CRITERIA FOR HIGH RISE OFFICE BUILDING DESIGN

BASED ON MARKET FEASIBILITY

By

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February, 1963

Submitted to the Faculty of the Graduate School
of Oklahoma State University
in partial fulfillment of the requirements
for the degree of
MASTER OF ARCHITECTURE
May, 1970

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Thesis Approved:

Thesis Adviser

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PREFACE

As our society developed, it brought about subsequent changes in office activities and an increasing awareness that only a thorough understanding of social, economical and other related environmental aspects of a project could produce a satisfactory design for both building owner and tenant.

This study was an attempt to offer a proposal concerning criteria for office building design based upon the investigation of an existing community to find out the feasibility and the scope of the additional need for office space and the most desirable site for the facility.

I would like to take this opportunity to express sincere appreciation for the assistance and guidance given by the members of my graduate committee: Professor F. Cuthbert Salmon, whose patient guidance and encouragement was invaluable; Professor R. Bruce Miller, whose suggestions and directions were of great value; Professor W. G. Chamberlain, for his personal interest and encouragement. A special acknowledgement goes to Mr. Robert E. Grant and Mr. Leo Hass of Whiteside and Grant Realtors, Tulsa, for their interest and assistance. Further acknowledgement goes to Mr. Jack W. Kelley of Transamerica Investment Group, Mr. Jim Ritchy and Mr. William H. Thomas of Tulsa Metropolitan Area Planning Commission and Mr. G. H. Dericks of Tulsa Building Managers Association who provided opportunities to gather the necessary data.

In addition, I would like to thank Mr. Glen A. Summers for his time and effort to proofread this dissertation.

Finally, I would like to thank my parents for their encouragement and sacrifice throughout my study in Oklahoma State University.

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CHAPTER I

INTRODUCTION

The purpose of the study was to develop an office design with specific interest in its economics through the research of real problems in office facilities and analysis of the existing market.

As the modern economy moves toward more service oriented activity, our society has seen a rapid increase in the number of white-collar workers since World War II. The need for integrated office space is increasing as modern office activity shifts from paper oriented work toward more sophisticated automation.

The important role of office buildings can be expressed in terms of capital formation, employment, national wealth, local tax bases, rental income and loan collateral. The construction of an office building, as well as its management are in the category of an income producing business. Investment in office building construction has a greater risk compared with investment in other local business, because any future income is based on counting speculative tenants. The owner's income is directly connected with the tenant's ever changing needs.

The economics of an office facility on the part of an owner (herein to be called client) as well as a tenant has been misunderstood in many cases. The economics must be understood in terms of life-long economy of the facility rather than the cheapest original investment and the lowest rental.

The architect's role in office building design should not be limited to the physical design of a building but extended to help the client analyze the feasibility of the investment and the utilization of his funds to produce maximum income from the investment.

Basic considerations included in the study are:

1) Analysis of the economics of an existing community to determine the feasibility of providing more office space and to determine the scope of the need through a general economics study.
2) Comparative analysis of strategic locations with respect to the locational need, prospect for future development, land availability and its cost, access and zoning requirements.
3) Study of managerial trends to find out the practical needs of tenants and clients.
4) Economic approach in schematic design phase to determine a reasonable way to cut building costs.
5) Basic convenience and flexibility study to design an integrated unit office system.

Building costs cannot be controlled until the problems of the ultimate function of the building are solved. The function of an office facility involves not only aesthetics, circulation and environmental control but flexibility to serve different activities at different times. The life of an office building is not only determined by the life of the structure but the function of the building.

Tulsa, Oklahoma, has been chosen for the purpose of the study in consideration of its significant economic growth in recent years and the consequent need for office facilities to meet business expansion.

CHAPTER II

MARKET SURVEY

Tulsa, Oklahoma

Description of the City

Being an oil capital and an aerospace center, the city of Tulsa is a retail and distribution center of the Southwest.

I-44, which is the major East-West road artery, passes through Tulsa. Four railroad systems and 40 motor carriers serve Tulsa.[1] Located in the center of the nation, it is 1,235 miles from New York, 1,580 miles from Seattle and 1,280 miles from Los Angeles.[2]

Tulsa International Airport is a major junction point for five airlines which schedule over 50 flights daily and the airline passengers during the past five years has increased by 82% from 536,465 in 1964 to 978,047 in 1968.[3]

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[1]Department of Housing and Urban Development, Federal Housing Administration, Tulsa, Oklahoma Housing Market, (Washington, D. C., 1967), p. 1.

[2]Tulsa Chamber of Commerce, Tulsa, the Beautiful City, (Tulsa, 1968), p.1.

[3]Business Research Department of Tulsa Chamber of Commerce, Economic Profile of Tulsa, (Tulsa, 1968), p.9.

Average annual temperature is 60 degrees F.; January average of 40 degrees F. and summertime average of 80 degrees F. The average rainfall is 30 inches annually.[4]

The city of Tulsa is one of the 18 cities in the nation predicted to have more than 4% growth during the 1970's.[5] Today, due to the current development of oil manufactoruing and processing industries and increasing emphasis on the national space program together with several research facilities and civil aviation industries, the city ranks as one of the Southwest's most important industrial centers.

Longtime landlocked Tulsa has become the Westernmost port in the extensive central inland waterway system, serving the warehousing and distribution gateways between a vast 8-state market.

The highrise office building boom starting around 1950 in New York, Los Angeles and San Francisco in 1955, Philadelphia in 1956, Chicago and Minneapolis in 1957, Seattle in 1959, Boston and Milwaukee in 1960, Baltimore in 1962[6] has finally arrived in Tulsa in 1967 with the construction of 610,000 sq. ft. of new office space in four high rise structures in the downtown area.[7]

All indications assure the explosion of industries and business of this city which is already undergoing a spectacular growth in manufacturing.

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[4]Tulsa Chamber of Commerce, Tulsa, The Beautiful City, (Tulsa, 1968), p. 1.

[5]Ibid.

[6]Robert Moore Fisher, The Boom in Office Buildings, Urban Land Institute, (Washington, 1967), p. 6.

[7]Robert E. Grant, Whiteside and Grant Realtors, Tulsa, Oklahoma, Direct Communication, July, 1969 .

The creation of an extensive industrial complex will require the establishment of contract organizations, construction companies and numerous related commercial enterprises, which will require additional office spaces to accomodate their business activities.

General Economics Background

1. Growth of Population: Population in the city of Tulsa has increased 15.5% during the past five years from 290,000 in 1965 to 355,000 in 1969. County population has increased from 378,000 to 424,000 during the same period of time, a rise of 12.2%. An average increase of 2.2% is forecast for 1969-1975 period, almost doubling the U. S. average.

A large portion of the increase has been benefited from the migration which appeared to be much more than the net natural increase during 1960-1967 period, and this trend is expected to continue as job opportunities increase.

TABLE I

INCREASE IN POPULATION IN TULSA AREA

	1960*	1965*	1969*	1980**	1990**	2000**
Tulsa	280,000	290,000	335,000	401,000	500,000	601,000
County	352,400	378,000	424,000	520,000	640,000	790,000

Source: *Economic Profile of Tulsa, 1968, p. 2.

**Ibid., p. 10.

Note: City has an increase of 2.6% during 1968-69 from 326,500 to 335,000. County has an increase of 2.9% during 1968-69 from 412,000 to 424,000.

TABLE II

CHARACTERISTICS OF POPULATION INCREASE IN TULSA HOUSING MARKET AREA

Type of Change	From Apr. 1950 To Apr. 1960	From Apr. 1960 To May 1967
Net Natural	6,000	4,800
Migration	3,100	5,050
Net Increase	9,100	9,850

Source: Tulsa, Oklahoma Housing Market, p. 12.

Note: Rural farm population of Tulsa Housing Market Area constitutes only 2.5% of the total population.

2. Changes in Dwelling Units: In 1968, the total number of dwelling units added for the year in the city jumped 44.6% above the total for 1967 from 3,844 to 5,558, but the city shows a very low vacancy ratio.[8]

During 1962-1968 period, the apartment vacancy ratio has decreased from 18.4% to 8.6% and single family dwelling unit vacancy ratio has shown a steady decrease from 2.7% to 1.8%, which is believed to be very low compared to all national figures.[9]

Building figures show a large increase in apartment construction reflecting a greater absorption rate in recent years.

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[8] William M. Waller, The Tulsa Economic Review, (Tulsa, 1969), p. 3.

[9] Tulsa Real Estate Board and the Tulsa Chamber of Commerce, Tulsa Housing Occupancy-Vacancy Survey Comparison, (Tulsa, 1969), p. 1.

TABLE III

GROWTH IN DWELLING UNITS IN TULSA

Date	Total Units	Vacancy %
May 1962	100,111	4.28 %
May 1964	108,256	4.27 %
May 1966	115,302	3.58 %
Sept. 1968	120,140	2.8 %

Source: Tulsa, Housing Occupancy-Vacancy Survey Comparison, p. 1.

Note: A total of 3,453 units, including 2,453 apartment units, were under construction as of Sept. 1968.

3. Income: Higher wages in manufacturing industries and more weekly hours reflect a rapid rate of economic expansion coupled with a tightening labor market although a large number of in-migration is present.

Along with the increase in income, the figures show a relatively small size of household which is continuously decreasing due to the declining birth rate and higher formation rate of one- and two-person households.

TABLE IV

AVERAGE GROSS WEEKLY HOURS AND EARNINGS OF MANUFACTURING PRODUCTION WORKERS IN TULSA

Year	Tulsa *		U. S.**	
1964	$105.16	41.4 hr.	$103.00	40.7 hr.
1965	111.14	42.1	108.00	41.2
1966	117.47	42.4	112.00	41.3
1967	119.11	41.5		
1968	126.46	41.6		

Source: *Economic Profile of Tulsa, 1968, p. 6.

**Tulsa, Oklahoma Housing Market, p. 9.

TABLE V

EFFECTIVE BUYING INCOME IN TULSA

	Per Capita		Per Family	
Year	Tulsa	U. S.	Tulsa	U. S.
1963	$2,467		$7,509	
1964	2,614		7,949	
1965	2,776		8,415	
1966	2,830	$2,543	8,508	$8,532
1967	2,955	2,697	8,848	9,012

Source: Economic Profile of Tulsa, 1969, p. 5.

Note: The comparison between Tulsa and U. S. in per capita and per family shows comparatively small household size in Tulsa.

Household size has decreased from 3.17 persons in 1950 to 3.11 persons in 1960 and 3.07 persons in 1967.[10]

4. Employment: Tulsa has seen an increase of 17% in its employment during 1964-1968 period, although there has been substantial decrease in agricultural jobs. Unemployment has decreased from 4.3% to 3.1% during this same period of time. The rate of the increase in employment was greater than the rate of increase in population reflecting a growing economy.

TABLE VI

EMPLOYMENT IN TULSA METRO AREA
(IN THOUSANDS)

	1964	1965	1966	1967	1968	1969*
Total Labor Force	178.8	187.1	194.5	200.4	207.50	209.3
Employment	171.2	179.7	188.0	193.9	200.4	201.7
Agriculture	5.6	5.5	5.4	5.2	5.1	5.0
Non-Agriculture	165.6	174.2	182.6	188.7	195.3	196.7
Unemployment	4.3%	3.9%	3.3%	3.2%	3.4%	3.1%
Idled by Labor Dispute	0.0%	0.1%	0.0%	0.0%	0.1%	1.2%

Source: Economic Profile of Tulsa, 1969, p. 8.

*1969 April Preliminary.

[10]Tulsa, Oklahoma Housing Market, p. 13.

TABLE VII

EMPLOYMENT BY MAJOR COMPANIES IN TULSA

	1967*	1968**
American Airline Inc.	4,750	5,000
North American Aviation	3,550	5,000
McDonnel-Douglas Corps.		3,300
Sunray DX		2,577
Pan Am Petroleum		2,016

Source: *Tulsa, Oklahoma Housing Market, pp. 6-7.

**Tulsa Employers Ranked by Extimated Number of Employees, p. 1.

5. Cost of Living and Utility Consumption: Of particular interest to manufacturers and industrialists are the low index figure of utility costs which includes the cost of electricity, natural gas, water and telephone. This figure is not only indicative of lower costs but the availability of these utilities.

The consumption of electricity increased by 44.4% during 1964-1968 period. An increase of 15.9% in commercial power consumption and 14.2% in commercial gas consumption during 1967-1968 period indicates gigantic growth of industry and business in recent years.[11]

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[11]William M. Waller, p. 2.

TABLE VIII

COST OF LIVING INDEX IN TULSA
(U. S. AVE. 100)

Year	All Items	Food	Housing	Utilities	Misc.
1968	91.8	100.5	100.0	82.9	104.0
1969	100.2	99.2	107.4	84.2	100.7

Source: Economic Profile of Tulsa, 1968, p. 12 and 1969, p. 12.

TABLE IX

UTILITY CONSUMPTION IN TULSA

Year	Electricity (KWH)	Gas (MCF)	Water (Gallons)
1964	1,403,949,129	64,056,653	18,558,300,000
1965	1,518,603,594	67,897,428	19,097,900,000
1966	1,678,818,136	69,069,226	19,528,000,000
1967	1,753,887,046	69,807,129	18,181,600,000
1968	2,026,315,097	71,497,568	19,122,200,000

Source: Public Service Co. of Oklahoma, Oklahoma Natural Gas Co., Tulsa City Water Department and Economic Profile of Tulsa, 1969, p. 12.

6. Construction Valuation: Value of total building permits has doubled during 1964-1968 period. Most of the increase occurred in the category of housing.

TABLE X

VALUE OF TOTAL BUILDING PERMITS IN TULSA

Year	Total Value
1964	$45,698,887
1965	45,896,856
1966	70,013,682
1967	85,448,648
1968	91,277,202

Source: Economic Profile of Tulsa, 1969, p. 7.

Business Characteristics

1. Major Business: Beginning around 1905, Tulsa became the major oil capital in U. S. which presently is more a center of oil industry administration than petroleum production. Over 800[12] oil companies maintain offices in Tulsa including the home of regional offices of large companies such as Sunray DX, Pan American, Sinclair and Skelly, as well as multiplicity of smaller producers, marketers, suppliers, etc

During World War II, Tulsa became an important air-frame productio center. Many of the facilities originally constructed for aircraft

[12]Tulsa, Oklahoma Housing Market, p. 3.

manufacturing are now being utilized in the development of Tulsa as a space, electronic and research center.

North American Aviation, a prime contractor for the Apollo project is increasing its business by seeking diversification into the manufacture of components for commercial aircraft.

American Airlines is continuously growing by extending its services to several other aircraft companies.

Douglas Aircraft Co., Tulsa Division, which has experienced a severe business cutback after World War II and the Korean War, is now coming out of its setback and presently is a modification and repair center for military aircraft and an assembly center for commercial aircraft.

2. Arkansas Navigation Project: The 450-mile waterway connects the Mississippi River to the Arkansas River with the Port of Catoosa, located near Tulsa. The nine-foot deep channel is 250 ft. wide on the Arkansas River and 150 ft. wide on the Verdigris River where the port is located.[13]

The project will return $1.50 for each $1.00 invested by the federal government, an estimated direct benefit of $7,000,000 annually.

The project will store an additional 1.2 million acre-ft. of water and generate 378,000 kw of power. An estimated 13-million tons of commerce will move on the waterway annually. Of the 65 commercially producible minerals in the Tulsa area, 3.5-billion tons of coal on the bank of the channel is of major interest.[14]

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[13] U.S. Army Engr. Dist., Tulsa, Barging Ahead on the Arkansas, (Tulsa, 1967), p. 1.

[14] Ibid.

The abundant and low-cost utilities have already been one of the major reasons of the city's attraction for new industries. Now the project is adding more utilities as well as transportation.

The 25 largest cities in the U. S. are served by water-transportation has doubled in the last 10 years.[15] The navigation channel means that Tulsa will experience a booming growth providing more job opportunities in the area.

Space Rental Potentials

1. Increased Retail Sales: The largest non-manufacturing category in the area is wholesale and retail trade reflecting, in part, the importance of Tulsa as a distribution and trade center.

The increase in recent years in retail sales explains the growth in business volume. With increase of retail sales activity, business and professional office spaces are demanding more attention than ever.

There has been a continuation of decentralization of office facilities toward suburban districts of the city creating some vacancies in downtown and creating more need for them in suburban areas. With the standard of $55.00 per sq. ft. for the retail sales projected and $37.50 per sq. ft. for existing space,[16] the city will need approximately 1,200,000-1,500,000 sq. ft. of additional retail space annually in the 1970's.

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[15] U. S. Army Engr. Dist., Tulsa, Barging Ahead on the Arkansas, (Tulsa, 1967), p. 1.

[16] Tulsa Metropolitan Area Planning Commission, Projection of Trip Generation Factors: Continuing Transportation Study, Tulsa Retail Sales Expenditures and Space, Research paper No. 40, (Tulsa, 1966), p. 13.

[17] Ibid.

TABLE XI

INCREASE IN RETAIL SALES IN TULSA AREA

Year	City	County
1964	$666,970,024	$705,711,249
1965	718,256,247	760,743,473
1966	753,919,155	797,749,105
1967	758,192,912	829,707,976
1968	821,429,175	905,596,159

Source: Economic Profile of Tulsa, 1969, p. 3.

2. Existing Office Market: The booming economy has brought tightening money and high interest rates which has inevitably affected the construction market. Moreover, the largest portion of the investment in the building industry is being used to solve the threatening housing problems.

The building value in apartment and in multi-family dwellings had increased by 85.3% during 1967-1968 period while the building value on commercial construction had decreased by 3% during the same period of time.

Most of the existing office buildings are obsolete with very low occupancy and many are to be demolished by urban renewal or for more parking space in downtown.

The need for more office space is estimated to be 5% over the previous year[18] considering practical demand for new spaces. With the pre-

[18] G. H. Dericks, Building Managers Association, Direct Communication, July, 1969.

sent office space of 4,487,290 sq. ft. as of Oct. 31, 1968[19], annual increase of 5% would be 350,000-400,000 sq. ft. of net rentable area.

TABLE XII

TOTAL BUILDING PERMIT NUMBER AND VALUE IN TULSA

	1967	1968	% Change
Total Bldg. Permit Number	9,887	9,070	-8.3%
" " " Value	$85,448,648	$91,277,202	6.8%
Comm. Bldg. Permit Number	698	666	-4.6%
" " " Value	$37,507,798	$36,378,366	-3.0%
Apt. & Multi-Family Permit Number	85	94	10.6%
" " " Value	$13,160,100	$24,440,300	85.7%
Number of New Dwelling Units	3,844	5,558	44.6%

Source: William M. Waller, pp. 2-3.

[19] G. H. Dericks, Building Managers Association, direct communication, July, 1969.

Strategic Locations

Basic Considerations

Selection of sites are of compelling significance because the selec tion of the site generally influences the ultimate cost of the building. The variations in costs are often caused by a composite of the influences of climate, codes and construction labor practices. In this study the regional characteristics of minor concern such as climate and labor practices were omitted.

Factors to be considered and weighed concerning the location of the building are; cost of land in various locations; competitive facilities in each area; availability of water, gas, electricity and sewage systems cost of preparation of site including landscaping and parking.

The first part of the study is to locate an area most suitable for an additional office facility in consideration of their respective business characteristics, future prospects, existing competitive facilities, transportation systems and land values.

The second part of the study is devoted to selection of an actual site within the region through a comparative analysis of land value, land size, access and zoning requirements.

Referring to the map of Tulsa on the next page, three areas, Sector 0, Sector 7 and Sector 4, have been chosen with respect to their significant characteristics. Four vacant sites have been selected from Sector 4 for the latter part of this discussion.

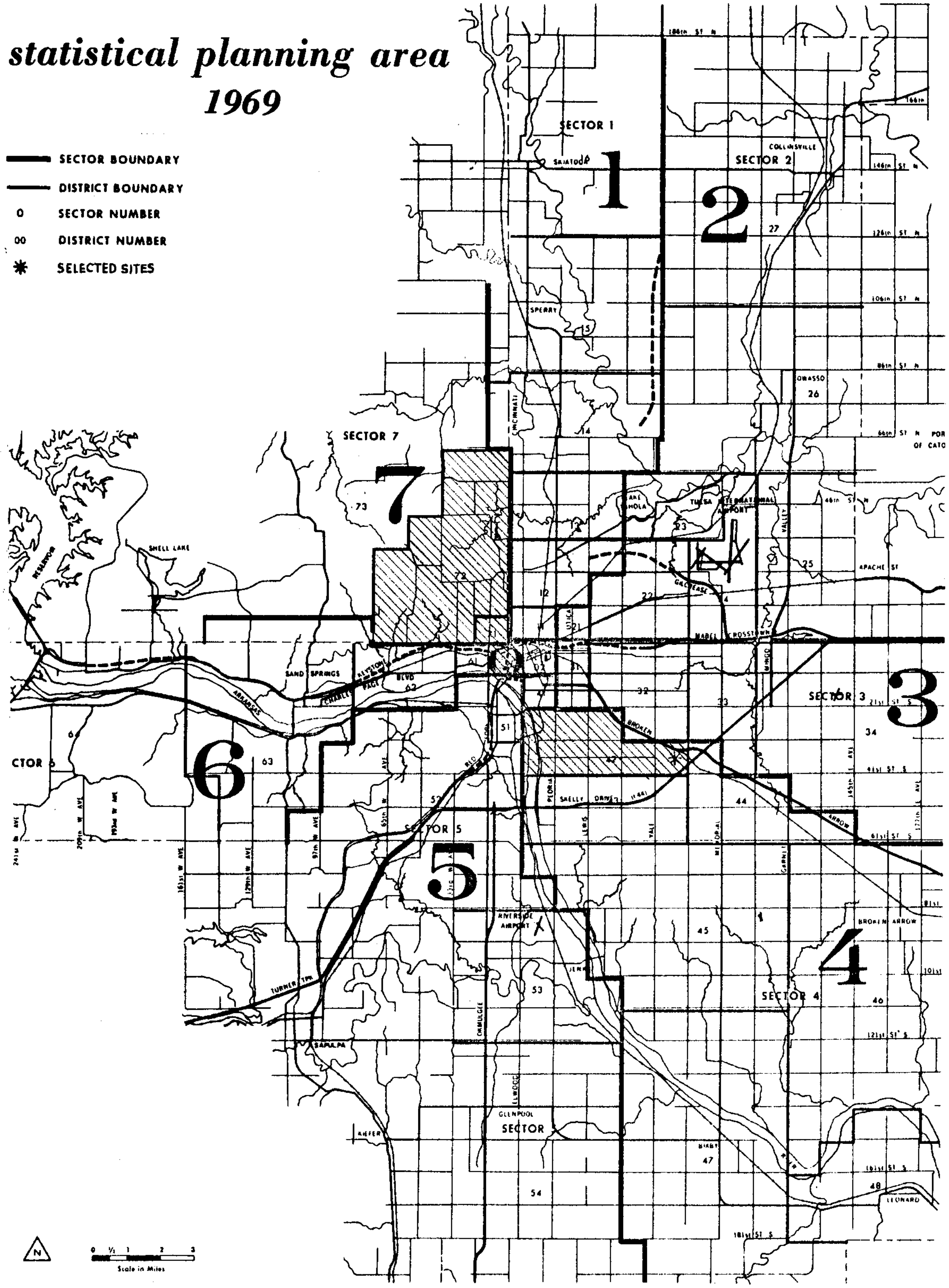

Figure 1. City Map

Locational Choice

1. Downtown Sector 0: The recent completion of the federal office building complex has caused a considerable amount of vacancy in some of the older structures in downtown, and proposed urban renewal projects will eliminate over 100,000 sq. ft. of older office space.[20] The overal office vacancy rate in the city of Tulsa was 7.33% as of Oct. 31, 1968[21] of which a large portion was contributed by the high vacancy ratio of older buildings mostly located in downtown. Large companies such as Pan Am, Skelly and the 4th National Bank have built their own private offices, leaving vacancies in the buildings they formerly occupied. The downtown area seems to keep its balance between new construction and the demand by increased business activities together with the vacancies caused by the removal of offices for new structures.

Several expressways are under construction of projected to serve downtown, forming an expressway loop around the downtown business district.

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[20] Leo Hass, Whiteside and Grant Realtors, Tulsa, Direct Communication, July, 1969.

[21] C. H. Dericks, Building Managers Association, Tulsa, Direct Communication, July, 1969.

TABLE XIII

HIGH RISE OFFICE BUILDINGS BUILT IN 1967 IN DOWNTOWN TULSA

Building Name	Total Area	Rentable Area	Vacancy	Rental
ɔurth National	260,000 sq. ft.	220,000 sq. ft	20%	$5.00
ɔme Federal	50,000	5,000	10	5.50
an Am South	100,000	none		
ederal (public)	200,000	none		

Source: Leo Hass, Whiteside and Grant Realtors, Tulsa, Direct ɔmmunication, July, 1969.

2. Sector 7: The northwest section of the city has not been devel- ɔed although it has the advantages of close proximity to downtown and ery low land costs.

This area is now housing low income groups of the city and land sage was only 9% as of 1964. Considering these advantages of easy ccess and low land cost, the housing authority is planning several ılti-family housing projects in the area.

The Sequoyah Loop penetrates the northwest area and connects Sand orings with Tulsa. The Osage Expressway will connect Skiatook with ılsa while serving the northwest area from downtown. Keystone Express- ıy will circle this area to the the north. When the downtown north- st Urban Renewal project is completed, futher development will spread ıto this area.

3. Sector 4: Among the several districts in Sector 4, District 42 ıs been chosen for the study. Along with the growth of the city toward e southeast, District 42 has increased more than double in its popula-

tion compared with the overall growth of the city, the area is becoming an active business center complementing the downtown.

On the east boundary of this district is the junction of I-44 and the Broken Arrow Expressway. The central portion is developed mostly for retail activities and the west side of the district has been developed for multi-family apartment housing complex. The west side of the district along the Arkansas River will be completely developed for housing in the near future with the completion of the Riverside Expressway.[22]

The location of this district is such that it provides easy access to Tulsa International Airport, to the Port of Catoosa, to the large Industrial Parks and to rapidly growing Broken Arrow which is the major satellite city in the county.

Southland Finance Center, built in 1968, shows a 10% vacancy rate of 95,000 sq. ft. of rentable space; Lewis Square Building having 19,000 sq. ft. of rentable space is 10% vacant; 5500 Skelly Drive Building shows a 16.6% vacancy rate of 27,000 sq. ft. of rentable space within 2 months of its operation as of August, 1969.[23]

Among the three areas, the downtown area has the greatest demand for more office spaces, but the scope of development in the area is somewhat restricted by the land costs and its availability and the investment will involve demolition of existing structures. Moreover, it is believed to be much more dependent upon the client's specific needs. Compared with Downtown, District 42 has the greatest

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[22]William H. Thomas, Traffic Assistant Engineer, T. M. A. P. C., Direct Communication, August, 1961.

[23]Leo Hass.

TABLE XIV

STATISTICS OF SELECTED AREA

	Sector 0	Sector 7	District 42
Description	Downtown	Near Slum	Major Residential
Population* 1967	1,000	5,100	98,000
1990	1,500	32,000	185,000
Land Value**	$20-50/sq. ft.	$1.50/sq. ft.	$1.50-2.00/sq. ft.
Total Land Acre***	189.34	9,761.38	21,951.27
Utilization of Land Acre****			
as of 1964 Resi.	49.65	600.94	9,753.91
Comm.	56.66	9.38	547.20
Indus.	13.89	211.75	853.71
Misc.	69.14	91.98	1,693.00
Total Development	189.34(100%)	914.04(9%)	12,847.82(59%)
Land Use Characteristic	Commercial	Under Developed	Large Residential
Retail Sale in thousands*****			
1964	65,000	2,256	83,700
1970	68,000	3,000	130,000
1975	74,000	5,000	170,000
1980	77,000	7,500	210,000
1985	80,000	12,000	249,000
Office Space Needs sq. ft.			
1964-1970	300,000	14,700	200,000
1970-1975	280,000	16,000	168,000
1975-1980	250,000	32,000	128,000
1980-1985	235,000	64,000	136,000
Retail Space Needs sq. ft.			
1964-1970	relatively	13,360	841,820
1970-1975	small and	36,360	727,270
1975-1980	fluctuating	45,450	727,270
1980-1985		81,820	718,180
Major Access***** Expressways (Only Broken Arrow and Skelly Drive existing now)	Broken Arrow Osage Cherokee Cross Town	Osage Sequoyah Keystone	Broken Arrow Skelly Drive Riverside Drive Mingo Valley
Expected Development Period		Remote	Immediate
Existing Competition	Heavy	None	Light

TABLE XIV (Continued)

Source: *T. M. A. P. C., Research Paper No. 2, pp.18-20.

**Robert E. Grant.

***T. M. A. P. C., Research Paper, No. 4, p. 3.

****T. M. A. P. C. Research Paper No. 10, pp. 9-12.

*****William H. Thomas.

potential for the increase in retail sale and population, and it was only 59% developed as of 1964. It is also believed to provide more flexibility in the choice of site and its scope of development.

The area near the juncture of I-44 and Broken Arrow Expressway is located adjacent to the eastern boundary of District 42 along Sheridan Ave. with Industrial Park across I-44, adjoining a recently developed shopping center, Pan Am and Sinclair research laboratories and newly built South-Eastern Bank and City Central Bank in near proximity.

The locational advantages are:

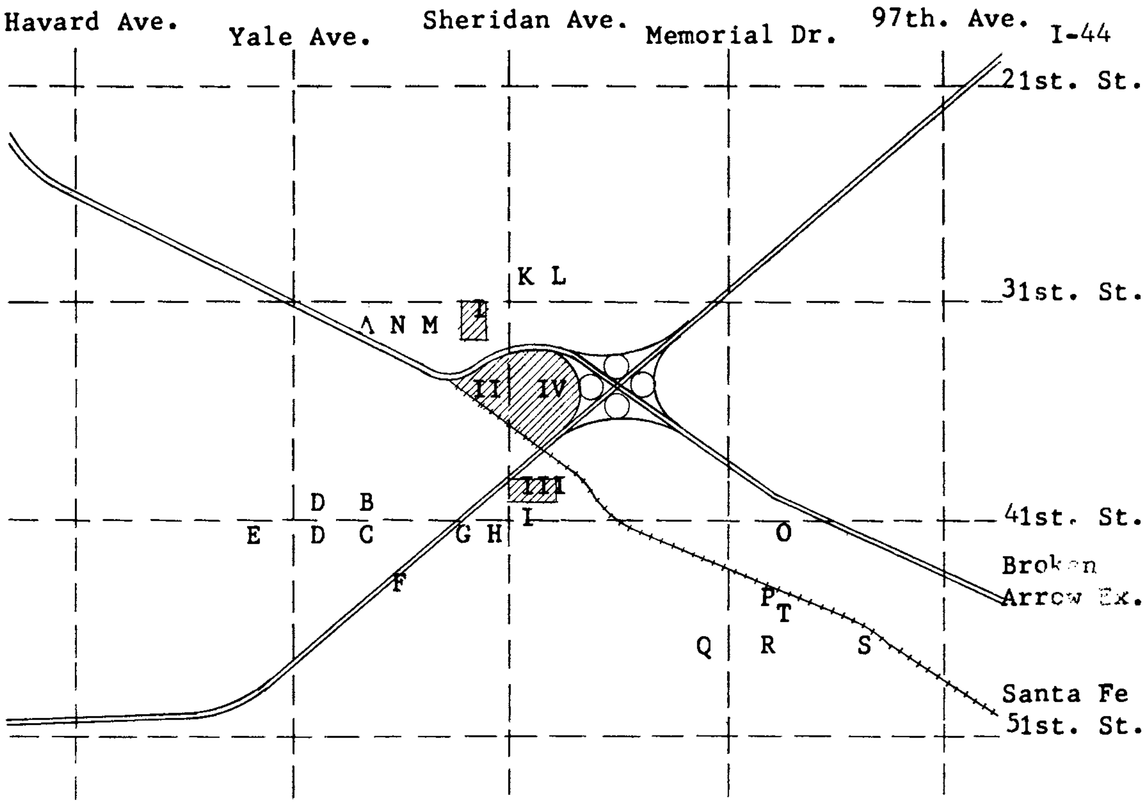
1) Situated in the city's most rapid growth area;
2) Easy access to major highways; and,
3) Proximity to and from downtown, industiral parks, International Airport, major housing, labor pool and the Port of Catoosa.

The selected site features are:

1) low land cost;
2) ample space for expansion;
3) easy approach;
4) good visibility from major highways;

5) surrounded by active business developments; and,

6) possibilities of absorbing existing nearby office tenants.



Site I
Site II
Site III
Site IV

A	City National Bank	L	Safeway Shopping
B	Southeastern Bank	M	Will Rogers Store
C	Mercantile Bank and State Federal Savings	N	Southeast Medical Center
D	Southland Shopping Center	O	Industrial Equipment Center
E	Pan-Am Research Center	P	Memorial Industrial
F	Sinclair Research Laboratory	Q	First Research and Development Center
G	Seismograph Service Company	R	Jones Trucking Center
H	Midwestern Instrument	S	Regency Industrial Addition
I	Nelson Electric, Tulsa Plant	T	Professional Office Buildings
J	Mamman Storage		
K	Boman Twin Shopping		

Figure 2. Selected Sites

<u>Comparative Site Analysis</u>

TABLE XV

EVALUATION OF THE SELECTED SITES

	I	II	III	IV
Size (ft.xft.)	303 x 405	1,000 x 1,500 (Approx.)	500 x 1,500 (Approx.)	1,000 x 2,000 (Approx.)
Land Cost $/sq. ft.*	.60	.75	1.00	.50
Level	Level with 31st St.	±4 ft. high from Sheridan	±2% slope dn. from Sheridan	Level with Sheridan
		Below Broken Arrow	Below I-44	Below I-44 & Broken Arrow
Room for Expansion	Restricted	Partially Restricted	Ample	Ample
Access to Broken Arrow	Fair	Immediate	Fair	Immediate
Access to I-44	Good	Fair	Immediate	Fair
Adjacent Road	W. 31st St.	Sheridan	Sheridan/West 40th St.	Sheridan
Adjacent Develop.	Shopping Medical	Minor Retail	Industrial	Highways
Railroad	Remote	Adjacent	Far	Near
Zoning*	U3D	U4A	U4A	U4A

Source: *Leo Hass.

Site I has been immediately removed from consideration because of its zoning requirement. Site II is a triangle surrounded by Sheridan Ave., Broken Arrow Expressway and Santa Fe Railroad and the price and the size are medium among the four sites. It has immediate access to Broken Arrow but Santa Fe blocks the site completely, leaving no chance of expansion on the site. It is ±4 ft. higher than Sheridan Ave. and ±20 ft. below Broken Arrow Expressway.

Site III is the highest in land cost and it has the advantage of facing Sheridan Ave. and 40th St. on both sides. Having ample room for expansion, it is the closest to the Industrial Park and highly developed Southland Shopping Center.

Site IV is across Sheridan east of Site II and has similar conditions as Site II, except the size is larger and the land cost is the lowest among the four sites. The ground is level with Sheridan Ave.

Site III and Site IV are believed to be the best locations for new office facilities.

These sites are all located nearby the Industrial Parks and all the utility mains are in easy access from the sites.

Zoning Requirements

Zoning and property restrictions, City of Tulsa, Oklahoma, Chapter 3, Classification of Uses:

U3D; Restricted Commercial District

All retail commercial uses (except those listed under U3E and U3F). Building limited to one story or 30 ft. in height and 50% coverage of the lot. Building must be set back 10 ft. from residential district.

U4A; Light Industrial District

Permitted uses beside U4A purpose are;
U3A Off Street Parking District
U3B Professional Office District
U3C Special Service District
U3D Restricted Commercial District
U3E General Commercial District
U3F Heavy Commercial District

U3B Professional Office District;

1) Permitted for offices of persons in the following professions; a. Law, b. Accounting, c. Architecture, d. Chiropody, e. Chiropractice, f. Dentistry, g. Engineering, h. Medicine, i. Optometry, j. Ostheopathy, k. Healing-arts, l. Electrology, m. Real Estate Brokage, n. The office of shop of pharmacist or druggist as defined in Title 59, o. Insurance Sales office or Insurance Brokage office, p. Funeral Homes

2) No building or structure shall be erected, arranged or maintained exceeding 60 ft. in height, provided the portion of any building in excess of 60 ft. is set back from the front property line 2 ft. horizontally for each foot in excess of said 60 ft.

CHAPTER III

DESIGN CRITERIA

General Economics

Value can be expressed in terms of the least cost to accomplish a given function. Maximum income from minimum investment is the best that can be expected in building an office facility. But the minimum investment should be enough to provide every opportunity to meet possible changes. The office is a facility based on change.

There are in excess of 21,000 distinct occupations,[24] over 2,000 different professions are primarily office dwellers. Moreover, the renewed rise of the individual as a value and the great diversity in what one may be required to do in an office does not allow a continuation of sterile uniformity in office space.

Recent statistics show that all the American enterprises must grow at least 8% annually[25] to be economical or to survive competition. So, the consideration of economics in office construction must be based on the provision for changes incident and the changes for the future.

The average post war office buildings, in fact, has been surprisingly small, partly reflecting widespread suburban construction. During

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[24] Robert Propst, The Office, A Facility Based on Change, (Elmhurst, 1968), p. 17.

[25] Ibid., p. 13.

1965, the average new private office building was valued at only $153,-500 containing no more than 15,000 sq. ft. or so. This was close to the average of 17,600 sq. ft. of floor space in new state and local public office and court building erected between 1961-1962.[26]

The tendency for a few large, new buildings to dominate local markets for high quality office space follows in part the limited annual production of new structures. Advantages of greater scale can bring maximum rent meeting the need of tenants both large and small.

The annual interest rate in Tulsa is 7%,[27] which is fairly low compared with the national rate of 7.5%. The investment in an office facility in the city of Tulsa can be more profitable than any other city if the utilization of funds are properly managed.

Interest of Client and Tenant

The interest of the client can be stated in terms of tenant's need as mentioned earlier in the Introduction. The tenants' needs change as their managerial systems change to accommodate their changing patterns of business activities.

Privacy has long been the prime and most important factors in office layout resulting in linear allocation of office cubicles with executive rooms at the end of long corridor, symbolizing an unapproachable status. As the labor costs and rentals go up, and the amount of work to be done in a limited space with a limited personnel increases, the office activity requires complete involvement of everyone concerned. Growing organ-

[26]Robert Moore Fisher, p. 12.

[27]Robert E. Grant.

tions are experiencing continuous re-organization to meet expansion h subsequent changes in their work patterns, and the executives be- ie more involved in activities within the office.

There has been a great revolution in office layout in the past few rs, the idea in Landscaping Office Layout and Action Office II are aiming to accomplish the best managerial results besides solving iberous problems such as flexibility, economy, acoustics and even chological aspects of the office workers.[28]

The introduction of computers and other electronic devices has nged the communication and administration patterns and is also chang- the environment at work stations. Traditional paper filing systems e been found inefficient to handle ever-increasing amounts of infor- ion. Added to these complexities are the greater need for individ- ity.

The office is a mind-oriented living space. The efficiency of the a is directly related to function in terms of human response. The erest of the client in designing office space should be centered n the provision and the maintenance of the space in a way the tenant ds, and with the least cost.

The investment in office building construction must be thoroughly died before any decision is made. In case of addiditonal investment, expected income from the added investment must be compared with the ome the owner could obtain on his additional money, if invested in ther project with the same risk (equivalent to a second mortgage). 5% interest is not unusual for commercial second mortgages, to the

[28]Charles W. Gilbert, Office Design, (Volume 7, No. 1), pp. 20-23, ume 7, No. 4), pp. 22-24, and Robert Propst, pp. 42-68.

extent they are marketable at all.[29] The income from added original cost can be interpreted in terms of savings in annual cost. A rough rule of thumb indicates that the original investment can be economical only when the original/annual cost ratio is over 5/1.[30]

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[29]King Roger and Brad Howes, "Cost Control for the Life of Building," Creative Control of Building Cost, William Dudley Hunt, Jr., ed., (New York, 1967), p. 31.

[30]Ibid., pp. 31-48.

The following table shows the managerial experience of office buildings in the City of Tulsa compared with all city averages in the U. S.

TABLE XVI

AVERAGE INCOME AND EXPENSE ($/SQ. FT. FOR TOTAL RENTABLE AREA)

	1966		1967	
	Tulsa	All City**	Tulsa***	All City****
Average Rental	4.18	4.61	4.29	4.85
Operating Cost (A)	1.94	1.57	1.95	1.67
Construct. Cost (B)	.279	.252	.463	.27
Fixed Charges (C)	1.35	1.35	1.37	1.49
Total Expenses (A + B + C)	3.45	3.19	3.63	3.43
Total Income	3.83	4.14	4.05	4.46
Operating Ratio	90.0%	75.1%	92.2%	75.4%
Management Ratio	55.3%	43.7%	57.3%	42.9%
Real Estate Taxes	.539	.655	.54	.72
Depreciation	.749	.660	.84	.73
Ave. Vacancy Ratio	4.5%	4.5%	5.9%	3.5%
Ave. sq. ft./Person	132.7	134.2	143.6	138.3
Ave. Tenant Occupation sq. ft.		5,857		2,447

Source: Office Building Experience Exchange Report, Building Owners and Managers Association International, (Chicago, 1967, 1968).

*1967, p. 41.

**1967, p. 9.

***1968, p. 45.

****1968, p. 9.

TABLE XVI (Continued)

Note: Operating Cost; Mechanical, Electrical and Plumbing Operation.
Construction Cost; Tenant Alteration, Repair-Maintenance and Tenant Decoration.
Fixed Charges; Insurance, Property Taxes and Depreciation
Operating Ratio; A Ratio of Total Expenses to Total Income
Management Ratio; Operating Ratio omitting Fixed Charges.

Among the items contributing to the total income, the rental reflects the typical economy of the respective office market. The office rental in the City of Tulsa ranges from $3.50/sq. ft. in old space to $5.50/sq. ft. in new structures. The discussion on the rental comparison in the table are beyond the scope of this study.

The higher operating ratios are somewhat unbelievable because the city has a low index figure in utility costs compared with the U. S. average. The figures reflect, in part, that the utility operation system in the buildings submitting the information are not properly managed. The higher construction costs show that these buildings are undergoing big reformation with excessive amounts of money. These figures reflect that the buildings have not been adequate for the tenants' usage and the systems have not been flexible enough to meet the changes easily, the discussion this study is mostly concerned with.

The resulting operating ratio of over 90% means that these buildings have failed in their operation, and that there have been significant mistakes on the part of the building management and on the part of the design itself.

Among the expenses, Fixed Charges are the kind that designers have almost nothing to do with except to cut down the insurance charges by

:ding adequate fire protection. The operating cost, composed of :ty comsumption and the necessary labor costs, can be controlled :fined utility distribution systems and proper selection of equip- , but the more important problem in the utility systems rests upon :lexibility of the system to meet the future changes of patterns.

.zation of Budget

1. Propoective Tenants and Type of Building: In actual design :, the size of an office building could be decided from the floor : estimation for the prospective tenants or the clients specific re- :ments.

Local prospects for the construction or leasing of floor space in ıtely owned building, accordingly, depends upon estimations about 'e floor space requirements of public tenants, and the degree to ı they will be met by privately owned structures.[31] Recently, the has completed its public office complex absorbing most of the public :es which formerly occupied private office buildings.

In this study, the speculative need for more office space has been ıated for each District without consideration of any need for large .c tenants.

The prospective major tenants for an office facility will be:*

a) local sales business;

b) highway business;

c) bank;

d) professional offices; and

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[31]Robert Moore Fisher, p. 4.

e) contract organizations (i.e. insurance, bonds, etc.).

* Information from Tulsa Chamber of Commerce Project for the Area.

For further study, floor space of 100,000-120,000 sq. ft. has been chosen in consideration of the speculative need with respect to the statistics discussed in CHAPTER II and the median size of the successful local office buildings.

The type of building will be a private office building. Private office buildings have a broader range of choice of financing than for many other types of income producing properties and loan terms on private office buildings tend to be somewhat more liberal, often reflecting the use of a relatively long-term lease.[32]

Considering the economic rentable area of 80-85%[33] of total floor area, the rentable area will be 80,000-92,000 sq. ft. Applying the recent need of 140-150 sq. ft./person,[34] the number of persons occupying the building will be 540-680 persons.

2. Parking: The most important problem in an office facility is the parking. The parking can be the most expensive investment in some cases, and it can be the added income source in other cases. In the case of this study, the land cost is fairly low and available so that it can be used to provide additional income to the client.

The economics of enclosed parking compared with open parking may be decided by the cost of the land. $5.00/sq. ft. is believed to be

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[32] Robert Moore Fisher, p. 4.

[33] Jack W. Kelley, Transamerica Investment Group, Inc., Direct Communication, July, 1969.

[34] Building Owners and Managers Association International, p. 9.

the maximum land cost on which open parking can be built economically.[35] The land cost of Site III and Site IV are under $2.00/sq. ft. The cost of enclosed parking ranges from $1,000-$4,500/car[36] or approximately $4.00-$11.00/sq. ft. Enclosed parking must consider the extra operating cost in addition to the original investment.

The open parking is obviously more desirable than enclosed parking in most cases, unless there is tenants' need for enclosed parking.

The City of Tulsa has no parking regulation for office facilities.[37] In 22 major cities in the U. S., the parking requirements for office facilities are minimum one car/3,000 sq. ft. of office floor area and maximum one car/150 sq. ft., or maximum one parking/3 employees and mimimum one car/5 employees. In centers more dependent upon automobile shoppers, parking/floor area ratio of 3/1 is said to be desirable and a ratio of 2/1 for less dependent areas.[38] The office under consideration will use the median requirement of the cities investigated; one car/300 sq. ft. of office floor space.

The number of parking spaces derived from applying one car/300 sq. ft. of office floor space will be 340-400 or approximately 100,000-130,-000 sq. ft. of parking area. For tenants who require more parking spaces than established one car/300 sq. ft. of floor space, enclosed

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[35]Jack W. Kelley.

[36]J. T. Greenberg, "Control During Schematic Design," William Dudley Hunt, Jr., ed., p. 172.

[37]William H. Thomas.

[38]The Eno Foundation for Highway Traffic Control, (Saugatuck, 1952), p. 59.

:ing will be arranged with a rent of $17.00-20.00/parking/month.[41]

3. Basement: The construction of basement for the purpose of ;e is very undesirable because the basement is the least income- lucing space.

TABLE XVII

ALL CITY RENTAL AVERAGE (BY THE TYPE OF SPACE)

	1965	1966	1967
Ave. Rental	$4,46	$4.61	$4.58
Store Rental	4.59	4.67	5.39
Basement Rental	1.73	1.99	2.03

Source: Office Building Experience Exchange Report, 1967, p. 4, 1968, p. 4.

The reasonable case for the construction of basement will be:

a) When the facility needs more space, yet its volume and height are restricted by zoning;

b) Structural reasons; and,

c) Managerial requirements.

In this study, the need for basement will be the managerial re- 'ements; housing of facilities directly connected with the management

[41]Robert E. Grant.

and maintenance of the building which are not direct income-producing sources. Since all the utilities are supplied from underground, the receiving and operating rooms of utilities would be better located in the basement rather than in superstructure which can produce direct income, but the location of each utility distribution station must be studied further to find out the optimum economy and flexibility of the distribution system.

4. Ground Floor: The ground floor should be the best income-producing space or at least it should contribute the most to the basic function of the building.

Possible tenants of the first floor are banks, retail stores, cafeterias or other tenants of public character. Among the speculative public tenants, the cafeteria is the least income-producing facility[42] and retail stores do not represent the character of the building. The bank is the most desirable and supporting character for the purpose of the building.

5. Economic Aspects of the Proposed Office Building: Following is the estimation of financing the building construction and its feasibility study.

a) Description of project

Building Type:	Office Building
Total Floor Area:	100,000 sq. ft.
Unit Floor Area:	10,000 sq. ft.
Land Value:	$1.00/sq. ft.

b) Economic Aspects

1) Construction Cost for 100,000 sq. ft. office space

Construction Cost	$24.50/sq. ft.
Construction Financing	$ 1.50/sq. ft.
	$26.00/ sq. ft.
Total Construction Cost	$26.00 x 100,000 = $2,600,000

[42] Jack W. Kelley.

2) Operating Cost for Total Rentable Area

Operating Expenses (Mechanical, Electrical & Plumbing)	\$1.70/sq.ft./year
Construction Costs (Tenant Alteration, Decoration & Repair-maintenance)	\$ .30/sq.ft./year
Fixed Charges (Taxes & Insurance)	\$ .60/sq.ft./year
Total Operating Cost	\$2.60/sq.ft./year

3) Financing

20% Equity $\$2,600,000 \times \frac{20}{100} = \$\ 520,000$

80% Mortgage $\$2,600,000 \times \frac{80}{100} = \$2,080,000$

4) Income

\$5.50/sq. ft.

5) Annual Debt Service

7% interest w/25 year mortgage (annual payment is 8.49% of total loan)

Annual payment $\$2,080,000 \times \frac{8.49}{100} = \$176,592$

6) Cash Flow

The annual cash flow should fall in between 10-12% of equity to be economical.[43]

\$/year	79% Rentable Area	82.5% Rentable
Total Income	435,000	453,750
Operating Expenses	205,400	214,500
Debt Service	176,400	176,592
Total Expenses	381,992	391,092
Cash Flow	53,008	62,658
Cash Flow/Equity	10%	12%

7) Depreciation, like interest and expenses, is tax deductable, and to the extent that depreciation exceeds amortization, there is a tax-sheltered cash flow. Selection of the type of running depreciation whether

[43] Leo Hass.

a straight-line depreciation or an accelerated depreciation is beyond the scope of this study.

Schematic Study

)e of Study

This study includes space and volume analysis, circulation problems economic aspects of utility systems.

Difference in the type of construction used and the quality of the :rials going into the building can result in a wide latitude of costs. building may have the same basic structural frame and still vary the .ity of finish from minimum, average and excellent, since cost in the of structural construction will vary only slightly.[44] In constrast, e are areas in which the range of cost is quite large; structural ems for ceiling; plumbing; sprinkler; air-conditioning and vention; electrical work; site work and elevators in high rise office dings. The range of costs between minimum quality and excellent ity may vary greatly.

The structural problems in this study will be dealt with only in ection with the function of the space, since the basic role of the cture is to provide a space that can work functionally and safely the intended purpose. The findings and decisions made in this study be applied in the Unit System Study in a later chapter.

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[44] Charles Luckman, "Determinant of Building Costs," William Dudley , Jr., ed., p. 24.

Circulation and Function

1. Shape and Form: All the modern living is based upon certain standards both in economic and practical aspects. Standardized systems, applied to building design, means repetition and interchangeability of parts and materials that assure the integrity of the space with satisfactory environmental control while providing flexibility for future assignments. Properly oversized utilities, structural members, etc., do not of themselves satisfy the criteria for flexibility. Needed is an integrated system which enables designers of the future addition to add and to alter without serious dislocation, service impediments or high cost.

The first stage in deciding the shape and volume will be determined by the size and shape of unit floor area in connection with total floor area.

> [45]The added cost of constructing a higher tower is offset by the premium rentals the upper floors bring. Such space is quiter and cleaner; offers daylight, privacy, prestige, and a view. At any level, the area not more than 26 to 30 ft. from daylight (inner plus outer space) pays larger rentals than darker space, hence, the popular slab form. Constructing large area floors with much inside space (i.e., the zoning ziggurat) is in most cases penny-wise and pound-foolish, for such space brings a lower rental in good times and in hard times, possibly none.
>
> The picture today: a real estate boom plus unprecedented demand for space plus high building costs mean higher buildings, higher rentals. The trend to taller, leanear buildings is everywhere evident.

Among the construction costs, a large amount goes into the construction of exterior walls and interior partitions. The building

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[45]F. W. Dodge Corp., Office Building, An Architectural Record Book, McGraw-Hill (New York, 1961), pp. 2-3.

shape can greatly affect the area of exterior walls. The most economic shape will have the most functional interior space with the least amount of exterior wall.

Proportion of the linear exterior wall length containing 10,000 sq. ft. of floor space are computed as follows.

TABLE XVIII

PROPORTION OF THE LINEAR WALL LENGTH

Plan Shape Wall Proportion	Square	1/1.2	1/1.5	1/2
Total Exterior Wall Length	400 ft.	401.7 ft.	407.5 ft.	424.2 ft.
Proportion of Linear Wall Length	100	100.4	102	106

The height of a building, like the plan shape, affects the exterior wall area. The height also affects the vertical utility supply length while affecting the horizontal distribution length conversely. The economy of height will be decided with priority given to the efficiency of plan and the size of the plan derived from the efficiency.

Following schematic studies are made to compare the efficiency of different plan shapes.

1) Square plan with service core in the center.

2) Square plan with service core on one side.

3) Rectangular plan with service core in the center.

4) Rectangular plan with service core on one side.

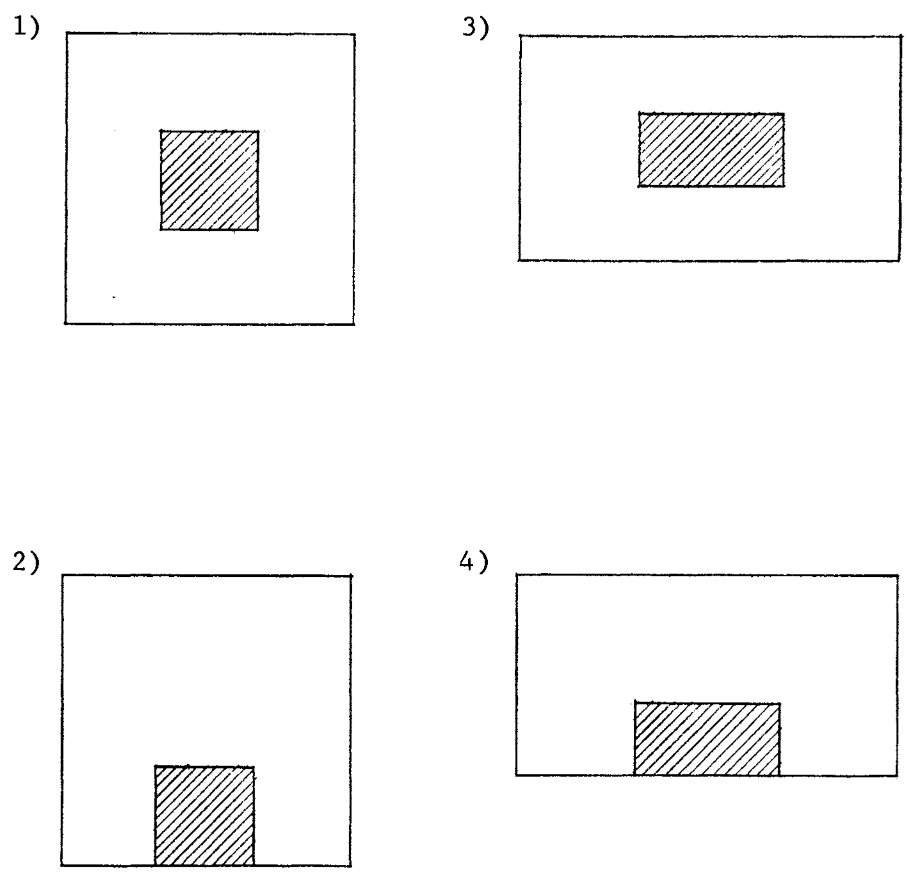

Figure 3. Example Plan Shapes

The expressions in ratings used in the following comparisons are shown for the four shapes.

TABLE XIX

EXAMPLE PLAN EFFICIENCY RATINGS

	1	2	3	4
:erior Wall ıgth	Shorter	Shorter	Longer	Longer
:rage :culation	Shorter	Short	Long	Longer
:ridor ıgth	Shorter	Short	Longer	Long
:ridor ıge	More Private	Public	Public	Private
loor .umn .mination	Possible	Practically Impossible	Possible	Practically Impossible
:ice Lay- : Dark ım	Less	Excessive	Medium	More
ıilable :n Space	Limited	Good	More Limited	Fair
'uctural :tem	Simple	Less Simple	Simple	Complicated
.lity .tribution .tem	Obstructive	Less Obstructive	Obstructive	Less Obstructive

The analysis shows that Type 1 is the most economical shape among four shapes, if the tenants do not require large open space.

TABLE XX

CONSTRUCTION COSTS ($/SQ. FT.)

Roof and Roofing	$2.00
Exterior Wall	6.00
Floor Slab	3.50
Slab on Grade	.80
Exterior Wall Underground	5.00
Partition	2.50
Door	.25
Floor Finish	.50
Suspended Ceiling	.90
Footing and Grade Beam	.50
Misc. Excavation and Fill	2.00
General Conditions	2.50
Mechanical Work	6.00
Electrical Work	2.50
Elevator	1.00
Sprinkler	.35

Source: J. T. Greenberg, "Control During Schematic Design," William Dudley Hunt, Jr., ed., pp. 173-174.

*Rolf Sklarek, "Budgeting of Probable Cost", William Dudley Hunt, Jr., ed., p. 161.

Note: The costs given in the table are not specific datas for high rise office buildings. It is given as an outline comparison of costs for different items used in building construction.

2. Service Core Circulation Study: With the idea of square plan with the core in the center of it, three different schemes will be discussed; 1) I-corridor in the core, 2) T-corridor in the core, 3) Cross-corridor in the core.

Basic considerations in the schemes are;

a) Location of vertical circulation and the efficiency.

b) Connection of vertical circulation with horizontal circulation.

c) Location of toilet and the efficiency.

d) Location of utility room and the efficiency.

e) Efficiency in arrangement of corridor and partition along the core wall.

f) Space usage.

Type of spaces to be included in the core;

a) Elevators.

b) Fire stairs.

c) Rest rooms.

d) Utility rooms.

The capacity and the number of elevators for this building is calculated as follows according to the "Selection of Passenger Elevator" in Architectural Graphic Standards.[46]

a) Type of Occupation: Office
b) Number of floors: Approximately 10 above ground
c) Floor to floor height: Approximately 12 ft.
d) Total Population: Approximately 700
e) Maximum intervals: 30 sec.
f) Total travel: 12 x 11 = 120 ft.
g) Assume light traffic; use 13% of 700 persons: 91 persons
h) Select speed of 500 ft./min. and capacity of 3,000 lb.
i) Round trip time: 122 sec.
j) Number of passengers/trip, normal peak for 3,000 lb.: 16
k) Passenger capacity per car 5 min.:

$$\frac{60 \times 5 \times 16}{122} = 39.3 \text{ person/5 min.}$$

l) Number of cars that can carry 91 persons in 5 min.:

$$\frac{91}{39.3} = 3$$

m) Check intervals: $\frac{\text{round trip time}}{\text{number of cars}} = \frac{122}{3} = 40$ sec. More than the maximum interval setup in e).

$\frac{122}{4} = 30$ sec. 4 cars will be adequate

[46]Ramsey & Sleeper, Architectural Graphic Standards, John Wiley & Sons, Inc., (New York, 1965), 5th edition, pp. 558-561.

n) The size of 3,000 lb. car bank is 17 ft. (width) x 7 ft. 4¼ in. (depth)

The regulations for fire exit-ways for office buildings are;[47]

602.1 Every story for 60+ occupants shall provide more than 2 separate exit-ways.

604.5 Number of occupants per story per unit (22 inch) of exit stairway width are 60 persons in busines occupants For occupants 45+, minimum width is 44 inch.

604.6 Treads (excluding nosing) shall be more than 9 inches, risers shall be less than 7 3/4 inches and the total of tread and riser shall be within 70-75 inches.

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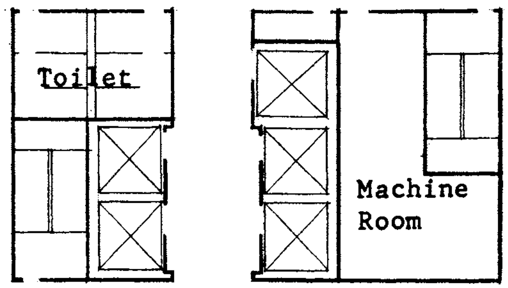
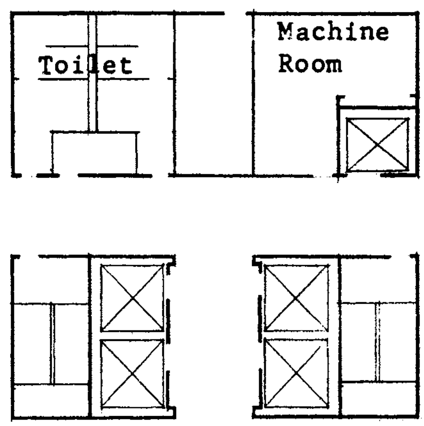
[47]The National Board of Fire Underwriters, National Building Code, (New York, 1955), pp. 54-60.

1) I-Corridor



2) T-Corridor



3) Cross-Corridor

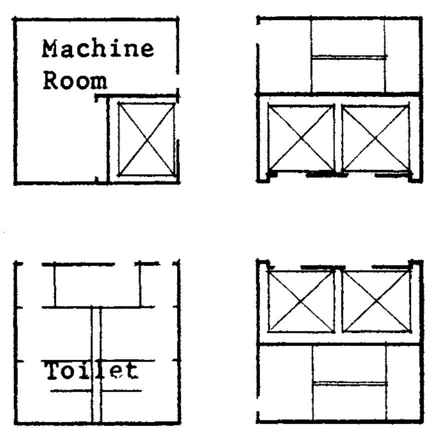


Figure 4. Example Core Plans

TABLE XXI

EXAMPLE CORE PLAN EFFICIENCY RATINGS

	a)	b)	c)
Location of Vertical Circulation	Good	Fair	Poor
Commection of Vert. with Hor. Circulation	Poor	Fair	Good
Location of Toilet	Fair	Good	Good
Location of Utilities	Fair	Fair	Good
Corridor and Partition Arrangement	Poor	Fair	Good
Space Usage	Poor	Fair	Good

It is found that the Cross-Corridor (3) is the most efficient type among the three examples. This type has the advantage of providing access to individual offices with emphasis on individuality and variety.

Utility and Function

Recent trends toward a basic low cost structure and an increased demand for better air-conditiong and lighting resulted in a higher proportion of the construction costs to cover mechanical installations. Mechanical and electrical work may cost from 20-50%[48], of the total cost of building, depending upon the type of construction. The proportion

[48]King Roger and Brad Howes, "Cost Control for the Life of Buildings," William Dudley Hunt, Jr., ed., p. 41.

of annual cost of mechanical installations are even greater.

1. Air-conditioning System: The central systems are not designed for particular tenants, and therefore, their life is determined by the building life; while the individual systems are designed for a particula tenant, and therefore, have no value as an installed unit after the lease has expired. Self-contained systems involve many individual units scattered over the building requiring more time and effort in maintenanc and are believed to be less reliable compared with central units. A central unit with constant and intensive maintenance can be performed more efficiently. A self-contained system will require an original investment of approximately $900/ton, while a central system will require approximately $1,200/ton.[49]

In all self-contained air-handling systems, utilities must be supplied to individual units on individual floors and the systems are believed to require major repair within 5-7 years of initial installation.[50] But in central systems using chilled water for cooling and hot water for heating, the main supply will be in piping systems and the duct space is not required except on each floor for horizontal distribution. Ducts will be required after the conditioned water pass through the fan coil. The central systems using water are believed to run at least 25-30 years without requiring any major repair.[51]

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[49] Netherton Dollmeyer-Solnok Engineers, Tulsa, Direct Communication, August, 1969.

[50] Ibid.

[51] Ibid.

The provision of individual thermostats in every room is most desirable. But it is impossible unless unit air-conditioners or a dual mixing box system for every supply opening is used. This is practically impossible because the exact size and the location of each room cannot be predicted in the planning stage of an office building.

Actually, a difference in requirement of heating and cooling occurs between interior and exterior spaces. The most practical method of providing an agreeable degree of individual comfort will be to divide each floor into two zones; interior and exterior. Rather than providing 2 units in every floor, each floor will have one fan-coil unit serving half of the floor and half of the immediately adjacent lower floor for either interior or exterior zones.

Along with return air in air-conditioning, ventilation is a major problem which also needs individual control for each individual room. If space could be allowed to make the air-conditioning and ventilation ducts cross in the ceiling, the problem could be solved quite easily. But if the crossing of ducts, which is necessary with air-conditioning and ventilation ducts, can be eliminated by good design, this excessive amount of space can also be eliminated. Utilization of the entire ceiling space for the ventilation-return air plenums would eliminate this excessive space. In this case, individual damper controls will be used in the return air grills to control the amount of air circulation for each room.

Air conditioning systems, today, are 100% all-season air-conditioning systems. Increases in their capacity are not expected to be very much compared with the case of lighting and power consumption. Considering the availability and low cost of natural gas, some combination of gas furnance economy and electric air-conditioning seems to be reasonable in Tulsa.

2. Electricity: Increase in power consumption will change more than any other utility in the future. Until 1945, the average lighting level requirement on an office desk was only 25 fc./sq. ft.,[52] now the level has increased to 150 fc./sq.ft.[53]. A requirement of 250 fc./sq. ft. will be possible ten years from now. Besides lighting, there will be a variety of power consumption increases in the future which depend upon the type of activity to be served.

High lighting levels usually demand year-round air-conditioning for all interior areas, which limits air-conditioning design to systems which can offer year-round cooling.

The use of high frequency ballasts can provide savings in cost of large fluorescent light installations needed in an office building. The high frequency ballast is less expensive and consumes less current. Annual costs are reduced by lower power costs and a lower rate of replacement of ballasts.

The most economic and conventional electrical system (this refers to the adaptability of modern equipment and consequent ease of workmanship) will be 227/480V.[54] Instead of installing a single large transformer, a unit (presumably 25KVA) transformer on each floor will better suit the varying requirements. The variables in the selection of the

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[52]George R. Bailey & Austin E. Moshier, Trends of Office Building Design and Comparative Operating Studies of New and Old Buildings, (Chicago, 1963), p. 17.

[53]Netherton Dollmeyer-Solnok Engineers.

[54]Ibid.

transformers location will be; distance to the major consumption point; distance from the main and unit floor distribution systems.

3. Plumbing: Since the city main pressure in Tulsa is approximately 50 psi.,[55] an additional water tank should be located on the proper floors to operate the fixtures at their proper pressure. The main water pump and tank will be located in the basement close to the water main. Variables as to the location of water tanks will be the maximum use of main pressure and minimum distance of distribution. The needs of plumbing other than the public uses on each floor (like executive rest rooms and possible dining facilities) will be met with the distribution system integrated into the unit floor systems.

4. Sprinkler System: Consideration of fire insurance rate on a building is of special importance because the annual cost of insurance, unlike other costs, can be accurately determined and minor details or workmanship can greatly affect the insurance rate. By the use of a sprinkler system, insurance rates are cut down much more than by structural improvements.[56] The sprinkler system cost is often compensated by the savings in structure and insurance. Moreover, sprinklers are the best safeguard against fire losses.

The sprinkler system should be located in a manner which will allow flexibility and efficiency in any given area. The system should be incorporated in the ceiling system.

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[55] Netherton Dooomeyer-Solnok.

[56] King Roger and Brad Howes, "Cost Control for the Life of Building," William Dudley Hunts, Jr., ed., p. 37.

Unit System Study

dular Approach

By the end of 1945, a concept of the module began to be applied in e spacing of columns in an office building which was in multiples of ft.[57] From a practical stand point, this meant columns at 18 ft. or ft. This column spacing permitted private offices along exterior lls slightly over 8 ft. in width, thus allowing for the efficient use space by those tenants who require small offices.

Since 1946, column spacing in office buildings have become a reflec-on of the module which evolved as the principal of design standard r the economical layout of typical floors.[58]

The conception of the module is based upon standardization of basic nveniences to facilitate office activities. Conveniences most impor-nt to one tenant may not be equally important to another. But, there n be certain common denominators of mutual satisfaction which are the sic conveniences that every tenant requires in order to build his own vironment with ease and maximum efficiency.

The standardization is also required to facilitate environmental ntrol, future expansion, and ease of maintenance, which is vital on e part of client to be able to operate the facility economically. In ew of construction methods, the ultimate objective will be the develop-nt of a system in which all materials, components, products, and equip-nt fit together simply and easily with minimum alterations required

[57] George R. Bailey and Austin E. Moshier, p. 19.

[58] Ibid.

on the job.[59]

Buildings serving different purposes may have different modules and the same purpose may require another module as our society changes its activities and material products. The concept of module in building design is becoming more dependent upon other modules set up by the devel opment of technology and industry.

A modular co-ordinated system relates to other things besides rectangles, plane surfaces and volumes. No matter whether projected on a plane or in space or characterized by component curves, the module applies to all points, lines and bodies. It also determines the installation and distribution of utilities, the size and shape of equipment and in some abstract sense, time and motion.

Among the various modules that are encountered in office design, the material module and the fixture module have significant importance in building economy.

The material module is the outcome of raw material sizes, production engineering requirements, quantitative properties, technical application, market requirements and economic conditions. The fixture module determines the dimensional and proportional order of all permanently built-in objects and appliances, which, without being part of the structure, must be adapted to the modular grid. In practical applications, it is necessary to find a synthesis of the problem, a common denominator which applied to the structural module, element module, component

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[59]Modular Building Standards Association, Modular Practice, (New York, 1962), p. 1.

›dule and installation module.[60]

Modular co-ordination with the integration of all the mechanical, lectrical and structural components must meet the need for an effective ıd flexible environment.

The process of developing modules will be,[61]

1) Selection of basic conveniences

   a. Selection of fundamental furniture types.

   b. Decision as to the typical arrangement of furniture with respect to personnel movement and fenestration.

   c. Determination of typical aisle width.

   d. Determination of the method of running services within unit spaces.

2) Derivation of modules

   a. Study of inter-relationship between floor and ceiling.

   b. Co-ordination of respective elements; architectural, mechanical, electrical, structural and other components.

This process was used as a guide for a research laboratory design, ich in itself is a compact module, and it is believed to have a prac- cal adaptability in office building design.

lection of Basic Conveniences

The true module will be a small unit of 3 to 4 inches, based on the mension of the materials to be used in construction, but this module

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[60] Konrad Wachsman, The Turning Point of Building, (New York, 1961), . 54-75.

[61] F. W. Dodge Corporation, Building for Research, An Architectural cord Book, (New York, 1958), pp. 3-19.

ıltiplied into a planning module which is usually of more comprehen- size.[62]

The module in this study will be a planning module. In developing anning module, the primary condition must be given in terms of the acter and the usage of the unit space. In this particular case, the will be a single work station. The individual worker, seated at his or table, is the basic unit of an office; the basic working area ı he has completely to himself is the foundation of all space plan- and administration.[63]

The size of the unit work station is determined by the basic furni- sizes, the seating space, the typical aisle width and the physical ıgement.

This unit scale shall be the common denominator of space required ›ther functions beyond work station purposes; private office, semi- ıte office, conference or board room, or other special purposes such camination room, interview room, etc.

These unit scales can vary from tenant to tenant and space standards ılso vary according to respective operation requirements. The solu- for a specific individual problem can only be achieved through a ›ugh understanding of the operational aims and requirements of each ıt.[64]

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[62] Leonard Manasseh and Roger Cunliffe, Office Buildings, (New York,), pp. 19-22.

[63] Kenneth H. Ripnen, Office Building and Office Layout Planning, York, 196), p. 5.

[64] Michael Saphier, Office Planning and Design, (New York, 1968), '-36.

As a first stage of single work station design, the identities of work station should be studied. The position or direction of desk with respect to wall and access creates problems, one is the human need of enclosure and the other is communication fluency and involvement. The answer to the subject of enclosure and openness seems to lie in bringing about a relative degree of enclosure. The premise that it is more comfortable and productive with territorial security should be coupled with the answer for the expression of access and involvement.

Three different desk arrangements are studied for their environmental aspect; 1) desk facing access, 2) desk facing wall, and 3) desk parallel to access.

In arrangement 1), the man is completely open to his surroundings, having no environmental support, thus creating a need for recognition of space and enclosure. He is directly involved to activities.

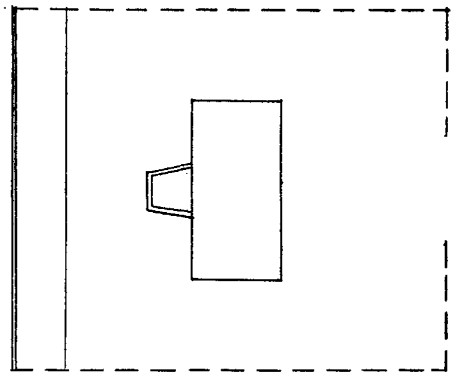
In arrangement 2), the man is provided with greater psychological comfort. He has a personal reference point but he is somewhat limited to his own environment.

In arrangement 3), the man realizes his territory while involving to activity. He has a better chance of having communication while doing his own work.

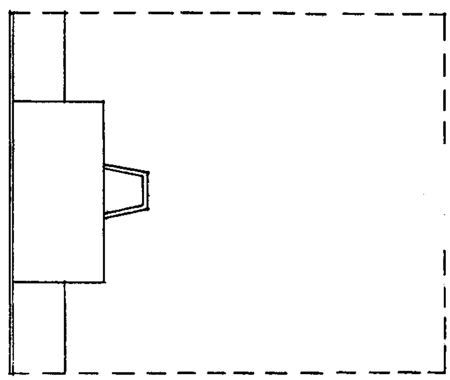
Modern office activity requires greater involvement of participants but it also requires more intensified work by each individual. The involvement, in a sense, is communication. Now, most of the communications are being accomplished through electronic devices except person-to-person conversations such as interviews and conversations.

The combination of arrangements 2) and 3) is believed to meet the objectives of module design to a greater degree. Priority is given to

1) Desk Facing Access



2) Desk Facing Wall



3) Desk Parallel to Wall

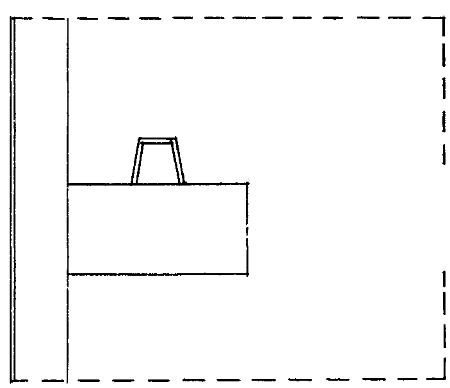


Figure 5. Example Desk Arrangements

individuals psychological comfort. Allowance for intensified work ce, a conversation table and a storage-display space should be pro- ed.

The work table should face the wall with the conversation table on side and the storage-display space on the other.

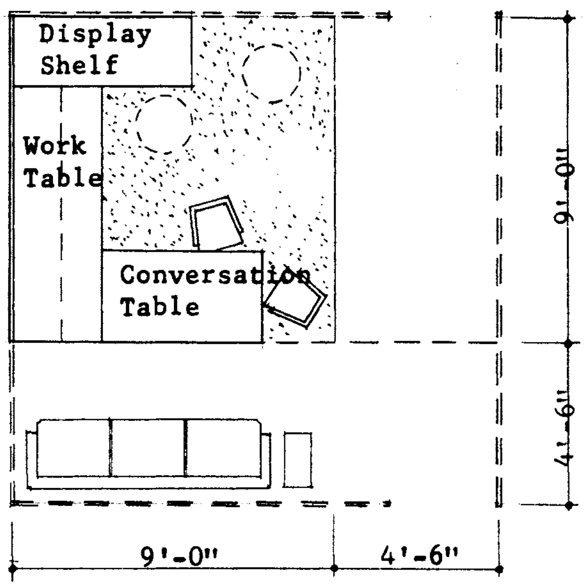
The most comfortable way to carry on a conversation is side-by-side a table. Face-to-face conversation directly across a table is formal contains a note of discretion. Knee-to-knee conversation also cre- s an uncomfortable feeling.[65]

By using the vertical space above and below the working table for rage, the worker is closer to his information, thus, the utilization vertical space is improved. By lowering the conversation table a le, the worker can carry on conversations in a more friendly way and he same time have easy access to secondary information since his l level (in a sitting position) is normally below the desk level.

The storage space on the opposite side of the conversation table also be used as a screen to separate the unit modules and provide acy. The screen can also provide display space as well as shelves books and informational materials. This display space (tackboard,) normally needs to be higher than desk level.

[65]Robert Propst, pp. 55-56.

1) Single Work Station



2) Multiple Work Station

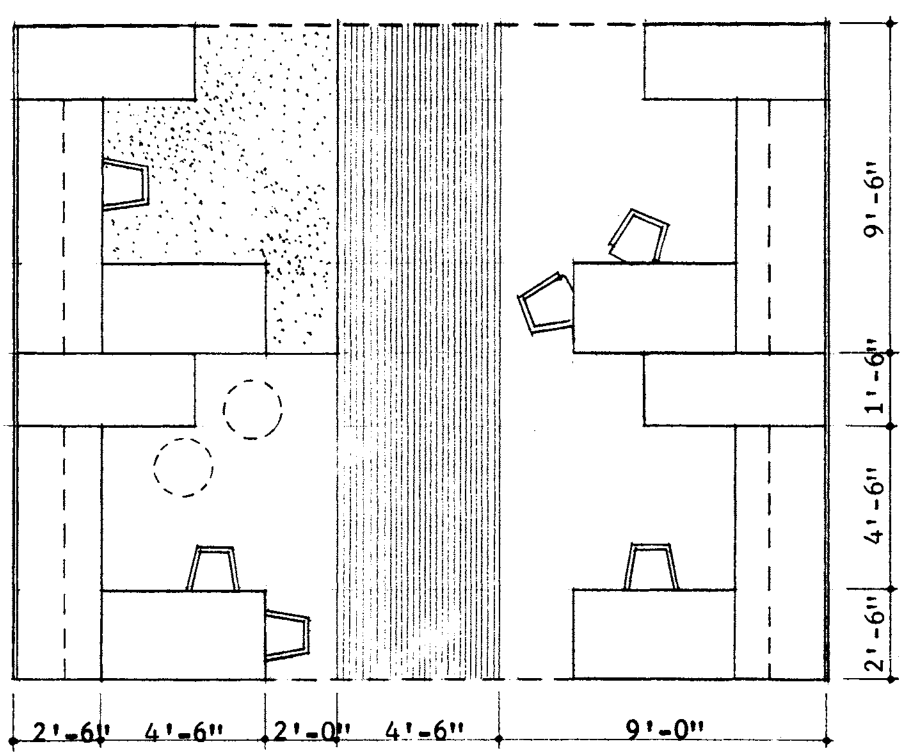


Figure 6. Proposed Work Station Layout

TABLE XXII

FURNITURE SIZE AND AISLE WIDTH WITHIN OFFICE

	Furniture Size*	Desk to Desk	Desk to Wall
Desk - Length	40 - 60 in.		
Width	29 - 36 in.		
Height	29 - 30½ in.		
Chair - Width	17½- 28 in.		
Depth	16 - 23 in.		
Height	29 - 36 in.		
Cabinet	varies		
Single Passage		3 ft.	4 ft.
Single Passage with Chair		5 ft.	6 ft.
Double Passage		5 ft.	5 ft.
Double Passage with Chairs		8 ft.	9 ft.

Source: *Ramsey and Sleeper, pp. 449-451.

Since a square plan with a service core in the center of the plan was used as a typical floor, all the utilities will run from inside out following the direction of structural members. Location of lighting fixtures, air-conditioning and ventilation openings shall be in accordance with basic work station layout.

Floor and Ceiling System

Recent effort in floor and ceiling system design is mainly concerned with the individual comfort of each tenant and the flexibility. Alon with these efforts, the combination of structural and utility systems have been studied concerning the elimination of ceilings, simplification of construction, economics of maintenance, and most of all the flexibility.[66]

In order to combine the structure with utilities, which was accomplished by including utilities within the structural members, the structural pattern followed the utility distribution pattern. Complete elimination of the ceiling was accomplished by including duct work inside of the structural members, but it required excessive form work in concrete work and excessive steel work in steel deck construction. In concrete work, it resulted in a predominant expression of structure in the ceilings. The location of light fixtures became inflexible and the selection of exposed decorative light fixtures required additional cost.

In the use of raised floors, the ceiling was eliminated but the structural members as well as the main duct work required a lower ceiling somewhere within the floor. The space between the structural floor and the raised floor was used as a supply plenum. This system duplicate floor work and furthermore, it requires more expense compared with a suspended ceiling system to make the raised floor strong enough to withstand the weight and vibration.

The major shortcoming of a suspended ceiling system containing duct work is that it consumes extra space compared with non-ceiling systems. But if the space could be reduced and utilized for the purpose of making the utility distribution system more flexible and making installation of partitions easier, the use of suspended ceilings could be justified.

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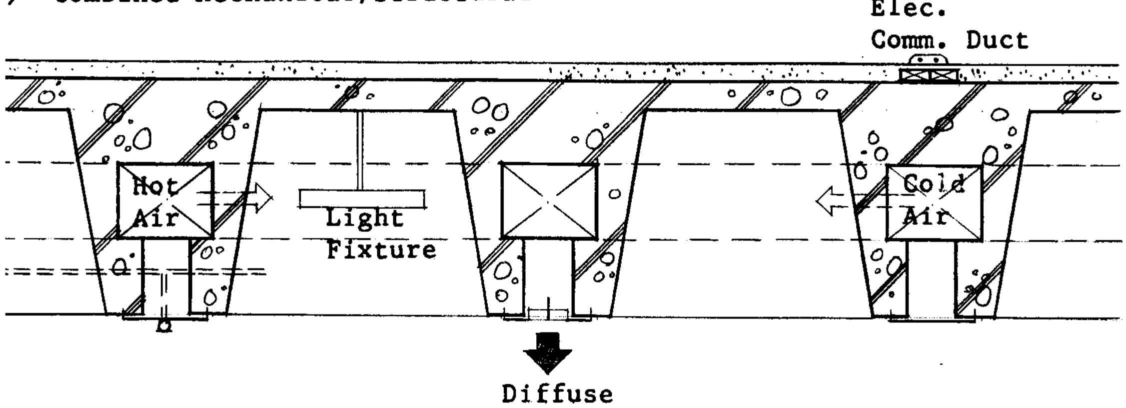
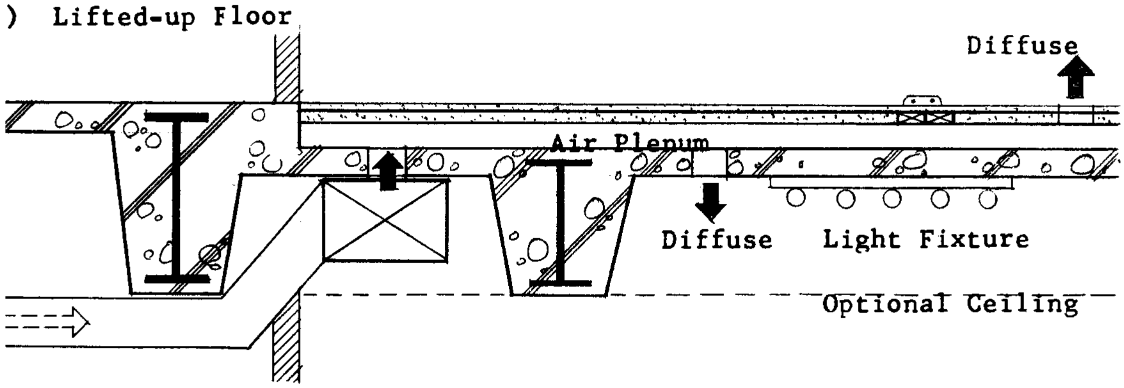
[66] Robert E. Fisher, Architectural Engineering, Environmental Control, (New York, 1965), pp. 24-41.

) Combined Mechanical/Structural



) Lifted-up Floor



) Composite Deck w/ceiling

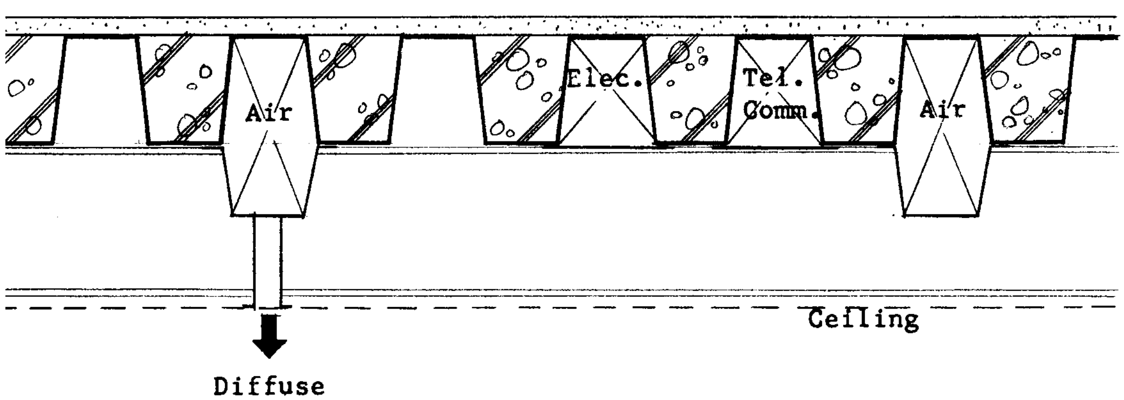


Figure 7. Integrated Mechanical/Structural Systems

Flexibility in terms of a planning module has an inevitable relationship with the location of partitions. Although the basic module has been found to be 9 ft., it cannot be guaranteed that the partitions will occur only at the 9 ft. grid because of the chance of inner corridors. With regard to the standard light fixture size of 4 ft., the probability of partitions in half modules should be incorporated. The partitions will be primarily an open-top type. This partition can provide a spacious feeling and it can also contribute to solving acoustical problems in the office. In order to make an ideal office without any noise interruption, a 12-inch thick slab of concrete without any openings would be required.[67] This is hardly a practical solution. The open space provided by lower partitions has a great sound absorption capacity and the typewriter sound can function as a homogeneous masking sound.

The partitions should be attached to the ceiling along the runner channels which will also be used as an air-diffuser channel. The air will be diffused on one side of the channel to avoid a seepage of sound across adjacent rooms where a full-length partition is installed along the channel (executive rooms, etc.). The return-ventilation grill will be located in the proper position after the partition is installlled simply by exchanging the ceiling panel with a porous panel. The whole ceiling space will be utilized as a return-vent plenum. The amount of air to be returned can be controlled by the number of return panels. The amount of air to be supplied will be controlled by the damper in each module, thus the double control of air flow can be accomplished by

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[67] Richard Hamme and Don Huggins, Office Design, Sound Noise, (Elmhurst, 1968), p. 5.

interior-exterior and supply-return; which would be as satisfactory as the dual-duct mixing system with less cost.

The lighting fixtures should be a hinged type having a 4½ ft. x 4½ ft. cover and adequate size bulbs. The hinged operation would provide convenience in maintenance.

The sprinkler system will run through the return air plenum with sprinkler heads at each module corner. Extra plumbing can also be provided within the ceiling space.

The telephone, signal and power supply ducts will run on the floor in the center of each module; 5 ft. is the minimum distance between electric ducts[68] recommended by Building Research Advisory Board. Power for lighting fixtures will be connected to the duct at each 9 ft. module.

To minimize the ceiling space and simplify the floor construction, the composite deck system will be used incorporating the electric duct and air-supply duct.

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[68] H. H. Robertson, Long Span Composite Deck, (Pittsburg, 1968), p. 11.

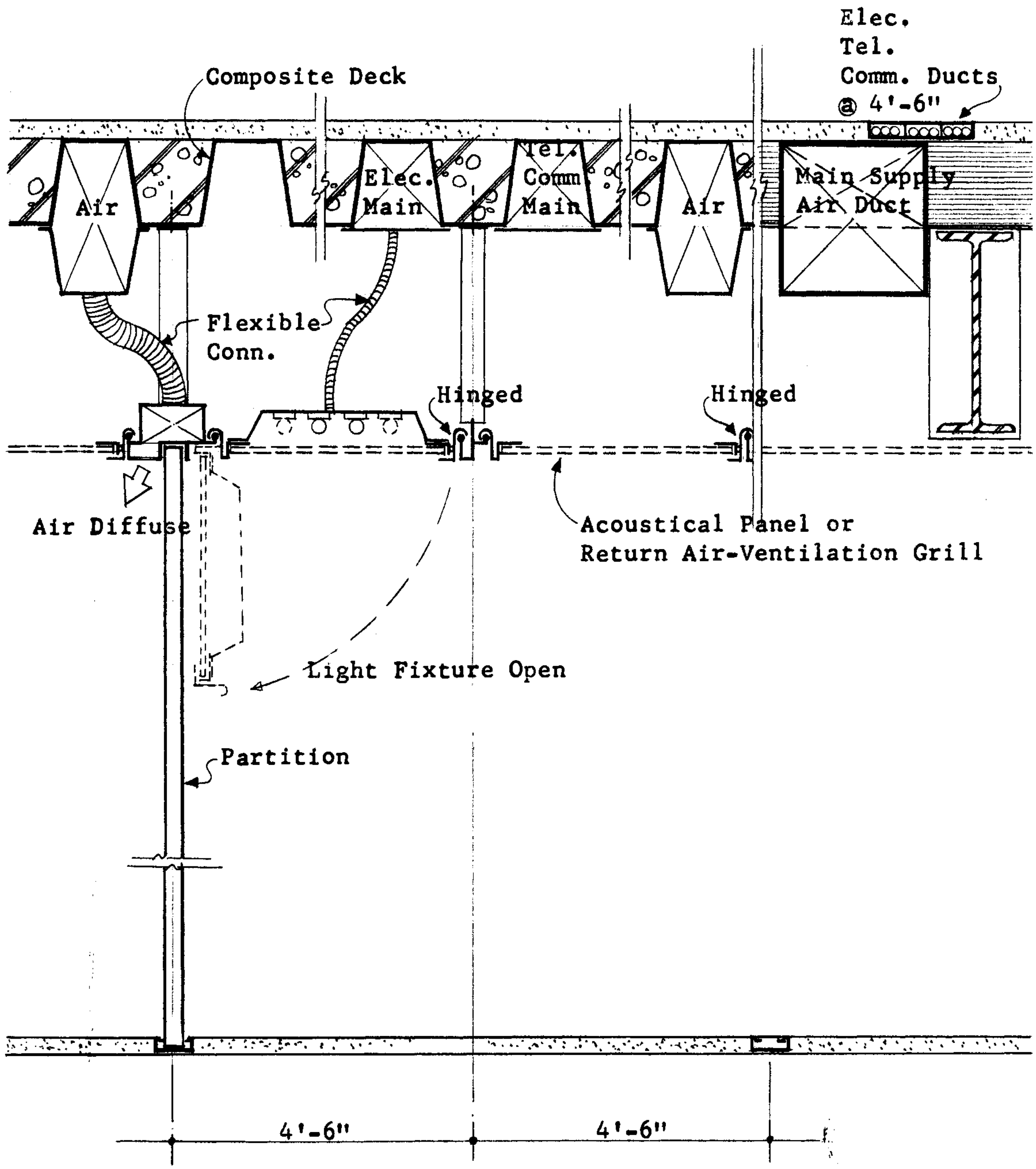
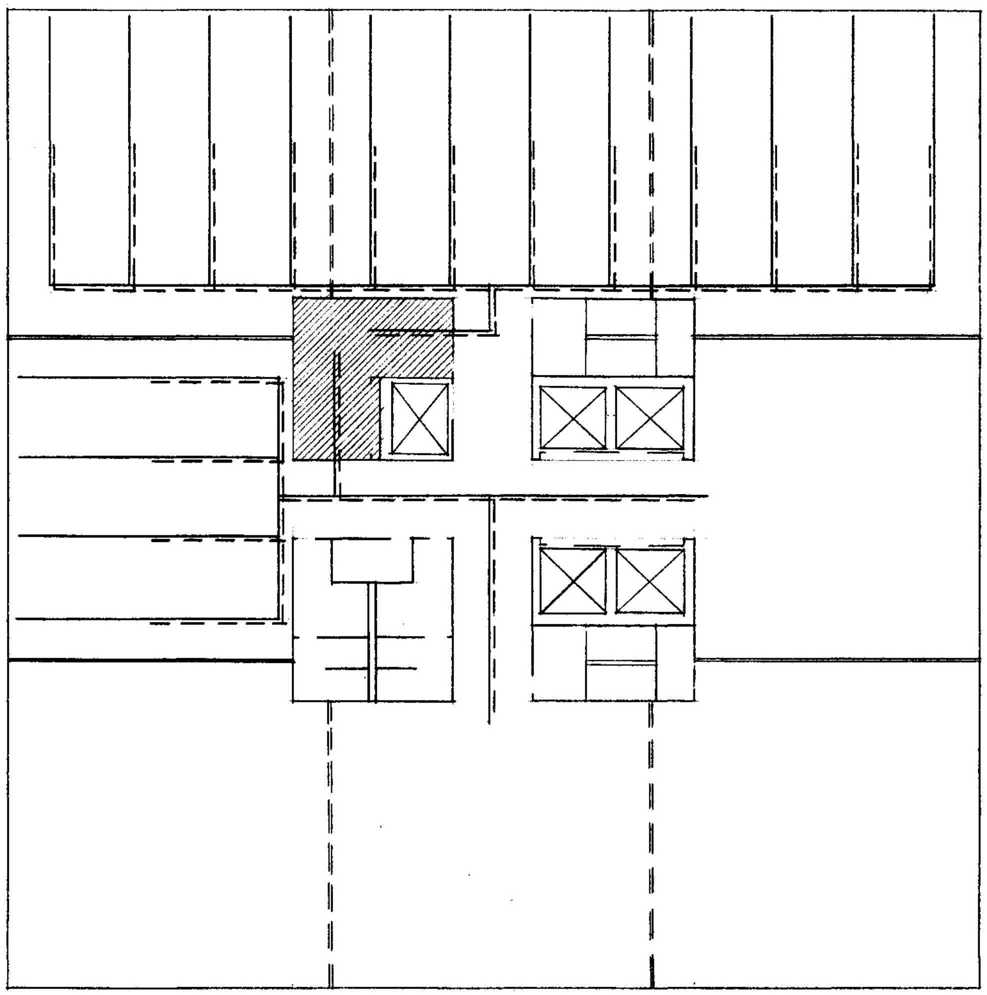
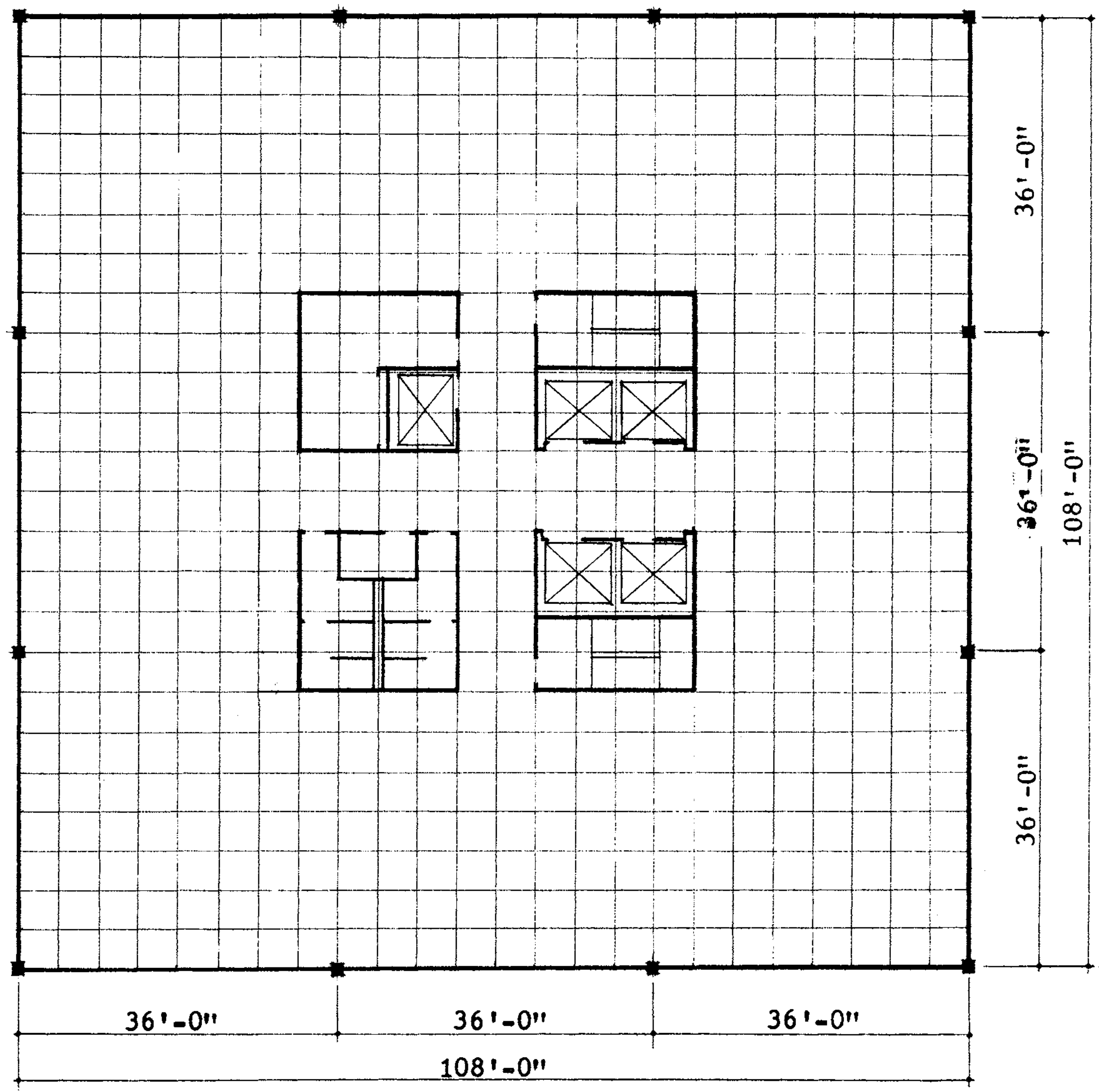


Figure 8. Proposed Floor and Ceiling System



——— Exterior Zone Supply
- - - - Interior Zone Supply
━━━ Heavy Structural Beam
═ ═ ═ Light Tie Beam
▨▨▨ Machine Room

Figure 9. Proposed Utility Distribution System



Total Floor Area: 11,664sq.ft.
Core Area: 2,025sq.ft.
Rentable Area Ratio: 82.6%

Figure 10. Proposed Floor Plan

Summary

As was discussed in previous chapters, the consideration as to the overall scheme of an office building and its cost must depend primarily upon the needs of its tenants.

1) Floor Area: The main factor used to determine floor area shall depend upon the distance from the daylight. Although artificial lightin can provide enough brightness in any place within the structure, it is found that 26-30 ft. from the daylight is the most reasonable distance from the windows. Constructing large area floors with much inside space is considered to be in most cases penny-wise and pound-foolish because such spaces bring lower incomes.

2) Floor Shape: With a predetermined floor area, the shape affect the efficiency as well as the construction cost of the floor. The largest single investment in construction being the exterior wall construction, a square plan with utility core in the middle of it is believed to be the most economical and efficient.

3) Building Height: Height is determined by the unit floor areas. The upper floors in any building are quieter, cleaner, offers daylight, privacy, prestige and a view so that they are demanded more and bring premium rentals. The height should be determined in connection with the land value in case of incorporating indoor parking.

4) Rentable Area: The common idea is that the greater rentable area brings more income, but there are more important factors besides the rentable area itself. The vacancy ratio, rentals and operating costs all contribute to the net income of total floor space. The decision as to the ratio of rentable area should be primarily based upon

considerations discussed in item 1). The general idea of economic
:able area ratio is believed to be 80-85%.

5) Partition: The decision as to the selection of partitions
ıld not necessarily depend upon its costs but the needs of the ten-
s, because most of the tenants want to have their partitions flexible
ıgh that they can change their work patterns easily without involving
ı disturbance or investment. The answer lies with the installation
removable partitions which incorporate all the utility distribution
:ems based on an efficient planning module.

6) Module: The primary discussion as to the selection of the
ıle should be based upon the efficiency and psychological comfort of
ers and their need for more intensified work and distinct individ-
ity that modern office activities require. The by-product will be
efficient and economical usage of floor space with consequent re-
:ion in sq. ft./person.

7) Structure: The structural materials and systems should be
gned that best benefit the forgoing discussions. The reduction in
ıctural cost should be sought only after the basic functions of the
ding has been solved.

8) Income: The economy of an office building for the purpose of
: should be considered in terms of life-long economy of the building.
reduction of fixed charges, operating costs and construction costs
ıld be based upon the provision of the most flexible work patterns.

9) Financial Concepts: Equity, amortization, method of control-
; depreciation and other factors affecting cash flow has not been
:ussed in this study.

CHAPTER IV

CONCLUSION

Although the facts and findings in Market Survey gives reasonable basis for the feasibility of investment and its scope, these findings are not supposed to be a guarantee of success in the practical decision of investment. The success of an office facility depends largely upon the impact of many individual decisions and desires. The strong indications of success found in the feasibility study will serve as a basis for further discussion leading to the realization of a project.

The discussions in Design Criteria were concerned with desirable office space both in economics and efficiency which is needed now and in the foreseeable future on behalf of the client as well as the tenants. Admitting that the life of the building outlasts the life of any function within the building, (in terms of the impact of technological changes), the degree of flexibility cannot be fully understood without living through that period of change.

> [69] In fact, we really don't know from one day to the next what our wants are, especially as scientific discovery and advancing technology make possible an ever-expanding availability and range of new products. So, we find that a part of the production overhead now is devoted to creating desire for new wants, and there has evolved a new dimension in the art of mass production-call it advertising.

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[69] William H. Davenport & Daniel Rosenthal, Engineering, Its Role and Function in Human Society, (New York, 1967), pp. 199-201.

> When a society, already affluent in the private sector begins to turn its new attention to its publicly provided goods and services, it is unlikely that it will settle for a bare bones, least cost job. It will demand niceties and amenities.

Vitruvius says in "On the Training of Architects";

> [70]So architects who, without culture, aim at manual skill cannot gain a prestige corresponding to their labor, while those who trust to theory and literature obviously follow a shadow and not reality. But those who have mastered both, like men equipped in full armor, soon aquire influence and attain their purpose.
>
> His personal service consists in craftsmanship technology. Craftsmanship is continued and familiar practice, which is carried out by the hands in such materials as is necessary for the purpose of a design. Technology sets forth and explains things wrought in accordance with technical skill and method.

The architects' service to a client in designing office buildings, as in every type of project, should be a comprehensive effort to help the client in every aspect; the total environment of building including its function, its aesthetics, its economics, etc. The client with no idea of construction and furnishing costs must be helped at the very beginning of a job to determine just where his available dollars can an should be allocated.

Completing this study, thr author realizes that many problems are yet to be solved. The modular system found in this study is only "a solution" and does not incorporate equipment such as conveyer belts, pneumatic tubes, and other moving services and the floor and ceiling system selected is still stationary. It is believed that further investigation of the possibilities of total flexibility including movemen of all parts of the building is necessary in order to accomplish ulti-

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[70]William H. Davenport & Daniel Rosenthal, p. 158

mate flexibility.

In this study, as was mentioned in the PREFACE, the office building was discussed in terms of its economics. But it bears importance beyond the purpose of an income-producing structure. A high rise office building in any community tends to be a dominant element of its environment. Its existence affects the business, the traffic, the air pollution...the total development of the community.

It is hoped that the economy and flexibility dealt with in this study will serve as a reference for further investigation and comprehensive understanding of the real problems in office building design.

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