

ESTHETIC ENHANCEMENT OF CONCRETE STRUCTURES USING
FERRO-CEMENT PANELS

by

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An investigation of ferro-cement indicates that when used in colored panels, such panels can be used to enhance the appearance of concrete structures. The panels are simply made, light in weight, and easily attached to either old or new structures. When the panels are used as accent colors, relatively few are required, and the cost is thereby minimized. A number of possible panel arrangements are illustrated, for both bridge spans and bridge abutments.

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INTRODUCTION

As described in the report "Public Response to Bridge Colors",⁽¹⁾ today's public appears to favor bridges possessing a degree of color. The coloring of steel bridges can be easily achieved by painting; however, the successful coloring of concrete structures is more difficult.

In normal practice, concrete is colored in one of two ways: by painting or by adding coloring additives into the wet mix. The disadvantages of painting concrete include added first cost as well as added maintenance cost for periodic repainting. The disadvantages of adding coloring additives into the wet mix include added first cost and nonuniformity of color. In adding coloring to the mix, the entire mass of concrete has to be colored (even though only the surface is seen), which adds to the cost. Since a large mass of concrete is generally involved, the shade of color tends to be different from batch to batch (caused by aggregate variations).

To avoid these prevailing problems, this study investigated a new approach to the coloring of concrete structures (as bridges, abutments, and retaining walls) by using thin precast colored concrete panels which can be overlaid and bolted to the surface of concrete structures. Such panels cannot only be colored, but textured or sculptured as well for additional esthetic enhancement. These panels can be applied to new structures as well as to old, with no change in the engineering aspects of these structures. Plain concrete surfaces are particularly vulnerable to graffiti disfigurement and it is believed that the addition of attractive panels would minimize such graffiti. On structures already displaying graffiti, overlay panels would conceal such vandalism. On new structures, less attention need be paid to surface finishing of the concrete as the colored panels would be the features that attract the eye. Construction costs could conceivably be lowered as a result.

The panels can be fabricated economically in a variety of shapes, sizes and colors and applied to structures in a variety of patterns to make each structure uniquely attractive. Several architectural precasting firms in Virginia could manufacture such panels. Although colored panels of other materials as plastic and metal could conceivably be used, concrete panels would be the ones most compatible esthetically with the nature of the basic concrete structure itself; and concrete is, therefore, the only material considered in this study.

The requirements for the concrete panels include ease of fabrication, ease of installation, durability, attractiveness, lightness in weight, low cost and adaptability to a variety of sites.

It is believed that all these conditions can be met using a relatively new reinforced concrete material called "ferro-cement". The use of ferro-cement for thin panels (flat or curved) was first popularized about 30 years ago by the Italian engineer Pier Luigi Nervi. The idea lay dormant until a few years ago when it became a widely used material for boat hull construction. Thousands of ferro-cement boats have now been built with hull thicknesses of only $\frac{1}{2}$ " to $1\frac{1}{2}$ ", and many of these boats have crossed the oceans of the world. (2, 3) Scientific tests have been performed on this material (4, 5, 6) which have proved out the highly resilient nature of this substance. Reference 7 describes its economy, adaptability, and ease of fabrication. Basically, ferro-cement is a thin composite of several layers of welded wire fabric, coated on both sides with sand-cement mortar. The stiff mortar is usually troweled on, penetrating the mesh. The high strength and ductility is achieved by virtue of the multiple layers of wire mesh. As ferro-cement panels are usually thin, galvanized wire mesh is recommended for the inhibition of corrosion.

PANEL DESCRIPTION

To make a determination of the strength, ductility, and durability of thin ferro-cement panels, 12 test sections, 6" wide and 36" long were cast for testing at the Virginia Highway Research Council. Variables included the panel thickness ($\frac{1}{2}$ " and $\frac{3}{4}$ "), size of galvanized wire mesh openings (sometimes called hardware cloth) ($\frac{1}{4}$ " and $\frac{1}{2}$ ") and number of layers of mesh (1, 2, and 3). After curing, these panels were tested as simply supported beams (lying flat) loaded at the center with a concentrated force imposed by a hydraulic testing machine. Plots of the load-deflection behavior are shown in Figures 1-6 (all figures attached).

In addition, a few "vandalism" tests were conducted in which an 8-pound steel weight was dropped onto the panel from a height of 4'. Such impact was intended to simulate an object as a rock thrown at a panel. Only after repeated blows at the same location did spalling occur in the panel.

Uncracked portions of the test panel were then cut into 3" by 4" blocks for repeated freeze-thaw action in a freeze-thaw machine. Unfortunately, due to a breakdown of the freeze-thaw equipment at the Research Council, final results of these tests are not available at this time.

After evaluating the data, a judgement was made to use a $\frac{1}{2}$ " thick panel with 2 layers of $\frac{1}{4}$ " galvanized welded wire mesh for the prototype panel. Details of typical prototype panels are shown in Figures 7 and 8. Coloring may be achieved through the addition of coloring dye to the mortar mix or through use of precolored cement which can be obtained in as many as 144 different hues. (8) In either case, the mortar mix must be exactly the same for each panel used on a given structure to maintain uniformity of color.

Figure 9 illustrates the manner of attachment of the panel to the concrete surface. The use of a stainless steel bolt will insure a maintenance free installation. A double nut on the bolt is recommended to prevent accidental loosening of the panel. By putting a little pressure on the panel through tightening of the nut, the panel will grip the concrete surface and prevent further movement. Note that the edges of the panel are beveled so as to deflect any water drip and thus prevent streaking or staining of the panel. The panel units shown in Figures 1 and 2 weigh about 25 pounds, making installation easy, and adding little extra dead weight to the structure.

Should the panels ever have to be removed, the anchor bolt arrangement shown in Figure 9 will allow such to be done without damage to the panels.

The estimated cost to produce the panel in Figure 7 is approximately \$6.00, and \$10.00 for the panel in Figure 8. The estimated cost for a single fabricated stainless steel bar with washer and nuts is about \$4.00. Installation costs on existing structures is estimated to be between \$5.00 and \$8.00 per panel, depending on site and location. The installation for new construction would be only about \$1.00 as embedment of the bolt would be merely a matter of presetting the bolt in place prior to casting of the concrete. The total cost per panel would therefore lie between \$11.00 and \$22.00. A 100'-long bridge would use between 50 and 100 such panels. For new construction, architectural grooving and finishing could be minimized, thereby offsetting the cost of the panels.

If these panels were made by Highway Department maintenance personnel during "slow" periods (as in winter months), costs may be reduced even further.

SAMPLE APPLICATIONS

By varying the size, shape or color of the panels, their application on almost any sort of concrete structure is possible. Two types of highway related concrete structures appear to be most conspicuously in need of esthetic enhancement. These are overpass bridges and retaining walls, particularly those of high visibility.

Figures 10-15 show a typical concrete bridge (actually patterned after an existing one near Charlottesville, Virginia) in which ferro-cement panels are attached to the exterior face of the parapet wall in various ways. The panels are used here as accent colors, which is believed to be all that is necessary to relieve the drabness of bare concrete. Coloring of all surfaces is not necessary as is generally done by painting. Obviously, many other shapes and patterns are possible with such panels. Opportunity is thus given to treat each structure uniquely if desired by using but one basic method.

Figures 16-21 show various applications of colored panels on a bridge retaining wall (also patterned after one existing near Charlottesville). Here again, the panels are used only for accent and do not have to cover the entire wall. While covering an entire wall is possible with this method, it would be obviously much more expensive to do. The designs shown in the figures are but samples of what might be done, and in no way restrict other possibilities.

ACKNOWLEDGEMENTS

In addition to acknowledging the general support for this study provided by the Virginia Highway Research Council, the author wishes to express particular appreciation to Wayne D. Tucker, student assistant, who performed the physical tests on the ferro-cement panels described.

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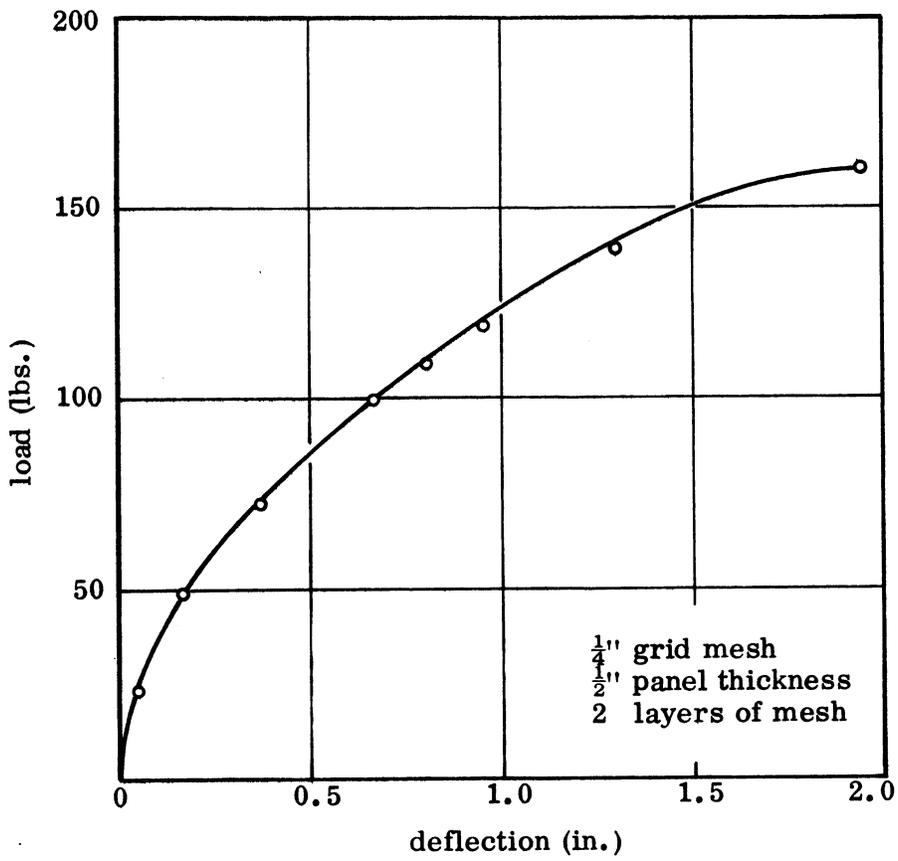
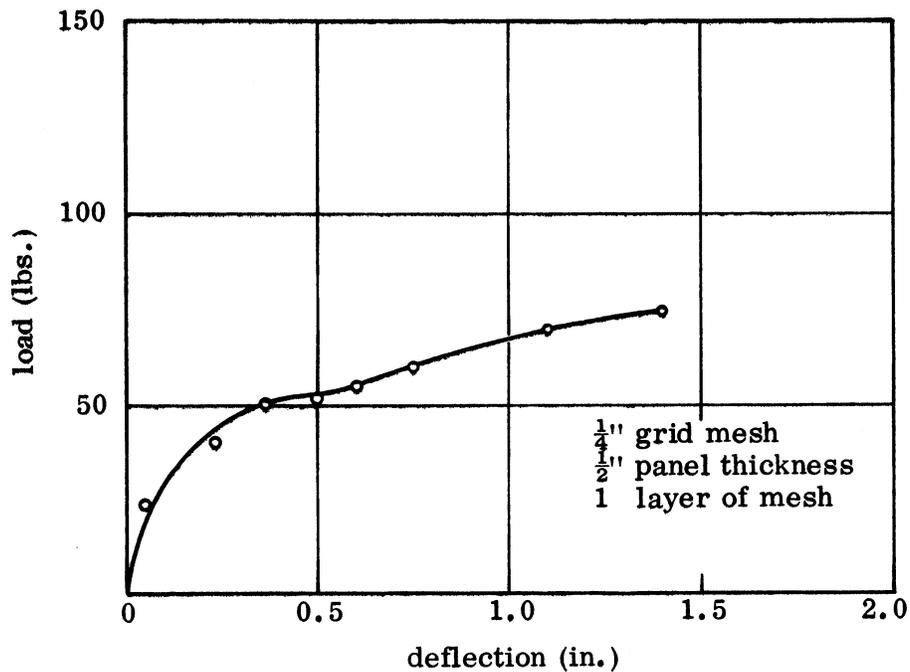


Figure 1. Load deflection diagrams.

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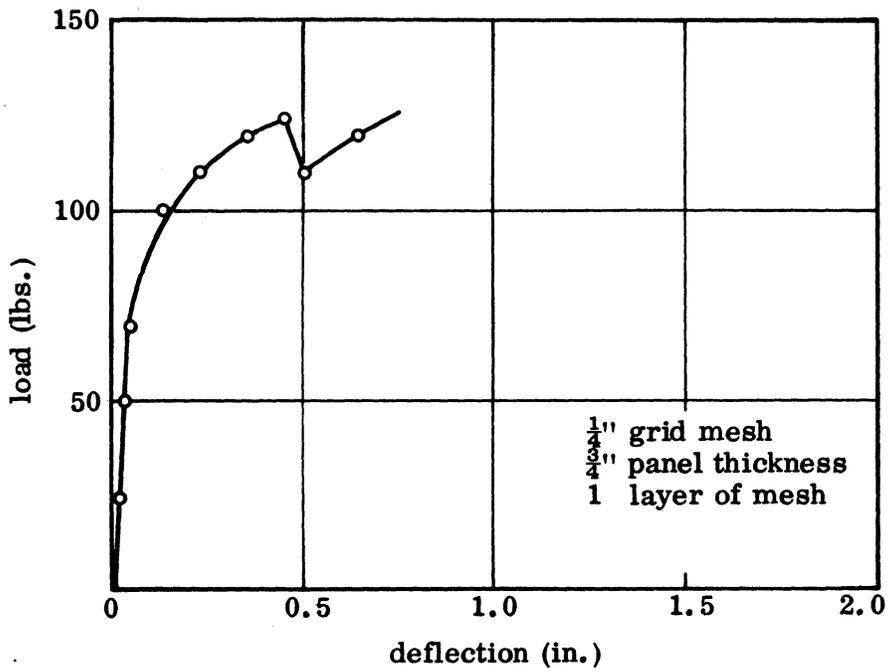
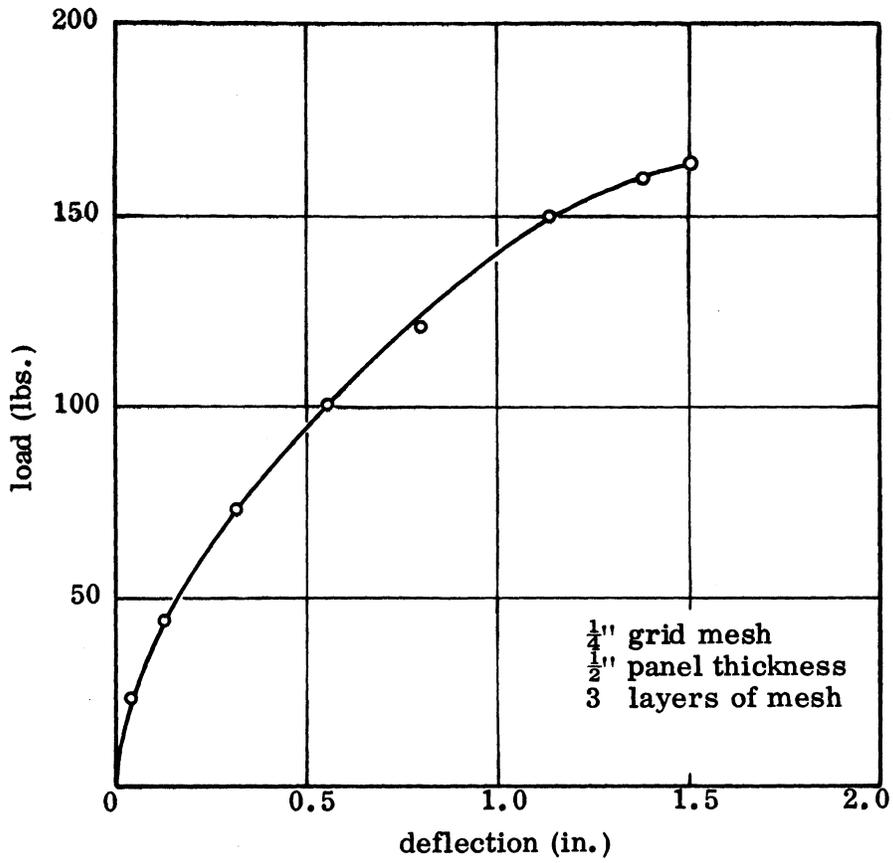


Figure 2. Load deflection diagrams.

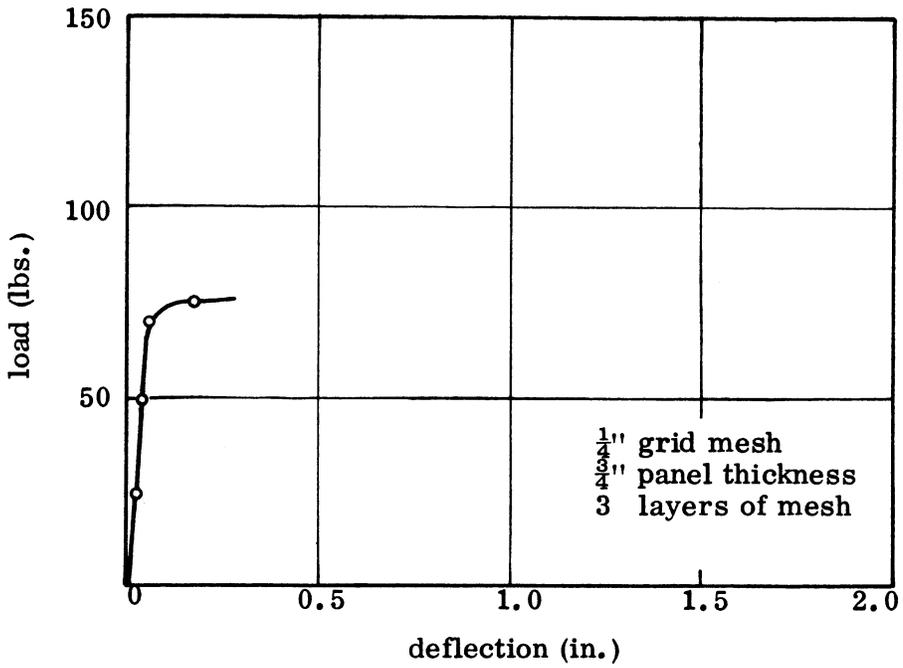
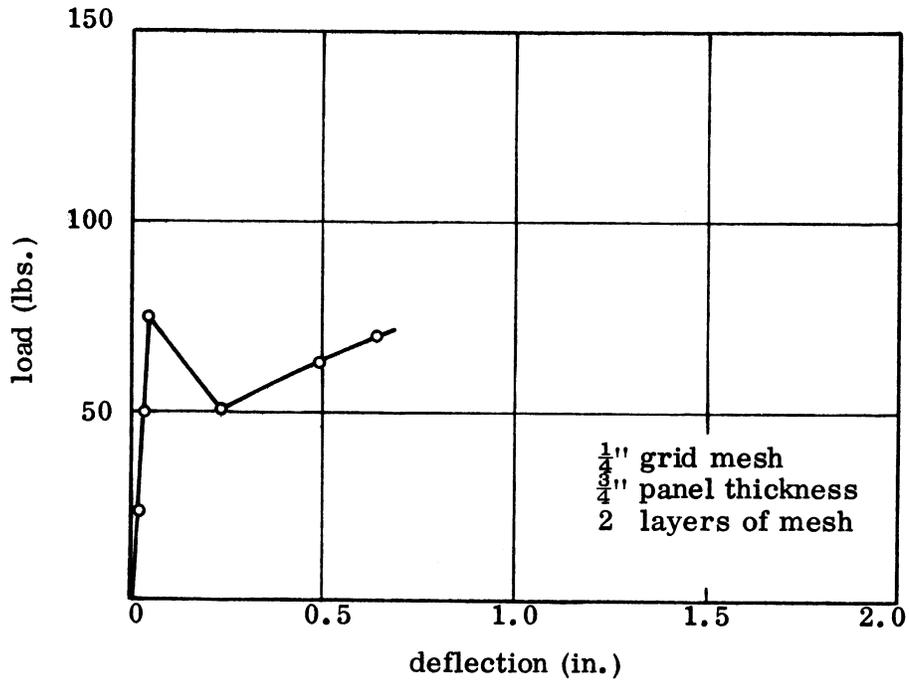


Figure 3. Load deflection diagrams.

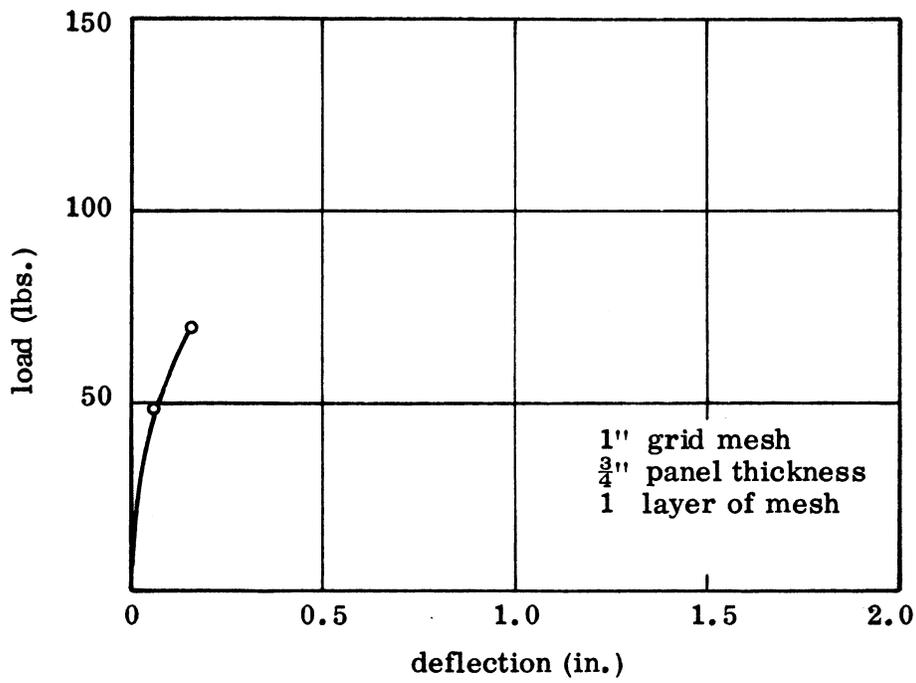
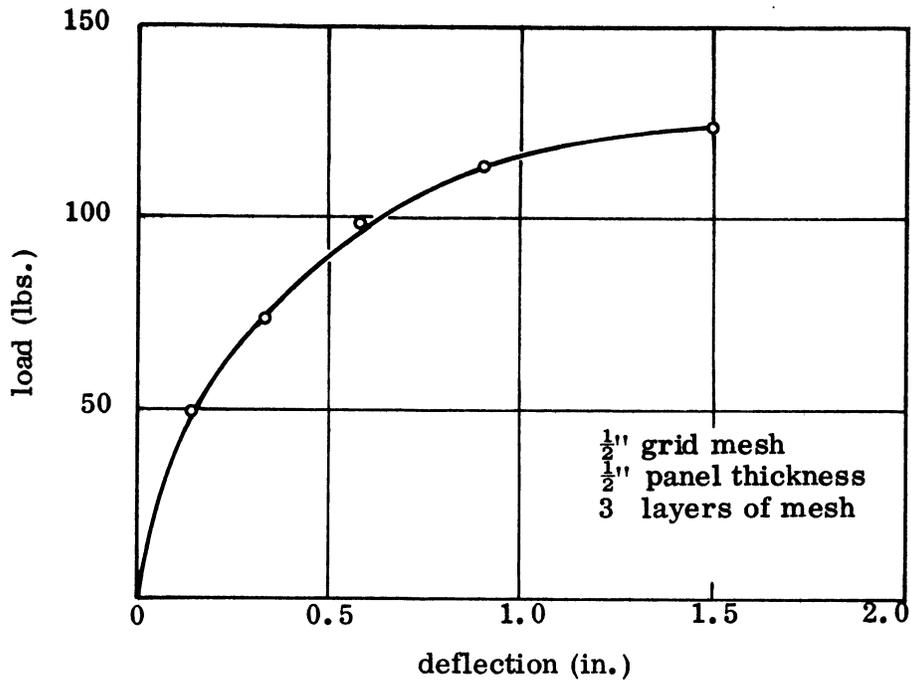


Figure 4. Load deflection diagrams

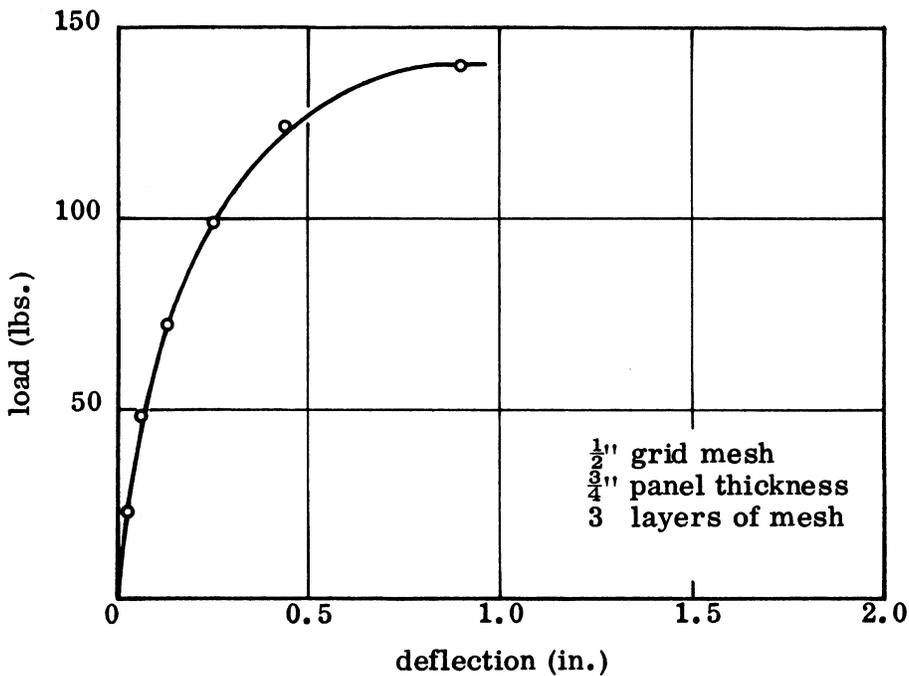
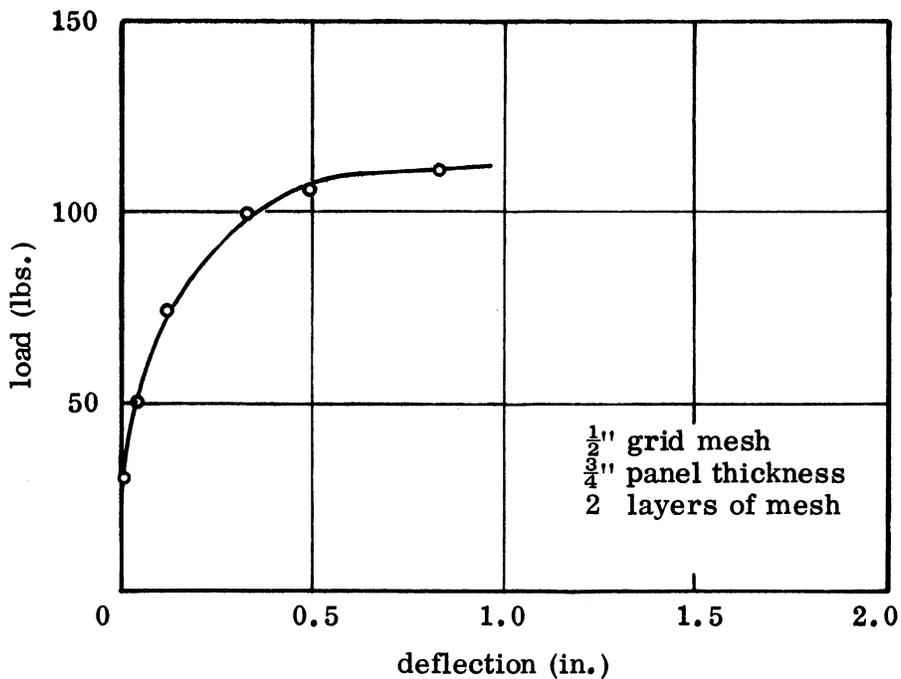


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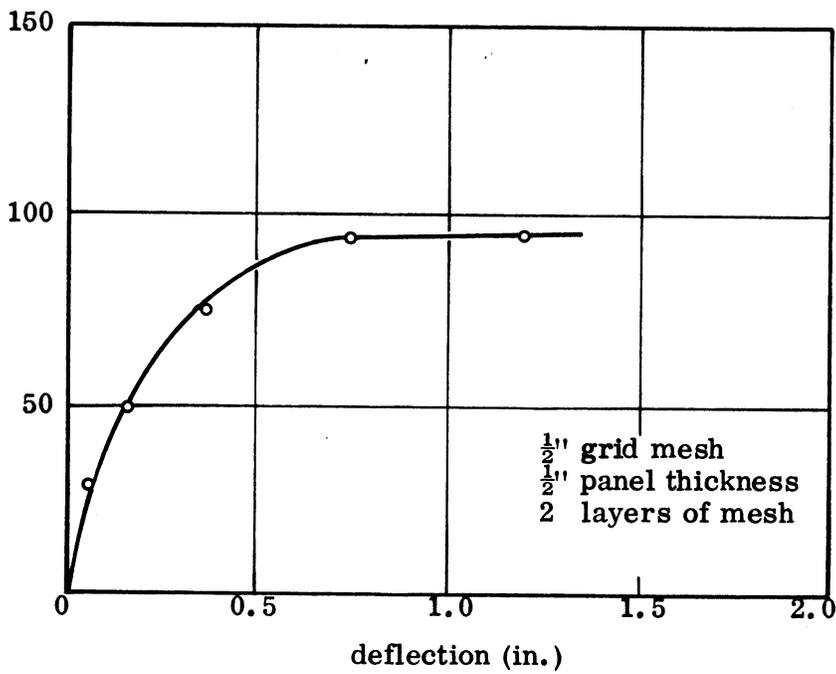
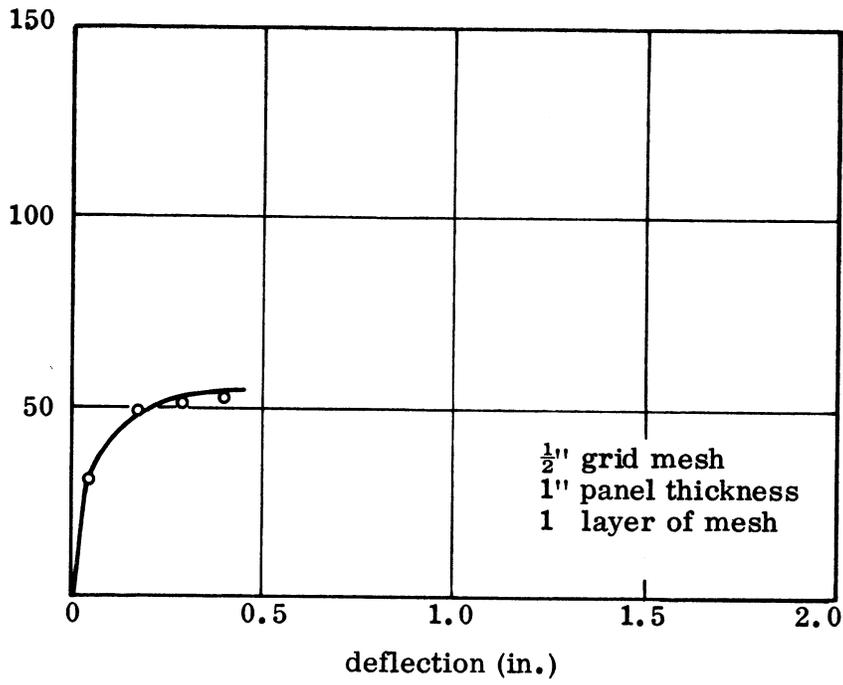
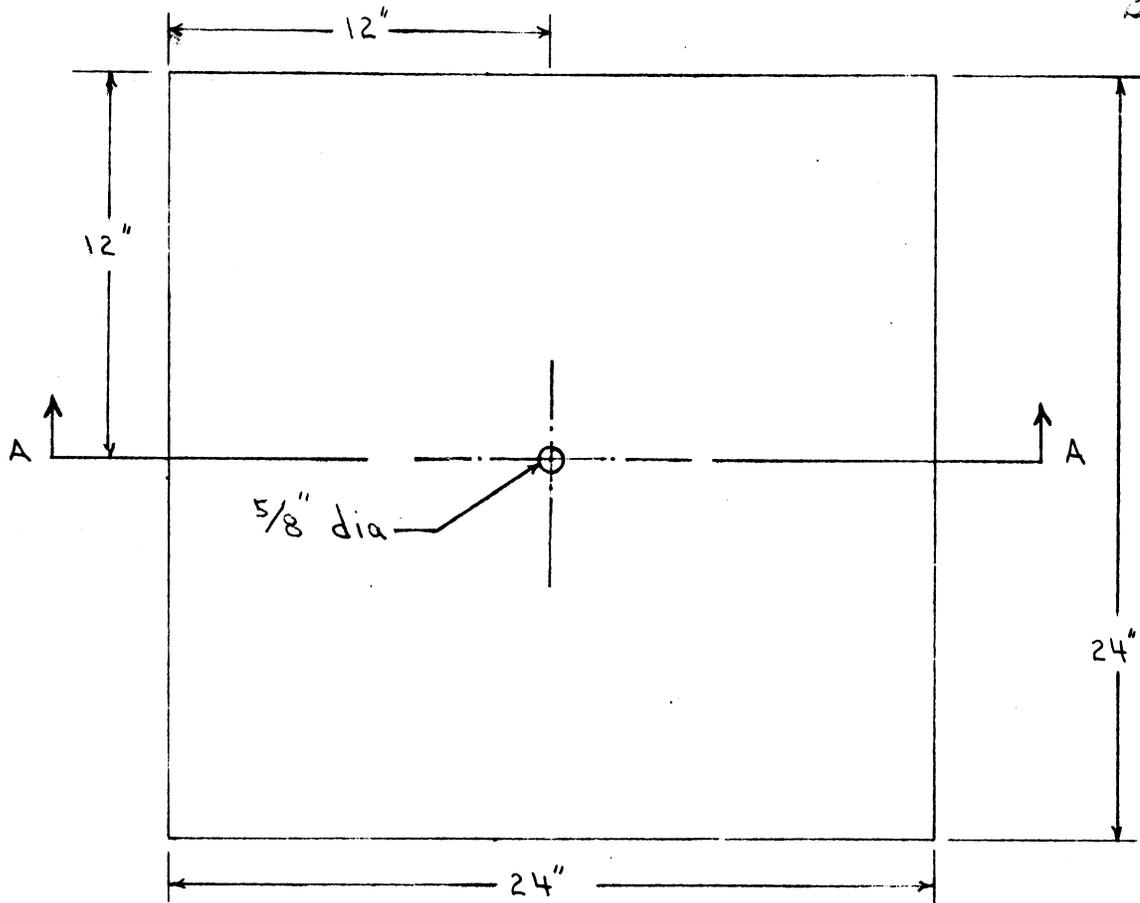
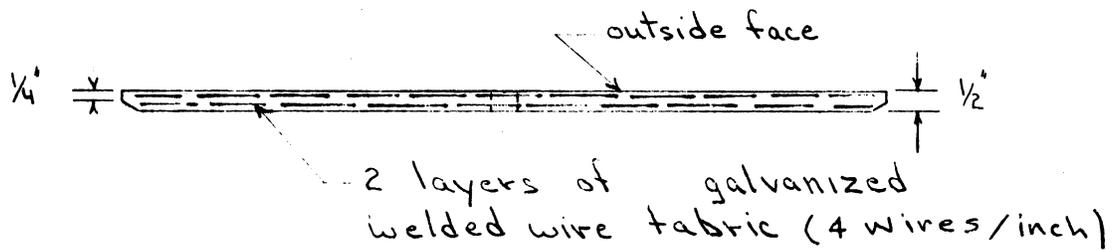


Figure 6. Load deflection diagrams.



Section A-A

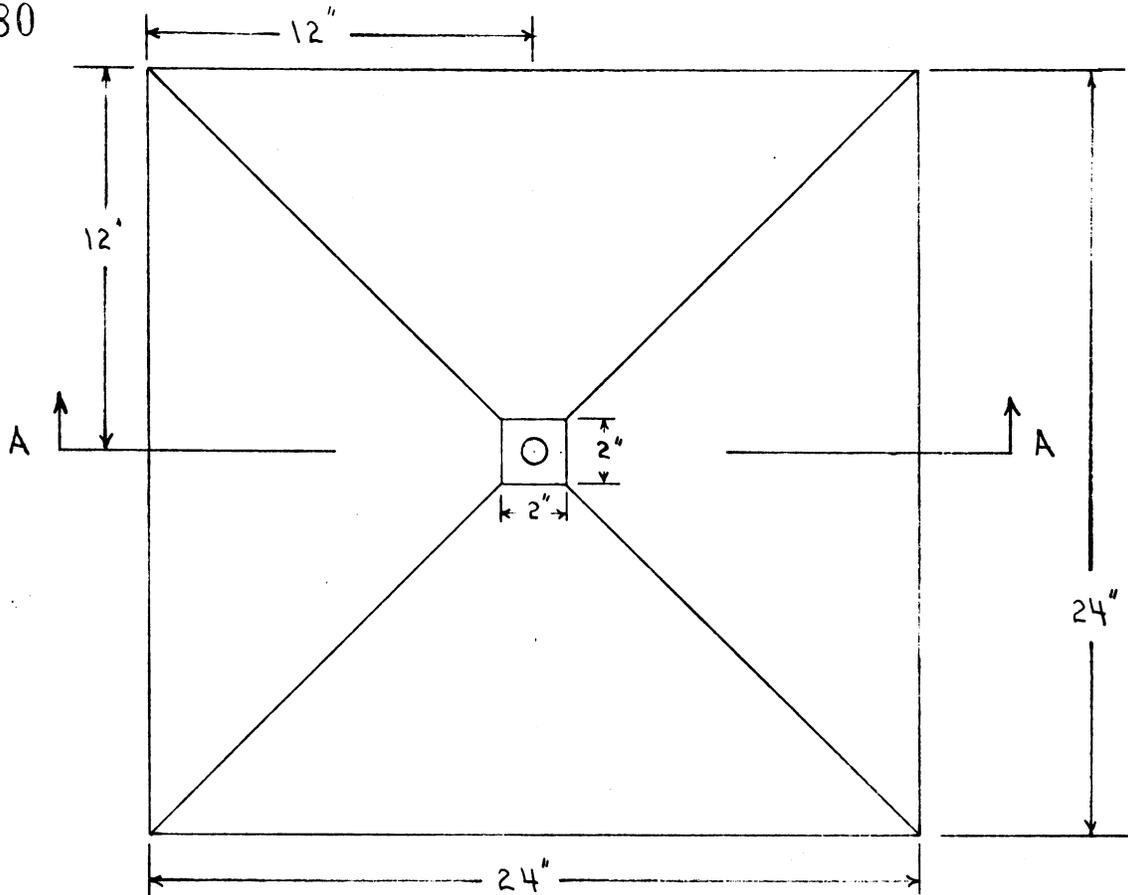


Mortar to be colored to suit, using precolored portland cement or cement dye.

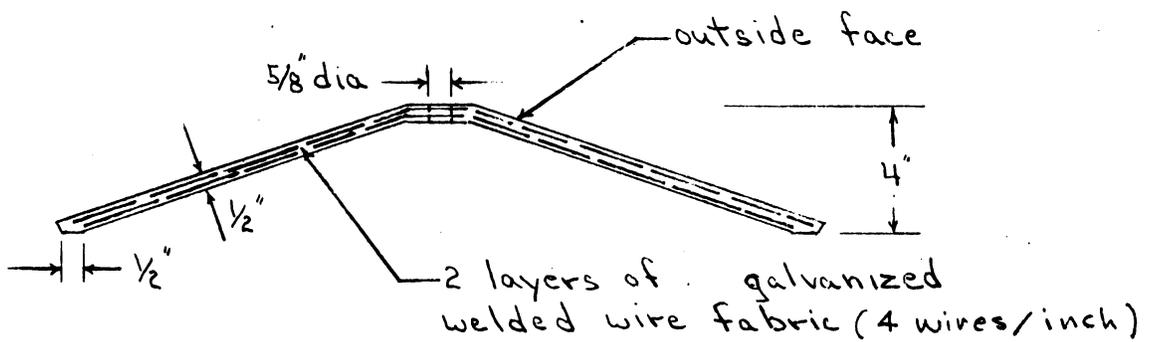
scale 10' : 2"

Figure 7. Typical panel details (precast).

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Section A-A



Mortar to be colored to suit, using precolored portland cement or cement dye.

scale 10" : 2"

Figure 8. Typical panel details (precast).

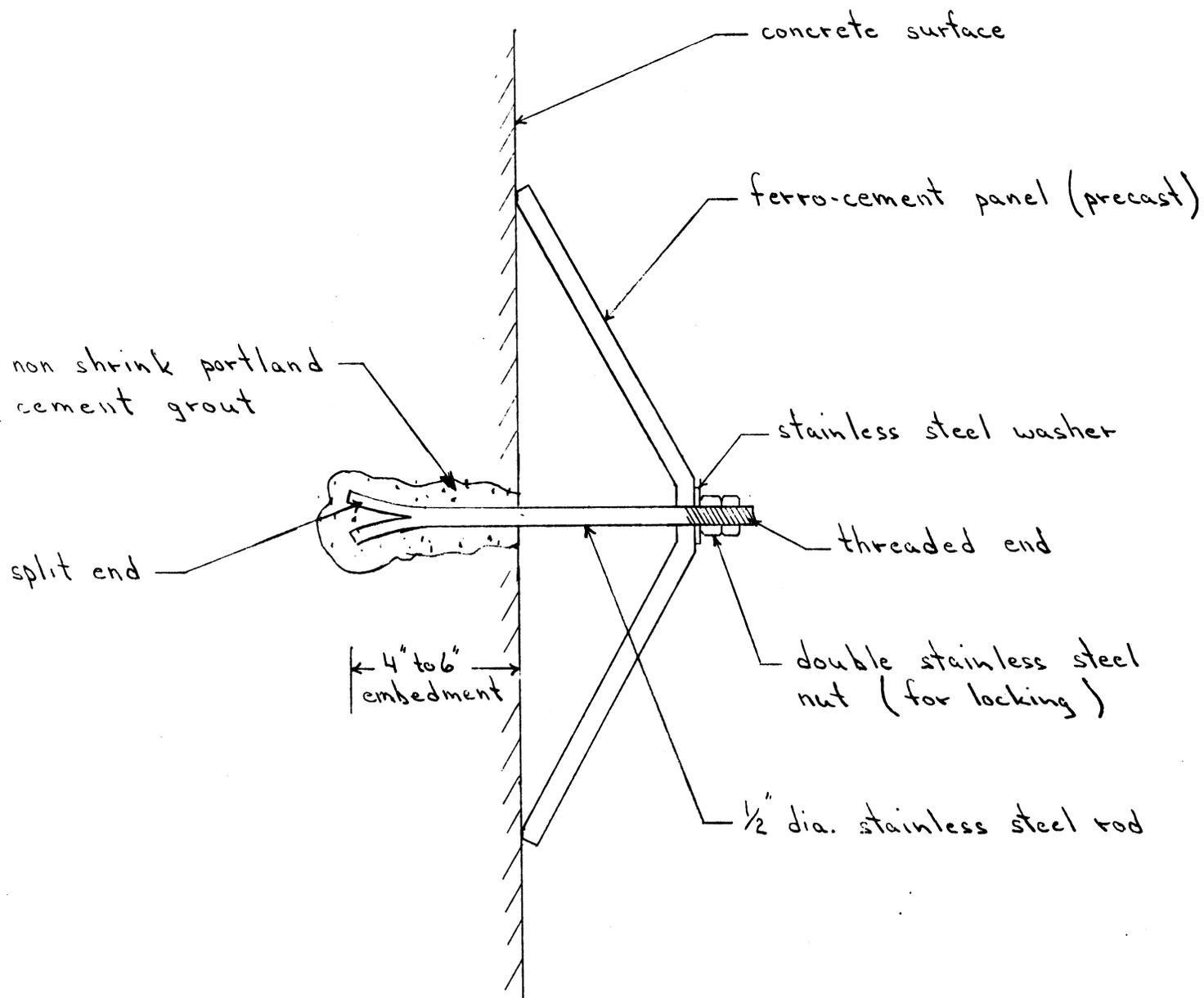
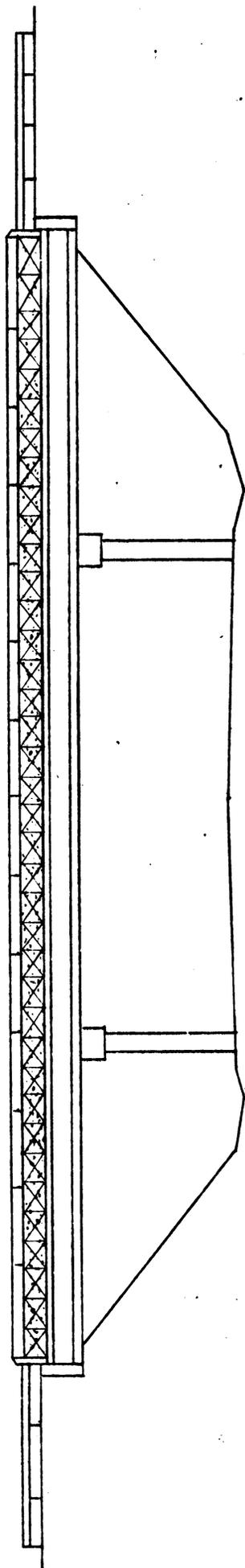


Figure 9. Attachment of ferro-cement panels to a concrete surface.



(shown attached to outside face of parapet)

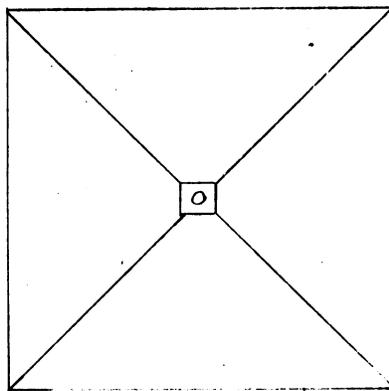
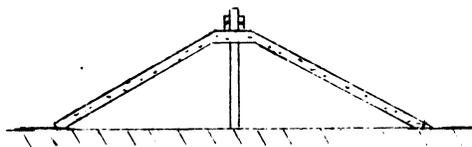


Figure 10. Panel configuration.

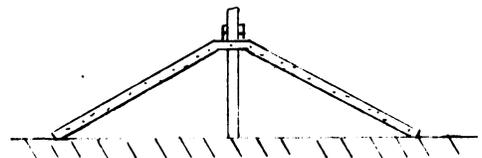
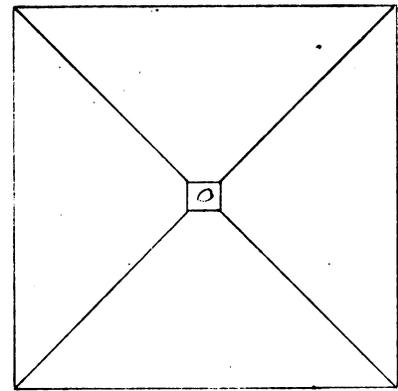
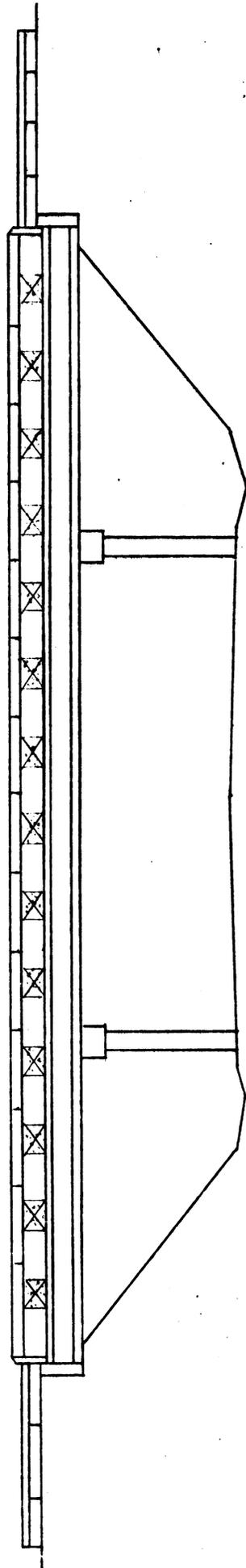


Figure 11. Panel configuration.

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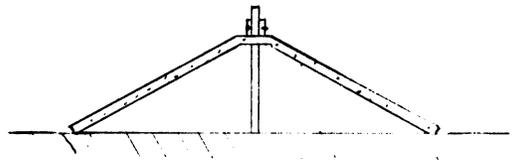
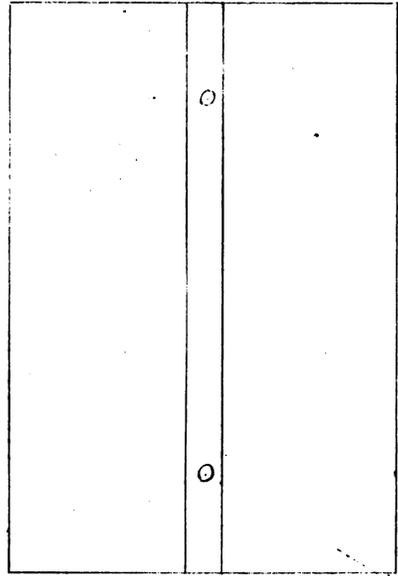
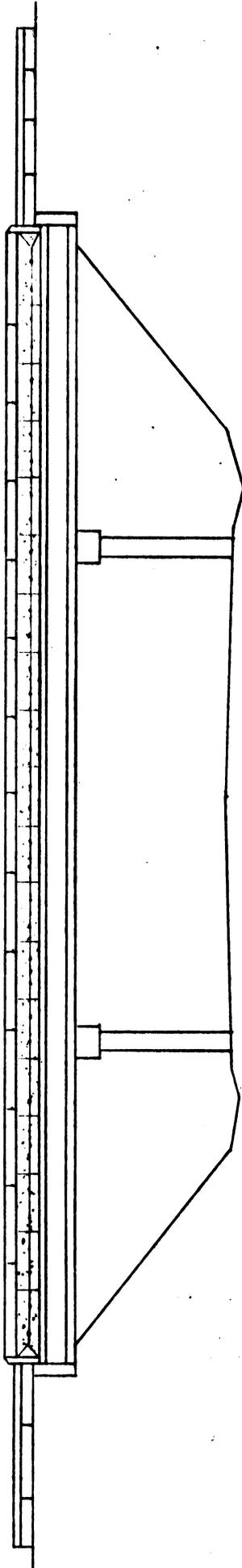


Figure 12. Panel configuration.

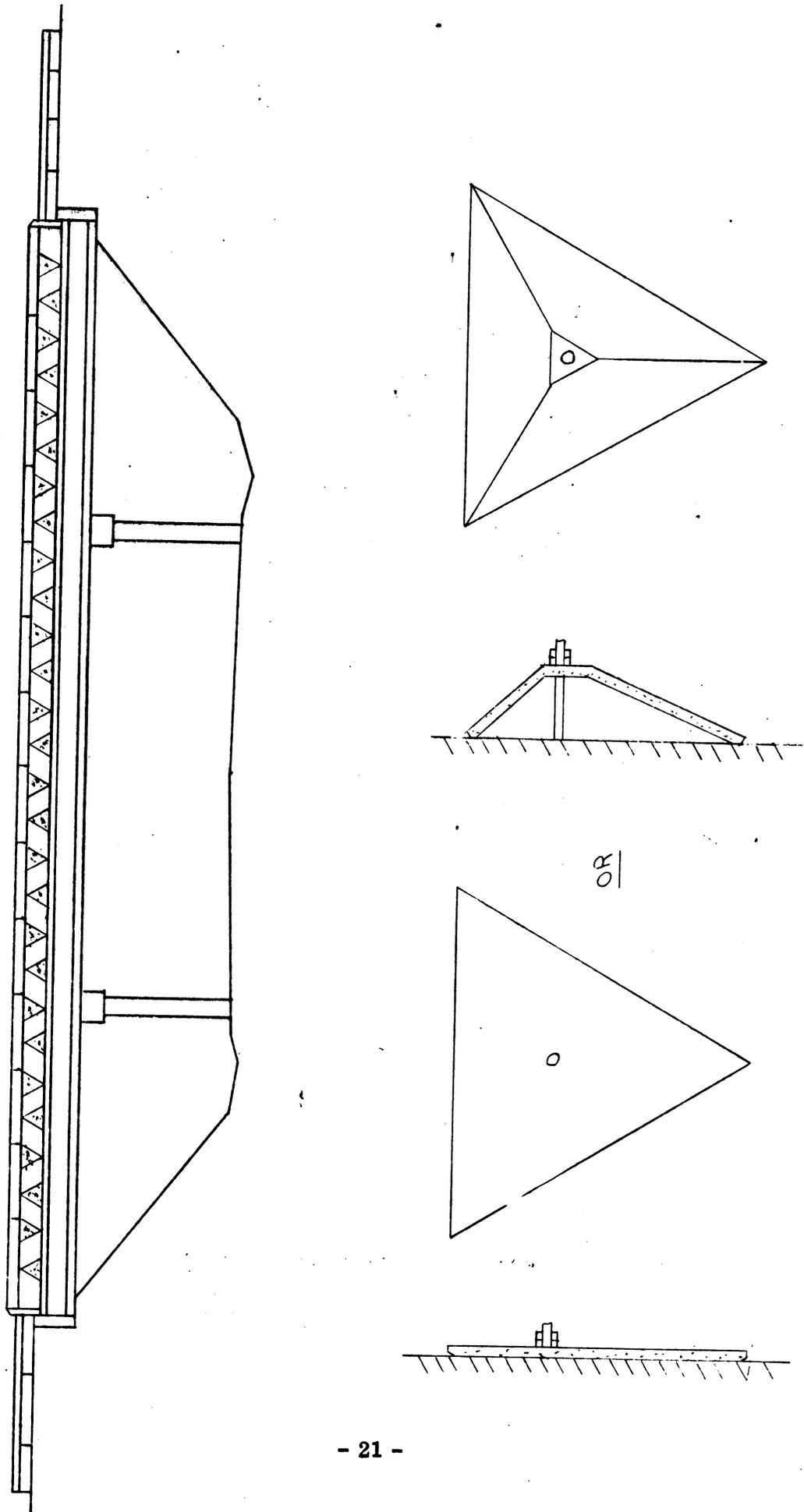


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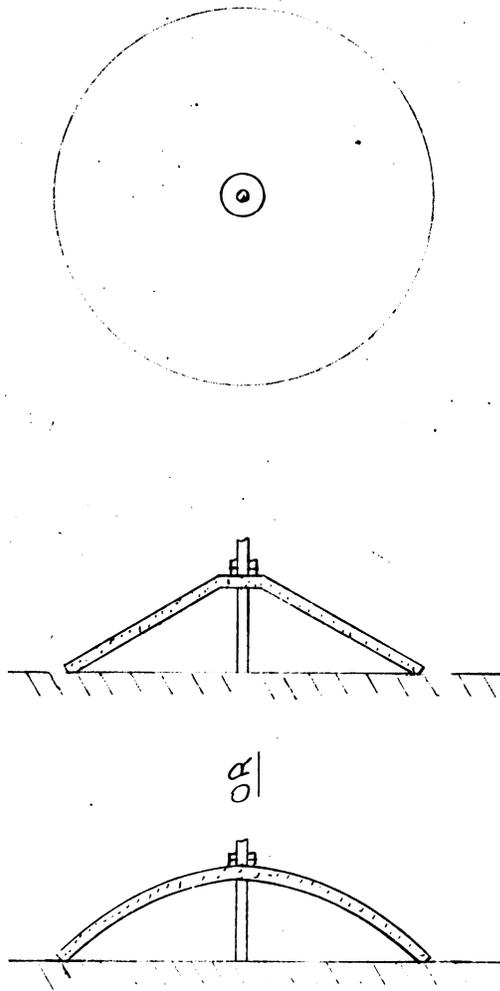
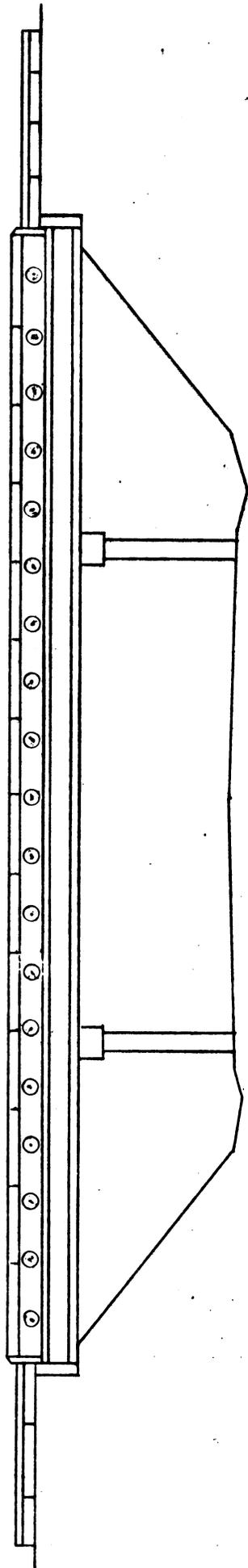


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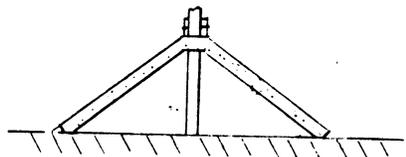
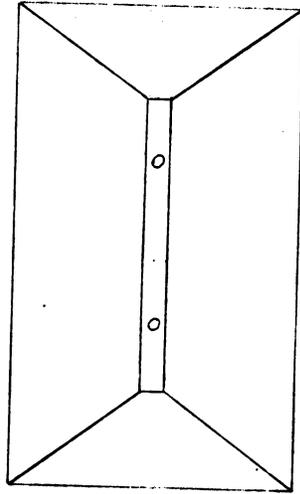
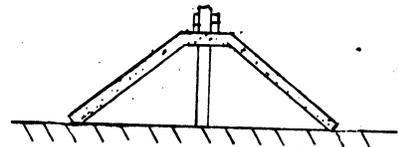
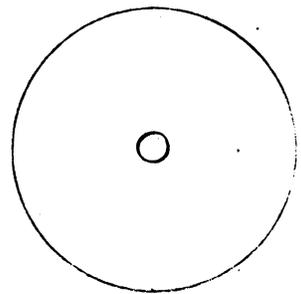
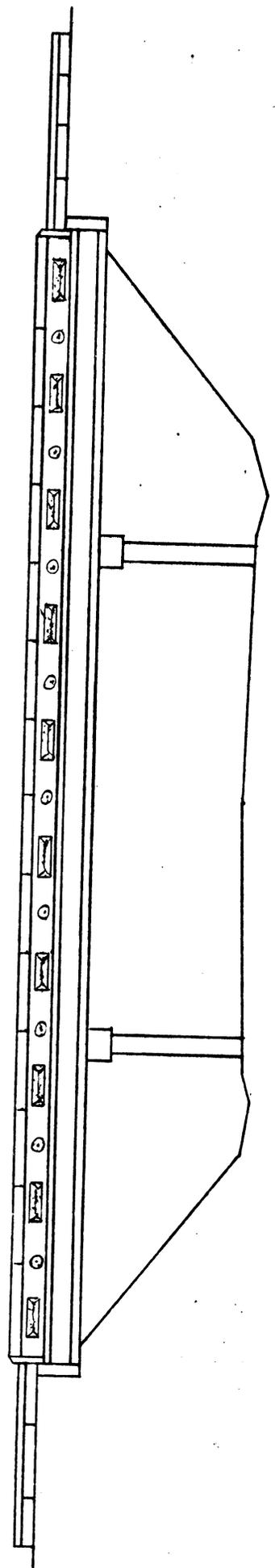


Figure 15. Panel configuration.

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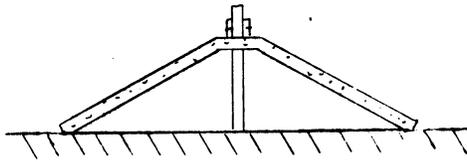
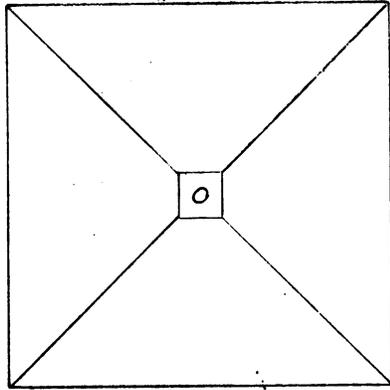
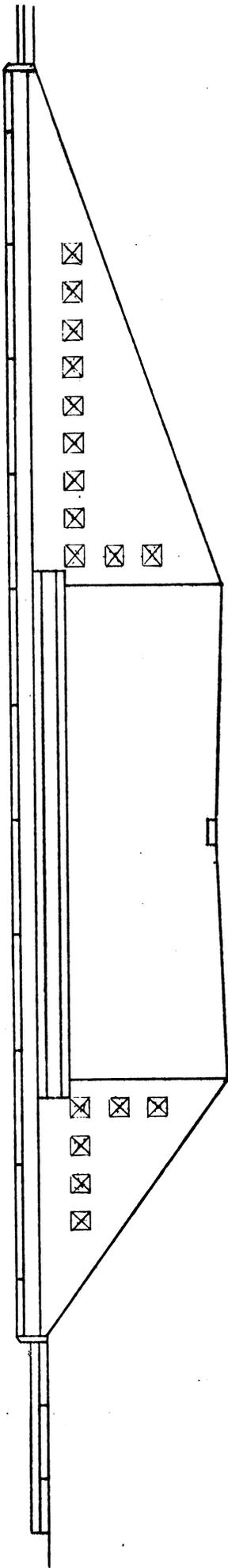


Figure 16. Panel configuration.

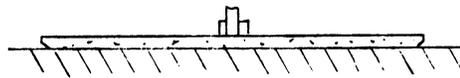
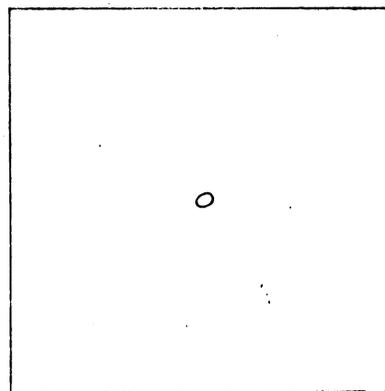
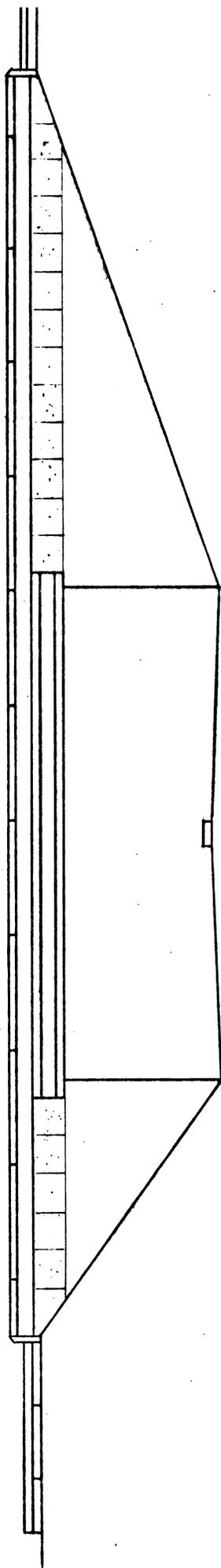


Figure 17. Panel configuration.

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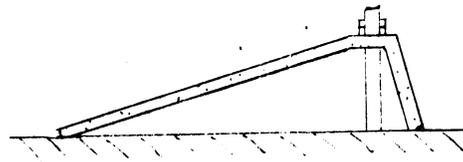
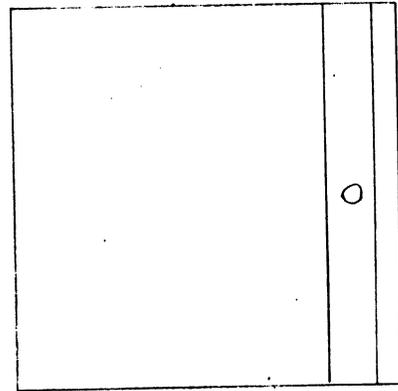
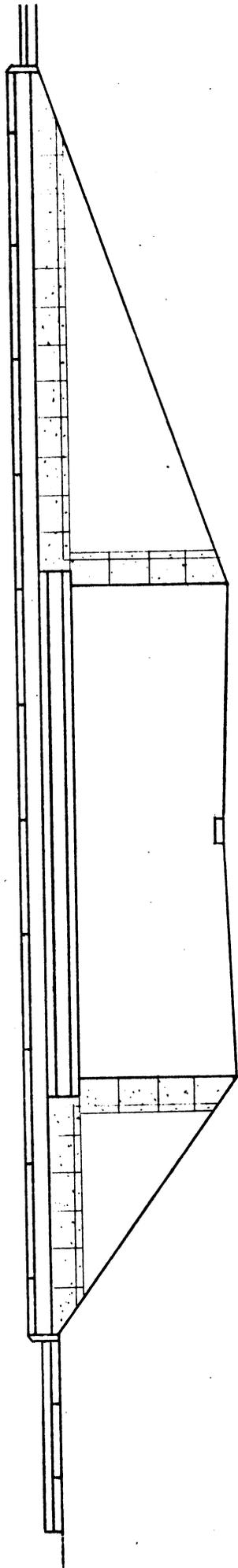


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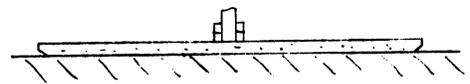
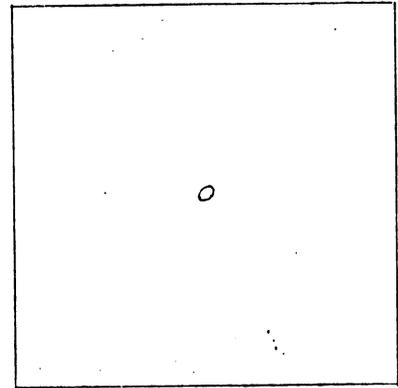
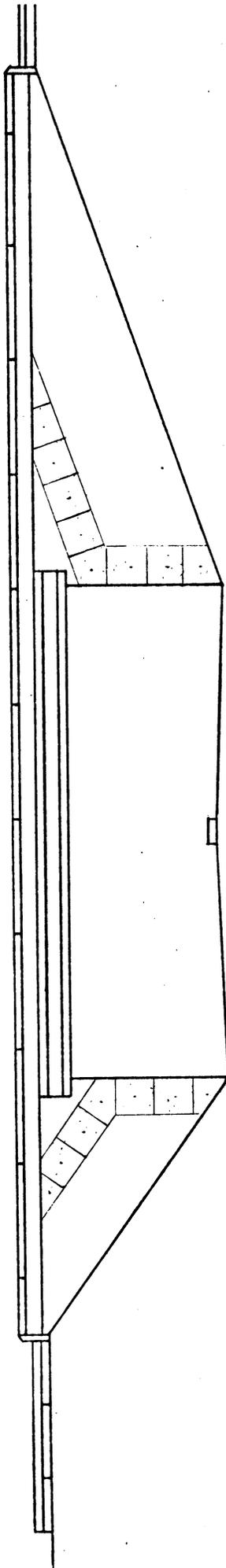


Figure 19. Panel configuration.

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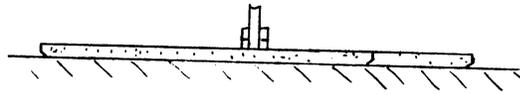
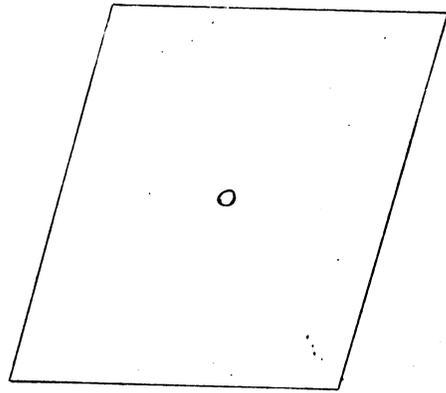
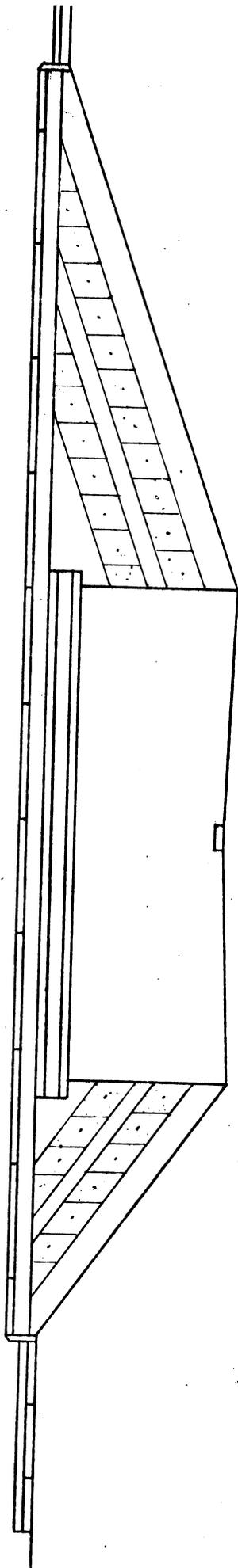
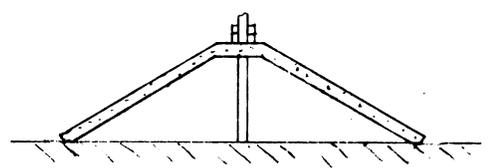
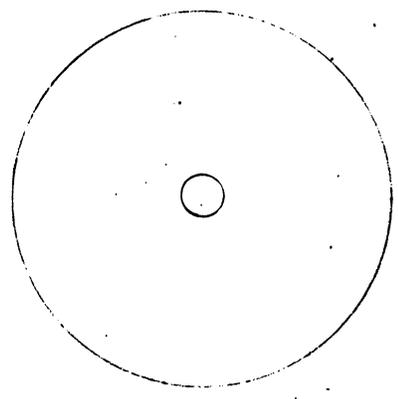
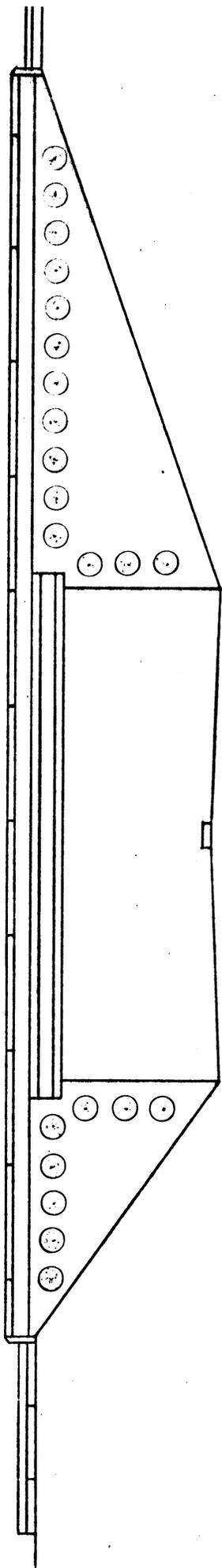


Figure 20. Panel configuration.



OR

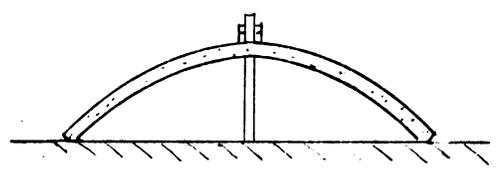


Figure 21. Panel configuration.

