Construction Standards and Costs

UC Irvine new construction pursues performance goals and applies quality standards that affect the costs of capital projects. Periodic re-examination of these goals and standards is warranted.

Construction costs are not "high" or "low" in the *abstract*, but rather in relation to specific quality standards and the design solutions, means, and methods used to attain these standards. Thus, evaluating whether construction costs are appropriate involves:

- first, determining whether quality standards are excessive, insufficient, or appropriate;

- second, determining whether resultant project costs are reasonable compared to projects with essentially the same quality parameters.

"Quality" encompasses the durability of building systems and finishes; the robustness and life-cycle performance of building systems; the aesthetics of materials, their composition, and their detailing; and the resource-sustainability and efficiency of the building as an overall system.

Overall Goals and Quality Standards

UC Irvine, in order to support distinguished research and academic programs, builds facilities of high quality. As such, UC Irvine's facilities aim to convey the "look and feel," as well as embody the inherent construction quality, of the best facilities of other UC campuses, leading public universities, and other research institutions with whom we compete for faculty, students, sponsored research, and general reputation.

Since 1992, new buildings have been designed to achieve these five broad goals:

1. New buildings must "create a place," rather than constitute stand-alone structures, forming social, aesthetic, contextually-sensitive relationships with neighboring buildings and the larger campus.
2. New buildings reinforce a consistent design framework of classical contextual architecture, applied in ways that convey a feeling of permanence and quality and interpreted in ways that meet the contemporary and changing needs of a modern research university.
3. New buildings employ materials, systems, and design features that will avoid the expense of major maintenance (defined as >1 percent of value) for twenty years.

4. New buildings apply "sustainability" principles -- notably, outperforming Title 24 (California's energy code) by at least 20 percent.
5. Capital construction projects are designed and delivered within the approved project budget, scope, and schedule.

UC Irvine's goals for sustainable materials and energy performance were adopted partly for environmental reasons, and partly to reverse substantial operating budget deficits. The latter problems included a multi-million dollar utilities deficit that was growing rapidly in the early '90s, and millions of dollars of unfunded major maintenance that was emerging prematurely in buildings only 10-20 years old. Without the quality and performance standards adopted in 1992, utilities deficits and unfunded major maintenance costs would have exceeded $20 million during the past decade, and these costs would still be rising out-of-control.

UC Irvine's materials standards, building systems standards, sustainability and energy-efficiency criteria, and site improvements all add cost increments that can only be afforded through aggressive cost management. Institutions that cannot manage capital costs tend to build projects that consume excessive energy, that cost a lot to maintain, that suffer premature major maintenance costs, and that require high costs to modify. Such problems tend to compound and spiral downward into *increasingly costly* consequences. Every administrator with facilities experience understands this dynamic. Without effective construction cost management, quality would suffer and UC Irvine would experience all of these problems.

The balance of this document outlines in greater detail the building performance criteria and quality standards generally stated above, organized according to building systems component classes. Each section discusses key cost-drivers, cost-control strategies, and important cost trade-offs. Design practices cited are consistently applied (although some fall short of hard and fast "rules").

Building Organization and Massing

Construction cost management starts with the fundamentals of building organization and massing. UC Irvine's new structures' floorplates tend to have length-to-width ratios <1.5, to avoid triggering disproportionate costs of external cladding, circulation, and horizontal mechanical distribution. Our new buildings tend to be at least three floors high -- taller if floorplate areas do not dip below a cost-effective threshold, and generally taller in the case of non-laboratory buildings (but not so tall that a high-rise cost penalty is incurred). Other design ratios are observed, such as exterior cladding area/floor area <0.5, and roof+foundation area/floor area <0.4.

Architectural articulation is generally achieved through textured or enriched materials, integral material detailing (such as concrete reveal patterning), and applied detailing (e.g., window frames and sills), particularly at the building base. Large-scale articulation is concentrated at the roofline (e.g., shaped roof forms) and at the pedestrian level (e.g., arcades), where it will "create the biggest bang for the buck," rather than through modulating the building form, itself. This is more than a subtle design philosophy, as the cost impact is substantial.

Lab buildings completed in the past decade separate laboratory and non-laboratory functions into distinct, adjoined structures (although such a building may *look* like one structure). Consolidated non-laboratory functions include faculty, departmental, staff, post-doc, and graduate student offices; restrooms; circulation (elevators, lobbies, primary stairways); classrooms, seminar rooms, conference rooms, and social areas designed to foster interaction and to provide a safe area for eating and drinking; dry labs and dry lab-support functions; and general administrative support.

Consolidating these functions into a separate structure provides considerable cost savings: lower-cost HVAC (heating/ventilation/air-conditioning) system, wider column-spacing, lower floor stiffness (less stringent vibration criterion), lower floor-loading, fewer fire-control features and other code requirements, steel-framed or steel/concrete hybrid structural system with concrete flat-slab flooring system, smaller footings, and (typically) curtainwall fenestration. This approach usually enables offices to have operable windows.

This two-building approach can be seen clearly at Gillespie Neurosciences Building, the Sprague Building, Hewitt Hall, and the UCI Medical Center Health Sciences Laboratory, where consolidating and separating non-laboratory functions saved 7-10 percent in overall construction costs and 15 percent/year in energy expense. (The non-laboratory building incurs a small fraction of the energy expense of the laboratory block.)

A set of design strategies, applied in combination, has proven effective in controlling the cost of laboratories:

- Utilizing a consistent lab module
- Utilizing a reasonable vibration criterion and locating ultra-sensitive conditions at-grade or employing benchtop vibration isolation
- Using 22 ft. X 22 ft. column-spacing
- Concentrating fume hoods and utility risers into a central "wet zone," thus limiting horizontal mechanical distribution
- Concentrating laboratory support areas into the central core of a laboratory structure, where utilities are available but daylight is not needed, thus enabling lab structures to be 110-132 feet wide
- Utilizing dual-usage circulation/equipment cross-corridors through this central lab support zone, with sufficient width (typically 11 feet) to line the corridors

with shared equipment while providing cross-circulation through the lab support zone

- Utilizing open laboratory layout with one or more "ghost" corridors for intra-lab circulation
- And, most importantly, concentrating non-laboratory functions into an adjoining, lower-cost structure (as discussed in detail above).

To further control laboratory construction costs, non-standard fume hood sizes are minimized, "generic" lab casework is specified, laboratory-grade movable tables substitute for fixed casework in some lab bays, building DI systems provide intermediate water quality (with localized water purity polishing in the lab, rather than building-wide), facility-wide piped services do not include gases that can be cost-effectively provided locally via canisters, and glass-wash facilities are consolidated -- typically, one glass-wash facility for an entire laboratory building.

Finally, our design philosophy leans toward generic, modular laboratories supported by a robust building infrastructure, rather than highly customized spaces with limited capacity to make later changes. This is an important tradeoff. Although some post-occupancy expenses may be necessary to "fine-tune" a laboratory to a PI's requirements, building infrastructure elements – typically oversized twenty percent, including HVAC supply ducts, exhaust system capacity, emergency generator capacity, and electric risers and service capacity – seldom limit the ability to modify labs to meet researcher needs.

Structural and Foundation Systems

For both cost-benefit reasons and past seismic performance, UC Irvine favors concrete shear wall or steel braced-frame structural systems. The correlating foundation systems depend on site-specific soil conditions. Past problems with undiscovered substrates and uncharacterized soil conditions are minimized through extensive, pre-design soil-testing. This minimizes risk to both the University and the design/build contractor.

When feasible, design/build contractors are allowed flexibility to propose alternate structural or seismic-force systems. All structural system designs must pass a peer-review, according to Regents' policy. This process results in conservative structural design, and an associated cost premium. However, the seismic performance of University of California buildings constructed since this policy went into effect in 1975 appears to substantiate the value of the Regents' Seismic Review Policy.

Structural vibration is carefully specified in research buildings where vibration-sensitive protocols and conditions must be maintained on above-grade floors. The most cost-effective tools to control vibration are generally employed: first, to program vibration-sensitive procedures at on-grade locations or to isolate them at the bench; second, to space columns at a distance that does not entail excessive structural costs. In laboratory buildings we typically utilize 22 ft. X 22 ft. column-spacing. Conversely, where vibration is not problematic a beam/column system can be cost-optimized and lighter floor loading can be tolerated. Design/build contractors are, accordingly, allowed more flexibility under such conditions.

To control costs, UC Irvine avoids use of moment-resisting structures; unconventional seismic systems; non-standard structural dimensions; inconsistent, unconventional, or non-stacking structural modules; and non-standard means and methods.

Building Mechanical Systems

Over the past decade, UC Irvine's new buildings have been designed to out-perform California's Title 24 (energy code) by at least 20 percent. However, sharply escalating, unfunded energy costs and The Regents' new Green Building Policy (adopted June 2003) point to the need to achieve 30-40 percent savings (with reference to Title 24) in the future. This represents an *enormous* challenge.

In order to approach 30 percent energy savings in wet laboratories, it will be necessary to install a type of low-flow, efficient fume hood that is certified for use in all states except California. UC Irvine technical staff are playing a leadership role in UC's bid to gain CalOSHA certification of an energy-efficient fume hood. Moreover, laboratory refrigeration equipment will need to attain the kinds of energy-efficiency improvements realized by "Energy Star" residential refrigerators over the past decade. Air exchange-rates in laboratories will need to be reduced, especially during unoccupied hours (using occupancy-sensors), and laboratories will need to employ best-practice mechanical system design features being developed by the DOE/LBNL Labs 21 project (affirmed in the Regents' new Green Building Policy).

Non-laboratory buildings will need to move beyond current energy design practices to incorporate such features as daylight-sensors for lighting control, higher-performance glazing systems, and transoms above office doors to improve natural ventilation in conjunction with operable windows. All of these measures and design features will add costs, although fossil fuel emissions and the campus' utility deficit will benefit, consistent with the Regents' intent as codified in their new Green Building Policy.

Energy-efficient mechanical systems entail a significant cost premium that the campus pays for using savings derived *elsewhere* throughout the project. These higher costs include premium-efficiency materials and components; increased duct, plenum, fan housing, and filter sizes to slow HVAC airspeeds (a primary factor in reducing HVAC energy consumption and operating costs); increased building volumes in terms of riser sizes, mechanical room sizes, and above-ceiling volume as needed for oversize HVAC distribution components; sophisticated, computer-based (digital) controls; and multiple, smaller, (typically) occupancy-controlled HVAC zones for control and efficiency. This is just a sampling of the energy-efficiency design practices we employ. In addition, many macro-scale efficiencies are realized at the Central Plant, and we intend to “count” these in documenting our progress toward the Regents’ Green Building Policy.

Other design objectives apply to laboratory mechanical systems, in particular. Safety is of paramount concern. Reliability and robustness are important to a first-rate research infrastructure. Avoidance of major maintenance for at least twenty years is necessary, given the University’s backlog of deferred maintenance, its underfunded routine maintenance, and its complete absence of funding for major and deferred maintenance. In addition to specifying premium-quality mechanical equipment, we typically install a weather-protection canopy over roof-mounted equipment, which adds years to the useful life of such equipment (even if it is rated for outdoor use).

Another important dimension of mechanical system “robustness” is the extra 20 percent capacity that is typically designed into primary, core distribution systems and risers. This enables future modifications without replacing or up-sizing risers, fans, conduits, and mechanical rooms. In other words, the elements that are practically impossible to expand later are intentionally oversized, while easy-to-add items, such as branch ducts and circuits, are *not* oversized.

Roofs and Flashings

UC Irvine specifies 20 year roofing systems and stainless steel or copper flashings whenever possible. At minimum, we specify hot-dip galvanized flashings.

Why this emphasis on flashings? Our roof replacement projects typically double in cost when the old roofing is torn off and it is determined that the flashings have deteriorated. Moreover, many roof leaks of recent years have been due to faulty flashings, rather than roofing membranes or coatings, per se. Saving money on flashings is false economy.

Another special roofing expense we may have to incur in order to attain the Regents’ Green Building Policy is that of reflective roofing. It is too early to understand the potential cost impact.

Site Development

In accord with the design goal to “create a place,” most UC Irvine projects include exterior landscape and “hardscape” elements such as plazas, walkways, seat walls and retaining walls, site lighting, and landscape materials that extend all the way to neighboring buildings. Since there is no capital budget for site development, per se, a new building project provides the “now or never” opportunity to fund site improvements.

We prefer to use interlocking, heavy-duty, concrete pavers rather than a poured monolithic material for walkways and plazas, for two reasons: aesthetics and cost. The latter reason centers around long-term costs, as pavers initially cost more than asphalt or concrete. However, pavers cost less on a *life-cycle* basis, because in a growing research campus practically every walking surface -- particularly near the Ring Mall -- will need to be excavated in order to install new utilities or to fix underground utilities problems. When pavers are involved, the patch is invisible once the job is completed; moreover, the materials are re-used, which is environmentally responsible.

UC Irvine uses reclaimed water for landscape irrigation, and landscape materials are specified in accord with the UC Irvine "Green & Gold Plan." These practices have been in effect for nearly a decade, and are consistent with The Regents' new Green Building Policy. Site lighting is provided by concealed-source fixtures, consistent with green building standards. Projects' site development costs include extension of utilities to the project as well as infrastructure capacity upgrades necessary to support a new building. Occasionally these infrastructure constraints are unforeseen at the time of project design, since the campus has not completed an infrastructure engineering master-plan.

During the past decade, practically every new building included a major public plaza. Most buildings constructed during the *prior* decade did not include extensive site development. However, now that we have constructed the Social Sciences Plaza, the Humanities Plaza, several new hardscape areas in the Biological and Physical Sciences, the new Engineering/ICS Plaza, and the new lower Gateway Plaza (near the Main Library), it may not be necessary to include extensive hardscape in upcoming capital projects. This budgetary shift, accordingly, may help enable us to address the costs stemming from the Regents' new Green Building Policy.

Exterior Cladding and Interior Finishes

Buildings completed during the past ten years use notably different exterior materials than those completed during the 1980s. Due to stringent capital budgets, many of the 1980s projects used exterior stucco cladding (including Social Ecology, GSM, the Science Library, Physical Sciences Annex, ICS/Engineering Research Facility, and Computer Science/Engineering). Buildings completed since 1993 are clad with masonry, poured-in-place concrete, and other permanent materials that do not require initial or periodic painting and patching. Exterior plaster (stucco) is now used only as a surface coating over a masonry substrate (as distinct from a lightweight stucco system), except for housing projects, where it is used in combination with generous eave overhangs and ample expansion joints.

Buildings completed over the past ten years have used high-performance glass on sun-exposed elevations, typically specified for a high ratio (~1.5) of visible light transmittance to shading coefficient. (This maximizes useful daylight relative to unwanted solar gain.) High-performance glass is our first line of defense -- by keeping solar heat gain out of buildings at the point-of-entry -- and a key tool in achieving our energy-efficiency objective for new buildings. Our buildings use generous amounts of north-facing glass for day-lighting. Well-detailed curtainwall window systems are readily used where cost-effective (e.g., office windows of Gillespie Hall, Sprague Hall).

Exterior materials and their application in recent buildings are consistent with a campus design philosophy that has been affirmed by Regents, Office of the President staff, Presidents Peltason and Atkinson, and by many members of the UC Irvine campus community. "Classical contextual architecture" derives partly from building forms and detailing, and partly from the consistent use of materials that reinforce a feeling of permanence and quality -- architecture that is "institutional" in the best sense of that term.

Interior finishes are typically conventional and employ standard materials, detailing, and means and methods of construction in order to control building costs. Durability is an important goal that leads to such features as quality hardware (e.g., locksets); corner-guards, plasticized coatings, chair-rails, and wall coverings in heavily trafficked corridors; full-height ceramic tile on restroom plumbing walls; welded door jambs; and institutional quality doors and hinges. We provide more acoustical isolation between adjacent offices than is conventional, and more bedroom and bath sound isolation in residential facilities (although we specify generic acoustical finishes and materials rather than specialized products). New classroom designs apply an extensive set of design standards and criteria in order to attain excellent seeing and hearing conditions as well as modern instructional resources (a good example is the Humanities Lecture Hall).

Sustainable Design

The Regents' Green Building Policy is consistent with many practices put into effect at UC Irvine during the past decade, which gives the campus a "head start" toward attaining the policy's goal of "silver" certification based on the sustainability standards of the U.S. Green Building Council. Despite this advantage, a definite, un-funded capital cost increment will be required in order to attain the Regents' policy.

While it is too early to understand with certainty what features will be needed, and their incremental and aggregate costs, we believe that a sharp improvement in energy-efficiency will be required in order to attain the new policy, as discussed above. In addition, we will likely install reclaimed water and/or waterless urinals in high-usage restrooms, include a number of on-site and off-site stormwater treatment components, install a men's and women's shower stall in each academic quad for bicyclists, require specified percentages of recycled and rapidly-renewable content in building materials, require recycling of a specified percentage of the construction waste-stream, install more user-operable windows, employ means to increase daylighting of interior spaces, and enforce a number of indoor air quality protocols and tests.

UC Irvine has been a leader in designing buildings for energy-efficiency and sustainability, and we intend to maintain this reputation.

Attachment A compares UC Irvine campus standards with standards typical for high quality office and R&D space in the local commercial real estate market. Cost vs. lifespan comparisons are provided for items that are typically proposed, but rejected, in value-engineering. The reasons are evident from the "Deltas" column in Attachment A.

Priorities and Trade-Offs

UC Irvine's building designs intentionally trade-off particular design decisions and the associated costs in order to achieve stated performance goals and quality standards. These goals and standards would not be attainable within established capital budgets without rigorous cost-control in the areas targeted for intentional trade-offs.

This entire decision-making system and its precepts warrant review, fine-tuning, and affirmation in order to assure that capital investment decisions are cost-effective, both initially and on a life-cycle basis. Incidentally, this is not only sound campus policy, but also an inherent part of the Regents' Green Building Policy.

To review, current practices and standards applied to new building designs at UC Irvine aim to effect the shifts in costs and quality summarized in the following table. There is no way to realize the benefits in the right-hand column without the cost-control strategies summarized in the left-hand column:

Cost-Control and Savings Strategies	**Areas Into Which Savings are Redirected**
Building ratios for floorplates, exterior "skin," etc. (page 2). Cost-effective architectural detailing and articulation strategies (page 2). Consolidation/separation of non-laboratory functions into adjoined structure (pages 2, 3). Portfolio of cost-effective laboratory design practices (pages 3, 4). Generic, modular approach to laboratory design (page 4). Conventional structural, seismic, and foundation systems (page 4). Close column-spacing in laboratory structures and cost-effective approaches to vibration-control (page 4). Exterior stairways. Avoidance of custom-fabricated, exotic, specialized materials (pages 4, 7, 8). Conventional interior finishes (page 8). Generic acoustical materials (page 8). Future possibility: Reduced hardscape (page 7). Curtain-wall window systems (page 8).	Regents' Green Building Policy requirements and UCI energy-efficiency objectives (pages 5, 8). In particular: • Reduced energy consumption and utilities expense (page 5) • Low life-cycle costs (pages 1, 2, 4, 5, 6, 7, 8) • Durable hardware and interior finishes (pages 7, 8) • Glazing that provides generous daylighting with high solar-gain performance (page 7) • Small, occupancy-controlled HVAC zones for comfort as well as efficiency (page 5). • Additional measures needed to attain 30% energy savings required by Regents' new policy (page 5). Robust laboratory core infrastructure systems to support inexpensive future modification and flexibility (pages 4, 6). Durable materials and system quality to avoid major maintenance expenses for 20 years (pages 1, 6). Quality exterior cladding systems (page 7). High quality teaching spaces (page 8). Flashings (page 6). Operable office windows (pages 3, 5, 8). Quality hardscape and landscape features (page 6). Sound-isolation (e.g., between offices) (page 8). Weather-protection canopy to extend life of roof-mounted equipment (page 6).

The priorities, trade-offs, and underlying assumptions inherent in the table above should be discussed, understood, and adjusted or reaffirmed periodically in order to ensure that the University's construction standards are appropriate and that the capital program remains cost-efficient and responsive to academic needs and priorities. And these standards and quality criteria need to be understood in order to arrive at valid cost comparisons.

Attachment A
Campus Standards Versus Commercial Standards
Cost vs. Lifespan Comparison for Items Frequently Proposed, but *Not Selected* , in Value Engineering

Component Group	Component Costs			Estimated Lifespan in Years		Deltas		Comments
	Good Commercial	UCI Campus Standard	Cost Difference	Good Commercial	UCI Campus Standard	Cost	Life	
HVAC								
Air-Handlers	$2.50/CFM	$4/CFM	$1.50/CFM	20	40	60%	100%	Extended service operation impacts service life, especially in 24X7 science buildings. Commercial grade air-handlers in campus installations have not lasted more than 20 years.
Reheat Coils	Aluminum	Copper	$0.36/CFM	15	40	130%	167%	Marine air due to proximity to the ocean causes corrosion on aluminum coil components, and campus installations have shown a maximum of 15 year life spans. Early campus installations of copper coils have lasted 40 years.
Exhaust Duct	Galvanized $7/lb	Stainless $10/lb	$3/lb	25	50	43%	100%	Stainless is used to resist the corrosion from chemicals and to allow for the maximum flexibility in use. Galvanized shows earlier deterioration, shortening service life.
Roofing								
Roof Warranty	10 year	20 year	$0.75/SF (for a $7/SF installation)	15	25	11%	66%	Extended warranty reduces UCI's maintenance costs over the life span of the roof and assures a higher quality intallation.
Flashings	Galvanized $6.70/SF (installed)	Stainless $9.80/SF (installed)	$3.10/SF	20	60	46%	200%	The Sheet Metal and Air Conditioning Contractors National Association (SMACNA) specifies stainless, copper, or zinc flashings for roofing systems with lifespans >15 years. Note that, in addition to lifespan considerations, water leakage due to flashing failure will damage underlying roofing materials and cause additional damage to finishes/interior space.
Door Hardware*								
Door Handles/Locksets	Grade 2 $250 (installed)	Grade 1 $350 (installed)	$150	5	20	60%	>200%	Most locksets are in areas that have high student use. Grade 1 hardware holds up better in high use areas and can be rebuilt economically. Tests of Grade 2 hardware in campus housing resulted in failures at <1 year.
Panic Hardware	$1,000 (installed)	$1,500 (installed)	$500	5	20	50%	>200%	Lower cost units installed on campus have required frequent maintenance and early replacement.
Plumbing								
Lavatory Faucets	$125 (installed)	$290 (installed)	$165	7	30	132%	>200%	Faucets must hold up to high use. Institutional quality units can be economically rebuilt and require less maintenance over their lifespans compared to commercial grade.

*Based on this evaluation, standards were reduced for door jambs, as follows:

Old standard: Welded jambs
New Standard:

A. Permanent doors, e.g., stairwells and restrooms: welded jambs
B. Other doors that might be relocated within 25 years: knock-down jambs