THESIS

Plan and design of a cinema in Beirut .

BY

JOSEPH MAZKUR

June 1948

C I N E M A

BY

JOSEPH MAZKUR

Thesis presented to the departement of engineering at the American University of Beirut in partial fulfillment of the requirement for the degree of Bachelor of Science in Engineering .

Beirut , Lebanon
May , 1948

EPsm
63

THESIS

"Design of a Modern CINEMA IN BEIRUT"

BY

JOSEPH MAZKUR

B.S.C.E

Full Official title

PREPARED UNDER THE ~~AUSPICES~~ Supervision OF :

PROF. J . R . OSBORN

AND

PROF. KHOSROF YA~~RA~~EAMIAN

J.R. Osborn
5/34

TABLE OF CONTENTS

INTRODUCTION

The population of Beirut which is increasing at a tremendously high rate due to the shift of people from rural to urban district givesa promising perspective of affairs to owners of cinemas and theaters . Post war prosperity has resulted in a larger demand of entertainment , and the only one that our city dwellers seem to enjoy is the motion picture .

According to the last statistics 27 cinemas exist now in Beirut ; and if we drop into any of these cinemas we usually find long queues of persons awaiting eagerly their turn for booking. Cinema going habit continues to find new adherents mainly in winter when it is the only pastime that our capital can afford us . On spare time one goes to the motion picture rather to any place else. It is the "rendez-vous" of all classes ; all cathegories of people villagers , workers , aristocrats , enjoy it equally and at the least cost .

With the realisation of the importance of the need for cinemas to satisfy the craving of the population for that kind of entertainment , the engineer should erect fine playhouses to meet the refined taste of the audience . In addition , competition between cinemas is made on the basis not of the kind of film projected but rather on how attractive the cinema is , and it is even claimed that the audience increases in proportion to the amount of ornament.

On the other hand , the widening of our views and the rapid change that took place in our social life during the last decade , imposes on the engineer a complete knowledge of all factors that will make the audience enjoy to the fullest the film being projected.

PHYSICAL CHARACTERISTICS OF A CINEMA:

Cinemas like our selves have personalities of their own . We learn to like or dislike them according to their size, decoration , cleaness , accoustics , lighting and the kind of people that use them . One's impression of a cinema is very definitely influenced by its location ; thus the choice of the site is of primary importance . As to the question of the building itself it should be of a pleasing and attractive aspect for the public, not acquainted with its technicalities, is likely to judge it from its appearance , both inside and outside . The erection of a majestic facade is not to be overlooked . It will serve as a background for the luminous letters informing the public of what film is being projected and at the same time it will promote good appearance and richness. In the auditorium , we should not find meaningless applied ornamentation ; since modernism is almost synonymous to simplicity . Color lighting should be prominent and the engineer will need to thoroughly understand color and color blending . Electric lighting will serve as the means by which the walls and ceiling of the room will be given various decorative treatments , so as to give gradual increase or decrease of the lighting at the biginning and end of the performance and during intermissions. The screen lighting is mostly indirect nowadays , and the drop curtain should open laterally at some distance ahead of the screen .

As to the shape of the auditorium , the horse shoe shape is becoming universally used due to its sound advantages in giving minimum reverberation . The seats should be ample and confortable , their model being almost standardized , they should be so placed as to give an uninterrupted view of the screen . Special thought should be given to the spacing of seats so as to ensure easy passageways between the rows ;thus latecomers will have little excuse for stepping on other people's toes. Regulations concerning fire precautions should not be overlooked Emergency exits are necessary and as a further safeguard sets of extinguishers should be placed in all corners . Tickets should be collected at the entrance to the auditorium , thus giving the public access to the standing places were illustrative pictures willbe exhibited . The provision for a well equipped bar is necessary . During intermission people like to get refreshments there , and if the bar is provided with a private entrance it may serve as an independent public bar.

One of the most important application of air conditioning is that for cinemas . In such heavily occupied place , the heat given off by persons and by lights necessitate the periodic replacement of the vitiated air by the so called conditioned air possessing all the desirable characteristics of fresh outdoor air and having at the same time all the health and confort promoting qualities . In summer , the hot air of the outside is cooled and dishumidified at the same time by a single unit placed in the basement . The need for an efficient heating and cooling system is felt more during winter when cinemas become stuffy and where all entrances ans openings are closed as tightly as possible to keep out the cold.

As a conclusion I can say that the planning of a modern cinema implies on the part of the engineer a complete study of all principles and regulations which govern such planning . If these regulations are altogether unobtainable in his own country he has to resort to universal regulations and compile all specific data which will fit the local conditions .

T H E   P R O B L E M

I have been asked by a group of business mento plan and design a cinema to seat 700-800 persons . It is to be erected in the center of a large block and it will have only one frontage on one of the most important street of Beirut . The balcony should accomodate for one fourth of the seats and the orchestra will take care of about 600 seats . Each person should be enough space for entering , leaving or standing while looking for his seat . Standing space should be allowed for , since admission is collected from any one whether standing or seated . They insist on having a bar of a suitable size overlooking the main street and adjoining the balcony . All interior lighting should be indirect to create shadow and contrast through different angular mouldings .

Steps followed in the solution of the problem :

a) Space problem :

I)Space given for every person

2)Space given for staircases

3)Space given for exits

4)Floor slopes

5)Screen

6)Toilet arrangements

7)Tickets room

8)Projection room

b) Architectural details :

I)Lighting

2) Accoustics

3) Decoration

4) Fire protection

5) Air conditionning .

c) <u>Conclusion</u>

The engineer in planning a new cinema should try to remedy all defects that he has noticed in already existing ones and thus profit from others'experiences to make something attracting the admiration of the public by its perfection and its originality .

He should give thought to the problem of fire protection .The choice of the materials and their disposition should be carefully determined according to rules universally approved and based on a thorough study of the causes of fire . Measures for the public should be taken : easy passageways , exits , etc ; these measures are given in most municipality codes and regulations .

<u>The space problem</u> .

According to the American regulations for cinemas and theaters , each person should be allowed I.5 sq. feet of space so that the area of the orchestra is to be about 900 sq. feet . This is exclusive of the standing space in the vestibule and of the staircase leading to the balcony . In my own design I used the French specifications which are applied in our country . As to the disposition of standing spaces and lobbies these specifications provide I sq.meter for every 3 persons and 50 cm in the row for every person . The number of seats in one row has been so arranged that one person leaving his own seat will not pass in front of more than 8 persons to reach the passageway . The distance back to back of seats is 90 cm and the width of the middle path is I.5 meters while that of the side path is I.30 meters . (See fig. page 27)

Staircases :

Staircases leading to the balcony are 2 meters wide . There are two flights , each one to be used by 250 persons and 2 emergency exits leading to different streets . Round staircases which would have given good effect have been avoided to comply with the above mentionned regulations . The floor of the vestibule has been raised 3 steps above the street level . The tread of the step is 30 cm and the rise I7 cm . The stair railing is a grab rail of polished wood .

Exits :

Enough space has been provided to allow the audience to enter the cinema confortably . According to American regulations , 3 doors 5 feet wide should be provided for every 500 persons . In my own plan , 2 doors 3 meters wide each have been used for the orchestra and complementary ones leading to the auxilliary staircases of the adjoining building have been provided .

Floor slopes :

Past practice has permitted conditions requiring spectators to look between the heads of those in front of them and over the heads of the ones two rows in front . This necessitates unconfortable adjustment to shifting obstacles in front especially when images shift from one side of the screen to another .

In my own design , the seating arrangement which permit completely unobstructed vision is a combination of downward and upward slope with staggered seating resulting in a minimum departure from the horizontal . This system has been employed considerably in America . On the other hand the screen has been so located that it will not cause any strained upward vision .

Screen :

The screen floor is I meter higher than the auditorium floor ; it is I2 meters wide and recessed 2 meters from the back of the room for the installation and servicing of necessary sound reproduction equipment . Two lateral staircases lead to the screen floor thus making the cinema liable to serve as a theater .

Toilets arrangement :

The minimum toilet fixture requirements according to American regulations are the following :

Men		Women
	Up to 400 seats	
I W.C.	I Basin	I W.C.
	400 to 600	
I W.C. 2 Urinals	I Basin	2 W.C.
	600 to I000	
2 W.C. 3 Urinals	2 Basins	3 to 4 W.C.

In my own design I have allowed in the orchestra 3 urinals and

and 2 W.C. for men , and 2 W.C. for women . The same arrangement has been adopted in the balcony too.

Tickets room:

Two ticket rooms have been allowed for . They are centered at the corner of the entrance and they extend under the staircase leading to the balcony . They are provided with air conditionning ducts ; and special arrangements have been made to install an outside telephone for the attendent's convenience in answering calls about the program and for reserving seats .

Projection room :

The usual American code requirements are 48 sq. feet for first projection machine and 24 sq. ft for each additional one . In my own design , a large projection room has been provided with a rewind room adjacent to it . The rewind room may serve as a film storage room .

Architectural details :

Lighting :

The lighting of a cinema auditorium serves three separate functions :

a) Emergency and decorative lighting

b) Lighting needed during intermission ,usually for only 2 minutes or less

c) Lighting of sufficient intensity needed for announcements , clearing the house or other rare occasions .

In my own design , walls and ceiling illumination is made by tubes and lamps installed in angular mouldings to give indirect lighting . During the presentation all lightings are supplied by screen reflected light . The placement of the tubes and standard lighting lamps is at the junction of ceiling and side walls . Emergency lighting may be provided for by means of an engine generator installed in the basement .

Accoustics :

The importance of improvement in accoustical conditions is becoming more and more imperative . It is easier to plan a house with a good accoustics than to remedy defective accoustics in already existing ones . If a sound is produced in a room whose interior wall surfaces reflect all of the sound , an echoe is formed and it will continue indefinitely because no sound is absorbed by the walls . The echoe increases directly with the size of the room . On the other hand , interior surfaces which absorb all of the sound which strikes them are as bad as the reflecting ones . Indeed no echoes are formed then , but these surfaces would be the same as outdoors. The prolongation of the sound after the sound ceases is called reverbaration . The reverbaration time is given by the formula

$$T = 0.5 V/A$$ * Source

where V is the volume of the room in cubic feet and A is the total of the absorption units in the room . This formula is used for predicting the reverbaration time of the room being planned . The intensity of sound at any point increases and the distinctness decreases as the reverbaration time increases .

The optimum reverbaration is 2 seconds for auditorium . To obtain accepted reverbaration time in a room , certain accoustical materials with high absorption units should be used . In my plan fiber boards will be used for this effect . This material is commonly used nowadays for it is a sound absorbing material , and since draperies give a satisfactory result too they will be used around openings and exits . A wood floor had also been used , it will act as an insulator and it will help at the same time to increase the total absorption units in the room . A long and narrow carpet will cover the middle lane and interior walls not covered with fiber board will be made wavy for the effect of ornamentation as well as accoustics .

Decoration :

Decorations reflect highly the taste and personality of the engineer and affect enormously the accoustics of the room . That is why if the engineer feels unable to fulfill efficiently this job , he should have recourse to competent authorities .

In my own problem , a false ceiling has been provided allowing for all kinds of architectural mouldings . The walls are made wavy and grey colored while at their lowest part oil paintings with nice views and panoramas have been set. Purple hangings will be installed on all openings for decorative and accoustical purposes . Grey stucco will be used every where it will produce maximum effect at the minimum cost .

Fire protection :

Automatic sprinklers are provided in the projection and rewind room where only up to I2000 feet of film is permitted. A signal system consisting of a house telephone connects the projection room to the manager's office or to the tickets room. In the auditorium , portable chemical extinguishers are set in all corners .

Air conditionning :

The auditorium , lobbies and balcony are provided with conditionned air from a central plant located in the basement . To make the installation as simple as possible and unexpensive , a duct system has been used . Air is supplied to the cinema through 2 large grilles , one on each side of the room and it is exhausted through openings located in the back of the room . This system has been designed to maintain an inside temperature of 70° F with a relative humidity of 55 per cent .

The amount of air circulating is I5 cubic ft per minute , this amount has proved to be ample for conditionning cinemas and public places and with a proper outlet velocity it will provide good air distribution . With this kind of installation , the change of air is thorough and stagnant corners are thus avoided . The in coming air will be clean and humid not deprived of its moisture by defective methods of warming . The temperature of the room will be uniform and controlled . Ducts bringing air to the grilles are in duplicate one for the cold air and one for the hot air .

Conclusion :

In the previous pages I have attempted to explain the growing importance of modern cinemas in Beirut ; cinemas which are spacious , large and confortable having all the desirable features of European and American motion picture theaters . The various aspects of accoustics , lighting , decoration and air conditionning have been outlined too.

I have considered the minute details in the general make up , with a view of adding architectural taste and economy in design . However these are several items in interior decoration which have been omitted purposely .

We have copied the westerners in all aspects of their civilization , yet as regards architecture and technique we lack a great deal .

Although my cinema is not a novelty in itself as regard design and architecture , yet I can say that the erection of such a cinema would embody all the desirable features which the other cinemas of Beirut are lacking at present .

D E S I G N

S P E C I F I C A T I O N S

a) SANDSTONES SPECIFIC WEIGHT ....2500 kg/cu.m

b) BEARING POWER OF SOIL ....3 kg/sqcm

c) ALLOWABLE STRESS IN CONCRETE.........................60 kg/sqcm

d) ALLOWABLE STRESS IN STEEL ....1200 kg/sqcm

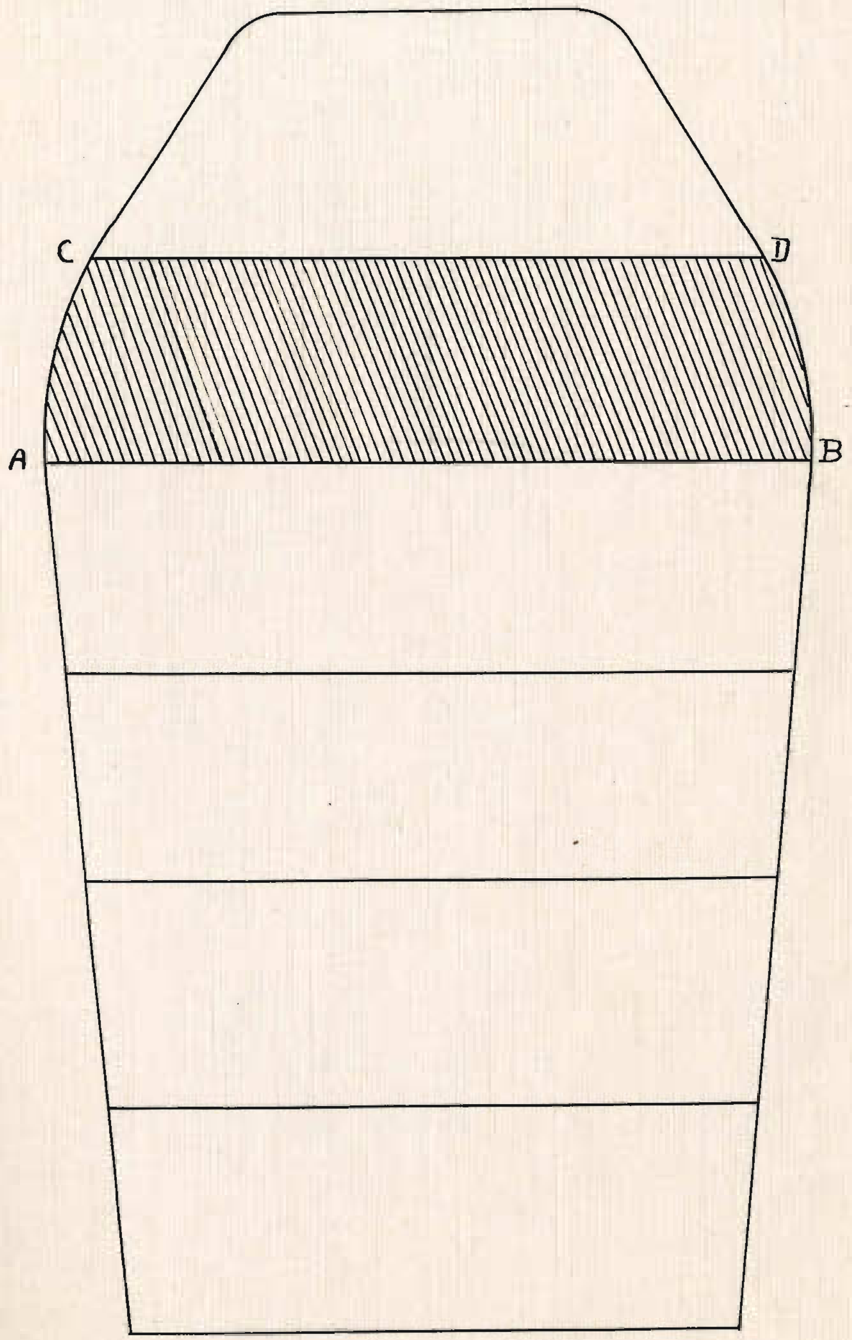
e) SHEAR IN CONCRETE...................................12 Kg/sqcm

f) LIVE LOAD FOR THE BALCONY......................300 kg/sq.m

g) LIVE LOAD FOR THE CEILING ....200 kg/sq.m

Slab A-B-C-D.

Beam A-B



Plan of the ceiling

SCALE : I/200

R O O F   D E S I G N

SLAB A-B-C-D.

Dimensions 20 x 5 units ?

Ratio of width to lenght 5/20 = 0.25

The whole moment is supposed carried by the short side

Assuming a slab thickness of I4 cm , the total weight per running meter will be :

$$200 + \frac{2500 \times I4}{IOO} = 550 \text{ kg per meter}$$

Moment : $I/IO\ WL^2$

$$\frac{I \times 550 \times 5 \times 5}{IO} = I375 \text{ kgm}$$

Depth of the slab :

$$h = 0.03883 \times M^{I/2}$$

$$h = 0.03883\ (I37500)^{I/2} = I3.8 \text{ cm}$$

Reinforcement :

$$S = 0.0237\ (M)^{I/2}$$

$$S = 0.0237 \times 37I = 8.8 \text{ cm}$$

8 round bars I2 mm will be used per meter in the short direction and 5 round bars 8 mm per meter in the long direction. Extremities of bars will be hooked over the support to provide for negative bending moment . The remaining parts of the ceiling are similar to A-B-C-D- ; so we shall use the same thickness and the same reinforcement .

(See detail drawing fig I)

B E A M A-B

Span : 20 m

WEIGHT FROM THE SLAB PER METER OF BEAMS

The spacing of beams being 5 meters ; this weight w will be :

550 x 5 x 2/3 = I825 kg

WEIGHT OF BEAM BELOW SLAB :

Assuming a beam 50 x I50 the weight will be :

I50 x 0.5 x 2500 = I875 kg

TOTAL LOAD ON BEAM :

I875 + I875 = 3700 kg per m

MOMENT :

$$\frac{WL^2}{IO} = \frac{3700 \times 20 \times 20}{IO} = I48000 \text{ kgm}$$

Assuming a width of 5o cm the depth of the beam below slab will be :

$$h' = 2.68\,(M)^{I/3} = 2.68\,(I48000)^{I/3} = I42 \text{ cm}$$

TOTAL HEIGHT :

The total height including the slab will be

I42 + I4 + 4 = I60 cm

CHECK FOR SHEAR :

Maximum shear at the support will be :

3700 x 20/2 = 37000 kg

$$bd = \frac{37000}{I2 \times 7/8} = 3500 \text{ sq cm}$$

The area chosen is I50 x 50 = 7500 sq cm is (O.K)

REINFORCEMENT :

$$S = \frac{14800000}{1200(156-14/2)} = 83.5 \text{ sq cm}$$

We shall use I2 bars of 3o mm

SIZE AND SPACING OF STIRRUPS:

Round bars of 8 mm will be used as stirrups.

Taking 6 vertical rows of reinforcement , the area of stirrups will be :

I2 x 0.50 = 6 sq cm

The spacing of the stirrups at the support will be

$$S = \frac{W \times R \times d}{V} = \frac{6 \times 1200 \times 156}{3700} = 30 \text{ cm}$$

The spacing should not however exceed 3/4 of h,or I20 cm

BENT UP BARS:

From the diagram (concrete text book) the bars will be bent at the following distance from the support :

2 bars at a distance of : 0.3I5 x 20 = 6.20 m

2 bars at a distance of : 0.24 x 20 = 4.80 m

3 bars at a distance of : 0.I5 x 2o = 3.00 m

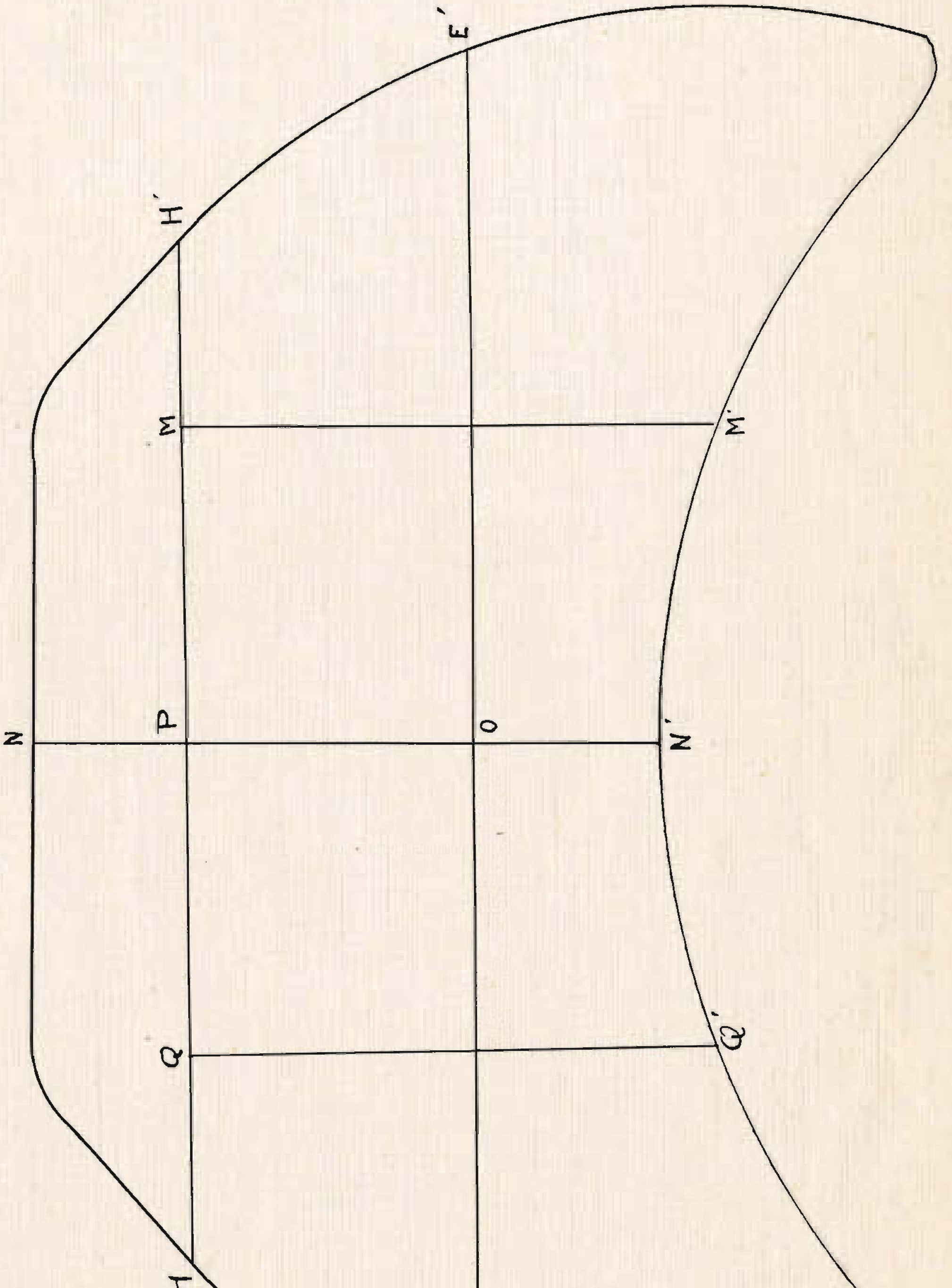
The remaining bars are carried straight to the support to for bond ; the number of bars required for that purposes is

$$\frac{37000}{6 \times 7/8 \times 155} = 45 \text{ cm}$$

As the perimeter of a 3o mm round bar is 9.42 ; we need then 5 bars at the support and the remaining bars are bent up as was explained above .

Plan of the balcony

SCALE : I/IO



DESIGN OF THE BALCONY :

Cantiliver N'O   Span 2.50 m

Taking a thickness of I0 cm for the slab , the weight per sq. meter will be :

Dead load per meter :

From slab : 4.30 x 2.50 = I025 kgs

Weight of beam assumed = 600 kgs

Live load per meter :

From slab : 4.30 x 300 = I290 kgs

Total load :

I025 + 600 + I290 = 2965 kgs

Moment due to balustrade :

M = P x L

= 4.30 x 0.20 x 0.50 x 2500 x 2.5 = 2700 kgm

Moment due to live and dead load :

$$M = \frac{W \times L^2}{2} = \frac{2965 \times 2.5 \times 2.5}{2} = 9300 \text{ kgm}$$

Total moment :

M = 9300 + 2700 = I2000 kgm

Depth of the cantiliver at the support :

Assuming a width of 30 cm the height will be:

$$h = 0.346 \left(I2000 / 0.30 \right)^{I/2} = 69.5 \text{ cm}$$

(Dahin ,reinforced concrete p. 83)

h will be taken as 75 cm

Reinforcement :

$$S = \frac{I200000}{I200 \times 69.5 \times 0.87} = I6.6 \text{ sq. cm}$$

This is furnished by 9 bars I6 mm .

DESIGN OF THE BALCONY (continued)

Beam E'E Span I9 m

Values of the concentrated loads:

Weight from beam Q'Q

5.5 x 0.30 x 0.75 x 2500 = 3080 kgs

Weight from beam M'M

5.5 x 0.30 x 0.75 x 2500 = 3080 kgs

Weight from beam N'O P

4.5 x 0.30 x 0.75 x 2500 = 2520 kgs

Values of the uniform loads

The average width of slab coming over the beam is 6 meters

Dead load from the slab per meter

6 x 250 = I500 kgs

Live load from the slab per meter

6 x 300 = I800 kgs

Assumed weight of the beam per meter = 3800 kgs

Total weight per meter :

I500 + I800 + 3800 = 7100 kgs

Moment due to concentrated load :

4340 x 9.5 - 3080 x 4.5 = 27500 kgm

Moment due to uniform load :

$$\frac{7100 \times 19 \times 19}{10} = 257000 \text{ kgm}$$

Total moment :

27500 + 257000 = 284500 kgm

$$k = \frac{n}{n + r} = \frac{I0}{20 + I0} = I/3$$

$$K = I/6 \times I200 \times I/3 \times (3 - I/3) = 200/27$$ (Massié page 222)

$$bH'^2 = M/K = \frac{28450000 \times 27}{200} = 3840000$$

Taking b = I80 cm the height of the beam will be :

$$H' = (3840000/I80)^{I/2} = I46 \text{ cm}$$

Location of the neutral axis /:

$$Z = k H' = I/3 \times I45 = 50 \text{ cm}$$

The height of the T beam flange will be taken as 50 cm ; the stem will be II0 cm and b' will be taken as 60 cm

Reinforcement :

The area of the steel needed is :

$$S = \frac{28450000}{I200 \times I50 \times 0.87} = I80 \text{ cm}^2$$

This is furnished by 25 bars of 30 mm

Check for shear :

Maximum shear =

4340 + 7I00 x 9.5 = 7I790 kgs

$$bd = \frac{7I790}{0.87 \times I2} = 6800 \text{ sq. cm}$$

The area chosen is I50 x 60 = 9000 sq. cm and it is satisfactory for shear

Number of bars required at the support to allow for bond:

$$\frac{7I790}{6 \times 0.87 \times I50} = 9I.50 \text{ cm}$$

The perimeter of a 30 mm round bar being 9.42 cm , the number of bars required at the support is :

$\frac{9I.5}{9.42}$ = IO bars. The remaining I5 bars may be bent up to provide for negative bending moment .

<u>Size and spacing of stirrups :</u>

IO mm round bars will be used as stirrups . Having 8 rows of bars as shown on the detail drawing the spacing at the support will be :

$$S = \frac{I2.5 \times I200 \times I50}{7I790} = 3I \text{ cm}$$

The spacing will be used with that spacing near the support and it will be increased gradually without reaching however the value of 3/4 of H or II5 cm

<u>Bent up bars :</u>

From the diagram (concrete text book) bars are bent at the following distance from the support :

3 bars at a distance of : 0.39 x I9 = 7.30 m

3 bars at a distance of : 0.28 x I9 = 5.30 m

4 bars at a distance of : 0.2I5 x I9 = 4.IO m

5 bars at a distance of : 0.I5 x I9 = 2.85 m

Design of the balcony :(continued)

Beam H'-H Span I5 m

Values of the concentrated loads :

a) Weight from beam Q'Q

0.30 x 0.75 x 2500 x I.75 = 985 kgs

b) Weight from beam N'N

0.30 x 0.75 x 2500 x 3 = I700 kgs

c) Weight from beam M'M

0.30 x 0.75 x 2500 x I.75 = 985 kgs

Values of the uniform load :

a) Dead load from slab :

3 x 250 = 750 kgs

b) Live load from slab :

3 x 300 = 900 kgs

c) Weight of the beam per meter :

Assumed = 2300 kgs

Moment due to concentrated loads

I835 x 7.5 - 985 x 4.5 = 9600 kgm

Moment due to uniform load :

The uniform load is equal to :

750 + 900 + 2300 = 3950 kgs

The moment will be :

$$\frac{3950 \times 15 \times 15}{10} = 89000 \text{ kgm}$$

Total moment :

89000 + 9600 = 98600 kgm

Assuming b= 50 cm the height of the beam will be :

$$H = 0.346 \ (98600/0.50)^{I/2} = I55 \text{ cm}$$

Reinforcement :

$$S = \frac{9860000}{I200 \times 0.87 \times I55} = 60.8 \text{ sq. cm}$$

This is furnished by IO round bars 28 mm

Check for shear :

Maximum shear is equal to :

3950 x 7.5 + I835 = 3I435 kgs

$$bd = \frac{3I435}{I2 \times 0.87} = 3000 \text{ sq. cm}$$

The area chosen is I55 x 50 = 7750 sq.cm

Stirrups and spacing of stirrups :

IO mm round bars will be used as stirrups.

The spacing at the end will be :

$$S = \frac{7.8 \times I200 \times I55}{3I435} = 46 \text{ cm}$$

Bars required at support to allow for bond:

$$\frac{3I435}{6 \times 0.87 \times I55} = 38.8 \text{ cm}$$

This is furnished by 38.8/8.7 = 5 bars since the perimeter of a 28 mm round bar is 8.7 cm

Bent up bars :

I bar will be bent at a distance of 0.36 x I5 = 5.4 m

2 bars at a distance of 0.26 x I5 = 3.9 m

2 bars at a distance of 0.I8 x I5 = 2.7 m

Columns design :

Column E'

a) Weight from slab :

$$\frac{20 \times 5 \times 550}{2} = 27000 \text{ kgs}$$

b) Weight from beam A-B :

I46 x 0.50 x 2500 x I0 = I8300 kgs

c) Assumed weight of column from ceiling to balcony :

= 4750 kgs

d) Weight from the balcony itself :

Reaction due to concentrated load:

4340 kgs , as found

Reaction due to uniform load :

7I00 x I9/2 = 67450 kgs

Total reaction :

4340 + 67450 = 7I790 kgs

e) Weight from the side wall:

0.40 x 2500 x I4 x I0 = I40000 kgs

f) Weight of the beam supporting the wall :

Assuming a beam 50 cm x I00 cm ; the weight per meter length of that beam will be :

Walls = I4 x 0.40 x 2500 = I4I00

Its own weight = I250

The total weight will be :

I4I00 + I250 = I5350 kgs per meter .

Moment:

$$\frac{15350 \times 5 \times 5}{10} = 38200 \text{ kgm}$$

Assuming b = 50 cm the height of the beam

will be :

$$H = 0.346\ (38200/0.50)^{I/2} = 96\ cm$$

The assumed dimensions are then exact and the

weight of the beam on the column is :

0.50 x I00 x 2500 x 5 = 6250 kgs

g) <u>Weight of the column itself</u> :

Assuming a weight of column of I300 kgs per meter and that the footing is 3 meters below the ground , the weight will be :

I300 x 7.50 = 9750 kgs

<u>h) Total weight on column :</u>

50550 + 7I790 + I40000 + 6250 + 9750 = <u>278340</u>kgs

<u>i) Area of column :</u>

$$\frac{278340}{60} = 4506\ sq.\ cm$$

<u>j) Dimensions of column :</u>

Taking a width of 60 cm the other dimension will be :

$$\frac{4506}{60} = 75\ cm$$

k) <u>Reinforcement of column</u> :

4506 x 0.005 = 22.53 sq. cm

This is furnished by I0 bars I8 mm

Footing design :

Area of the footing :

The allowable bearing pressure on the soil being 3 kgs per sq. cm the area of the footing will be :

$$\frac{278340}{3} = 92780 \text{ sq. cm}$$

Dimensions of the footing :

$$3I5 \times 3I5 = 94500 \text{ sq. cm}$$

Depth of the footing :

The allowable stress in concrete for punching shear is I5 kgs per sq. cm

$$d = \frac{(94500 - 4500)\ 3}{270 \times I5} = 67 \text{ cm}$$

Reinforcement of footing : (See fig.page 28)

Moment about the X axis :

$$3/2\ (60 + I.2 \times I20)\ I20 \times I20 = 4400000 \text{ kgcm}$$

Area of steel needed :

$$\frac{4400000}{I200 \times 0.87 \times 67} = 62.50 \text{ sq. cm}$$

This is furnished by 20 round bars 20 mm

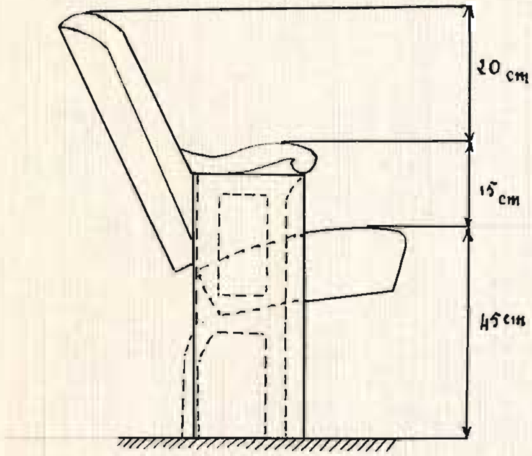
Moment about the Y axis :

$$3/2\ (75 + I.2 \times I20)\ I20 = 4725000 \text{ kgcm}$$

Area of steel needed :

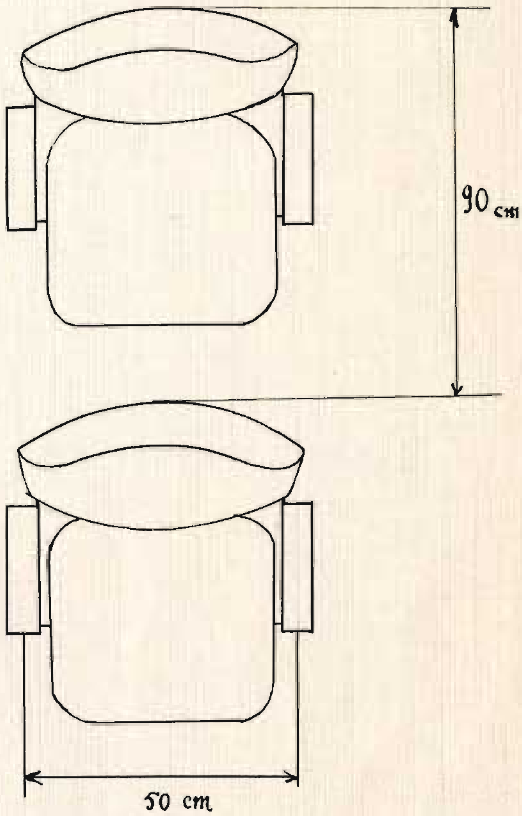
$$\frac{4725000}{I200 \times 0.87 \times 67} = 67 \text{ sq. cm}$$

This is furnished by 22 round bars 20 mm



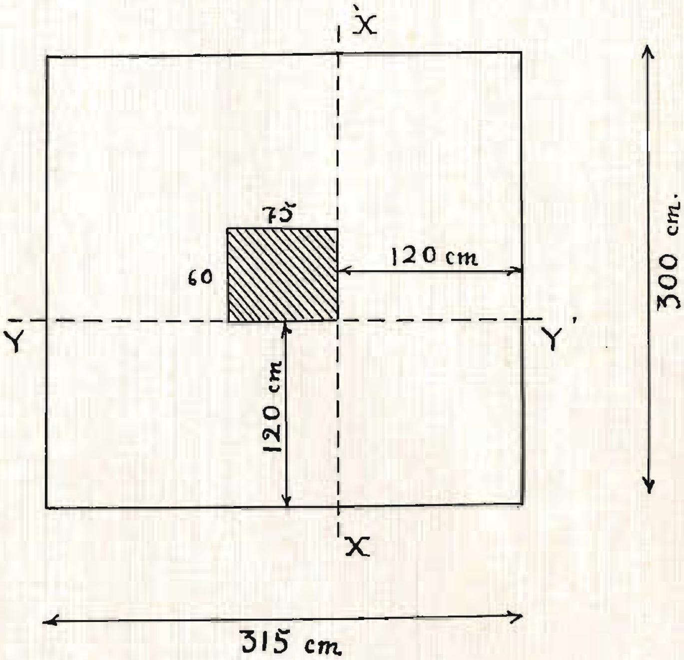
Side elevation

(End standard shown solid
middle standard dotted)



Plan- Back to back of seats
90 cm.

Seating arrangement



Design of footing

SCALE: I/50