



11. COST ANALYSIS

The proposed system requires the addition of many design elements and the elimination of others. The goal of the proposed systems is also to reduce energy use and costs, which factor into the payback period of the proposed design. This section analyzes the costs associated with the construction of the original VAV and "cool roof" design and the proposed DOAS and green roof design..

11.1. ORIGINAL DESIGN COST

Heery International prepared a cost estimate when 100% construction documents were completed in September 2006. The breakdown of the estimated project cost by CSI Division is included in Table 11.1 below.

100% Cost Estimate

CSI Division	Description	Estimate	Per SF*	\$ %
1	General Requirements, OH&P	\$3,089,683	\$35.23	13.5%
2	Site Work	\$1,892,332	\$21.58	8.3%
3	Concrete Work	\$1,450,126	\$16.53	6.4%
4	Masonry Work	\$672,143	\$7.66	2.9%
5	Metals	\$2,457,684	\$28.02	10.8%
6	Wood and Plastics	\$297,970	\$3.40	1.3%
7	Thermal and Moisture Protection	\$1,331,078	\$15.18	5.8%
8	Doors and Windows	\$1,351,056	\$15.40	5.9%
9	Finishes	\$2,407,854	\$27.45	10.6%
10	Specialties	\$145,529	\$1.66	0.6%
11	Equipment	\$69,701	\$0.79	0.3%
12	Furnishings	\$33,018	\$0.38	0.1%
13	Special Construction	\$0	\$0.00	0.0%
14	Conveying Systems	\$274,720	\$3.13	1.2%
15	Mechanical Systems	\$3,835,441	\$43.73	16.8%
16	Electrical Systems	\$2,364,277	\$26.96	10.4%
SUB-TOTAL		\$21,672,612	\$247.11	
5.25% Escalation to Const.:		\$22,810,424	\$260.08	

*Area [SF] = 87,704

Table 11.1: Total project cost estimate (Heery).



11.2. PROPOSED DESIGN FIRST COST

Based on the costs estimates of the original design and proposed changes, an itemized cost analysis (Table 11.2) shows an additional \$1.03M first cost for the proposed DOAS system and green roof. The breakdown of the project cost by CSI division may be seen in Table 11.3. This increase in first cost equates to about a 4.5% increase in the total project first cost (Table 11.4).

Itemized Cost of Proposed Systems										
CSI Code	Description	Original Design				Proposed Design				Additional Cost
		Quantity	Unit	Unit Cost	Total	Quantity	Unit	Unit Cost	Total	
02510	Chilled Water Supply & Return Piping	1	LS	\$182,500.00	\$182,500	1	LS	\$209,875.00	\$209,875	\$27,375
02630	Storm Drains Structures	11	EA	\$3,052.50	\$33,578	7	EA	\$3,052.50	\$21,368	-\$12,210
2	Site Work Changes SUB-TOTAL				\$216,078				\$231,243	\$15,165
07202	Storm Drainage System	900	LF	\$35.00	\$31,500	900	LF	\$28.00	\$25,200	-\$6,300
07203	Asphalt Paving	1,220	SY	\$35.25	\$43,005	1,220	SF	\$40.00	\$48,800	\$5,795
07200	Green Roof	0	SF	\$7.00	\$0	24,400	SF	\$7.00	\$170,800	\$170,800
07500	Waterproofing	24,400	SF	\$5.09	\$124,196	24,400	SF	\$10.00	\$244,000	\$119,804
7	T&M Protection Changes SUB-TOTAL				\$198,701				\$488,800	\$290,099
09510	Suspended Acoustic Ceilings	46,566	SF	\$4.07	\$189,524	41,966	SF	\$4.07	\$170,802	-\$18,722
9	Finishes Changes SUB-TOTAL				\$189,524				\$170,802	-\$18,722
15160	Booster Pump Equip. (to water roof)	1	EA	\$12,000.00	\$12,000	2	EA	\$8,040.00	\$16,080	\$4,080
15160	Roof Drainage System	1,445	LF	\$42.21	\$60,993	1,445	LF	\$30.15	\$43,567	-\$17,427
15514	Plate & Frame Heat Exchanger	0	EA	\$32,500.00	\$0	1	EA	\$32,500.00	\$32,500	\$32,500
15114	Energy Recovery Ventilator	0	EA	\$25,000.00	\$0	6	EA	\$25,000.00	\$150,000	\$150,000
15000	Chilled Water Expansion Tank	1	EA	\$3,500.00	\$3,500	1	EA	\$5,000.00	\$5,000	\$1,500
15000	Chilled Water Air Separator	1	EA	\$4,000.00	\$4,000	1	SF	\$5,500.00	\$5,500	\$1,500
15181	Hot Water Pipe w/ Insulation	7,834	LF	\$25.50	\$199,767	23,502	LF	\$25.50	\$599,301	\$399,534
15181	Chilled Water Pipe w/ Insulation	1,862	LF	\$48.50	\$90,307	9,310	LF	\$48.50	\$451,535	\$361,228
15110	Valves and Fittings	1	LS	\$63,024.00	\$63,024	1	LS	\$88,233.60	\$88,234	\$25,210
15185	Chilled Water Pumps (w/ VFD)	2	EA	\$13,653.00	\$27,306	5	EA	\$13,653.00	\$68,265	\$40,959
15185	Hot Water Pumps (w/ VFD)	7	EA	\$3,693.00	\$25,851	10	EA	\$3,693.00	\$36,930	\$11,079
15855	Duct Heating Coils	5	EA	\$1,000.00	\$5,000	0	EA	\$5,000.00	\$0	-\$5,000
15725	Air Handling Units	6	EA	\$29,525.00	\$177,150	5	EA	\$16,238.75	\$81,194	-\$95,956
15840	VAV Boxes	140	EA	\$810.00	\$113,400	0	EA	\$810.00	\$0	-\$113,400
15840	Chilled Beams	0	LF	\$165.00	\$0	2,300	LF	\$165.00	\$379,500	\$379,500
15080	Ductwork Blanket Insulation	41,884	SF	\$2.50	\$104,710	25,130	EA	\$2.50	\$62,826	-\$41,884
15080	Ductwork Internal Soud Lining	23,167	SF	\$5.00	\$115,835	10,425	EA	\$5.00	\$52,126	-\$63,709
15836	Fans & Ventilators	17	EA	\$4,250.00	\$72,250	16	EA	\$2,337.50	\$37,400	-\$34,850
15071	Sound Attenuators	55	EA	\$755.00	\$41,525	0	EA	755	\$0	-\$41,525
15815	Ductwork	94,878	LBS	\$7.25	\$687,866	61671	EA	\$7.25	\$447,113	-\$240,753
15855	Grilles/Registers/Diffusers	549	EA	\$115.00	\$63,135	686	EA	\$115.00	\$78,919	\$15,784
15855	Linear Diffusers	655	LF	\$70.00	\$45,850	262	EA	\$70.00	\$18,340	-\$27,510
15	Mechanical Systems Changes SUB-TOTAL				\$1,913,469				\$2,654,328	\$740,859
PROPOSED SYSTEM CHANGES SUB-TOTAL					\$2,517,771				\$3,545,172	\$1,027,401

Table 11.2: Itemized cost of proposed changes to SLCC design.



Proposed 100% Cost Estimate

CSI Division	Description	Estimate	Per SF*	\$ %
1	General Requirements, OH&P	\$3,089,683	\$35.23	12.9%
2	Site Work	\$1,907,497	\$21.75	8.0%
3	Concrete Work	\$1,450,126	\$16.53	6.1%
4	Masonry Work	\$672,143	\$7.66	2.8%
5	Metals	\$2,457,684	\$28.02	10.3%
6	Wood and Plastics	\$297,970	\$3.40	1.2%
7	Thermal and Moisture Protection	\$1,621,177	\$18.48	6.8%
8	Doors and Windows	\$1,351,056	\$15.40	5.7%
9	Finishes	\$2,389,132	\$27.24	10.0%
10	Specialties	\$145,529	\$1.66	0.6%
11	Equipment	\$69,701	\$0.79	0.3%
12	Furnishings	\$33,018	\$0.38	0.1%
13	Special Construction	\$0	\$0.00	0.0%
14	Conveying Systems	\$274,720	\$3.13	1.1%
15	Mechanical Systems	\$4,576,300	\$52.18	19.2%
16	Electrical Systems	\$2,364,277	\$26.96	9.9%
SUB-TOTAL		\$22,700,013	\$258.83	
5.25% Escalation to Const.:		\$23,891,764	\$272.41	

*Area [SF] = 87,704

Table 11.3: Total proposed project cost estimate.

Comparison of Design First Costs

	First Cost	Change	% Change
Original SLCC Design	\$22,810,424	0	0.00%
Proposed SLCC Design	\$23,837,825	\$1,027,401	4.50%

Table 11.4: Comparison of design first costs.

Table 11.5: Additional parallel cooling system cost (green roof).



11.3. ENERGY & MAINTENANCE COSTS

Based on the energy cost data from the Carrier HAP models annual energy costs estimates are approximated for both the original design and proposed design. The proposed system saves approximately \$25,000 per year in energy costs. Regular maintenance is also an issue. The expected annual maintenance cost of the mechanical system is assumed to be approximately 3-5% of the mechanical system first cost. The proposed system is assumed to have less maintenance costs because there is smaller equipment and fewer moving parts. Regular overhauls of the system are assumed to occur every 5 years with major overhauls every 20 years. Finally, the green roof is assumed to require approximately the same total annual maintenance cost over its life because the plants are relatively self sustaining, but may need replacement. The cool roof, however, requires regular cleaning to maintain the high reflectance and thermal performance. Table 11.6 shows the O&M costs for the original design and Table 11.7 shows the O&M costs for the proposed design.

Operation and Maintenance Costs (Original Design)

Description	Unit	Total	Comment
Electricity	\$/yr	\$61,591.00	
Chilled Water	\$/yr	\$90,174.00	
Hot Water	\$/yr	\$1,237.00	
Mech. System Maintenance	\$/yr	\$115,063.23	3% of first cost
Mech. System Repairs/Replacement	\$/5yr	\$575,316.15	15% of first cost
Mech. System Repairs/Replacement	\$/20yr	\$2,876,580.75	75% of first cost
Roof Maintenance	\$/yr	\$9,935.05	5% of first cost
Roof Replacement	\$/20yr	\$198,701.00	100% of first cost

Table 11.6: Original design operation and maintenance costs.

Operation and Maintenance Costs (Proposed Design)

Description	Unit	Total	Comment
Electricity	\$/yr	\$54,344.00	
Chilled Water	\$/yr	\$67,024.00	
Hot Water	\$/yr	\$494.00	
Mech. System Maintenance	\$/yr	\$137,289.01	3% of first cost
Mech. System Repairs/Replacement	\$/5yr	\$686,445.03	15% of first cost
Mech. System Repairs/Replacement	\$/20yr	\$3,432,225.17	75% of first cost
Roof Maintenance	\$/yr	\$9,776.00	2% of first cost
Roof Replacement	\$/20yr	\$0.00	0% of first cost

Table 11.7: Proposed design operation and maintenance costs.



11.4. SIMPLE PAYBACK PERIOD

Based on the first cost and annual energy, operation, and maintenance costs, a simple payback period of 33.8 years is expected. The desired payback period is typically less than 3 years, but since the building owner is an institution a slightly longer payback period may be justified. The expected payback far exceeds this reasonable payback period. Instead, justification for the designs must come from a life cycle cost evaluation and additional intangible benefits of the proposed system such as a higher LEED Rating and improved interior acoustics.

	First Cost	Change in First Cost	O&M Cost per year	Payback (yrs.)
Original Design	\$22,810,424	\$0	\$278,000	0.00
Proposed Design	\$23,891,764	\$1,081,340	\$246,046	33.84

Table 11.8: Simple payback period for proposed design.