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## The Self Compacting Concrete Material for Repairing

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### ABSTRACT

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*Self-compacting concrete SCC is a material known in fresh state for its workability and stability and it can be set up without any vibration. This characteristic is distinguished in order to use the SCC as a material of repair. The experimental work was carried out in order to repair a concrete beam by means of “reshaping”. It is understood by reshaping, a coating of SC concrete put over the surface of the concrete beam to be repaired, without using any reinforcement. The work was conducted over test specimens made up of ordinary concrete prepared and hardened in advance (the material to be repaired) over which a self compacting concrete layer is poured. Three alternatives of SC concrete and one ordinary concrete (comparison) were tested. The tests were carried out with the aim of studying bond, compatibility and fracture. Through the compatibility and bond tests, it appears that the self-compacting concrete constitutes a good material for repairing, thanks to its qualities such as: stability, homogeneity and deformability while the SCC is fresh. It follows perfectly the surfaces’ forms to be repaired and allows a perfect bond. Fracture tests made on specimens of self-compacting concrete show a brittle behaviour. However when a small percentage of fibres is added, the resistance to cracking is very much improved.*

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**Keywords:** *Concrete, Self compacting, Repairing, Experimental.*

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### **1. INTRODUCTION**

The objective of this work is the retrofit (thin repair) of damaged concrete elements, with the SCC. Fluidity, principal characteristic of the SCC, would enable it to cover and adhere to the concrete to be repaired. Two aspects of repair are considered, that of mechanical grip and the strength to tensile and cracking.

### **2. EXPERIMENTAL PROCEDURE**

#### **2.1 Material and Specimens**

The investigation is experimental; it is performed on specimens produced in two phases. Initially substratums are manufactured with ordinary concrete (concrete repair). Later, the repair material is poured (SCC).

The substrates are streamed 5 months before the test. The concrete used is made with an ordinary Portland cement of a water / cement ratio of 0.50 and compressive strength  $f_{c28} = 20\text{Mpa}$ . The composition is presented in Table 1. For the repair material of SCC, three alternatives were considered in addition to a plain concrete for comparison.

Therefore, the following variations are investigated:

SCC						
SCC	+	FS:	SCC	with	silica	fume
SCC	+	Fibre:	SCC	with	synthetic	fibres
OC:			ordinary			concrete

The composition of different variants of concrete is shown in Table 2

Table 1 : Composition of substratum

<b>Constituant</b>	<b>OC</b>
Cement ( $\text{kg}/\text{m}^3$ )	392
Water ( $\text{l}/\text{m}^3$ )	159
Sand 0-5 mm ( $\text{kg}/\text{m}^3$ )	752
Gravels ( $\text{kg}/\text{m}^3$ )	938



Figure 1: Ordinary concrete substratum

Table 2: Composition of different concretes

	<b>OC weight (kg)</b>	<b>SCC weight (kg)</b>	<b>SCC+10%SF weight (kg)</b>	<b>SCC+10%SF+ synthétic fibre weight (kg)</b>
<b>Sa 0/3</b>	630	770	831.6	831.6
<b>Gravel 3/8</b>	261	380	410.4	410.4
<b>Gravel 8/15</b>	851	370	399.6	399.6
<b>Cement</b>	350	500	540	540
<b>Water</b>	200	200	216	216
<b>Superplastizer</b>	/	7	7.56	7.56
<b>Silica fume</b>	/	/	40	40
<b>Synthétic fibre</b>	/	/	/	60
<b>W/C</b>	0.5	/	/	/
<b>G/S</b>	/	0.891	0.891	0.891
<b>W/L</b>	/	0.4	0.4	0.4
<b>Flow (mm)</b>	/	710	690	650
<b>Time flow (s)</b>	/	3.5	4.5	7.7

The surface of the substrate, where will be cast the layer of repair, has an important role in the adhesion of repairing, depending on whether it is smooth or rough wet or dry, inclined or right. We are studying the influence of its parameters as well as the thickness of the layer of the repair and use or not liaison products (glue). The rough surface was obtained by traits saw to a depth of about 25mm. In summary, the alternatives considered are as follows:

- 4 types of materials  $\left\{ \begin{array}{l} OC \\ SCC \\ SCC + FS \\ SCC + SF + fibres \end{array} \right.$

- Surfaces states  $\left\{ \begin{array}{l} Saturation \left\{ \begin{array}{l} DS \\ SDS \\ SWS \end{array} \right. \\ Roughness \left\{ \begin{array}{l} rough \\ smooth \end{array} \right. \end{array} \right.$

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- Height of the repair layer  $\begin{cases} 2,5 \text{ cm} \\ 5 \text{ cm} \\ 7,5 \text{ cm} \end{cases}$

- Use or not of adhesion products (glue, studs)

The parameters SDS, SWS, and DS reflect the state of the substrate surface as the moisture

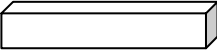
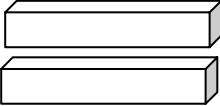

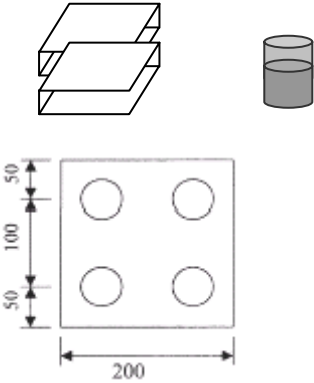
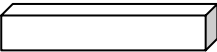
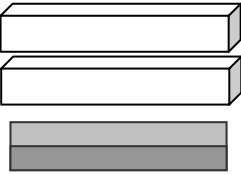
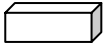

SDS = saturated dry surface, (substrate saturated with water and dried surface)

SWS = surface wet and saturated, (saturated substrate surface water and not dried)

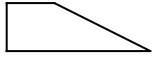
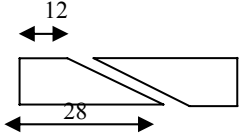

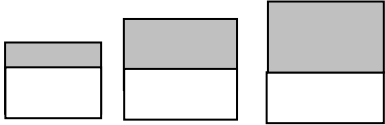
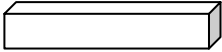

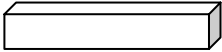
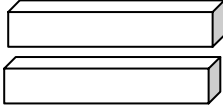
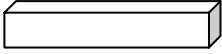
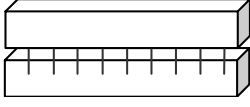
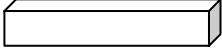
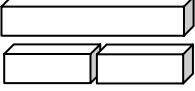
DS = dry surface

The specimens size, as well as the summary of the tests carried out, is shown in table 3.

Table 3: Summary of different tests

Element	Repair plan	Parameters	Tests
		D.S, S.W.S, S.D.S,  h= 5cm, roughness	Bending
 (20x20x5)		D.S, S.W.S, S.D.S,  h= 5cm, Roughness	(Adhesion test) direct tensil
 (5x10x40)		D.S, S.W.S, S.D.S,  h= 5cm, roughness	Bending
 (20x10x10)		End to end 0°	Three points Bending

Continue... Table 3: Summary of different tests

Element	Repair plan	Parameters	Tests
 (28x12x40)		Inclination 32°	Three points Bending
 (20x20x5)		S.D.S, roughness H= 2.5, 5 and 7.5	Adhesion test direct tensil
		S.D.S, roughness Repair layer h = 2, 5 et 8 cm	Bending
		S.D.S, roughness, synthetic fibres	Bending
 (5x10x40)		Roughness, S.D.S, Height, Studs	Bending
 (5x10x40)		S.D.S, roughness	Bending

## 2.2 Tests and Measurements

It is important to be familiar with the materials before starting the repair. The strength (compression and tensile bending) was measured, as well as the shrinkage. The results are presented in Figures 5 and 6 and 7

### 2.2.1 Tensile Strength

The purpose of this test is to measure the tensile strength to evaluate the adhesion between the two layers (the old concrete and concrete repair). It performed on carrots of 5cm in diameter

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from prisms of 10x20x20. The tensile force is exerted on the head anchor fixed on the ends of the specimen.

Only results for which the fractures occur in the central  $\frac{3}{4}$  of specimens were considered. The result is the average of three measurements. The average tensile stress is the ratio of the average nominal load on the surface of the specimen.



Figure 2 : Specimens of direct tensile

### **2.2.2 Tensile Strength by Bending**

In the bending test, the stresses generated are a combination of normal stresses and shearing. Three point bending tests with horizontal repairs and inclined at  $32^\circ$  were undertaken.

### **2.2.3 Shear Resistance by Oblique Compression.**

An axial compressive force is applied on a test sample which is inclined. At the oblique interface the applied force is broken down in terms of the interface and on the perpendicular plane. Failure by slipping is due to component parallel to the interface. The purpose of this test is to evaluate the effect of the incompatibility between the old mechanical and concrete repair material, on the behaviour of their interface and on the failure modes that can have the whole system.

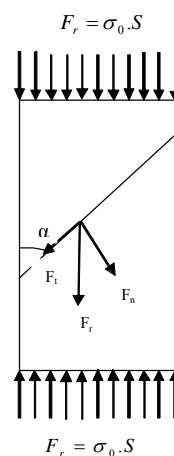


Figure 3. Shear resistance by oblique compression

### 2.2.3 Fracture Tests

It is a three points bending test conducted on notched specimens. The crack is simulated by artificial notch which is on the substratum and stops at the interface between the repair material and the old concrete, according to the following pattern.

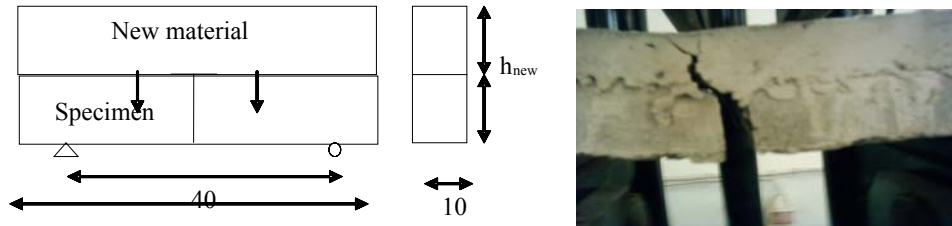


Figure 4: bending test on notched specimen

## 3. RESULTS

### 3.1 Mechanical Resistances of used Materials.

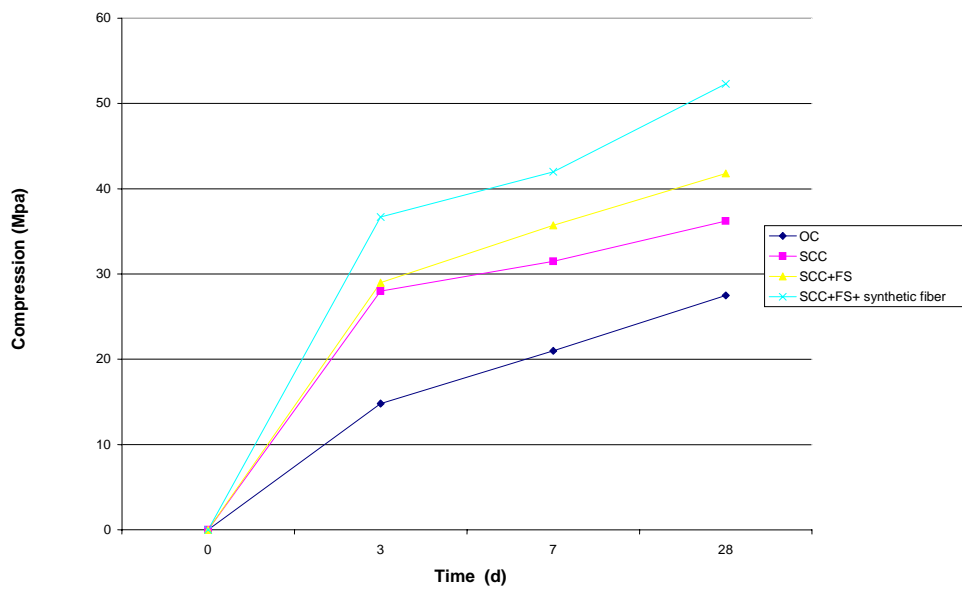


Figure 5: Compression strengths

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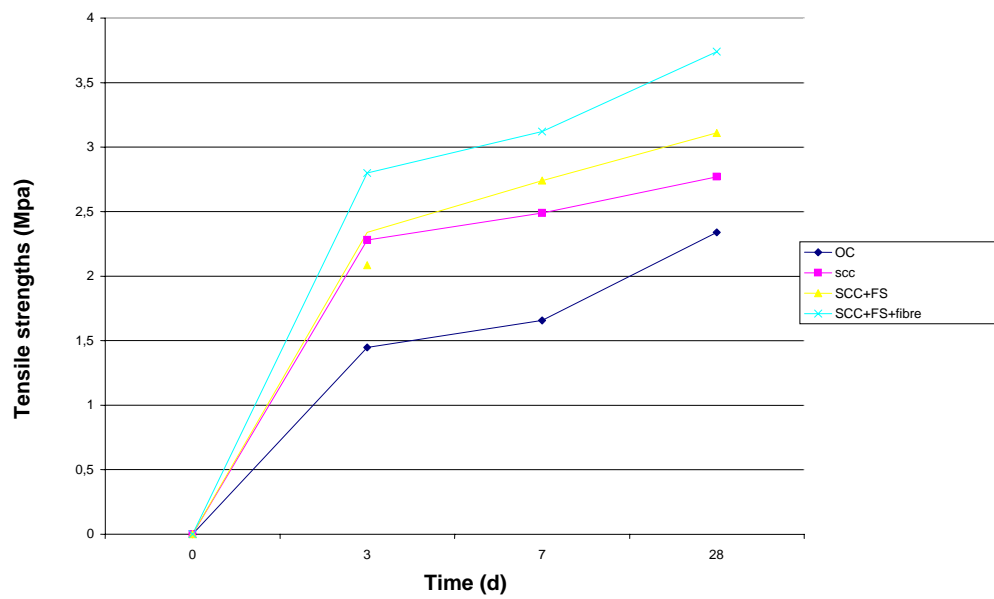
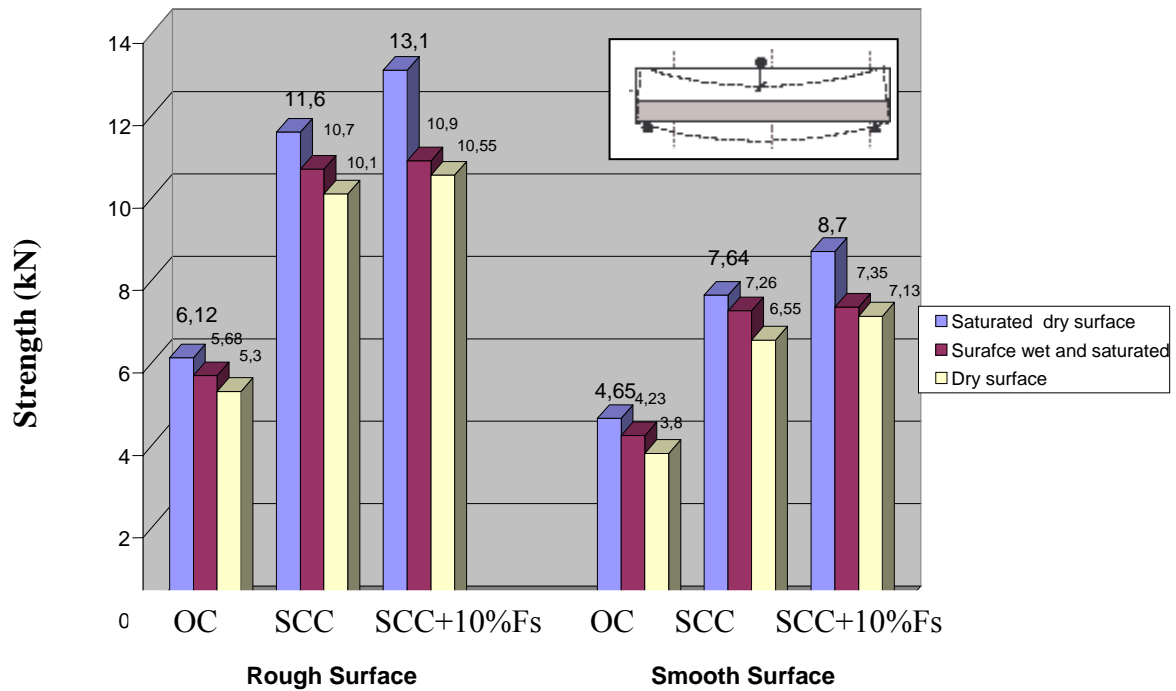


Figure 6: Tensile strengths

The results are not surprising, the SCC, in general, are more resilient because the cement mix exceeds that of the OC. By comparing the various SCC, we note the positive result of the silica fume, and fibres.

### 3.2 Optimizing Moisture and Surface Roughness

The optimization is undertaken from the results of mechanical tests of direct traction and traction by bending. The results are presented in the following diagrams.



**Figure 7:** Influence of moisture and surface type (OC, SCC, SCC+10% silica fume)

#### 3.2.1 Moisture of the Support

The results of Figure 7 show that low values are given by dry support(DS), water contained in the repair material is absorbed by the substrate before the soluble compounds cement have reacted. This undermines the hydration and interfacial area becomes heterogeneous and porous. The saturated wet surfaces (SWS) provide values unsatisfactory, because of the quantity of water acts as a screen in the interfacial area. This undermines the grip because it prevents the interpenetration of hydrates in the porosity of the substrate. In cases DS and SWS, there is a reduction of local resistance repair material. However, dry surfaces saturated SWS have given satisfactory results vis-à-vis the adhesion test where we found a constraint of 2 MPa,

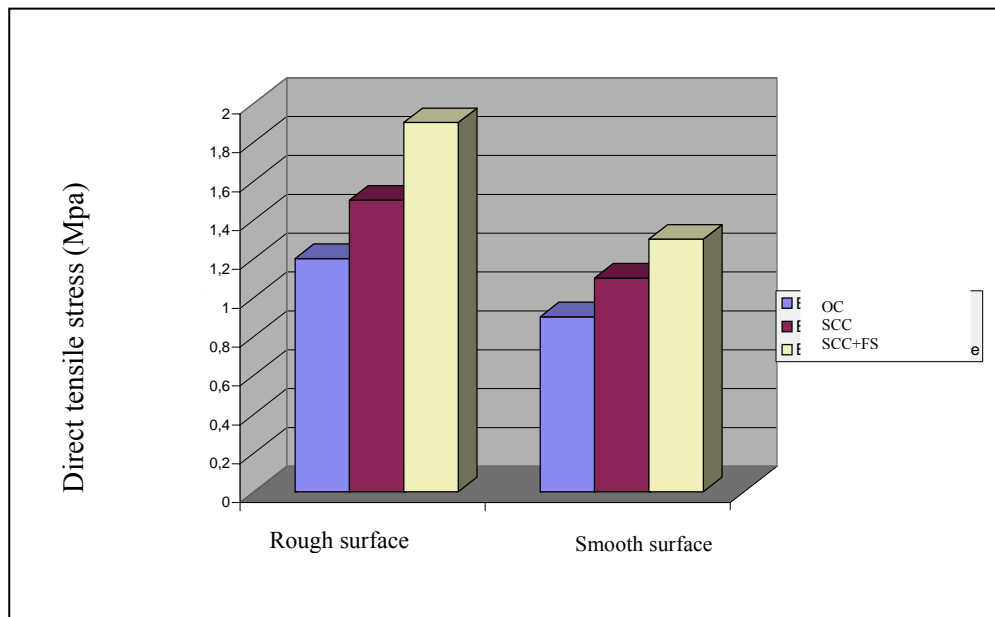


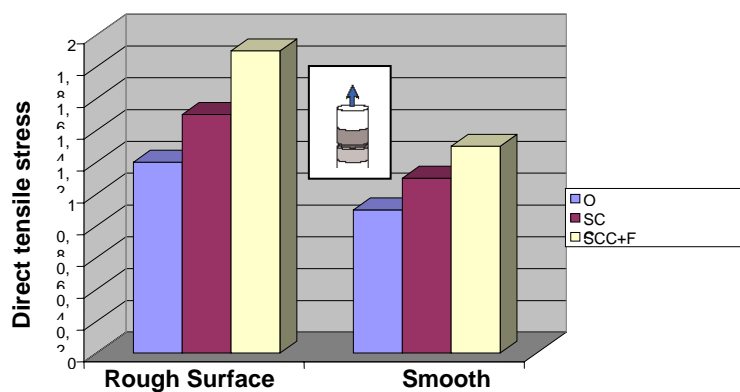
Figure 9: influence of the surface in the retrofit

### 3.2.2 Roughness of the Support

Still on figures (7) and (8), it was noted that good results are obtained by rough materials. This means that the surface of these materials has asperities of sufficient size, which enables the matrix of new material interbreed with the material support. It promotes mechanical adhesion of repairs to its support

At the microscopic level, the porous surface of the support facilitates an anchor by hydrates entanglement, similar to a locking mechanism promoting direct tensile strength of the interface. The magnitude of the forces developed by this mechanism would be linked to the topography of the surface

These results show that the resistance of the element repaired by the SCC and SCC+ FS, with dry saturated supports, is comparable to those of main concrete. This means that the repaired specimen have a monolithic behaviour.



### 3.3.3 Optimization of the Height of the Repair Layer

The results of the effect of height on the adhesion are summarized in Figure 9

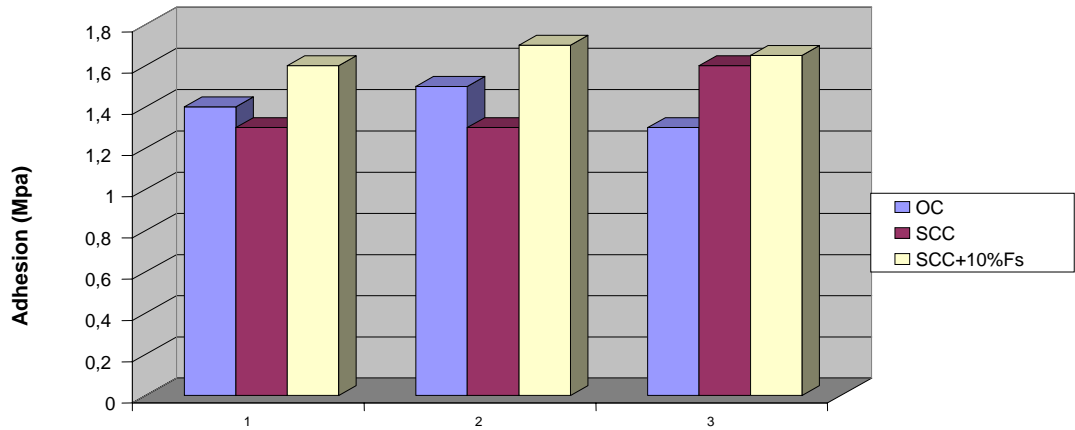


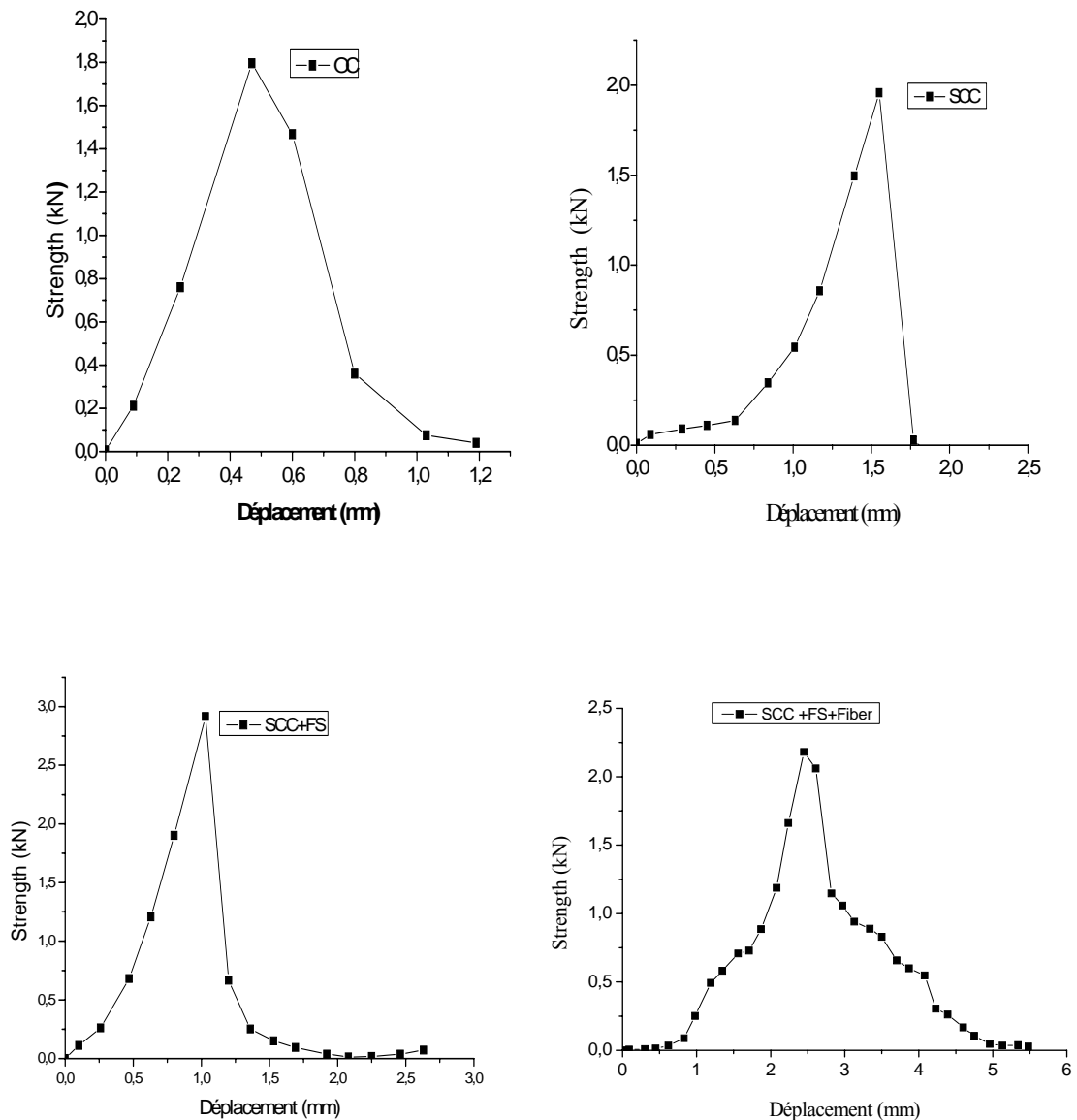
Figure 9: Effects of repair height

There is not a big difference in behaviour between the alternatives. However, we can say for the SCC that the optimum is reached at 75mm for the SCC + FS and the OC; It is achieved at 50mm.

### 3.3.4 Cracking Behaviour

The results of bending tests on notched specimens are presented on the figure 10. It is clear that the best response as cracking is the SCC + FS + fiber. This is certainly due to the presence of fibers which prevent the propagation of cracks. The SCC alone shows behaviour almost fragile behaviour.

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### 3.3.5 Influence of Products Liaison and Studs.

The tests have shown that the product of linkage has no added value in our case. By contrast the studs significantly improve the resistance. The tensile strength due to bending was improved by 29%.

#### **4. CONCLUSION**

The qualities of stability, uniformity and deformability of the fresh material mean that the SCC allows good adhesion, it is easy to form a surface to be repaired. The surface preparation has a direct impact on the behaviour of double layer elements. Roughness and moisture influence on the adhesion between the two materials. The state of ideal moisture from the surface of the support to receive a new concrete is not to be saturated, but rather to be dry saturated. A surface preparation allows rough enough surface in a comparable manner to a monolithic.

The addition of silica fume improved results as the strength and decreased the withdrawal The use of synthetic fibres improved strength and increased especially ductility and resistance to crack propagation the element reprofiled.

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