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# Mechanical Strength of Concrete and Steel and Bond Strength of Reinforced Concrete

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**Abstract:- In this research work, we have proposed to study the behavior of the compressive, flexural strength of concrete and compressive bond strength of reinforced concrete. After a vast literature among which these three forces are defined. The simulations show that all these strength decrease with the increase in y or z or both at the same time in one hand and decrease when L increases in another hand. As a result, our contribution shows that strength of reinforced concrete is stronger than strength of concrete only, which is true in the reality.**

***Keywords:-*** *Granulate, Sand, Cement, Steel, Concrete, Strength of Concrete, Compressive Strength of Concrete, Flexural Strength of Concrete, Reinforced Concrete Bond Strength.*

## I. INTRODUCTION

A composite material is an assembly or a heterogeneous mixture of at least two components, immiscible but having a high capacity for interpenetration and adhesion, whose mechanical properties complement each other. The new material thus formed has advantageous properties that the components alone do not possess. Although the term composite is modern, such materials were invented and widely used long before antiquity, such as cob for the construction of buildings [1,2].

This assembly phenomenon, which makes it possible to improve the quality of the material for a certain use such as lightness, mechanical rigidity and so on, explains the growing use of composite materials in many industrial sectors. During the 20th century, the development of computers allowed the precision in calculation of mechanical properties and the field of use of these artificial materials exploded. Nevertheless, the fine description of composites remains complex from a mechanical point of view due to the non-homogeneity of the material [3,4].

Nowadays, composite materials with fibrous reinforcements are increasingly used. The choice of constituent materials as well as the mode of assembly of the various components allow them to meet numerous specifications. Among the major properties they offer we can note [5,6]:

- Their good specific characteristics (characteristics per unit of mass) allowing again in weight; their good tenacity (or resistance to damage) offering great safety to structures; the possibility of making complex shapes, allowing the integration of several functions. Where an equivalent metal part would require many machining and/or assembly operations, some of these operations can be avoided with composite materials;
- Their vibration damping qualities allowing, among other things, the reducion of noise pollution;
- Their good resistance to fatigue allowing the creation of durable structures;
- The absence of subjection to corrosion, unlike metallic materials.

In this research work, we have proposed to study the compressive and flexural strength of concrete and bond strength steel on . We will define some words, give some experimental datas on concrete and steel and give the mathematical expressions of the previous strengths in preliminaries. We will simulate those three forces to see theoretically how the reinforced concrete is better than the concrete without a reinforcement.

## II. PRELIMINARIES

### *A. Granulate*

Granulate, sometimes also called aggregate, is a rough (crushing) or rounded (natural erosion: pebbles) rock fragment, or an artificial granular material (e.g. metallurgical slag), with a size of less than 125 mm (sands , gravel and gravel). Aggregates are used in the composition of various materials, bound or not (concrete, macadam, and embankment ballast) intended for the construction of public works, civil engineering and building works. It is among the most underground minerals resource exploited in in senegal with million of tonnes extracted any years.

### *B. Sand*

Sand is a granular solid material made up of small particles resulting from the disintegration of materials of mineral origin (essentially rocks) or organic (shells, coral skeletons, etc.) whose size is between 0.063 mm (silt) and 2 mm (gravel) according to the definition of granular materials in geology. Its composition can reveal up to 180 different minerals (quartz, micas, feldspars, etc.) as well as limestone debris. Sand has many applications as a granular material, the main one being in the manufacture of concrete. It is a non-renewable resource.

### C. Cement

Cement is a hydraulic binder (which hardens under the action of water), used in the preparation of concrete, and today most often used in the manufacture of paving, concrete blocks, coatings and mortars. Cements are currently classified under the name "CEM" followed by a Roman numeral ranging from I to V followed by a capital letter according to their clinker content and other components (lime, silica fumes, pozzolan, slag blast furnaces, etc.). It is the result, originally, of the endothermic reaction between limestone and clay which, mixed with water, set and allow sand and aggregates to agglomerate between them. Since then, many other elements have been incorporated depending on the use of cement, thus making it possible to constitute real artificial rocks, concretes and mortars.

### D. Acier

A steel is a metallic alloy made mainly of iron and carbon. It is distinguished from cast irons and ferroalloys by its carbon content of between 0.02 and 2 by mass. It is essentially this carbon content that gives steel its properties.

## III. EXPERIMENTAL RESULTS

### A. Concrete

Although it resists very well in compression, concrete is a material with low tensile strength. This is why reinforcement is placed in concrete. Compressive strength is the most important characteristic sought for hardened concrete. It is on this that the calculation and dimensioning of a concrete structure are based. It depends in particular on the quantity of cement, the type of cement and the quantity of water. Conventionally, concrete is classified according to its mechanical compressive strength measured at 28 days. It is expressed in mega-pascals (MPa). The class of compressive strength of concretes at 28 days is designated by the letter C of Concrete followed by two numbers corresponding to the strengths measured respectively on cylindrical specimens and cubic specimens (example concrete C25 / 30). The NF EN 206/CN standard defines 16 normalized strength classes for normal concrete.

- *Trength Classes of Normal Concrete According to NF EN 206/CN*

The following table presents the 16 strength classes of normal concrete according to NF EN 206/CN.

Table 1 The 16 Strength Classes of Normal Concrete According to NF EN 206/CN

| Classe de résistance à la compression | Résistance caractéristique minimale sur cylindres $f_{ck,cyl}$ N/mm$^2$ | Résistance caractéristique minimale sur cubes $f_{ck,cube}$ N/mm$^2$ |
|---|---|---|
| C8/10 | 8 | 10 |
| C12/15 | 12 | 15 |
| C16/20 | 16 | 20 |
| C20/25 | 20 | 25 |
| C25/30 | 25 | 30 |
| C30/37 | 30 | 37 |
| C35/45 | 35 | 45 |
| C40/50 | 40 | 50 |
| C45/55 | 45 | 55 |
| C50/60 | 50 | 60 |
| C55/67 | 55 | 67 |
| C60/75 | 60 | 75 |
| C70/85 | 70 | 85 |
| C80/95 | 80 | 95 |
| C90/105 | 90 | 105 |
| C100/115 | 100 | 115 |

➢ *The Concrete Strength Class Determined During the Design Calculation of the Structure*

This dimensioning is carried out according to the Eurocodes, which are European standards relating to the design and calculation of reinforced concretestructures. Depending on the size of the site, it is the responsibility of a specialized design office or the company for the smallest works. If your structure has been dimensioned, refer to the calculation note which mentions the class of compressive strength at 28 days of the concrete which will be used. Indeed, the NF EN 206/CN standard sets minimum resistance classes to be respected according to the exposure class of the concrete chosen to be able to satisfy the criteria in terms of durability.

Table 2 The Concrete Strength Class Determined During the Design Calculation of the Structure

| CLASSE D'EXPOSITION | CLASSE DE RESISTANCE BETON MINIMALE |
|---|---|
| XO | – |
| XC1 – XC2 | C20/25 |
| XC3 – XC4 – XD1 – XF1 – XF2 | C25/30 |
| XD2 – XS1 – XS2 – XF3 – XF4 – XA1 | C30/37 |
| XD3 – XS3 – XA2 | C35/45 |
| XA3 | C40/50 |

➢ *Strength of Concrete*

In a concrete structure, the resistance of this structure is calculated by the following formula:

$$R = K\left(\frac{C}{(E+V)^{-\frac{1}{2}}}\right), \tag{1}$$

- "R", the compressive strength of the concrete,
- "C", the weight of cement per $m^3$ of concrete in place
- "E", the weight of water per $m^3$ of concrete in place
- "V", the volume of voids after compaction
- "K", the coefficient depending on the nature of the cement and the age of the concrete.

➢ *Compressive Strength of Concrete*

The compressive strength of the specimen is calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area, i.e. by using the following formula:

$$f_1 = \frac{P_c}{A}, \tag{2}$$

Where $f_1$ is the Compressive strength of concrete in MPa; $P_c$ is the Maximum applied load in kN and A is the Cross sectional area in $mm^2$.

➢ *Flexural Strength of Concrete*

The flexural strength of the specimen $f_2$ is calculated by using following expression:

$$f_2 = \frac{Pa}{bd^2}, \tag{3}$$

Where P is the maximum applied load to the specimen in kN ; a is the span of the beam in mm; b is the width of the beam specimen in mm and d is the depth of the beam specimen in mm.

*B. Bond Strength of Concrete on Steel*

The tensile load was applied on steel bar for pullout purpose. The loads and slips were recorded at every 400Kg interval till failure of specimen. The maximum pull-out force is recorded in the test at bond failure. The deformations (slips) were recorded with sensitive dial gauge of least count 0.01mm. The maximum pull force, P and corresponding slip, Δ were used to calculate the pull-out work done (P × Δ) from this test. The bond strength is calculated by using the equation:

$$f_3 = \frac{P}{\pi dl}, \tag{4}$$

Where $f_3$ is the bond strength of concrete on steel in M P a; P is the pull-out force in kN ; d is the diameter of steel bar embedded in concrete cube in mm and l length of the bar embedded in concrete in mm.

## IV. SIMULATION AND INTERPRETATION

Here we consider a cubic column section with a length L = 4m, a width l = 0.15m and a height h = 0.30m, we propose to simulate the different expressions when the different parameter varied according to x, y and z and the others parameters.

### A. *Case of $f_1$*

$$f_1 = \frac{F}{lhyz}, \tag{5}$$

Where F is the applied load.

F = 150*9.81; L = 4000; l = 150; h = 200; y = 0 : 3.7 : 150; z = 200; A = 150*200;

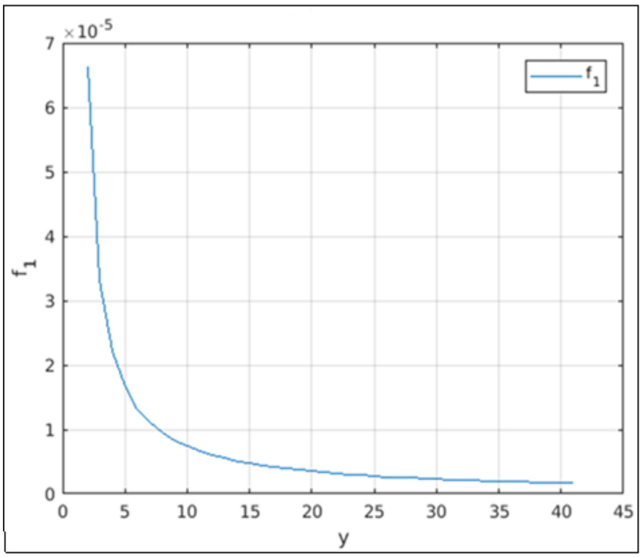


Fig 1 $F_1$ Behavior According y

F = 150*9.81; L = 4000; l = 150; h = 200; y = 150; z = 0 : 4.9 : 200; A = 150*200;

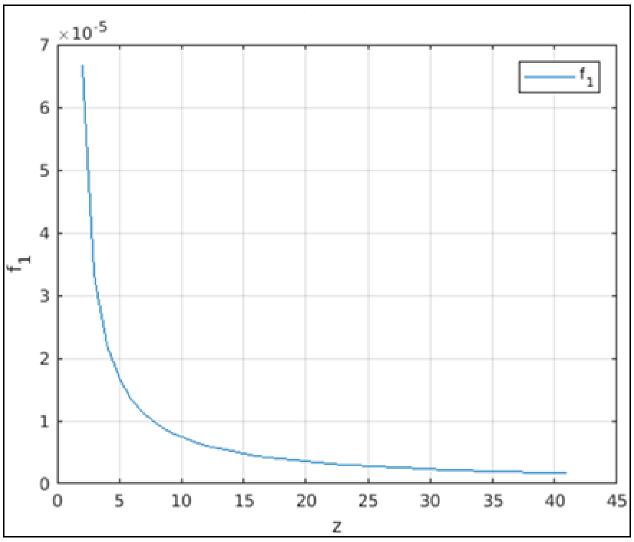


Fig 2 $F_1$ Behavior According z

F = 150*9.81; L = 4000; l = 150; h = 200; y = 0 : 3.7 : 150; z = 0 : 4.9 : 200;

A = 150*200;

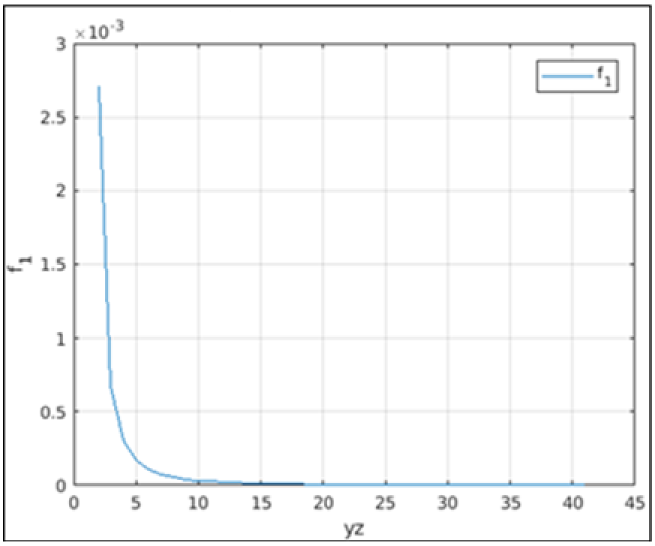


Fig 3 $F_1$ Behavior According yz

In these three previous figures, we can see that the compressive strength of concrete decreases with the increase in y or z or both at the same time. This means that the further away from the support points, the less resistance the concrete has, Which is often true in reality.

### B. *Case of $f_2$*

$$f_2 = \frac{Fa}{bd^2yz}, \tag{6}$$

F = 150*9.81; L = 4000; l = 150; h = 200; y = 0 : 3.7 : 150; z = 200; A = 150*200;

a = 5; b = 4; d = 10;

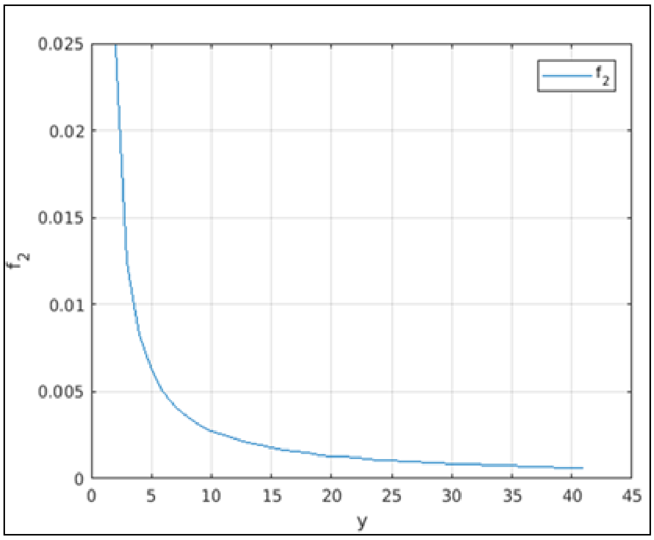


Fig 4 $F_2$ Behavior According y

F = 150*9.81; L = 4000; l = 150; h = 200; y = 150; z = 0 : 4.9 : 200; A = 150*200;

a =5; b = 4; d = 10;

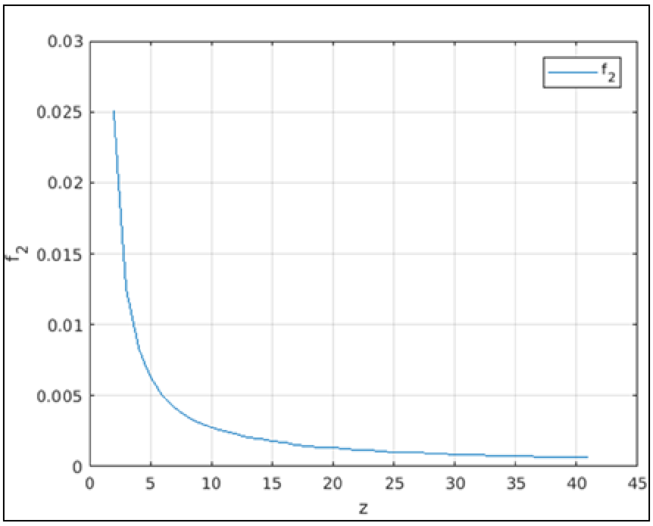


Fig 5 $F_2$ Behavior According z

F = 150*9.81; L = 4000; l = 150; h = 200; y = 0 : 3.7 : 150; z = 0 : 4.9 : 200;

A = 150*200; a = 5; b = 4; d = 10;

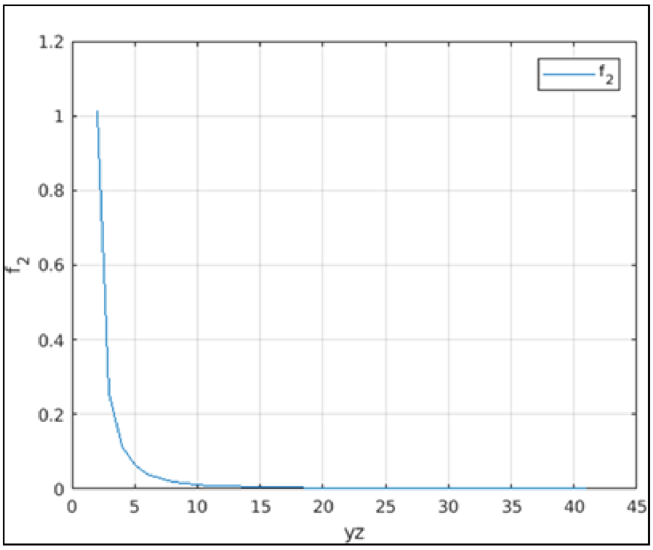


Fig 6 $F_2$ Behavior According yz

In these three previous figures, we can also see that the flexural strength of concrete decreases with the increase in y or z or the both at the same time as with the compression strength. This means that the further away from the support points, the less resistance the concrete has, which is often true in reality.

*C. Case of $f_3$*

$$f_3 = \frac{F}{\pi d L}, \quad (7)$$

F = 150*9.81; L = 0 : 100 : 4000; d = 10;

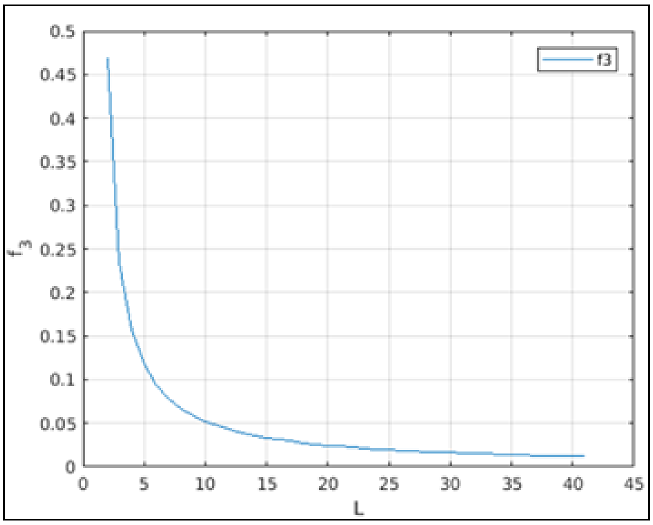


Fig 7 $F_3$ Behavior According L

In the case of a bond strength of concrete on steel , the figure shows that the flexural strength decreases with the increase of the length L. This means that more the steel bar is longer more the bond strength is low. We also note that more far away from the support points we applied a force, the less resistance the concrete the reinforced concrete has, Which is often true in reality. From our study, we can see that the resistance of concrete is more important in compression than in traction and that steel bond very good on concrete as we can see in the graphic. As a result our simulations show that reinforced concrete is more resistant than concrete only, which is true in the reality.

## V. CONCLUSION

In this research work, we have proposed to study the behavior of the compressive strength of concrete, the flexural strength of concrete and Compressive strength of reinforced concrete. Some words are difined, some experimental datas were given and some expression were difined in preliminaries.

- In these three previous figures, we can see that the compressive strength of concrete decreases with the increase in y or z or both at the same time. This means that more we are away from the support points, the less resistance the concrete has.
- In these three previous figures, we can also see that the flexural strength of concrete decreases with the increase in y or z or the both at the same time as with the compression strength. This means that more we are away from the support points, the less resistance the concrete has.
- In the case of a a reinforced concrete, we show that the bond strength decreases with the increase of L and that the steel bond well on concrete.

As a result, our simulations show that concrete bond very well on steel, so that reinforced concrete is more resistant than concrete only, which is true in the reality.

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