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The Challenges of placing 67T Stand-by Generators on the Roof of a Long Span Commercial Structure

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ABSTRACT

It is becoming increasingly common for mechanical equipment to be placed on the roofs of buildings rather than in the basement. However because modern commercial and residential buildings are becoming more lightweight, and clear uninterrupted space is an important architectural requirement, this can present difficulties in relation to noise and vibration transmission.

This paper studies the acoustic challenges of a project where very heavy stand-by generators were placed on the roof of a long-span commercial structure.

1. RIVERBANK HOUSE

Riverbank House is a new 10-storey office development on the north bank of the River Thames in between Southwark Bridge and London Bridge.

Figure 1: *Picture of Riverbank House taken in November 2009*

The main contractor on this project had experienced problems on a very similar structure which had resulted in a very costly exercise. In the Riverbank House project it was decided that they needed to ensure that the solution worked well as the cost of solving the problem on site would run into multiple millions of pounds. It was for this reason that the main contractor insisted on an off-site test.

The roof structure consists of 14m span steel beams spanning from the central cores to the external columns. These beams support metal decking and composite reinforced concrete floors. The natural frequency of the supporting beams is 7-8Hz.

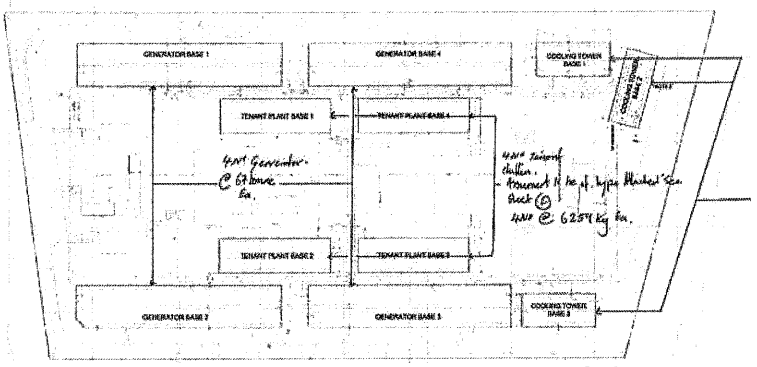

Figure 2: *Plan of Roof showing locations of Plant*

The 67T stand-by generators are supported on 8Hz elastomer bearings inside a steel container with noise attenuation at each end. The container then sits on top of a 150mm thick reinforced concrete floating floor supported on elastomer bearings.

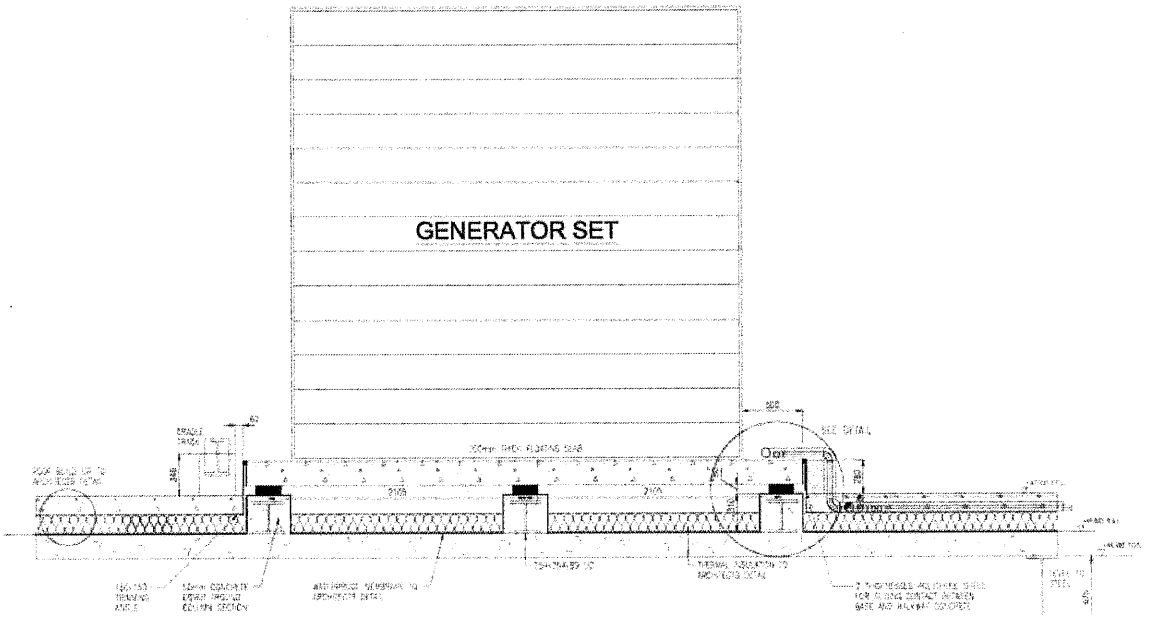

Figure 3: *Section through Generator Container and Floating Slab*

2. ACOUSTIC ISSUES

The main running speed of the diesel stand-by generators is 25Hz and to achieve the required attenuation a natural frequency of 8Hz was specified. However this raised significant concerns over what would happen during the start up of the diesel engine as it passed through 8Hz: structure = 8Hz; elastomer bearings under generator = 8Hz; elastomer bearings under floating slab = 8Hz.

To avoid this triple coincidence the specification for the bearings beneath the floating slab was changed to between 11-12Hz. To achieve this we needed to provide a high performance 30mm thick bearing with a controlled deflection of ~3mm.

Due to the low deflection required this raised a question of the deflection of the roof slab when the floating slabs and generator containers were placed on the roof. The differential deflections were calculated as follows:

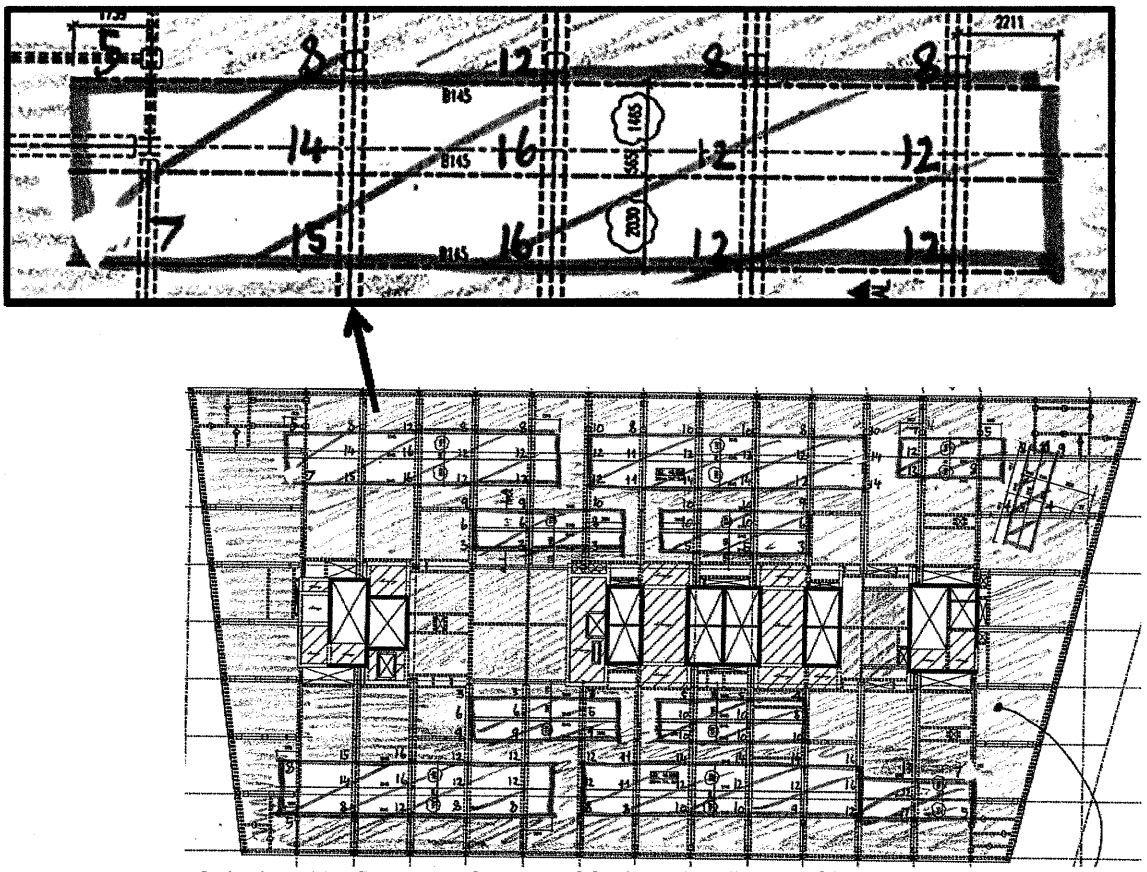

Figure 4: *Calculated Deflections of the Roof Slab under Floating Slab + Plant Loadings*

The assumption was that the floating slab with the generator container on top would be infinitely stiff therefore the bearings would have to be able to cope with a differential deflection of ±5mm. Therefore to achieve a maximum natural frequency of 12Hz the bearings were designed to a deflection (assuming an infinitely stiff foundation slab) of 8mm. Under a differential deflection of ±5mm the bearings as a worst case would have a range of

3mm to 13mm deflection = 8Hz to 12Hz, which again raised the potential perceptible vibration problem at 8Hz during start-up.

As the generator container had to have an off-site acoustic test to ensure that the sound insulation of the box and attenuation was sufficient to meet the project requirements it was decided that a test floating slab was built to allow vibration measurements to be taken.

3. OFF-SITE TEST

A site was found in Leicestershire where the off-site testing could take place.

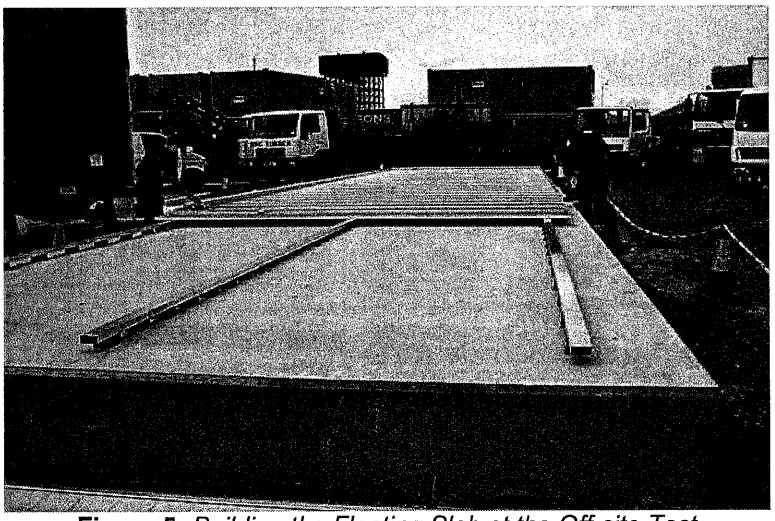

Figure 5: *Building the Floating Slab at the Off-site Test*

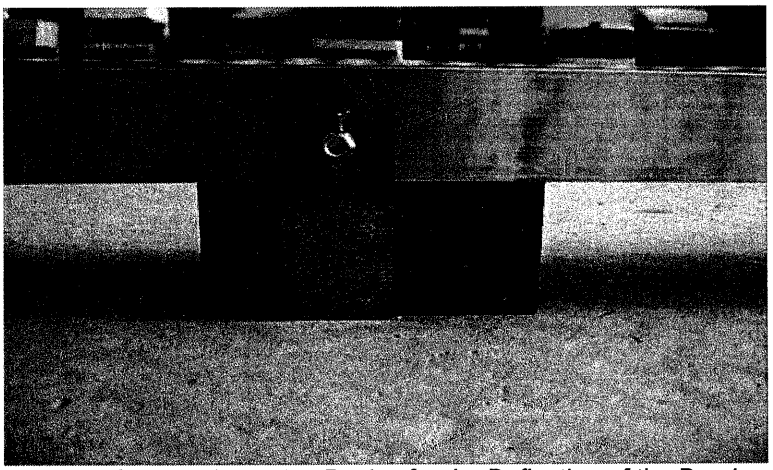

Figure 6: *Simple Measuring Device for the Deflection of the Bearings*

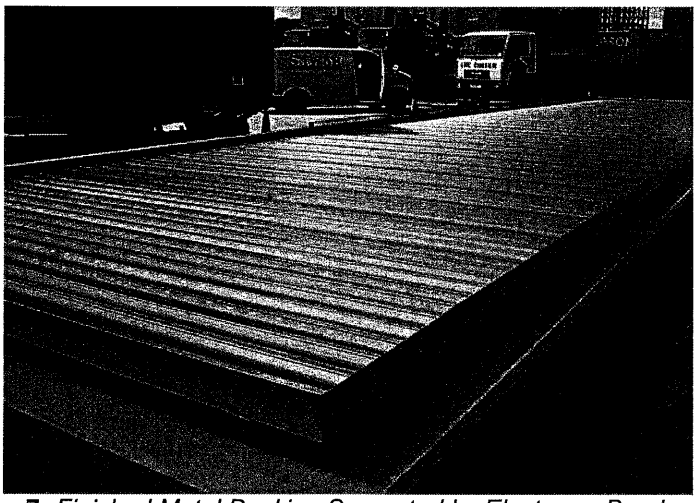

Figure 7: *Finished Metal Decking Supported by Elastomer Bearings*

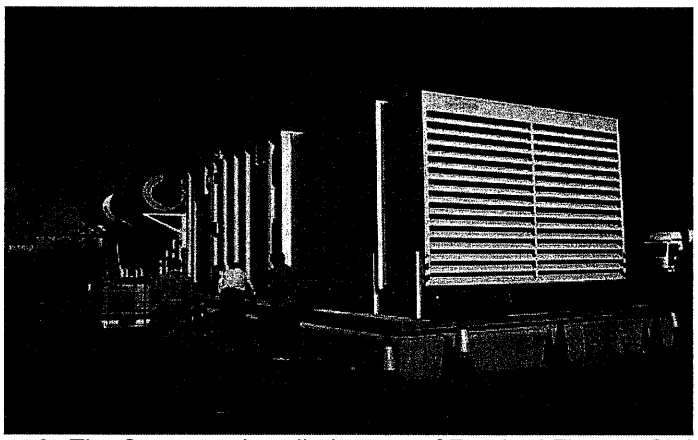

Figure 8: *The Generator Installed on top of Finished Floating Slab*

Figure 9: *Vibration Measurements*

Detailed vibration measurements were taken above and below the Floating Slab and these were analysed by a structural dynamics expert. The results indicated there would not be a problem on the main installation of Riverbank House.

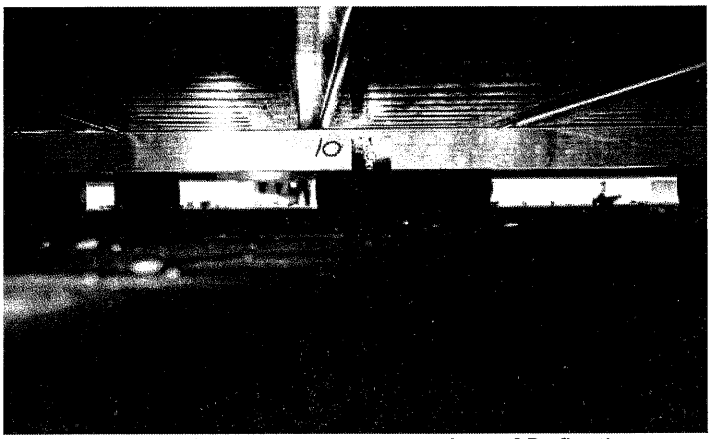

Figure 10: *Measurements were taken of Deflections*

Measurements were taken of the deflections and it was found that the container was not infinitely stiff and higher deflections were seen directly underneath where the generator itself was located. This enabled us to adapt the design to have a stiffer support underneath the generators.

4. ON SITE INSTALLATION

4 no. floating slabs were installed for the 4 no. generators, 4 additional slabs for the tenant plant and 3 for the chillers.

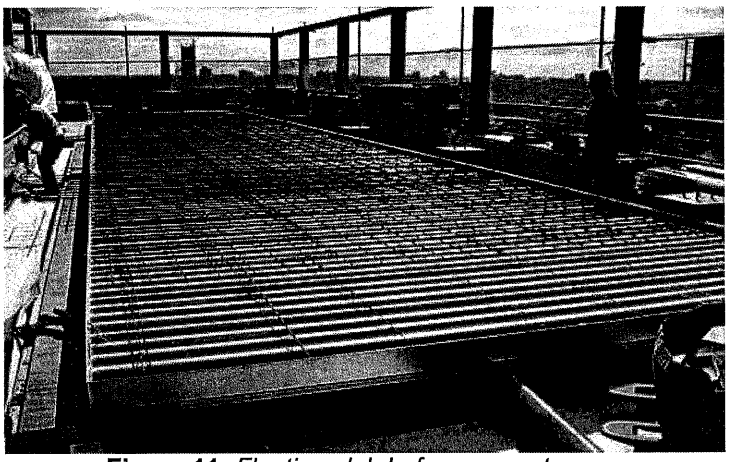

Figure 11: *Floating slab before concrete pour*

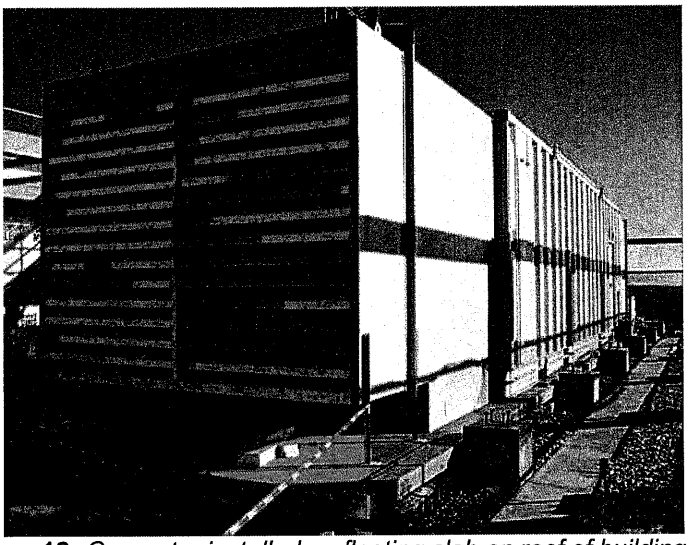

Figure 12: *Generator installed on floating slab on roof of building*

Testing was carried out when the generators were running and there were no issues with perceptible vibration or instructive noise from the generators.

5. CONCLUSIONS

As a supplier of vibration isolation systems we have learnt the following from this job:

- Take into consideration the deflection of the structure you are placing the floating slab and plant on
- Try not to match the natural frequencies of other resonating structures or isolators
- Involve dynamics specialists if there is doubt over performance of the structure under the imposed dynamic loads
- Get accurate loading information from the structural engineer
- do not assume that loads are evenly distributed over large areas and thought needs to be given as to how this is dealt with in-situ

ACKNOWLEDGMENTS

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