SPANCRETE MANUFACTURERS ASSOCIATION

RESEARCH NOTES

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.

$$f_o = \frac{0.74}{L^2}\sqrt{\frac{EI}{wb}}$$

(for simple spans only)

where L = span, ft.
I = slab moment of inertia, in.^{4}
w = uniform slab weight, psf
E = modulus of elasticity, psi
b = slab width, ft.

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.

$$f_{omin} = f_i\sqrt{\left(1 + \frac{k}{a_o/g}\, DLF\, \frac{w_p}{w}\right)}$$

where f_{omin} = minimum floor natural frequency
f_i = forcing frequency from activity
k = factor for modes of vibration
DLF = dynamic load factor
w = weight of participants plus floor
a_o/g = acceptable acceleration
w_p = 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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DESIGN EXAMPLE

SPAN LIMITATIONS

Floor Vibrations - Rhythmic Activity

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 (1st harmonic)
		4 to 5.5	2.0	0.6 (2nd harmonic)
		6 to 8.25	2.0	0.1 (3rd harmonic)
Stadium	30 psf	3	1.3	0.25 (1st harmonic)
		5.5	1.3	0.05 (2nd 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)

$$f_{omin} = f_i\sqrt{\left(1 + \frac{k}{a_o/g}\,DLF\,\frac{w_p}{w}\right)}$$

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

2nd harmonic $f_{omin} = 7.69\text{Hz}$

3rd harmonic $f_{omin} = 7.75\text{Hz}$

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.

MIDWEST
Hanson Structural Precast Midwest, Inc.
Maple Grove, Minnesota

Spancrete, Inc.
Green Bay, Wisconsin

Spancrete Industries, Inc.
Waukesha, Wisconsin

Spancrete of Illinois, Inc.
Arlington Heights, Illinois

Wells Concrete
Wells, Minnesota

WEST
Hanson Structural Precast Pacific, Inc.
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KIE-CON
Division of Kiewit Pacific Co.
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Armenia, China, Denmark, Guatemala, Hungary, Ireland, Japan, Russia, South Korea, Switzerland

Spancrete® hollowcore is a registered trademark

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