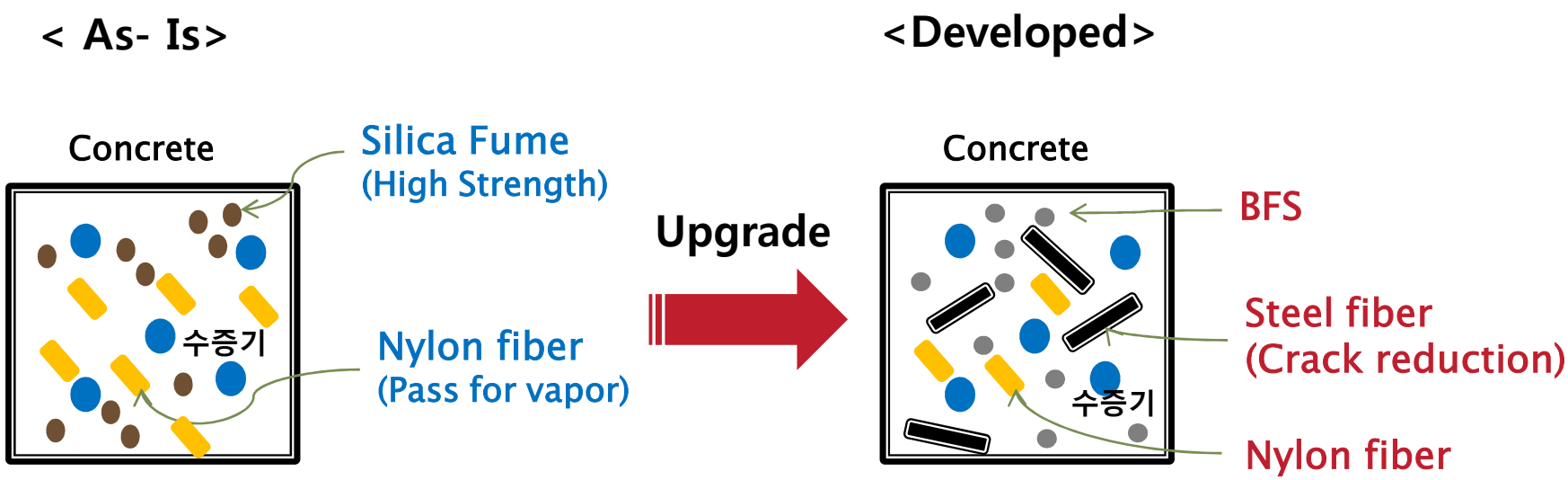
- Steel fiber can prevent peeling of the concrete due to crack or spalling

Nylon fiber : melt in high temperature, pass for the heated vapor

Steel fiber : improve the tensile strength for crack reduction

Solve

- Solution
  - ➢ CFT using high volume BFS and hybrid fiber

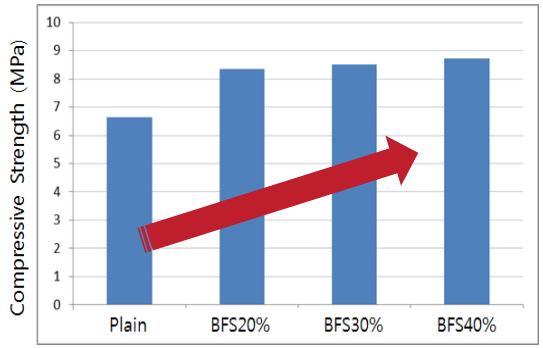


Design

- Effect of slag powder on fire resistance

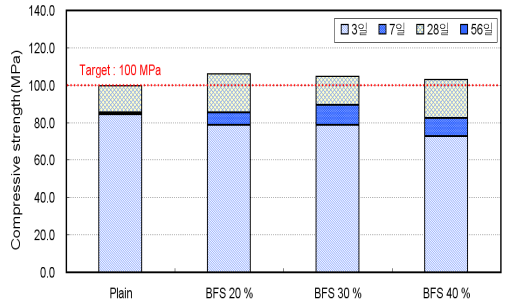
<Residual strength after fire test>

- Type : Blast furnace slag powder 20, 30, 40 % of binder



<Concrete workability / strength test>

	Plain	BFS 20 %	BFS 30 %	BFS 40 %
Slump flow(mm)	740	725	730	740
500 mm arrival time(s)	19.56	17.62	13.47	10.20
O-lot(s)	55.22	46.33	41.09	39.06

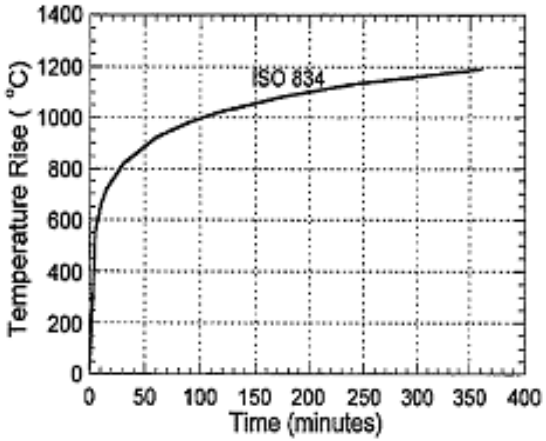


Design

- Effect of Hybrid fiber on fire resistance of CFT

<Fire test with loading>

- Type : Steel fiber 0, 20, 40 kg/m^3 + Nylon fiber 1.5 kg/m^3
- Load : 400 ton (Axial force ratio 0.3)
- Temperature : Heating following ISO 834
- Criteria : Axial deformaiton < length / 100(mm)



<ISO curve>

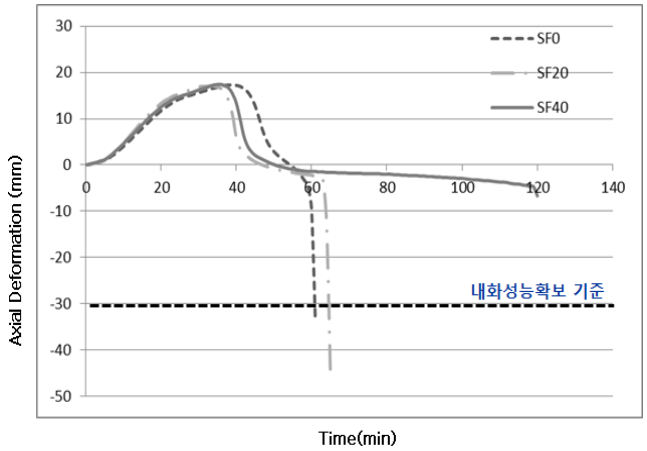
<Fire Test>

<Specimen>

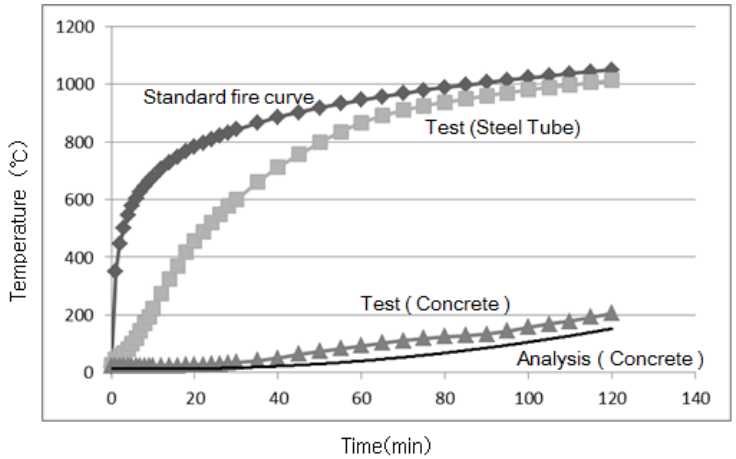
Design

- Effect of Hybrid fiber on fire resistance of CFT

<Fire test Result>



<Axial Deformation>



<Temperature>

2 hour fire resistance performance
(200% increasing than plain)

<Certification>

<Press publication>

Implement

- Full scale test on the Developed CFT

<Fire test with loading (Scheduled)>

- Type : Steel fiber 40 kg/m^3 + Nylon fiber 1.5 kg/m^3
- Load : 400 ton (Axial force ratio 0.3)

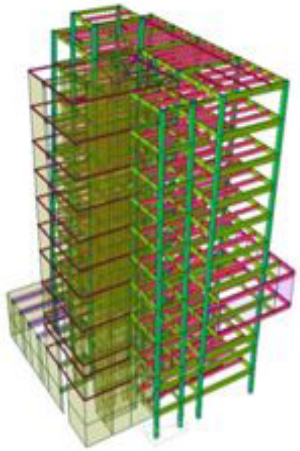
<Manufacturing Specimen>

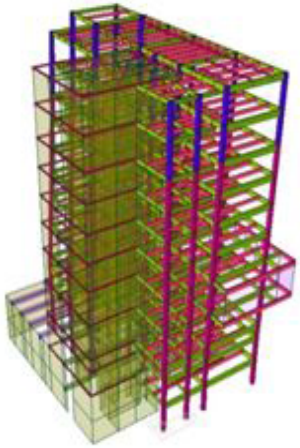
Wanted result : 3 hour fire resistance performance
(criteria for High rise building)

Implement

Economic evaluation

<40 story-building>





<SM 490> <Developed CFT>

- Total fire protection : 12,580 m^2
- Fire protection unit cost : 19,200 won
- Fire protection cost : 241 mil won ⬇

⇒ High strength concrete : 108 mil won ⬆
⇒ Steel Tube 40% reduction : 27 mil won ⬇
⇒ Usable space increasing : 270 mil won ⬇

➡ **Total 430 mil won saving**

Effect

- Construction time ⬇ Quality control ⬆ Cost for materials ⬇
- Application of POSCO's new developed steel (HSA800)