Architecture Breadth

Introduction

One feature present in all buildings as defined by code is a fire prevention system. The Hershey Academic Support Center in accordance with the Pennsylvania Department of Labor and Industry's Fire and Panic Code designed the building to have a standard 2 hour fire rating throughout the building. Aside from the standard pull box switches, a hydraulic sprinkler system fire suppressant is in place throughout the building. Smoke detectors are placed in all major areas including hallways, elevator shafts, and ducts. The pipes that relegate water throughout the building are located in the stairwells that have a 3-hour fire rating. This type of fire prevention is standard practice, but there is one interesting detail. For a composite lightweight concrete slab, a 2 hour fire rating can be obtained by having a 3.5" thick slab. Instead of doing this, the Hershey Academic Support Center has a 2.5" thick slab with cementitious spray on fireproofing on all of the columns, beams, and decking. For this study, the cementitious fireproofing will be removed in all locations, but the stairwells and the concrete slab will be increased to 3.5" to meet the 2 hour fire rating requirement. The extra weight of concrete will be checked to make sure the system still works.

Calculations

Pricing calculations are shown below:

Cost Calcs

Concrete

Each floor is $30,000\ ft^2$ of area

Thickness needs 1" for 2-hour fire rating

RS Means lists the price of Concrete at $\$91.00/yd^3$

Total price increase = $2500\ ft^3 \left(\frac{1\ yd^3}{27\ ft^3}\right)(\$91.00/yd^3)(5\ floors) = \$42,130$

Assume 10% material waste → $\$42,130\ (1.1) = \$46,343$

Assume 10% extra labor & equipment costs → $\$46,343\ (1.1) = \$50,977$

Cementitious Fireproofing 1" thick for 2 hour fire-rating

$30,000\ ft^2$ of deck area per floor → $150,000\ ft^2$

TYPICAL W14×120 W21×50

225 total columns @ $101\ ft^2$ per floor per column → $113,625\ ft^2$

620 total beams @ $156\ ft^2$ per floor per beam → $483,600\ ft^2$

All cost data taken from RS Means

Materials (Add 10% overspray cost)

Deck: $(150,000\ ft^2)(0.08\bar{3}\ ft)(\$0.64/ft^3) = \$8,000\ (1.1) = \$8,800$

Columns: $(113,625\ ft^2)(0.08\bar{3}\ ft)(\$0.48/ft^3) = \$4,545\ (1.1) = \$5,000$

Beams: $(483,600\ ft^2)(0.08\bar{3}\ ft)(\$0.43/ft^3) = \$17,329\ (1.1) = \$19,062$

Labor & Equipment

Deck: $(150,000\ ft^2)(0.08\bar{3}\ ft)(\$0.65/ft^3) = \$8,125$

Columns: $(113,625\ ft^2)(0.08\bar{3}\ ft)(\$0.75/ft^3) = \$7,102$

Beams: $(483,600\ ft^2)(0.08\bar{3}\ ft)(\$0.55/ft^3) = \$22,165$

Individual Totals

Deck = \$16,925 Columns = \$12,102 Beams = \$41,227

Grand Total = \$70,254

The new system was found to be cheaper and saved $70,254 over the spray on fireproofing system. Eliminating the spray on fireproofing also gives more options architecturally since beams and columns do not necessarily have to be covered since cementitious fireproofing is not aesthetically pleasing. In doing a weight comparison between the systems, cementitious fireproofing was found to be half as heavy as concrete with ½" of lightweight concrete equal to 1" of fireproofing. The spray on fire-proofing in the Hershey Academic Support Center is ½" so ¾" of concrete weight must be accounted for in the system. Strength calculations for the columns were performed and are shown below. The first column was chosen at connection B between the East section and the Center section. The second column was selected at connection D between the West section and the Center section. To compare the values, the equation Pu/b + Mu/m < 1 was used. Table 6-2 from the Steel Manual was used to obtain the b and m values for each column.

Section B:
W14x193, Pu/b + Mu/m = (196.37)/(0.47) + (387.34)/(0.668) = 0.998 < 1
ALLOW

Section D:
W14x175, Pu/b + Mu/m = (203.08)/0.516) + (403.23)/(0.741) = 0.938 < 1
ALLOW

Both columns pass the strength check, so the new design is feasible.