DOCUMENT RESUME

ED 035 197 EF 002 884

TITLE Modern Steel Framed Schools.
REPORT NO PUB-G416
PUB DATE Apr 62
NOTE 44p.

EDRS PRICE EDRS Price MF-$0.25 HC-$2.30
DESCRIPTORS Architectural Elements, Building Design, *Building Materials, *Component Building Systems, Construction (Process), *Construction Costs, Design Needs, *School Buildings, School Construction, *Structural Building Systems

ABSTRACT

In view of the cost of structural framing for school buildings, ten steel-framed schools are examined to review the economical advantages of steel for school construction. These schools do not resemble each other in size, shape, arrangement or unit cost; some are original in concept and architecture, and others are conservative. Cost and construction data, plans, and details are included to provide a comprehensive picture of the structural and architectural features of each school building. A comparison of steel with other framing materials for schools is included. (FS)

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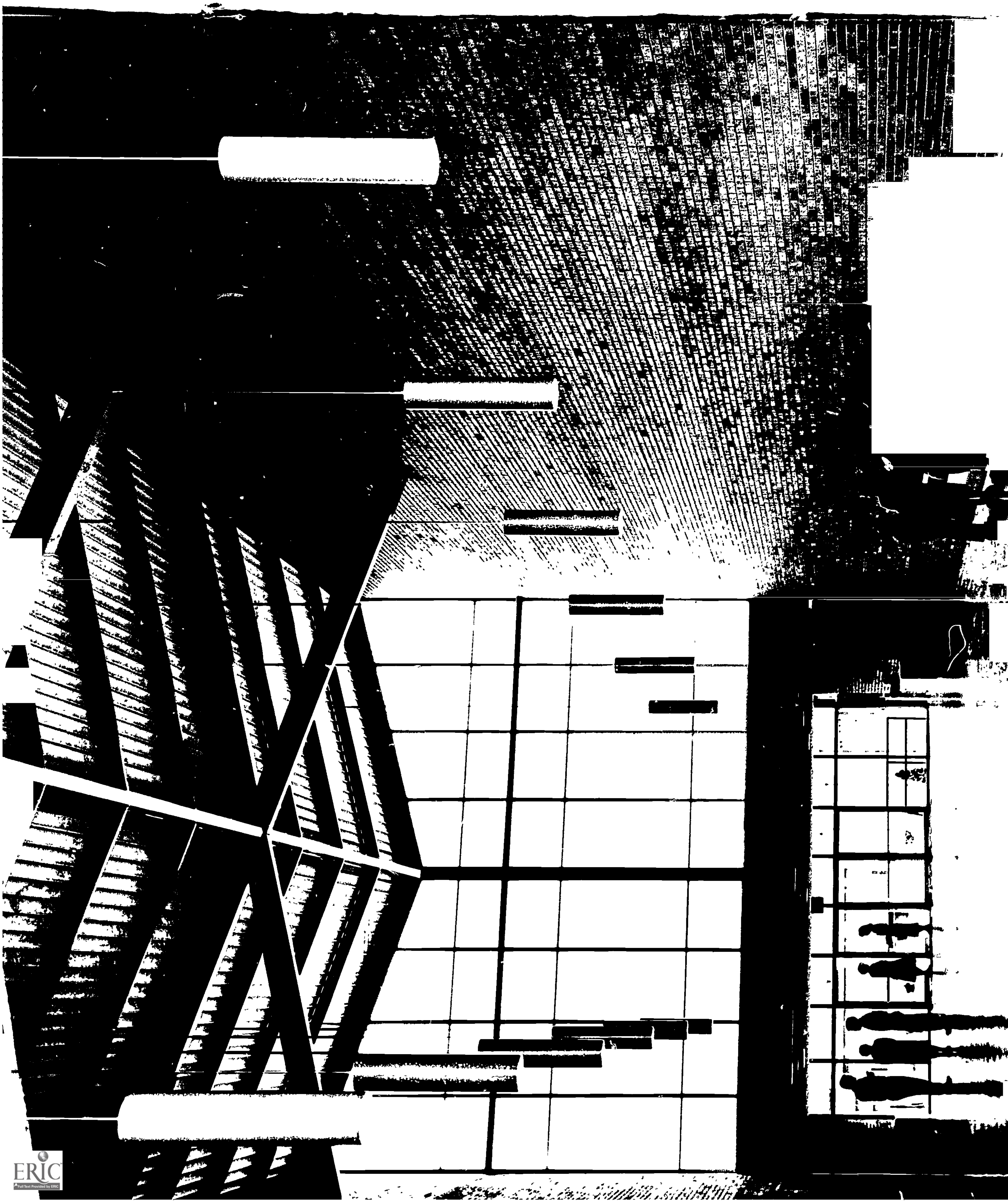
Modern Steel-Framed Schools

AISC



Cover art based on floor plan of Lincoln Park High School, Lincoln Park, Michigan. Eberle M. Smith Associates, architects.

Frontispiece: Lobby of the Carbon High School, Price, Utah. Edwards & Daniels, architects.

MODERN STEEL-FRAMED SCHOOLS

The cost of structural framing for school buildings is a subject often clouded by confusion, misconception and controversy.

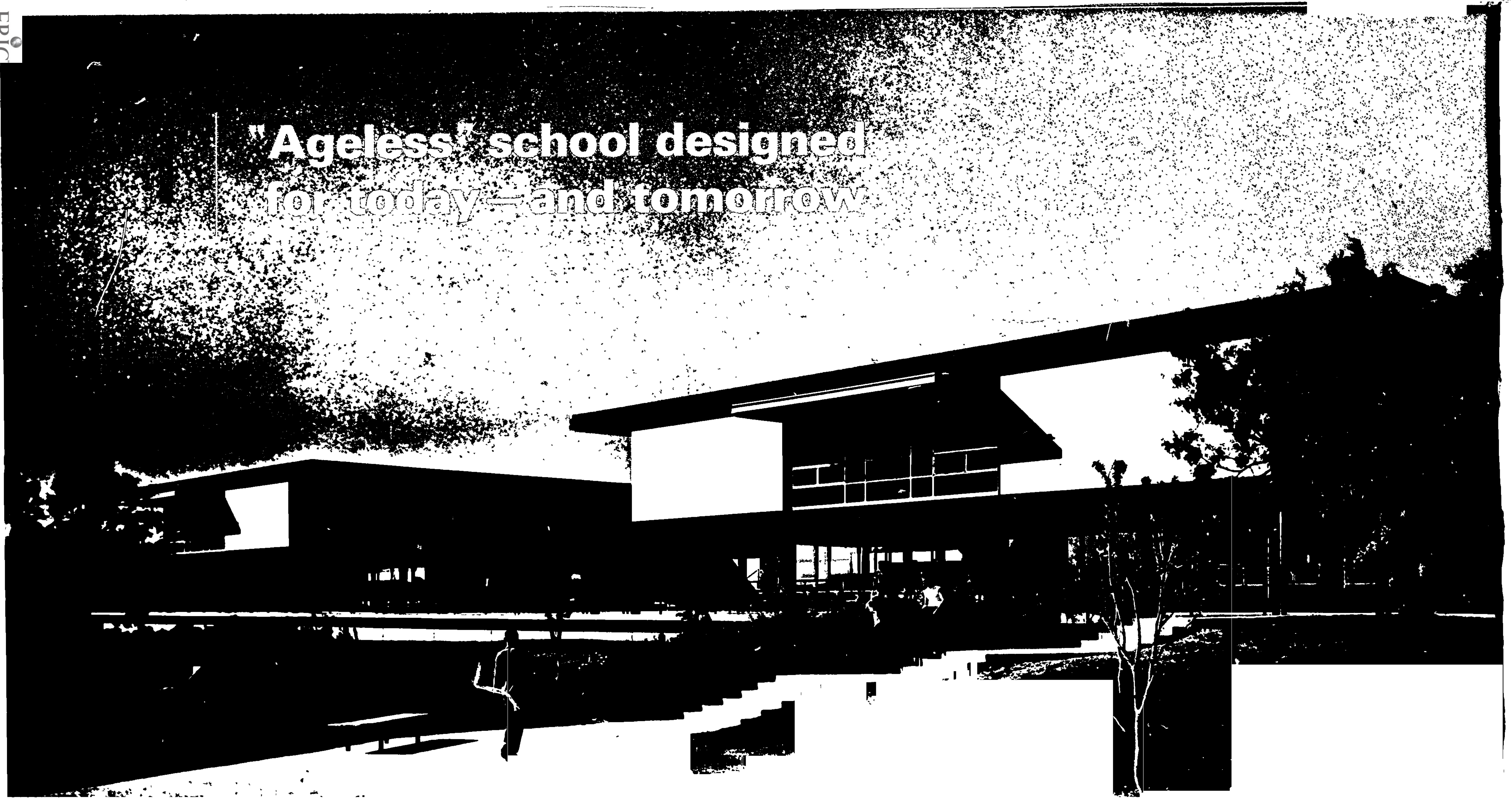
ECONOMY | In no other type of construction is the architect under comparable pressure to provide required facilities at minimum building cost. Yet every architect knows that minimum cost for a school building, if achieved by the sacrifice of quality, function or appearance, may result in maximum cost to the taxpayer. Cheapness cannot be equated with economy. The difference is basic—but to a tax-conscious public the distinction is often obscure.

COMPETITION | Several structural materials and systems are available and competitive for school construction. Each of these materials—structural steel, concrete, and wood—will sometimes be less costly, sometimes more costly than its competitors. The difference in first cost of structural framing, however, is usually less than one percent of the total cost of the school building. Other factors, such as differences in quality, durability, design flexibility, fire-resistance, speed of construction, aesthetic appearance and ease of future alterations, must also be evaluated if true economy is to be achieved.

ADVANTAGES | Structural steel often has the advantage of lowest first cost. Equally significant to the architect, the school board, and the informed taxpayer, however, are other very real and specific economic advantages of steel framing, which reduce both first and future costs of the entire school structure. These advantages are unmatched by any other structural system.

EXAMPLES | This booklet will review the economic advantages of steel for school construction by examining 10 outstanding steel-framed schools. Cost and construction data, plans and details are included to provide a comprehensive picture of the structural and architectural features of each school building. These buildings were designed before the introduction of the new AISC Specification in 1962. New high-strength steels and improved design rules now permit even greater economies.

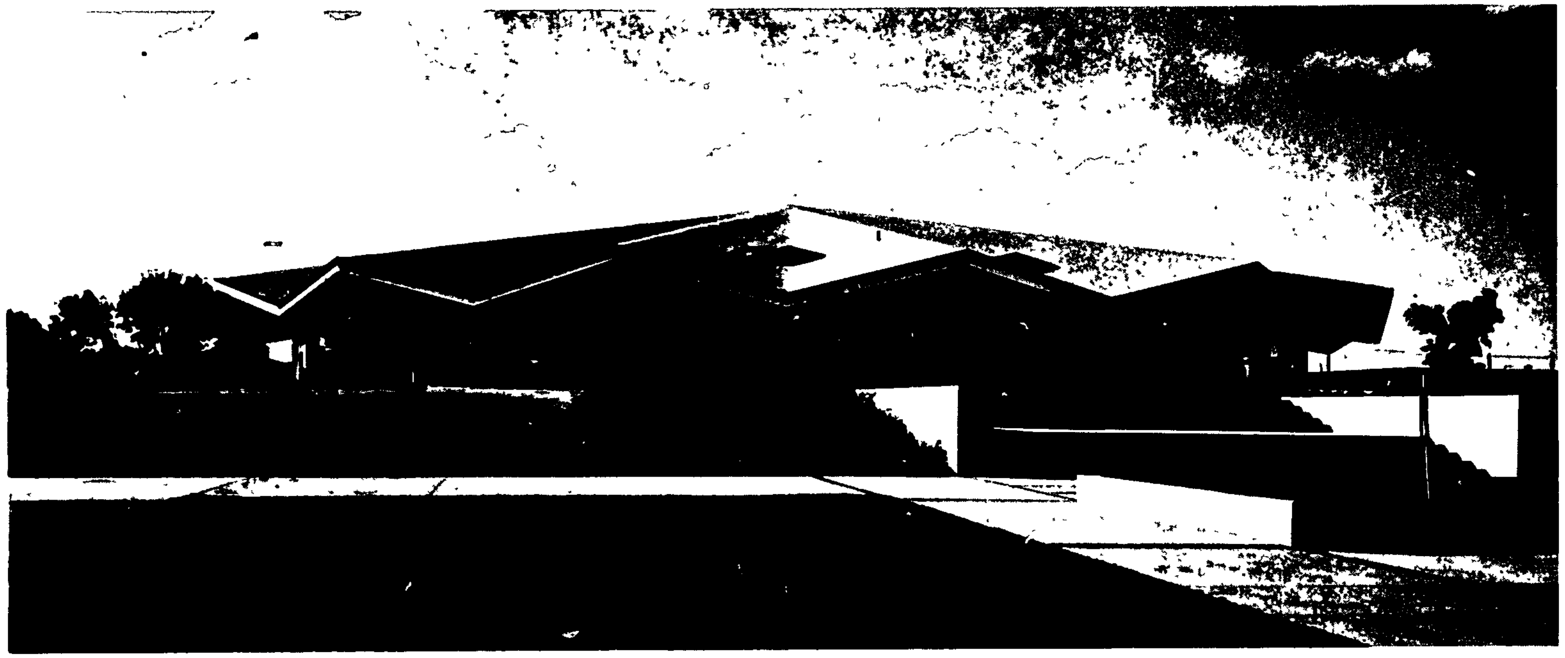
VALUE | These schools do not resemble each other in size, shape, arrangement or unit cost. Some are excitingly original in concept and architecture, others are quietly conservative. All are framed in steel because in each case an outstanding architect found steel construction provides more value for the taxpayers' school construction dollar.


"Ageless" school designed
for today—and tomorrow

In planning a new high school for the rapidly growing community of San Angelo, Texas, architects Caudill, Rowlett and Scott and associate architect Max D. Lovett were faced with the problem of providing not only high quality facilities for current needs, but also a high degree of flexibility for a continuing increase in student enrollment. They solved the problem with one of the nation's outstanding campus type high schools—designed with steel to achieve lowest framing cost *plus* the advantage of steel's adaptability for future change.

Compared to schools of similar size and quality, the cost figures for San Angelo Central High School are exceptionally favorable. Building construction cost was $2,501,649, amounting to $12.02 per square foot and $1,164 per pupil. Total air conditioning of the buildings is included in these unit prices.

Eleven separate buildings, each designed for a specific use, provide the educational advantage of permitting small units of age-group students to spend about half a day under the supervision of familiar teachers, and the remainder of the day in other buildings designed for elective courses to meet a wide variety of special needs. The multi-building plan permits the use of any building at times outside the nor-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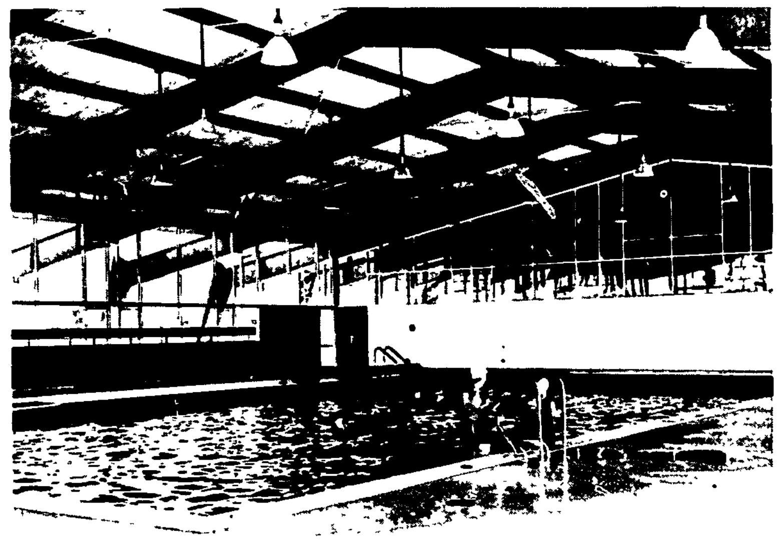
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(1) The circular auditorium is a steel-framed umbrella which cantilevers over perimeter pipe columns. Its roof is a fan of folded plates.

(2) Classroom buildings are wide open loft spaces subdivided with glass screens. These classrooms have the feeling of an open plan and actually have no doors at the corridor entrances.

(3) Exposed steel rigid frames form an attractive and colorful ceiling over the gymnasium and swimming pool.

mal school day without adding operating costs to other buildings.

Typical structural bay sizes in classroom buildings are 22-ft x 23-ft and 24-ft. Repetition of bay sizes led to significant savings in the cost of fabricating and erecting the steel framing.

Interior classrooms are provided with simple chalkboard and tackboard on easily moveable, non-load-bearing wood stud walls. The interior of each building unit can be rearranged with minimum cost and effort to allow for growth in teaching unit sizes or changes in curriculum. Because the buildings are steel-framed, they can easily and economically be extended if additional floor space is required.

Beauty is not sacrificed to economy in the San Angelo High School—they are compatible. Skillful architectural design utilizes exposed steel framing—one of the most economical of structural systems—to achieve outstanding aesthetic effects. The painting of all exterior and interior steel complements the color and texture of adjacent building finishes. Clean, smooth, carefully detailed welded connections contribute to the attractive appearance of the architecturally exposed steel.

DATA SHEET

Name of Structure: San Angelo Central High School

Location: San Angelo, Texas

Type of School: High School

Applicable Building Code: National Building Code

Owner: San Angelo Independent School District

Architect: Caudill, Rowlett and Scott, Houston;
Max D. Lovett, San Angelo (Associate Architect)

Structural Engineer: Edward F. Nye of
Caudill, Rowlett and Scott, Houston

General Contractor: Rose Construction Company, Abilene

Building Layout and Description:
No. of Stories: Sophomore and Junior buildings: two; all others: one
Floor Area: 208,086 sq ft (gross)
Structural Module: Academic buildings: 16 ft Gymnasium: 18 ft
No. of Students: 2,150

Design Live Loads: Classrooms: 40 lbs/sq ft
Corridors: 100 lbs/sq ft Roof: 20 lbs/sq ft

Structural Steel: Total Weight: 955 tons
Weight per sq ft: 9.2 lbs Method of Connection: Welded

Wind Bracing: Column X-bracing (end walls only)

Floor System: Concrete slab; corrugated floor forms in gymnasium

Roof Construction: Gypsum deck on form boards

Exterior Wall Construction: 12" brick cavity, window walls with aluminum windows in porcelain panels

Interior Partitions: Wood studs with chalkboard, tackboard, plywood, glass and glazed tile

Foundation: Grade beams, retaining walls and floor slabs on grade

Acoustical Treatment: 1" rigid fiberglass behind perforated fiberboard wall panels; rock wool blankets in partition walls

Fire Resistant Construction: Only one building, auditorium, has fire protection of steel columns. This is primarily for insurance reasons

Construction Cost:	General Contract	$1,815,048
	Plumbing	99,928
	Heating & Ventilating	379,691
	Electrical	206,982
	Total	$2,501,649

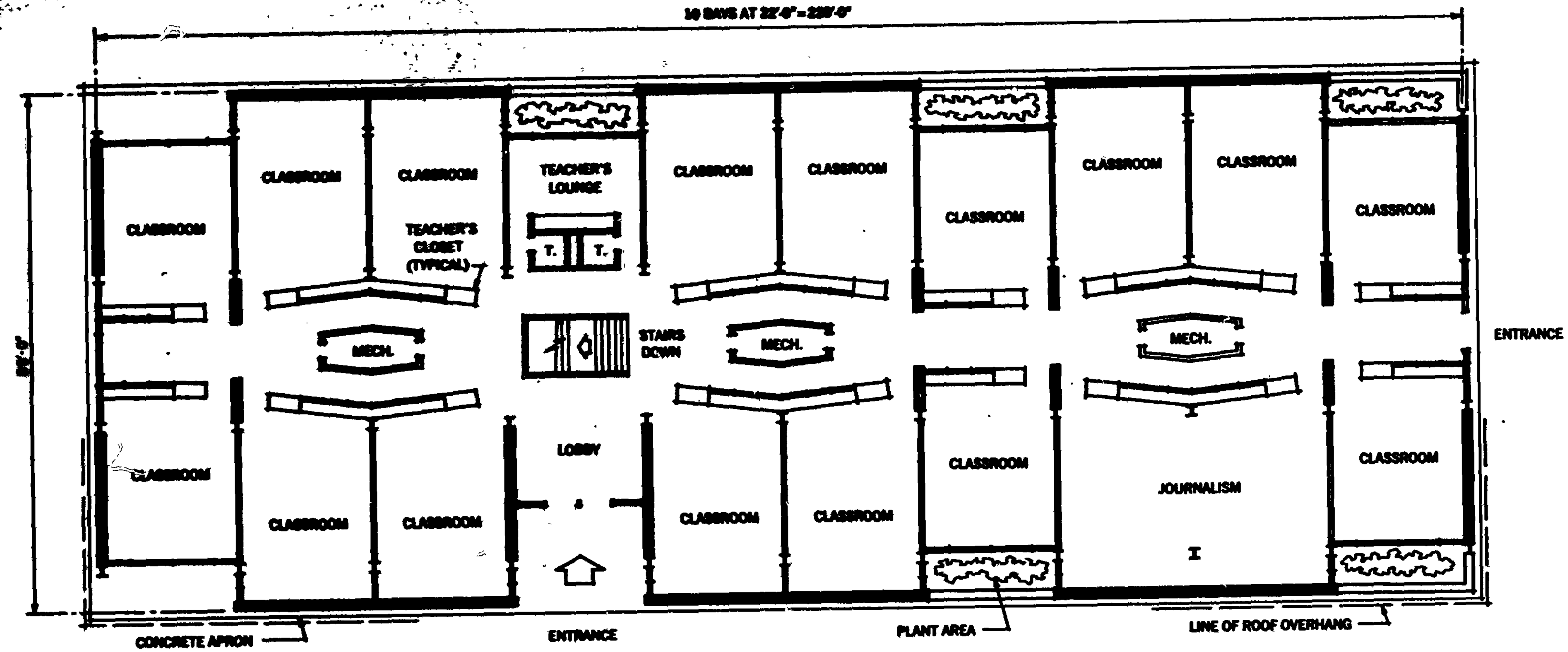
Cost per sq ft of gross area: $12.02 Cost per Student: $1,164
Fixed Equipment: $124,249 Site Work: $276,065

Date Construction Began: December, 1956

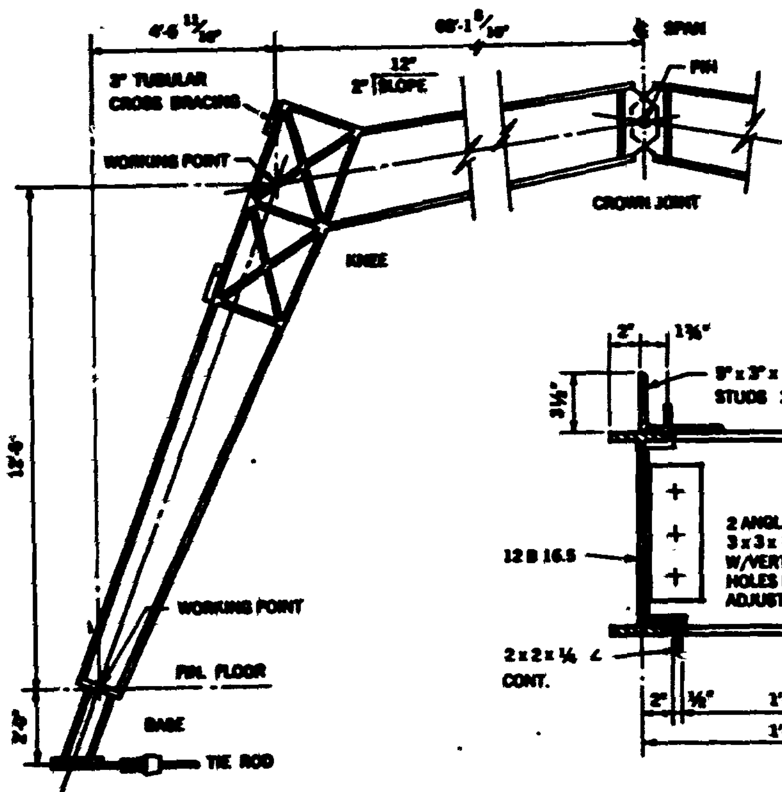
Date Construction Completed: April, 1958

FLOOR PLAN

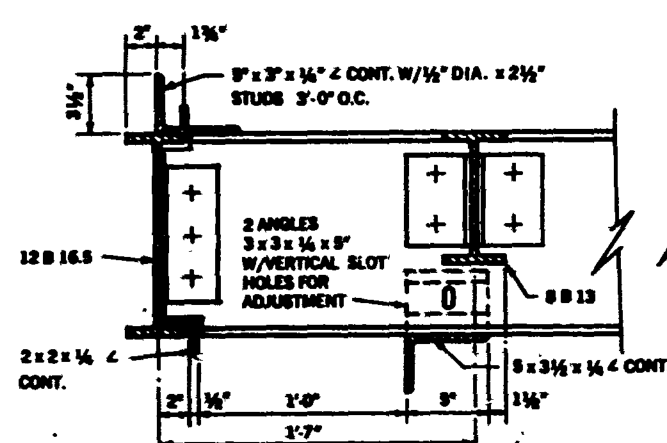
CLASSROOM BUILDING



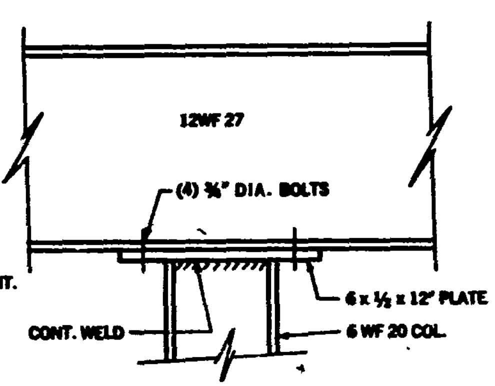
DETAILS



ELEVATION OF RIGID FRAME AT GYMNASIUM

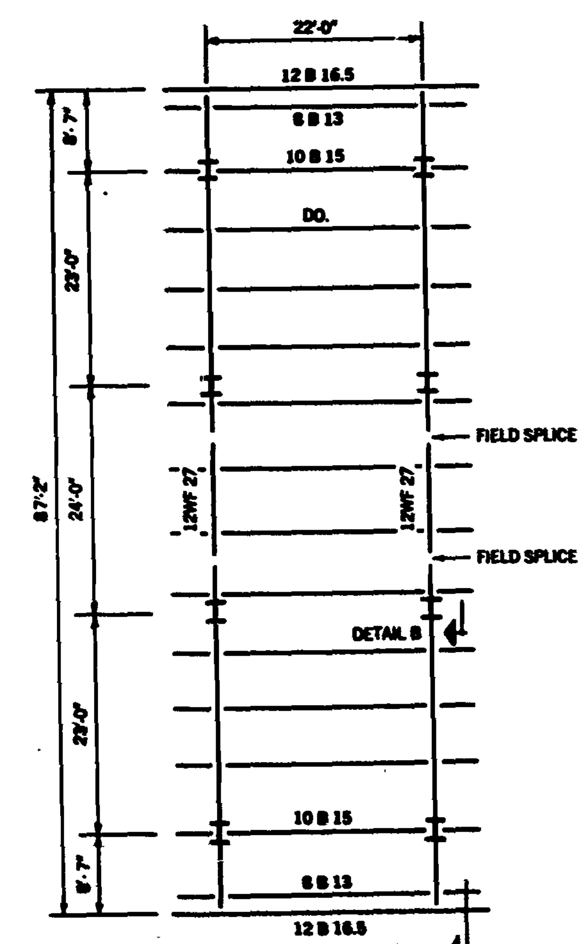


DETAIL A

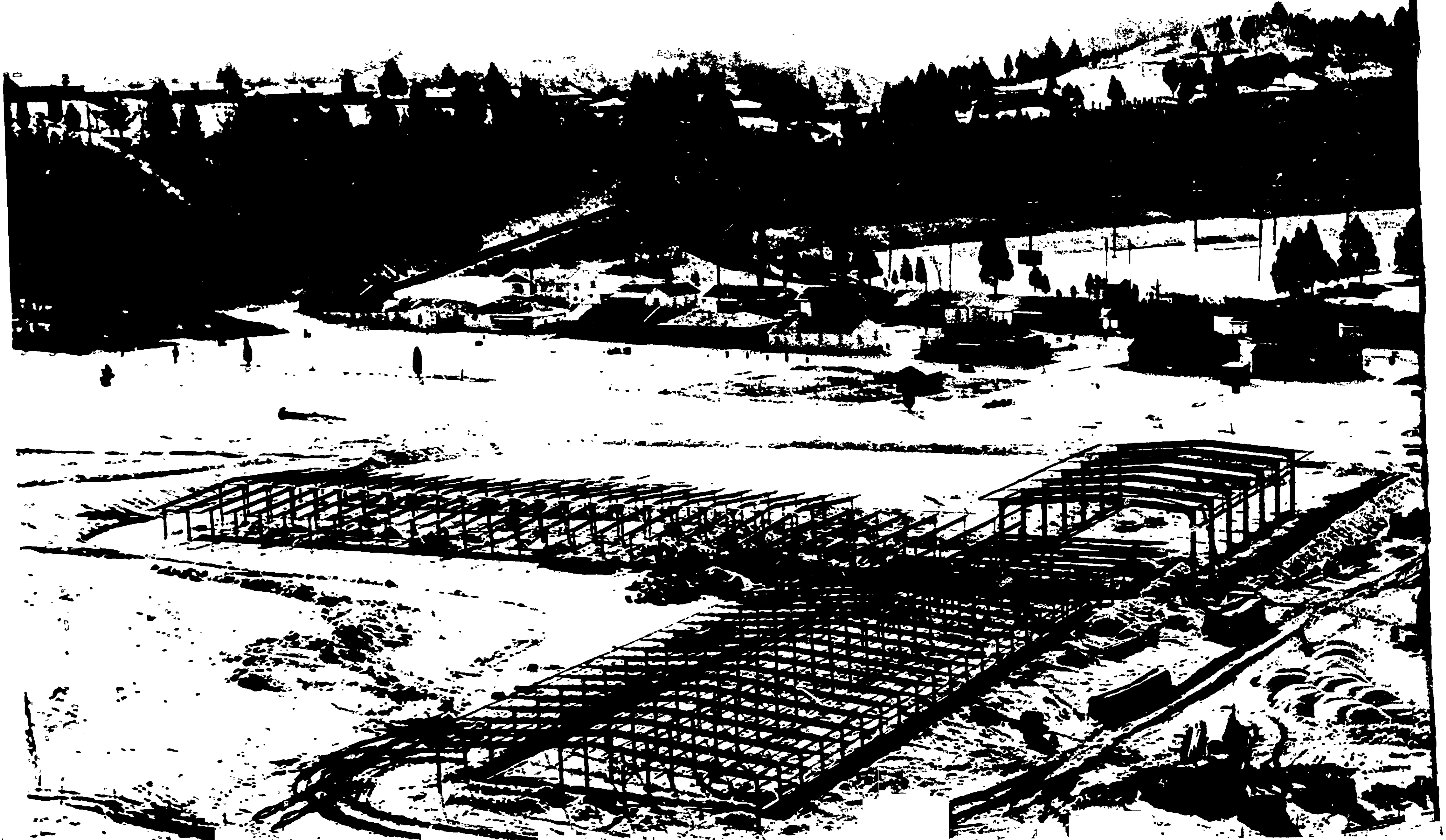


DETAIL B

TYPICAL FRAMING ACROSS CLASSROOM BUILDING



2 Steel cuts construction time—and cost



"Why not design one-and two-story schools for a quick installation of the roof by eliminating all exterior bearing walls? Then, protected from the elements, masons, carpenters and other trades can work sooner and more efficiently."

Architect Henry Elden asked himself this question several years ago, when one of his projects had been delayed three months because masonry end bearing walls could not be built during severe winter weather. He decided to design his school buildings with a lightweight structural steel frame, to eliminate all masonry bearing walls, and to install the roof as soon as steel erection was completed. He has now successfully completed 18 steel-framed schools using this principle with the following results: Contractors are pleased with the ease and speed of construction, construction time has been cut by as much as 40 percent, and unit cost has been considerably reduced.

Ripley Elementary School, Ripley, West Virginia is typical of the success of Elden's construction system. Only 13 months after award of the general contract, the school was ready for occupancy. Unit cost was $13.15 per square foot, approximately 20 percent less than many comparable schools in the area.

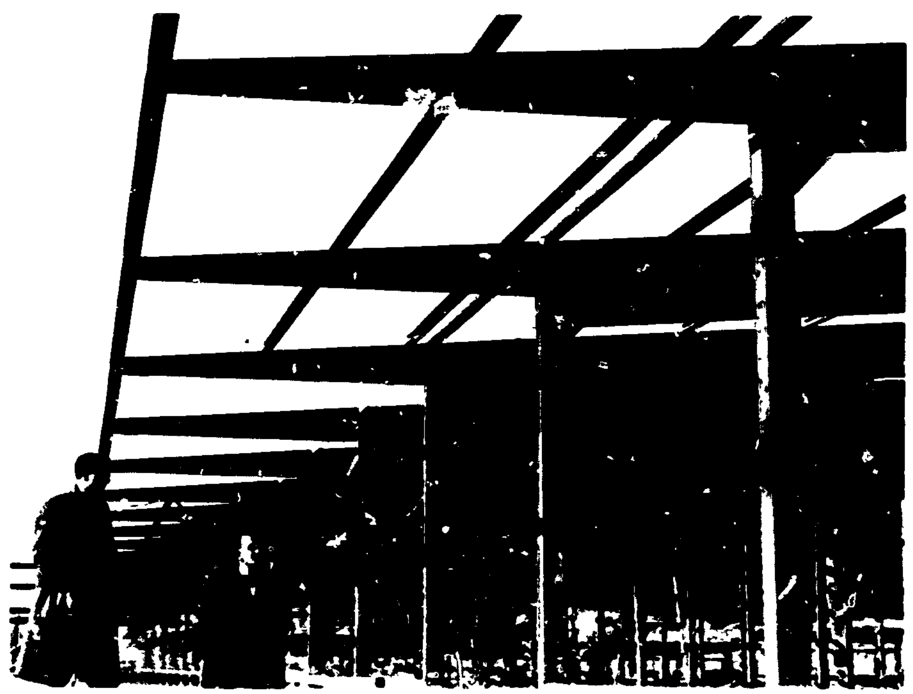
The structural design is simple beam and column framing in the classroom areas, with 4-in. x 4-in. tubular steel columns and lightweight junior beams. Steel rigid frames span 50 feet at the Multi-Purpose room. The structural module is 8 ft-8 in.

Beams project six feet beyond the building line, so that windows are completely shaded by the roof, eliminating the need for shades within the classroom. To resist wind forces before erection of the side walls, stiffened seat brackets cut from lightweight beams were shop welded to the columns and field bolted to the beams. Bulb tees, spaced 32 inches on center, are welded to the roof beams to support a 3-in. fiber-board deck and built-up roofing. Double bulb tees in the corridor provide a chase for electrical conduit. Non-bearing exterior masonry walls start at a precast grade beam and run to the continuous sill.

The entire plan, making use of repeating units, was prepared on just eight sheets of working drawings which took only six weeks to prepare.

Three months after the contract was awarded, structural steel was completely erected and roof deck was being installed. Exterior masonry and interior work then proceeded simultaneously. Polyethylene plastic sheets were used during cold weather as a temporary "close-in" until the exterior walls were completed. The speed of this method is indicated by the actual construction dates:

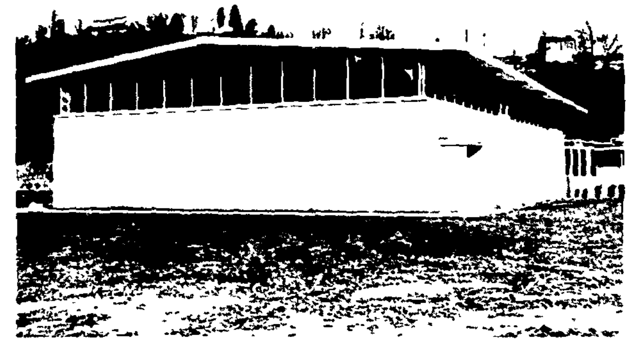
Contract awarded .... ***September 8, 1960***
Excavation started ..... ***September 20, 1960***
Excavation completed, concrete work started ...... ***October, 1960***
First structural steel delivered .... ***November, 1960***
Structural steel completed, roof deck started .... ***December, 1960***
Roof deck finished, roofing complete .... ***January, 1961***
Completion date .... ***October 15, 1961***



(left) Light steel framing for the Ripley School erected in just ten days — despite November snows and freezing weather. Enclosing walls will be non-bearing.

(right) Bulb tees, shown prior to welding, will support fiber deck and built-up roofing.

1



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(1) Only 13 months after award of general contract the school is ready for occupancy.

(2) Masonry enclosing walls run up to sill, are non-bearing. Note exposed rigid frames on interior of multi-purpose room.

DATA SHEET

Name of Structure: Ripley Elementary School

Location: Ripley, West Virginia

Type of School: Elementary

Applicable Building Code: National Building Code
Classification· Educational

Owner: Jackson County Board of Education

Architect: Henry Elden & Associates, Charleston

Structural Engineer: R. W. Haworth, Charleston

General Contractor:
Carl E. Stephens Construction Company, Parkersburg

Building Layout and Description: No. of Stories: One
Floor Area: 35,300 sq ft (gross) Cubic Footage: 404,250 cu ft
Building Dimensions: 324′ x 65′ plus 220′ x 65′ (wing)
Floor-to-Ceiling Height: 10′-4″ (average)
No. of Students: 700 No. of Classrooms: 23
Other Facilities: Combination cafeteria and multi-purpose room, kitchen and administrative areas

Design Live Loads: Roof: 30 lbs/sq ft
Classrooms: 40 lbs/sq ft Corridors: 100 lbs/sq ft

Structural Steel: Total Weight: 112 tons
Weight per sq ft: 6.6 lbs Method of Connection: Common bolted

Wind Bracing: Stiffened seat brackets

Floor System: Slab on grade

Roof Construction: 3″ fiber-board deck on steel bulb tees, built-up bonded roofing

Exterior Wall Construction: 4″ white brick,
4″ limestone block back-up

Interior Partitions: 6″ limestone block,
block face grooved to match mortar joints

Foundation: Pre-cast grade beams on concrete piers

Acoustical Treatment: Exposed underside of fiber-board deck

Fire Resistant Construction: Incombustible; no fireproofing required

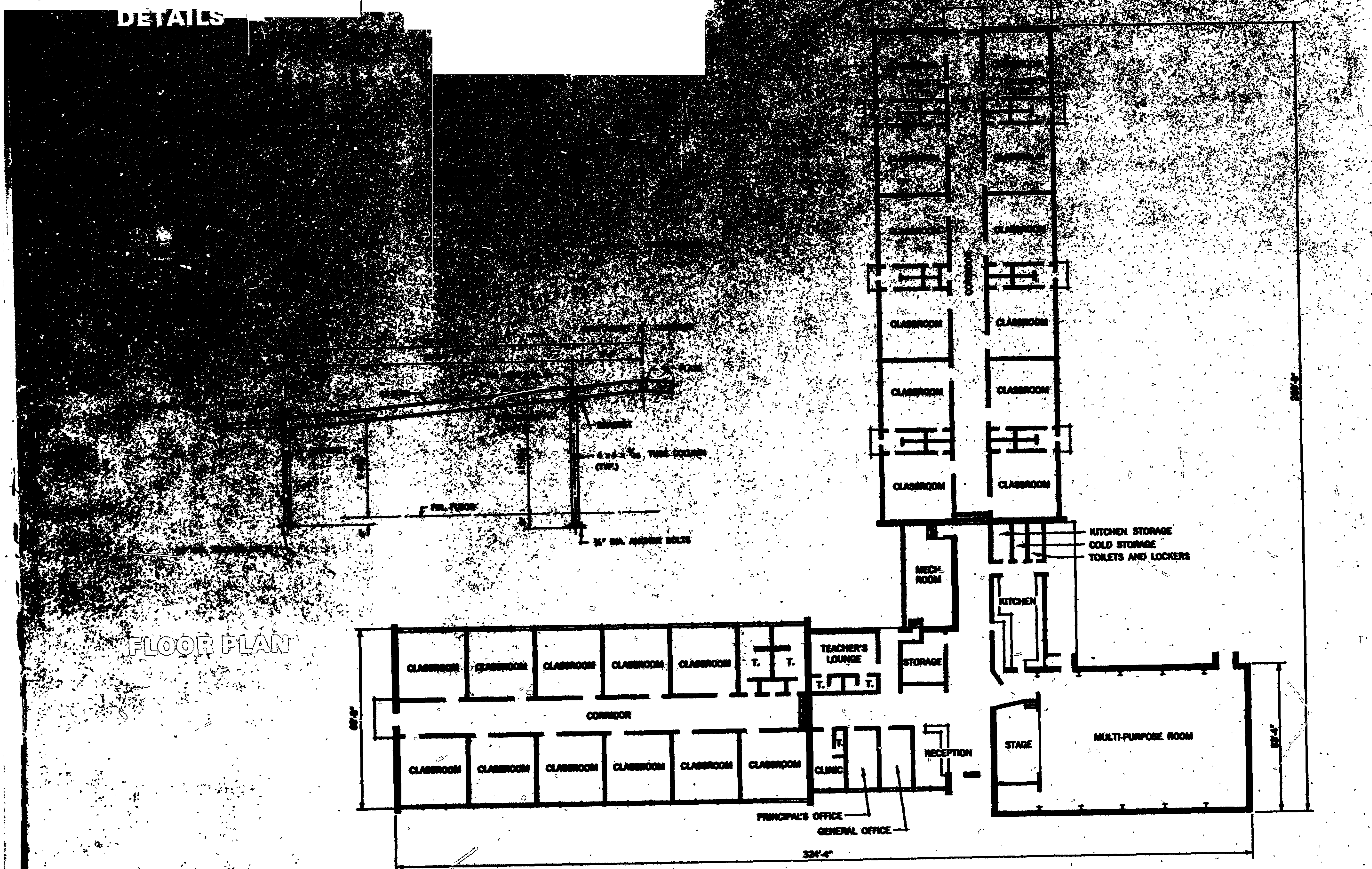
Construction Cost:	General Contract	$330,746
	Plumbing	33,826
	Heating & Ventilating	55,490
	Electrical	45,036
	Total	$465,098

Cost per sq ft of gross area: $13.15
Cost per cubic ft: $1.15 Cost per student: $664

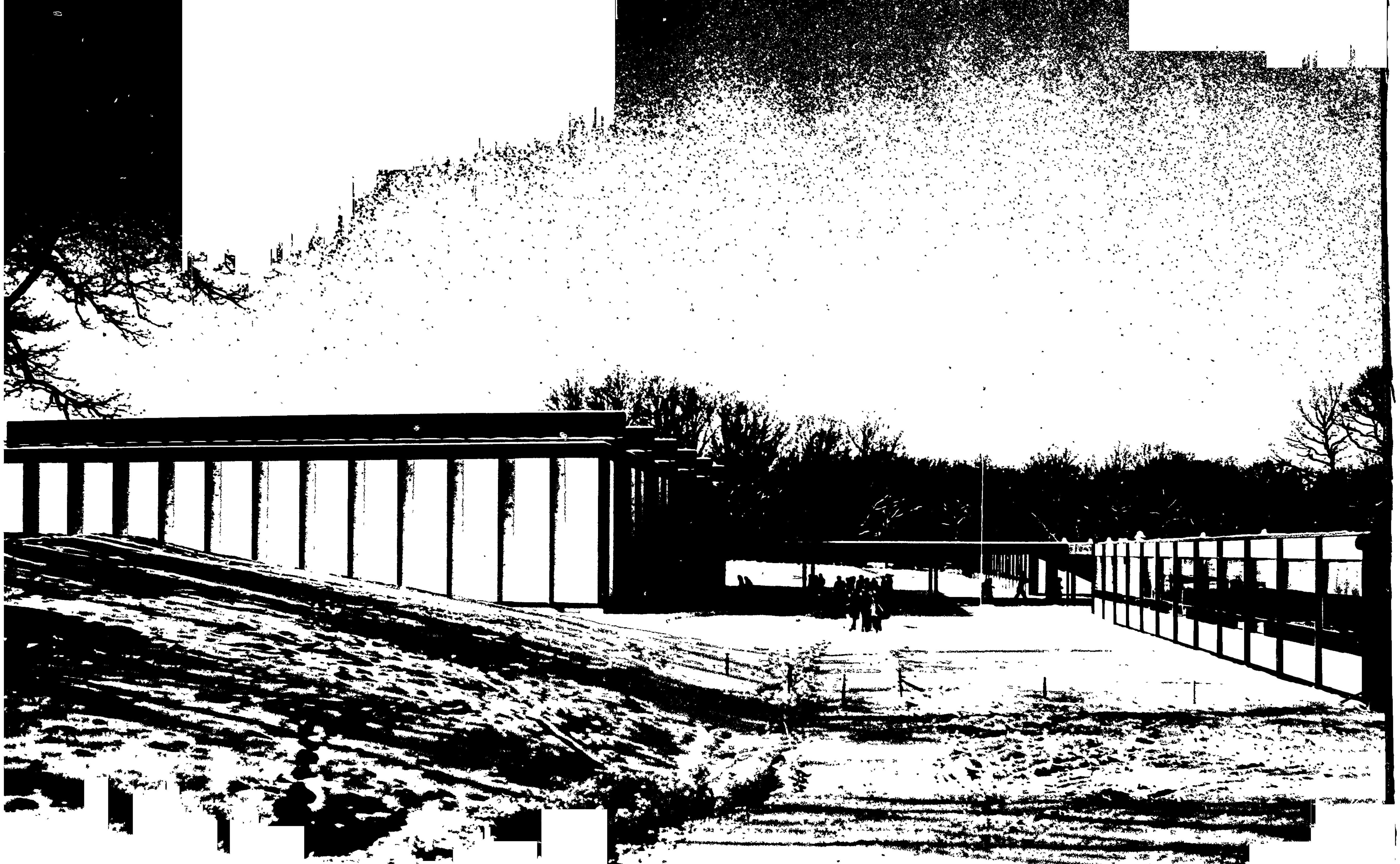
Date Construction Began: September 8, 1960

Date Construction Completed: October 15, 1961

Steel Erection Time: 10 working days

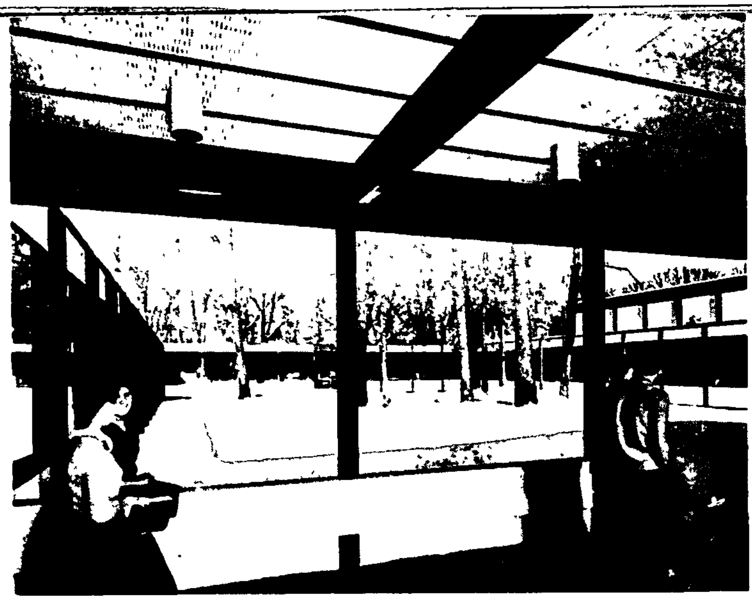

DETAILS
FLOOR PLAN
CLASSROOM
CORRIDOR
T.
TEACHER'S LOUNGE
MECH. ROOM
STORAGE
KITCHEN
KITCHEN STORAGE
COLD STORAGE
TOILETS AND LOCKERS
STAGE
MULTI-PURPOSE ROOM
RECEPTION
CLINIC
PRINCIPAL'S OFFICE
GENERAL OFFICE
324'-4"
¾" DIA. ANCHOR BOLTS
(TYP.)

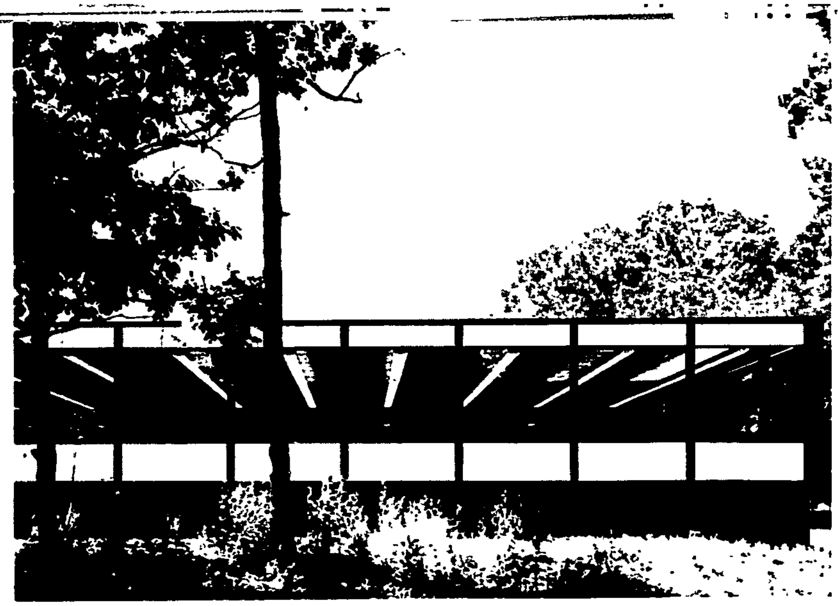
Steel as an expressive architectural element



Lowest in framing cost, most suitable for future expansion, and an expressive architectural element, structural steel was the logical and economical framing choice for the Gompers Junior High School, Joliet, Illinois. Skidmore, Owings and Merrill, and Levon Seron, associated architects, have designed a school building which fully utilizes steel's potential for economy, flexibility and beauty.

According to the architects, "the building was designed with architecturally exposed steel for direct and economical expression of the building structure. We believe strong structural expression to be an integral part of clear architecture consistent with the technology of our time. Lightness and rhythm of structural members arranged to best accommodate the various needs of this school form the core of the architectural quality of the building."





Exposed steel framing, painted two shades of brown, delineates the structure on both the interior and exterior of the Gompers Junior High School.

The school is designed to capitalize on a beautifully wooded site. The classroom building is a simple rectangle containing two large courts. The external exposures are lined with academic classrooms, manual training shops, cafeteria, and the music department. Within this rectangular structure is a windowless auditorium. The gymnasium is a separate building connected by a covered passageway to the classroom building.

Both the architectural expression and the actual construction are based on the pure frame and panel principle. The light steel structure is bolted for rapid field erection and is laid out on a very economical 24-ft square bay grid, which in turn is divided into an 8-ft module. Bulb tees two feet on center rest on 12-in. purlins and receive formboard for the poured gypsum roof. In the gymnasium, long span plate girders, which run exposed above the roof, allow a smooth ceiling, cut down the amount of heating volume inside, and reduce the scale of the exterior form. The structural frame is exposed throughout. The steel is painted two shades of brown, contrasting with white porcelain and precast exterior panels, and with interior plaster finish.

Significant savings were achieved by repetition of the same bay size over the large floor area. This design led to the use of identical size beams and purlins with identical details, and resulted not only in a favorable steel price, but contributed to ease and speed of erection. Speed was an important consideration to the school board. The architects also found that the exposed steel frame lent itself readily to the ease of fastening of wall panels and to making weather-tight joints. Unit cost of construction was $14.14 per square foot.

Special attention was given to acoustic control throughout the building. Classroom ceilings are on a module with alternating reflective (smooth) and absorptive (slotted) formboard panels to give necessary reinforcement or reduction of noise levels according to the purpose of the different teaching areas. Suspended acoustical tiles form the ceilings in corridors and conference rooms. Plywood sound deflectors and sound-absorptive wall materials control the acoustics in the auditorium.

Provision for expansion was a prime consideration in the design of the Gompers school, since it is expected that within five years the school system may establish a unit district program. Present school population is 600 students. Central facilities are sized to accommodate an enrollment of 900, and extension of classroom facilities was planned for ready execution. Because steel framing is the most suitable of all structural systems for future alterations, changes will be easier and less costly.

DATA SHEET

Name of Structure: Gompers Junior High School

Location: Joliet, Illinois

Type of School: 7th and 8th Grades

Applicable Building Code:
City of Joliet Building Code and National Building Code

Owner: School District #86, Will County, Illinois

Architect: Skidmore, Owings & Merrill, Chicago
Levon Seron, Joliet (Associate Architect)

Structural Engineer: Skidmore, Owings & Merrill, Chicago

General Contractor: Mercury Builders, Inc., Forest Park

Building Layout and Description:
No. of Stories: One and partial basement
Floor Area: 95,392 sq ft (gross)
Building Dimensions: 218′ x 412′ (including courts)
105′ x 116′ (gymnasium)
Structural Module: 8′-0″
Floor-to-Ceiling Height: 10′-0″ (classrooms) 21′-9″ (gymnasium)
No. of Students: 600 (central facilities for 900)
No. of Classrooms: 19
Other Facilities: Gymnasium, cafeteria, auditorium, home arts, shops, arts and crafts, music room, activities room

Structural Steel: Total Weight: 359 tons
Weight per sq ft: 7.5 lbs
Method of Connection: Interior - bolted; exterior - welded

Floor System: Concrete slab on compacted fill; perimeter insulated by continuous concrete service tunnel; asphalt tile flooring

Roof Construction: 12″ structural steel purlins support bulb tees which receive formboards for roof. Poured gypsum deck over gypsum, acoustical or asbestos formboard

Exterior Wall Construction: Window wall is an adaptation of standard sash to an 8″ modular prefabricated unit. 1/4″ plate glass and white porcelain panels inserted in the field. Opaque walls are 5″ thick precast concrete sandwich panels with an insulating core and white quartz exposed aggregate finish

Interior Partitions: Steel stud and plaster, gypsum block and plaster, glazed structural tile

Foundation: Spread footings

Wind Bracing: No special provision except for stiffness of connections

Acoustical Treatment: 50% acoustical (slotted) and 50% smooth formboard used for poured roof deck (classrooms, corridors, cafeteria, library, music rooms, lobby, etc.). Mechanically suspended mineral acoustical tile (corridors, conference rooms). Plywood sound deflectors suspended at varying degrees to form ceiling (auditorium)

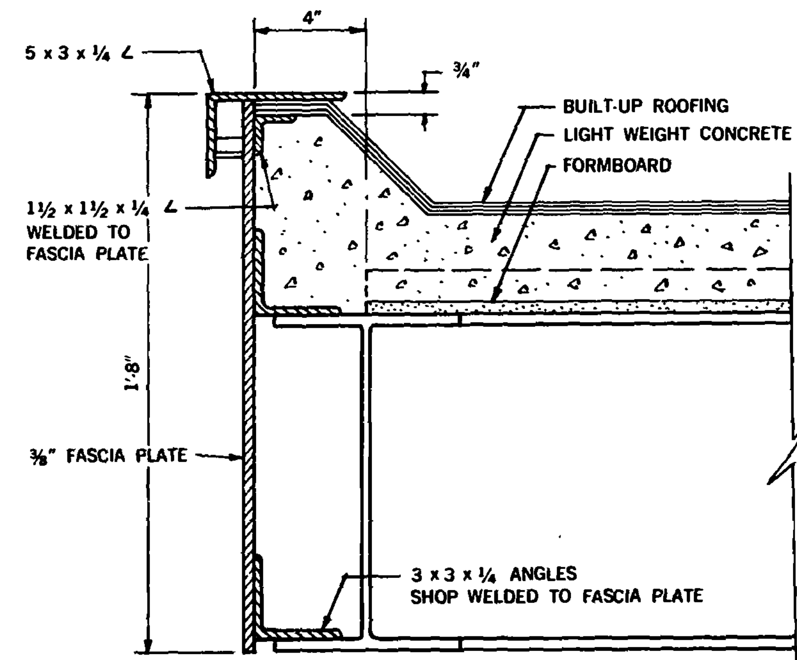
Construction Cost:	General Contract	$ 888,468
	Plumbing	127,972
	Heating & Ventilating	220,972
	Electrical	108,958
	Total	$1,346,370

Cost per sq ft of gross area: $14.14

Date Construction Began: November, 1955

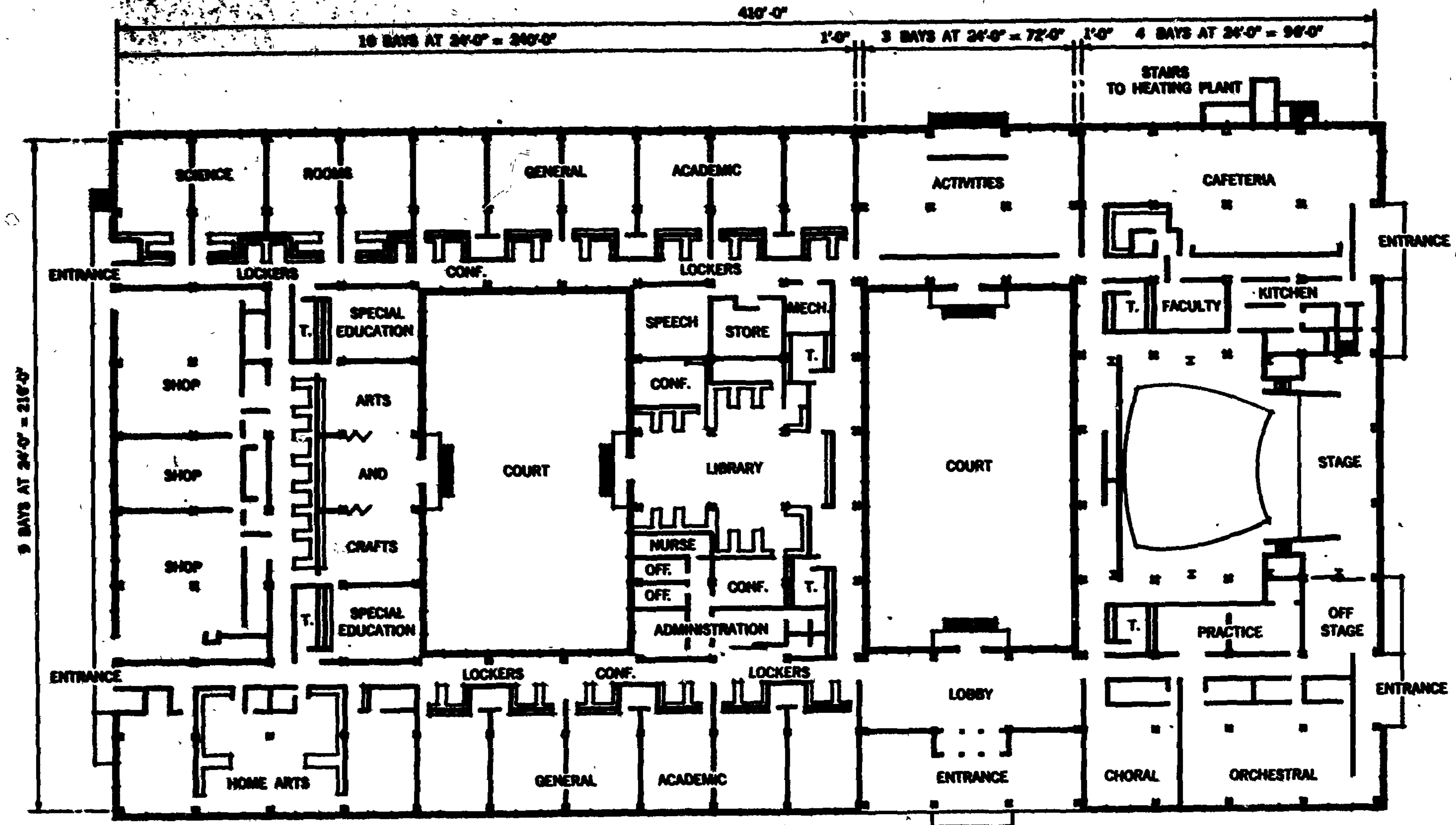
Date Construction Completed: October, 1957

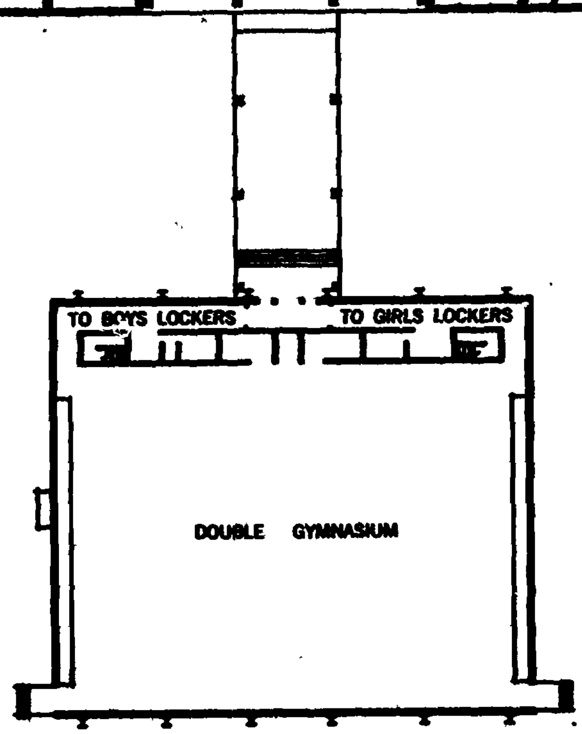
Steel Erection Time: Approximately 3 months (intermittent)



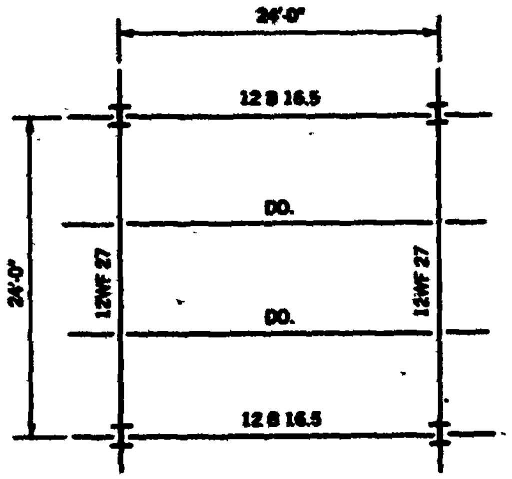
FASCIA DETAIL

FLOOR PLAN





DETAILS



FRAMING OF TYPICAL BAY


Keeping

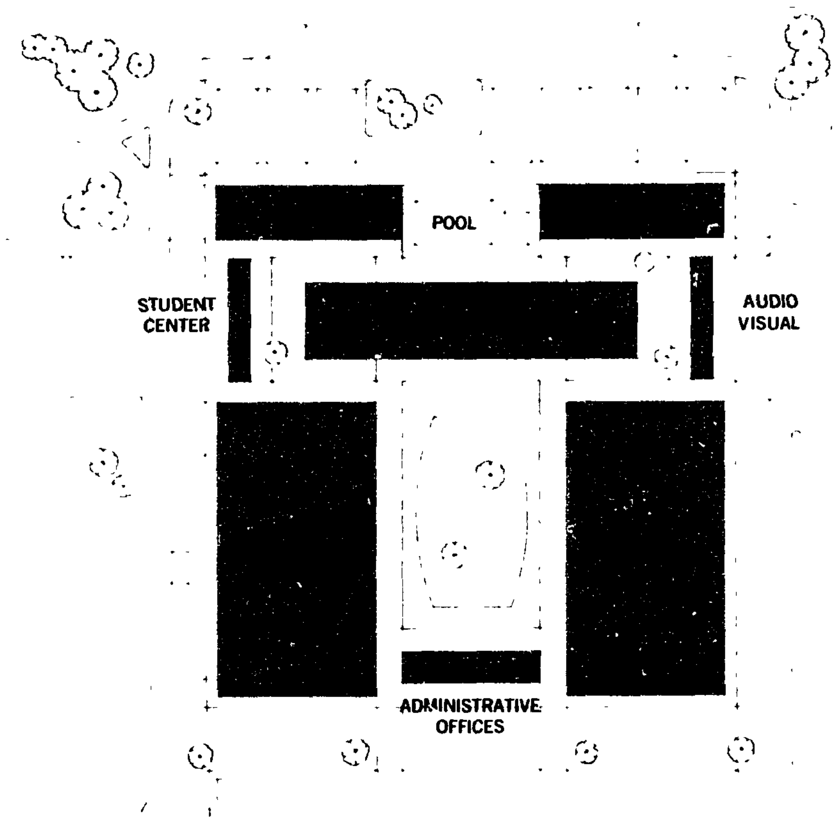
Ten cents of every school tax dollar is spent on maintenance, repairs, operation, administration and transportation, according to the 1958 report "Recent School Building Costs in California", prepared by the California State Department of Education. The report shows that a dollar saved in construction is soon spent if it increases maintenance and administration costs.

The Mills High School, Millbrae, California, has been designed to keep maintenance and administration costs low. School district records of the cost of custodial maintenance, compared with some of the older schools in the district, show significant savings. In every phase of construction, architects-engineers Reid, Rockwell, Banwell & Tarics selected materials with both present and future costs in view. Throughout the school the designers used modular construction. Size of window glass, wall material panels, and the size of doors and hardware equipment were all standardized. Uniformity of color and finish were utilized wherever possible. Such features as baked-on enamel finish for partitions and carefully located custodial spaces were planned to keep maintenance costs low. Exposed steel framing, properly painted, was chosen for low maintenance, as well as low first cost and aesthetic appearance.

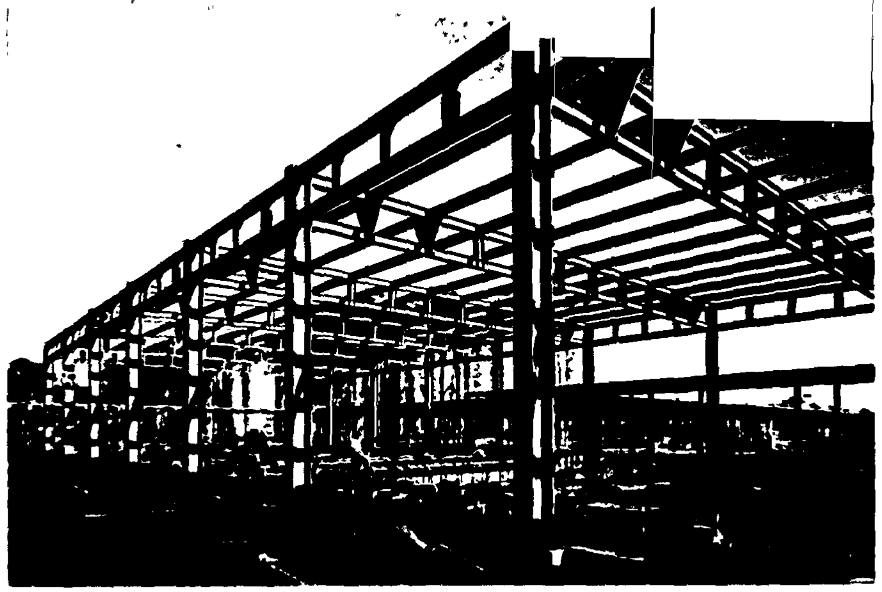
Flexibility of space and utilities for future change is another important attribute of the Mills High School. Architect John Lyon Reid believes that "in secondary education, curricula and teaching are constantly improving and the school building must be able to accommodate changes easily in order that improvements in education may be encouraged." Flexibility has been achieved by the provision of large clear spaces, uniformly illuminated to high standards by artificial light and daylight through prismatic glass skylights; moveable partitions with interchangeable window, solid or door panels; and utility stub-outs, so that educational aids can be added as needed, where needed. Corridor walls are not related to column locations, and can be relocated at any time that revised classroom arrangements are required.

Steel was the logical choice of framing material for this flexible school design. The large bay spacing (28-ft x 28-ft) was most economical with steel construction. Future framing alterations, if required, can be easily accomplished. By maintaining the same structural module throughout the building, the designers were able to utilize 12-in. deep sections of various weights for all roof framing members. This permitted an efficient and economical layout of mechanical ducts and pipes by avoiding vertical turns to clear deeper structural members.

According to the architects, "the inherent economies of steel construction were greatly enhanced by uniformity in the sizes of structural steel components, by the large grid of repetitive bays, and by repetitive detailing for the entire structural frame. Our hopes for economy and speed materialized in the prices received and in the remarkably speedy construction time." Throughout the building, repetition of elements and compactness of plan kept the per-pupil cost of the school equal to that of earlier schools in the district, despite rising costs.



SITE PLAN



Welded Vierendeel-truss bents span 88 feet over the gymnasium-auditorium areas. Note the brackets providing lateral support for trusses.

DATA SHEET

Name of Structure: Mills High School

Location: Millbrae, California

Type of School: High School

Applicable Building Code: Uniform Building Code;
California Administrative Code — Title 21

Owner: San Mateo Union High School District

Architect: Reid, Rockwell, Banwell & Tarics, San Francisco

Structural Engineer: Dr. Alexander G. Tarics, San Francisco

General Contractor: Rothschild, Raffin & Weirick, San Francisco

Building Layout and Description: No. of Stories: One
Floor Area: 188,000 sq ft (net); 220,000 sq ft (gross)
Building Dimensions: 560′ x 532′ Structural Module: 28′-0″
Floor-to-Ceiling Height: 12′-0″
No. of Students: 1,800 No. of Classrooms: 60
Other Facilities: 2 gymnasiums, cafeteria, auditorium, music rooms, laboratories, shops, library, administration, pool

Design Live Loads: Roof: 20 lbs/sq ft

Structural Steel: Total Weight: 847 tons
Weight per sq ft: 7.7 lbs
Method of Connection: All connections welded, except purlins are connected with machine bolts

Lateral Bracing: Moment resisting frames

Floor System: Concrete slab on grade

Roof Construction: Composition roof on steel deck

Exterior Wall Construction:
Aluminum curtain wall, transite sandwich panels

Interior Partitions: Unit moveable metal partitions

Foundation: Individual column footings interconnected with moment resisting grade beams

Acoustical Treatment: Hung ceiling with acoustical panels and acoustical tile on walls

Fire Resistant Construction: Incombustible, sprinklered

Construction Cost:		
	General Contract	$1,966,514
	Plumbing	355,000
	Heating & Ventilating	710,000
	Electrical	470,000
	Total	$3,501,514

Cost per sq ft of gross area: $15.87 Cost per student: $1,945
Fixed equipment $233,463

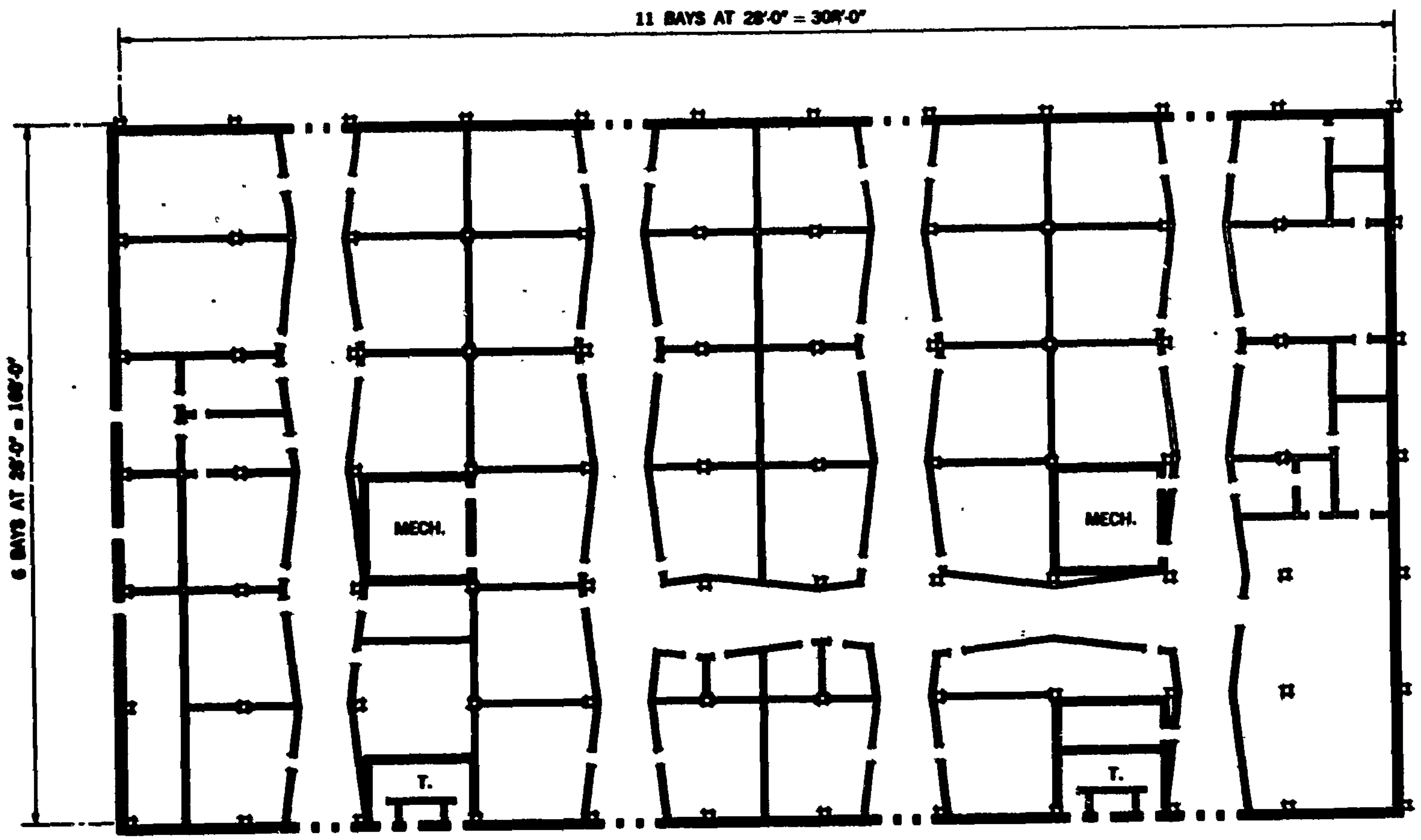
Date Construction Began: April 17, 1957

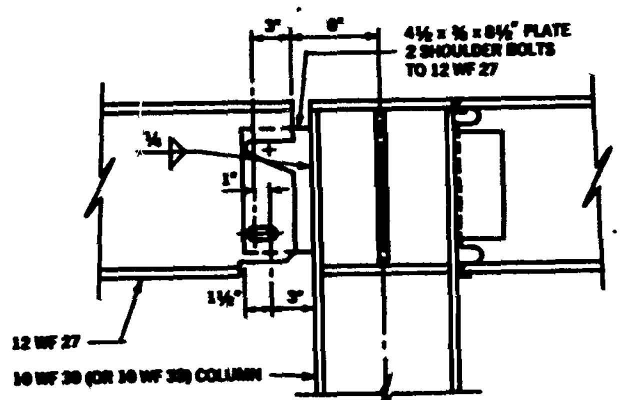
Date Construction Completed: January 25, 1959

Steel Erection Time: 6 weeks

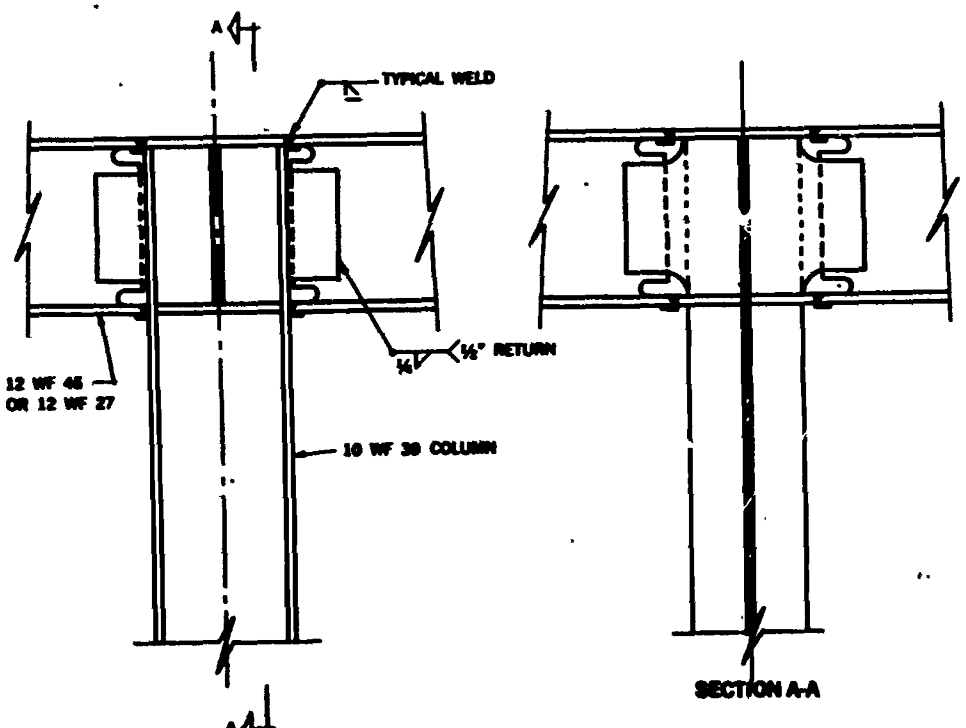
Special Features: The gymnasium-auditorium areas are framed with 88′ span Vierendeel-truss rigid bents;
all roof framing members including the Vierendeel trusses are made of 12″ deep sections of various weights

CLASSROOM BUILDING

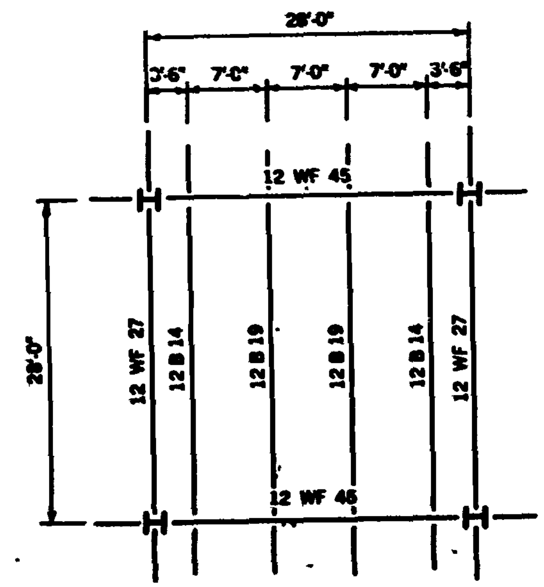




GIRDER-TO-COLUMN CONNECTION
AT EXPANSION JOINT



TYPICAL GIRDER-TO-INTERIOR COLUMN CONNECTION



FRAMING OF TYPICAL BAY

5 High speed at low cost

Identical steel rigid bents, 8 feet on centers, frame classroom areas. Repetitive framing led to low fabrication costs, fast erection.

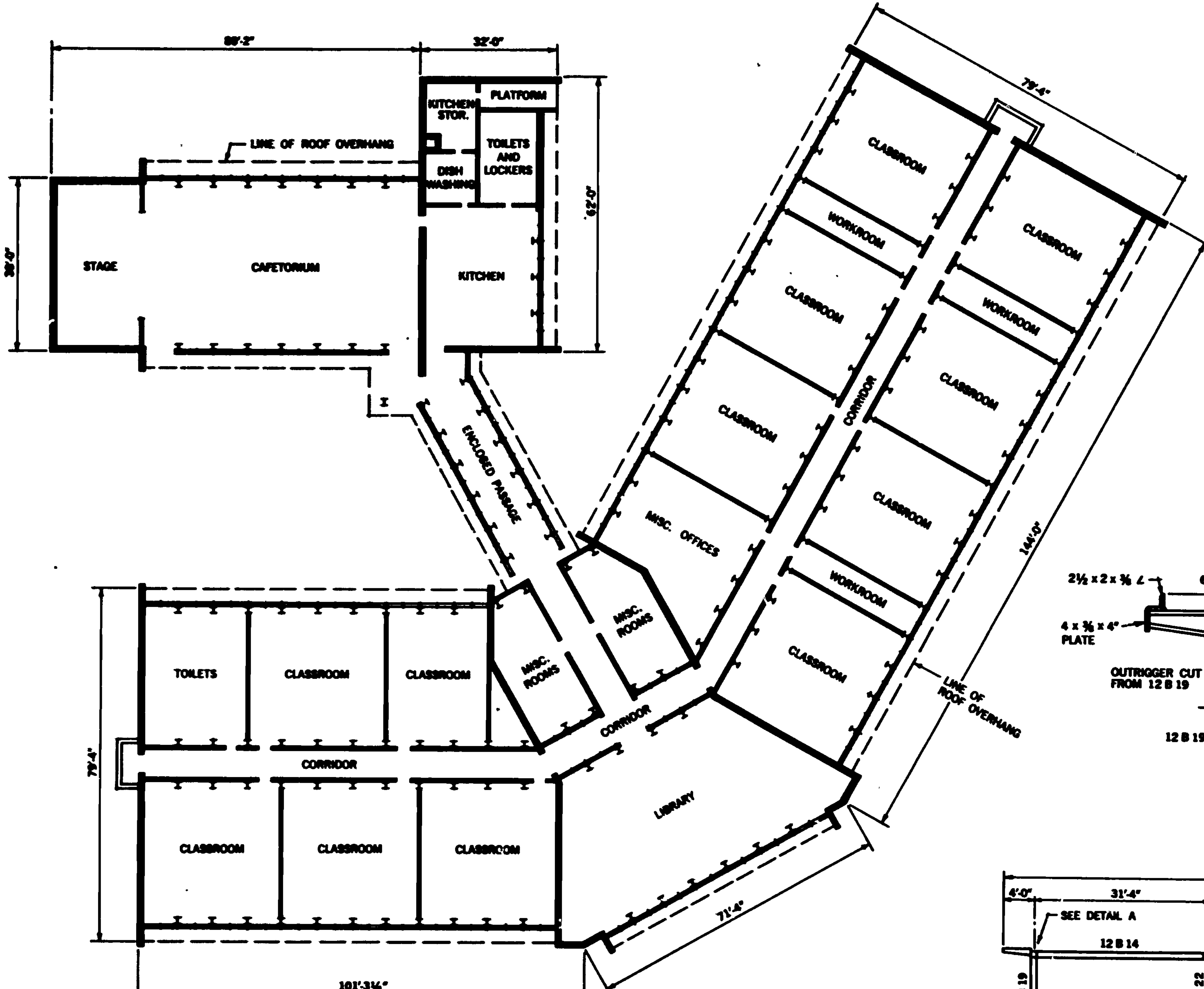
Construction of the Braxton Craven Elementary School in Greensboro, N. C. began in May of 1960. By the start of the September term, construction was completed and the school was ready for occupancy. According to architect Albert C. Woodroof, only steel construction could have achieved this rapid building schedule — so important to the Greensboro school board.

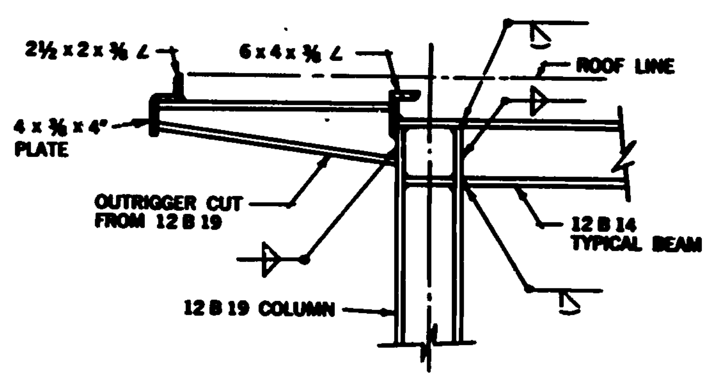
Fabrication of the steel framing began while the excavation work was underway. As soon as footings were ready to receive the frame, steel erection began. Within two weeks the entire structural frame was completed.

The basic design of the roof of the Craven school is a series of 12B14 rigid frames spaced 8-ft on center and spanning 31 ft-4 in. from center corridor to exterior wall. Steel bulb tees support formboard and a poured gypsum slab, providing an incombustible roof, insulation, and an acoustical ceiling over the exposed steel beams. The compatability of this roof system with the steel frame permitted construction to continue at a rapid rate.

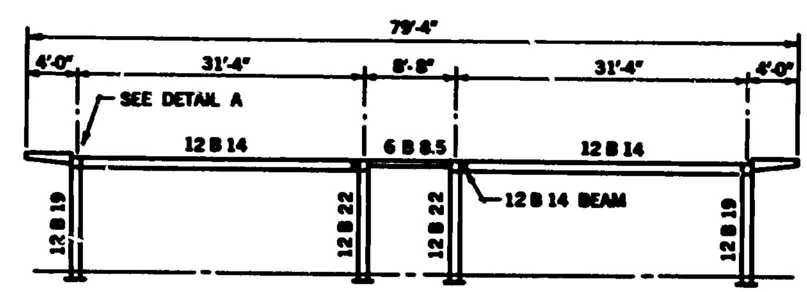
Alternate bids were taken for a steel joist floor system, and a concrete joist and filler block system. Steel joists saved $0.30 per square foot, according to the actual bids received. Total cost of the building, including fixed equipment, was $10.42 per square foot.

Color is an important feature of the interior and exterior of the Craven school. All structural members are painted in harmony with the multi-color lacquers on the exposed masonry blocks. Experience has satisfied architect Woodroof that exposed structural steel, properly painted, requires little maintenance to remain attractive and colorful indefinitely.





DETAIL A



'RANSVERSE SECTION CLASSROOM FRAMING

DATA SHEET

PROJECT 5

Name of Structure: Braxton Craven Elementary School

Location: Greensboro, North Carolina

Type of School: Elementary

Applicable Building Code: North Carolina State Building Code
Classification: Noncombustible

Owner: City of Greensboro, North Carolina

Architects & Structural Engineer:
Albert C. Woodroof and A. C. Woodroof, Jr., Greensboro

General Contractor: Brooks Lumber Company, Greensboro

Building Layout and Description:
No. of Stories: One, plus a boiler room and fuel room underneath
Floor Area: 27,880 sq ft (gross)
(does not include 4'-0" overhang around perimeter of building)
Floor-to-Ceiling Height: 10'-3"
No. of Students: 360 No. of Classrooms: 12
Other Facilities: Cafetorium
(combined cafeteria & auditorium) 62' x 117'

Design Live Loads: Floor: 40 lbs/sq ft
Corridors: 100 lbs/sq ft Roof: 20 lbs/sq ft

Structural Steel: Weight:

Structural Steel	66 tons
Bar Joists	60 tons
Total	126 tons

Weight per sq ft: 9.0 lbs
(includes overhang brackets and perimeter angles)
Method of Connection: Welded and machine bolts

Wind Bracing: None

Floor System: 2½" reinforced concrete slab on bar joists, with 6" concrete slab over Boiler-Fuel Rooms

Roof Construction: Steel rigid frames spaced 8'-0" o.c., 2½" poured gypsum deck on formboard and bulb tees, 1" insulation and built-up roofing

Exterior Wall Construction: Insulated panels below windows — steel panels (green) with fiber-glass insulation.
All other wall construction is block and face brick

Interior Partitions: 4" concrete masonry block

Acoustical Treatment: Inherent with the formboard roof construction

Fire Resistant Construction: None required

Construction Cost:

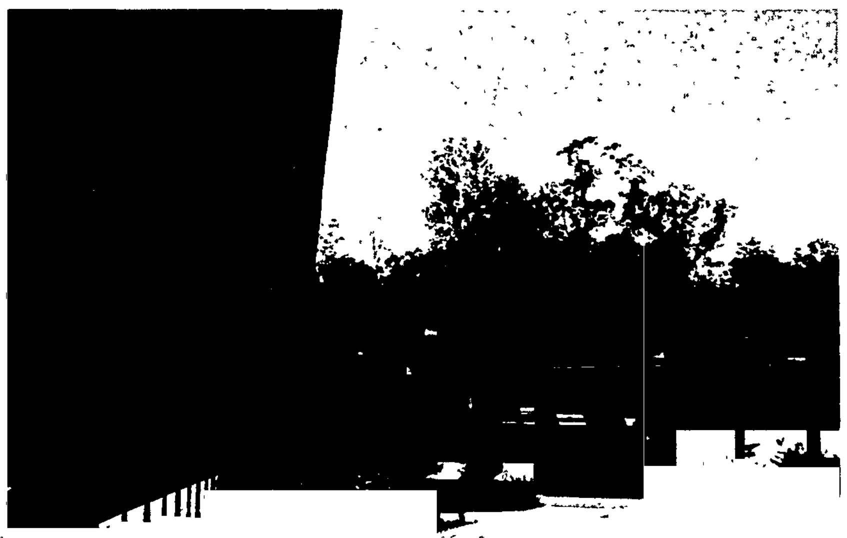
General Contract (incl. fixed equipment)	$236,968
Plumbing	16,584
Heating & Ventilating	21,512
Electrical	15,474
Total	$290,538

Cost per sq ft of gross area: $10.42 Cost per student: $807

Date Construction Began: May 1, 1960

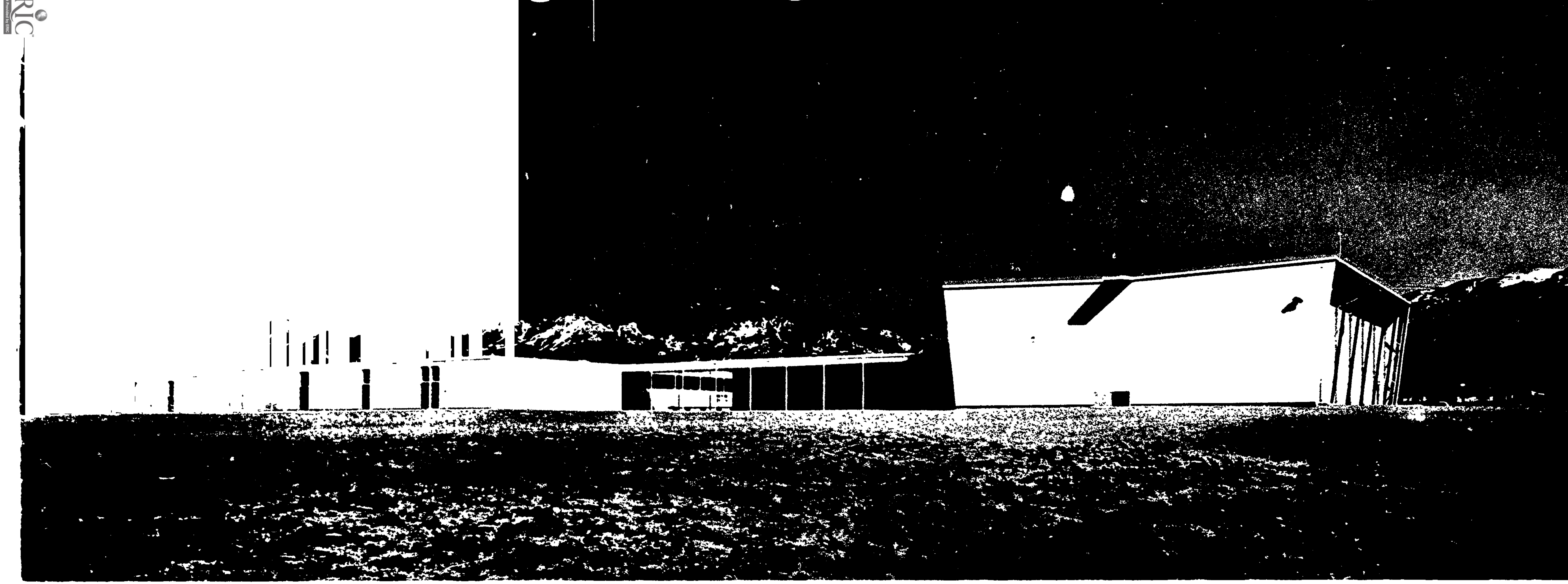
Date Construction Completed: September 1, 1960

Steel Erection Time: Two weeks



Classroom windows are shaded by a 4-ft overhang. In background, enclosed passageway joins Cafetorium to classroom wings.

Making the most of a low budget



Madison Junior High School in Albuquerque, New Mexico, is a ''lot of school for the money''. Working within a very limited budget, architects-engineers Ferguson, Stevens, Mallory and Pearl have designed a simple, clean cut structure without any frills, but one which fulfills its function as a fine school facility.

Unit cost of construction was only $9.35 per square foot. Steel frames this building because steel cost less than other framing systems, yet provided more value for the taxpayer's dollar. Incombustible construction, ease of future alterations, flexibility of design, speed of construction, low maintenance, the attractiveness of exposed steel framing — and low first cost — made steel the choice of the architect and the school board.

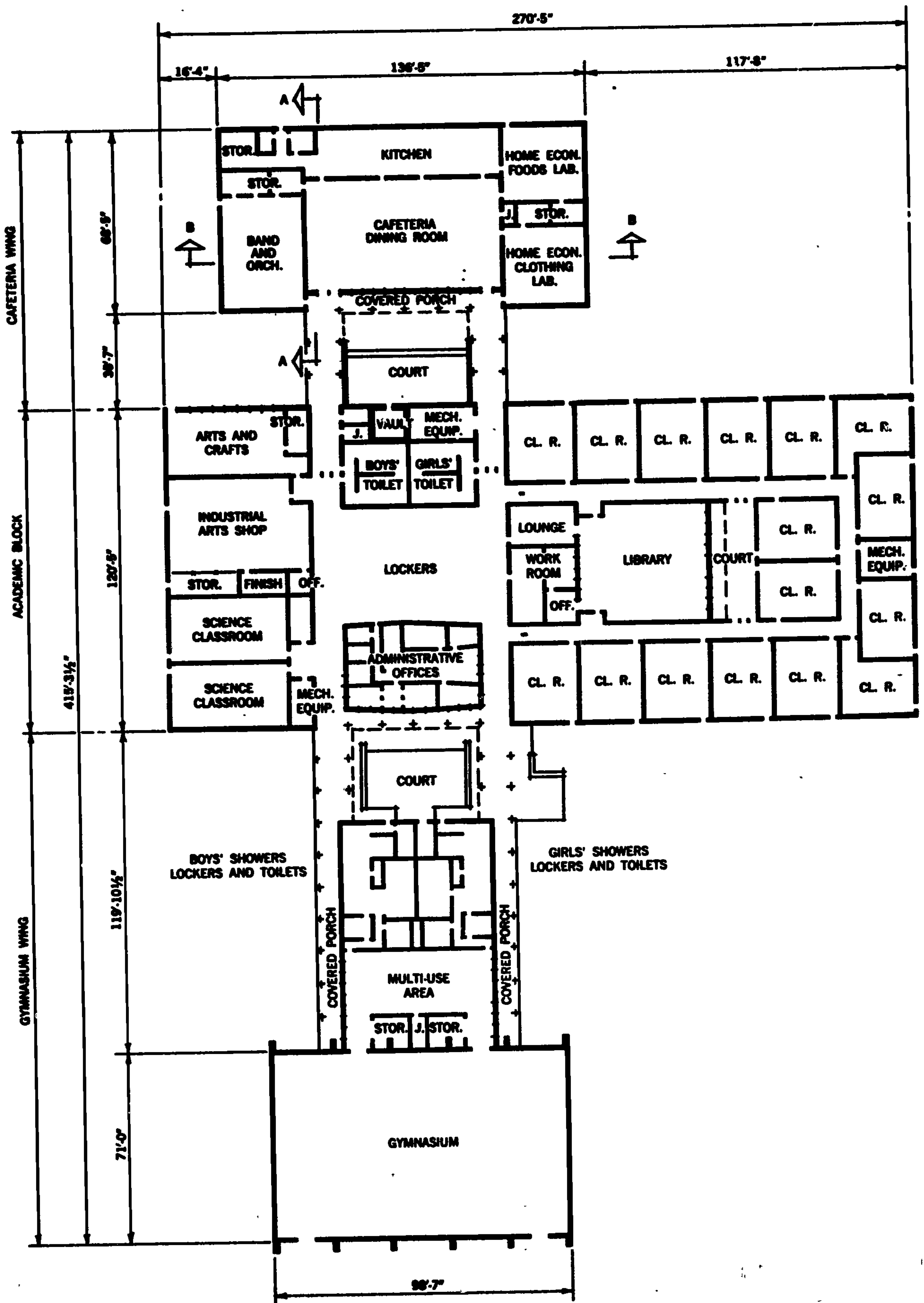
Simplicity is the keynote of the structural design. Bolted beam and column framing is utilized in the academic and cafeteria build-

Steel truss rigid frames span the 71 ft wide gymnasium. Vertical legs of frames are outside of exterior walls.

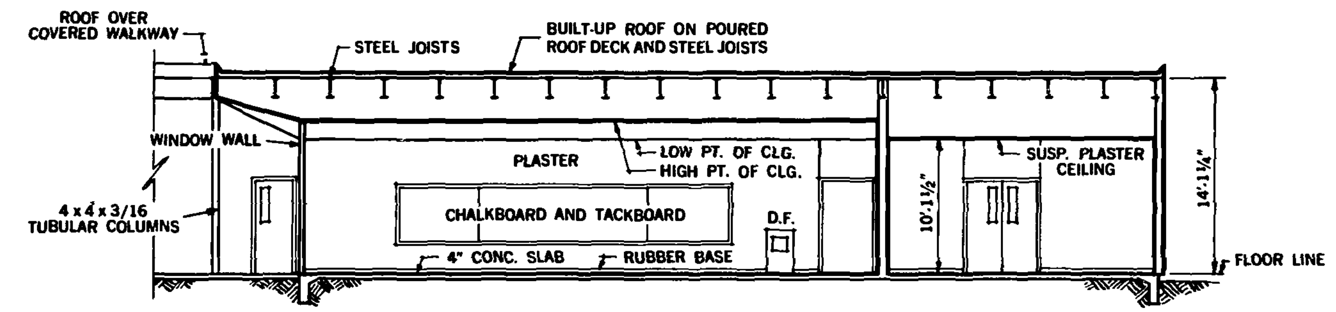
ings. Column grids are typically 24-ft x 24-ft and 24-ft x 20-ft. Larger clear areas are provided in the band-orchestra and home economic areas (68-ft x 32-ft each), the cafeteria (72-ft x 48-ft), and the library (44-ft x 44-ft). Open-web steel joists welded to the frame, corrugated steel forms, a vermiculite slab, and built-up roofing form the typical roof construction throughout. Exterior walls are 4-in. steel studs with ½-in. fiberboard sheeting each side, plaster on the inside and stucco on the outside. Insulation batts are placed between the studs.

A series of simple, low cost steel truss rigid frames span the 71-ft wide x 96-ft long gymnasium. The legs of the trussed frames taper from 2 ft-8 in. at the floor line to a 5 ft-11 in. depth at the high point of the frame. The sloping trusses are exposed, providing an attractive and unusual architectural effect.

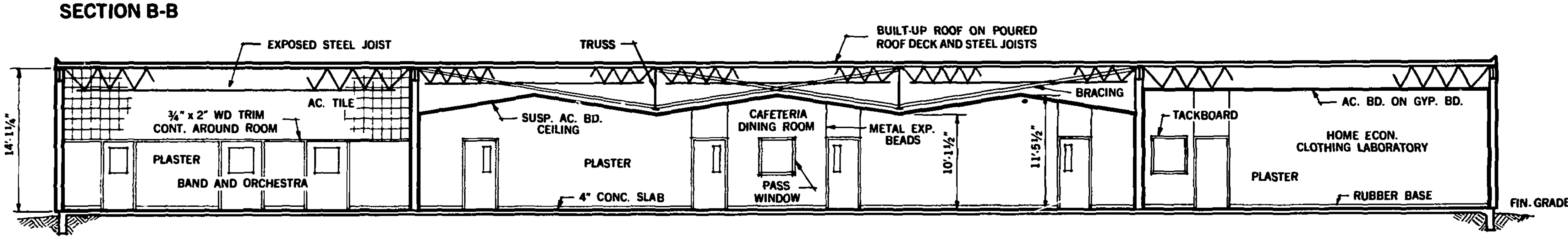
In Madison Jr. H. S., as in thousands of low budget schools throughout the United States, structural steel is providing top quality, top flexibility, top durability — at no extra cost.



SECTION A-A



SECTION B-B



DATA SHEET

Name of Structure: Madison Junior High School

Location: Albuquerque, New Mexico

Type of School: Junior High School

Applicable Building Code: Uniform Building Code; Group C Occupancy

Owner: Albuquerque Public Schools

Architect & Structural Engineer:
Ferguson, Stevens, Mallory & Pearl, Albuquerque

Contractor: Lemke Construction Company, Albuquerque

Building Layout and Description: No. of Stories: One
Floor Area: 54,225 sq ft (gross)
Floor-to-Ceiling Height: Halls: 8'-0" Classrooms: 10'-6"
No. of Students: 900 (present); 1200 (future)
No. of Classrooms: 23
Other Facilities: Gymnasium, library and cafeteria

Design Live Loads: Roof: 20 lbs/sq ft
Wind: 20 lbs/sq ft Seismic load for Zone 2

Structural Steel: Total Weight: 90 tons
Weight per sq ft: 3.5 lbs
Method of Connection: Bolted, except beam splices welded and joists welded to beams

Wind Bracing: 4WF13 diagonals in walls and bracing in plane of roof

Floor System: Concrete floor slabs on fill, resilient tile flooring

Roof Construction: Bar joists and long span joists supported by steel beams. Corrugated steel forms welded to joists, vermiculite slab over forms, then built-up roof

Exterior Wall Construction: 4" steel stud walls with ½" fiberboard sheeting each side, and insulation batts between studs. Plaster inside and stucco outside

Interior Partitions: 3⅝" metal studs with lath and plaster

Foundation: Footings and grade beams

Acoustical Treatment: Acoustical tile

Fire Resistant Construction: Corridors have 1 hour fireproofing (⅝" sheetrock). All other areas non-combustible

Construction Cost:	General Contract:	$359,051
	Plumbing & Heating	92,510
	Electrical	55,439
	Total	$507,000

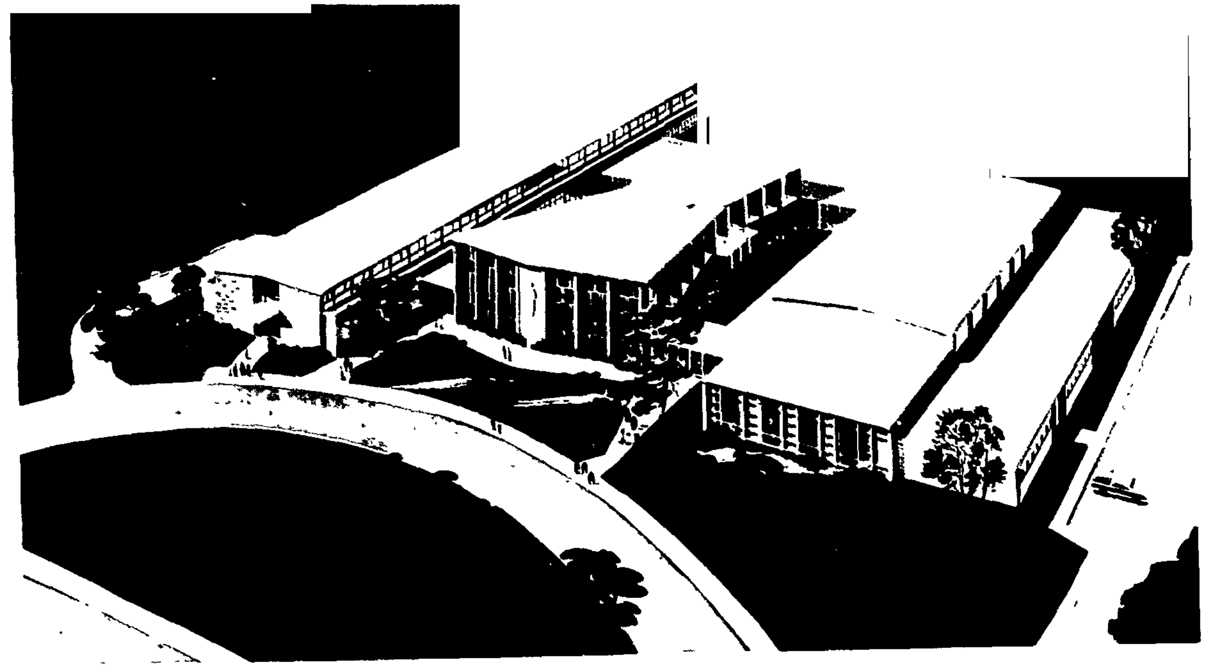
Cost per sq ft of gross area: $9.35
Cost of Fixed Equipment (Kitchen): $23,400

Date Construction Began: December 1, 1958

Date Construction Completed: August 15, 1959

Steel Erection Time: Three weeks

7 Light steel for long span economy



Quietly contemporary, the centrally located chapel building states, architecturally, the religious nature of the entire school complex.

One of the nation's outstanding secondary school buildings is the new St. Pius X Seminary in Uniondale, Long Island, N. Y. Architects Eggers & Higgins have achieved a well arranged, highly attractive facility, architecturally keyed to the religious nature of the educational program. Steel was clearly the economical choice of structural framing.

The basic layout is a "quadrangular" or "courtyard" plan, which interpositions but separates four major program areas: academic and administration, resource (chapel and library), faculty residence, and areas such as the cafeteria and all-purpose room which are shared with the public.

Center of all activity, and focal point of the school complex, is the chapel. This unusual wedge-shaped building is two stories high, seats 400 persons, and includes a two-level library with a capacity of 30,000 volumes. Steel beams span 50 to 70 feet over the chapel and library, so that all interior areas are completely column-free. According to the architects, "only structural steel framing could have achieved the desired lightness of feeling and low cost of construction for this building. In any other structural system much heavier members would have been necessary, not only for the horizontal framing, but for the columns in the walls. We wanted to keep the structure as open, as light in spirit as possible."

Because of site limitations, the faculty residence quarters are located on the second floor of the academic wing. With any framing system other than steel, this combination of a smaller residential module over a larger classroom module might have created difficult and expensive structural problems. The design flexibility of light steel framing permitted economical setbacks along both sides of the entire second story. Upper columns were moved inward, creating perimeter balconies which are a useful and attractive architectural feature. Steel joists on steel beams frame both the floor and roof of the academic wing.

The cafeteria and all-purpose room are contained in a separate wing. The all-purpose room can be used for assemblies, stage presentations, or as a gymnasium. It includes a basketball court, two cross-courts, volleyball equipment, as well as fold-out bleachers seating 200 and chair storage space under the stage. Operable partitions between the all-purpose room and cafeteria permit overflow in both directions. These operable walls, as well as similar moveable walls in the academic area, provide program flexibility and economy through the multiple use of space.

One of the important advantages of steel framing for the St. Pius X school was the speed of steel construction. The architects estimate that the use of steel framing saved at least two months of construction time, and permitted completion and occupancy in time for the September school term without the need for expensive overtime.

DATA SHEET

Name of Structure: St. Pius X Seminary

Location: Uniondale, New York

Type of School: Preparatory Seminary

Applicable Building Code: University of the State of New York School Code; Class A

Owner: Rockville Centre Diocese

Architect: Eggers & Higgins, New York

Structural Engineer: Di Stasio & Van Buren, New York

General Contractor: Leon D. De Matties, Elmont

Building Layout and Description:
No. of Stories: One and one-half (chapel, library area); one story cafeteria-dining, all-purpose; two-story classroom and priest's quarters
Floor Area: 98,336 sq ft (gross)

(1) Two landscaped interior courts on either side of the chapel form quiet areas for contemplation.

(2) The logic of the steel structure is complemented with a light and open sense of space and simple, carefully detailed interiors.

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Building Dimensions: 338′ x 210′ (approx.)
Floor-to-Floor Height: 11′-2″
Floor-to-Ceiling Height: 9′-0″ in classrooms, 8′-0″ corridor
No. of Students: 640 No. of Classrooms: 19
Other Facilities: All purpose room: 134′ x 70′
Cafeteria: 50′ x 70′ Library: 68′ x 48′ Chapel: 100′ x 68′

Design Live Loads: Classrooms: 75 lbs/sq ft
Cafeteria, Library, Storage, Corridors: 100 lbs/sq ft
Roof: 40 lbs/sq ft

Structural Steel: Weight: Structural Steel .... 491 tons
Bar Joists .... 91 tons
Total .... 582 tons

Weight per sq ft: 11.8 lbs
Method of Connection: Shop connections riveted, field connections common bolted. High strength bolts at beams for machine room floors

Wind Bracing: None

Floor System: Generally 2″ precast concrete plank on steel joists — except chapel area which has 6″ concrete one-way slabs

Roof Construction: Generally 2″ precast concrete plank on steel joists — except chapel room, which has steel roof deck on structural steel

Exterior Wall Construction: Beige brick, block back-up walls and painted block interior finishes

Interior Partitions: Block partitions, painted. Sprayed-on finish in corridors, utility areas and toilets

Foundation: Reinforced concrete walls and piers on spread footings

Acoustical Treatment: Acoustical tile ceilings

Fire Resistant Construction: Non-combustible

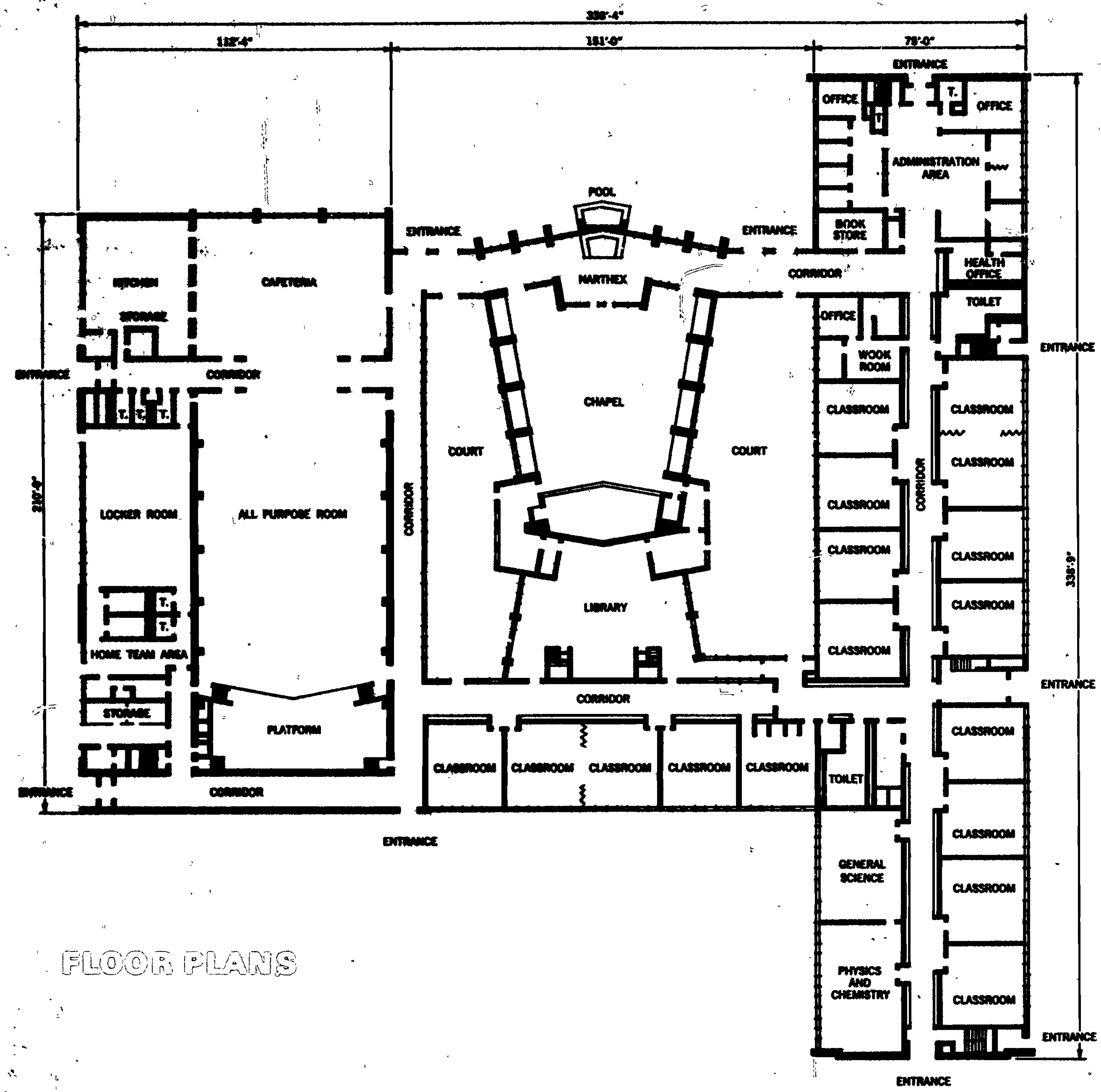
Construction Cost: General Contract: $1,890,000
(includes plumbing, heating & ventilating, electrical)
Cost per sq ft of gross area: $19.22 Cost per student: $2,953

Date Construction Began: December 11, 1959

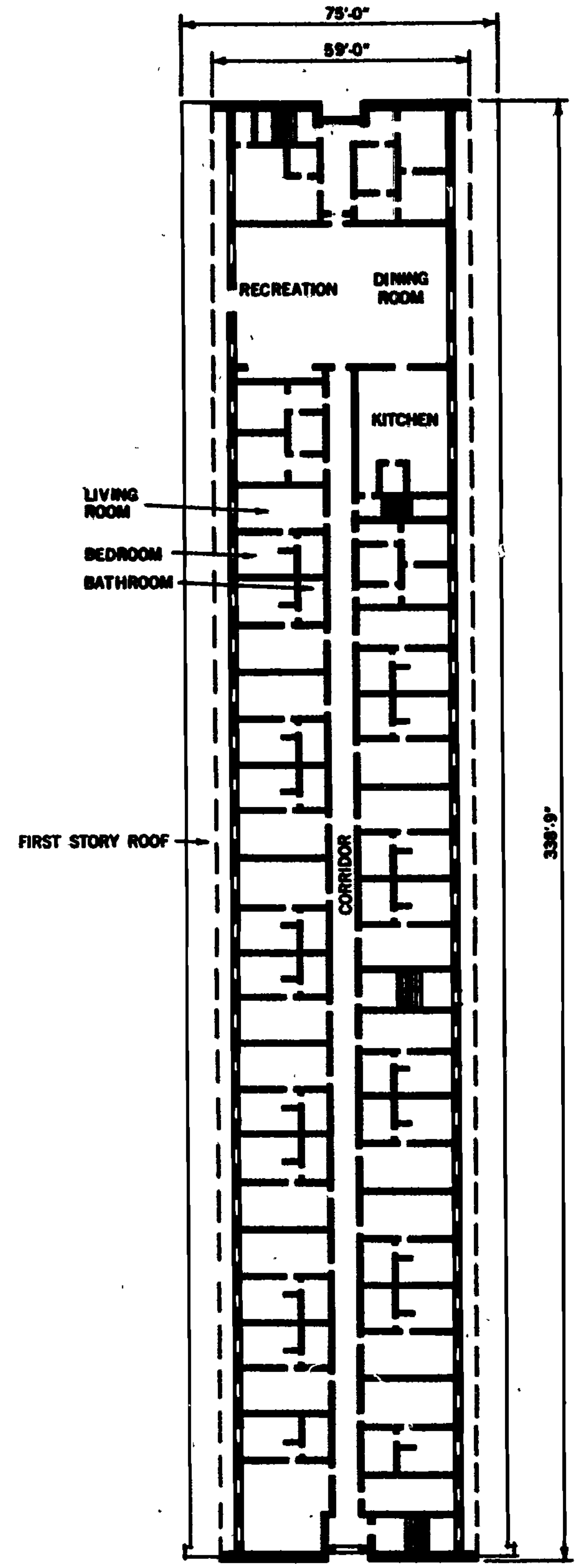
Date Construction Completed: September 3, 1961

Steel Erection Time: 3 weeks

FLOOR PLANS

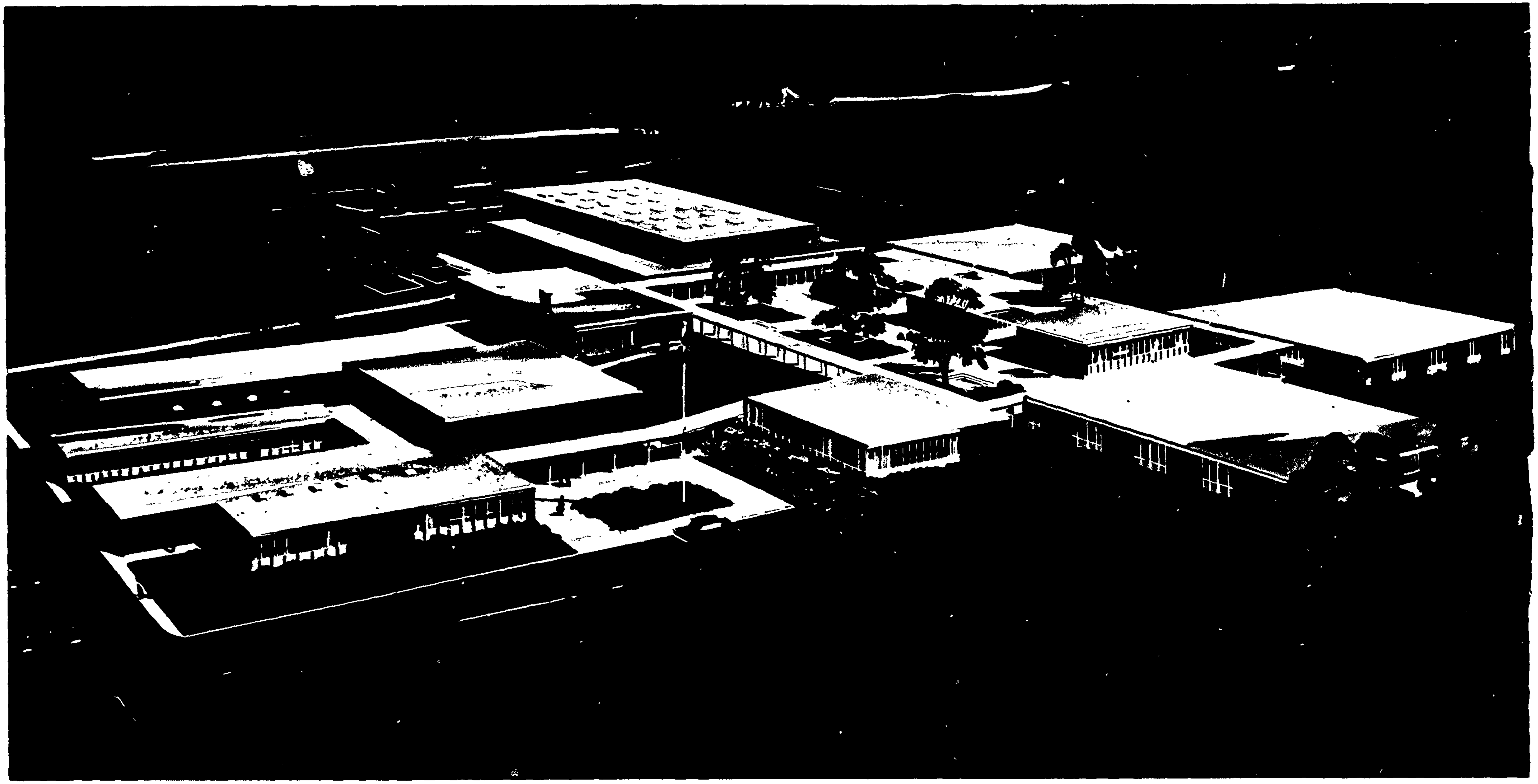


FIRST FLOOR



SECOND FLOOR

8 | Steel construction saves $30,000



All seven buildings of the new Topeka West High School, Topeka, Kansas, are framed in steel. Careful cost studies showed that structural steel framing cost less than competitive incombustible systems for this "campus type" school, without any sacrifice of quality or functional arrangement. In fact, the steel design provided advantages not available with higher priced framing systems.

Architects Ekdahl, Davis and Depew designed Topeka West as a "school within a school", splitting the major academic areas into two parallel units of 450 pupils each. These "little schools", as they are called, house the common learnings portion of the program and serve as a home base for the student throughout his high school career.

Six of the buildings are arranged around a paved pedestrian court containing landscaped areas and two stepped recesses for casual seating and outdoor classes. All buildings will be linked in the future by a covered walkway.

Main column spacings in the two "little schools", the science building, the cafeteria and the library are 24-ft to 36-ft. The gymnasium is spanned with steel rigid frames, the auditorium with trusses, and the music and shop wings with long span open-web steel joists. The steel columns are generally exposed, except in the auditorium which has a one-hour fire rating.

According to Finney and Turnipseed, consulting engineers for the project, "a number of framing schemes were studied and comparative cost estimates prepared. The most economical framing in structural steel was approximately $0.25 per square foot less than the most economical concrete framing for the roof areas and the column arrangement dictated by the building usage." Wood framing was not considered because incombustible construction was required.

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(1) Aluminum window walls permit natural light in reading rooms of library building. Native limestone panels are used under windows.

(2) A clear span of 104 feet is provided by steel rigid frames in the gymnasium. Folding partitions and folding bleachers provide flexibility of space and activity.

(3) Exposed steel columns in corridor require no maintenance other than decorative painting.

DATA SHEET

Name of Structure: Topeka West High School

Location: Topeka, Kansas

Type of School: High School

Applicable Building Code: Uniform Building Code, modified by Topeka Building Code Supplement

Owner: Board of Education, Topeka

Architect: Ekdahl, Davis & Depew, Topeka (Educational Consultants: Engelhardt, Engelhardt, Leggett & Cornell)

Structural Engineer: Finney & Turnipseed, Topeka

General Contractor: M. W. Watson, Inc. Topeka (all buildings except library); Bowers Construction Co., Topeka (library building)

Building Layout and Description: Campus type — seven buildings
No. of Stories: One, except cafeteria building which has a basement
Floor Area: 114,550 sq ft (gross) Structural Module: 4′-0″
Floor-to-Ceiling Height: 9′-9″ (classrooms), 24′-6″ (gymnasium), 16′-5″ (shops), 14′-0″ (music rooms)
No. of Students: 900 (present); 1350 (future)
No. of Classrooms: 32 (includes labs, music rooms, arts & crafts, etc.)
Other Facilities: Auditorium, gymnasium, library, cafeteria

Design Live Loads: Roof: 30 lbs/sq ft

Structural Steel: Weight:

Structural Steel	519 tons
Bar Joists	22 tons
Total	541 tons

Weight per sq ft: 9.4 lbs Method of Connection: Common bolted

Wind Bracing: None required

Floor Systems: Concrete slab on grade, except cafeteria and library, which have concrete joist and beam construction

Roof Construction: 1½″ steel roof deck, 1½″ rigid insulation and 20 year built-up roof

Exterior Wall Construction: Face brick with back-up of light aggregate block

Interior Partitions: Light aggregate block

Foundation: Gymnasium: Concrete piers and grade beams
Other Buildings: Concrete walls and footings

Acoustical Treatment: Acoustical plaster ceiling in auditorium; acoustical tile ceilings in other classroom buildings

Fire Resistant Construction: Incombustible

Construction Cost:

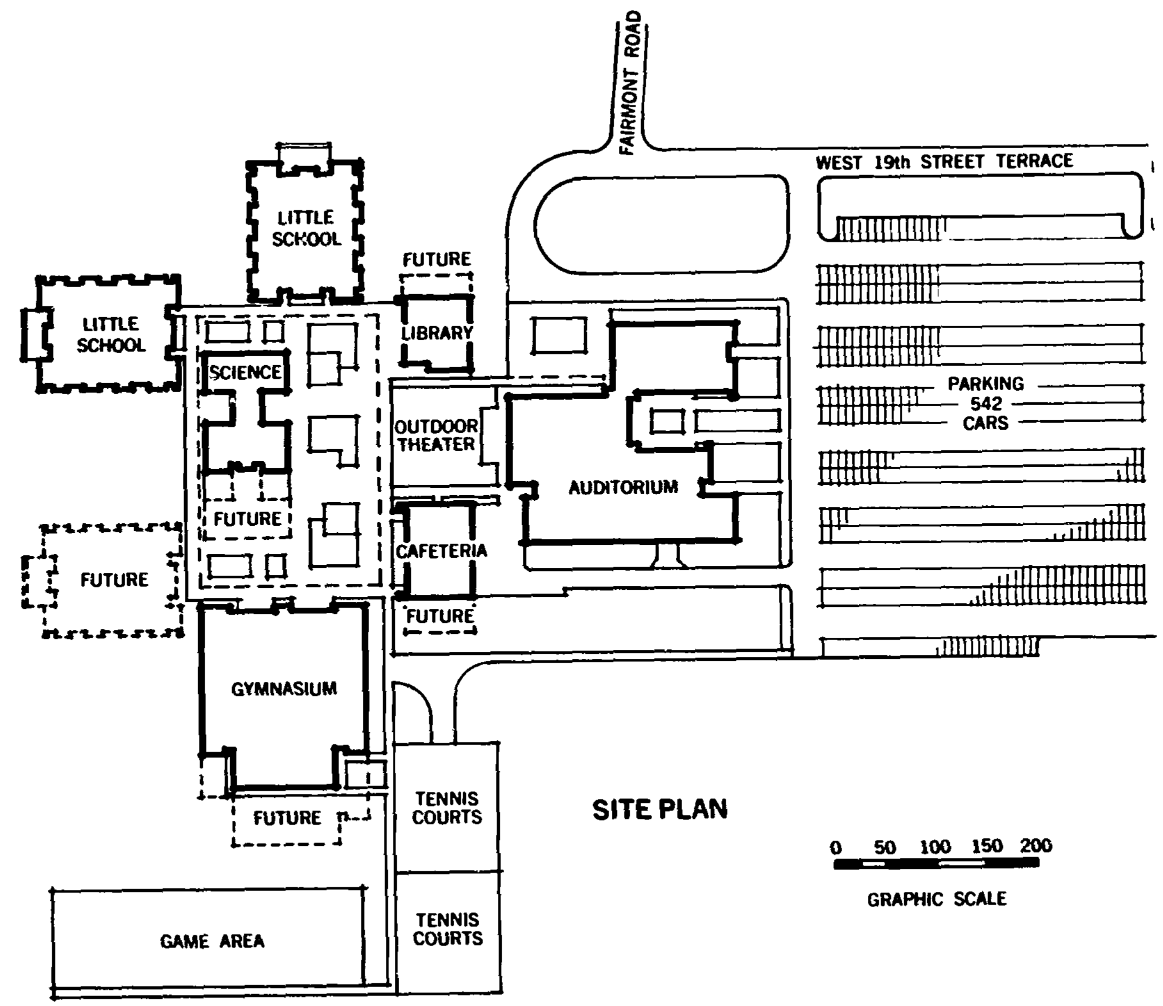
General Contract	$1,209,810
Plumbing, Heating & Ventilating	417,490
Electrical	207,740
Total	$1,835,040

Cost per sq ft of gross area: $16.02 Fixed Equipment: $152,625

Date Construction Began: September, 1959

Date Construction Completed: September, 1961

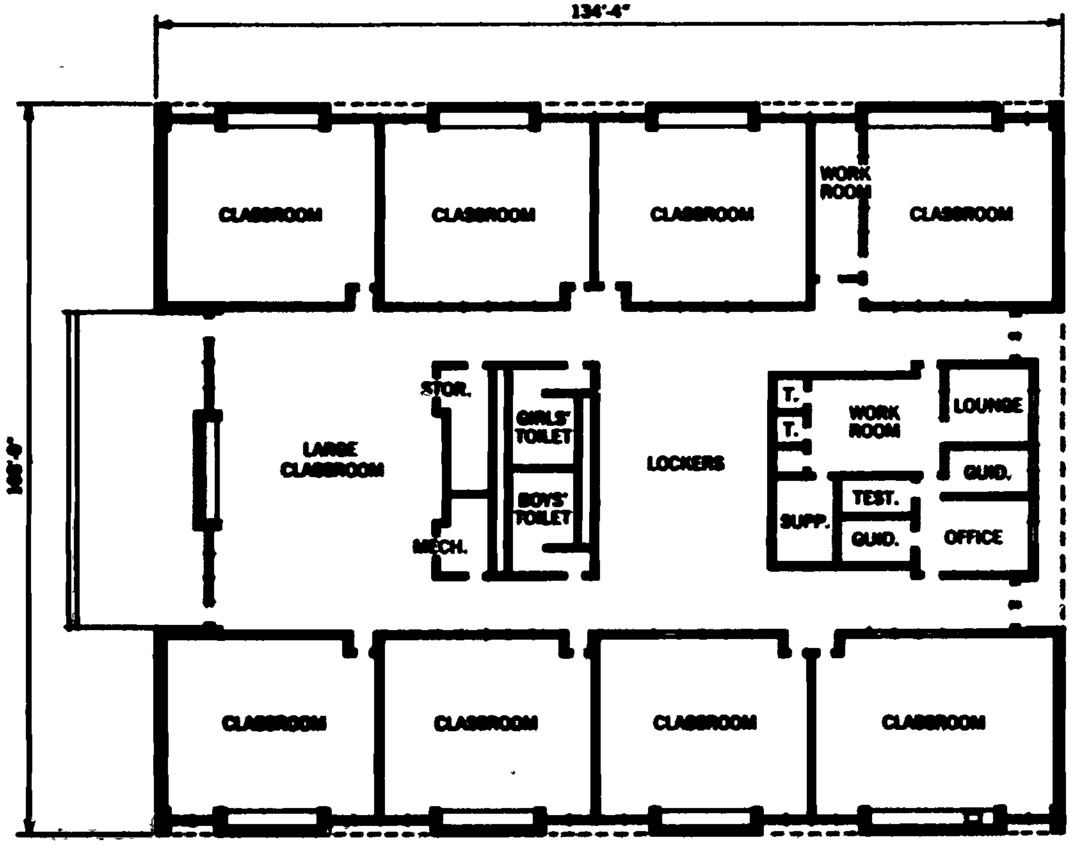
Steel Erection Time: 2½ months (intermittent)



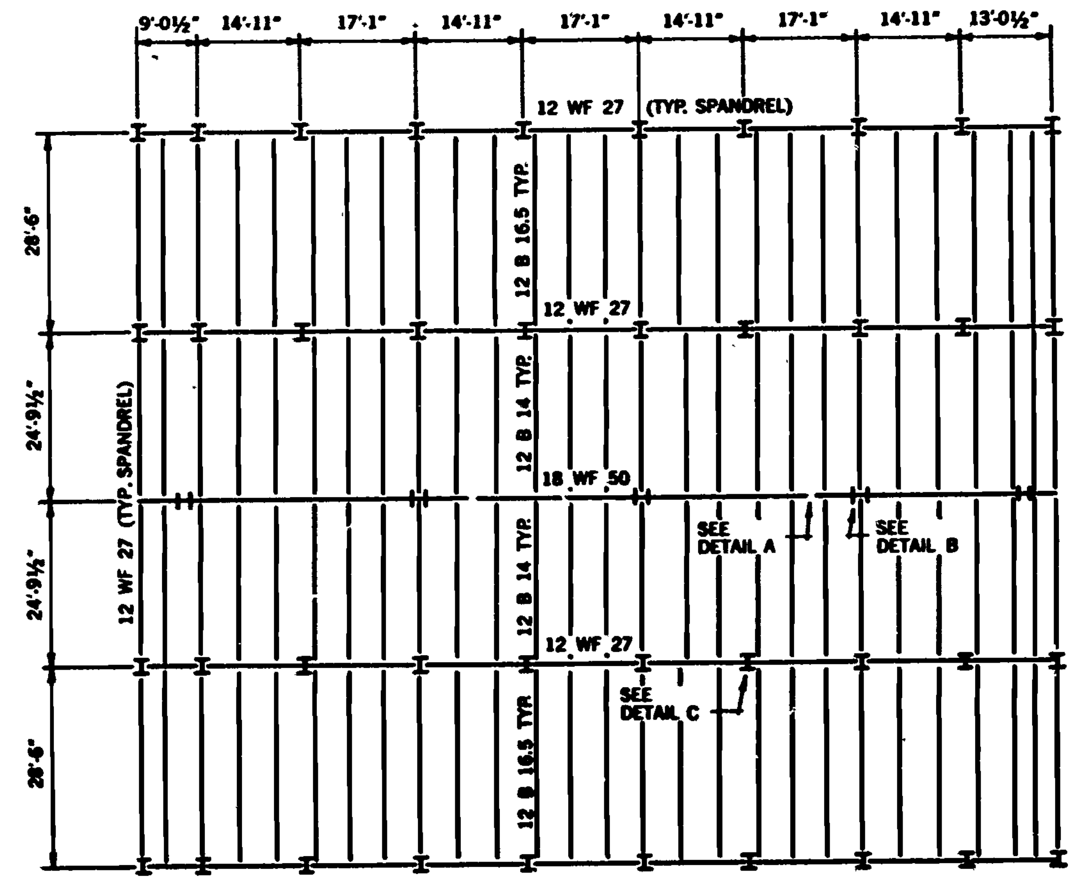
SITE PLAN

FLOOR PLAN

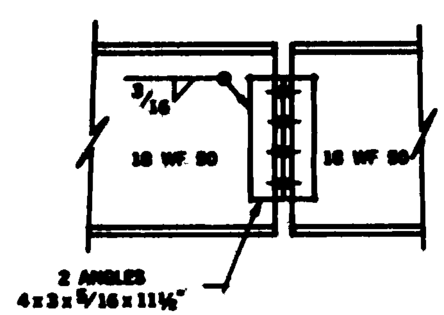
(LITTLE SCHOOL)



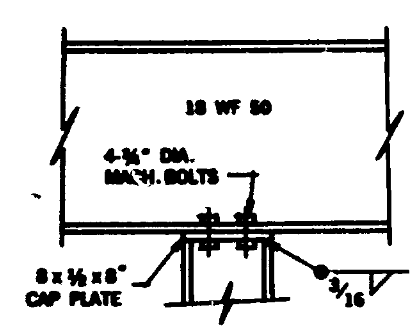
(LITTLE SCHOOL)



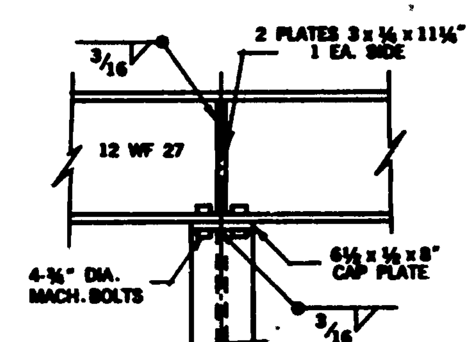
DETAILS



DETAIL A
SPLICE



DETAIL B
AT INTERIOR COLUMN



DETAIL C
AT INTERIOR COLUMN

9

Three-story fire-rated school at single-story unit cost

Rising land costs have led to an increasing number of two- and three-story school buildings in recent years, particularly in metropolitan areas. In these structures, as in single story school buildings, structural steel framing offers unmatched economic benefits.

Architects Kistner, Wright and Wright specified steel framing for the 3-story Building Trades center of the Los Angeles Trade-Technical College. Their reasons — low first cost, long span efficiency, flexibility of design and low maintenance costs.

This shop, laboratory and classroom building was designed to provide special teaching stations for students planning to enter the construction industry. The first floor houses facilities for carpentry and millwork. The second floor provides for training in sheet metal, refrigeration and upholstery, and the third floor is for instruction and practice in plastering, painting, wall papering and masonry.

The basic plan of the building is 130-ft x 160-ft. Covered exterior corridors, stairwells and utility rooms extending beyond the basic dimensions brought the out-to-out building dimensions to 148-ft x 213-ft on the ground floor, and slightly less on the upper floors. A 21 ft-8 in. x 40 ft-0 in. column grid proved most efficient for the specialized use of the building. Steel framing was the logical and economical choice to frame these large bays.

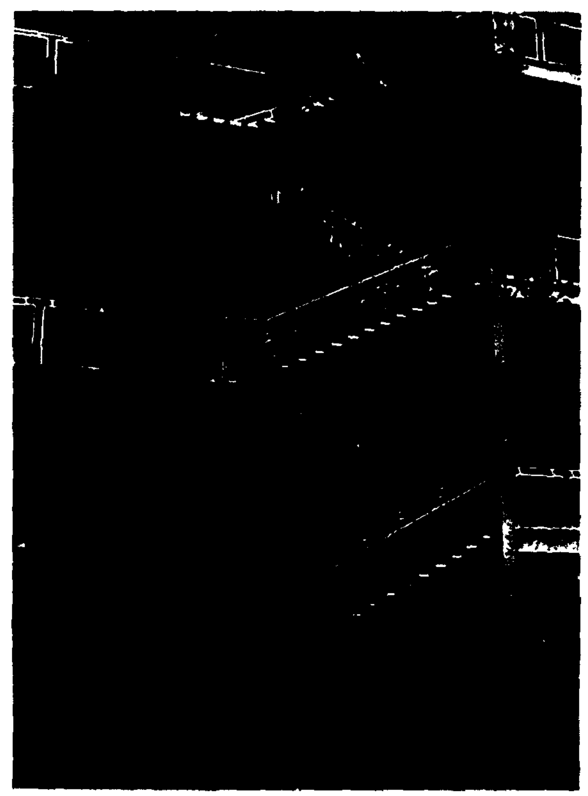
According to the architects, "several types of framing systems using different materials were investigated. Economic considerations coupled with architectural space and clearance requirements, and the advantage of shorter construction time led to the selection of structural steel framing."

Because this school building is located in an area subject to earthquake shocks, seismic requirements controlled the lateral bracing design. An unusual and efficient system of steel bracing trusses in the perimeter metal lath and plaster walls was developed. These trusses accommodate the architectural design, minimize dead load, and the checkerboard pattern reduces stresses due to lateral loads by distributing them over 160 feet of the length of the building. Cost studies showed this system to be considerably advantageous over any system of shear walls. These bracing trusses are also used for the vertical support of floor and roof loads, and take full advantage of continuity without any increases in connection size.

All structural steel is fire protected with vermiculite-gypsum plaster on metal lath to provide a two-hour fire-resistant rating. Unit cost of the building was $13.58 per square foot, an amount comparable to the cost of typical one-story non-fire-rated schools in the area.

(1) Stainless steel rods suspended from a structural steel beam support the outer edge of stair treads and landings of this unusual ornamental stair.

(2) Wide column spacing permits flexible arrangements of equipment in shop areas.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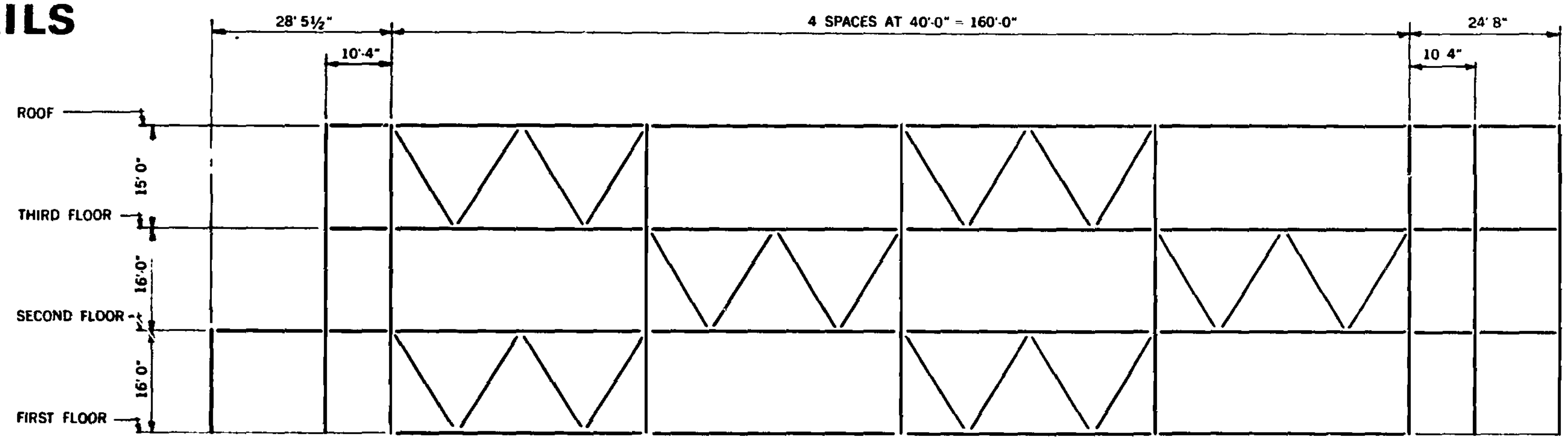
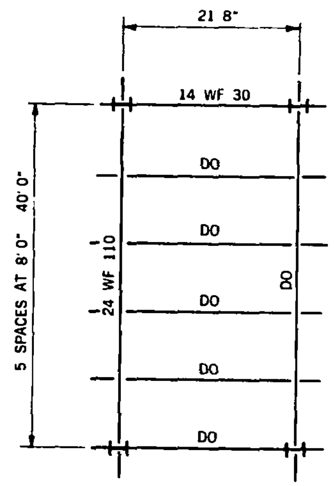
DETAILS



SIDE ELEVATION
SHOWING PATTERN OF TRUSSES IN EXTERIOR WALLS



FRAMING OF TYPICAL BAY

DATA SHEET

Name of Structure: Los Angeles Trade-Technical College

Location: Los Angeles, California

Type of School: Accredited Junior College

Applicable Building Code: California Administrative Code — Title 21

Owner: Los Angeles City Board of Education

Architect & Structural Engineer:
Kistner, Wright & Wright, Los Angeles

General Contractor: B. L. Metcalf, Los Angeles

Building Layout & Description: No. of Stories: Three
Floor Area: 81,000 sq ft (gross)
Floor-to-Floor Height: 16′ (1st and 2nd stories); 15′ (3rd story)
Floor-to-Ceiling Height: 12′ (1st story); 11′ (2nd and 3rd stories)
No. of Students: 300

Design Live Loads: Roof: 20 lbs/sq ft
Floors: Generally 75 lbs/sq ft (varies in special areas)

Structural Steel: Total Weight: 485 tons
Weight per sq ft: 12.0 lbs Method of Connection: Common-bolts

Wind Bracing: Seismic requirements control design; steel trusses in exterior walls provide lateral bracing

Floor System: One-way reinforced concrete slab on steel beams

Roof Construction: 4″ concrete slab. 20 year roofing with gravel

Exterior Wall Construction: Curtain walls, stucco on metal lath and steel studs

Interior Partitions: Steel studs — metal lath and plaster

Foundations: Spread footings

Acoustical Treatment: Acoustical formboard for floor forming (left in place exposed)

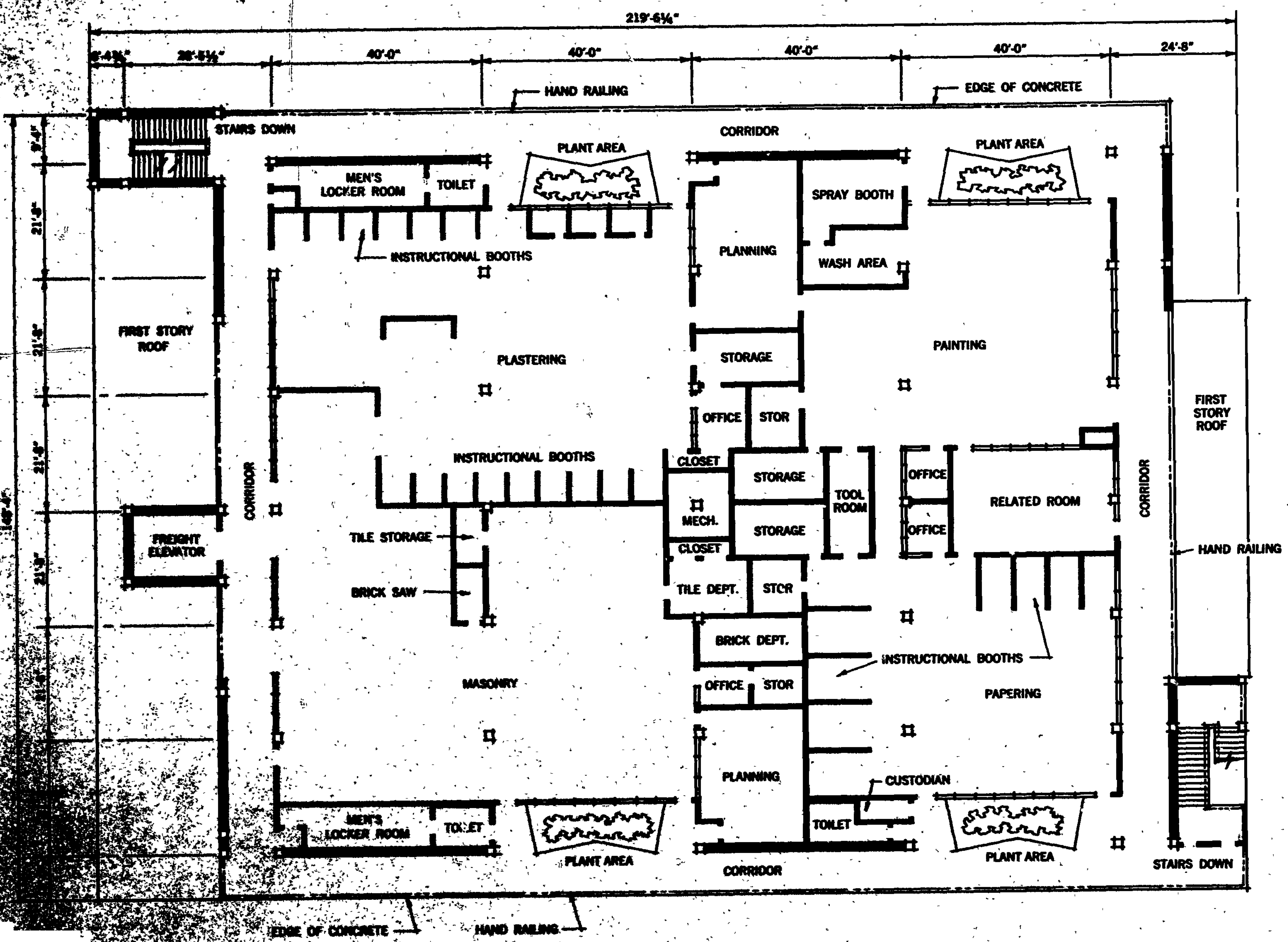
Fire Resistant Construction: 2-hr. structural frame; vermiculite-gypsum plaster on metal lath

Construction Cost: Total: $1,100,000
Cost per sq ft of gross area: $13.58 Cost per student: $3,667

Date Construction Began: July 10, 1960

Date Construction Completed: August 15, 1961

FLOOR PLAN


219'-6¼"
9'-4½"
28'-5½"
40'-0"
40'-0"
40'-0"
40'-0"
24'-8"
HAND RAILING
EDGE OF CONCRETE
STAIRS DOWN
CORRIDOR
PLANT AREA
MEN'S LOCKER ROOM
TOILET
INSTRUCTIONAL BOOTHS
SPRAY BOOTH
WASH AREA
PLANNING
PAINTING
FIRST STORY ROOF
PLASTERING
STORAGE
OFFICE
STOR
CLOSET
MECH.
TOOL ROOM
RELATED ROOM
FREIGHT ELEVATOR
TILE STORAGE
BRICK SAW
TILE DEPT.
BRICK DEPT.
MASONRY
PAPERING
CUSTODIAN

10 Designed for beauty—with economy

Concord-Carlisle High School, Concord, Massachusetts, is an excellent example of skillful and imaginative design with architecturally exposed steel. Architect Warren H. Ashley has provided a simple, functional and flexible school plant, distinctively beautiful, yet unusually low in first and future costs. Unit cost of this high quality school amounted to only $15.87 per square foot, less than that of typical comparable schools in the New England area.

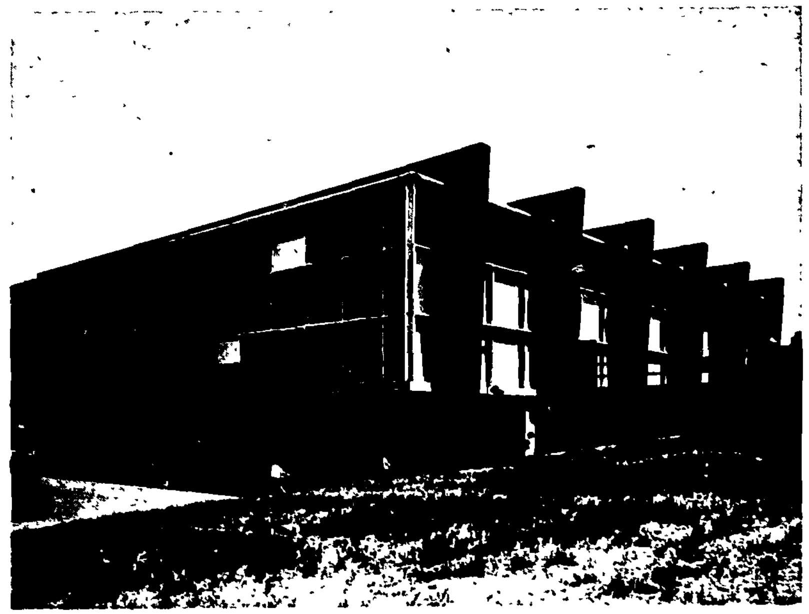
Extensive preliminary cost studies assured the architect and school board that exposed steel framing was the most economical structural system for this project. Structural engineers Onderdonk & Lathrop prepared several preliminary designs, and obtained cost estimates for cast-in-place concrete, precast prestressed concrete, lift slab, and glue-laminated timber. Steel proved lower than any of these systems.

Several imaginative design features led to cost savings through maximum useability of enclosed cubage. Roof beams, 12-in. deep, serve as the top portion of interior walls, reducing masonry requirements by ten percent with no loss of classroom space. Where deeper beams span larger rooms, the ends are tapered to meet corridor and spandrel girders.

A spectacular yet economical use of steel was accomplished in hanging the gymnasium roof from exposed welded rigid frames which are clear of the building. This resulted in a reduction of over 40,000 cubic feet of unuseable enclosed space, reduced heating costs and freed the interior walls of any projections which might interfere with the stored bleachers or other athletic equipment. An exposed formboard ceiling is supported by 10-in. roof beams which are in turn suspended from the exposed frames by pipe hangers passing through pitch pockets in the roof.

Vertical steel tee sections serve as columns at the exterior walls of the classroom buildings. These are arranged to suit the glass and panel modules, and contribute to the light, airy feeling created by the architectural design.

Each of the five structures in this "cluster" type school is designed for change by eliminating all loadbearing walls and partitions. This flexibility will permit the educational function to shape the school, rather than permitting the buildings to dictate the educational pattern. Both interior partition changes and future structural alterations can be easily and economically accomplished in these steel-framed buildings.



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2

(1) Exposed steel rigid frames are painted royal blue to blend with colorful baked porcelain metal panels of gymnasium exterior walls. More than 40,000 cubic feet of unuseable enclosed space is eliminated by hanging the roof from the steel framing.

(2) Dining-Social Center is bright and cheerful. Window walls and column-free interior contribute to the open feeling of the building.

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(3) Overhead canopy between buildings is supported by tubular columns. Horizontal members are welded steel box sections, economically fabricated with structural channels and plates.

(4) Steel beams form upper 12 inches of interior walls between classrooms. Vertical steel tees serve both as exterior columns and as mullions of window walls.

DATA SHEET

Name of Structure: Concord-Carlisle High School

Location: Concord, Massachusetts

Type of School: High School

Applicable Building Code: Town of Concord

Owner: Regional School District, Concord, Massachusetts

Architect: Warren H. Ashley, West Hartford, Connecticut

Structural Engineer:
Onderdonk & Lathrop, Glastonbury, Connecticut

General Contractor: Grande & Son, Inc., Malden, Massachusetts

Building Layout and Description: No. of Stories: One
Floor Area: 136,910 sq ft (gross)
Floor-to-Ceiling Height: 9'-4" to 12'-8" (classrooms)
20'-8" to bottom of steel (gymnasium)
No. of Students: 900

Design Live Loads: Roof: 40 lbs/sq ft
Gymnasium: 100 lbs/sq ft

Structural Steel: Total Weight: 518 tons
Weight per sq ft: 6.6 lbs
Method of Connection: Bolted, except for rigid frames which were welded

Wind Bracing: None at one story buildings except for partially stiffened column connections. Gymnasium: rigid frames with stiffened connections and crossbracing rods parallel to and 1'-0" above top of roof

Floor System: Concrete slab on fill, except corridors which are precast plank so that space below can be used as air plenum

Roof Construction: Precast insulating roof deck on welded bulb tee subpurlins

Exterior Wall Construction:
Metal panel with baked porcelain, and window wall

Interior Partitions: Painted cinder block

Foundation: Poured concrete

Acoustical Treatment: Exposed insulating roof deck, painted; acoustical profile ceiling in auditorium

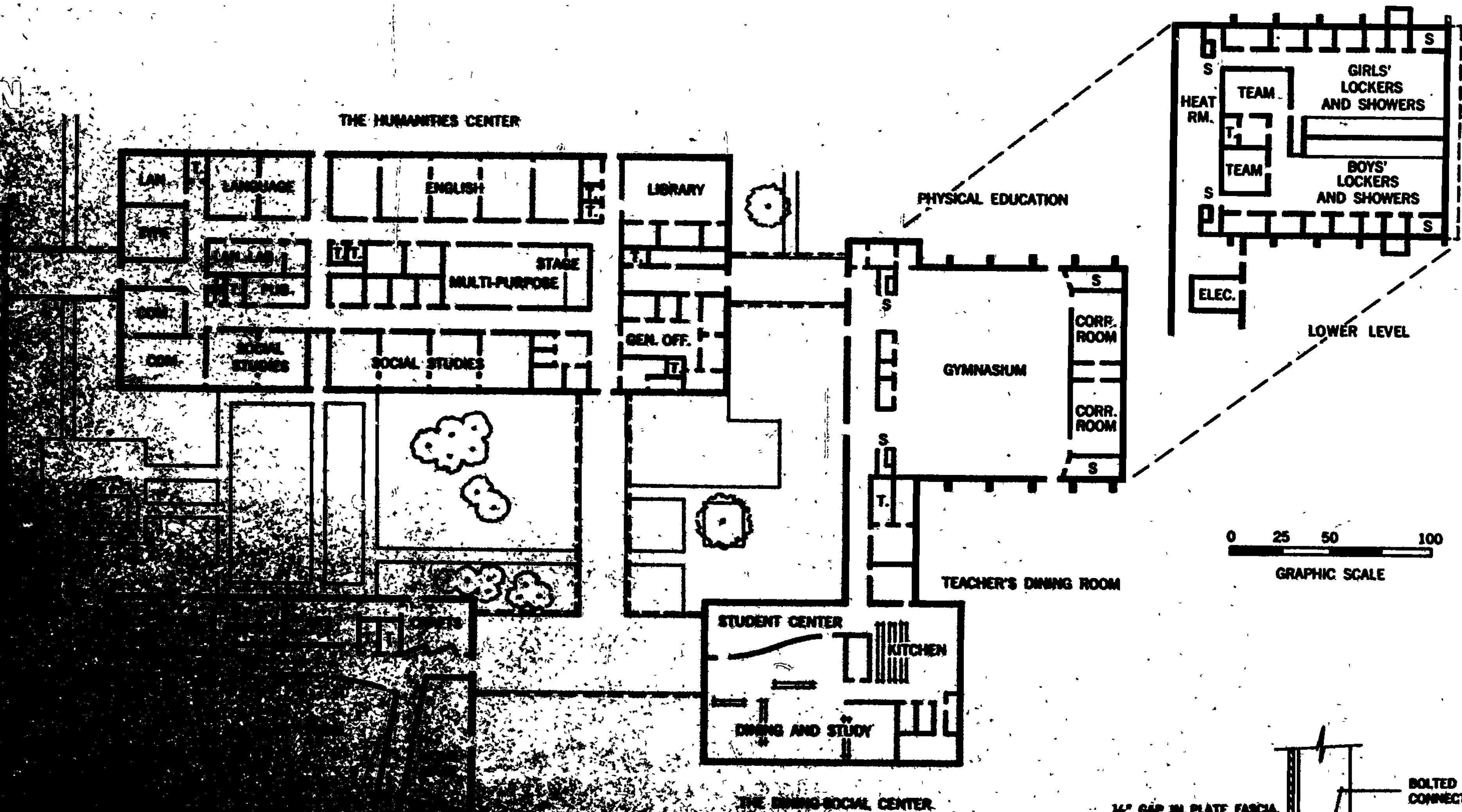
Construction Cost:	General Contract	$1,431,246
	Plumbing	175,800
	Heating & Ventilating	263,167
	Electrical	302,450
	Total	$2,172,663

Cost per sq ft of gross area: $15.87
Cost per student: $2,414
Sitework & Fixed Equipment: $65,362

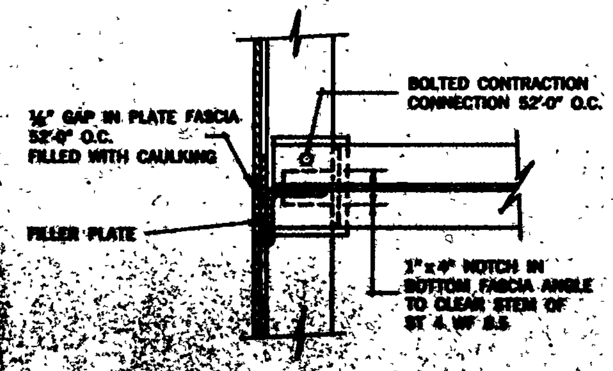
Date Construction Began: September, 1958

Date Construction Completed: June, 1960

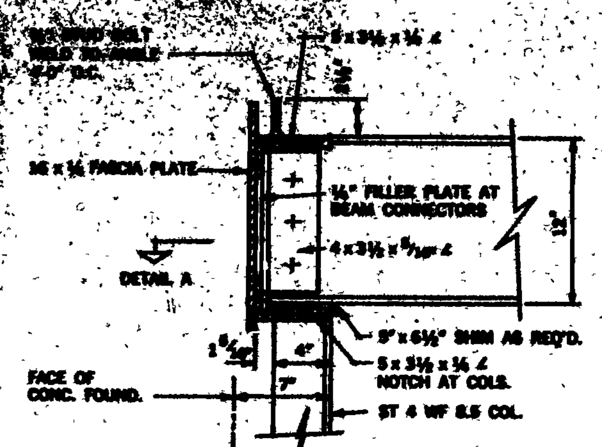
FLOOR PLAN



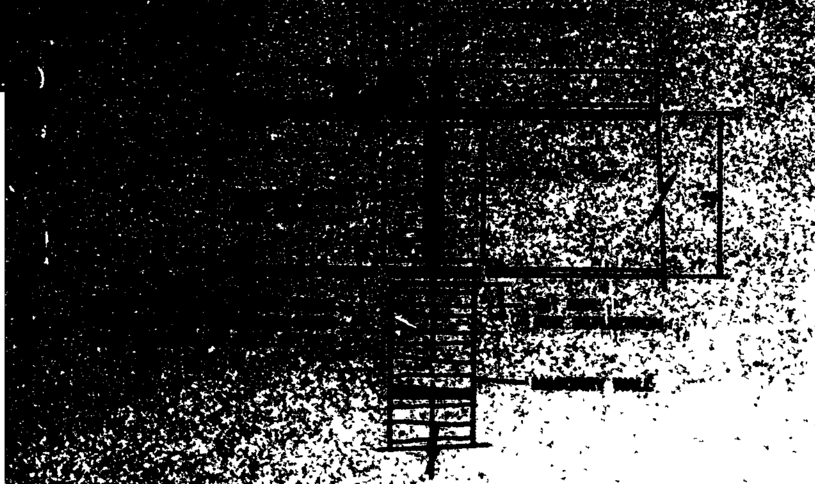
DETAILS



DETAIL A



SECTION THROUGH FASCIA AT EXTERIOR COLUMN



TYPICAL CONNECTION AT EXPANSION JOINT

A Comparison of STEEL With Other Framing Materials for Schools

FRAMING MATERIALS	QUALITY	MAINTENANCE & DURABILITY	ALTERATIONS
WOOD	Varies. Depends on species, grade and quality of each lot. Long term heavy loading may cause progressive sagging. Construction grades subject to shrinkage across the grain.	Depends on quality, grade and species. Exterior exposed wood requires painting or other finish for appearance in all climates. In damp areas, subject to rot and warping unless specially protected. Termite damage a threat.	Easy and low in cost.
CONCRETE	Varies. Depends on field control, water-cement ratio, methods of placement, curing time and procedure, temperature conditions. Dimensions subject to change if forms sag or bow. Uniform camber of precast sections difficult to achieve.	Depends on quality of mix and placement. Subject to cracking from shrinkage, creep, settling or improper curing. Exterior exposed concrete subject to weathering and spalling in low temperature climates.	Difficult and costly.
MASONRY BEARING WALL	Varies. Depends on type of masonry, standards of manufacturer, field control of placement, and quality of roof or floor framing material.	Exterior maintenance depends on type of masonry. Roof or floor framing maintenance and durability depends on material used (wood, concrete, steel).	Difficult and costly.
STEEL	**Always uniform. Meets ASTM specifications. Mill test reports certify physical properties of every steel member before it is incorporated into the structure. Has dimensional stability.**	**Exterior exposed steel requires painting cycle of 5 to 12 years, depending on climate. Properly painted, steel will endure forever. Interior steel requires no maintenance except decorative painting if desired.**	**Easy and low in cost.**

SPEED OF CONSTRUCTION	FIRE RESISTANCE	DEAD LOAD (on foundation)	EARTHQUAKE RESISTANCE	FIRST COST
Rapid. Not affected by weather or temperature.	Combustible, even when specially treated. Unsuitable for fire-rated construction in most cases. Charring and dehydration reduce load-carrying capacity after fire.	Fairly light. Although individual framing members are not as dense as other structural materials, more or larger members are often required for equal load carrying capacity.		
Poured-in-place: Slowest. Subject to delays because of weather and temperature extremes. Requires curing time before load can be safely applied. Precast: Rapid. Not affected by weather or temperature. Requires more careful handling than wood or steel.	Incombustible. Suitable for rated construction. After exposure to fire, dehydration and spalling of undetermined depth of material reduces load-carrying capacity and lowers fire resistance. Prestressed concrete loses some strength permanently when prestressing strands are heated over 600°F. Reinforced concrete fire tests are therefore not applicable to prestressed concrete.	Heaviest.	For the normal range of school building heights, all of the materials in this comparison can be satisfactory when designed under modern seismic building code requirements. Masonry bearing wall construction must be reinforced in all cases. In multi-story structures, steel is recognized as the standard of performance by modern seismic codes. Steel's ductility and superior energy absorption qualities permit structural framing to withstand severe seismic overloads without permanent damage.	The difference in first cost between steel, concrete, wood, and masonry bearing wall construction is usually less than 1% of total construction cost. Bearing wall construction may be slightly lower in cost when buildings are narrow. Steel has definite cost advantage when large, clear interior areas are required.
Medium. Subject to delays because of weather and temperature extremes.	Incombustible (with steel or concrete floor and roof framing).	Medium to heavy. Depends on type of masonry and roof framing.		
Rapid. Not affected by weather or temperature.	Incombustible. When fire rating is required, a wide variety of fireproofing materials assure superior resistance to fire damage. After fire, replacement or repair of fireproofing materials assures original rated fire resistance, with no loss of load carrying capacity.	Lightest. Extremely high strength-to-weight ratio.		

1 **SAN ANGELO CENTRAL HIGH SCHOOL, San Angelo, Texas**
Caudill, Rowlett & Scott, architects; Max D. Lovett, assoc. architect

2 **RIPLEY ELEMENTARY SCHOOL, Ripley, West Virginia**
Henry Elden & Associates, architects

3 **GOMPERS JUNIOR HIGH SCHOOL, Joliet, Illinois**
Skidmore, Owings & Merrill, architects; Levon Seron, assoc. architect

4 **MILLS HIGH SCHOOL, Millbrae, California**
Reid, Rockwell, Banwell & Tarics, architects

5 **BRAXTON CRAVEN ELEMENTARY SCHOOL, Greensboro, North Carolina**
Albert C. Woodroof & A. C. Woodroof, Jr., architects

6 **MADISON JUNIOR HIGH SCHOOL, Albuquerque, New Mexico**
Ferguson, Stevens, Mallory & Pearl, architects

7 **ST. PIUS X SEMINARY, Uniondale, New York**
Eggers & Higgins, architects

8 **TOPEKA WEST HIGH SCHOOL, Topeka, Kansas**
Ekdahl, Davis & Depew, architects

9 **LOS ANGELES TRADE-TECHNICAL COLLEGE, Los Angeles, California**
Kistner, Wright & Wright, architects

10 **CONCORD-CARLISLE HIGH SCHOOL, Concord, Massachusetts**
Warren H. Ashley, architect

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AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.

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