

SPAN LIMITATIONS

Floor Vibrations - Rhythmic Activity

Earlier Research Notes resulted from tests conducted on Spancrete® hollowcore sections. This issue is presented as an empirical guide to analyze floor vibrations caused by a specific type of activity.

Floor vibrations due to rhythmic activities, such as aerobics or dancing, have long been a problem in steel construction. There have been few problems in precast concrete construction, but as spans get longer, questions occasionally arise. Here are the required steps to evaluate a Spancrete floor system for vibration performance.

Step 1. Determine the activity causing the vibration and the activity of the occupants affected by the vibration.

Step 2. Calculate the natural frequency of the floor plank.

$$f_o = \frac{0.74}{L^2} \sqrt{\frac{EI}{wb}} \quad \text{where } L = \text{span, ft.} \quad E = \text{modulus of elasticity, psi}$$

(for simple spans only) $I = \text{slab moment of inertia, in.}^4$ $b = \text{slab width, ft.}$
 $w = \text{uniform slab weight, psf}$

Step 3. Establish the acceptable acceleration based on the activity of the affected occupants. A sample table is given with a design example on the reverse side.

Step 4. Determine the factors required based on the activity causing the vibrations. A sample table of functions is given with a design example on the reverse side.

Step 5. Calculate the minimum required natural frequency.

$$f_{omin} = f_i \sqrt{\left(1 + \frac{k}{a_o/g} \text{DLF} \frac{w_p}{w} \right)} \quad \text{where } f_{omin} = \text{minimum floor natural frequency}$$

$f_i = \text{forcing frequency from activity}$
 $k = \text{factor for modes of vibration}$
 $\text{DLF} = \text{dynamic load factor}$
 $w = \text{weight of participants plus floor}$

$a_o/g = \text{acceptable acceleration}$
 $w_p = \text{weight of participants}$

Step 6. Compare results. The floor plank will be acceptable if the natural frequency provided as determined in Step 2 is greater than that required from Step 5.

Note: The support system can have a significant influence on performance, and may require a separate analysis. This presentation assumes a rigid support, such as a wall bearing structure. See RESEARCH NOTE "Floor Vibrations - Spancrete on Flexible Supports" for additional information.

A design example is given on the reverse side.

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GIVEN:

| Acceptable Acceleration | |
|-------------------------|-------------------|
| Affected Occupancy | a _o /g |
| Office & Residential | 0.004 to 0.007 |
| Dining | 0.015 to 0.025 |
| Weightlifting | 0.015 to 0.025 |
| Rhythmic Activity | 0.040 to 0.070 |

Forcing Functions

| Activity | w _p | f _i | k | DLF |
|----------|----------------|----------------|-----|---------------------------------|
| Dancing | 12.5 psf | 1.5 to 3.0 | 1.3 | 0.2 to 0.5 |
| Aerobics | 4 psf | 2 to 2.75 | 2.0 | 1.5 (1 st harmonic) |
| | | 4 to 5.5 | 2.0 | 0.6 (2 nd harmonic) |
| | | 6 to 8.25 | 2.0 | 0.1 (3 rd harmonic) |
| Stadium | 30 psf | 3 | 1.3 | 0.25 (1 st harmonic) |
| | | 5.5 | 1.3 | 0.05 (2 nd harmonic) |

PROBLEM:

Determine if 8" Spancrete® hollowcore with a unit weight of 60 psf will result in acceptable vibrations on a 22 ft. span with aerobics as both the forcing function and the response occupancy.

SOLUTION:

Step 1. Aerobics, in this case, is both the causal and affected activity.

Step 2. The natural frequency provided is

$$f_o = \frac{0.74}{L^2} \sqrt{\frac{EI}{wb}} = \frac{0.74}{(22^2)} \sqrt{\frac{4300000(1730)}{60(4)}} = 8.51 \text{ Hz}$$

Step 3. Use a_o/g = 0.055 as acceptable vibration (midrange in table for this activity)

Step 4. From the Forcing Functions table use: f_i = 2.5, 5, 7 for the 1st, 2nd, and 3rd harmonics
 k = 2.0 DLF = 1.5, 0.6, 0.1 for the 1st, 2nd, and 3rd harmonics w_p = 4 psf (thus w = 64 psf)

$$f_{omin} = f_i \sqrt{\left(1 + \frac{k}{a_o/g} \text{ DLF} \frac{w_p}{w}\right)} \quad \text{1st harmonic } f_{omin} = 2.5 \sqrt{\left(1 + \frac{2.0}{0.055} (1.5) \frac{4}{64}\right)} = 5.25 \text{ Hz}$$

Similarly, calculate

| | |
|--------------------------|-----------------------------|
| 2 nd harmonic | f _{omin} = 7.69 Hz |
| 3 rd harmonic | f _{omin} = 7.75 Hz |

Conclusion: The natural frequency provided, 8.5 Hz, is greater than that required in all three harmonics. Therefore, 8" Spancrete will provide an acceptable floor.

Note: Sample calculations are intended to illustrate the concept presented and do not represent all considerations necessary for the complete design.

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Precast Midwest, Inc.
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Spancrete Industries, Inc.
Waukesha, Wisconsin

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Camlica-Istanbul, Turkey

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Products LLC
Abu Dhabi, UAE

MACHINE

MANUFACTURER
Spancrete Machinery
Corporation

N16 W23415 Stoneridge Drive
Waukesha, WI 53188
Telephone: 414-290-9000
Fax: 414-290-9130
www.spancrete-machinery.com

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| | |
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