PARAMETRIC STUDY OF THE STRUCTURES (INFLUENCE OF THE SHELLS)

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ABSTRACT:

The conception (design) of an earthquake-resistant structure is a complex problem seen the necessity of meeting the requirements of security been imperative by the regulations, and of economy been imperative by the increasing costs of the structures. The resistance of a building in the horizontal actions (shares) is mainly ensured by a mixed brace system; for a concrete building this system is constituted by frame or shells; or both at the same time.

After the earthquake of Boumerdes (May 23; 2003) in Algeria, the studies made by experts, ended in modifications of the Algerian Earthquake-resistant Regulation (AER 99). One of these modifications was to widen the use of shells for the brace system. This modification has create a conflict on the quantities, the positions and the type of the shells at adopt.

In the present project, we suggest seeing the effect of the variation of the dimensions, the localization and the conditions of rigidity in extremities of shells.

The study will be led on a building (F+5) implanted in zone of seismicity average. To do it, we shall proceed to a classic dynamic study of a structure by using 4 alternatives for shells by varying the lengths and number in order to compare the cost of the structure for 4 dispositions of the shells with a technical-economic study of the brace system by the use of different dispositions of shells and to estimate the quantities of necessary materials (concrete and steel).

KEYWORDS: Reinforced concrete, mixed brace system, dynamic analysis, beams, shells.

1. INTRODUCTION

The conception of an earthquake-resistant structure is a complex problem seen the necessity of meeting the requirements of security been imperative by the regulations, and of economy been imperative by the increasing costs of the structure. The resistance of a structure in the horizontal actions is mainly assured by the mixed brace system of the structure. For a concrete structure this system is constituted by frames and shells or both at the sametime.
After the earthquake of Boumerdes, studies made by experts, ended in modifications of the Algerian Earthquake-resistant Regulation (AERR). One of these modifications was to widen the use of shells for the brace system of buildings. This modification has created a conflict on the quantities, the positions and the genre of the shells to adopt.

2. DIMENSIONS OF THE CONCRETE SHELLS

The shells are an elements a plan resisting, the capacity of which to resume the horizontal efforts is very important seen the big slowness of their horizontal sections. The sizing of shells is made by empirical formulae on the minimal dimensions according to the height of floor and the conditions of butts of the shells.

2.1.Thickness

Under the seismic action (share) of the parts (parties) more at least important of the extremity of the shells, requested in compression, can be in the inelastic domain; this situation can be at the origin of side instability.

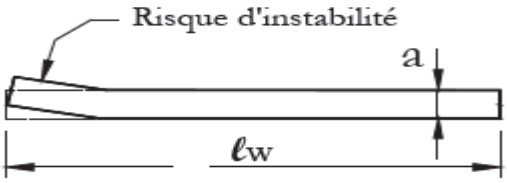


Figure 1. Side Instability of the shells

Account held by this eventuality, the (AERR version 2003) (article 7.7) imposes a minimal thickness of 15 cm; and from certain level of constraint, the expert plan in the extremities of the shells of the reinforcements as posts or shells in return.

- Shells with two butts on posts
- Shells with a single button a post
- Shells from free butts.

2.2.Height

the height of the shell is link at the conception of the structure, she has to insure the continuity between the levels; in the sizing we are interested the free height he.

2.3.Length

For reasons of modeling the (AERR version 2003) demands a minimum of length of $L \geq h$; should the opposite occur these elements are considered as linear elements

3. MODELLING

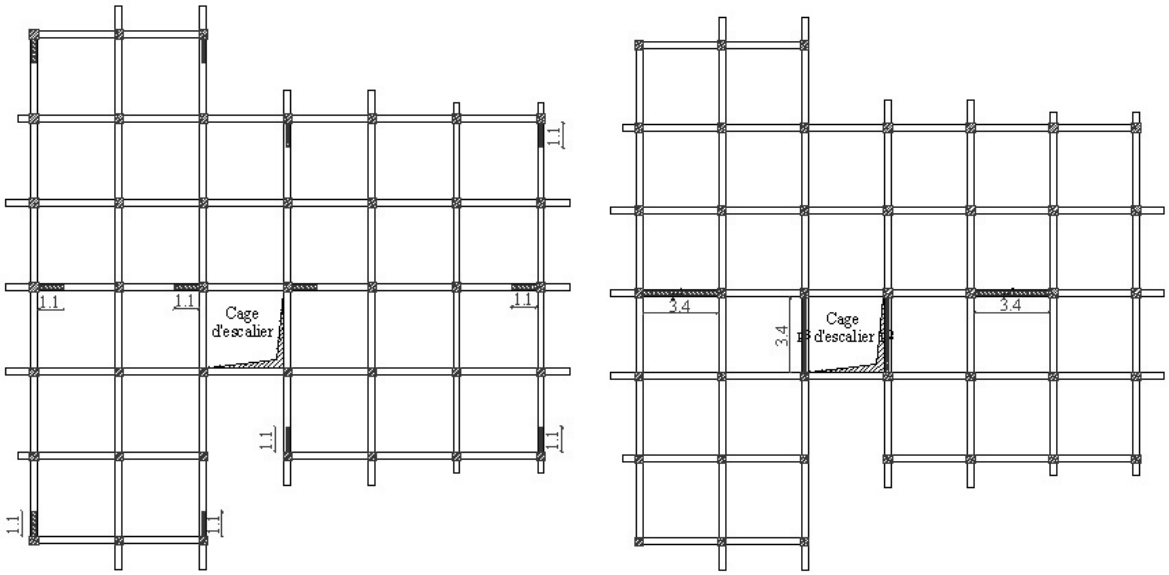
The building studies is (F+5) with 24.4 m of length and 23.5 transversely implanted in zone III, with the "Robobat" software ; we model the structure by introducing shells with various disposition and conditions of butt.

- Shells with posts in both ends;
- Shells with a free extremity.

The parameter of comparison will be the quantity of materials (concrete and steel) necessity for the structural elements (posts, beams and shells).

We are study four (4) alternatives for the disposition of the shells

- 1st disposition:12 shells of 1,1 m; an extremity succeeds in a post and the other one is free (figure 2.a)
- 2nd disposition identical for the first one with the length of 1.3m (figure 2.a).
- 3rd disposition identical for the first one with the length of 1.5 m (figure 2.a).
- 4th disposition: 4 shells of 3.4 m with two butts on posts (figure 2.b).



(a) (b)

Figure 2. Studied dispositions

4. SEISMIC SHARE

The determination of the reaction of the structure can be made by two methods of calculation the choice of which is a function at the same time of the type of the structure and of the nature of the dynamic excitement:

- The static method amounts;
- The spectral modal method of analysis.

4.1. Static Method Amounts

the calculation of the seismic load on the basis of the building by the static method is made by the values of the following parameters.

Table 1. Seismic load on the basis by the static method

Disposition	A	D	Q	R	W	Vt
1fs disposition	0.25	1.909	1.3	5	4094.93	508.12
2nd disposition	0.25	1.909	1.3	5	4112.66	510.32
3rd disposition	0.25	1.909	1.3	5	4134.10	512.98
4th disposition	0.25	1.909	1.3	5	4039.57	501.25

4.2. Spectral Modal Method of Analysis

the introduction of the seismic share in the form of the answer spectrum to predict the movements and the requests in the elements of a structure with (T1=0.15 and T2=0.7). The method insures the calculation of the maximal values only in every mode by using a spectrum which represents the average of several seismic shares.

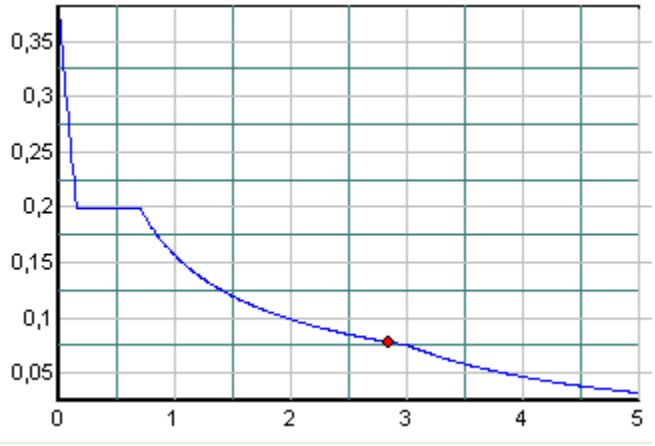


Figure 3. Answer spectrum of calculation

4.3. Check of the Resultant Seismic Strength

the resultant of the seismic strengths on the Vt obtained by the combination of the modal values must be equal at least to 80 % of that calculated by the equivalent static method V Should the opposite occur, this resultant must be increased as follows:

$$Vt = 0.8\ (Vt\ /V\ esm)\ Vt \qquad (1)$$

The results of the check of four dispositions are given in the table 2.

Table 2. Correction of the resultant of the seismic strengths given by the spectrum

Disposition	V esm	Vt		Min Vt/ Vesm	Vt Increased	
		X	Y		X	Y
1	508.12	406.12	370.42	0.73	445.06	405.93
2	510.32	406.98	370.52	0.72	452.20	411.68
3	512.98	407.32	371.17	0.72	452.57	412.41
4	501.25	387.21	383.56	0.76	407.58	403.74

5. IRON FRAMEWORK OF THE STRUCTURAL ELEMENTS

The variation of the rigidity of shells (by varying the length) influence on the necessary quantity of armatures in the structural elements (posts, beams and shell). This will allow choosing the optimal configuration of shells. To facilitate the calculation of the quantities of necessary longitudinal armatures in the structural elements, we are going to introduce the following simplifications:

- Only the variation of the quantity of longitudinal armatures is to be considered.
- The section of armatures in posts will be calculated for every post, what is not the case for a study intended for the execution;
- Beams will be clattered with the necessary maximal quantity on every span.

5.1. Section of Minimal Iron

The minimal section to be planned for every element is the one datum by the earthquake-resistant regulation indicated in the following table:

Table 3. Minimal Iron framework

Element	Dispositions			
	1	2	3	4
Post (40*40)	8T12+4T14			
Beam (30*35)	6T12			
shells (e=20)	12T10	14T10	16T10	32T10

5.2. Quantity of Materials

5.2.1 Steels

The necessary quantities of steel are recapitulated on the table.

Table 4. Weight of necessary steel for every disposition

Disposition	weight of steel (kg)			Total weight(Kg)
	shell	Post	Beam	
1	4887.146	11192.028	12325.425	28404.599
2	5536.701	11193.790	11828.379	28558.870
3	6350.357	11136.996	11662.585	29149.938
4	5022.468	9953.682	10870.735	25846.885

We notice that the disposition 4 allows to save 10 in 15 % of steel with to compared with the other envisaged alternatives.

5.2.2 Concrete

Table 5. Necessary volume of concrete for every disposition.

Disposition	Volume de béton pour les éléments m3			Total volume (m^3)
	shell	Post	Beam	
1	43.402	121.459	158.575	323.436
2	49.233			329.267
3	55.064			335.098
4	45.970			326.004

5.3. Rigidity of Shells

Table 6. Rigidity of shells in every disposition

Disposition	I of one shell(m^4)	R of Shell (MPa.m)	Number of shell	R all shells (MPa.m)
1	0.045	606,102	12	7273.224
2	0.065	882.304	12	10587.648
3	0.091	1231.778	12	14781.336
4	0.988	13305.145	4	53220.58

6. VARIATION OF THE PRIZE OF THE STRUCTURE

Knowing the quantity of necessary materials for every disposition, the prize of the structure can be estimated.

Table 7. Prize of the structure with the various dispositions

Disposition	Quantity		Prize AD		
	Concrete (m^3)	Steel (kg)	Concrete	Steel	Sum (AD)
1	323.436	28404.599	6468720	2.414391	8883111
2	329.267	28558.870	6585340	2.427504	9012844
3	335.098	29149.938	6701960	2.477745	9179705
4	326.004	25846.885	6520080	2196985	8717065
Unitarian Prize			20000	85	

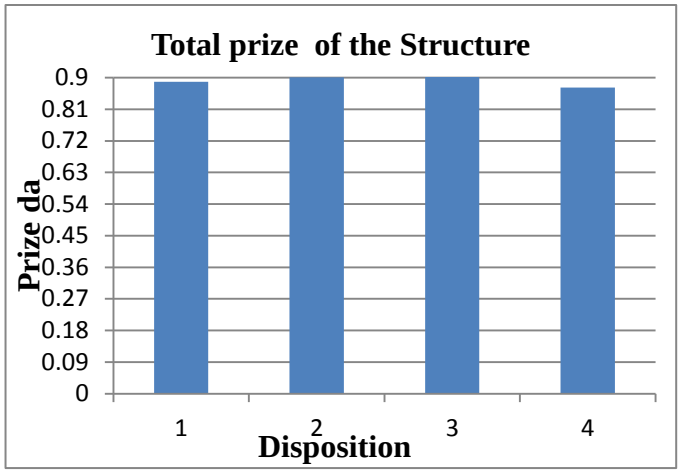


Figure 4. Global Variation of the prize of the structure with the various dispositions

By considering the price factor, the best disposition is the 4th disposition. The gains on the total cost will be from 5 to 8 % with compared with the other disposition.

7. CONCLUSION

The conception of an earthquake-resistant structure for a building, can be made of several manners, and the best conception is the one which is in compliance with the codes of calculation and which is the most economic.
For the structures in mixed brace system and shells .the cost factor is a factor which can be envisaged only with a big experience, and it is due to the present difficulty during the introduction of shells; position, dimension and type of shells to be used.
The comparison of four dispositions studied in this work allowed us to recommend the use of shells with both extremities

- Have least coffering;
- Have the biggest rigidity of shells;
- Eliminate the formation of the short beams;
- Avoid the concentration of the efforts in certain posts;
- Have the optimal cost.

Finally, the irregular shape of the building is a negative factor which limited the possibilities of positioning of shell and which increased the complexity of the behavior of the structure.

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