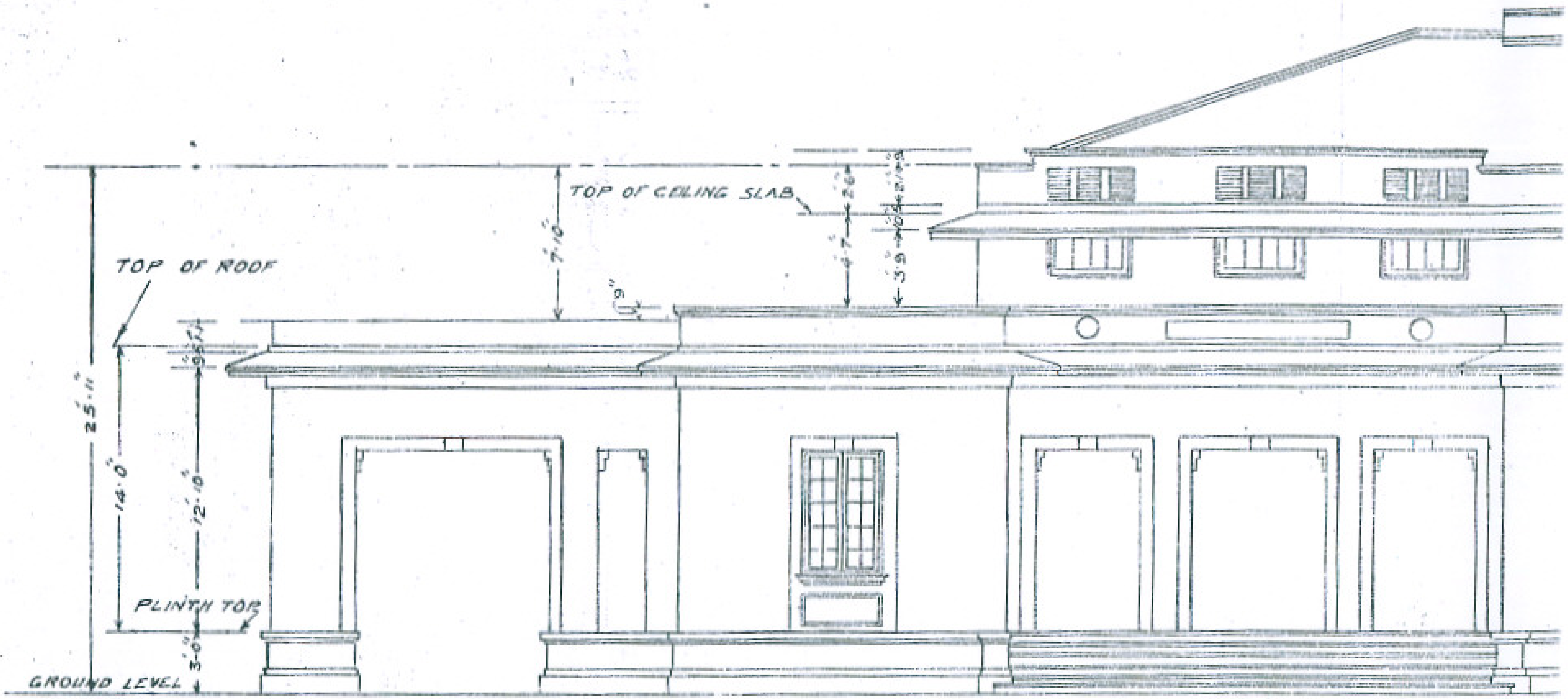
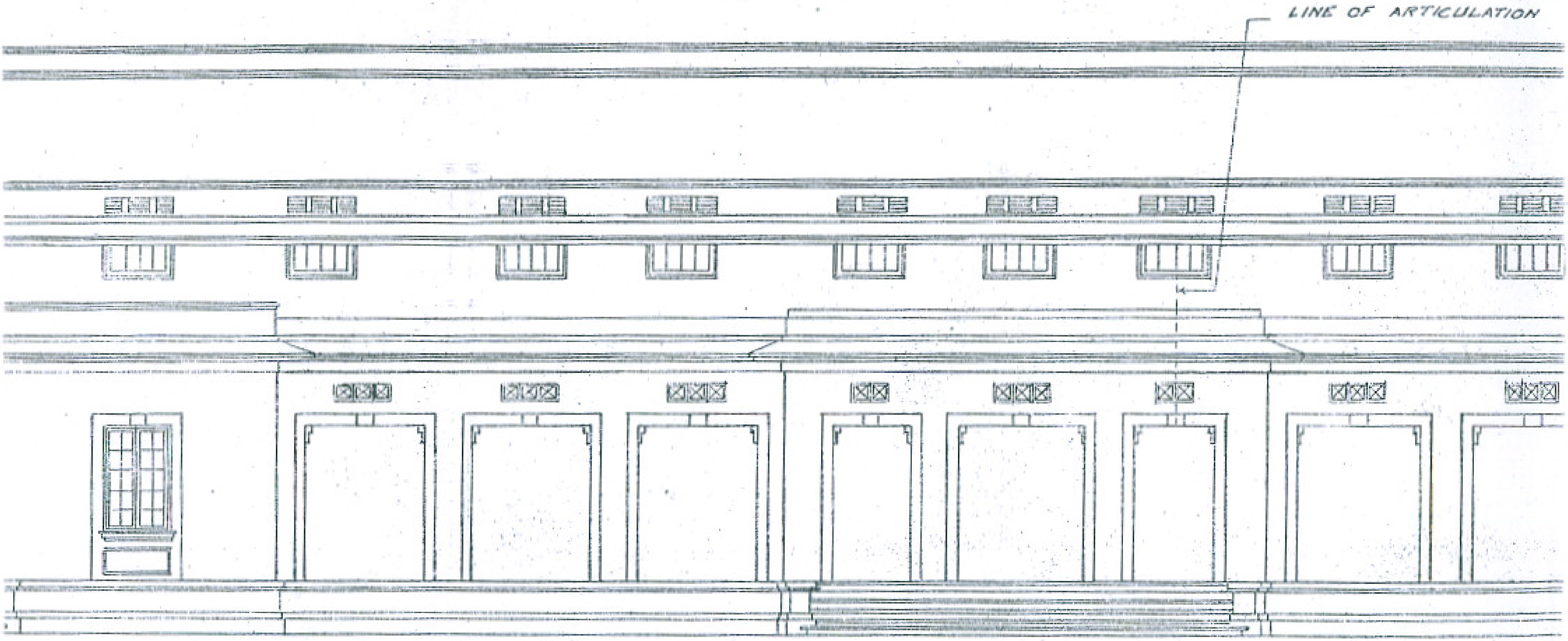


NOTE:—
ALL WALLS IN SUPERSTRUCTURE TO BE 1'8" THICK EXCEPT WHERE OTHERWISE SPECIFIED.
ALL DOORS TO BE 5'0"×9'0" EXCEPT WHERE OTHERWISE SPECIFIED.
ALL WINDOWS TO BE 4'0"×6'0" EXCEPT WHERE OTHER WISE SPECIFIED.

FOUNDATION HAS BEEN DESIGNED FOR A BEARING PRESSURE ON THE SOIL OF 0·5 TON PER SFT.

NOTE:—
ALL CLERESTORY TO BE 4'×
THE ONE OVER DOOR IN EAST
JUDGES BATH ROOM WHICH
ALL R.C. STIFFENERS TO BE
EXCEPT WHERE OTHERWISE
ALL TRUSSES TO BE AT 10'

PLAN OF PROPOSED JUDGE'S COURT BUILDING AT MUZAFFARPUR



PART EAST ELEVATION
SCALE 1" = 8 FEET

: 4'×2' EXCEPT
EAST WALL OF
CH WILL BE 3'×2'
BE 1'8"×1'8"
ISE SPECIFIED.
10'-2" CENTRES.

D

NG

'ICULATION

NOTE:—

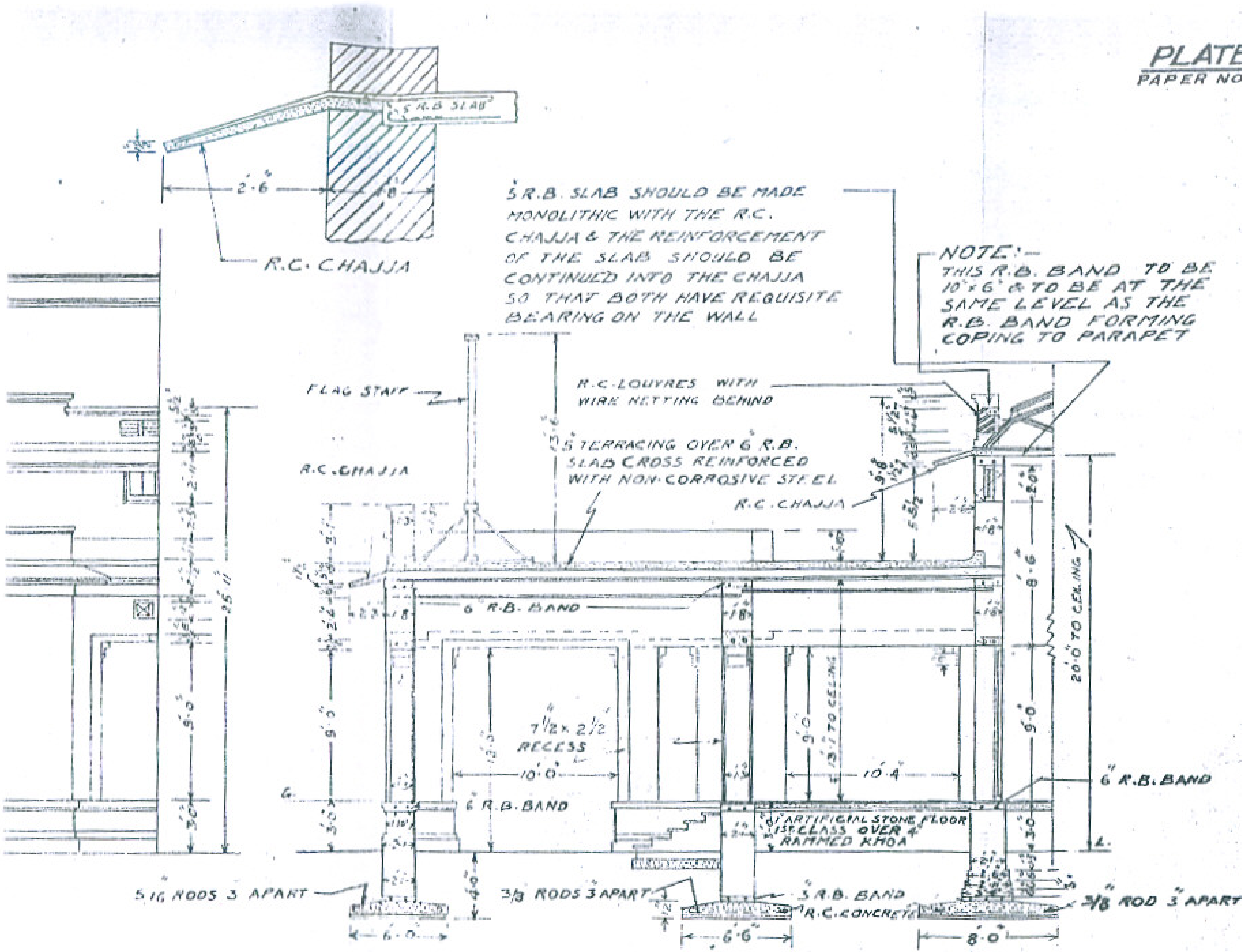
ESTIMATED COST RS....1,22,989/–

P.A. 26041 SFT: COST PER SFT: RS 4/11/6

PORCH.....{ESTIMATED COST RS....4939/–

{P.A. 1425 SFT: COST PER SFT: RS 3/7/6

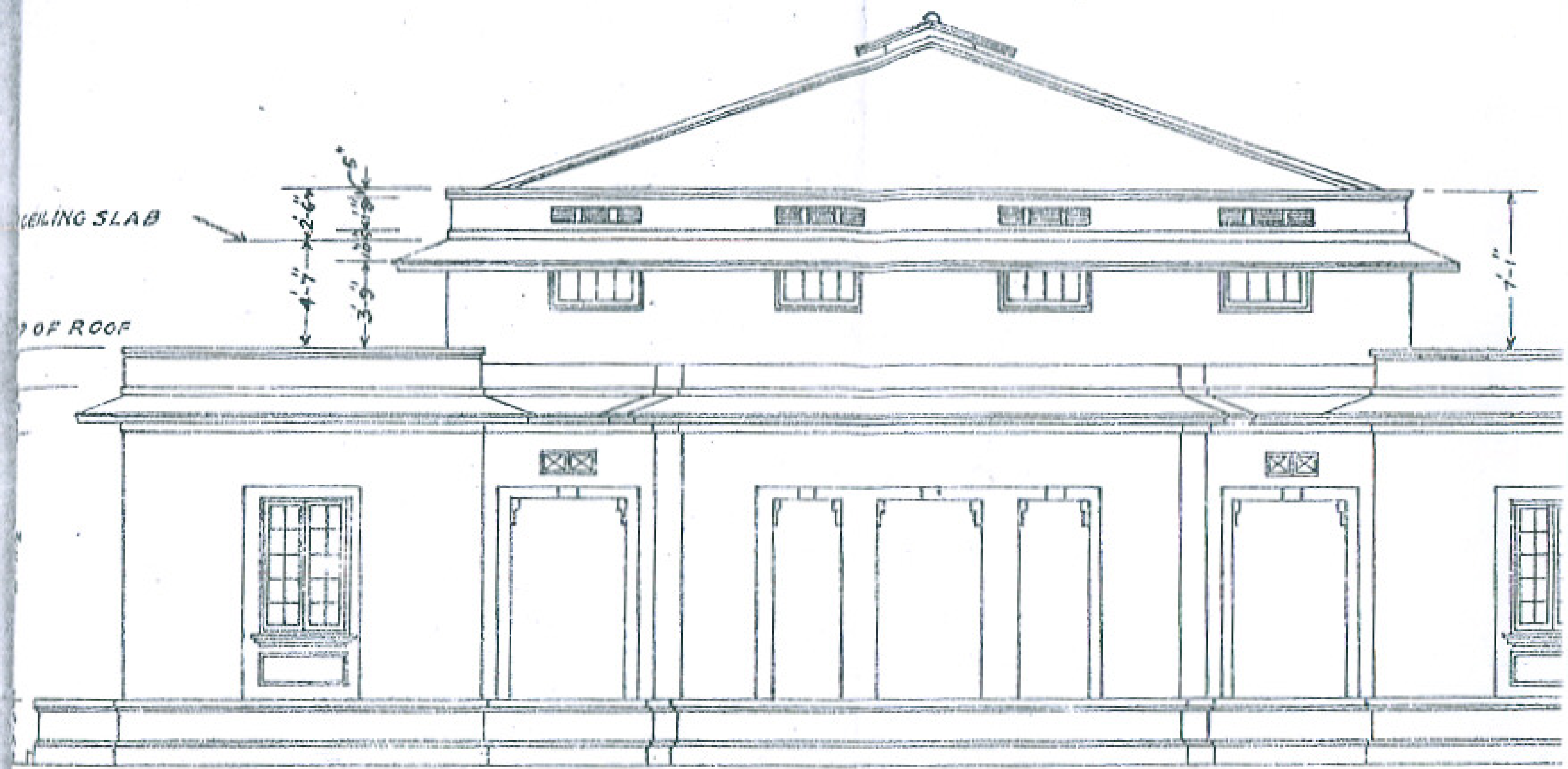
PLATE III
PAPER NO. 217



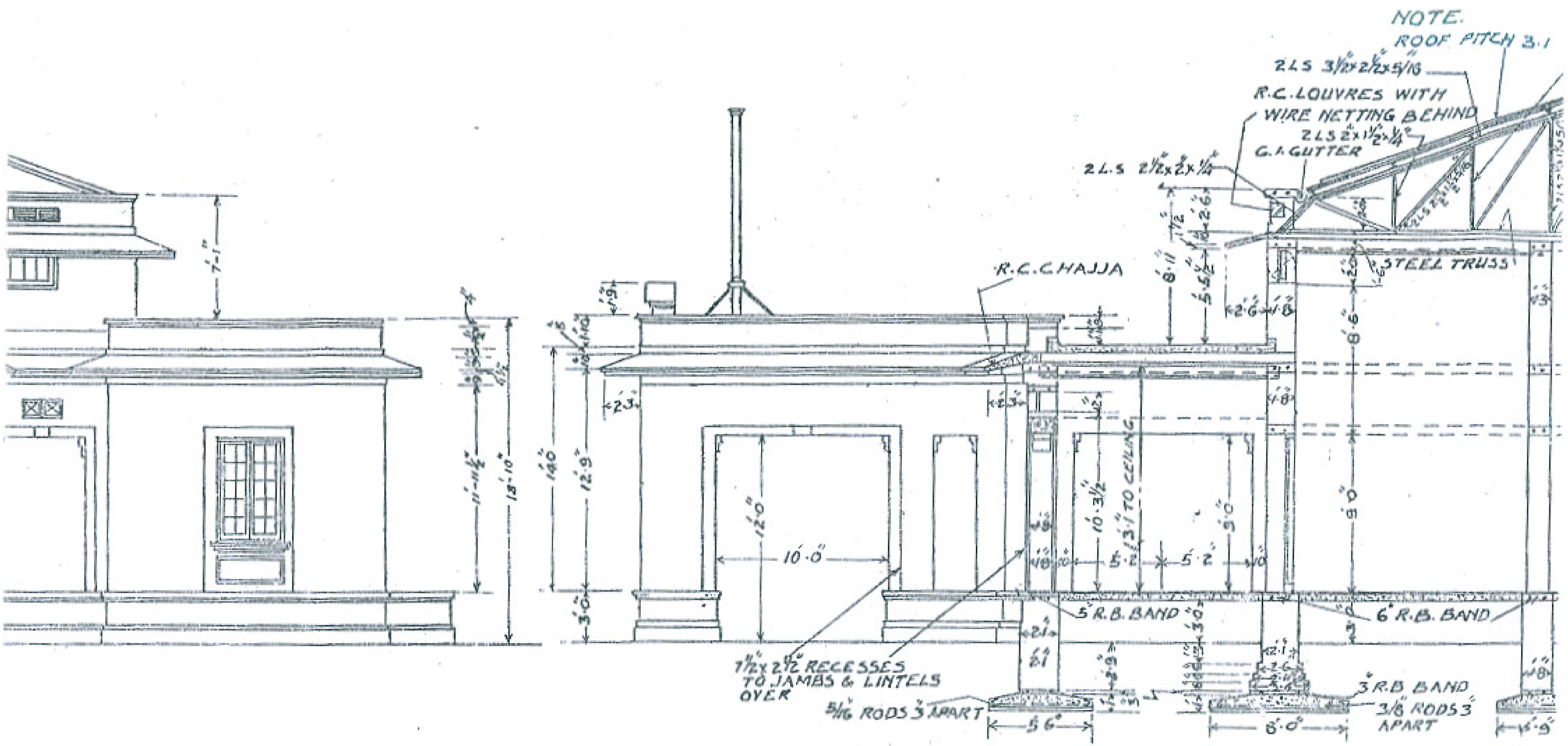
SECTION ON LINE B.B.

SCALE 8 FT = 1 INCH

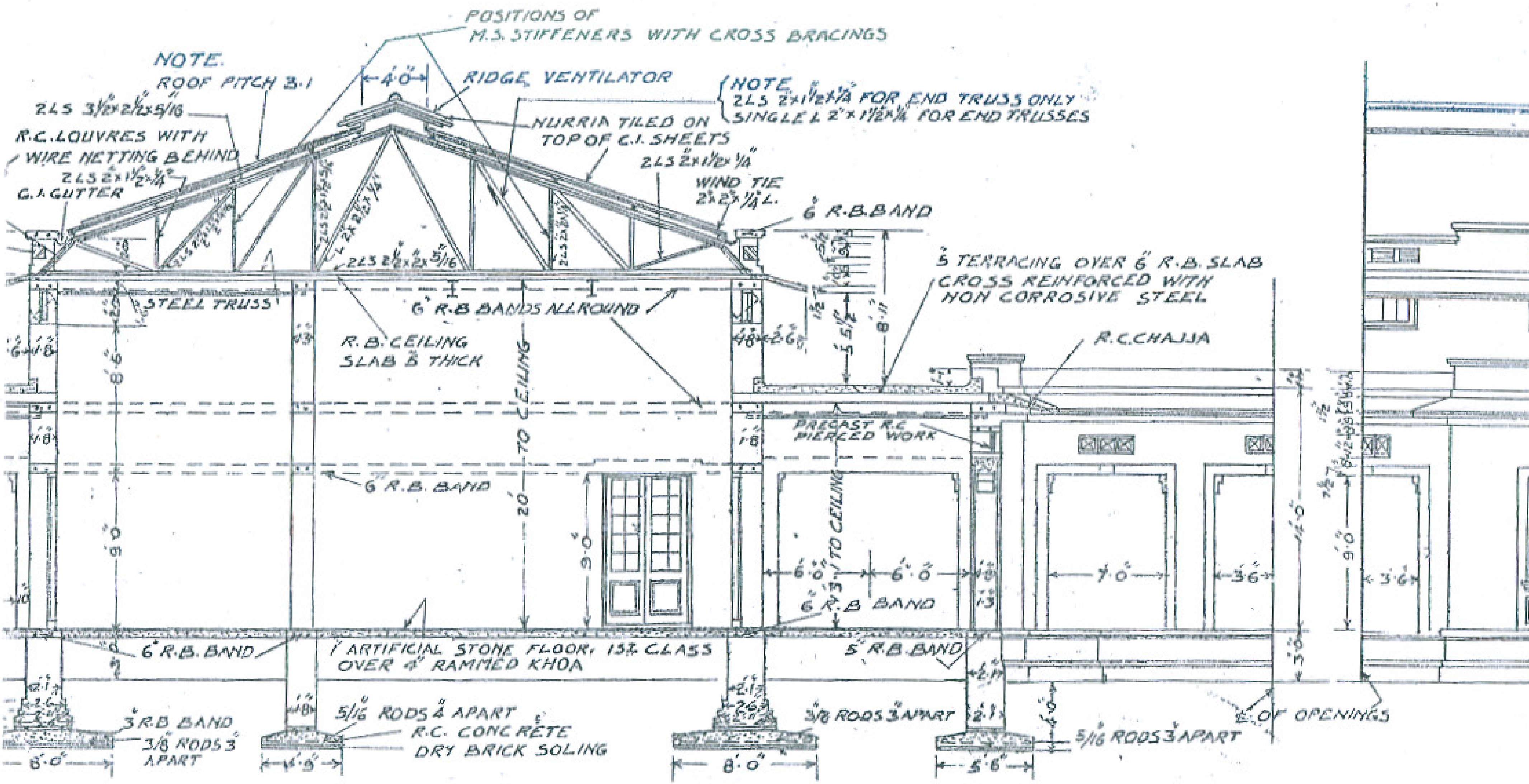
PUNJAB ENGINEERING CONGRESS
1938



END ELEVATION
SCALE 1"=8'


NOTE.
ROOF PITCH 3.1
2LS 3½"x2½"x5/16"
R.C. LOUVRES WITH
WIRE NETTING BEHIND
2LS 2"x1½"x¼"
G.I. GUTTER
2LS 2½"x2"x¼"
R.C. CHAJJA
STEEL TRUSS
1½"x2½" RECESSES
TO JAMBS & LINTELS
OVER
5/16" RODS 3" APART
5" R.B. BAND
6" R.B. BAND
3" R.B. BAND
3/8" RODS 3"
APART
13'1" TO CEILING

SE

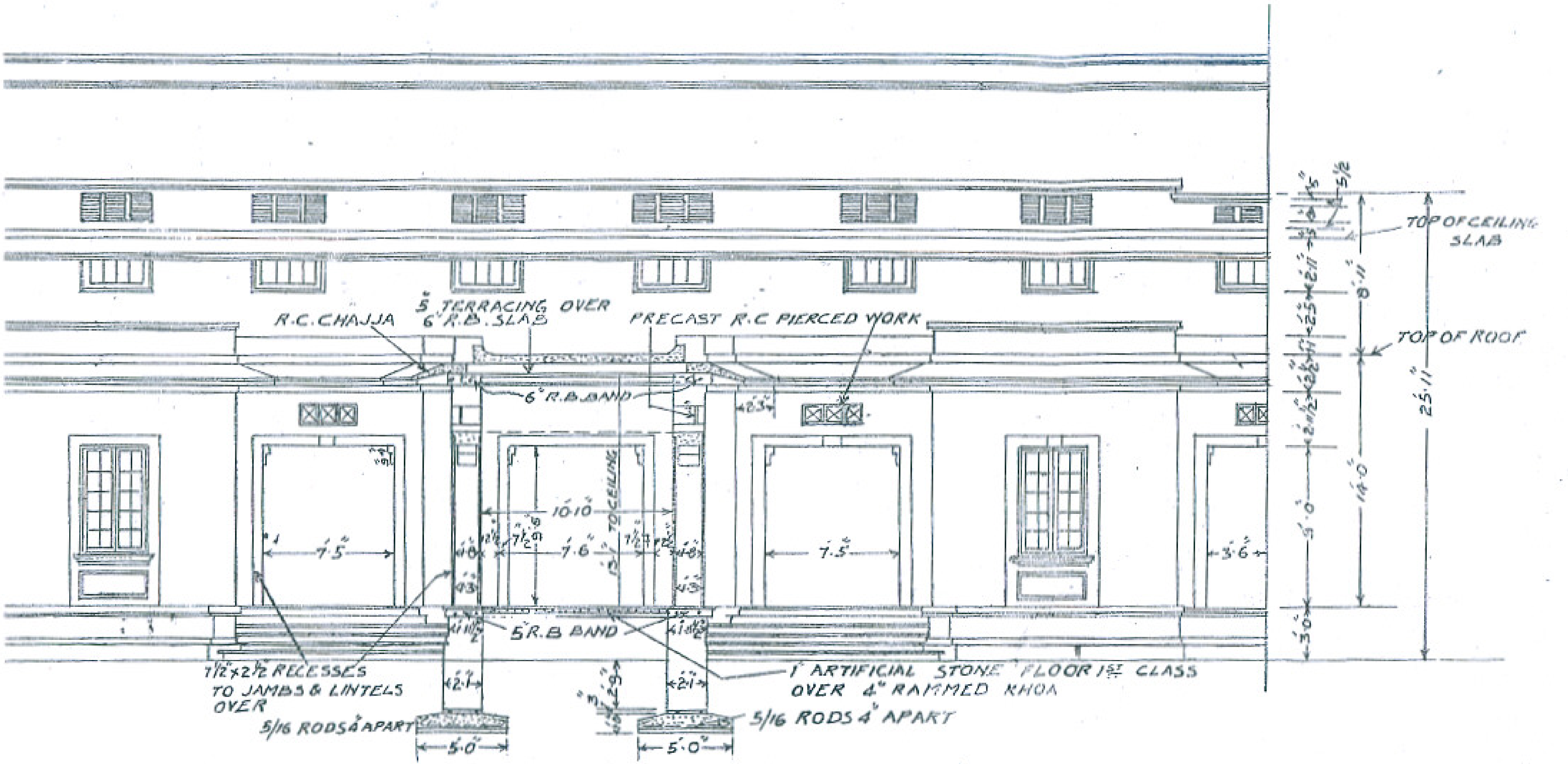


SECTION ON LINE A.A.

SCALE 8 FEET = 1 INCH

PLATE III a

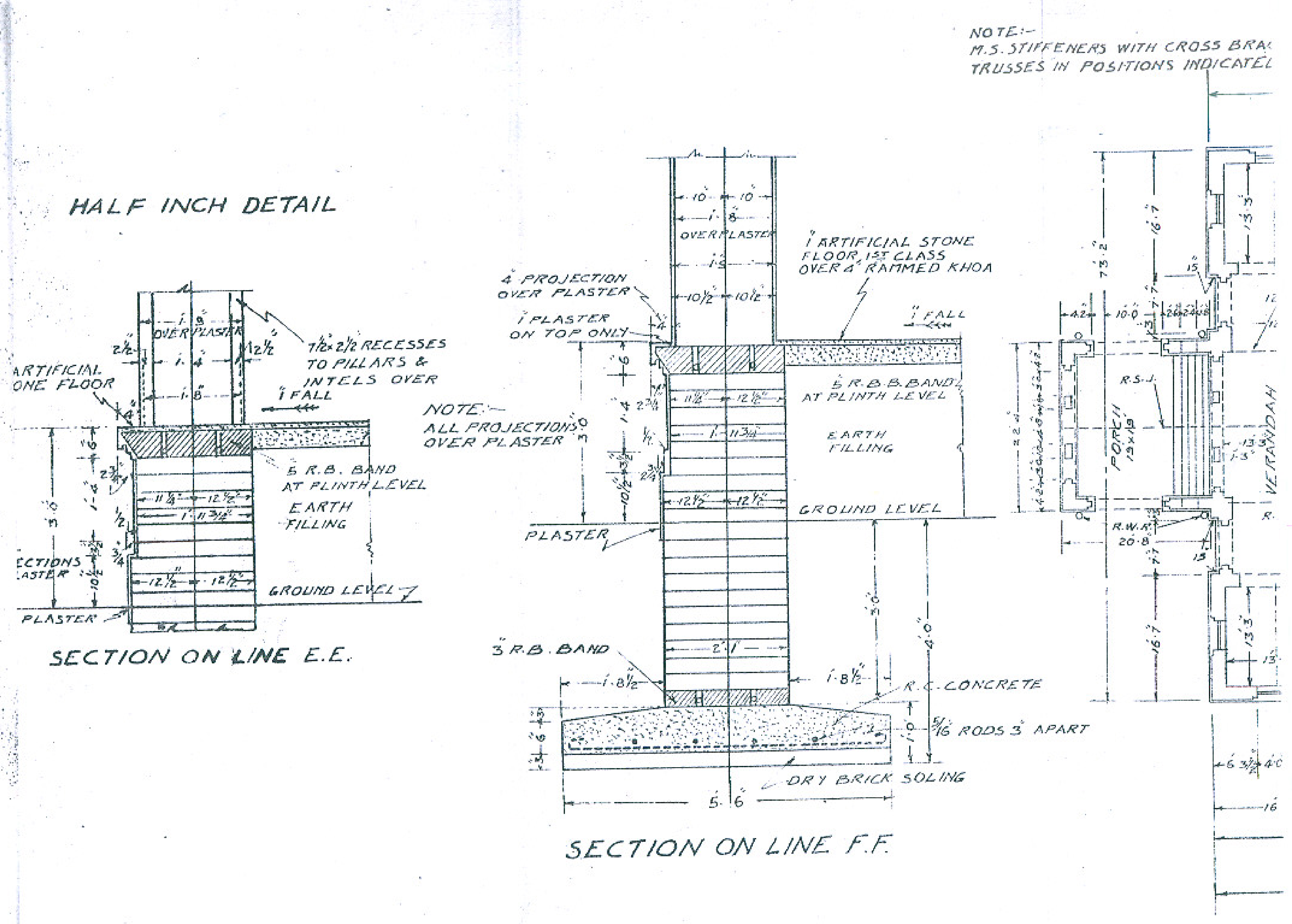
PAPER NO. 217

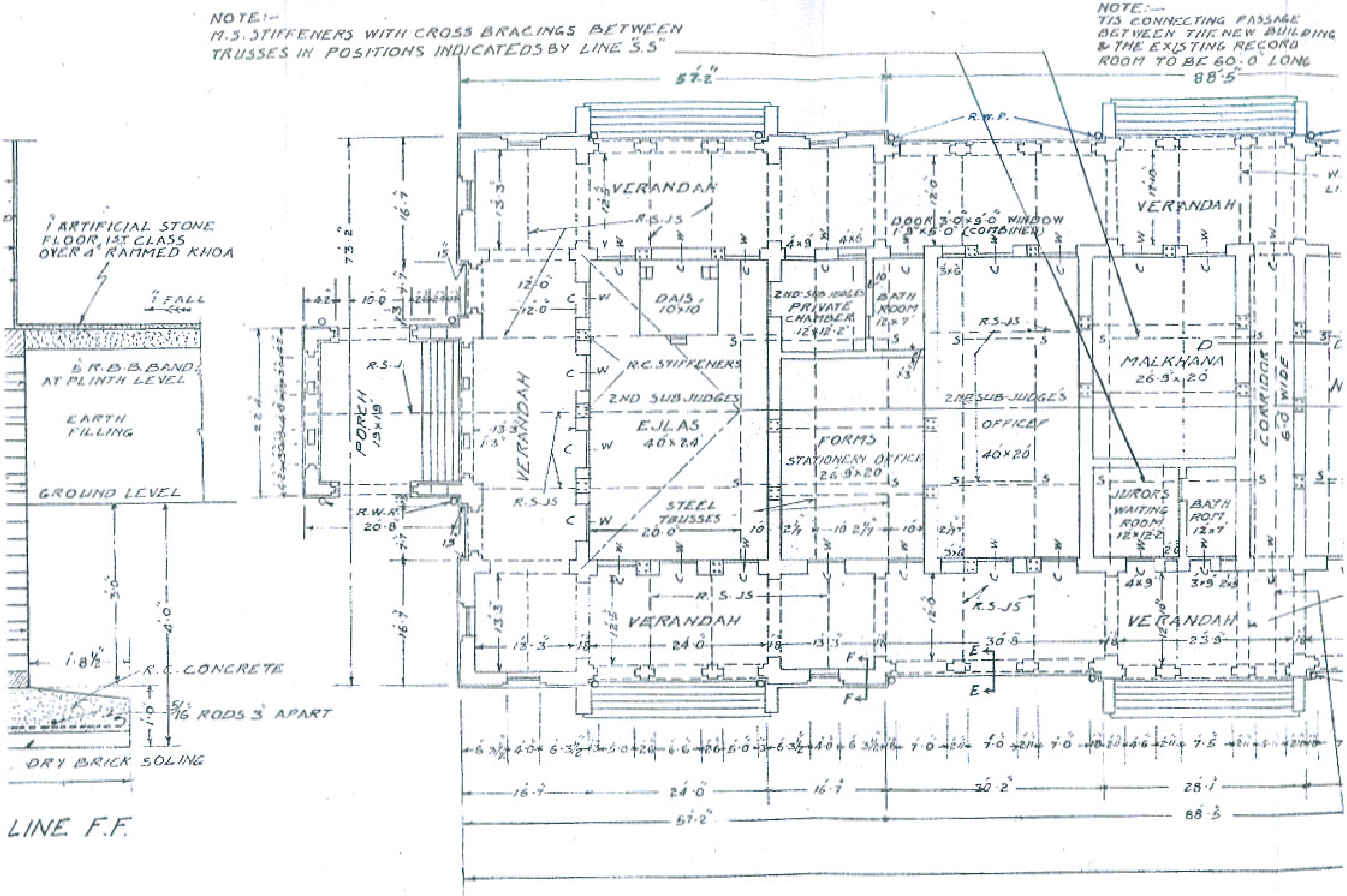


SECTIONAL ELEVATION ON LINE C. C

SCALE 1"= 8 FEET

PUNJAB ENGINEERING CONGRESS
1938


HALF INCH DETAIL
NOTE:-
M.S. STIFFENERS WITH CROSS BRA
TRUSSES IN POSITIONS INDICATEL
ARTIFICIAL
ONE FLOOR
OVER PLASTER
7½ x 2½ RECESSES TO PILLARS & INTELS OVER
1" FALL
5" R.B. BAND AT PLINTH LEVEL
EARTH FILLING
GROUND LEVEL
PLASTER
SECTION ON LINE E.E.
NOTE:-
ALL PROJECTIONS OVER PLASTER
4" PROJECTION OVER PLASTER
1" PLASTER ON TOP ONLY
1" ARTIFICIAL STONE FLOOR, 1ST CLASS OVER 4" RAMMED KHOA
1" FALL
5" R.B.B. BAND AT PLINTH LEVEL
EARTH FILLING
GROUND LEVEL
PLASTER
3" R.B. BAND
R.C. CONCRETE
5/16 RODS 3" APART
DRY BRICK SOLING
SECTION ON LINE F.F.
PORCH
19 x 19
R.S.J.
R.W.R.
VERANDAH


NOTE:-
M.S. STIFFENERS WITH CROSS BRACINGS BETWEEN TRUSSES IN POSITIONS INDICATED BY LINE "S.S"
NOTE:-
T/S CONNECTING PASSAGE BETWEEN THE NEW BUILDING & THE EXISTING RECORD ROOM TO BE 60'-0" LONG
1" ARTIFICIAL STONE FLOOR, 1ST CLASS OVER 4" RAMMED KHOA
1" FALL
6" R.B.B. BAND AT PLINTH LEVEL
EARTH FILLING
GROUND LEVEL
R.C. CONCRETE
5/16 RODS 3" APART
DRY BRICK SOLING
LINE F.F.
PORCH 19x19'
R.S.J.
R.W.P.
VERANDAH
R.S.JS
DAIS 10x10
R.C. STIFFENERS
2ND SUB JUDGES EJLAS 40'x24'
STEEL TRUSSES
2ND SUB JUDGES PRIVATE CHAMBER 12'x12'2"
BATH ROOM 12'x7'
FORMS STATIONERY OFFICE 26'9"x20'
DOOR 3'0"x9'0" WINDOW 7'9"x5'0" (COMBINED)
2ND SUB-JUDGES OFFICE 40'x20'
MALKHANA 26'9"x20'
JURORS WAITING ROOM 12'x12'2"
BATH ROOM 12'x7'
CORRIDOR 6'0" WIDE
57'2"
88'5"
73'2"
16'7"
24'0"
30'2"
28'1"

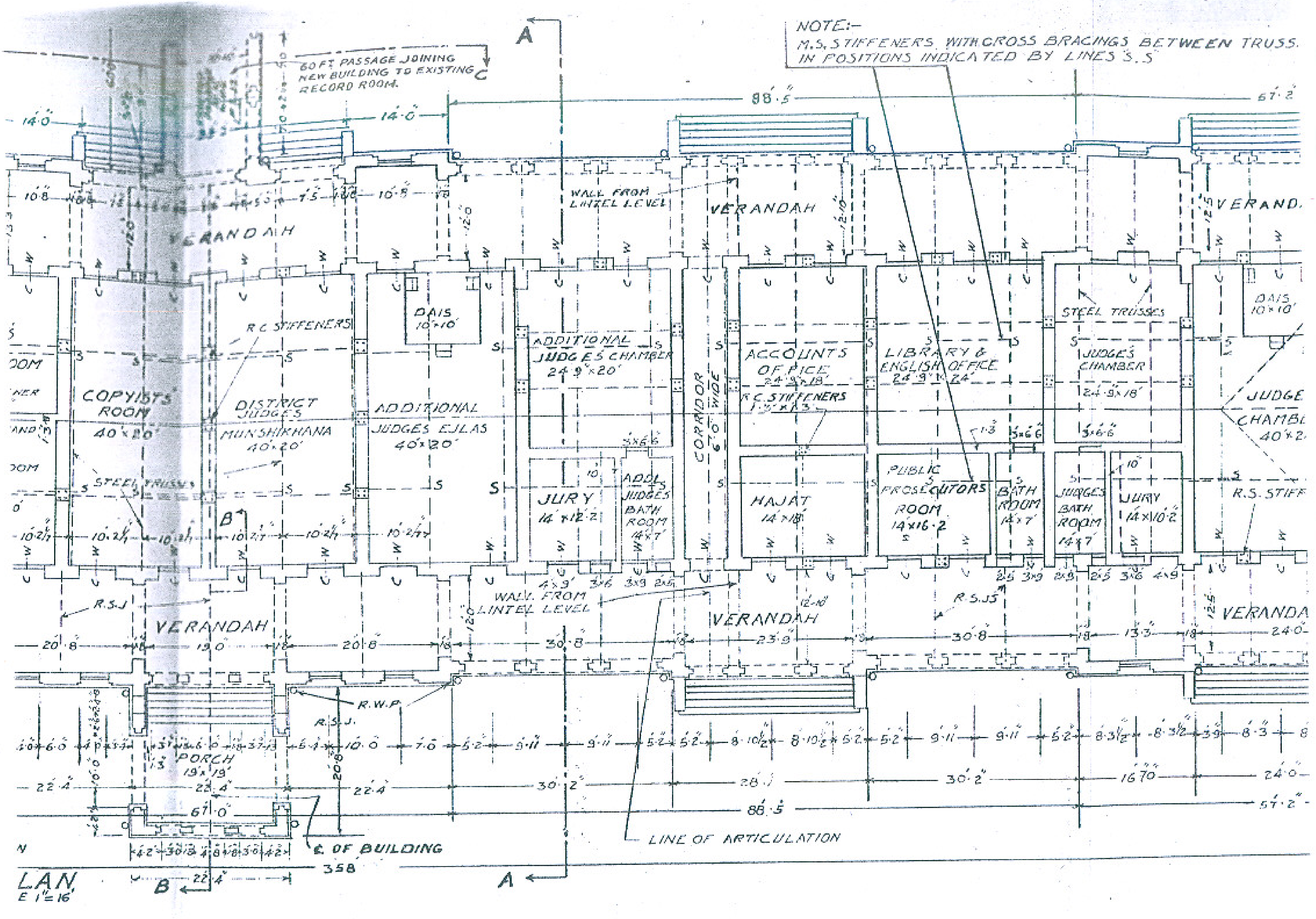
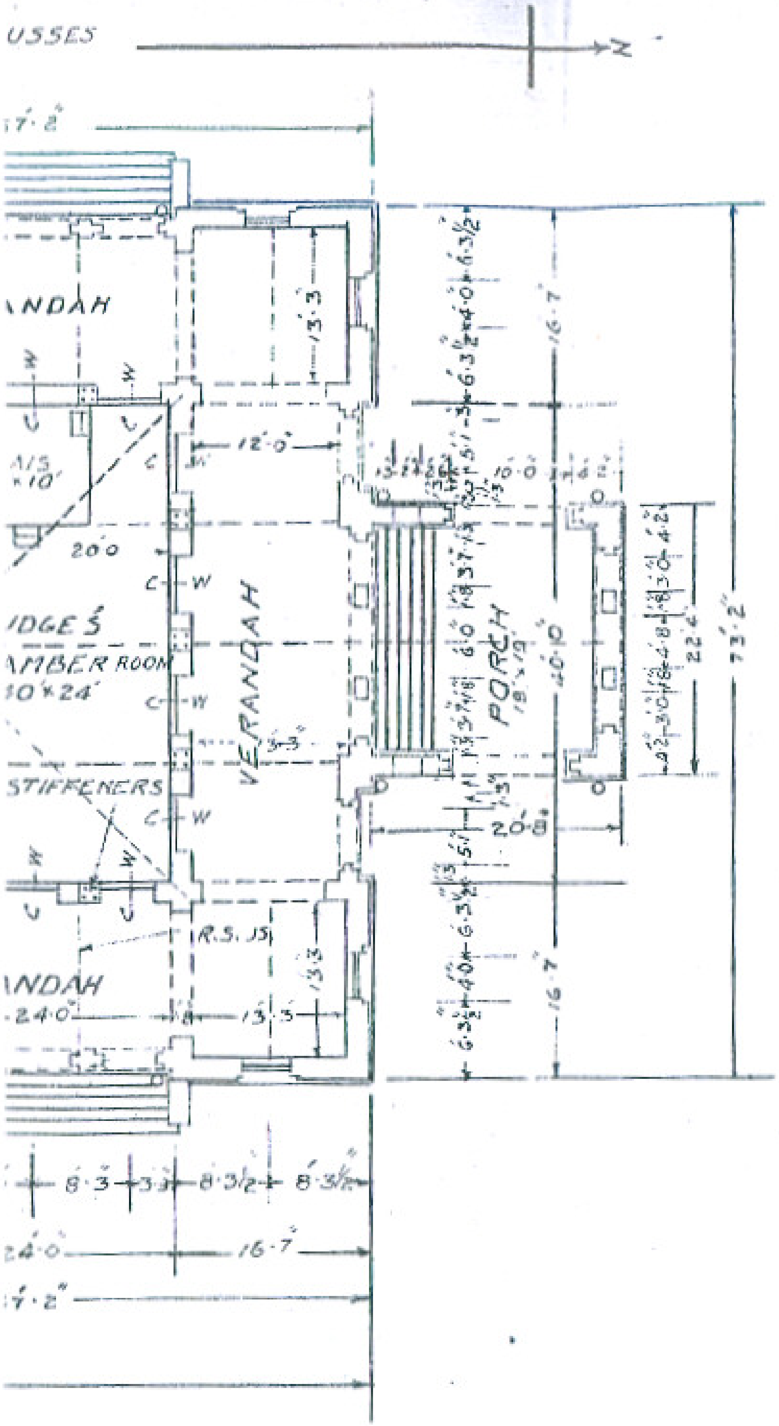
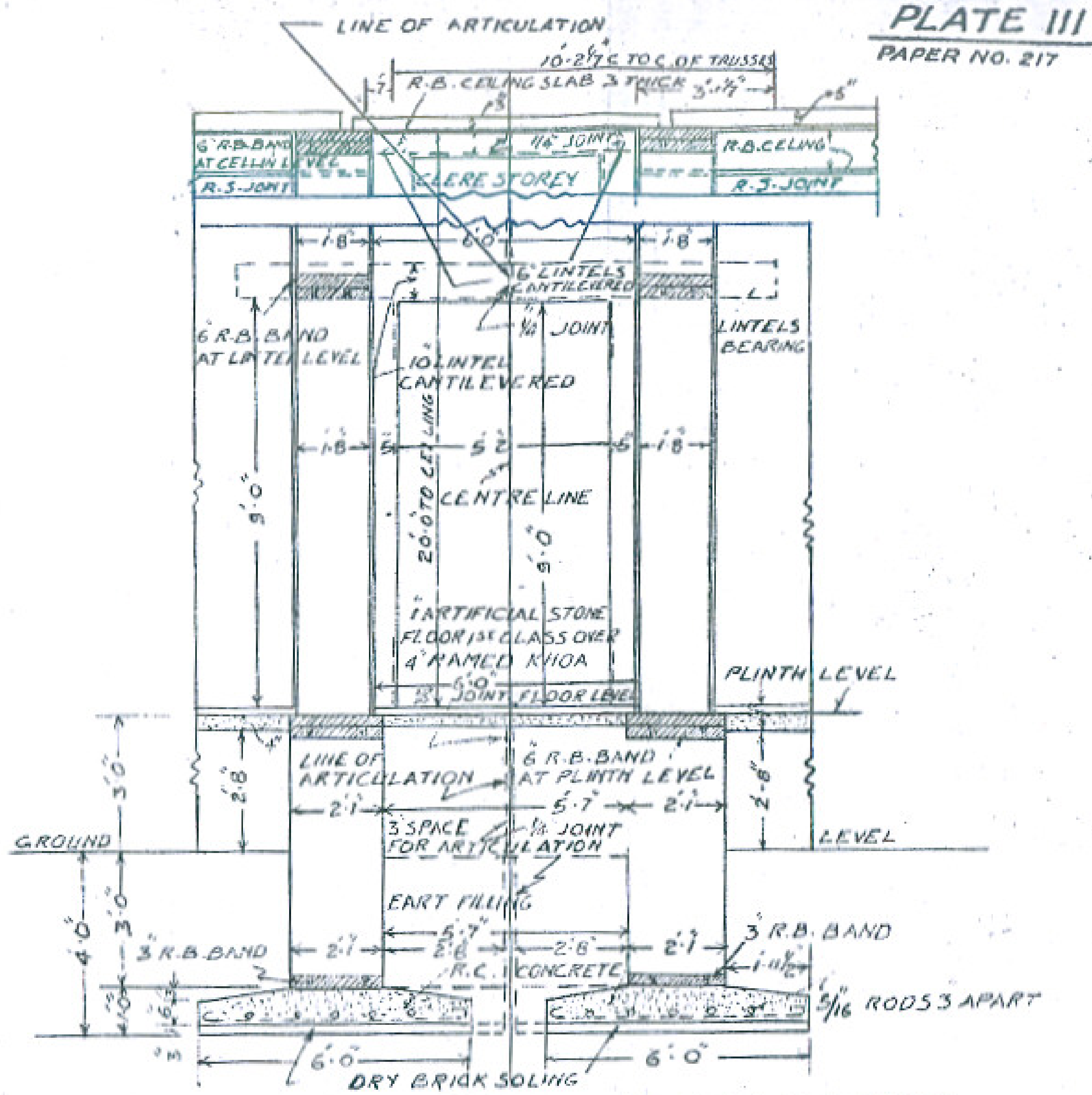

NOTE:-
M.S. STIFFENERS WITH CROSS BRACINGS BETWEEN TRUSS. IN POSITIONS INDICATED BY LINES S.S
60 FT PASSAGE JOINING NEW BUILDING TO EXISTING RECORD ROOM.
VERANDAH
WALL FROM LINTEL LEVEL
COPYISTS ROOM 40'x20'
DISTRICT JUDGES MUNSHIKHANA 40'x20'
R.C. STIFFENERS
ADDITIONAL JUDGES EJLAS 40'x20'
DAIS 10'x10'
ADDITIONAL JUDGES CHAMBER 24'9"x20'
JURY 14'x12'2"
ADDL JUDGES BATH ROOM 14'x7'
CORRIDOR 6'0" WIDE
ACCOUNTS OFFICE 24'9"x18'
R.C. STIFFENERS
HAJAT 14'x18'
LIBRARY & ENGLISH OFFICE 24'9"x24'
PUBLIC PROSECUTORS ROOM 14'x16'2"
BATH ROOM 14'x7'
STEEL TRUSSES
JUDGES CHAMBER 24'9"x18'
JUDGES BATH ROOM 14'x7'
JURY 14'x10'2"
JUDGE CHAMB 40'x2
R.S. STIFF
STEEL TRUSSES
R.S.J
R.S.J.
R.W.P
PORCH 19'x19'
℄ OF BUILDING
LINE OF ARTICULATION
88'5"
67'2"
358'
LAN
E 1"=16'
A
B

PLATE III b

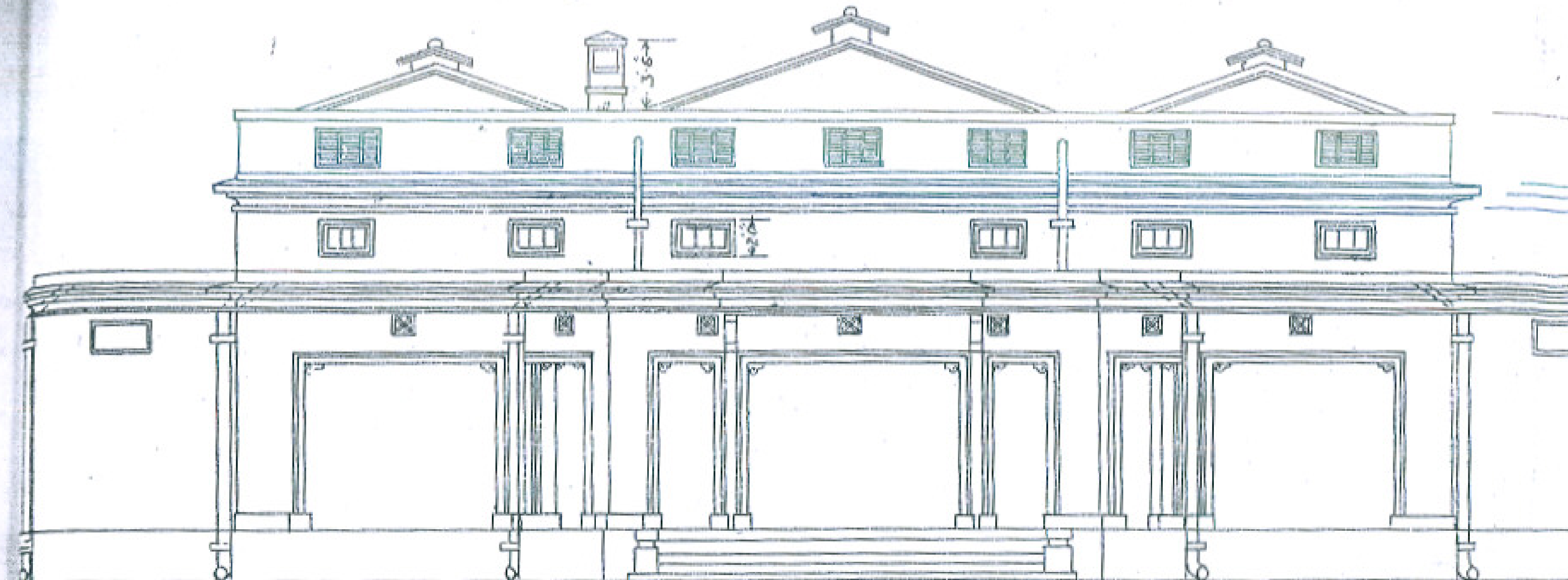
PAPER NO. 217



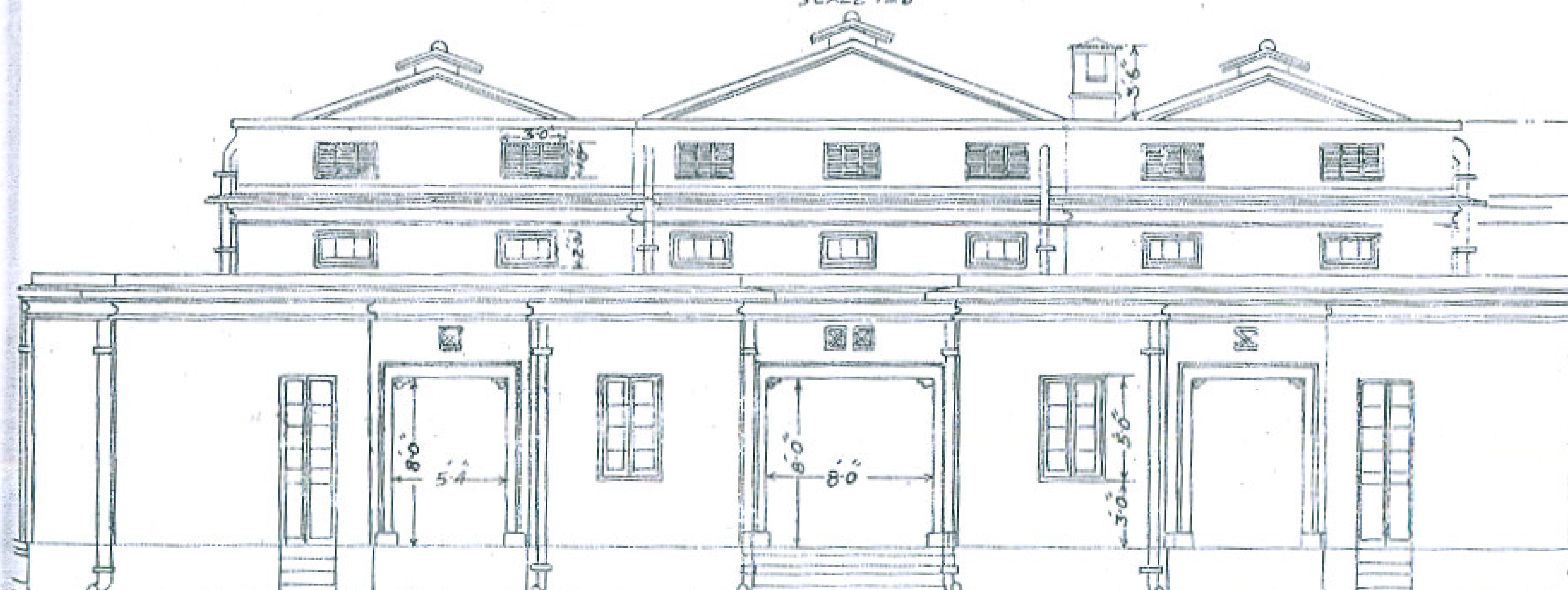


DETAIL SECTION ON LINE D.D THRO
CORRIDOR SHOWING THE METHOD OF ARTICULATION

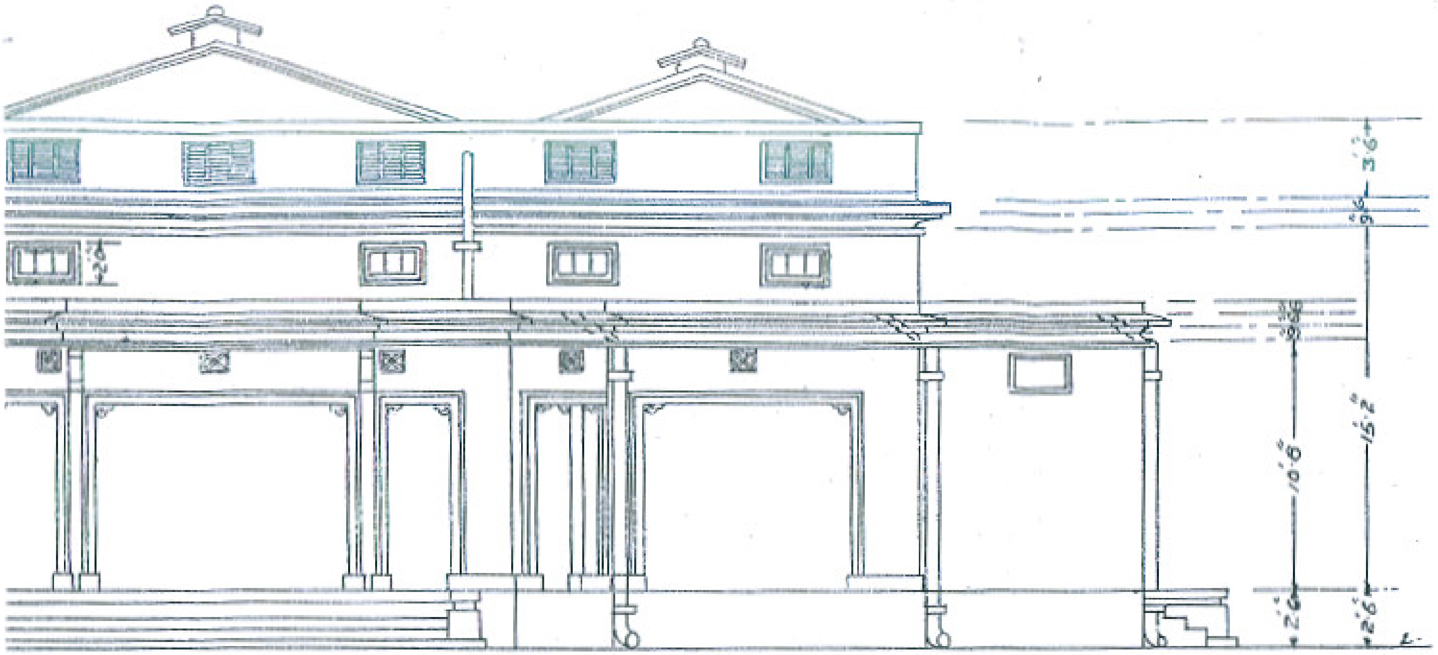
SCALE 1" = 4 FEET



FRONT ELEVATION
SCALE 1"=8'



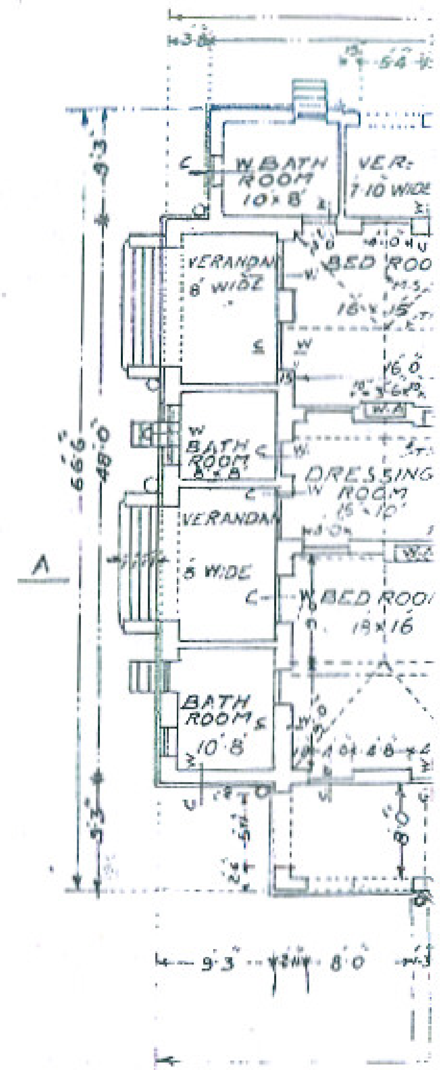
BACK ELEVATION SCALE 1"=8'



FRONT ELEVATION
SCALE 1"=8'

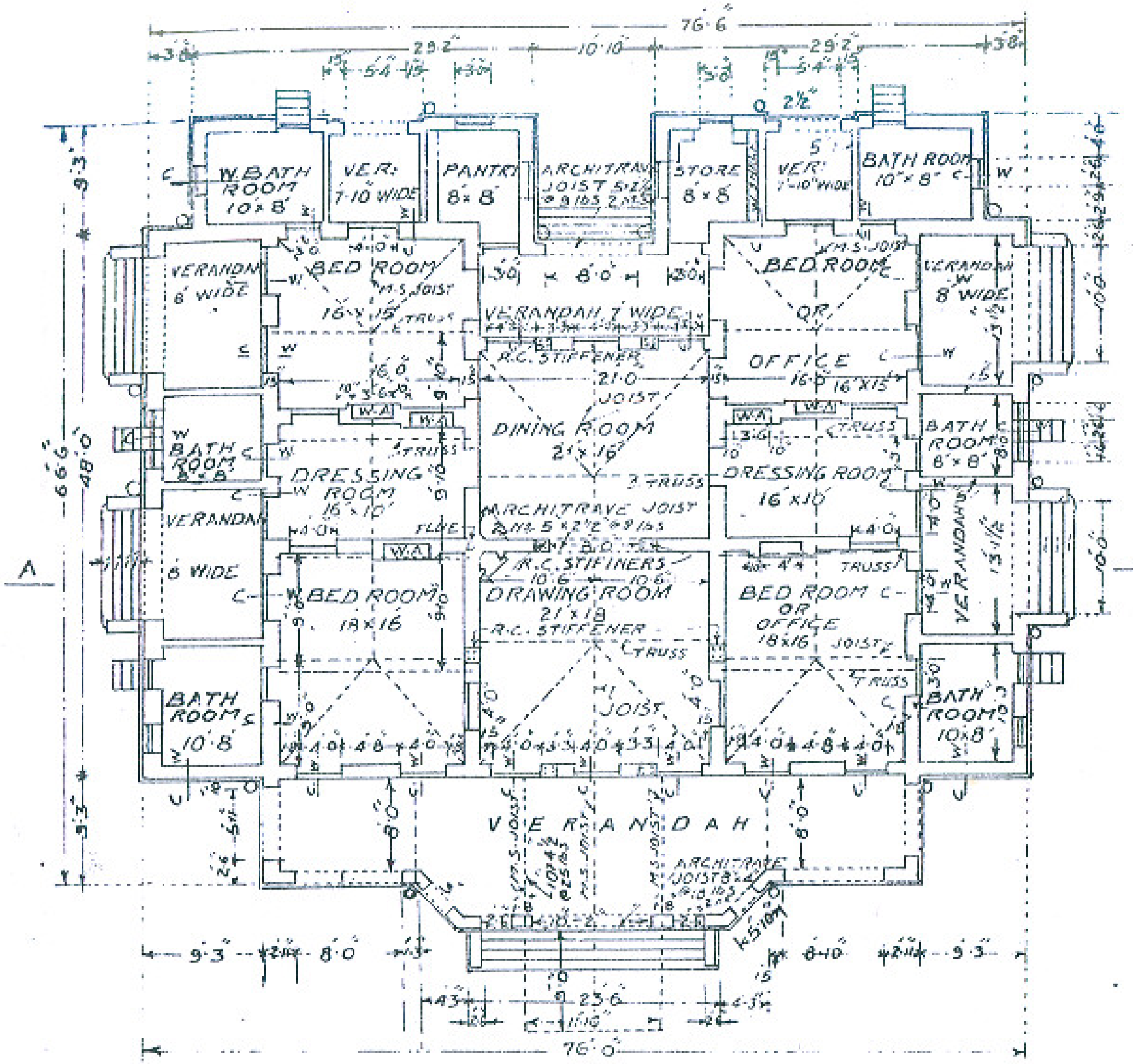
BACK ELEVATION SCALE 1"=8'

PLAN OF PROPOSE
AT L



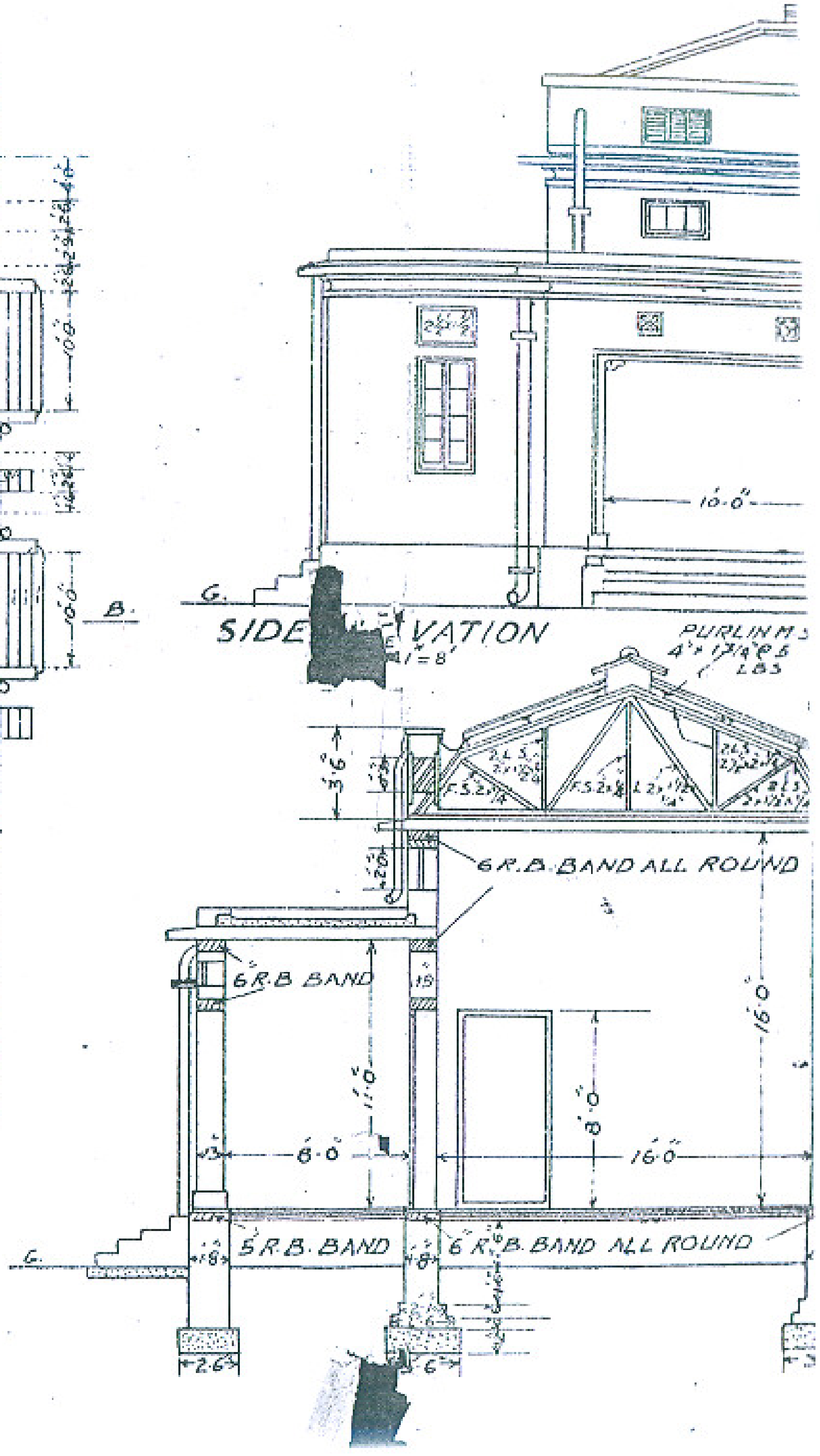
NOTE:–
ESTIMATED CC
P.A. 4922 SFT. C

PLAN OF PROPOSED RESIDENCE FOR THE EXECUTIVE ENGINEER
AT LUATHAHA (NEW MOTIHARI)



PLAN

SCALE 1"=16 FEET



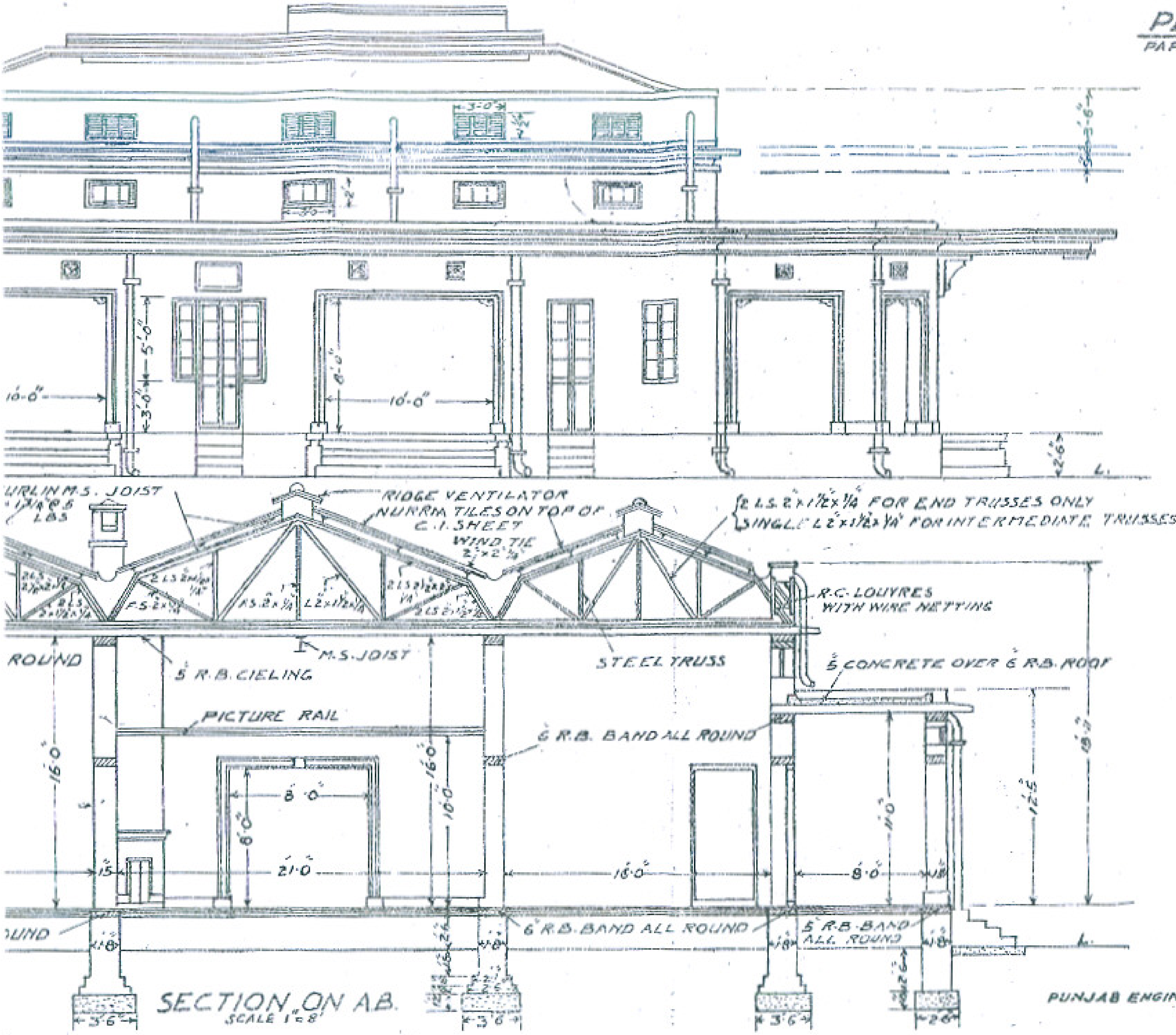
NOTE:—

ESTIMATED COST RS...25,231/-

P.A. 4922 SFT. COST PER SFT. RS....5/2/3

PLATE IV

PAPER NO. 217

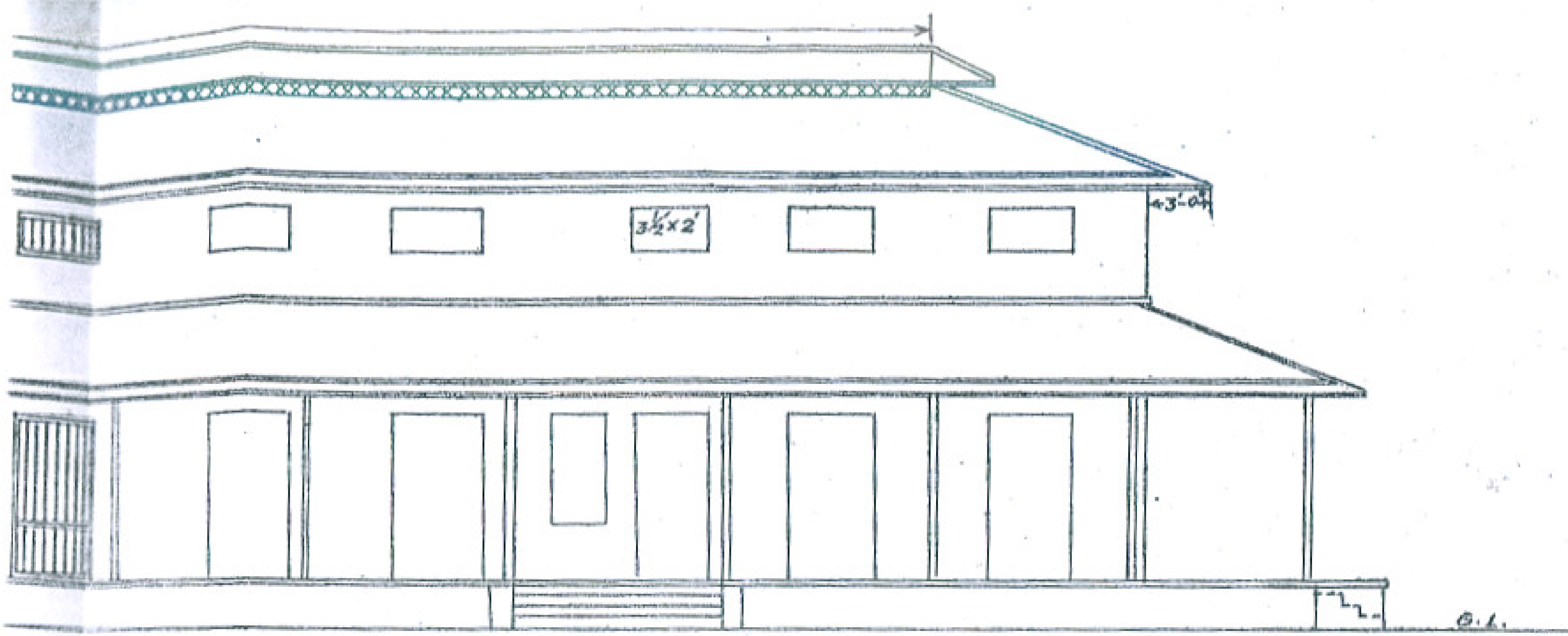


SECTION ON A.B.

SCALE 1"=8'

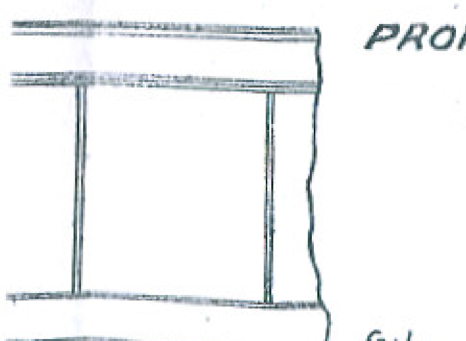
PUNJAB ENGINEERING CONGRESS 1938

SIDE ELEVATION
SCALE 1"=8'



FRONT ELEVATION

SCALE 1"=8'



PROPOSED PLAN OF SUB-DIVISIONAL COURT BUILDING
AT SITAMARHI
DISTRICT MUZAFFARPUR
SLUMP BELT TYPE

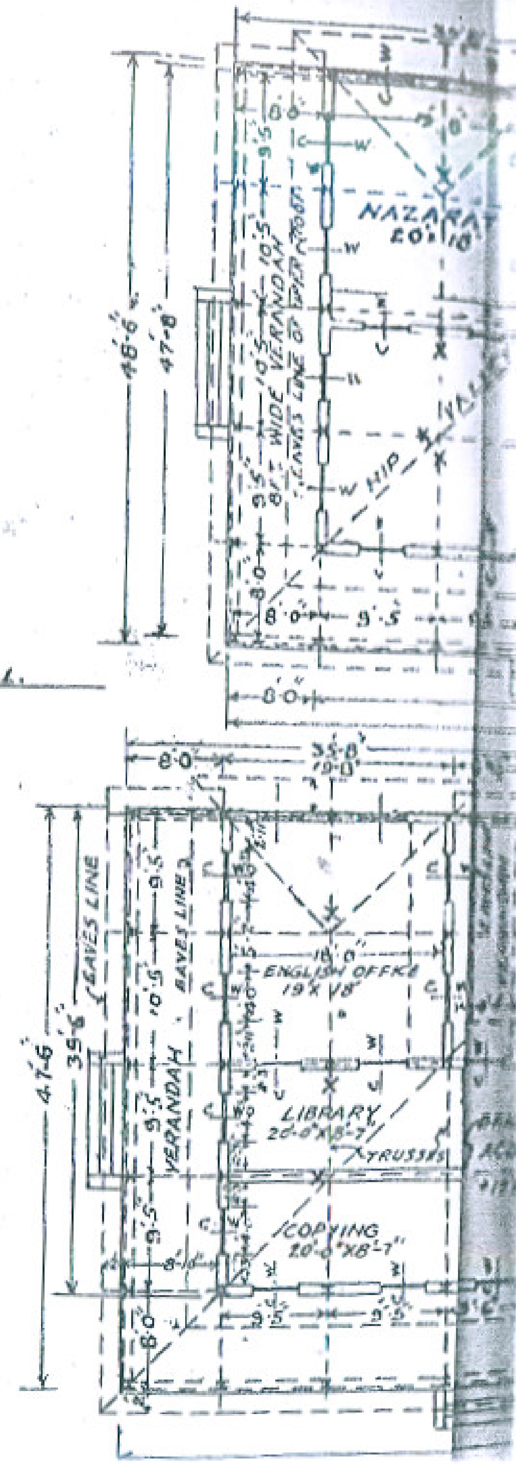
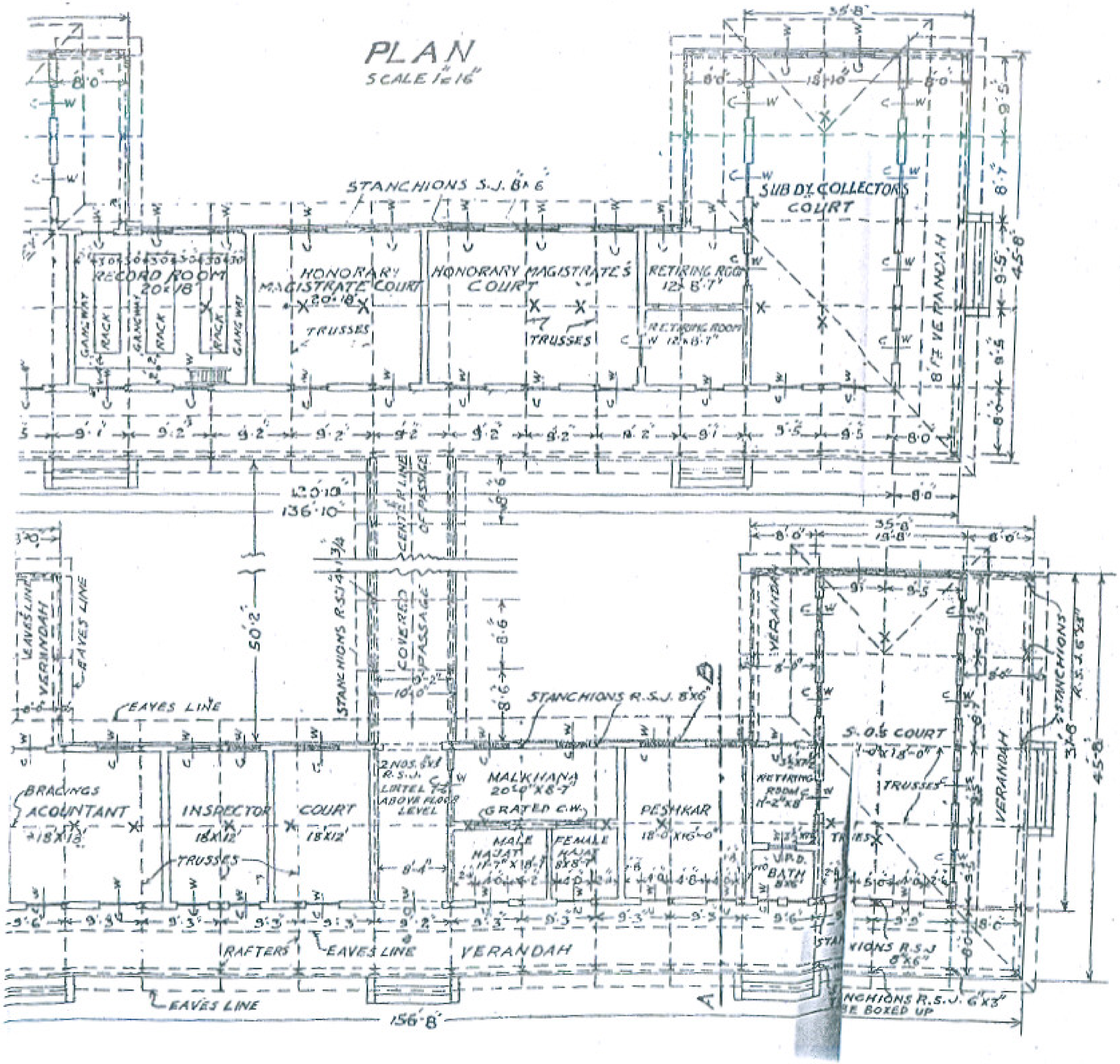


PLATE V

PAPER NO. 217

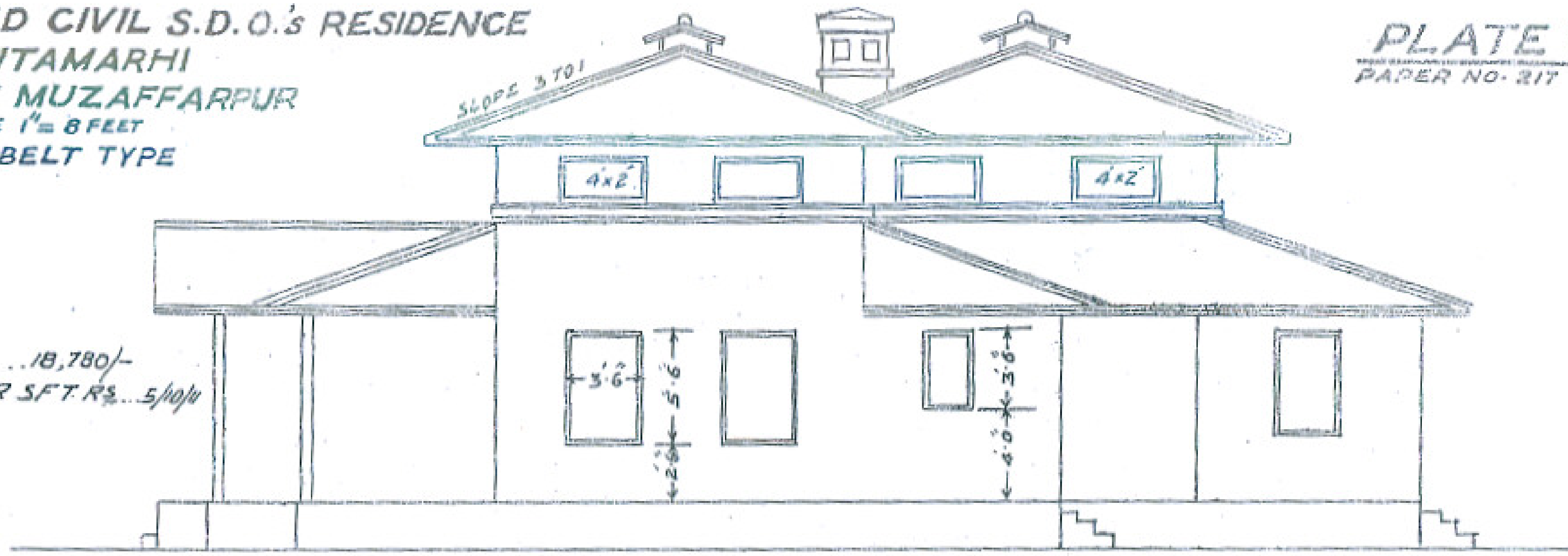


PUNJAB ENGINEERING
1938

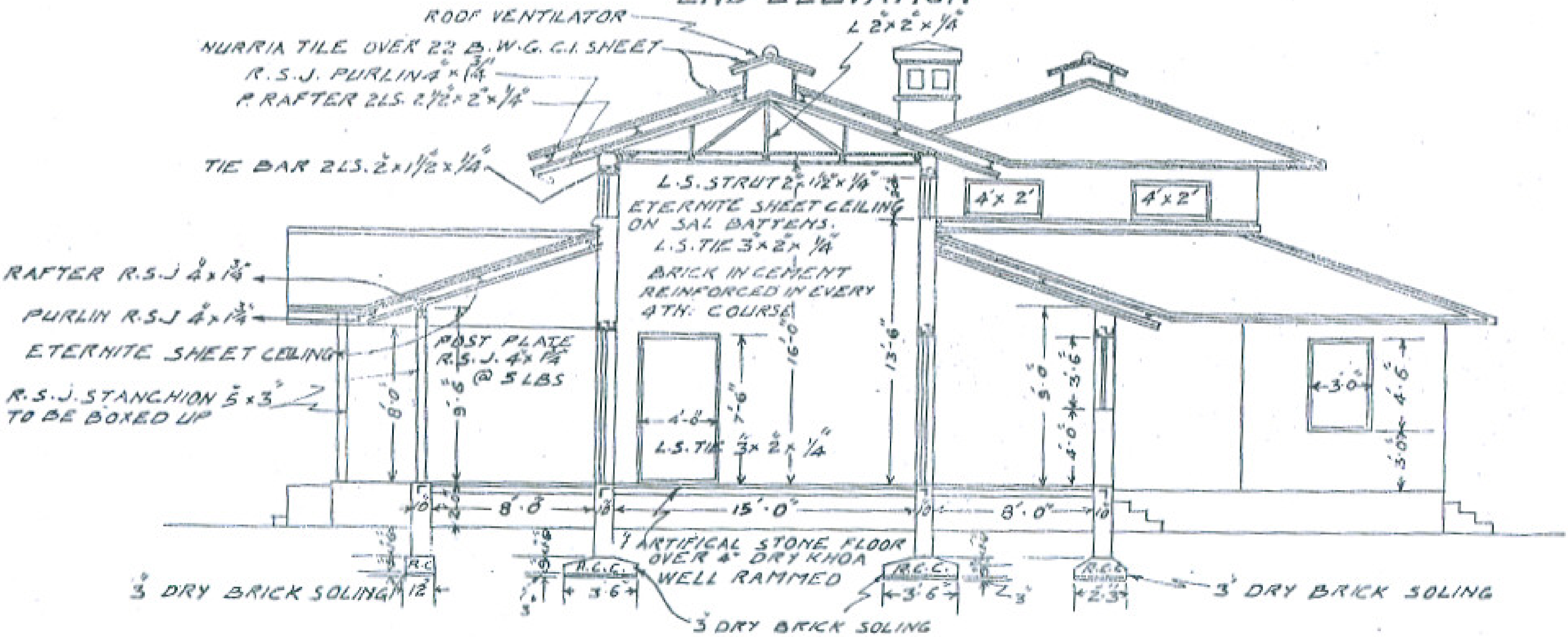
...OF PROPOSED CIVIL S.D.O.'s RESIDENCE
AT SITAMARHI
DISTRICT MUZAFFARPUR
SCALE 1" = 8 FEET
SLUMP BELT TYPE

PLATE VI
PAPER NO. 217

...E:—
...IMATED COST RS.....18,780/-
3.305 SFT. COST PER SFT. RS....5/10/4



END ELEVATION

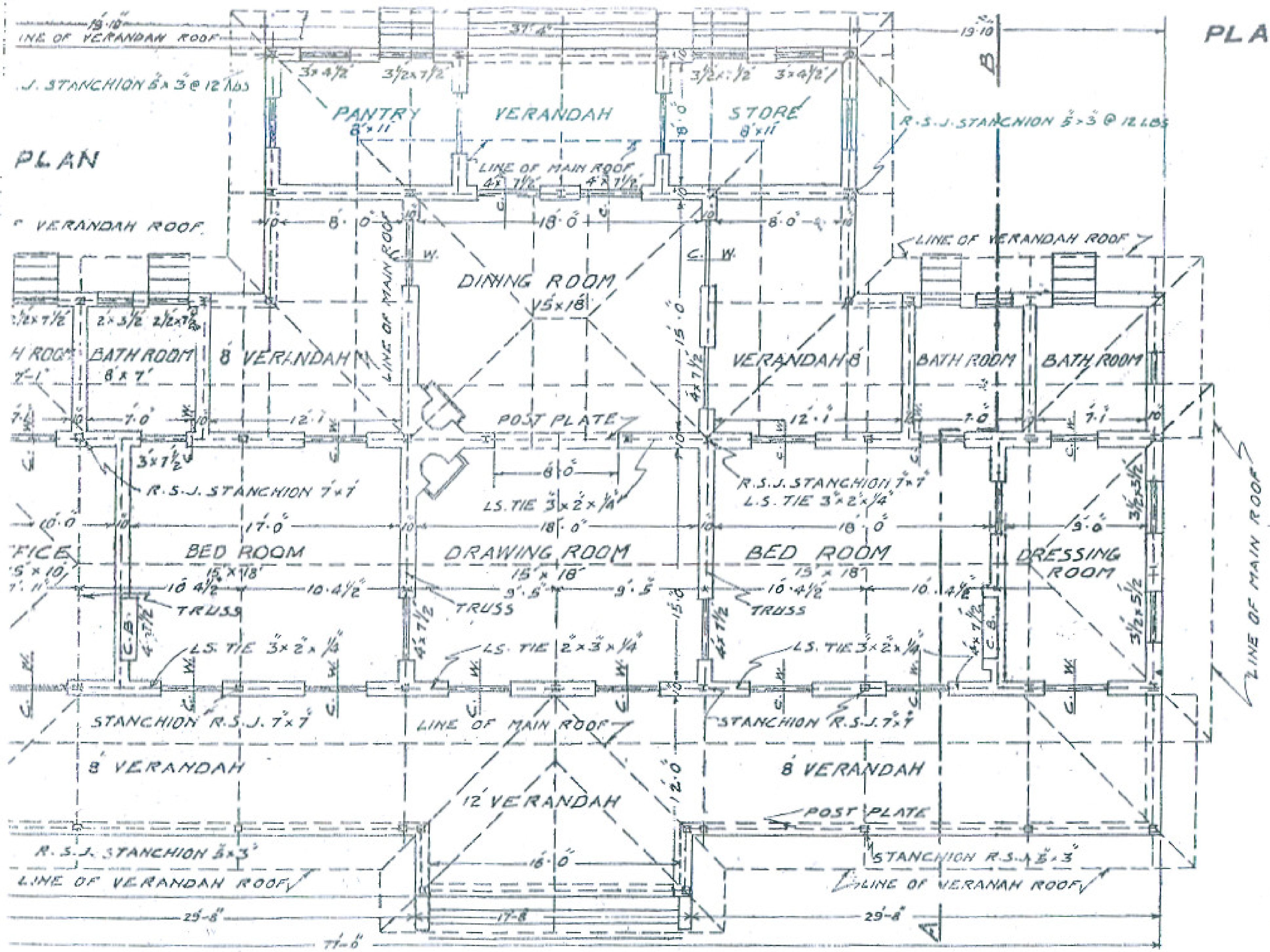


SECTION ON A.B

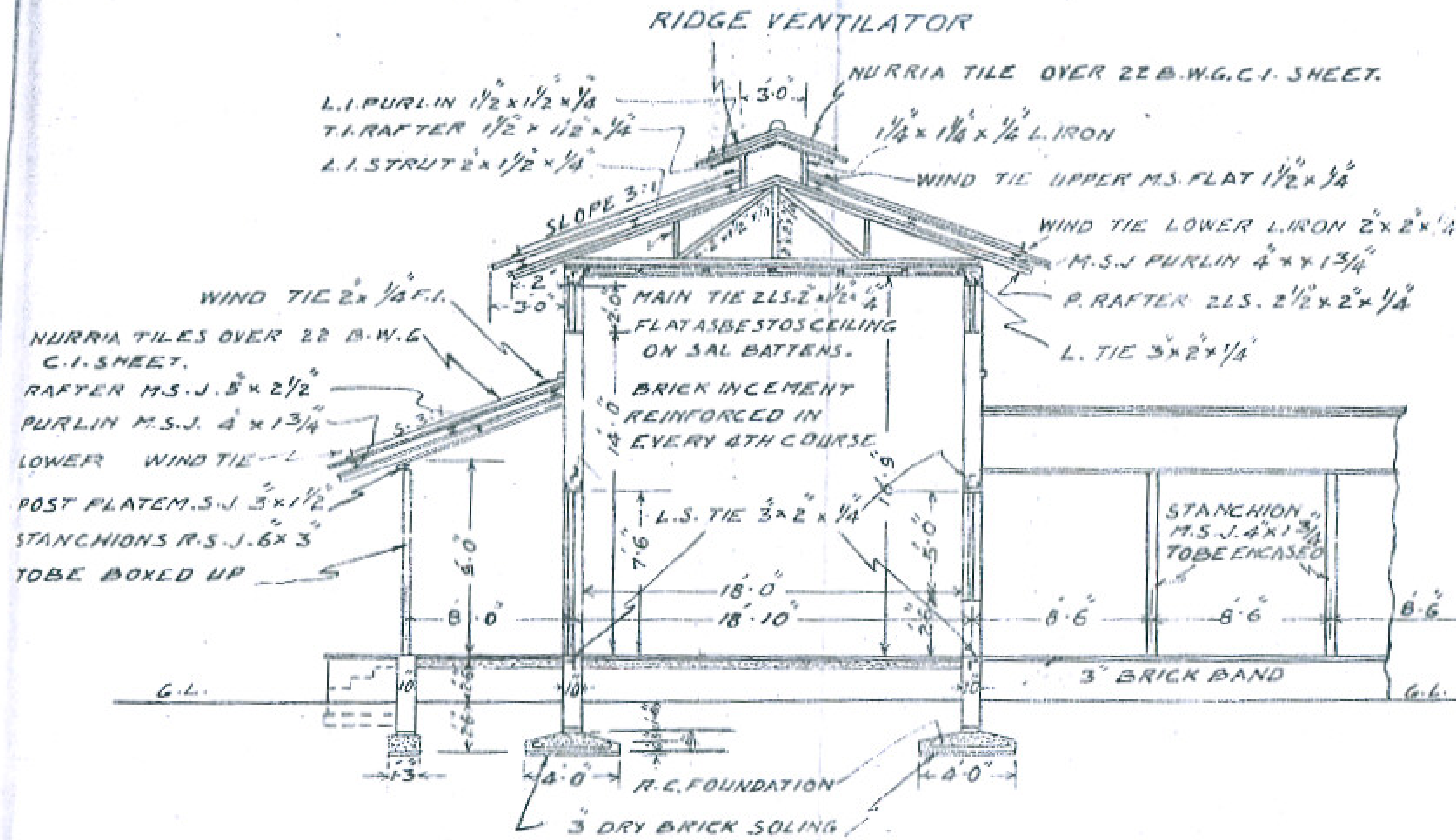
PUNJAB ENGINEERING CONG...
1938

PLAN OF PR

DI



NOTE:—
ESTIMATED C
P.A. 3.305 SF.

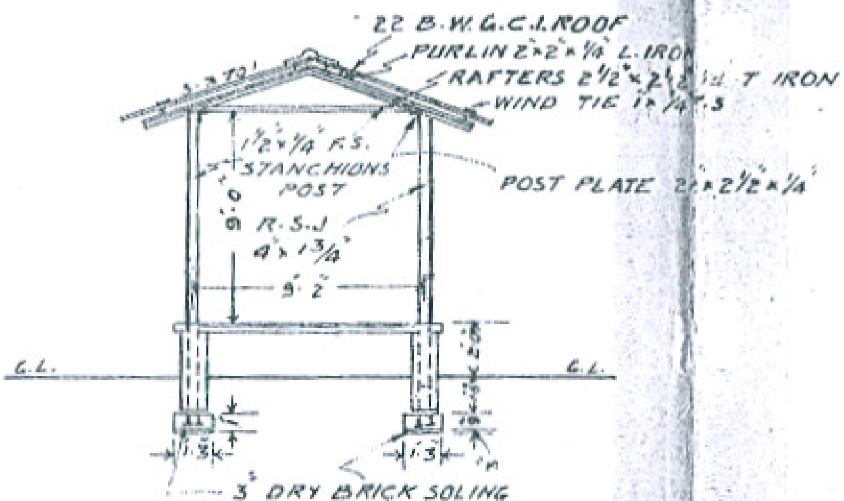


SECTION ON A.B.

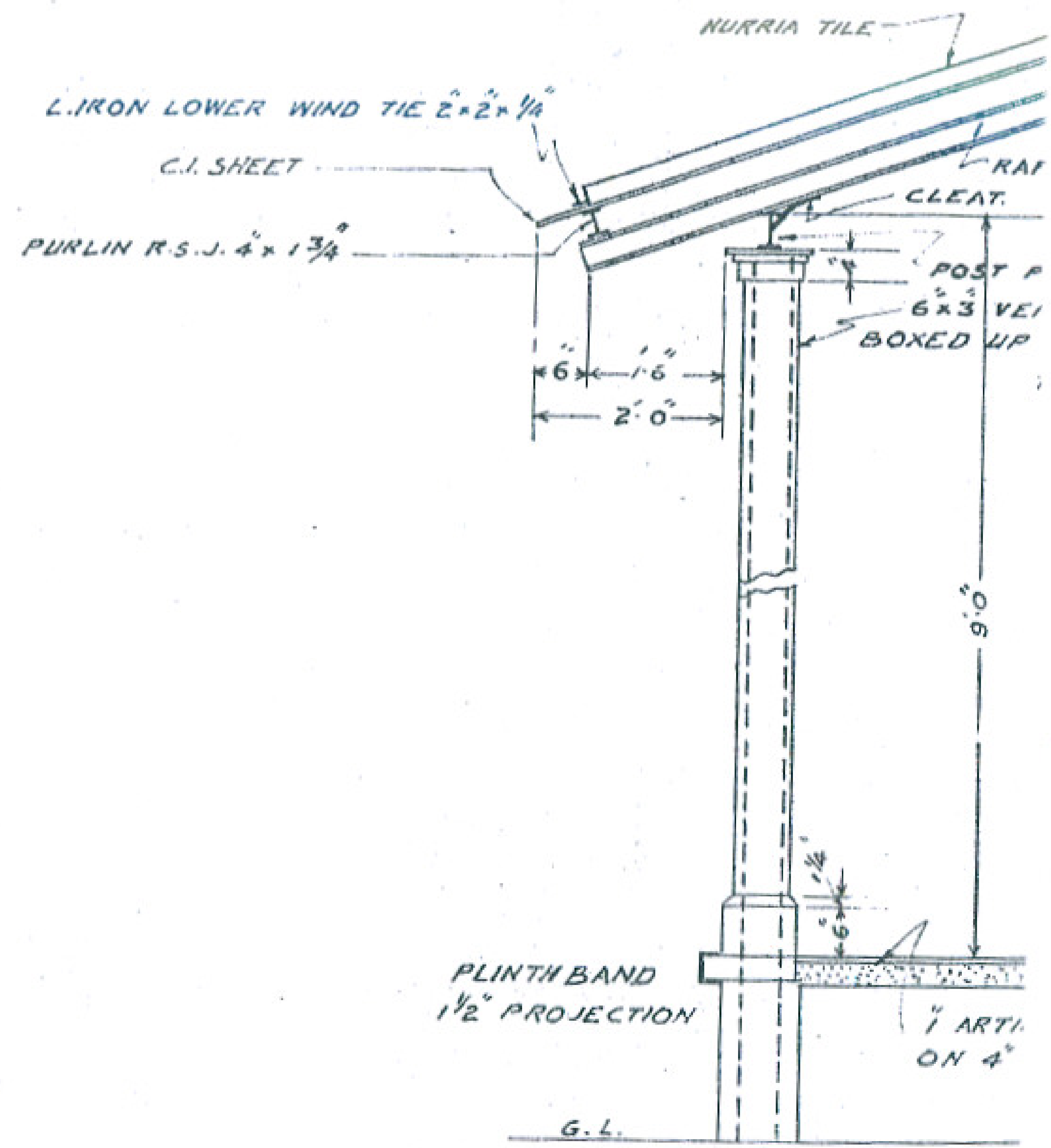
SCALE 1" = 8 Ft.

NOTE:—

THE FOUNDATION BELOW VERANDAH STANCHION ARE 1'-8" SQUARES AND THE FOUNDATION BELOW MAIN ROOMS STANCHION ARE 5'-4" SQUARES.

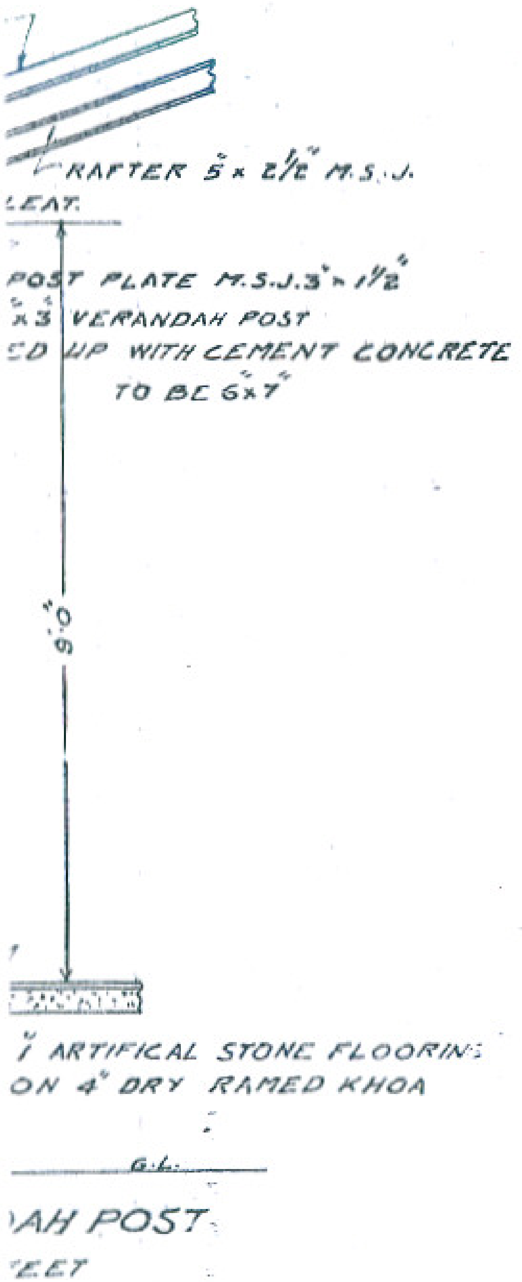


CROSS SECTION OF COVERED PASSAGE
SCALE 1"=8 FT.



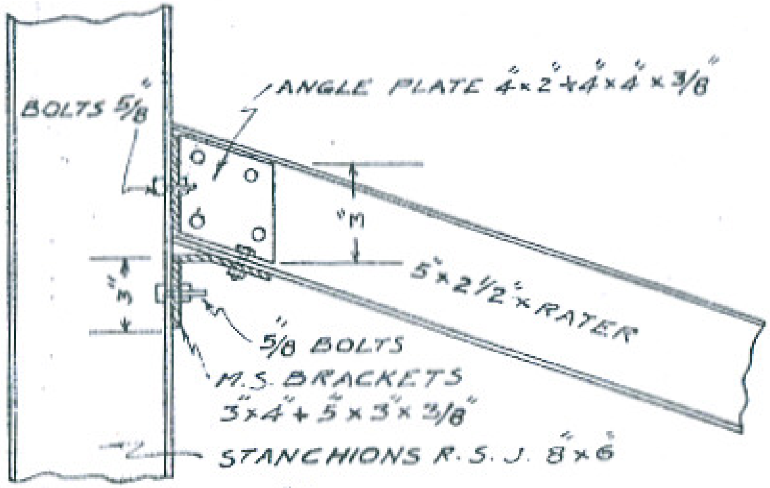
DETAIL OF VERANDAH F
SCALE 1"= 2 FEET

5.



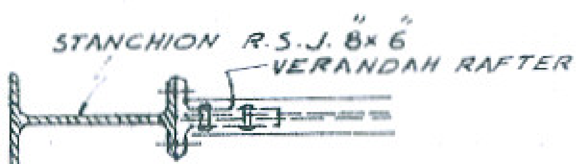
ROOF MEMBERS.......

STANCHIONS..........



DETAILS OF AT "A"

SHOWING THE METHOD OF FIXING VERANDAH RAFTER WITH STANCHION



PLAN OF AT "A"

SCALE 1 1/2" = 1 FT.

DETAIL OF STEEL WORKS

PLATE V a

PAPER NO. 217

P. RAFTERS 2 LS. 2½"×2"×¼"
STRUTS M.S.L. 2"×1½"×¼"
BOOTOM TIE 2 M.S.L. 2"×1½"×¼"
CENTRAL TIE M.S.L. 2"×2"×¼"
DIAGONAL BRACINGS LS 2"×1½"×¼"
PURLINS R.S.J. 4"×1¾"
VERANDAH RAFTERS R.S.J. 5"×2½"
PURLINS R.S.J. 4"×1¾"
WIND TIE UPPER M.S. FLAT 1½"×¼"
WIND TIE LOWER LS 2"×2"×¼"

STANCHIONS OF MAIN WALL R.S.J. 8"×6" @ 35 LBS.
STANCHIONS FOR VERANDAH POSTS R.S.J 6"×3"
POST PLATE R.S.J. 3"×1½"
HORIZONTAL TIE OF WALLS 3"×2"×¼"

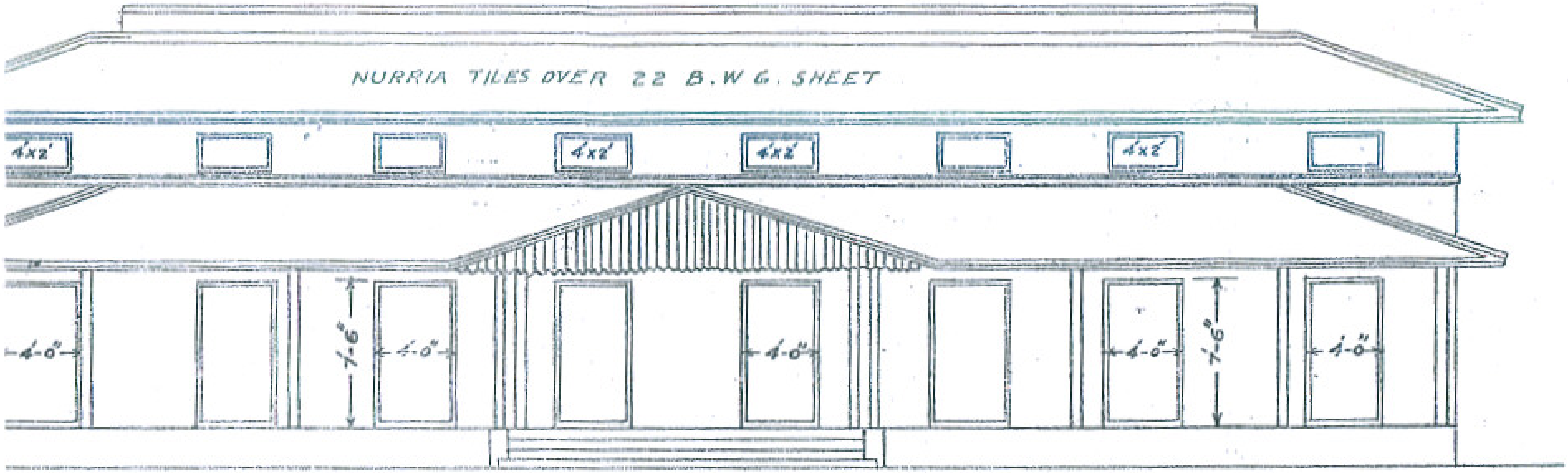
NOTE:-
ESTIMATED COST RS: 62,860/-
P.A. 11,522 SFT. COST PER SFT. 5/7/3

NOTE:—

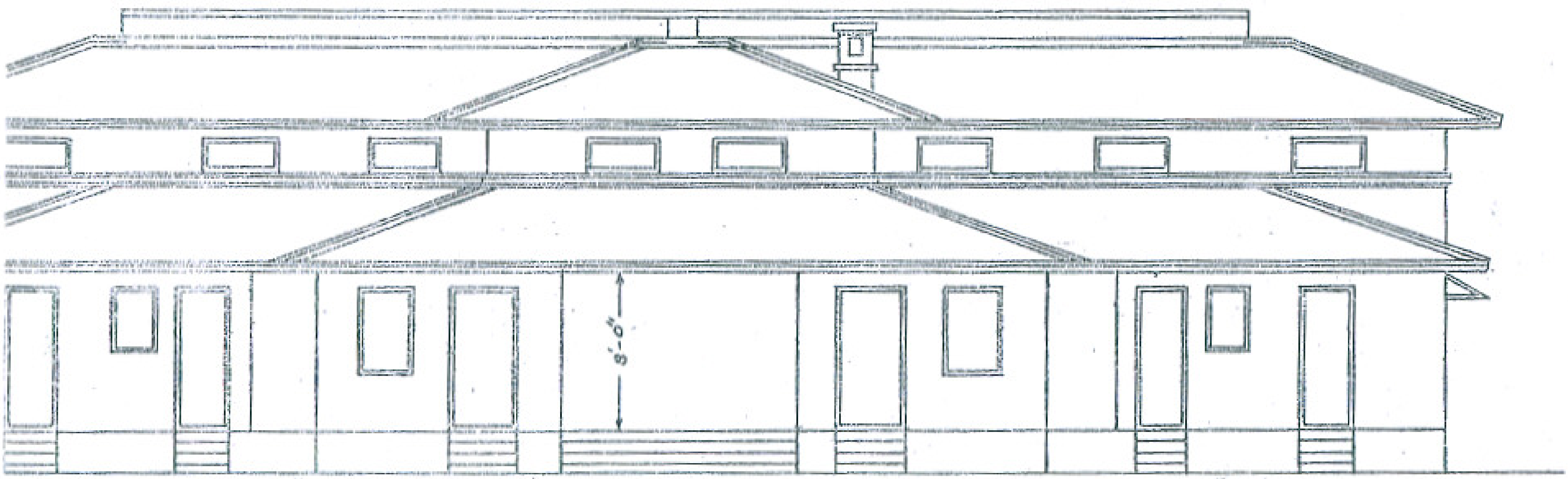
ALL TRUSSES AND VERANDAH RAFTERS TO BE CONNECTED DIRECT TO THE STANCHIONS, TRUSSES TO BE PROPERLY STIFFENED TO GETHER BY DIAGONAL BRACING AS INDICATED ON PLAN VIDE FIGURES X-X

NOTE:—

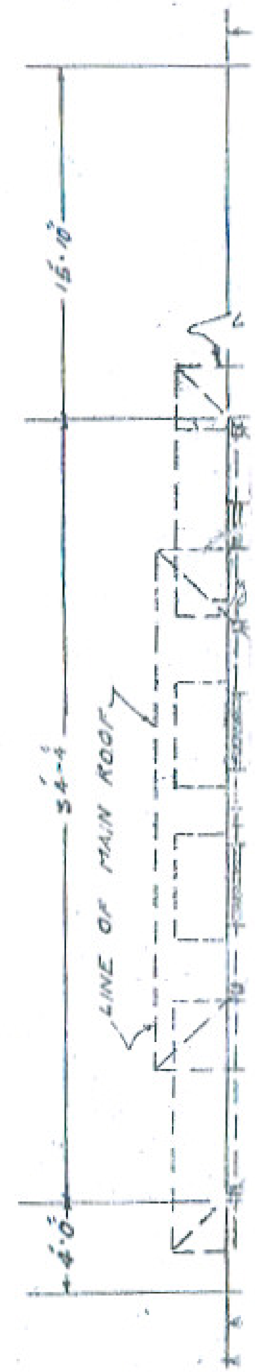
ALL DOORS TO BE 4'×7'-6" ⅓ PANEL ⅔ GLAZED WINDOWS TO BE 4'×5' GLAZED
CLERESTORY WINDOW 4'×2' EXCEPT FOR BATH ROOM WHICH WILL BE 3'-6"×2'-0"
GRATED DOORS FOR HAJAT & MALKHANA 4'×7'-6"
CLERESTORY WINDOWS FOR HAJAT & MALKHANA TO BE FIXED GRATING WINDOWS
FOR MALKHANA 4'×5' WITH IRON GRATINGS & GLAZED DOORS FOR TREASURY ROOM
4'×7'-6" GRATED ⅓ PANEL ⅔ GLAZED.



FRONT ELEVATION



BACK ELEVATION



DISCUSSION

The **Author,** in introducing his Paper, said that he had very little to add to what he had said in his Paper. He mentioned that when he came to set down in writing an account of the reconstruction work in North Bihar he found that no clear idea could be given of the magnitude of the task without giving a brief account of the havoc wrought.

Such a catastrophe brought the normal administrative machinery to a standstill and the reorganization of this machinery to meet the new state of affairs and the creating of a condition in which the technical services could perform their proper functions was probably the most difficult part of the problem.

As regards the technical details of the new buildings, engineers found themselves in the presence of forces which they could not measure and which would act at a time and in a direction which could not be predicted. The solution arrived at in North Bihar was within the limits of reasonable expense.

One or two printer's errors required to be pointed out :—

On page 216 in the paragraph on *Office Staff*, line 11 should read " The quality obtainable in this way was *not* good." The words *no good* as printed were an unmerited slur on the individuals concerned.

On page 224. A whole line had been omitted between lines 14 and 15 of the 2nd paragraph which should read :—

" In the case of Calcutta firms they were always unwilling to allow their designs to pass into the hands of local *contractors but were always willing to submit them direct to the* Superintending Engineer."

Page 236, paragraph 2. Last line should read "The reinforcement in bands to consist of 3/8" diameter rods of copper bearing steel."

Same page, paragraph 4 should commence, :—
" The main *roof*"

Mr. **M. S. Dhody** said that the earthquake of 1897 that occurred in Shillong (Assam) was more destructive to property, if not to human life, than that of 1934 was in Bihar. Houses in the Civil Station built in stone masonry without any through bond as was the prevailing practice suffered the most. The larger the house, the heavier the walls, and the greater the collapse. The lighter type of houses belonging to the Khasia people which had a low plinth wall and where rough wooden posts supported a thatched roof suffered the least. The walls in these buildings consisted of reeds held in panels between the posts and were plastered with mud. There was nothing in this to come down with a crash. This gave the cue to a future safe design that would resist earthquake shocks. A study of the literature on the problem that was received from Japan (which suffered heavily from earthquake tremors of great intensity and frequency) confirmed the views as to the type of building that might be adopted.

Briefly, the specification would be as under:—

Foundation and Plinth.—This was built in stone masonry and in lime and surkhi mortar with through bond stones adequately spaced.

Wooden sill.—A sill of 8″×4″ hard timber was laid flat on the plinth.

Wooden framework.—Wooden posts were mortised into the sill in such a way that they stood in corners of rooms or formed vertical members for doors, windows, etc. Horizontal timbers were given at the levels of window cills or door tops.

Wall plates.—These joined up the tops of the posts.

Iron work.—The posts were held to wooden sills and wall plates by means of angle straps with through bolts and corkscrews as laid down by the engineer-in-charge.

Wooden roof trusses.—Depending on the size of the rooms, wooden trusses were designed and placed to obtain a suitable roof plan and elevation and then other rafters, valleys and purlins were given.

Roofing.—This was done in C.I. Sheet or teak according to the class of building in hand.

Wind ties.—Flat iron wind ties were fixed over the C. I. sheets to hold the roof down to the rafters and purlins.

Wall filling.—This was done in panels of suitable dimensions in double or single lath and plaster work for ordinary buildings or in expanded metal for superior buildings.

The type of buildings described in the above specification gave complete satisfaction and sense of safety in all the buildings from Government House down to a small store in a place where the frequency of earthquakes might safely be put at one a day as far as five years after the earthquake that occurred in 1897.

The Speaker said it would be of interest to know if such a proposal was considered, or considered and tried, or considered and given up; and to know the reasons. The cross sections of buildings as given in the Paper would show that masonry walls were given in the majority of buildings constructed in North Bihar. In Shillong the only work above plinth that was done in masonry brickstone was a fireplace, though here too the chimney and chimney breast were done in sheet iron covered with asbestos and expanded metal respectively.

Mr. **G. C. Trehan** said that the subject of Paper was of particular interest to North Western Railway engineers who had to design and execute structures to withstand earthquake shocks in an area of considerable seismic activity where the recent disastrous cataclysm in Quetta following so closely on the heels of the one in Bihar (the subject of this Paper) must still be in the memory of all. The work of re-construction of railway structures damaged or destroyed during the last Quetta Earthquake in 1935 was still in progress and a railway engineer was naturally keen to compare notes with others who were, or had been faced with similar problems elsewhere, and to benefit by their experience.

Most of the descriptive portion of the Paper, dealing with the question of organization, relief measures, control of prices of material, etc., was, however, of general interest and called for no comments from an engineering view point. The structural details of the types adopted and the specifications, however, called for some remarks.

The Author's statement that the specifications for the types adopted were merely evolved from a careful study of the replies to the questionnaire issued on the subject, and that no calculations were ever made to determine the strength of the proposed structures against earthquake shock, was startling. He had sought to justify this by suggesting that calculations were only necessary for tall buildings, and that single storey buildings needed no such consideration. The distinction was unscientific, considering that inertia forces followed identical laws and applied equally to low and to tall buildings. The only point of difference in these two types of buildings was that whereas in tall buildings there was a possibility of their period synchronizing with that of the earthquake, no such possibility existed in the case of low buildings—a fact which could easily be expressed in mathematical terms and just as easily allowed for in calculations. Even with our present limited knowledge of the effect of seismic forces on structuress, enough was known for a careful designer to be able to fairly assess the value of these forces in most cases, and to provide for them adequately. Any designs, therefore, that neglected to take these into account scientifically were apt to be either inadequate or wasteful through wrong proportioning and wrong distribution of strength between the various parts of a structure.

The Speaker said that the Author was right when he went on to say that in epicentral regions the fact of a shock was so severe that the forces acting were not susceptible of calculation. In such areas, however, it did not appear advisable to erect buildings having brick panelling and isolated foundation footings of the sort provided by him in the Slump Belt in Bihar, which could not but be dangerous for the occupants. Light huts or completely framed steel or R. C. structures, filled with light R. C. panels used with some suitable insulating material like *Heraklith* and having an R. C. mat foundation, would appear to be more suitable.

The Author had mentioned two types of earthquake proof buildings erected in Bihar, viz., (*i*) Ordinary type, and (*ii*) Slump type. He did not clearly specify the areas where these two types of buildings had been erected, but he presumed that the Slump type had been erected in the Slump Belt shown shaded in Plate I and the Ordinary type elsewhere. From Plate I it would appear that the Slump Belt comprised the whole of the epicentral tract in which intensity "X" of Rossi-Forel scale was said to have been experienced and a large portion of the area bounded by isoseismal IX whereas most of the remaining area, where re-construction had been done, was bounded by isoseismals VIII and IX. The following table gave the maximum acceleration of the earthquake motion pertaining to intensities VIII, IX and X of Rossi-Forel scale :—

SCALE VIII.

(*i*) From 1·75 ft./sec^2. to 3·33 ft./sec^2 or roughly from $\frac{1}{5}$ to $\frac{1}{10}$ of the acceleration due to gravity.

SCALE IX.

(*ii*) From $\frac{1}{10}$ to $\frac{1}{5}$ of the acceleration due to gravity.

SCALE X.

(*iii*) From $\frac{1}{5}$ to $\frac{1}{3}$ of the acceleration due to gravity.

From these it would appear that the Slump type was calculated to withstand the ground acceleration up to $g/3$ and the Ordinary type up to $g/5$. The structural details adopted for such high ground accelerations were extremely inadequate.

In case of Ordinary types the bracing members in the form of R. B. bands and ties connecting stanchions were too weak. The New Zealand Byelaws which provided for a maximum ground acceleration of $g/10$ laid down the following standards under similar conditions, *i.e.*, for single storey buildings having intersecting walls at distances not exceeding 50 ft. centres).

Thickness of wall	*Depth of R. C. band*	*Longitudinal reinforcement*	*Stirrups*
9″	$13\frac{1}{2}$″	4 rods, $\frac{5}{8}$″ dia.	$\frac{1}{4}$″ dia.
$13\frac{1}{2}$″	$13\frac{1}{2}$″	,, ,, $\frac{3}{4}$″ ,,	$\frac{1}{4}$″ ,,
18″	$13\frac{1}{2}$″	,, ,, $\frac{3}{4}$″ ,,	$\frac{1}{4}$″ ,,

In this type, moreover, the use of an R. B. ceiling was apt to be dangerous for the occupants.

In case of the Slump type buildings, if calculated to withstand a maximum ground acceleration of $g/3$ nothing but completely braced and panelled R. C. structures with continuous mat founds would be adequate. The construction shown in plates V and VI combined the use of R. S. joist stanchions and brick panels—a most unsatisfactory combination. In the Japanese Earthquakes of 1923 Dr. Naito had found that buildings with steel frames and brick masonry walls which had been previously favourably considered had suffered open cleavage in the walls. Moreover, the 10″ thick brick partitions standing to a height of 16 ft. and having no adequate bond with R. S. joist columns whose strength had not been considered from the seismic point of view afforded a very unsatisfactory design.

On the North Western Railway where provision had been made for a maximum ground acceleration of only $g/8$ the following main features had been embodied in the "Framed Type" which corresponds to the "Slump Type" in Bihar:—

(*i*) The main building frames consisted of R. C. columns braced horizontally with R. C. beams placed at the floor, lintel and eaves levels.

(*ii*) The wall panelling was of brickwork in cement mortar reinforced longitudinally every fourth course and securely bonded to the R. C. columns at each end.

(*iii*) The foundation was of a continuous ribbed mat type or of braced beam type.

(*iv*) Roofing was of light steel trusses, securely anchored to the bearing walls.

The strength of all the members in all cases had, moreover, been carefully calculated in accordance with the latest methods applicable to rigid framed structures. In spite of the above, the figures so far available showed that the cost per square foot of plinth area of the buildings already completed compared very favourably with those shown by the Author for his Slump type buildings. This cost in case of the biggest type of quarter so far built came to Rs. 5/12, as against Rs. 5/7/3 to Rs. 5/10 shown by the Author, and when it was considered that the cost of labour and material in Baluchistan was inordinately high, when compared to that in Bihar, it showed clearly the economies that could be effected through careful planning and scientific design.

Mr. **Trevor Jones** noticed that reinforced brick work was generally advocated for the reconstruction work. He understood that a great many of the Government buildings at Patna were originally constructed by this method, and it would be of interest to know the real facts as to how reinforced brick work withstood the earthquake.

Mr. **S. L. Kumar** remarked that the Author had divided the devastated area into two sub-divisions—one the slump belt and the other the area outside the slump belt. It was clear from the specifications given at the end of the Paper that the new buildings inside the slump belt were very much stronger and more rigid than those rebuilt outside it. This distinction was based on an assumption that the next severe earthquake whenever it occurred in this Province would have its epicentres somewhere in the slump belt. This assumption was not supported by statistics which indicated that no two earthquakes had originated from precisely the same location of the epicentre. It would have been much better if this fact had been appreciated and all reconstructed buildings of the same importance should have been designed for the same strength all over the affected area.

The use of *nurria* tiles above the corrugated sheet roofing without any firm anchorage was to be deprecated. In the reconstruction of Railway buildings in Baluchistan where extremes of temperatures were common, the Railway had provided the necessary insulation against heat and cold by using a ceiling of wooden planks under the C. I. sheets.

On page 230, the Author had stated that "the value of buttresses was doubtful though the Muzaffarpur Church was practically undamaged". Mr. Kumar thought that the buttresses certainly strengthened the buildings. In the Mach earthquake of 1931 the loco shed, though of brick work in lime mortar, stood intact because of the buttresses, though not a single building in the neighbourhood survived the shock.

Nowhere in the specifications had it been stated that doors and windows should open outwards to provide easy exits during earthquake. It was hoped that this important feature of the earthquake resisting construction had not been overlooked.

Mr. **Freak**, referring to the remarks of another speaker on wooden frame or *dhajji* construction as a type of earthquake resisting building, said that care needed to be taken that such wooden frame construction was not used where it was liable to attract white ants. After the 1905 earthquake in the Kangra Valley, many buildings there were constructed of the *dhajji* type and these proved their worth in the severe earthquake of 1917. However in Lower Dharamsala at under 4500 feet elevation, white ants were particularly voracious and roof timbers of one house in particular had already had to be replaced twice by 1931 due to damage by white ants and so it was extremely doubtful if the wooden frame work of that house was now of any use at all. Mr. Freak stressed that it was no use putting faith in a wooden framework as being earthquake resisting if that framework was liable to serious attack by white ants. The Speaker also enquired whether the special anti-corrosive steel used in reinforced brickwork had proved successful. In Lahore he knew of cases where ordinary steel in reinforced brickwork had rusted right through and in one particular case a first floor verandah floor was giving trouble, though only exposed to beating rain coming in through the verandah openings.

The **Author** in reply to Mr. M.S. Dhody said that he was not able to say with certainty whether the type of building described as adopted in Shillong after the Assam Earthquake of 1897 was considered for use in Bihar. It might be pointed out however that the principle of a strong frame work tying the whole building together and transmitting the weight of the roof direct to the foundations was adhered to in the Bihar Earthquake specification in which a Reinforced Concrete Framework took the place of the wooden framework in Assam and in the Slump Area type a steel framework was used and the brick panelling of the walls kept as light as possible. The Assam type was the lighter but the less durable of the two.

In reply to Mr. Trehan, the Author said he was not able to agree that the same laws applied to low and tall buildings. The accelerations produced by earthquake shock were worked out by Japanese engineers by the use of models and by observation of tall buildings of several stories. The movement of such buildings was controlled by their harmonic periods. Buildings of cubical shape have no harmonic period. A building with walls 16 ft. high had height as its least dimension and the possibility of harmonic period in the case of buildings of great length was provided for by articulation joints. Mr. Trehan admitted that in a severe shock the forces acting were not susceptible of calculation and yet claimed to make accurate calculations for the buildings subject to such shocks. He did not agree that the Bihar Slump Type was dangerous. No building was safe from damage but he was confident that the Bihar buildings would not collapse wholesale on their occupants, which was the main cause of mortality in an earthquake. The difference between the Slump area and the area for which the "Slump Type" was specified was fully described in the Paper. Mr. Trehan gave the precise acceleration for different degrees of the earthquake scale. If we were confident of this we could design accordingly but when the ground opened and part of a building was torn off from the remainder and sank a foot or more, no reinforced concrete mat foundation or rigid frame work that was within practical limits was going to prevent that disruption. The object aimed at in Bihar was to design buildings which would not collapse on the occupants even when so disrupted.

Regarding Mr. Trevor Jones' remark he said that the reinforced brick ceilings used in Government buildings in Patna stood remarkably well in the earthquake. The shock was sufficiently severe to send all the occupants of the courts and offices scrambling for the open air but very little damage was done except to a high clock tower on the Secretariat building which had since been reduced in height and strengthened.

Replying to Mr. S. L. Kumar the Author disclaimed any ability to predict the point of origin of the next earthquake but an earthquake map of the world showed that the areas of greatest frequency occurred where there was a sudden structural change in the earth's surface. For example, the rock formation of the Himalayas extended steeply downwards to a great depth below the Gangetic plain which made it probable that the centres of origin of future earthquakes would occur near the foot of the mountains rather than near the River Ganges. The Author agreed that the use of *nurria* tiles was inadvisable as already stated in the Paper. The question of buttresses was very difficult to decide. Their value seemed to depend very much on the direction of movement. The church at Muzaffarpur stood well, almost undamaged, while the racquet court completely collapsed. Similar discrepancies were noticed elsewhere.

As regards Mr. Freak's comments the Author remarked that the caution as to the use of wooden framework because of its liability to destruction by white ants was timely and a useful contribution to the subject. Sufficient time had not passed to report on the value of "anticorrosive steel". The Author personally attached more importance to keeping the joint in which the steel was laid thick, and working the cement mortar so as to remove air bubbles and surround the steel with a dense cement mortar. If air were present in a porous concrete, corrosion of the steel would occur whenever damp penetrated it.