PLANS AND DESIGN
OF AN ARTS CENTRE IN JAFFA

KHALID H. KHALIDI

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A Thesis submitted to the Department of Engineering, American University of Beirut in preparation for the Bachelor of Science in Civil Engineering.

BEIRUT - LEBANON

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C O N T E N T S

Property Store and Studio

Projection or operating Room

Staff Rooms and manager's office

Open air terrace

Areas.

CHAPTER III

STRUCTURAL DESIGN.

Design of truss for hall

Design of beams and girders for Restaurant.

P R E F A C E

This thesis is an architectural and structural design study of an arts centre. No attempt has been made to give a complete and thorough design of either, but the major and vital part of both has been attempted.

The structural design includes the design of the trusses of the auditorium and the beam and girder type of construction of the restaurant; the architectural part includes the design of the plan of the centre, and two main elevations, no sections perspectives are included.

The Architectural Design follows the recommedations and Practice of the Arts Council in Great Britian, the structural design follows the American Practise and the recommedations of the Joint Code and the American Institute of Steel Construction.

The thesis includes three chapters, firstly an introduction, secondly a general description of building with some construction notes, thirdly the structural design of both the trusses and the beams, and girders.

A I M S

The Basic Aims of centres may be summerized from the following article in "the Architect and Building News" by E.G. Farrow, November I946.

" It is to create in the community positive instrument, to promote culture and promote harmonious and balanced living so that the individual finds purpose and achieves expression in service of the community and learns to live a fuller life ".

What better form of memorial could be better devised than a centre where present and future generations can enjoy in comfort their rightful heritage of music, drama and visual art?

C H A P T E R

I

I N T R O D U C T I O N

CHAPTER I

INTRODUCTION.

" Art is any skill in production, skill of representation of design, and perfection of science, it is an expression of human activity requiring not only paint brushes, and canvas, instruments of music , chisels and stones, scenery and costumes, but buildings where we can congregate to injoy and make them our own ". Says Mr. A. W. Farmer of the Arts Council of Great Britain.

In all the Middle East, there is a deplorable lack of proper buildings and concerts, plays, exhibitions, have to be given in hotels, restaurants, hostels and every kind of building except one specially designed, properly equipped, and harmoniously decorated for the purpose.

Sentence Construction ?

The arts should be honourably housed with its accommodation properly related to the size of the community it serves.

This design is to show how the arts can be accommodated in a medium-sized town as Jaffa of an eighty thousand population where it is not economically possible to run a seperate theatre, art gallery and a hall for concerts.

For these reasons, the arts centre should house in a single multi-purpose hall, the Occasional visiting companies touring exhibitions, orchestras, concert and artists.

Punctuation ?

Such a centre should play a vital part in the life of the community it serves, and in the frame work of the city.

During the last years the activities of the amateurs of arts have increased in this part of the world. Many new music and arts clubs and dramatic societies have been formed. The Centre is designed for both the local amateurs as well as the visiting professionals if it is to have its full value.

If Jaffa can afford only a community centre and regards a special building for an arts centre as an inaccessible luxury, then it is vitally important that the community centre should be designed so as to include adequate provision for the Arts, and a part of this arts centre can be incorporated in the general scheme of the community centre.

The Municipality or Government should be responsible for the provision of both the community and Arts Centres which should be designed to serve the social, cultural, moral and artistic needs of the town.

The success and enjoyment of Arts need happy, beautiful and stimulating surroundings, they must not dominate the sort of dull background of an institutional atmosphere, that so frequently accompanies social, educational and religious activities.

For this reason it is essential that the arts centre should have an attractive, well run restaurant where meals, snaks and drinks can be obtained.

A touch of abundance, taste and colour in furnishing and fitting and a general atmosphere of comfort are essential to this centre if it is to be a live one.

C H A P T E R II

A R C H I T E C T U R A L S T U D Y

O F C E N T R E

CHAPTER II

THE BUILDING.

DESCRIPTION.

There are three main componants of this Arts Centre and each is planned to function in combination with the others.

The three componant Parts are :

I.- A hall to seet 600-800 with stage, property store, paint shop, studio, dressing rooms, and store rooms.

2.- An Exhibition with adjoining reading room.

3.- Restaurant to seat 200 with bar service counter, kitchen, store rooms, wash room, staff room.

The entrance hall, cloak room, office foyer, and corridor comptete indoor accommodations.

GENERAL PLAN AND SYSTEM.

The Arts Centre is divided into three main parts, the hall, the Restaurant and the Exhibition Room, There is only one public entrance with a counter to control it, but other entraces are provided for the use of the centre's staff, for goods and for emergency in the case of fire.

The plan should insure the following :

a)- Simplicity and economy of operation including corridors, wide enough to avoid congestion both for visitors and services.

b)- Efficient lighting, both natural and artificial, the latter preferably, fluorescent strip lightening and least in the exhibition room.

c)- Good ventilation preferably air-conditioned.

d)- Ample space and reasonable comfort for the individual.

e)- Quiete,(x) to be insurred by rubber, cork or wooden flooring and noiseless fitting. In view of the close proximity of the hall, exhibition room and restaurant special precautions should be taken in the construction. There are double doors between the hall and foyer, the folding doors to the exhibition room are insulated as for broadcasting studios, the folding screens between the hall and the restaurant are insulated and along the balustrading to the restaurant, heavy curtains are provided.

There are six structural Requirements which must be met in the centre.

I) Strength and stability. 2) freedom from damp.
3) thermal installation. 4) sound instulation
5) resistance to fire 6) durability and ease of

(x) Recommendations of the Arts Council in Great Britian, I945 maintenance.

SITE.

The building should occupy a commanding site and should be adequately and efficiently designed interpreting the purpose and ideals of the community, focusing the city's activities and symbolizing the artistic achievement and aspiration.

The site should be in such a position that reasonably good transport facilities are available, the provision of suitable parking systems for motor cars and ample facilities for bicycles are most essential. The site must be accessible to the whole area it serves and should be grouped with other recreational facilities, social services, and sports centres, as pointed out in Principales of city planning by Karl Lohamann.

Is should be chosen on an eminance (if available) to give an opportunity for more satisfactory monumental type of approach, overlooking a water front i.e. the sea.

Poor grammatical construction

The site should be selected large enough both to insure to the building plenty of light and air and to prevent any over dominance by any other structure in the neighborhood.

Repetition

FURNITURE.

It is certain that if the Arts Centre should make a success of its component parts, they must go all out for furnishings and decorations which at once symbolise efficiency and cleanliness.

The success of the restaurant is largly dependant on its ability to catch the eye of the centre-goer on his way from the foyer to the hall and this can only be done if the decoration and furnishing present an appearance which is at once compelling.

The interior effect of the hall is made by the way it is furnished and decorated good windows and stage curtians harmonising with the color scheme will add dignity to the hall.

Chairs should be strong and comfortable and able to be stacked for storing.

Steel chairs are light, strong, made in various attractive colors and easily stacked, arm-chairs in the reading room should be provided.

Strong solid tables should be provided for the restaurant to suit two, three and four. They may be round or oval.

CAR PARK.

An adequate car park is provided by which the front of the centre and the line of the side walk are set back to such a degree as to allow additional paving space to accommodate a standard length of car - at least I4' - in addition to allow a side walk of such a width as to allow for the project of the fender of a parked car.

ENTRANCE.

The entrance is planned generously in area and is related to the various groups in such a way as to reduce cross-circulation to minimum. It might be desirable to provide seating for visitors waiting in the entrance. The entrance is designed with greatest care to ensure that the public can leave the centre quickly and easily, other minor entrances are provided for emergency cases.

OFFICE.

Facing the cloak room to the left of the entrance door is the office for the secretary, manager or warden responsible for running the centre.

CLOAK ROOMS AND SANITARY ACCOMMODATIONS.

The Cloak room and sanitary accommodation for each sex are provided independently. The Cloak room in the centre is on a generous scale almost as generous as for secondary school buildings, based on the maximum population at any time. As it is better that out door clothing is normally left in cloak rooms rather than scattered in the individual rooms of the building. Poor Construction,

The location of the cloak room and the sanitary accommodations are at the right of the main entrance hall, the cloak room has a small crush room, and the men's lavatories are one side the women's on the other.

RESTAURANT.

The doors to the restaurant face the main entrance, there is a pay-box near the restaurant doors. It is lit from the side by a large continous windows. There are tables for two hundred and opposite the pay box near the entrance is a bar for drinks and snacks. The service to the restaurant is from the kitchen which is adjacent to the back stage. There is a direct access from the hall to the restaurant across a spacious corridor.

It is important to provide table accomodations to suit two, three and four people for the most part, though it is well to provide accomodation for larger parties.

Round tables 3'-6" in diameter or less are suitable the absence of sharp angles being highly desirable, some table-tops might be provided oval say 3'-4" by I'-8".

KITCHEN

The kitchen should be large enough to give ample space for the preparation of refreshments and full service meal for two hundred persons to be served at one time.

The equipment needed is an electric cooker, a large cooker sink, tables and storage cupboards for china and glass. Some fire-proof wall and floor covering should be provided.

FOYER.

The entry into the Arts Centre ought to prepare the spectator for the change from the outside world of reality to the world of screen and screen conventions.

The transition from the atmosphere of the street to that of the screen should be gradual, ceremonious and accompanied by subtle decorative inflections.

The foyer illumination should be of the type known as the cornise lighting recessed behind horizontal mouldings or plastered bevels. Indirect lighting is gradual with variations of colour from a subdued domestic note inside the main entrance to a blaze of brillance before the principal door giving access to the auditorium. Which is illustrated Clearly in "Modern Theatres and Cinemas" by P. Morton Shand. Sentence Construction

The Foyer is well lit through glass domes in the roof, the floor is covered with large squares of brightly polished cork.

On some walls of the foyer pictures can be hung. The foyer can easily be made an extension to the exhibition and reading room by opening the double doors against the deep reveals of the columns.

EXHIBITION AND READING ROOM.

The reading room may be considered as an extension of the exhibition room it can be cut off by folding and sliding doors, similerly the foyer may also be considered as an extension, and a spacious hall is obtained from the foyer, reading room and exhibition room for the great shows and competitions of visual arts, namely, painting, sculpture, photography, costumes and stage scenery where they can be exhibited.

The reading room is a small room in which the members may read current periodicals. It contains a small arts referance library.

The general appearance and decoration should be homely and have a club atmosphere rather than an institutional character.

The furniture should be strong and well made to with stand the hard usage but could well be more comfortable than that generally provided in public libraries.

Quitness and pleasunt aspect are an essential factors in placing the reading room and exhibition room as a whole.

THE HALL OR AUDITORIUM

The hall is the most important element in the building, has a stage adeuqate for theatrical and film show, concerts and debates. The front part which is level can also beused for dances and other social activities this part is laid with hardwood strips suitable for dancing, when there is a dance the stepped portion can be used for sitting, at the back of the hall there is a chair store.

Very Poor Sentence Constr.

In estimating the accommodation per individual for an approximate total calculation all passages have to be included and on this basis not less than seven square feet. As indicated in "Principles of Planning Buildings" by P.L. Marks.

Better to place in footnotes superseded by quotation marks

The area of the Hall is 4530 sq.ft. which can easily accommodate 650 persons on this basis.

The seating per individual is I'-9" width by a generous allowable depth of 2'-9". Although the Horse-shoe shaped auditorium is found by experience to be the best suited, yet a fan shaped hall has been effectively used. The Arts centre hall is designed as a fan shaped of a central angle I2° (the tangent of half I2 degrees in one tenth approximately).

THE STAGE.

The width of the proscenium is 24 ft. and the height is I8 ft. The width of the stage is 50 ft. which is approximately twice the width of the proscenium, the height of the latter being 40 ft. which is approximately equal to its width (Acoustical requirements, As recommended in Principles of Planning Buildings).

The depth of the stage is 20' ft. and it slopes upwards from the foot lights at a gradiant of I/2 in to a foot (I/24).

Infront of the curtain there is a small orchestra pit which is sunk four feet below the level of the auditorium floor. The stage is 3'-6" above the main floor

The equipment is to professional standards.

DRESSING ROOMS.

The dressing rooms are behind the stage so that the players can change without having to pass where the audience may see them.

There is a corridor seperating these rooms from the stage so that the players can freely enter from either side of the stage. There are one large and three small dressing rooms, each room will need several seperate lights, mirrors for make-up, wash basins and cupboards. Lavatory accommodation is available on both ends of the dressing rooms.

PROPERTY STORE AND STUDIO.

On one side of the stage is an opening leading to a property store and paint shop which is used by amateur theatrical societies, next to the property store is a studio wich is used by art classes or individual painters, sculptors and designers of stage scenery.

PROJECTION OR OPERATING ROOM.

Is a small compartment raised well over the ground floor and is accessible by stairs from the foyer. This compartment has a film winding room and a film store or lobby in connection to it. A screen and sound horns are suspended from the stage grid. The picture screen which occupies more or less the position of the drop curtain, should be as large as the proscenium.

STAFF ROOMS AND MANAGERS OFFICE.

Rest rooms for male and female staff are located behind the kitchen, Also provision is made for an office leading off the kitchen for the manager or steward.

OPEN AIR TERRACE.

The doors of the hall give on to an open air terrace which on summer evenings can be used for concerts given on the small band stand or for out door dancing.

AREAS.

The various dimensions, areas and arrangements of the rooms of the component parts of the centre follow the recommendations of " The Principles of Planning Buildings" by P.L.Marks and the Arts Council in Great Britian 1945.

The dimensions are measured centre to centre of the partition walls. The exhibition room, foyer, hall, and dressing rooms are fan shaped and the dimensions of the radius, chord, and area are recorded, the central angle of the segment being 12°.

The centre is 260' x 185' or 48100 square feet (~~1.121 acres,~~ 4470 sq. m.), the total built up area is ~~23,100~~ 23,220 square feet.

not used for bldgs

INTRANCE HALL

			sq. feet.
Entrance	20' x 10'	=	200
Vestibule	12' x 10'	=	120
Entrance hall	40' x 20'	=	800
Crush hall	20' x 10'	=	200
Cloaks Room	30' x 20'	=	600
Men Lavatory	20' x 15'	=	300
	20' x 10'	=	200

			sq. feet.
Women Lavatory	20'x I5'	=	300
	20'x I0'	=	200
2 cupboards	4'x I0'	=	80
			3000

RESTAURANT.

Restaurant	80'x40'	=	3200
Restaurant Service Counter	40'x I0'	=	400
Restaurant Pay box	I0'x I0'	=	I00
Restaurant Entrance		=	I60
Bar	20'x 5'	=	I00
Store	30'x 8'	=	240
Kitchen	40'x 20'	=	800
Dry Store	I0'x I0'	=	I00
Cold Store	I0'x I0'	=	I00
Vegetable Store, preparation and Wash room	I0'x 36'	=	360
Managers office	I0'x I6'	=	I60
Women staff room	I0'x I6'	=	I60
			5880

Corridor between kitchen and stage 26'x 7 = I82

" " hall and Restaurant 90'x I0' = 900

			sq.feet.
Corridor between two pay boxes	I3'x I0'	=	I30
" " Entrance Hall and foyer	20'x I0'	=	200
Store	I5'x I0'	=	I50
Office	35'x I0'	=	350
			I9I2

HALL, FOYER AND EXHIBITION ROOM.

Dimensions in feet.

	RADIUS	CORD	ARC
I.-	230'	46'	48.3'
2.-	3I0'	62'	65.I'
3.-	323'	64.6'	67.9'
4.-	343'	68.6'	7I.8'
5.-	347'	69.4'	72.9'
6.-	377'	75.4'	79.I'

Areas

				sq.feet.
Hall	=	I440 π	=	4530
Stores & Entrance	=	274.3 π	=	865
Foyer	=	444 π	=	I395
Double Doors	=	92 π	=	290
Exhibition room	=	724 π	=	2280
		2974.3 π		9360

STAGE AND DRESSING ROOMS.

Dimensions in feet.

	RADIUS	CORD	ARC
1.-	184	36.8	38.4
2.-	194	38.8	40.7
3.-	200	40.0	42
4.-	220	44.0	46.1
5.-	230	46.0	48.3

Areas

		sq. ft.
Front Stage	$= 150\pi + 10 \times 2 \times 3 =$	530
Stage	$= 280\pi + 30 + 20 \times 2 \times 3 =$	1030
Corridor	$= 78.8\pi - 30 + 6 \times 2 \times 3 =$	256
Dressing Rooms	$= 126\pi + 10 \times 2 \times 3 =$	455
		2271

TOTAL AREA OF THE BUILDING.

Entrance Hall	3000
Restaurant	5880
Corridors	1912

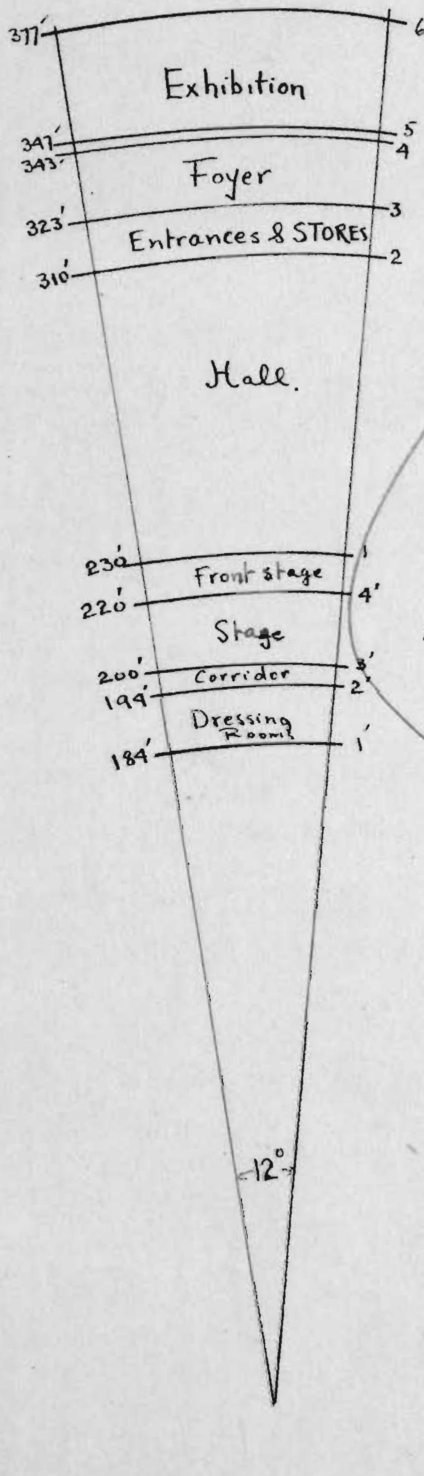
Hall, Foyer, Exhibition Room	9360
Stage and Dressing Room	2271
Property 20'x20'	
Studio 20'x 20'	800
	~~23,106~~ 23,223

<u>Area of Centre</u>

I85' x 260' = 48I00 sq. feet.

= 4468.5 M^2

(I sq. ft. = 0.0929 meter sq.)



The Number on right indicates the reference number, on the left the measurement of the radius from the origin
N.B. For Length of arcs, chords and areas see detailed dimensions.

Should be typed or lettered better

CHAPTER III

STRUCTURAL DESIGN

OF CENTRE

CHAPTER III.

STRUCTURAL DESIGN OF THE ARTS CENTRE

The Design of the Arts centre shall include only the two main components of the centre namely the Hall or auditorium and the restaurant .

The Hall is designed as steel structures frames i.e. trusses simply supported on reinforced concrete columns. The restaurant is designed as beam and girder type of construction, which consists of a series of parallel beams supported at their extremities by girders which in tern frame into concrete columns placed at regular intervals over the entire floor area.

No attempt is made for the design of the exhibition room which might be likewise designed as a bean and girder type of construction, neither the design of the columns and foundation has been attempted.

THE STEEL FRAMING OF THE AUDITORIUM ROOF

The auditorium Roof is composed of three trusses of 50', 54', 58' feet respectively. The purlins, the bracings and the struts of the end trusses are simply suported on the end bearing walls of 46 + 62 feet length. The spacing of the trusses is 20' c to c. As the spans of the trusees are close in length, it is sufficient calculate the sections for the members of the maximum span truss which is 58 ft.

The wind load is assumed as 25 Lb. per square ft. of roof surface. The snow load is not taken into consideration because it has never been expected in the town. Show?

As it is essential to provide a roof-covering which is always the least expensive in the long run, flat tiles are undoubtedly the best roof materials. Asbestos roofs should be avoided as condensation is apt to occur, their acoustic quality are poor and they are liable to crack if Knocked. Flat tiles of I5 Lb. square foot are provided. The A.I.S.C. specifications are followed in design. Source? Source?

The weight of truss and bracing is assumed to be approximately IO % of the weight to be supported, and any error in estimating the weight will have little effect on the design. As Thomas Shedd points out in Structural design in Steel. "Footnote"

ASSUMED LOADS

Wind	=	25 Lb./sq.ft. of roof surface
Flat Tiles	=	I5 Lb./" " " " "
Gypsum Plank	=	II " " " " " "
Purlins	=	I I/2 " " " " "
Truss and Bracing	=	3 " " " " " "
		55,5" " " " " "

PANEL LOADS ON TRUSS

$\frac{55.5 \times I4.5 \times 32.45}{3}$ = 8650 Lb./Panel Vertical

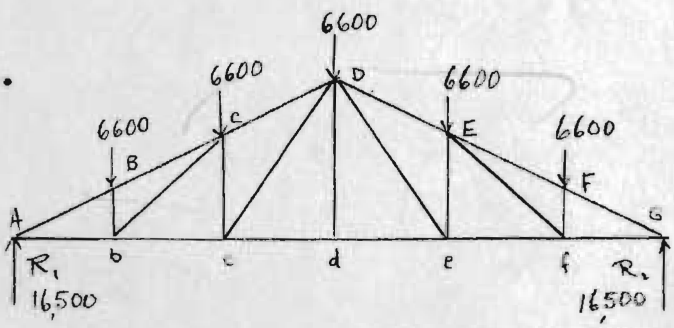
Normal to Roof = 8650 x $\frac{29}{32 - 45}$ = 7720 Lb./Panel

Parallel to Roof = 8650 x $\frac{I4.5}{32.45}$ = 3860 Lb./Panel

DUE TO DEAD LOAD

$\frac{30\ I/2 \times 20 \times 32.45}{3}$ = 6600 Lb.

$R_1 = R_2$ = 6600 x 2.5 = I6500 Lb.



DUE TO WIND FROM LEFT

Pn/p = .75 Pnormal = .75 x 25 = I8.75 Lb.

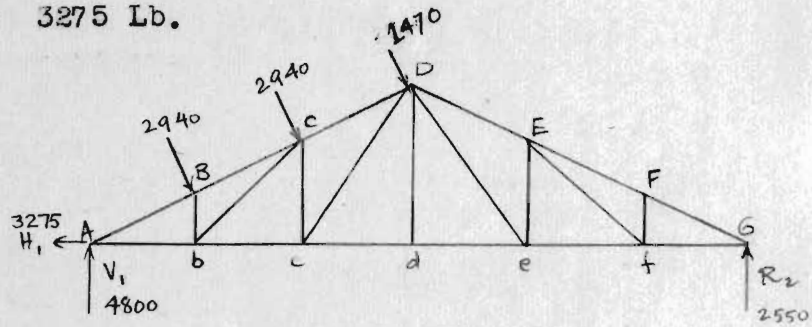
$\frac{22.5 \times I4.5 \times 32.45}{3}$ = 2940 Lb. per panel.

$$R_2 = I/58 \left(2940 \times \frac{32.45}{3} + 2940 \times \frac{2}{3} \times 32.45 + \right.$$

$$\left. + 2940 \times \frac{I}{2} \times 32.45 \right) = 2550$$

V_1 = 2940 x 2.5 - 2550 = 4800 Lb.

H_1 = I310 x 2.50 = 3275 Lb.



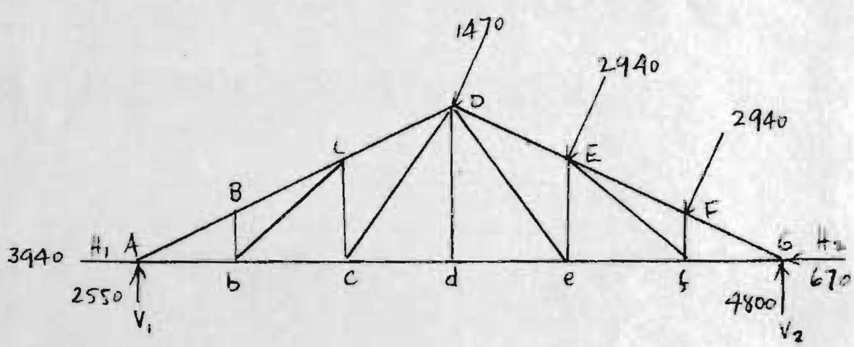
WIND FROM RIGHT

H_1 = 3275 + 665 = 3940 Lb.

V_1 = 2550 Lb.

H_2 = $I/2 \times 2940 \times \frac{I4.5}{32.45}$ = 670 Lb.

V_2 = 4800 Lb.



STRESSES

DEAD LOAD

A B = I6500 x $\frac{32.45}{I4.5}$ = = 36,800#(–)

B C = A B = 36,800#(–)

C D = (2 x I1800 x 3/$\sqrt{13}$ + TT00) $\frac{32.45}{29}$ = 29400# (–)

A b = 36800 x 2&/32.45 = 33000# (+)

b c = (I6500 x I9.33 - 6600 x 9.67) I/9.67 = 25400# (+)

c d = (I6500 x 29 - 6600 x I9.33 - 6600 x 9.67)/I4.5 = I9800# (+)

B b = 6600 = 6600# (–)

C c = I1800 x 3/$\sqrt{13}$ = 9900# (–)

D d = 0 = 0 # (–)

C b = 6600 x $\sqrt{2}$ = 9350# (+)

D c = (25400 - I9800) $\sqrt{13}$/2 = I1800# (+)

WIND FROM LEFT

A B = 4800 x $\frac{32 - 45}{14.5}$ = I1750# (–)

D C = $\frac{(4800 \times 19.33 - 2640 \times 9.67 + 1300 \times 14.5)}{9.67 \times 29/32.45}$ = 9950# (–)

B C = $\frac{4800 \times 9.67 + 1300 \times 488}{488 \times 29/32.45}$ = I2200# (–)

D E = E F = F G = 2550 x $\frac{32.45}{14.5}$ = 5700# (–)

A b = 3300 + I1750 x 29/32.45 = I3800# (+)

b c = $\frac{2950 \times 10.82 - 3300 \times 9.67 - 4800 \times 19.33}{9.67}$ = 9600# (+)

c d = $\frac{4800 \times 29 + 3300 \times 14.5 - 2950 \times 32.45}{14.5}$ = 5700# (+)

$$de = ef = fG = 5700 \times \frac{29}{32.45} = 5100^{\#}\ (+)$$

$$Bb = 2950 \times \frac{10.82}{9.67} = 3300^{\#}\ (-)$$

$$Cc = \frac{2950 \times 10.82 + 2950 \times 21.64}{19.33} = 4950^{\#}\ (-)$$

$$Dd = 0\ ,\ Ee = 0\ ,\ Ff = 0 = 0^{\#}\ (-)$$

$$Eb = \frac{2950 \times 10.82 \times \sqrt{2}}{9.67} = 4700^{\#}\ (+)$$

$$Dc = Cc \times \sqrt{13}/3 = 4950 \times \sqrt{13}/3 = 5950^{\#}\ (+)$$

$$De = 0\ ,\ Ef = 0$$

<u>WIND FROM RIGHT</u>

$$AB = BC = CD = 2550 \times \frac{32.45}{14.5} = 5700^{\#}\ (-)$$

$$DE = \frac{4800 \times 19.33 + 1300 \times 3/2 \times 9.67 - 26400 \times 9.67}{9.67 \times 29/32.45} = 9950^{\#}\ (-)$$

$$EF = \frac{4800 \times 9.67 + 1300 \times 1/2 \times 9.67}{1/2 \times 29/32.45} = 12200^{\#}\ (-)$$

$$FG = 4800 \times 32.45/14.5 = 11750^{\#}\ (-)$$

$$Ab = 5100 \times \frac{29}{32.45} - 3950 = 1150^{\#}\ (+)$$

$$Ab = bc = cd = de = 1150^{\#}\ (+)$$

$$ef = \frac{4800 \times 19.33 - 2950 \times 10.82}{9.67} = 6450^{\#}\ (+)$$

f G = II750 x 29/32.45 - 670 = 9800 # (+)

B b = 0 , C e = 0 , D.d = 0

E e = 2950 x 32.45/I9.33 = 4950 # (-)

F f = 2950 x I0.82/9.67 = 3300 # (-)

C b = 0 D c = 0

$$D\ e = \frac{1470 \times 32.45 \times \sqrt{13}}{14.5 \times 2} = 5950\ \#\ (+)$$

$$E\ f = \frac{2950 \times 10.82 \times \sqrt{2}}{9.67} = 4700\ \#\ (+)$$

CONTINUE

Member.	D.L.	WIND		COMBINED STRESS		MAX STRESS			
		Left	Right	D.L + W.L.	D.L. + W.R.	With Wind T	With Wind C	Without Wind T	Without Wind C
A B	36.8	II.75	5.7	48.55	42.5		36.8		48.55
B C	36.8	I2.2	5.7	49	42.5		36.8		49.0
C D	29.4	9.95	5.7	39.35	35.I		29.4		39.35
D E	29.4	5.7	9.95	35.I	39.35		29.4		39.35
E F	36.8	5.7	I2.2	42.5	49		36.8		49
F G	36.8	5.7	II.75	42.5	48.55		36.8		48.55
A b	33	I3.8	I.I5	46.8	34.I5	33		46.8	
b c	25.4	9.6	I.I5	35	26.I5	25.4		35.0	
c d	I9.8	5.7	I.I5	25.5	20.95	I9.8		25.5	
d e	I9.8	5.I	I.I5	24.9	20.95	I9.8		24.9	
e f	25.4	5.I	6.45	30.5	3I.85	24.4		30.5	
f G	33	5.I	9.8	38.I	42.8	33		42.8	

Member.	D.L.	WIND		COMBINED STRESS		MAX STRESS			
		Left	Right	D.L + W.L.	D.L. + W.R.	With Wind T	With Wind C	Without Wind T	Without Wind C
B b	6.6	3.3	0	9.9	6.6		6.6		9.9
C e	9.9	4.95	0	I4.85	9.9		9.9		I4.85
D d	o	o	o	o	o		o		o
E e	9.9	0	4.95	9.9	I4.85		9.9		I4.85
F f	6.6	0	3.3	6.6	9.9		6.6		9.9
b C	9.35	4.7	0	I4.05	9.35	9.35		I4.05	
c D	II.8	5.95	0	I7.75	II.8	II.8		I7.75	
D e	II.8	0	5.95	II.8	23.7	II.8		I7.75	
E f	9.35	0	4.7	9.35	I4.05	9.35		I4.05	

PURLINS

$$\frac{52.5 \times 32.45}{6} = 2840 \text{ Lb./ft. Vertical}$$

$$284.0 \times \frac{29}{32.45} = 254 \text{ Lb./ft. Normal}$$

$$254 \times \frac{20^2}{8} = I2700 \text{ ft. Lb. at centre}$$

$$254 \times \frac{6.67 \times I3.3}{2} = II250 \text{ ft. Lb. at third points.}$$

$$284 \times \frac{I4.5}{32.45} = I28 \text{ Lb./ft. Parallel to roof.}$$

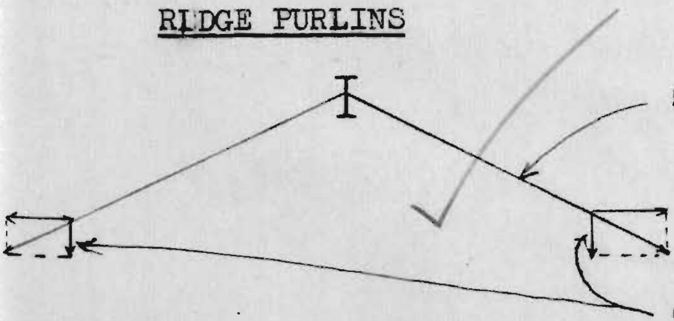
$$I28 \times \frac{6.67^2}{I0} = 570 \text{ ft.Lb.Parallel to roof at I/3 pt.}$$

Assume S/S' = 22 ±

$$S = \frac{I}{c} = \frac{II250}{I8000} \times I2 + \frac{570 \times I2 \times 2 \times II}{I8000} = I5.85 \pm$$

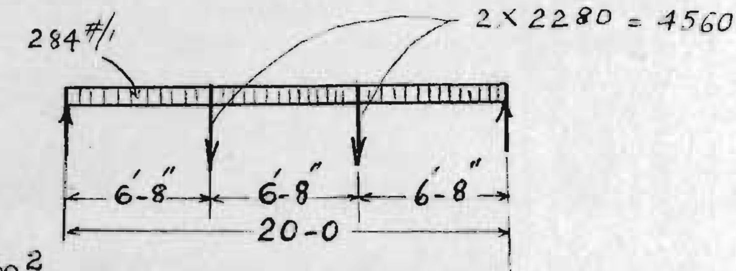
Use I0" [a 25 Lb. ($\frac{I}{c}$ = I8.I)

RIDGE PURLINS



$$52.5 \times \frac{20}{3} \times 32.45 \times \frac{I4.5}{32.45} = 5070 \text{ Lb.}$$

$$5070 \times \frac{I4.5}{32.45} = 2280 \text{ Lb.}$$



$$284 \times \frac{20^2}{8} = 14200$$

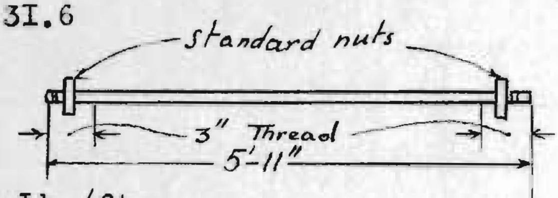
$$4560 \times \frac{20}{3} = 30400$$

44600

a $\frac{12}{18}$, $\frac{I}{c}$ = 29.8

Use 10" I a 40 Lb. $\frac{I}{c}$ = 31.6

SAG RODS



Use 5/8 ϕ Rods a 1.043 Lb./ft.

Standard Nuts a 10 Lb./100

TOP CHORD BRACING

7/8 ϕ Rods (No upset)

Use 7/8 ϕ Rods a 2.044 Lb./ft.

Standard nuts a 18 Lb./100

DESIGN OF MEMBERS

COMPRESSION MEMBERS

A B , B C , C D = 49.0 k (-)

Moment = $\frac{3860 \times 10.81}{6}$ = 6950 ft. Lb.

$$\text{min.r.} = \frac{I0.8I \times I2}{I20} = I.08I$$

$$\text{max.r.} = \frac{I0.8I \times I2}{60} = 2.I6$$

Assume 2Ls5x3 I/2 x I/2 a I3.6

$$l/r = \frac{I0.8I \times I2}{I.58} = 82 \qquad s = I3.74 \text{ k.}$$

$$A = \frac{49000}{I3740} + \frac{6950 \times I2 \times I.66}{I800 \times I.58^2} = 6.66 \text{ in sq.}$$

Formula 94 page 222

$$\text{or} = \frac{49000}{I3740} + \frac{6950 \times I2 \times 2.33}{I8000 \times I58} = 7.88 \text{ in sq.}$$

Area provided = 8.0 in sq. o.k.

C c , B b = I4.85 k (-)

Assume 2 Ls 3 I/2 x 2 I/2 x I/4 a 4.9 Lb.

$$\text{min. r.} = \frac{9.67 \times I2}{I20} = .967$$

$$\text{max. r.} = \frac{9.67 \times I2}{60} = I.934$$

$$l/r = \frac{9.67 \times I2}{I.I2} = I03.5 \qquad s = II.80$$

I4.85/II.80 = I.26 sq. in.

Area provided 2.88 sq. in. o.k.

DESIGN OF TENSION MEMBER

3/4 in Rivits

A b = b c = 46.8 k (+)

46.8 a I8 = 2.6 sq. in. net.

Use 2 Ls 3 I/2 x 2 I/2 x 5/I6 a 6.I = 3.36 - .55 = 2.8I sq.in.net.

c d = 25.5 k (+)

a I8 = I.42 sq. in. net.

Use 2 Ls 2 I/2 x 2 x I/4 a 3.6 = 2I2 -.44 = I.78 sq. in.net.

b c = c D = I7.75 k (+)

Use 2 Ls 2 I/2 x 2 x I/4

Member	Designed Stress	SECTION	WEIGHT	LB.
A B B C C D	- 49.0	2 Ls5 x 3 I/2 x I/2 @I3.6	I3.-x32.45x2x2	I770
C c B b	- I4.85	2Ls 3 I/2x2 I/2 xI/4 @4.9	4.9x I4.5 x2x2	284
D d	0	I L 2 I/2 x 2 x I/4 @ 3.6	3.6 x I4.5 x IxI	52
A b b c	+ 46.8	2Ls 3 I/2x2 I/2x5/I6 @6.I	6.IxI9.33x2x2	47I
c d	+ 25.5	2Ls 2 I/2x2xI/4 @ 3.6	3.6 x 9.67x2x2	I39
b C c D	+ I7.75	do	3.6 x 24.7x2x2	356
				3072
	Détails about 25 % includes wall plates			768
			For I truss	3840

BOTTOM CHORD BRACINGS

All Diagonals I L 3 x 2 x I/4 a 4.I Lb.

STRUTS.

2 Ls 3 I/2 x 3 x I/4 a 5.4 Lb.

DESIGN OF CONNECTIONS.

A.I.S.C. Specifications

3/4" Rivets, I3/I6" holes, gusset plate 3/8" Thick

Single shear 3/4" rivet = 6630 Lb.

Bearing 3/8" gusset (double shear) = II300 Lb.

Bearing I/4" angle (single shear) = 6000 Lb.

JOINT A

A B = 49.0/II.3 = 4.35 -- 5 rivets

A b = 46.8/II.3 = 4.I5 -- 5 rivets

JOINT B

B A , B C -- I rivet

B b = $\frac{9.9}{II.3}$ = 0.88 -- 2 rivets

JOINT C

49 - 39.35 = 9.65/II.3 = .855 use I rivet

C c = I4.85/II.3 = I.45 -- 2 rivets

C b = I4.05/II.3 : I.25 -- 2 rivets

JOINT D

C D 39.35/II.3 = 2.65 -- 3 rivets

D c I7.75/II.3 = I.57 -- 2 rivets

JOINT b

46.8 - 35/II.3 = II.3/II.3 = I.0 -- 2 rivets

JOINT c

35 - 25.5/II.3 = 9.5/II.3 = 0.85 -- I rivet

DESIGN OF BEAM & GIRDER FLOOR

Data and Specifications.Live Load:- The range of minimum live load value in pounds per square of floor or roof Area is given in several Building codes for flat roofs as 30 - 40 Lb/sq ft. and 50 Lb/sq ft. shall be designed for.

The columns supporting the floor are 20'-0" centre to centre in one direction and 40'-0"c.to c. in the other direction. The Beams span the 20'-0" direction and are placed at one fourth of the supporting girders.

A I" granolithic finish is to be included in the dead load of the slab. The allowable stresses are to be as specified by the Joint Code for 2500 Lb concrete and structural grade steel (f_s = 18000 p.s.i.)

The span length of the slab, the beams and the girders be taken as the distance centre to centre of supports.

DESIGN OF SLAB

Assuming the weight of slab and finish as 60 Lb. per sq. ft., the total load is 110 Lb. per sq. ft. and since the beam is partially continuous.

$$M = 1/10 \times 110 \times 10^2 \times 12 = 13200 \text{ in Lb.}$$

$$d = \sqrt{\frac{13200}{173 \times 12}} = 2.53 \text{ "Say 3"}$$

Allowing 1" of instulation below the centre of steel, the total weight of the slab agrees closely with the assumed value.

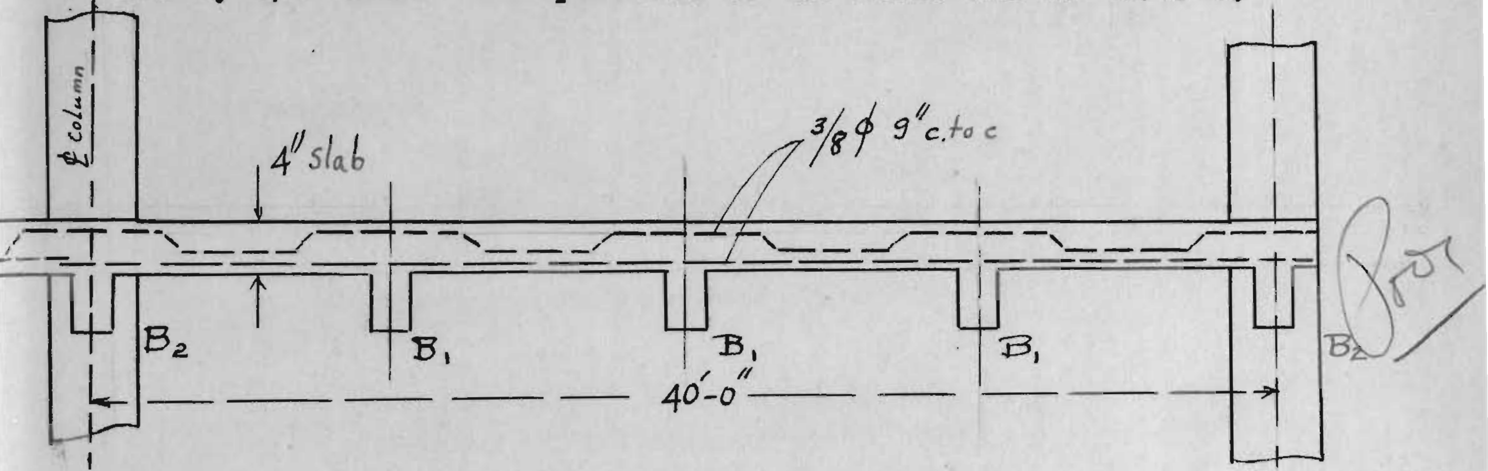
The steel area for 12" slab width.

$$As = \frac{13200}{18000 \times 0.867 \times 3} = 0.282$$

This is furnished by 3/8 "round bars 4 1/2" c.to c.

Alternate bars are bent up over the support, the remaining bars are straight through the supports and terminating beyond B_2. By adding 3/8" round bars, 40'-0" at 9" on centres in the top of the slab between the supports B_2, the area of tension steel at the supports B_1 would be sufficient. The bars should bent approximatdy at the quarter points.

Temperature and shrinkage reinforcement are provided for by 3/8" round bars parallel to the beams and I5" c. to c.



DESIGN OF BEAMS

Design of stem:- The beams are designed as T beams since the slab and beams are poured at the same time. The span is 20'-0". The total load from the slab = I0 x II0 = II00.#/ The total load on the beam is equal to I200 Lb/ ft. assuming I00 Lb/ft. the waight of the stem.

$$M = I/I2 \times I200 \times 20^2 \times I2 = 480{,}000 \text{ in Lb.}$$

$$V = \frac{I200 \times 20}{2} = I2{,}000 \text{ Lb.}$$

$$b'd \text{ required} = \frac{I2000}{7/8 \times I50} = 9I.5 \text{ in-sq.}$$

$b' = 6\ I/2''$ $\qquad d = I4.I''$

$b = 7''$ $\qquad d = I4''$

The beam bars pass below the girder bars an insulation of 2 I/2" to the centre of the upper most row of beam bars, a vertical distance of 2" in is between upper and lower rows.

The upper most row of the girder is placed I I/2" from the top slab, this arrangement will allow the bars not to interfere.

A section at the support of 7"x I4" is selected which satisfics the I/2 to I/3 ratio, the depth is measured from the bottom of the beam to the top of the tension steel. Allowing two rows of bars at the support the total depth of the beam is I4 + 3.5 = I7.5" and the depth below the slab is I7.5 - 4 = I3.5". The weight of the slab agrees with the assumed value.

<u>DESIGN AT CENTRE</u>.

The effective depth at the centre is I7.5 - 3 I/2 = I4". Assuming j.d. = d - I/2 t.

$$A_s \quad \frac{480000}{I8000\ (I4-2)} = 2.22 \text{ in-sq.}$$

Use 6 a 3/4 round bars (A_s = 2.65)

DESIGN AT THE SUPPORT

In each beam 3 bars are bent up and carried over to the support to a third of the adjoining span and 3 bars are carried straight to develop their strength in bond.

$$d'/d = 3.5/I4 = 0.25$$

$$\text{and } np = np' = I2 \times \frac{2.65}{7 \times I4} = 0.324$$

From formula 35 and 36 page I46 - 7 for beams reinforced for compression (Urquhart and Orourke)

$$k = \sqrt{.8I + .42} - .648 = .4I$$

$$j = \frac{.4I^2 - I/3 \times .4I^3 + .648 \times .I6 \times .75}{.4I^2 + .648 \times .I6} = 0.82I$$

$$f_s = \frac{480000}{2.65 \times .82I \times I4} = I5{,}750 \text{ p.s.i.}$$

$$f_c = \frac{I5750 \times .4I}{I2\ (I - .4I)} = 9I0 \text{ p.s.i.}$$

allowable $f_c = .45\ f'_c = I{,}I25$ p.s.i.

$$f'_s = I5750 \times \frac{.4I - .25}{I - .4I} = 4{,}280 \text{ p.s;i.}$$

Hence the design is satisfactory since f_c = II25 p.s.i.

ARRANGEMENT OF REINFORCEMENT

The maximum unit bond stress in tension bars

$$u = \frac{12000}{6x2.356x7/8x14} = 69.5 \text{ p.s.i.}$$

Shear at support

$$v = \frac{12000}{7 \times 7/8 \times 14} = 140 \text{ p.s.i.}$$

The middle bar of the upper row may be bent at a point .34 x 20 x 12 = 81.5 in , the outer bars are bent at a point .21 x 20 x 12 = 50.5 in. from the support but not less than.

$$1/2 \times \frac{20 \times 12}{3} = 40 \text{ in for the middle bars}$$

$$\text{and } 1/3 \times \frac{20 \times 12}{3} = 26.7 \text{ in for the outer bars}$$

say 5' - 0" the middle bar from support and 3' - 8" the outer bar from support.

DIAGONAL TENSION.

External shear resisted by concrete

$$V_c = 50 \times 7/8 \times 14 = 4280 \text{ Lb.}$$

The distance from the support over which wet reinforcement is required.

$$X_1 = 1/2 - v_c bjd/w = 1/2 - V_c/w$$

$$= 20/2 - \frac{4280}{1200} = 6.44' \text{ or } 78"$$

The bars are bent at 45° and the maximum distance for the single bar to resist diagonal tension with out overstressing the tension bars .

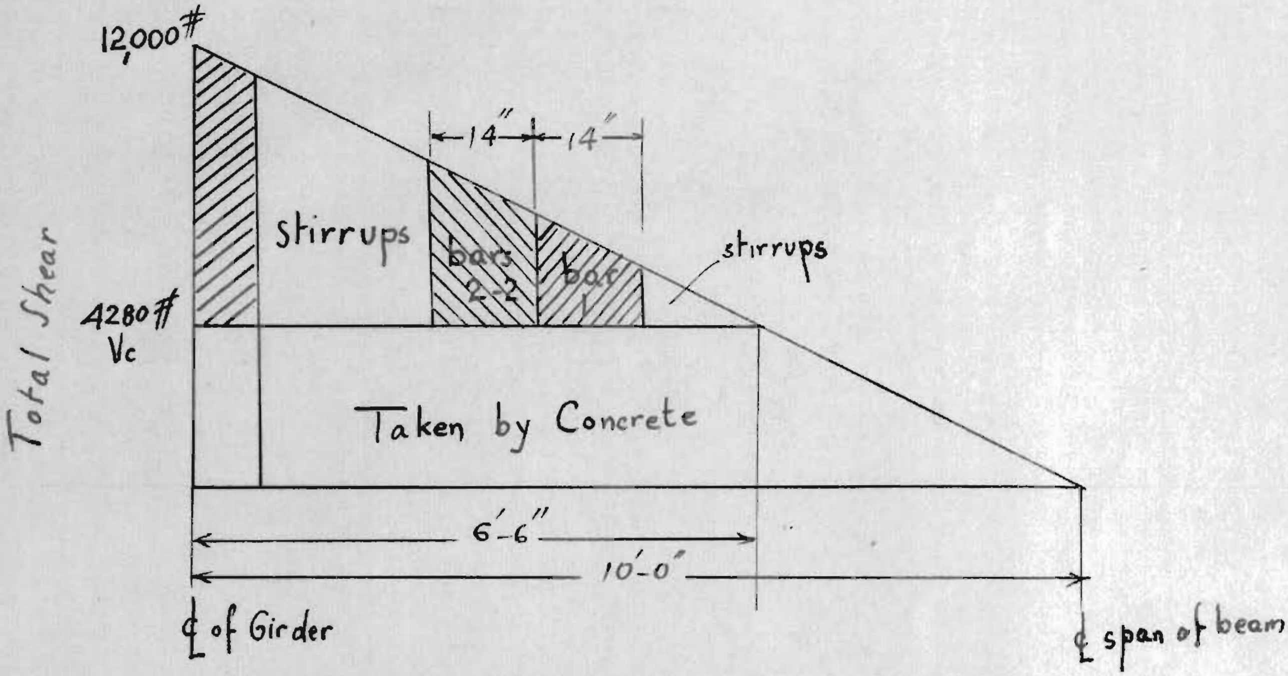
$$S = \frac{0.4418 \times 18000 \times 7/8 \times 14}{0.7\ (V - 4280)} = 81 \text{ in.}$$

The distance s after the point of bending is greater than the maximum distance the bar can resist diagonal tension, a distance of 14" is selected according to specifications.

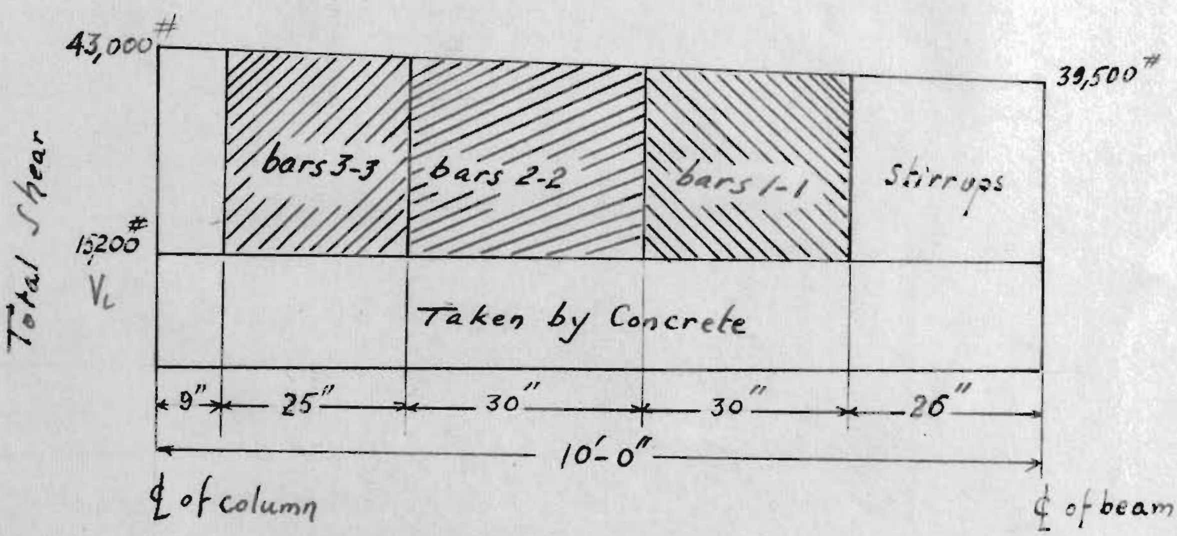
Max. allowable spacing of 3/8 round bars U Stirrups at support.

$$S = \frac{2 \times 0.1104 \times 18000 \times 7/8 \times 14}{(12000 - 4280)} = 6.3" \text{ say } 6"$$

$$s_1 = \frac{2 \times .1104 \times 18000 \times 7/8 \times 14}{12000 - 5 \times 12000 - 4280} = 28.3"$$



Shear Diagram of beam.



Shear Diagram of Girder

Max. spacing = I/2 x I4 = 7"

The bent bars are continued to I/3 the span of the beam or 80". The straight bars are continued I'- 6" beyond the centre of the girder.

DESIGN OF GIRDER.

Girder's span 40' with 3 concentrated Loads I2000 x 3 = = 36000 at I/4 point. Maximum moment .

M_1 = 5/I6 x 36000 x 40 x I2 = 5400000 in Lb.

Assume 350#/I wt. of stem, Max. Moment due to uniform load. M_2 = I/I0 x 350 x 40^2 x I2 = 672000 in Lb.

Total M = 6072000. Total max. shear

$$V = 36000 + 350 \times \frac{40}{2} = 43000$$

$$b'd = \frac{43000}{7/8 \times I50} = 328 \text{ in}^2$$

Taking into consideration the I/2 to I/3 ratio the section is I2 x 30

The centre of the upper row of bars at the support is I I/2 in from the top of the slab, and the bars are two in centre to centre. At the centre an insulation of 2 I/2 in below the lower bars is provided and a distance of 2" centre to centre. The effective depth at the centre is 29 in and at the support 30 in the total hight of the girder is 29 + 3 I/2 = 32 I/2 the depth below the slab is 28 I/2 and the assumed value is close.

$$A_s = \frac{6072000}{18000 \times (29 - 4/2)} = 11.95 \text{ sq. in.}$$

Use 8 - I I/4 ϕ (As = I2,5)

While there is no negative moment at one end of the span, in order to privide for a possible developement on account of becoming somewhat fixed .

Four bars in each gircer are bent up and carried over the support to provide for negative. Two more bars are bent up and hooked into the column to assist diagonal tension. The remaining bars arecarried straight to develope bond strength.

At the support.

$$d'/d = \frac{2.5}{30} = 0.083$$

$$np = I2 \times \frac{I2.5}{I2 \times 30} = 0.4I7 \qquad np' = I/2\ np = .208$$

From diagram 3 + 4 $k = 0.487$, $j = 0.895$

$$f_s = \frac{6072000}{I7.5 \times .895 \times 30} = I8000 \text{ p.s.i.}$$

$$f_c = \frac{I8000 \times 0.487}{I2\ (I - 0.487)} = I400 \text{ p.s.i.}$$

$$f'_c = I8000 \times \frac{.483 - .083}{I - 0.487} = I4I00 \text{ p.s.i.}$$

The max. unit bond stress at point of max. shear on tension bars .

$$u = \frac{43000}{40 \times 7/8 \times 30} = 4I \text{ p.s.i.}$$

At the support the external shear resisted by concrete

$$V_c = 50 \times I2 \times 7/8 \times 30 = I5750 \text{ Lb.}$$

Away from the support.

$$V_c = 50 \times I2 \times 7/8 \times 29 = I5200 \text{ Lb.}$$

The points at which the bars are bent up the first pair may be bent up at a distance I/4 x 3/4 40 x I2 x I/4 = 22 I/2" the next pair at a distance of 45 in, the third at 67 I/2 in from concentrated Load to provide for positive moment. Also the one pair may be bent down at a distance of 22 I/2 in, the second 45 from the support to provide for negative moment.

Stirrups between concentrated load and the point of bending of the first pair of bars .

$$S = \frac{2 \times 0.II04 \times I8000 \times 7/8 \times 29}{(43000 - 7.5 \times 350) - I5200} = 4.0 \text{ in}$$

A spacing of 3/8 ϕ stirrups @ I6" centre to centre is used in the remaining portion of the girder.

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