Chapter 3
Cost of Composite and Non-Composite Floors

3.1 Overview

In recent years, composite construction has been used to improve cost efficiency by reducing structural weight and in some cases by reducing story height. However, vibration problems are a design consideration in composite floors because lighter floors tend to be more lively. It is not clear if cost savings can be obtained with hot-rolled section composite construction when floor vibration serviceability controls the design.

To compare the cost of composite and non-composite floors that satisfy the AISC/CISC Design Guide criterion for walking excitation, four typical size bays were analyzed: 28 ft x 40 ft, 30 ft x 40 ft, 30 ft x 30 ft, and 40 ft x 40 ft. For each bay, beam spacing, hot-rolled beam and girder depths, floor acceleration, and other parameters were assigned acceptable values. Table 3.1 shows these parameters. Using the design software SDI FLOOR (Elhouar and Murray 1993), which checks the various parameters and the vibrations criteria, all acceptable bay configurations of member sizes and spacing were evaluated for least non-composite cost, and then least composite cost. Acceptable vibration levels were also checked with the design software FLOORVIB2 (Elhouar and Murray 1994).

Three separate trials were conducted using the above procedure. Varying between the trials, were the initial dead load deflection limit and the unit stud cost. Trial 1 evaluations had an initial dead load deflection limit of L/360 and a unit stud cost of $1.25. The initial dead load deflection of Trial 1 is based on the assumption that the members are not cambered. Trial 2 evaluations had an initial dead load deflection limit of L/240 (camber assumed) and a unit stud cost of $1.25. Trial 3 is with an initial dead load deflection limit of L/240 (camber assumed) and a unit stud cost of $2.25. Table 3.2 shows these trial specific parameters.

Table 3. 1—SDI FLOOR Evaluation Parameters

Concrete		Design Loads	
f'_c	4 ksi	Live	50 psf
Weight	145 pcf	Partition	20 psf
Steel		Mechanical	5 psf
Type	A572 Gr 50	Ceiling	3 psf
Cost	$0.25/lb	Construction	20 psf
Shear Studs		Deck	3 psf
Length	3.5 in	Vibration Loads	
Diameter	0.75 in	Live	11 psf
F_u	60 ksi	Dead	4 psf
Cost	(per Table 3.2)	Maximum Deflections	
Member Size and Spacing		Live Load	L/360
Min. Beam Spacing	60 in.	Dead Load	L/360
Max. Beam Spacing	102 in.	Initial Dead Load	(per Table 3.2)
Beam Depth	L/24 +/- 3 in.	Miscellaneous	
Girder Depth	L/24 +/- 3 in.	Construction Type	Unshored
Concrete Depth	5.25 in.	Load Combination	1.2 D + 1.6 L
Deck Height	2 in.	Live Load Reduction	ASCE 7-88
		Min. Composite Action	25%

Table 3. 2—Trial Specific Parameters

	Initial DL Deflection	Stud Cost ($/stud)
Trial 1	L/360	$1.25
Trial 2	L/240	$1.25
Trial 3	L/240	$2.25

3.2 Results

The least expensive composite and non-composite bay configurations are shown in Tables 3.3-3.6. The tables, grouped by bay size, contain the results of the three trials.

Table 3. 3—28 ft x 40 ft Bay Results

Trial	Const. Type	Longer Members	Bay Cost ($)	Beams	Percent Composite Action	Number of Beams	Beam Spacing (in.)	Beam Panel Freq. (Hz)	Girders	Percent Composite Action	Girder Panel Freq. (Hz)	System Natural Freq. (Hz)	Combined Mode a_p/g
1	NC	Girder	**$1,850**	W14 x 26	-	4	96	6.94	W24 x 94	-	5.00	4.06	0.37%
	C	Girder	**$1,948**	W14 x 26	33.9%	4	96	6.94	W24 x 94	26.3%	5.00	4.06	0.37%
2	NC	Girder	**$1,750**	W14 x 26	-	4	96	6.94	W24 x 84	-	4.74	3.91	0.39%
	C	Girder	**$1,538**	W12 x22	40.2%	4	96	5.92	W24 x 68	25.9%	4.30	3.48	0.46%
3	NC	Girder	**$1,750**	W14 x 26	-	4	96	6.94	W24 x 84	-	4.74	3.91	0.39%
	C	Girder	**$1,608**	W12 x22	40.2%	4	96	5.92	W24 x 68	25.9%	4.30	3.48	0.46%

Table 3. 4—30 ft x 40 ft Bay Results

Trial	Const. Type	Longer Members	Bay Cost ($)	Beams	Percent Composite Action	Number of Beams	Beam Spacing (in.)	Beam Panel Freq. (Hz)	Girders	Percent Composite Action	Girder Panel Freq. (Hz)	System Natural Freq. (Hz)	Combined Mode a_p/g
1	NC	Girder	**$1,915**	W16 x 26	-	4	96	6.56	W24 x 94	-	4.84	3.90	0.37%
	C	Girder	**$2,019**	W16 x 26	33.9%	4	96	6.56	W24 x 94	26.3%	4.84	3.90	0.37%
2	NC	Girder	**$1,915**	W16 x 26	-	4	96	6.56	W24 x 94	-	4.84	3.90	0.37%
	C	Girder	**$1,601**	W14 x 22	40.2%	4	96	5.58	W24 x 68	28.5%	4.16	3.33	0.45%
3	NC	Girder	**$1,915**	W16 x 26	-	4	96	6.56	W24 x 94	-	4.84	3.90	0.37%
	C	Girder	**$1,678**	W14 x 22	40.2%	4	96	5.58	W24 x 68	28.5%	4.16	3.33	0.45%

Table 3. 5—30 ft x 30 ft Bay Results

Trial	Const. Type	Bay Cost ($)	Beams	Percent Composite Action	Number of Beams	Beam Spacing (in.)	Beam Panel Freq. (Hz)	Girders	Percent Composite Action	Girder Panel Freq. (Hz)	System Natural Freq. (Hz)	Combined Mode a_p/g
1	NC	**$1,358**	W16 x 26	-	3	90	6.74	W16 x 77	-	5.74	4.44	0.40%
	C	**$1,440**	W16 x 26	33.9%	3	90	6.74	W16 x 77	25.4%	5.74	4.44	0.40%
2	NC	**$1,358**	W16 x 26	-	3	90	6.74	W16 x 77	-	5.74	4.44	0.40%
	C	**$1,165**	W14 x 22	40.2%	3	90	5.73	W16 x 57	27.9%	5.04	3.93	0.47%
3	NC	**$1,358**	W16 x 26	-	3	90	6.74	W16 x 77	-	5.74	4.44	0.40%
	C	**$1,227**	W14 x 22	40.2%	3	90	5.73	W16 x 57	27.9%	5.04	3.93	0.47%

Table 3. 6—40 ft x 40 ft Bay Results

Trial	Const. Type	Bay Cost ($)	Beams	Percent Composite Action	Number of Beams	Beam Spacing (in.)	Beam Panel Freq. (Hz)	Girders	Percent Composite Action	Girder Panel Freq. (Hz)	System Natural Freq. (Hz)	Combined Mode a_p/g
1	NC	**$3,510**	W21 x 44	-	4	96	5.60	W24 x 131	-	4.82	3.65	0.30%
	C	**$3,640**	W21 x 44	28.1%	4	96	5.60	W24 x 131	25.5%	4.82	3.65	0.30%
2	NC	**$3,170**	W18 x 40	-	4	96	4.86	W24 x 117	-	4.59	3.33	0.35%
	C	**$2,813**	W18 x 35	35.4%	4	96	4.55	W24 x 94	26.3%	4.18	3.08	0.38%
3	NC	**$3,170**	W18 x 40	-	4	96	4.86	W24 x 117	-	4.59	3.33	0.35%
	C	**$2,911**	W18 x 35	35.4%	4	96	4.55	W24 x 94	26.3%	4.18	3.08	0.38%

3.3 Conclusions

Trial 1. Initial dead load deflection, which can not be lessened by composite action, governed member selection. Consequently, composite bays were approximately 5% more costly. Because large members were required to control initial dead load deflection, vibrations were not problematic in this trial.

*Trial 2***.** With a liberalized initial deflection allowance, the least costly floor system was composite for all four bays. On average, composite systems had a 15% cost savings. Vibrations were satisfactory for all designs, but peak acceleration was nearly 0.5 % for some composite bays. Allowing greater initial deflections made little or no difference in non-composite cost

*Trial 3***.** Increasing the unit stud cost from $1.25 to $2.25, between Trial 2 and Trial 3, reduced the composite-system cost advantage to 11 %—compared to 15 % in Trial 2. The other results of Trial 3 (member size and spacing and percent composite action) were no different from Trial 2.

In Trial 1, member camber was not assumed and thereby initial deflections were limited to L/360. Composite construction did not lessen cost with this restriction. On the other hand, significant cost savings can be made using composite construction under the parameters of Trials 2 and 3, which both had an initial dead load deflection limit of L/240. Vibrations were marginal in some composite bays. However, the cost margin is large enough that the composite floors could be improved for vibrations (if necessary), while remaining less costly than the non-composite designs.