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The Edward R. Roybal Federal Building in Los Angeles houses federal courts and executive agencies.

An Overview Of Thermal Envelopes In Federal Buildings

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The U.S. General Services Administration (GSA) is the Federal Government's landlord. GSA manages federal real estate for over 100 civilian federal agencies and commissions, making its portfolio of general office space among the largest in the United States -- over 8,000 buildings with nearly 300,000,000 ft^2 (27.9 km^2). Of this total, 48 percent is owned, and 52 percent is leased.

GSA's building inventory is as diverse as the clients it serves. Buildings range from a 3,000 ft^2 (279 m^2) border station at the Canadian border to a several-million-square foot Social Security Administration payment center. Buildings are as varied as their purposes and include federal courthouses, Food and Drug Administration laboratory facilities, and firing ranges for the Federal Bureau of Investigation.

The purpose of this article is to provide an overview of the different types of thermal envelopes GSA has used in recent years and a brief review of the total energy use in those buildings.

GSA's policy is described in its ***Facilities Standards for the Public Buildings Service (PBS-PQ100.1),*** as follows:

Energy Conservation Standards. The governing energy design standard is the Department of Energy Standard 10 CFR, Part 435 *Energy Conservation Voluntary Performance Standards for Commercial and Multi-Family High Rise Residential Buildings; Mandatory for New Federal Buildings; Interim Rule.* GSA has adopted the latest edition of *ASHRAE/IES Standard 90.1 Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings,* published for energy conservation, with the two amendments that follow:

1. Since it is an industry standard, ASHRAE/IES 90.1 typically uses the verbs "recommended," "suggested," etc. Any text phrased as a recommendation in the Standard will be understood as a mandatory requirement.

2. Performance requirements designated as taking effect in 1992 will be understood to be current requirements.

The buildings described in this article were planned or designed prior to this new policy. However, because the federal government owns and operates its buildings for periods of 30 - 50 years, and half of its owned buildings are 50 years old or older, GSA's policy prior to 1993 was to utilize energy-efficient

About the Author

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Base Or Alternate	Elec Energy Cost	Gas Cost (All HVAC)	Elec Energy Cost/SF/Yr	HVAC Energy Cost	HVAC Energy Cost/SF/Yr (Including Gas And Elec)
Base 0.24 U-wall, 0.654 kW/Ton 0.38 U-glass, 0.81 SC-glass	$358,498	$1,905	$0.7966	$136,091	$0.3024
Alt. #1 0.1 U-wall, 0.654 W/Ton 0.38 U-glass, 0.81 SC-glass	$357,899	$1,503	$0.7953	$135,787	$0.3017
Alt. #2 0.24 U-wall, 055 kW/Ton 0.38 U-glass, 0.81 SC-glass	$357,400	$1,959	$0.7942	$134,519	$0.2989
Alt. #3 0.24 U-wall, 0.654 kW/Ton, 1.15 U-glass, 0.709 SC-glass	$351,205	$3,373	$0.7804	$130,123	$0.2892

Table 1. Federal Building/U.S. Courthouse in Tucson It should be noted that none of the alternates provide a large percentage improvement relative to the base study.

Alternate #1 *provides an HVAC energy cost decrease of approximately 0.22% relative to the base study, due to increased wall performance.*

Alternate #2 *provides an HVAC energy cost decrease of 1.1% relative to the base study, due to improved chiller electrical performance.*

Alternate #3 *resulted in an increase in total (combined electrical and gas) energy consumption, no doubt due to use of a much poorer glass U-value, albeit with a slightly better shading coefficient. Interestingly, though, HVAC energy cost was less than in the base study by a small margin. Electrical consumption and demand decreased slightly and gas increased. The sum of these changes represented an approximately 4.4% decrease in energy cost relative to the base study. Electrical demand and consumption generally decreased relative to the base study during the winter months and increased during the peak cooling months. This could be explained by a heat loss from the building during winter occupied hours, which resulted in a reduction in required cooling due to internal heat gains. This reduction was significant enough to provide the small reduction total HVAC energy cost indicated above, due to differences in utility company charges between electrical and gas consumption, and demand.*

building envelopes. The policy will help GSA reach its goal of reducing energy consumption in federal buildings by 30 percent of 1993 levels by the Year 2005.

Federal Building and U.S. Courthouse Tucson, Ariz.

This building is in the planning stages and will be located in downtown Tucson. It will have 14 courtrooms, with 419,000 ft^2 (38 927 m^2) of gross space and 257,000 ft^2 (23 876 m^2) of occupiable space. The estimated construction cost is $67,182,000. Construction is projected to be completed by March 1999.

A building energy base study was performed with numerous options for the building envelope as well as the high-efficiency refrigeration machine. The simulation was performed based on a commercially available building energy analysis computer simulation program.

A summary of the results of the base study and the three alternates are listed in the *Table 1*.

Russell B. Long Federal Building and U.S. Courthouse in Baton Rouge, La.

• **The Building in Brief:** The Russell B. Long Federal Building and U.S. Courthouse in Baton Rouge is a four-story, 169,000 ft^2 (15 701 m^2) addition to the existing federal courthouse. Completed in August 1994, the facility provides 114,886 ft^2 (10.673 m^2) of occupiable space and 10,000 ft^2 (929 m^2) of secured parking in its lowest level. While a majority of the space is configured for federal courts, other tenants include the U.S. Marshals Service, U.S. Attorney, U.S. Department of Agriculture, Social Security Administration, and the Environmental Protection Agency.

Procured via a traditional design and construction methodology, the facility had a total construction cost of $19,456,900, or approximately $115 per square foot.

• **Thermal Envelope:**

Roof	Built-up with rigid insulation R=21.3 U=0.05
Windows	Single pane U=1.12
Walls	Outside surface air film Precast concrete Rigid insulation CMU Air space 5/8-inch gypsum board Inside surface air film R=14.4 U=0.07

• **Energy Usage:** See Table 2.

Ralph H. Metcalfe Federal Building in Chicago

• **The Building in Brief:** The Ralph H. Metcalfe Federal Building, completed in June 1991, has taken its place as an integral part of the Chicago Federal Center designed by Mies van der Rohe. The 28-story building incorporates de-

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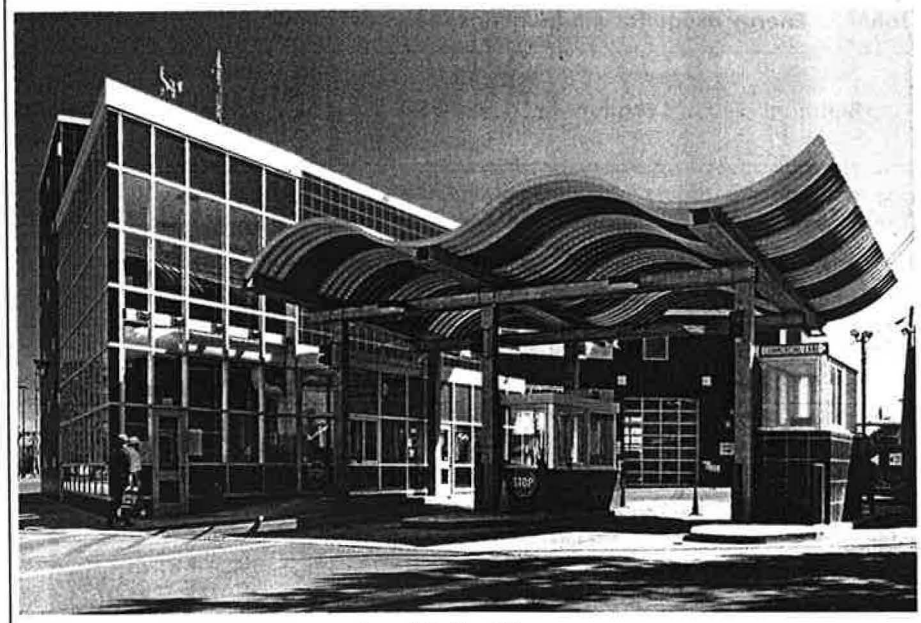
Editor's note: To convert inches to millimeters, multiply inches by 25.4. To convert to centimeters, multiply inches by 2.54.



The Border Station at International Falls, Minn.

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signs and materials used in the other federal buildings, and has 758,000 ft^2 (70 421 m^2) of gross area with approximately 530,000 ft^2 (49 239 m^2) of occupiable space. Occupied by multiple tenant agencies, the Environmental Protection Agency and the Department of Housing and Urban Development are major tenants. Metcalfe was the first GSA design-build project of its kind. At the completion of construction, the government decided to purchase the facility at a price of $157 million.

- **Thermal Envelope:**

Roof	Single ply membrane with extruded polystyrene insulation R=24 U=0.04
Windows	Double pane U=0.55
Walls	Outside surface air film Thermal granite Semi-rigid mineral fiber insulation 5/8-inch gypsum board Inside surface air film R=20 U=0.05

- **Energy Usage:** See Table 2.

Border Station in International Falls, Minn.

- **The Building in Brief**: The International Falls border station is a new facility, occupied in November 1993, with a 1.4-acre (.57- hectare) site and a 14,000 ft^2 (1 301 m^2) of gross built area, built at a cost of $2.2 million. It is a two-story structure, with approximately 4,000 ft^2 (372 m^2) at the main level and 10,000 ft^2 (929 m^2) on the upper level.

The building serves the Immigration and Naturalization Service (INS) and the Customs Service (a total of about 10 employees), plus traffic including pedestrians, automobiles, light trucks, and heavy, oversized trucks. The facility is in operation 24 hours a day.

- **Thermal Envelope:**

Roof	Ballasted membrane roof on 6 inches of ridged insulation on gyp board on metal deck on gyp board above ceiling air space and acoustic tile R=27.48 U=0.036
Windows	1-inch insulated U=0.38
Walls	Outside surface air film 8-inch CMU 4-inch rigid insulation Air space resistance 4-inch glazed CMU Inside surface air film R=18.75 U=0.053

- **Energy Usage:** See Table 2.

U.S. Courthouse Kansas City, Kan.

- **The Building in Brief:** The new U.S. Courthouse in Kansas City provides 274,820 ft^2 (25 532 m^2) of gross space, with 165,000 ft^2 (15 329 m^2) of

Table 2. Energy usage for the buildings in this overview of thermal envelopes.

Building	Location	GSF	BTU Totals (millions)	Btu/ SF/Yr (thousands)	Cost Totals	Cost/ SF
Richard B. Russell FB/CT[1]	Baton Rouge, LA	270,497	9,424	38.43	$174,374	$.64
Ralph J. Metcalfe FB	Chicago	828,782	54,251	65.45	$1,186,253	$1.43
Border Station[2,3]	International Falls, MN	11,954	2,720	227.53	$24,709	$2.06
Kansas City FB/ CT	Kansas City	273,220	15,970	58.45	$261,152	$.95
Edward R. Roybal FB/CT[1]	Los Angeles	2,237,619	129,198	57.73	$3,150,471	$1.40
Oakland CT/FB	Oakland, CA	816,944	51,952	63.59	$1,205,681	$1.47
Border Station[2]	Otay Mesa, CA	231,532	28,208	121.83	$393,103	$1.69
Robert A. Young FB	St. Louis	1,102,938	70,223	63.69	$1,101,617	$.99

[1] Includes existing building.
[2] Border station is 24-hour operation.
[3] Excessive energy use is caused by the sidelighting and extreme temperature conditions.

occupied space to house courts' functions and other federal agencies. Constructed to meet the courts' 10-year plan, it includes a conversion strategy to change office space to courtrooms when necessary to meet projected 30-year needs. The courthouse was completed in 1993, on a budget of $33.5 million, at about $123 per square foot. The eight-story facility houses 280 employees.

- **Thermal Envelope:**

Roof Rubber membrane with polyisopropolene insulation
R=20 U=0.05

Windows Double-pane with .25-inch air space
U=0.60

Walls Outside surface air film
6-inch precast concrete
6-inch insulation R-19
.75-inch gypsum board
Inside surface air film
R=21.5 U=0.047

- **Energy Usage:** See Table 2.

Edward R. Roybal Federal Building in Los Angeles

- **The Building in Brief:** The Edward R. Roybal Federal Center and Federal Courthouse/Building is located in the Federal Center in downtown Los Angeles. The new 21-story federal building houses the U.S. Courts and federal executive agencies. It is situated on a landscaped plaza linking it with three other buildings that comprise the center (the existing federal building, the new Metropolitan Detention Center, and the new Veterans Affairs Outpatient Clinic). Below the plaza is a three-level parking garage with 1,200 parking spaces. The gross area is approximately 1,200,000 ft^2 (111 484 m^2) and includes parking. Net building occupiable space is approximately 570,000 ft^2 (52 955 m^2).

- **Thermal Envelope:**

Roof Single-ply rubber membrane with polyurethane insulation
R=15.5 U=0.06

Windows Single pane
U=1.12

Walls Outside surface air film
1.25-inch limestone
4-inch masonry
1-inch airspace
3.5-inch batt insulation
5/8-inch gypsum board
Inside surface air film
R=12.8 U=0.08

- **Energy Usage:** See Table 2.

Oakland Federal Building in Oakland, Calif.

- **The Building in Brief:** The twin tower building is 18 stories, and consists of 1,058,000 ft^2 (98 292 m^2) of gross space and 723,000 ft^2 (67 169 m^2) of occupiable space. At the base of the building, the lower five floors create a U-shape. Linking the two towers is a 75-foot high skylit rotunda. A glazed bridge links the two towers at the 13th and 14th levels. On either side of the plaza in the low-rise five-story wings are the courthouse and the auditorium.

Housing more than 3,300 employees, the primary occupants of the building are the Internal Revenue Service, Veterans Affairs, Department of Energy, the U.S. District Courts and other federal agencies from the Greater Bay Area.

Construction began in December of 1990 and was completed in August 1993. Construction cost for base building and tenant improvements totaled $156 million.

- **Thermal Envelope:**

Roof Single-ply rubber membrane with polyurethane insulation
R=15.5 U=0.06

Windows	Single pane U=1.12
Walls	Outside surface air film 1.25-inch limestone 4-inch precast concrete 1-inch airspace 3.5-inch batt insulation 5/8-inch gypsum board Inside surface air film R=12.8 U=0.08

• **Energy Usage:** See Table 2.

United States Border Station at Otay Mesa, Calif.

• **The Building in Brief:** The Border Station at Otay Mesa consists of seven buildings, four original buildings constructed between 1984 and 1985, and three completed between 1993 and 1994. New work included development of a 101-truck-bay commercial inspection dock with associated import cargo building, canopied entry and exit booths, bulk import lot and warehouse, hazardous waste facility, and site work.

Renovation work included replacement of glazing at the headhouse and main building, expansion of primary and secondary inspection areas in the noncommercial vehicle inspection area, and alterations to provide commercial export facilities. Design began in June 1991, the construction contract was awarded in March 1993, and the facility opened in September 1994. The approximate construction cost for new construction and renovation was $21,284,000. The entire complex has 231,532 ft^2 (21 509 m^2).

Federal inspection services with border-related responsibilities include the U.S. Customs Service, Department of Agriculture, Food and Drug Administration, Immigration and Naturalization Service, and the Fish and Wildlife Service. Traffic figures for 1994 recorded 3,860,909 passengers, 439,654 commercial vehicles, and 361,159 pedestrians.

• **Thermal Envelope:**

Roof	Built-up roof on concrete toping slab on metal deck with R-19 batt insulation R-22.34 U=0.045
Windows	Single pane U=1.12
Walls	Outside surface air film 8-inch CMU 4-inch rigid insulation

Air space resistance
4-inch rigid insulation
Air space resistance
4-inch glazed CMU
Inside surface air film
R=18.75 U=0.053

• **Energy Usage:** See Table 2.

Robert A. Young Federal Building in St. Louis, Mo.

• **The Building in Brief:** Built in 1931 as a display and distribution center, the Mart Building was acquired after the war by the Army and then by GSA, and eventually converted to office space.

When GSA began to plan consolidation of tenants from leased space to federally owned buildings in the early 1980s, GSA designated the Mart Building a Demonstration Building in its Advanced Technologies Buildings program and began the necessary major renovations to bring the space up to the standards of contemporary office space. The entire facility was gutted, circulation patterns revised, and all systems replaced.

Renovations were completed in September 1990 at the cost of $55 million. The building consists of 1,162,900 ft^2 (108 037 m^2) of gross space, with 818,000 ft^2 (75 995 m^2) of occupiable space, including a 10-story tower and a 10-story main building plus basement.

• **Thermal Envelope:**

Roof Rubber membrane with extruded polystyrene insulation
R=20 U=0.05

Windows Single pane
U=0.95

Walls Outside surface air film
12-inch masonry
3.5-inch insulation
.75-inch sheetrock
inside surface air film
R=13.5 U=0.072

• **Energy Usage:** See Table 2.

Conclusion

This overview of thermal envelopes and energy usage illustrates the wide variations that can exist. A number of factors affect energy usage: geographic location, type of occupancy, building envelope, local climatic conditions, ventilation requirements, and efficiency of equipment. Although a building envelope's energy performance can be simulated (as discussed in the Tucson project), the optimization of a building envelope to minimize energy usage is a complex and challenging task. With so many variables present, it is very difficult, if not impossible, to manipulate each one to achieve the optimum solution.

The data serve to illustrate the wide variations in construction of typical federal buildings. It can be seen that while envelope design must of necessity impact total energy use, there are so many other factors involved that in many cases it plays only a minor role. ■

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