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REPORT
ON
STORAGE STRUCTURES

COMMITTEE ON PLAN PROJECTS
(Buildings Projects Team)
NEW DELHI
August, 1961



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Composition of the Team for Selected Buildings Projects.

Leader

Shri S. K. Patil, Minister for Food and Agriculture.

Members

Shri Sarup Singh, ISE (Retd.), formerly Director, National Buildings Organisation.

Shri N. G. Dewan, ISE, Chief Engineer, Central Public Works Department.

Maj. Genl. Harkirat Singh, Engineer-in-Chief, Army Headquarters.

Dr. Eng. A. Carbone, Consulting Engineer, Calcutta.

Shri C. P. Malik, Director, National Buildings Organisation (*ex-officio*).

Member-Secretary

Shri T. S. Vedagiri, Superintending Engineer.



MINISTER FOR -
FOOD AND AGRICULTURE
GOVERNMENT OF INDIA
New Delhi, January 10, 1961.

My dear Chairman,

I am sending herewith a report of the Buildings Projects Team on Storage Structures. You will recall that the first subject taken up by the Team for evaluation was the construction of grain godowns. We brought out a report which was accepted by the Ministry of Food as well as by the Ministry of W.H. & S. The solution then proposed was an *ad hoc* one to meet the immediate needs of the situation, specially for large sized storages.

Now the requirements of storage facilities of various type and capacities have increased so as to cope with the increased food production and large scale imports from abroad. Considering the magnitude of the problem and the changing situation in the availability of materials, we considered it worthwhile to examine the question in a broader perspective and evolved several designs which could be adopted at different places in the country to suit the needs of the different regions and demands of varying situations. The study was undertaken by a composite Panel under the chairmanship of Shri U. J. Bhatt, Chief Engineer (B. & R.), Government of Gujrat. The Ministries of Food and W.H. & S. were fully represented on the Panel. A representative of the Warehousing Corporation was also associated with the work of the Panel.

After considering a number of alternatives the Panel has recommended a few typical ones and has given broad indications as to the considerations, both technical and financial, that should govern the selection of a particular type. I hope the report will be of use to the Ministry of Food as well as the Warehousing Corporation who have a big programme of construction before them.

I take this opportunity of thanking Shri U. J. Bhatt, Chairman of the Panel and other Members for the trouble they have taken in preparing this report.

Yours sincerely,
S. K. Patil

Chairman,
Committee on Plan Projects,
Government of India,
New Delhi.

REPORT ON STORAGE STRUCTURES

CONTENTS

REPORT	PAGES
0. Introduction	i—iii
1. Sizes and Spans of Warehouses	1
2. Structural Pattern	2
3. Specifications and Costs	5
4. Suggestions for further Economy	8

Appendices

I Description of Alternatives,	10
II Relative merits of different structures	12
III Cost study of alternative structures	14
IV Abstract of Estimates	16
V Cost study of C.G.I. sheet vs. Asbestos Cement sheet	30
VI Present-Worth-Cost study of different structures	32

Plates

Indicative Sketches (I—VII)

INTRODUCTION

0.1. The Committee on Plan Projects took up the study of grain godown in 1957 when difficulty was experienced in getting structural steel sections. The Panel set up for this purpose analysed a number of alternative designs, namely, (a) timber trusses and purlins with sheeted roofing, (b) pre-stressed concrete girders and rafters with sheeted roofing, (c) modified steel trusses and purlins with sheeted roofing and (d) shell construction.

0.2. Considering the acute shortage of timber for structural purposes and the necessity of putting up large number of godowns for storage, the Panel did not recommend the adoption of timber roofing for godowns at that time. Similarly, the pre-stressed concrete alternative was ruled out due to want of high tensile steel wire and equipment. The Panel could not recommend steel trusses as the very purpose of setting up of the Panel was to explore ways and means of curtailing the use of structural steel. After processing a number of other alternatives in concrete, the Panel came to the conclusion that shell construction with a chord width of 90' and a double span of 35' would meet the requirements. The width of 90' was chosen to eliminate the central row of columns and the valley gutters which are always a source of trouble and recurring expense.

0.3. The report of the Panel was accepted by all concerned and the C.P.W.D. has already constructed a few godowns with shell roof in Calcutta and has programmed to extend it to Delhi and Bombay. The solution then proposed was *an ad hoc* one to meet the immediate needs of the situation, specially for large sized storage.

0.4. In the planned development of the country, emphasis is being laid on increasing the production of foodgrains. Noticeable progress has already been made. At the beginning of the First Plan, in 1950-51 the food grains production amounted to 52.2 million tons. At the end of the First Five Year Plan, in 1955-56 it amounted to 65.5 million tons and in 1958-59 to 73.5 million tons. At the end of the Second Five Year Plan, the production is expected to go up to 75 million tons and by the end of the Third Five Year Plan to 100-105 million tons. Along with the efforts to increase production, it is proposed to maintain sufficiently large quantities of food grain in reserve to stabilize prices and meet emergencies.

0.5. It is estimated that about 30 to 35% of food grains produced in the country move through trade channels. These would need storage facilities right from the centre of production to the centre of consumption. Construction of storage structures with varying capacities, therefore, becomes essential. Further, large scale imports of food grains are expected in the next few years, which would require additional storage facilities. Considering the magnitude of the problem and the changing situation in the availability of steel, the Committee on Plan Projects considered it worthwhile to re-examine the question in a broader perspective and evolve several alternative designs which could be adopted at different places in the country, to suit the needs of different regions and the demands of varying situations.

0.6. A Panel to consider this question, was set up in consultation with the Ministry of Food & Agriculture. Its composition is as follows:—

Shri U. J. Bhatt, Chief Engineer (B&R), Public Works Department, Ahmedabad.	Chairman
Shri V. D. Bhandari, Central Warehousing Corporation, New Delhi.	Member
Shri O. Muthachan, Addl. Chief Engineer, Food Zone, C.P.W.D., New Delhi.	Member
Dr. S. V. Pingle Director Storage, Ministry of Food & Agriculture, New Delhi.	Member
Shri K. V. Thadaney, Regional Engineer, Concrete Association of India, 9, Mount Road, Madras.	Member
Shri K. G. Rajagopalan, Superintending Surveyor of Works, Central Public Works Department, New Delhi.	Member
*Shri R. P. Mhatre, General Manager, Hindusthan Housing Factory, New Delhi.	Member
Shri T. S. Vedagiri, Superintending Engineer, Buildings Projects Team, New Delhi.	Member-Secretary

*Shri S. D. Pathak, General Manager, Hindusthan Housing Factory, New Delhi, took the place of Shri R.P. Mhatre from September, 1959 as the latter was transferred to Bombay.

Shri P. M. Thomas, Storage Adviser, Central Warehousing Corporation, also attended the last meeting of the Panel.

0.7. A preliminary meeting of the Panel was held on the 6th June, 1959 in New Delhi. The Panel had its first meeting on the 30th September, 1959 in New Delhi, followed by three meetings held on the 15th March, 1960, the 12th and 13th of July, 1960 and 2nd & 3rd December, 1960.

0.8. The Panel during its meetings considered in detail the requirements of bagged storage as most of the grain which flows in trade channels is handled in jute bags. The Panel is aware that it would be more expeditious and economical to handle and store grain in bulk as done in countries like the U.S.A., Canada and Argentina. Its adoption in this country, however, is beset with difficulties at present as there are no suitable arrangements for carrying and storing grain in bulk. As bulk storage affords better preservation of grain over longer periods, economy in space and saving in the cost of bags and bagging, it is necessary to create facilities progressively for resorting to it in future. These facilities will include varying capacities of bulk storage in the distribution centres, mechanical equipment for charging and discharging, suitable wagons and trucks for bulk transport by rail and road etc. The structural arrangements for bulk storage are under active consideration of the Panel and will be dealt with in a subsequent report.

1. SIZES AND SPANS OF WAREHOUSES

1.1 The capacity of storage at different places has to vary with the purpose of storage and the demands of different locations. Keeping in view the programme before the Ministry of Food as also that of the Warehousing Corporations, the Panel would recommend that storage buildings should be of three categories: small, medium and large. The small storage buildings will have a capacity of 100 to 500 tons, the medium will have a capacity of 500 to 1,000 tons and the large ones above 1,000 tons.

1.2 The size of warehouses for these different capacities depends upon the size and shape of plot available, the mode of transport, rail or road or both, the stacking arrangements for optimum utilisation of godown space and the lead involved in handling within the godown.

1.3 Godowns of small capacities will be required in interior locations where transport will be invariably by road. There is no necessity to provide elaborate platforms in these cases. A covered doorway would suffice. The spans adopted should be such as to facilitate the use of materials like timber where good quality is available at comparatively low cost. The fixing of spans also depends on the special storage requirements of commodities like spices and copra which require relatively narrow godown space. Considering these factors as well as the size of stacks for optimum space utilisation, the Panel would recommend the adoption of single or double spans of 20'. The length can be adjusted to suit the requirements.

1.4 For medium storage, single or double spans of 30' would be suitable. Platforms can be provided on one side or both the sides according to requirements. There is, however, no need to roof the platforms fully. Suitable covers over doorways should suffice.

1.5 For large godowns, double spans of 45' or a single span of 90' would be advantageous. Platforms on both the sides, one to serve the rail and the other to serve the road would be necessary. Roofing should normally be provided over these platforms except in places where rainfall is very low. Where there is no roofing suitable covers may be provided at entrance doors.

2. STRUCTURAL PATTERNS

2.1. Having decided upon the size and spans of godowns of different capacities, the Panel analysed various structural arrangements that are possible. It is obvious that no single pattern can be prescribed for these godowns as the availability of material, labour and fabricating capacity vary widely from place to place. Further, the time element involved in construction also plays a prominent part. Considering this, the Panel would recommend the adoption of the following patterns for different spans, as given below:—

20' Span

- (a) Timber Trusses and rafters with sheet roof.
- (b) RCC Gable frame and RCC purlins with sheet roof.
- (c) Precast RCC rafters and sheet roof.

30' Span

- (a) Timber trusses and purlins with sheet roof.
- (b) RCC Gable frame and RCC purlins with sheet roof.
- (c) Space purlins of Structural Steel with sheet roof.
- (d) Precast prestressed truss and purlins with sheet roof.

45' Span.

- (a) RCC Gable frame and RCC purlins with sheet roof.
- (b) Space trusses of steel and steel purlins with sheet roof.
- (c) Tubular Trusses with sheet roof.
- (d) RCC semi-elliptical shell.
- (e) RCC segmental Shell with 90' chord width without central row of columns.
- (f) Precast Prestressed Truss and Purlins with sheet roof.
- (g) Timber Truss with Sheet Roof.

2.2 The Panel would emphasize that while choosing the particular type of structure to be adopted the economic aspects of several alternatives should be studied in a realistic manner taking into account not only the initial cost of outlay but also the recurring cost of operation and maintenance including insurance and the effect of economic lives of different structures.

2.3 In such an analysis it is possible to exhibit and account for the tangibles such as the cost of operation and of maintenance. There will be certain intangibles which will not be susceptible for evaluation in monetary terms. All these have been listed out so that a comprehensive consideration is possible while deciding upon the type of structure at a particular location at a point of time, vide Appendix II.

2.4 In order to justify the expenditure of time and money, an economy study on the basis of the following is quite necessary:—

- (1) It should be based upon consideration of all available factors.
- (2) The cost of construction etc. should be intelligently estimated in the light of experience and sound judgement.
- (3) The study should show a measure of financial efficiency based on any of suitable methods listed below.
- (4) The study should contain a recommended course of action together with the reasons for the recommendations.

2.5 There are several procedures for making such studies. Each procedure has certain advantages and limitations. Some of them are applicable only to industrial processes. The patterns suitable for application to public works where alternative structures of different lives are to be considered are (a) the Present-Worth-Cost Method and (b) the Capitalised-Cost Method. Of the two the Present-Worth-Cost procedure provides a more satisfactory and realistic basis.

2.6 The Present-Worth-Cost may be computed in two ways. The first determines the present worth of the annual costs. In this case depreciation, taxes, operation and maintenance costs, and amortization of non-recurring expenses are included. The Procedure is most advantageous when the annual cost will be uniform throughout the life. For these conditions the basic pattern is Present-Worth-Cost $(D + C + M + I)a_L$
 Where D = Depreciation (Annual)

$$= \frac{\text{Original Cost—Scrap value at the end of life.}}{\text{Amount of Annuity of 'one' for Life in Years}}$$

- O = Operation Charges (annual)
- M = Maintenance Charges (annual)
- I = Interest on borrowed capital (annual)
- a_L = Present Worth conversion factor for 'L'
Number of Years of life.
- L = Life in years (period)

2.7 More generally, the expenditure is not uniform every year. For this condition the present worth of all lump-sum expenditure plus the present worth of any recurring annual expenditure is determined.

2.8 It is customary to include the first cost of all assets thus eliminating the consideration of amortization costs. The inclusion of first cost provides for recovery of capital plus a return on the investment. Using this very general concept the basic pattern for a Present-Worth-Cost is $C + (O + M + I)_1 v^1 + (O + M + I)_2 v^2 + \dots + (O + M + I)_L v^L$ where C equals first cost of assets; O, Operation Charges; M, Maintenance Charges; I, Interest on borrowed capital and v^n the Present Worth conversion factor.

2.9 The importance of such an analysis lies in the fact that it takes into account not only the capital cost of construction but also the cost of operation and maintenance throughout the life of the structure. Where lives of two structures are different, the effect of this also is reflected in the analysis.

2.10 Applying this principle of Present-Worth-Cost six alternative structures for twin spans of 45' have been analysed and the results are given in Appendix III. The method of arriving at the Present-Worth-Cost is given for three cases in Appendix VI for reference.

2.11 The alternatives suggested for Storage Structures in para 2.1 above may be broadly grouped into two categories namely a) structures with sheeted roof, b) Structures with non-sheeted roof. The sheeted roof structure can again be subdivided into those having Tubular Truss, Welded Frame, RCC, or Prestressed Concrete supporting structures etc. The relative merits of these structures are given in Appendix II. Plans of these alternatives together with brief descriptive notes (vide Appendix I) are also appended to this report.

3. SPECIFICATIONS & COSTS

3.1 The godown must satisfy the basic requirements of storage. They should be leak proof, damp proof and rodent proof. The specifications for different components of the structure must satisfy its requirements commensurate with its economy. Certain suggestions of the Panel in this behalf are listed below:—

(i) Foundation

The present practice is to take the foundation of the columns to a depth of 4 feet below ground level under normal conditions, the longitudinal panel walls to a depth of 2'-6" and the gable end walls and platform retaining walls to a depth of 3 feet below ground level. This is quite satisfactory.

(ii) Plinth Height

The plinth height adopted at present is 3'-6" above ground level to facilitate loading and unloading from railway wagons. Where there is no provision for railway siding, plinth height can be reduced to 2'-6" and in particularly high location even to 2'. To keep off the storm water the top of the coping over the edge of platform may be kept 3 inches lower than the floor level of the main godown, the difference being effected by providing a fall of $1\frac{1}{2}$ inches across the doorway and $1\frac{1}{2}$ inches across the platforms.

(iii) Height of Walls

The height of wall depends upon the type of roofing and the height of stacks. It has been possible to increase the height of stacks to 15'. Further increase may not be possible as the grain in the lower layers will get crushed. It would be sufficient if $1\frac{1}{2}$ ' clearance is given above the edge of stacks near the wall provided further clearance is available towards the ridge. This is possible in roofs without tie beams. In these cases the height of wall can be so kept that a clearance of $16\frac{1}{2}$ ' is available at a distance of 2'-6" from the wall. In cases where ties and bracings are to be adopted the wall height must be 17'-6". In particular cases where the height of stacks can be further increased the wall height may go upto 20'.

(iv) Thickness of Walls

The present practice of constructing brick masonry walls $13\frac{1}{2}$ inches thick may be continued. This may be increased suitably in case of 20 ft. high walls in heavy wind pressure zone. Where stone masonry is adopted, the walls may be 15" or 18" thick according to the quality and size of stone available.

In gable ends, pillar and panel construction can be adopted with either masonry or reinforced concrete pillars and $13\frac{1}{2}$ " thick panel walls in between pillars.

(v) Flooring

The flooring in a grain godown should be damp-proof, rigid and durable. It is considered that 9 inches thick layer of pure sand, free from all deleterious materials, especially clay, or cinder, whichever is cheaper should be provided under the rigid part of the floors. Prior to sand or cinder filling, the earth filling under the floor must be properly stabilised as otherwise, there would be danger of settlement and cracks.

The top layer of the floor may consist of 4 inches lime or lean cement concrete 1:4:8 with 2" thick wearing surface of rich concrete 1:2:3.

The provision of Ironite, Hardonate or Rockite is prohibitive and may be avoided.

Where the sub-soil water level is within 5 feet of the prevailing ground level or conditions otherwise demand, a membrane of tar-felt (3 ply) or alkathene sheets film of not less than 400 G., may be introduced between the base course and the wearing surface.

If it is difficult or expensive to obtain clean sand, two-coat treatment of Bitumen at 50 lbs. per 100 sft. should be given above the lean concrete course. In such cases, the thickness of the sand layer can be reduced to 6 inches.

(vi) Finish of walls

For cleanliness it was considered necessary that the inside of the walls may be plastered and white washed. The outside may be pointed or plastered.

(ii) Ventilation

Adequate ventilation within the godown is essential for preservation of grain. Ventilators, therefore, must be provided in all walls both at top and bottom. The top ventilators should have wire gauze protection on the external side and provided with central or bottom hung shutters to keep off moisture. The lower ventilators should have expanded metal or grill protection outside and sliding or hinged shutters and wire gauze on the inside.

(viii) Lighting

The light derived from the ventilators on all sides appears to be quite sufficient, more so if the length of the godown is limited to 100 feet to 200 feet. Hence it is considered that the provision of skylight in the roof is not essential.

(ix) Platform Protection

The Platforms should have a minimum width of 8 feet. Where they are utilized for weighing, batching, drying and temporary storing of grains, they require adequate covering also. The present practice is to have 8 feet wide platform on roadside and 10 feet wide platform on rail side.

To prevent damage to the platform by the backing of transport vehicles, it should be provided with wooden fenders throughout, backed by hard rubber backing at intervals.

(x) Drainage

It is considered desirable to avoid location of down water pipes and drains inside the godown. This could be made possible if the length of the godown is limited to about 150 feet where water can be drained off along the valley right outside the godown. This would require a fall of 9 inches on either side which can be achieved by raising the central columns by 9 inches and arranging the height of other columns suitably.

3.2. Costs

Details of estimates of cost and requirement of materials have been worked out for the several types of structures cited above. Abstract of cost of each type is given in Appendix IV Tables 1-6. The estimates are based on the current schedule of rates applicable for Delhi. The designs have been made to suit the wind pressure of Zone III and for bearing capacity of soil of 1 Ton per sq. ft.

The Panel hopes that the information regarding cost and consumption of materials will be useful to the authorities in making comparative economy studies, for fixing up the type of structure to be adopted.

4. SUGGESTIONS FOR FURTHER ECONOMY

4.1. The recommendations in the earlier section of the report deal with the structural pattern and specifications to be adopted for grain godowns with a view to achieving economy and efficiency. It is possible to effect further economy through standardisation, institution of work study on the entire pattern of handling and storing of grains and other commodities and organised research on the type of structure and materials to be adopted for such construction.

4.2. Standardisation

4.2.1. The need for finalising designs and specifications before the award of work needs no special emphasis. Experience shows that frequent and major changes during execution are not uncommon leading to contractual obligation and delay in execution. With the material available in this report, it is hoped that it would not be difficult for the departments concerned to standardise the design for grain storage structures in order to minimise, if not totally avoid the changes during execution.

4.2.2. Where shell or folded plate construction is adopted, it will be an added advantage to standardise the shuttering and supply the same departmentally to contractors or else tenders may be called for group of godown in an area in order to facilitate repetitive use of shuttering which will certainly lead to reduction in cost.

4.3. Application of Works Study

4.3.1. Works study represents a philosophy of management and all that it implies and connotes is "techniques and analysis with a view to better fact finding, more orderly thinking of work practices and scheduling and ensuring better quality of work within the specified time commensurate with targets fixed." The technique of works study which includes in its purview methods, work measurement etc. has been successfully adopted in U.S.A. and U.K. for critical evaluation of all types of industrial processes. The utility of this technique in assessing and modifying various work procedures with a view to economy and efficiency has been increasingly recognised and its sphere of application is widening day by day. The handling and the storage of grain are such operations where systematic works study may yield rich dividends.

4.3.2. The lay out of stacks within the godowns, the operation of receipt and despatch of grain bags are some of the items where detailed works study would be able to pinpoint sources for economy. In a limited works study sponsored by the Panel, it was found that the utilisation of space within the godowns could be improved by about 10 per cent by changing the length of stacks to 29' and 34', alternately with a constant width of 25'. The aisles in between the stacks could be so manipulated to be brought beneath the roof trusses thus obviating the inconvenience in fumigation. It is gratifying to note that already this factor has been considered and put into practice in less humid regions.

4.3.3. Similarly, the study of handling and operation may be useful in deciding the width of platforms and the necessity of providing platforms on either side. It may also be considered whether it will be possible to eliminate altogether one of the platforms by making a study of the movement of trains and trucks to and fro.

4.4. Research

4.4.1. The Panel during its study has examined a number of structural patterns for adoption, though only a few of them have been recommended in the report. There are other structural patterns such as hyperbolic paraboloid and folded plate construction which have found increased application in foreign countries, especially U.S.A. The Central Building Research Institute in India has recently put up a laboratory with folded plate roof. They have also prepared a type design for grain godowns with roof of folded plate construction. The design is given in plate No. VII.

The advantages of folded plate construction are that the shuttering required is quite simple and with repetitive use, the cost of shuttering would decrease considerably. This type of construction also leads to considerable economy in the consumption of materials in addition to giving an architecturally pleasing appearance. The Panel feels that this type of construction has a great future in this country. The Central Building Research Institute should study in detail the performance and cost aspects of such structure and produce illustrative brochure with a view to promoting this form of construction.

DESCRIPTION OF ALTERNATIVES

1. Sheeted Roof Structure with Tubular Roof Truss.

Plate No. I gives the details of the structure commonly adopted for constructing godowns for storing grains and other commodities. The godown is 90' wide with covered platforms of 8 feet width on road side and 10 feet width on rail side. The structure consists of RCC columns spaced 45 feet apart laterally and 15 feet apart longitudinally with brick masonry walls 13½ inches thick. The roof consists of Tubular Trusses supported on RCC columns and covered with Asbestos Cement Sheets.

2. Sheeted Roof Structure with Mild Steel Portal Frame (Welded).

Plate No. II gives the details. The godowns is 90 feet wide with covered platforms of 8 feet width on road side and 10 feet width on rail side. The structure consists of RCC columns spaced 45 feet apart laterally and 28 feet 7½ inches apart longitudinally, cloaked with brick masonry walls of 13½ inches thick. The roof consists of welded space purlins covered with Asbestos Cement Sheets.

3. Sheeted Roof Structure with RCC Gable Frame.

Plate No. III gives the details of the structure as designed by the Concrete Association of India.

The Godown is 90 feet wide with covered platforms of 8 feet width on road side and 10 feet width on rail side, spaced 45 feet apart laterally and 12'-6" apart longitudinally. The structure consists of RCC Gable Frames and RCC purlins covered with Asbestos Cement Sheets. Platforms are also covered with Asbestos Cement Sheet supported by RCC purlins and RCC framed brackets fixed to the columns.

4. RCC Semi-Elliptical Shell Roof Structure.

Plate No. IV gives the details of the structure with elliptical shell roofing. The godown is 90 feet wide with covered platforms for a width of 8 feet on road side and of 10 feet on rail side.

The structure consists of RCC columns spaced 45 feet apart laterally and 35 feet apart longitudinally, cloaked with brick masonry walls of 13½ inches thick. The roof consists of RCC traverses (frames) supporting the RCC shell continuous over two spans of 45 feet each. The platforms may be covered either with Asbestos Cement Sheet or RCC slab over brackets of RCC or Tubes.

Placing concrete along the edges at angles steeper than 45° would require top forms and greater care in concreting.

5. RCC Segmental Shell Roof Structure.

Plate No. V gives the details of shell roof structure with a chord width of 90 feet.

The godown is 90 feet wide with covered platforms on either side for a width of 8 feet on road side and 10 feet on rail side. The structure consists of RCC columns spaced 90 feet apart laterally and 35 feet apart longitudinally, cloaked with brick masonry walls of 13½ inches thick. The roof consists of RCC Trusses supporting the RCC shell continuous over two or three spans. Provision for expansion is made between the continuous units. The platform roofs covered with Asbestos cement sheets are supported by cantilivered brackets of RCC or Tubes fixed to RCC columns.

6. Sheeted Roof Structure with Prestressed, Precast Truss and Purlins.

Plate No. VI gives the details of the structure as designed by the Hindusthan Housing Factory, New Delhi-1. The godown is 90 feet wide with covered platforms of 8 feet width on road side and 10 feet width on rail side. The structure consists of RCC columns spaced 45 feet apart laterally and 18 feet to 20 feet apart longitudinally cloaked with brick masonry walls of 13½ inches thick. The roof consists of RCC Trusses with Precast Prestressed Members, and prestressed concrete purlins, covered with Asbestos Cement Sheets.

7. Sheeted Roof Structure with Timber Truss.

In places where timber of suitable quality could be made available, it is worth adopting timber trusses and purlins in roofing. The use of timber results in the saving of steel. Recent developments of timber technology make it possible to use even subsidiary species, provided they are seasoned scientifically. The setting up of timber seasoning plants, is, however, a pre-requisite if subsidiary species are to be used for the fabrication of the trusses. Where several structures are proposed to be put up, a small seasoning plant would be quite justified. The plant, set up, could serve construction also in the neighbourhood subsequently.

Laminated construction with nailed joints and with connectors is popular in U.K. and other countries. The Forest Research Institute, Dehra Dun have also conducted useful experiments and have evolved designs of trusses for 45, 50 and 60 feet spans.

RELATIVE MERITS OF DIFFERENT STRUCTURES

Sl.No.	Description of Structure	Tubular Truss	Welded Frame	R.C.C. Gable	R.C.C. shell (Elliptical)	R.C.C. shell (Segmental)	Prestressed Prefabricated Truss
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Capital cost per sft. of Godown Area (C)	9.95	8.05	8.25	9.89	10.32	8.54
2.	Maintenance cost (Comparative) in terms of present-worth per sft. of Godown Area (M)	2.14	2.12	1.93	1.92	2.05	1.96
	TOTAL—C+M(i.e., Items 1+2)	12.09	10.17	10.18	11.81	12.37	10.50

INTANGIBLES :

I. Execution :

(a) Skilled labour or ordinary labour	Ordy.	Skilled	Ordy.	Ordy.	Ordy.	Skilled
(b) Competent firms (A) or ordinary firms (B)	B	A	B	A	A	A
(c) Special trained supervision or ordinary supervision	Ordy.	Special	Ordy.	Special	Special	Special
(d) Special equipment or ordinary equipment	Ordy.	Special	Ordy.	Ordy.	Ordy.	Special
(e) Time of execution more or less	Less (6 months)	(Less 7 months)	Less (7 months)	More (9 months)	More (9 months)	Less (7 months)
(f) Foreign exchange involved, if any	Nil.	Nil.	Nil.	Nil.	Nil.	Yes
(g) Many godowns in a place for economic repetitive use of centering and mould or not	No	No	Yes	Yes	Yes	Yes

II. Efficiency :

(a) Economic Life of structures	Equal	Equal	Equal	Equal	Equal	Equal
(b) Relative maintenance cost	More	More	Less	Less	Less	Less

(c) Flexibility of layout inside Godown	Less	Less	Less	Less	More	Less
(d) Leakage through roof and Valley Gutters	More	More	More	Nil	Nil	More
(e) Effective volume inside Godown	Less	More	More	Less	More	Less
(f) Dispersion of natural light	Less	Less	Less	More	More	Less
(g) Insulation against heat and cold	Less	Less	Less	More	More	Less
(h) Consumption of materials :—						
(i) Structural Steel	Nil	More	Nil	Nil	Nil	Nil
(ii) Mild steel	Less	Less	More	More	More	Less
(iii) M. S. Tubes	More	Nil	Nil	Nil	Nil	Nil
(iv) High Tensile steel	Nil	Nil	Nil	Nil	Nil	Yes
(v) Accessories	More	More	More	Less	Less	More
(vi) Cement	Less	Less	More	More	More	More
(i) Resistance to fire	Less	Less	More	More	More	More
(j) Insurance rates	More	More	More	Less	Less	More

*As long as there is Shortage of structural Steel in the Country, the adoption of these alternatives will involve foreign exchange directly or indirectly.

COST STUDY OF ALTERNATIVE STRUCTURES

Sl. No.	Description	Unit	Tubular Truss (with A.C. Sheet)	Welded frame (with A.C. Sheet)	R.C.C. Gable Frame (with A.C. Sheet)	Shell Roof (with Elliptical)	Shell Roof (Segmental)	Prefabricated Precast and Pre-tensioned (with A.C. Sheet)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Size of Godown (Clear dimension)		148'-9" x 87'-6"	142'-0" x 88'-10 1/2"	150'-0" x 87'-9"	138'-0" x 89'-0"	140'-10" x 88'-9"	148'-6" x 88'-3"
	(a) Plinth area	Sft.	16,335	15,850	16,524	15,322	15,880	16,602
	(b) Godown Area	Sft.	13,016	12,620	13,163	12,282	12,500	13,105
	(a) Cost of frame work	Rs.	75,800	48,100	52,500	73,000	75,000	57,000
	(b) Cost of filler work	Rs.	53,700	53,500	56,100	48,500	54,000	55,000
	(c) TOTAL COST	Rs.	1,29,500	1,01,600	1,08,600	1,21,500	1,29,000	1,12,000
4.	(a) Cost of frame work per sft. of Godown Area	Rs.	5.82	3.81	3.99	5.94	6.00	4.35
	(b) Cost of filler work per sft. of Godown Area	Rs.	4.13	4.24	4.26	3.95	4.32	4.19
	(c) TOTAL COST PER SFT. OF GODOWN AREA	Rs.	9.95	8.05	8.25	9.89	10.32	8.54
5.	(a) Equated cost of maintenance per year	Rs.	1,300	1,250	1,200	1,100	1,200	1,200
	(b) Equated cost of maintenance over capital cost %	%	1.00	1.23	1.12	0.91	0.93	1.04
	(c) Present worth cost of maintenance per sft. of Godown Area	Rs.	2.14	2.12	1.93	1.92	2.05	1.96

6.	Present worth cost of capital and maintenance 4(e)+5(e)	Rs.	12.09	10.17	10.18	11.81	12.37	10.50
7.	Quantity of Steel per 100 sft. of Godown Area.							
(a)	Structural steel	Cwts.	Nil.	2.31	Nil	Nil	Nil	0.07
(b)	M. S. Reinforcement	Cwts.	1.57	1.29	4.03	4.36	4.26	1.14
(c)	M. S. Tubes	Cwts.	2.40	Nil	Nil	Nil	Nil	Nil
(d)	Accessories	Cwts.	0.19	0.19	0.19	0.05	0.09	0.35
								(H. T. Steel) 0.19
(a)	TOTAL QUANTITY OF STEEL (a+b+c+d)	Cwts.	4.16	3.79	4.22	4.41	4.35	1.75
8.	Quantity of cement per 100 sft. of Godown Area.	Cwts.	18.89	17.91	21.12	27.52	29.60	18.01
9.	Economic life of structure	Years	75	75	75	75	75	75
10.	Time of Construction	Months	6	7	7	9	9	7
11.	Materials for Frame and filler works							
(a)	Cement	Cwts.	2,525	2,300	2,750	3,420	3,580	2,650
(b)	Steel							
(i)	Mild steel	Cwts.	204	163	530	535	532	150
(ii)	Structural Steel	Cwts.	Nil	292	Nil	Nil	Nil	10
(iii)	High tensile steel	Cwts.	Nil	Nil	Nil	Nil	Nil	45
(iv)	M. S. tubes	Cwts.	316	Nil	Nil	Nil	Nil	Nil
(v)	Accessories	Cwts.	25	25	25	8	12	25
(c)	Sand	Cft.	10,000	9,000	10,400	12,000	12,800	10,000
(d)	Ballast							
(i)	1½" size	Cft.	6,200	6,000	6,500	6,000	6,000	6,500
(ii)	¾" & ½" size	Cft.	4,700	3,600	4,500	10,200	9,500	4,500
(e)	Bricks	Nos.	1,85,000	1,80,000	1,80,000	1,50,000	2,00,000	2,05,000

Note.—(1) The costs apply to Delhi and will vary at other places according to basic rates of material and labour.

(2) All structures are suitable for Zones, I, II, and III of wind pressure. The estimate of welded frame structure relates to Zone III, and quantity of steel and cement will be higher for Zone I.

(3) Quantity of sand in 11 (c) does not include sand used in basement filling.

TABLE I

ABSTRACT OF COST—STRUCTURE WITH TUBULAR TRUSS

Item	Quantity	Rate Rs.	Per	Amount Rs.
A. FRAME WORK				
1 Earth work in foundation for columns	2,600 cft.	33·00	1,000 cft.	86
2 Lean concrete (c. c. 1:5:10) below footing	160 cft.	93·00	100 cft.	149
3 R. C. C. 1:2:4 in column footing (c ₁ , c ₂ & c ₃)	500 cft.	2·19	cft.	1,095
4 R. C. C. 1:2:4 in column (c ₁ & c ₂) and beams	1,140 cft.	2·50	cft.	2,850
5 R. C. C. 1:1½:3 in columns (c ₂)	820 cft.	2·75	cft.	2,255
6 M. S. Reinforcement in columns, footings & beams	193 cwts.	42·00	cwt.	8,106
7 Providing tubular truss with purlins and accessories	16,335 sft.	2·30	sft.	37,571
8 Erection	16,335 sft.	0·08	sft.	1,307
9 Roofing with A.C. Sheet	18,700 sft.	75·00	100 sft.	14,025
10 Ridge	312 rft.	2·19	rft.	683
11 Valley Gutter	156 rft.	4·25	rft.	663
12 Eave Gutter	312 rft.	3·75	rft.	1,170
13 ¾" dia. holding down bolts 5'-0" long for main truss	36 sets	19·25	set	693
14 ¾" dia. bolts 1'-0" long for platform brackets	44 sets	13·00	set	572
15 Wind ties 1½" × 1¼" M.S. Plate	7 cwts.	41·00	cwt.	287
16 Lead sheets 1/8" thick for columns c ₁ & c ₂	2·2 cwts.	140·00	cwt.	308
17 Painting Iron work	2,700 sft.	18·50	100 sft	500
18 Add extra cost for cement	26 tons	15·00	Ton	390
19 Add extra cost for steel	10·0 tons	70·00	Ton	700
20 Contingencies about 3%				2,390
			TOTAL	75,800

1	2	3	4	5
B. FILLER WORK				
1 Earth work in foundation	4,300 cft.	33·00	1,000 cft.	142
2 Filling with carted earth in basement	22,100 cft.	113·62	1,000 cft.	2,511
3 Filling with sand in basement	11,400 cft.	17·00	100 cft.	1,938
4 Lean concrete (C. C. 1:5:10) in foundation	1,270 cft.	93·00	100 cft.	1,181
5 C.C. 1:4:8 under floor	5,030 cft.	104·00	100 cft.	5,231
6 R. C. C. (1:2:4) in corbels and lintels	150 cft.	2·50	cft.	375
7 C. C. (1:2:4) in Platform coping	265 cft.	2·12	cft.	562
8 C. C. (1:2:4) for embedding bolts etc.	17 cft.	1·94	cft.	33
9 M. S. Reinforcement in lintels and corbels	11 cwt.	42·00	cwt.	462
10 D. P. C. 1½" thick in c.c. 1:2:4 including water proofing	550 sft.	49·33	100 sft.	271
11 Brick work in C. M. 1:6 in foundation	4,150 cft.	97·00	100 cft.	4,026
12 Brick work in C. M. 1:4 in foundation	750 cft.	108·00	100 cft.	810
13 Brick work in C. M. 1:4 in superstructure	7,200 cft.	116·00	100 cft.	8,352
14 Brick work in C. M. 1:6 in superstructure	850 cft.	105·00	100 cft.	893
15 Flooring 2" thick in c.c. 1:2:3	15,100 sft.	44·60	100 sft.	6,735
16 Hot Bitumen painting (water proofing)	15,300 sft.	9·50	100 sft.	1,454
17 Rolling shutters	640 sft.	10·00	sft.	6,400
18 Ventilators V (in gable end Walls)	160 sft.	6·96	sft.	1,114
19 Ventilators V ₁ (Top in longitudinal Panel walls)	400 sft.	4·91	sft.	1,964
20 Ventilators V ₂ (Bottom in longitudinal Panel walls)	40 sft.	8·34	sft.	334
21 Grating to V ₂	180 lbs.	0·81	lbs.	146
22 M. S. Hold fasts	132 Nos.	0·81	each	107
23 Channels to V ₂	2 cwt.	43·00	cwt.	86
24 Plastering with C. M. 1:6 both inside & outside	18,300 sft.	12·50	100 sft.	2,288

	1	2	3	4	5
25	White washing . . .	18,500 sft.	1.19	100 sft.	220
26	Painting wood work (Ventilators) . . .	600 sft.	17.75	100 sft.	107.
27	Painting Iron work (Doors and gratings) . . .	2,100 sft.	18.50	100 sft.	389
28	6" dia. A. C. Rain water pipes . . .	132 rft.	3.00	rft.	396
29	6" A.C. Head . . .	6 nos.	4.25	each	26
30	6" A.C. Bend . . .	8 nos.	5.50	each	44
31	9" Open Masonry drain . . .	500 rft.	2.05	rft.	1,025
32	Bird Proof Netting . . .	100 sft.	2.00	sft.	200
33	Wooden fenders of Hard wood . . .	28 cft.	11.62	cft.	325
34	1/2" thick rubber backing . . .	11 sft.	4.10	sft.	45
35	5/8" dia. bolts 1'-9" long for fixing in blocks . . .	42 nos.	2.62	each	110
36	5/8" dia. bolts 1'-0" long for fixing in corbels . . .	30 nos.	1.44	[each	43.
37	Plinth protection . . .	550 sft.	41.35	100 sft.	227
38	Painting wooden fenders with Solignum . . .	300 sft.	3.00	100 sft.	9
39	Add for extra cost of cement . . .	97 tons	15.00	ton	1,455
40	Add for extra cost of steel . . .	0.7 ton	70.00	ton	49
41	Contingencies about 3%				1,615
					53,700

APPENDIX IV

TABLE 2

ABSTRACT OF COST—STRUCTURE WITH WELDED PORTAL FRAME

Sl. No.	Item	Quantity	Rate Rs.	Per	Amount Rs.
A. FRAME WORK					
1	Earth work in foundation	1,810 cft.	33·00	1,000 cft.	60
2	Lean concrete (c.c. 1:5:10) under columns	115 cft.	93·00	100 cft.	1 07
3	R. C. C. 1:2:4 in columns and footings	380 cft.	2·19	cft.	832
4	R. C. C. 1:2:4 in columns and beams	1,150 cft.	2·50	cft.	2,875
5	M.S. Reinforcement	142 cwts.	42·00	cwt.	5,964
6	Structural steel	290 cwts.	63·50	cwt.	18,415
7	Roofing with A. C. Sheet	16,500 sft.	75·00	100 sft.	12,375
8	Ridging	292 rft.	2·19	rft.	639
9	Valley Gutter	146 rft.	4·25	rft.	621
10	Eave Gutter	292 rft.	3·75	rft.	1,095
11	M.S. wind ties 1½" × 1/4"	7 cwts.	41·00	cwt.	287
12	Providing M. S. Anchor bolts 1½" dia 1'-6" long with 4" × 4" × ½" M.S. Plate in R. C. C. columns (4 sets for truss)	64 nos.	5·50	each	352
13	Painting structural steel	7,200 sft.	18·50	100 sft.	1,332
14	Add extra cost for cement	15 tons	15·00	ton	225
15	Add extra cost for steel	22 tons	70·00	ton	1,540
16	Contingencies about 3%				1,381
TOTAL					48,100

B. FILLER WORK

1	Earth work in foundation	4,500 cft.	33·00	1,000 cft.	149
2	Filling with carted earth	21,700 cft.	113·62	1,000 cft.	2,466
3	Filling with sand	11,000 cft.	17·00	100 cft.	1,870
4	Lean concrete (c.c. 1:5:10) in foundation	1,255 cft.	93·00	100 cft.	1,167
5	C.C. 1:4:8 under floors	4,860 cft.	104·00	100 cft.	5,055
6	R.C.C. 1:2:4 in lintels	350 cft.	2·50	cft.	875
7	M.S. Reinforcement	20 cwts.	42·00	cwt.	840

1	2	3	4	5	6
8.	C.C. 1:2:4 for embedding bolts.	10 cft.	2.12	cft.	21
9.	Cement concrete in coping	250 cft.	1.94	cft.	485
10.	D.P.C. 1½" thick c. c. 1:2:4 including water proofing	550 sft.	49.33	100 sft.	271
11.	1st Brick work in c. m. 1:6 in foundation	4,100 cft.	97.00	100 cft.	3,977
12.	Brick work in c. m. 1:4 in foundation	750 cft.	108.00	100 cft.	810
13.	Brick work in c. m. 1:4 in superstructure	7,600 cft.	116.00	100 cft.	8,816
14.	Flooring 2" thick c. c. 1:2:3	14,600 sft.	44.60	100 sft.	6,512
15.	Hot bitumen painting (water proofing)	14,800 sft.	9.50	100 sft.	1,406
16.	Rolling shutters	640 sft.	10.00	sft.	6,400
17.	Ventilators V in gable end walls	200 sft.	6.96	sft.	1,392
18.	Ventilators V ₁ in panel walls	400 sft.	4.91	sft.	1,964
19.	Ventilators V ₂ in panel walls	40 sft.	8.34	sft.	334
20.	Grating to V ₂	180 lbs.	0.81	lb.	146
21.	M. S. Hold fasts	140 nos.	0.81	each.	113
22.	Channel for V ₂	2 cwts.	43.00	cwt.	86
23.	Plastering with c. m. 1:6, ½" thick	17,000 sft.	12.50	100 sft.	2,125
24.	White washing 3 coats	17,200 sft.	1.19	100 sft.	205
25.	Painting wood work	640 sft.	17.75	100 sft.	114
26.	Painting Iron work	2,100 sft.	18.50	100 sft.	389
27.	6" dia. A.C. Rain Water pipes	132 rft.	3.00	rft.	396
28.	6" A.C. head	6 nos.	4.25	each	26
29.	6" A.C. Bend	8 nos.	5.50	each	44
30.	9" open Masonry drain	500 rft.	2.05	rft.	1,025
31.	Bird proof netting	100 sft.	2.00	sft.	200
32.	Wooden fenders of hard wood	26 cft.	11.62	cft.	302
33.	½" thick rubber backing	10 sft.	4.10	sft.	41
34.	5/8" dia. bolts 1'-9" long for fixing in blocks	40 nos.	2.62	each	105
35.	5/8" dia. bolts 1'-0" long in corbels	30 nos.	1.44	each	43
36.	Plinth protection	550 sft.	41.35	100 sft.	227
37.	Painting wooden fenders with solignum	300 sft.	3.00	100 sft.	9
38.	Add extra cost of cement	98 tons.	15.00	ton	1,470
39.	Add extra cost of steel	1 ton.	70.00	ton	70
40.	Contingencies about 3%				1,554
TOTAL					53,500

APPENDIX IV

TABLE 3 F

ABSTRACT OF COST—STRUCTURE WITH RCC GABLE FRAME

Sl. No.	Item	Quantity	Rate Rs.	Per	Amount Rs.
A. FRAME WORK					
1.	Earth work in foundation for columns	2,000 cft.	33·00	1,000 cft.	66
2.	Lean concrete (c.c.1:5:10) under columns	120 cft.	93·00	100 cft.	112
3.	R. C. C. 1:1½: 3½ in column footings and pedestals	600 cft.	2·65	cft.	1,590
4.	R. C. C. 1:2:3 in gable frames, brackets & purlins	2,550 cft.	3·00	cft.	7,650
5.	M.S. Reinforcement	500 cwts.	42·00	cwt.	21,000
6.	Asbestos Sheet	18,600 sft.	75·00	100 sft.	13,950
7.	Ridge	308 rft.	2·19	rft.	675
8.	Valley Gutter	154 rft.	4·25	rft.	655
9.	Eave Gutter	308 rft.	3·75	rft.	1,155
10.	¾" dia. bolts and nuts for brackets 1'-4" long	88 nos.	3·00	each	264
11.	7/8" dia. bolts and nuts at joints in rafter 2'-0" long	88 nos.	5·00	each	440
12.	½" dia. bolts and nuts 9" long	1,144 nos.	0·75	each	858
13.	Wind ties 1½" x 1/4"	7 cwts.	41·00	[cwt.	287
14.	Add extra cost for cement	35 tons	15·00	ton	525
15.	Add extra cost for steel	25 tons	70·00	ton	1,750
16.	Contingencies about 3%				1,523
TOTAL					52,500
B. FILLER WORK					
1.	Earth work in foundation	5,100 cft.	33·00	1,000 cft.	168
2.	Filling with carted earth	22,500 cft.	113·62	1,000 cft.	2,556
3.	Filling with sand	11,500 cft.	17·00	100 cft.	1,955
4.	C.C. 1:5:10 in walls etc.	1,400 cft.	93·00	100 cft.	1,302
5.	C.C. 1:4:8 under floors	5,100 cft.	104·00	100 cft.	5,304
6.	R.C.C. 1:2:4 in lintels etc.	350 cft.	2·50	cft.	875
7.	C.C. 1:2:4 in coping	270 cft.	2·12	cft.	572
8.	C.C. 1:2:4 for embedding bolts etc.	25 cft.	1·94	cft.	49
9.	D. P. C. 1½" thick c.c. 1:2:4 including water proofing	550 sft.	49·33	100 sft.	27

1	2	3	4	5	6
10.	M.S. Reinforcement	26 cwts.	42.00	cwt.	1,092
11.	Brick work in c. m. 1:6 in foundation	3,900 cft.	97.00	100 cft.	3,783
12.	Brick work in c. m ² 1:4 in foundation	850 cft.	108.00	100 cft.	918
13.	Brick work in c. m. 1:4 in superstructure	7,850 cft.	116.00	100 cft.	9,106
14.	Flooring 2" thick c. c. 1:2:3	15,250 sft.	44.60	100 sft.	6,802
15.	Hot bitumen painting	15,400 sft.	9.50	100 sft.	1,463
16.	Rolling shutters	512 sft.	10.00	sft.	5,120
17.	Ventilators V.	160 sft.	6.96	sft.	1,114
18.	Ventilators V ₁	480 sft.	4.91	sft.	2,357
19.	Ventilators V ₂ in panel walls	400 sft.	4.91	sft.	1,964
20.	Grating to V ₂	288 lbs.	0.81	lb.	233
21.	M.S. Hold fasts	160 nos.	0.81	each	130
22.	Channels to V ₂	3 cwts.	43.00	cwt.	129
23.	Plastering with c. m. 1:6 1/4" thick	17,600 sft.	12.50	100 sft.	2,200
24.	White washing 3 coats	17,600 sft.	1.19	100 sft.	209
25.	Painting wood work	700 sft.	17.75	100 sft.	124
26.	Painting Iron work	1,750 sft.	18.50	100 sft.	324
27.	6" dia. A.C. Rain Water pipes	132 rft.	3.00	rft.	396
28.	6" dia. A.C. Head	6 nos.	4.25	each	26
29.	6" A.C. Bends	8 nos.	5.50	each	44
30.	9" dia. open Masonry drain	500 rft.	2.05	rft.	1,025
31.	Wooden fenders	28 cft.	11.62	cft.	325
32.	1/4" Rubber backing	11 sft.	4.10	sft.	45
33.	5/8" dia. bolts 1'-9" long	42 nos.	2.62	each	110
34.	5/8" dia. bolts 1'-0" long	30 nos.	1.44	each	43
35.	Plinth Protection	550 sft.	41.35	100 sft.	227
36.	Painting wooden fenders with solignum	300 sft.	3.00	100 sft.	9
37.	Extra cost of cement	104 tons	15.00	ton	1,560
38.	Extra cost of steel	1.5 tons	70.00	ton	105
39.	Contingencies about 3%				1,630
TOTAL					56,100

APPENDIX IV

TABLE 4

ABSTRACT OF COST—STRUCTURE WITH RCC SEMI-ELLIPTICAL SHELL ROOF

Sl. No.	Item	Quantity	Rate Rs.	Per	Amount Rs.
A. FRAME WORK					
1.	Earth work in foundation for columns	3,500 cft.	33.00	1,000 cft.	116
	Lean concrete (c.c.1:5:10) under columns	220 cft.	93.00	100 cft.	205
3.	R. C. C. 1:2:4 in column footings	1,100 cft.	2.19	cft.	2,409
4.	R.C.C. 1:2:4 in columns	325 cft.	2.50	cft.	813
5.	R.C.C. 1:2:4 for Trusses	1,440 cft.	3.00	cft.	4,320
6.	R.C.C. 1:2:4 in shell	4,720 cft.	2.75	cft.	12,980
7.	Centering for shell	14,800 sft.	0.80	sft.	11,840
8.	R.C.C. 1:2:4 in flat roof	1,425 cft.	2.50	cft.	3,563
9.	Centering for flat roof	4,600 sft.	0.50	sft.	2,300
10.	M.S. Reinforcement	505 cwts.	42.00	cwt.	21,210
11.	Providing Tarfelt	17,000 sft.	45.00	100 sft.	7,650
12.	White washing inside roof	21,400 sft.	1.25	100 sft.	268
13.	Add extra cost of cement	80 tons	15.00	ton	1,200
14.	Add extra cost of steel	25 tons	70.00	ton	1,750
15.	Contingencies about 3%				2,376
				TOTAL	73,600
B. FILLER WORK					
1.	Earth work in foundation	4,500 cft.	33.00	1,000 cft.	149
2.	Filling with carted earth	20,000 cft.	113.62	1,000 cft.	2,272
3.	Filling with sand	10,600 cft.	17.00	100 cft.	1,802
4.	Lean concrete (c.c.1:5:10) in foundation	1,225 cft.	93.00	100 cft.	1,138
5.	C.C. 1:4:8 under floors	4,700 cft.	104.00	100 cft.	4,888
6.	R.C.C. 1:2:4 in lintels	200 cft.	2.50	cft.	500
7.	Cement concrete 1:2:4 in platform coping	250 cft.	2.12	cft.	530
8.	Cement concrete 1:2:4 for embedding bolts	11 cft.	1.94	cft.	21
9.	M. S. Reinforcement	15 cwts.	42.00	cwt.	630

1	2	3	4	5	6
10.	D. P. C. 1½" thick c. c. 1:2:4 including water proofing	550 sft.	49.33	100 sft.	277
11.	Brick work in c. m. 1:6 in foundation upto plinth	4,000 cft.	97.00	100 cft.	3,880
12.	Brick work in c. m. 1:4 in foundation and plinth	800 cft.	108.00	100 cft.	864
13.	Brick work in c. m. 1:4 in superstructure	5,700 cft.	116.00	100 cft.	6,612
14.	Flooring 2" thick c. c. 1:2:3	14,100 cft.	44.60	100 sft.	6,289
15.	Hot Bitumen Painting (Water proofing)	14,300 sft.	9.50	100 sft.	1,359
16.	Rolling shutters	512 sft.	10.00	sft.	5,120
17.	Ventilators V.	200 sft.	6.96	sft.	1,392
18.	Ventilators V ₁	320 sft.	4.91	sft.	1,571
19.	Ventilators V ₂	64 sft.	8.34	sft.	534
20.	Grating to V ₁	288 lbs.	0.81	lb.	233
21.	M S. Hold fasts	136 nos.	0.81	each	110
22.	Channels to V ₂	3 cwt.	43.00	cwt.	129
23.	Plastering with c. m. 1:4, ½" thick	14,100 sft.	12.50	100 sft.	1,763
24.	White washing 3 coats	14,100 sft.	1.19	100 sft.	168
25.	Painting wood work	600 sft.	17.75	100 sft.	107
26.	Painting Iron work	1,700 sft.	18.50	100 sft.	315
27.	6" dia. A. C. Rain Water pipes	84 rft.	3.00	rft.	252
28.	" A. C. Head	6 nos.	4.25	each	26
29.	6" dia. R.C.C. Pipes	42 rft.	3.12	rft.	131
30.	Brick Masonry chambers	6 nos.	148.00	each	888
31.	9" open Masonry drain	500 rft.	2.05	rft.	1,025
32.	Wooden fenders of hard wood	26 cft.	11.62	cft.	302
33.	Rubber backing ½" thick	11 sft.	4.10	sft.	45
34.	5/8" dia. bolts 1'-9" long fixed in blocks	42 nos.	2.62	each	110
35.	5/8" dia. bolts 1'-0" long fixed in corbels	30 nos.	1.44	each	43
36.	Plinth protection	550 sft.	41.35	100 sft.	227
37.	Painting wooden fenders with solignum	300 sft.	3.00	100 sft.	9
38.	Add extra cost of cement	89 tons	15.00	ton	1,335
39.	Add extra cost of steel	1 ton	70.00	ton	70
40.	Contingencies about 3%				1,485
TOTAL					48,500

APPENDIX IV

TABLE 5

A3STRACT OF COST—STRUCTURE WITH RCC SEGMENTAL SHELL ROOF

Sl. No.	Item	Quantity	Rate Rs.	Per	Amount Rs.
A. FRAME WORK					
1.	Earth work in foundation .	4,800 cft.	33.00	1,000 cft.	158
2.	Lean concrete (c.c. 1:5:10)	300 cft.	93.00	100 cft.	279
3.	R. C. C. 1:2:4 in column footings .	3,540 cft.	2.19	cft.	3,373
4.	R. C. C. 1:1½:3 in columns c ₁ and c ₂ .	230 cft.	2.75	cft.	633
5.	R. C. C. 1:2:4 in columns c ₃ and c ₄ and Ties .	620 cft.	2.50	cft.	1,550
6.	R. C. C. 1:2:4 in Trusses .	1,600 cft.	3.00	cft.	4,800
7.	R. C. C. 1:2:4 in shel .	3,600 cft.	2.75	cft.	9,900
8.	Centering for shell .	13,700 cft.	1.00	sft.	13,700
9.	R. C. C. 1:2:3 for brackets and purlins in plat-forms .	400 cft.	3.00	cft.	1,200
10.	M. S. Reinforcement .	520 cwt.	42.00	cwt.	21,840
11.	Roofing with Asbestos Sheet .	2,900 sft.	75.00	100 sft.	2,175
12.	Eave Gutter .	296 sft.	3.75	sft.	1,110
13.	¾" dia. bolts & nuts 1'-4" long for brackets .	112 nos.	3.00	each	336
14.	½" dia bolts and nuts 9" long for fixing purlins .	158 nos.	0.75	each	126
15.	Wind ties 1½" x 1¼" M. S. flat .	3.5 cwt.	41.00	cwt.	144
16.	White washing inside shell roof .	14,000 sft.	1.25	100 sft.	175
17.	Providing Tarfelt over shell roof .	15,500 sft.	45.00	100 sft.	6,975
18.	Providing copper plate 1'-0" x 1/16" (100 sft.)	300 lbs.	3.00	lb.	900
19.	Bitumen filling in expansion joints .	L.S.	..	..	200
20.	Providing 6" Asbestos sheets for covering expansion joints .	L.S.	..	..	50
21.	Add extra cost of cement .	80 tons	15.00	ton	1,200
22.	Add extra cost of steel .	28 tons	70.00	ton	1,960
23.	Contingencies about 3% .	L.S.	..	..	2,216
				TOTAL	75,000

1	2	3	4	5	6
B. FILLER WORK					
1.	Earth work in foundation	4,500 cft.	33.00	1,000 cft.	149
2.	Filling with carted earth	20,000 cft.	113.62	1,000 cft.	2,272
3.	Filling with sand	11,000 cft.	17.00	100 cft.	1,870
4.	Lean concrete (c. c. 1:5:10) in foundation	1,300 cft.	93.00	100 cft.	1,209
5.	Lean concrete (c. c. 1:4:8) under floors	4,760 cft.	104.00	100 cft.	4,950
6.	R. C. C. 1:2:4 for lintels etc.	200 cft.	2.50	cft.	500
7.	C. C. 1:2:4 in platform coping	250 cft.	2.12	cft.	530
8.	C. C. 1:2:4 for embedding bolts	11 cft.	1.94	cft.	21
9.	D. P. C. 1½" thick c. c. 1:2:4 including water proofing	550 sft.	49.33	100 sft.	271
10.	M. S. Reinforcement	12 cwts.	42.00	cwt.	504
11.	Brick work in c. m. 1:6 in foundation upto plinth	4,100 cft.	97.00	100 cft.	3,977
12.	Brick work in c. m. 1:4 in foundation upto plinth	850 cft.	108.00	100 cft.	918
13.	Brick work in c. m. 1:4 in superstructure	9,000 cft.	116.00	100 cft.	10,440
14.	Flooring 2" thick c. c. 1:2:3	14,600 cft.	44.60	100 sft.	6,512
15.	Hot Bitumen painting (water proofing)	14,800 sft.	9.50	100 sft.	1,406
16.	Rolling shutters	512 sft.	10.00	sft.	5,120
17.	Ventilators V	200 sft.	6.96	sft.	1,392
18.	Ventilators V ₁	320 sft.	4.91	sft.	1,571
19.	Ventilators V ₂	64 sft.	8.34	sft.	534
20.	Grating to V ₂	288 lbs.	0.81	lb.	233
21.	M.S. hold fasts	136 nos.	0.81	each.	110
22.	Channels to V ₂	3 cwts.	43.00	cwt.	129
23.	Plastering with c. m. 1:6, ½" thick	19,200 sft.	12.50	100 sft.	2,400
24.	White washing	19,200 sft.	1.19	100 sft.	228
25.	Painting wood work	600 sft.	17.75	100 sft.	107
26.	Painting Iron work	1,700 sft.	18.50	100 sft.	15
27.	6" dia. A. C. Rain water pipe	216 rft.	3.00	rft.	648
28.	6" dia. A. C. Heads	12 nos.	4.25	each	51
29.	6" dia. A. C. Bends	8 nos.	5.50	each	44
30.	6" dia. R. C. C. pipes	36 rft.	3.12	rft.	112
31.	Masonry chambers	2 nos.	148.00	each	296
32.	9" open masonry drain	500 rft.	2.05	rft.	1,025
33.	Wooden fenders of hard wood	26 cft.	11.62	cft.	302

1	2	3	4	5	6
34.	Rubber backing $\frac{1}{2}$ " thick	11 sft.	4.10	sft.	45
35.	$\frac{5}{8}$ " dia. bolts 1'-9" long for fixing blocks	42 nos.	2.62	each	110
36.	$\frac{5}{8}$ " dia. bolts 1'-0" long in corbels	30 nos.	1.44	each	43
37.	Plinth protection	550 sft.	41.35	100 sft.	227
38.	Painting wooden fenders with solignum.	300 sft.	3.00	100 sft.	9
39.	Add for extra cost of cement	100 tons.	15.00	ton.	1,500
40.	Add for extra cost of steel	15 cwts.	70.00	ton.	11
41.	Contingencies about 3%	L.S.			1,909
				TOTAL	54,000

APPENDIX IV

TABLE 6

ABSTRACT OF COST—STRUCTURE WITH PRESTRESSED—PREFABRICATED TRUSS.

Sl. No.	Item	Quantity	Rate Rs.	Per	Amount Rs.
A. FRAME WORK					
1.	Earth work in foundation for columns	1,400 cft.	33.00	1,000 cft.	46
2.	Lean concrete (C.C. 1:5:10) under columns	85 cft.	93.00	100 cft.	79
3.	R. C. C. 1:2:4 in column footings	340 cft.	2.19	cft.	745
4.	R.C.C. 1:2:4 in columns	640 crft.	2.50	cft.	1,600
5.	R. C. C. 1:2:4 in platform cantilever arms	200 cft.	2.75	cft.	275
6.	M. S. Reinforcement in columns & cantilever arms	52 cwts.	42.00	cwt.	2,184
7.	R. C. C. 1:2:3 in precast struts, Tie beam, Main Rafter & Purlins	1,100 cft.	$16,602 \times \frac{2.88}{100 \text{ sft.}}$		
8.	M. S. Reinforcement in Trusses and purlins and cantilever arms	68 cwts.			
9.	Structural Steel in trusses	7 cwts.			
10.	High Tensile Steel in Trusses and purlins	45 cwts.			
11.	Roofing with Asbestos Sheet	17,700 sft.			
12.	Ridge	304 rft.			48,214
13.	Valley Gutter	152 rft.	4.25	rft.	646
14.	Eave Gutter	304 rft.	3.75	rft.	1,140
15.	Anchor Bolts 1" dia in columns (Top)	21 sft.	10.00	sft.	210
16.	Wind Ties 1½" x ½"	7 cwts.	41.00	cwt.	287
17.	Painting Iron Work	300 sft.	18.50	100 sft.	56
18.	Add extra cost of cement	10 tons.	15.00	ton.	150
19.	Add extra cost of steel	3.0 tons.	70.00	ton	210
20.	Contingencies about 3%				1,433
					57,000

1	2	3	4	5	6
B. FILLER WORK					
1.	Earth work in foundation	5,500 cft.	33.00	1,000 cft.	182
2.	Filling with carted earth	23,000 cft.	113.62	1,000 cft.	2,613
3.	Filling with Sand	11,500 cft.	17.00	100 cft.	1,955
4.	Lean concrete (C.C. 1:5:10) in foundation	1,525 cft.	93.00	100 cft.	1,419
5.	Lean concrete (C.C. 1:4:8) under floors	5,110 cft.	104.00	100 cft.	5,325
6.	R.C.C. 1:2:4 in lintels carbels	300 cft.	2.50	cft.	750
7.	C. C. 1:2:4 for embedding bolts	20 cft.	1.94	cft.	39
8.	C. C. 1:2:4 for coping	260 cft.	2.12	cft.	551
9.	D.P.C. 1 1/2" thick C.C. 1:2:4 including water proofing	550 sft.	49.33	100 sft.	271
10.	M. S. Reinforcement	20 cwt.	42.00	cwt.	840
11.	Brickwork in C. M. 1:6 in foundation	4,500 cft.	97.00	100 cft.	4,365
12.	Brickwork in C. M. 1:4 in foundation	850 cft.	108.00	100 cft.	918
13.	Brickwork in C. M. 1:4 in superstructure	9,100 cft.	116.00	100 cft.	10,556
14.	Flooring 2" thick in C. C. 1:2:3	15,310 sft.	44.60	100 sft.	6,828
15.	Hot Bitumen painting (water proofing)	15,500 sft.	9.50	100 sft.	1,473
16.	Rolling Shutters	512 sft.	10.00	sft.	5,120
17.	Ventilators V	160 sft.	6.96	sft.	1,114
18.	Ventilators V ₁	320 sft.	4.91	sft.	1,571
19.	Ventilators V ₂	32 sft.	8.34	sft.	267
20.	Grating to V ₂	144 lb.	0.81	lb.	117
21.	M. S. Hold Fast	112 nos.	0.81	each.	91
22.	Channels to V ₂	1.5 cwt.	43.00	cwt.	65
23.	Plastering with C. M. 1:6, 1/2" thick	19,300 sft.	12.50	100 sft.	2,413
24.	White washing 3 coats	19,300 sft.	1.19	100 sft.	230
25.	Painting Wood Work	520 sft.	17.75	100 sft.	92
26.	Painting Iron Work	1,650 sft.	18.50	100 sft.	305
27.	6" dia. R.W. Pipes (A.C.)	132 rft.	3.00	rft.	396
28.	6" dia. A. C. Heads	6 nos.	4.25	rft.	26
29.	6" dia. A. C. Bends	8 nos.	5.50	rft.	44
30.	9" Open Masonry drain	500 rft.	2.05	rft.	1,025
31.	Wooden fenders	28 cft.	11.62	cft.	325
32.	1/2" thick Rubber backing	11 sft.	4.10	sft.	45
33.	5/8" dia. 1'-9" long bolts	42 nos.	2.62	Each.	110
34.	5/8" dia. 1'-0" long bolts	30 nos.	1.44	Each.	43
35.	Plinth Protection	550 sft.	41.35	100 sft.	227
36.	Painting Wooden fenders	300 sft.	3.00	100 sft.	9
37.	Add extra cost of cement	108 ton.	15.00	ton.	1,620
38.	Add extra cost of Steel	1.2 tons.	70.00	ton.	84
39.	Contingencies about 3 %				1,586
				TOTAL	55,000

APPENDIX V

COST STUDY OF G.G.I. SHEETS VS. ABESTO CEMENT SHEET

Data : Godown area 13,016 sft.
 Period of life 75 years

Capital Cost.	Quantity	Rate Rs.	Per	Amount Rs.		
(C. G. I. Sheet)						
I. (1) G.I. Sheet 24G	18,700 sft.	80.00	100 sft.	14,960		
(2) Ridge 24 G	312 rft.	2.19	rft.	683		
(3) Valley Gutter 16G	156 rft.	4.25	rft.	663		
(4) Eave Gutter 18G	312 rft.	3.75	rft.	1,170		
				<u>17,476</u>		
II. Contingencies @ 3 percent				524		
III. TOTAL				<u>18,000</u>		
IV. Present value of capital cost per sft. of Godown area				1.38		
Maintenance Cost					Sinking fund factor (Divided by)	Sinking fund value.
I. (1) Painting G. I. Sheet, Ridge and Eave Gutters once in 4 years.	24,500 sft.	7.50	100 sft.	1,838	4.267	430.80
(2) Replacing Valley Gutter once in 4 years Deduct salvage value 10 %	156 rft.	4.30	rft.	671		
				<u>67</u>		
				604	4.267	141.60
(3) (a) Replacing G. I. sheet once in 10 years	18,700 sft.	85.00	100 sft.	15,895		
(b) Replacing Eave Gutter once in 10 years	312 rft.	3.80	rft.	1,186		
(c) Replacing Ridge once in 10 years	312 rft.	2.24	rft.	699		
(d) Deduct Salvage value (20%) G.I. Sheet 18,700 × 80 per 100 sft = 14,960 Eave Gutter 312 × 3.75 per rft = 1,170 Ridge 312 × 2.19 per rft. = 683 16,813 × 20/100				<u>17,788</u>		
				3,363		
				14,417	12.267	1,175.00
						1,747.40
					or	1,750/-

	1	2	3	4	5	
II. Present worth of Maintenance per sft.		$1,750 \times 21 \cdot 401$			2.88	
TOTAL		<u>13,016</u>				
Present worth cost (capital + maintenance) per sft. of Godown Area:					Ra. 4.26	
		<i>(A. C. Sheet)</i>				
I. (1) Asbestos Sheet	18,700 sft	75.00	100 sft	14,025		
(2) Ridge	312 rft.	2.19	rft.	683		
(3) Valley Gutter	156 rft.	4.25	rft	663		
(4) Eave Gutters	312 rft.	3.75	rft	1,170		
				<u>16,541</u>		
II. Contingencies about 3%				499		
				<u>17,040</u>		
III. Cost per sft. of Godown Area		<u>17,040</u>			1.31	
Maintenance Cost		<u>13,016</u>				
					Sinking fund factor (Divided by)	
I. Replacing Valley Gutter once in 5 years	156 rft.	4.30	rft.	671	5.467	122.80
II. (1) Replacing sheet once in 15 years	18,700 sft.	80.00	100 sft.	14,960		
(2) Replacing Eave Gutter once 15 years	312 rft.	3.67	rft.	1,145		
(3) Replacing Ridge once in 15 years	312 rft.	2.24	rft.	699		
				<u>16,804</u>		
(4) Deduct Salvage value 5%, $16804 \times 1/20$				<u>840</u>		
				<u>15,964</u>	20.156	<u>792.00</u>
IV. Present worth cost of maintenance per sft. of Godown area		$915 \times 21 \cdot 401$				914.80 or 915
		<u>13,016</u>				1.50
V. Present worth of (Capital + Maintenance) per sft. of Godown Area						2.81
		<i>Analysis</i>				
(a) Difference in capital cost		1.38	—	1.31		0.07
(b) Difference in maintenance cost		2.88	—	1.50		1.38
Difference : Total						<u>1.45</u> per sft. of Godown Area

TABLE I

PRESENT-WORTH-COST STUDY OF TUBULAR ROOF TRUSS STRUCTURE

Data :

1. Godown Area : 13016 sft.
2. Capital cost Rs. 1,29,500/-
3. Rate per sft. of Godown Area : Rs. 9.95
4. Rate of Compound Interest (i)=4.5% per annum

Maintenance

Sl. No.	Description	Quantity	Rate	Per	Amount	Sinking fund factor (divided by)	Sinking fund value
1	2	3	4	5	6	7	8
			Rs.		Rs.	No.	Rs.
I. 1.	White washing—every year	18,500 sft.	0.62	100 sft.	115	1.008	115.00
2.	Painting wood work—once in 3 years.	600 sft.	7.50	100 sft.	45	3.133	14.40
3.	Painting Iron work—once in 4 years	4,800 sft.	7.50	100 sft.	360	4.267	84.37
4.	Replacing Valley Gutter once in 4 years	156 sft.	4.30	sft.	671		
	Deduct salvage value 10%				67		
					604	4.267	141.60
5. (a)	Replacing A.C. Sheet—once in 15 years	18,700 sft.	80.00	100 sft.	14,960		
(b)	Replacing Eave Gutter—once in 15 years	312 sft.	3.80	sft.	1,186		
(c)	Replacing Ridge—once in 15 years	312 sft.	2.24	sft.	699		
					16,885		

(d) Deduct salvage value				
Sheet 5%	} 16,885		842	
Gutter 5%			16,043	20.156
Ridge 5%		20			795.94
16. Miscellaneous				148.69
			TOTAL	<u>1,300</u>
7. Annuity of maintenance				
8. (a) Present worth cost of maintenance				
Present value of an annuity of 1 for a period of 75 years at 4.5% compound interest	} $= \frac{1-v^n}{i}$ where $v^n = \frac{1}{(1+i)^n}$		21.401	
(b) Present-worth cost of Maintenance per sft. of Godown Area			1300×21.401		2.14
			13,016	
9. Equated cost of maintenance per year per sft. of Godown Area	1300		0.10	
	<u>13016</u>			
10. Percentage cost of maintenance over capital cost.	1300×100		1.00%	
	1,29,500			
II. Capital Cost	1,29,500			
Cost per sft. of Godown Area				9.95
III. Present worth cost of trusses replaced at 50th year. Cost=39000				
Present-worth-factor = $\frac{1}{(1+i)}$ = 0.1109				
Present worth-cost per sft. of Godown Area . 39000×0.1109				0.31
	<u>13016</u>			

I	2	3	4	5	6	7	8
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IV. Total outlay : 12.40

V. *D. duct* :
 Salvage value of the truss replaced at 50th year = 39000 x 25% = 9750. Present worth cost per sft. 0.

9750×0.1109
13016

VI. Salvage value at 75th year. 0.10

(a) A.C. Sheet
 (b) Eave Gutter
 (c) Ridge
 (d) Valley Gutter } 5% of cost 876
 (e) Doors, ventilators etc. 2000
 (f) Salvage value of Tubular Truss at 25th year 31692

34568 or 34600

(g) Present worth cost per sft. of Godown area for a period of 75 years 0.0369

34600×0.0369
13016

$$\left[\frac{1}{(1+i)^{75}} \left(1 + \frac{4.50}{100} \right)^{75} = 0.0369 \right]$$

VII. Total 0.18

VIII. Net Present worth cost per sft. of Godown Area 12.22

34

TABLE 2

PRESENT-WORTH-COST OF RCC GABLE ROOF STRUCTURE

Data :

1. Godown Area : 13163 sqft.
2. Capital Cost : Rs. 1,08,600
3. Rate per sqft.
of Godown Area : Rs. 8.25
4. Rate of Compound Interest (i) = 4.5% per annum

Maintenance

Sr. No.	Description	Quantity	Rate	Per	Amount	Sinking fund factor (divided by)	Sinking fund value.
1	2	3	4	5	6	7	8
			Rs.		Rs.	No.	Rs.
1.	White washing—every year	17600	0.62	100 sqft.	109.	1.000	109.00
2.	Painting wood work—once in 3 years	700	7.50	100 sqft.	53	3.133	16.92
3.	Painting Iron work—once in 4 years	1750	7.50	100 sqft.	131	4.267	30.70
4.	Replacing Valley Gutter once in 4 years	154	4.30	sqft.	662		
	Deduct 10% salvage				66		
					<u>598</u>	4.267	139.60

1	2	3	4	5	6	7	8
					Rs.	No.	Rs.
5. Replacing Asbestos Sheet—once in 15 years .		18600	80.00	100 sft.	14,800	..	..
Ridge—once in 15 years		308	3.80	ft.	1,170	..	..
Have Gutter—once in 15 years		308	2.24	ft.	690	..	..
					<u>16,740</u>	..	..
<i>Deduct Salvage value</i>							
Sheet 5%	}	<u>16740</u>			837		
Gutters 5%							
Ridge 5% . . . . .								20
					<u>15,903</u>	20.156	788.90
							<u>1085.12</u>
6. Miscellaneous							114.88
							<u>1200.00</u>
7. Present worth cost of maintenance per sft. .		<u>1200 × 21.401</u>					1.95
		13163					
8. Equated cost of maintenance		<u>1200</u>			0.09		..
		13163					
9. Percentage cost of maintenance		<u>1200 × 100</u>			1.12%		
		1,07,000					

10. Deduct Salvage Value	.	.	.	.	.	.	.	.	.
Roof 5%	.	.	.	.	837	..	.	..	..
Doors 1/5 x 5120=1024	.	.	.	.	1024	..	.	..	..
Ventilators 1/20 x 4000=200	.	.	.	.	00	..	.	..	..
Frame $\frac{30000}{10}$	.	.	.	.	3000	..	..	..	..
Miscellaneous	.	.	.	.	939	..	..	..	..
					<u>6000 x .0369</u>				0.02
					13163				<u>1.93</u>
11. Capital cost :						..	..	..	8.25
12. Present worth cost of capital & maintenance per sft. of Godown Area						..	..	..	<u>10.18</u>

TABLE 3

PRESENT—WORTH—COST STUDY OF RCC SEMI-ELLIPTICAL SHELL ROOF STRUCTURE

Data :

1. Godown Area : 12,282 sft.
2. Capital Cost : Rs. 1,21,500
3. Rate per sft. of Godown Area : Rs. 9.89
4. Rate of Compound Interest (i) = 4.5 % per annum

Maintenance

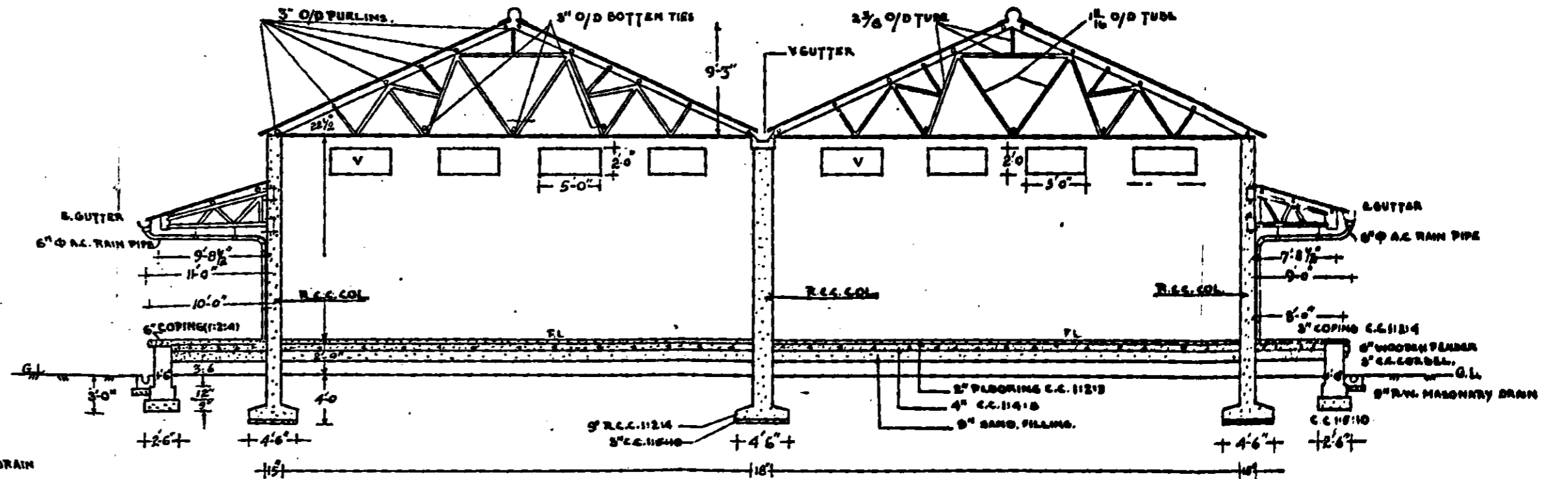
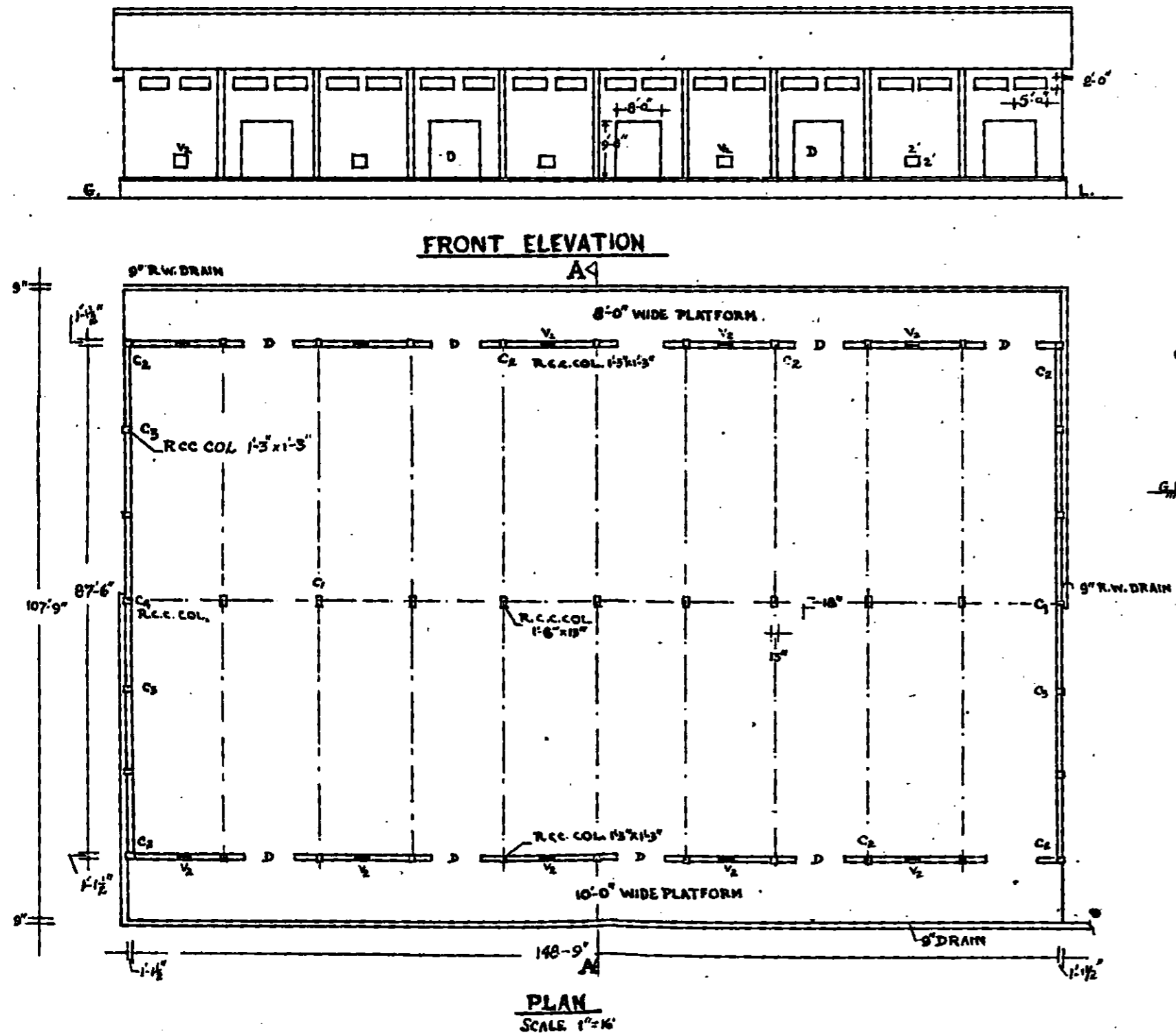
Sl. No.	Description	Quantity	Rate	Per	Amount	Sinking fund factor (divided by)	Sinking fund value
1	2	3	4	5	6	7	8
			Rs.		Rs.	No.	Rs.
1.	White washing—every year	35500	0.62	100 sft.	220	1.000	220.00
2.	Painting wood work—once in 3 years	600	7.50	100 sft.	45	3.133	14.40
3.	Painting iron work—once in 4 years	1700	7.50	100 sft.	128	4.267	30.00
4.	Replacing tarfelt—once in 8 years	17000	45.00	100 sft.	7650	9.378	815.80
							1989.20

5. Miscellaneous	L.S.	..	..	<u>19.80</u>
6. Present worth of Maintenance	$1,100 \times 21.491$	..	..	<u>1100.00</u>
	<u>12,282</u>	..	..	1.92
7. Equated cost of Maintenance per year per sft. of Godown Area	$\frac{1100}{12,282}$	..	0.09	..
8. Equated percentage cost of Maintenance per year over capital cost	$\frac{1100 \times 100}{12,282}$	..	9.91%	..
9. Capital cost per sft. of Godown Area	121500			<u>9.89</u>
10. Total Capital cost and Maintenance		..	..	<u>11.81</u>
Deduct				
Doors : $5120 \times 1/5$	= 1024			
Ventilators $3700 \times 1/20$	= 185			
Miscellaneous L.S.	= 291			
	} 1500			
	1500×0.0369			
Present worth per sft.	<u>12,282</u>	..	..	0.01
11. Net Present worth cost per sft. of Godown Area		..	..	<u>11.80</u>

39

FOOD GRAIN STORAGE GODOWN
OF
TUBULAR TRUSS

INDICATIVE SKETCH
PLATE NO I

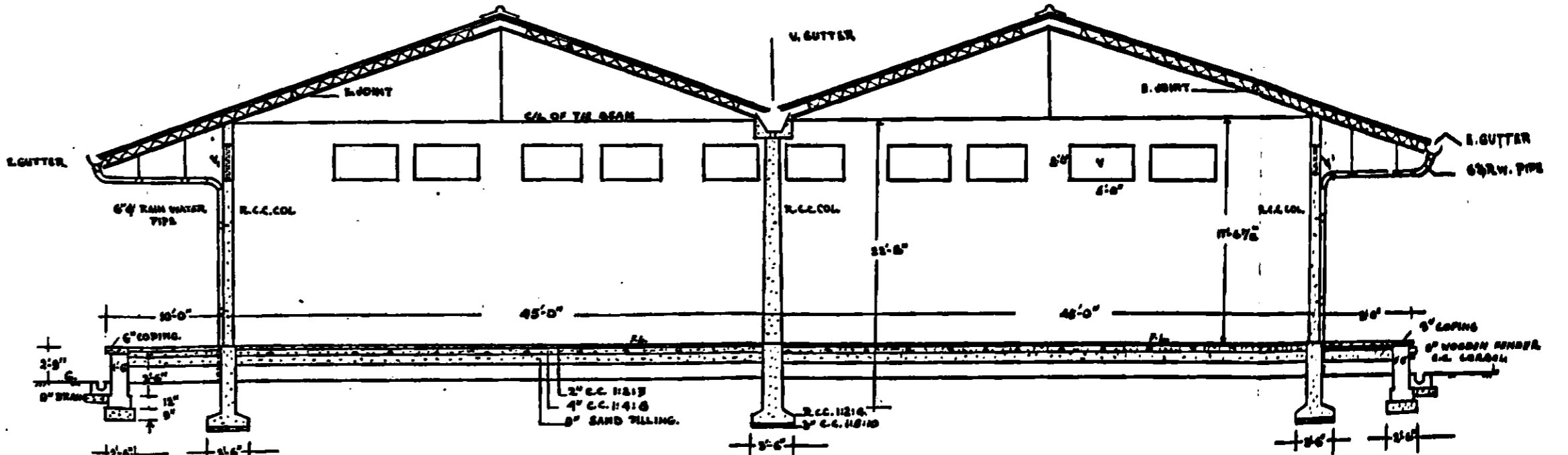
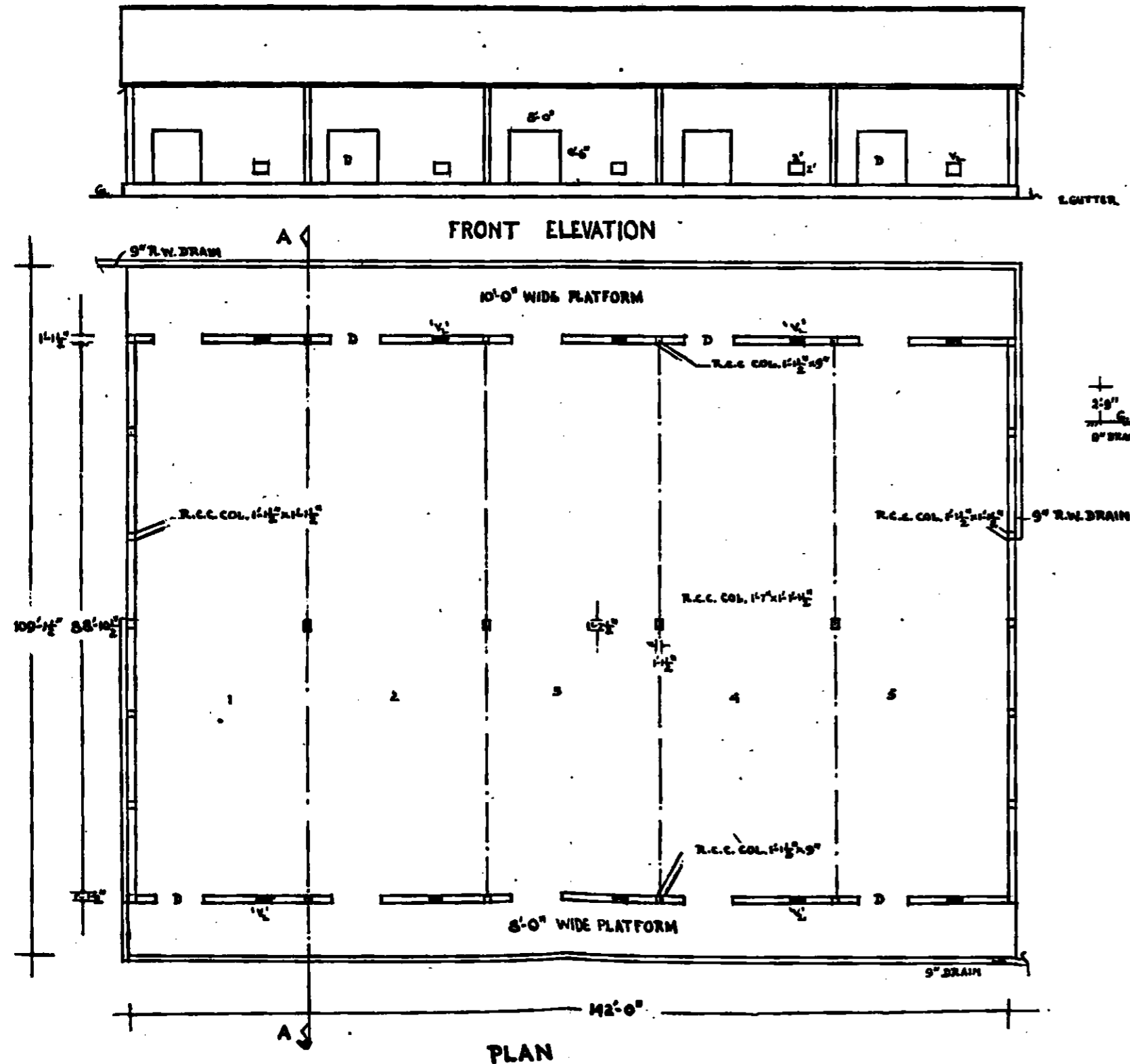


SCHEDULE OF DOORS & WINDOWS		
TYPE	DESCRIPTION	SIZE
'D'	OPENING WITH ROLLING SHUTTERS.	9'-6" X 8'-0"
'V'	OPENING WITH FIXED GLAZING & BRL. FABRIC	5'-0" X 2'-0"
'W'	OPENING WITH WIRE MESH ONLY	5'-0" X 2'-0"
'L'	OPENING WITH GLASS LOUVERS, GRILL WORK AND WIRE MESH	2'-0" X 2'-0"

Note: This is not a working drawing.

**FOOD GRAIN STORAGE GODOWN
OF
WELDED ROOF TRUSS**

INDICATIVE SKETCH
PLATE NO. II.



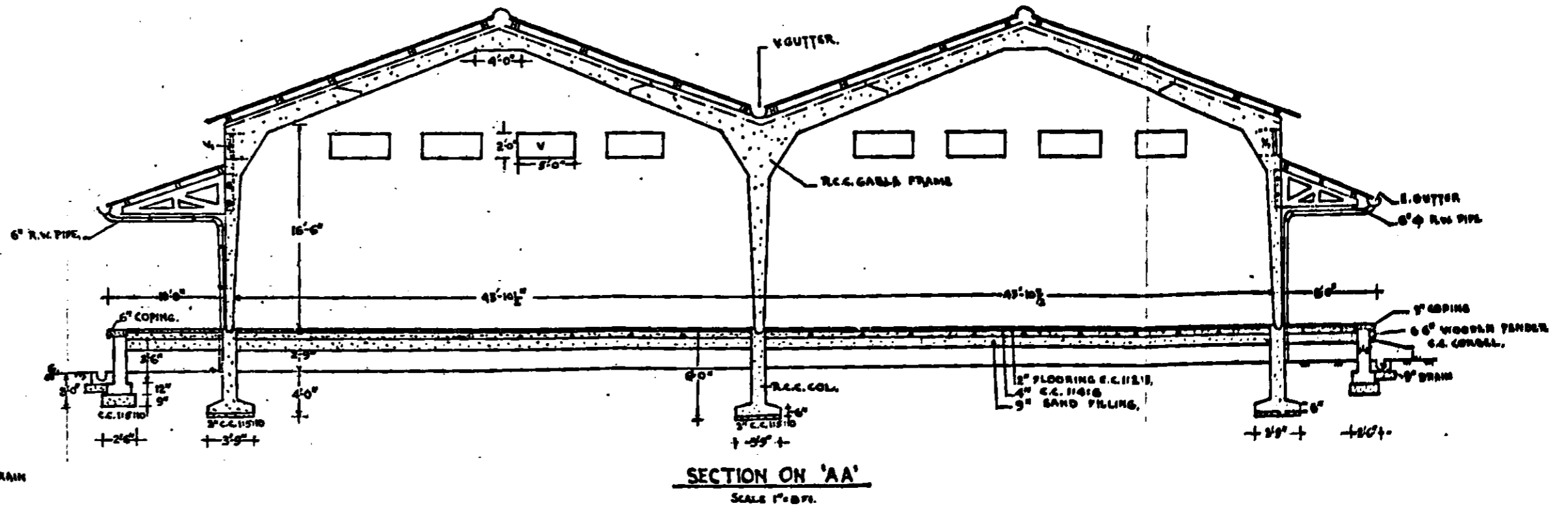
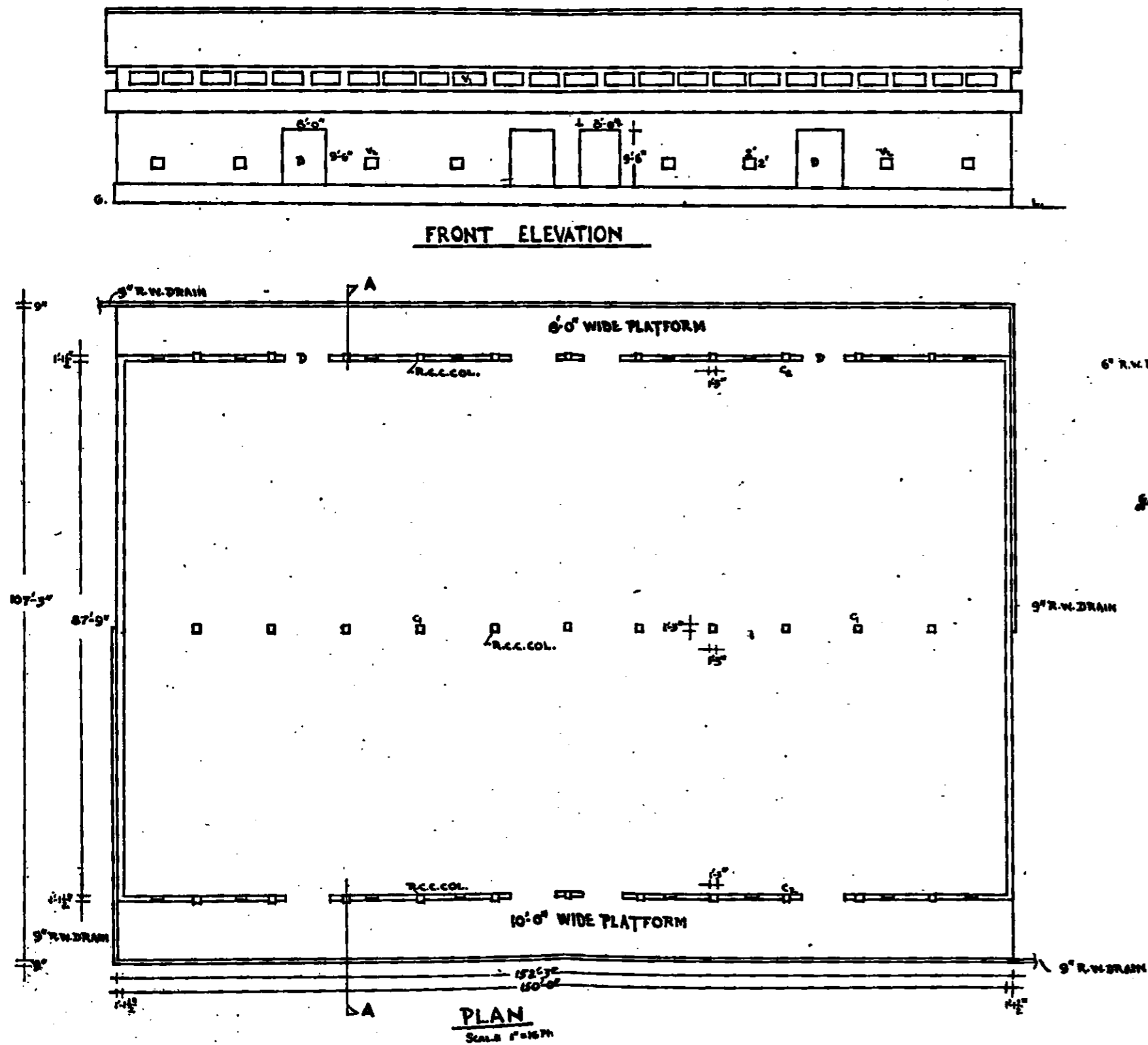
SECTION ON 'AA'

SCHEDULE OF DOORS & WINDOWS.		
TYPE	DESCRIPTION	SIZE
'D'	OPENING WITH ROLLING SHUTTERS	9'-0" X 8'-0"
'W'	OPENING WITH FIXED GLAZING OF BRN. FABRIC	8'-0" X 2'-0"
'V'	OPENING WITH WIRE MESH ONLY	3'-0" X 2'-0"
'V'	OPENING WITH GLASS LOUVERS, GRILL WORK & WIRE MESH.	2'-0" X 2'-0"

NOTE:- THIS IS NOT A WORKING DRAWING.

**FOOD GRAIN STORAGE GODOWN
OF
R.C.C. GABLE ROOF**

INDICATIVE SKETCH
PLATE NO. III

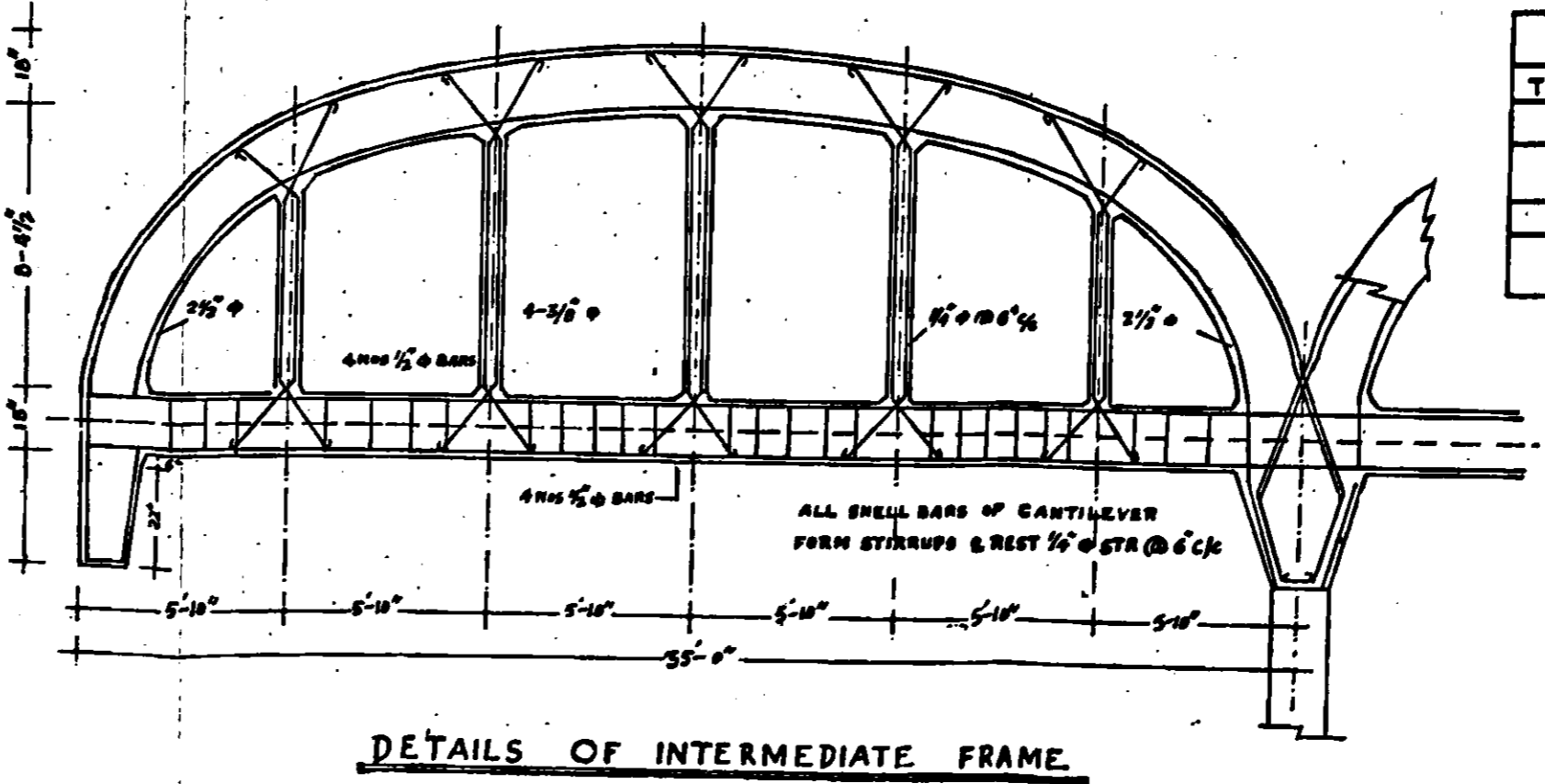
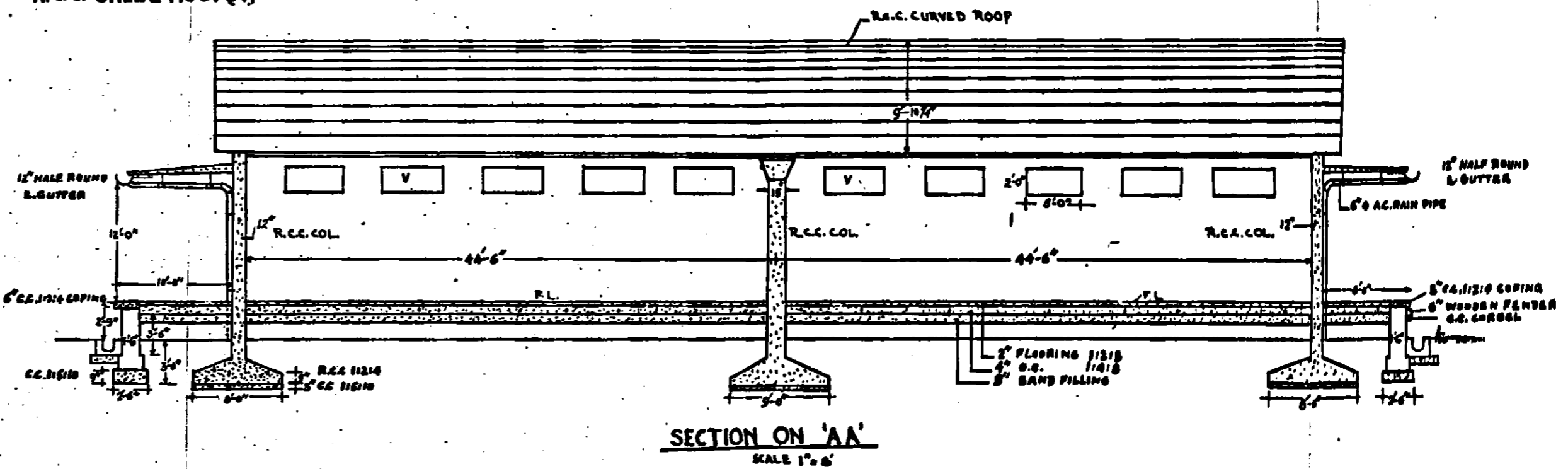
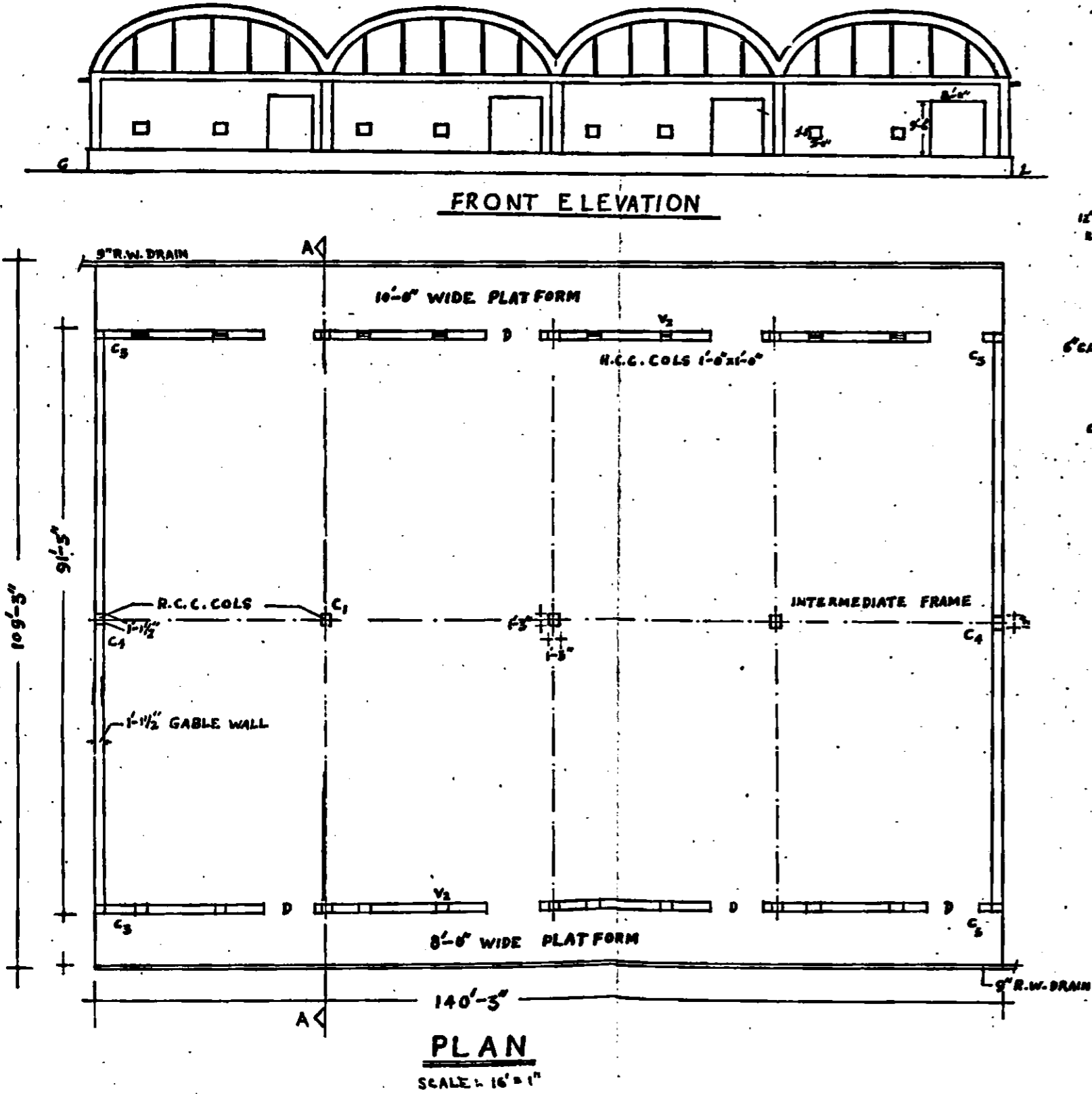


SCHEDULE OF DOORS & WINDOWS		
TYPE	DESCRIPTION	SIZE
'D'	OPENING WITH ROLLING SHUTTERS.	8'-6" X 8'-0"
'V'	OPENING WITH FIXED GLAZING & R.C.C. FRAME	5'-0" X 2'-0"
'W'	OPENING WITH WIRE MESH ONLY	5'-0" X 2'-0"
'V'	OPENING WITH GLASS LOUVERS, GRILL WORK & WIRE MESH	2'-0" X 2'-0"

NOTE:- THIS IS NOT A WORKING DRAWING.

**FOOD GRAIN STORAGE GODOWN
OF
R.C.C. SHELL ROOF(A)**

INDICATIVE SKETCH
PLATE NO. IV

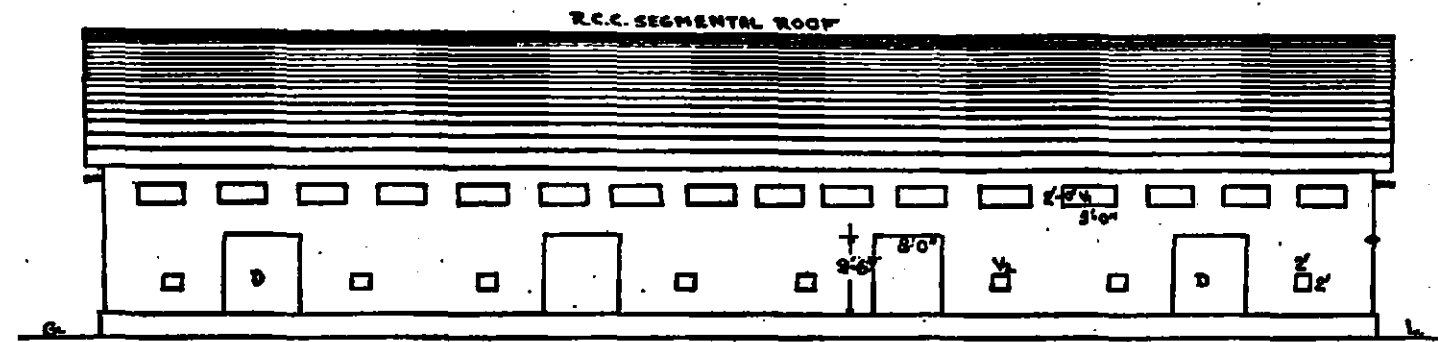


SCHEDULE OF DOORS & WINDOWS		
TYPE	DESCRIPTION	SIZE
'D'	OPENING WITH ROLLING SHUTTERS.	8'-6" x 8'-0"
'V'	OPENING WITH FIXED GLAZING & BR.C. FABRIC	5'-0" x 2'-0"
'V'	OPENING WITH WIRE MESH ONLY	5'-0" x 2'-0"
'V'	OPENING WITH GLASS LOUVERS, GRILL WORK, WIRE MESH.	2'-0" x 2'-0"

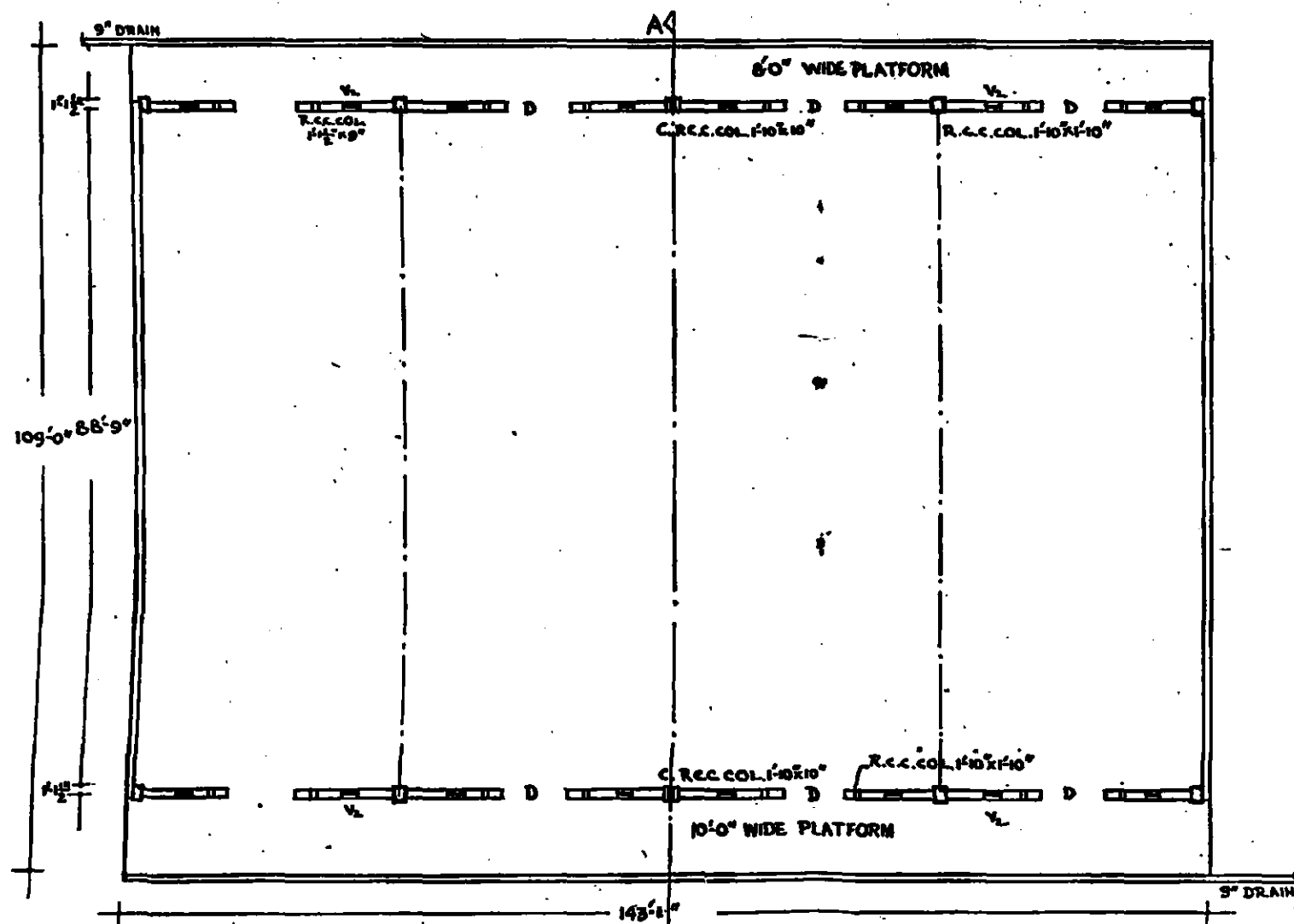
NOTE:- THIS IS NOT A WORKING DRAWING.

FOOD GRAIN STORAGE GODOWN
OF
R.C.C. SHELL ROOF (SEGMENTAL)

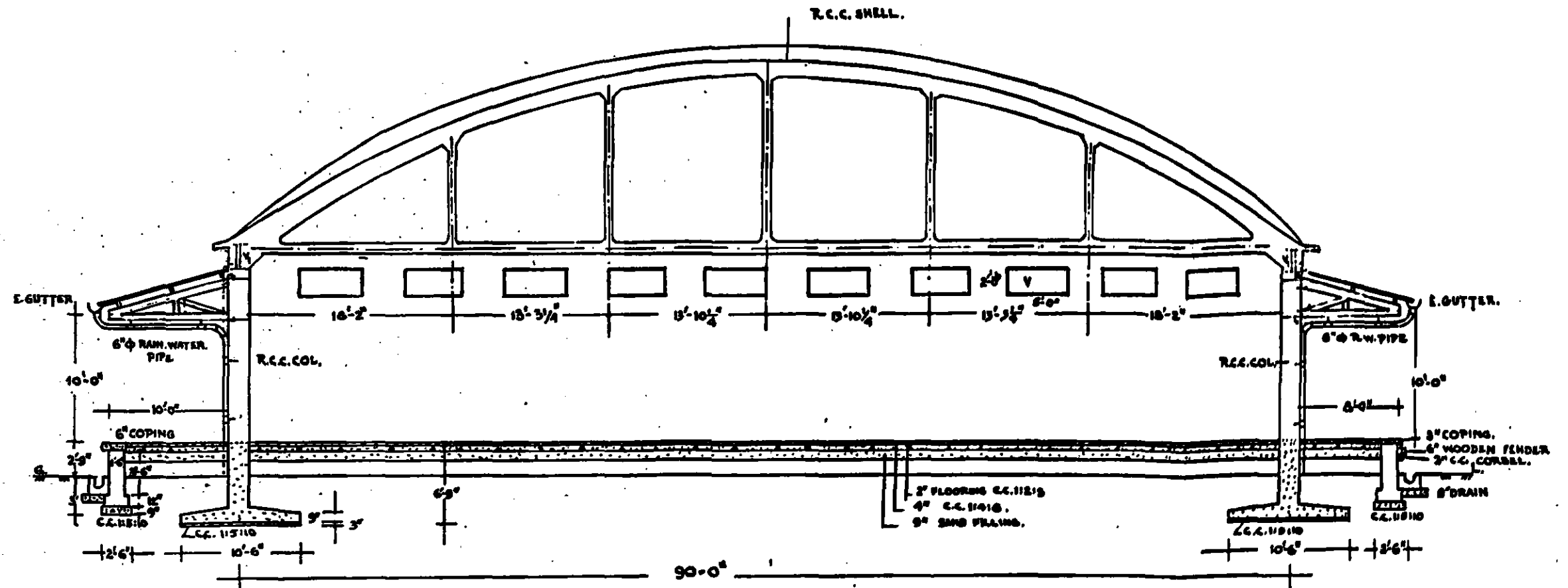
INDICATIVE SKETCH
PLATE NO V



FRONT ELEVATION



PLAN
SCALE: 1"=10'-0"



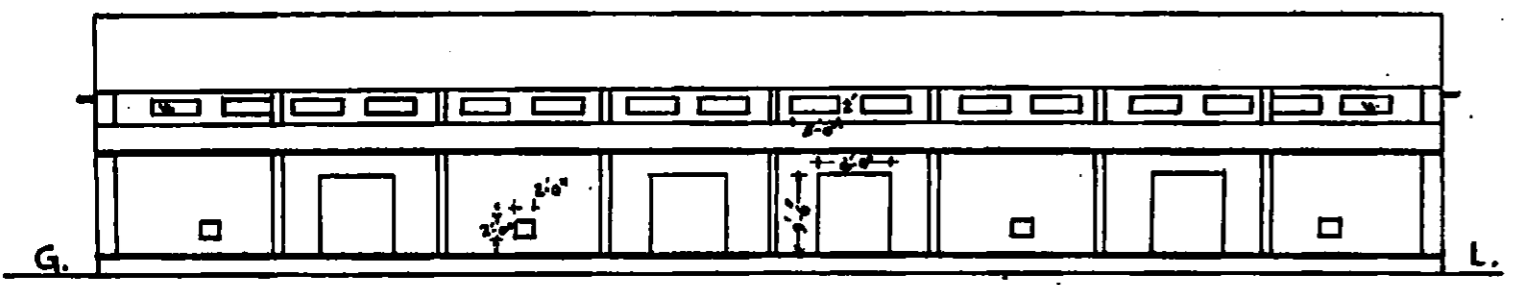
SECTION ON 'AA'
SCALE: 1"=6'-0"

SCHEDULE OF DOORS & WINDOWS		
TYPE	DESCRIPTION	SIZE
'B'	OPENING WITH ROLLING SHUTTERS	9'-6" x 8'-0"
'V'	OPENING WITH FIXED GLAZING & B.L.C. FRAME	5'-0" x 2'-0"
'W'	OPENING WITH WIRE MESH ONLY.	5'-0" x 2'-0"
'X'	OPENING WITH GLASS LOUVERS, GRILL WORK & WIRE MESH	2'-0" x 2'-0"

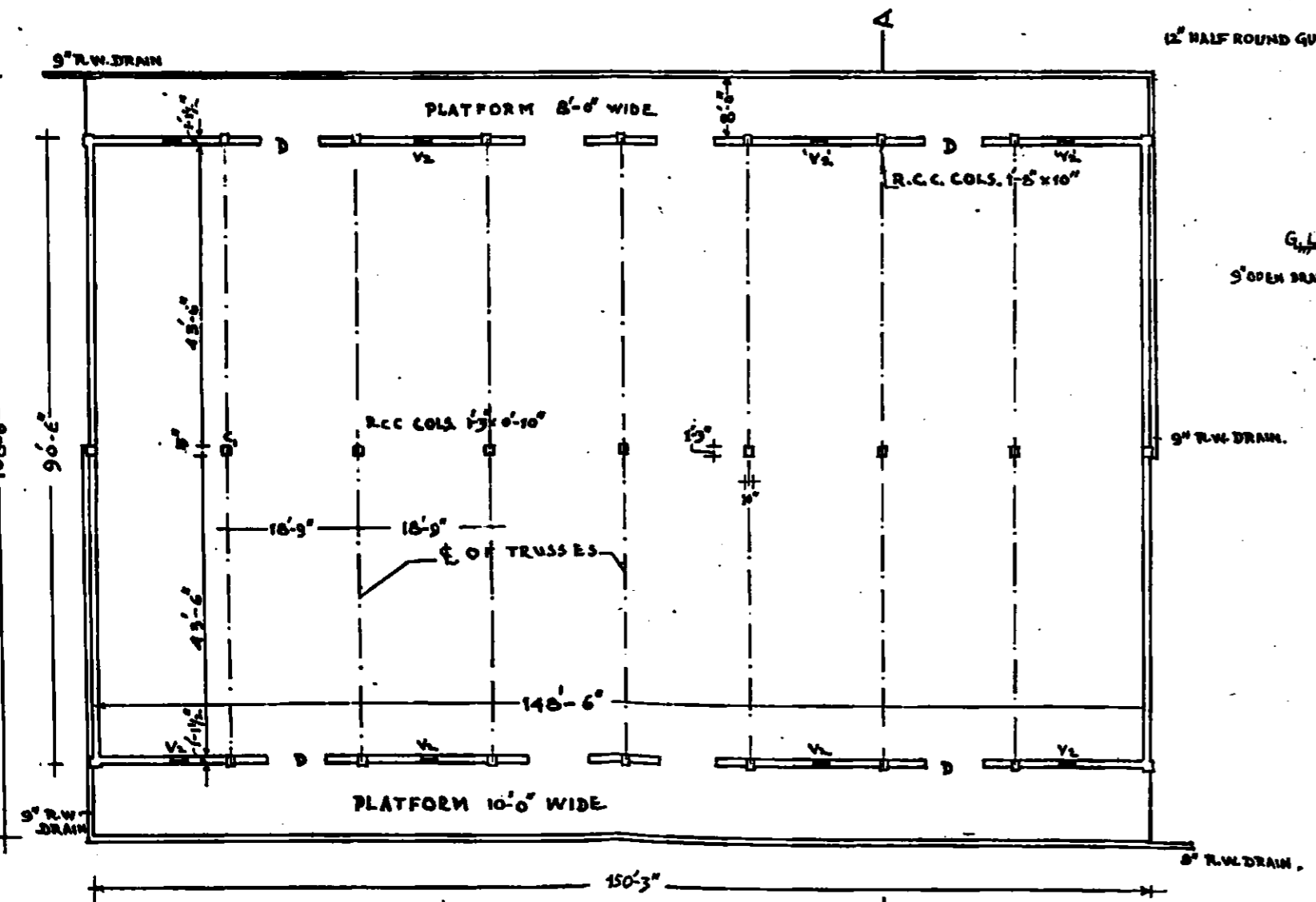
NOTE:- THIS IS NOT A WORKING DRAWING.

FOOD GRAIN STORAGE GODOWN
OF
PREFABRICATED PRECAST STRUCTURE

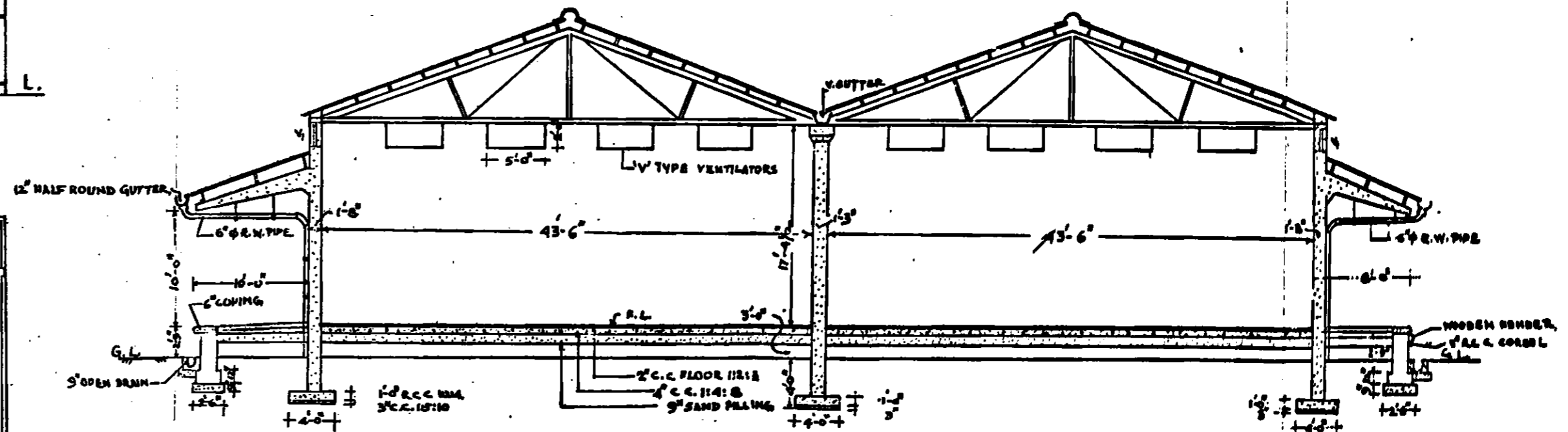
INDICATIVE SKETCH
PLATE NO. III



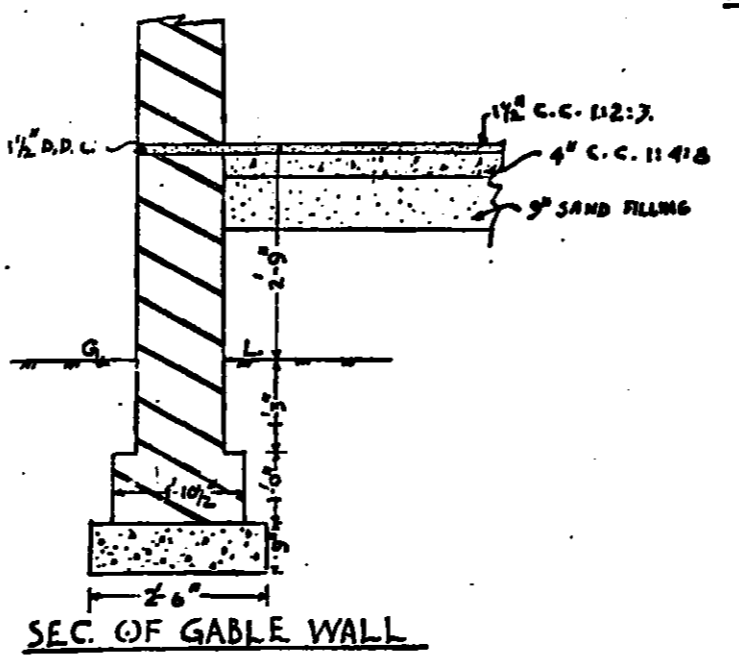
FRONT ELEVATION



PLAN
SCALE: 1/8" = 1'



SECTION ON A-A
SCALE: 1" = 8' PL.



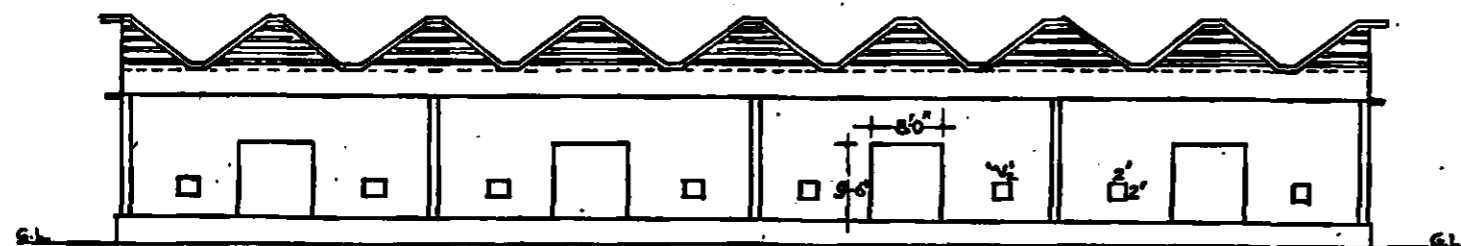
SEC. OF GABLE WALL

SCHEDULE OF DOORS & WINDOWS			
TYPE	DESCRIPTION	SIZE	REP. IN SCALE & C.S. DETAILS
'D'	OPENING WITH ROLLING SHUTTERS	9'-6" x 8'-0"	"
'V'	OPENING WITH SIZED GLAZING & D.R.C. FABRIC	5'-0" x 2'-0"	"
'V1'	OPENING WITH WIRE MESH ONLY	5'-0" x 2'-0"	"
'V2'	OPENING WITH GLASS LOUVERS, GRILL WORK & WIRE MESH	2'-0" x 2'-0"	"

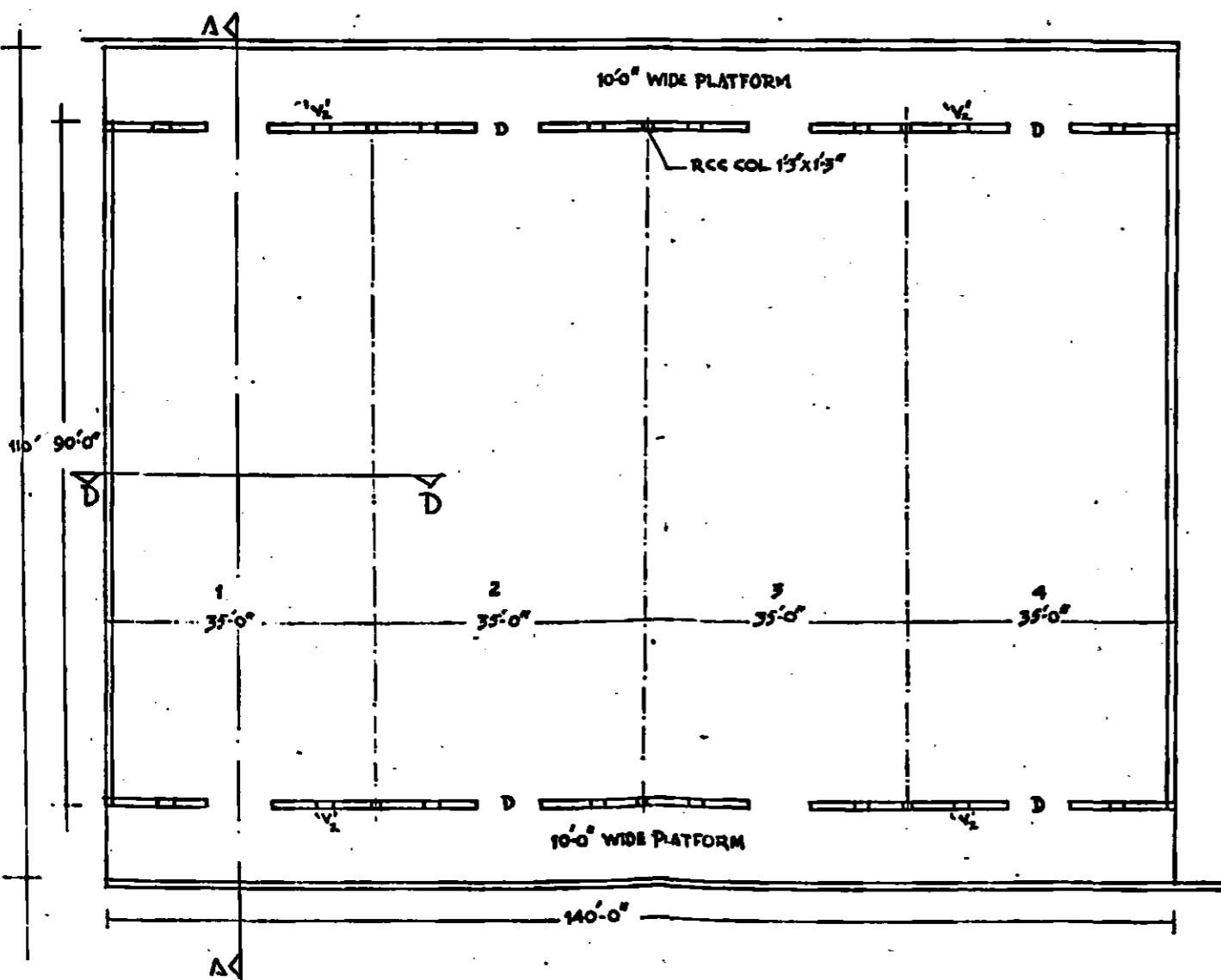
NOTE:- THIS IS NOT A WORKING DRAWING.

GRAIN STORAGE GODOWN
OF
FOLDED PLATE ROOF

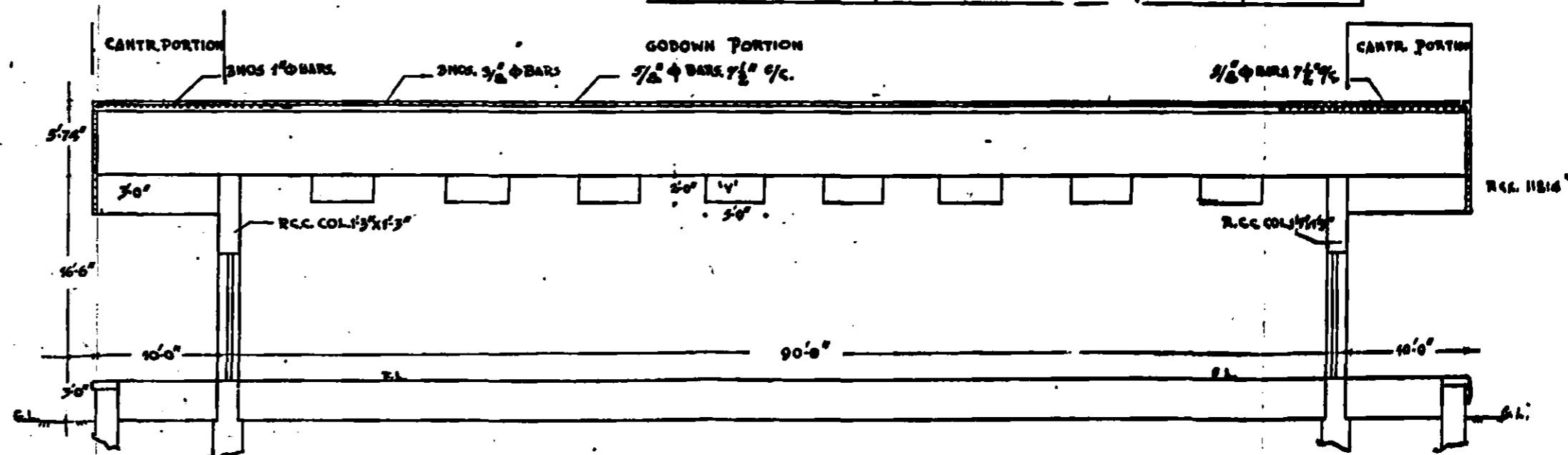
SCHEDULE OF DOORS & WINDOWS		
TYPE	DESCRIPTION	SIZE
'D'	OPENING WITH ROLLING SHUTTERS	8'-6" x 8'-0"
'V'	OPENING WITH FIXED GLAZING B.R.C. FABRIC	8'-0" x 2'-0"
'V'	OPENING WITH WIRE MESH ONLY	8'-0" x 2'-0"
'V'	OPENING WITH GLASS LOUVERS—GRILL WORK & WIRE MESH.	2'-0" x 2'-0"



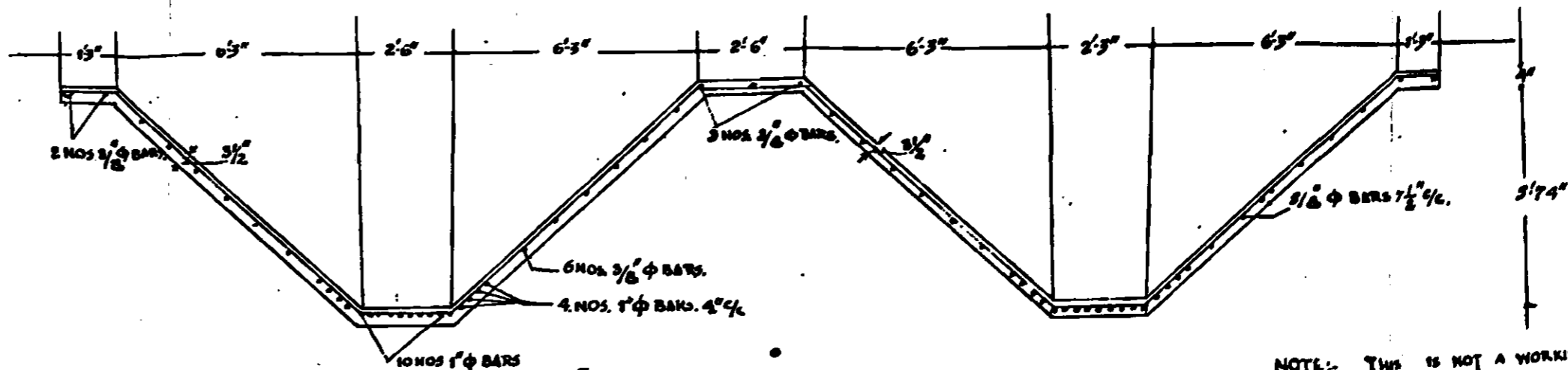
FRONT ELEVATION



PLAN
SCALE 3/8" = 16 FT.



SECTION ON 'AA'
SCALE 1" = 8 FT.



SECTION ON 'DD'
SCALE 3/8" = 1 FT.

NOTE: THIS IS NOT A WORKING DRAWING.