CALCULATION OF FUNDAMENTAL PARAMETERS BY THE CLASSICAL APPROACH AND DETERMINATION OF THE CROSS-CUTTING COEFFICIENT (CCC)

Nie Noumsi Thierry Constant[1], Kamdjo Grégoire[2], and MADJADOUBAYE Jeremie[3]

[1]Fotso Victor University Institute of Technology, Civil Engineering Department, Laboratory of Mechanical and Modeling of Physical Systems (L2 MSP**)** Laboratory of Industrial and Engineering Systems Environment (LISIE), University of Dschang Cameroon, PO BOX 134 IUT FV BANDJOUN, Cameroon

[2]Fotso Victor University Institute of Technology, Civil Engineering Department, Laboratory of Industrial and Systems Engineering Environment (LISIE), University of Dschang
Cameroon, PO BOX 134 IUT FV BANDJOUN, Cameroon

[3]Departement de Génie Civil, Université de Yaounde 1, Cameroon

ABSTRACT: This project entitled Design, Sizing and Planning of the works of a reinforced concrete girder bridge was carried out in Tunisia. The objective of this work is based on the determination of the geometrical characteristics and the determination of the cross-cutting coefficient (CCC) for the dimensioning of the various elements of the Apron such as beams, spacer and slab. In this work, we used two methods or (approaches) for the determination of the geometrical characteristics of the beams. The study led to the determination of the various fundamental parameters which are the parameter of bracing and the torsion parameter. The conventional method or approach given by the SETRA references, for which the geometrical characteristics of the different sections were obtained by the following formula:

B_{moy} (m^2) = B $_{appui}$ C_1 + B $_{central}$ C_2; C_1 and C_2 the interpolation coefficients which describe the variation of the section of the beam as a function of the length and when d= 0.5m.

$C_1 = \frac{1}{3} + \frac{4}{3Lp} = \frac{1}{3} + \frac{4}{3x21} = 0.3968$; $C_2 = \frac{2}{3} - \frac{4}{3Lp} = \frac{2}{3} - \frac{4}{3x21} = 0.6032$

This for bending inertia and also for torsional inertia. Thus the torsion parameter α = 0.54 and the spacing parameter θ = 1.29.

KEYWORDS: Parameters; Fundamentals; Characteristics; Geometric; Coefficient; Beam; Rigidity.

1   INTRODUCTION

Economic development remains a major concern in all countries. This development often follows the creation of road, rail or river networks. In order to improve and facilitate the movement of its population, the Government of Tunisia decided to build a 3 x 3-lane A3 motorway between Bousalem and Beja. Hence the importance and pertinence of our study theme of the study of a Great Hydraulic Works.

In this work, we propose to carry out the detailed study of a bridge made of reinforced concrete composed of the different elements such as beams, slab, strut, abutment, gravel, support apparatus, stack And foundations. All this being done by taking care to multiply the various estimated loads on the weighting coefficients in order to ensure its stability and the safety of its users.

LITERATURE REVIEW

Many works have been carried out (huge work has been done on the calculation of the fundamental parameters and the determination of the Coefficient of Transversal Distribution) in the dimensioning of the Road Bridges. Bridges are works of art for which a taxiway crosses a natural obstacle or other road of land, river or sea. In practice, it is called Works of Art to designate a Bridge. In addition, the Bridges, Raiders and Buses have been the subject of careful studies carried out by several researchers such as:

[3] "CONCRETE AND ARTICLES OF ART Volume 1: Concrete bridges" document was drafted by a working group composed of experts from FIB, CERIB, SNBPE, SNPB and CIMBETON. [2] «The calculation at the limit states of slabs and planar structures" Annals ITBBTP, No. 257 (Bernaert, May 1969). [4] Applications of Eurocode 2: calculation of buildings in concrete, Press of roads and bridges (Calgaro and Cortade 2005). "[9].[10] " Master BAEL 91 and UTD associates, Practice BAEL 91 (J.PERCHAT and J.ROUX 2000, 1993)."[11].[12]" Course of Art »Volume 1: Conception, « Course of Art »Volume 2: Dimensioning (BEN OUZDOU Mongi 2008). [1] "Design of bridges" Anne BERNARD-GELY and Jean-Armand CALGARO. [5] Origin of Pathologies, Observations, Diagnosis in Structures Annals of ITBTP No. 523 (POINEAU., May 1994). [6] "Technical Rules for the Design and Calculation of Foundations of Structures in Civil Engineering » (Fascicle 62 Title V., 1999).[7] « Practical course of prestressed concrete BPEL rules » (GEORGE DREUX., 1984).[8] « Concrete prestressed to the limit states » (HENRY Thonier., 1985). [13] Annals of ITBTP No. 169 (Method of Guyom-Massomnet., January 1962). [14] (Roads restablishement) «General Direction of roads and bridges of Tunis » (M.HOSNI Sami.,2007).[15] "Plastic calculations", ESTP course (Perchat M., 1973). [16] [17] [18] [22] [23] [24] "Planning of main roads", (Bridges with prefabricated beams prestressed by post tensionVIPP), "Transitional bridge bridges","Support of the aprons" (1.2.3 Models of the piers and abutments: PP73), «Support of the aprons» (1.3.2 Additional calculation and Reinforcement type: PP73), «1.3.2 Pre-dimensioning Geometric & Costs and Quantities: PP73. Supporting appliances made of shrink-wrapped elastomer » (SETRA., 1994, 1984, 1981, 2007).

2 METHODOLOGY

2.1 GEOGRAPHIC LOCATION

This is a road crossing on the Oued Zarga-Rhayette of 31.5 m total width located in the region of Boussalem. The axis of the structure has a right angle to the axis of the channel as shown in the map below.
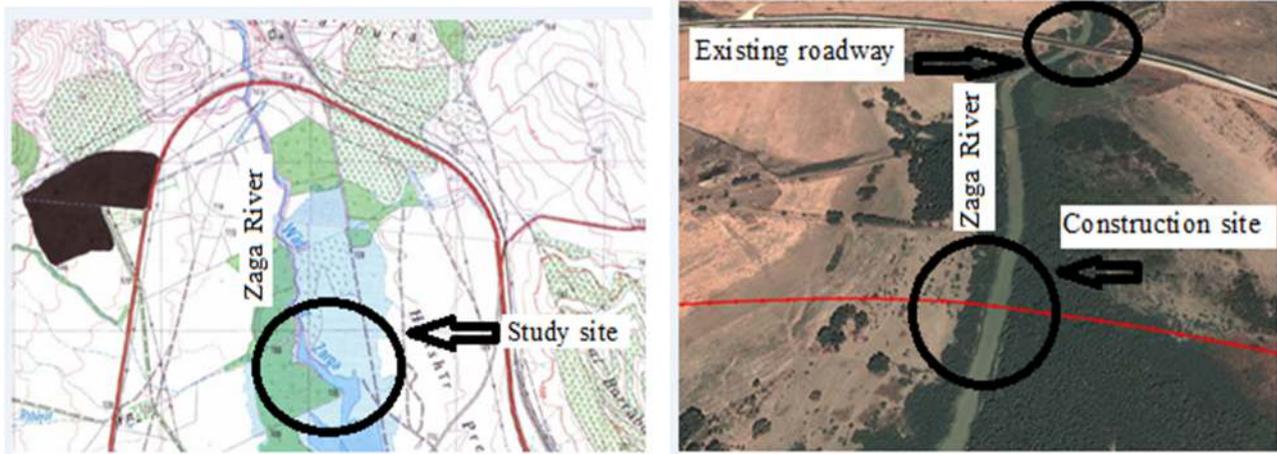

Figure 1: Location plan and construction site

The method of Guyom Massonnet which is defined as a method of calculation of slabs or networks of beams. This method is stated according to two fundamental principles which are the following:

- To substitute to the actual bridge a bridge with a continuous structure which has the same average stiffness for flexion and torsion as the real bridge.
- Approximately analyze the effect of the transverse distribution of the tanks assuming that this distribution is the same as if the distribution of the loads along the axis of the bridge is sinusoidal.
- The determination of the fundamental parameters depends on the different aspects of:

- The longitudinal design
- The transverse design
- The geometry of the sections of the beams

Which led us to carry out the study for an independent span of span (Lc) of our work (according to the longitudinal design, the roll able width "Lr "According to the cross-section and the slab acting as the intermediate spacers and also the spacing between the beams" b0 ")

2.2 LONGITUDINAL DESIGN OF THE DECK

Thanks to the hydrological studies and the topography of the terrain, For a reinforced concrete girder bridge of 84.27m length with 4 independent spans, thus two spans of 21.34 m of axis in axis and two spans Of shore of 20.67m. This allows us to determine the following characteristics:

- Intermediate span length: L_t = 21.34 m
- edge which is taken equal: d= 0.5m
- calculation length: L_C = 21.34 -2 x 0,5 -2 x 0.17 = 20m
- Beam length: L_P = 21m

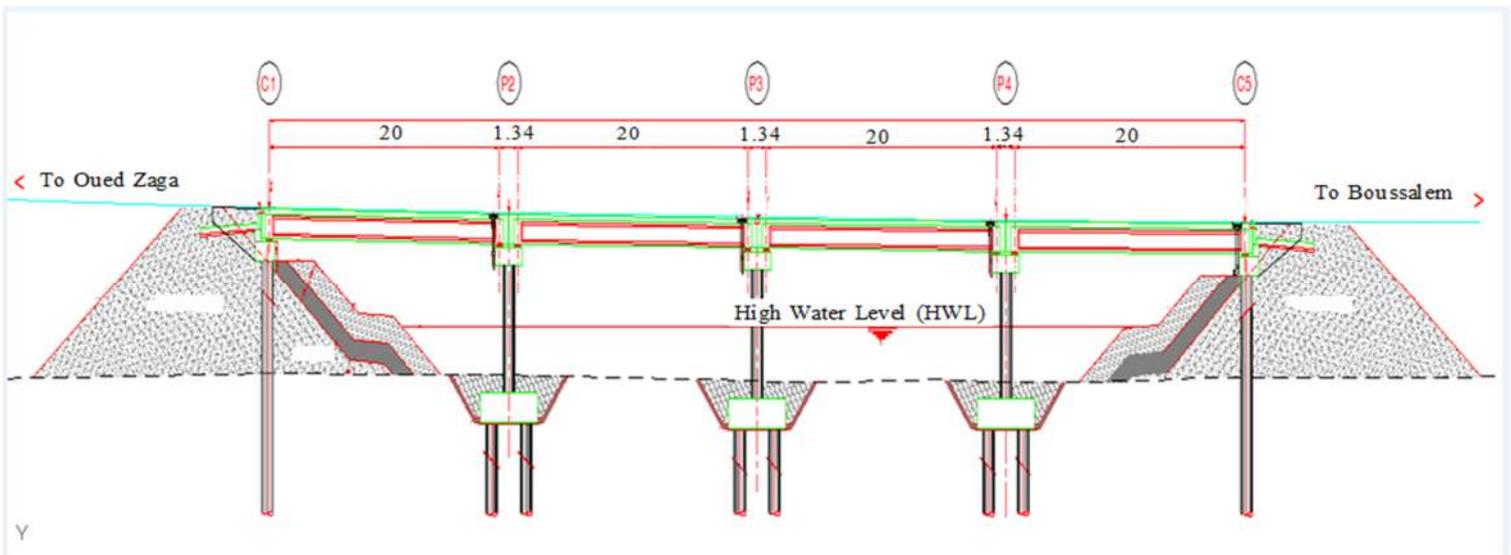Below is the longitudinal section of the proposed bridge:

Figure 2: Longitudinal section of the bridge

2.3 TRANSVERSAL DESIGN

The width of the bridge depends on the road requirements. The road crossing this structure is equipped with 3 x 3 lanes, one lane will be blocked, and this lane will be unblocked as traffic increases. A bridge with two independent decks of 14.75m each, separated by a 2m grating, will be considered and a part of the deck will be worked on. An emergency stopping strip of 2 m and a left stray strip of 1 m are provided on each apron width and also a normal BN4 - type barrier placed on a set of cornices and against a cornice of 0.75 m on the right bank and a 0.5 m safety slide located on the left bank.
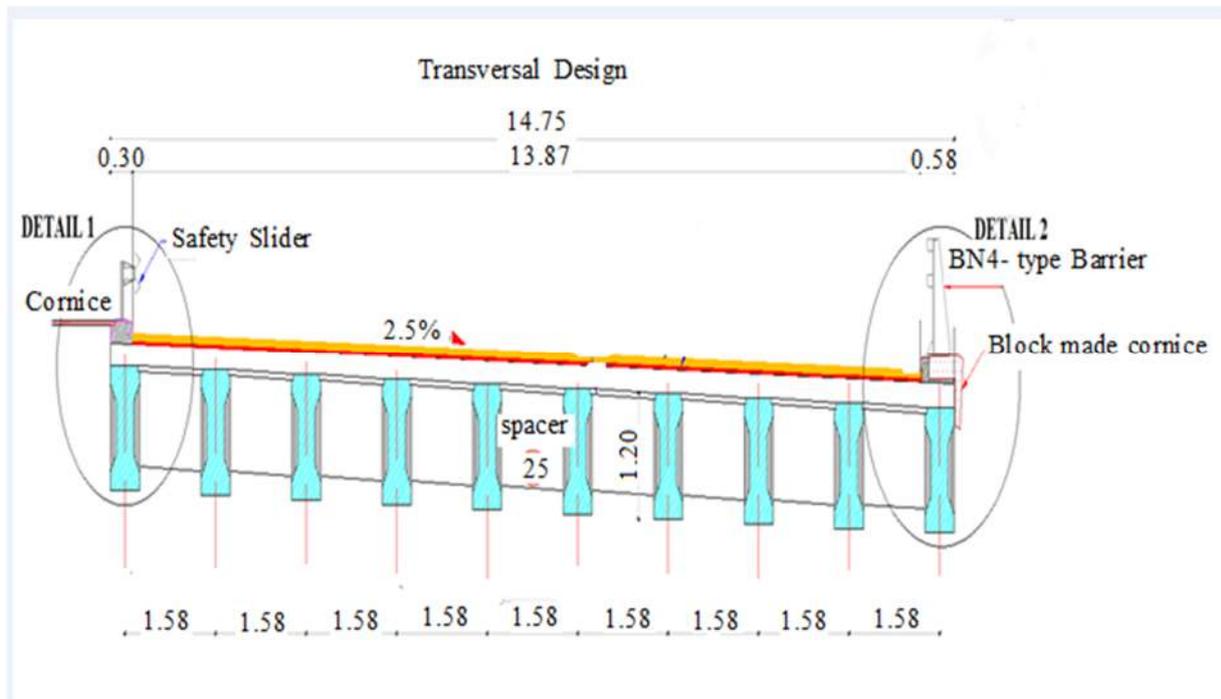
Figure 3: Cross section of the bridge

2.4   EXPERIMENTAL METHODS

In our case, the absence of intermediate spacers in the cross-section of the bridge is deformable; hence the Guyom-Massonnet method is used for the calculation of the longitudinal moments taken up by the beams and the beams. Transverse moments taken up by the slab.

CALCULATION OF THE FUNDAMENTAL PARAMETERS BY THE CLASSICAL APPROACH GIVEN BY THE REFERENCES SETRA

The choice of the cross section of the beam allows us to calculate the geometrical characteristics, to facilitate the calculations we used the traditional approach which consists of decomposing the different sections on the surface and to facilitate this task we have used EXEL and the theory of equivalent rectangles for torsional inertia. Since the beam along its length is variable, which leads us to work on two sections: central and support. In addition, it is imperative to determine the average geometric characteristics of the section. The fundamental parameters are summarized in the determination of the torsion parameter α and the spacing parameter θ which serve to define the behavior of the bridge. To determine these we will need their stiffness's which are determined as follows:

flexion stiffness :   Beam: $\rho_P = \dfrac{ExIp}{b1}$

                          Spacer: $\rho_E = \dfrac{ExIE}{L1}$

torsion stiffness: Beam: $\gamma_P = \dfrac{ExKp}{2xb1}$

                          Spacer: $\gamma E = \dfrac{ExIE}{L1}$

The parameters are:

- **Torsion parameter**: $\alpha = \dfrac{\gamma P + \gamma E}{2\sqrt{\rho p x \rho E}}$;

- **Spacing parameter**: $\theta = \dfrac{b}{L}\sqrt[4]{\dfrac{\rho p}{\rho E}}$

CALCULATION OF THE TRANSVERSAL DISTRIBUTION COEFFICIENT (TDC)

The calculation of the TDC coefficient depends on the number of main beams, the position of the beams in relation to Axis of the cross-section and a coefficient K determined from the table Guyom-Massonnet.

✓ **Determination of the lines of influences**

Our study in the determination of the lines of influences will be done on the edge beam and the intermediate beam determined only after three interpolations as follows:

- Interpolation on (Y), which is defined as the distance in the transverse direction between the vertical axis of the bridge and that of the beam to be studied

- Interpolation on (α)

- Interpolation on (θ)

• **Intermediate beam and edge beam**

The abscissa (y) of the intermediate beam and edge beam is determined as follows:

$$Y = \frac{0.79}{7.375} b = 0.11b \qquad ; \qquad Y = \frac{7.11}{7.375} b = 0.96b$$

Since we have the values of bracing, we will choose the values in the table of Guyom-Massonnet and then we carry out the interpolations.
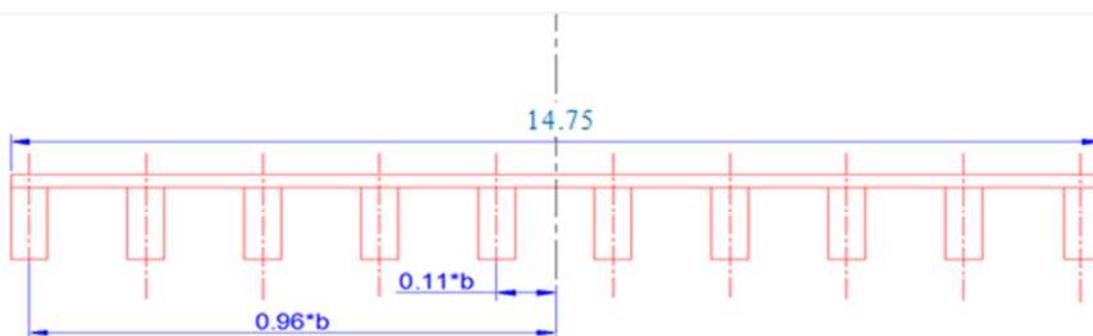

Figure 4: Position of the abscissa on the cross-section

✓ **Loading system and arrangement**

➢ **Loading case A_L**

This system consists of uniformly distributed loads of varying intensity depending on the overloaded length and which correspond to one or more lines of vehicles when stationary on the bridge. The AL load according to the loading rules is placed in the most unfavorable manner.

For this purpose and because of the variation of A1 and the loading width LAL, the following cases (one, two, three and four loaded channels) will be tested. We will do caseloads for the beam bank and that of the intermediate beam (see Annex 1).

With: the coefficient K:

$$K_{AL} = \frac{\text{transversely area covered by the line of influence K}}{\text{width covered transversely by AL}} = \frac{\mathbf{wAL}}{\mathbf{LAL}}$$

Such as: WAL that is the area of the influence line corresponding to the load divided by the width of the load is determined by the AutoCAD software or by the decomposition of the surface surfaces elementary.

➢ **Loading case Bc**

For Bc loading, the longitudinal layout requires a maximum of two trucks per lane and as many lanes as the number of lanes in the transverse direction. Since bc coefficient varies we will try 4files bc we will place them on the loadable width to obtain the case of the most unfavorable loading while respecting the characteristics of Bc convoy: the distance between Bc queue is 2 m, the Distance between two lines of Bc is 0.5 m and leave a distance of 0.25 m between the edge of the sidewalk and the first line of wheels, if there are the restraints, a distance of 0.75 m is allowed. The loads of the influence lines of the edge beam and of the intermediate will be loaded.

With the Ki which are the ordinates at the location of the wheels, they are determined graphically in the AutoCAD software.

✓ **Loading case MC120**

For this type of load, only one vehicle is used in the transverse direction regardless of the width of the roadway and has two tracks with the following characteristics: the distance between two tracks is 2.30 m and the distance between the tracks a caterpillar is 1m.

3 RESULTS

After this study, it appears that the values of the fundamental parameters by the conventional approach given by the SETRA references and determination of distribution coefficient of Transverse beams Rives, Intermediate and beam model are presented in the following tables and figures:

- **Geometrical characteristics**

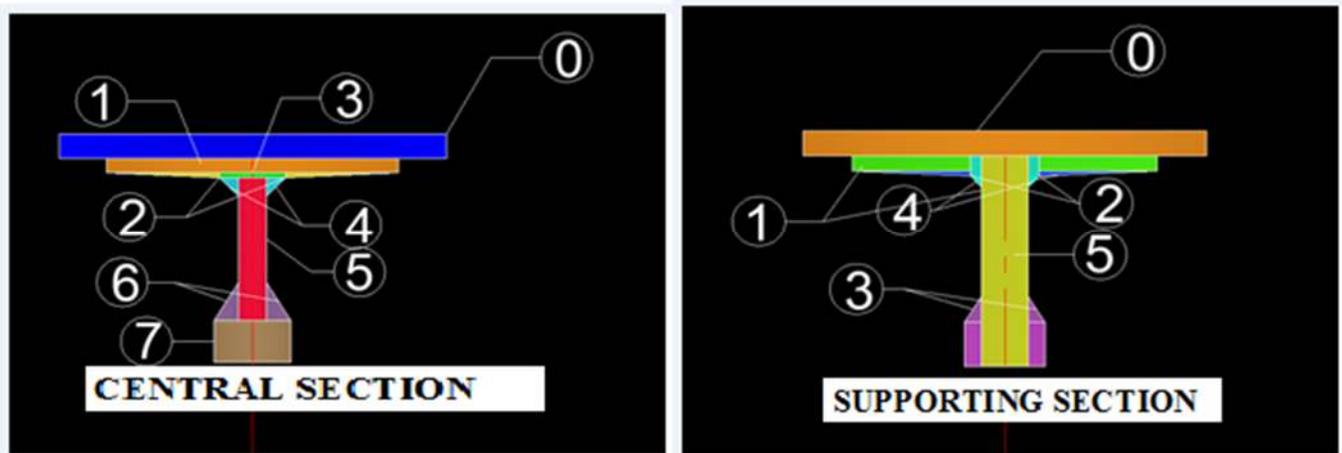*Figure 5: Quantification of the central section and the supporting section by elements*

Table 1: Results of geometric characteristics in central section

Central section	beam without slab	beam with slab
B (m^2)	0.470	0.786
V$'$(m)	-0.616	-0.881
V(m)	0.584	0.519
I (m^4)	0.06	0.161
ρ (section yield)	0.36	0.45
Γ (m^4)	0.01122	0.01332

Table 2: Results of the geometrical characteristics of the support section

Section on supports	beam without slab	beam with slab
B (m^2)	0.6	0.916
V′ (m)	-0.61	-0.85
V (m)	0.59	0.55
I (m^4)	0.065	0.164
ρ (section yield)	0.3	0.38
Γ (m^4)	0.04309	0.04519

- **Fundamental parameters**

Table 3: Results of geometrical characteristics and fundamental parameters

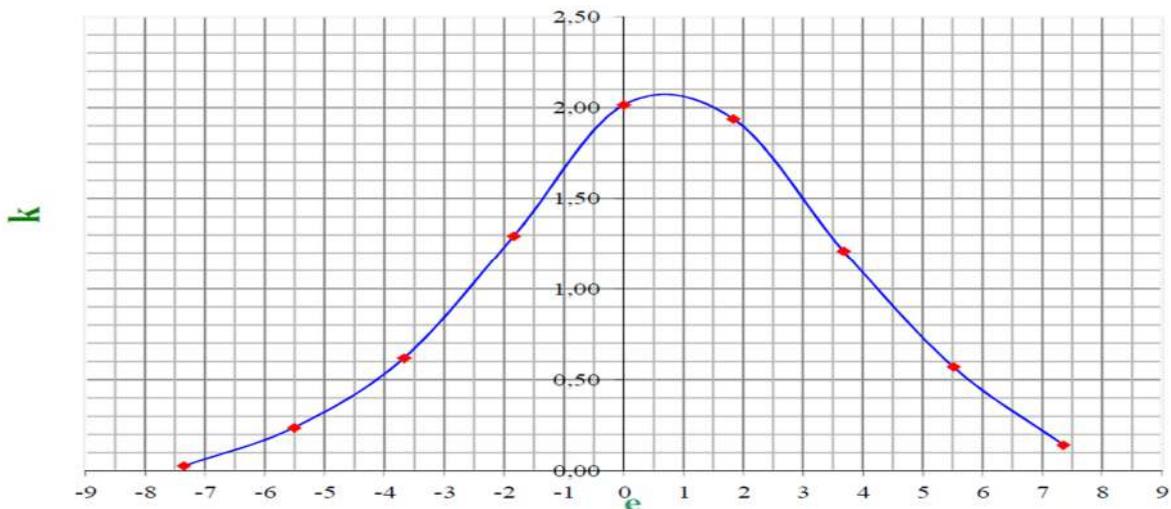| Fundamental parameters									
Mean section without slab	Mean section with slab	Average bending inertia with slabs	Average inertia of torsion with slab	γ_P	ρ_P	γ_E	ρ_E	α	θ
0.522	0.837	0.162	0.0260	264.68	3301.29	21.44	21.44	0.54	1.29

✓ **Intermediate beam**

- **Interpolation on (Y), α and θ**

  - (Y) is between Y= 0 and Y= $\frac{1}{4}$ b therefore $Y_{0,\,11b} = 0.56 Y_{0.\,25b} + 0.44 Y_0$

  - (α) is between 0 and 1 therefore : $K_\alpha = K_0 + (K_1 - K_0)\sqrt{\alpha}$

  - θ is between 1.2 and 1.3 therefore : $K_{\theta=1.29} = 0.9 K_{\theta=1.2} + 0.1 K_{\theta=1.3}$

Table 4: Results of the interpolation at the level of the intermediate beam

θ = 1.29 α = 0.54	-b	-0.75b	-0.5b	-0.25b	0	0.25b	0.5b	0.75b	b
y = 0.11b	0.03	0.24	0.62	1.29	2.01	1.94	1.21	0.57	0.14

- **Drawing of the influence curve on the intermediate beam**
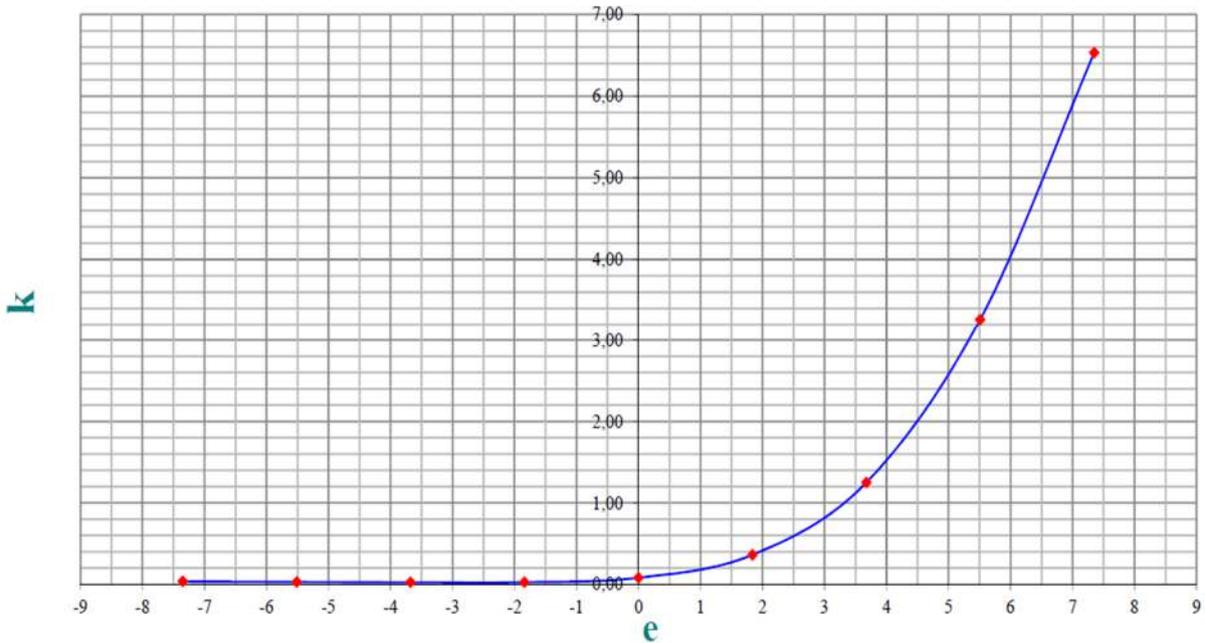
- ✓ **Edge beam**

- • **Interpolation on (Y), α and θ**

    - (Y) is between $Y = \frac{3}{4}b$ and $Y = b$ therefore $Y_{0.96b} = 0.12Y_{0.75b} + 0.88Y_b$

    - (α) is between 0 and therefore: $K_\alpha = K_o + (K_1 - K_0)\sqrt{\alpha}$

    - (θ) is between 1.2 and 1.3 therefore : $K_{\theta = 1.29} = 0.9K_{\theta = 1.2} + 0.1K_{\theta = 1.3}$

Table 5: Results of the interpolation at the level of the edge beam

θ = 1.29 α = 0.54	-7.375	-5.53	-3.6875	-1.84375	0	1.84375	3.6875	5.53	7.375
y = 0.96b	0.0344	0.0277	0.0231	0.0238	0.0791	0.3613	1.2504	3.2697	6.5342

- • **Drawing of the influence curve on the edge beam**

- ✓ **Loading case A_L**

- • **Intermediate beam**

Table 6: summary of the TDC intermediate beam case load AL

Loading case	Coef a_1	Surface W_{AL} (m²)	Coefficient $K_{AL} = \frac{wAL}{LAL}$	TDC $\eta_{AL} = \frac{KAL}{n}$	a_1x η_{AL}xL_{AL}
1file (L_{AL}= 3.17m)	1	6.2715	1.978	0.198	0.62766
2files (L_{AL}= 6.34m)	1	10.7242	1.6915	0.169	1.07242
3 files (L_{AL}= 9.51m)	0.9	13.2824	1.3967	0.1397	1.1954
4 files (L_{AL}= 12.7m)	0.75	14.4503	1.1378	0.11378	1.08377

- **Edge beam**

Table 7: summary of the TDC edge beam case load AL

Loading case	Coef a_1	Surface W_{AL} (m²)	Coefficient $K_{AL} = \frac{wAL}{LAL}$	TDC $\eta_{AL} = \frac{KAL}{n}$	a_1x η_{AL}xL_{AL}
1 file (L_{AL}= 3.17m)	1	8.4749	2.673	0.2673	0.847
2 files (L_{AL}= 6.34m)	1	9.8038	1.5463	0.1546	0.98016
3 files (L_{AL}= 9.51m)	0.9	9.925	1.044	0.1044	0.8935
4 files (L_{AL}= 127m)	0.75	10.0062	0.788	0.0788	0.7506

✓ **Loading case Bc**

- **Intermediate beam**

Table 8: TDC summarized intermediate beam load case Bc

Loading case	Disposition	Coef bc	Coefficient $K_{Bc} = \frac{\sum Ki}{2}$	TDC $\eta_{Bc} = \frac{KBc}{n}$	bcx η_{Bc}
1file of Bc	symmetric arrangement	1.2	1.9556	0.19556	0.23467
	asymmetric arrangement		1.8537	0.18537	0.2244
2 files of Bc	symmetric arrangement	1.1	3.554	0.3554	0.3909
	asymmetric arrangement		3.542	0.3542	0.3896
3files of Bc	symmetric arrangement	0.95	4.702	0.4702	0.44669
	asymmetric arrangement		4.3957	0.43957	0.4176
4files of Bc	symmetric arrangement	0.8	5.31755	0.531755	0.425
	asymmetric arrangement		5.332	0.5332	0.4266

- **Edge beam**

Table 9: TDC summarized Edge beam load case Bc

Loading case	Disposition	Coef bc	Coefficient $K_{Bc} = \frac{\sum Ki}{2}$	TDC $\eta_{Bc} = \frac{KBc}{n}$	bcx η_{Bc}
1file of Bc	one disposition	1.2	3.159	0.3159	0.3791
2files of Bc	2 files of Bc(after 0.75m)	1.1	4.0046	0.40046	0.44051
3files of Bc	3 files of Bc	0.95	4.1439	0.4144	0.39368
4files of Bc	4 files of Bc	0.8	4.1706	0.4171	0.334

✓ **Loading case MC120**

• **Intermediate beam**

Table 10: TDC summarized intermediate beam load case Mc$_{120}$

Loading case	$K_{MC} = \frac{\sum K_i}{4}$	$\eta_{MC} = \frac{KMC}{n}$
1st disposition	1.455	0.1455
2nd disposition	1.5626	0.15626
3th disposition	1.71885	0.17188

• **Edge beam**

Table 11: TDC summarized Edge beam load case MC$_{120}$

Loading case	$K_{MC} = \frac{\sum K_i}{4}$	$\eta_{MC} = \frac{KMC}{n}$
2chanels at 0.5m from GBA	2.428	0.2428

• **Model beam**

Table 12: Summary of Model beam CRTs following the different loads

Loads	TDC	Characteristics	Most critical case
Al	0.1397	$a_1 = 0.9$ et $L_{AL} = 9.51$ m	3 loaded lanes
Bc	0.4702	$bc = 1.1$ $P = 12t. 6t$	3files of Bc
Mc$_{120}$	0.2428	$P = 110t. L_{Mc} = 1m$	2chanels at 0.5m from GBA

4 DISCUSSION

After performing the various calculations according to the Standards, SETRA documents and UTD (Unified Technical Documents), it follows:

The different geometric characteristics of the two sections are different. This is due to the variation of the section along the beam. The following variations are observed:

• A variation of 14.2% between the air of the central section and the air of the section;

• A variation of 1.83% between the flexural inertia of the central section and the flexural inertia of the support section;

• A variation of 70.52% between the torsional inertia of the central section and the torsional inertia of the bearing section.

It is therefore imperative to determine the average geometric characteristics of the section in order to optimize the reinforcement of the beam to different sections which leads to the Barres stop.
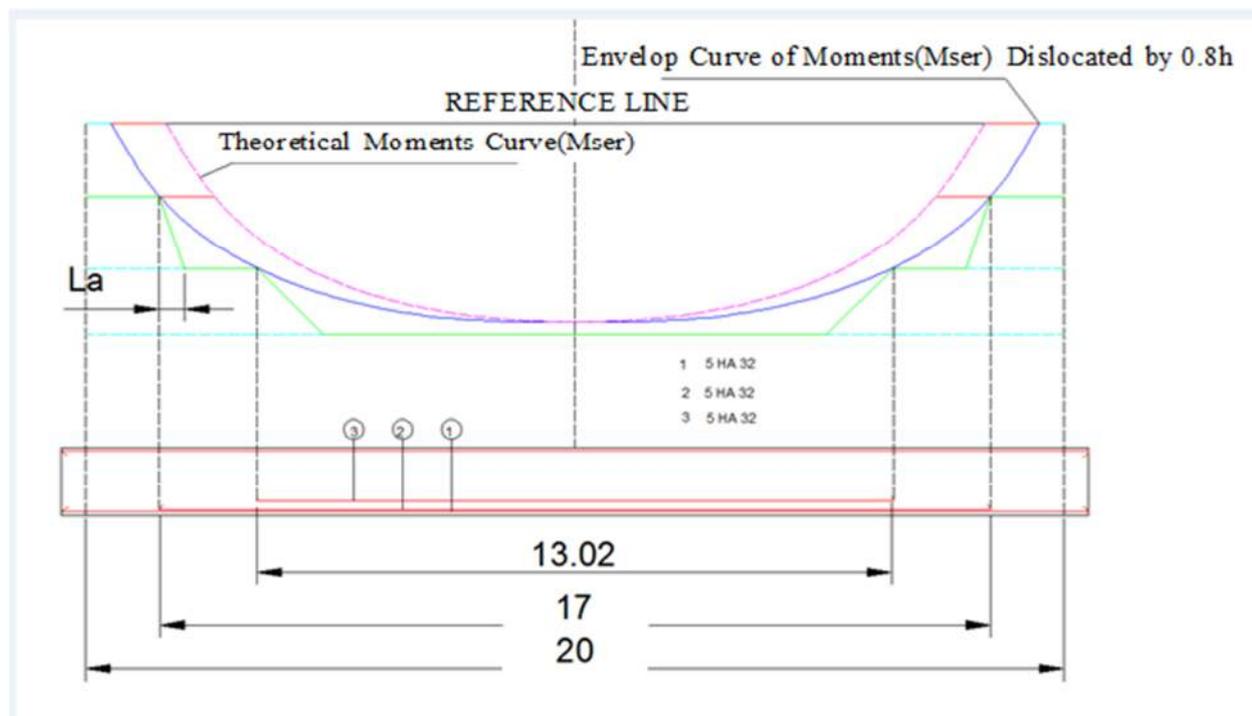
Figure 6: Barrel

The reinforcement consists of several beds; the time taken by each of the beds is plotted on the diagram of the bending moments. The intersection of these resistant moment lines with the envelope curve determines the bar stops.

- From the table 6 we find that loaded rounds are the worst case because a_1x $\eta_{AL}xL_{AL}$ = 1.1954 is the max and according to the table 7 we find that for the loaded edge beam is the worst case because a_1x $\eta_{AL}xL_{AL}$ = 0.98016 is the max.
- We find that 2 lines of Bc is the worst case because bcx ηBc = 0.44051 is the max and we also find that 3 lines of Bc is the worst case for the intermediate beams because bcx ηBc = 0.44669 is the maximum.
- By comparing the CCC values of these different beams, the most unfavorable values are derived to calculate a single model beam. Thus, the reinforcement will be the same as the other beams.

5 CONCLUSION

In this project, we were interested in the design, dimensioning and planning of execution and financial works of a crossing on Oued Zarga -Rhayette situated On the A3 motorway in the Bousalem area. During this project we tried to carry out a general and complete study of a structure and for this it was necessary to follow and study closely each step of design and dimensioning of the bridge to beam. From this it follows the calculation of the fundamental parameters by the classical approach given by the SETRA references and the determination of the Transversal Repartition Coefficient (CCC) of the different Beams. The calculations of the different elements of our work are carried out with reference to the recommendations of SETRA and based on the rules of the BAEL 91.

Finally, the results obtained during this study pose the milestones constituting the fundamental parameters and the coefficient of Transversal Distribution of a Beam Model for the dimensioning of the beams of the structure.

PERSPECTIVES

- Calculation of the different loads of the overloads and the permanent load
- Determination of the reinforcement of the various elements of the deck with reinforcement plan
- Use of Euro code 2 for the calculation of reinforced concrete

IMPLICATION OF THE MODEL TO RESEARCH AND PRACTICE

EXEL micros programs for the determination of the geometrical characteristics, pre-dimensioning, dimensioning of the beam and the design of the structure and planning.

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