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ABSTRACT STUDY AND VALIDATION OF A DEVICE OF TESTS OF QUALITY CONTROL OF THE MECHANICAL CHARACTERISTICS OF TILES IN MICRO-CONCRETE

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ABSTRACT

The entitled work "abstract Study and validation of a device of tests of quality control of the mechanical characteristics of tiles, wide size in micro-concrete " has for main object to propose a technology of improvement of the tests of quality control of the mechanical characteristics such as: fold resistance three (3) points and four (4) points, shock resistance and traction resistance of the heel. For That purpose, an abstract study based on the NEWTON's 3rd law : " Principle of the action and the reaction " and the calculation of structures by the method of the finished elements allowed to model, to analyze and to size a new device which respects with a good rigor the recommendations and the requirements of the normative documents. This new device which groups the various tests of control of the mechanical characteristics mentioned above was conceived and validated by link of the results stemming from digital simulations by finished elements and from real tries.

INTRODUCTION

In the West African sub-region, particularly in Benin, tile manufacturers produce increasingly micro-concrete tiles, large format because of its many advantages. Tile production seems very simple and inexpensive. Quality tiles produced good weather resistant, shock and point loads (ODUL, 1996; GAY and GAMBELIN, 1999). They offer good thermal and acoustic insulation. Implementation of large format tiles easier than tiles small. We can see that during the installation of new tiles or during maintenance, the breakage rate is high enough (BAGAN, 2002) which raises many questions in relation to the conditions of realization. In analyzing the results of control tests of mechanical strength achieved in some building workshops, we can say that there are problems on devices testing flexural strength. In most cases, the tiles are poorly supported and poorly loaded, resulting in a lack of flatness. As for testing resistance to shocks, ball steel ball of 200 g is dropped from a height of 20 cm on the upper convex part of the tile and not the other, and for testing tensile strength of the heel, load of 20 kg and 50 mm distance between the axis of the load and the device that holds the tile are not met. Having regard to all the foregoing, we have developed in the laboratory of applied mechanics and energy (LEMA), a new test which includes three control tests. This initiative promotes the resolution of problems encountered at artisans. According to YAMBA and al. (1997), the testing device installed LEMA respects in detail the rigors demanded by normative documents LOCOMAT Our study is suitable for teaching logic and reflects the need for an analytical approach to solve the problem of mechanical tests on the tiles, which we discuss next the following lines (ROBERT K. TURTON. 1994); (HARRAS *et al*., 2002):

- A numerical approach using calculation software using the method of finite elements;
- An experimental approach: the device is designed and instrumented to allow control testing mechanical strength of the tiles (bending, impact, pull the heel);
- The use of strain gauges and comparators is possible to validate the test apparatus;
- Simulation study of the mechanical behavior of the two formats tile (variation of displacement field and stress), using the Robot Millennium software 17.0.

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MATERIAL AND METHODS

Material

Our trial device contains 3 big components the description of which is made below, Figure 1, 2, 3.

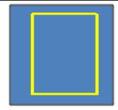
Figure 1. Device of resistance tests in the flexion.

Figure 3. Device of resistance tests in the drive of the heel.

Resistance test in the flexion

A device constituted by a mobile lever articulated in a vertical fixed embedded foot (see Figure 1). We hang on the weight equivalent to the load normative minimum to be applied to the tile on the other end free of the lever and a system of load fixed to the lever passes on (transmits) this normative in the tile.

Picture 1. Characteristics of the sections of profiles and materials.

Name of the section		Element	AX (cm^2)	IX (cm^4)	IY (cm^4)	IZ (cm^4)
I-SYM_1		E(1) et E(2)	08.000	4.839	10.667	02.667
UUAP 80		E(3)	21.350	0.396	214.000	98.070
Material		E (Mpa)	G (Mpa)	ν	ρ	R_e (Mpa)
Steel E24		210 000	80800	0.30	77.00	235

Resistance test in the shocks

A system of loose ball sliding on a gradual vertical stalk is fixed to a support embedded on the table (Figure 2). We watch that the prescriptions of the normative document are respected (YAMBA, 1997); (ROBERTO MUSCIA. 1991). This essay being destructive, we realize it on the tiles of small size 500 x 250 x 8 mm3.

Resistance test in the drive of the heel

We fix to the Table a piece of wood in which we realized a notch 10 cm deep (Figure 3) to maintain the tile on the table and we apply the normative loads to the heel of the tile in 5 cm of the edge of the table. We realize this essay on the tiles of small size 500 x 250 x 8 mm3. These 3 various devices (fold resistances, in the shocks and in the drive of the heel) are combined in the only one on a table which can support the tiles of 2m of length and 1,6 m of wide.

Methods

modeling and analysis of the device of the tests of fold resistance

Physical model

We present here the physical model of the component of flexure test which will be numerically modeled. We identified five components of the model parameters that characterize the physical: number of knots (4); number of elements (3); number of degrees of freedom (6); linear finished Elements (3); surface and volume finished Elements (0); Case of load (8).

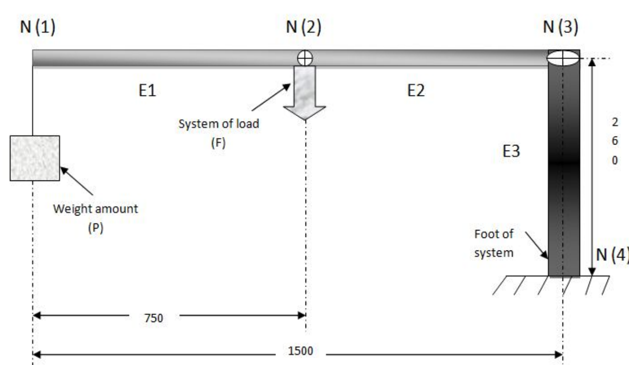


Figure 4. Pre-dimensioning of the device testing flexural strength 3 and 4 points

Manual Analysis

Of all the information which we collected during the modeling, the method of the finished elements appears as the ideal method among those whom we learnt until then to analyze manually the structure of the device. Indeed, the structure works in the plan XZ. It is constituted by a lever articulated on a foot and the connections are:

- A simple support (Knot N (2)) : one (1) unknown (T2);
- An articulation (Knot N(3)) : two (2) unknowns (N3 etT3);
- An embedding (Knot N(4)) : three (3) unknowns (N4, T4 and M4).

We have in the plan XZ of three equations only to determine six (6) aforesaid unknowns. The system is consequently hyper static. By applying the method of the finished elements: We divide the structure into three (3) linear elements different numbered E(1), E(2) and E(3). These elements work as simple beams when we apply a load T1 = - 0.35KN to the knot N(1) (to See the Figure 1 above).

Element N°1

His matrix of rigidity in the local mark is:

$$[K]^{1Local} = \frac{EI_1}{L^3}\begin{bmatrix} 12 & 6L & -12 & 6L \\ 6L & 4L^2 & -6L & 2L^2 \\ -12 & -6L & 12 & -6L \\ 6L & 2L^2 & -6L & 4L^2 \end{bmatrix} \quad (1)$$

With E = 21000 KN/cm², $I_1 = I_2 = 10.667 cm^4$; L= 75 cm

We observe between the local mark of the element N° 1 and the global mark of the structure the following relation:

$$\begin{cases} \overrightarrow{x_1} = \vec{X} \\ \overrightarrow{z_1} = \vec{Z} \end{cases} ; \quad \begin{Bmatrix} \overrightarrow{x_1} \\ \overrightarrow{z_1} \end{Bmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{Bmatrix} \vec{X} \\ \vec{Z} \end{Bmatrix} \quad (2)$$

Cos α = 1 et sin α = 0, ⇒ α = 0

His matrix of passage [P] of the global mark in the local mark is consequently equal in:

$$[P] = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} = [P]^T \quad (3)$$

Let us resume the matrix of steepness in the local mark by means of the following principle : when a flat structure possesses an element beam working only in flat flexion this last one is generally characterized in the global mark by three (3) degrees of freedom by knots that is six (6) degrees of freedom by element [GAY and GAMBELIN, 1999]. We obtain :

$$[K]^{1Local} = \frac{E.I_1}{L^3}\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 12 & 6L & 0 & -12 & 6L \\ 0 & 6L & 4L^2 & 0 & -6L & 2L^2 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -12 & -6L & 0 & 12 & -6L \\ 0 & 6L & 2L^2 & 0 & -6L & 4L^2 \end{bmatrix} \quad (4)$$

In the global mark, the matrix of steepness of the element 1 spells:

$$[K]^{1Global} = [P]^T.[K]^{1Local}.[P] \quad (5)$$

$$[K]^{1Global} = \frac{E.I_1}{L^3}\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 12 & 6L & 0 & -12 & 6L \\ 0 & 6L & 4L^2 & 0 & -6L & 2L^2 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -12 & -6L & 0 & 12 & -6L \\ 0 & 6L & 2L^2 & 0 & -6L & 4L^2 \end{bmatrix} \quad (6)$$

Element N°2

(Idem element N ° 1)

$$[K]^{1Global} = [K]^{2Global} \quad (7)$$

Element N°3

His matrix of rigidity in the local mark is:

$$[K]^{3Local} = \frac{EI_3}{l^3}\begin{bmatrix} 12 & 6l & -12 & 6l \\ 6l & 4l^2 & -6l & 2l^2 \\ -12 & -6l & 12 & -6l \\ 6l & 2l^2 & -6l & 4l^2 \end{bmatrix} \quad (8)$$

With E = 21 000 KN/cm², $I_3 = 214 cm^4$, l= 26 cm

We observe between the local mark of the element N°3 and the global mark of the structure the following relation:

$$\begin{cases} \overrightarrow{x_3} = -\vec{Z} \\ \overrightarrow{z_3} = \vec{X} \end{cases} ; \quad \begin{Bmatrix} \overrightarrow{x_3} \\ \overrightarrow{z_3} \end{Bmatrix} = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix} \begin{Bmatrix} \vec{X} \\ \vec{Z} \end{Bmatrix} \quad (9)$$

Cos α = 0 et sin α= -1, ⇒ $\alpha = -\frac{\Pi}{2}$

His matrix of passage [P] of the global mark in the local mark is consequently equal in:

$$[P] = \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (10)$$

His transposed is:

$$[P]^T = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (11)$$

Let us resume the matrix of steepness in the local mark by means of the principle already expressed for the element N°1, or:

$$[K]^{3Local} = \frac{E.I_3}{L^3}\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 12 & 6L & 0 & -12 & 6L \\ 0 & 6L & 4L^2 & 0 & -6L & 2L^2 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -12 & -6L & 0 & 12 & -6L \\ 0 & 6L & 2L^2 & 0 & -6L & 4L^2 \end{bmatrix} \quad (12)$$

In the global mark, the matrix of rigidity of the element 3 spells:

$$[K]^{3Global} = [P]^T.[K]^{3Local}.\ [P] \quad (13)$$

$$[K]^{3Global} = \frac{E.I_3}{l^3}\begin{bmatrix} 12 & 0 & 6l & -12 & 0 & 6l \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 6l & 0 & 4l^2 & -6l & 0 & 2l^2 \\ -12 & 0 & -6l & 12 & 0 & -6l \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 6l & 0 & 2l^2 & -6l & 0 & 4l^2 \end{bmatrix} \quad (14)$$

Assembly of the matrix of steepness of the structure: $[K]^S$

We work henceforth in the global mark. The assembly of three elementary matrix $[K]^{1Global}$, $[K]^{2Global}$ and $\{K\}^{3Global}$ three (3) elements of the structure of the device allows to obtain the global matrix of the structure $[K]^S$ from dimension 12 x 12. Indeed, for an element in flat simple flexion, every knot is three (3) degrees of freedom. As the structure has four (4) knots, 3x4 = 12 degrees of freedom. The matrix of steepness $[K]^S$ obtained by bill of three (3) elementary matrices of steepness 12x12.

Knot 1: free	$N_1 = 0$	T_1 = Weights amount P variable of 0 à -0. 35 KN	$M_1 = 0$	$U_1 = ?$	$V_1 = ?$	$\theta_1 = ?$
Knot 2 : Simple support	$N_2 = 0$	$T_2 = ?$	$M_2 = 0$	$U_2 = ?$	$V_2 = 0$	$\theta_2 = ?$
Knot 3 : Support articulation	$N_3 = ?$	$T_3 = ?$	$M_3 = 0$	$U_3 = 0$	$V_3 = 0$	$\theta_3 = ?$
Knot 4 : Support embedding	$N_4 = ?$	$T_4 = ?$	$M_4 = ?$	$U_4 = 0$	$V_4 = 0$	$\theta_4 = 0.$

Resolution of the linear system

We obtain a system of twelve (12) equations. The procedure of resolution of such a system comes down to the creation of two sub-systems.

Sub-system 1

We obtain it by eliminating in $\{F\}^S = [K]^S.\{U\}^S$ lines corresponding to the invalid or " blocked" degrees of freedom and the columns of the same row. In the sub-system so obtained appear only the unknown nodal movements (degree of free freedom) and the known nodal actions, or here:

0	*0*	*0*	*0*	*0*	*0*
0	$12\frac{EI_1}{L^3}$	$6\frac{EI_1}{L^2}$	*0*	$6\frac{EI_{12}}{L^2}$	*0*
0	$6\frac{EI_1}{L^2}$	$4\frac{EI_1}{L}$	*0*	$2\frac{EI_1}{L}$	*0*
0	*0*	*0*	*0*	*0*	*0*
0	$6\frac{EI_1}{L^2}$	$2\frac{EI_1}{L}$	*0*	$8\frac{EI_{12}}{L}$	$2\frac{EI_1}{L}$
0	*0*	*0*	*0*	$2\frac{EI_{12}}{L}$	$4E(\frac{I_1}{L}+\frac{I_3}{l})$

0	0	0	0	0	0	0	0	0	0	0	0
0	$12\frac{EI_1}{L^3}$	$6\frac{EI_1}{L^2}$	0	$-12\frac{EI_1}{L^3}$	$6\frac{EI_1}{L^2}$	0	0	0	0	0	0
0	$6\frac{EI_1}{L^2}$	$4\frac{EI_1}{L}$	0	$-6\frac{EI_1}{L^2}$	$2\frac{EI_1}{L}$	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	$-12\frac{EI_1}{L^3}$	$-6\frac{EI_1}{L^2}$	0	$24\frac{EI_1}{L^3}$	0	0	$-12\frac{EI_1}{L^3}$	$6\frac{EI_1}{L^2}$	0	0	0
0	$6\frac{EI_1}{L^2}$	$2\frac{EI_1}{L}$	0	0	$8\frac{EI_1}{L}$	0	$-6\frac{EI_1}{L^2}$	$2\frac{EI_1}{L}$	0	0	0
0	0	0	0	0	0	$12\frac{EI_3}{l^3}$	0	$6\frac{EI_3}{l^2}$	$-12\frac{EI_3}{l^3}$	0	$6\frac{EI_3}{l^2}$
0	0	0	0	$-12\frac{EI_1}{L^3}$	$-6\frac{EI_1}{L^2}$	0	$12\frac{EI_1}{L^3}$	$-6\frac{EI_1}{L^2}$	0	0	0
0	0	0	0	$6\frac{EI_1}{L^2}$	$2\frac{EI_1}{L}$	$6\frac{EI_3}{l^2}$	$-6\frac{EI_1}{L^2}$	$4\frac{EI_1}{L}+4\frac{EI_3}{l}$	$-6\frac{EI_3}{l^2}$	0	$2\frac{EI_3}{l}$
0	0	0	0	0	0	$-12\frac{EI_3}{l^3}$	0	$-6\frac{EI_3}{l^2}$	$12\frac{EI_3}{l^3}$	0	$-6\frac{EI_3}{l^2}$
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	$6\frac{EI_3}{l^2}$	0	$2\frac{EI_3}{l}$	$-6\frac{EI_3}{l^2}$	0	$4\frac{EI_3}{l}$

Implementation of the conditions of support and load:

The behavior in the global mark of the structure puts itself under the shape:

$$\{F\}^S = [K]^S.\{U\}^S \quad (15)$$

Avec $\{F\}^S = [N_1, T_1, M_1, N_2, T_2, M_2, N_3, T_3, M_3, N_4, T_4, M_4]^T$
Et $\{U\}^S = [U_1, V_1, \theta_1, U_2, V_2, \theta_2, U_3, V_3, \theta_3, U_4, V_4, \theta_4]^T$
It is necessary to maintain on every line the association: "mechanical Action ⇔ Degree of freedom" [GAY and GAMBELIN, 1999].

With

$\{F\} = [N_1=0, T_1=-0.35, M_1=0, N_2=0, M_2=0, M_3=0]^T$ *et* $\{U\} = [U_1=?, V_1=?, \theta_1=?, U_2=?, \theta_2=?, \theta_3=?]^T$

We note $[K]^{S1}$ the sub-matrix of steepness (6x6), who characterizes the relation:

$$\{F\}^S = [K]^S.\{U\}^S \quad (16)$$

This system cannot be reasonably inverted by a classic manual procedure. We have to appeal to a utility of formal calculation or to a pocket calculator to obtain the components of $\{U\}^S$.

Principle

We introduce the components of the sub-matrix of steepness $[K]^{S1}$ and those of {F} = [N1=0, T1 = 0,35KN, M1=0, N2=0, M2=0, M3=0] in a calculator TI - 89 for example.

Sub-system 2

We obtain it by returning to lines previously eliminated by eliminating the invalid (useless) terms. The sub-matrix of steepness $[K]^{S2}$ comes:

0	$-12\frac{EI_1}{L^3}$	$-6\frac{EI_1}{L^2}$		0	$6\frac{EI_1}{L^2}$
0	0	0	0	0	$6\frac{EI_3}{l^2}$
0	0	0	0	$-6\frac{EI_1}{L^2}$	$-6\frac{EI_1}{L^2}$
0	0	0	0	0	$-6\frac{EI_3}{l^2}$
0	0	0	0	0	0
0	0	0	0	0	$2\frac{EI_3}{l}$

With

$\{F\} = [T_2= ?, N_3= ?, T_3= ?, N_4= ?, T_4= ?, M_4= ?]^T$ et $\{U\}= [U_1, V_1, \theta_1, U_2, \theta_2, \theta_3]^T$

As we made it for the sub-matrix of steepness $[K]^{S1}$, we introduce the components of the sub-matrix of steepness $[K]^{S2}$ and those of $\{U\}= [U_1, V_1, \theta_1, U_2, \theta_2, \theta_3]$ previously calculated in under - système1, in a calculator TI - 89.

Reminder of the results of $\{U\}$: V_1= -0.3852 cm ; θ_1= 0.0068 Rad ; θ_2= 0.0022 Rad et $\theta_3 = -1.8741.10^{-5}$ Rad.

Digital model

An abstract study based on the calculation of the structures by the method of elements finished with the software Robot millennium 17.0 and the NEWTON's third law: "principle of action and the reaction" allowed us to model and to analyze the structure of the new device of tests for the flexion three (3) points. For the sizing of this device, we used the rules CM66 which govern the metallic constructions. Robot Millennium software version 17.0 was allowed to choose the configuration of the structure to study, among other things: the porch plan, porch space, the lattice plane, the spatial lattice, roasting, plate and shell. This is the case in our study a gantry plane (X, Z) consisting of:

A steel lever length = 1.5 m, with a rectangular section (I-SYM_1) = 0.02 m x 0.04 m;

A steel base: height = 0.26 m, and section 80 UUAP;

The lever is articulated on the base (node 3) and the foot is in turn built on a fixed support (node 4).

Window "View" consists of a grid of horizontal and vertical rulers appear on the screen and allow you to define:

- Construction lines 1, 2, 3 along the axis ($\vec{x}$) and A, B along the axis ($\vec{z}$) for positioning the various elements of our device (supports and loads).
- Supports: a simple support (lbl) at node N (2), the middle of the lever articulation (bbl) to node N (3) between the lever and the foot a recess (bbb) to node N(4) between the foot and support.
- loads to be applied to node N(1) lever, for example, charges 0Kg, 5Kg, 10Kg, 15Kg, 20Kg, 25Kg, 30Kg and 35Kg, which represent the equivalent weight of the load minimum allowable applied to node N(1) device to determine the reactions at node N(2) for each load case.

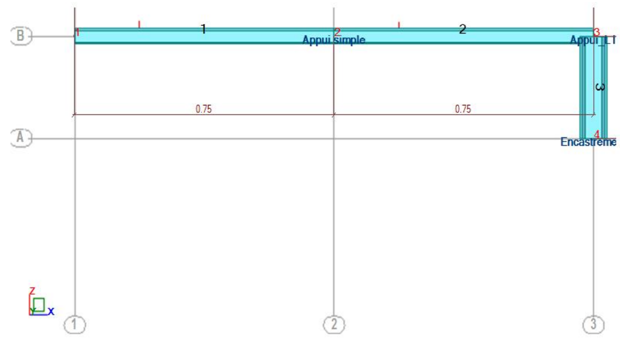


Figure 5 : modelling of the device in the window seen by Robot Beats.

We begin the analysis of the structure of our device manually. After comparison of the first manual results (reactions of supports) with those calculated with the computer and if the results are the same, we continue the analysis with the software Robot Millennium 17.0 to avoid mistakes in calculation afterward and spare time.

Software Analysis

After the modeling, we throw the command "Calculer" of the menu "Analyse". The software robot Millennium establishes automatically the mathematical model of calculations representing at best the real structure of our device: it is the "discrétisation" of the structure in finished elements. You are free to modify the mathematical model create automatically by the software by clicking the command «generate model «of the menu "Analyse". We can make a static analysis (by default) or (modal) dynamics of the structure. For every finished element, the software determines in the order, the matrix of interpolation connecting the movements of an internal point of the element with the nodal movements, establishes the relation between deformations and movements, establishes the relation between constraints and deformations, calculates elementary matrices (rigidity or mass) and finally proceeds to the assembly of the elementary matrices. With all this combined information, the software can now calculate the values of the internal and external nodal movements, the reactions to the knots of supports, the efforts, the deformations and the constraints in the whole structure. All these results, two (2) only are important for the continuation of our study. It is a question:

- Reactions to knots N°2 (case of load N°1 in 8) for the determination of the equivalent weight P in an acceptable minimal load F;
- The maximal constraints obtained in elements N°1, 2 and 3 for the sizing of these.

RESULTS AND DISCUSSION

Results of manual calculation

After treatment and calculation, we obtain the results which are the components of $\{U\}^S$.

For the values below: E = 21 000 KN/cm² ; L= 75 cm ; l = 26 cm; I_1=I_2= 10.667 cm^4; I_3= 214.0 cm^4, we obtain (BROCH J.T., 1984); (DAOUI. 2009):

Picture 2 : Results of manual calculation (nodal movements).

$U_1 = 0$	$V_1 = \frac{(6l.I_1+7L.I_3).L^3.T_1}{[3E.I_1\,(3l.I_1+4L.I_3)]}$ = - 0.3852 cm	$\theta_1 = \frac{-(5l.I_1+6L.I_3).L^2.T_1}{[2E.I_1\,(3l.I_1+4L.I_3)]}$ = 0. 0068 Rad
$U_2 = 0$	$V_2 = 0$	$\theta_2 = \frac{-(l.I_1+L.I_3).L^2.T_1}{[E.I_1\,(3l.I_1+4L.I_3)]}$ = 0.0022 Rad
$U_3 = 0$	$V_3 = 0$	$\theta_3 = \frac{L^2.l.T_1}{[2E.(3l.I_1+4L.I_3)]}$ = - 1. 8741.10^{-5} Rad
$U_4 = 0$	$V_4 = 0$	$\theta_4 = 0$

After treatment and calculation, we obtain the results which are the components of $\{F\}^S$

Picture 3 : results of manual calculation (reactions) for the case of load 8 = 35Kg are 0. 35 KN.

$N_1 = 0$	T_1 = -0.35 KN	$M_1 = 0$
$N_2 = 0$	$T_2 = 6\frac{EI_1}{L^3}.(-2\frac{V_1}{L} - \theta_1 + \theta_3)$ = 0.825 KN	$M_2 = 0$
$N_3 = 6\frac{EI_3}{l^2}.\theta_3$= - 0, 748KN	$T_3 = -6\frac{EI_1}{L^2}(\theta_2 + \theta_3)$= - 0.521 KN	$M_3 = 0$
$N_4 = -6\frac{EI_3}{l^2}.\theta_3$= 0,748 KN	$T_4 = 0$	$M_4 = 2\frac{EI_3}{l}.\theta_3$ = - 0.065 KNm

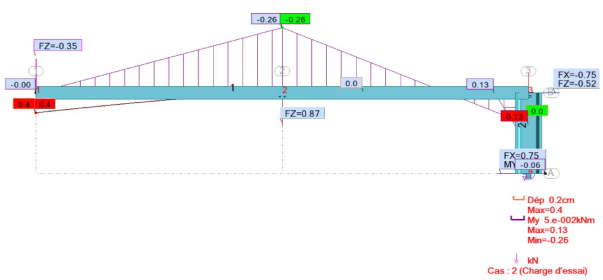


Figure 6 : Strengths and Moments of reactions : case of load 8, FZ = - 0.35KN.

Comparison of the results of manual and software calculations

In the picture below, we made a synthesis of the results stemming from analytical and digital studies concerning the device of flexion.

weight when we know the acceptable minimal load. In appendix, the copy of an index card of the tests of mechanical resistances of tiles allows us to understand how to use these results?

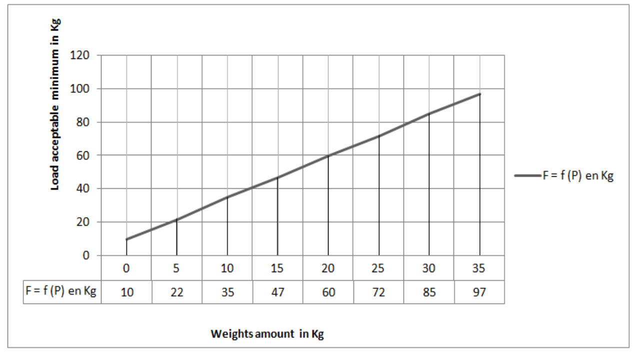


Figure 7 : curve Loads acceptable minimum F - Weights amount P.

Calculation of the acceptable minimal load F of a tile

According to the relation (BAILON and al, 2000), we have :

$$\sigma_{max} = \frac{3\,F\,L}{2BH^2} \quad (1)$$

Where from we pull: $F = \frac{35BH^2}{3L}.10^5$ (en Kg) (2)

F : load applied to the center; B : width of the tile;
H : height of the Tile; L_t: length of the tile and
L: distance between supports, L = 7/10 L_t.

The tiles of dimensions (500 mm x 250 mm), considered small-format, the standard plans in the picture below a load minimum according to the thickness of tiles.

Picture 5: Minimal normative load F according to the thickness of the tile (GRAM H.-E. and GUT P.. 1991).

Thickness tile (mm)	6	8	10	Average	Distance
Load (daN)	30	50	80		
Maximal constraint (Mpa)	17.5	16.41	16.8	16.90	0.55

Considering the results of the picture above and the low distance between the values of the constraints developed in tiles, we hold σ_{max} = 17.5 Mpa as maximal value of the constraint on the outside faces of the tile when we apply him the acceptable minimal load F (SEKLER J., and al.. 1988). It corresponds to the minimal constraint which a tile has considered as resistant in the flexion three (3) points some are its dimensions.

Picture 4 : Comparison of the results of manual and software calculations.

REACTIONS (KN or KNm)		N_1	T_1	M_1	N_2	T_2	M_2	N_3	T_3	M_3	N_4	T_4	M_4
Results	Analytics	0	0.35	0	0	0.825	0	-0.748	-0.521	0	0.748	0	- 0.065
	Digital technology	0	0.35	0	0	0.873	0	-0.748	-0.523	0	0.748	0	- 0.065
	Distance	0	0	0	0	0.048	0	0	0.002	0	0	0	0

Exploitation method of the results of the analysis

If we admit by hypothesis that the relation between the reaction of the tile and the equivalent weight P is linear, we can draw the curve which allows obtaining the equivalent

Validation of the device

- For the sizing of the device of the tests of fold resistances, the analysis of the structure gives us :

- Type of analysis : statics
- Loads acceptable : F= 97 kg, is equivalent weight P = 35 kg.
- Material steel E24 : Sigfy = 235.000 Mpa

Element E (1) and E (2) : LEVER

- Constraints : Sigfy = 0.280/5.333 = 52.468 Mpa
- Parameter of pouring : kD=1.00
- Formulae of verification : Standard CM66
-

KD*SigFy = 1.00*-52.468 = ¦ 52.468 ¦ < 235.000 MPa (3.611)
1.54*Tauz = 1.54*-0.660 ¦ = ¦ 1.017 ¦ < 235.000 MPa (1.313)

Element E(3) : FOOT

- Contraints **:** Sigfy = 0.134/53.500 = 2.502 mpa
- Formulae of verification : Standard CM66

SigFy = 2.502 < 235.000 MPa (3.212)
1.54*Tauz = |1.54*-0.965| = |-1.486| < 235.000 MPa (1.313)

- By means of the capacities of extension, resistances, the bridge of Wheatstone and accessories, we were able to verify that the load F passed on (transmitted) in the tile, during the tests of fold resistance, by the system of load fixed in the middle of the lever is appreciably equal to the load F theoretical calculated higher for every equivalent weight P. Consequently we accept that the lever passes on (transmits) effectively a load F in the tile.

- During the essay of fold resistance, every tile which rests on the adjustable supports receives the load passed on (transmitted) by the lever. The movements (arrows) which ensue from these various requests are registered by two comparators placed in the middle and below the tile in charge of (blow in charge of, tile loaded with). We make the average of the results of the movements raised on two comparators and finally we compare these results (arrows) to those obtained by the digital simulation. As two results are appreciably equal for the various tiles tested, we conclude that the device is valid.

Picture 6 : Results of maximal arrows in mm

Type of tiles	Flemish		Flat	
Size (mm^3)	Small 500x250x8	Wide 1200x500x8	Small 500x250x8 mm^3	Wide 1200x500x8
Experience	0,071	0,089	1,501	9,810
Simulation	0,078	0,093	1,436	9,865
Standard deviation	7%	4%	6,5%	5,5%

Conclusion

Test devices or tests for determining mechanical properties of materials are kept in a state of information in the normative documents. Design of the equipment testing and monitoring has validated the quality of the tiles in small and large formats micro-fabricated concrete Benin. This initiative has contributed significantly to the development of the use of micro-concrete tiles in West Africa in full development in the habitat. Manufacturing technology of this type of tile made new tiles very competitive compared to previous models developed based on the use of local materials.

NOMENCLATURE

Symbol	Description	Symbol	Description
A_x; A_y; A_z	Quadratics moments	$SigF_y$	Constraint
Cm	Centimeter	T	Transposed
E	Module of	U	
E (n)	longitudinal elasticity	(X ,Y, Z)	Vector movement
F	Element Number n		Coordinates of a
G		N_n	point in a three-
I_n	Vector forces	T_n	dimensional space
[K]	Module of transverse	M_n	Normal effort
KN	elasticity	U_n	Cutting effort
L_n	Moment of inertia of	V_n	Moment yielding in
Mpa	the element n		the knot
N (n)	Matrix of rigidit	θ_n	Movement
[P]			following X axis
R_e	KiloNewton	ν	Movement
	Length of the element		following Z axis
	n		Rotation around
	mégapascal		the Y axis in the
	Knot number n ;		Knot number n
	Matrix of Pass		Poisson's
	Limit elastic		coefficient
	Constraint		
CM66	Calculation rules for	daN	décaNewton= 1 kg
	under construction	$1P_o$	= 2,54 cm.
UUAP80	metallic structure	LOCOMAT	Project Burkinabe
I-SYM_1	Section doubles U of		for the promotion
	80mm steel		of the local
Appui_L1	Rectangular		materials
	reconstituted section		
SKAT	of 20mm x steel 40		
	mm		
	Support articulation		
	(pivot) around Y in		
	the knot N ° 3		
	Swiss Center for		
	Appropriate		
	Technology		

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