EFFECT OF THE OPTIMAL EMPLACEMENT OF THE BASE SEISMIC ISOLATION SYSTEMS ON THE SEISMIC RESPONSE OF BUILDINGS

B. Athamnia[1], A. Ounis[2] and M.Z. Kaab[3]

[1] *Civil Engineering Department Faculty of Sciences University of Tebessa, Algeria*
[2] *Civil Engineering and Hydraulics Department Faculty of Sciences, University of Biskra, Algeria*
[3] *Hydraulics Department Faculty of Sciences, University of El Oued, Algeria*
Email: athamnia.brahim@gmail.com

ABSTRACT:

To limit the damage caused by the seismic as well human as material, one can use devices being able to be used to dissipate the energy induced at the time of this last before it is not transferred to the structure. Generally one calls these devices of the seismic isolators. With an aim of better including/understanding the effect of the emplacement of these devices on the response of the structures, the comparative studies were carried out in this article. The analysis is carried out by three comparative studies: the 1st between a fixed base structure and a base isolated (FPS and LRB) and the 2nd comparative study between two base isolated structures, respectively LRB and FPS and the 3rd between two base isolated structures (FPS+LRB) and (LRB+FPS). So that shows the structure isolated by FPS decreases displacements, accelerations and shear forces compared to the structure isolated by LRB.

KEYWORDS: Seismic response, LRB, optimal emplacement, FPS.

1. INTRODUCTION

The seismic is the major natural risk most fatal and which causes the most damage. Among these catastrophes, we quote the example of the seismic of Boumerdes which has occurred into 2003. To decrease, and even, to avoid this kind of damage, seismic protection proves to be essential.
Indeed the protection of a structure with respect to the seismic risk can be obtained with three different methods of design:

- The structure is equipped with a sufficient resistance so that it resists the seismic while remaining in the linear elastic range.
- The structure is equipped with a capacity of sufficient yield elastic deformation (which one often calls, by abuse language, ductility) to resist the seismic request by accepting a certain level of damage.
- The seismic excitation is filtered at precise places using the specific devices. This filtering can be carried out by elastic or inelastic deformation. It is about the seismic isolation i.e., dissipated the maximum of energy.

By its principle, the seismic isolation decreases, in the majority of the cases, the sensitivity of the seismic response to modifications of the structural characteristics, this allows a greater flexibility of modifications and intervention in the phases of study, construction or even of exploitation. Moreover, certain types of devices have the property to lead to seismic requests in the structure which, to a certain measure, subject to quasi linear behavior of the structure, are not very sensitive at the seismic excitation. The objective of this work is to study the effect of the distribution of the systems of damping on the seismic response of the buildings. For that we chose the seismic case of a building staged with isolator at the base has various sites of the systems considered (LRB and FPS) and subjected to a seismic request in order to study the dynamic response with the linear elastic behavior of this last.

2. DESCRIPTION OF THE STRUCTURE

The structure used in our study is a building of reinforced concrete of 10 levels with rectangular form (Figure.1a and Figure.1b) in plan 19x20m² including four spans respectively in the two directions, longitudinal and transverse (Figure.1c).The beams are of section 30x60cm^2, the columns are 60x60cm^2 and the height of each stage is the 3.08 m with thickness of the slap is 18cm (that not lose its shape in their plan) in order to satisfy the assumption of rigid diaphragm.

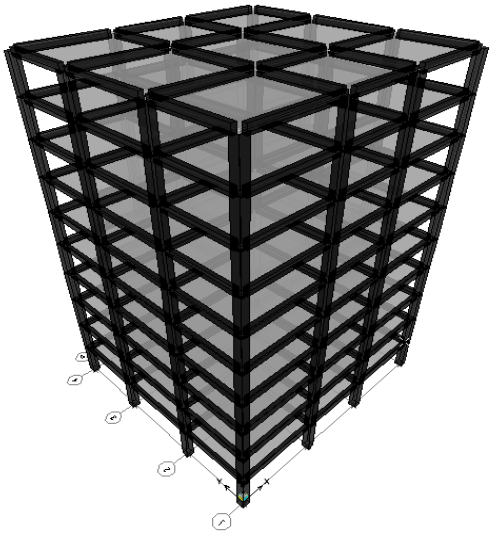


Figure 1a. 3d view of the structure without seismic isolation system

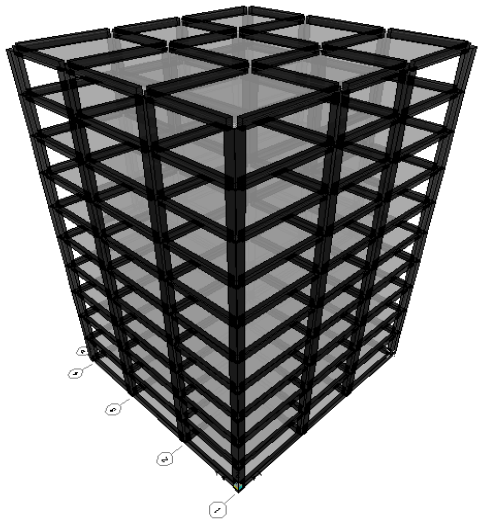


Figure 1b. View in 3d of the structure with base seismic isolation

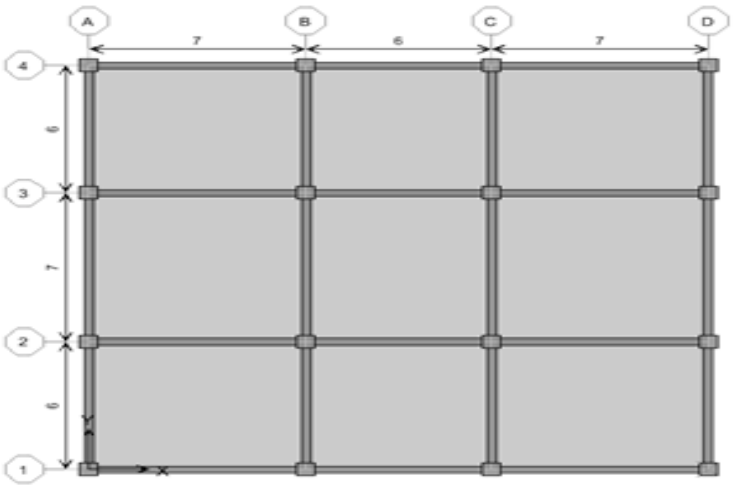
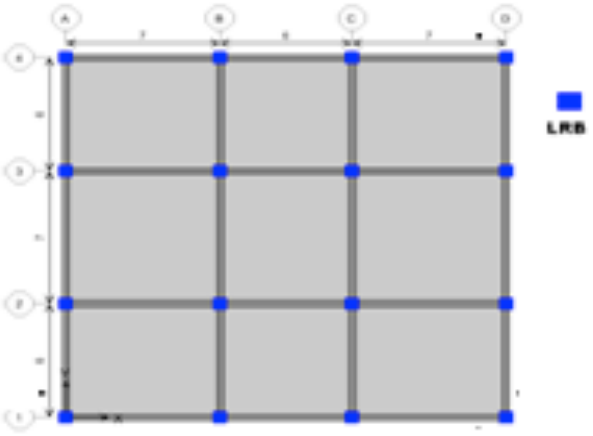
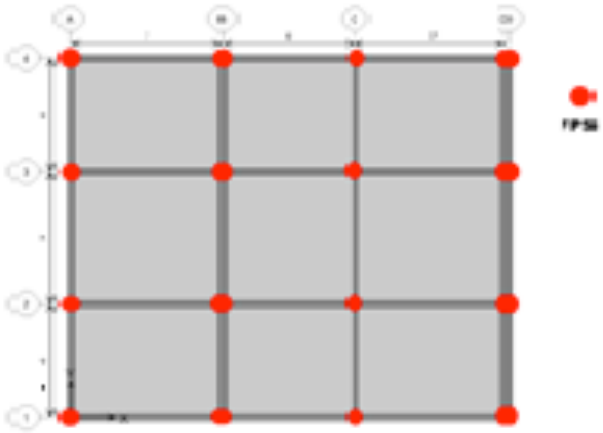


Figure 1c. Plan view of the fixed base structure

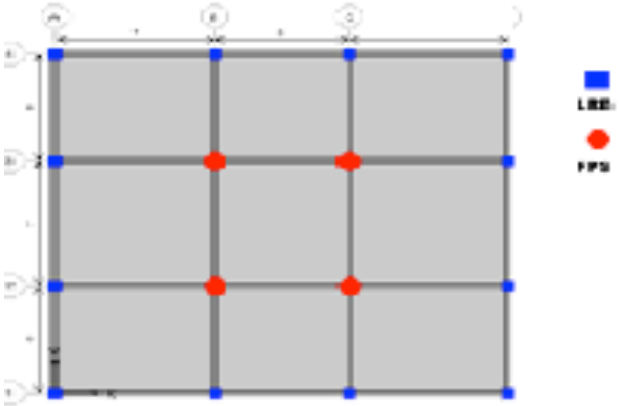
3. CASES STUDIES OF VARIOUS EMPLACEMENTS OF THE SEISMIC BASE ISOLATION



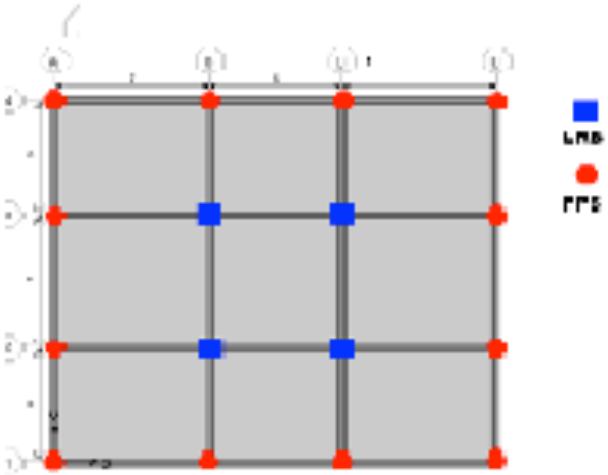
Structure with LRB system
(a)



Structure with FPS system
(b)



Structure with LRB system in outside and FPS system inside the structure
(c)



Structure with LRB system inside and FPS system outside
(d)

Figure 2. Various emplacements of the seismic base isolation

4. PARAMETERS OF THE SEISMIC ISOLATION SYSTEMS

The characteristics of the apparatuses of seismic isolation are indicated in the following tables:

Table 1. Characteristics of LRB system (Lead Rubber Bearing)

$K_v(KN/m)$	$K_{eff}(KN/m)$	$K_e(KN/m)$	$F_y(KN)$	α
2837175.94	1917.634	13151.916	150.467	0.1

Table 2. Characteristics of FPS system (Friction Pendulum System)

μ_{max}	μ_{min}	$K_v(KN/m)$	$K_{eff}(KN/m)$	$K_e(KN/m)$	$R(m)$
0.06	0.04	14403563.60	2696.35	79383.93	1.55

5. SEISMIC EXCITATION

A dynamic analysis of the response by time history is used for the three types of studied structures (at base fixes and base insolated, LRB, FPS, LRB+FPS and FPS+LRB). One considers an excitation of the Loma Prieta (October 17, 1989) recorded by the station Lexington Dam with a magnitude of 7.1 and maximum accelerations of the ground 0.442g and 0.409g respectively. The time histories of this excitation are represented on the following figures:

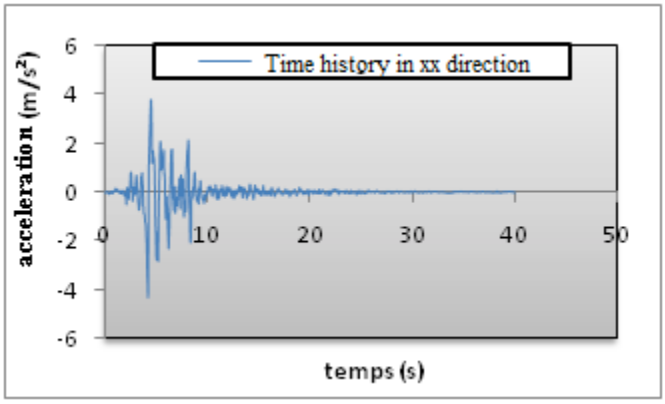


Figure 3. Time history of Lexington Dam of the seismic Loma Prieta In X direction

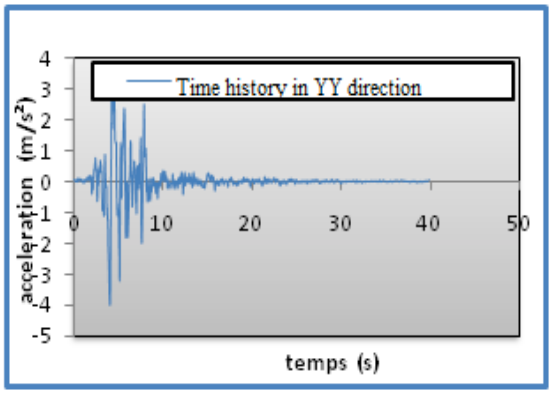


Figure 4. Time history of Lexington Dam of the seismic Loma Prieta In Y direction

6. COMPARISON OF THE RESULTS

6.1. Comparison "Fixed Base Structure / Base İsolated Structure (LRB)"

The dynamic analysis carried out for the two structures (fixed and isolated) enabled us to compare the results of displacements, accelerations of last level, and the base shears in the two directions (X) and (Y). These results are represented as follows:

6.1.1. Displacements

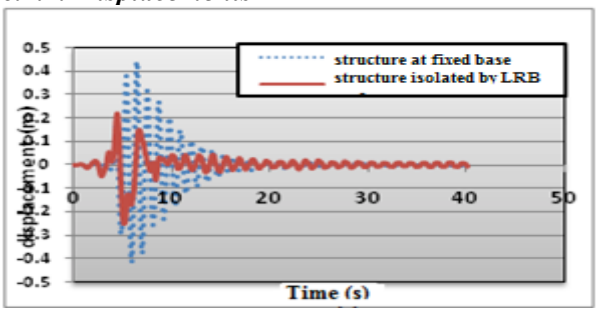


Figure 5. Comparison of displacements of structures of 10 levels in X direction

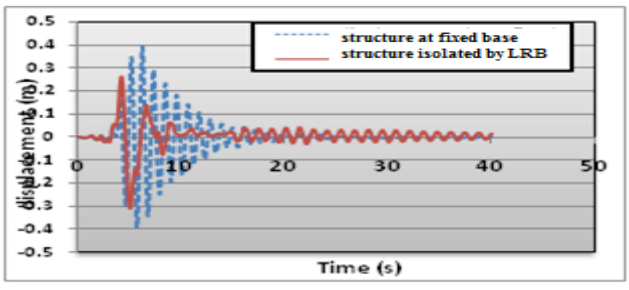


Figure 6. Comparison of displacements of structures of 10 levels in Y direction

According to the results obtained, the fixed base structure gives a significant displacement in the last levels compared to the base isolated structure with LRB system (Figure 5 and Figure 6). Moreover, the structure with base isolator (LRB) moves almost as one rigid block.

6.1.2. Accelerations

According to the results obtained in the (Figure.7 and Figure.8), one notices a reduction in accelerations in the LRB base isolated structure compared to the fixed base structure at the last level.

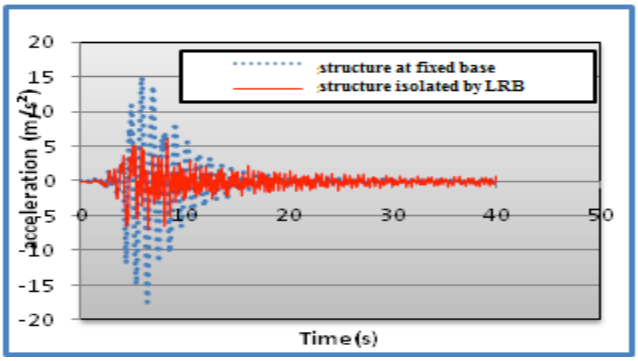


Figure 7. Comparison of accelerations of structures of 10 levels in X direction

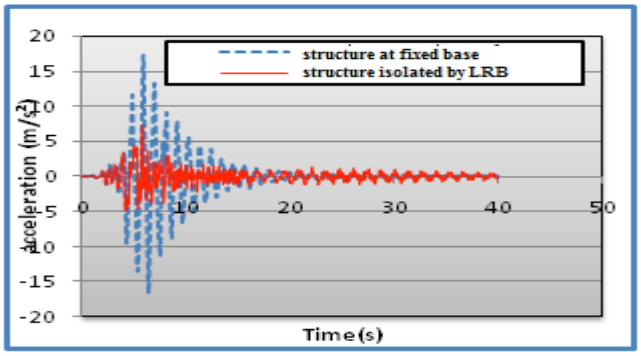


Figure 8. Comparison of accelerations of structures of 10 levels in Y direction

6.1.3. Base Shear Forces

According to the Figure 9 and Figure10, the comparison of the base shear forces for the two structures (fixed and isolated by LRB) in two directions X and Y, shows that the system of isolation reduces the base shear forces. This reduction is caused by the lengthening of the fundamental period.

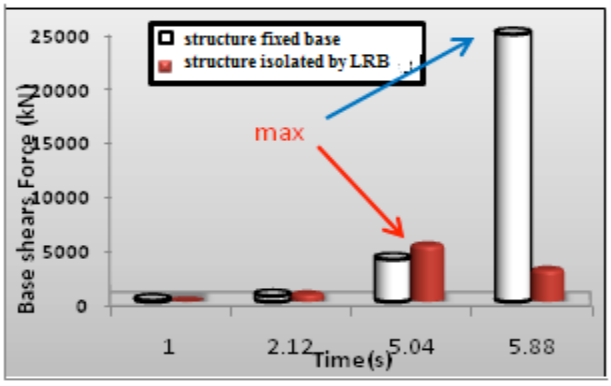


Figure 9. Comparison of the base shears force in X direction

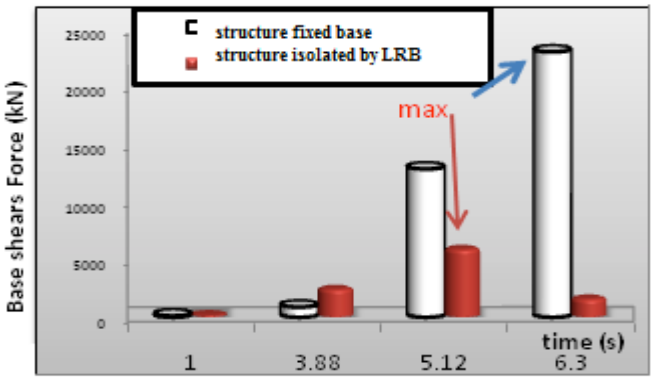


Figure 10. Comparison of the base shears force in Y direction

6.2. Comparison "Fixed Base Structure / Base İsolated Structure with FPS"

The dynamic analysis carried out for the two structures (fixed and isolated by FPS) enabled us to compare the results of displacements, accelerations of last level, and the base shears force in the two directions X and Y are as follows:

6.2.1. Displacements

According to the results, the Figure 11 and Figure 12 shows that the fixed base structure give a significant displacement in the last level compared to the base isolated structure with FPS system.

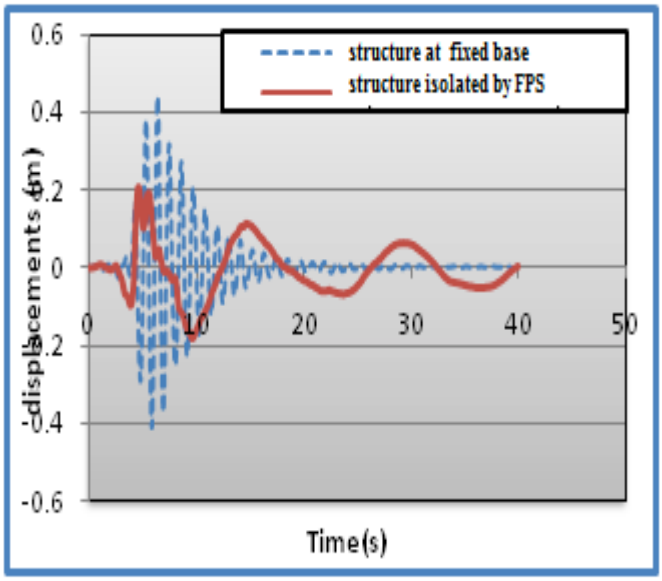


Figure 11. Comparison of displacements of structures of 10 levels in X direction

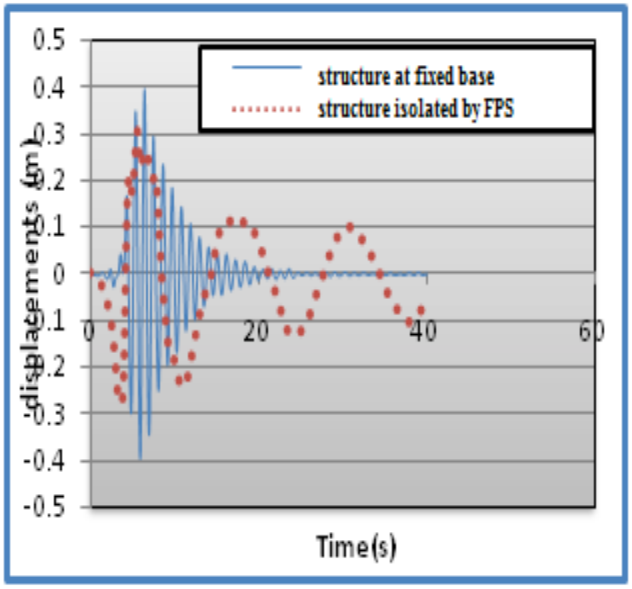


Figure 12. Comparison of displacements of structures of 10 levels in Y direction

6.2.2. Accelerations

According to the Figure13 and Figure14 one notices that accelerations are reduced for the isolated structures with FPS by contribution with the fixed base structure.

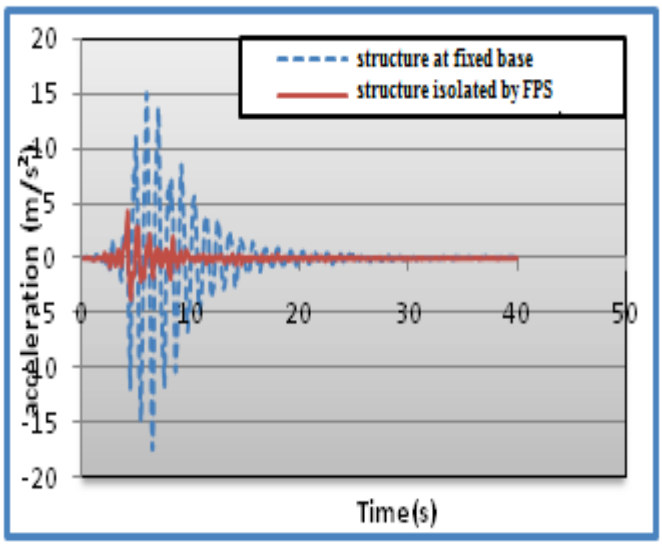


Figure 13. Comparison of accelerations of structures of 10 levels in X direction

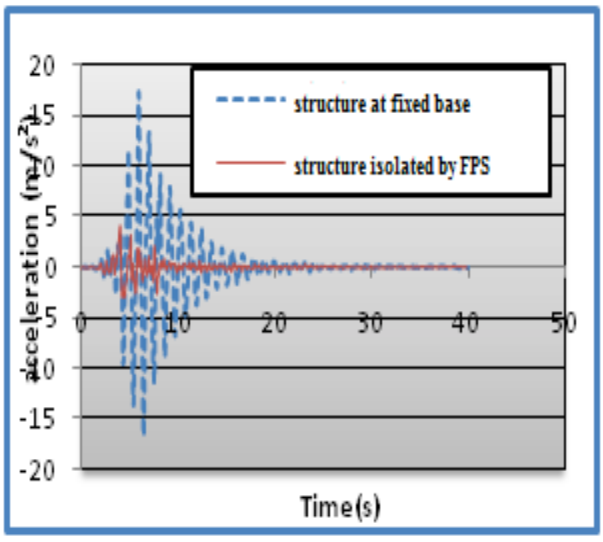


Figure 14. Comparison of accelerations of structures of 10 levels in Y direction

6.2.3. Base Shear Forces

The comparison of the base shear forces for the two structures (fixed and isolated by FPS) in two directions X and Y is represented on the Figure15 and Figure16.

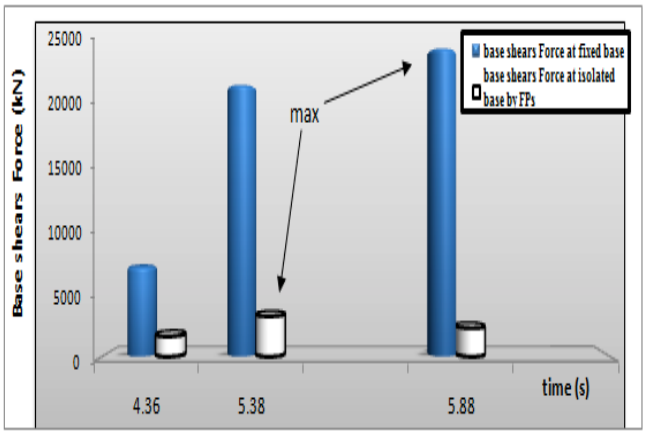


Figure 15. Comparison of the base shear forces in X direction

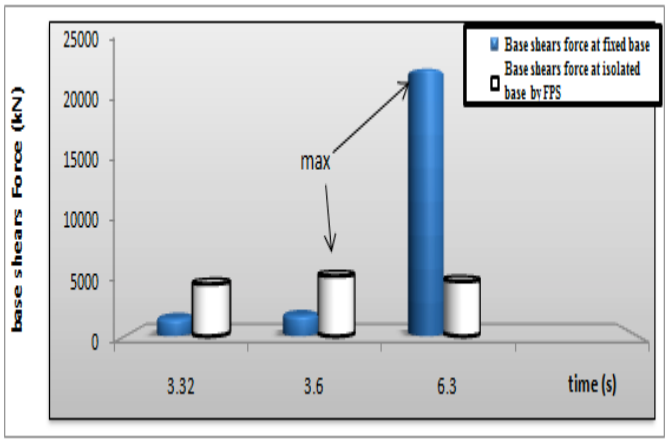


Figure 16. Comparison of the base shear force in Y direction

This result shows that the isolation system reduces the base shear forces because of the increase in the fundamental period.

6.3. Comparison of Various Emplacements of the Structures

6.3.1. Comparison of Displacements

According to the Figure 17, one notices that system FPS decreases displacement compared to the other systems.

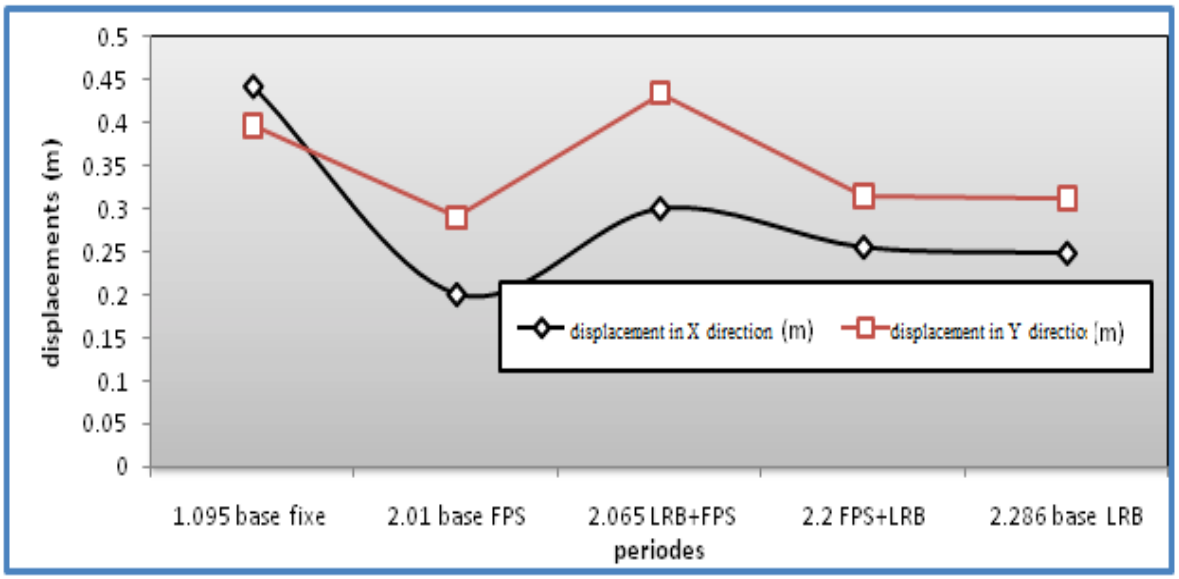


Figure 17. Comparison of displacements of last level according to the period of various emplacements

6.3.2. Comparison of Accelerations

According to the Figure 18, one notices that FPS system decreases accelerations compared to the other system.

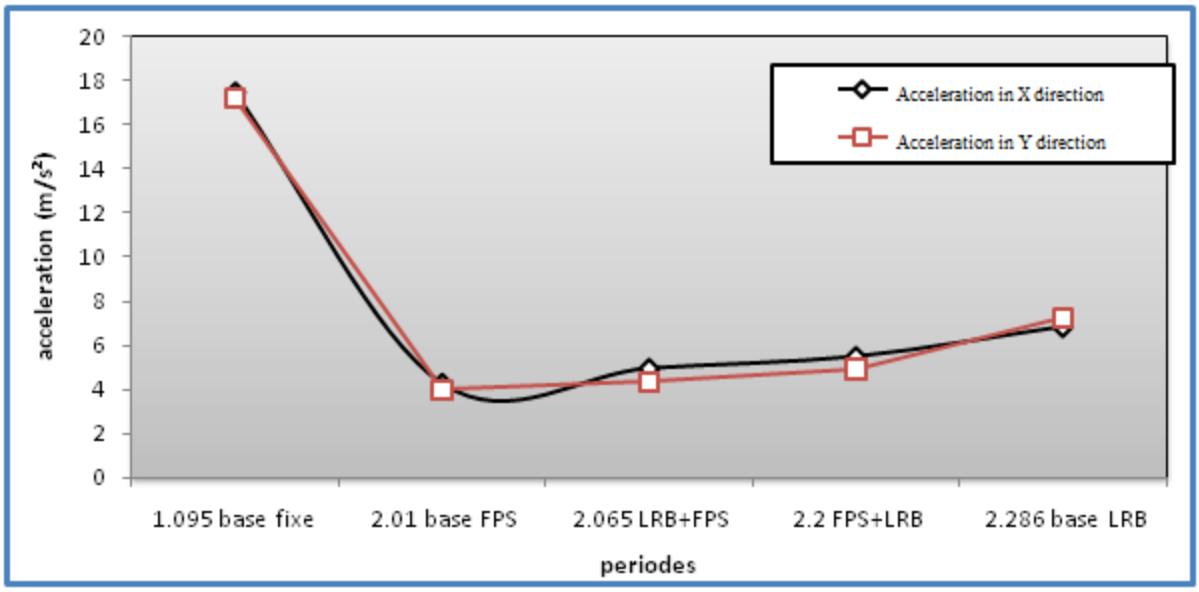


Figure 18. Comparison of acceleration of last level according to the period of various emplacements

6.3.3. Comparison of Base Shear Forces

According to the Figure 19, one notices that system FPS decreases the base shears force compared to the other systems:

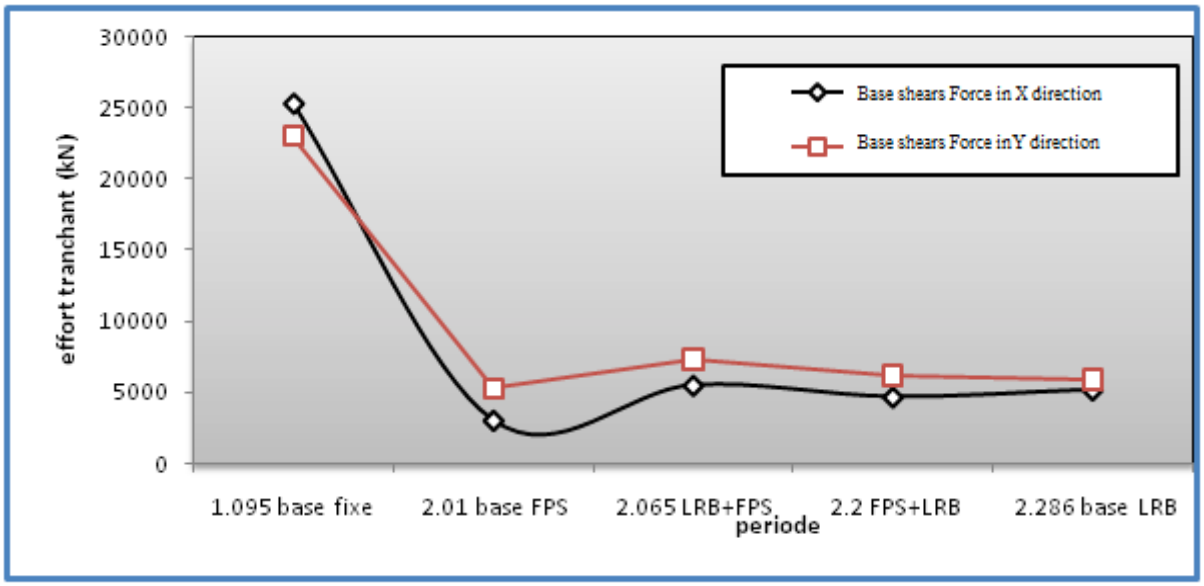


Figure 19. Comparison of base shears force according to the period of various emplacements

7. CONCLUSION

This analysis carried out by three comparative studies, the 1st between the fixed base structure and the base isolated structure (FPS and LRB) and the 2nd comparative study between two isolated structures, respectively LRB and FPS and the 3rd between two isolated structures with (FPS+LRB) and (LRB+FPS).

The 1st comparative study enabled us to deduce the following conclusions:

- The isolated structure moves on the supports like a rigid body
- The system of base isolation decreases the displacements, accelerations and base shear forces.

The 2nd comparative study enabled us to deduce the following conclusion:

- The isolated structure by FPS system decreases displacements, accelerations and shear forces compared to the structure isolated by LRB.

The 3rd comparative study enabled us to deduce the following conclusions:

- The periods are increased for the modes of the structure isolated by (FPS+LRB) combined system (see the plan view, case c) compared to the isolated structure with (LRB+FPS) combined system (see the plan view, case d)
- The isolated structure with (FPS+LRB) combined system decreases the displacements and shear force compared to the isolated structure with LRB system and isolated structure with (LRB+FPS) combined system.
- The isolated structure with combined (LRB+FPS) system decreases acceleration compared to the isolated structure with (FPS+LRB) combined system and the base isolated structure with LRB system.

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