Replaceable Building Base Isolation

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Summary

There is an increasing demand for Building Base Isolation (BBI). Buildings are being built closer to railways, tramways and metro lines since only the more difficult areas in cities are still at disposal for new constructions, while at the same time higher comfort levels - with respect to noise and vibrations - need to be met for people living and/or working in these buildings. When a building base isolation system is installed at the foundations of a new building, it is recommended to have access to it in order to monitor its well-functioning over time, and to be able to replace the isolators when necessary (e.g. in case of a fire, explosion, flooding, overloading, etc.). Up to now, replacement was only possible through the use of large precompressed steel boxes containing springs or rubbers. However, this paper and related presentation brings an alternative method for replacing "Very-High-Stress" rubber bearings (VHS) using the "frozen bearing technology" (FBT), which was recently developed by CDM. This technology has already been applied meanwhile at some occasions, like in a new building complex in Nijmegen (NL), showing its functionality.

1. Introduction

The increasing demand for BBI ("Building Base Isolation") is related with the increasing comfort requirement of the people occupying the building, regarding noise & vibrations generated by nearby train traffic for instance. In such cases the building foundations are cut with a BBI system typically resonating at 10Hz: railway noise & vibrations generate energy mainly between 50 and 100Hz, so a filter at 10Hz is usually sufficient to decrease the reradiated noise & vibrations towards an acceptable level of comfort (fexc / fres = β > 5).

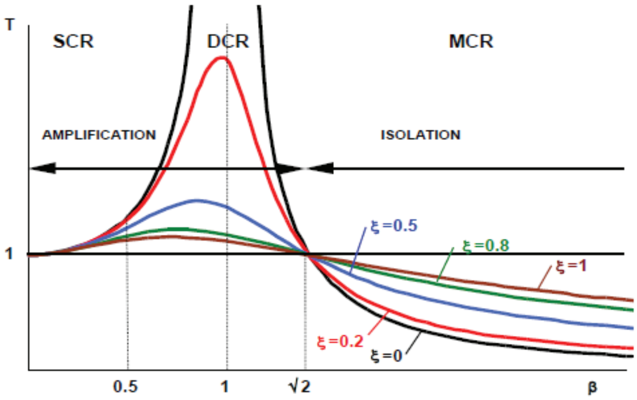

Figure 1. The transmissibility (T) graph for a mass-spring-damper system

A resonance frequency of 10Hz can be reached using rubber bearings (PS: springs are only used for very critical situations, i.e. when the required fr < 5Hz).
It is recommended to have access to all isolating elements of the BBI system for monitoring its well-functioning over time, but more in particular to be able to replace elements when damaged (e.g. in case of fire, explosion, overloading, flooding, seism, etc.). So far, this replaceability was only possible through the use of large precompressed boxes containing rubber or springs...

2. Replaceable BBI through FBT

Briefly explained, the FBT ("Frozen Bearing Technology") allows a rubber bearing to be maintained in a precompressed state (realized in a lab) by keeping its temperature at -79°C, well below the glass transition temperature Tg. The precompressed bearing can be transported to the construction site in a coolbox and introduced into the BBI cut, where it will gradually take over the building load when its temperature increases to the ambient temperature.

3. Lab testing

Several lab test campaigns have been carried out on resilient materials for BBI applications in order to validate the FBT: static and dynamic stiffness tests, tensile strength tests, height recuperation tests, etc. were launched to compare the material characteristics before and after precompression through deep-freezing. Practically no differences were registered, validating the well-functioning of the proposed technology.

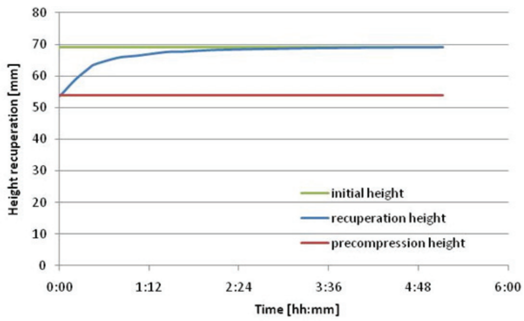

Figure 2. Height recuperation test on CDM-82

4. Project "Poppodium Doornroosje - Talia" in Nijmegen (NL)

This complex is situated near the central railway station of Nijmegen (NL) and consists of 3 parts: a high building ("Talia") with 15 levels, which is residential, a large polyvalent hall for large cultural events (1100p), and also a smaller polyvalent room for smaller events (400p). Both halls are referred to as "Doornroosje".

Figure 3. View on the complex

The chosen BBI system for this complex was of the type CDM-VHS ("Very-High-Stress"), i.e. discrete bearings made of 4 high-stress rubber layers of 20mm thick each, all separated by somewhat larger plates in 5mm galvasteel, in order to reach a resonance frequency of approx. 10Hz under the "Acoustical Design Load" (in this case ADL = G) of about 12N/mm² = 12MPa.

Figure 4. CDM-VHS bearing with 4 rubberlayers

For the high building, these CDM-VHS elements have been installed at the column heads, leaving always a central part open in such a way that there exists the possibility to introduce a hydraulic jacking device for blocking further deflection of the building in case one or more CDM-VHS elements would need to be replaced (e.g. in case of a fire, explosion, flooding, overloading, seism, etc.). In addition, all CDM-VHS elements (also for the 2 halls) have been installed on top of a separate stiff package made of 3 glued layers of 18mm thick high-dense fiber-cement board.

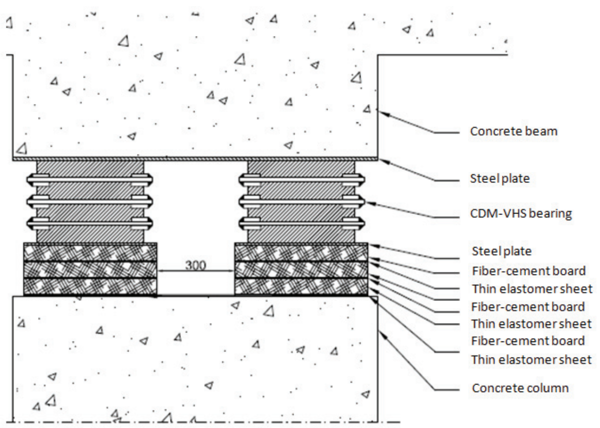

Figure 5. Schematical section of the BBI setup for the high building ("Talia")

In case replacement would be needed of one or more CDM-VHS elements, the fiber-cement package is drilled away sideways without damaging the structural concrete (after of course having structurally blocked that part of the building to prevent any deflection when taking away one or more bearings). This blocking can be done through the use of steel studs installed sideways (for the halls) or hydraulic jacks (for the high building).

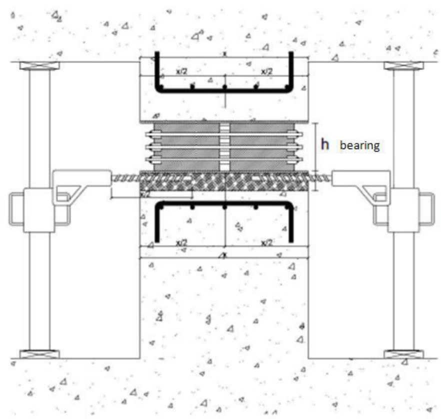

Figure 6. Drilling away the fiber-cement package after placing studs to block the deflection of the building

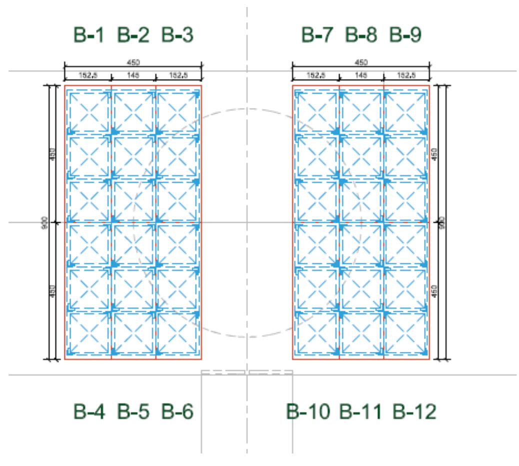

Figure 7. Layout plan for a column of the high building, showing the individual VHS bearings

The existing isolator element can be taken out and replaced by a new element, which must be in a state of precompression, realized via the FBT ("Frozen Bearing Technology", developed by CDM in 2009). Next, the blocking (studs or jacks) can be removed. This technique was successfully applied at the end of the construction phase of the concerning building, when some CDM-VHS bearings had to be moved for rather practical reasons.

Figure 8. Picture of the installed frozen VHS bearings

5. BBI for existing buildings

The FBT could also be used to insert a BBI system under existing buildings that suffer from excessive vibrations. This is however only possible in case of simple structures based on columns with a minimized number of loadbearing walls (e.g. the core walls). In that case one could treat one column after another until the entire building is treated. In such a process, the concerning column is first foreseen with studs to take over the load so that the column can be cut completely without stability risk. The cut must be made sufficiently spacious for the installation of FBT-precompressed VHS bearings, which take over the load as soon as they have warmed up to the ambient temperature. The studs can be removed then and a next column (or wall) can be treated.

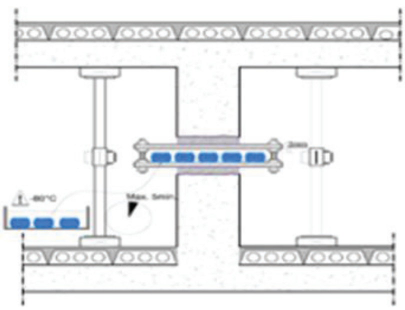

Figure 9. Sectional view on a cut column

The FBT allows inserting a BBI system without any deflection of the existing building thanks to the unique precompression method.

6. Conclusions

This paper presents a specific technique that allows replacing BBI bearings based on very-high-stress rubber in a straightforward manner, making use of the "Frozen Bearing Technology". This means that the rubber is frozen in a precompressed state at a temperature of -79°C, well below the glass transition temperature Tg. This technology could possibly be used as well for inserting a BBI system in existing buildings with a simple structure.