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BASE ISOLATION OF ALLIED JOIN FORCE COMMAND HEADQUARTES NAPLES

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ABSTRACT

Seismic protection is a primary task for strategic structures such as military buildings, power stations, chemical and nuclear plants, hospitals; these structures must survive and be functioning during emergencies due to strong earthquakes.
In order to guarantee the previous task the seismic isolation technique has been adopted for the new allied command headquarters located in south Italy near Napoli.
The base isolation seismic protection technique allows the structure to function with no damage after major earthquakes with a negligible construction costs increase or even cost reduction in high intensity seismic areas.
This paper describes a general overview of the project and the adopted seismic protection devices provided by ALGA S.p.A.

1. INTRODUCTION

The main task of an optimal seismic isolation system is to minimize the acceleration into the structure limiting as much as is possible the relative displacement between the structure and the ground; in order to reach the previous goals the isolation system must be flexible in order to reach the target isolation period and capable to dissipate energy to reduce the response.
The strategy to obtain the previous performances for this project a combined base isolation system composed by high damping rubber bearings (HDRB) and hysteretic dissipators coupled with free sliding POT bearings has been adopted. The design follows the new Italian code for earthquake resistance structure design.
The combination of HDRB isolators and hysteretic dampers provides a very effective seismic protection system coupling the flexibility and the dissipation capacity of the rubber isolators with the high damping capacity of the hysteretic dampers.
The suitable location in plan of the devices allows the isolated structure to behave as a rigid

body that during earthquake is moving principally along the two main axis with undesidered torsion motions.
The structure is under construction by Società Italiana per Condotte d'Acqua and ALGA manufactures the bearings and tests them in its own and official laboratories according to the tests required by the code.
The designer of the structure is Dott. Arch. Prof. Mario Antonio Arnaboldi, professor at the Politecnico di Milano and member of the Studio Architetti Associati Arnaboldi & Partners - Milano.

2. STRUCTURE DESCRIPTION

The allied joint force command headquarters consists of different buildings isolated at the base, the seismic devices provide by ALGA S.p.A. are number 299 high damping rubber isolators (there are 4 types with different horizontal stiffness and vertical load capacity) and number 104 slider POT bearings equipped by hysteretic dampers (there are 2 types with different vertical load capacity).

Figure 1 General view of the headquarters

The isolation system is placed at the foundation level; the foundation plinths are connected each other by concrete beams in order to realize the rigid foundation plane while the isolated structure lays on a rigid concrete frame obtained by concrete beam with variable sections. The beams are realized by a precast concrete formwork (see the figures 4 and 5) that realizes the designed variable section, allows the positioning of the frame on the isolators and by inserting the reinforcement steel bars gives the final reinforced concrete supporting frame. This construction technique allows to lay the supporting beams directly on the seismic devices without any external formwork to be removed after the concrete pouring; the only tool to be removed is the very simple steel frame (see the figure 4) that is placed around each seismic devices to allow the positioning of beam precast formwork on them.

Figure 2 – View of the foundation frame on which the isolation devices have to be placed

Figure 3 View of the foundation level with some isolators already installed

Figure 4 Detail of the building base level laying on the isolation devices, the precast concrete formwork is used to realize the supporting beams to carry the structure and guarantee the suitable stiffness in the horizontal plane. On the left corner the simple steel frame to be placed around the seismic devices is shown

Figure 5 Detail of a beams joint on a rubber isolators; the steel reinforcements are inserted into the precast concrete formwork to obtain the reinforced concrete supporting beam

Figure 6 General view of the headquarters

3. SEISMIC ISOLATION DEVICES

The seismic protection devices manufactured by ALGA S.p.A. for this project are: high damping rubber bearings and slider POT bearing with hysteretic dissipators. The combination of the two types of devices allows a very effective reduction of the seismic effects on the structure and provides also an optimal recentering capacity given by the linear elastic response of the rubber isolators and also by the intrinsic recentering capability of the C shape steel dissipators.

3.1. High damping rubber bearing

The high damping rubber bearing are the most used and kwon isolation devices suitable for building and bridges. They allow to carry the isolated structure vertical loads, to obtain a flexible connection between structure and ground to reach the optimal isolation period and to dissipate energy thanks to a suitable rubber compound. The isolators have a very high durability and they are designed to be replaceable if required.
The rubber compound used for this project is the Algasism SOFT, the main properties of the isolators are:

- rubber G modulus = 0.4 Mpa
- damping = 10 %

- design displacement = 250 mm, the stress checks are done with a safety factor 1.2 (so 300 mm) as required by the Italian code
- diameters from 700 to 900 mm

The summary of the high damping rubber isolators used in the project is shown in the table 1.

Table 1 – Summary table of HDRB devices

Device	diameter	number
B	700	87
C	800	133
D	900	68
E	900	11

Figure 7 HRDB isolator installed on the foundation

The bearings have been tested both in the ALGA own laboratory and also at the EUCENTRE test facility at the University of Pavia, part of the tests were endorsed by Politecnico of Milano.

3.2 Slider POT bearing with hysteretic dampers

The hysteric devices are obtained by the combination of POT slider bearings to carry the vertical load and hysteretic steel dissipators for the response in the horizontal plane. The hysteretic dissipators acts as force control devices: they react as an elastic component up to a defined displacement and they work with a plastic reaction with predefined maximum reaction force if the displacement exceeds the elastic one. In this way is possible to limit the horizontal force in a defined support of the structure and to dissipate a lot of energy in case of earthquake excitation.
The hysteric dissipators, patented by ALGA S.p.A., have been deeply investigated and applied in many projects and the design is made according to the theory shown in the paper 1. The hysteretic dissipators are made of high ductility steel and are capable to allow great displacement with an high dissipation over 60%.

The main properties of POT slider bearing with hysteric dampers are:

- vertical load capacity 3000 kN and 4000 kN
- design displacement = 250 mm, the stress checks are done with a safety factor 1.2 (so 300 mm) as required by the Italian code
- maximum horizontal reaction force = 175 kN

The summary of the hysteretic devices used in the project is shown in the table 2.

Table 2 – Summary table of the POT sliders with hysteretic dissipators

Device	V load (kN)	number
A1	3000	86
A2	4000	18

Figure 8 POT slider bearings with hysteretic C-shape dampers

The hysteretic steel dissipators have been tested by the dynamic test machine of the ALGA laboratory using a suitable test frame shown in the figure 9. The test is performed using two couples of dissipators and during the test two are subjected to compression force and two to tension simultaneously in order to obtain a symmetric hysteresis response curve to reproduce the real configuration of the bearing where 4 hysteretic elements are used. In the bearing one side of the C-shape dissipator is fixed to the bearing lower sliding plate and the other is connected to the bearing central body that is fixed to the superstructure; in this was during the motion two dissipators are compressed and two tensioned to have a global symmetric response curve.

Figure 9 Steel frame and hysteretic C-shape dissipators for the laboratory test

Figure 10 Tests on C-shape dissipators at full stroke of 300 mm in both directions

4. CONCLUSIONS

The papers showed the seismic protection system for a strategic headquarters of military forces; the use of the base isolation technique allows the structure to survive being operative to high intensity earthquakes with return period at least of 475 years according to the Italian seismic code.

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