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MODERN STEEL CONSTRUCTION

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CONTENTS

Fifth Annual Architectural Awards Program Opens

All registered architects practicing in the United States are invited to submit entries in the 1964 Architectural Awards of Excellence Competition. Any type of building completed after January 1, 1963 is eligible for entry. Contest closes June 10, 1964. Rules are available from AISC headquarters. Be sure to enter this program which recognizes the professionals who design the nation's buildings—using structural steel in imaginative and esthetic ways.

National Engineering Conference Scheduled For Omaha

American Institute of Steel Construction will hold its 16th National Engineering Conference in Omaha, Nebr., May 14 and 15, 1964 with headquarters at the Sheraton-Fontenelle Hotel.

The Engineering Conference is the nation's leading symposium dedicated to the design and fabrication of steel structures, and will have foremost authorities as speakers.

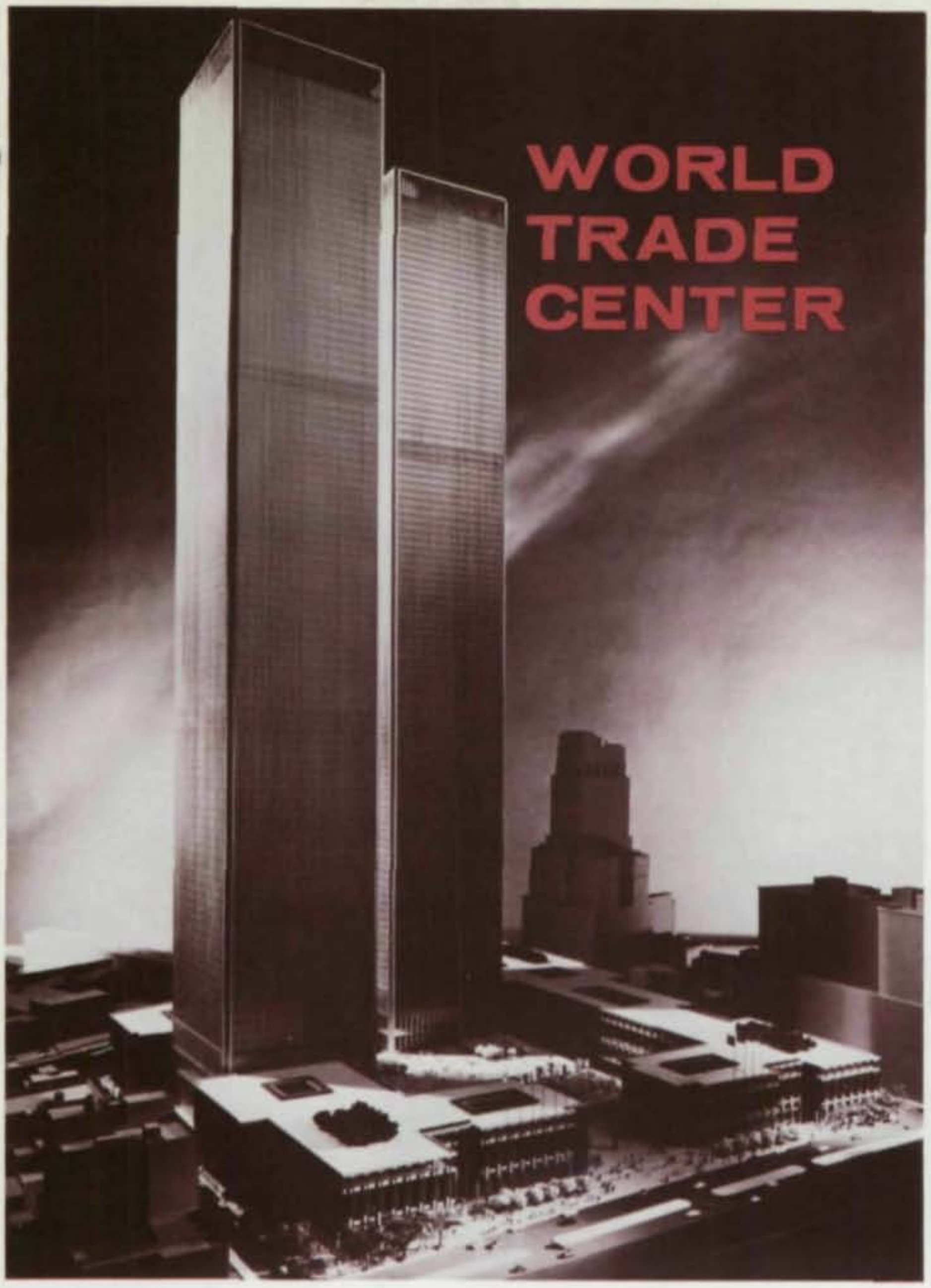
A tour of the Strategic Air Command Headquarters in Omaha will be conducted.

The Conference program is presented on the back cover of this issue.

Reservations can be made through AISC, 101 Park Avenue, New York, N. Y. 10017.

Articles For Modern Steel Construction Invited

Modern Steel Construction aims to focus attention on unusual architectural and engineering accomplishments made possible through the use of structural steel. The editors invite your participation. While publication of all articles cannot be guaranteed, the editors welcome and encourage the submission of any which fit the purpose of the magazine.



WORLD TRADE CENTER

AN INNOVATION IN STEEL CONSTRUCTION

Plans for a World Trade Center, whose twin towers of gleaming metal, the tallest buidings in the world, will soar 110 stories, 1,350 feet, above a great open Plaza of almost five acres, were announced recently by the Port of New York Authority. *The great Trade Center* on the lower west side of Manhattan will provide a unified community in the Port of New York for Americas export-import business and act as a clearing house for the handling, development and expansion of such business. The Port Authority will develop The World Trade Center in accordance with legislation enacted by the States of New York and New Jersey.

The 16-acre site on which the international trade complex will be built is bounded by West Street on the west, Barclay and Vesey Streets on the north, Church Street on the east, and Liberty Street on the south. It is estimated that the construction cost of the Center will be $350 million. It will be financed and *built by the Port Authority on a self-*supporting basis. Construction, which may involve as much as $200 million in wages to labor, is expected to begin early in 1965. The first stage of construction will be completed in 1968 and the balance of the project will be completed in stages during 1969 and 1970.

The Center will have a total rentable area of 10,000,000 square feet. About two-thirds of this space will be in the twin 110-story steel-framed towers. The towers will be 209 feet square with an area of almost one acre (43,000 square feet) per floor. Approximately 160,000 tons of structural steel will be required.

Two of the world's leading architectural firms, Minoru Yamasaki and Associates of Birmingham, Michigan, and Emery Roth & Sons of New York City, were engaged by the Port Authority in September 1962 as architects for The World Trade Center.

They have been assisted throughout by the World Trade Center Planning Division under the direction of Malcolm P. Levy, Chief, and the Port Authority Engineering Department under the direction of John M. Kyle, Chief Engineer. Also assisting them have been the consulting engineering firms of Jaros, Baum and Bowles, and Joseph R. Loring and Associates, both of New York City; and Worthington, Skilling, Helle and Jackson of Seattle, Washington.

Load-Bearing Exterior Walls

The design of the twin towers is an engineering *tour de force* – solving the two problems which long have plagued conventional skyscraper design: space-consuming elevator shafts and high structural cost.

In the unique structural framing system proposed for The World Trade Center, the exterior wall of the buildings will carry the vertical loads, resist the lateral wind loads and provide a dividend in the form of column-free interiors, which will permit complete flexibility in space layout. The design also offers maximum efficiency in structural resistance to wind load. Each of the great steel columns which will form the exterior wall and support the structures at 3¼-foot intervals will serve as dramatic frames for the floor-to-ceiling windows in each tower. These 22-inch-wide windows provide magnificent views and reduce heating and cooling loads.

Many structural systems were investigated, ranging from the conventional steel-framed building with concrete floor slabs to the bearing wall-space frame design eventually adopted. The Center's structural system places a major part of gravity resistance and all wind load resistance in the exterior wall of the building. The wall consists of a series of columns placed 3-foot 3-inches on center around the entire periphery and running uninterruptedly from lobby level to roof. About 80 feet above grade, the load is transferred to larger columns, 9-feet 9-inches on center, providing a wider spacing at lobby level for entrance doors and picture windows overlooking the Plaza. The resulting exterior appearance features graceful arches.

The vertical columns are tied together by a four-foot-deep channel-shaped spandrel beam which circles the building at every floor.

The columns are welded box shapes and vary in composition from A-36 steel at the top to heat treated low alloy steel at the bottom. A detailed study was carried out to determine what combination of cross-sectional area and alloy would produce the most economical design. The column sizes and steel alloys are varied in accordance with formulae developed to produce maximum structural economy.

The spandrel-column elements of the exterior wall will be welded assemblies. Because of the large number of joints and the high load transfer through them, the joints are detailed for welding in order to simplify the design and substantially reduce steel requirements for connections. It was also deemed advantageous to reduce the number of field connections to a minimum. For this reason, the wall panels will be shop welded into units three modules wide (9-feet, 9-inches) and two stories high (24 feet).

The column butt ends will be milled, both ends simultaneously on special equipment in order to eliminate inaccuracies due to repositioning the assembly in the milling machine. This design and procedure will improve structural economy by reducing field splices and will provide lifts within a satisfactory weight range for handling and will also permit close erection tolerances to be maintained with a minimum of shimming and field adjustments.

The 22-inch spaces between the columns will form floor-to-ceiling windows at each floor, with the spandrel beams between the floors covered with tinted or opaque glass. These glass areas will be recessed about ten inches, so that they will be shaded from all but direct rays of the sun. The three sides of the columns projecting beyond the windows will be covered with a thin skin of aluminum or steel.

All interior columns are placed within the elevator-service core, eliminating obstructions due to columns and duct shafts within the usable space and permitting tenants maximum flexibility in office layout. The core of the towers is rectangular so that the floor system has a clear span of 60 feet on two sides of the building and 35 feet on the other two sides.

The floor system consists of 33-inch-deep trusses spanning from core to exterior wall. Corrugated metal formwork at the top chord permits pouring of the floor slab without construction of additional formwork. The floor is of composite construction. Dead and live loads are taken by the slab, which forms the permanent top chord of the trusses. Also used is a light steel top chord to support the corrugated deck and resist the erection stresses.

A novel system of anchorage is provided for tieing the steel and concrete together. This consists of a single round bar located at the center of the slab and supported at each truss panel point. As shown on the accompanying sketch, the floor system will be preassembled into panels 60 or 35 feet long and three modules wide, or 9-feet, 9-inches. This assembly will be erected as a single unit, posted from the finished floor below. When all units on the floor have been placed and auxiliary reinforcing located, the concrete slab will be poured to provide the finished floor.

On the exterior, use of the bearing wall-space frame system offers high efficiency in resisting wind load. In effect, the building, becomes a beam 209 feet deep, with the inherent stiffness and structural efficiency of such a shape. The towers require approximately 40 per cent less structural steel than conventional buildings. Because of the Center's exposed location, the structural engineer used a design wind load of 45 pounds per foot over the entire structure from street to roof line. This is 2¼ times the New York City Code requirement of 20 pounds per square foot, and far in excess of the design load for any other New York City office building.

The structural design dictates limitations on the building shape, however. For instance, there can be no setbacks, since the closely spaced exterior wall columns cannot be allowed to penetrate wider portions of the building near the base where they would interfere in the use of interior space. In addition, the building must be approximately square to provide equal resistance to wind loads from any direction.

"Skylobby" system

The skyscraper cannot exist without the elevator, but all skyscrapers pay a penalty because of the large floor areas consumed by elevator shaftways. This problem was brilliantly solved in The World Trade Center by the introduction of the "skylobby" system.

People entering the building and bound for the upper two zones are moved by 55-passenger express elevators to the skylobbies. Here they transfer to local elevators which serve all floors within the zone.

The lower skylobby is served by 11 and the upper skylobby by 12 high-speed express cars traveling nonstop from the ground floor lobby. The 72 local elevators in each tower will have a speed of more than 1,700 feet per minute, the fastest elevators in the world.

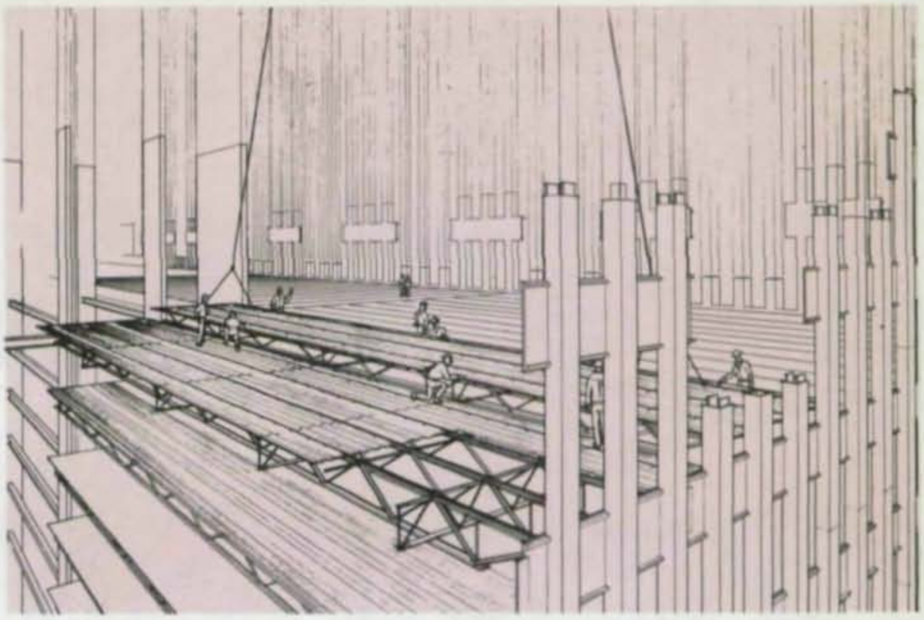
Because of the compact arrangement of this elevatoring system the ratio of net rentable to gross area of the tower is approximately 87 per cent. If a conventional elevatoring system were used, the ratio would be closer to 77 per cent.

"Slurry Wall" Foundation

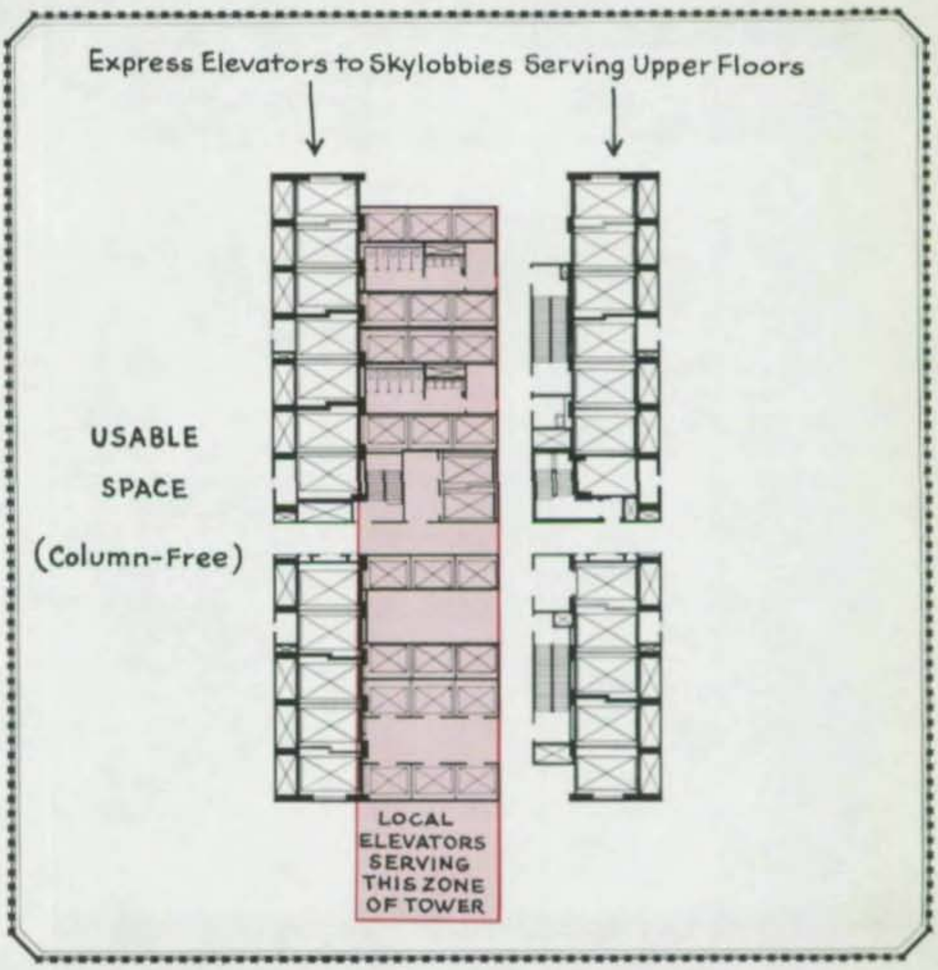
The foundations for the great towers of the Center must be placed on bedrock, which is approximately 75 feet below grade. The site of The World Trade Center is in an area which formerly lay in the bed of the Hudson River. Over the years land was created by a variety of fill so that the area is underlaid by a strata of rubble, timber, and old building foundations. Ground water occurs about 5 feet below existing grade. Because of the anticipated difficulty of building conventional foundations within this area, the Engineering Department of the Port Authority is considering using the "slurry wall" foundation system, a method first used in Italy and since used in Canada.

In the slurry wall system, excavating equipment is used to dig a trench from 30 to 48 inches wide from grade to bedrock. This trench, constructed in segments 25 feet long, is placed around the entire periphery of the site. As the trench is dug, a Bentonite slurry is poured into it. The slurry, which is a viscous semi-fluid material, serves to brace the wall of the trench to prevent its collapse and tends to seal the trench against ground water intrusion. After the trench has been extended to bedrock a chopping bit is used to extend the trench into the rock. A preassembled cage of reinforcing is then lowered in the Bentonite filled trench. Next tremi concrete is placed within the trench. The concrete displaces the Bentonite which flows from the trench where it is collected, cleaned and made available for re-use. In this way a reinforced concrete wall keyed into bedrock is constructed around the entire site. The site area is then dewatered. Because of the impervious wall, ground water level in adjacent areas is not affected and damage to adjacent structures does not occur.

The area is then excavated, using scrapers and conveyors. This would be impossible within the confined site of a typical skyscraper. When an excavation level 20 feet below existing grade is reached, the concrete wall is braced by drilling through it on a diagonal line from the interior to rock and placing preassembled wire pretensioning units in the bore holes. These are socketed into the bedrock and then jacked against the wall to permit it to carry the earth pressure against its exterior face.



The World Trade Center 60-foot by 13-foot prefabricated section of floor framing is lowered into place. This unique type of floor construction results in economy and speed.



Typical floor Plan – Lower Tower floor.

TRI-LEVEL RESIDENCE

An outstanding use of structural steel, beyond its normal use as a basic structural frame, was provided in the residence "Villa Leilani" located with a view toward Lake Michigan in Beverly Shores, Indiana. Through skillful architectural treatment the steel did more than just carry loads. It was ornamentally treated.

Exterior and interior steel members were left exposed. The interior steel was painted to contrast with the other building materials such as redwood, limestone, glass and translucent panels.

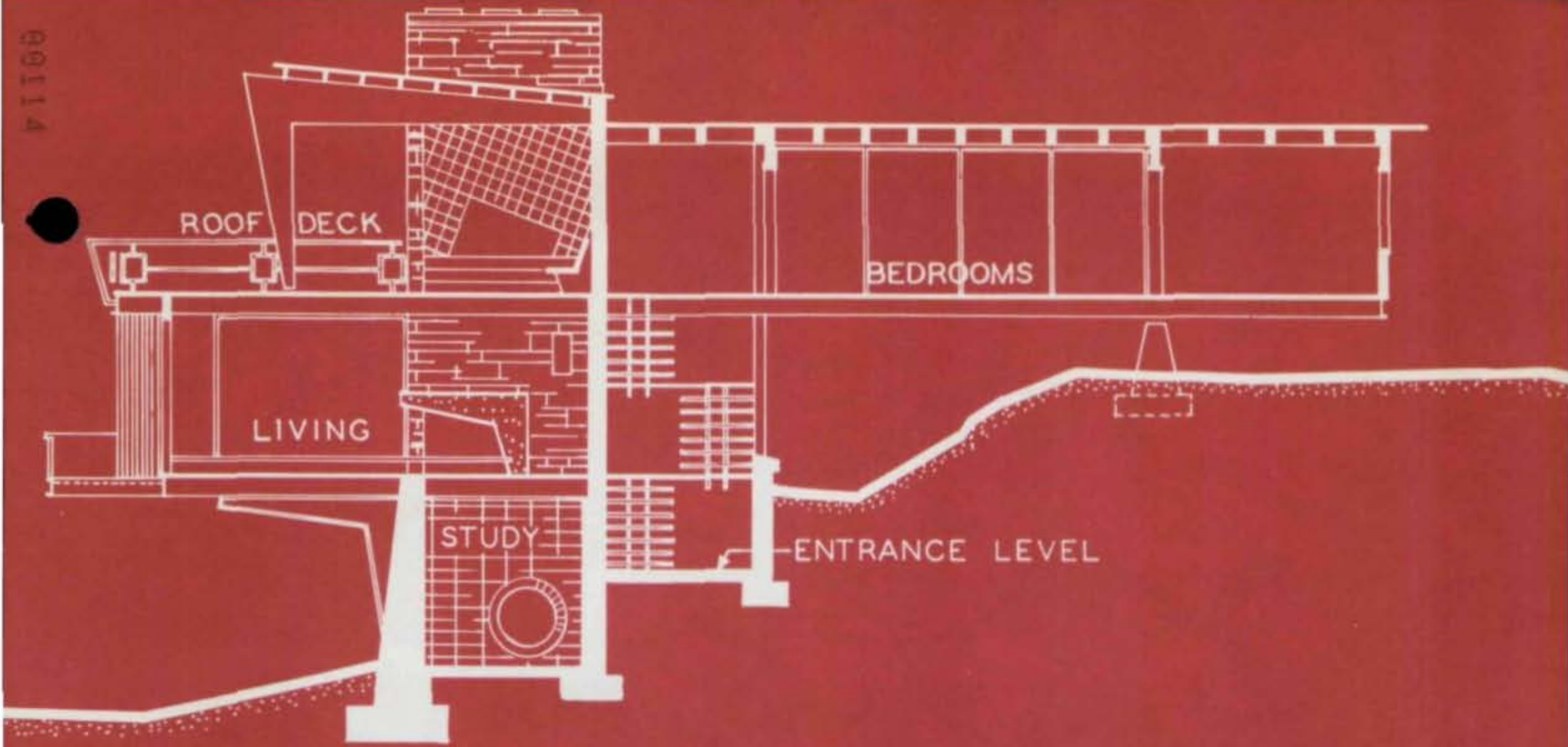
Certain requirements of the owner were exacting. Situated on a sand dune it was required that the dune's appearance remain undisturbed. A living area of 3000 sq. ft. with a 3 to 4 car storage under the house as well as a lake view from a part of the house called for a unique structural solution.

The entire steel structure, consisting of 10 tons of structural steel and 1 ton of ornamental iron, is well balanced on a comparatively small foundation. The frame is made up of 12 in. girders, built-up cantilevers and 6 in. columns. With the lower flanges of the girders exposed, the larger room areas are effectively broken up. Within the 12 in. depth the space is used to support the utilities. On the external side of the structure the upper and lower fascias are made of 12 in. lightweight channels.

In the study where the heavier girders are exposed the girders serve a dual function. In addition to supporting the loads the 12 in. girders are the bookshelves. The stairs are framed with 7 in. channels back to back providing an interesting ornamental treatment.

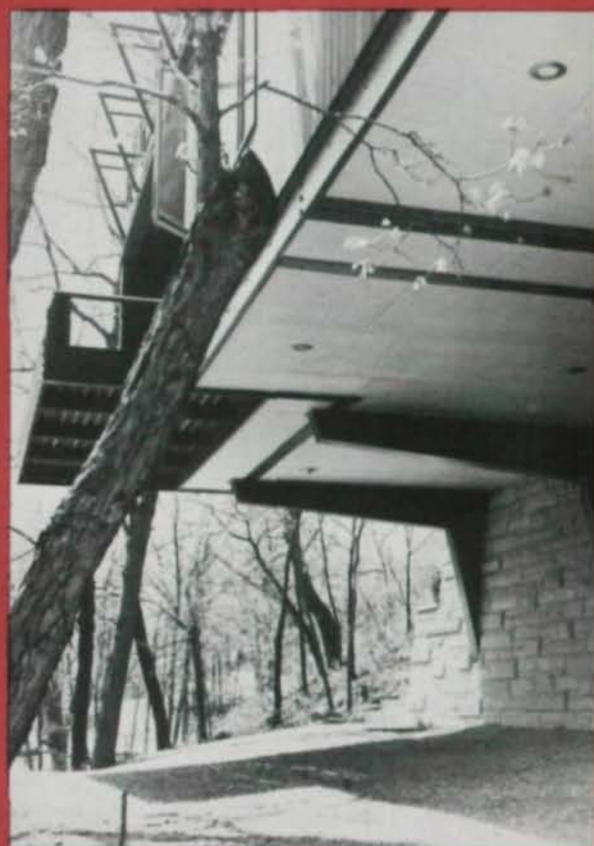
The selection of steel for framing offered other desirable advantages. The framework was erected in 2 days permitting immediate work of the other trades. All faciities are readily accessible. With only 13 cu. yds. of concrete for the foundation, a substantial saving resulted, according to the engineer-owner. Finally, the owner realized considerable overall cost savings.

The structural engineer and owner is Eugene A. Bartkus. Collaborating with him the architectural design was done by Erdivilas Masiulis, both of Beverly Shores, Indiana. The structural and ornamental steel fabricator was Pan American Bridge Co. of New Castle, Indiana.

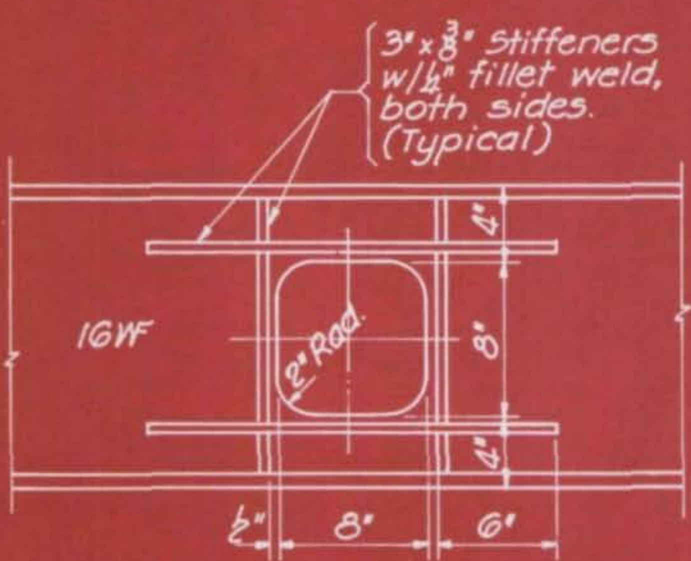


CROSS SECTION

5' 0' 5' 10' 15'



Exposed steel beams support the living room and roof deck of Villa Leilani.



REINFORCEMENT FOR OPENING IN BEAM

DIGITAL COMPUTORS - where to start

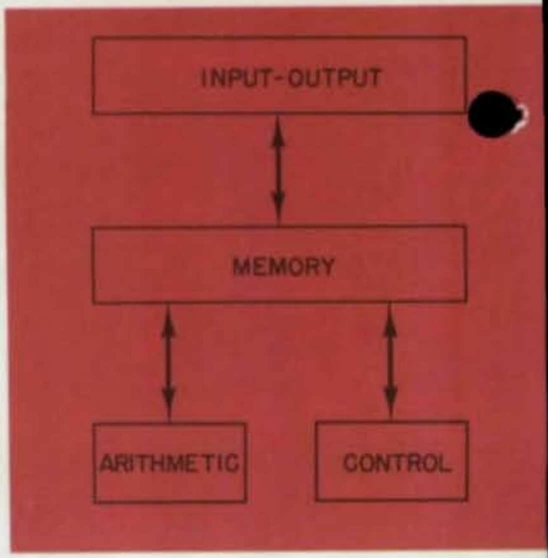


Figure 1.

*by Mauro Cetra
and Fred DeFalco

Every businessman and engineer has heard of digital computers and the marvelous feats they can perform. But the question asked is "How can I get access to the machine? How does the machine solve my problems?"

A digital computer, like a desk calculator, can add, subtract, multiply, and divide, but it can also store information and make limited decisions.

A digital computer is programmed to follow a series of arithmetic operations without interruption, and it performs these calculations at tremendous speeds. The amount of storage and the speed at which the calculations are performed are dependent upon the type of machine.

The basic components of the digital computer are shown schematically in Figure 1. A typical computer system is shown in Figure 2.

Programming is the detailed outline of the arithmetic procedures for the machine to follow.

The **input** consists of the instructions and data. The **output** is the results of the problem. The instructions and data are read from punched cards, magnetic tape or punched paper tape depending on the type of machine. After receiving the instructions and data, the input transfers this information to the **memory** or storage. Information in the storage remains there until called upon to perform specific **arithmetical** operations. The control unit is the electronic circuitry which interprets program instructions and directs the operation.

A program is a sequence of step-by-step operations performed to solve a problem. The program must then be prepared in a coded language that the machine can understand. One of the major advances in recent years has been the development of symbolic languages, such as FORTRAN, MAD, UMAC and ALGOL. A symbolic language uses symbols instead of numbers and allows the programmer to express numerical and logical procedures with relative ease. This program is then automatically compiled and translated by the computer into machine language.

If a problem is programmed in a symbolic "language" for a particular machine, this source program can be used for any machine capable of receiving the "language" with very little modification. For example, a FORTRAN program can be used with the IBM 1620, RCA 301 and CDC 160-A.

The use of computers can be considered practical and economical when:

1. The same type of problem is used over and over again with different numerical values, such as the design of a steel beam. The span and load are the variables and the solution would be to find the beam size.
2. Optimizing a solution. Optimizing means finding the best solution based on many alternatives. As an example, this could mean determining the most economical floor framing system for a building in which the column spacing and live load will be the variables.

If an engineer wants to use a digital computer for his work he can do so by one of the following alternatives:

1. Purchase or rent the machine and train present personnel or hire new personnel for programming and processing. This is an expensive undertaking that the small firm would probably find impractical.

2. Use a computer service center — a firm which provides a computer service and is available to write programs for particular problems. This program is then the property of the engineer, and every time a solution is required only the machine time will be charged.

3. As an alternate to the above, the service center may have developed programs to solve particular problems — programs which have a marketable demand. These programs are owned by the service center and can be rented.

4. Program libraries are made available to computer users by manufacturers. These libraries are utilized in sales promotion and contain programs of every description. In addition, owners of computers generally belong to user-groups who share programs among themselves. The donation of programs to the user-group library is the usual prerequisite for membership. Certain public agencies, such as the Bureau of Public Roads, maintain an extensive program library, which is available to the public. Engineers who are interested in

*Mssrs. Cetra and DeFalco are regional engineers for the AISC.

Figure 2.

specific problems may obtain the appropriate program and, after proper coding, run the program through a rented computer at a service center or another user's machine.

Programs which are written for a specific problem usually have limited applicability. In general, a program should be written for as wide a range of conditions as possible. By careful selection of input variables, the program will cover most of the repetitive-type problems engineers encounter in their work. In similar manner, programs which are obtained from outside a particular firm must be evaluated, and careful documentation is required. The information should include a complete description with illustrative examples and flow diagram.

A description of a typical design program taken from the IBM 1620 program library is shown in Exhibit A.

The alternative chosen by the engineer depends upon his particular circumstances. For quick solutions to existing problems, a service bureau can be of great assistance. If the requirements of the project are exactly defined, the work can be quickly programmed and processed by the bureau. The main advantage here is speed because the programs are written specifically to solve the client's problem.

However, in any long range view, lease or purchase of a computer with the concurring development of computer skills within a particular firm has important advantages. Close cooperation between engineer and programmer is most desirable, both in setting up the work to be performed and extending the use of the computer in new directions. Ideally, the engineer would program the work himself, but the difficulties involved in making such a system economical should not be minimized. The full utilization of a computer requires a great deal of attention and the formation of a specialized computer group is generally necessary. Such a group usually consists of several program engineers assisted by technicians who actually run the machine.

With proper guidance, the group will fundamentally change engineering office procedure, and productive output will be greatly increased. The computer will handle routine calculations. And the computer can be used for clerical accounting work: job costing, billing, scheduling manpower and developing

EXHIBIT A

IBM 1620 PROGRAM LIBRARY ABSTRACT — **File Number 9.2.017**

CONTINUOUS BEAM ANALYSIS AND STEEL BEAM DESIGN (Tape)
James F. Gibbons

Direct Inquiries to: James F. Gibbons
State Highway Commission
Bridge Section
State Office Building
Madison, Wisconsin
Alpine 6-4411 — Ext. 471

Purpose/Description: The program computes beam characteristics, dead load moments and shears, influence lines, and live load moments, shears, and reactions. A steel beam is then designed non-compositely and compositely for up to three different allowable steel stresses.

Method: A.A.S.H.O. '61 Specifications. Slope Deflection Solution by Matrix Algebra.
Restrictions/Range: 2 to 5 continuous spans.

Storage Requirements: N/A

Equipment Specifications: Tape System, Memory 20K, and no other special features required.

Additional Remarks: Fortran and machine language, fixed and float. 30 minutes for a complete design of a symmetrical 3-span girder. Since it is composed of 5 separate programs, in line, the number of successful runs varies. The least number is about 50.

There are two extra tapes that can be used with the main program. One for intermediate expansion hinges and one for an influence line listing. These are operational and will be submitted as soon as writeups are made.

A typical design program from the IBM 1620 program library.

critical path method of operation. The latter has been receiving a great deal of interest lately for use in planning construction jobs.

The future of the digital computer in engineering holds great promise. Changes in methods and procedures have already affected traditional ideas concerning personnel and schedules. The day of the routine design task has passed because the tremendous speed and accuracy of these computers makes thorough analytical investigation possible to insure the most economical solutions. The engineer will now be called upon for his scientific and mathematical background to make decisions of judgment.

The challenge to the steel fabrication industry consists in the development of improved fabricating techniques to keep pace with improvements in structural design. The struggle to reduce construction costs is never-ending. Shop detail drawings from a computer system are now a possibility, and job management procedures in office and field will soon be handled with its help.

Exhibit B presents a partial list of available computers capable of handling construction industry problems.

In summary, the impact of the modern computer on the national economy has yet to be realized. Careful study is necessary to assess the realities of this new technological revolution.

EXHIBIT B*

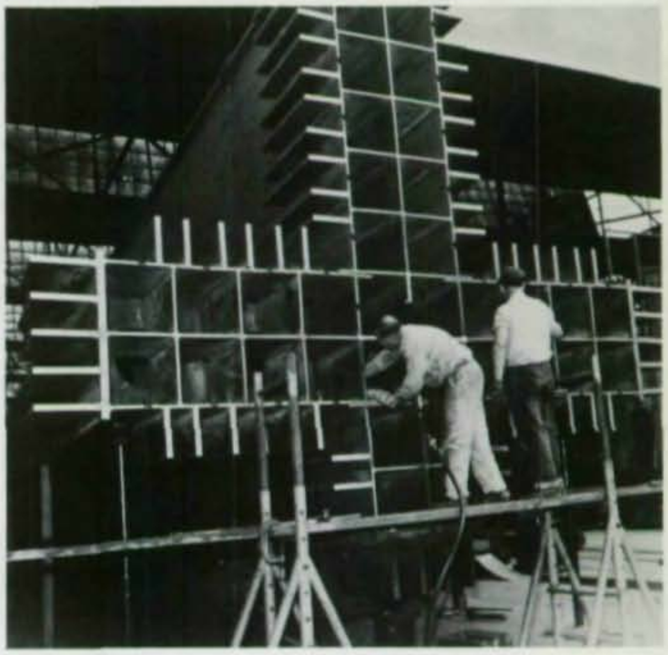
SMALL SCALE (UNDER $60,000)

Manufacturer and Model	Average Work Area (Sq. Ft.)	Price (Average System)	Average Monthly Rental	Core Storage (Words)	Word Length (Binary)	Input Output (See Note)	Symbolic Coding	Users' Group
General Precision LGP-30	12	$49,500	$1,100	4,000	32	1,3,4	Act III	Pool
MEDIUM SCALE ($50,000 — $750,000)								
Burroughs B220	1,200	$560,000	$14,000	2-10K	11	1,2,3,4	—	—
Control Data 160A	90	90,000 up	2,250 up	8-32K	12	1,2,3,4,5	Fortran	Swap
Control Data G15	60	70,000	2,000	2K	29	1,2,3,4	Algo	Exchange
General Electric 215	400	375,000	6,500	4- 8K	20	1,2,3,4,5	Gecom	Get
General Precision 4000	120	87,500	1,750	8K	32	1,4	Act IV	Pool
Honeywell 400	360	225,000	8,000	1- 4K	54	1,2,3,4,5	Automath 400	400 Group
IBM 1620	100	95,000	2,000	20K (Characters)	Variable	1,3,4	Fortran	1620 Group
Philco 1000	300	250,000	7,000	8-32K (Characters)	Variable	1,2,3,4,5	—	—
RCA 301	400	271,000	5,500	10, 20 or 40K (Characters)	Variable	1,2,3,4,5	Cobol, Fortran	RCA Group
Scientific Data 910	—	73,000	2,190	2-16K	24	1,2,3,4,5	Fortran	—
Univac 1050	800	350,000	7,250	8-32K (Characters)	Variable	2,3	—	Univac Group
LARGE SCALE ($750,000 UP)								
Burroughs B5000	1,000	$ 790,000	$13,000	8-32K	48	1,2,3,4,5	Algol 60	Cube
Control Data 1604-A	600	1,750,000 up	36,650	32K	48	1,2,3,4,5	Fortran	Co-Op
General Electric 210	850	750,000	14,000	4- 8K	28	1,2,3,4	—	—
Honeywell 800 II	950	815,000	17,000 up	4-32K	54	1,2,3,4,5	Automath 1800 800	800 Group
IBM 7010	—	945,000	19,175	40-100K	Variable	2,3,4,5	Fortran	Guide
Philco 210	1,200	2,000,000	28,000	8-32K	48	1,2,3,4,5	Cobol, Altac	—
RCA 3301	1,000	900,000	18,000 up	160K (Characters)	Variable	1,2,3,4,5	Fortran	RCA Group
Univac III	2,000	1,100,000	22,500	8-32K	27	1,2,3,4	Cobol and Fortram	Univac Group
IBM 7090/7094	—	3,000,000	64,000 up	32K	36	2,3,4,5	Fortran	Guide

NOTE: INPUT-OUTPUT (1) Typewriter (2) Magnetic Tape (3) Punched Card (4) Punched Paper Tape (5) Remote Station

The main towers of the Vincent Thomas bridge are the first welded suspension towers in the United States. The trim, clean design is a fine example of the progressive use of welding and high-strength bolting techniques.

WELDING GIVES NEW LOOK TO SUSPENSION BRIDGE



The fabricated "box sections" comprising the 335' towers were fully assembled in the shop in order to insure precise fit in the field.

By Jerome R. Senese, Project Manager
Kaiser Steel Corporation

The recently completed Vincent Thomas Bridge is the only vehicular suspension bridge in Southern California, and is fast gathering support from its admirers as the most beautiful bridge in the State.

Progressive design, precise fabrication, and engineered erection were the factors responsible for the success of this project, and its unique features have generated a great deal of interest in the steel fabrication and construction industry.

Some of the unusual aspects of the Vincent Thomas Bridge are:

It is believed to be the only suspension bridge in the world supported entirely on piles.

Over 6000 tons of welded steel piles were used. This the first time these sections have been employed to such a great extent on a major structure.

Its main towers are the first welded suspension towers in the United States.

Side-span steel and center-span steel were not erected in the conventional sequence. Instead, the side spans were used as counterweights and erected after the entire main span had been completed.

Six thousand and sixty-two feet long, the bridge spans the main channel of busy Los Angeles Harbor from Terminal Island to San Pedro with a 1500′ center span and two 506.5′ side spans. The steel plate girder approach spans stretch out 1841′ on the San Pedro side and 1708′ on the Terminal Island side. The clear height from mean higher high water to the bottom of the suspended main span is 185′, allowing passage of the largest ships in the world. The main steel towers extend 360′ above M.H.H.W.

The Bridge was designed by the Bridge Department of the Division of Highways, State of California, and is a fine example of a modern steel design that utilizes structural members fabricated from plate.

Kaiser Steel Corporation was the prime contractor for the superstructure. Major steel fabrication was done at Kaiser's Montebello, California plant. The company's two principle subcontractors were Yuba Erectors for the steel erection, and John A. Roebling's Sons for the cable spinning.

The main towers are designed entire-

ly of steel plate. The major components of the suspended span steel are shapes welded from plate and the steel piling was fabricated of three steel plates welded together to form the conventional H. Section.

The design configuration of the main towers is an assemblage of four cellular boxes approximately 50' in length for each of the seven tiers of each leg. The challenge in fabricating the tower sections was controlling the dimensional characteristics of the cruciform configuration while having to assemble, weld and mill each box section individually.

The design established by the Bridge Department of the California Division of Highways utilizes a most efficient arrangement of metal, taking full advantage of the speed of field-bolting erection techniques. The design is simple, straightforward, and achieves a slender appearance unusual in modern tower construction.

In utilizing this design to develop the lower cost method of fabrication, three fundamental problems had to be resolved:

1. Maximum duplication of individual components in the metal preparation phase.
2. *The dimensional characteristics* of the weldments had to be closely controlled and weld-distortion minimized.
3. Since the massive equipment necessary to end-mill a complete leg assembly was not available, it was essential that each of the four sections making up the tier of a leg be independently milled with absolute accuracy to insure full bearing in the tower assembly.

It was recognized at the outset that the squareness, straightness and freedom from twist of the individual sections would have to be carefully controlled. *This was achieved by assembling* each unit in a jig which controlled squareness, tacking together all of the plates going into an assembly before any production welding was performed, and developing a welding sequence. The jig used to maintain squareness was an adaptation of an existing girder assembly fixture. This required only the installation of perpendicular supports for *the mating flanges and the accurate lo*cation of gauge-holes corresponding to those drilled in the plates in which full size pins were installed prior to assembly. With the first two plates in place, the diaphragms and vertical members were easily installed, fit-tight and securely tacked.

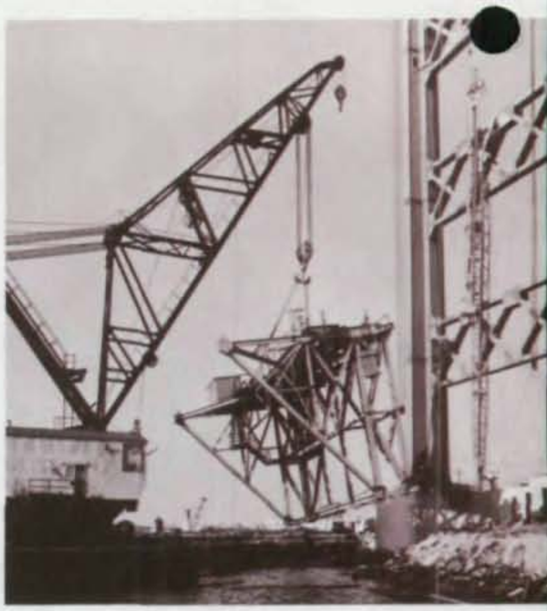
At this point there was a great temptation to proceed with the strength welding before accessibility was impaired with the closure plate. However, it was felt that dimensional stability would be jeopardized if this procedure were employed, so the closure plate was also set and tacked before **any** produc*tion welding ensued.*

With all members securely tacked the section was removed from the jig and positioned for welding. Welds were made in a predetermined sequence so as to first completely weld up the weld up the web "egg crate" joints. Next the longitudional welds were made and lastly the exterior longitudinal welds were completed. This procedure required additional turns of the member to put the welds into the most favorable position, but the lack of distortion justified the additional handling.

On completion of the welding the member was moved to the futur-mill *where special stops had been estab*lished to accurately position the member with respect to the plane of the milling cutter. These stops enabled the positioning of the member to the full size gauge-holes. The location of these holes as well as their elevation with respect to the milling cutter was accurately shot in and frequently checked. A milling sequence was developed to insure that any inaccuracy built into the setup would be counteracted in succeeding cuts.

The fabricated "box sections" were then fully assembled in the shop, the entire seven tiers totaling 335'8" long. *The milled joints were pulled into bear*ing and all dimensions thoroughly checked. The over-all length of the tower leg was measured with a full length calibrated tape. The struts were also fully assembled and mated to the connecting "box section'. All holes in the struts were sub-drilled and then reamed full size at asssembly.

From this point on it was a matter of



Valuable time was saved by moving the "creeper" platform, used to erect the first tower, across the channel to the second tower by means of a 125 ton floating crane.

developing special reaming equipment for the thousands of sub-drilled holes. Self feeding drill motors were used for the interior reaming because of their portability and high-power. On the exterior, standard reaming motors were *used, most of which were adapted for* one man operation.

The approach girders that supported the roadway were unusual only in size. They averaged 11' deep and 170' long and ranged in weight from 24 to 57 tons. These members were fabricated in halves, in a hydraulic bridge girder fixture and then spliced in the shop and shipped in one piece to the job site.

The suspended span truss steel was made up almost entirely of welded shapes. The lateral trusses were shop assembled and shipped to the job site in one piece. The stiffening trusses were shop assembled in sections and *then knocked down prior to shipment* to the job.

Welded piling and welded shapes for the suspended span steel were produced on Kaiser's continuous beam welding machine. The basic principle around which this equipment operates is the simultaneous assembly and welding of three plates into beam sections. This is accomplished by a system of rolls arranged to orient flange and web material into their correct position. The main rolls provide constant hydraulic pressure to fit the material for welding as well as the tractive force to propel the material through the machine. The welding process is automatic tandem submerged arc.

The first phase of tower erection started on the Terminal Island tower. Stress rods 2½" in diameter and 25' long were used to anchor the towers to the footings, each tower leg being anchored to the footing with 39 individual rods. Stress rods were equipped with a special Howlett spherical wedge grip nut and washer assembly on each end to hold the rod in tension after jacking.

Before placing the 3" thick base plates for the tower legs, the concrete pedestal was ground to correct elevation and true plane to assure good bearing and good vertical alignment of the towers. A ⅛" thick layer of red lead paste was applied to the bearing area before setting the base plates.

The first tier of each tower leg was erected on the base plates with a 60-ton capacity crawler crane. After erection of the first tier of each tower leg, the stress rods were stressed to 360,000 pounds each with hydraulic jacks. Since the stress rods were placed in 3" pipes and anchored in the concrete at the bottom only, the entire length of the rod was under full stress.

When the first tier of both legs of one tower was erected and completely bolted up with high strength bolts, a "creeper" working platform was assembled and bolted to the channel side of the tower legs for erection of the remaining tiers. The creeper consisted of a trussed support framework on which was mounted a stiffleg derrick with a 100' boom. A four drum hoist located on the ground near the base of the tower operated the derrick.

The second tier of tower sections was placed with the creeper derrick, and after the second tier was completely bolted to the first, the creeper was raised to the top of the second tier. Raising of the creeper was performed by attaching two large jumping brackets with two sets of cable falls, each of 15 part lines, to the tops of the second tier of the tower legs. Load lines from the cable falls connected to a three drum hoist at the base of the tower furnished the lifting power.

Jumping the creeper occurred in like manner for each successive tower tier placing.

When the creeper reached the top, its derrick placed the cable saddles and erected a smaller stiffleg derrick on top of the tower to service the cable spinning operations.

The creeper was then lowered to the first tier by means of the jumping brackets and cable falls. A 125 ton capacity derrick barge picked the creeper off the tower and moved it across the channel to the San Pedro side for erection of the second tower.

During the cable spinning operation, steel erection was starting on the approach girders, and coordinated so that the last girders were set immediately after the cable spinning operation. When the main cable had been erected, cable bands installed and suspender ropes dropped into position, it was time for the erection of the suspended span steel.

Normally, steel erection of this type is performed by setting the steel work in a sequence that proceeds out from both sides of both towers simultaneously so that the loads on the cable are balanced to avoid cable distortion. In this instance, however, since the side spans were over dry land Yuba Erectors elected to assemble the side span steel in sections under the suspender ropes and by hanging pendants from the suspenders to the steel work, they were able to utilize the side span steel as a counterweight. This enabled them to complete erection of the main span steel before any side span steel was raised into position.

The main span steel was assembled on barges in 80 ton sections. The barges were then towed into the channel where the sections were raised into position and secured to the suspender ropes. A pair of cable travelers working out from each tower were used in making the lifts. After the erection of the main span steel was complete, both travelers meeting at mid-span, the travelers were moved up the cable to the towers where they were disassembled, lowered to the roadway level, threaded through the tower, and then raised and reassembled on the side span cables. The erection of the side span steel then proceeded as each traveler worked down the cable, raising one section at a time in alternate sequence, ending at the cable bents where they were disassembled and removed using mobile cranes, working off the roadway.

The Vincent Thomas suspension bridge spans the main channel of busy Los Angeles Harbor from Terminal Island to San Pedro with a 1500' main span and two 506.5' side spans. Including the steel plate girder approach spans, the bridge totals 6,062' long.

RETAIL STORE BUILT OVER DOWNTOWN ARTERY

Two of the four 50-ton 115-foot long Vierendeel trusses, which support Hamburgers' "bridge" wing," are shown being welded in Bethlehem Fabricators' plant, in Bethlehem, Pa.

The completed structural frame work blends nicely into the background of the Blaustein Building designed by Mies van der Rohe.

The decision to bridge over Fayette Street, a traffic artery in downtown Baltimore, with a retail clothing store resulted in an extremely dramatic building according to the architects, Tyler, Ketcham and Myers.

Located in the well-known Charles Center, the site for Hamburgers store made it desirable that this large retail clothing store appear integrated with the entire Center. At the same time, the site had to be closely related to the rest of Charles Street. Pedestrian traffic normally flows along Charles Street or across Fayette Street. Ideally then, a selling area at grade was established, with entrances to the store on the east and west sides. Easy access between this level and the main selling area on the second floor was provided by up-and-down escalators. The upper selling area opens out on an elevated mall of Charles Center.

The third floor of the structure is used for alterations, storage, employees area and administrative offices. This level lies between four gigantic Vierendeel trusses spanning 105 feet over Fayette Street. These trusses support the main selling area at the level of the

mall and at the required clearance above the street.

The main selling area is situated so that pedestrians have a full view of the merchandise as they walk along cantilevered walkways. They can also view the busy thoroughfare below. A stairway at Charles Street gives access to this walkway thereby eliminating the need for people to cross Fayette Street at grade.

For architectural reasons an effort was made to eliminate columns wherever possible. There are only ten columns in the entire selling area. In most floor areas the floors are a thin set terrazzo on a cellular steel floor with concrete fill. The interior walls are of various hardwoods and paint.

Exterior wall construction up through the first two levels is duranodic aluminum of a bronze color, glass and travertive. The upper story is an off-white brick and the penthouse a black brick. Selection of colors and materials was carefully made so that they would harmonize with the One Charles Center Building.

The underside steel construction spanning over the street was first treated with a sprayed-on coat of insulation and fireproofing. Next installed was a ceiling of oriental plaster.

Hamburgers' store, fully air conditioned and fire resistive costing approximately 2 million dollars, was opened for business on October 14, 1963.

Van Rensselaer P. Saxe, the consulting structural engineer, when given the architectural requirements, decided to use Vierendeel trusses. The structural problem involved a floor construction of not over two foot depth and spanning 105 feet. Trusses of depth to include the third floor level were the answer. Since this floor included alterations and offices, daylight was not important. Vierendeel trusses were the answer. They could be used with hanging supports from the bottom chords at the third floor level, picking up the second floor loads over the street area.

Four lines of trusses are used in the structure. The two outside lines are set back two feet from the exterior walls. Architecturally it was desirable that the members of the trusses be of reasonable size and in keeping with the scale of the structure. Since the loading was heavy, the engineers decided to use high strength steels, and fully weld the trusses. The fabricator, Bethlehem Fabricators, Inc. selected V50 and V55 steels manufactured by Bethlehem Steel Company. The trusses were completely assembled in the shop.

All welds were made with low hydrogen E70XX series electrodes or SA1 submerged arc. The V50 and V55 steels were preheated to the temperature recommended by the steel supplies.

Sequence of welding followed a definite order: 1. assembled the chords to full length and welded splices, 2. fitted diagonal stiffeners to chords and then welded same, 3. fitted vertical stiffeners to chords and welded same, 4. subassembled and welded vertical members, 5. milled vertical members to proper length, then scarfed ends for welding, 6. assembled truss and tacked securely, and 7. welded vertical members to the chords.

Plate thickness over 1½ inch thick were made up of multiple plates with slot welds, since the maximum plate thickness of V steel rolled is 1½ inch. Through the use of Temsticks the fabricator was certain that the pre-heat temperatures strictly followed pre-heat requirements.

This project is an excellent example of the use of welded high-strength steels, and cellular steel floor assembly to minimize the size of structural members and the depth of floor construction.

PROGRAM

Sixteenth National Engineering Conference

The Sheraton-Fontenelle Hotel, Omaha, Nebr.

THURSDAY, MAY 14, 1964

8:00 A.M. – Registration

Chairman: T. R. Higgins
Director of Engineering
and Research, AISC

Introductory Remarks,
John K. Edmonds,
Executive Vice President, AISC

President's Welcome
R. C. Palmer, President
R. C. Mahon Company
Detroit, Michigan

The Effect of the New Developments in Structural Steel

"On Design Practice"
Ira Hooper

"On Engineering Education"
James Q. Hossack

"On High Strength Steels"
John A. Gilligan

"Where Do We Go from Here"
T. E. Dalby

"Static Strength of Hybrid Composite Beams"
A. A. Toprac

"Steel Framed Tier Buildings"
A. J. Julicher

12:15 P.M. – Luncheon

1:30 P.M. – Continuity in Steel – Research and Practice

"Plastic Design in Multi-Story Buildings" – Lynn S. Beedle and George C. Driscoll

"Steel Is Changing the Los Angeles Skyline"
Roy G. Johnston

"Practical Aspects of Field Welding" – J. E. Hinkel

"Continuity in Steel Highway Bridges"
Darrel D. Girton

Panel Discussion
E. H. Gaylord, Moderator
Lynn S. Beedle
George C. Driscoll
Roy G. Johnston
J. E. Hinkel
Darrel D. Girton

"Architecture Around the World – A First Hand Report"
Harold Spitznagel

6:00 P.M. – Reception

7:00 P.M. – Banquet

Master of Ceremonies–E. F. Owen
Speaker–Jack Veller

FRIDAY, MAY 15, 1964

8:00 A.M. – Registration

Chairman: Robert O. Disque,
Chief Engineer, AISC

Motion Picture
"Designs against the Sky"
Courtesy of the American Iron and Steel Institute

Orthotropic Bridges
"Using the AISC MANUAL"
W. A. Milek

"Clues to Steel Deck Performance"–Roman Wolchuk

Coffee Break

Roofs of the Future

"Cable Suspended Roofs"
Lev Zetlin

"The Hyperbolic Paraboloid"
Charles R. Hutton

"Thin Shells"
Kenneth P. Buchert

"The Space Frame"
Kenneth C. Naslund

12:15 P.M. – Luncheon

1:45 P.M. – Recent Development in the West

"San Francisco Rapid Transit System" – S. H. Clark

"Welded Structural Shapes"
Charles A. Zwissler

"Delta Girder Bridges"
Homer M. Hadley

"Castellated Beams – New Developments"–J. Parke Boyer

3:15 P.M. – Tour –
Strategic Air Command Headquarters in Omaha

Registration forms are available from

AISC, 101 Park Avenue
New York, N. Y. 10017

or your local AISC Regional Engineer.