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ABSTRACT

This report, the second in a series which present the results of a systems analysis of the problem of providing science and engineering buildings at the university level, is a detailed analysis of California and Indiana buildings. It relates construction costs to performance and includes studies of alteration costs and different space types in these buildings. The document covers (1) cost/performance data -- summaries and comparisons; (2) cost/performance data -- bioscience buildings; (3) cost/performance data -- science and engineering buildings; (4) cost/performance data -- classroom office buildings; (5) alteration costs, and (6) functional area costs. Each section consists largely of cost charts and diagrams with analysis. Related documents are EA 003 886 and EA 003 887. (Author)

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cost performance study ABS

2 six science and engineering buildings

EA 003 888

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ACADEMIC BUILDING SYSTEMS

A Joint Effort of
Indiana University and the University of California
Supported by the Legislatures of the
States of Indiana and California
and by
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and the
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Facilities Engineering and Construction Agency
U.S. Department of Health, Education and Welfare

July 1971

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INTRODUCTION

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[illegible] the ABC [illegible] the ABC [illegible] assumed the responsibility for designing and coordinating [illegible] Also, the large [illegible] construction [illegible] single [illegible] projects [illegible] the goals and objectives of the ABC [illegible] the basis for development of a building system.

[illegible] the ABC [illegible] University of California [illegible] and Indiana [illegible] the ABC [illegible] performance and [illegible]

Descriptions of each of the six sample buildings [illegible] in the publication ABC *Environmental Details, Science and Engineering Buildings*. The same six sample buildings were used for the [illegible] study. These buildings are as follows and are designated in this study as indicated:

1. Biological Sciences Unit 2 [illegible] University of California, Irvine, California
2. Natural Sciences Unit [illegible] University of California, Irvine, California
3. Biological Sciences Unit 2, University of California, Santa Barbara, California
4. [illegible] Hall, Indiana University, Bloomington, Indiana
5. [illegible] Hall, Indiana University and Purdue University, Indianapolis, Indiana
6. Civil Engineering Building, Purdue University, Lafayette, Indiana

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

OPERATION AND MAINTENANCE COSTS

[illegible]

[illegible]

[illegible]

ALTERATION AND MODIFICATION COSTS

A major objective of the ABS project is to meet the continuing need for change by providing buildings that can better accommodate both foreseeable and unanticipated trends during their lifetimes, and in a realistic cost context. The goal is to lower the cost of change while at the same time maintaining or improving the performance of buildings.

To provide a measure for the cost of adaptability, the ABS consultant developed a hypothetical time-stage model of typical alterations that might take place in a segment of any laboratory building. The costs of these alterations were determined for each of the six sample buildings and compared with initial construction costs for the [illegible] segment in each building. Also studied in this connection was the amount of disruption time affecting adjacent spaces. The findings are included in this document.

Another study of alteration and modification costs [illegible] concerns the costs incurred in changing space from one type of occupancy to another (e.g., from office to research laboratory) in the sample buildings. Graphs are also included showing cost histories of several other university buildings, illustrating the accelerating rate of change.

PROGRAMMING, PLANNING, AND CONSTRUCTING

Under conventional procedures, several years usually elapse between the time a major building is programmed and the time it is occupied. Programming must be completed before planning can be started, and full working drawings must be finished before construction can be contracted for. The time interval must account for substantial construction cost increases and some degree of built-in obsolescence in the completed facility.

Where normally sequential procedures can be overlapped, the time interval and consequently costs can be reduced. The use of a building system affords such opportunity. A building system provides "knowns" of subsystem design and cost performance control, allowing project development to be split into three phases. In the first phase only that planning to establish the general area and mass configuration of the building need be done. Then, following design of the basic framing and foundation plan, construction of site work and foundations can start. As this construction work proceeds, the second phase of general planning of the interiors can be commenced. When the shell of the building is nearing completion, the third phase involving final planning decisions on detailed departmental space arrangement, equipment provisions, and furnishings can be undertaken with the direct users walking around within the actual space they will occupy.

The combination of phased planning and construction and the use of an adaptable building system can result in academic facilities which are more responsive to user needs and also less costly.

The cost performance [illegible]udy was conducted to provide the statistical data base for ABS subsystems des[illegible]he purpose of this report is to document the effort and summarize the findings of the ABS consultants. Hopefully, the study will provide new insights for significant analyses and compar[illegible] of academic facilities.

[illegible]

[illegible]

[illegible] Assistant Vice President [illegible]

[illegible] University Architect

[illegible] Director Department of Physical Plant

[illegible] ABS Program Coordinator

[illegible] Secretary

[illegible]

[illegible] Assistant Vice President Physical Planning and Construction

[illegible] Director Building Systems Projects and ABS Project Director

[illegible] Assistant Director Building Systems Projects

[illegible] Administrative Analyst

[illegible] Administrative Assistant

[illegible]

Building Systems Development, Inc. San Francisco

[illegible], President

[illegible], Vice President, Officer in Charge of ABS

[illegible], ABS Project Manager

Consultants to Building Systems Development, Inc.

[illegible] Engineers, Inc

[illegible] and Associates, Inc.

[illegible] and Associates

The [illegible] Company

[illegible] and McLellan

[illegible] Associates

[illegible] Demonstration Building

The Indiana University/Purdue University campus, Indianapolis, Indiana

[illegible]

Building Systems Development, Inc.

[illegible] Associates

[illegible] Burkart, Shropshire, Boots, Reid & Associates

California Demonstration Building

To be designated at a later date

ABS PUBLICATIONS

ABS documents have been prepared by the ABS staff of the Office of the President, University of California. Except for a limited printing by the University of California Printing Department, the documents have been printed by Indiana University Publications, at the expense of Educational Facilities Laboratories, Inc. Copies are available from either of the two Universities.

Performance data becomes extremely useful to the subsystems designer when it is presented along with costs—an essential ingredient in the systems approach. For this reason, and also to establish the actual cost targets for ABS, an extensive cost study was undertaken.

This section presents summaries and comparisons of the cost and performance data (detailed in the sections following) for six science and engineering buildings, selected as typical examples in Indiana and at the University of California. These buildings are as follows:

Bioscience Buildings: Californiaa
- U.C. Davis — Biological Sciences Unit 3
- U.C. Irvine — Natural Sciences Unit 1
- U.C. Santa Barbara — Biological Sciences Unit 2

Science, Engineering Buildings: Indiana
- Jordan Hall — Indiana University, Bloomington
- Krannert Hall — Indiana University and Purdue University, Indianapolis
- Civil Engineering Building — Purdue University, Lafayette

The source materials were the working drawings, specifications and bid documents of the six buildings, estimated for purposes of comparison as if they had been bid in January 1970, in the San Francisco Bay Area, with an Engineering News-Record (ENR) Construction Cost Index of 1300.

The buildings are presented in terms of their individual subsystems. This organization of cost and performance data readily permits comparisons between buildings or subsystems. Each building can be considered as a separate package of subsystems which, working together, exemplify the ranges of performance of that building. Once the buildings are seen as packages, or related groups of subsystems, it is possible to consider and evaluate other hypothetical combinations or packages of subsystems. Thus the subsystems were considered in terms of performance and cost separately, and new groupings formed of the highest and lowest performance packages of subsystems, and of the highest and lowest cost packages. The hypothetical packages provide a base of the extremes of existing costs and performance against which proposed packages may be evaluated.

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The following charts are included in this Summaries and Comparisons Section:

Chart	Description
A	Subsystem Equivalent Costs, $/OGSF
B	Component Unit Costs, $/Component Quantity
C	Subsystems Cost/Performance
	Structure Subsystem
	HVAC Subsystem
	Partitions Subsystem
	Lighting/Ceiling Subsystem
	Exterior Skin Subsystem
	Laboratory Casework Subsystem
D	Highest Cost Package of Subsystems
E	Lowest Cost Package of Subsystems
F	Highest Cost Performance Package of Subsystems
G	Lowest Performance Package of Subsystems

Summary charts of alteration costs and functional area costs appear in other sections of this document.

Cost/Performance data on other than science and engineering buildings is presented in the section dealing with a classroom-office building beginning on page 149.

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SUMMARY CHART A – SIX EXISTING BUILDINGS

SUBSYSTEM EQUIVALENT COSTS, $/OGSF – ENR 1300*

	DAVIS	IRVINE	SANTA BARBARA	CALIF. AVG.	BLOOM-INGTON	INDIAN-APOLIS	PURDUE	INDIANA AVG.	SIX BLDGS. AVG.
SYSTEM**									
Structure	7.29	7.38	7.78	7.48	4.54	4.82	5.96	5.10	6.29
HVAC	4.20	3.66	5.83	4.56	4.56	4.85	4.17	4.53	4.54
Partitions	3.39	2.96	2.80	3.06	4.98	3.96	5.33	4.76	3.91
Lighting/Ceiling	1.80	1.40	1.62	1.61	1.61	1.43	1.44	1.49	1.55
Subtotal	16.68	15.40	18.03	16.71	15.69	15.06	16.90	15.88	16.29
NON-SYSTEM									
Site Work, Below Grade and Basement	2.35	3.33	3.34	3.01	1.87	3.00	2.07	2.31	2.66
HVAC	.34			.11	2.58		.30	.96	.54
Partitions	.72	.49	1.26	.82	.90	1.10	1.29	1.10	.96
Plumbing	3.76	3.51	6.07	4.44	3.84	2.54	3.66	3.35	3.90
Electrical	2.91	2.13	4.04	3.03	2.59	3.18	3.48	3.08	3.05
Ceiling	.06	.02	.02	.03	.03	.08	.06	.06	.05
Exterior Skin	4.03	3.91	2.67	3.54	7.03	2.44	3.61	4.36	3.95
Elevators	.72	.60	1.25	.86	.33	.53	.33	.40	.63
Other	1.38	2.27	2.58	2.07	2.37	1.73	2.99	2.36	2.21
General Contractor	1.87	1.74	2.27	1.96	3.52	1.52	2.83	2.62	2.29
Subtotal	18.14	18.00	23.50	19.87	25.06	16.12	20.62	20.60	20.24
TOTAL	34.82	33.40	41.53	36.58	40.75	31.18	37.52	36.48	36.53
Laboratory Casework	4.38	4.20	3.35	3.98	3.38	2.26	1.12	2.25	3.11
TOTAL	**39.20**	**37.60**	**44.88**	**40.56**	**44.13**	**33.44**	**38.64**	**38.73**	**39.64**

*January 1970 prices, San Francisco Bay Area.

**Includes all components equivalent to ABS subsystems.

SUMMARY CHART B – SIX EXISTING BUILDINGS
COMPONENT UNIT COSTS, $/COMPONENT QUANTITY – ENR 1300*

	FLOORS (STRUCTURE) $/S.F.	ROOF** $/S.F.	INTERIOR PARTITIONS $/S.F.	EXTERIOR SKIN $/S.F.
Davis	5.39	5.60	4.88	9.78
Irvine	5.89	6.06	4.23	12.75
Santa Barbara	4.83	6.73	3.64	7.69
Calif. Avg.	5.36	6.12	4.24	10.06
Bloomington	4.99	6.84	5.76	17.58
Indianapolis	5.17	5.26	4.90	11.40
Purdue	6.29	7.33	5.74	10.76
Indiana Avg.	5.48	6.47	5.46	13.23
Six Buildings Avg.	**5.43**	**6.30**	**4.86**	**11.66**

*January 1970 prices, San Francisco Bay Area.

**Includes ceilings and finishes.

SUMMARY CHART C – SIX EXISTING BUILDINGS
SUBSYSTEMS COST/PERFORMANCE
ABS SUBSYSTEMS

	DAVIS	IRVINE	SANTA BARBARA	BLOOMINGTON	INDIANAPOLIS	PURDUE
STRUCTURE SUBSYSTEM						
Material	poured concrete	poured concrete	poured concrete	poured concrete	poured concrete	poured concrete
Type	slab and frame	waffle slab and frame	waffle slab and frame	slab and frame	slab and frame	slab and frame
Bay Size	20×30 20×40	30×30	30×30	[illegible]	[illegible]	[illegible]
Floor Live Load	50 lbs	50 lbs	100 lbs	80-100 lbs	50-100 lbs	50-[illegible] lbs
Stories	6	5	6	5	5	5
Shear Structure	poured concrete walls	poured concrete walls	poured concrete walls	moment frame	moment frame	[illegible]
Floor-Floor Height	14'-0"	12'-0"	[illegible]	[illegible]	[illegible]	[illegible]
Structure Depth	7.4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Structure/Service Depth	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/SQ.FT.* (floor component)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/OGSF*	7.29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* January 1970 prices, San Francisco Bay Area

CHART C AIR SUBSYSTEMS (continued)

	[illegible]	[illegible]	SANTA BARBARA	[illegible]	[illegible]	[illegible]
HVAC SUBSYSTEM						
Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Energy Source	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CFM/GSF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Outside Air	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GSF/Ton	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Filtration %	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Humidity Control %	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fan Room Location	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Intake Location	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Exhaust Location	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/GSF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

CHART C [illegible] (continued)

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]						
Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fire Rating	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Combustibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Height	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/SQ.FT. (of partition)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/CU.FT.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

CHART C [illegible] (continued)

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LIGHTING/CEILING/HVAC SUBSYSTEM						
Ceiling Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ceiling Height	[illegible]	[illegible]	[illegible]			
HVAC	[illegible]	[illegible]	[illegible]			
Lighting Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Watts/S.F.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fixture Spacing	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Switching Form	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Switching Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/SQ.FT.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*January 1971 prices, San Francisco Bay Area

CHART C NON AIR SUBSYSTEMS (continued)

	[illegible]	[illegible]	SANTA BARBARA	[illegible]	[illegible]	[illegible]
EXTERIOR SKIN SUBSYSTEM						
% Total S.F. Glazed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Glass Operable	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sun Control	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Unglazed U-Factor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ext. Face Material	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ext. Finish	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/SQ.FT.*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNIT COST $/CUBE*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* January 1970 prices, San Francisco Bay Area.

CHART C NON ABS SUBSYSTEMS (continued)

	DAVIS	IRVINE	SANTA BARBARA	[illegible]	[illegible]	[illegible]
LAB CASEWORK SUBSYSTEM						
Case Materials	wood	wood	wood	wood	wood	wood
Bench Top Materials	plastic laminate stainless steel cement asbestos	plastic laminate stainless steel cement asbestos	plastic laminate stainless steel epoxy resin composition	stainless steel polyethylene Duriron polypropylene	plastic laminate polyethylene	polyethylene
Sink Materials	stainless steel epoxy resin composition polyethylene	stainless steel cement asbestos polyethylene epoxy resin composition	stainless steel epoxy resin composition	stainless steel polyethylene Duriron	stainless steel	stainless steel
UNIT COST, $/OGSF *	4.38	4.20	3.26	3.20	3.26	[illegible]

* January 1970 prices, San Francisco Bay Area

SUMMARY CHART D SIX EXISTING BUILDINGS
HIGHEST COST PACKAGE OF ABS SUBSYSTEMS

SUBSYSTEM DESCRIPTION		PERFORMANCE
STRUCTURE	**PURDUE**	**$6.29/S.F. (floor)**
Poured concrete slabs, beams, joists and columns		Bay sizes 20' x 24'-6", 28', 34'-6" 13'-1 3/8" floor to floor heights 2'-8" structure depth
Fourth floor steel. Rigid connections		Floor live load 50 to 300 PSF
HVAC	**SANTA BARBARA**	**$5.83/OGSF**
Double duct system with mains running over corridors		100% building served, 175 OGSF/ton, 1.25 CFM/OGSF 100% fresh air, 50% filter efficiency 15% of building has humidity control
PARTITIONS	**BLOOMINGTON**	**$5.76/S.F. (partition)**
80% concrete block replaceable		4" and 6" thick, STC 41-48, 1 hour fire rating
20% metal demountable		3" thick STC 40
LIGHTING/CEILING	**DAVIS**	**$1.80/OGSF**
8'-2T fluorescent suspended in labs and offices		5' and 6' o.c., 3 to 4 watts/S.F.
8' & 4'-2T recessed in classrooms		5' o.c., 4 watts/S.F.
4'-2T recessed in corridors		10' o.c., 0.6 watts/S.F.
TOTAL SUBSYSTEMS COST PACKAGE		**$19.68**

SUMMARY CHART E – SIX EXISTING BUILDINGS
LOWEST COST PACKAGE OF ABS SUBSYSTEMS

SUBSYSTEM DESCRIPTION		PERFORMANCE
STRUCTURE	**SANTA BARBARA**	**$4.83/S.F. (floor)**
Poured concrete columns and waffle slab poured concrete shear walls.		30′ x 30′ bay size 14′-6″ floor-to-floor height 1′-7½″ structural depth Floor live load uniform @ 100 PSF
HVAC	**IRVINE**	**$3.66/OGSF**
Double duct system with mains running over corridor.		100% building served. 1.14 CFM/OGSF 40% return air 295 OGSF/ton, 35% filter No humidity control
PARTITIONS	**SANTA BARBARA**	**$3.64/S.F. (partition)**
Metal studs, lath and plaster.		6″ and 4″ thick, STC 40 2 and 1 hour fire rating
Demountable laminated gypsum board 2½″ thick.		2½″ thick, STC 35 2 hour fire rating
LIGHTING/CEILING	**IRVINE**	**$1.40/OGSF**
4′-2T fluorescent, suspended in labs and classrooms.		Fittings @ 6′ o.c., 3.0 to 3.4 watts/S.F.
4′-2T fluorescent recessed in offices.		Fittings @ 8′ o.c., 3.5 watts/S.F.
4′-2T fluorescent recessed in corridors.		Fittings @ 10′ o.c., 1.3 watts/S.F.
TOTAL SUBSYSTEMS COST PACKAGE		**$13.53**

SUMMARY CHART F – SIX EXISTING BUILDINGS
HIGHEST PERFORMANCE PACKAGE OF ABS SUBSYSTEMS

SUBSYSTEM DESCRIPTION		PERFORMANCE
STRUCTURE	**SANTA BARBARA**	$4.83/S.F. (floor)
Poured concrete columns and waffle slab; poured concrete shear walls.		30′ x 30′ bay size 14′-6″ floor-to-floor height 1′-7½″ structural depth Floor live load uniform @ 100 PSF
HVAC	**SANTA BARBARA**	$5.83/OGSF
Double duct system with mains running over corridors.		100% building served, 175 OGSF/ton, 1.25 CFM/OGSF 100% fresh air, 50% filter efficiency 15% of building has humidity control
PARTITIONS	**BLOOMINGTON**	$5.76/S.F. (partition)
80% concrete block replaceable.		4″ and 6″ thick, STC 41-48 1 hour fire rating
20% metal demountable		3″ thick STC 40
LIGHTING/CEILING	**INDIANAPOLIS**	$1.43/OGSF
4′-2T fluorescent suspended in labs		5′ o.c., 3.1 watts/S.F.
4′-2T recessed in classrooms and offices		5′ o.c., 4.5 - 5.2 watts/S.F.
4′-4T recessed in corridors.		16′ o.c., .98 watts/S.F.
TOTAL SUBSYSTEMS COST PACKAGE		**$17.85**

SUMMARY CHART G – SIX EXISTING BUILDINGS
LOWEST PERFORMANCE PACKAGE OF ABS SUBSYSTEMS

SUBSYSTEM DESCRIPTION		PERFORMANCE
STRUCTURE	**BLOOMINGTON**	**$4.99/S.F. (floors)**
Poured concrete slab, columns, beams and joists, rigid connections.		Variety of bay sizes 14′ x 30′ to 22′ x 32′ 11′-6″ floor-to-floor height 2′-2″ structural depth Floor live load 40 to 100 PSF
HVAC	**BLOOMINGTON**	**$4.56/OGSF**
Single duct with local reheat coils		100% heating, 80% air conditioning .66 CFM/OGSF; 75% return air 450 OGSF/ton, electrostatic filter 90% efficiency No humidity control
PARTITIONS	**SANTA BARBARA**	**$3.64/S.F. (partition)**
Metal studs, lath and plaster		6″ and 4″ thick, STC 40 2 and 1 hour fire rating
Demountable laminated gypsum board 2½″ thick.		2½″ thick, STC 35 2 hour fire rating
LIGHTING/CEILING	**BLOOMINGTON**	**$1.61/OGSF**
8′-2T fluorescent, suspended in labs, classrooms and offices.		8′ o.c., 2.2 watts/S.F. in classrooms and labs 2.5 watts/S.F. in offices
1T no lens surface mounted in corridors		1.1 watts/S.F. in corridor
TOTAL SUBSYSTEMS COST PACKAGE		**$14.80**

COMPARISONS

General Building Characteristics and Costs: Of the six buildings studied, Bloomington is by far the largest with 222,065 OGSF; the middle-sized group includes Indianapolis with 134,276 OGSF, Santa Barbara with 132,000 OGSF, and Irvine with 121,000 OGSF; the smallest buildings are Purdue with 113,000 OGSF and Davis with 92,167 OGSF. Purdue has the most efficient ratio of assignable to gross square feet: ASF/OGSF = .61. Bloomington has the least efficient ratio: ASF/OGSF = .54. Of the Indiana buildings, Indianapolis has the most efficient ratio of exterior wall area to gross square feet: .26, because in plan it is a simple rectangle with a length to width ratio of 2 to 1, and a good deal of interior space. Of the California buildings, Irvine has the most efficient ratio of exterior wall area to gross square feet: .37, due to combined factors such as a relatively low floor-to-floor height and a very large area per floor; like Indianapolis, it also has a simple rectangular shape without projections, which tend to dramatically increase the perimeter area. The other two California buildings are rectangular in plan, but Bloomington is U-shaped and Purdue is L-shaped. All of the Indiana buildings have five stories, with one floor below grade in both Bloomington and Indianapolis, and two in Purdue. In California, Irvine has five stories, Santa Barbara and Davis have six, and all have one story below grade.

All the buildings analyzed as part of this project were estimated to the same cost base. The average cost was $38.73/OGSF for the Indiana buildings and $40.56 for the California buildings. The range of the six buildings is from $33.44/OGSF for Indianapolis to $44.88/OGSF for Santa Barbara. Although all the California examples are similarly complex, rather heavily serviced buildings, of the Indiana buildings only Bloomington is strictly a science building. Its cost is $44.13/OGSF. In spite of these similarities in total cost per OGSF, there are significant differences in the areas of expenditure in the two groups of buildings. In Indiana, the buildings tend to have more costly exterior walls and HVAC systems, whereas the California buildings are costly in plumbing and electrical installations.

The three Indiana buildings range from $33.44 to $44.13/OGSF. The highest cost at Bloomington results from such factors as the cut stone and ashlar exterior wall, a complex configuration, heavy utility services and an extensive greenhouse installation. The least costly building is Indianapolis, a simple rectangular block with a brick cavity exterior wall and a very high percentage of general classrooms requiring minimum services.

Of the California buildings, ranging from $37.60 to $44.88/OGSF, the facility at Santa Barbara is conspicuously more costly than the other two. The reason for this is principally the higher performance characteristics of the building. Santa Barbara has more plumbing systems (sea water, etc.), more electrical power capacity, air conditioning with 100% fresh air (no recirculation), humidifiers which none of the other buildings have, considerably more instrumentation and controls on all systems, a completely separate air conditioning system for the animal study areas in the upper floors, and similar refinements. Irvine is the least costly of the California buildings for a combination of reasons; it has a very large area per typical floor (reducing the relative amount and therefore price of the exterior wall), a lower floor-to-floor height, and lower service capacity, particularly electrical, than the other buildings.

The Indiana buildings vary in construction over a fairly long period of time. Bloomington was contracted for in 1952, Indianapolis in 1960, and Purdue in 1962; whereas Irvine was bid in 1963, and Davis and Santa Barbara in 1966. Naturally there have been changes in construction materials during that time, and some of the materials and mechanical equipment would be exorbitantly expensive to duplicate. Yet, in spite of the cut stone walls and terazzo corridors in Indiana, even at today's prices the buildings are slightly less costly than their more recent California equivalents.

Structure: All six buildings have reinforced concrete structures, but each of the subsystems has a set of performance characteristics particular to it. The three Indiana buildings have a poured concrete joist, beam and column structural system using a moment resisting frame to take the lateral forces. In California, Davis has a poured concrete frame and slab, and both Irvine and Santa Barbara have poured concrete columns and waffle slabs; in all three the lateral forces are taken by shear walls. The California buildings are all in UBC Earthquake Zone 3. In the six buildings the range of bay sizes is fairly consistent, with primary spans from 14' to 30', and secondary spans from 30' to 40'. The waffle slabs at Santa Barbara and Irvine are 30' square. The structural depths range from 3'-0" at Indianapolis to 1'-7" at Irvine. One advantage of the waffle slab is this relatively shallow structural depth. A disadvantage is the lack of horizontal permeability that the waffle slab implies. The structure-services depth is greatest at Davis, where it is 5'-10", the second deepest at Santa Barbara, where it is 5'-5"; and least at Bloomington, where it is 2'-6". In this latter case the users complained that when air conditioning had been added, there was inadequate space for ductwork and terminals. Laboratories at

Davis, Irvine and Bloomington are designed for floor live loads of 50 psf at Indianapolis for 75 psf and at Santa Barbara and Purdue for the highest loading of 100 psf

Although all the buildings are essentially of concrete frame construction, the California buildings are generally more expensive than their Indiana counterparts as a result of the high seismic design loads The one Indiana building that is exceptionally high in cost is Purdue, with some areas designed for 300 psf live load In terms of cost of structure per OGSF, not including costs of foundations or slabs on grade, the Indiana subsystems average $5 10/OGSF, the California structural subsystems average $7 48/OGSF

HVAC: Davis, Irvine and Purdue have heating and cooling supplied from central campus sources. Santa Barbara and Indianapolis have their own heating and cooling plants. Bloomington has its own cooling plant, but heating comes from a central plant. Air handling units are central to the buildings at Santa Barbara, Irvine, Bloomington and Indianapolis. Davis has an air handling unit on each floor of the building. Purdue has a combination of multi-zone units on each floor with local unit ventilation and reheat coils. Indianapolis has unit ventilators under the windows to minimize window drafts, but at the expense of possible casework locations. The multiple air-handling units at Davis appear to take up a slightly higher percentage of floor area than a single unit, but with various advantages for zoning and adaptability

The six buildings use fume hoods for exhaust, but intake locations vary from basement, grade, each floor (Purdue and Davis), or the roof. The distribution system at Santa Barbara and Irvine takes air from two separate air handling units in the basement, via two separate vertical cores, each serving half the building, to main horizontal ducts in the corridor ceilings. In Bloomington, the perimeter is heated by radiation, air handling units feed air in four separate shafts. Air conditioning was an after-thou t, and the chiller was placed under the main auditorium with high disruption to the use of this space. Further, cold air ducts run down the non-air-conditioned corridors causing extensive condensation through the metal ceiling. The dual duct system at Indianapolis feeds up the middle of the building in a vertical service shaft.

The California buildings have 100% heating and air conditioning. The Indiana buildings all have 100% heating and 80%, 90% and 75% air conditioning in Bloomington, Indianapolis and Purdue respectively. The capacities of the buildings

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vary, with a much higher heating capacity in all the Indiana buildings, and a generally higher cooling capacity in the California buildings. Davis and Irvine have 795 tons and [illegible] tons respectively, and Santa Barbara 752 tons. Bloomington is the only exception to this with a cooling capacity of 500 tons. These relationships reflect the special demands of the climates of the two states.

A more revealing figure about the performance of the systems is the relation of OGSF/ton of refrigeration. Santa Barbara is the highest performing system with [illegible] OGSF/ton, second best is Davis, third is Irvine, and the three Indiana buildings follow, with the lowest performance that of Indianapolis, with [illegible] OGSF/ton. According to the users, ventilation is inadequate in all six buildings. The highest performance is at Davis with 1.8 cfm/OGSF, second Santa Barbara with [illegible] cfm/OGSF, third Irvine, Purdue and Indianapolis fourth and fifth, and Bloomington lowest with [illegible] cfm/OGSF. Again, in terms of percentages of air returned and recirculated in the system, the California buildings have a higher level of performance. Santa Barbara exhausts all its air, Davis uses 16.9% return air, and Irvine uses 40%. Purdue, Indianapolis and Bloomington use 69%, 77% and 79% respectively. The highest quality filter is in Bloomington, which has an electrostatic filter with 90% efficiency. Second highest is the replaceable filter at Santa Barbara which is 50% efficient. All the others are around 35%, the California examples being replaceable and the Indiana ones roll type. Of the six buildings, only Santa Barbara has any humidity control: 15% of the building.

The HVAC costs for Indiana average $4.53/OGSF and for California $4.56/OGSF. The California average is considerably higher than its mean of $4.20/OGSF because of the influence of the elaborate system at Santa Barbara, costing $5.83/OGSF.

Although the California buildings have a considerably larger percentage of air-conditioned floor space than the Indiana projects, the heating, ventilating and air conditioning costs for Indiana are generally higher. Only Santa Barbara and Indianapolis contain their own heating and chilling plant. In the charts, the cost of this plant has been omitted so that overall costs are comparable. The Indiana buildings have a tendency to mix several different types of heating and cooling systems in one building. This and the much greater heating demands in their climate have created generally more expensive HVAC subsystems. Only the very elaborate Santa Barbara system, using no return air, is more costly than the Indiana systems.

Interior Partitions: Nearly all of the interior partitions in the three Indiana buildings are non-structural concrete block. In California, however, where there are shear walls, 50-77% of the partitions in the study buildings are poured structural concrete and the replaceable partitions are generally either gypsum board on treated wood studs or plaster on metal lath and metal studs. The Sound Transmission Coefficient (STC) ranges from 40 at Bloomington to 35 at Davis. At Santa Barbara 50% of the partitions are demountable laminated gypsum board. The only other demountable partitions are at Bloomington where they amount to 20% of the total partitions, and are metal. The STC of these partitions is 35 at Santa Barbara and 40 in Bloomington. The demountable walls at Bloomington seemed fairly adequate acoustically but on account of their design are seriously limited in their adaptability. Those at Santa Barbara were thought to be poor acoustically and were ineffective in supporting furniture and equipment, although they were adaptable and were penetrable by utilities where block walls are not. In terms of acoustics and durability, the block partitions of the Indiana buildings have the highest performance. Like most of the replaceable partitions studied they provide good furniture support but for relocation or changing utilities they present difficulties and high expense. Electricity is, in fact, the only utility which can be supported by the partitions without extensive attachment devices. The costs of the Indiana partitions are all greater than those in the California buildings.

The cost per square foot of partition averages $5.46 in the Indiana buildings and $4.75 in the California buildings. The highest cost, at Bloomington, results from extensive use of steel demountable partitions and structural facing tile. The highest cost, but most praised by the users, California partitions are the treated wood studs and gypsum board at Davis which, among other things, provide excellent support for equipment, casework and utilities.

Lighting-Ceiling: Of the Indiana buildings, Bloomington and Purdue have hung ceilings throughout and Indianapolis has a hung ceiling in classrooms, offices and corridors. Of the California buildings, laboratories are ceilingless, but Davis and Irvine have hung ceilings in the offices and corridors, and Santa Barbara has them in the corridors only. Some acoustic treatment has been applied to the coffers of the structural slab at Irvine. All six buildings have fluorescent lighting. In Purdue, the light fixtures are recessed throughout, and recessed in the offices, classrooms, and corridors in Indianapolis. Bloomington has suspended fixtures. At Davis, lights are suspended in laboratories and offices, recessed in classrooms and corridors; in Irvine they are suspended in laboratories and classrooms and recessed in offices and corridors, and in Santa Barbara they are suspended in laboratories, classrooms and offices and surface mounted in corridors.

In studying the lighting subsystem it was impossible to measure foot candles of light in all of the various functional areas of each building. For this reason, the design performance of the system, taken from the original documents, is expressed in watts per square foot to measure the comparative performance of the various lighting subsystems. Of the Indiana buildings, Indianapolis has the highest light levels in offices and classrooms (5.2 and 4.5 watts/SF) but low levels in corridors (.98 watts/SF) which the users found too low, although this level is about the same as at Bloomington and Purdue, which the users considered excellent. Probably this is because of the extreme contrast in illumination levels between corridor and the other spaces. The lowest light levels in Indiana are in Bloomington (2.2-1.1 watts/SF) but there were no adverse remarks by users. Davis had the highest light level of the California buildings, where laboratories and classrooms were 4 watts/SF, and Santa Barbara is second with 3.4 watts/SF. Irvine has a higher light level in offices than laboratories (3.5 watts/SF versus 3.0 watts/SF).

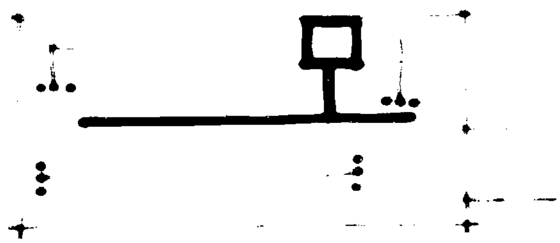
Variation in the lighting costs reflects the quality of fixtures selected rather than the quality of illumination. The average lighting cost in the lighting ceiling subsystem in the Indiana buildings is $.87/OGSF and in California $1.16/OGSF.

Ceiling costs per OGSF reflect both quality and quantity of ceiling. Many laboratories do not have ceiling treatment other than paint. Offices and classrooms generally have acoustical ceilings. Corridors must usually have a one-hour, fire-rated ceiling. In spite of the possible variations, the combined lighting-ceiling subsystem averages of $1.49 in Indiana and $1.61 in California appear representative of academic buildings of this type.

Services Organization. The six buildings illustrate a variety of ways of handling services organization. The term "services" is inclusive of electrical, plumbing, utility services, and HVAC. Three of the buildings—Indianapolis, Irvine, and Santa Barbara—demonstrate very strong patterns of vertical organization, and three—Bloomington, Purdue and Davis—are less formal and demonstrate an ad hoc placement of vertical service risers. The strong vertical patterns are of three different types. Indianapolis has a simple, continuous interior cavity or vertical service space; Irvine has a combination of two major interior, structural shafts housing service

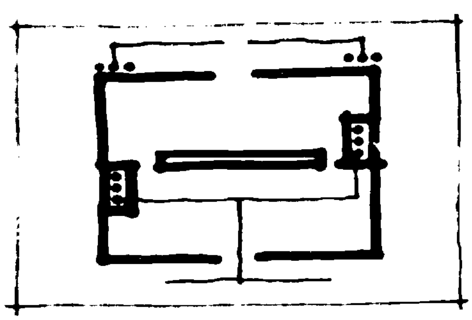
SERVICES ORGANIZATION

DAVIS random

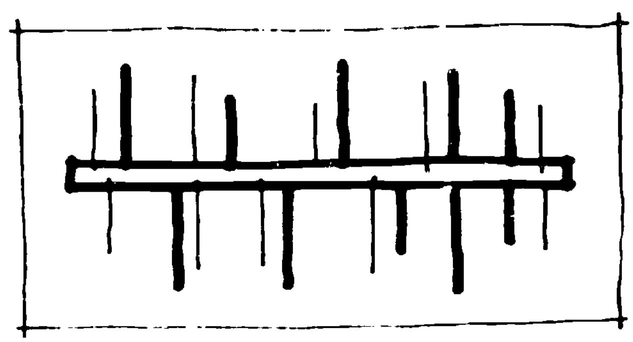


BLOOMINGTON random/cavity

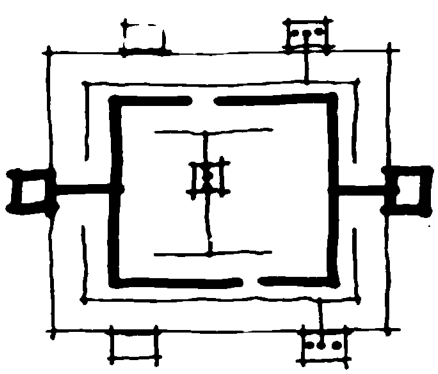
IRVINE: interior shafts/interior cavity



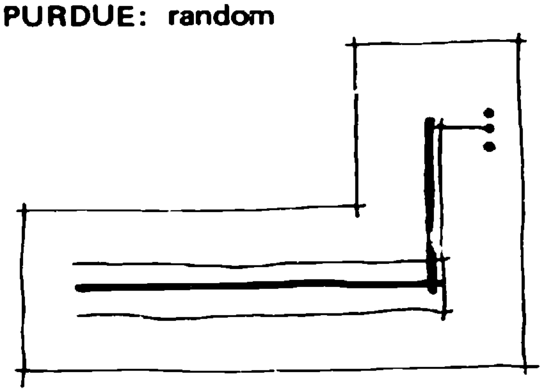
INDIANAPOLIS: interior cavity



SANTA BARBARA: exterior shafts



PURDUE: random



risers with a less significant ca ıty; Santa Barbara has six structural shafts housing service risers on the perimeter of the building. In the other three buildings the risers are randomly placed but usually related to another building element such as a staircase, elevator shaft or corridor. Horizontal services movements are all related to the corridor patterns of the buildings with the exception of Indianapolis, where horizontal movements are direct between the vertical mains and the spaces they supply. In all six buildings, floor drains are randomly positioned.

The greatest problem of services distribution in most existing buildings is in the area of accessibility; most services are hard to get at and modify or repair. Users at Indianapolis were enthusiastic about their generous vertical service cavity which made possible the repair of services distribution elements without disruption to usable space and without physical difficulty. A problem brought up recurrently by building users concerns the fact that drainage is always below the structural floor of the space it serves. When it has to be r ›aired or rerouted because of a desired change in that space, the space directly below must also be disturbed. Generally any major alteration to services distribution has been difficult, costly, and formidable to the point of constraining users from making desirable changes.

Exterior Walls: In terms of exterior materials, the six buildings fall into three groups: (1) the three California buildings are concrete, Davis poured and Santa Barbara and Irvine precast; (2) Indianapolis and Purdue are concrete block and brick, with limestone trim at the windows; and (3) Bloomington is sheathed in split-face ashlar limestone, with smooth-face and carved limestone at the doors and windows. Davis is the only building with structural exterior walls. With the exception of the collegiate Gothic detailing at Bloomington and the highly sculptured walls at Irvine, the buildings have quite simple, straightforward exterior treatments.

In Indiana, the exterior wall itself makes no provision for sun control, and of the three buildings, only Indianapolis has any exterior sun control, with metal sunscreens attached to individual windows on the south side. In California buildings, however, where sunlight is a greater problem, elaborate provision is made for sun control: applied sculptured window surrounds at Irvine, cantilevered shades over each window at Davis, and cantilevered extension of the complete floor slab at Santa Barbara. The percentages of glazed area to total exterior wall area are surprisingly close in the six buildings, with a range from 5% at Santa Barbara to 32% at Indianapolis.

The cost/OGSF of exterior skin ranges from $2.44 to $7.03. The cost per square foot of exterior ranges from $7.69 to $17.58. Bloomington is highest in cost because of the block cavity wall with limestone facing and elaborately carved bay windows, entrances and trim; the other Indiana buildings were $10.76 and $11.40/SF wall. The exterior skin of the California projects is generally less costly than the Indiana projects because of the lesser insulating requirements. They do, however, have extensive structural shear walls. It is clear that the lower buildings, with large areas per floor, have relatively low exterior wall costs if stated in dollars per OGSF. Thus the expensive Irvine enclosure is only $3.91/OGSF, compared to $2.67/OGSF at Santa Barbara and $4.03/OGSF at Davis.

Casework: All six buildings have a complete range of laboratory furniture. Hardwood and plywood casements are used in all the buildings with a variety of bench tops, including materials such as plastic laminates, stainless steel, epoxy resin compound, cement asbestos and soapstone. Sinks are generally made of similar materials.

SUBSYSTEMS PACKAGES

The comparative cost and performance data are of use in evaluating the effectiveness of subsystems in existing facilities. These data may be further developed in order to demonstrate the extremes of cost and performance which are represented. This will be of great value to the subsystems designer and building user in outlining the range of choices available to them. From the complete range of subsystems cost and performance hypothetical combinations or packages of subsystems have been composed in order to demonstrate:

1. The highest cost package of subsystems (Summary — Chart D)
2. The lowest cost package of subsystems (Summary — Chart E)
3. The highest performance package of subsystems (Summary — Chart F)
4. The lowest performance package of subsystems (Summary — Chart G)

The extraction of highest and lowest costs is a simple mechanical process whereas the extraction of highest and lowest performance is judgmental. Summary Charts D-G represent the four packages drawn from the existing facilities subsystems, and consist of a statement of subsystem cost and its related performance, and a total cost for all the subsystems in the package. The names of buildings from which the subsystems are extracted are interesting, retrospectively, but incidental to formulating the projections which are the object of this exercise.

Significant comparisons may be made between these subsystem packages. *The highest cost package is not the highest performance package.* HVAC and partitions in these packages are identical. However, there is a noticeable difference of $.37/OGSF in the lighting-ceiling subsystem cost, and a substantial difference of $1.46/SF in the cost of the structural floor component.

The lowest performance package is not the lowest cost package. Although partitions are the same in both cases, there is a much higher level of performance in the lower cost ($.21/OGSF) lighting-ceiling subsystem. The cost difference of $.90/OGSF in the HVAC subsystem is not substantiated by the performance difference. The less expensive subsystem of the two has a higher level of performance, providing .48 cfm/OGSF more than the other and 35% more fresh air. Of particular significance is the fact that the lowest cost structural floor component has also the highest performance in the six buildings.

It would be a mistake to oversimplify the conclusions from this kind of comparison, but they are indicative of the kinds of savings possible without loss of performance, or where performance may be increased and paid for by a more economical toal package. It must also be borne in mind that reshuffling of different packages may not result in the same unit costs and could increase the total package cost. However, this same consideration is vital to the subsystems design process of formulating packages of proposed subsystems performance and cost. Therefore this method is valid for making comparisons between the cost and performance range of theoretical packages and the content of any proposed package.

The ABS consultant analyzed and compared three University of California biological sciences buildings recently completed at the Davis, Irvine, and Santa Barbara campuses. These buildings are:

Biological Sciences Unit No. 3, Davis (Storer Hall)
Natural Sciences Unit No. 1, Irvine
Biological Sciences Unit No. 2, Santa Barbara

Cost and performance data in the preceding "Summaries and Comparisons" section are extracted from the detailed information herein.

COST DATA

The costs of existing facilities establish the bases for those cost parameters applicable to ABS subsystems. Working drawings, specifications, and bidding documents for the three buildings were submitted to the Koch Company, Construction Cost Consultants, of San Francisco, assisted by J. Rumsey for mechanical and electrical work. They prepared an estimate for each project as if it were bid January 1970 in the San Francisco Bay Area with an Engineering News-Record (ENR) Construction Cost Index of 1300.

The base bid, without alternates or change orders, was the amount estimated. For comparison, the actual base bids were projected to ENR 1300 and adjusted from the campus location to the San Francisco Bay Area by application of the American Appraisal Company's Boeckh Time-Location Modifiers for institutional reinforced concrete frame buildings. The estimates exceeded the adjusted actual low bids by 2% in two cases and 3% for Irvine. The three study projects are compared by component costs. Within the component cost divisions the cost of elements equivalent to the ABS subsystems were isolated and tabulated separately, for use in establishing target prices for the subsystems. Upon completion of the subsystems design, these tabulations were reassessed and revised to correspond as precisely as possible with the ABS final design. No change was made in cost division estimates except for redistribution of cost elements between systems and non-systems categories.

Table 1 indicates, in dollars per outside gross square foot ($/OGSF), the costs of components equivalent to ABS subsystems and components outside of the ABS system. Table 2 indicates, for certain cost divisions, the component unit cost in terms of dollars per square foot of component surface area as tabulated in the last column of cost division breakdowns.

All costs represent subcontract prices, including subcontractor's overhead and profit, but general contractor's mark-up is itemized separately.

The three buildings studied at the Davis, Irvine, and Santa Barbara campuses are quite similar in character, although the costs of some of their elements vary considerably. Observed reasons for variation are discussed with relationship to the individual cost divisions.

In general, the higher cost of the Santa Barbara building may be attributed to meachanical, plumbing and electrical systems which are more elaborate than the others, even though the cost of steam boilers, chillers, and their electrical switchgear was omitted for comparison with the other two buildings served by central plants.

A number of the more costly items at Santa Barbara such as the ocean water supply system and the lecture hall, were postponed or eliminated by alternate bids or change orders during construction.

The relatively low unit cost of the Irvine building results from mechanical efficiencies, and from most of the site work and utility installations being completed under a previous contract.

The relatively high cost laboratory utility distribution at Santa Barbara is mostly "non-subsystem" in the tabulations. It should be noted that these systems are designed for a high degree of adaptability.

For the purposes of this study, laboratory casework estimates for all three buildings were based on the same unit pricing structure, without cost adjustment for individual differences in laboratory tops, types of fume hoods and quantity of fixtures, since it was believed that the installations were comparable in quality and the differences were not significant.

PERFORMANCE DATA

The performance characteristics of subsystems in the three sample buildings were studied concurrently with costs for analysis of the relationships and for projection of proposed performance requirements for ABS subsystems. The intent was to indicate in simple descriptive terms the subsystems capabilities and how well they perform. Data, in the form of gross measurable quantities expressed as percentages of gross floor area, are supplemented with descriptive and quantitative statements of the performance characteristics.

ERIC

U.C. Davis – Biological Sciences Unit No. 3 (Storer Hall)

Architect:	Anderson, Simonds, Dusel & Campini
Structural Engineer:	McClure & Messenger
Mechanical Engineer:	Ralston & Dwyer
Electrical Engineer:	C. P. Martineau, Jr.
Bid Date: April 12, 1966	Completion Date: June 1968

U.C. Irvine – Natural Sciences Unit No. 1

Architect:	W. L. Pereira & Associates
Structural Engineer:	Brandow & Johnson & J. A. Martin & Associates
Mechanical Engineer:	Ralph E. Philips, Inc.
Electrical Engineer:	Ralph E. Philips, Inc.
Bid Date: October 31, 1966	Completion Date: July 1968

U.C. Santa Barbara – Biological Sciences Unit No. 2

Architect:	A. Quincy Jones & Frederick Emmons
Structural Engineer:	Greve & O'Rourke
Mechanical Engineer:	Ayres & Hayakawa
Electrical Engineer:	Frumhoff & Cohen
Bid Date: July 7, 1966	Completion Date: June 1968

TABLE 1

SUBSYSTEM EQUIVALENT COSTS, $/OGSF   ENR 1300

	U.C. DAVIS		U.C. IRVINE		U.C. SANTA BARBARA	
	$/OGSF	%	$/OGSF	%	$/OGSF	%
SYSTEM*						
Structure	[illegible]	18	7.38	19	7.78	17
HVAC	4.70	11	3.66	10	5.83	13
Partitions	3.39	9	2.96	8	2.80	6
Lighting/Ceiling	1.80	5	1.40	4	1.62	4
Subtotal	16.68	43%	15.40	41%	18.03	40%
NON-SYSTEM						
Site Work, Below Grade and Basement	2.35	6	3.33	9	3.34	7
HVAC	.34	1				
Partitions	.72	2	.40	1	1.26	3
Plumbing	3.70	10	3.51	9	6.07	14
Electrical	2.91	7	2.13	6	4.04	9
Ceiling	.06		.02		.02	
Exterior Skin	4.03	10	3.91	10	2.67	6
Elevators	.72	2	.60	2	1.26	3
Other	1.38	3	2.27	6	2.58	6
General Contractor	1.87	5	1.74	5	2.27	5
Subtotal	18.14	46%	18.00	48%	23.50	53%
TOTAL	34.82		33.40		41.53	
Laboratory Casework	4.38	11	4.20	11	3.35	7
TOTAL	**39.20**	**100%**	**37.60**	**100%**	**44.88**	**100%**

NOTE: Costs in Table 1 are expressed in terms of the total cost of the subsystem divided by the total outside gross building floor area (OGSF).

In contrast, costs in Table 2 are expressed in terms of the total cost of the subsystem divided by the total area of the components involved.

*Includes all components equivalent to ABS subsystems.

ERIC Full Text Provided by ERIC

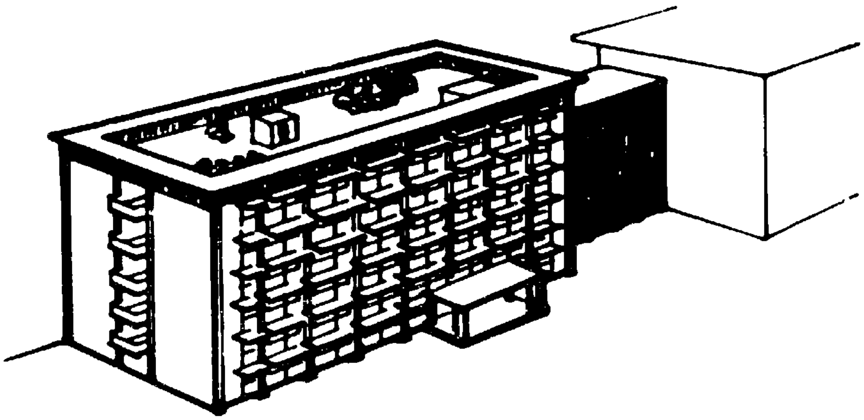
TABLE 2

COMPONENT UNIT COSTS, $/COMPONENT QUANTITY – ENR 1300

FLOORS (STRUCTURE)	ROOF*	INTERIOR PARTITIONS	EXTERIOR SKIN
U C DAVIS BIOLOGICAL SCIENCES UNIT 3			
$/S F	$/S F	$/S F	$/S F
5.39	5.60	4.88	9.78
U C IRVINE NATURAL SCIENCES UNIT 1			
$/S F	$/S F	$/S F	$/S.F.
5.89	6.06	4.23	12.75
U C SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2			
$/S F	$/S F	$/S F	$/S.F.
4.83	6.73	3.64	7.69

NOTE Costs in Table 2 are expressed in terms of the total cost of the subsystem divided by the total area of the components involved.

*Includes ceilings and finishes.



Cost Divisions

U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3
Bid April 12, 1966; ENR Construction Cost Index 1006
92,167 Outside Gross Square Feet (OGSF)

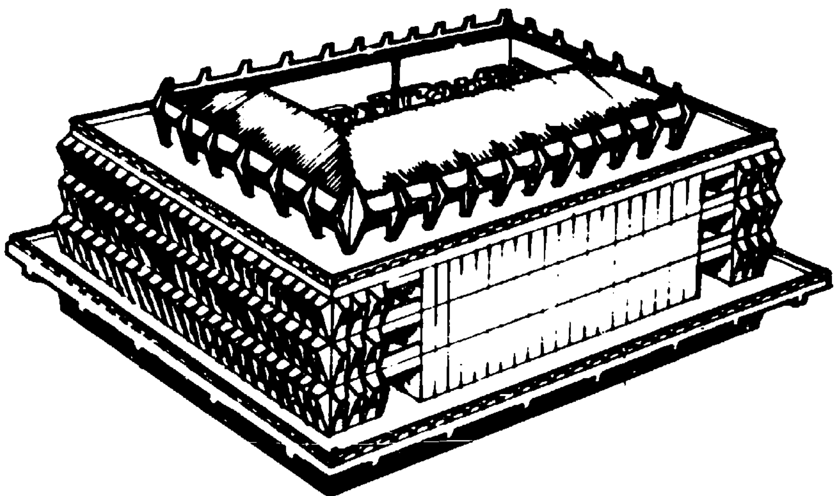
Base Bid:	$2,606,000 @ ENR 1006 ($28.27/OGSF)
Projected:	$3,367,500 @ ENR 1300 ($36.53/OGSF)
Geographical Adjustment:	$3,535,900 ($38.36/OGSF)*

Cost Estimate (Jan. 1970 – ENR 1300)

		$/OGSF	%
Site Work, Below Grade & Basement	$ 217,260	2.35	6
Floors	508,600	5.52	14
Roof	77,350	.84	2
Interior Partitions	497,200	5.37	14
Interior General	457,700	4.97	13
Exterior Skin, above ground	450,390	4.89	12
HVAC	419,386	4.54	12
Plumbing	346,465	3.76	9
Electrical	402,129	4.37	11
Elevators	65,000	.72	2
General Contractor	172,075	1.87	5
	$3,613,555	$39.20	

The cost estimate exceeds the projected and adjusted base bid figure by 2%.

*Boeckh Modifier Sacramento to San Francisco Bay Area = 1.05



Cost Divisions

U.C. IRVINE NATURAL SCIENCES UNIT 1

Bid October 31, 1963; ENR Construction Cost Index 910
121,000 Outside Gross Square Feet (OGSF)

Base Bid:	$2,844,500 @ ENR 910 ($23.50/OGSF)
Projected:	$4,063,370 @ ENR 1300 ($33.58/OGSF)
Geographical Adjustment:	$4,429,080 ($36.60/OGSF)*

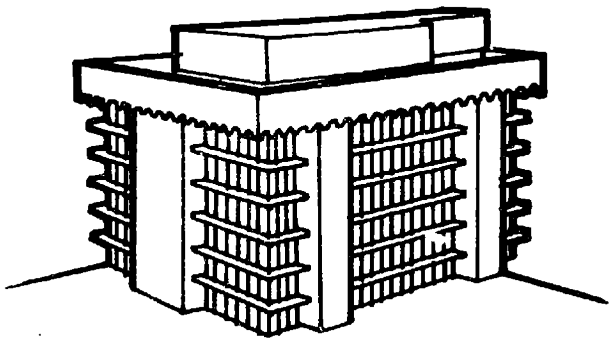
Cost Estimate (Jan. 1970, ENR 1300)

		$/OGSF	%
Site Work, Below Grade & Basement	$ 403,410	3.33	9
Floors	761,140	6.29	17
Roof	187,860	1.55	4
Interior Partitions	558,020	4.61	12
Interior General	620,040	5.12	13
Exterior Skin, above ground	524,600	4.34	11
HVAC	442,548	3.66	10
Plumbing	424,981	3.51	9
Electrical	344,655	2.85	8
Elevators	72,000	.60	2
General Contractor	211,000	1.74	5
	$4,550,254	$37.60	

The cost estimate exceeds the projected and adjusted base bid by less than 3%.

*Boeckh Modifier Los Angeles – San Diego to San Francisco Bay Area = 1.09

NOTE: This cost estimate is based on the contract documents as bid, and it includes an attached lecture hall (not illustrated) of 13,200 OGSF.



Cost Divisions

U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2
Bid July 7, 1966; ENR Construction Cost Index 1047
132,000 Outside Gross Square Feet (OGSF)

Base Bid:	$4,936,000 @ ENR 1047 ($37.39/OGSF)
Projected:	$6,128,540 @ ENR 1300 ($46.43/OGSF)*
Geographical Adjustment:	None. Santa Barbara and San Francisco Bay Area costs are approximately equal.

Cost Estimate (Jan. 1970 – ENR 1300)

		$/OGSF	%
Site Work, Below Grade & Basement	$ 440,580	3.34	7
Floors	666,210	5.05	11
Roof	170,550	1.29	3
Interior Partitions	706,410	5.35	12
Interior General	663,670	5.02	11
Exterior Skin, above ground	537,870	4.08	9
HVAC*	769,768	5.83	13
Plumbing	800,537	6.07	14
Electrical	703,618	5.33	12
Elevators	165,000	1.25	3
General Contractor	300,000	2.27	5
	$5,924,213	$44.88	
Boiler and Chiller Plant*	356,877	2.70	
	$6,281,090	$47.58	

*The total cost estimate of $6,281,090 ($47.58/OGSF) exceeds the projected base bid by 2%. Unlike the Davis and Irvine buildings, served by central plants, this building supplies its own steam for heating and its own chilled water. For comparison, therefore, the costs of boilers and chillers and their electrical switchgear are excluded in this cost analysis.

COST/PERFORMANCE DATA
BIOSCIENCE BUILDINGS

Cost Division: SITE WORK, BELOW GRADE & BASEMENT	$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF / Non-Subsystem	$/S.F. Basement
U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3				
1. Concrete Work	188,580	2.04	2.04	
2. Site Preparation & Grading	24,360	.26	.26	
3. Waterproofing	4,320	.05	.05	
	217,260	2.35	2.35	16.09
Basement Area = 13,500 S.F. = .15 OGSF				
U.C. IRVINE NATURAL SCIENCES UNIT 1				
1. Concrete Pavers	14,230	.12	.12	
2. Concrete Work	287,120	2.37	2.37	
3. Earthwork	79,560	.65	.65	
4. Grouted Rock Riprap	8,000	.07	.07	
5. Membrane Waterproofing	8,100	.07	.07	
6. Precast Concrete Benches	6,400	.05	.05	
	403,410	3.33	3.33	25.21
Basement Area = 16,000 S.F. = .13 OGSF				
U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2				
1. Bldg. Excavation	119,470	.91	.91	
2. Caissons	8,250	.06	.06	
3. Concrete	275,650	2.09	2.09	
4. Resilient Floor Cover	1,960	.01	.01	
5. Site Prep. Grading, Paving, Drainage	31,890	.24	.24	
6. Waterproofing	3,360	.03	.03	
	440,580	3.34	3.34	25.10
Basement Area = 17,555 S.F. = .13 OGSF				

Site Work, Below Grade and Basement Cost Division.

This cost division includes basement walls and slab, foundations and sitework. None of these are within the scope of an ABS subsystem.

The Davis building has a full basement containing laboratories as well as mechanical rooms.

The Irvine building has a partial basement containing storage, mechanical and electrical rooms.

The Santa Barbara building has a full basement with boiler and chiller rooms, fan rooms and electric switchgear.

The lower cost of this division for the Davis project results from simple foundation and wall conditions and a minimum of site improvement work.

COST/PERFORMANCE DATA
BIOSCIENCE BUILDINGS

Cost Division: FLOORS		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Structure	Ceiling	Non-Sub System	$/S.F. Floors Structure
U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3							
1.	Acoust. Tile Ceiling	25,160	.27		.21	.06	
2.	Ceramic Tile Floor	6,400	.07			.07	
3.	Concrete	410,520	4.46	4.46			5.39
4.	Gyp. Bd. Ceiling & Insulation	1,060	.01		.01		
5.	Lath & Plaster Ceiling	5,330	.06		.06		
6.	Membrane	840	.01			.01	
7.	Painting	5,580	.06		.06		
8.	Resilient Floor	47,950	.52			.52	
9.	Terrazzo Floor	5,760	.06			.06	
		508,600	5.52	4.46	.34	.72	5.39

Floor Cost Division Area = 76,200 S.F. = .83 OGSF

U.C. IRVINE NATURAL SCIENCES UNIT 1							
1.	Acoustical Ceiling	29,390	.24		.24		
2.	Concrete	582,150	4.81	4.81			5.89
3.	Concrete Pavers	84,110	.69			69	
4.	Membrane Waterproofing	2,790	.08			.08	
5.	Paint Ceiling	13,720	.11		.11		
6.	Resilient Flooring	24,040	.20			.20	
7.	Special Floor Finishes	8,3[illegible]0	.07			.07	
8.	Susp. Plaster Ceiling	8,470	.07		.05	.02	
9.	Wood Flooring	2,100	.02			.02	
		761,140	6.29	4.81	.40	1.08	5.89

Floor Cost Division Area = 9[illegible] S.F. = .81 OGSF

U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2							
1.	Acoustical Ceiling	13,320	.10		.10		
2.	Ceramic Floor Tile	23,940	.18			.18	
3.	Composition Deck	1,090	.01			.01	
4.	Concrete Work	507,360	3.84	3.84			4.60
5.	Insulation	5,280	.04			.04	
6.	Metal Deck & Stainless Steel Floor	14,690	.11			.11	
7.	Misc. Metal-Unistrut	18,000	.14			.14	
8.	Paint Ceiling	9,000	.07		.07		
9.	Resilient Floor Cover	24,680	.19			.19	
10.	Suspended Plaster Ceiling	10,570	.08		.06	.02	
11.	Vermiculite Fills	25,620	.19	.19			.23
12.	Waterproof & Dampproofing	12,660	.10			.10	
		666,210	5.05	4.03	.23	.79	4.83

Floor Cost Division Area = 110,350 S.F = .84 OGSF

Floors Cost Division.

The Irvine and Santa Barbara buildings have similar floor construction systems, concrete waffle slabs with 30'-0" x 30'-0" bays. The variance in cost per OGSF of the complete floor components results mainly from the degree of finish, with Irvine having a paved cantilevered deck and considerably more ceiling, which is included as an element of the Floors Cost Division.

The Davis building is principally of long-span joist construction in concrete, with more suspended ceiling than Santa Barbara.

COST/PERFORMANCE DATA
BIOSCIENCE BUILDINGS

Cost Division: ROOF	$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Struc-ture	Ceil-ing	Non-Sub System	$/S.F. Roof
U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3						
1. Concrete	65,520	.71	.71			
2. Misc. Metalwork	1,500	.02			.02	
3. Roofing & Insulation	7,690	.08			.08	
4. Sheet Metal	2,640	.03			.03	
	77,350	.84	.71		.13	5.60
Roof Cost Division Area = 14,000 S.F. = .15 OGSF						
U.C. IRVINE NATURAL SCIENCES UNIT 1						
1. Acoustical Treatment	11,879	.10		.10		
2. Clay Tile Roofing	17,010	.14			.14	
3. Concrete Work	26,980	.23	.23			
4. Membrane Waterproofing	3,780	.03			.03	
5. Sheet Metal	6,050	.05			.05	
6. Special Ceiling	10,200	.08		.08		
7. Sprayed-on Fireproofing	13,920	.11	.11			
8. Struct. Gypsum Concrete	14,170	.12	.12			
9. Structural Steel	63,000	.52	.52			
10. Susp. Plaster Ceiling & Soffit	11,940	.10		.10		
11. Thermal Insulation	8,940	.07			.07	
	187,860	1.55	.98	.28	.29	6.06
Roof Cost Division Area = 31,000 S.F. = .26 OGSF						
U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2						
1. Concrete Structure	87,140	.66	.66			
2. Metal Deck & Flashing	5,600	.05			.05	
3. Met. Lath & Plas. Ceiling	13,610	.10		.10		
4. Roofing	11,990	.09			.09	
5. Structural Steel	36,000	.27	.27			
6. Vermiculite Fill	16,210	.12	.12			
	170,550	1.29	1.05	.10	.14	6.73
Roof Cost Division Area = 24,580 S.F. = .19 OGSF						

Roof Cost Division.

The $/OGSF cost of the roof components, including ceilings, insulation and surfacing, naturally varies with the size of the roofed area compared with the OGSF of the building. Therefore, Irvine is the most costly and Davis the least.

Further, however, Irvine has a considerable amount of relatively expensive clay tile.

In unit cost per square foot of roof, the Santa Barbara project is the most costly, principally because of provisions for equipment and penthouses requiring special steel structures.

ERIC

COST/PERFORMANCE DATA
BIOSCIENCE BUILDINGS

	Cost Division INTERIOR PARTITIONS	$ Sub Contracts	$/OGSF	Subsystem Equiv. $/OGSF Structure	Partitions	Non-Sub System	$/S.F. Partitions
	U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3						
1.	Ceramic Tile Finish	8,120	.09			.09	
2.	Concrete Walls	116,600	1.26	1.26			
3.	Finish Hardware	23.520	.25		.21	.04	
4.	Hollow Metal Doors & Frames	21,380	.23		.19	.04	
5.	Met. Stud & Plaster Part.	82,220	.89		.54	.35	
6.	Paint and Finishing	54,090	.58		.53	.05	
7.	Rubber Base	6,720	.07		.07		
8.	Sound Insulation	1,270	.01			.01	
9.	Treated Wood Stud & Gyp. Bd. Part.	158,560	1.72		1.62	.10	
10.	Wood Doors	24,720	.27		.23	.04	
		497,200	5.37	1.20	3.39	.72	4.88

Interior Partitions Cost Division Area = 109,450 S.F. = 1.10 OGSF

	Cost Division INTERIOR PARTITIONS	$ Sub Contracts	$/OGSF	Subsystem Equiv. $/OGSF Structure	Partitions	Non-Sub System	$/S.F. Partitions
	U.C. IRVINE NATURAL SCIENCES UNIT 1						
1.	Ceramic Wall Tile & Base	19,610	.16			.16	
2.	Cold Glaze Finish	1,920	.02		.02		
3.	Concrete Walls	140,020	1.16	1.16			
4.	Cork and Sound Insulation	3,250	.03		.03		
5.	Finish Hardware	32,900	.27		.24	.03	
6.	Hollow Metal Work	35,280	.29		.27	.02	
7.	Met. Stud & Plaster Partitions	208,320	1.72		1.55	.17	
8.	Painting	66,420	.55		.47	.08	
9.	Panelling	7,820	.06		.06		
10.	Unistrut Supports	12,400	.10		.10		
11.	Wood Doors	30,080	.25		.22	.03	
		558,020	4.61	1.16	2.96	.49	4.23

Interior Partitions Cost Division Area = 132,000 S.F. = 1.09 OGSF

	Cost Division INTERIOR PARTITIONS	$ Sub Contracts	$/OGSF	Subsystem Equiv. $/OGSF Structure	Partitions	Non-Sub System	$/S.F. Partitions
	U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2						
1.	Ceramic Tile Finish	46,880	.36			.36	
2.	Finish Hardware	28,800	.22		.18	.04	
3.	Glazing	1,220	.01		.01		
4.	Insulation (Sound, Thermal)	10,560	.08		.08		
5.	Interior Concrete Walls	170,120	1.29	1.29			
6.	Masonry Interior Walls	2,770	.02		.02		
7.	Metal Doors & Frames	29,310	.22		.19	.03	
8.	Met. Studs, Lath & Plaster	147,850	1.12		.74	.38	
9.	Movable Partitions	144,630	1.09		1.09		
10.	Painting & Finishing	53,940	.41		.38	.03	
11.	Special Doors (Refrig., etc.)	27,500	.21			.21	
12.	Special Finish & Trim	16,500	.12			.12	
13.	Wire Partitions	5,940	.05			.05	
14.	Wood Doors	20,390	.15		.11	.04	
		706,410	5.35	1.29	2.80	1.26	3.64

Interior Partitions Cost Division Area = 193,750 S.F. = 1.47 OGSF

Interior Partitions Cost Division.

The costs of interior partitions per OGSF reflect both planning characteristics and the quality of the products used. The floor-to-floor height at Irvine is considerably less than that of the other projects, so results in a saving in quantity and the lowest cost per OGSF.

The highest partition cost, at Davis, is due to fire-retardent wood studs with gypsum board faces. This design has been very satisfactory according to interviews and inspection. It permits easy attachment of equipment to the walls. This relatively expensive wall (treated studs at this date are about three times the cost of untreated Douglas fir studs) is approximately the same cost per OGSF as the lower cost partitions at Santa Barbara because the Davis plan is essentially a double-loaded corridor, whereas the Santa Barbara plan is an interior "race track" corridor requiring more lineal feet of partition. ("Race track" is a double-loaded corridor encircling the entire floor, generally with offices on the outside and laboratories inside.)

The Santa Barbara partitions are laminated gypsum board with relatively simple demountability.

COST/PERFORMANCE DATA
BIOSCIENCE BUILDINGS

Cost Division: INTERIOR GENERAL		$ Sub Contracts	$/OGSF	Subsystem Equiv. $/OGSF Lab. Casework	Non-Sub System
U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3					
1.	Chalk and Tackboards	6,950	.08		.08
2.	Laboratory Casework	403,080	4.38	4.38	
3.	Misc. Metal, Stairs, Rails	20,500	.22		.22
4.	Painting	2,000	.02		.02
5.	Reception Counter, Coat Racks	2,910	.03		.03
6.	Seating, Cabinets, Shelves, Mailchute	17,910	.19		.19
7.	Toilet Partitions	4,350	.05		.05
		457,700	4.97	4.38	.59
U.C. IRVINE NATURAL SCIENCES UNIT 1					
1.	Blocking, Backing	8,280	.07		.07
2.	Chalk and Tack Boards	16,100	.13		.13
3.	Laboratory Casework	508,630	4.20	4.20	
4.	Miscellaneous Metals, Gratings, Ladders	31,930	.26		.26
5.	Miscellaneous Specialties Conc. Fountain, Stair Rails, Bulletin Boards, Display Cases	3,590	.03		.03
6.	Revolving Stage	15,000	.13		.13
7.	Room Signs	4,950	.04		.04
8.	Seating	25,500	.21		.21
9.	Toilet Partitions & Accessories	6,060	.05		.05
		620,040	5.12	4.20	.92
U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2					
1.	Blocking, Backing & Bucks	8,000	.06		.06
2.	Chalk & Tackboard, Directory	16,300	.12		.12
3.	Controlled Temperature Rooms	31,680	.24		.24
4.	Fixed Seating	7,200	.05		.05
5.	Incinerator, Appliances Misc. Equip.	29,680	.22		.22
6.	Laboratory Casework	441,950	3.35	3.35	
7.	Misc. Metal, Stairs, Rails	98,520	.75		.75
8.	Shielding & Trolleys	8,180	.06		.06
9.	Tanks, Storage Shelves	13,050	.10		.10
10.	Toilet Partitions & Accessories	9,110	.07		.07
		663,670	5.02	3.35	1.67

Interior General Ccst Division.

The principal interest in subsystems in this division concerns the educational and scientific aids such as laboratory casework and chalk and tack boards.

The cost differences in these elements mainly reflect the degree to which sinks and utility connections were specified under "laboratory equipment" or "plumbing." The quality and nature of all installations are similar.

ERIC

COST/PERFORMANCE DATA
BIOSCIENCE BUILDINGS

Cost Division: EXTERIOR SKIN — ABOVE GROUND		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Ext. Skin	Subsystem Equiv. $/OGSF Structure	$/S.F. Exterior
U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3						
1.	Alum. Entrance Doors	3,070	.03	.03		
2.	Caulking	6,050	.07	.07		
3.	Concrete Work	348,030	3.78	2.92	.86	
4.	Dampproofing	2,650	.03	.03		
5.	Door Hardware	2,300	.03	.03		
6.	Exterior Doors	2,750	.03	.03		
7.	Glass & Glazing	13,430	.15	.15		
8.	Metal Windows	38,300	.41	.41		
9.	Painting	10,550	.11	.11		
10.	Sheet Metal Work	7,710	.08	.08		
11.	Stucco Dash on Concrete	7,320	.08	.08		
12.	Venetian Blinds	8,230	.09	.09		
		450,390	4.89	4.03	.86	9.78
	Exterior Skin—Above Ground Cost Division Area = 46,000 S.F. = .50 OGSF					
U.C. IRVINE NATURAL SCIENCES UNIT 1						
1.	Alum. Window Wall	32,780	.27	.27		
2.	Alum. Windows	30,600	.25	.25		
3.	Caulking	3,630	.03	.03		
4.	Concrete Work	104,470	.86	.43	.43	
5.	Glass & Glazing	41,880	.35	.35		
6.	Plaster & Stucco	31,020	.26	.26		
7.	Precast Concrete	280,220	2.32	2.32		
		524,600	4.34	3.91	.43	12.75
	Exterior Skin—Above Ground Cost Division Area = 41,000 S.F. = .34 OGSF					
U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2						
1.	Alum. Windows	30,380	.23	.23		
2.	Caulking	13,200	.10	.10		
3.	Concrete Work incl. Precast	398,650	3.02	1.61	1.41	
4.	Ext. Doors & Frames	5,290	.04	.04		
5.	Glass & Glazing	18,550	.14	.14		
6.	Insulation	1,500	.01	.01		
7.	Masonry	24,130	.18	.18		
8.	Met. Studs, Lath & Plaster	31,150	.24	.24		
9.	Painting & Finishing	15,020	.12	.12		
		537,870	4.08	2.67	1.41	7.69
	Exterior Skin—Above Ground Cost Division Area = 70,000 S.F. = .53 OGSF					

Exterior Skin Above Ground Cost Division.

The exterior skin costs relate to building configuration. Although the Irvine building has by far the most elaborate exterior treatment, with sculptured precast concrete sunshades at each opening, its low floor-to-floor heights and a large floor area to peripheral area ratio result in a cost per OGSF which is median in the group.

The Santa Barbara building has the lowest unit cost, either per OGSF or per square foot of wall, yet it includes large areas of exterior utility shafts.

The Davis exterior wall costs are increased by the use of an elaborate five-story precast concrete grille in the wing connecting to Hutchison Hall, and a trellis-like screen concrete parapet around the roof.

Cost Division: HVAC	$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF HVAC	Subsystem Equiv. $/OGSF Non-Subsystem
U.C. DAVIS BIOLOG CAL SCIENCES UNIT 3				
1. Controls	37,000	.04	.40	
2. Ductwork and Insulation	167,900	1.82	1.82	
3. Laboratory Steam	31,914	.34		.34
4. Supply Units each floor	182,572	1.98	1.98	
	419,386	4.54	4.20	.34

NOTE: Steam and chilled water from central plant. Only the connections were in contract.

Cost Division: HVAC	$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF HVAC	Subsystem Equiv. $/OGSF Non-Subsystem
U.C. IRVINE NATURAL SCIENCES UNIT 1				
1. Controls	32,700	.27	.27	
2. Ductwork and Insulation	173,825	1.44	1.44	
3. Supply, Air-Handling and Fans	236,023	1.95	1.95	
	442,548	3.66	3.66	

NOTE: High temperature and chilled water from central plant. Only connections in contract.

Cost Division: HVAC	$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF HVAC	Subsystem Equiv. $/OGSF Non-Subsystem
U.C. SANTA BARBARA, BIOLOGICAL SCIENCES UNIT 2				
1. Building and Laboratory A.C.	398,718	3.03	3.03	
2. Controls	57,000	.43	.43	
3. Ductwork and Insulation	313,950	2.37	3.39	
	769,668	5.83	5.83	
4. Chilled Water Generation	254,423	1.93		
5. Steam Generation, Boilers	92,424	.70		
	1,116,615	8.46		

NOTE: Items 4 and 5 are central plant costs amounting to $2.63/OGSF and are peculiar to Santa Barbara only, and are, therefore, excluded in cost comparisons.

Heating, Ventilating, Air Conditioning Cost Division.

A conspicuous reason for the highest cost HVAC system at Santa Barbara is that it supplies its own steam for heating and its own chilled water, the o[illegible]ne of the three projects to do so. Also, it is more elaborate in controls, supplies [illegible] BTU per area unit, has the lowest OGSF per ton of refrigeration, and is the only project with 100% fresh air, no return. The location of the shafts at the outside corners of the building contributes to large runs of ductwork.

By contrast, the Irvine building uses high temperature water and chilled water from a campus central plant. The building is served from a central core of essentially two basic zones from a basement air-handling room. This has resulted in the lowest cost installation.

The Davis system has an air handling unit at each floor, utilizing campus-plant steam and chilled water. The lower cost of controls is because there is one thermostat per 1,000 square feet at Davis as against 2½ per 1,000 square feet at Irvine and Santa Barbara.

ERIC

COST/PERFORMANCE DATA
BIOSCIENCE BUILDINGS

Cost Division: PLUMBING		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Non-Subsystems
U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3				
1.	Acid waste	105,936	1.15	1.15
2.	Air	12,569	.14	.14
3.	Building plumbing	90,399	.98	.98
4.	Chilled water, steam, gas and demineralized water connections	5,835	.06	.06
5.	Distilled and aquarium water	11,301	.12	.12
6.	Fire protection and dry standpipe	13,695	.15	.15
7.	Gas	7,619	.08	.08
8.	Industrial cold water	15,475	.17	.17
9.	Industrial hot water	14,047	.15	.15
10.	Insulation	7,800	.09	.09
11.	Lab. casework connections	43,709	.48	.48
12.	Outside utilities	12,342	.13	.13
13.	Vacuum	5,738	.06	.06
		346,465	3.76	3.76
U.C. IRVINE NATURAL SCIENCES UNIT 1				
1.	Building plumbing	110,860	.92	.92
2.	Fire protection – sprinklers	9,360	.08	.08
3.	Hookups	1,435	.01	.01
4.	Laboratory plumbing	303,326	2.50	2.50
		424,981	3.51	3.51
U.C. SANTA BARBARA, BIOLOGICAL SCIENCES UNIT 2				
1.	Acid waste	162,357	1.24	1.24
2.	Building plumbing	134,919	1.02	1.02
3.	Carbon dioxide and oxygen	7,040	.05	.05
4.	Compressed air	64,736	.49	.49
5	Distilled water	41,165	.31	.31
6.	Fire Protection, sprinklers	9,100	.07	.07
7	Gas system	48,908	.37	.37
8	Laboratory plumbing	220,503	1.67	1.67
9	Outside utilities	13,733	.11	.11
10.	Sea water	26,816	.20	.20
11.	Vacuum system	71,260	.54	.54
		800,537	6.07	6.07

Plumbing Cost Division.

The Santa Barbara project is again conspicuous in the cost of its plumbing because it has more systems than the others and more elaborate details. The acid waste, for instance, extends throughout the entire building; whereas in the other buildings it extends only to the point where it is mixed with other effluent. The water and gas supply lines provide valves periodically for new tap-ins so that extension may be made without shutting down the system. Although costly initially, these provisions enable additions or relocation of facilities at a minimum cost.

The plumbing costs at Davis and Irvine reflect good current practice but not as much flexibility as at Santa Barbara.

Cost Division: ELECTRICAL		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Lighting	Non-Subsystem
U.C. DAVIS BIOLOGICAL SCIENCES UNIT 3					
1.	Clock system and TV	3,776	.04		.04
2.	Fire alarm	6,724	.07		.07
3.	Laboratory distribution	80,828	.88		.88
4.	Lighting — fixtures and switches	147,963	1.61	1.46	.15
5.	Lighting — wire and conduit	38,400	.42		.42
6.	Other building distribution	27,746	.30		.30
7.	Site work	5,510	.06		.06
8.	Telephone and sound	9,428	.11		.11
9.	Total building power	81,754	.88		.88
		402,129	4.37	1.46	2.91
U.C. IRVINE NATURAL SCIENCES UNIT 1					
1.	Alarm-clock sound, conduit only	5,487	.05		.05
2.	Building power	101,361	.83		.83
3.	Laboratory distribution	89,310	.74		.74
4.	Lighting, fixtures and switches	118,348	.98	.72	.26
5.	Lighting, wires and conduit	19,752	.16		.16
6.	Underground	10,397	.09		.09
		344,655	2.85	.72	2.13
U.C. SANTA BARBARA BIOLOGICAL SCIENCES UNIT 2					
1.	Fire alarm	8,641	.07		.07
2.	Laboratory distribution	117,381	.88		.88
3.	Lighting fixtures	185,389	1.40	1.29	.11
4.	Lighting — panels and switches	15,313	.12		.12
5.	Lighting — wire and conduit	41,474	.31		.31
6.	Other building distribution	36,283	.28		.28
7.	Site work and yard lighting	8,466	.06		.06
8.	Telephone and intercom	11,622	.09		.09
9.	Total building power	268,360	2.04		2.04
10.	TV and clocks	10,689	.08		.08
		703,618	5.33	1.29	4.04
11.	Boiler, chiller switchgear	10,030	.07		
		713,648	5.40		

Electrical Cost Division.

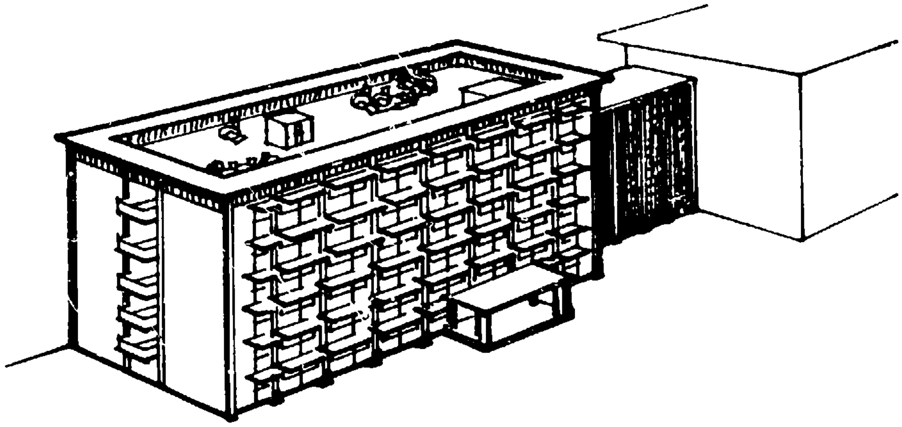
The difference in the $/OGSF costs of the three projects varies with the capacities provided, except that Santa Barbara provides a continuous bus-duct system around each corridor. This makes additions and changes very easy to accommodate.

The relative lighting costs again reflect capacity. In none of the buildings was there complaint about the quanity of light. Location of fixtures, however, because of shadows, was criticized in some cases.

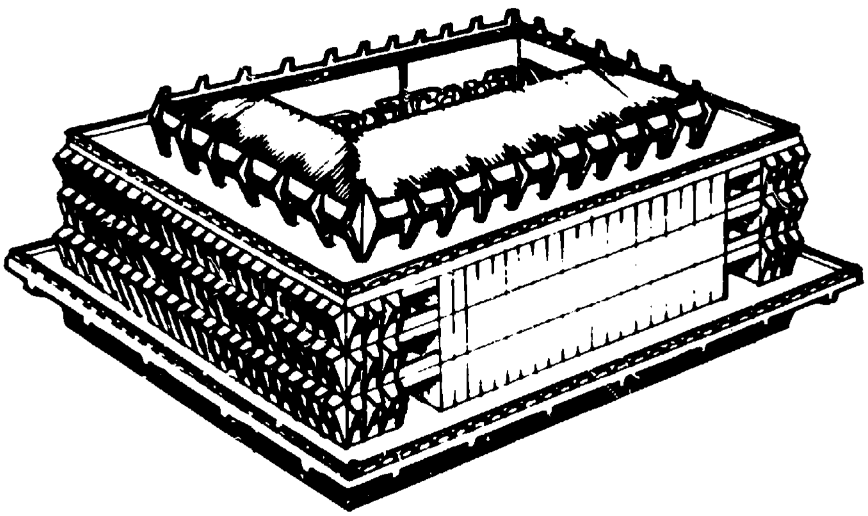
GENERAL DATA

	DAVIS	IRVINE	SANTA BARBARA
OGSF	92,167 S.F.	111,580 S.F.	132,000 S.F.
ASF	51,702 S.F.	65,922 S.F.	77,579 S.F.
AREA TYPICAL FLOOR	12,800 S.F.	21,600 S.F.	17,000 S,F,
ASF / OGSF	0.56	0.59	0.59
AREA OF EXTERIOR WALLS / OGSF	0.580	0.370	0.523
AREA SERVED BY HVAC	100%	100%	100%
LINEAR FEET PARTITIONS / OGSF	0.08	0.1	0.08
FLOORS AT AND ABOVE GRADE	6	5	6
FLOORS BELOW GRADE	1	1	1
TOTAL STRUCTURE/SERVICES DEPTH	5'-10"	4'-0"	5'-5"

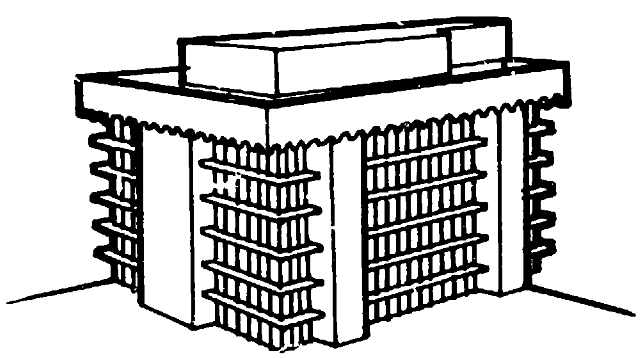
NOTE: For Irvine, data relates only to the main building, exclusive of the attached lecture hall.



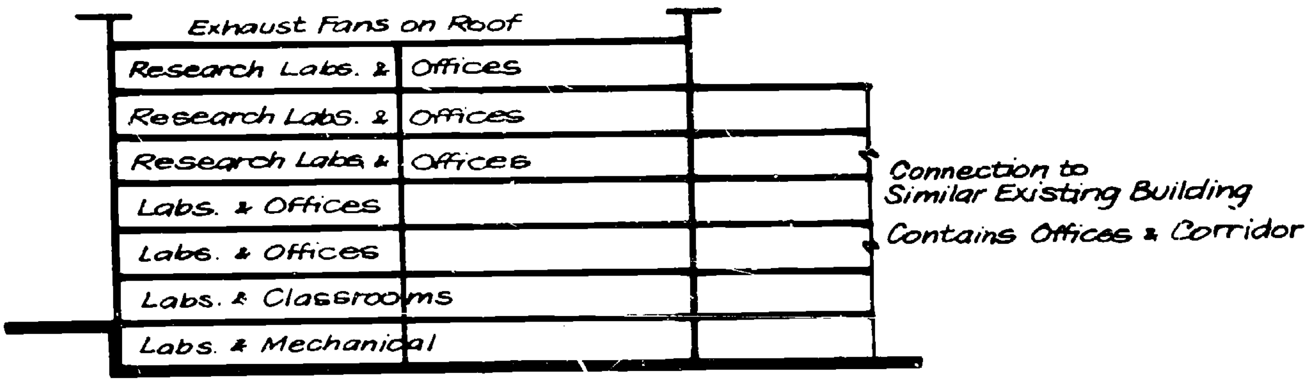
U.C. DAVIS – BIOLOGICAL SCIENCES UNIT 3



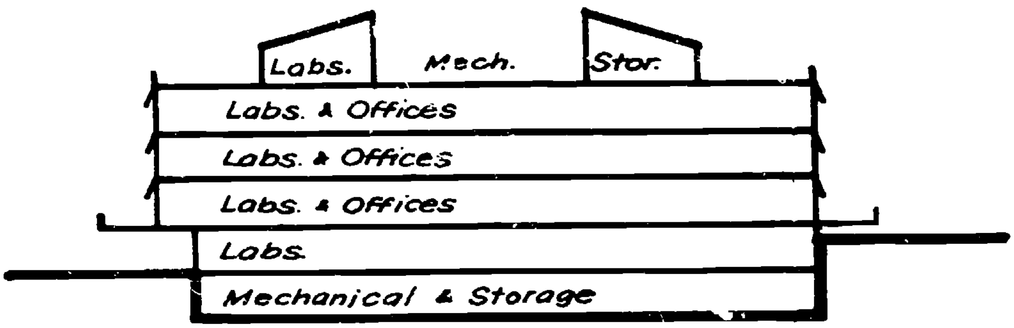
U.C. IRVINE – NATURAL SCIENCES UNIT I



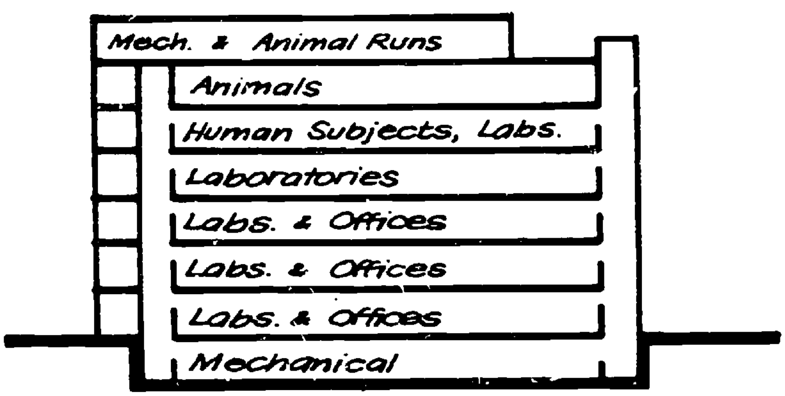
U.C. SANTA BARBARA – BIOLOGICAL SCIENCES UNIT 2



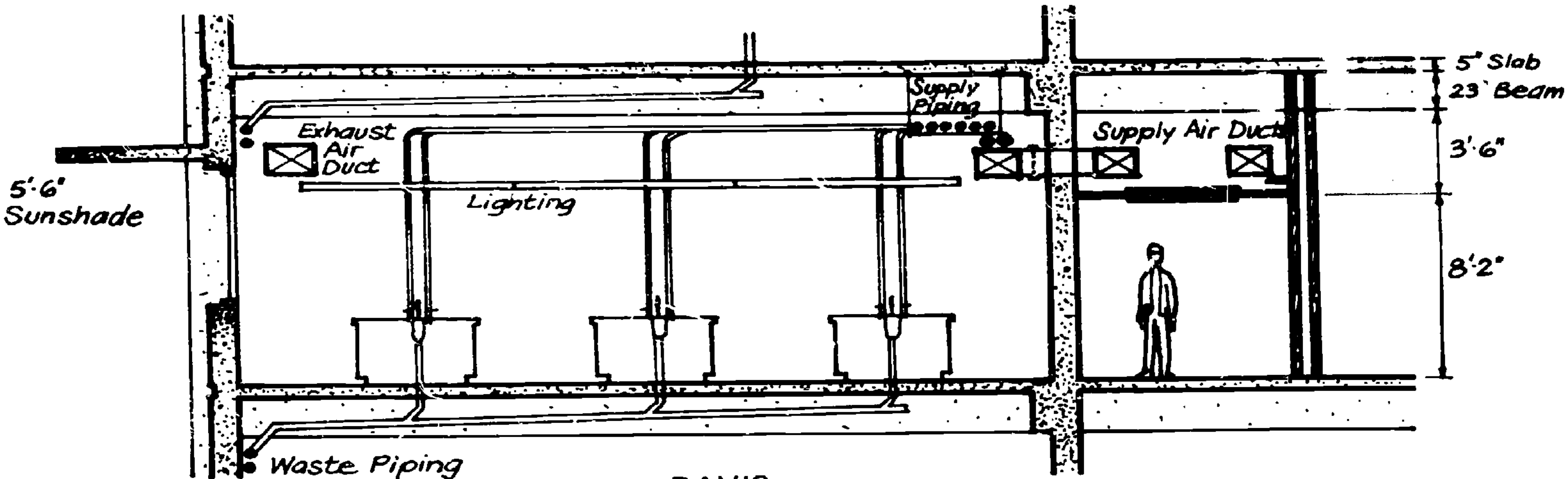
DAVIS



IRVINE



SANTA BARBARA



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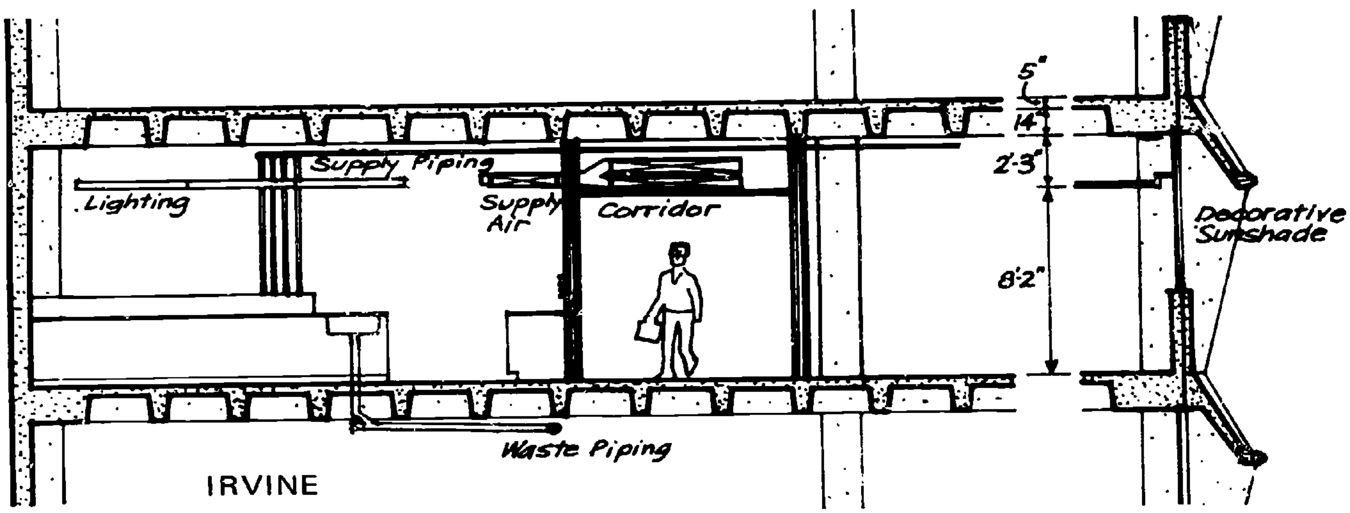
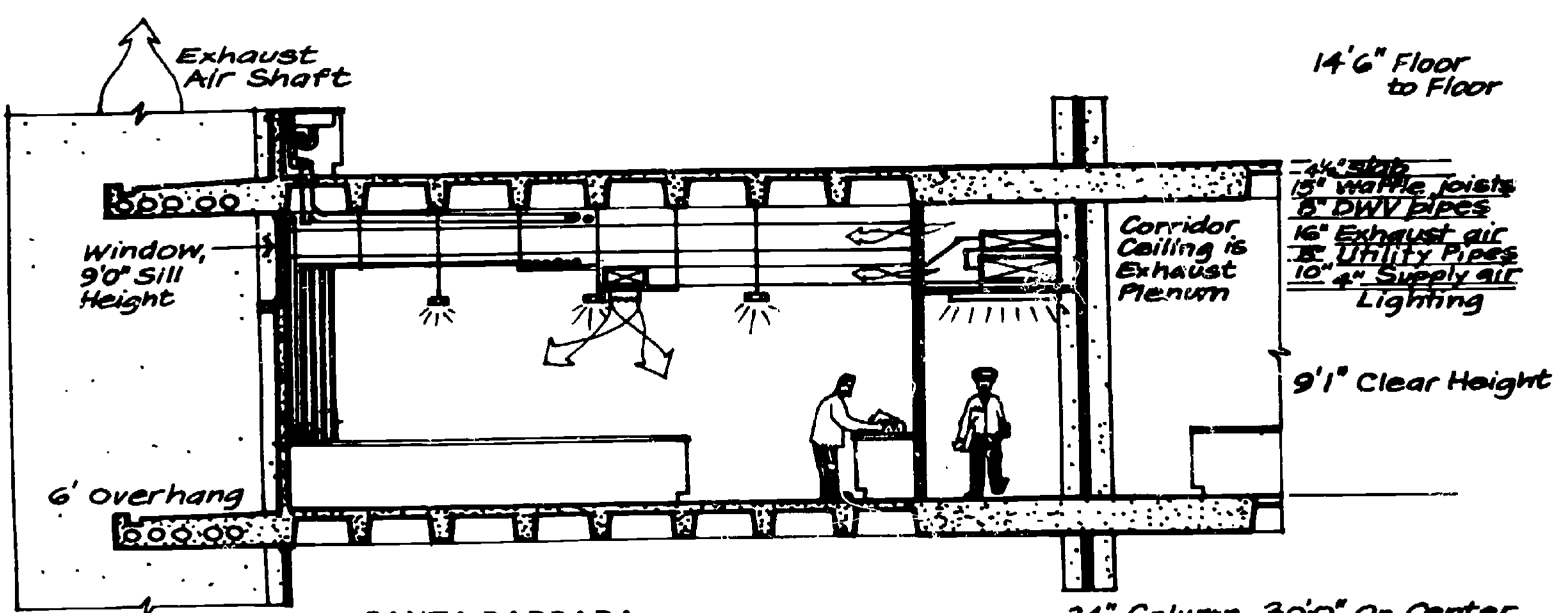


IRVINE

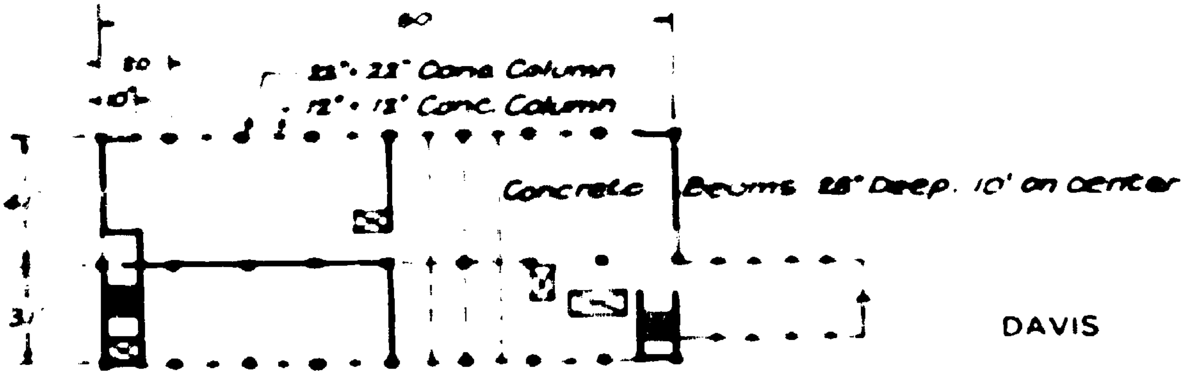


SANTA BARBARA

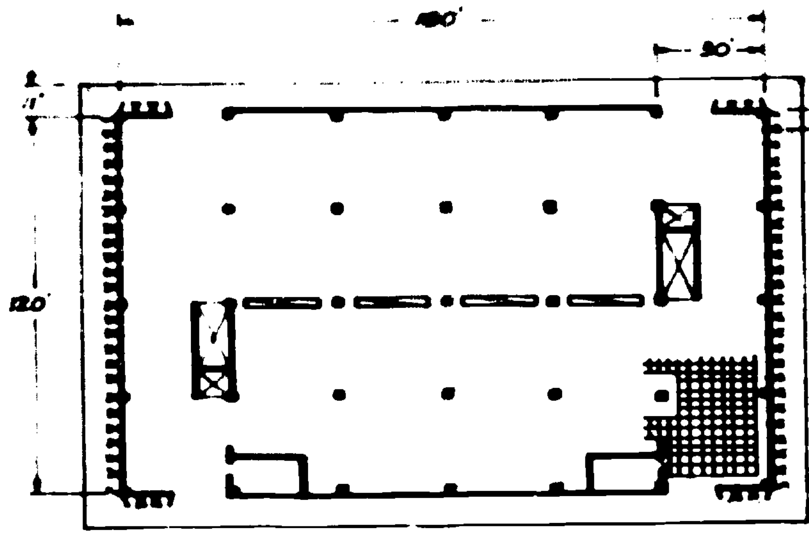
ERIC

STRUCTURE SUBSYSTEM

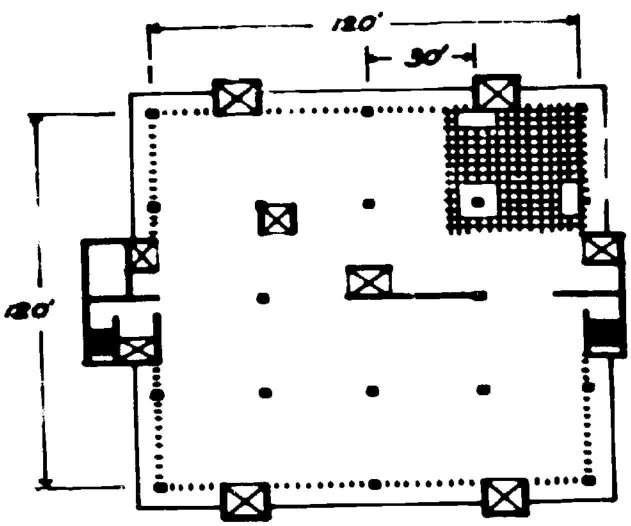
	DAVIS	IRVINE	SANTA BARBARA
STRUCTURE TYPE	Flat Slab Beams Posts	Waffle Slab Posts	Waffle Slab Posts
MATERIAL	Poured Concrete	Poured Concrete	Poured Concrete
SHEAR STRUCTURE	Internal Walls	Internal Cores and Moment Frame	Internal Walls and Cores
STRUCTURAL BAY SIZES	30′ x 20′ 40′ x 20′	30′ x 30′	30′ x 30′
FLOOR TO FLOOR HEIGHTS	14′ - 0″	12′ - 0″	14′ - 6″
STRUCTURAL DEPTH	2′ - 4″	1′ - 7″	1′ - 7½″
HORIZONTAL AREA OF VERTICAL STRUCTURE WITHIN EXT. WALLS	240 S.F.	195 S.F.	225 S.F.
FLOOR LIVE LOADING	50 lbs.	50 lbs.	100 lbs.
ROOF LIVE LOADING	20 lbs.	20 lbs.	20 lbs.



DAVIS



IRVINE



SANTA BARBARA

DAVIS STRUCTURE

Poured concrete floor and roof slabs are supported by poured concrete columns and beams. Shear resistance is by internal poured concrete shear walls

IRVINE – STRUCTURE

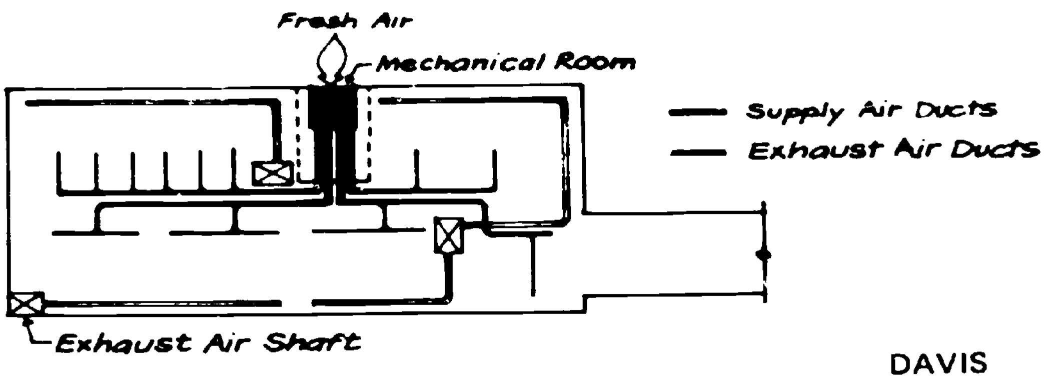
A poured concrete waffle slab is supported on poured concrete columns. The precast concrete panels on the north and south walls are structural. The roof framing to the fifth floor penthouse is structural steel. Shear resistance is by internal poured concrete shear walls to vertical shafts and by poured concrete spandrels.

SANTA BARBARA – STRUCTURE

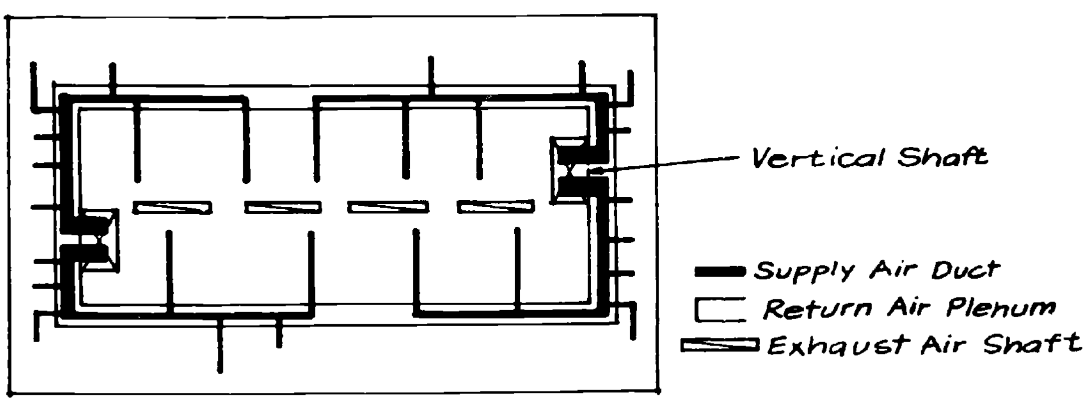
A poured concrete waffle slab is supported on poured concrete columns. Shear resistance is by internal poured concrete shear walls and by poured concrete walls to vertical shafts.

HVAC SUBSYSTEM

	DAVIS	IRVINE	SANTA BARBARA
% BUILDING SERVED	100	100	100
HEATING SOURCE	Central (HPS)	Central (HTW)	Building (HPS Boiler)
FUEL	Gas/HPS	Gas/HTW	Gas
COOLING SOURCE	Central (CHS)	Central (CHS)	Building (Absorption)
FUEL	Electricity/Gas	Electricity/Gas	Gas/HPS
AIR HANDLING SOURCE	Floor Zones	2 Units ½ Building Each	Building Basement – 5 Floors Roof – 2 Floors
EQUIPMENT ROOM SIZE HEATING COOLING AIR HANDLING TOTALS	600 S.F./Floor 4,200 S.F.	4,000 S.F.	3,000 S.F. 4,600 S.F. 4,000 S.F. 11,600 S.F.
CAPACITIES HEATING	5,620,000 BTUH	7,100,000 BTUH	9,600,000 BTUH
COOLING	385 Tons	380 Tons	753 Tons
AIR HANDLING CFM	117,255 CFM	127,000 CFM	166,000 CFM
BTUH/OGSF	61	63	73
OGSF/TON	240	295	175
CFM/OGSF	1.80	1.14	1.25
% RETURN AIR	16.5	40	--
% EXHAUSTED VIA HOODS	16	25	14
% MAIN EXHAUST	67.5	35	86
INTAKE LOCATIONS	Each Floor	Basement Area	Basement and Roof
EXHAUST LOCATIONS	Roof	Roof	Roof
MAXIMUM GROSS SECTIONAL AREA MAIN VERTICAL SUPPLY DUCTS	--	85 S.F.	88 S.F.
MAXIMUM GROSS SECTIONAL AREA MAIN HORIZONTAL SUPPLY DUCTS	12 S.F.	7.0 S.F.	7.5 S.F.
FILTER TYPE AND EFFICIENCY	Replaceable 30% - 35%	Replaceable 35%	Replaceable 50%
HUMIDITY CONTROL % BUILDING	--	--	15%



DAVIS



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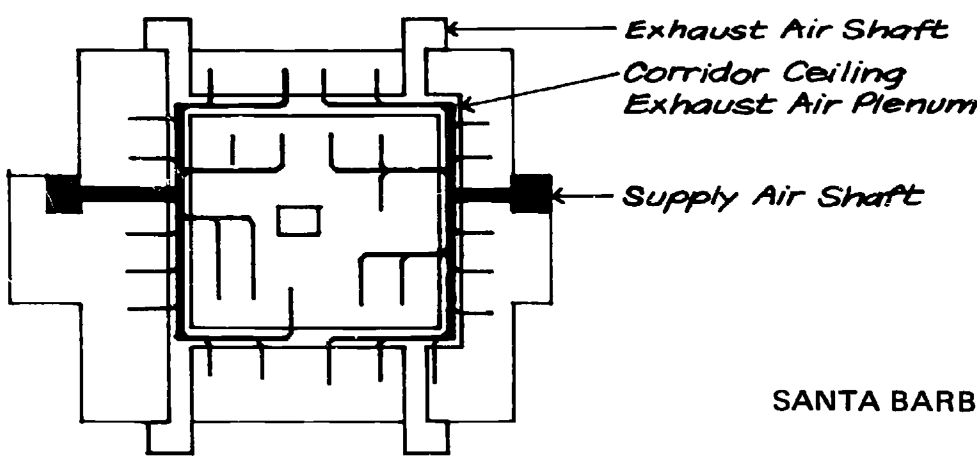


SANTA BARBARA

DAVIS – HVAC

High pressure steam and chilled water supply are from a central campus plant. Each floor has a machinery room consisting of air handling unit and fresh air intake with cooling and preheat coils. Air is recirculated from classrooms and offices. Each floor is a separate HVAC zone in which distribution is by a single duct with reheat coils in each room. Temperature control is by a thermostat in each room. Air is exhausted by exhaust ducts (to which fume hoods are also connected) via periodic vertical mains with fans at roof level.

IRVINE – HVAC

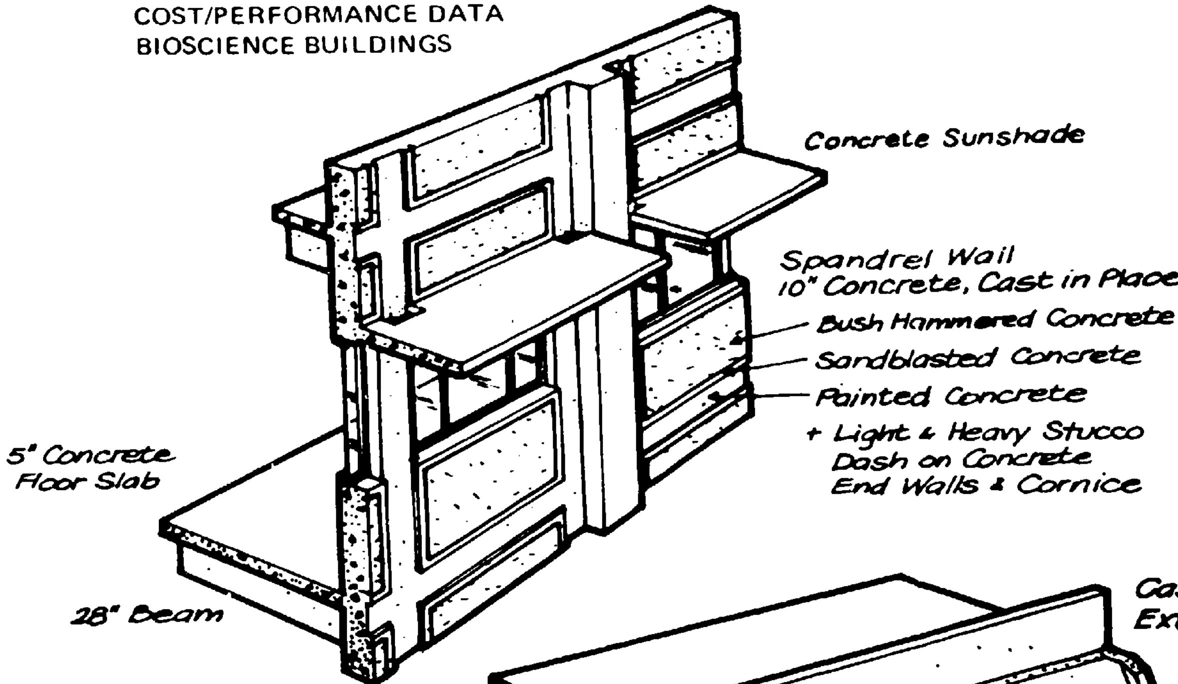
High temperature water and chilled water supply are from a central campus plant. Two air handling units and preheat coils, each serving one half of the building, are located in the basement with air intakes. Air is recirculated from classrooms, offices and miscellaneous spaces via corridor ceiling plenum and main vertical shafts. Vertical distribution is via two main shafts within the building, and from these, double ducts over the corridors serve each floor. Control is by zones of one or two rooms. Air is exhausted by fume hoods and exhaust plenum both contained in a central services cavity. Air supply, return and exhaust is at low pressure.

SANTA BARBARA – HVAC

High pressure steam and chilled water are from gas fired boilers and absorption chiller in the basement machinery room. Air handling and preheat coils for the first to fifth floors are in the basement with 100% fresh air intake. The sixth floor and penthouse are served by a separate air handling unit on the roof. This is the only zoning of HVAC in the building. Vertical distribution is via two main shafts on the perimeter of the building, and from these, double ducts over the corridors serve each floor. There are a number of special temperature rooms on reheat coils or refrigeration coils with humidity control. HVAC control in the building is central. Air is exhausted at roof level via fume hoods and corridor ceiling plenum carried vertically in perimeter shafts.

EXTERIOR WALLS SUBSYSTEM

	STRUCTURAL			NON-STRUCTURAL		
	DAVIS	IRVINE	SANTA BARBARA	DAVIS	IRVINE	SANTA BARBARA
% SQ. FT. OF EXTERIOR WALL	100	50	50	--	50	50
% TOTAL SQ. FT. GLAZED	20	--	--	--	21	15
% GLASS AREA OPENABLE	50	--	--	--	100	25
SUN CONTROL MEASURE	Cantilever Shades Ven. Blinds	--	Cantilever Floor Slabs	--	Precast Concrete Sculptured Forms	
PLANNING MODULE	10' - 0"	30' - 0"	30' - 0"	--	5' - 0"	3' - 0"
WALL CORE	Poured Concrete	Poured Concrete	Poured Concrete	--	Precast Concrete	Precast Concrete
WALL/COLUMN THICKNESS	11½" 24"	10" 18"	-- 24"	-- --	-- --	5" 14"
UNGLAZED U FACTOR	0.53 --	0.63 --	-- --	-- --	-- --	0.08 --
INSIDE FACE MATERIAL	Plaster	Concrete	Exposed Concrete	--	--	Exposed Concrete
INTERIOR FINISH	Painted	Painted	--	--	--	--
EXTERIOR FACE MATERIAL	Concrete	Precast Concrete	Concrete	--	Precast Concrete	Concrete
EXTERIOR FINISH	Natural Bush-Hammer Stucco	Exposed Aggregate	Painted	--	Exposed Aggregate	Painted



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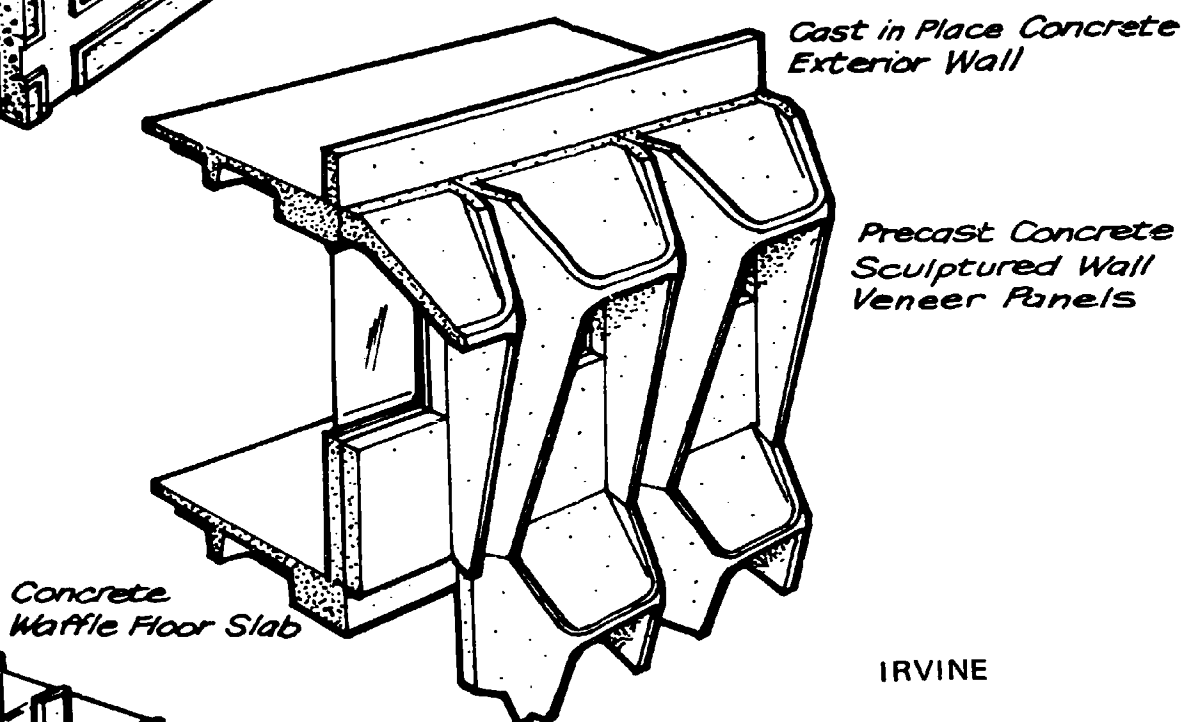

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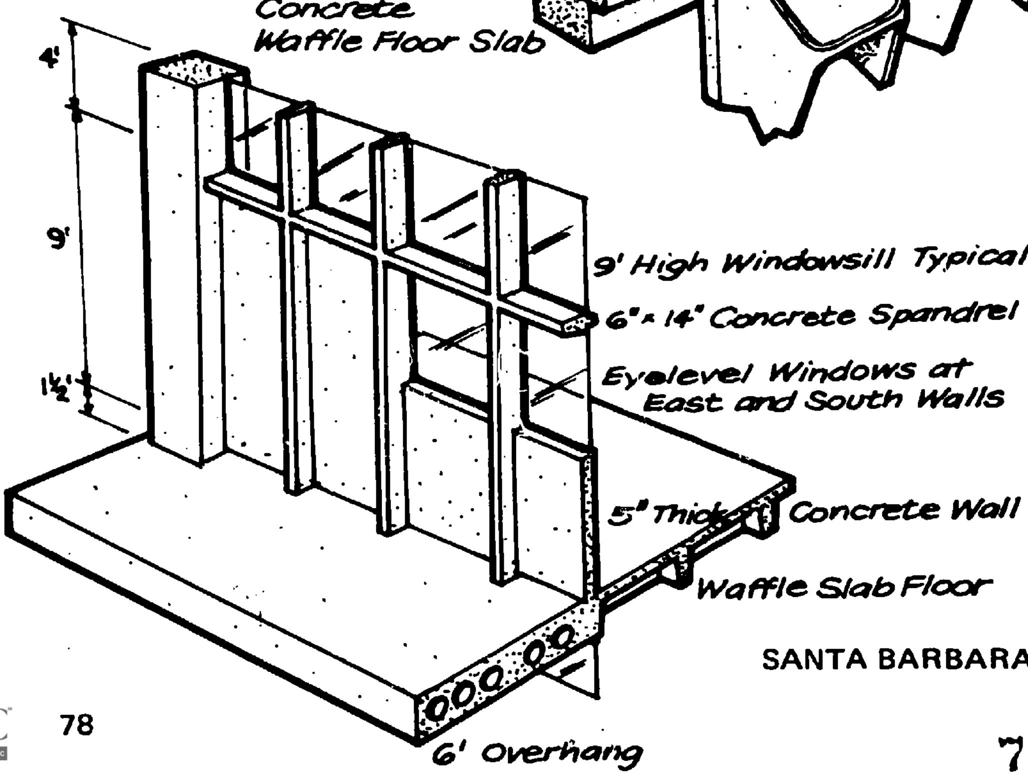


SANTA BARBARA

DAVIS – EXTERIOR WALLS

The spandrel walls are poured concrete with poured concrete cantilever sunshades over windows. The exterior finish of the spandrel panels is bush hammered and delineated by a sand blasted edge or trim. The interior finish is plaster and paint.

IRVINE – EXTERIOR WALLS

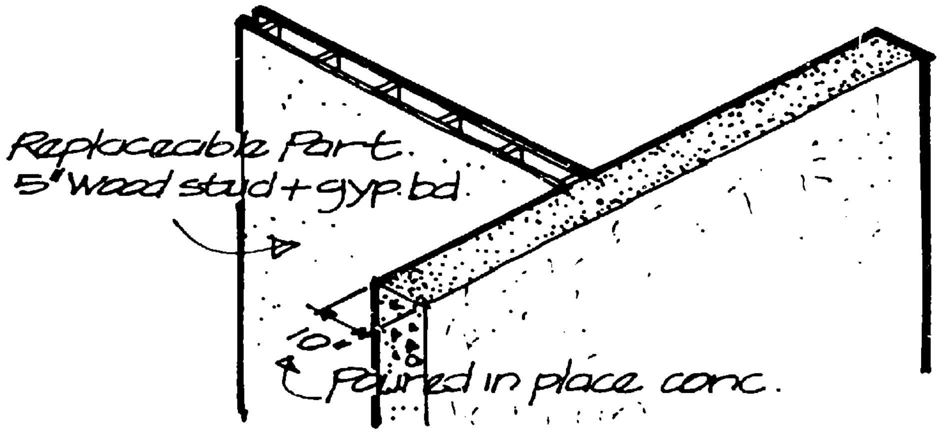
The panels on the north and south walls are structural precast concrete welded in place. They have an exposed aggregate finish. Spandrel panels are poured concrete with an exposed aggregate, precast concrete facing. Interior finishes are exposed concrete. Windows are surrounded by a precast concrete sculptured form for sun protection with exposed concrete finish. The poured concrete casing to the penthouse framing is also sculptured and has an exposed concrete finish.

SANTA BARBARA – EXTERIOR WALLS

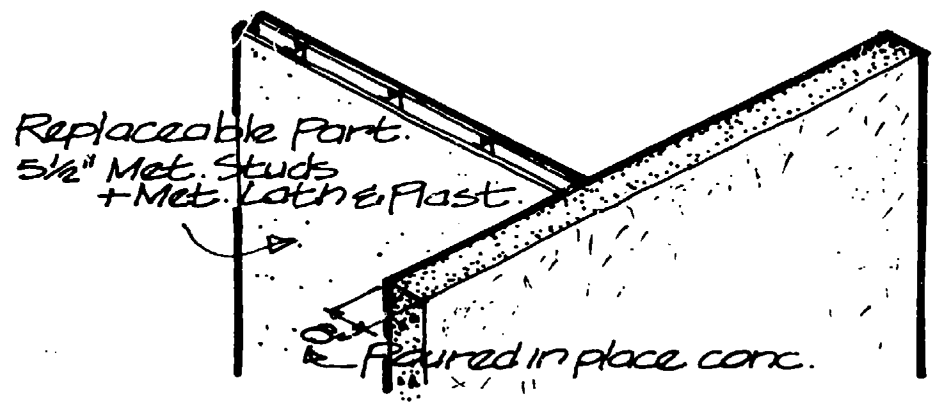
Mullions and spandrels with varying window sill heights are formed in precast concrete with a plain, painted concrete finish. The interior finish is exposed concrete. Sun shades are formed by cantilever floor slabs.

INTERIOR PARTITIONS SUBSYSTEM

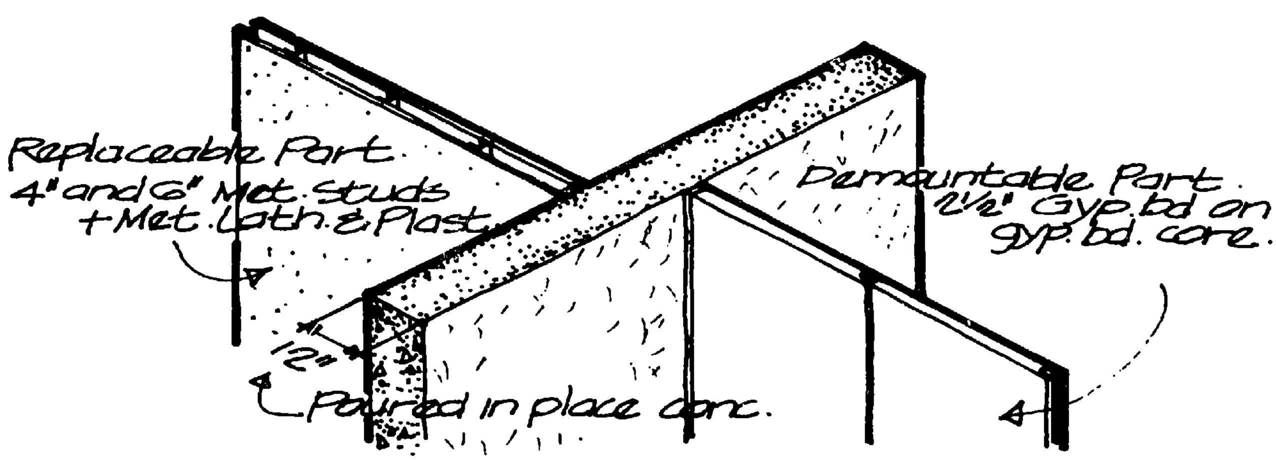
	STRUCTURAL			REPLACEABLE			DEMOUNTABLE		
	DAVIS	IRVINE	SANTA BARBARA	DAVIS	IRVINE	SANTA BARBARA	DAVIS	IRVINE	SANTA BARBARA
% OF LINEAR FEET OF INTERIOR WALLS	10	17	15	90	83	35	--	--	50
MATERIAL	Concrete	Concrete	Concrete	Gyp. Bd. on Wooden Studs Metal Lath and Plaster	Metal Studs Metal Lath and Plaster	Metal Studs Metal Lath and Plaster			Laminated Gypsum Board
PLANNING MODULE	10' - 0"	--	--	10' - 0"	3' - 0"	3' - 0"			3' - 0"
HEIGHTS	11' - 0" 13' - 0"	10' - 6"	13' - 0"	11' - 0" 13' - 0"	10' - 6"	13' - 0"			13' - 0"
THICKNESS	10"	8"	12"	5½"	5½"	6" and 4"			2½"
SOUND TRANSMISSION COEFFICIENT DECIBELS	55	50	60	35 and 40	[illegible]	40			35
FIRE RATING	4 hr.	4 hr.	4 hr.	1 hr. 2 hr.	2 hr.	2 hr. & 1 hr.			2 hr.
UTILITY SUPPORT	Yes	Yes	Yes	Yes	Yes	Yes			Yes
FURNITURE SUPPORT	Yes	Yes	Yes	Yes	Yes	Yes			Yes
PERMEABILITY	Doors Services	Doors Services	Doors Services	Doors Services	Doors Services	Doors Services			Doors Services



DAVIS



IRVINE



SANTA BARBARA

DAVIS – INTERIOR PARTITIONS

10% of the interior walls are structural poured concrete plastered and painted. The remainder are replaceable: 52% are gypsum board on wooden studs; 23% are plaster on metal laths and metal studs; and 15% are solid plaster partitions. There are no demountable partitions.

IRVINE - INTERIOR PARTITIONS

17% of the interior walls are structural poured concrete plastered and painted. The remainder are replaceable: plaster on metal laths and metal studs. There is a small amount of gypsum rib partition. There are no demountable partitions.

SANTA BARBARA – INTERIOR PARTITIONS

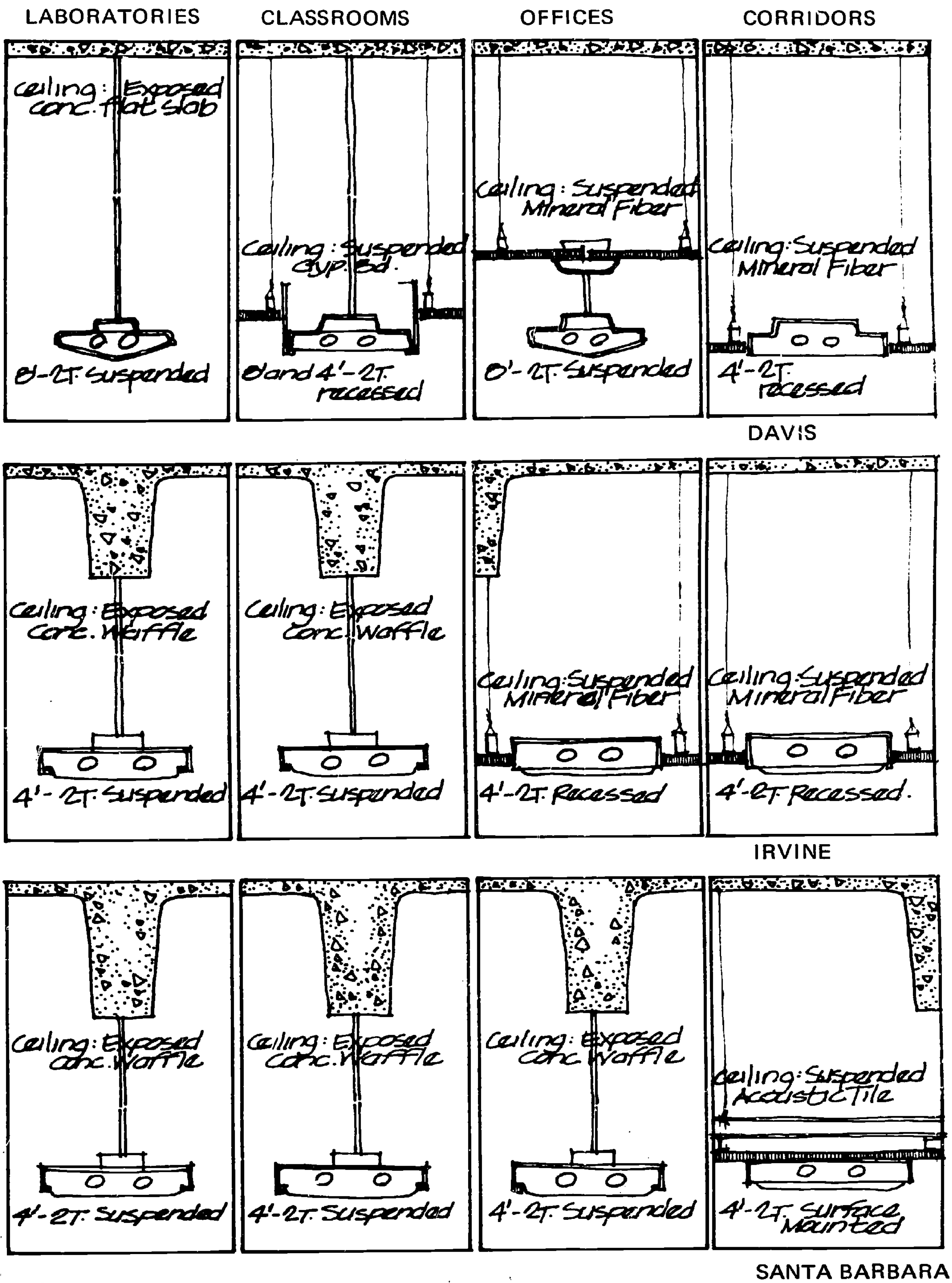
15% of the interior walls are structural poured concrete painted finish. 35% are replaceable: plaster on metal laths and metal studs. 50% are demountable: laminated gypsum board.

LIGHTING/CEILING SUBSYSTEMS

	LABORATORIES			CLASSROOMS		
	DAVIS	IRVINE	SANTA BARBARA	DAVIS	IRVINE	SANTA BARBARA
LIGHTING TYPE	8′ - 2T Susp. Direct	4′ - 2T Susp. Direct	4′ - 2T Susp. Direct	8′ and 4′ - 2T Recessed	4′ - 2T Susp. Direct	4′ - 2T Susp. Direct
SPACING	Cont. 5′ oc	Cont. 6′ oc	Cont. 6′ oc	Cont. 5′ oc	Cont. 6′ oc	Cont. 6′ oc
WATTS/SQUARE FOOT	4.0	3.0	3.4	4.0	3.4	3.4
VOLTAGE	277	277	277	277	277	277
SWITCHING ZONE	Room	Room	Room	Room	Room	Room
SWITCHING TYPE	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way
CEILING TYPE	Struct.	Struct.	Struct.	Susp.	Struct.	Struct.
MATERIAL	Concrete	Concrete	Concrete	Gypsum Board	Concrete	Concrete
MODULE	10′ - 0″	3′ - 0″	3′ - 0″	10′ - 0″	3′ - 0″	3′ - 0″
NOISE REDUCTION COEFFICIENT	0.07	Poor (Waffle Slab)	Poor (Waffle Slab)	0.06	Poor (Waffle Slab)	Poor (Waffle Slab)

LIGHTING/CEILING SUBSYSTEMS

	OFFICES			CIRCULATION		
	DAVIS	IRVINE	SANTA BARBARA	DAVIS	IRVINE	SANTA BARBARA
LIGHTING TYPE	8' - 2T Susp. Direct	4' - 2T Recessed	4' - 2T Susp. Direct	4' - 2T Recessed	4' - 2T Recessed	4' - 2T Surface
SPACING	Separate 6' oc	Cont. 5' oc	Cont. 5' oc	Separate 10' oc	Separate 10' oc	Separate 9' oc
WATTS/SQUARE FOOT	3.0	3.5	3.4	0.6	1.3	2.0
VOLTAGE	277	277	277	277	277	277
SWITCHING ZONE	Room	Room	Room	Floor	Floor	Half Floor
SWITCHING TYPE	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Remote Control	Remote Control (Key)	Remote Control
CEILING TYPE	Susp.	Susp.	Struct.	Susp.	Susp.	Susp.
MATERIAL	Mineral Fiber	Mineral Fiber	Concrete	Mineral Fiber	Mineral Fiber	Acoustic Tile
MODULE	2' x 4'	2' x 4'	3' - 0"	2' x 4'	2' x 4'	2' x 2'
NOISE REDUCTION COEFFICIENT	0.7	0.7	Poor (Waffle Slab)	0.75	0.7	0.7


LABORATORIES
CLASSROOMS
OFFICES
CORRIDORS
Ceiling: Exposed Conc. flat slab
8'-2T. Suspended
Ceiling: Suspended Gyp. Bd.
8' and 4'-2T. recessed
Ceiling: Suspended Mineral Fiber
8'-2T. Suspended
Ceiling: Suspended Mineral Fiber
4'-2T. recessed
DAVIS
Ceiling: Exposed Conc. Waffle
4'-2T. Suspended
Ceiling: Exposed Conc. Waffle
4'-2T. Suspended
Ceiling: Suspended Mineral Fiber
4'-2T. Recessed
Ceiling: Suspended Mineral Fiber
4'-2T. Recessed.
IRVINE
Ceiling: Exposed conc. Waffle
4'-2T. Suspended
Ceiling: Exposed Conc. Waffle
4'-2T. Suspended
Ceiling: Exposed Conc. Waffle
4'-2T. Suspended
Ceiling: Suspended Acoustic Tile
4'-2T. Surface Mounted
SANTA BARBARA

DAVIS – LIGHTING/CEILING

There are no suspended ceilings provided in labs; fluorescent light fixtures are suspended from the structural ceiling. In classrooms suspended ceilings are painted gypsum board; fluorescent light fixtures are recessed in wooden trims. In offices, suspended mineral fiber tile ceilings are provided; fluorescent light fixtures are suspended below the ceilings. In corridors suspended mineral fiber tile ceilings are provided; fluorescent light fixtures are recessed into the ceilings.

IRVINE – LIGHTING/CEILING

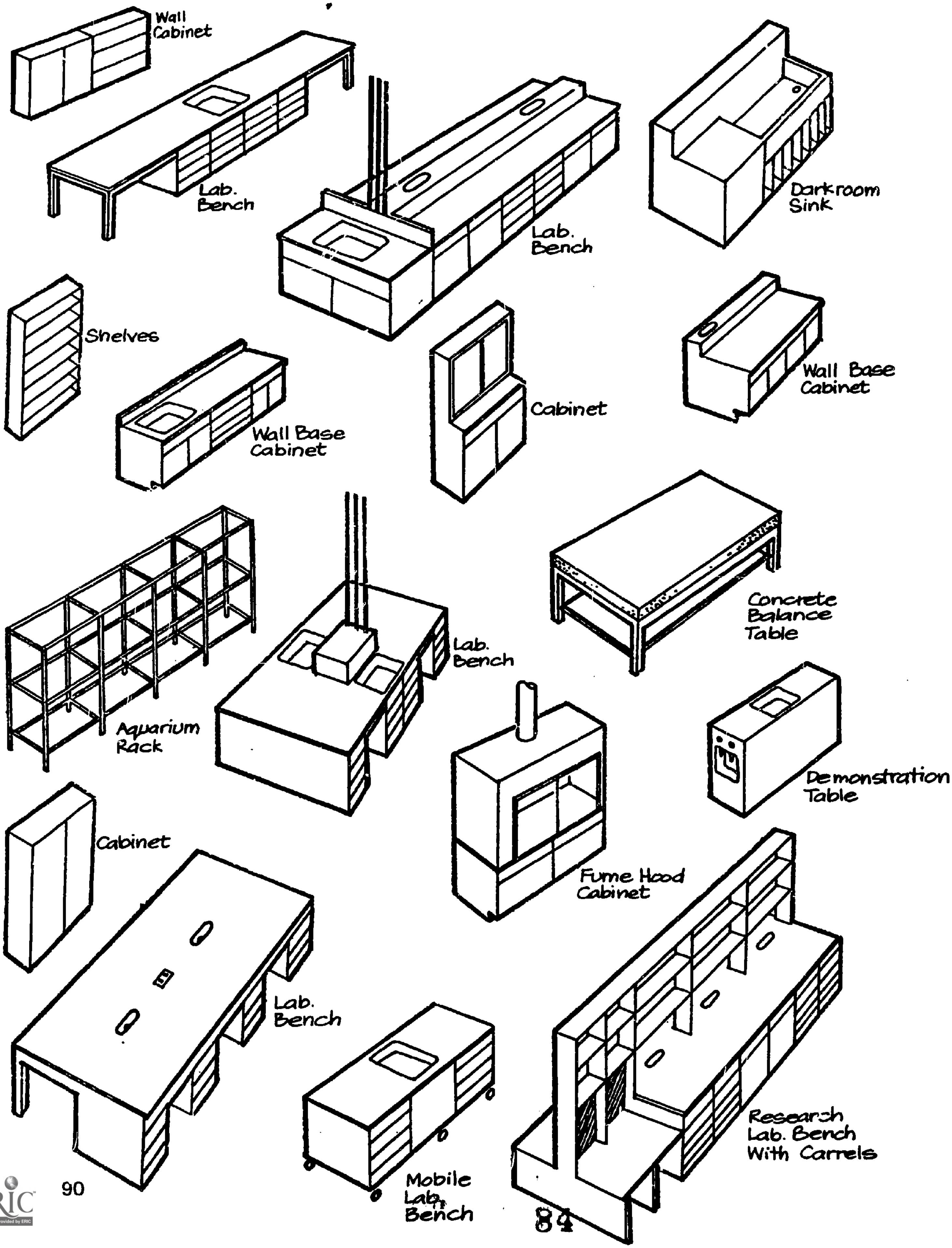
There are no suspended ceilings provided in labs; fluorescent light fixtures are suspended from the structural ceilings. There are no suspended ceilings provided in classrooms; some acoustic tiling is applied to the coffers of the waffle slabs; fluorescent lighting fixtures are suspended from the structural ceilings. In offices, suspended mineral fiber ceilings are provided; fluorescent light fixtures are recessed into the ceilings. In corridors suspended mineral fiber ceilings are provided; fluorescent light fixtures are recessed into the ceilings.

SANTA BARBARA – LIGHTING/CEILING

There are no suspended ceilings provided in labs; fluorescent light fixtures are suspended from the structural ceiling. There are no suspended ceilings provided in classrooms; fluorescent light fixtures are suspended from the structural ceiling. There are no suspended ceilings provided in offices; fluorescent light fixtures are suspended from the structural ceiling. In corridors suspended acoustic tile ceilings are provided; fluorescent light fixtures are mounted on the surface of the ceilings.

CASEWORK SUBSYSTEM

	DAVIS	IRVINE	SANTA BARBARA
	WIDTHS	WIDTHS	WIDTHS
FREESTANDING CABINETS	1'-6",2'	2'-3", 2'-9"	1', 1'-6", 2', 2'-6", 4'
WALL BASE CABINETS	2'-6", 3'	2'	2', 2'-6"
WALL MOUNTED CABINETS	1'	1'	1', 1'-4"
SINGLE LOADED BENCHES	2'-6"	2'-6", 3'	2'-6"
DOUBLE LOADED BENCHES	4'-6'	4", 4'-6"	4'-6"
FUME HOOD CABINETS	2'-6"	2'-4", 2'-9"	3'
CONCRETE BALANCE TABLES	–	Varies	2'-6"
MOVEABLE BENCHES	–	3'	2'-8"
CASE MATERIALS	Hardwood, Plywood	Hardwood, Plywood	Hardwood, Plywood
FINISH – WOOD	Varnish	Stain and Lacquer	Stain and Clear Plastic Coating
FINISH – METAL	Epoxy Coating	Epoxy Coating	Epoxy Coating
BENCH TOP MATERIALS	Plastic Laminate, Stainless Steel, Cement Asbestos	Plastic Laminate, Stainless Steel, Cement Asbestos	Plastic Laminate, Stainless Steel, Epoxy Resin Composition
SINK MATERIALS	Stainless Steel, Epoxy Resin Composition Polyethylene	Stainless Steel, Cement Asbestos, Soapstone, Epoxy Resin Composition	Stainless Steel Epoxy Resin Composition


Wall Cabinet
Lab. Bench
Lab. Bench
Darkroom Sink
Shelves
Wall Base Cabinet
Cabinet
Wall Base Cabinet
Concrete Balance Table
Lab. Bench
Aquarium Rack
Demonstration Table
Cabinet
Fume Hood Cabinet
Lab. Bench
Research Lab. Bench With Carrels
Mobile Lab. Bench

DAVIS – CASEWORK

A complete range of wood laboratory furniture is supplied. Bench tops are plastic laminate, stainless steel or cement asbestos ("Colorlith").

IRVINE – CASEWORK

A complete range of wood laboratory furniture is supplied. Bench tops are plastic laminate, stainless steel or cement asbestos ("Colorlith").

SANTA BARBARA – CASEWORK

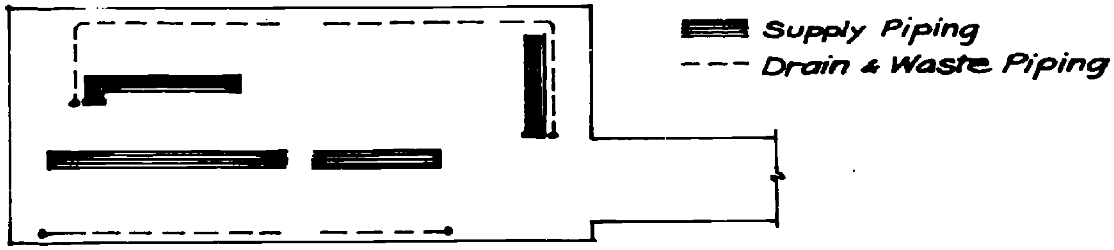
A complete range of wood laboratory furniture is supplied. Bench tops are plastic laminate, stainless steel or epoxy resin composition ("Durcon").

SERVICES SUBSYSTEM

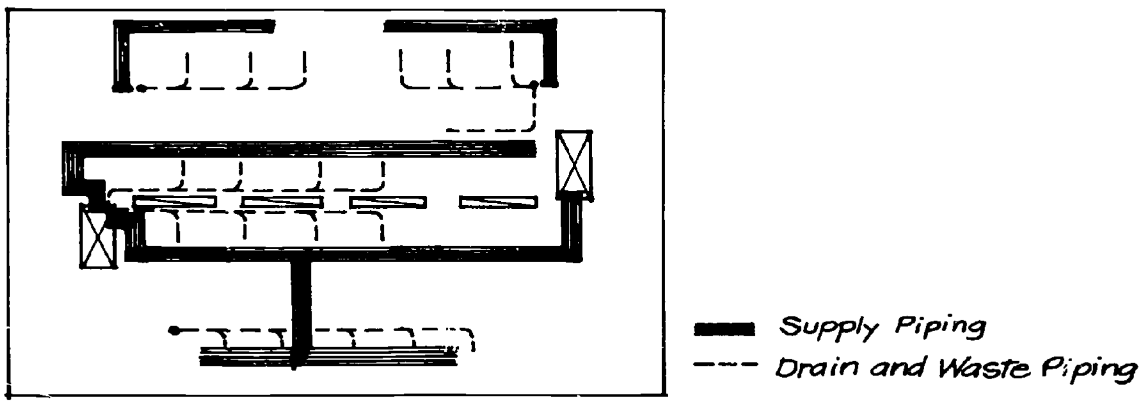
	DAVIS	IRVINE	SANTA BARBARA
PLUMBING			
DOMESTIC COLD WATER	Copper Tubing L	Copper Tubing K	Copper Tubing L
DOMESTIC HOT WATER	"	"	"
INDUSTRIAL COLD WATER	"	"	"
INDUSTRIAL HOT WATER	"	"	"
COMPRESSED AIR	"	Black Steel 40	Black Steel 40
VACUUM	"	"	"
GAS	Black Steel 40	"	"
DISTILLED WATER	Aluminum	Polyethylene 40	PVC 80
SEA WATER	PVC 80	--	"
SANITARY SOIL	Cast Iron	Cast Iron	Cast Iron
SANITARY WASTE, VENT	Galv. Steel 40	"	Copper Tubing DWV
ACID WASTE, VENT: above grade	Cast Iron XH	Tempered Glass	Epoxy Resin
buried	Corrosion-Resisting Iron	Corrosion-Resisting Iron	Corrosion-Resisting Iron
STEAM	--	--	Black Steel
OXYGEN	--	Copper Tubing K	Copper Tubing K
CARBON DIOXIDE	--	--	"
INDIRECT DRAINS	Copper Tubing L	--	Copper Tubing L
PIPE HANGER SPACING			
FOR: STEEL PIPE, under 1-¼"	8'	8'	6'
STEEL PIPE, over 1-¼"	,10'	10'	9'
COPPER TUBING,			
under 1-¼"	6'	5'	6'
over 1-¼"	8'	10'	9'
CAST IRON PIPE	5'	5'	
PVC PIPE, under 3"	--	--	Continuous
PVC PIPE, over 3"	--	--	6'
POLYETHYLENE PIPE	Continuous	--	--
ALUMINUM PIPE,			
under 1-¼"	6'	--	--
over 1-¼"	8'	--	--
PIPE SLEEVES THROUGH CONCRETE SLAB	Removable Form — Pipe Grouted With Mastic	14 Ga. Iron, or Iron Frame, Pipe Packed With Lead	14 Ga. Iron, Pipe Packed and Sealed With Lead
FREQUENCY OF PIPE PENETRATION OF FLOOR SLAB, OGSF/HOLE	162	274	220

SERVICES SUBSYSTEM

	DAVIS	IRVINE	SANTA BARBARA
PLUMBING (continued)			
FREQUENCY OF PIPE DROPS FROM CEILING MAINS TO BENCH	413 S.F.	254 S.F.	174 S.F.
OGSF PER VERTICAL SUPPLY PIPE MAIN CHASE, PER FLOOR	3,200	10,800	8,500
OGSF PER VERTICAL DRAIN PIPE MAIN CHASE, PER FLOOR	3,200	4,300	3,400
ELECTRIC POWER			
OGSF PER VERTICAL ELECTRIC MAIN, PER FLOOR	12,800	10,800	8,500
OGSF PER BRANCH CIRCUIT	840	1,540	1,350
OGSF PER CIRCUIT BREAKER	56	100	39
CIRCUIT BREAKERS PER BRANCH CIRCUIT	15	15	35
AMPS PER CIRCUIT BREAKER	20	20,50	
OGSF PER AMPERE	25.6	39	22
AREA OF FLOOR ELECTRIC CLOSET, S. F.	30	22	176
COMMUNICATIONS			
FIRE ALARM VERTICAL MAINS	1	1	2
TV CONDUIT VERTICAL MAINS	1	--	2
TELEPHONE VERTICAL MAINS	1	2	2
MOTOR CONTROL CIRCUITS	Yes	--	Yes
CLOCK	Yes	Yes	--



DAVIS



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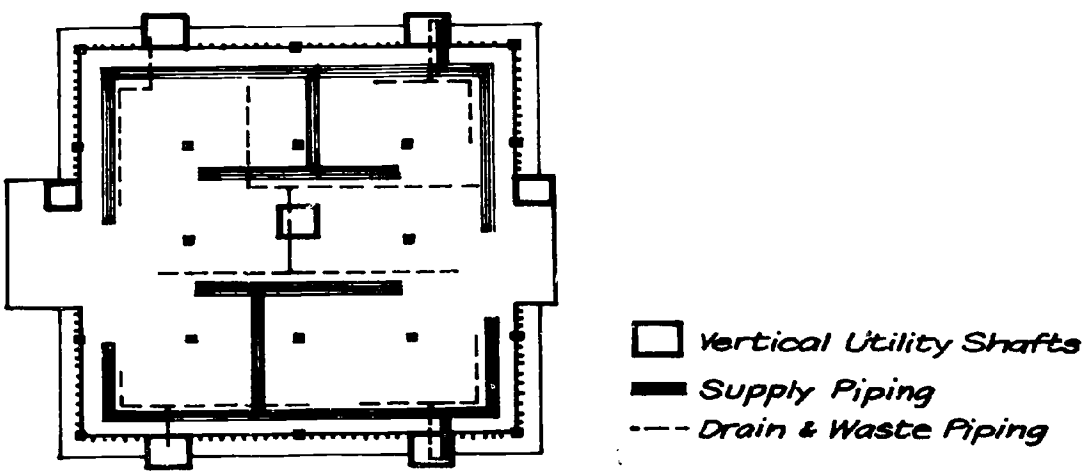

SANTA BARBARA

DAVIS – SERVICES

This building has four main vertical risers for plumbing, and one for electricity and communications. The corridor and HVAC ducts separate the horizontal plumbing distribution zones. Benches are supplied down from ceiling mains. Floor penetrations for drain lines are random. Bus ducts for horizontal electrical distribution are a feature of this building.

IRVINE – SERVICES

This building has four main vertical risers for plumbing and two for electricity. The corridors, HVAC ducts and main vertical chases separate the horizontal plumbing distribution zones. Benches are supplied down from ceiling mains or up through the floor with main runs on alternate floors. Floor penetrations for drain lines are random.

SANTA BARBARA – SERVICES

This building has three main vertical risers for plumbing and one for electricity. The corridor and HVAC ducts separate the horizontal plumbing distribution zones. There are five main vertical risers for plumbing waste lines. Benches are supplied down from ceiling mains or up through the floor with main runs on alternate floors. Floor penetration for drain lines are random.

The ABS consultant analyzed and compared three existing science and engineering buildings in Indiana. These buildings are:

Jordan Hall, Indiana University, Bloomington, Indiana
Krannert Hall, Indiana University and Purdue University, Indianapolis, Indiana
Civil Engineering Building, Purdue University, Lafayette, Indiana

Cost and performance data in the preceding "Summaries and Comparisons" section are extracted from the detailed information herein.

COST DATA

The costs of existing facilities establish the bases for those cost parameters applicable to ABS subsystems. Working drawings, specifications, and bidding documents for the three buildings were submitted to the Koch Company, Construction Cost Consultants, of San Francisco, assisted by J. Rumsey for mechanical and electrical work. They prepared an estimate for each project as if it were bid January 1970 in the San Francisco Bay Area, with an Engineering News-Record (ENR) Construction Cost Index of 1300.

Estimates were based on contract documents without change orders. In the case of the Krannert Building, the estimate includes work under contracts bid in April 1960 for the original building, but not contracts bid February 1966 for an addition. For comparison, except for Jordan Hall, the actual bids were projected to ENR 1300 and adjusted to San Francisco Bay Area prices by the application of the American Appraisal Company's Boeckh Time-Location Modifiers for institutional reinforced concrete frame buildings. For Jordan Hall, because of the lengthy interval from the bid date of March 1952 to January 1970, Marshall Valuation Indexes were used instead. The estimates varied from the projected and adjusted bids by minus 4% for Jordan Hall, minus 2% for Krannert Hall, and plus 7% for the Civil Engineering Building at Purdue.

The three study projects are compared by component costs. Within the component cost divisions the cost of elements equivalent to the proposed ABS subsystems were

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isolated and tabulated separately, for use in establishing target prices for the subsystems. Upon completion of the subsystems design, these tabulations were reassessed and revised to correspond as precisely as possible with the ABS final design. No change was made in cost division estimates except for redistribution of cost elements between systems and non-systems categories.

Table 1 indicates, in dollars per outside gross square foot ($/OGSF), the costs of components equivalent to ABS subsystems and components outside of the ABS system. Table 2 indicates, for certain cost divisions, the component unit costs in terms of dollars per square foot of component surface area as tabulated in the last column of cost division breakdowns.

All costs represent subcontract prices, including subcontractor's overhead and profit, but general contractor's mark-up is itemized separately.

The three buildings studied at Bloomington, Indianapolis, and Purdue are generally similar in character, although the costs of some of their elements vary considerably. Observed reasons for variation are discussed with relationship to the individual cost divisions.

Laboratory casework estimates were not included initially, but were added for cost comparison with the three California buildings, wherein the general contract work included laboratory casework.

PERFORMANCE DATA

The performance characteristics of subsystems in the three sample buildings were studied concurrently with costs for analysis of the relationships and for projection of proposed performance requirements for ABS subsystems. The intent was to indicate in simple descriptive terms the subsystems capabilities and how well they perform. Data, in the form of gross measurable quantities expressed as percentages of gross floor area, are supplemented with descriptive and quantitative statements of the performance characteristics.

Jordan Hall, Indiana University, Bloomington, Indiana

Architects, Engineers: A. M. Strauss, Inc.
Bid Date: March 1952

Krannert Hall, Indiana University and Purdue University, Indianapolis, Indiana

Architects, Engineers: Walter Scholer & Associates, Inc.
Bid Date: April 1960

Civil Engineering Building, Purdue University, Lafayette, Indiana

Architects, Engineers: Walter Scholer & Associates, Inc.
Bid Date: June 1962

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TABLE 1

SUBSYSTEM EQUIVALENT COSTS, $/OGSF – ENR 1300

	BLOOMINGTON		INDIANAPOLIS		PURDUE	
	$/OGSF	%	$/OGSF	%	$/OGSF	%
SYSTEM*						
Structure	4.54	10	4.82	14	5.96	15
HVAC	4.56	10	4.85	15	4.17	11
Partitions	4.98	11	3.96	12	5.33	14
Lighting/Ceiling	1.61	4	1.43	4	1.44	4
Subtotal	15.69	35%	15.06	45%	16.90	44%
NON-SYSTEM						
Site Work, Below Grade and Basement	1.87	4	3.00	9	2.07	5
HVAC	2.58	6			.30	1
Partitions	.90	2	1.10	3	1.29	3
Plumbing	3.84	9	2.54	8	3.66	10
Electrical	2.59	6	3.18	9	3.48	9
Ceiling	.03		.08		.06	
Exterior Skin	7.03	16	2.44	7	3.61	9
Elevators	.33	1	.53	2	.33	1
Other	2.37	5	1.73	5	2.99	8
General Contractor	3.52	8	1.52	5	2.83	7
Subtotal	25.06	57%	16.12	48%	20.62	53%
TOTAL	40.75		31.18		37.52	
Laboratory Casework	3.38	8	2.26	7	1.12	3
TOTAL	**44.13**	**100%**	**33.44**	**100%**	**38.64**	**100%**

NOTE: Costs in Table 1 are expressed in terms of the total cost of the subsystem divided by the total outside gross building floor area (OGSF).

In contrast, costs in Table 2 are expressed in terms of the total cost of the subsystem divided by the total area of the components involved.

*Includes all components equivalent to ABS subsystems.

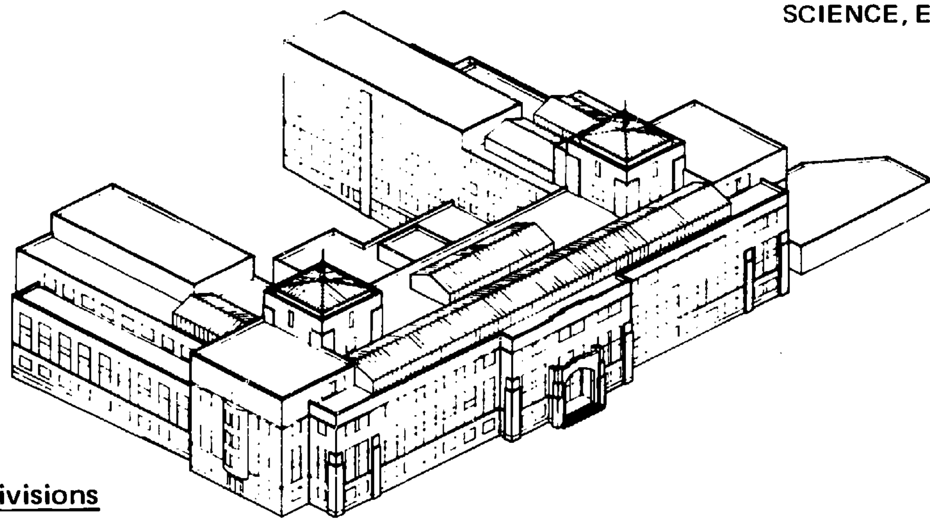
TABLE 2

COMPONENT UNIT COSTS, $/COMPONENT QUANTITY – ENR 1300

FLOORS (STRUCTURE)	ROOF*	INTERIOR PARTITIONS	EXTERIOR SKIN
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON, INDIANA			
$/S.F. 4.99	$/S.F. 6.84	$/S.F. 5.76	$/S.F. 17.58
KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS, INDIANA			
$/S.F. 5.17	$/S.F. 5.26	$/S.F. 4.90	$/S.F. 11.40
CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE, INDIANA			
$/S.F. 6.29	$/S.F. 7.33	$/S.F. 5.74	$/S.F. 10.76

NOTE: Costs in Table 2 are expressed in terms of the total cost of the subsystem divided by the total area of the components involved.

*Includes ceilings and finishes.



Cost Divisions

JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON, INDIANA

Contracts Bid March 1952; 222,065 Outside Gross Square Feet (OGSF)

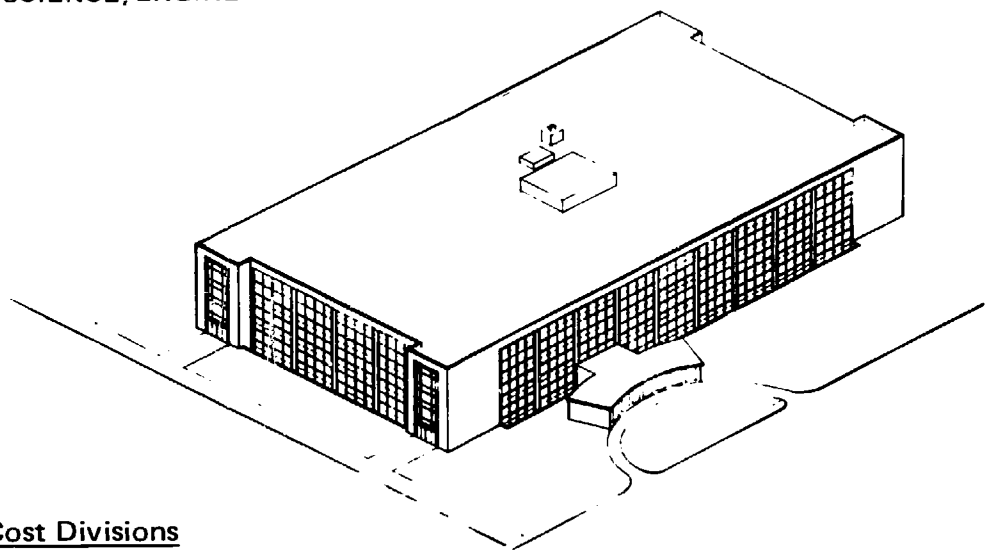
General	$2,892,495	
Mechanical	1,444,620	
Electrical	243,675	
Elevators	64,585	
Steam & Electric Dist.	51,438	
	$4,696,813	($21.15/OGSF)
Projected:*	$8,876,976	($39.97/OGSF)
Geographical Adjustment:*	$9,587,134	($42.16/OGSF)

Cost Estimate (Jan. 1970 – ENR 1300)

		$/OGSF	%
Site Work, Below Grade & Basement	$ 471,290	1.87	5
Floors	1,254,270	5.64	14
Roof	336,180	1.51	4
Interior Partitions	1,305,820	5.88	14
Interior General	146,110	.65	2
Exterior Skin, above ground	1,564,570	7.03	17
HVAC	1,582,612	7.14	18
Plumbing	851,527	3.84	9
Electrical	740,823	3.34	8
Elevators	70,000	.33	1
General Contractor	780,000	3.52	8
	$9,049,202	$40.75	
Chilled Water Plant	117,515	.53	
	$9,166,717	$41.28	
Laboratory Casework	750,580	3.38	

For comparison with other buildings served by central plants, the cost of the building chilled water plant is excluded from the HVAC cost division. The cost of laboratory casework was estimated separately and is not included in the Interior General cost division.

*Because of the long time period from bidding to date, the bid total was projected and adjusted on the basis of Marshall Valuation Indexes, rather than ENR. The cost estimate of $9,166,717 is 4% less than the projected and adjusted bid total.



Cost Divisions

KRANNERT HALL, INDIANA UNIVERSITY AND PURDUE UNIVERSITY, INDIANAPOLIS, INDIANA

Original contracts bid April 1960; ENR Construction Cost Index 813

134,276 Outside Gross Square Feet (OGSF)

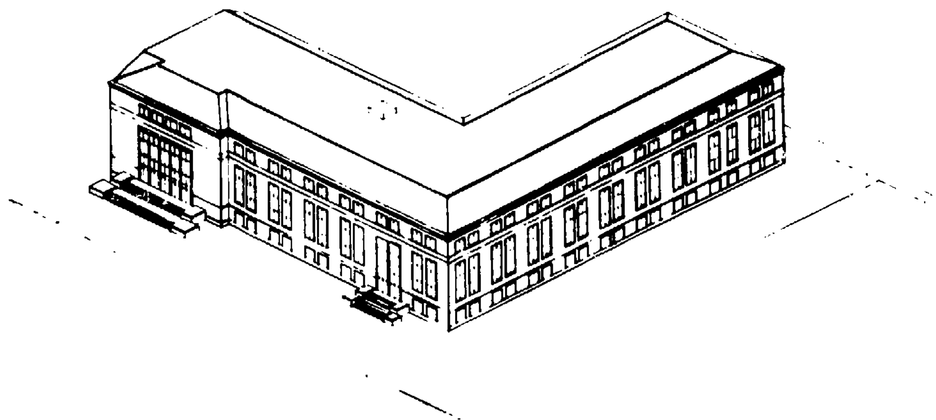
General	$1,213,540
Mechanical	544,445
Electrical	448,500
	$2,206,485 @ ENR 813 ($16.43/OGSF)
Projected:	$3,530,376 @ ENR 1300 ($26.29/OGSF)
Geographical Adjustment:	$4,201,147 ($31.28/OGSF*)

Cost Estimate (Jan. 1970 – ENR 1300)

		$/OGSF	%
Site Work, Below Grade & Basement	$ 403,190	3.00	10
Floors	665,810	4.96	16
Roof	172,700	1.29	4
Interior Partitions	680,500	5.06	16
Interior General	121,660	.90	3
Exterior Skin, above ground	327,540	2.44	8
HVAC	652,091	4.85	15
Plumbing	341,027	2.54	8
Electrical	549,786	4.09	13
Elevators	70,500	.53	2
General Contractor	204,000	1.52	5
	$4,188,804	$31.18	
Boiler, Chilled Water Plant	112,647	.84	
	$4,301,451	$32.02	
Laboratory Casework	303,464	2.26	

For comparison with other buildings served by central plants, the cost of the building boiler and chilled water plant is excluded from the HVAC cost division. The cost estimate of $4,301,451 exceeds the projected and adjusted bid total of 2%. The cost of laboratory casework was estimated separately and is not included in the Interior General cost division. This cost estimate does not include a 35,454 OGSF addition bid February 1966.

*Boeckh Modifier, Indianapolis to San Francisco Bay Area = 1.19



Cost Divisions

CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE, INDIANA

Original contract bid June 1962; ENR Construction Cost Index 872
113,000 Outside Gross Square Feet (OGSF)

Bid Amount:	$2,218,037 @ ENR 872 ($19.63/OGSF)
Projected:	$3,327,055 @ ENR 1300 ($29.44/OGSF)
Geographical Adjustment:	$3,959,195 ($35.04/OGSF)*

Cost Estimate (Jan. 1970 – ENR 1300)

		$/OGSF	%
Site Work, Below Grade & Basement	$ 234,470	2.07	6
Floors	703,430	6.22	16
Roof	145,630	1.29	3
Interior Partitions	747,710	6.62	18
Interior General	229,870	2.04	5
Exterior Skin, above ground	408,940	3.61	10
HVAC	504,780	4.47	12
Plumbing	412,926	3.66	10
Electrical	495,415	4.38	11
Elevators	37,500	.33	1
General Contractor	320,000	2.83	8
	$4,240,671	$37.52	
Laboratory Casework	126,560	1.12	

The cost estimate exceeds the projected and adjusted bid by 7%.

The cost of laboratory casework was estimated separately and is not included in the Interior General cost division.

*Boeckh Modifier Indianapolis to San Francisco Bay Area = 1.19

Cost Division: SITE WORK, BELOW GRADE AND BASEMENT	$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Non-Subsystem	$/S.F. Basement
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON				
1. Demolition, Preparation & Earthwork	51,650	.23	.23	
2. Site Concrete	39,190	.18	.18	
3. Building Concrete	300,700	1.35	1.35	
4. Green Houses	4,990	.02	.02	
5. Stone Work (Site)	20,760	.09	.09	
	417,290	1.87	1.87	8.10

Basement Area = 51,500 S.F. = .23 OGSF

KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS				
1. Demolition, Preparation & Earthwork	97,780	.73	.73	
2. Paving	84,100	.61	.61	
3. Site Concrete	22,110	.16	.16	
4. Building Concrete	193,560	1.44	1.44	
5. Waterproofing	5,640	.06	.06	
	403,190	3.00	3.00	11.93

Basement Area = 33,800 S.F. = .25 OGSF

CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE				
1. Preparation and Earthwork	69,440	.61	.61	
2. Site Concrete and Paving	7,710	.07	.07	
3. Building Concrete	154,180	1.36	1.36	
4. Waterproofing	3,140	.03	.03	
	234,470	2.07	2.07	12.10

Basement Area = 19,365 S.F. = .17 OGSF

Cost Division: FLOORS		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Structure	Ceiling	Non-Sub System	$/S.F. Floors Structure
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON							
1.	Structural Concrete	767,200	3.45	3.45			4.73
2.	Structural Steel	42,750	.19	.19			.26
3.	Green Houses	13,360	.06			.06	
4.	Steel Stairs	47,200	.21			.21	
5.	Resilient Flooring	59,580	.27			.27	
6.	Terrazzo	87,520	.39			.39	
7.	Lath & Plaster	9,340	.04		.01	.03	
8.	Controlled Temp. Rooms	37,920	.18			.18	
9.	Painting & Misc. Spec.	6,240	.03		.03		
10.	Acoustical Work	183,160	.82		.82		
		1,254,270	5.64	3.64	.86	1.14	4.99

Floor Cost Division = 162,573 S.F. = .73 OGSF

Cost Division: FLOORS		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Structure	Ceiling	Non-Sub System	$/S.F. Floors Structure
KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS							
1.	Structural Concrete	459,980	3.42	3.42			4.74
2.	Metal Specialties	41,500	.31	.31			.43
3.	Resilient Flooring	37,070	.28			.28	
4.	Terrazzo and Tile	54,250	.40			.40	
5.	Lath and Plaster	13,410	.10		.10		
6.	Painting and Misc. Spec.	500	.01		.01		
7.	Acoustical Work	59,100	.44		.36	.08	
		665,810	4.96	3.73	.47	.76	5.17

Floor Cost Division = 96,936 S.F. = .72 OGSF

Cost Division: FLOORS		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Structure	Ceiling	Non-Sub System	$/S.F. Floors Structure
CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE							
1.	Structural Concrete	579,040	5.12	5.12			6.17
2.	Metal Specialties	11,840	.10	.10			.12
3.	Resilient Flooring	25,640	.23			.23	
4.	Terrazzo and Tile	39,330	.35			.35	
5.	Lath and Plaster	8,920	.08		.02	.06	
6.	Painting and Misc. Spec.	5,930	.05		.05		
7.	Acoustical Work	32,730	.29		.29		
		703,430	6.22	5.22	.36	.64	6.29

Floor Cost Division = 93,629 S.F. = .83 OGSF

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Cost Division: ROOF

		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Struc-ture	Ceil-ing	Non-Sub System	$/S.F. Roof
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON							
1.	Concrete	200,150	.90	.90			
2.	Built-up Roofing	19,670	.09			.09	
3.	Metal Roofing	8,000	.03			.03	
4.	Green Houses	88,500	.40			.40	
5.	Water Proofing	9,100	.04			.04	
6.	Sheet Metal & Misc.	10,760	.05			.05	
		336,180	1.51	.90		.61	6.84

Roof Cost Division Area = 49,150 S.F. = .22 OGSF

		$ Sub-Contracts	$/OGSF	Struc-ture	Ceil-ing	Non-Sub System	$/S.F. Roof
KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS							
1.	Concrete	146,380	1.09	1.09			
2.	Built-up Roofing	9,560	.07			.07	
3.	Lathing and Plastering	6,370	.05		.05		
4.	Insulation	6,370	.05			.05	
5.	Sheet Metal and Misc.	4,020	.03			.03	
		172,700	1.29	1.09	.05	.15	5.26

Roof Cost Division Area = 32,940 S.F. = .24 OGSF

		$ Sub-Contracts	$/OGSF	Struc-ture	Ceil-ing	Non-Sub System	$/S.F. Roof
CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE							
1.	Precast Concrete Roof and Concrete	44,340	.39	.39			
2.	Built-up Roofing and Insulation	4,540	.04			.04	
3.	Iron and Steel	39,180	.35	.35			
4.	Tile Roofing	10,960	.10			.10	
5.	Lath and Plaster	14,260	.12		.12		
6.	Sheet Metal and Misc.	25,870	.23			.23	
7.	Acoustical Treatment	6,480	.06		.06		
		145,630	1.29	.74	.18	.37	7.33

Roof Cost Division Area = 19,852 S.F. = .18 OGSF

Cost Division: INTERIOR PARTITIONS		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF		$/S.F. Partitions
				Partitions	Non-Sub System	
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON						
1.	Special Doors	30,400	.14	.14		
2.	Rubber Base	14,050	.06	.06		
3.	Terrazzo Base	32,400	.15		.15	
4.	Lath and Plaster	16,000	.07	.07		
5.	Structural Facing Units and Masonry Block	629,740	2.84	2.19	.65	
6.	Controlled Temperature Part.	75,840	.34	.34		
7.	Movable Partitions	333,520	1.50	1.50		
8.	Hollow Metal Work	64,950	.29	.27	.02	
9.	Wood Doors & Casework	25,170	.11	.09	.02	
10.	Finish Hardware	46,500	.21	.18	.03	
11.	Painting	32,050	.15	.12	.03	
12.	Miscellaneous Specialties	5,200	.02	.02		
		1,305,820	5.88	4.98	.90	5.76

Interior Partition Cost Division Area = 226,580 S.F. = 1.02 OGSF

KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS

		$ Sub-Contracts	$/OGSF	Partitions	Non-Sub System	$/S.F. Partitions
1.	Doors and Finish Hardware	46,890	.35	.27	.08	
2.	Rubber Base	7,680	.06	.06		
3.	Tile Work	1,800	.01	.01		
4.	Lath and Plaster	35,200	.26	.26		
5.	Rough Bucks	3,000	.02	.02		
6.	Masonry Block	510,760	3.81	2.87	.94	
7.	Glass and Glazing	7,000	.05	.05		
8.	Painting	32,840	.24	.20	.04	
9.	Metal Specialties	35,330	.26	.22	.04	
		680,500	5.06	3.96	1.10	4.90

Interior Partition Cost Division Area = 138,720 S.F. = 1.03 OGSF

CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE

		$ Sub-Contracts	$/OGSF	Partitions	Non-Sub System	$/S.F. Partitions
1.	Rough Carpentry	8,000	.07	.07		
2.	Rubber Base	14,200	.13	.13		
3.	Glass and Glazing	7,000	.06	.06		
4.	Lath and Plaster	73,080	.65	.59	.06	
5.	Acoustical Treatment	5,950	.05	.05		
6.	Masonry Block	364,710	3.23	2.26	.97	
7.	Concrete	99,940	.88	.83	.05	
8.	Marble	9,470	.08	.08		
9.	Wood Doors and Casework	26,610	.24	.18	.06	
10.	Finish Hardware	30,000	.27	.21	.06	
11.	Painting and Vinyl Wall Covering	92,480	.82	.78	.04	
12.	Miscellaneous Specialties	16,270	.14	.09	.05	
		747,710	6.62	5.33	1.29	5.74

Interior Partition Cost Division Area = 130,310 S.F. = 1.15 OGSF

Cost Division: INTERIOR GENERAL

		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Non-Subsystem

JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON

		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Non-Subsystem
1.	Railings	4,320	.02	.02
2.	Toilet Partitions	6,620	.03	.03
3.	Toilet Accessories	8,550	.04	.04
4.	Chalk and Tack Boards	20,540	.09	.09
5.	Bulletin Boards, Directories	5,500	.02	.02
6.	Casework	65,480	.29	.29
7.	Seating	15,750	.07	.07
8.	Miscellaneous Specialties	19,350	.09	.09
		146,110	.65	.65

The cost of laboratory casework was estimated separately and is not included above.

KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS

		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Non-Subsystem
1.	Iron and Steel	26,150	.19	.19
2.	Toilet Partitions, Metal Specialties	39,580	.29	.29
3.	Toilet Accessories	2,960	.02	.02
4.	Counters and Cabinets	36,800	.27	.27
5.	Casework Installation	12,670	.10	.10
6.	Incinerator	3,500	.03	.03
		121,660	.90	.90

The cost of laboratory casework was estimated separately and is not included above.

CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE

		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Non-Subsystem
1.	Railings and Anchors	56,500	.50	.50
2.	Toilet Partitions	2,530	.02	.02
3.	Toilet Accessories	2,650	.02	.02
4.	Chalk and Tack Boards	4,080	.04	.04
5.	Casework	15,380	.14	.14
6.	Misc. Specialties, Constant Head Tanks and Other Equipment	148,730	1.32	1.32
		229,870	2.04	2.04

The cost of laboratory casework was estimated separately and is not included above.

Cost Division: EXTERIOR SKIN — ABOVE GROUND		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Exterior Skin	$/S.F. Exterior
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON					
1.	Building Concrete	5,000	.02	.02	
2.	Green Houses	125,640	.56	.56	
3.	Caulking	10,700	.05	.05	
4.	Stone Work	703,500	3.17	3.17	
5.	Glass and Sash	98,400	.44	.44	
6.	Water Proofing	22,500	.10	.10	
7.	Sheet Metal	21,600	.10	.10	
8.	Special Doors, Enclosures, Ornamental Metal, Paint	10,210	.05	.05	
9.	Misc. Metal — Inserts, Lintels	89,600	.40	.40	
10.	Structural Facing Units	140,380	.63	.63	
11.	Masonry Block	273,680	1.23	1.23	
12.	Movable Partitions (Face)	63,360	.28	.28	
		1,564,570	7.03	7.03	17.58

Exterior Skin Above Ground Cost Division Area = 90,000 S.F. = .40 OGSF

KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Exterior Skin	$/S.F. Exterior
1.	Building Concrete	6,000	.05	.05	
2.	Caulking	10,460	.08	.08	
3.	Stone Work	99,740	.74	.74	
4.	Lath and Plaster	4,500	.03	.03	
5.	Marble Work	10,800	.08	.08	
6.	Metal Specialties, Windows, Doors	116,070	.87	.87	
7.	Misc. Metal — Inserts, Lintels	20,000	.14	.14	
8.	Brick Masonry	59,970	.45	.45	
		327,540	2.44	2.44	11.40

Exterior Skin Above Ground Cost Division Area = 28,770 S.F. = .21 OGSF

CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Exterior Skin	$/S.F. Exterior
1.	Building Concrete	35,880	.32	.32	
2.	Cut Stone, Granite and Marble	132,780	1.17	1.17	
3.	Lath and Plaster	12,430	.11	.11	
4.	Waterproofing, Caulking, Painting	12,420	.11	.11	
5.	Sheet Metal	4,860	.04	.04	
6.	Misc. Metal Doors, Windows — Inserts, Lintels	56,480	.50	.50	
7.	Masonry	154,090	1.36	1.36	
		408,940	3.61	3.61	10.76

Exterior Skin Above Ground Cost Division Area = 38,000 S.F. = .34 OGSF

Cost Division: HVAC		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF HVAC	Subsystem Equiv. $/OGSF Non-Subsystem

JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON

		$ Sub-Contracts	$/OGSF	HVAC	Non-Subsystem
1.	Building Heating and A.C.	880,953	3.97	3.97	
2.	Greenhouse Heating	118,893	.53	.53	
3.	Constant Temperature Rooms	330,558	1.49		1.49
4.	Process Heating and Cooling	146,128	.66		.66
5.	Autoclaves	94,500	.43		.43
6.	Hood Fans and Duct Work	11,580	.06	.06	
		1,582,612	7.14	4.56	2.58
7.	Chilled Water Plant	117,515	.53		
		1,700,127	7.67		

NOTE: Central Plant Costs (Item 7) are excluded in cost comparisons.

KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS

		$ Sub-Contracts	$/OGSF	HVAC	Non-Subsystem
1.	Building Heating and A.C.	632,268	4.70	4.70	
2.	Hood Fans and Duct Work	19,823	.15	.15	
		652,091	4.85	4.85	
3.	Boiler and Chilled Water Plant	112,647	.84		
		764,738	5.69		

NOTE: Central Plant Costs (Item 3) are excluded in cost comparisons.

CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE

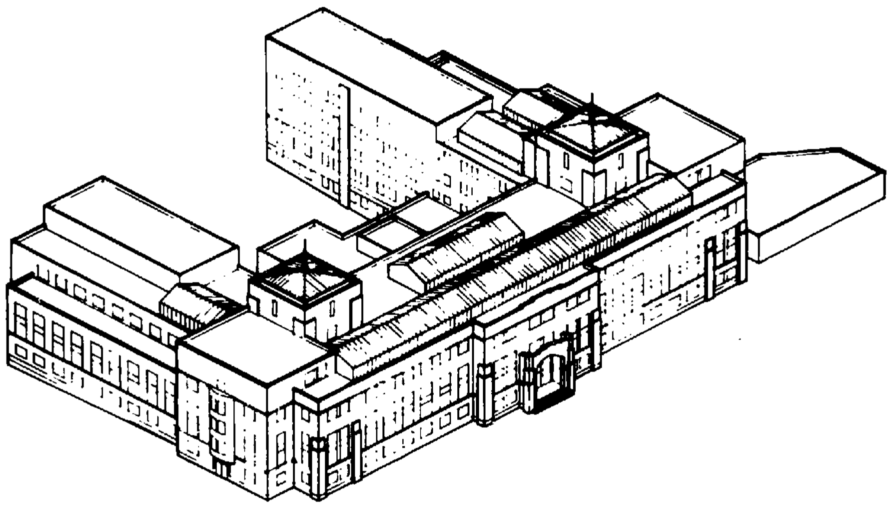
		$ Sub-Contracts	$/OGSF	HVAC	Non-Subsystem
1.	Steam Piping	55,280	.49	.38	.11
2.	Chilled Water Piping	10,070	.09	.09	
3.	Radiators, Unit Ventilators, Convectors	29,160	.26	.12	.14
4.	Ductwork	187,040	1.65	1.65	
5.	Controls	40,800	.36	.36	
6.	Insulation	41,600	.37	.32	.05
7.	Fans, Heating/Cooling Units, Etc.	140,830	1.25	1.25	
		504,780	4.47	4.17	.30

Cost Division: PLUMBING	$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF / Non-Subsystems
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON			
1. Site Utilities	51,671	.23	.23
2. Fixtures and Piping	80,418	.36	.36
3. Laboratory Fixtures and Piping (Rough in only)	261,713	1.18	1.18
4. Rainwater Leaders	41,472	.19	.19
5. Fire Protection	66,791	.30	.30
6. Demineralized Water	30,038	.14	.14
7. Compressed Air	28,360	.13	.13
8. Water Heating	76,999	.35	.35
9. Water Softener	47,568	.21	.21
10. Cold Water System	87,611	.39	.39
11. Gas system	36,390	.16	.16
12. Greenhouse Cooling	42,496	.20	.20
	851,527	3.84	3.84
KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS			
1. Site Utilities	46,215	.34	.34
2. Fixtures and Piping	109,426	.81	.81
3. Laboratory Fixtures and Piping (Rough in only)	168,943	1.26	1.26
4. Fire Protection	16,443	.13	.13
	341,027	2.54	2.54
CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE			
1. Site Utilities	18,937	.17	.17
2. Building Fixtures and Piping	97,904	.87	.87
3. Laboratory Fixtures and Piping (Rough in only)	296,085	2.62	2.62
	412,926	3.66	3.66

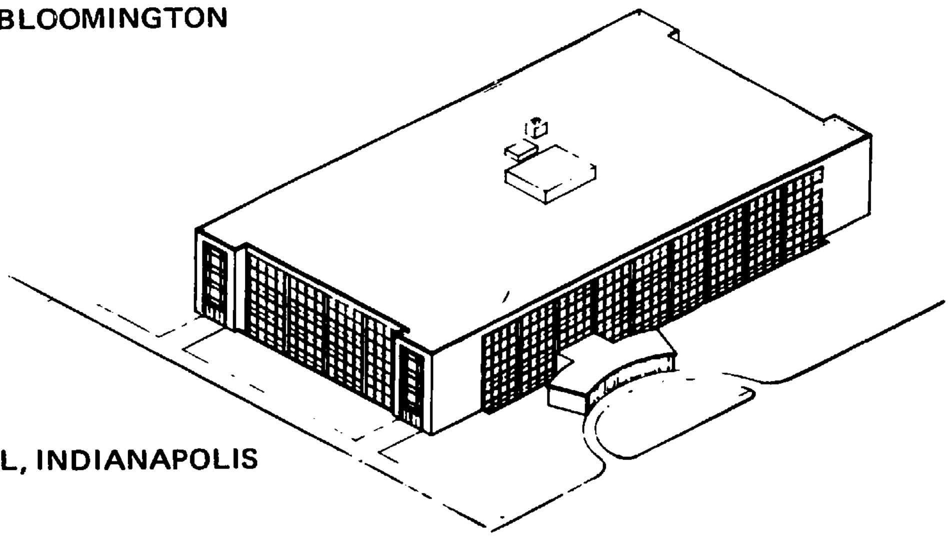
Cost Division: ELECTRICAL		$ Sub-Contracts	$/OGSF	Subsystem Equiv. $/OGSF Lighting	Subsystem Equiv. $/OGSF Non-Subsystem
JORDAN HALL, INDIANA UNIVERSITY, BLOOMINGTON					
1.	Power Distribution	235,433	1.06		1.06
2.	Lighting – Fixtures and Switches	325,695	1.47	.75	.72
3.	Lighting Panels	75,179	.34		.34
4.	Telephone, Fire Alarm, P.A. Buzzer and Clock Systems	31,901	.14		.14
5.	Motors & Lab Equip. Connection	72,615	.33		.33
		740,823	3.34	.75	2.59
KRANNERT HALL, INDIANA UNIVERSITY/PURDUE UNIVERSITY, INDIANAPOLIS					
1.	Site Work and Area Lighting	22,671	.17		.17
2.	Power Distribution	137,234	1.02		1.02
3.	Lighting – Fixtures and Switches	244,754	1.82	.91	.91
4.	Lighting Panels	18,805	.14		.14
5.	Telephone, Fire Alarm, P.A. Buzzer Clock Systems and Television	79,570	.59		.59
6.	Motors and Lab. Equip. Connection	46,752	.35		.35
		549,786	4.09	.91	3.18
CIVIL ENGINEERING BUILDING, PURDUE UNIVERSITY, LAFAYETTE					
1.	Site Work and Yard Lighting	20,034	.18		.18
2.	Power Distribution	174,632	1.54		1.54
3.	Lighting – Fixtures and Switches	126,314	1.12	.90	.22
4.	Lighting Panels	12,296	.11		.11
5.	Wire and Conduit	43,050	.38		.37
6.	Telephone, P.A. Buzzer and Clock Systems	41,972	.37		.37
7.	Motors and Lab. Power	77,112	.68		.68
		495,415	4.38	.90	3.48

GENERAL DATA

	BLOOMINGTON	INDIANAPOLIS	PURDUE
OGSF	222,065	134,276	113,000
ASF	120,277	79,230	69,000
AREA TYPICAL FLOOR	38,500	34,450	19,980
ASF / OGSF	0.54	0.59	0.61
AREA OF EXTERIOR WALL / OGSF	0.472	0.260	0.477
AREA SERVED BY HV/AC	100%/80%	100%/90%	100%/75%
LINEAR FEET PARTITIONS / OGSF	0.0704	0.1260	0.0635
FLOORS AT AND ABOVE GRADE	5	5	5
FLOORS BELOW GRADE	1	1	2
TOTAL STRUCTURE-SERVICES DEPTH	2'-6"	3'-6"	3'-2"



JORDAN HALL, BLOOMINGTON



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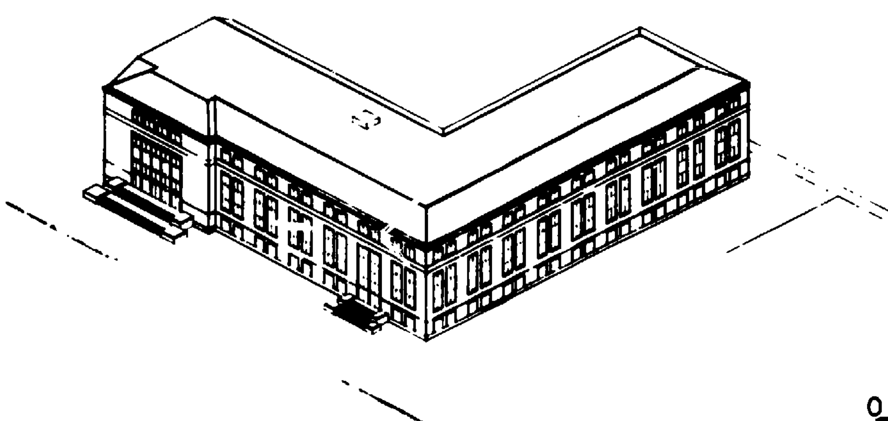
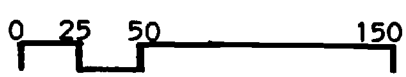
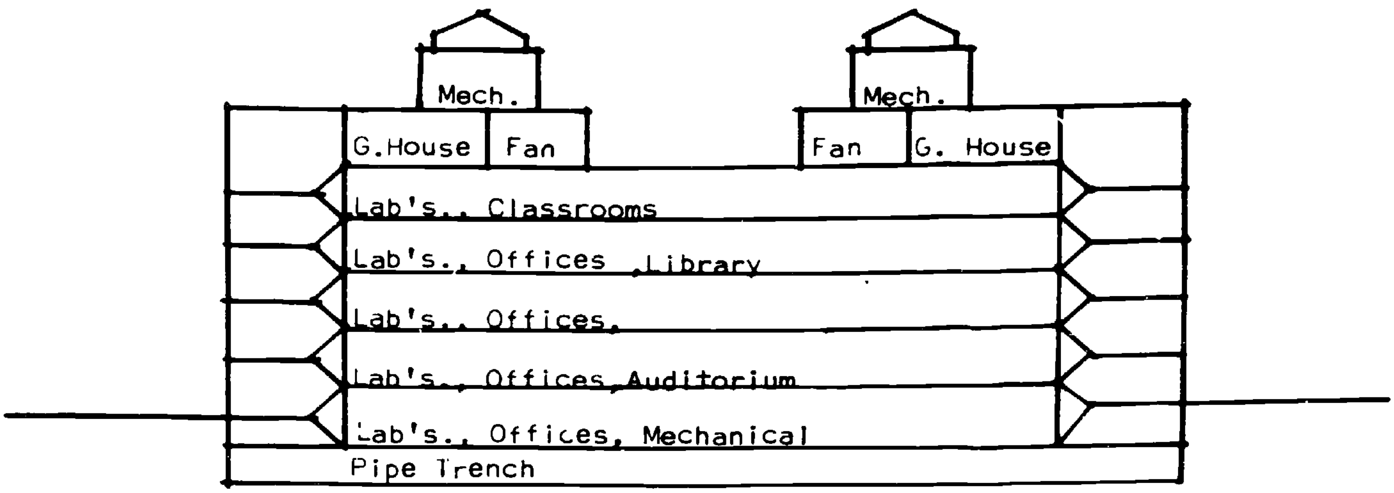
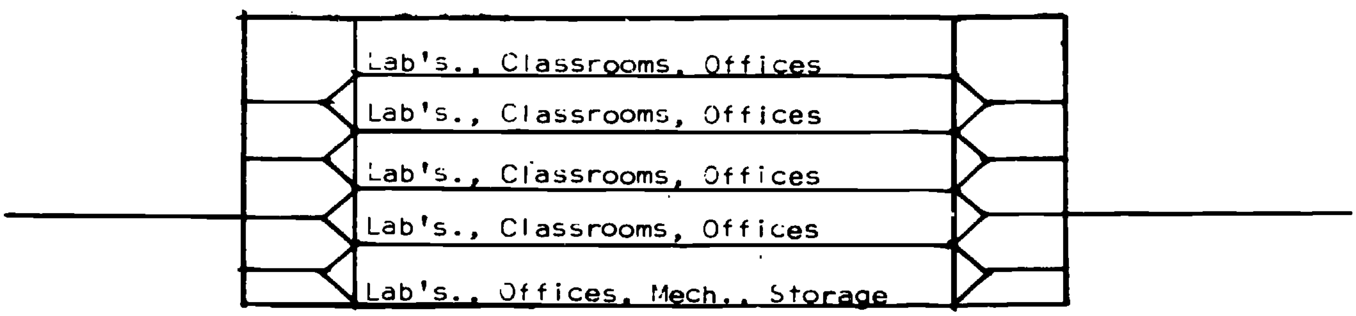




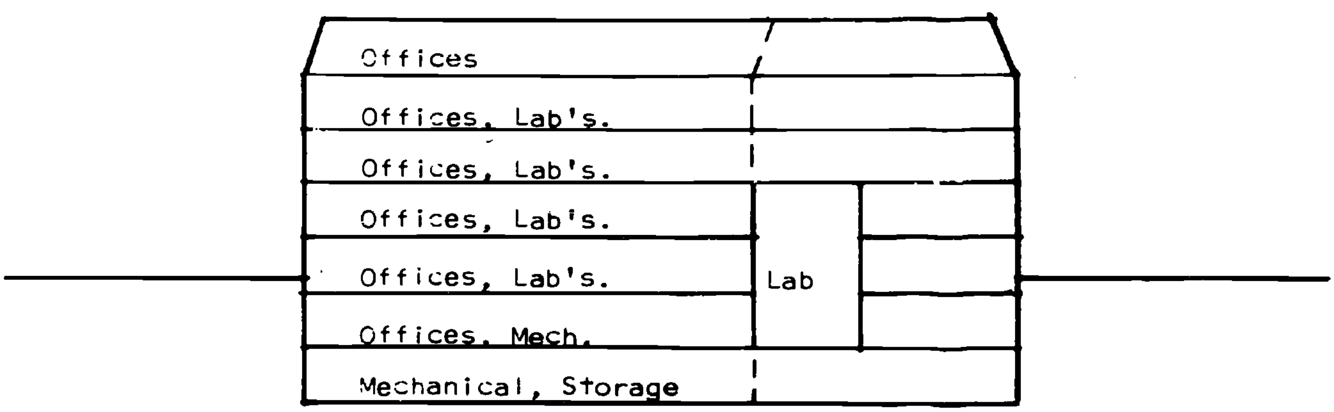
CIVIL ENGINEERING BUILDING, PURDUE



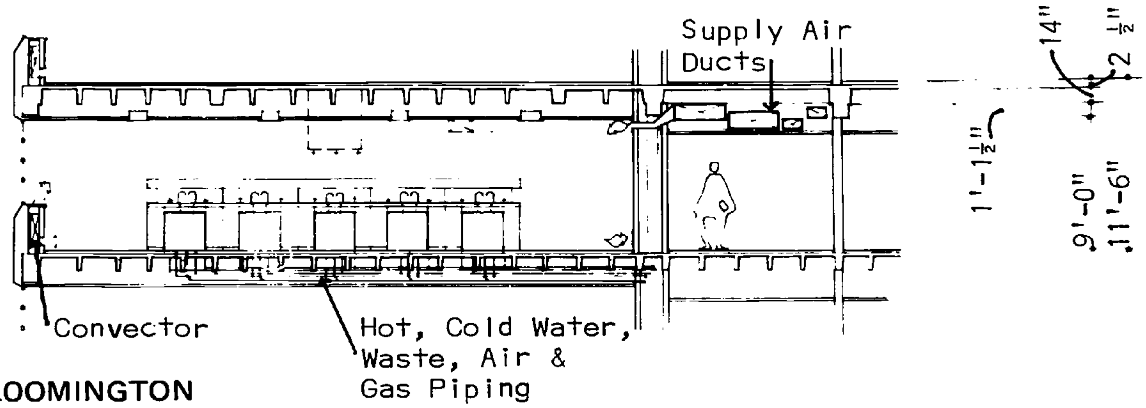
BLOOMINGTON



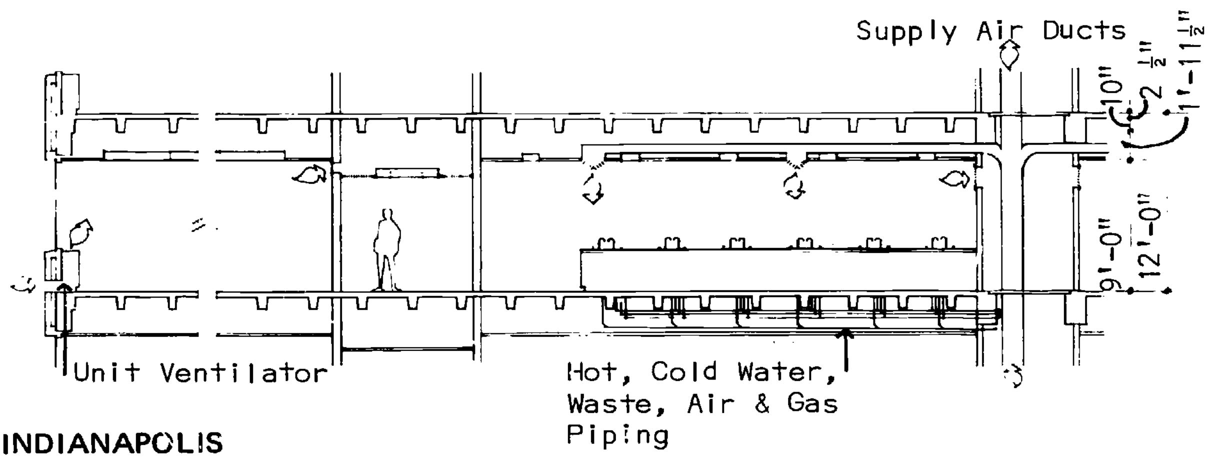
INDIANAPOLIS



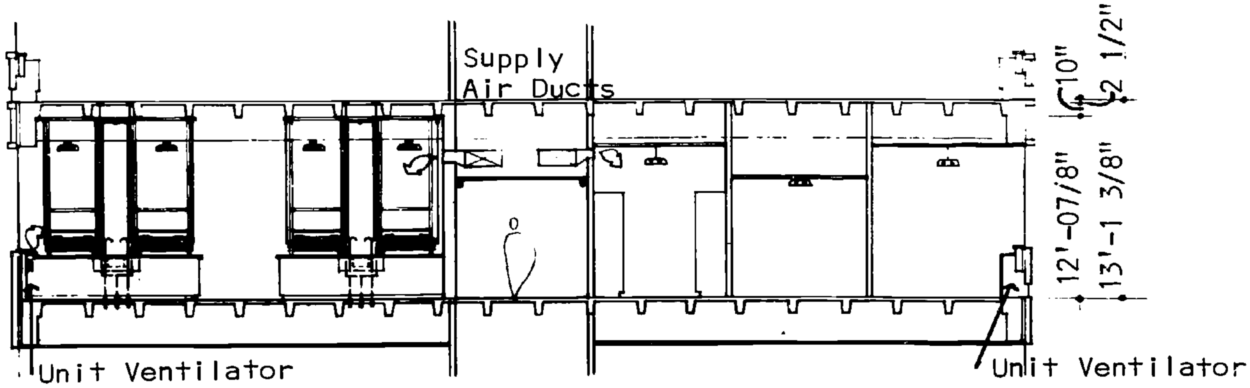
PURDUE



BLOOMINGTON



INDIANAPOLIS

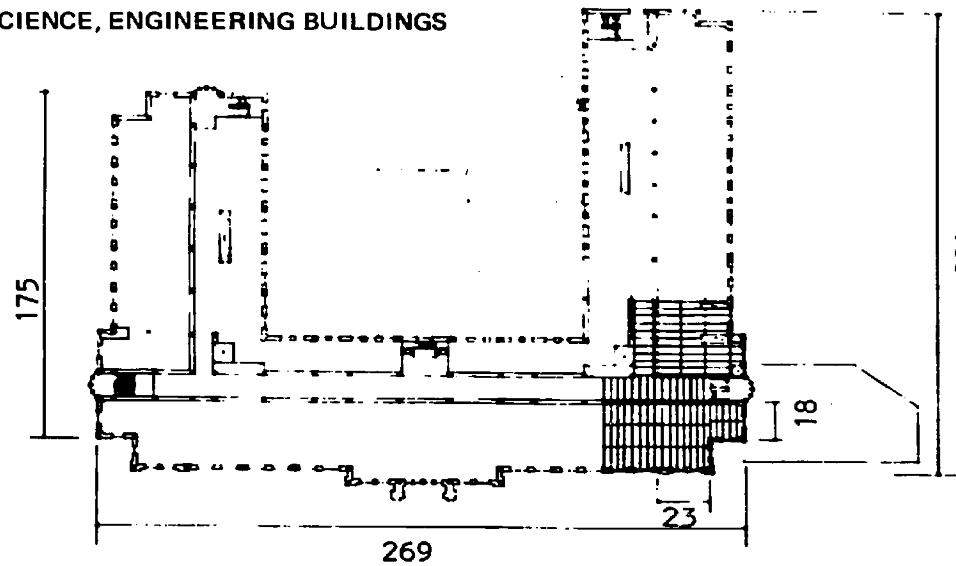


PURDUE

STRUCTURE SUBSYSTEM

	BLOOMINGTON	INDIANAPOLIS	PURDUE
STRUCTURE TYPE	Joist, Beam and Columns	Joist, Beam and Columns	Joist, Beam and Columns
MATERIAL	Poured Concrete	Poured Concrete	Poured Concrete 4th Floor Steel
SHEAR STRUCTURE	Moment Frame	Moment Frame	Moment Frame
STRUCTURAL BAY SIZES	22′ x 32′, 14′ x 32′ 22′ x 30′, 14′ x 30′	22′ x 30′ 22′ x 35′	20′ x 24′-6″ 20′ x 34′-6″ 20′ x 28′
FLOOR TO FLOOR HEIGHTS	11′-6″	12′-0″	13′-1-3/8″
STRUCTURAL DEPTH (MAXIMUM)	2′-2″	3′-0″	2′-8″
AREA OF STRUCTURE WITHIN EXTERIOR WALLS	917, S.F.		1,024 S.F.
FLOOR LIVE LOAD, CORRIDORS—STAIRS	60 PSF/100 PSF	100 PSF	100 PSF
FLOOR LIVE LOAD, CLASSROOMS	40 PSF	50 PSF	75 PSF
FLOOR LIVE LOAD, LABORATORIES	50 PSF	75 PSF	100 PSF
FLOOR LIVE LOAD, OFFICES		50 PSF	50 PSF
FLOOR LIVE LOAD, SANITARY PILOT PLANT LABORATORY			300 PSF
ROOF LIVE LOAD	30 PSF	30 PSF	30 PSF

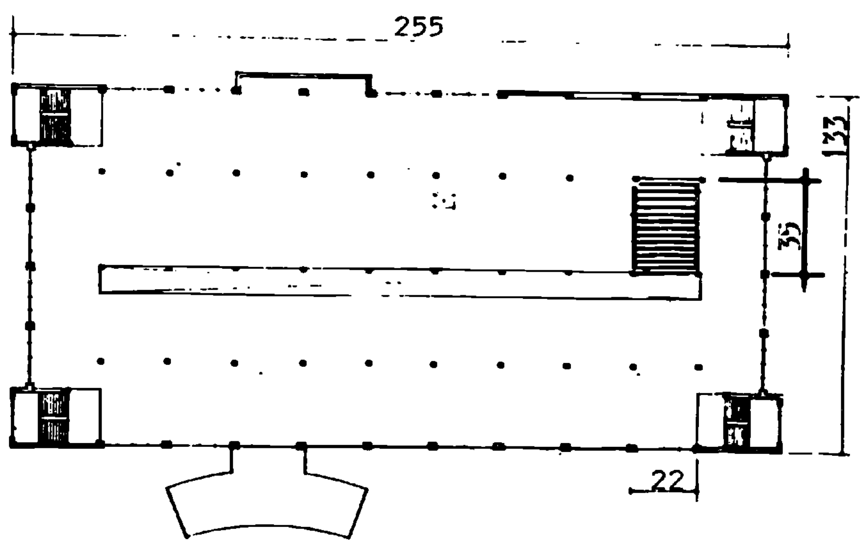
COST/PERFORMANCE DATA
SCIENCE, ENGINEERING BUILDINGS



Column Size

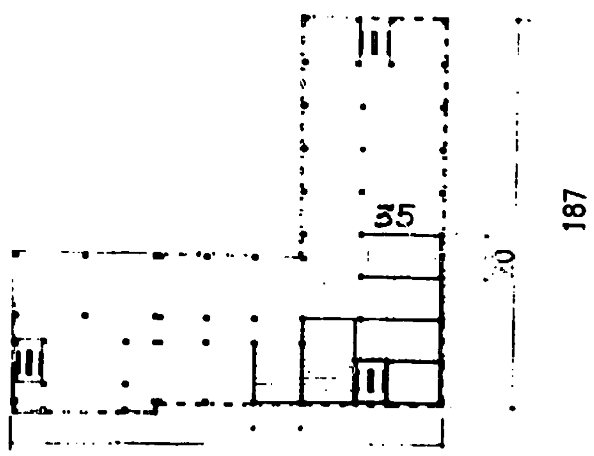
Concrete Beams, 14" Joists and 2½ Slab

BLOOMINGTON

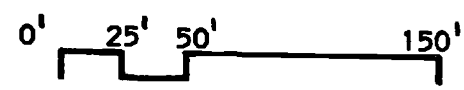


INDIANAPOLIS

Concrete Beams, 10" Joists and 2½ Slab.



Concrete Beams
10" Joists and
2 ½ Slab.



PURDUE

ERIC Full Text Provided by ERIC

BLOOMINGTON – STRUCTURE

Poured concrete floor and roof slabs are supported by poured concrete columns, joists and beams. Shear resistance is achieved through rigid column and beam connection.

INDIANAPOLIS – STRUCTURE

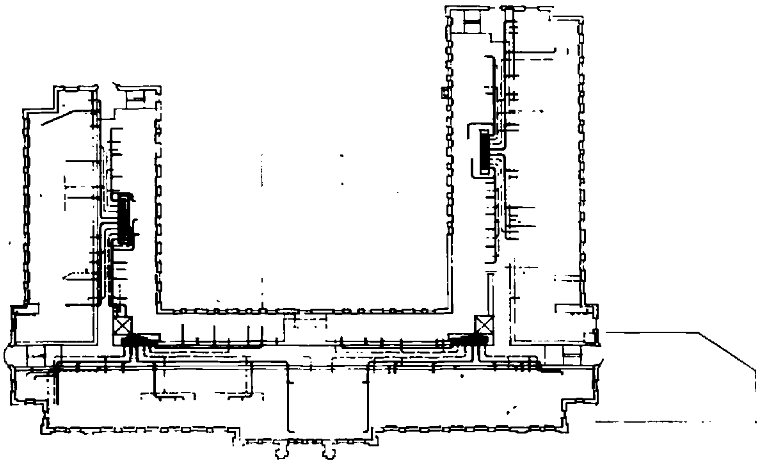
Poured concrete floor and roof slabs are supported by poured concrete columns, joists and beams. Shear resistance is achieved through rigid column and beam connection.

PURDUE – STRUCTURE

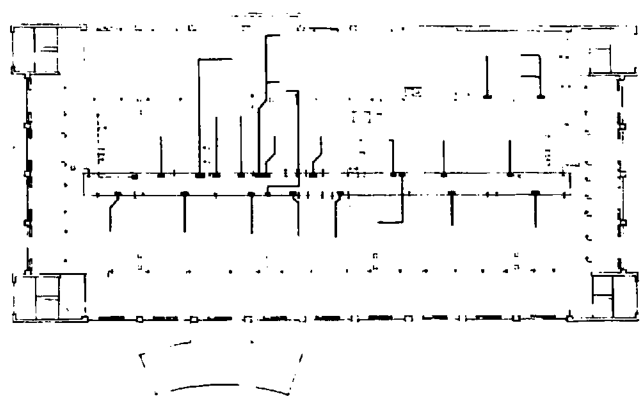
Poured concrete floor and roof slabs are supported by poured concrete columns, joists and beams. Shear resistance is achieved through rigid column and beam connection.

HV/AC SUBSYSTEM

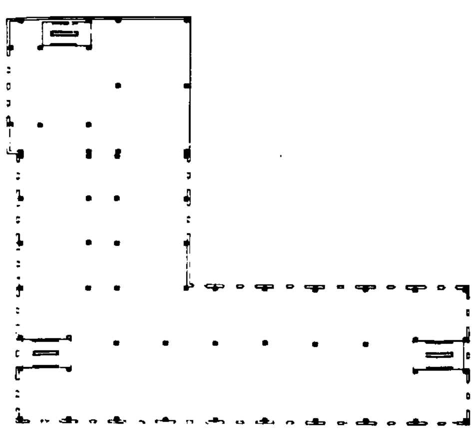
	BLOOMINGTON	INDIANAPOLIS	PURDUE
% BUILDING SERVED HV/AC	100%/80%	100%/90%	100%/75%
HEATING SOURCE	Central HPS	Building Hot Water	Central HPS
COOLING SOURCE	Building—Electric	Building—Electric	Building—Electric
FUEL	Electricity	Electricity	Coal
AIR HANDLING SOURCE	Central With Reheat	Central Dual Duck	Multi-Zone, Room UV, Fan Coil, Reheat Coils
EQUIPMENT ROOM SIZE HEATING COOLING, AIR HANDLING	7,000 S.F.	3,000 S.F. 2,540 S.F.	8,405 S.F.
TOTALS	7,000 S.F.	5,540 S.F.	8,405 S.F.
CAPACITIES, HEATING	24,384,000 BTU/H	13,118,000 BTU/H	14,400,000 BTU/H
COOLING	500 Tons	299 Tons	275 Tons
AIR HANDLING CFM	148,000	166,930	101,400
BTUH/OGSF	108	83	155
OGSF/TON	450	530	340
CFM/OGSF	0.66	1.05	1.10
% RETURN AIR	75	72	69
% EXHAUSTED VIA HOODS	9.2	28	17
% MAIN EXHAUST	15.8	0	14
INTAKE LOCATIONS	Roof	Grade	Each Floor
EXHAUST LOCATIONS	Roof	Roof	Roof
MAXIMUM GROSS SECTIONAL AREA MAIN VERT. SUPPLY DUCTS	5.5 S.F.	3.25 S.F.	4.5 S.F.
MAXIMUM GROSS SECTIONAL AREA HORIZ. SUPPLY DUCTS	3.3 S.F.	10.1 S.F.	5.5 S.F.
FILTER TYPE & EFFICIENCY	Electrostatic 90%	Roll Type 35%	Roll Type 35%
HUMIDITY CONTROL % BUILDING	None	None	None
TERMINALS PER 1,000 S.F.	2	2	2
THERMOSTATS PER 1,000 S.F.	1	1	1
CONTROL ZONE	Room	Room	Room



BLOOMINGTON



INDIANAPOLIS



PURDUE

- Vertical supply duct
- Supply air duct
- Return air duct
- Exhaust ducts
- Unit ventilators or convectors

0' 25' 50' 150'

BLOOMINGTON – HVAC

High pressure steam is from a central plant. Chilled water is from an electric chiller in the basement. Air handling equipment is installed in four fan rooms located on the roof. Perimeter of building is heated by radiation. Each floor has four cooling and ventilating zones with radiation control in each room. Air is exhausted by fume hoods and exhaust ducts via periodic vertical mains with fans at roof level.

INDIANAPOLIS – HVAC

Hot water and chilled water are from gas fired boilers, and electric chiller is located in the basement. Air handling units are in the basement with provision for 30% outside air. Dual duct system feeds vertically in the center of the building. Provisions have been made for an additional floor. Classroom type unit ventilators are installed around the perimeter of the building. Control is by room with individual thermostats. Air is exhausted by fume hoods. Air supply and return are low pressure.

PURDUE – HVAC

High pressure steam and chilled water supply are from a central campus system. The building system consists of a combination of multi-zone units on each floor plus heating-cooling type unit ventilators. Control is by individual room. Air is exhausted by fume hoods and exhaust ducts at the roof level. Fresh air is taken in at each floor. Air supply, return and exhaust is at low pressure.

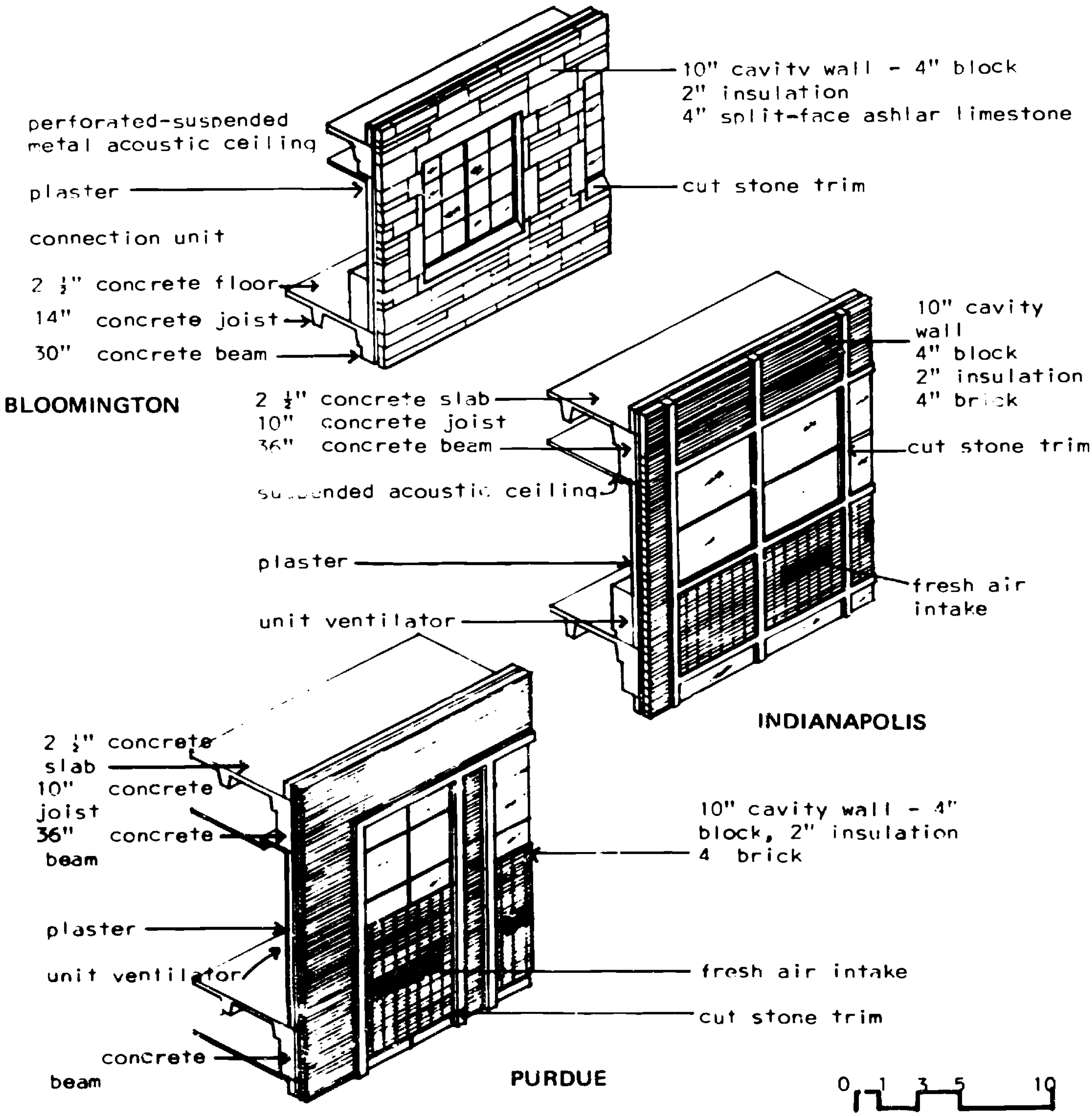
ERIC

EXTERIOR WALLS SUBSYSTEM

	STRUCTURAL			NON-STRUCTURAL		
	BLOOMINGTON	INDIANAPOLIS	PURDUE	BLOOMINGTON	INDIANAPOLIS	PURDUE
% SQ. FT. OF EXTERIOR WALL	0	0	0	100	100	100
% TOTAL SQ. FT. GLAZED				29+	32	15.8
% GLASS AREA OPENABLE				48+	79	35.4
SUN CONTROL MEASURE				Venetian Blinds	Metal Sun Screens on Individual Windows	
PLANNING MODULE		22′	20′		5′	10′
WALL CORE				Cavity	Cavity	Cavity
WALL/COLUMN THICKNESS	.. 1′-9″++	.. 2′-8″++	.. Varies	1′-9″++ ..	10-½″ ..	10½″ ..
UNGLAZED U FACTOR				.100 ..	.100 ..	.099 ..
INSIDE FACE MATERIAL				Plaster	Plaster	Plaster
INTERIOR FINISH				Paint	Paint	Vinyl Wall Fabric
EXTERIOR FACE MATERIAL				Split-Face Ashler Limestone	Brick	Brick
EXTERIOR FINISH				Waterproof	Waterproof	Waterproof

+Includes Greenhouses.

++Furred


10" cavity wall - 4" block
2" insulation
4" split-face ashlar limestone
perforated-suspended metal acoustic ceiling
plaster
cut stone trim
connection unit
2 ½" concrete floor
14" concrete joist
30" concrete beam
BLOOMINGTON
10" cavity wall
4" block
2" insulation
4" brick
2 ½" concrete slab
10" concrete joist
36" concrete beam
cut stone trim
suspended acoustic ceiling
plaster
fresh air intake
unit ventilator
INDIANAPOLIS
2 ½" concrete slab
10" concrete joist
36" concrete beam
10" cavity wall - 4" block, 2" insulation
4 brick
plaster
unit ventilator
fresh air intake
cut stone trim
concrete beam
PURDUE
0 1 3 5 10

BLOOMINGTON – EXTERIOR WALLS

The exterior walls are concrete block and split-face limestone insulated cavity wall construction. Smooth-faced and carved limestone is also used at doors and windows. The interior finish is plaster and paint.

INDIANAPOLIS – EXTERIOR WALLS

The exterior walls are concrete block and brick, insulated cavity-wall construction. Limestone trim is used at the windows. The interior finish is plaster and paint.

PURDUE – EXTERIOR WALLS

The exterior walls are concrete block and brick, insulated cavity-wall construction. Limestone trim is used at the windows. The interior finish is plaster and paint.

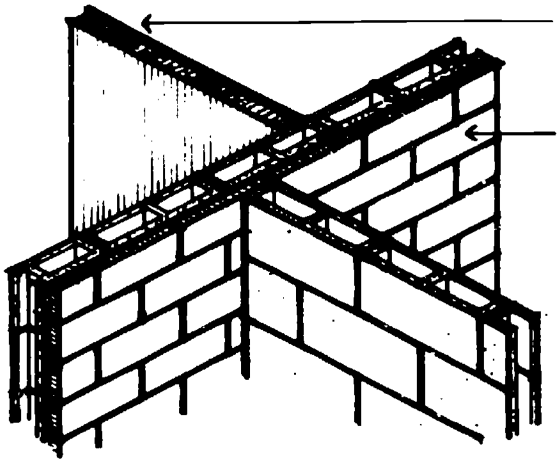
INTERIOR PARTITIONS SUBSYSTEM

	STRUCTURAL			REPLACEABLE			DEMOUNTABLE		
	BLOOMINGTON	INDIANAPOLIS	PURDUE	BLOOMINGTON	INDIANAPOLIS	PURDUE	BLOOMINGTON	INDIANAPOLIS	PURDUE
% LINEAR FEET OF INTERIOR WALLS	0	0	6.2	100	100	93.8	20	0	0
MATERIAL			Poured Concrete	Block-Paint Block-Tile	Block-Plaster+ Block-Tile Block-Paint	Block-Paint+ Block-Plaster Block-Tile	Metal		
PLANNING MODULE					5'	10'	4		
HEIGHTS			To Structure	8', 9', Varies++	9', Varies++	9', Varies++			
THICKNESS			1'	4" & 6"	4" & 6"	4" & 6"	3"		
SOUND TRANSMISSION COEFFICIENT (DECIBELS)			53	4" = 41+++ 6" = 48+++	4" = 41+++ 6" = 48+++	4"-Plaster 2 Sides, 44	40		
FIRE RATING			4 hr.	1 hr.+	1 hr.+	1 hr.+			
UTILITY SUPPORT			No	Electrical Only	Electrical Only	Electrical Only			
FURNITURE SUPPORT			No	Yes	Yes	Yes			
PERMEABILITY			Services	Doors Services	Doors Services	Doors Services			

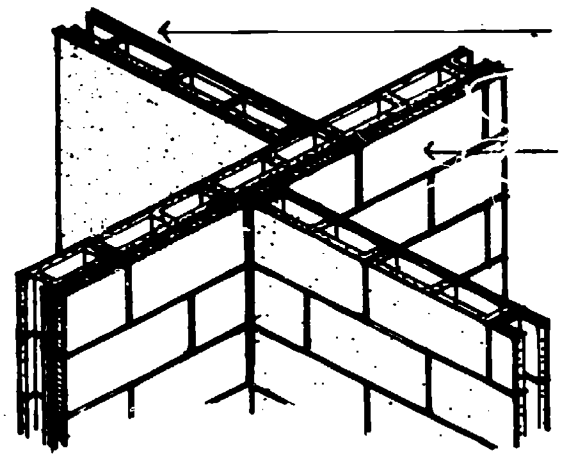
+2-Hour Stairwells.

++To Structure.

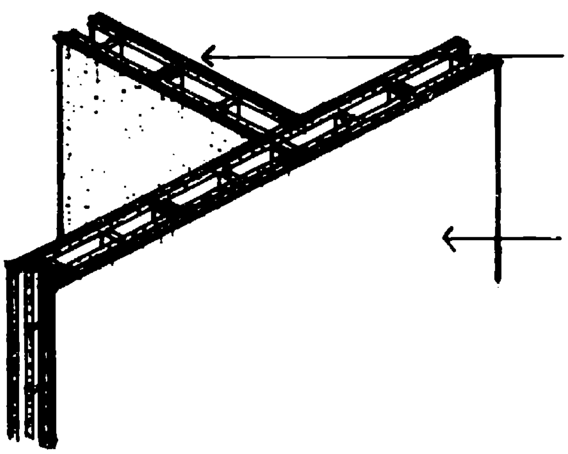
+++4" Block With Facing Tile = 46 DB



BLOOMINGTON



INDIANAPOLIS



PURDUE

GRAPHIC SCALE 0" 4" 8" 12" 16" 24" 32" 48"

BLOOMINGTON – INTERIOR PARTITIONS

None of the interior walls are structural; 80% of the walls are replaceable and 20% are demountable. Replaceable walls are constructed of concrete block with and without structural facing tile. Demountable walls are made of manufactured metal panels with baked-on enamel finish and an insulation core.

INDIANAPOLIS – INTERIOR PARTITIONS

None of the interior walls are structural; 100% are replaceable. Replaceable walls are constructed of concrete block, painted concrete block and structural facing tile and concrete block plastered and painted.

PURDUE – INTERIOR PARTITIONS

6.2% of the interior walls are structural; 93.8% are replaceable. Structural walls are reinforced concrete and occur below grade. Replaceable walls are concrete block plastered and painted or covered with vinyl wall fabric.

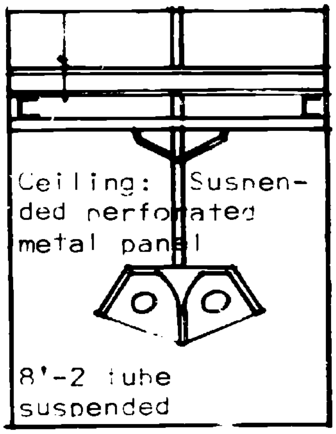
LIGHTING/CEILING SUBSYSTEM

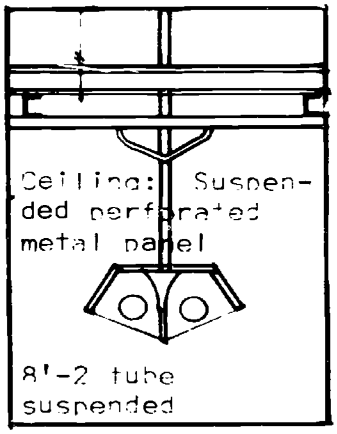
	LABORATORIES			CLASSROOMS		
	BLOOMINGTON	INDIANAPOLIS	PURDUE	BLOOMINGTON	INDIANAPOLIS	PURDUE
LIGHTING TYPE	8'-2T Suspended Direct	4'-2T Suspended Direct	2' × 4' 3T Recessed	8'-2T Suspended Direct	4'-2T Recessed	2' x 4' 3T Recessed
SPACING	Continued 8' o.c.	Continued 5' o.c.	Continued 8' o.c.	Continued 8' o.c.	Continued 5' o.c.	Continued 8' o.c.
WATTS/SQUARE FOOT	2.2	3.1	3.75	2.2	4.5	3.75
VOLTAGE	208	208	208	208	207	207
SWITCHING ZONE	Room	Room	Room	Room	Room	Room
SWITCHING TYPE	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way

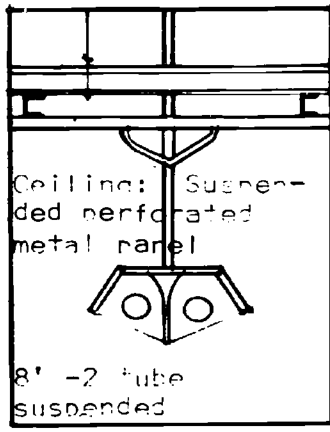
LIGHTING/CEILING SUBSYSTEM

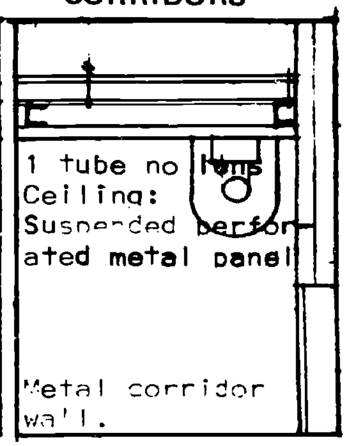
	OFFICES			CIRCULATION		
	BLOOMINGTON	INDIANAPOLIS	PURDUE	BLOOMINGTON	INDIANAPOLIS	PURDUE
LIGHTING TYPE	8'-2T Suspended Direct	4'-2T Recessed	2' x 4' 4T Recessed	8' Cove	4'-4T Recessed	2' x 4' 4T Recessed
SPACING	Continued	Continued 5' o.c.	Continued 8' o.c.	Continued	16' o.c.	12' o.c.
WATTS/SQUARE FOOT	2.5	5.2	3.9	1.1	.98	.84
VOLTAGE	208	208	208	208	208	208
SWITCHING ZONE	Room	Room	Room	Room	Room	Room
SWITCHING TYPE	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way

LABORATORIES | **CLASSROOMS** | **OFFICES** | **CORRIDORS**

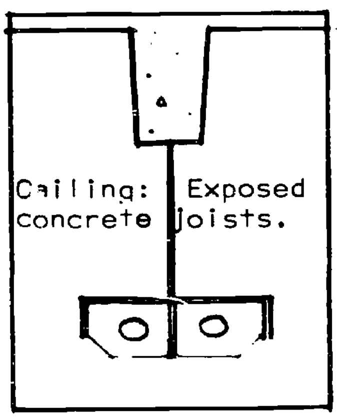


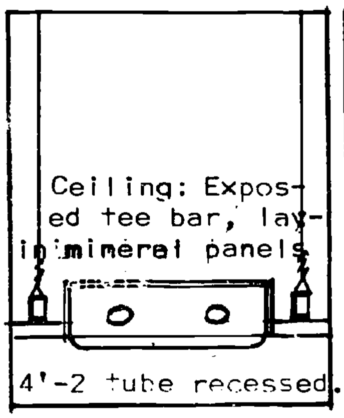


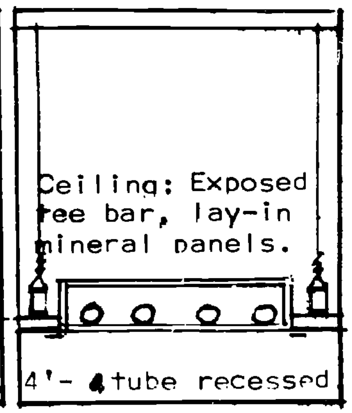




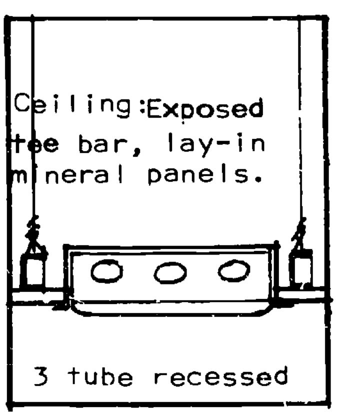
BLOOMINGTON

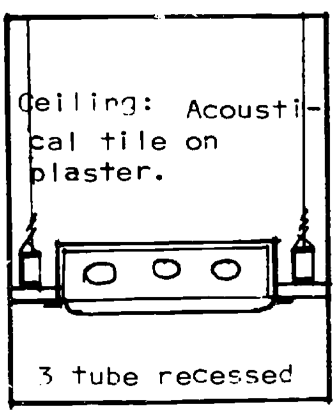


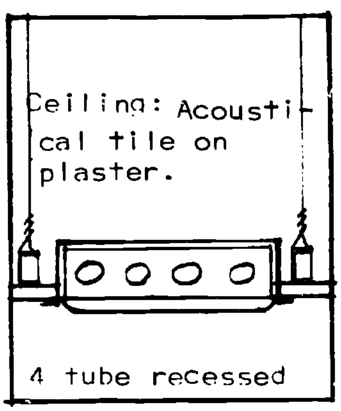


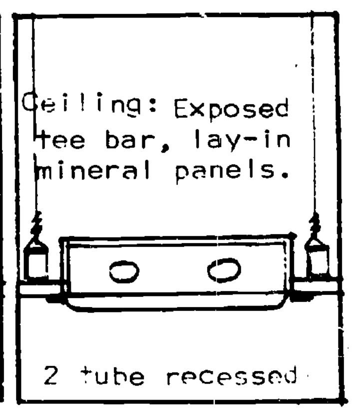


INDIANAPOLIS









PURDUE

BLOOMINGTON -- LIGHTING/CEILING

Suspended perforated metal pan ceilings are provided in laboratories, classrooms, offices and corridors. Pendent mounted eight-foot fluorescent fixtures are provided in the laboratories, classrooms and offices. In corridors fixtures are single tube fluorescent cove type.

INDIANAPOLIS — LIGHTING/CEILING

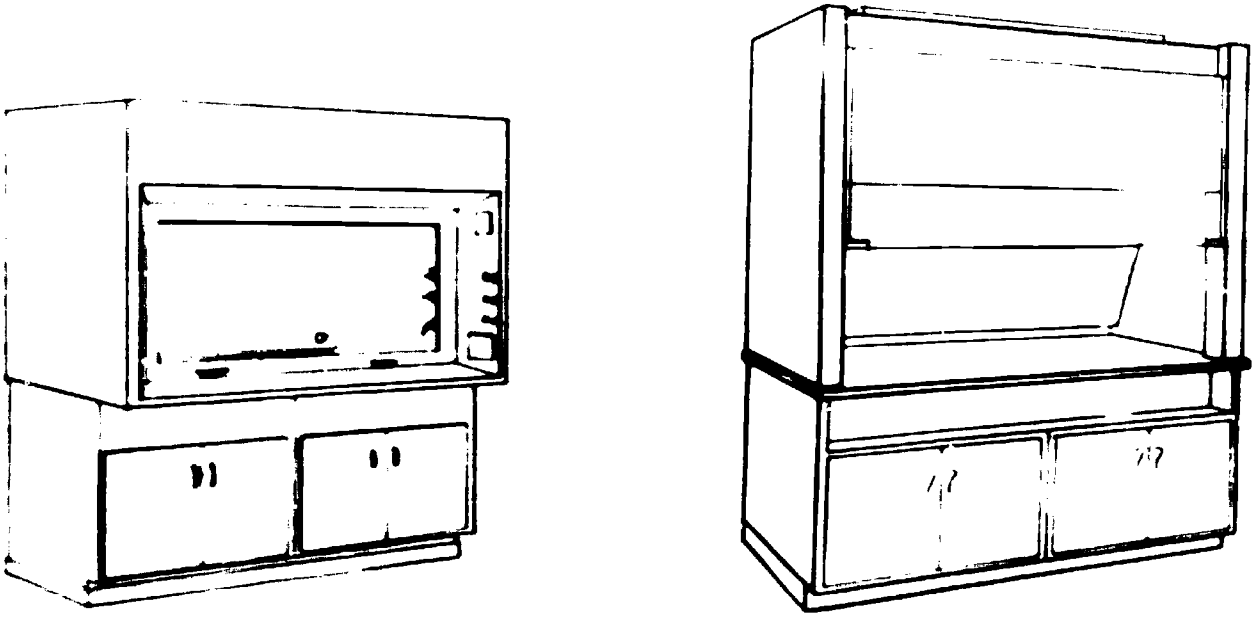
No finish ceiling is provided in the laboratories. Ceilings in the classrooms, offices and corridors are suspended exposed tee bar with lay-in mineral panels. Lighting in the laboratories is provided by means of a pendent mounted fluorescent fixture. Light fixtures in the classrooms and offices are recessed fluorescent with a drop lens. Light fixtures in the corridors are fully recessed fluorescent with a flush lens.

PURDUE — LIGHTING/CEILING

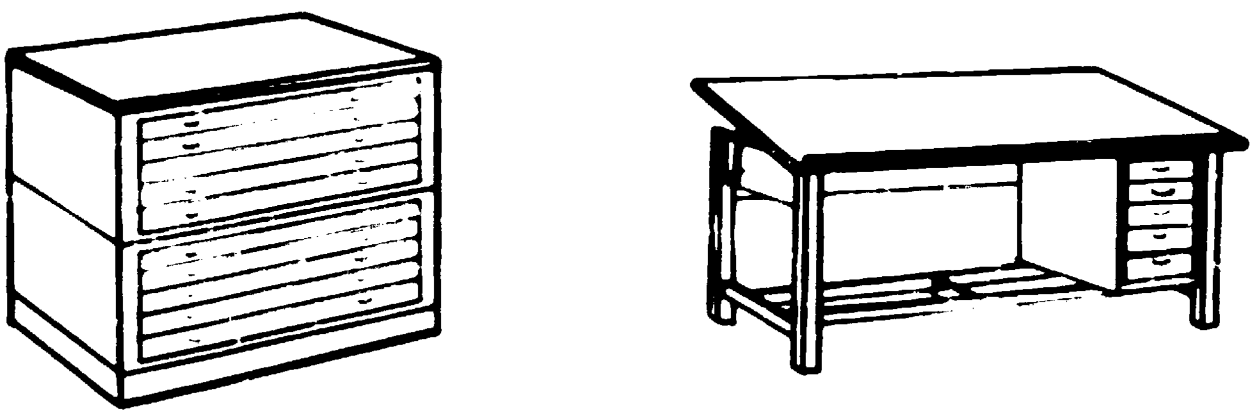
Ceilings in laboratories and corridors are suspended exposed tee bar with lay-in mineral panels. Ceilings in classrooms and offices are acoustical mineral tile mounted to suspended plaster. Light fixtures in laboratories, classrooms, offices, and corridors are recessed with a drop lens.

CASEWORK SUBSYSTEM

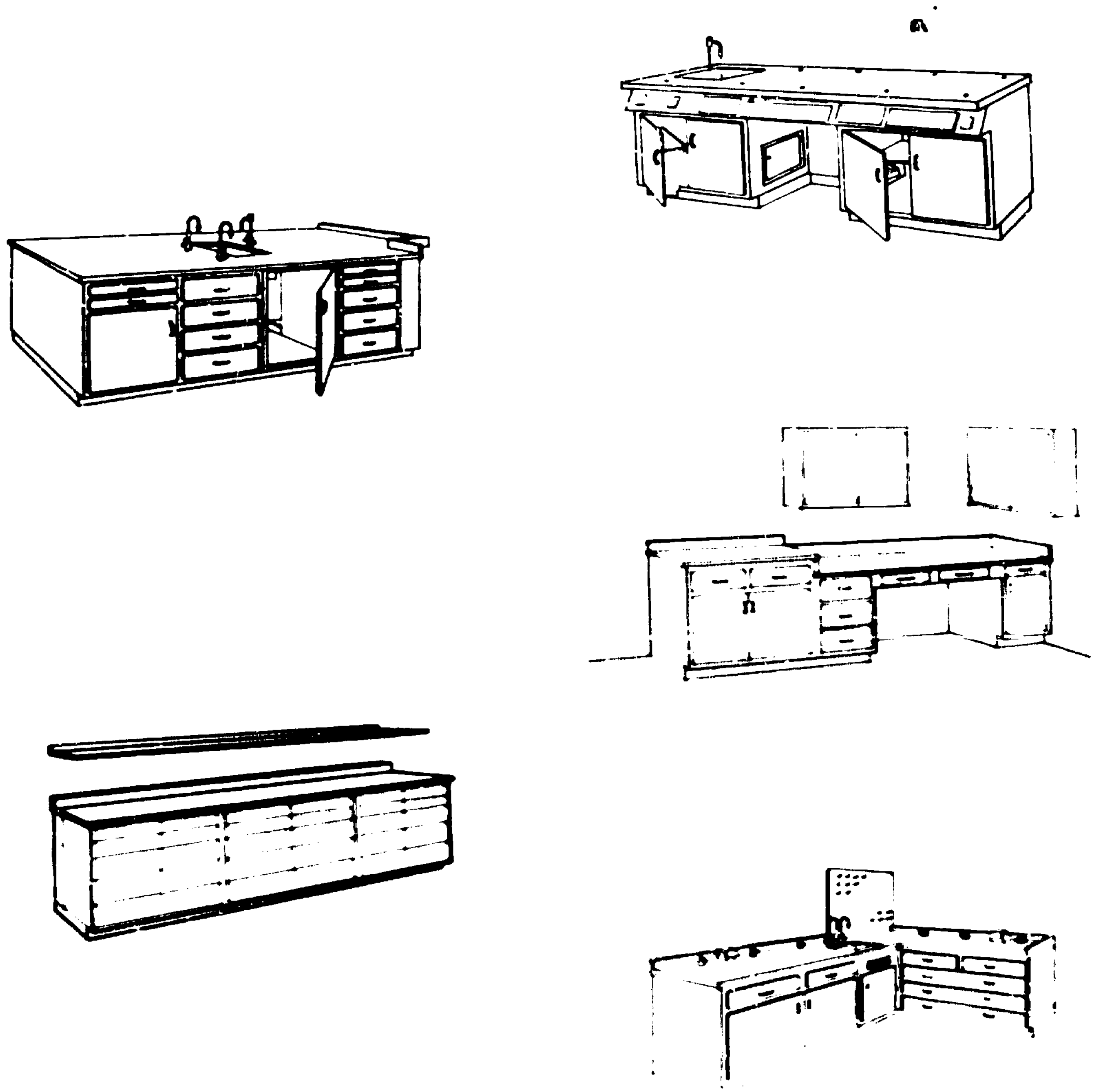
	BLOOMINGTON DEPTHS	INDIANAPOLIS DEPTHS	PURDUE DEPTHS
FREESTANDING CABINETS	1'-2"	1'-0" 2'-0"	
WALL BASE CABINETS	22" With 25" Top	2'-6" 2'-7"	2'-7"
WALL HUNG CABINETS	1'-0"	1'-4"	1'-4"
SINGLE LOADED BENCHES	22" with 25" top	3'-6" 2'-5" 3'-0"	2'-7" 3'-2"
DOUBLE LOADED BENCHES	3'-9" 4'-6" 3'-10"	5'-0" 3'-2"	4'-6"
FUME HOOD CABINETS	2'-8"	2'-6"	2'-8" 2'-5" 3'-1"
CONCRETE BALANCE TABLES	2'-0"		
MOVEABLE BENCHES	4'-0"	2'-6"	
CASE MATERIALS	Hardwood, Plywood	Hardwood, Plywood	Hardwood, Plywood
FINISH – WOOD	Stain, Varnish	Stain, Varnish	Stain, Varnish
FINISH – METAL	Paint	Paint	Paint
BENCH TOP MATERIALS	Stainless Steel, Soapstone, Durcon, Hamilcore	Laminated Plastic Soapstone	Soapstone
SINK MATERIALS	Stainless Steel, Soapstone, Durcon	Stainless Steel	Stainless Steel
SPECIAL BENCHES WITH UPPER WORK TOP		4'-2" 3'-1" Electrical Labs.	
WALL MOUNTED BENCHES		1'-8" 2'-0"	
WALL CABINETS			1'-10" 1'-4"
AUDIO TUTORIAL CARRELS	3'-8"		Yes, Similiar



UME HOODS



RAFTING ROOM



LABORATORY BENCHES

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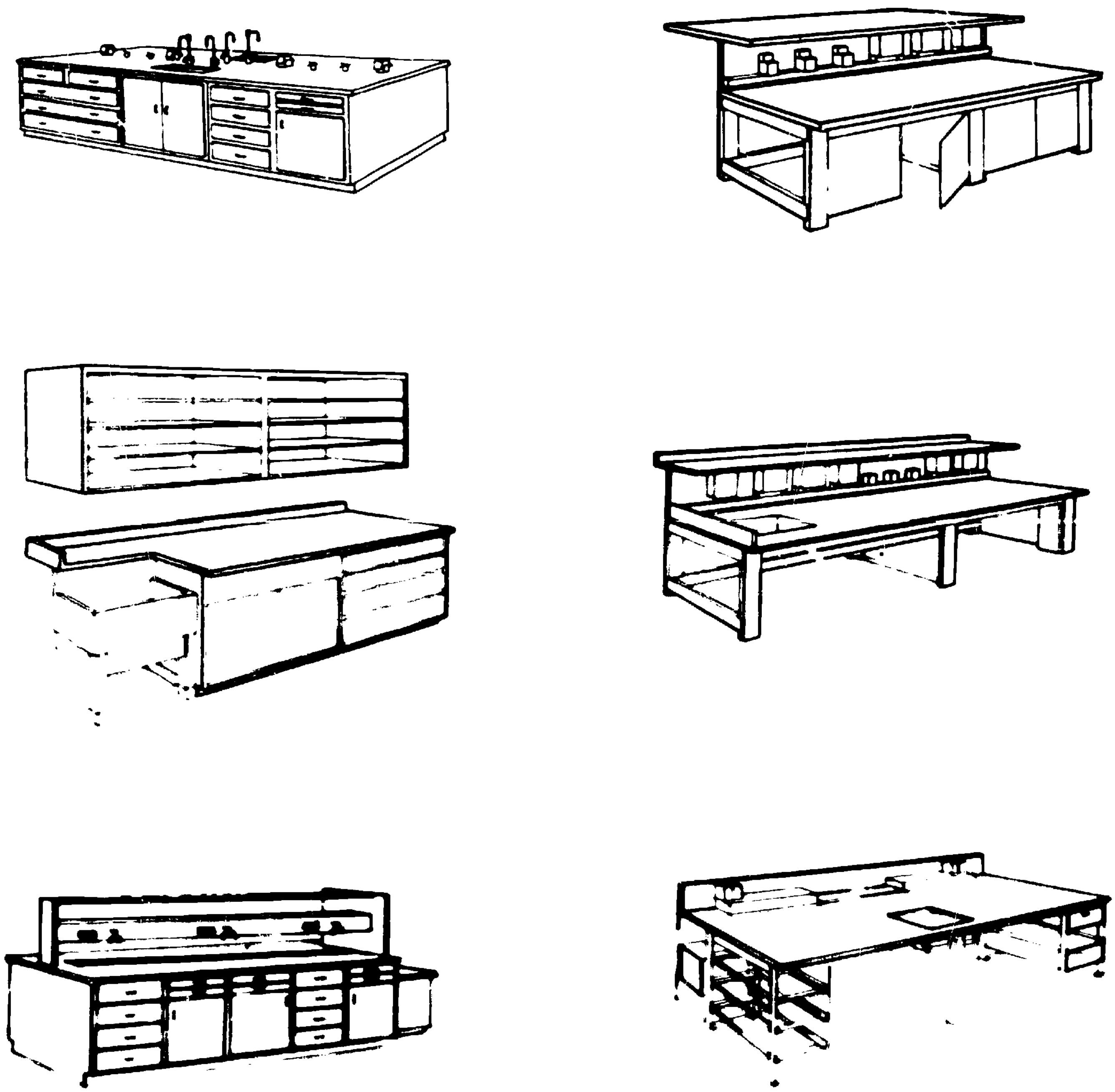
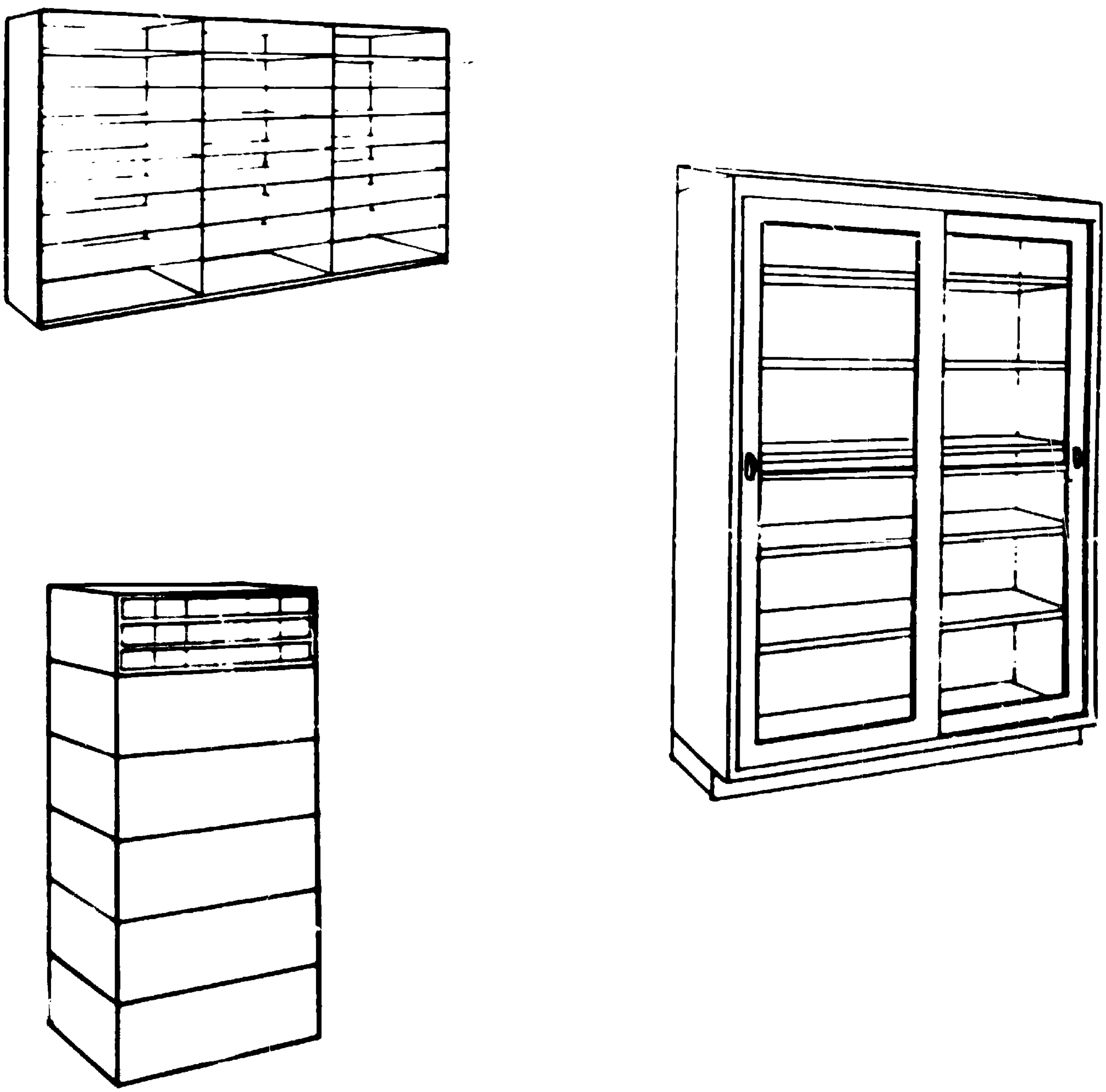


LABORATORY BENCHES



STORAGE CABINETS

BLOOMINGTON – CASEWORK

A complete range of wood laboratory furniture is supplied. Bench tops are stainless steel, soapstone, "Hamilcore" and "Durcon."

INDIANAPOLIS – CASEWORK

A complete range of wood laboratory furniture is supplied. Bench tops are plastic laminate and soapstone.

PURDUE – CASEWORK

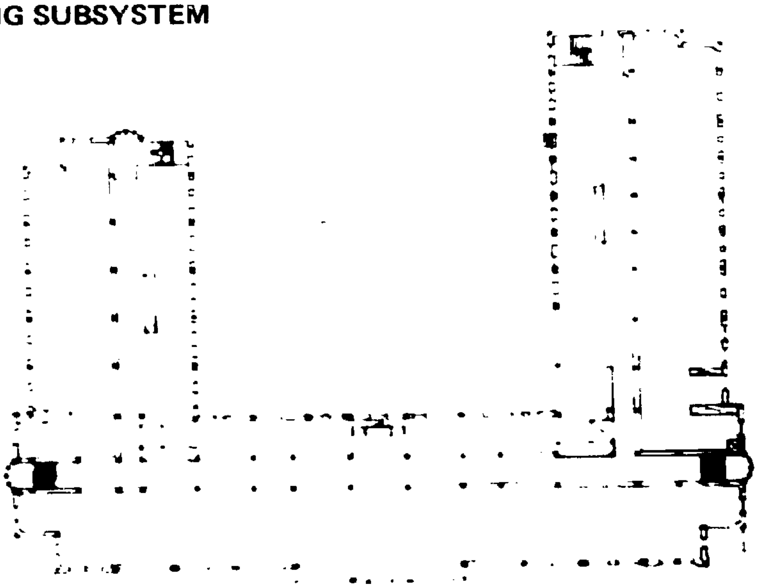
A complete range of wood laboratory furniture is supplied. Bench tops are soapstone.

SERVICES SUBSYSTEM

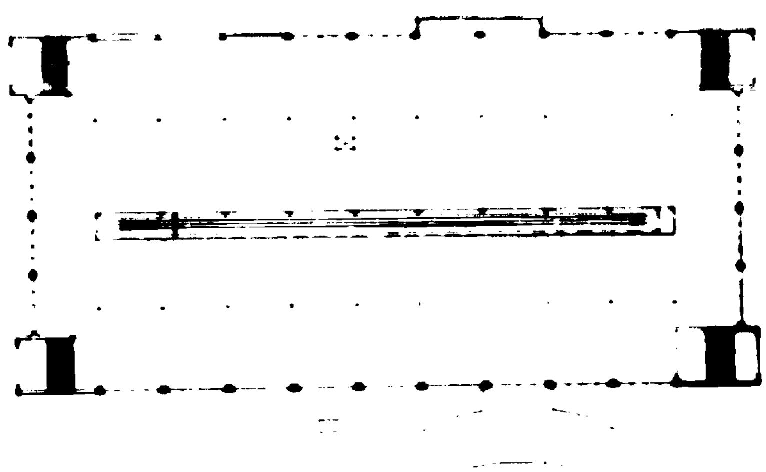
	BLOOMINGTON	INDIANAPOLIS	PURDUE
DOMESTIC COLD WATER		Galvanized Steel	Copper-Tubing 'K'
DOMESTIC HOT WATER		Galvanized Steel	Copper-Tubing 'K'
INDUSTRIAL COLD WATER		Galvanized Steel	Copper-Tubing 'K'
INDUSTRIAL HOT WATER		Galvanized Steel	Copper-Tubing 'K'
COMPRESSED AIR		Galvanized Steel	Copper-Tubing 'K'
VACUUM			
GAS		Black Iron	Black Iron
DISTILLED WATER		Aluminum	Koroseal
SEA WATER			
SANITARY SOIL		Cast Iron	Cast Iron
SANITARY WASTE VENT		Cast Iron	Cast Iron
ACID WASTE above grade		Corrosion Resisting Iron	Corrosion Resisting Iron
ACID WASTE below grade		Corrosion Resisting Iron	Corrosion Resisting Iron
STEAM			Black Steel
OXYGEN			
CARBON DIOXIDE			
INDIRECT DRAINS		Galvanized Steel	Galvanized Steel
OGSF / ELECTRICAL MAINS PER FLOOR	9,50)	15,000	16,800
OGSF / BRANCH CIRCUIT	6 [illegible]	5,000	3,000
OGSF / CIRCUIT BREAKER			
CIRCUIT BREAKER / BRANCH CIRCUIT	31	18	26
AMPS / CIRCUIT BREAKER	20-30	20	2ʋ 30
OGSF / AMPERE	62	50	37 5
AREA OF FLOOR, ELECTRIC CLOSET (SQ FT)	126 S F	Panels in Corridors	100 S F

ERIC

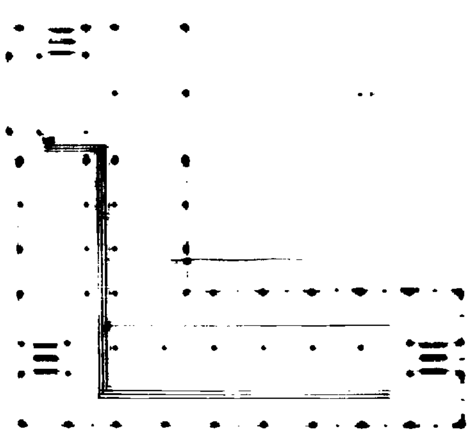
PLUMBING SUBSYSTEM



BLOOMINGTON



INDIANAPOLIS



PURDUE

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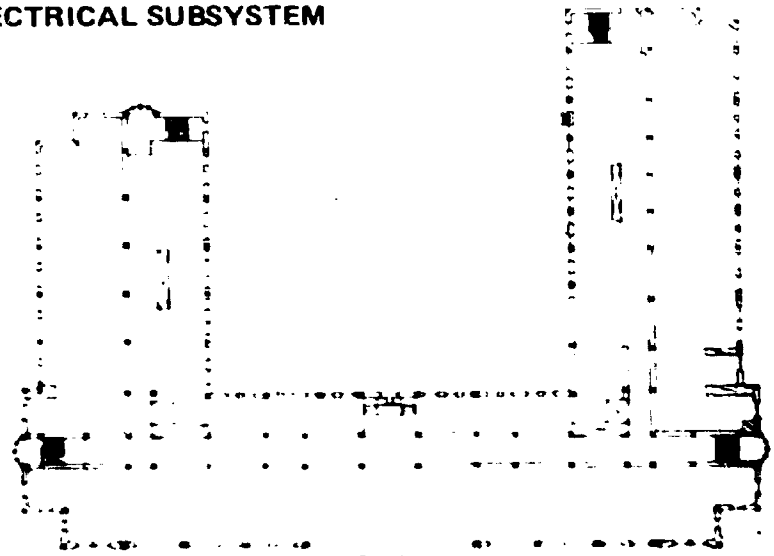
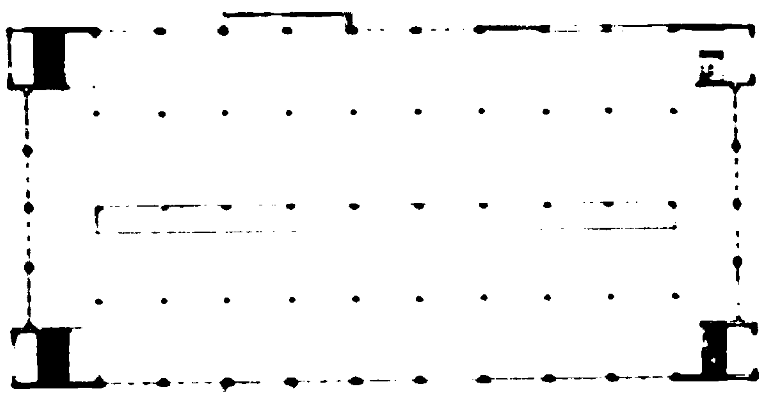
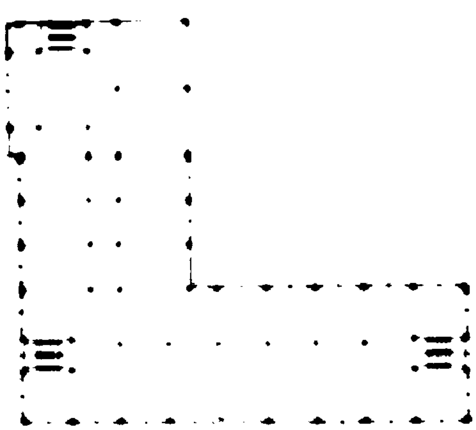
ELECTRICAL SUBSYSTEM



BLOOMINGTON



INDIANAPOLIS



PURDUE

BLOOMINGTON – SERVICES

Plumbing vertical risers are dispersed throughout the building going down in the corridor walls. Benches are supplied up through the floor. There are four main electrical vertical risers.

INDIANAPOLIS – SERVICES

The building has one main vertical riser for plumbing with each electrical distribution having an individual feed. There are two vertical risers for plumbing waste lines. Horizontal mains at each floor are located in the central utility core. Floor penetration for drain lines are at random.

PURDUE – SERVICES

The building has one main vertical riser for plumbing with one vertical electrical feed. Floor penetration for drain lines are at random. Horizontal mains run above the corridor ceilings.

The Cost/Performance Study was centered on six science and engineering buildings in California and Indiana. However, for comparison with a different type of building, the ABS consultant analyzed a classroom-office building at the University of California Berkeley campus—Barrows Hall.

Cost data was developed in exactly the same way. The cost estimate was based on contract documents, without change orders, and was prepared as though the project was bid January 1970 in the San Francisco Bay Area with an Engineering News-Record (ENR) Construction Cost Index of 1300.

The Barrows Hall HVAC cost ($4.44/OGSF) was about the same as the average for the six science and engineering buildings ($4.54/OGSF). While this, at first, did not appear realistic (Barrows is a non-laboratory building without air conditioning), investigation showed higher control, duct and insulation costs and a lower fan cost than the other buildings. Apparently the higher percentage of smaller zones in Barrows balanced the higher airflow and air conditioning costs in the science and engineering buildings.

As far the other ABS subsystems equivalents, the cost of the structure at $7.14/OGSF was comparable to the average cost of $7.48/OGSF for the three California bioscience buildings; the cost of partitions at $3.72/OGSF was higher than the $3.06/OGSF California average; and the lighting/ceiling cost of $1.93/OGSF was higher than for any of the six science and engineering buildings.

ABS subsystems equivalents in Barrows Hall accounted for 56% of the total construction cost. This, of course, is considerably greater than for any of the other six buildings, and indicates that an economical ABS system would have application to classroom-office buildings and similar non-science buildings.

U.C. Berkeley [illegible] High

Architect	Alack L. Wilson & Associates
Structural Engineer	Paquette & Maurer
Mechanical Engineer	Buonaccorsi & Murray
Electrical Engineer	Buonaccorsi & Murray
Bid Date October 31 1961	Completion Date July 1964

TABLE 1

SUBSYSTEM EQUIVALENT COSTS, $/OGSF ENR 1300

U.C. BERKELEY BARROWS HALL

	$/OGSF	%
SYSTEM*		
Structure	7.14	23
HVAC	4.44	15
Partitions	3.72	12
Lighting Ceiling	1.93	6
Subtotal	17.23	56%
NON-SYSTEM		
Site Work, Below Grade & Basement	2.24	7
HVAC	-0-	
Partitions	.43	1
Plumbing	1.07	4
Electrical	1.89	6
Ceiling	.06	
Exterior Skin	3.66	12
Elevators	1.06	4
Other	1.43	5
General Contractor	1.46	5
Subtotal	13.30	44%
TOTAL	30.53	100%

TABLE 2

COMPONENT UNIT COSTS, $/COMPONENT QUANTITY – ENR 1300

FLOORS (STRUCTURE)	ROO **	INTERIOR PARTITIONS	EXTERIOR SKIN
U.C. BERKELEY, BARROWS HALL			
$/S.F.	$/S.F.	$/S.F.	$/S.F.
5.28	7.74	3.68	11.20

NOTE: Costs in Table 1 are expressed in terms of the total cost of the subsystem divided by the total outside gross building floor area (OGSF).

In contrast, costs in Table 2 are expressed in terms of the total cost of the subsystem divided by the total area of the components involved.

*Includes all components equivalent to ABS subsystems.

**Includes ceilings and finishes.

Cost Divisions

U.C. BERKELEY, BARROWS HALL
Bid October 31, 1961; ENR Construction Cost Index 854
192,000 Outside Gross Square Feet (OGSF)

Base Bid:	$3,855,389 @ ENR 854 ($20.08/OGSF)
Projected:	$5,855,631 @ ENR 1300 ($30.49/OGSF)

Cost Estimate (Jan. 1970 – ENR 1300)

		$/OGSF	%
Site Work, Below Grade & Basement	$ 430,380	2.24	7
Floors	1,284,650	6.69	22
Roof	216,480	1.13	4
Interior Partitions	957,000	4.98	16
Interior General	82,040	.43	1
Exterior Skin, above ground	839,990	4.37	14
HVAC	853,100	4.44	15
Plumbing	205,210	1.07	4
Electrical	511,520	2.66	9
Elevators	202,000	1.06	3
General Contractor	279,200	1.46	5
	$5,861,570	30.53	

The cost estimate exceeds the projected base bid by 1/10 of 1%.

U.C. BERKELEY, BARROWS HALL

		$ Sub Contracts	$/OGSF	Subsystem Equiv $/OGSF		Non Sub System	$/S.F. Component
SITE WORK, BELOW GRADE & BASEMENT (Ground Floor)							
1.	Excavating, Grading & Preparation	88,660	.46			.46	
2.	Site Concrete	29,370	.15			.15	
3.	Building Concrete	272,530	1.42			1.42	
4.	Site Utilities	39,820	.21			.21	
		430,380	2.24			2.24	13.77

Ground Floor Area = 31,263 S.F. = .16 OGSF

		$ Sub Contracts	$/OGSF	Structure	Ceiling	Non Sub System	Structure
FLOORS							
1.	Concrete	849,880	4.43	4.43			5.28
2.	Balcony Waterproofing	18,070	.09			.09	
3.	Struct. Steel & Misc. Iron	31,680	.16	.16			
4.	Plaster Ceiling	8,570	.04		.01	.03	
5.	Ceramic Tile—Terrazzo	26,680	.14			.14	
6.	Floor Covering (Linoleum)	124,160	.65			.65	
7.	Acoustical Ceiling	225,630	1.18		1.15	.03	
		1,284,650	6.69	4.59	1.16	.94	5.28

Floor Cost Division Area = 160,737 S.F. = .84 OGSF

		$ Sub Contracts	$/OGSF	Structure		Non Sub System	$/S.F. Component
ROOF							
1.	Concrete	174,260	.91	.91			
2.	Struct. Steel & Misc. Metal	19,010	.10	.10			
3.	Roofing & Flashing	23,210	.12			.12	
		216,480	1.13	1.01		.12	7.74

Roof Cost Division Area = 27,945 S.F. = .14 OGSF

		$ Sub Contracts	$/OGSF	Structure	Partitions	Non Sub System	$/S.F. Component
INTERIOR PARTITIONS							
1.	Concrete	158,650	.83	.83			
2.	Doors & Frames	123,130	.64		.58	.06	
3.	Lath & Plaster	434,420	2.26		2.07	.19	
4.	Glass & Glazing	9,510	.05		.05		
5.	Ceramic Tile	17,200	.09			.09	
6.	Rubber Base	10,750	.05		.05		
7.	Finish Hardware	66,200	.34		.32	.02	
8.	Painting	113,830	.59		.56	.03	
9.	Plastic Wall Covering	16,660	.09		.09		
10.	Misc. Equipment	6,650	.04			.04	
		957,000	4.98	.83	3.72	.43	3.68

Interior Partitions Cost Division Area = 260,000 S. F. = 1.35 OGSF

COST PERFORMANCE DATA
CLASSROOM OFFICE BUILDING

U C BERKELEY, BARROWS HALL

		$ Sub Contracts	$/OGSF	Subsystem Equiv. $/OGSF		Non Sub System	$/S.F Component
INTERIOR GENERAL							
1	Misc. Metal Stairs, Rails	21,360	11			11	
2	Paneling, Cabinetwork	37 410	17			• 17	
3	Toilet Partitions	8 140	.04			04	
4	Chalk & Tackboards	13,410	07			07	
5	Fireplace & Misc	6,720	04			04	
		82,040	43			43	
EXTERIOR SKIN ABOVE GROUND				Ext Skin	Structure		
1	Concrete	430,470	2 24	1 53	71		
2	Misc. Metal - Railing	29,020	15	15			
3.	Sheet Metal	15,840	08	08			
4.	Windows & Doors	114,120	59	59			
5.	Metal Stools & Enclosures	53,500	28	28			
6.	Furring	116,730	61	61			
7.	Glass & Glazing	62,830	.33	33			
8.	Painting	17,480	.09	.09			
		839,990	4 37	3.66	71		11.20

Exterior Skin Above Ground Cost Division Area = 74,980 S.F. = 39 OGSF

		$ Sub Contracts	$/OGSF	Subsystem Equiv. $/OGSF		Non Sub System	$/S.F Component
HVAC				HVAC			
1.	Controls	70,200	.36	.36			
2.	Ductwork & Insulation	439,280	2.29	2.29			
3.	Supply Air Handling	343,620	1.79	1.79			
		863,100	4.44	4.44			

NOTE: Heating and Ventilating Only.

		$ Sub Contracts	$/OGSF	Subsystem Equiv. $/OGSF		Non Sub System	$/S.F Component
PLUMBING							
1.	Building Plumbing	154,410	.80			.80	
2.	Rain Water Leaders	34,410	.18			.18	
3.	Fire Protection	16,390	.09			.09	
		205,210	1.07			1.07	
ELECTRICAL				Lighting			
1.	Light Fixtures	154,087	.80	77		.03	
2.	Building Power & Distribution	238,541	1.50			1.50	
3.	Telephone	26,000	.14			.14	
4.	Fire Alarm	13,530	.07			.07	
5.	Clock, TV, Communications	29,362	.15			.15	
		511,520	2.66	.77		1.89	

PERFORMANCE DATA – U C BERKELEY, BARROWS HALL

GENERAL DATA	
OGSF	192 000 S F
ASF	111 667 S F
AREA TYPICAL FLOOR	17 400 S F
ASF / OGSF	0 58
AREA OF EXTERIOR WALLS / OGSF	0 4
AREA SERVED BY HV/AC	100%/2 7%
LINEAR FEET PARTITIONS / OGSF	0 08
FLOORS AT AND ABOVE GRADE	8
FLOORS BELOW GRADE	1
STRUCTURE SUBSYSTEM	
STRUCTURE TYPE	Flat Slab Posts
MATERIAL	Poured Concrete
SHEAR STRUCTURE	Internal Walls
STRUCTURAL BAY SIZES	22' x 18', 22', 23', 25'
FLOOR TO FLOOR HEIGHTS	12'-6" typ
FLOOR LIVE LOADING	75 lbs
ROOF LIVE LOADING	50 lbs.

HVAC SUBSYSTEM	
% BUILDING SERVED	100% HV 27% HVAC
HEATING SOURCE	Central (HPS)
FUEL	Gas, HPS
COOLING SOURCE	Building
FUEL	Electricity
AIR HANDLING SOURCE	Roof
EQUIPMENT ROOM SIZE HEATING AIR HANDLING TOTAL	1,490 S.F. 3,676 S.F. 5,166 S.F.
CAPACITY HEATING	5,242,000 BTUH
AIR HANDLING CFM	165,340 CFM
BTUH/OGSF	27
CFM/OGSF	0.81
% RETURN AIR	15
% MAIN EXHAUST	85
INTAKE LOCATIONS	Roof
EXHAUST LOCATIONS	Roof

EXTERIOR WALL SUBSYSTEM	STRUCTURAL
% SQ. FT. OF EXTERIOR WALL	100
% TOTAL SQ. FT. GLAZED	30
% GLASS AREA OPENABLE	85
SUN CONTROL MEASURE	Venetian Blinds
PLANNING MODULE	22'-0"
WALL CORE	Poured Concrete
INSIDE FACE MATERIAL	Plaster
INTERIOR FINISH	Painted
EXTERIOR FACE MATERIAL	Concrete, Plaster
EXTERIOR FINISH	Painted

INTERIOR PARTITIONS SUBSYSTEM

	STRUCTURAL	REPLACEABLE
% OF LINEAR FEET OF INTERIOR WALLS	12.5	87.5
MATERIAL	Concrete	Metal Studs Metal Lath and Plaster
HEIGHTS	12' 0" Typ	9' 0" 10' 0" 12' 0"
THICKNESS	10"	6"
SOUND TRANSMISSION COEFFICIENT DECIBELS	55	40
FIRE RATING	4 hr	2 hr
UTILITY SUPPORT	Yes	Yes
FURNITURE SUPPORT	Yes	Yes
PERMEABILITY	Doors Services	Doors Services

LIGHTING/CEILING SUBSYSTEM

	(18%) CLASSROOMS	(57%) OFFICES	(25%) CIRCULATION
LIGHTING TYPE	4'-4T Rec and Surf Direct	4'-4T Rec and Surf Direct	2'-4T, 4'-6T Rec and Surf Direct
SPACING	Cont 8' oc	Cont 8' oc	Separate 11' oc
WATTS/SQUARE FOOT	1.84 to 2.5	1.95	1.45
SWITCHING ZONE	Room	Room	Floor
SWITCHING TYPE	Line 1 Way 2 Way	Line 1 Way 2 Way	Line 1 Way 2 Way
CEILING TYPE	Susp.	Susp.	Susp.
MATERIAL	Mineral Fiber	Mineral Fiber	Mineral Fiber
MODULE	12" x 12"	12" x 12"	12" x 12"
NOISE REDUCTION COEFFICIENT	0.7	0.7	0.7

ALTERATION COSTS

GENERAL

One of the main objectives of the ABS project is to attack the problems inherent in methods of design and construction that result in buildings not easily adaptable to changing educational, technological, and administrative conditions. The ABS goals are to increase building adaptability and to reduce building life costs by permitting faster and more economical changes.

In studies of the cost of adaptability, the ABS consultant investigated the following

1. Cost histories of several science buildings.
2. Comparative alteration costs—six existing buildings.
3. Comparative disruption costs—six existing buildings.
4. Cost of change of occupancy.

These investigations provided the bases for evaluating relative costs of adaptability in existing facilities and for establishing target costs for ABS.

COST HISTORIES

The need for adaptability in university laboratory buildings may be dramatically expressed by graphs relating costs of construction, additions, and alterations to the life and evolution of a few existing laboratory buildings. These graphs were derived from records of construction costs incurred during the life of the buildings, to date. The extent of change in some buildings is surprisingly high, as illustrated by the Life Sciences Building at Berkeley. It now represents a 330% increase in investment over the initial construction cost of 40 years ago.

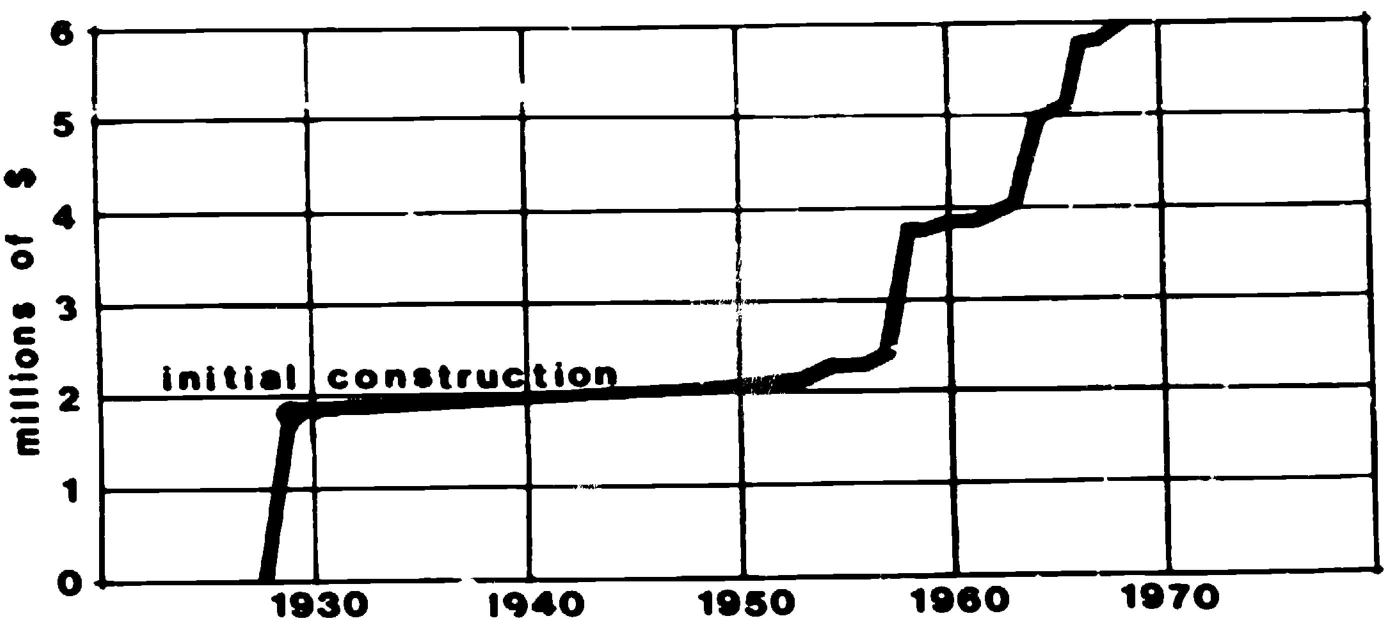
Costs for alterations have increased substantially in recent years, due to rising construction costs, more rapid evolution of the sciences, and more sophisticated service and equipment requirements. This trend toward more expensive changes in laboratory buildings clearly indicates the need for improved adaptability.

ERIC

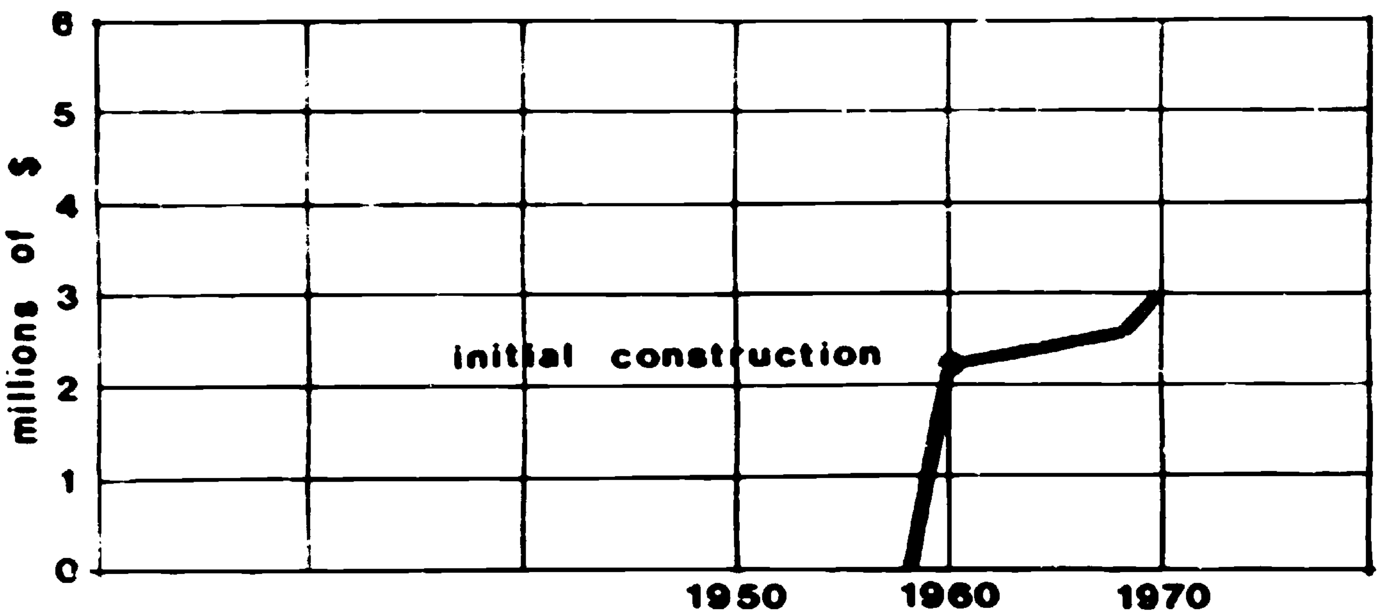
The graph representing an old building, the Life Sciences Building at Berkeley, shows very little dollar increase for the first 25 years of the building's life. Thereafter, however, the alteration costs rise sharply. This example may be contrasted with the other graphs pertaining to more recent laboratory buildings, where costs for changes are felt much sooner after their initial construction.

Whether this pattern is due more to obsolescence of the building, or to the evolution of research and teaching techniques, is not known. The fact that the newer buildings need alterations so early in their lives, however, tends to indicate that physical obsolescence is not a major cause of change, since components do not become antiquated in a very short period of time. Thus, the growing rate of evolution in science and related teaching methods is strong evidence in favor of providing maximum adaptability within an academic building system.

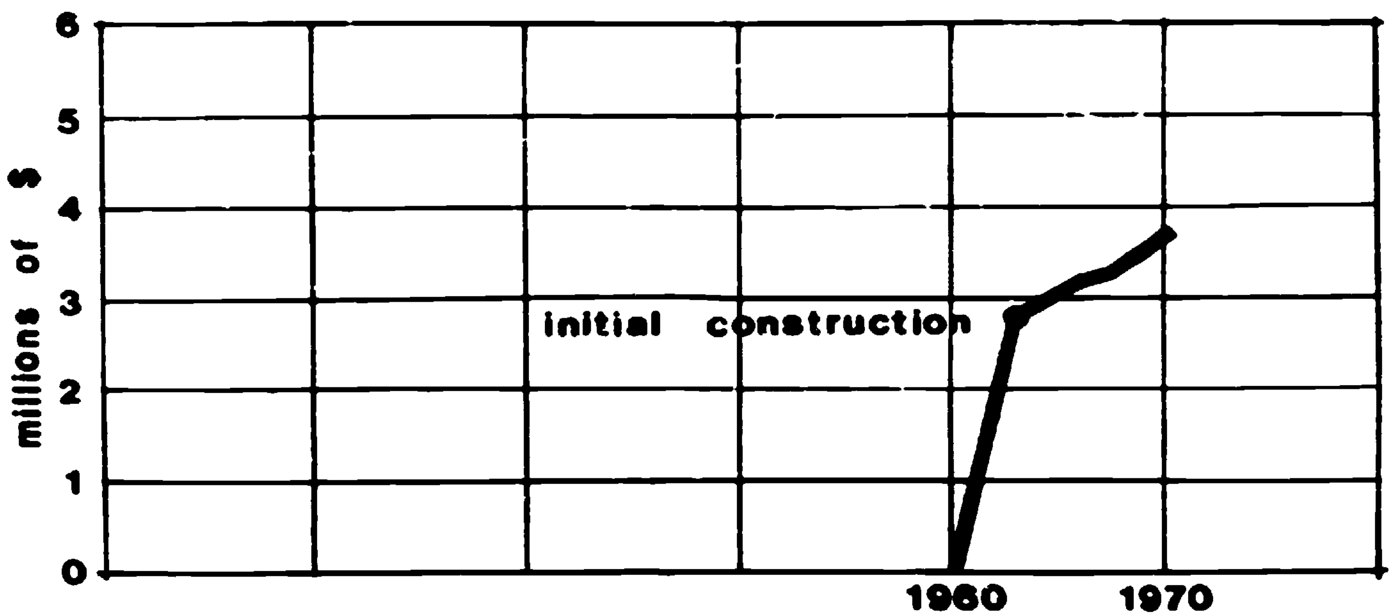
LIFE SCIENCE BUILDING
U.C. BERKELEY 1928-1968
CUMULATIVE CAPITALIZED COSTS (BOOK VALUE)



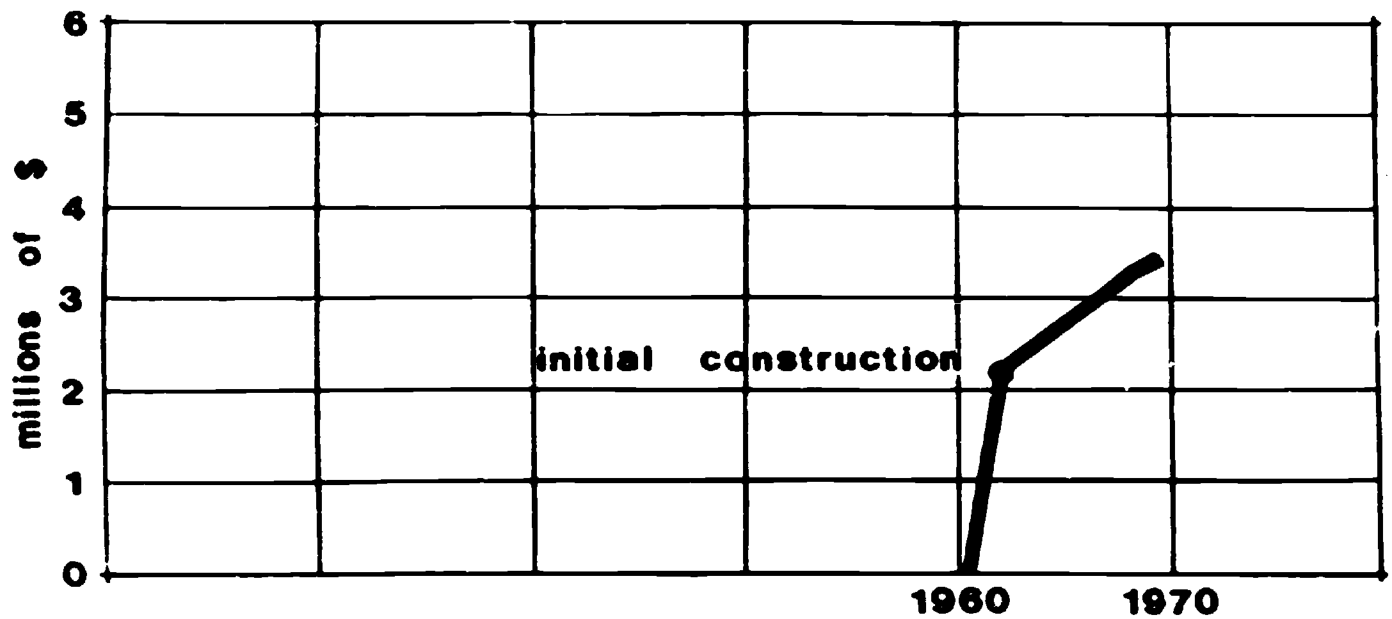
BIOLOGICAL SCIENCES I
U C DAVIS 1958 1968
CUMULATIVE CAPITALIZED COSTS (BOOK VALUE)



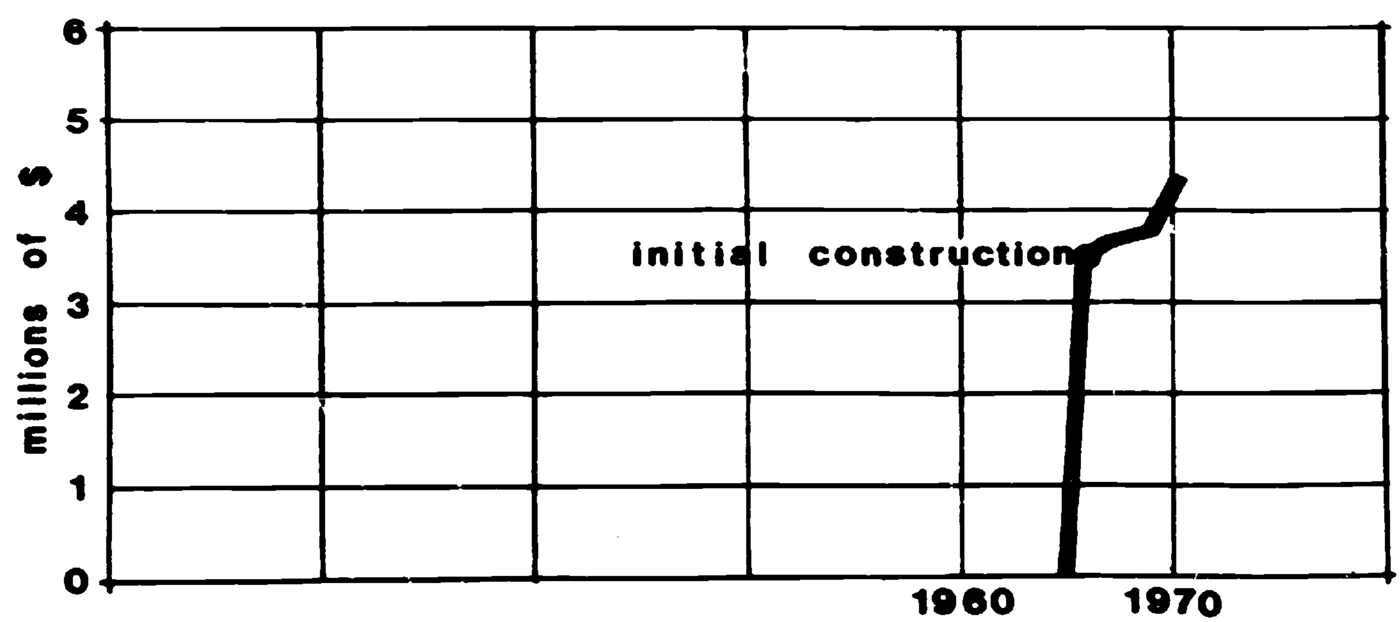
REVELLE COLLEGE BUILDING B
U.C. SAN DIEGO 1960-1970
CUMULATIVE CAPITALIZED COSTS (BOOK VALUE)



KRANNERT BUILDING
INDIANAPOLIS 1960 1969
CUMULATIVE CAPITALIZED COSTS (BOOK VALUE)



NATURAL SCIENCE UNIT I
U.C. IRVINE 1966 1970
CUMULATIVE CAPITALIZED COSTS (BOOK VALUE)



ALTERATION COSTS -SIX EXISTING BUILDINGS

The basic measure for adaptability is the cost of making changes relative to first cost. The cost of change itself depends on such factors as the ease or difficulty of access to components, the skill required of the labor involved, the time it takes, disruption to other users, mechanical system "down-time" and the size of the isolation zone, and the equipment used.

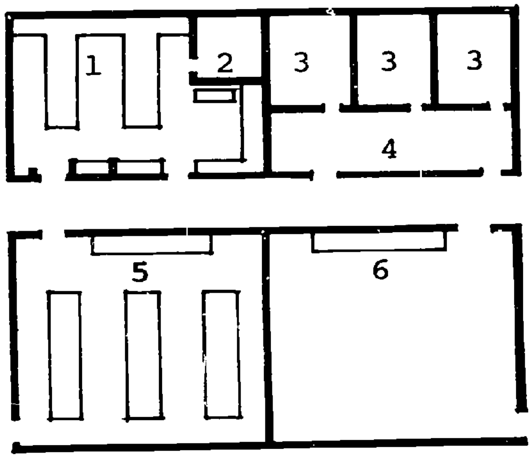
Life costs of existing buildings are high in relation to first costs, partly because traditionally built facilities are so expensive to change. In considering how to provide buildings that easily and relatively inexpensively respond to changing needs, it was necessary to study the particulars of alterations and modifications in existing buildings. Since comparing costs of actual changes made in the six existing buildings was not practicable, a hypothetical model was developed to illustrate an opening condition and two successive changes.

A laboratory plan segment (four 30' x 30' bays) applicable to any of the six existing buildings was chosen. A logical service configuration was selected from the original drawings of the three Indiana and the three California buildings as a potential location for change, and so applied to the model. This Initial Plan A was analyzed for cost. Two subsequent alterations were then made to each model, and the services modified accordingly. These changes generated cost estimates and provided a cost breakdown by subsystem to show the areas most expensive and least costly to modify. Thus, by demonstrating the common cost hierarchies involved in most alterations, the models provide guidelines for designing more adaptable components.

Certain assumptions were made upon which the cost estimates were based. These assumptions were reassessed at the completion of system design. Cost estimates were modified as required to compare with systems composition and to eliminate inconsistencies of assumption application among the California and Indiana facilities. Following are some of the general assumptions in the final analysis:

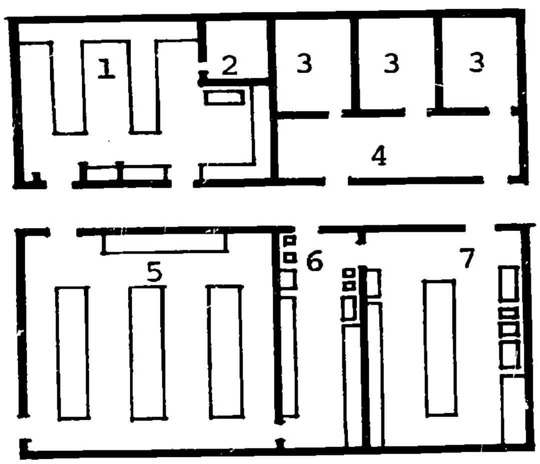
1. Resilient base is used on both sides of all partitions and walls (except outside surface of exterior walls).

2. Where new resilient tile is added, new resilient base is also added.



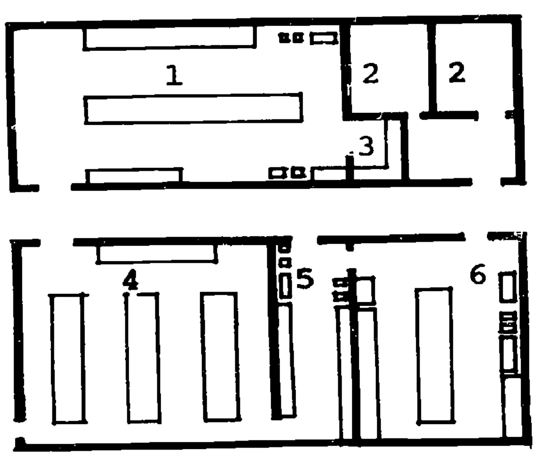
1. chemistry lab
2. office
3. faculty offices
4. typists
5. teaching lab
6. storage

A. INITIAL PLAN



1. chemistry lab
2. office
3. faculty offices
4. typists
5. teaching lab
6. prep room
7. graduate research

B. ALTERATION



1. biology lab
2. TA offices
3. dark room
4. teaching lab
5. prep room
6. graduate research

C. ALTERATION

3. Existing resilient tile and base is patched as necessary in modification areas, not replaced entirely.

4. Storage room floors and concrete ceilings are unfinished.

5. In modification areas, existing partitions, concrete walls, and exposed concrete ceilings are painted. However, the cost of repainting existing walls untouched by modification is not included in this cost estimate.

6. Casework and fume hoods, including sinks and trim, are not included in this cost estimate.

7. Removal of deleted casework is included in this cost estimate. Space is emptied of all deleted items, ready to receive new casework and equipment.

8. All plumbing, electrical and mechanical hook-up for casework is included in this cost estimate.

9. All deleted waste lines are capped-off at floor. No pipes are removed.

10. All deleted utility supply lines are capped-off at ceilings with only vertical drops removed.

11. All deleted mechanical ductwork is removed.

12. Acid vents are not included in this cost estimate.

13. New electrical distribution is surface mounted, rather than concealed.

14. Lighting fixtures are salvaged, relocated.

15. For HVAC changes, zone addition costs are identical for reheat systems or double duct systems; diffusers are salvaged, relocated.

16. The general contractor's cost is estimated at a fixed percentage, the same in all cases.

17. Five percent of suspended ceilings is replaced in modification areas.

18. Alterations from A to B and from B to C are made five years apart.

ALTERATION COSTS

Following are tables showing estimated costs in each of the six buildings studied for the Initial Plan A, Alteration B (changing a store room to a preparation room and graduate research laboratory), and Alteration C (converting a chemistry laboratory and two offices into a biology laboratory and darkroom). The same cost base applicable to all other studies is used herein (ENR 1300, January 1970, San Francisco Bay Area prices).

Cost estimate tabulations and drawings for U.C. Irvine are included as illustrative samples only.

INITIAL PLAN A (COST – EXISTING CONDITIONS)

	CALIFORNIA			INDIANA		
	DAVIS	IRVINE	SANTA BARBARA	BLOOMINGTON	INDIANAPOLIS	PURDUE
STRUCTURE	27,000	23,400	23,400	16,344	17,352	21,456
EXTERIOR	13,440	16,704	13,224	24,260	16,416	16,925
PAINTING	354	354	750			
CEILING	1,614	1,614	756	4,536	4,536	4,536
PARTITIONS	17,138	16,738	17,726	19,803	16,485	19,734
FLOORING	2,244	1,884	2,244	1,080	1,080	1,080
PLUMBING	18,000	18,000	18,000	18,000	18,000	18,000
ELECTRICAL	10,800	10,800	12,600	10,800	10,800	10,800
LIGHTING	6,500	5,310	5,510	5,292	6,552	4,032
HVAC	27,720	16,200	25,200	18,324	19,944	16,092
MISCELLANEOUS						
GENERAL CONTRACTOR	13,760	12,239	13,165	12,140	11,395	11,547
TOTALS	138,570	123,243	132,575	130,579	122,561	124,202

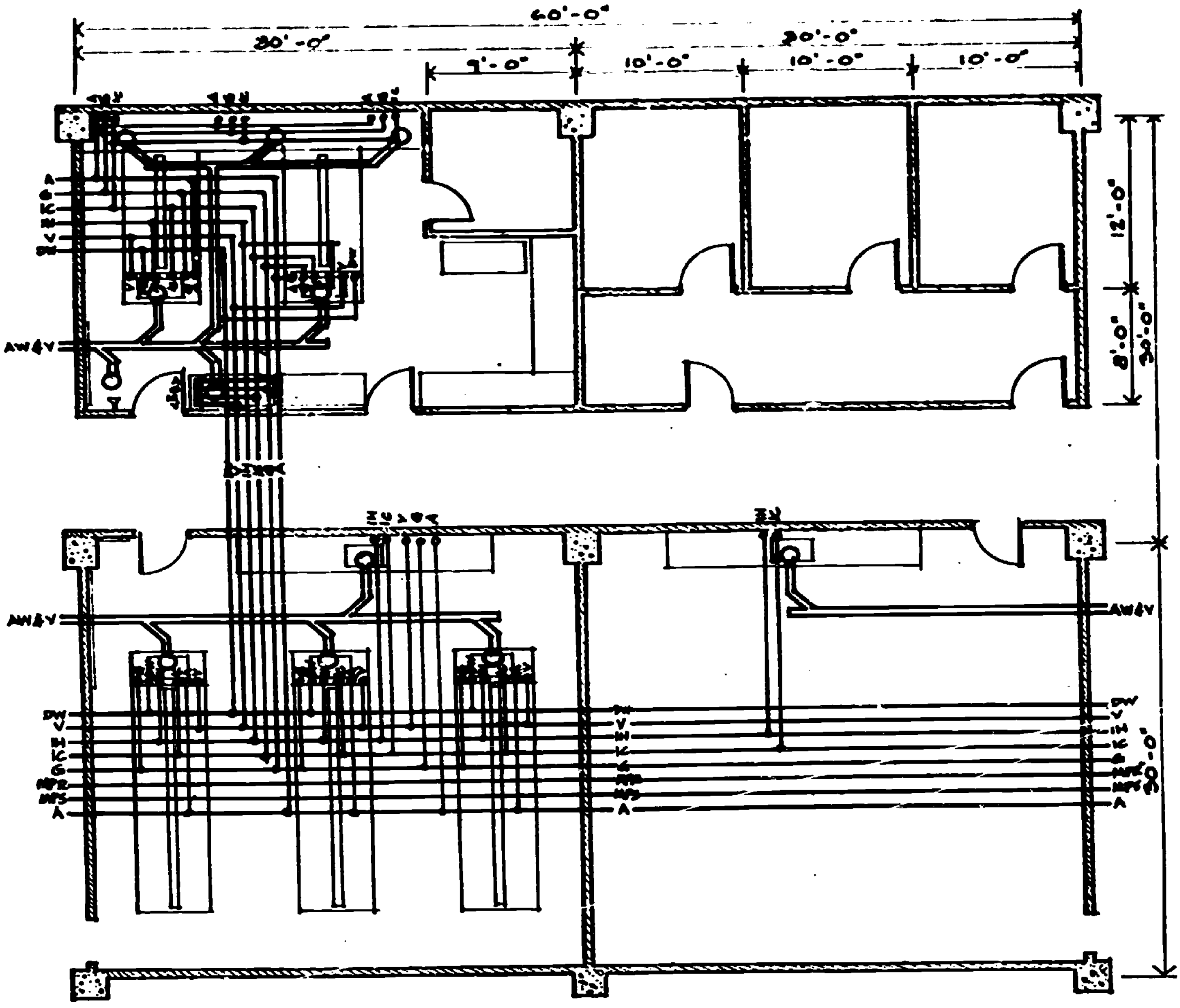
ALTERATION B (COST OF CHANGE FROM A TO B)

	CALIFORNIA			INDIANA		
	DAVIS	IRVINE	SANTA BARBARA	BLOOMINGTON	INDIANAPOLIS	PURDUE
PAINTING	483	426	474	172	173	172
CEILING				3,195	3,195	3,195
PARTITIONS	1,797	1,762	1,871	2,036	1,803	2,030
FLOORING	1,080	1,080	1,080	1,080	1,080	1,080
PLUMBING	5,360	4,247	4,713	3,956	3,459	3,594
ELECTRICAL	474	501	748	628	564	667
LIGHTING	170	330	490	210	170	290
HVAC	676	916	802	1,510	1,342	2,170
MISCELLANEOUS	60	60	60	60	60	60
GENERAL CONTRACTOR	2,121	1,958	2,150	2,698	2,488	2,784
TOTALS	12,221	11,280	12,388	15,544	14,334	16,042

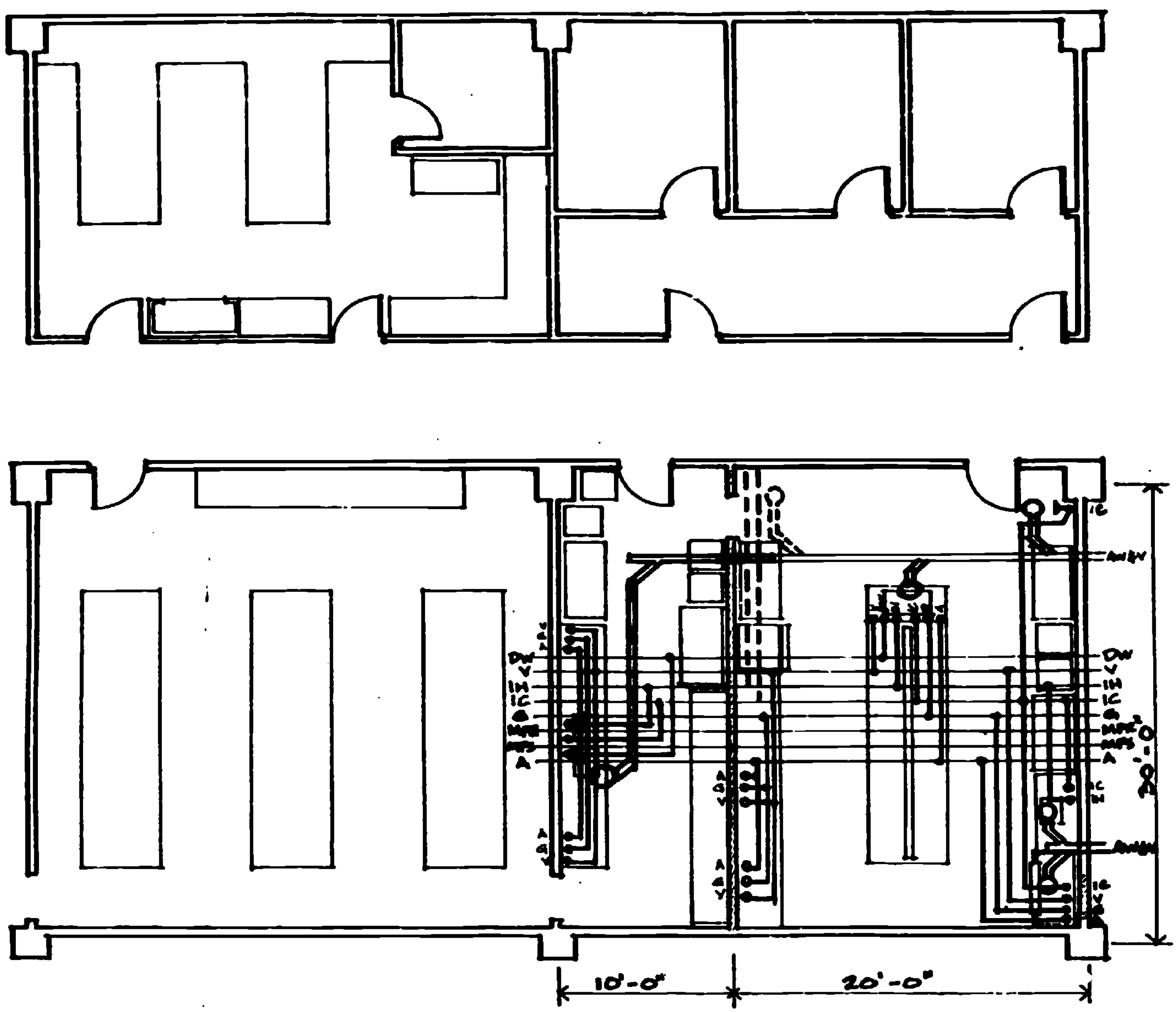
ALTERATION C (COST OF CHANGE FROM B TO C)

	CALIFORNIA			INDIANA		
	DAVIS	IRVINE	SANTA BARBARA	BLOOMINGTON	INDIANAPOLIS	PURDUE
PAINTING	545	469	589	231	231	231
CEILING	150	150		2,840	2,840	2,840
PARTITIONS	1,284	1,286	1,248	1,669	1,546	1,667
FLOORING	120	120	120	120	120	120
PLUMBING	1,650	985	786	1,677	1,233	1,309
ELECTRICAL	355	369	383	369	432	350
LIGHTING	720	930	620	380	920	920
HVAC	758	480	558	360	806	210
MISCELLANEOUS	180	180	180	180	180	180
GENERAL CONTRACTOR	1,210	1,043	942	1,643	1,745	1,644
TOTALS	6,972	6,012	5,426	9,469	10,053	9,471

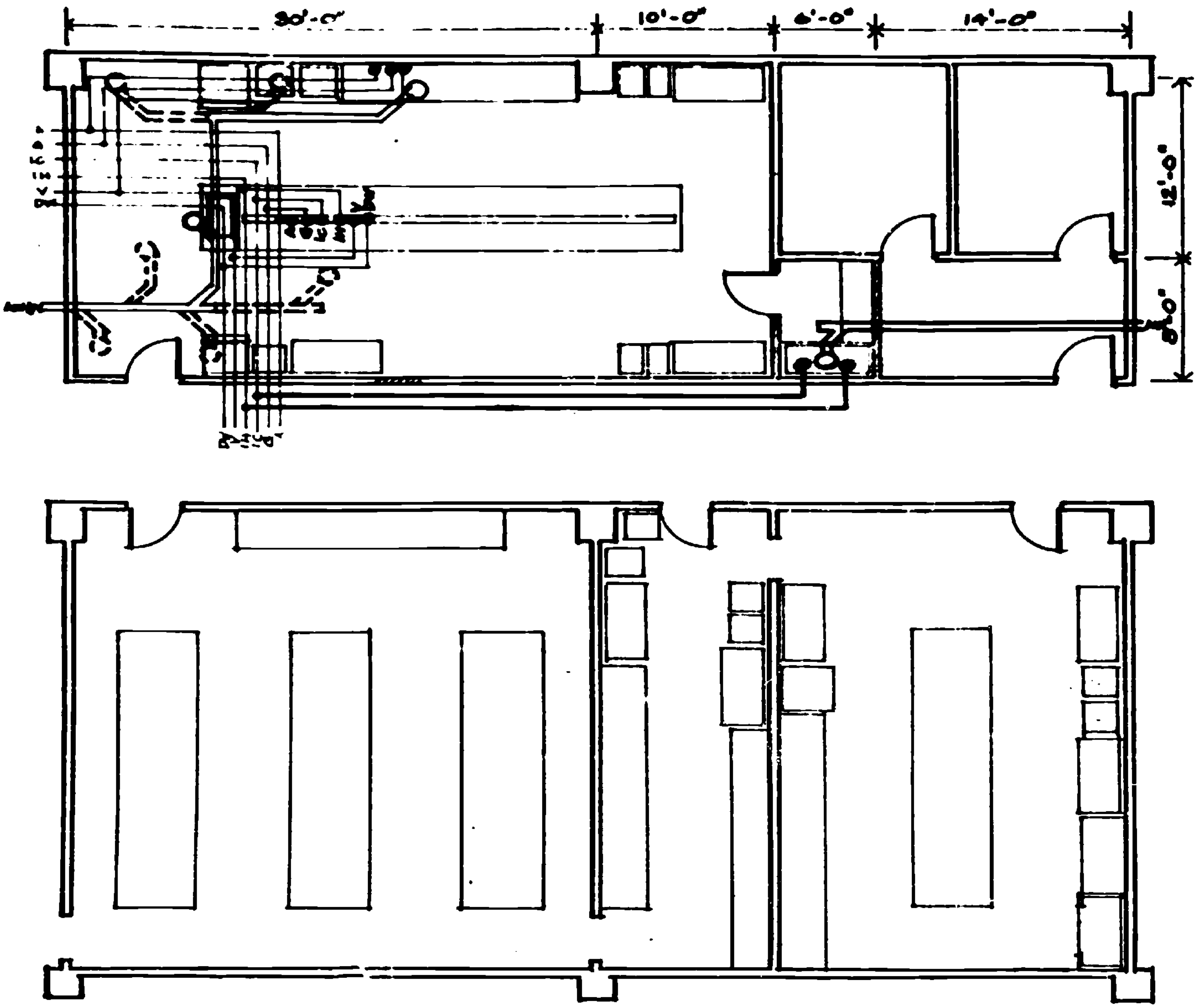
SAMPLE DRAWING
A. INITIAL PLAN PLUMBING—U.C. IRVINE



SAMPLE DRAWING
B. ALTERATION–PLUMBING–U.C. IRVINE



SAMPLE DRAWING
C. ALTERATION–PLUMBING–U.C. IRVINE



ERIC

SAMPLE COST ESTIMATE

BUILDING: U.C. IRVINE
CONDITION: "A" INITIAL

MATERIAL DESCRIPTION	QUANTITY	UNITS	COST/UNIT	COST
STRUCTURE	3,600	S.F.	6.50	$ 23,400
EXTERIOR WALL	1,440	S.F.	11.60	16,704
PARTITIONS	3,591	S.F.	4.26	15,298
DOORS	12	EA	120.00	1,440
PAINTING – CONCRETE CEILING	1,419	S.F.	.25	354
HUNG CEILING	1,281	S.F.	1.26	1,614
FLOOR – CONCRETE HARDNER	1,419	S.F.	.40	568
RESILIENT TILE	1,281	S.F.	.40	512
RESILIENT BASE	804	LF	1.00	804
PLUMBING	3,600	S.F.	5.00	18,000
ELECTRICAL (NON-LIGHTING)	3,600	S.F.	3.00	10,800
HVAC	3,600	S.F.	4.50	16,200
ELECTRICAL (LIGHTING)				
4'-0" FLUOR. FIXTURES	99	EA	50.00	4,950
SWITCHES	12	EA	30.00	360
SUBCONTRACTS – TOTAL				111,004
GENERAL CONTRACT (1.05 x 1.05)				12,239
TOTAL				$123,243

SAMPLE COST ESTIMATE

BUILDING: U.C. IRVINE
CONDITION: "B" ALTERNATE

MATERIAL DESCRIPTION	QUANTITY	UNITS	COST/UNIT	COST
PARTITIONS – NEW	315	S.F.	4.26	$ 1,342
DOORS – NEW	3	EA	120.00	360
PATCH EXISTING PARTITIONS	1	MD	60.00	60
REPAINT EXISTING PARTITIONS	945	S.F.	.16	151
REPAINT EXISTING WALL	315	S.F.	.16	50
REPAINT EXISTING CEILING	900	S.F.	.25	225
RESILIENT TILE	900	S.F.	1.00	900
RESILIENT BASE	180	LF	1.00	180
REM. EXISTING CASEWORK	1	MD	60.00	60
PLUMBING				
CAP-OFF EXISTING	1½	MD	100.00	150
LAB TABLE OUTLETS	28	EA	50.00	1,400
WASTE CONNECTIONS	5	EA	15.00	75
PIPING (G,W&V)	529	LF	3.50	1,852
PIPING (AW)	52	LF	10.00	520
SHOWER & EYE BATH	1	EA	250.00	250
ELECTRICAL (NON-LIGHTING)				
DELETE OUTLETS	2@ ½	MD	80.00	40
RELOCATE OUTLETS	2@ ½	MD	80.00	40
ADD OUTLETS	9	EA	7.00	63
FUME HOOD CONNECTIONS	1@ ½	MD	80.00	40
LAB TABLE CONNECTIONS	1@ ½	MD	80.00	40
CONDUIT	185	LF	1.50	278
HVAC				
NEW DUCTWORK	30	LF	12.00	360
MIXING BOX	1	EA	320.00	320
THERMOSTAT	1	EA	80.00	80
FUME HOOD DUCT	8	LF	12.00	96
FUME HOOD CONNECTIONS	1	MD	60.00	60
RELOCATE DIFFUSERS	1	MD	60.00	
ELECTRICAL (LIGHTING)				
DELETE FIXTURES	1@ ½	MD	80.00	40
RELOCATE FIXTURES	8@ 2½	MD	80.00	200
SWITCHES	3	EA	30.00	90
SUBCONTRACT TOTAL				9,322
GENERAL CONTRACT (1.1 x 1.1)				1,958
TOTAL				$11,280

SAMPLE COST ESTIMATE

BUILDING: U.C. IRVINE
CONDITION: "C" ALTERNATE

MATERIAL DESCRIPTION	QUANTITY	UNITS	COST/UNIT	COST
PARTITIONS – NEW	168	S.F.	4.26	$ 716
REMOVE DOORS	2@ 1	MD	60.00	60
RELOCATE DOORS	1@ 1	MD	60.00	60
REMOVE EXISTING PARTITIONS	48 LF 6	MD	60.00	360
PATCH EXISTING PARTITIONS	1½	MD	60.00	90
REPAINT EXISTING PARTITIONS	1,260	S.F.	.16	202
REPAINT EXISTING WALLS	420	S.F.	.16	67
REPAINT CONCRETE CEILING	800	S.F.	.25	200
PATCH RESILIENT TILE & BASE	2	MD	60.00	120
REMOVE EXISTING CASEWORK	3	MD	60.00	180
REMOVE SUSPENDED CEILING	2	MD	60.00	120
PATCH SUSPENDED CEILING	½	MD	60.00	30
PLUMBING				
CAP-OFF EXISTING	2	MD	100.00	200
LAB TABLE OUTLETS	2	EA	50.00	100
PIPING (G,W&V)	97	LF	3.50	340
PIPING (AW)	30	LF	10.00	300
WASTE CONNECTIONS	3	EA	15.00	45
ELECTRICAL (NON-LIGHTING)				
DELETE OUTLETS	8@ 1½	MD	80.00	120
RELOCATE OUTLETS	5@ 1	MD	80.00	80
NEW OUTLETS	2	EA	7.00	14
DELETE TELEPHONE OUTLETS	½	MD	80.00	40
LAB TABLE CONNECTIONS	½	MD	80.00	40
CONDUIT	50	LF	1.50	75
HVAC				
DELETE EXISTING DUCTWORK	2	MD	60.00	120
DELETE FUME HOOD DUCT	½	MD	60.00	30
NEW DIFFUSERS	3	EA	50.00	150
RELOCATE DIFFUSER	1	MD	60.00	60
NEW DUCTWORK	10	LF	12.00	120
ELECTRICAL (LIGHTING)				
RELOCATE FIXTURES	7@ 3	MD	80.00	240
ADD FIXTURES 4'-0"	9	EA	50.00	450
ADD FIXTURES INCAND.	2	EA	25.00	50
SWITCHES	1	EA	30.00	30
RECIRCUIT LIGHTING	2	MD	80.00	160
SUBCONTRACTS – TOTAL				4,969
GENERAL CONTRACT (1.1 × 1.1)				1,043
TOTAL				$6,012

The cost breakdown of the hypothetical alterations on the six buildings discloses a number of interesting conclusions about the comparative costs of adaptability in existing buildings and in future ABS buildings. The task here is not to analyze precise cost breakdowns in the six existing building, but to identify and analyze areas where costs are significantly different.

Alteration B involved changing a storeroom to a prep-room and graduate research laboratory.

In the California examples, by far the most expensive item to change was the plumbing, ranging from 38% to 44% of the total cost. The second most costly item was General Contractor's Fee, in all cases amounting to around 17% of the total cost. Third most costly item was partitions at 15% of the cost, and fourth was flooring.

In the Indiana buildings, several items amounted to large expenditures. Because their plaster suspended ceilings must be ripped out and replaced in the space being remodeled as well as the one below, the ceiling costs represented from 20% to 22% of the total. Plumbing costs were high for essentially the same reasons as the California buildings and accounted for 22% to 25% of the total. Third was the General Contractor's Fee. Partitions accounted for 10% to 13% of the total. HVAC ranged from 9% to 14%.

In Alteration C, a chemistry laboratory and two offices were converted into a biology laboratory and darkroom. Total remodeling costs were highest in the Indiana buildings, where the average is $9,664; the California average is $6,137.

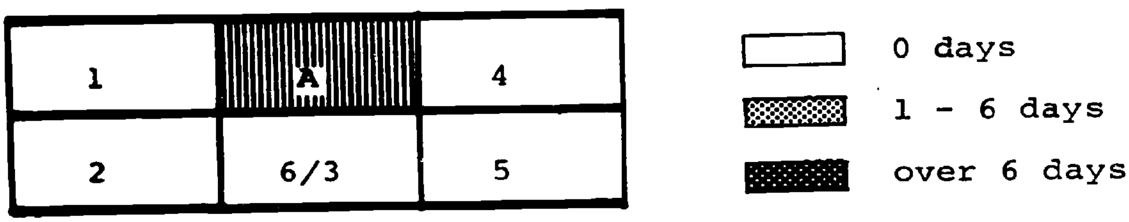
In the California buildings, partitions and plumbing were the most expensive items to change. The partitions costs were especially high because of adding new partitions and removing old ones, accounting for 18% to 23% of the remodeling costs. The plumbing costs were due to the addition of pipe and outlets, accounting for 14% to 24%. Aside from the 17% General Contractor Fee, the next most expensive items to change are HVAC and lighting, which range from 8% to 15% of the costs. Although material costs here are significant, so are labor factors for such tasks as removing existing ductwork and light fixtures.

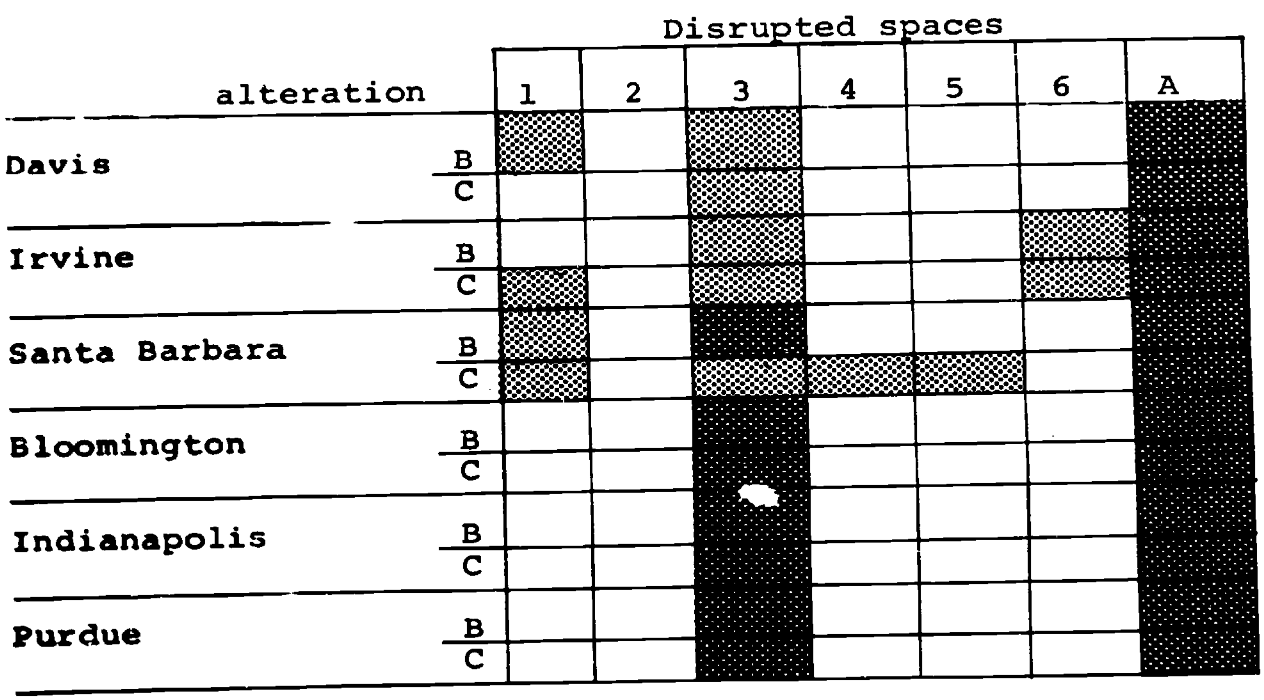
In the Indiana buildings, the ceiling again was the most costly item to change, accounting for 28% to 30% of the total remodeling expenses. Second was the partitions at 15% to 18%, principally because the block partitions are difficult and slow to remove. Third was plumbing at 12% to 18% of the total.

DISRUPTION COSTS – SIX EXISTING BUILDINGS

Although alteration cost is usually used to measure adaptability in a general sense, the evaluation of a building's adaptability must take into account other, less quantifiable considerations. The most important of these concerns disruption of spaces other than those being remodeled.

In the Alterations and Modifications study of the sample buildings, a brief study was made of disruption to users during alteration. The results of this study are tabulated below.





NOTE:
1. Disruption in corridor ignored.
2. Casework assumed ready for installation.
3. Ten days down-time attributed to necessity of removing and replacing hung ceiling in Indiana buildings.

In the existing buildings, conventional plumbing is the major expense, especially when plumbing services must be brought from another area in use, involving new plumbing connections or rerouting. Because waste lines are under the floor, in the ceiling of the space below, that space is also disrupted.

Disruption time for university personnel costs, conservatively, is $70 per room disrupted per day of disruption. In most alterations to academic facilities today, disruption to personnel costs an additional 15 to 30 percent of the total remodeling work. The elimination or reduction of these costs would represent a sizeable cost saving.

Changes are continually occurring in university academic programs, and the physical facilities that house them are subject to correspondingly changing requirements.

In general, academic buildings have not been able economically to meet new demands, thus placing major physical constraints on the changing activities of the building users. Traditional design and construction methods are in large measure responsible for the lack of adaptability of these buildings, principally because the need for change has only recently been recognized. Partitions are built as virtually immovable walls, plumbing and services are fixed. When physical changes are needed, major remodeling work is necessary. This in itself is costly, and inevitably involves disruption to the normal activities of the users. Not only is the space being remodeled disrupted, but also the adjacent spaces. The rooms below, providing access to drains and plumbing for the remodeled space, cannot be used while the workmen are active. Those rooms directly above may be affected by the noise of hammering or of making connections in the floor slab. Because of this, even when administrators acknowledge the need of one man or a department for physical changes, they are constrained by the costs and the disruption to others that the changes would entail.

COST OF CHANGE OF OCCUPANCY

A major objective for ABS is to meet the continuing need for change by providing buildings that can better accommodate both foreseeable and unanticipated trends during their lifetimes, and within a realistic cost context. The goal is to lower the cost of change, while, at the same time, maintaining or improving the performance of the building. In designing for adaptability, it must be recognized that, on account of costs, compromise will be necessary. Immediate changes of services and total interchangeability of different space types (laboratories, offices, specialty rooms, etc.) is not economically feasible. The task is to determine the degree of spatial and service capability to provide, in order to give the best dollar return for future alterations. In doing so, all the subsystems of the building must be considered as a unit; the cost of providing a higher degree of adaptability in one subsystem will be wasted if the remaining subsystems cannot adapt to the same degree. The first step in the process is to examine the potential range of adaptability and its implications, and then to set realistic design goals.

ADAPTABILITY OF SPACE AND SERVICES

The two related aspects of a building most susceptible to change are the area requirements of various space types, such as research labs, teaching labs and offices, and the required services which vary in intensity according to the activity housed. Because the utility and mechanical services are the most expensive subsystems to alter, they typically account for up to 50% of remodeling costs. In science buildings, especially, it is important to understand how services relate to particular space types, and how those space types are likely to be affected by demands for change.

A simplified set of adaptability characteristics related to spaces makes the following distinctions:

1. High intensity of service requirements.
2. Low intensity of service requirements.
3. High likelihood of service and/or spatial change.
4. Low likelihood of service and/or spatial change.
5. Minimal likelihood of service and/or spatial change.

The following chart relates these characteristics to typical space types in present laboratory buildings.

	HIGH SERVICE HIGH CHANGE	HIGH SERVICE LOW CHANGE	LOW SERVICE HIGH CHANGE	LOW SERVICE LOW CHANGE	MINIMAL CHANGE
RESEARCH LABS — LARGE, SMALL	X				
ANCILLARY SPACE — PREPARATION ROOMS, ETC.	X				
TEACHING LABS		X			
OFFICES				X	
SEMINAR ROOMS, LIBRARIES, CONFERENCE ROOMS, ETC.				X	
CLASSROOMS				X	
WORKSHOPS			X		
CORRIDORS, LOBBIES					X
LECTURE THEATER (SLOPED FLOOR)				X	
SPECIAL EQUIPMENT ROOMS					X
ANIMAL ROOMS		X			

ADAPTABILITY SCALE

NOTE: This scale refers to existing conditions; a more adaptable building might change the scale; e.g., offices and classrooms might become high change spaces.

As far as the space/services relationship affects adaptability, it is easy to "downgrade" a space, that is, to move from a high degree of services to a low one. Although it is not usually economical to utilize a space at a lower standard than it was designed for, laboratories, for example, can fairly easily become classrooms. On the other hand, a move from low to high on the scale greatly affects the costs of structures and services. For example, if the capacity for "upgrading" is to be built into an office, it must be built initially with a high degree of service capability but without certain equipment.

The Adaptability Scale groups space types on the basis of likely changes and degree of services. Clearly, those spaces on the same scale should be economical to interchange, though often today they are not.

The following chart compares the relative costs of changing space uses under conventional conditions today, and clearly illustrates the principle of "downgrading" as it operates in traditional laboratory buildings. Presented in dollars per square foot, the figures are taken from the cost data generated in the studies of the six existing buildings, and are estimated to the same bases (ENR Construction Cost Index 1300).

COST OF CHANGE OF OCCUPANCY TYPE — CONVENTIONAL BUILDINGS

FROM: / TO:	RES. LABS	TEACH. LABS	CLASS-ROOMS	SEMINAR, CONF.	OFFICES	CIRC. LOBBIES	WORK-SHOPS	STORAGE SPACES
RESEARCH LABS		23.75	7.90	11.75	13.60	8.70	2.15	2.15
TEACHING LABS	23.75		7.90	11.75	13.60	8.70	2.15	2.15
CLASSROOMS	29.40	29.40		5.25	6.75	7.25	.45	.45
SEMINAR, CONF.	30.15	30.15	1.10		7.10	7.60	.80	.80
OFFICES	34.35	34.35	11.95	16.10		8.25	.05	.05
CIRC., LOBBIES	32.60	32.60	6.05	10.20	12.45		2.95	2.95
WORKSHOPS	30.40	30.40	6.55	10.70	9.95	7.25		0.00
STORAGE SPACES	30.40	30.40	6.55	10.70	9.95	7.25	0.00	

This study is based on the hypothetical model of a typical 30′ x 30′ bay of a conventionally constructed laboratory building to which various uses and their accustomed services are applied, and upon which subsequent changes of occupancy are imposed.

For example, in determining the cost of change from a research laboratory to a teaching laboratory, first the scope of the alteration is delineated by tasks, such as "remove and replace laboratory equipment and casework," and "add acoustical ceiling"; each of the necessary operations is then estimated for cost; and finally these figures are added up to show total cost of change of each occupancy type. In cases when a space is to be "upgraded," or changed to an occupancy type with a higher degree of service provision, utilities mains are assumed to be in the adjacent corridor and submains may be connected to them. It is the objective of ABS to lower these costs, and to provide a higher standard of adaptability performance.

FUNCTIONAL AREA COSTS

The cost data provided for each subsystem in the existing facilities has a direct application in establishing cost targets for the proposed ABS system. When these data are presented as price per OGSF, they include statements about both the quality and the quantity of the subsystem as used in the context of each building wherein its own particular configuration and size affect the cost figures. In order to establish an equitable basis of comparison of subsystems, both quality and quantity must be well defined. Some subsystems, such as partitions, provide a rapid quantity analysis by the simple computation of area as of partition. This type of enumeration of quantity characteristics has been done for structure and partitions, but HVAC and Lighting/Ceiling have been omitted. Quantity is more elusive, particularly as regards the HVAC subsystem. The number of quantity variables in HVAC (such as cfm, BTU, number and size of zones, number of controls, quantity and size of ducts, number and size of fans), and those of the Lighting/Ceiling to a lesser degree, become overwhelming when subjected to quick review.

An alternative method of assessing the quantity characteristics of subsystems, in a general way, is to determine the cost impact of various occupancy types. It is assumed that certain occupancy types consume more of some subsystems than others. It has been verified that a spectrum of costs exists, where occupancy types such as laboratories are highest and storage is lowest, and that the contribution of specific subsystems is significant. With these relationships established, the comparison of occupancy type percentages with subsystem costs tends to substantiate a general quantity level for a specific subsystem. For example, it is known from analysis that HVAC costs are higher for laboratories than any other space. If laboratories for a particular building occupy a small percentage of the building, it can be deduced that the quantity level should be lower for that building, with a resultant lower HVAC unit cost.

Costs of functional areas in the six buildings studied have been compiled in the tables of Functional Area Costs, on pages 183 and 184. The quantities are expressed as percentages of gross square feet. Average costs on page 184 for occupancy types derived from the studies of existing facilities provide an accurate and useful tool for the facilities planner in establishing a building budget.

The traditional means of establishing building budgets begins with a program of assignable areas for departments to be housed. An acceptable ratio of assignable to gross area is applied. The resulting gross area is multiplied by a cost per gross square foot factor to determine building cost. The cost per gross square foot is a figure generally acceptable for that particular type of building, such as classroom-office building, engineering building, bio-science laboratory building. The accuracy of this method is dependent on assumed ratios of space use or occupancy types.

The first table indicates the variation in occupancy types of six similar facilities; all could be classified under the same building type. The disproportion of the more expensive laboratory space in one building could cause a serious budget constraint on quality within a fixed building area cost. A more accurate method is the direct application of area costs for the specific functional use within the indicated percentage of total space.

These costs will vary for building types other than the six studied. For example the cost of offices will differ among science, humanities, or administration. Although offices do not need the services or the sophisticated HVAC systems of laboratories, they must share part of the basic costs of such systems when grouped together in the same building. Office buildings do not have this degree of basic services sophistication and therefore will have lower unit costs. Breakdown of unit costs within a proposed science and engineering facility provides a more meaningful basis of budget projections than the customary single unit figure for the total building, since the latter does not take the proportion of various occupancy types into account.

In the following tabulations, specific costs were assigned to the precise functional area types within each building to discover how the types of uses directly affect cost. The procedure was as follows: costs of finishes unique to a specific functional area (such as an office, a classroom, a teaching laboratory, a research laboratory) were tabulated for each building. To these are added a general figure called the "common component costs," which signifies the costs of shared elements: site work, floors excluding finishes, roof, interior partitions, general interior features, exterior wall, plumbing for fire protection and outside lines, general electrical costs for clocks, fire alarms, telephones, elevators and general contractor. Although these costs do not pertain to a specific space but to the building as a whole, the costs are shared by every square foot of the building, and are therefore incorporated equally into all functional and non-assignable areas.

FUNCTIONAL AREA COSTS – ENR 1300*

	DAVIS		IRVINE		SANTA BARBARA		BLOOMINGTON		INDIANAPOLIS		PURDUE	
	%	$/S.F.	%	$/S.F.	%	$/S.F.	%	$/S.F.	%	$/S.F.	%	$/S.F.
CLASSROOM	3.9	32.79	11.6	35.12	3.0	34.51	2.8	38.24	19.9	32.79	3.7	36.47
OFFICE	6.7	32.54	8.1	34.87	6.5	34.42	6.5	38.53	10.7	33.08	15.3	36.92
TEACHING LAB	15.1	53.39	11.0	53.27	11.8	59.04	9.7	58.75	19.4	50.98	13.4	53.77
RESEARCH LAB	25.8	53.12	22.6	52.97	30.1	59.04	29.3	58.75	0.7	50.98	25.6	53.77
LIBRARY							4.9	41.23			1.8	40.57
GENERAL SERVICE	4.5	28.04	4.7	31.27	7.6	31.58	1.1	33.87	8.3	28.91	1.2	33.50
NON-ASSIGNABLE	44.0	28.92	42.0	27.90	41.0	34.99	45.7	33.37	41.0	26.16	39.0	23.75
OGSF		92,167		121,000		132,000		222,065		134,276		113,000
ASF		51,702		70,180		77,579		120,277		79,230		69,000
ASF/OGSF		.56		.58		.59		.54		.59		.61
$/S.F. FROM ABOVE		39.21		37.92		44.87		44.13		33.44		38.36
$/OGSF COST ESTIMATE**		39.20		37.60		44.88		44.13		33.44		38.64

*January 1970 prices, San Francisco Bay Area.

**Refer to Cost/Performance Data Section.

TABLE 2

AVERAGE FUNCTIONAL AREA COSTS

FUNCTIONAL AREAS	AVERAGE $/S.F.
CLASSROOM	34.99
OFFICE	35.06
TEACHING LAB	54.87
RESEARCH LAB	54.83
LIBRARY	40.90
GENERAL SERVICE	31.20
NON-ASSIGNABLE	29.18

Where significantly higher costs occur they appear to result from one or more of the following reasons:

1. A program requirement for the higher performance.
2. Redundancy in materials or equipment.
3. Relatively inefficient configuration or arrangement of spaces.

The most conspicuous difference between the unit costs is the much greater cost of laboratory spaces in the Santa Barbara project than in the others. This project resulted in the highest cost per OGSF also. The apparent principal reason for this is the higher performance characteristics of the building.

The higher performance capabilities of the Santa Barbara laboratories result from more plumbing systems, more electrical power capacity, air conditioning with 100% fresh air (no recirculation), humidifiers (lacking in the other projects), considerably more instrumentation and controls on all systems, a completely separate air conditioning system for the animal study areas in the upper floors and similar refinements. The result is the capability of alterting offices to laboratory use and of revising space arrangements with a minimum of disruption.

The high cost of Bloomington's Non-Assigned Area reflects its exterior wall construction, corridor treatment and collegiate Gothic stone detailing. The low costs of the other Indiana examples reflect their relative simplicity and inexpensive treatments of non-assigned space.