AD-756 303

# POSSIBLE AUXILIARY USES OF EXTRUDED T-11 ALUMINUM AND T-8 MAGNESIUM LANDING MATS

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Vicksburg, Mississippi

May 1957

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MISCELLANEOUS PAPER NO. 4-221

May 1957

[Reprinted October 1957]

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under

Contract No. DA-22-079-eng-205

for

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS.

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## CONTENTS (cont'd)

## SYMBOLS
## USED ON
## DRAWINGS AND TABLES

| | | |
|---|---|---|
| B- | . . . | Beam |
| BL | . . . | Building |
| C- | . . . | Column |
| (C) | . . . | Concentrated Load |
| CU- | . . . | Culvert |
| J- | . . . | Joint |
| S- | . . . | Slab |
| (U) | . . . | Uniformly Distributed Load |
| (UV) | . . . | Uniformly Varying Load |

# SYNOPSIS

A casual observation by a structural engineer of the multiple bulb tee section designed for landing mats -- the T-11 Aluminum and the T-8 Magnesium -- results in a preliminary conclusion that the sections are adaptable for other structural uses. This study analyses the sections, determines their load carrying capacities and deflection characteristics under the various load conditions expected in quite general cases, and shows specific instances where the data so obtained may be directly applied in auxiliary uses. Quantitative values obtained in the study support the conclusion mentioned above. Fabrication, erection, and cost considerations are weighed. Modifications are specified in the instances where they are needed.

## METHOD OF ATTACK

A detailed study and analysis of each possible application of the landing mats would be not only of indefinite duration, but also unnecessarily repetitious. But specific uses produce classifyable loading conditions; hence, the analyses which follow in this report are classified

I. According to loading conditions; namely,
    (a) Uniformly distributed loads
    (b) Uniformly varying loads, and
    (c) Concentrated loads; and
II. According to structural types; namely,
    (a) Simply supported slabs, beams, and columns
    (b) Continuous slabs and columns, and
    (c) Cantilever slabs.

One or more of the conditions listed above, or some combination of the conditions, will apply to any conceivable use. For example: The sides of a box culvert are subjected to uniformly varying loads, for which data are given in Drawing S-23, (UV), Sheet 13 . And an observation of the loads given there will show that the mat used as a simple slab, supported top and bottom, will carry any expected culvert load.

More details of the information and procedure needed to adapt the data given to any required use or application will appear as the report progresses.

A list of applications is given immediately following the data for each structural element, and referred to the loading condition each application produces. The list is not exhaustive, of course. The engineer or technician in field or office -- informed on field operation -- will be finding new uses for this mat section long after any formal research and development is ended.

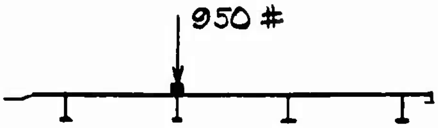
Where the mechanics of a condition is obvious, (and this is generally the case), no explanation of mathematical procedure is given. For columns certain information is given to show the theory on which the calculations were based.

All structures are composed of useful combinations of slabs, beams, and columns. These three basic elements of structures are treated here separately. From the data given, any required form, carrying an almost unlimited range of loads, can be arranged.

## SLABS

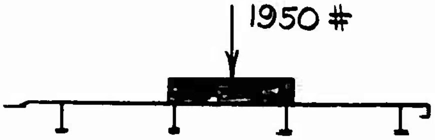
In this discussion SLAB has the usual connotation; that is, it is a wide, thin beam. Except for the rare case where the mats are layed in two layers -- either cross laminated or not -- SLAB means the mat section AS IS, with the load applied at right angles to the plane of the plate. The magnesium section T-8, because of the difference in the compressive and tensile strength of the material, is strongest when loaded to place the top plate in compression. In the data given here the load is applied to the top plate in all cases, so that the section may be used in the dual purpose of structural slab and surfacing material. This means that we are recording minimum yield point loads. Uses will probably occur where a designer working on details of a specific application may be able to increase the allowable loads, or increase the safety factor, by loading the Tee side of the section.

In the load diagrams (S-1-U to S-24-UV) uniform loads which produce yield point stresses are given in thousands of pounds per square foot, ksf. Concentrated loads are given in thousands of pounds, k, and are values for a line load one (1) foot wide, supported only by the section of the same width as the load. Now, it is to be expected that there will be considerable lateral distribution of a concentrated load, the amount of this distribution depending on the span length, the end conditions, the distance of the load from the nearest support, and the width of the load. In order to obtain some idea of this lateral distribution, a test was made using Extrusion B, Magnesium, spanning four (4) feet, and with a concentrated load of varying width located at the mid point of the span. The results of this test follow:



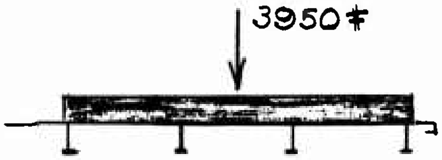
(1) Tee number 2 loaded

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | - - - - - - - - - Tee number |
| 278 | 297 | 224 | 151 | - - - - - - - - - Load on each Tee |
| 29% | 31% | 24% | 16% | - - - - - - - - - Per cent of total load |



(2) Tees 2 and 3 loaded

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | - - - - - - - - - Tee number |
| 450 | 535 | 530 | 435 | - - - - - - - - - Load on each Tee |
| 23% | 27% | 27% | 23% | - - - - - - - - - Per cent of total load |



(3) All Tees loaded

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | - - - - - - - - - Tee number |
| 995 | 987 | 988 | 977 | - - - - - - - - - Load on each Tee |
| 25% | 25% | 25% | 25% | - - - - - - - - - Per cent of total load |

Although the results of the test are satisfactory, (note "All Tees loaded"), they are true only for this one condition, and no lateral distribution is considered in recording the allowable loads. An acceptably accurate equation for determining the "effective width" of slab supporting a concentrated load can be developed by analyzing a series of tests similar to the one described above. The effective width for the loading condition of this test is about 1.5 times the width of the load. Therefore, such a series of test would necessarily be a part of any comprehensive testing program, so that the advantages of lateral distribution can be realized.

For many uses the maximum loads will be limited by permissable deflections. This is especially true for magnesium whose modulus of elasticity is only about 22% of the modulus of steel. (The T-8 mat, for example, will support a uniform load of 300 psf on a 12' simply supported span; but the deflection is 12.0".) An engineer developing details for a particular use will need to make a noticeable mental adjustment, if he is accustomed to the use of steel, for the strength/modulus ratio for this material is higher than any material available for structures.

## UNIT STRESSES USED

| | (T11) Aluminum | (T8) Magnesium |
|---|---|---|
| Compression | 35,000 psi | 25,000 psi |
| Tension | 35,000 psi | 36,000 psi |
| Shear | 26,000*psi | 20,000*psi |

*These values bear the same ratio to test results as the specified tension and compression values bear to test results.

## PROPERTIES OF THE SECTION

| | (T11) Aluminum | (T8) Magnesium |
|---|---|---|
| Moment of inertia | 1.404 in.$^4$/ft. width | 1.767 in.$^4$/ft. width |
| C (Top) | 0.652 in. | 0.688 in. |
| C (Bottom) | 0.973 in. | 0.937 in. |

## RESISTING MOMENTS

| Critical Area | (T11) Aluminum | (T8) Magnesium |
|---|---|---|
| Top Tension | ------- | ------- |
| Top Compression | ------- | 5.34 kf |
| Bottom Tension | 4.21 kf | ------ |
| Bottom Compression | 4.21 kf | 3.92 kf |

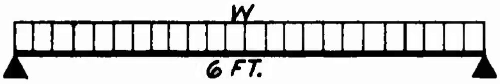
# ALLOWABLE SLAB LOADS

| MAXIMUM APPLIED LOADS | |
|---|---|
| ALUMINUM T-11 | MAGNESIUM T-8 |

S-1 (U) - SIMPLE SLAB, UNIFORM LOAD,
1 SPAN AT 12 FEET

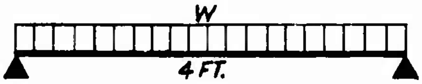
| | |
|---|---|
| w = .23 K.S.F. | w = .30 K.S.F. |
| Y = 7.5 IN. | Y = 12.0 IN. |

S-2 (U) - SIMPLE SLAB, UNIFORM LOAD
1 SPAN AT 6 FEET



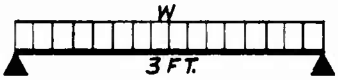
| | |
|---|---|
| w = .90 K.S.F. | w = 1.20 K.S.F. |
| Y = 1.9 IN. | Y = 3.0 IN. |

S-3 (U) - SIMPLE SLAB, UNIFORM LOAD
1 SPAN AT 4 FEET



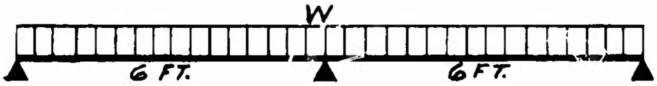
| | |
|---|---|
| w = 2.10 K.S.F. | w = 2.70 K.S.F. |
| Y = .80 IN. | Y = 1.30 IN. |

S-4 (U) - SIMPLE SLAB, UNIFORM LOAD
1 SPAN AT 3 FEET



| | |
|---|---|
| w = 3.70 K.S.F. | w = 4.70 K.S.F. |
| Y = .60 IN. | Y = .70 IN. |

S-5 (U) - CONTINIOUS SLAB, UNIFORM LOAD
2 SPANS AT 6 FEET



| | |
|---|---|
| w = .93 K.S.F. | w = .87 K.S.F. |
| Y = 1.30 IN. | Y = 1.50 IN. |

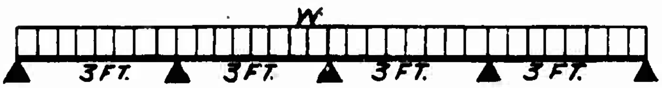
S-6 (U) - CONTINIOUS SLAB, UNIFORM LOAD
3 SPANS AT 4 FEET

| | |
|---|---|
| w = 2.23 K.S.F. | w = 2.10 K.S.F. |
| Y = .60 IN. | Y = .80 IN. |

# ALLOWABLE SLAB LOAD
(CONTINUED)

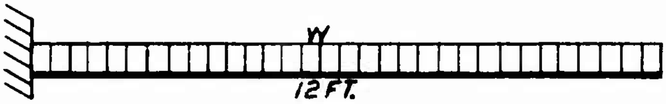
| MAXIMUM APPLIED LOADS | |
|---|---|
| ALUMINUM T-11 | MAGNESIUM T-8 |

S-7(U) - CONTINIOUS SLAB, UNIFORM LOAD
4 SPANS AT 3 FEET



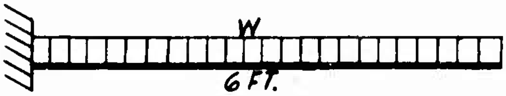
| | |
|---|---|
| w =3.90 K.S.F. | w =3.70 K.S.F. |
| Y =.40 IN. | Y =.40 IN. |

S-8(U) - CANTILEVER SLAB, UNIFORM LOAD
1 SPAN AT 12 FEET



| | |
|---|---|
| w =.060 K.S.F. | w =.055 K.S.F. |
| Y = 18.0 IN. | Y = 21.0 IN. |

S-9(U) - CANTLIVER SLAB, UNIFORM LOAD
1 SPAN AT 6 FEET



| | |
|---|---|
| w = .23 K.S.F. | w =.22 K.S.F. |
| Y = 4.50 IN. | Y = 5.40 IN. |

S-10 (UV) - SIMPLE SLAB, UNIFORMLY VARYING LOAD
1 SPAN AT 12 FEET

| | |
|---|---|
| w =.46 K.S.F. | w =.58 K.S.F. |
| Y = 7.40 IN. | Y = 11.70 IN. |

S-11 (UV) - SIMPLE SLAB, UNIFORMLY VARYING LOAD
1 SPAN AT 6 FEET

| | |
|---|---|
| w = 1.80 K.S.F. | w = 2.30 K.S.F. |
| Y = 1.80 IN. | Y = 2.90 IN. |

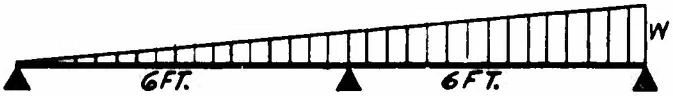
S-12 (UV) - SIMPLE SLAB, UNIFORMLY VARYING LOAD
1 SPAN AT 4 FEET

| | |
|---|---|
| w =4.10 K.S.F. | w =5.20 K.S.F. |
| Y =.80 IN. | Y = 1.30 IN. |

# ALLOWABLE SLAB LOADS
(CONTINUED)

| MAXIMUM APPLIED LOAD | |
|---|---|
| ALUMINUM T-11 | MAGNESIUM T-8 |

**S-13 (UV) - CONTINIOUS SLAB, UNIFORMLY VARYING LOAD, 2 SPANS AT 6 FEET**



| | |
|---|---|
| w = 1.90 K.S.F. | w = 2.00 K.S.F. |
| y = 1.90 IN. | y = 2.40 IN. |

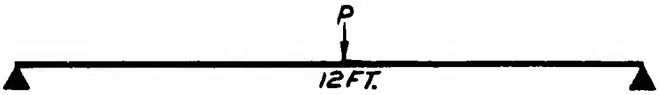
**S-14 (UV) - CANTILEVER SLAB, UNIFORMLY VARYING LOAD, 1 SPAN AT 12 FEET**

| | |
|---|---|
| w = .18 K.S.F. | w = .16 K.S.F. |
| y = 14.50 IN. | y = 17.00 IN. |

**S-15 (UV) - CANTILEVER SLAB, UNIFORMLY VARYING LOAD, 1 SPAN 6 FEET**

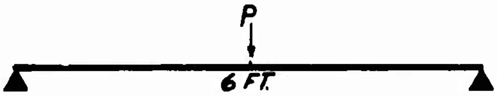
| | |
|---|---|
| w = .70 K.S.F. | w = .65 K.S.F. |
| y = 3.60 IN. | y = 4.20 IN. |

**S-16 (C) - SIMPLE SLAB, CONCENTRATED LOAD 1 SPAN AT 12 FEET**



| | |
|---|---|
| P = 1.40 KIPS | P = 1.80 KIPS |
| y = 6.00 IN. | y = 9.60 IN. |

**S-17 (C) - SIMPLE SLAB, CONCENTRATED LOAD 1 SPAN AT 6 FEET**



| | |
|---|---|
| P = 2.80 KIPS | P = 3.60 KIPS |
| y = 1.50 IN. | y = 2.40 IN. |

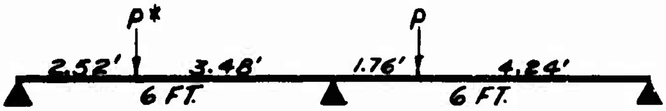
**S-18 (C) - SIMPLE SLAB, CONCENTRATED LOAD 1 SPAN AT 4 FEET**

| | |
|---|---|
| P = 4.20 KIPS | P = 5.30 KIPS |
| y = .80 IN. | y = 1.10 IN. |

# ALLOWABLE SLAB LOADS
(CONTINUED)

| MAXIMUM APPLIED LOADS | |
|---|---|
| ALUMINUM<br>T-11 | MAGNESIUM<br>T-8 |

S-19 (C) - CONTINIOUS SLAB, CONCENTRATED LOAD, 2 SPANS AT 6 FEET

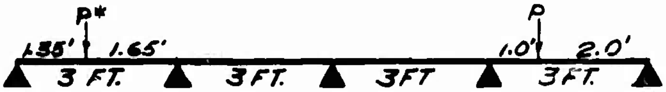


| | |
|---|---|
| P=3.40 KIPS | P=4.30 KIPS |
| Y=1.20 IN. | Y=2.30 IN. |

S-20 (C) - CONTINIOUS SLAB, CONCENTRATED LOAD, 3 SPANS AT 4 FEET

| | |
|---|---|
| P=5.10 KIPS | P=6.60 KIPS |
| Y=.50 IN. | Y=.90 IN. |

S-21 (C) - CONTINIOUS SLAB, CONCENTRATED LOAD, 4 SPANS AT 3 FEET



| | |
|---|---|
| P=6.80 KIPS | P=8.60 KIPS |
| Y=.30 IN. | Y=.60 IN. |

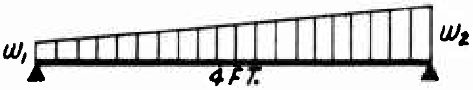
S-22 (C) - CONTINIOUS SLAB, CONCENTRATED LOAD, 6 SPANS AT 2 FEET

| | |
|---|---|
| P=10.20 KIPS | P=13.00 KIPS |
| Y=.10 IN. | Y=.20 IN. |

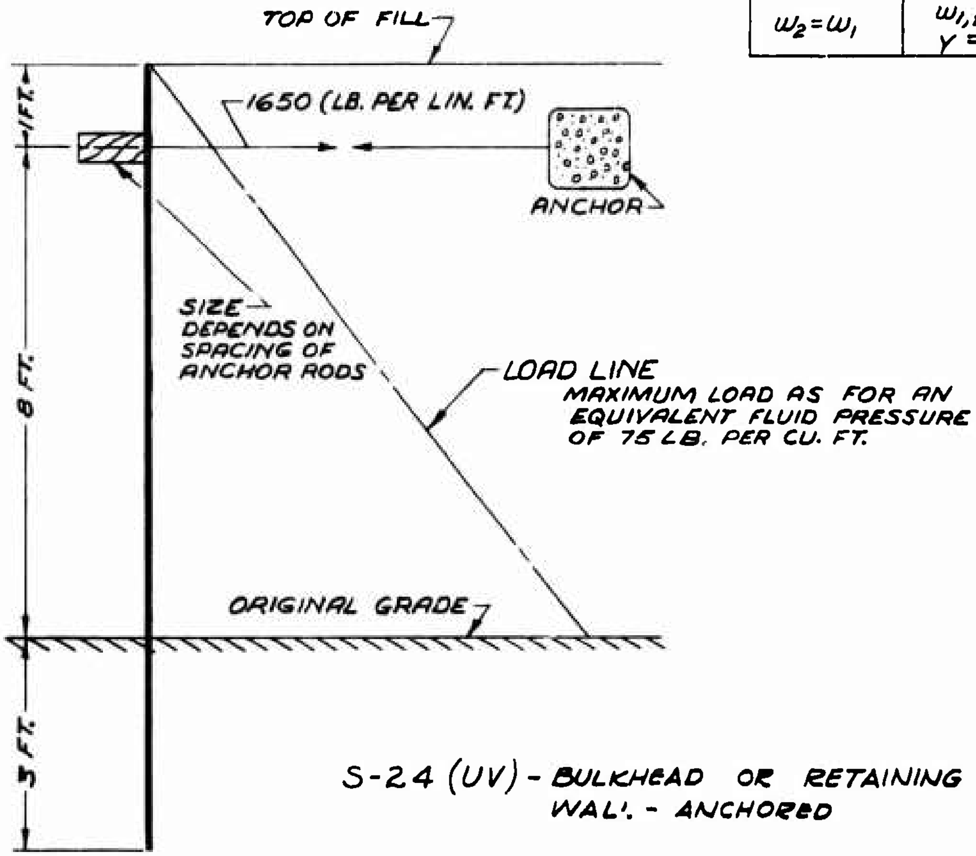
*CRITICAL POSITION

# ALLOWABLE SLAB LOADS
(CONTINUED)

S-23(UV) - SIMPLE SLAB, UNIFORMLY VARYING LOAD, 1 SPAN AT 4 FEET



| MAXIMUM APPLIED LOADS MAGNESIUM T-8 | |
|---|---|
| $w_1 = 0$ | $w_2 = 5.20$ K.S.F.<br>$Y = 1.30$ IN. |
| $w_2 = 4\,w_1$ | $w_1 = 1.00$ K.S.F.<br>$w_2 = 4.20$ K.S.F.<br>$Y = 1.30$ IN. |
| $w_2 = 2\,w_1$ | $w_1 = 1.70$ K.S.F.<br>$w_2 = 3.50$ K.S.F.<br>$Y = 1.30$ IN. |
| $w_2 = 1\frac{1}{3}w_1$ | $w_1 = 2.30$ K.S.F.<br>$w_2 = 3.00$ K.S.F.<br>$Y = 1.30$ IN. |
| $w_2 = w_1$ | $w_{1,2} = 2.70$ K.S.F.<br>$Y = 1.30$ IN. |



S-24 (UV) - BULKHEAD OR RETAINING WAL'. - ANCHORED

## SPECIFIC APPLICATION

### (Slabs)

| APPLICATION | REFERENCE FOR LOAD DATA |
|---|---|
| I. BUILDINGS: | |
| Floors | S-5(U) to S-7(U) |
| Roofs | S-1(U) |
| Siding | S-1(U) |
| Foundation Plate (Light Loads) | S-5(U) (approximately) |
| II. BRIDGES: All types | |
| Decking | S-21(C) and S-22(C) |
| Sub-Flooring | S-22(C) |
| Bent Bracing | S-21(C)<br>(Normally, P/A will be well below any critical value.) |
| Abutment | S-5(U) to S-7(U) |
| Footbridges; Fixed, Floating | S-1(U) to S-5(U) |
| III. CULVERTS | |
| General | CU-1 to CU-4 |
| Ribs longitudinal | S-5(U) and S-6(U) |
| Ribs Transverse | S-2(U), S-3(U), S-4(U) and S-23(UV) |
| Headwalls | (Loading will depend on method of support.) |

| APPLICATION | REFERENCE FOR LOAD DATA |
|---|---|
| IV. ROADWAYS | |
| Beach Landing Strips, Treadways, etc. | (Landing Mat Loads) |
| Surfacing; short impassable stretches | (Landing Mat Loads) |
| Guard Rails | S-16(U) and S-19(U) |
| Approach Ramps | S-21(C) and S-22(C) |
| V. BULK HEADS AND RETAINING WALLS | |
| General | S-5(U), S-6(U), S-15(UV), and S-23(S) |
| Low Head Dams | S-15(UV) |
| VI. MISCELLANEOUS | |
| Tanks, Circular | |
| (Water, Sewage, etc.)<br>(Canvas Lined?) | (Transverse tensile strength of the longitudinal joint must be determined.) |
| Work Benches, Shelves, Counters, Drying Racks, Seat Benches | S-1(U), S-2(U), and S-5(U) |
| Wharf Decking | S-6(U) and S-7(U) |
| Truck Beds | S-21(C) and S-22(C) |
| Truck Sides | S-5(U) and S-6(U) |
| Surface Drains | (Either Landing Mat Loads or no critical Load.) |
| Earth Covered Shelters<br>(Fox holes, dugouts, bomb shelters) | S-5(U) and S-6(U) |

# BEAMS

The extruded landing mat can be built-up into beams which will have almost unlimited possibilities. For the purpose of this report only the simplest and most versatile sections were selected for analysis.

An effort was made to select sections that would involve simple beam mechanics in a specific adaptation. Beam sections were kept symmetrical and loads were calculated for laterally supported beams.

Each beam section has two section moduli, a condition of no importance in the aluminum beams for which the tensile and compression yield stresses are equal. For magnesium beams the least bending moment value was used so that there is no need for designating a top or bottom for these beams.

For beam sections consisting of two B Extrusions, the section modulus was determined neglecting 2.45 inches of the splice connection edge because of the possibility of local buckling. The resulting section modulus was greater than that for the entire section. Therefore, buckling of this outstanding leg would not indicate failure of the beam.

## Beam Sections

Three beam sections, for both aluminum and magnesium, were developed and are shown in Table B-1, Sheet 19 and in TableB-8 , Sheet 26 . It can readily be seen that the extrusions used in each case can be arranged in a variety of ways without changing the properties as given. For example, the extrusions may be reversed from the position shown. In either position they can be separated by spreader blocks to any desired width.

Extrustions A and B were not used singly or in combination with each other because of the unsymmetrical section which results. This is not meant to imply that for light load conditions, such as those that are encountered in one story buildings and sheds, individual extrusion beams cannot be used, for which case use 1/2 the loads shown in the beam tables.

It became evident early in the study of beams that box type beams and girders would be difficult to fabricate from the extruded landing mat in its present form. The necessity of transferring shear across the corner connection of a box section makes its fabrication impractical. It can also be seen that beams of any desired capacity can be fabricated simply by the addition of extrusions to sections shown in Drawings B-1 and B-8 . The box girder is not needed.

## Beam Lengths

The analysis and presentation of beam data is separated into three span ranges. The divisions are, spans up to twelve feet, spans from twelve to twenty-four feet and spans from twenty-four to forty-eight feet. The first two divisions consist of beams fabricated from Extrusions A or B; the third division consists of beams fabricated from the landing mat as a unit.

Beams having spans less than twelve feet can be fabricated from the mat by separating the A and B Extrusion and using each part as it is. For beam fabricated from the individual extrusions having spans greater than twelve feet, two splice connections have been developed. The details of these connections are shown in the section on joints. (Sheet 60 ).

Beams fabricated from full width landing mats are generally limited in capacity by longitudinal shear in the splice connection between Extrusions A and B. Load values are tabulated for the section as is, and for a similar section in which the mat is modified in the field by the addition of 1/4 inch rivets or bolts equally spaced between the shop rivets connecting Extrusion A and B. A long span beam using these sections can be fabricated lapping the panels with staggard end joints. For example, to build a beam having a span of thirty-six feet with a capacity indicated in Table B-6 , Sheet 24 , ten landing mat sections are required. Except for a six foot length at each end of the beam the full width of the beam is twice the effective width. The splice connection is similar to that shown in Drawing J-5 , Sheet 65 , for long span individual extrusion beams, except that the length of the splice plate is extended to twelve feet.

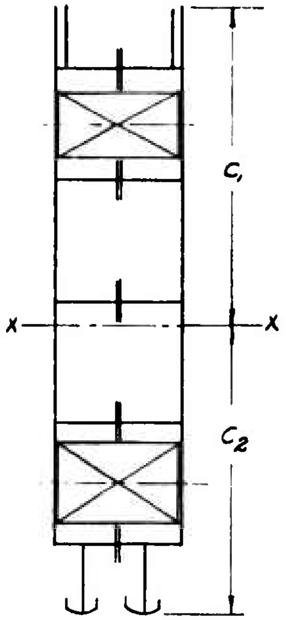
## Loads and Stresses

The following tables contain the maximum uniform loads and maximum concentrated load at mid-span for various span lengths for the sections shown in Drawings B1 and B8. These values are based on the yield point stresses as given in Tables B1 and B8. For the sections and spans for which shear was a controlling factor the maximum concentrated load which can be placed any where on the beam is also given. For all other cases this load is equal to the maximum concentrated load at mid-span.

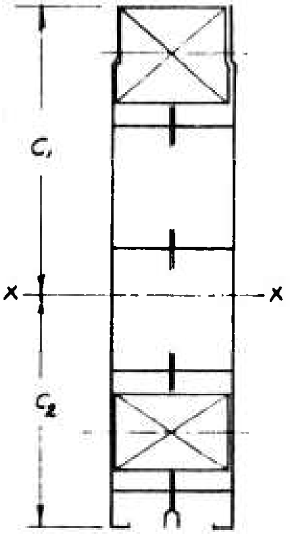
The transfer of applied loads to the edge of the beams in most practical applications is not a problem, but for very high concentrations of load, physical testing will be required to determine the ability of the different edges to receive such loads. Several methods for transferring reaction loads to supports are shown in the section on joints, Sheet 64.

DRAWING B-1

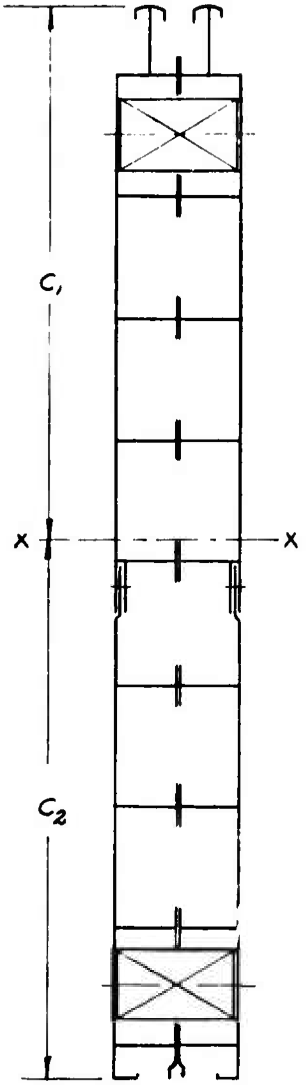
## BEAM DESIGN DATA
## ALUMINUM LANDING MAT T-11



SECTION 1
2 EXTRUSIONS "A"



SECTION 2
2 EXTRUSIONS "B"



SECTION 3
2 FULL WIDTH MATS

TABLE B-1

| | SECTION 1 | SECTION 2 | SECTION 3 |
|---|---|---|---|
| AREA | 9.12 | 6.90 | 16.02 |
| WT. PER FOOT | 11.4 | 8.63 | 20.1 |
| $I_{xx}$ | 203.6 | 97.2 | 1047 |
| $C_1$ | 7.87 | 7.11 | 13.13 |
| $C_2$ | 7.22 | 5.66 | 13.50 |
| $Z_1$ | 25.7 | 13.7 | 78.8 |
| $Z_2$ | 28.2 | 17.2 | 77.5 |
| M- KIP FT | 74.7 | 39.9 | 226 |

DESIGN STRESSES

| | | |
|---|---|---|
| TENSION - | 35,000 | PSI |
| COMPRESSION - | 33,000 | PSI |
| SHEAR - | 24,000 | PSI |
| BEARING - | 56,000 | PSI |

## DRAWING B-2

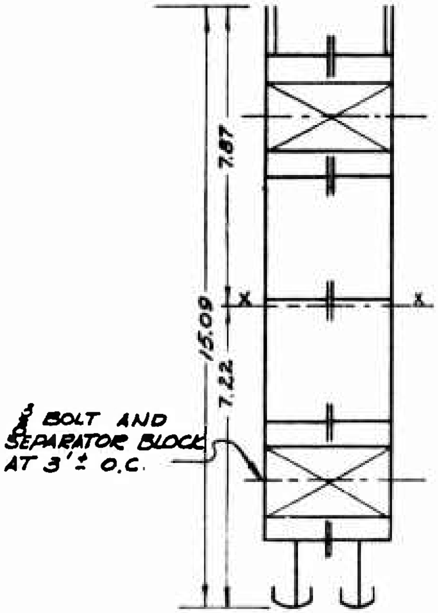
# YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

ALUMINUM LANDING MAT T-11
EXTRUSION "A"

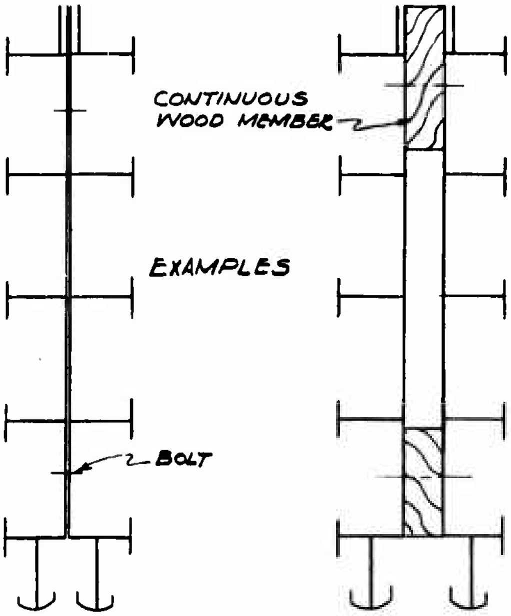
BEAM SPAN 6 TO 12 FEET

TABLE B-2

| SPAN FEET L | LOADS | | | |
|---|---|---|---|---|
| | W K/FT<br>L | | P<br>L/2 L/2 | |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES |
| 6 | 16.60 | 0.24 | 49.8 | 0.19 |
| 7 | 12.20 | 0.32 | 42.7 | 0.26 |
| 8 | 9.35 | 0.42 | 37.4 | 0.34 |
| 9 | 7.38 | 0.54 | 33.2 | 0.43 |
| 10 | 5.98 | 0.66 | 29.9 | 0.53 |
| 11 | 4.94 | 0.80 | 27.2 | 0.64 |
| 12 | 4.16 | 0.95 | 25.0 | 0.76 |



1. Either edge of section may be used as top, depending on application.
2. See the section of the report on connections for reaction details. ( **Sheet** 60 )
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. The extrusions may be orientated several ways without changing the properties from those of the section above. Several **possible** combinations are shown at right.



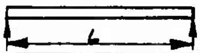
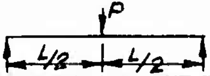
# DRAWING B-3

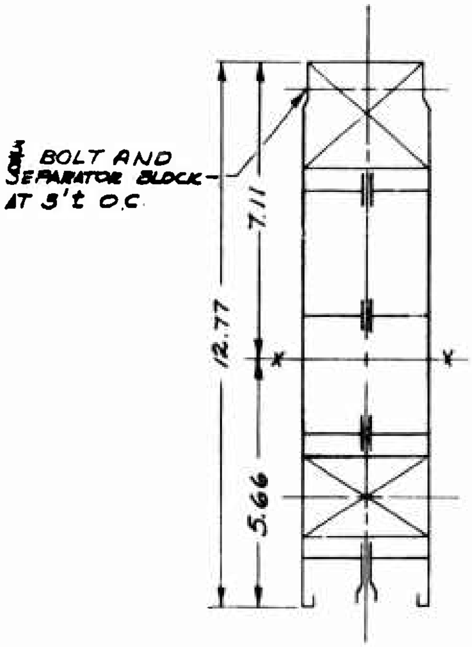
## YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

ALUMINUM LANDING MAT T-11
EXTRUSION "B"

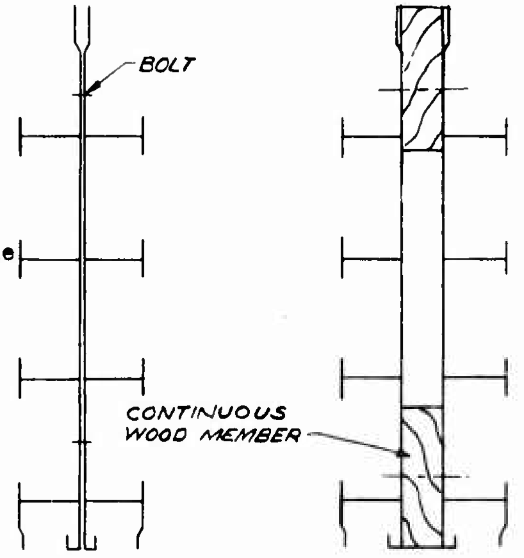
BEAM SPAN 6 TO 12 FEET

### TABLE B-3

| SPAN FEET L | LOADS | | | |
|---|---|---|---|---|
| | W K/FT  | | P  | |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES |
| 6 | 8.87 | .27 | 26.6 | .21 |
| 7 | 6.51 | .36 | 22.8 | .29 |
| 8 | 4.98 | .47 | 19.9 | .37 |
| 9 | 3.94 | .60 | 17.7 | .48 |
| 10 | 3.19 | .74 | 15.9 | .59 |
| 11 | 2.64 | .89 | 14.5 | .70 |
| 12 | 2.22 | 1.06 | 13.3 | .84 |



1. Either edge of section may be used as top, depending on application.
2. See the section of the report on connections for reaction details. ( Sheet 60)
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. The extrusions may be orientated several ways without changing the properties from those for the section above. Several possible combinations are shown at right.



EXAMPLES

# DRAWING B-4

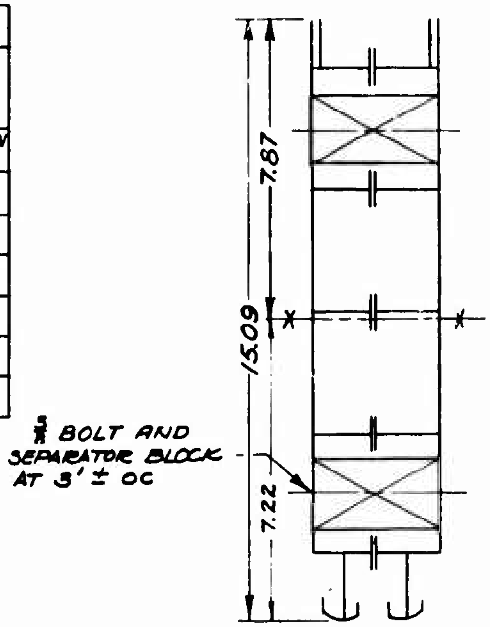
## YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

ALUMINUM LANDING MAT T-11
EXTRUSION "A"

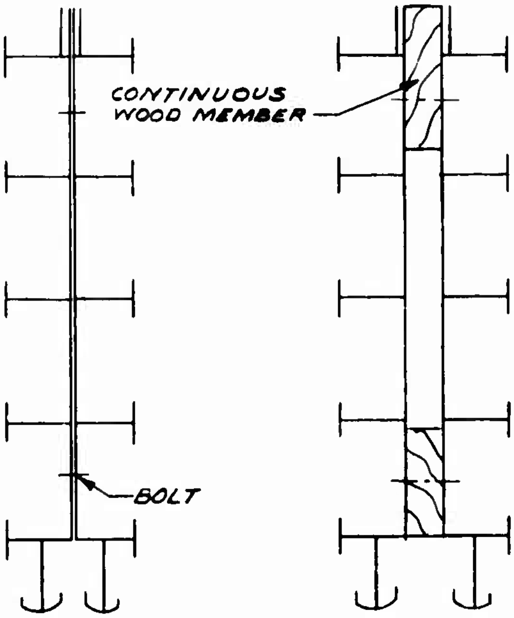
BEAM SPAN 14 TO 24 FEET

### TABLE B-4

| SPAN FEET L | LOADS | | | |
|---|---|---|---|---|
| | W K/FT L | | P L/2 L/2 | |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES |
| 14 | 3.05 | 1.30 | 21.3 | 1.03 |
| 16 | 2.32 | 1.68 | 18.6 | 1.33 |
| 18 | 1.84 | 2.14 | 16.6 | 1.70 |
| 20 | 1.50 | 2.66 | 15.0 | 2.11 |
| 22 | 1.24 | 3.21 | 13.6 | 2.54 |
| 24 | 1.02 | 3.74 | 12.2 | 2.96 |



1. Either edge of section may be used as top, depending on application.
2. The extrusions may be orientated several ways without changing the properties from those for the section above. Several possible combinations are shown at right.
3. For beams with spans from 12 to 21 feet see sheet 64 for splice details.
4. Deflection computations are based on constant section conditions.
5. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of Sections.
6. For beams with spans from 21 to 24 feet see sheet 65 for splice details.



EXAMPLES

## DRAWING B-5

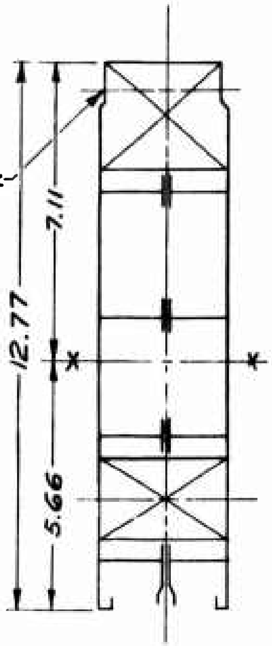
## YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

ALUMINUM LANDING MAT T-11
EXTRUSION "B"

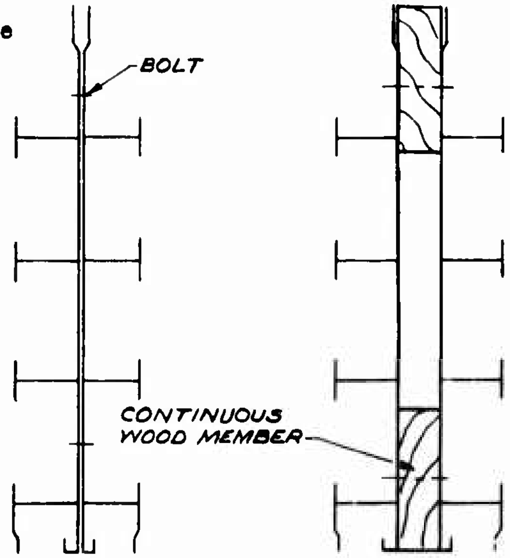
BEAM SPAN 14 TO 24 FEET

### TABLE B-5

| SPAN FEET L | LOADS | | | |
|---|---|---|---|---|
| | W K/ L | | P L/2 L/2 | |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES |
| 14 | 1.63 | 1.45 | 11.2 | 1.15 |
| 16 | 1.24 | 1.88 | 9.9 | 1.49 |
| 18 | .98 | 2.39 | 8.9 | 1.90 |
| 20 | .80 | 2.97 | 8.0 | 2.35 |
| 22 | .66 | 3.58 | 7.3 | 2.84 |
| 24 | .55 | 4.17 | 6.5 | 3.31 |



1. Either edge of section may be used as top, depending on application.
2. The extrusions may be orientated several ways without changing the properties from those for the section above. Several possible combinations are shown at right.
3. For beams with spans from 12 to 21 feet see sheet 64 for splice details.
4. Deflection computations are based on constant section conditions.
5. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
6. For beams with spans from 21 to 24 feet see sheet 65 for splice details.



EXAMPLES

# DRAWING B-6

## YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

ALUMINUM LANDING MAT T-11 BEAM SPAN 24 TO 48 FEET

FULL WIDTH MAT WITH NO MODIFICATIONS

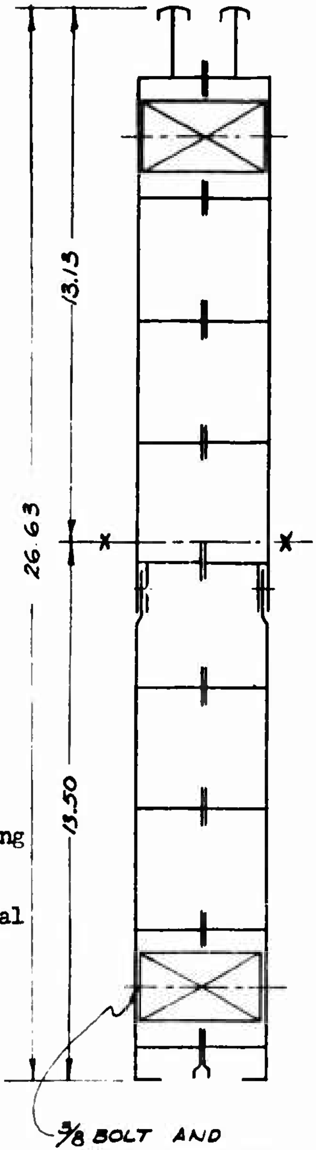
### TABLE B-6

| SPAN FEET L | LOADS* | | | | |
|---|---|---|---|---|---|
| | W K/FT<br>L | | P<br>L/2 L/2 | | MAXIMUM MOVING CONCENTRATED LOAD K |
| | W ** K/FT. | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES | |
| 24 | 1.27 | .86 | 30.4** | 1.38 | 15.2 |
| 28 | 1.08 | 1.36 | 30.4** | 2.20 | 15.2 |
| 32 | .95 | 2.05 | 28.2 | 3.06 | 15.2 |
| 36 | .84 | 2.90 | 25.2 | 4.08 | 15.2 |
| 40 | .76 | 4.01 | 22.5 | 4.75 | 15.2 |
| 44 | .69 | 5.33 | 20.5 | 5.75 | 15.2 |
| 48 | .63 | 6.90 | 18.8 | 6.87 | 15.2 |

* Values are based on the properties of two panels.

** These values are determined by the shear on the rivеted connection between extrusion A and extrusion B.

1. See sheet 65 for details on the necessary splice connection.
2. Either edge of section may be used as top , depending on application.
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. See the section of the report on connections for reaction details. (Sheet 60 )
5. Deflection values are based on the properties of the two panels.



# DRAWING B-7
# YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

ALUMINUM LANDING MAT T-11
PANEL MODIFIED BY THE ADDITION
OF 1/4" RIVETS BETWEEN EXISTING
RIVETS IN CONNECTION BETWEEN
EXTRUSION "A" AND "B"

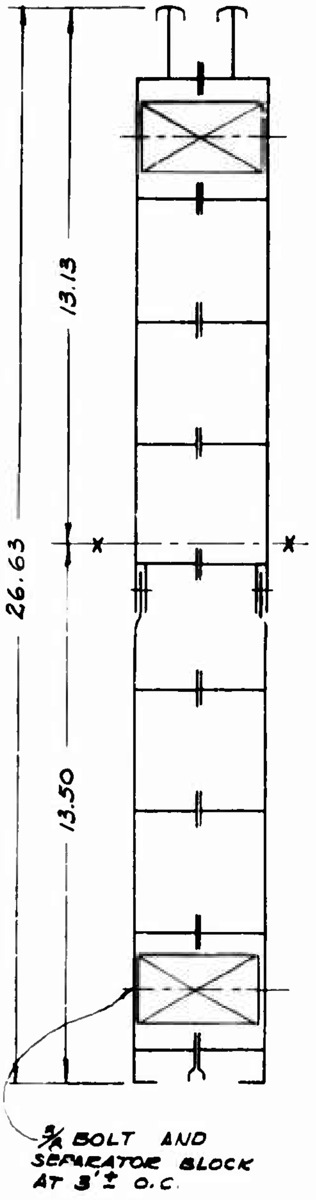
BEAM SPAN 24 TO 48 FEET

## TABLE B-7

| SPAN FEET L | LOADS* | | | | |
|---|---|---|---|---|---|
| | W K/FT, L | | P, L/2, L/2 | | MAXIMUM MOVING CONCENTRATED LOAD K |
| | W** K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES | |
| 24 | 3.13 | 2.14 | 37.6 | 1.72 | 30.4** |
| 28 | 2.31 | 2.92 | 32.3 | 2.34 | 30.4** |
| 32 | 1.77 | 3.78 | 28.2 | 3.06 | 28.2 |
| 36 | 1.40 | 4.83 | 25.1 | 4.08 | 25.2 |
| 40 | 1.13 | 5.93 | 22.5 | 4.75 | 28.5 |
| 44 | .93 | 7.18 | 20.5 | 5.75 | 20.5 |
| 48 | .79 | 8.59 | 18.8 | 6.87 | 18.8 |

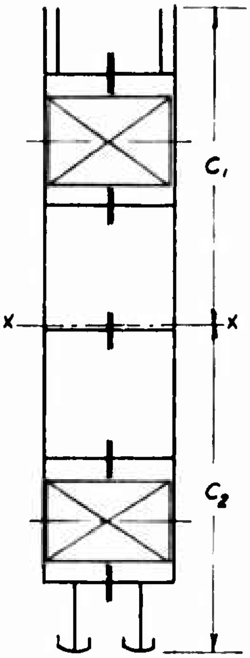
* Values are based on the properties of two panels.
** These values are determined by the shear on the riveted connection between extrusion A and extrusion B.

1. See sheet 65 for details on necessary splice connection.
2. Either edge may be used as top, depending on application.
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. See the section of the report on connections for reaction details. (Sheet 60)
5. Deflection values are based on the properties of the two panels.

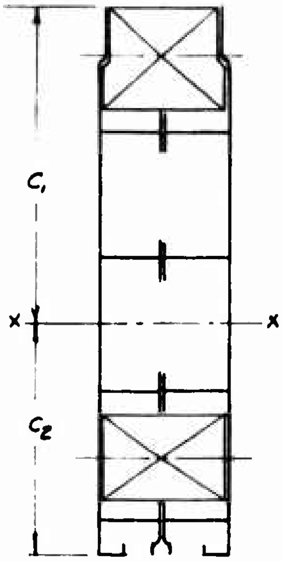


DRAWING B-8

## BEAM DESIGN DATA
### MAGNESIUM LANDING MAT T-8



SECTION 1
2 EXTRUSIONS "A"



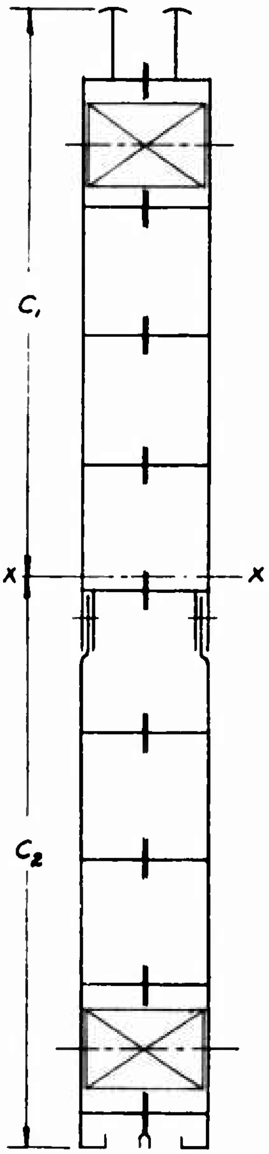
SECTION 2
2 EXTRUSIONS "B"

TABLE B-8

| | SECTION 1 | SECTION 2 | SECTION 3 |
|---|---|---|---|
| AREA | 6.06 | 4.76 | 10.82 |
| WT. PER FOOT | 10.7 | 8.5 | 19.2 |
| $I_{xx}$ | 241.2 | 129.8 | 1511 |
| $C_1$ | 7.96 | 7.66 | 14.27 |
| $C_2$ | 7.93 | 5.88 | 13.92 |
| $Z_1$ | 30.3 | 16.9 | 106 |
| $Z_2$ | 30.4 | 22.1 | 108.6 |
| M-KIP FT | 63.2 | 35.1 | 221 |

DESIGN STRESSES

| | | |
|---|---|---|
| TENSION | 36,000 | PSI |
| COMPRESSION | 25,000 | PSI |
| SHEAR | 22,000 | PSI |
| BEARING | 45,000 | PSI |



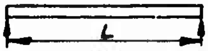
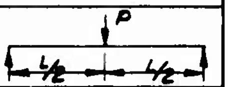
SECTION 3
2 FULL WIDTH MATS

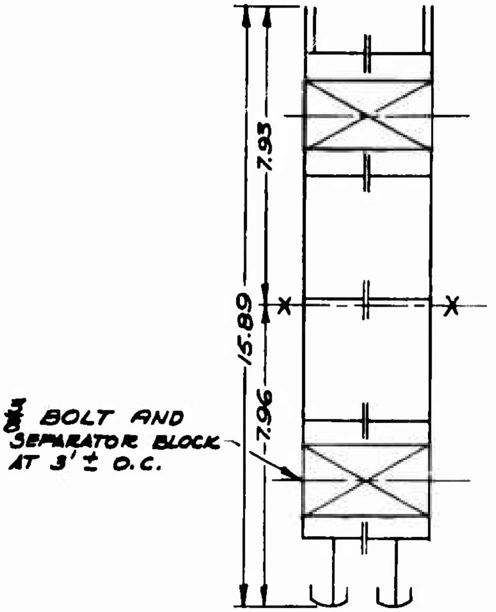
# DRAWING B-9

## YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

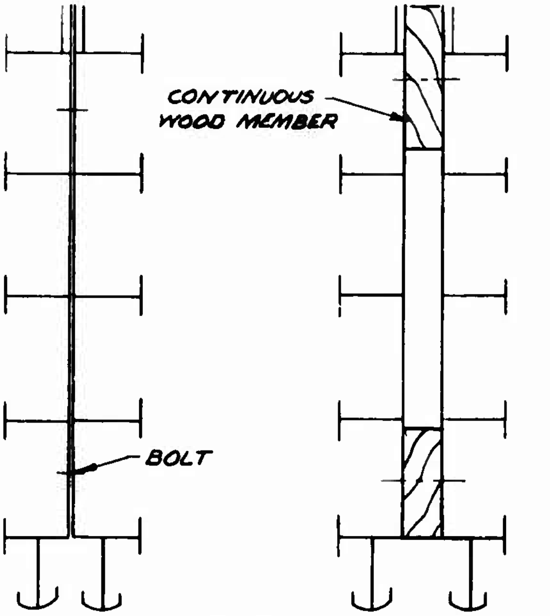
MAGNESIUM LANDING MAT T-8 BEAM SPAN 6 TO 12 FEET
EXTRUSION "A"

### TABLE B-9

| SPAN FEET L | LOADS | | | |
|---|---|---|---|---|
| | W K/FT  L | | P  L/2 L/2 | |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES |
| 6 | 14.0 | 0.26 | 42 | 0.21 |
| 7 | 10.3 | 0.35 | 36 | 0.28 |
| 8 | 7.90 | 0.46 | 31.6 | 0.37 |
| 9 | 6.23 | 0.59 | 28.1 | 0.47 |
| 10 | 5.05 | 0.72 | 25.2 | 0.58 |
| 11 | 4.17 | 0.88 | 22.9 | 0.71 |
| 12 | 3.51 | 1.04 | 21.1 | 0.84 |



1. Either edge of section may be used as top, depending on application.
2. See the section of the report on connections for reaction details. ( Sheet 60)
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. The extrusions may be orientated several ways without changin the properties from those for the section above. Several possible combinations are shown at right.



EXAMPLES

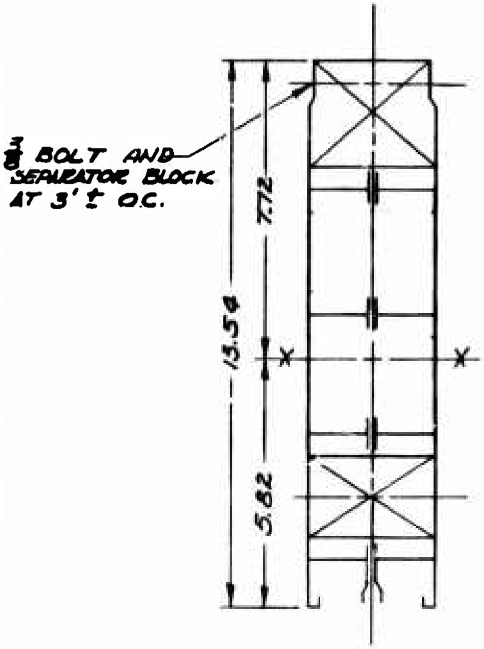
DRAWING B-10

# YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

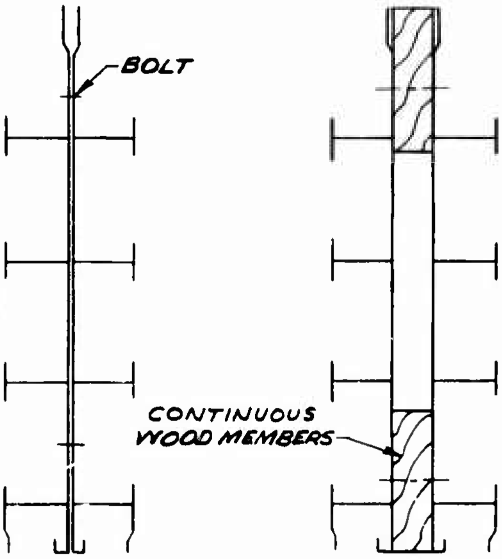
MAGNESIUM LANDING MAT T-8 BEAM SPAN 6 TO 12 FEET
EXTRUSION "B"

## TABLE B-10

| SPAN<br>FEET<br>L | LOADS | | | |
|---|---|---|---|---|
| | W K/FT<br>L | | P<br>L/2 L/2 | |
| | W<br>K/FT | DEFLECTION<br>INCHES | P<br>KIPS | DEFLECTION<br>INCHES |
| 6 | 7.75 | .27 | 23.3 | .22 |
| 7 | 5.71 | .36 | 20.0 | .29 |
| 8 | 4.38 | .47 | 17.5 | .38 |
| 9 | 3.45 | .61 | 15.6 | .49 |
| 10 | 2.80 | .74 | 14.0 | .59 |
| 11 | 2.31 | .91 | 12.7 | .73 |
| 12 | 1.94 | 1.07 | 11.7 | .86 |



1. Either edge of section may be used as top, depending on application.
2. See the section of the report on connections for reaction details. ( Sheet 60 )
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. The extrusions may be orientated several ways without changing the properties from those for the section above. Several possible combinations are shown at right.



EXAMPLES

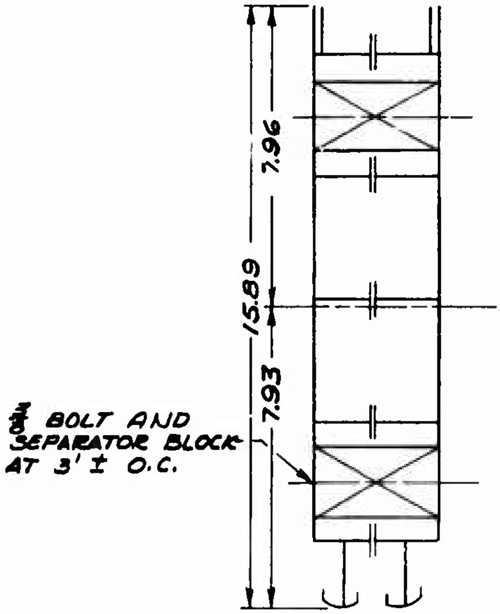
# DRAWING B-11

## YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

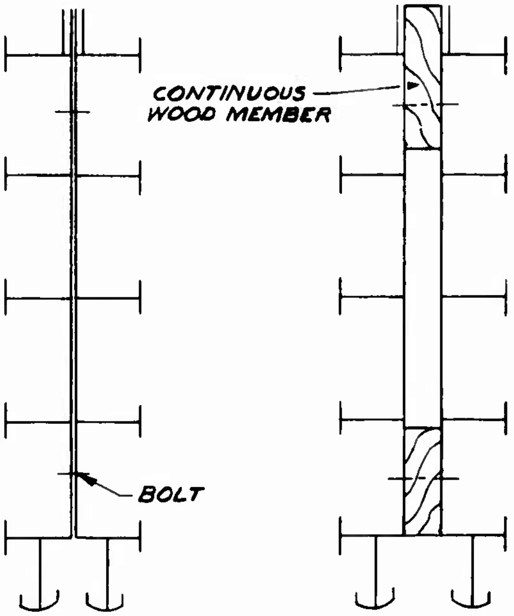
MAGNESIUM LANDING MAT T-8 BEAM SPAN 12 TO 24 FEET
EXTRUSION "A"

TABLE B-11

| SPAN FEET L | LOADS | | | |
|---|---|---|---|---|
| | W K/FT | | P | |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES |
| 14 | 2.58 | 1.43 | 18.0 | 1.15 |
| 16 | 1.96 | 1.85 | 15.7 | 1.49 |
| 18 | 1.56 | 2.36 | 14.1 | 1.90 |
| 20 | 1.27 | 2.94 | 12.7 | 2.36 |
| 22 | 1.05 | 3.54 | 11.5 | 2.85 |
| 24 | .86 | 4.13 | 10.3 | 3.32 |



1. Either edgs of section may be used as top, depending on application.
2. The extrusions may be orientated several ways without changing the properties from those of the section above. Several possible combinations are shown at right.
3. For beams with spans from 12 to 21 feet see sheet 64 for splice details.
4. Deflection computations are based on constant section conditions.
5. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
6. For beams with spans from 21 to 24 feet see sheet 65 for splice details.



EXAMPLES

DRAWING B-12

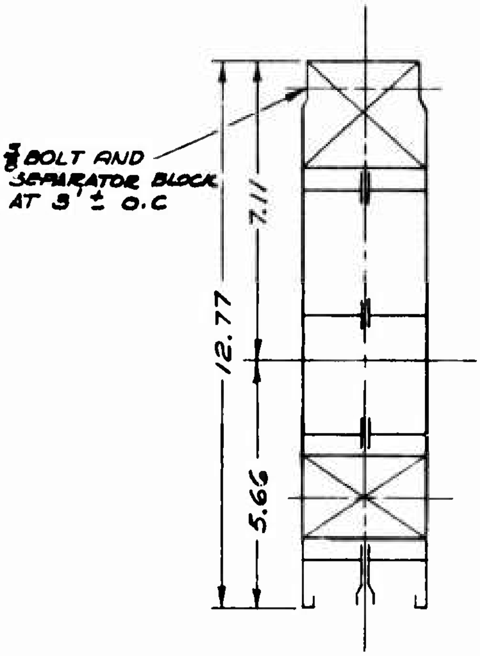
# YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

MAGNESIUM LANDING MAT T-8  
EXTRUSION "B"

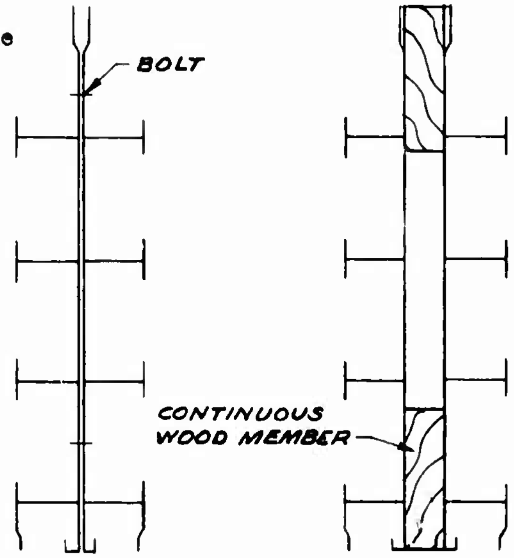
BEAM SPAN 14 TO 24 FEET

## TABLE B-12

| SPAN FEET L | LOADS | | | |
|---|---|---|---|---|
| | W K/FT<br>L | | P<br>L/2 L/2 | |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES |
| 14 | 1.43 | 1.47 | 10.0 | 1.10 |
| 16 | 1.09 | 1.91 | 8.7 | 1.53 |
| 18 | .86 | 2.43 | 7.8 | 1.95 |
| 20 | .70 | 3.01 | 7.0 | 2.42 |
| 22 | .58 | 3.63 | 6.4 | 2.92 |
| 24 | .48 | 4.22 | 5.7 | 3.39 |



1. Either edge of section may be used as top, depending on application.
2. The extrusions may be orientated several ways without changing the properties from those for the section above. Several possible combinations are shown at right.
3. For beams with spans from 12 to 21 feet see sheet 64 for splice details.
4. Deflection computations are based on constant section conditions.
5. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
6. For beams with spans from 21 to 24 feet see sheet 65 for splice details.



EXAMPLES

## DRAWING B-13

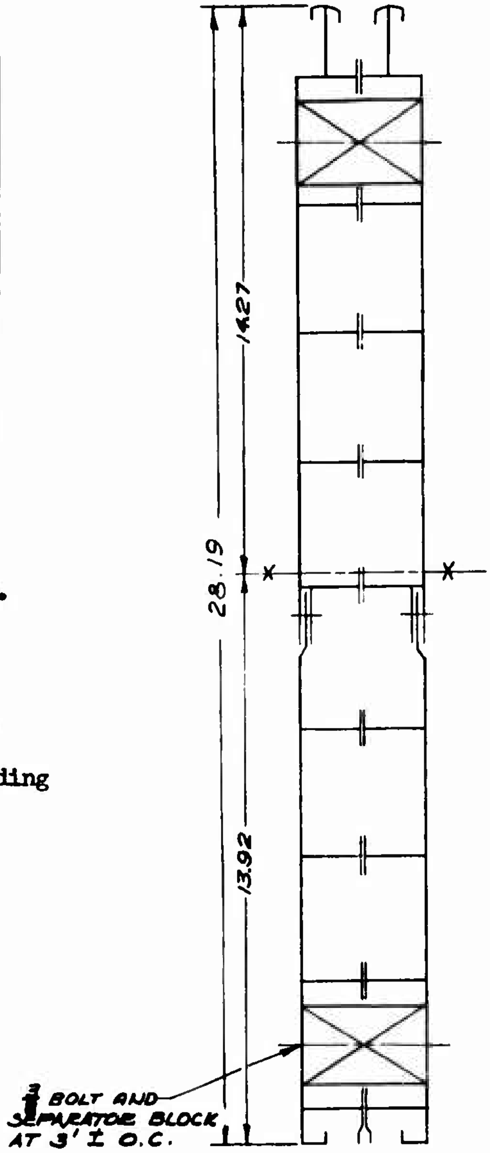
## YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

MAGNESIUM LANDING MAT T-8 BEAM SPAN 24 TO 48 FEET

FULL WIDTH MAT WITH NO MODIFICATION

### TABLE B-13

| SPAN FEET L | LOADS * | | | | |
|---|---|---|---|---|---|
| | W K/FT. L | | P L/2 L/2 | | MAXIMUM MOVING CONCENTRATED LOAD KIPS |
| | W ** K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES | |
| 24 | 1.05 | .81 | 25.2** | 1.30 | 12.6 |
| 28 | .90 | 1.28 | 25.2** | 2.06 | 12.6 |
| 32 | .79 | 1.92 | 25.2** | 3.08 | 12.6 |
| 36 | .70 | 2.73 | 24.5 | 4.50 | 12.6 |
| 40 | .63 | 3.74 | 21.9 | 5.23 | 12.6 |
| 44 | .57 | 4.96 | 19.9 | 6.32 | 12.6 |
| 48 | .53 | 6.41 | 18.4 | 7.59 | 12.6 |



* Values are based of the properties of two panels.

** These values are determined by the shear on the riveted connection between extrusion A and extrusion B.

1. See sheet 65 for details of the necessary splice connection.
2. Either edge of section may be used as top, depending on application.
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. See the section of the report on connections for reaction details. ( Sheet 60 )
5. Deflection values are based on the properties of the two panels.

DRAWING B-14

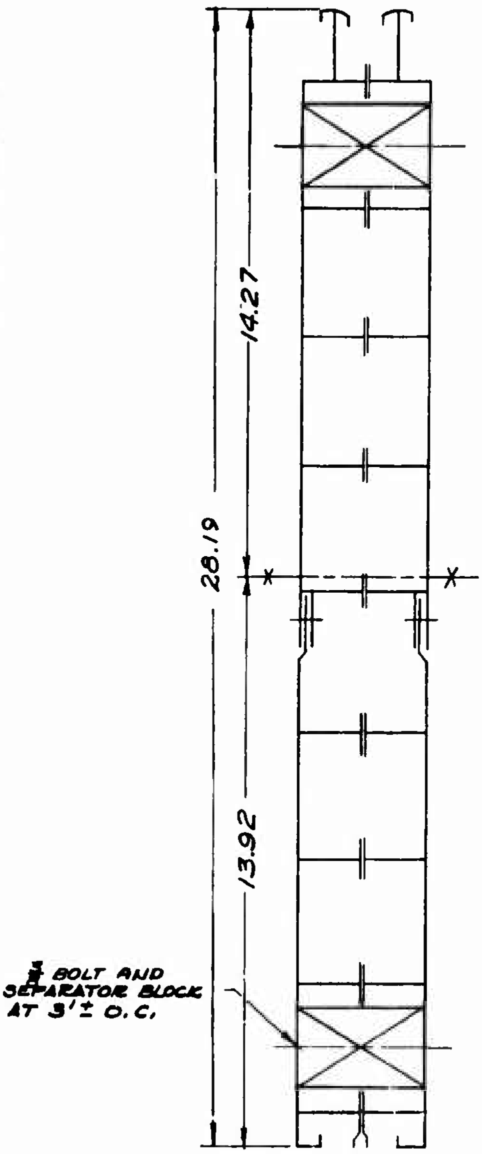
# YIELD POINT LOADS FOR LATERALLY SUPPORTED BEAMS

MAGNESIUM LANDING MAT T-8
PANEL MODIFIED BY THE ADDITION OF 1/4"
RIVETS BETWEEN EXISTING RIVETS IN
CONNECTION BETWEEN EXTRUSIONS "A" AND "B"

BEAM SPAN 24 TO 48 FEET

## TABLE B-14

| SPAN FEET L | LOADS | | | | |
|---|---|---|---|---|---|
| | W K/FT. L | | P L/2 L/2 | | MAXIMUM MOVING CONCENTRATED LOAD KIPS |
| | W K/FT | DEFLECTION INCHES | P KIPS | DEFLECTION INCHES | |
| 24 | 3.05 | 2.34 | 36.6 | 1.89 | 25.2 |
| 28 | 2.24 | 3.21 | 33.6 | 2.58 | 25.2 |
| 32 | 1.72 | 4.21 | 27.5 | 3.38 | 25.2 |
| 36 | 1.36 | 5.33 | 24.5 | 4.28 | 24.5 |
| 40 | 1.10 | 6.58 | 21.9 | 5.30 | 21.9 |
| 44 | .91 | 7.96 | 19.9 | 6.40 | 19.9 |
| 48 | .76 | 9.42 | 18.4 | 7.57 | 18.4 |



1. See sheet 63 for details on necessary splice connection.
2. Either edge may be used as top, depending on application.
3. Beams of greater capacity may be fabricated using several sections. The load will be proportional to the number of sections.
4. See the section of the report on connections for reaction details. ( Sheet 60 )
5. Deflection values are based on the properties of the two panels.

## SPECIFIC APPLICATION

### (Beams)

| ITEM | REFERENCE FOR LOAD DATA |
|---|---|
| I. BUILDINGS | |
| Flooring Framing | B-1 to B-5<br>B-8 to B-12 |
| Roof Framing | B-1 to B-14 |
| Grade Beam | B-1 to B-14 |
| II. TOWERS | |
| Control | B-1 to B-5<br>B-8 to B-12 |
| Elevated Tank | B-1 to B-5<br>B-8 to B-12 |
| Drying (Parachute) | B-1 to B-5<br>B-8 to B-12 |
| III. BRIDGES | |
| Fixed | B-1 to B-14 |
| Floating (Stiffener Girder) | B-6, B-7, B-13 and B-14 |
| Ferries | B-1 to B-14 |
| Bents (Trestle & Pier) | B-1 to B-5<br>B-8 to B-12 |
| Sills and Caps | B-1 to B-5<br>B-8 to B-12 |
| Bridge Repair | B-1 to B-14 |

| ITEM | REFERENCE FOR LOAD DATA |
|---|---|
| **IV. MISCELLANEOUS** | |
| Grease Rack | B-1 to B-5<br>B-8 to B-12 |
| Hose Drying Rack | B-1 to B-5<br>B-8 to B-12 |
| Long Ridge Poles | B-1 to B-5<br>B-8 to B-12 |
| Covered Walkways | B-1 to B-5<br>B-8 to B-12 |
| Storage Rack | B-1 to B-5<br>B-8 to B-12 |

## COLUMNS

Single extrusions will be used as struts in structures only where conditions are such that they may be laterally supported. Generally, columns will be built up of two or more extrusions. The information which follows is limited to true columns, where the unsupported length is a consideration in the load carrying capacity.

Allowable loads were calculated to produce specified yield point stresses. Any factor of safety may be applied for a particular condition.

Column theory as illustrated by the composite curve on Drawing No. CT-1, Sheet 37 , was used in determining the allowable concentric loads on built-up columns. This approach is based on classic column theory, with the crippling stress limitations for aluminum as recommended in Paper No. 970, "Specifications for Structures of Aluminum Alloy 6061-T6", as reported in the Journal of the Structural Division of the American Society of Civil Engineers. For magnesium, crippling stress limitations were used as given in Technical Memorandum No. 15, "Crippling Strength of Magnesium Sheet and Extrusion", published by the Dow Chemical Company.

### End Fixity Condition

The column sections were investigated for the end fixity values, k equals 1.0 and k equals 0.75. (Where k is 1.0 for pin end conditions and k is 0.5 for fixed end conditions.) Ordinarily the value for partial restraint ($k = .75$) should be used unless tests or known conditions indicate a higher or lower value.

### Accidental or Unknown Eccentricity

Eccentricity caused by fabrication or construction is assumed to be $ec/r^2 = 0.25$, where:

$e$ = eccentricity in loading

$c$ = distance to extreme fiber subject to compression

$r$ = radius of gyration

The equation that follows was used to determine the allowable bending stress produced by the assumed eccentric loading:

$$f_b = f_B \left[ 1 - \frac{P/A}{f_c} \right] \left[ 1 - \frac{P/A}{f_{ce}} \right]$$ (1.)

Where

$f_b$ is the maximum bending stress that may be permitted in addition to the uniform compression.

P/A is the average compressive stress on gross section produced by the column load, P.

$f_B$ is the allowable compressive working stress for the member considered as a beam.

$f_c$ is the allowable working stress for the member considered as an axially loaded member.

$f_{ce} = \frac{\pi^2 E}{(L/r)}$ where L/r is the slenderness ratio.

The preceeding equation results in a trial and error solution for the maximum allowable load.

The same formula can be used in any special application to design a member subjected to combined bending and axial stress.

## Spacing of Wood Blocks

The spacing of the wood blocks between the extrusions used to build up the section was determined by considering the individual extruded sections as columns of length equal to the spacing of the blocks. A very conservative assumption of end fixity, k = 1.0, was used for these individual columns.

## Selection of Bolts

2024-T4 Aluminum Alloy bolts were used to design all joints for both the aluminum and magnesium columns. Replacement of the aluminum bolts by bolts of steel or of other materials is certainly acceptable for field operations.

Allowable loads for the bolts were computed using minimum guaranteed shear stress for 2024-T4 Aluminum Alloy and minimum guaranteed bearing yield stress for 6061-T6 Aluminum Alloy or ZK60A-T5 Magnesium Alloy.

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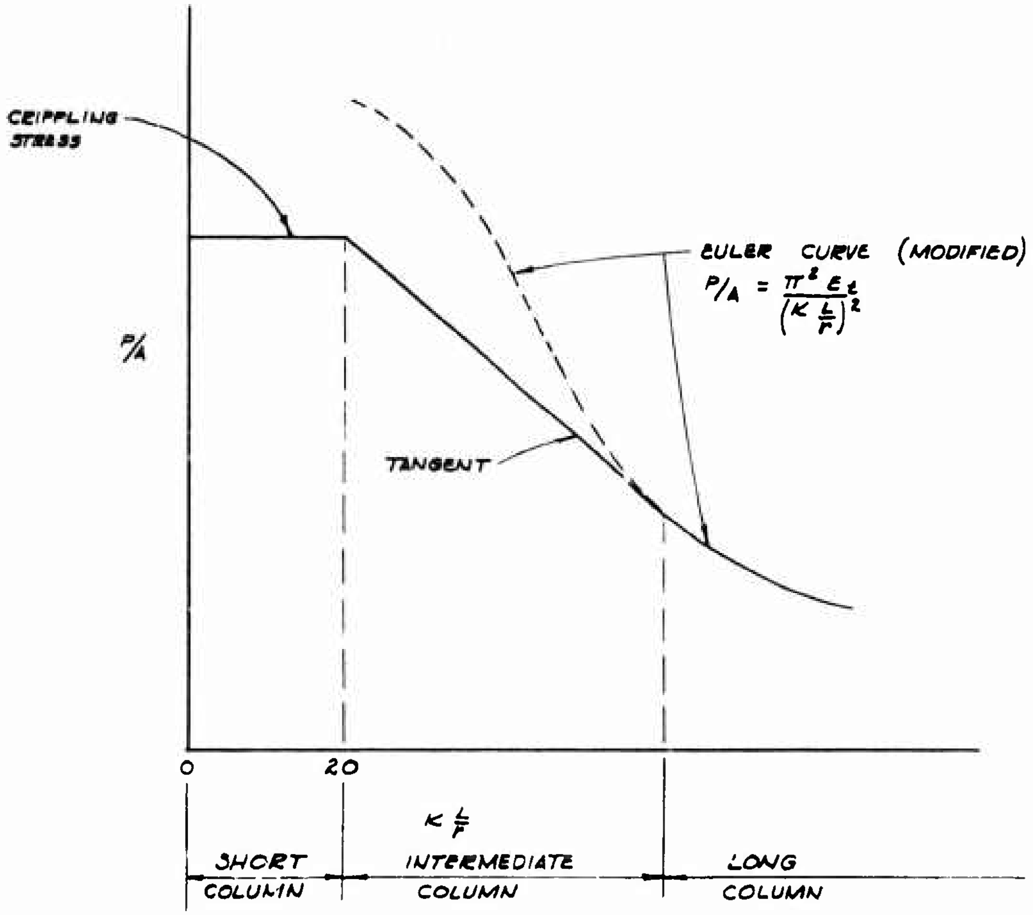
1. Previous reference (Paper 970).

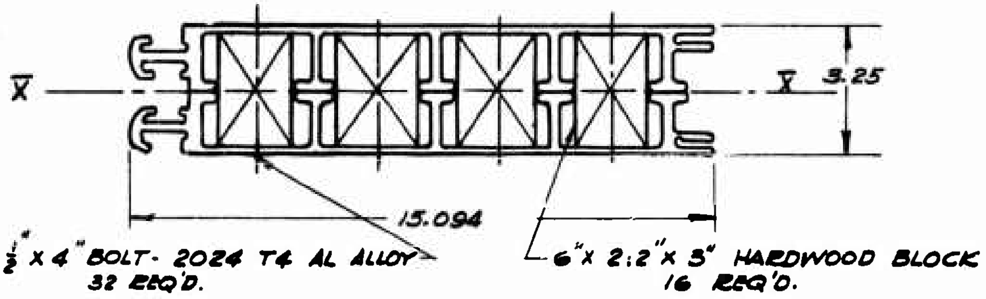
DRAWING CT-1



DRAWING CT-1
COMPOSIT COLUMN CURVE

DRAWING C-1

# ALLOWABLE COLUMN LOADS
# DOUBLE EXTRUSION "A" ALUMINUM COLUMN

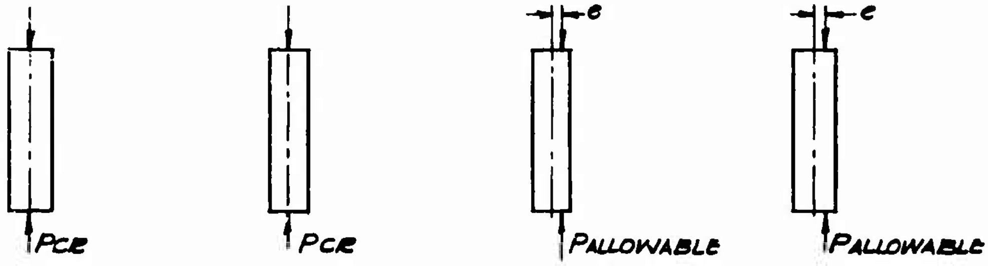


## TYPICAL CROSS SECTION

## PROPERTIES

AREA – A = 9.12 IN$^2$
MOMENT OF INERTIA - $I_X$ = 11.80 IN$^4$
RADIUS OF GYRATION - $r_X$ = 1.15 IN.

## LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - $k = 1$

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
$k = .75$ [1]

CONDITION III
ECCENTRIC LOADING [2]
$e\,c/r^2 = .25$
PIN ENDS - $k = 1$

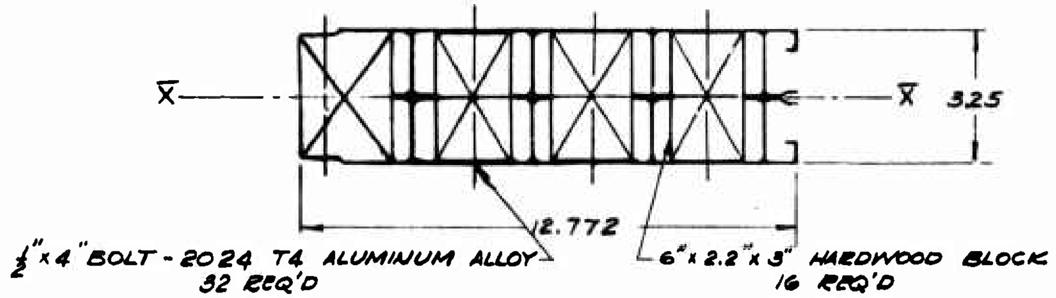
CONDITION IV
ECCENTRIC LOADING
$e\,c/r^2 = .25$
PARTIAL RESTRAINT - $k = .75$

## TABLE C-1

| UNSUPPORTED COLUMN-LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS [3] INCHES | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | 6×2.2×3 | 4 | 46 | 59 | 100 | 47 | 75 |
| 11 | 132 | 6×2.2×3 | 4 | 42 | 71 | 120 | 55 | 88 |
| 10 | 120 | 6×2.2×3 | 4 | 38 | 85 | 150 | 65 | 106 |
| 9 | 108 | 6×2.2×3 | 4 | 34 | 102 | 183 | 77 | 124 |
| 8 | 96 | 6×2.2×3 | 4 | 30 | 128 | 218 | 92 | 144 |

1. PARTIAL RESTRAINT OF $k = .75$ CAN NORMALLY BE ASSUMED IN STRUCTURAL DESIGN FOR BOLTED OR RIVETED CONNECTIONS.
2. $ec/r^2 = .25$ WHERE $e$ = ECCENTRICITY, $c$ = DISTANCE TO EXTREME FIBER, $r$ = RADIUS OF GYRATION THIS VALUE OF $ec/r^2$ IS NORMALLY ASSUMED TO EXIST TO TAKE INTO ACCOUNT ANY LACK OF STRAIGHTNESS AND ANY INDETERMINATE ECCENTRICITY IN LOADING - DOES NOT PROVIDE FOR ANY KNOWN ECCENTRICITY.
3. IN EACH CELL A BLOCK IS PLACED FLUSH WITH EACH END OF THE COLUMN. TWO BOLTS ARE PLACED THROUGH EACH BLOCK ON ℄ 1½ INCHES FROM EACH END.

# DRAWING C-2 ALLOWABLE COLUMN LOADS DOUBLE EXTRUSION "B" ALUMINUM COLUMN



TYPICAL CROSS SECTION

## PROPERTIES

AREA – $A = 6.90\ IN^2$
MOMENT OF INERTIA – $I_{\bar{X}} = 9.42\ IN^4$
RADIUS OF GYRATION – $r_{\bar{x}} = 1.17\ IN.$

## LOADING AND END CONDITIONS

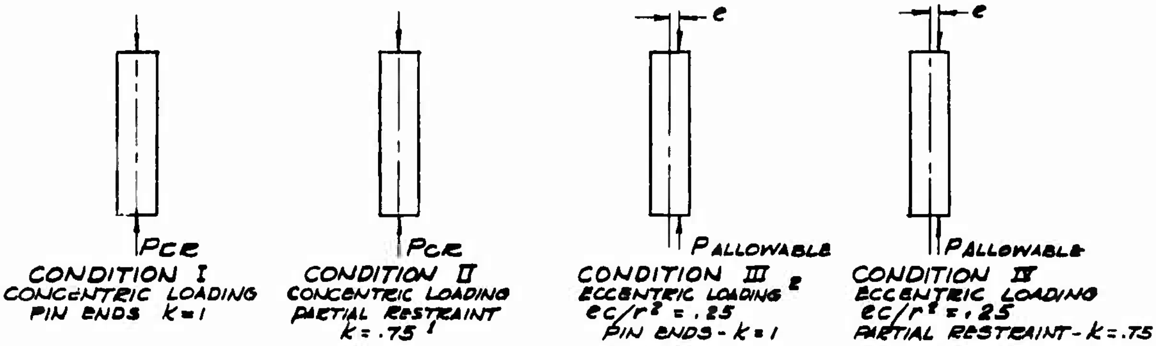


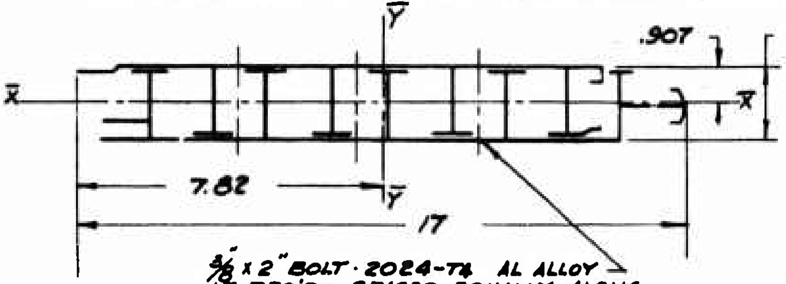
TABLE C-2

| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS[3] INCHES | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | 6x2.2x3 | 4 | 46 | 47 | 79 | 38 | 59 |
| 11 | 132 | 6x2.2x3 | 4 | 42 | 55 | 94 | 43 | 69 |
| 10 | 120 | 6x 2.2x3 | 4 | 38 | 66 | 115 | 51 | 81 |
| 9 | 108 | 6 x 2.2 x 3 | 4 | 34 | 80 | 144 | 60 | 98 |
| 8 | 96 | 6 x 2.2 x 3 | 4 | 30 | 101 | 168 | 73 | 111 |

1. PARTIAL RESTRAINT OF $k = .75$ CAN NORMALLY BE ASSUMED IN STRUCTURAL DESIGN FOR BOLTED OR RIVETED CONNECTIONS.
2. $ec/r^2 = .25$ WHERE $e$ = ECCENTRICITY, $c$ = DISTANCE TO EXTREME FIBER, $r$ = RADIUS OF GYRATION. THIS VALUE OF $ec/r^2$ IS NORMALLY ASSUMED TO EXIST TO TAKE INTO ACCOUNT ANY LACK OF STRAIGHTNESS AND ANY INDETERMINATE ECCENTRICITY IN LOADING - DOES NOT PROVIDE FOR ANY KNOWN ECCENTRICITY.
3. IN EACH CELL A BLOCK IS PLACED FLUSH WITH EACH END OF THE COLUMN. TWO BOLTS ARE PLACED THROUGH EACH BLOCK ON ℄ 1½ INCHES FROM EACH END.

DRAWING C-3

# ALLOWABLE COLUMN LOADS - INTERLACED EXTRUSIONS "A" AND "B" ALUMINUM COLUMN

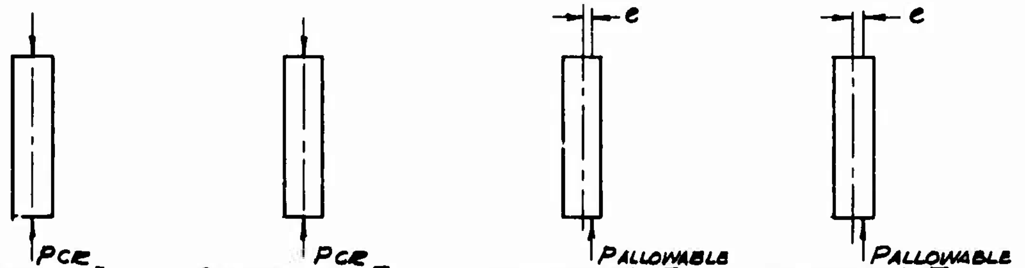


3/8" x 2" BOLT - 2024-T4 AL ALLOY
13 REQ'D - SPACED EQUALLY ALONG
COLUMN LENGTH

## TYPICAL CROSS SECTION PROPERTIES

AREA - $A = 8.01\ IN^2$
MOMENT OF INERTIA - $I_{\bar{x}} = 11.80\ IN^4$
RADIUS OF GYRATION - $r_x = .702\ IN.$

## LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - $k = 1$

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
$k = .75$[1]

CONDITION III
ECCENTRIC LOADING[2]
$ec/r^2 = .25$
PIN ENDS - $k = 1$

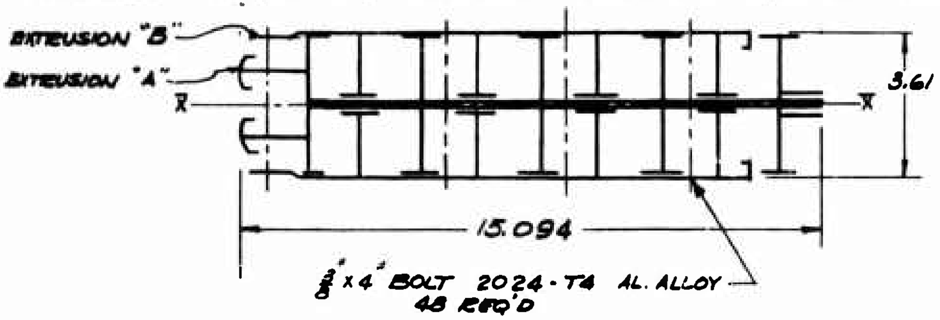
CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT - $k = .75$

## TABLE C-3

| UNSUPPORTED COLUMN LENGTH | | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|
| FEET | INCHES | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | 19.2 | 32.0 | 12.7 | 18.9 |
| 11 | 132 | 24.0 | 40.0 | 15.1 | 22.0 |
| 10 | 120 | 28.8 | 49.6 | 17.3 | 25.3 |
| 9 | 108 | 35 | 61.7 | 20.3 | 29.2 |
| 8 | 96 | 43.3 | 73.7 | 23.4 | 33.1 |

1. Partial restraint of $k = .75$ can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where: e = eccentricity, c = distance to extreme fiber, r = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any origional lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.

## DRAWING C-4 ALLOWABLE COLUMN LOAD - DOUBLE EXTRUSION "B" ALUMINUM COLUMN FOR LENGTHS GREATER THAN 12 FEET

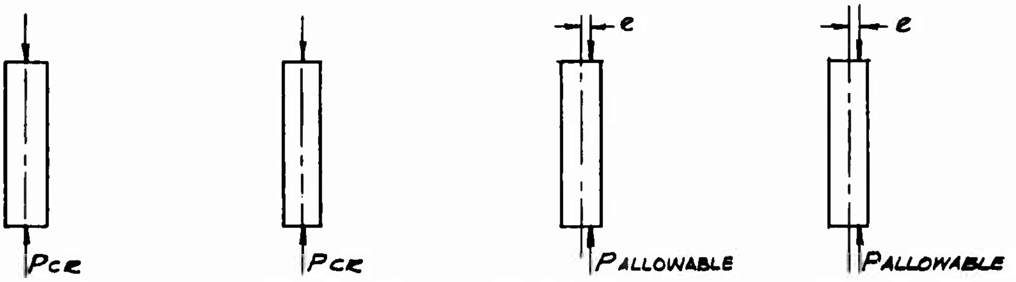


THE CROSS SECTION SHOWN ABOVE IS AT THE JOINT. TWO EXTRUSIONS "B" FORM THE COLUMN. THE OVERLAPPING JOINT IS FORMED BY TWO 3 FOOT SECTIONS OF EXTRUSION "A". THE LOCATION OF THE JOINT AS TO POSITION IN LENGTH IS NOT SPECIFIED FOR EASE OF FABRICATION.

PROPERTIES OF COLUMN CROSS SECTION (EXTRUSION "B" ONLY)

AREA - $A = 6.90 \text{ IN}^2$
MOMENT OF INERTIA - $I_x = 11.27 \text{ IN}^4$
RADIUS OF GYRATION - $r_x = 1.28 \text{ IN}$

### LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - $k = 1$

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
$k = .75$[1]

CONDITION III[2]
ECCENTRIC LOADING
$ec/r^2 = .25$
PIN ENDS $k = 1$

CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT - $k = .75$

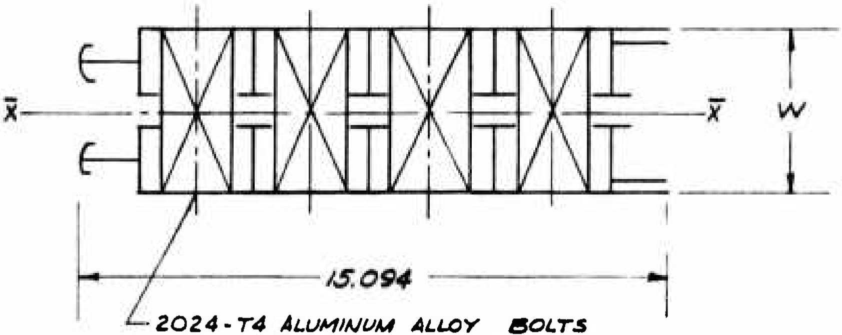
CONTINUED
ON
NEXT SHEET

## TABLE C-4

| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | MINIMUM NUMBER OF WOOD BLOCKS PER CELL | MAXIMUM SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES [3] | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 24 | 288 | 2.2 × 3.35 × 6 | 3 | 78 | 13.8 | 24.1 | 12.2 | 20.5 |
| 23 | 276 | 2.2 × 3.35 × 6 | 3 | 7.5 | 15.2 | 26.8 | 13.4 | 22.5 |
| 22 | 264 | 2.2 × 3.35 × 6 | 3 | 72 | 16.7 | 29.0 | 14.5 | 24.4 |
| 21 | 252 | 2.2 × 3.35 × 6 | 3 | 67 | 18.4 | 32.2 | 16.0 | 26.7 |
| 20 | 240 | 2.2 × 3.35 × 6 | 3 | 65 | 19.9 | 35.4 | 17.1 | 29.0 |
| 19 | 228 | 2.2 × 3.35 × 6 | 3 | 62 | 22.0 | 38.4 | 18.9 | 31.1 |
| 18 | 216 | 2.2 × 3.35 × 6 | 3 | 58 | 24.4 | 43.5 | 20.8 | 34.8 |
| 17 | 204 | 2.2 × 3.35 × 6 | 3 | 55 | 27.6 | 49.0 | 23.2 | 38.8 |
| 16 | 192 | 2.2 × 3.35 × 6 | 3 | 52 | 31.1 | 54.8 | 25.8 | 42.8 |
| 15 | 180 | 2.2 × 3.35 × 6 | 3 | 48 | 35.5 | 62.8 | 29.1 | 48.4 |
| 14 | 168 | 2.2 × 3.35 × 6 | 3 | 45 | 40.9 | 73.1 | 33.2 | 55.6 |
| 13 | 156 | 2.2 × 3.35 × 6 | 3 | 41 | 47.3 | 84.3 | 37.8 | 62.3 |

1. Partial restraint of $k = .75$ can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where $e$ = eccentricity, $c$ = distance to extreme fiber, $r$ = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each block on it's ℄ 1½ inches from the ends. Since the location of the joint is not specified, exact spacing of the wood blocks is not specified.

# DRAWING C-5 ALLOWABLE COLUMN LOADS - EXPANDED EXTRUSION "A" ALUMINUM COLUMN (EXPANDED BY BLOCKS CUT FROM STANDARD 4x4 AND 6x6 LUMBER)



2024-T4 ALUMINUM ALLOY BOLTS
CASE A - $\frac{1}{2}$" x $4\frac{1}{2}$" BOLT - 40 REQ'D
CASE B - $\frac{1}{2}$" x 6" BOLT - 48 REQ'D

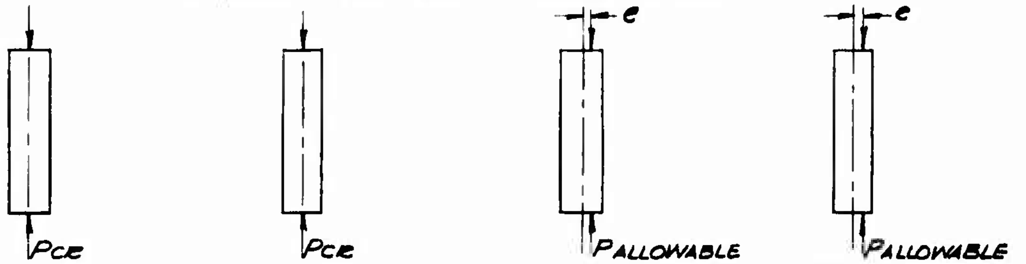
TYPICAL CROSS SECTION

## PROPERTIES OF THE SECTIONS

CASE A - EXPANDED BY BLOCKS CUT FROM 4x4 LUMBER
WIDTH OF COLUMN - $W = 3.89$ IN.
AREA - $A = 9.12$ $IN.^2$
MOMENT OF INERTIA - $I_{\bar{x}} = 18.27$ $IN.^4$
RADIUS OF GYRATION - $r_x = 1.414$ IN.

CASE B - EXPANDED BY BLOCKS CUT FROM 6x6 LUMBER
WIDTH OF COLUMN - $W = 5.76$ IN.
AREA - $A = 9.12$ $IN^2$
MOMENT OF INERTIA - $I_{\bar{x}} = 48.36$ $IN^4$
RADIUS OF GYRATION - $r_x = 2.30$ IN

## LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - $k = 1$

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
$k = .75$

CONDITION III
ECCENTRIC LOADING
$ec/r^2 = .25$
PIN ENDS - $k = 1$

CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT - $k = .75$

CONTINUED
ON
NEXT SHEET

## TABLE C-5

### (CASE A)

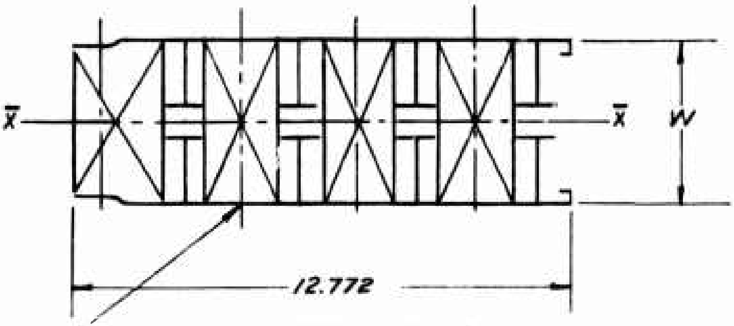
| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES 3 | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | $2.2 \times 3\frac{5}{8} \times 12$ | 4 | 44 | 88 | 155 | 67 | 109 |
| 11 | 132 | $2.2 \times 3\frac{5}{8} \times 12$ | 4 | 40 | 106 | 189 | 80 | 128 |
| 10 | 120 | $2.2 \times 3\frac{5}{8} \times 12$ | 4 | 36 | 126 | 217 | 92 | 143 |
| 9 | 108 | $2.2 \times 3\frac{5}{8} \times 12$ | 4 | 32 | 159 | 232 | 111 | 151 |
| 8 | 96 | $2.2 \times 3\frac{5}{8} \times 12$ | 4 | 28 | 205 | 246 | 137 | 159 |

### (CASE B)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12 | 144 | $2.2 \times 5\frac{1}{2} \times 14$ | 5 | 32.5 | 212 | 255 | 142 | 163 |
| 11 | 132 | $2.2 \times 5\frac{1}{2} \times 14$ | 5 | 29.5 | 225 | 264 | 148 | 167 |
| 10 | 120 | $2.2 \times 5\frac{1}{2} \times 12$ | 5 | 27 | 237 | 273 | 154 | 172 |
| 9 | 108 | $2.2 \times 5\frac{1}{2} \times 12$ | 5 | 24 | 251 | 281 | 160 | 176 |
| 8 | 96 | $2.2 \times 5\frac{1}{2} \times 12$ | 5 | 21 | 258 | 290 | 165 | 180 |

1. Partial restraint of $k = .75$ can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where: e = eccentricity, c = distance to extreme fiber, r = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each interior block on its ℄ $1\frac{1}{2}$ inches from each end. Three bolts are placed through each block flush with end of column.

# DRAWING C-6 ALLOWABLE COLUMN LOADS - EXPANDED EXTRUSION "B" ALUMINUM COLUMN (EXPANDED BY BLOCKS CUT FROM STANDARD 4×4 AND 6×6 LUMBER)



2024-T4 ALUMINUM ALLOY BOLTS
CASE A - $\frac{1}{2}$ x $4\frac{1}{2}$ BOLT - 32 REQ'D
CASE B - $\frac{1}{2}$ x 6 BOLT 40 REQ'D

TYPICAL CROSS SECTION

PROPERTIES OF THE SECTIONS

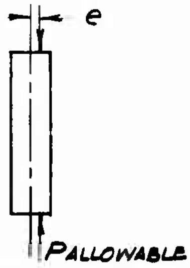
CASE A - EXPANDED BY BLOCKS CUT FROM 4×4 LUMBER
WIDTH OF COLUMN - W = 3.89 IN.
AREA - A = 6.90 $IN^2$
MOMENT OF INERTIA - $I_{\bar{X}}$ = 14.29 $IN^4$
RADIUS OF GYRATION - $r_{\bar{X}}$ = 1.446 IN.

CASE B - EXPANDED BY BLOCKS CUT FROM 6×6 LUMBER
WIDTH OF COLUMN - W = 5.76 IN.
AREA - A = 6.90 $IN^2$
MOMEN OF INERTIA - $I_{\bar{X}}$ = 37.08 $IN^4$
RADIUS OF GYRATION - $r_{\bar{X}}$ = 2.315 IN.

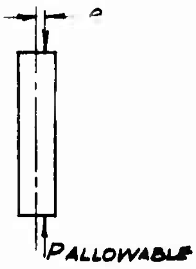
## LOADING AND END CONDITIONS

CONDITION I
CONCENTRIC LOADING
PIN ENDS - K = 1

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
K = .75



CONDITION III
ECCENTRIC LOADING
$ec/r^2 = .25$
PIN ENDS - K = 1



CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT - K = .75

CONTINUED
ON
NEXT SHEET

## TABLE C-6

### (CASE A)

| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES 3 | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | $2.2 \times 3\frac{5}{8} \times 12$ | 4 | 44 | 69 | 122 | 55 | 89 |
| 11 | 132 | $2.2 \times 3\frac{5}{8} \times 12$ | 4 | 40 | 84 | 149 | 65 | 106 |
| 10 | 120 | $2.2 \times 3\frac{5}{8} \times 9$ | 4 | 37 | 100 | 165 | 76 | 115 |
| 9 | 108 | $2.2 \times 3\frac{5}{8} \times 9$ | 4 | 33 | 123 | 176 | 90 | 121 |
| 8 | 96 | $2.2 \times 3\frac{5}{8} \times 9$ | 4 | 29 | 153 | 189 | 109 | 128 |

### (CASE B)

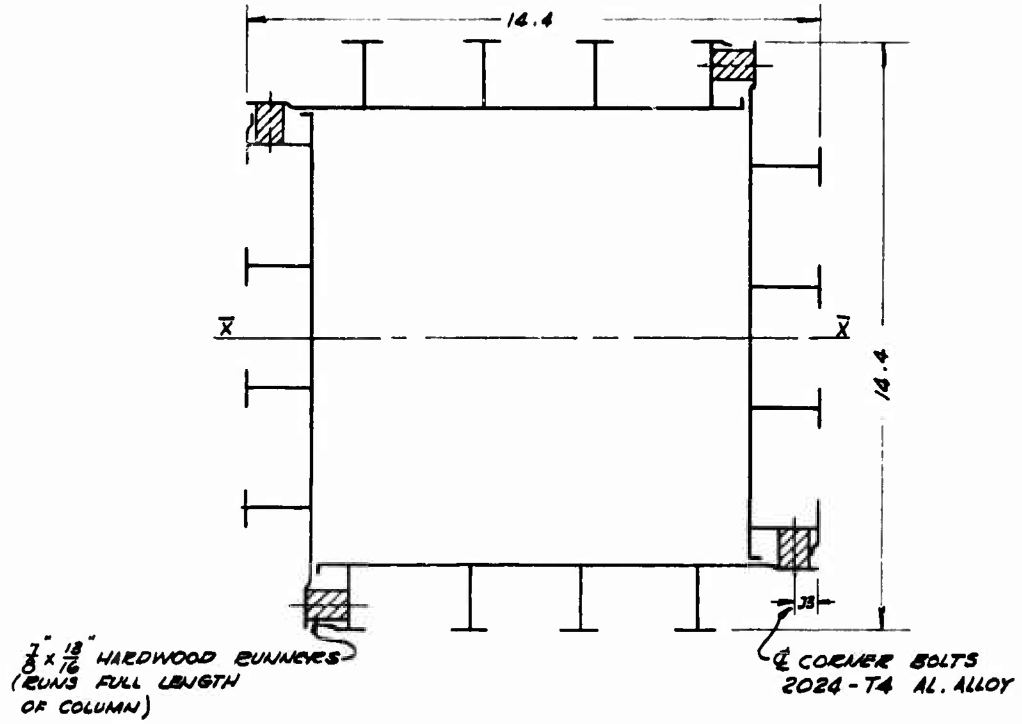
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12 | 144 | $2.2 \times 5\frac{1}{2} \times 12$ | 5 | 33 | 161 | 193 | 106 | 124 |
| 11 | 132 | $2.2 \times 5\frac{1}{2} \times 12$ | 5 | 30 | 171 | 201 | 111 | 127 |
| 10 | 120 | $2.2 \times 5\frac{1}{2} \times 12$ | 5 | 27 | 180 | 207 | 117 | 130 |
| 9 | 108 | $2.2 \times 5\frac{1}{2} \times 10$ | 5 | 24.5 | 190 | 212 | 122 | 13[illegible] |
| 8 | 96 | $2.2 \times 5\frac{1}{2} \times 8$ | 5 | 22 | 197 | 219 | 126 | 136 |

1. Partial restraint of $k = .75$ can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where: $e$ = eccentricity, $c$ = distance to extreme fiber, $r$ = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each block on ℄ $1\frac{1}{2}$ inches from each end.

DRAWING C-7

## ALLOWABLE COLUMN LOADS

## ALUMINUM BOX COLUMN FORMED FROM EXTRUSION "B"



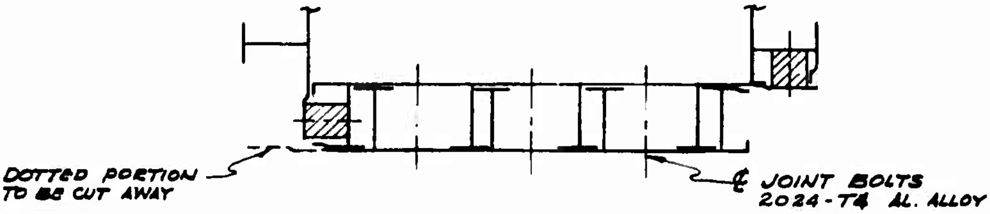
TYPICAL CROSS SECTION

PROPERTIES

AREA - $A = 13.8\ IN^2$

MOMENT OF INERTIA - $I_{\bar{X}} = 369.1\ IN^4$

RADIUS OF GYRATION $r_{\bar{x}} = 5.17\ IN$



TYPICAL JOINT CROSS SECTION

SPECIFICATIONS:

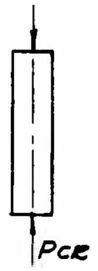
1. USE 3 FEET OF EXTRUSION "B" TO FORM CONNECTION AS SHOWN.
2. MAKE JOINT ON ONLY THE TWO OPPOSITE SIDES OF THE COLUMN AT ANY ONE LOCATION ALONG THE LENGTH OF COLUMN.

ASSEMBLY PROCEDURE FOR MAKING THE JOINT

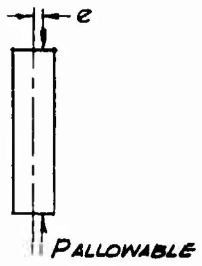
1. DRILL ALL HOLES FOR CORNER CONNECTIONS - WITH WOOD BLOCK IN PLACE.
2. DRILL HOLES FOR JOINT CONNECTIONS.
3. PLACE BOLTS IN POSITION FOR CORNER CONNECTIONS.
4. PLACE 3 FOOT SECTION OF EXTRUSION "B" IN POSITION AND COMPLETE CONNECTIONS.

CONTINUED
ON NEXT SHEET

## LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - K = 1



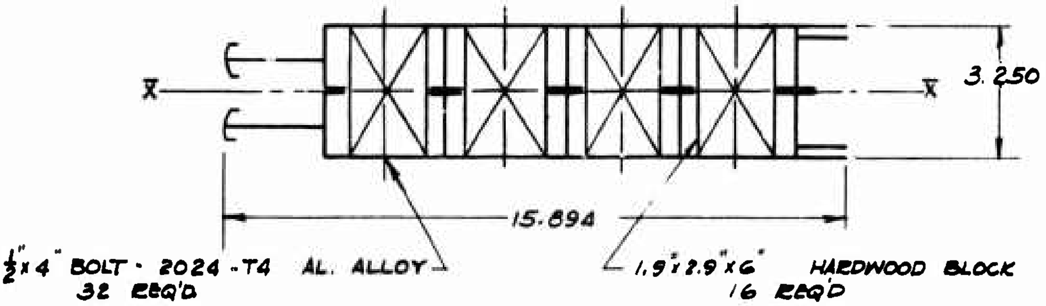
CONDITION II
ECCENTRIC LOADING [1]
$ec/r^2 = .25$
PIN ENDS - K = 1

## TABLE C-7

| UNSUPPORTED COLUMN LENGTH | | BOLT REQUIREMENTS | | | | | ALLOWABLE LOADS | |
|---|---|---|---|---|---|---|---|---|
| | | CORNER BOLTS | | | JOINT BOLTS | | CONDITION I | CONDITION II |
| FEET | INCHES | SIZE | REQUIRED NUMBER PER CORNER | SPACING ℄ TO ℄ INCHES | SIZE | REQUIRED NUMBER PER JOINT PER SIDE OF COLUMN | KIPS | KIPS |
| 12 | 144 | $\frac{1}{2} \times 1\frac{1}{2}$ | 23 | 6 | — | — | 445 | 271 |
| 14 | 168 | $\frac{1}{2} \times 1\frac{1}{2}$ | 23 | 7 | $\frac{1}{2} \times 2\frac{1}{4}$ | 60 | 429 | 267 |
| 16 | 192 | $\frac{1}{2} \times 1\frac{1}{2}$ | 23 | 8 | $\frac{1}{2} \times 2\frac{1}{4}$ | 60 | 413 | 260 |
| 18 | 216 | $\frac{1}{2} \times 1\frac{1}{2}$ | 21 | 10 | $\frac{1}{2} \times 2\frac{1}{4}$ | 60 | 398 | 252 |
| 20 | 240 | $\frac{1}{2} \times 1\frac{1}{2}$ | 21 | 11 | $\frac{1}{2} \times 2\frac{1}{4}$ | 54 | 381 | 244 |
| 22 | 264 | $\frac{1}{2} \times 1\frac{1}{2}$ | 20 | 13 | $\frac{1}{2} \times 2\frac{1}{4}$ | 54 | 364 | 237 |
| 24 | 288 | $\frac{1}{2} \times 1\frac{1}{2}$ | 20 | 14 | $\frac{1}{2} \times 2\frac{1}{4}$ | 48 | 346 | 225 |
| 26 | 312 | $\frac{1}{2} \times 1\frac{1}{2}$ | 19 | 16 | $\frac{1}{2} \times 2\frac{1}{4}$ | 48 | 328 | 216 |
| 28 | 336 | $\frac{5}{8} \times 1\frac{1}{2}$ | 24 | $13\frac{1}{2}$ | $\frac{1}{2} \times 2\frac{1}{4}$ | 48 | 313 | 210 |
| 30 | 360 | $\frac{5}{8} \times 1\frac{1}{2}$ | 23 | 15 | $\frac{5}{8} \times 2\frac{1}{4}$ | 54 | 280 | 190 |
| 35 | 420 | $\frac{5}{8} \times 1\frac{1}{2}$ | 20 | $20\frac{1}{2}$ | $\frac{5}{8} \times 2\frac{1}{4}$ | 42 | 234 | 164 |
| 40 | 480 | $\frac{5}{8} \times 1\frac{1}{2}$ | 20 | $23\frac{1}{2}$ | $\frac{5}{8} \times 2\frac{1}{4}$ | 30 | 160 | 120 |
| 45 | 540 | $\frac{5}{8} \times 1\frac{1}{2}$ | 22 | 24 | $\frac{5}{8} \times 2\frac{1}{4}$ | 24 | 127 | 98 |
| 50 | 600 | $\frac{5}{8} \times 1\frac{1}{2}$ | 24 | $24\frac{1}{2}$ | $\frac{5}{8} \times 2\frac{1}{4}$ | 24 | 105 | 83 |

[1] $ec/r^2 = .25$ WHERE $e$ = ECCENTRICITY, $c$ = DISTANCE TO EXTREME FIBER, $r$ = RADIUS OF GYRATION. THIS VALUÉ OF $ec/r^2$ IS NORMALLY ASUMED TO EXIST TO TAKE INTO ACCOUNT ANY LACK OF STRAIGHTNESS AND ANY INDETERMINATE ECCENTRICITY. DOES NOT PROVIDE FOR ANY KNOWN ECCENTRICITY.

# DRAWING C-8 ALLOWABLE COLUMN LOAD DOUBLE EXTRUSION "A" MAGNESIUM COLUMN

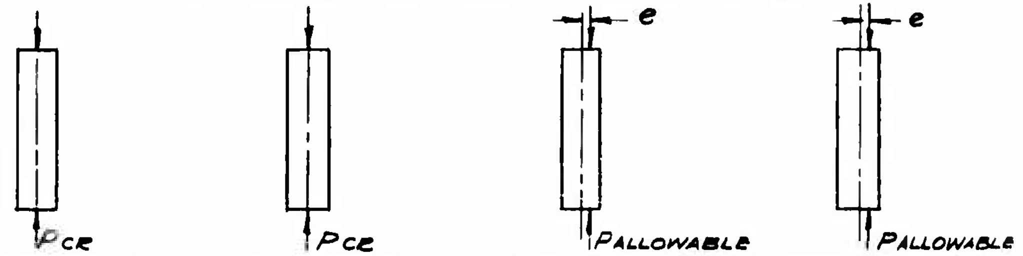


## TYPICAL CROSS SECTION

## PROPERTIES

AREA - A = 12.12 $IN^2$
MOMENT OF INERTIA - $I_X$ = 14.98 $IN^4$
RADIUS OF GYRATION - $r_X$ = 1.11 IN

## LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - k = 1

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
k = .75 [1]

CONDITION III [2]
ECCENTRIC LOADING
$ec/r^2 = .25$
PIN ENDS k = 1

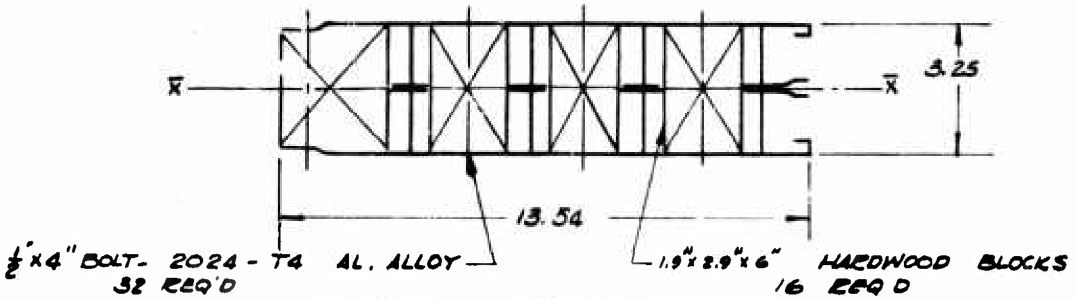
CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT - k = .75

## TABLE C-8

| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES [3] | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | 1.9 x 2.9 x 6 | 4 | 46 | 36.4 | 68.0 | 31 | 54 |
| 11 | 132 | 1.9 x 2.9 x 6 | 4 | 42 | 44.8 | 81.3 | 37 | 63 |
| 10 | 120 | 1.9 x 2.9 x 6 | 4 | 38 | 57.0 | 97.0 | 46 | 73 |
| 9 | 108 | 1.9 x 2.9 x 6 | 4 | 34 | 70.4 | 117.5 | 55 | 86 |
| 8 | 96 | 1.9 x 2.9 x 6 | 4 | 30 | 88.5 | 141.0 | 67 | 100 |

1. Partial restraint of k = .75 can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where: e = eccentricity, c = distance to extreme fiber, r = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each block on ℄ 1½ inches from each end.

# DRAWING C-9 ALLOWABLE COLUMN LOAD
# DOUBLE EXTRUSION "B" MAGNESIUM COLUMN



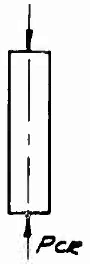
## TYPICAL CROSS SECTION

## PROPERTIES

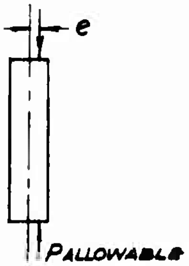
AREA - A = 9.52 $IN^2$
MOMENT OF INERTIA - $I_x$ = 12.05 $IN^4$
RADIUS OF GYRATION - $r_x$ = 1.12 IN

## LOADING AND END CONDITIONS

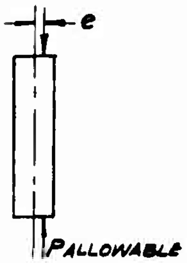
CONDITION I
CONCENTRIC LOADING
PIN ENDS - k = 1



CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
K = .75



CONDITION III
ECCENTRIC LOADING
$ec/r^2$ = .25
PIN ENDS - k = 1



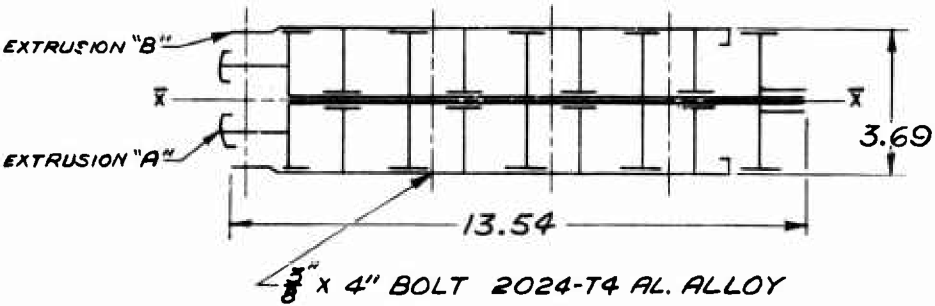
CONDITION IV
ECCENTRIC LOADING
$ec/r^2$ = .25
PARTIAL RESTRAINT - k = .75

## TABLE C-9

| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES 3 | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | 1.9×2.9×6 | 4 | 46 | 30.4 | 54.2 | 25 | 42 |
| 11 | 132 | 1.9×2.9×6 | 4 | 42 | 36.2 | 64.7 | 30 | 50 |
| 10 | 120 | 1.9×2.9×6 | 4 | 38 | 45.7 | 76.1 | 37 | 58 |
| 9 | 108 | 1.9×2.9×6 | 4 | 34 | 57.1 | 94.2 | 45 | 69 |
| 8 | 96 | 1.9×2.9×6 | 4 | 30 | 69.5 | 110.3 | 53 | 79 |

1. Partial restraint of k = .75 can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2$ = .25 where: e = eccentricity, c = distance to extreme fiber, r = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each block on ℄ 1½ inches from each end.

# DRAWING C-10 ALLOWABLE COLUMN LOAD - DOUBLE EXTRUSION "B" MAGNESIUM COLUMN FOR L > 12 FEET



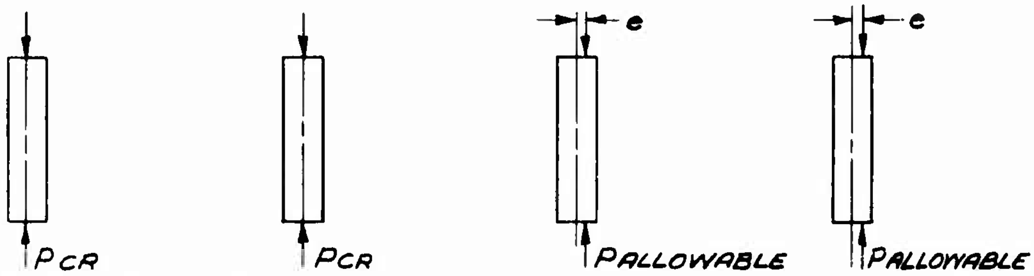
$\frac{3}{8}$" x 4" BOLT 2024-T4 AL. ALLOY
48 REQ'D

THE CROSS SECTION SHOWN ABOVE IS AT THE JOINT. TWO EXTRUSIONS "B" FORM THE COLUMN. THE OVERLAPPING JOINT IS FORMED BY TWO 3 FOOT SECTIONS OF EXTRUSION "A". THE LOCATION OF THE JOINT AS TO POSITION IN LENGTH IS NOT SPECIFIED FOR EASE OF FABRICATION.

PROPERTIES OF COLUMN CROSS SECTION (EXTRUSION "B" ONLY).

AREA - $A = 9.52$ IN.$^2$
MOMENT OF INERTIA - $I_{\bar{X}} = 15.40$ IN.$^4$
RADIUS OF GYRATION - $r_X = 1.273$ IN.

## LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - K=1

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
K = .75

CONDITION III
ECCENTRIC LOADING
$ec/r^2 = .25$
PIN ENDS - K=1

CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT - K=.75

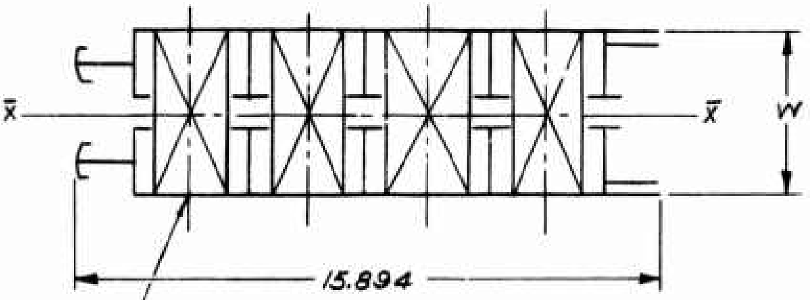
CONTINUED
ON
NEXT SHEET

## TABLE C-10

| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | MINIMUM NUMBER OF WOOD BLOCKS PER CELL | MAXIMUM SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 24 | 288 | 1.9x3.35x6 | 4 | 75 | 9.4 | 17.1 | 8.5 | 14.9 |
| 23 | 276 | 1.9x3.35x6 | 4 | 72 | 10.0 | 18.4 | 9.0 | 16.0 |
| 22 | 264 | 1.9x3.35x6 | 4 | 69 | 11.1 | 20.0 | 9.9 | 17.2 |
| 21 | 252 | 1.9x3.35x6 | 4 | 66 | 12.4 | 22.0 | 11.0 | 18.9 |
| 20 | 240 | 1.9x3.35x6 | 4 | 63 | 13.6 | 24.2 | 12.0 | 20.6 |
| 19 | 228 | 1.9x3.35x6 | 4 | 60 | 15.4 | 27.0 | 13.4 | 22.6 |
| 18 | 216 | 1.9x3.35x6 | 4 | 57 | 16.9 | 29.8 | 14.7 | 24.8 |
| 17 | 204 | 1.9x3.35x6 | 4 | 53 | 19.1 | 33.9 | 16.4 | 26.8 |
| 16 | 192 | 1.9x3.35x6 | 4 | 51 | 21.7 | 37.8 | 18.5 | 30.6 |
| 15 | 180 | 1.9x3.35x6 | 4 | 48 | 24.6 | 43.0 | 21.0 | 35.2 |
| 14 | 168 | 1.9x3.35x6 | 4 | 45 | 28.1 | 49.5 | 23.6 | 39.1 |
| 13 | 156 | 1.9x3.35x6 | 4 | 42 | 32.8 | 57.6 | 27.2 | 44.9 |

1. Partial restraint of $k = .75$ can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where $e$ = eccentricity, $c$ = distance to extreme fiber, $r$ = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each block on its ℄ 1½ inches from the ends. Since the location of the joint is not specified, exact spacing of the wood blocks is not specified.

# DRAWING C-11 ALLOWABLE COLUMN LOADS - EXPANDED EXTRUSION "A" MAGNESIUM COLUMN (EXPANDED BY BLOCKS CUT FROM STANDARD 4 X 4 AND 6 X 6 LUMBER).



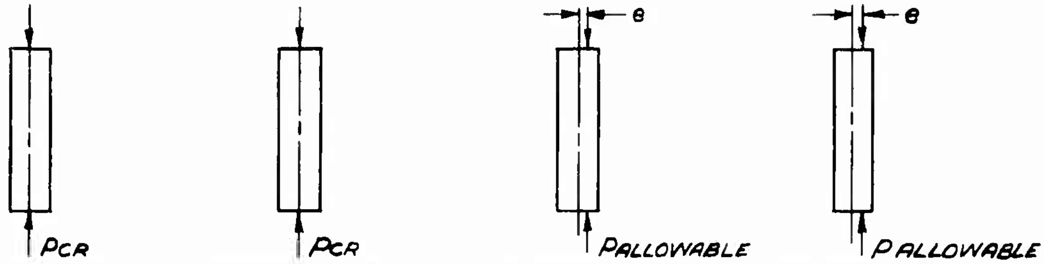
2024-T4 ALUMINUM ALLOY BOLTS
CASE A - $\frac{1}{2}$ X $4\frac{1}{2}$ BOLTS - 32 REQ'D
CASE B - $\frac{1}{2}$ X 6 BOLTS - 40 REQ'D

## PROPERTIES OF THE SECTIONS

CASE A - EXPANDED BY BLOCKS CUT FROM 4 X 4 LUMBER
WIDTH OF COLUMN - W = 3.97 INCHES
AREA - A = 12.12 INCHES$^2$
MOMENT OF INERTIA - $I_{\bar{X}}$ = 23.35 INCHES$^4$
RADIUS OF GYRATION - $r_X$ = 1.39 INCHES

CASE B - EXPANDED BY BLOCKS CUT FROM 6 X 6 LUMBER
WIDTH OF COLUMN - W = 5.84 INCHES
AREA - A = 12.12 INCHES$^2$
MOMENT OF INERTIA - $I_{\bar{X}}$ = 62.38 INCHES$^4$
RADIUS OF GRYATION - $r_X$ = 2.265 INCHES

## LOADING AND END CONDITIONS



CONDITION I
CONCENTRIC LOADING
PIN ENDS - K=1

CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
K = .75

CONDITION III
ECCENTRIC LOADING
$ec/r^2 = .25$
PIN ENDS - K=1

CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT K=.75

CONTINUED
ON
NEXT SHEET

## TABLE C-11

### (CASE A)

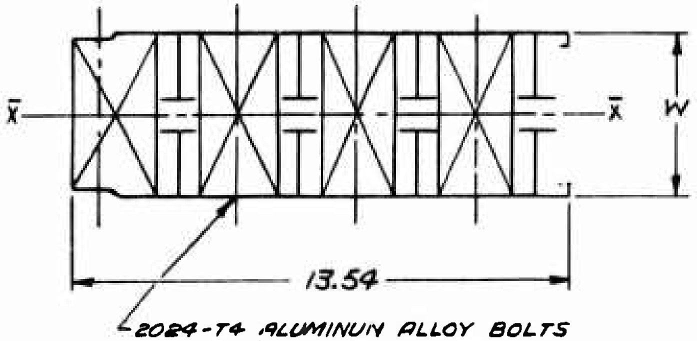
| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | $1.9 \times 3\frac{5}{8} \times 12$ | 4 | 44 | 62 | 104 | 49 | 77 |
| 11 | 132 | $1.9 \times 3\frac{5}{8} \times 12$ | 4 | 40 | 74 | 121 | 57 | 88 |
| 10 | 120 | $1.9 \times 3\frac{5}{8} \times 9$ | 4 | 37 | 87 | 141 | 66 | 100 |
| 9 | 108 | $1.9 \times 3\frac{5}{8} \times 9$ | 4 | 33 | 104 | 162 | 77 | 112 |
| 8 | 96 | $1.9 \times 3\frac{5}{8} \times 9$ | 4 | 29 | 126 | 189 | 91 | 127 |

### (CASE B)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12 | 144 | $1.9 \times 5\frac{1}{2} \times 12$ | 5 | 33 | 143 | 196 | 101 | 131 |
| 11 | 132 | $1.9 \times 5\frac{1}{2} \times 12$ | 5 | 30 | 165 | 208 | 114 | 137 |
| 10 | 120 | $1.9 \times 5\frac{1}{2} \times 12$ | 5 | 27 | 182 | 223 | 124 | 144 |
| 9 | 108 | $1.9 \times 5\frac{1}{2} \times 10$ | 5 | 24.5 | 200 | 236 | 134 | 151 |
| 8 | 96 | $1.9 \times 5\frac{1}{2} \times 10$ | 5 | 21.5 | 221 | 247 | 144 | 158 |

1. Partial restraint of $k = .75$ can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where $e$ = eccentricity, $c$ = distance to extreme fiber, $r$ = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each block on its ℄ $1\frac{1}{2}$ inches from the ends. Since the location of the joint is not specified, exact spacing of the wood blocks is not specified.

# DRAWING C-12 ALLOWABLE COLUMN LOADS - EXPANDED EXTRUSION "B" MAGNESIUM COLUMN (EXPANDED BY BLOCKS CUT FROM STANDARD 4×4 AND 6×6 LUMBER)



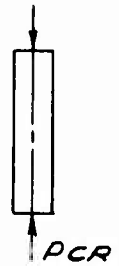
2024-T4 ALUMINUM ALLOY BOLTS
CASE A - ½ × 4½ BOLTS - 32 REQ'D
CASE B - ½ × 6 BOLTS - 40 REQ'D

## PROPERTIES OF THE SECTIONS

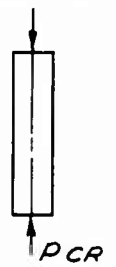
CASE A - EXPANDED BY BLOCKS CUT FROM 4×4 LUMBER
WIDTH OF COLUMN - W = 3.97 INCHES
AREA - A = 9.52 INCHES$^2$
MOMENT OF INERTIA - $I_x$ = 18.57 INCHES$^4$
RADIUS OF GRYATION - $r_x$ = 1.397 INCHES

CASE B - EXPANDED BY BLOCKS CUT FROM 6×6 LUMBER
WIDTH OF COLUMN - W = 5.84 INCHES
AREA - A = 9.52 INCHES$^2$
MOMENT OF INERTIA - $I_{\bar{x}}$ = 49.20 INCHES$^4$
RADIUS OF GYRATION - $r_x$ = 2.265 INCHES

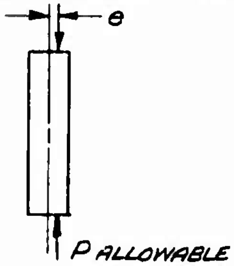
## LOADING AND END CONDITIONS



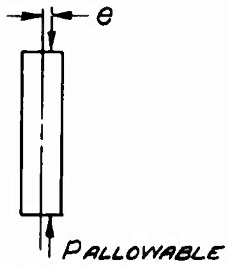
CONDITION I
CONCENTRIC LOADING
PIN ENDS - K = 1



CONDITION II
CONCENTRIC LOADING
PARTIAL RESTRAINT
K = .75



CONDITION III
ECCENTRIC LOADING
$ec/r^2 = .25$
PIN ENDS - K = 1



CONDITION IV
ECCENTRIC LOADING
$ec/r^2 = .25$
PARTIAL RESTRAINT - K = .75

CONTINUED
ON
NEXT SHEET

## TABLE C-12

### (CASE A)

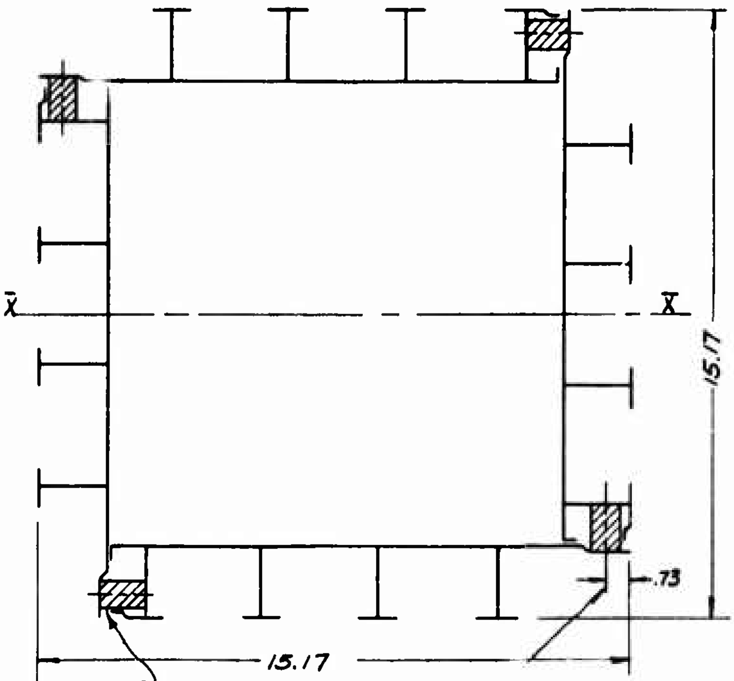
| UNSUPPORTED COLUMN LENGTH | | DIMENSIONS OF WOOD BLOCKS INCHES | NUMBER OF WOOD BLOCKS PER CELL | SPACING IN CELLS ℄ TO ℄ OF WOOD BLOCKS INCHES | ALLOWABLE LOAD | | | |
|---|---|---|---|---|---|---|---|---|
| FEET | INCHES | | | | CONDITION I KIPS | CONDITION II KIPS | CONDITION III KIPS | CONDITION IV KIPS |
| 12 | 144 | 1.9x3$\frac{5}{8}$x12 | 4 | 44 | 50 | 83 | 39 | 61 |
| 11 | 132 | 1.9x3$\frac{5}{8}$x9 | 4 | 41 | 59 | 96 | 45 | 70 |
| 10 | 120 | 1.9x3$\frac{5}{8}$x9 | 4 | 37 | 70 | 110 | 53 | 78 |
| 9 | 108 | 1.9x3$\frac{5}{8}$x9 | 4 | 33 | 83 | 128 | 61 | 88 |
| 8 | 96 | 1.9x3$\frac{5}{8}$x9 | 4 | 29 | 101 | 150 | 73 | 101 |

### (CASE B)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12 | 144 | 1.9x5$\frac{1}{2}$x12 | 5 | 33 | 112 | 154 | 80 | 103 |
| 11 | 132 | 1.9x5$\frac{1}{2}$x12 | 5 | 30 | 129 | 164 | 89 | 108 |
| 10 | 120 | 1.9x5$\frac{1}{2}$x10 | 5 | 27.5 | 143 | 175 | 97 | 114 |
| 9 | 108 | 1.9x5$\frac{1}{2}$x8 | 5 | 25 | 157 | 186 | 105 | 119 |
| 8 | 96 | 1.9x5$\frac{1}{2}$x8 | 5 | 22 | 173 | 194 | 112 | 124 |

1. Partial restraint of $k = .75$ can normally be assumed in structural design for bolted or riveted connections.
2. $ec/r^2 = .25$ where $e$ = eccentricity, $c$ = distance to extreme fiber, $r$ = radius of gyration. This value of $ec/r^2$ is normally assumed to exist to take into account any lack of straightness and any indeterminate eccentricity in loading. Does not provide for any known eccentricity.
3. In each cell a block is placed flush with each end of the column. Two bolts are placed through each block on its ℄ $1\frac{1}{2}$ inches from the ends. Since the location of the joint is not specified, exact spacing of the wood blocks is not specified.

## DRAWING C-13 ALLOWABLE COLUMN LOADS
## MAGNESIUM BOX COLUMN FORMED FROM EXTRUSION "B"



$\frac{7}{8}$" x $\frac{13}{16}$ HARDWOOD RUNNERS
(RUNS FULL LENGTH OF COLUMN)

℄ CORNER BOLTS
2024-T4 AL ALLOY

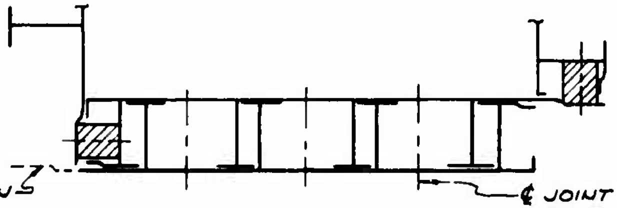
### TYPICAL CROSS SECTION

PROPERTIES

AREA - A = 19.04 $IN^2$

MOMENT OF INERTIA - $I_x$ = 572 $IN^4$

RADIUS OF GYRATION - $r_x$ = 5.49 IN



DOTTED PORTION
TO BE CUT AWAY

℄ JOINT BOLTS
2024-T4 ALLOY

### TYPICAL JOINT CROSS SECTION

SPECIFICATIONS:

1. USE 3 FEET OF EXTRUSION "B" TO FORM CONNECTION AS SHOWN.
2. MAKE JOINT ON ONLY THE TWO OPPOSITE SIDES OF THE COLUMN AT ANY ONE LOCATION ALONG THE LENGTH OF COLUMN.

ASSEMBLY PROCEDURE FOR MAKING THE JOINT

1. DRILL ALL HOLES FOR CORNER CONNECTIONS WITH WITH WOOD BLOCK IN PLACE.
2. DRILL HOLES FOR JOINT CONNECTIONS.
3. PLACE BOLTS IN POSITION FOR CORNER CONNECTIONS.
4. PLACE 3 FOOT SECTION OF EXTRUSION "B" IN POSITION AND COMPLETE CONNECTION.

CONTINUED
ON NEXT SHEET

LOADING AND END CONDITION

CONDITION I
CONCENTRIC LOADING
PIN ENDS - k=1

CONDITION II
ECCENTRIC LOADING [1]
$ec/r^2 = .25$
PIN ENDS - k=1

TABLE C-13

| UNSUPPORTED COLUMN LENGTH | | BOLT REQUIREMENTS | | | | | ALLOWABLE LOADS | |
|---|---|---|---|---|---|---|---|---|
| | | CORNER BOLTS | | | JOINT BOLTS | | CONDITION I KIPS | CONDITION II KIPS |
| FEET | INCHES | SIZE | REQUIRED NUMBER PER CORNER | SPACING ℄ TO ℄ INCHES | SIZE | REQUIRED NUMBER PER JOINT PER SIDE OF COLUMN | | |
| 12 | 144 | $\frac{1}{2}\times1\frac{1}{2}$ | 28 | 5 | — | — | 433 | 268 |
| 14 | 168 | $\frac{1}{2}\times1\frac{1}{2}$ | 29 | $5\frac{1}{2}$ | $\frac{1}{2}\times2\frac{1}{4}$ | 42 | 415 | 262 |
| 16 | 192 | $\frac{1}{2}\times1\frac{1}{2}$ | 26 | 7 | $\frac{1}{2}\times2\frac{1}{4}$ | 42 | 390 | 246 |
| 18 | 216 | $\frac{1}{2}\times1\frac{1}{2}$ | 26 | 8 | $\frac{1}{2}\times2\frac{1}{4}$ | 42 | 366 | 234 |
| 20 | 240 | $\frac{1}{2}\times1\frac{1}{2}$ | 23 | 10 | $\frac{1}{2}\times2\frac{1}{4}$ | 36 | 339 | 220 |
| 22 | 264 | $\frac{1}{2}\times1\frac{1}{2}$ | 23 | 11 | $\frac{1}{2}\times2\frac{1}{4}$ | 36 | 312 | 206 |
| 24 | 288 | $\frac{1}{2}\times1\frac{1}{2}$ | 21 | 13 | $\frac{1}{2}\times2\frac{1}{4}$ | 30 | 293 | 196 |
| 26 | 312 | $\frac{5}{8}\times1\frac{1}{2}$ | 27 | 11 | $\frac{5}{8}\times2\frac{1}{4}$ | 36 | 266 | 181 |
| 28 | 336 | $\frac{5}{8}\times1\frac{1}{2}$ | 25 | 13 | $\frac{5}{8}\times2\frac{1}{4}$ | 36 | 238 | 167 |
| 30 | 360 | $\frac{5}{8}\times1\frac{1}{2}$ | 22 | 16 | $\frac{5}{8}\times2\frac{1}{4}$ | 30 | 217 | 154 |
| 35 | 420 | $\frac{5}{8}\times1\frac{1}{2}$ | 18 | 23 | $\frac{5}{8}\times2\frac{1}{4}$ | 30 | 169 | 125 |
| 40 | 480 | $\frac{5}{8}\times1\frac{1}{2}$ | 20 | $23\frac{1}{2}$ | $\frac{5}{8}\times2\frac{1}{4}$ | 18 | 137 | 104 |
| 45 | 540 | $\frac{5}{8}\times1\frac{1}{2}$ | 22 | 24 | $\frac{5}{8}\times2\frac{1}{4}$ | 18 | 108 | 83 |
| 50 | 600 | $\frac{5}{8}\times1\frac{1}{2}$ | 24 | $24\frac{1}{2}$ | $\frac{5}{8}\times2\frac{1}{4}$ | 12 | 86 | 68 |

[1] $ec/r^2 = .25$ WHERE $e$ = ECCENTRICITY, $c$ = DISTANCE TO EXTREME FIBER, $r$ = RADIUS OF GYRATION. THIS VALUE OF $ec/r^2$ IS NORMALLY ASSUMED TO EXIST TO TAKE INTO ACCOUNT ANY LACK OF STRAIGHTNESS AND ANY INDETERMINATE ECCENTRICITY. DOES NOT PROVIDE FOR ANY KNOWN ECCENTRICITY.

## SPECIFIC APPLICATION

### (Columns)

| ITEM | REFERENCE FOR LOAD DATA |
|---|---|
| I BUILDINGS | C-1 to C-6 and C-8 to C-12 |
| II. BRIDGE BENTS (Trestle and Pier) | C-1 to C-6 and C-8 to C-12 |
| III. STIFF LEG | |
| (Cableway, Tramway, A-Frames Tripods, Gin Poles, etc.) | C-7 and C-13 |
| IV. TOWERS | |
| (Water, Control Drying, Miscellaneous Expedient Towers -- Temporary Air-fields) | C-1 to C-6,<br>C-8 to C-12,<br>C-7 and C-13 |
| V. MISCELLANEOUS | |
| Grease Racks | C-1 to C-6 |
| Storage Racks | C-1 to C-6 |
| Tent Framing | C-1 to C-6 |
| Covered Walkways | C-1 to C-6 |

## JOINTS

The question of joints arose early in attempting to determine the feasibility of auxiliary uses for the extruded sections of the T-8 and T-11 landing mats. Certainly the load carrying ability of the various fabricated forms of the mat as presented here would be of little value unless these sections could be combined to form complete and useful structures. Joint details are quite simple and are similar to routine structural practice. Joint descriptions and details follow.

Typical Joint Number 1 - Shear Connection - Beam to Column or Beam to Girder

Drawing J-1, Sheet 63 , shows a built-up beam consisting of two extrusions of the T-11 Aluminum Mat connected Tee to Tee with no spacer. The load is transferred from beam to column by the shear connection shown. If angles are available in the field, the 4 x 4 wood connection may be replaced by steel angles with no reduction in load carrying capacity. Table J-1, Sheet 63 , shows the total shear load transferred by the joint when 2024-T4 aluminum alloy bolts are used.

Typical Joint Number 2 - Shear Connection - Beam to Column or Beam to Girder

Drawing J-2, Sheet 63 , shows a built-up beam of two extrusions connected back to back and expanded by a 4 x 4 wood spacer. Use Table J-1 to find the allowable shear.

Typical Joint Number 3 - Bearing Connection - Beam to Support

Drawing J-3, Sheet 64 , shows a built-up beam consisting of two extrusions connected Tee to Tee with no spacer. The beam is shown resting on a support with the load transferred in bearing. Bolts transfer the reaction by shear from the metal beam to the wood 2 x 6 members. The load is then transferred to the support by bearing parallel to the grain. The 2 x 6 wood sections act also as web stiffeners. The same effect may be obtained by using a wood spacer as a bearing member.

Typical Joint Number 4 - Moment Splice-Lap Joint

Drawing J-4, Sheet 64 , shows the details of the moment joint required to develop the total bending strength of the beam section. Six 3/8 inch diameter 2024-T4 aluminum alloy bolts on an extrusion "B" beam, and eight 1/2 inch 2024-T4 aluminum alloy bolts on an extrusion "A" beam are required to develop the strength of the section. (Note that by changing the moment couple from longitudinal to transverse, any required lever arm can be used.)

Typical Joint Number 5 - Moment Splice - Butt Joint with Splice Plates

Drawing J-5, Sheet 65 , shows the details of a moment transferring butt joint designed for use on beams of spans greater than twelve feet. The extrusions used to form the splice plates (see Section A-A, Drawing J-5) are the same as the extrusions used to form the beam. The required number of bolts each side of the butt joint is six 3/8 inch diameter 2024-T4 aluminum alloy bolts if Extrusion"B" is used and eight 1/2 inch diameter 2024-T4 aluminum alloy bolts if extrusion"A" is used. The required longitudinal spacing of the bolt rows - the lever arm of the transverse couple - is shown on Drawing J-5.

Typical Joint Number 6 - Slab Attachment to Beams for Flooring, Decking, etc.

Drawing J-6, Sheet 65 , shows the use of nails to attach slabs to beams. In applications where shear must be transferred from the slab to the beam type "A" connection should be used. The slab must be drilled previous to nailing.

Typical Joint Number 7 - Moment Splice - Butt Joint Using Connector Bar "A" of the Landing Mat.

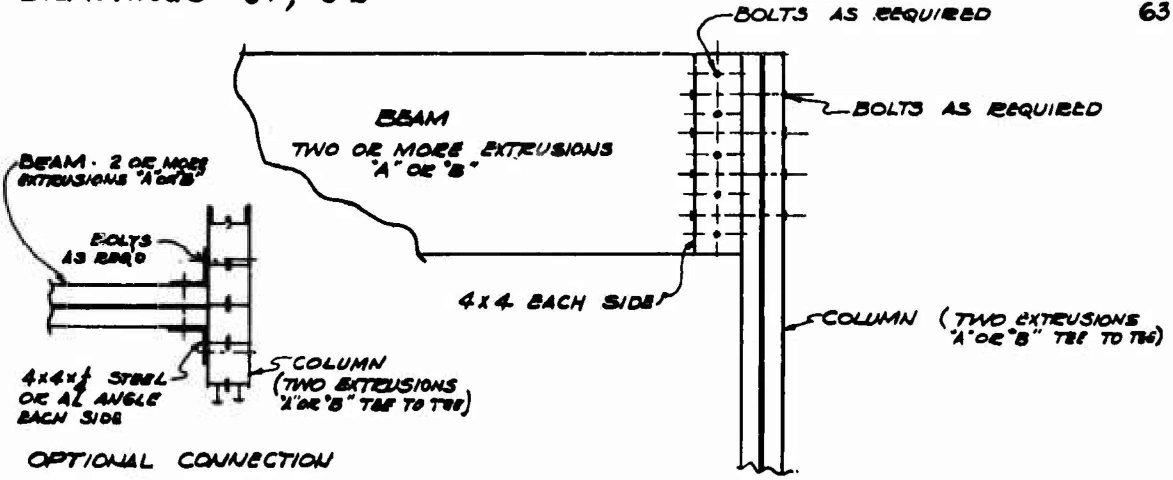
Drawing J-7, Sheet 66 , shows joint details using end connector bar "A" as a splice for transferring moment. The method is identical to its use in the landing mat.

Most of the joints presented in this section of the report and also the majority used in other sections have been designed using 2024-T4 aluminum alloy bolts. The allowable bolt loads were calculated using an ultimate shear strength of 37,000 psi for the 2024-T4 aluminum alloy and bearing stresses of

56,000 psi for 6061-T6 aluminum alloy and 45,000 psi for ZK60AT-5 magnesium alloy. Table J-2, Sheet 66, gives the maximum bolt loads as calculated for various diameter bolts. The minimum plate thickness of the T-8 Magnesium Landing Mat and the T-11 Aluminum Landing Mat were use in calculating the bearing values.

## WELDING

If the equipment (and skills) are available, joining can be greatly simplified by welding. Certainly when elements are prefabricated, welding should receive first consideration. Welding would not only simplify details and increase the strength of the joint, but would most likely result in saving manpower and in decreasing costs.



OPTIONAL CONNECTION

DRAWING J-1
SHEAR CONNECTION, BEAM TO COLUMN
(BEAM TO GIRDER SAME)

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## TABLE J-1
SHEAR LOAD TRANSFERRED BY JOINTS J-1 & J-2

| NUMBER OF BOLTS CONNECTED EACH MEMBER | TOTAL LOAD TRANSFERRED | |
|---|---|---|
| | BY $\frac{5}{8}$" BOLTS KIPS | BY $\frac{3}{4}$ BOLTS KIPS |
| 2 | 10.9 | 14.6 |
| 3 | 16.4 | 21.8 |
| 4 | 21.7 | 29.1 |
| 5 | 27.2 | 36.4 |
| 6 | 32.6 | 43.7 |
| 7 | 38.0 | 51.0 |
| 8 | 43.5 | 58.3 |

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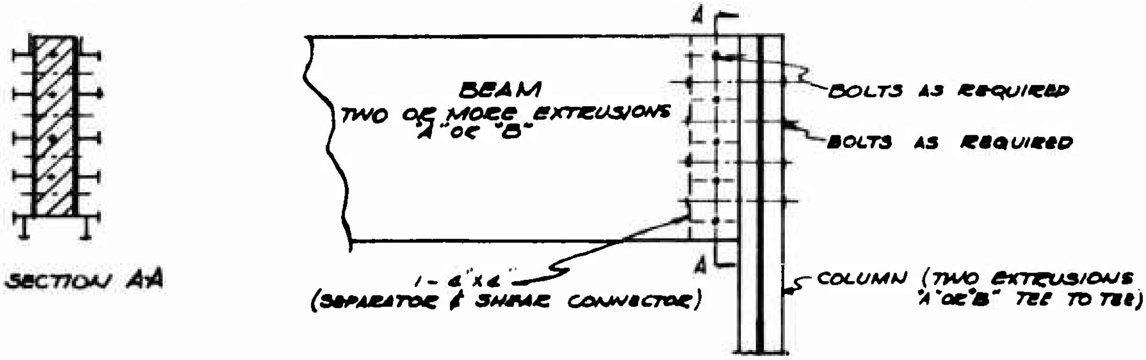
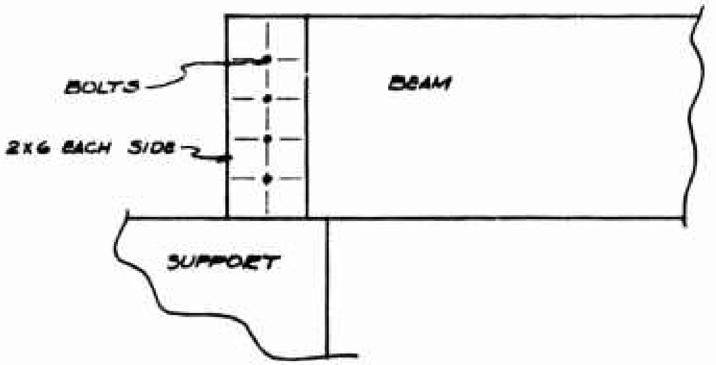


DRAWING J-2
SHEAR CONNECTION, BEAM TO COLUMN
(BEAM TO GIRDER SAME)



DRAWING J-3
BEARING CONNECTION - BEAM TO SUPPORT

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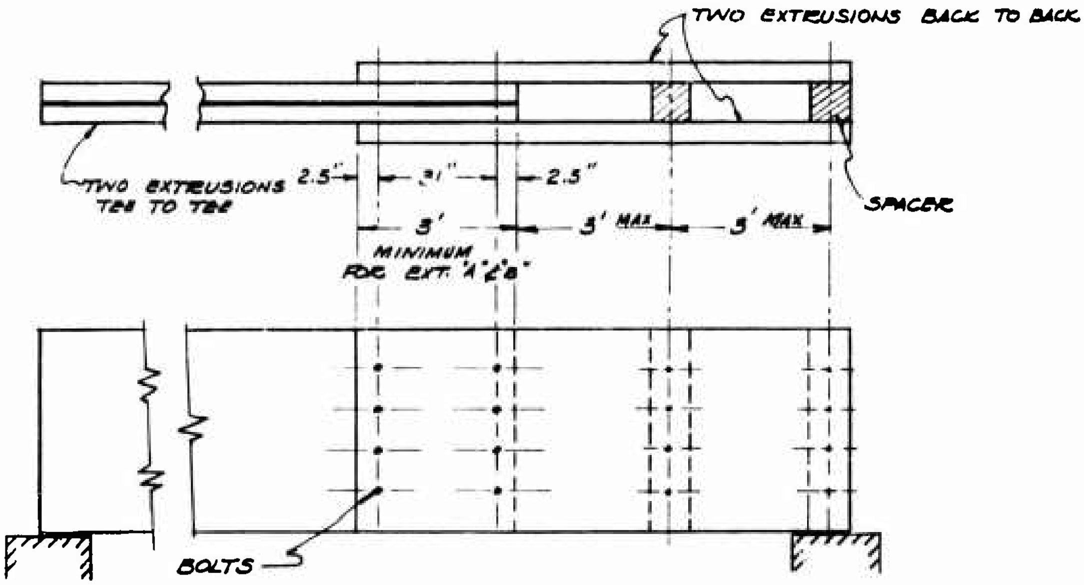
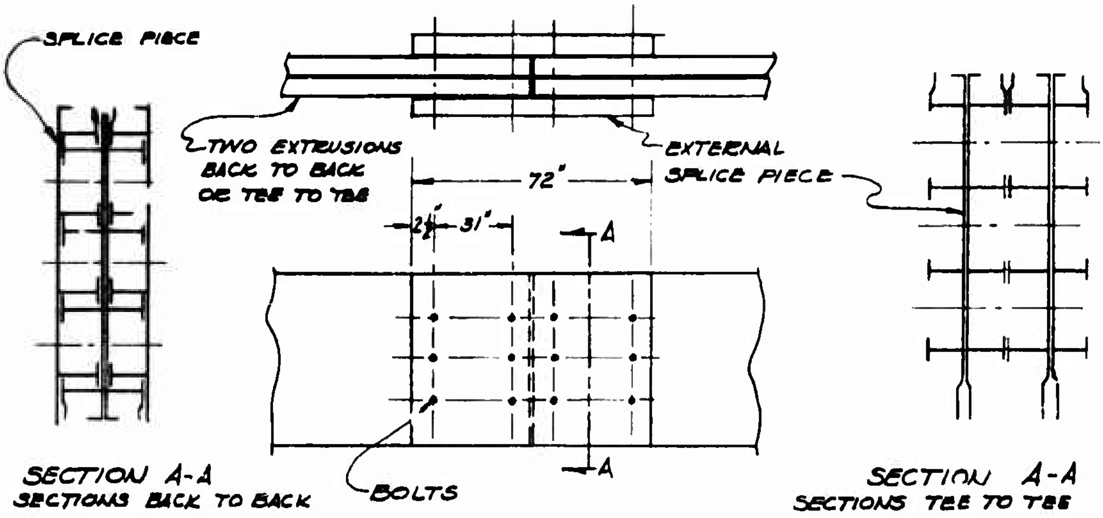


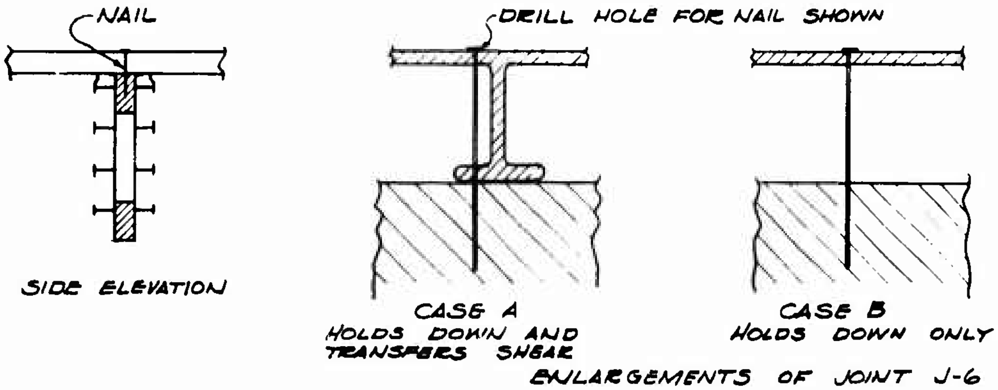
DRAWING J-4
MOMENT SPLICE - LAP JOINT
(DETAIL OF MOMENT CONNECTION FOR BEAMS HAVING
SPANS GREATER THAN 12 FEET)

# DRAWINGS J-5, J-6



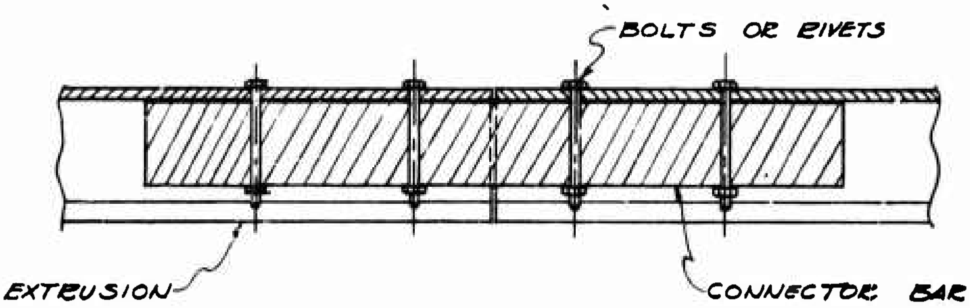
DRAWING J-5

MOMENT SPLICE - BUTT JOINT USING SPLICE PLATE
(SPANS GREATER THAN 12 FEET - SIMILAR JOINTS
CAN BE USED FOR FULL PANEL BEAM)



DRAWING J-6

SLAB ATTACHMENT TO BEAMS FOR FLOORING, SIDING
SHELVING, ETC.



DRAWING J-7
END CONNECTION FOR FLOORING, SIDING, SHELVING, ETC.
(STANDARD LANDING MAT CONNECTION)

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TABLE J-2
ULTIMATE SHEAR AND BEARING YIELD LOADS FOR 2024-T4 ALUMINUM ALLOY BOLTS

| BOLT DIA. INCHES | SHEAR ALLOWABLES | | BEARING T-8 MAT | | BEARING T-11 MAT | |
|---|---|---|---|---|---|---|
| | SINGLE SHEAR KIPS | DOUBLE SHEAR KIPS | SINGLE BEARING T=.172 IN. KIPS | DOUBLE BEARING T=.178 IN. KIPS | SINGLE BEARING T=.130 IN. KIPS | DOUBLE BEARING T=.180 IN. KIPS |
| 1/4 | 1.81 | 3.62 | 1.93 | 3.86 | 1.82 | 3.64 |
| 5/16 | 2.83 | 5.66 | 2.42 | 4.84 | 2.27 | 4.54 |
| 3/8 | 4.08 | 8.16 | 2.90 | 5.80 | 2.73 | 5.46 |
| 9/16 | 5.56 | 11.12 | 3.24 | 6.48 | 3.19 | 6.38 |
| 1/2 | 7.25 | 14.50 | 3.87 | 7.74 | 3.64 | 7.28 |
| 5/8 | 11.32 | 22.64 | 4.83 | 9.66 | 4.55 | 9.10 |

# EXAMPLES OF ASSEMBLED STRUCTURES

## BUILDINGS

The T-8 Landing Mat is usable as building components. Drawings are attached which show the mat used as side walls, floors, roof, and the structural frame -- beams, girders, and columns. In this study a typical bay size 24' by 24' was selected as being a practical bay size well suited to the dimensions of the mat. Other bay sizes in multiples of mat dimensions are possible. Where alternate long and short spans fit use requirements, alternate suspended slabs and cantilever slabs can be used.

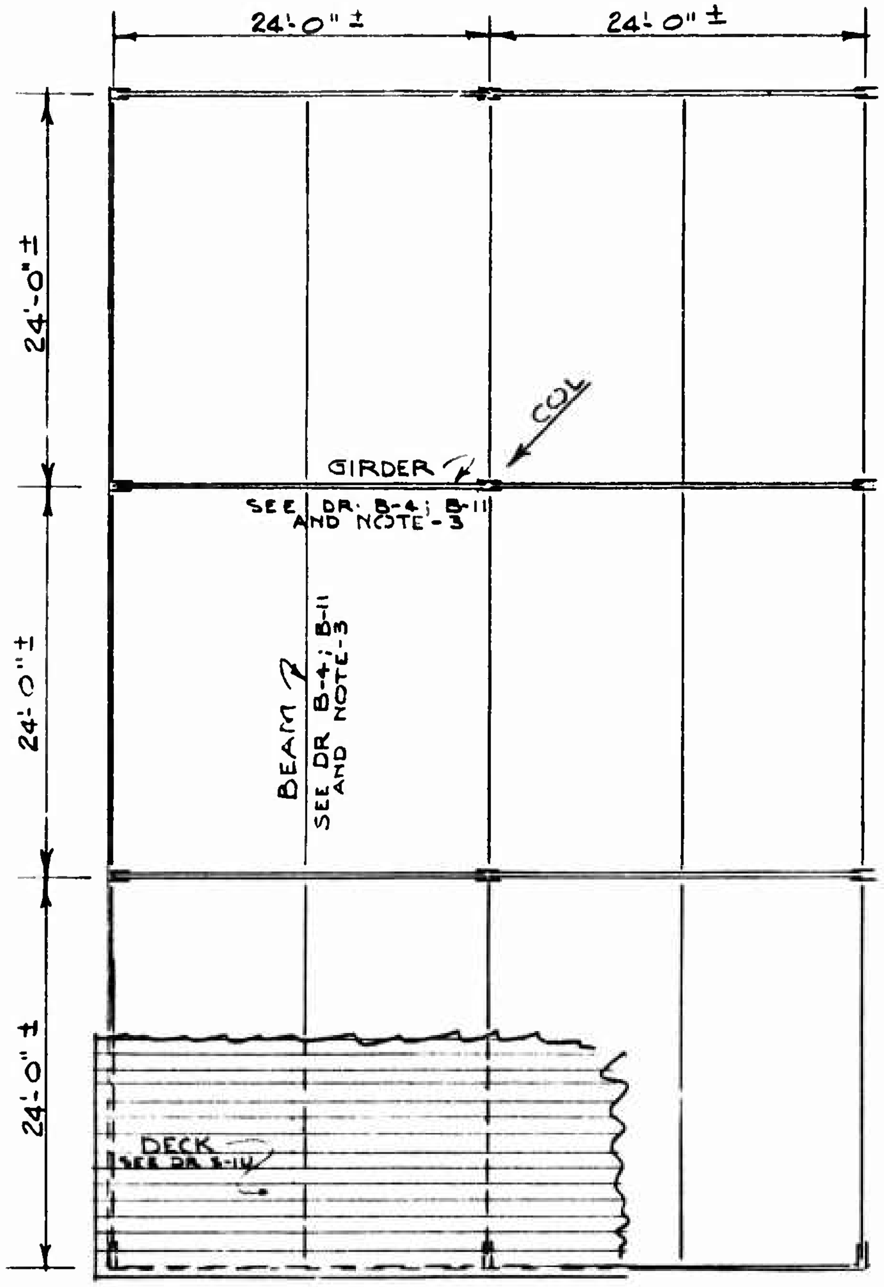
The mat is used without modification except for one condition shown on Drawing BL-5. In this detail the flange is cut in order for the beam to fit flush against the web of the column section. All connections can be done on the job by bolting. Field drilling for bolts will be necessary.

A structure any number of bays wide may be constructed of any desired length. Openings for doors and windows may be made by omitting the side wall panels. Maximum door or window opening would be 22' wide by 11' 0" high. Conventional doors and windows could be installed in the side walls to a wood rough buck bolted to side wall panels.

The results of this study as shown in Drawings BL-1 through BL-8 verifies the utility of the sections in question not only that it is feasible to be used in functions other than landing mats, but it lends itself extremely well to use as a building component.

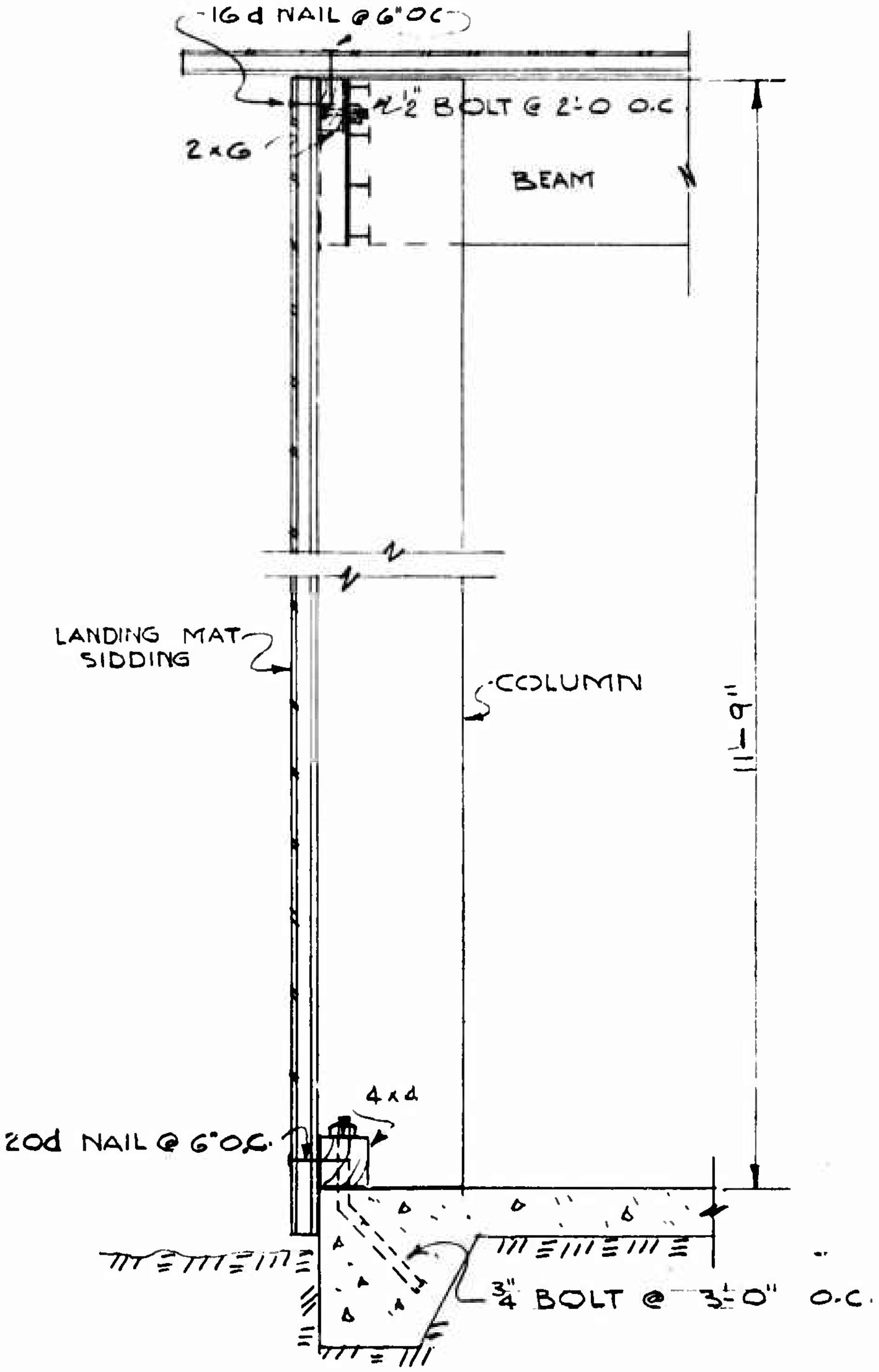
<u>List of components</u>

1. Size 48' x 72'
2. Roof Deck - T-11 or T-8 Landing Mat (Span 12' 0")
3. Girder - 2 sections of Extrusion A (Span 24' 0")
4. Beam - 1 section of Extrusion A (Span 24' 0")
5. Column - 2 sections of Extrusion A (24' 0" o.c.e.w.)
6. Siding - T-11 or T-8
7. Floor - Either concrete, T-11 or T-8 mat, earth, wood, etc.



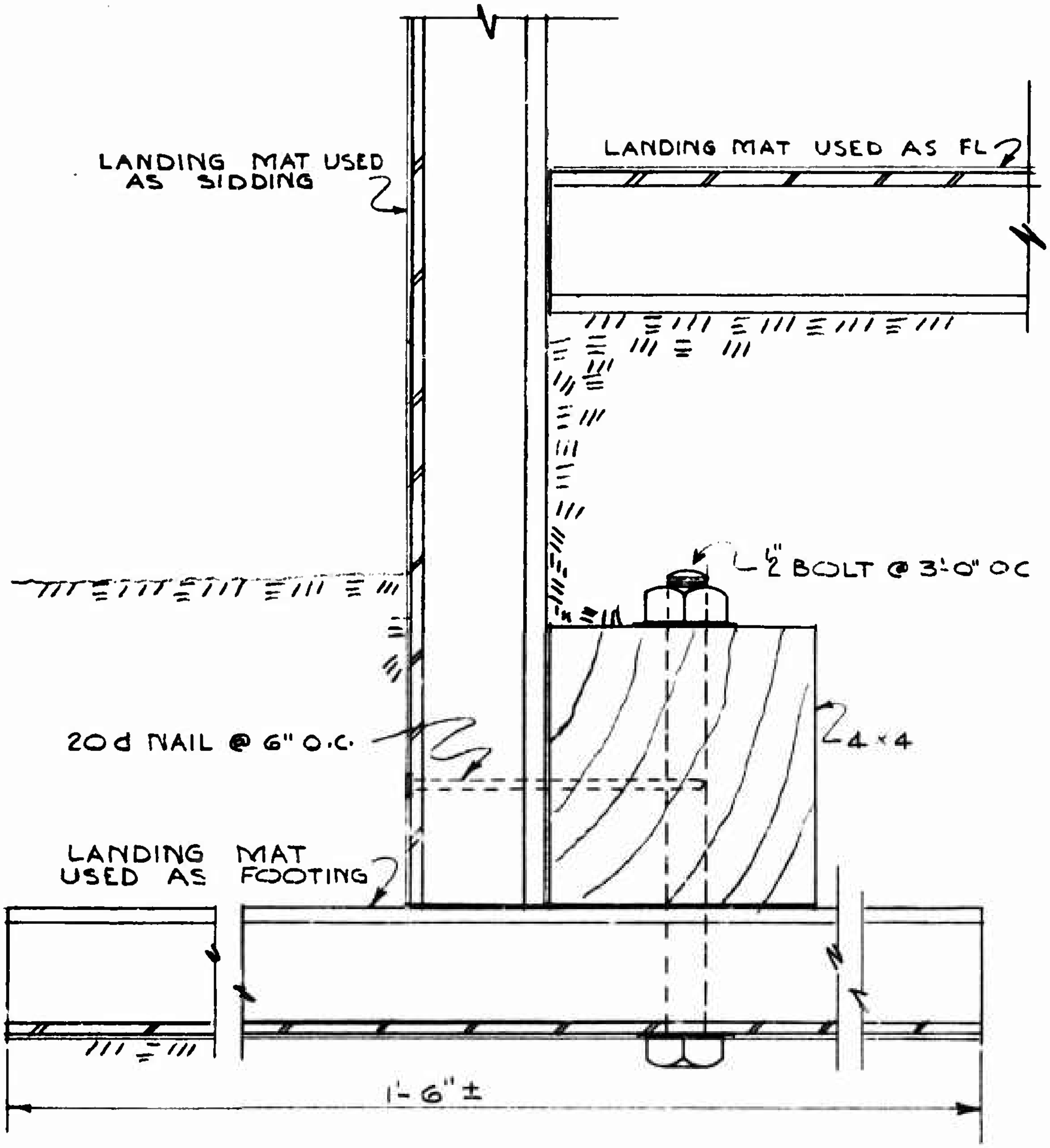
ROOF PLAN TYPICAL BUILDING

SCALE 1" = 10'-0"



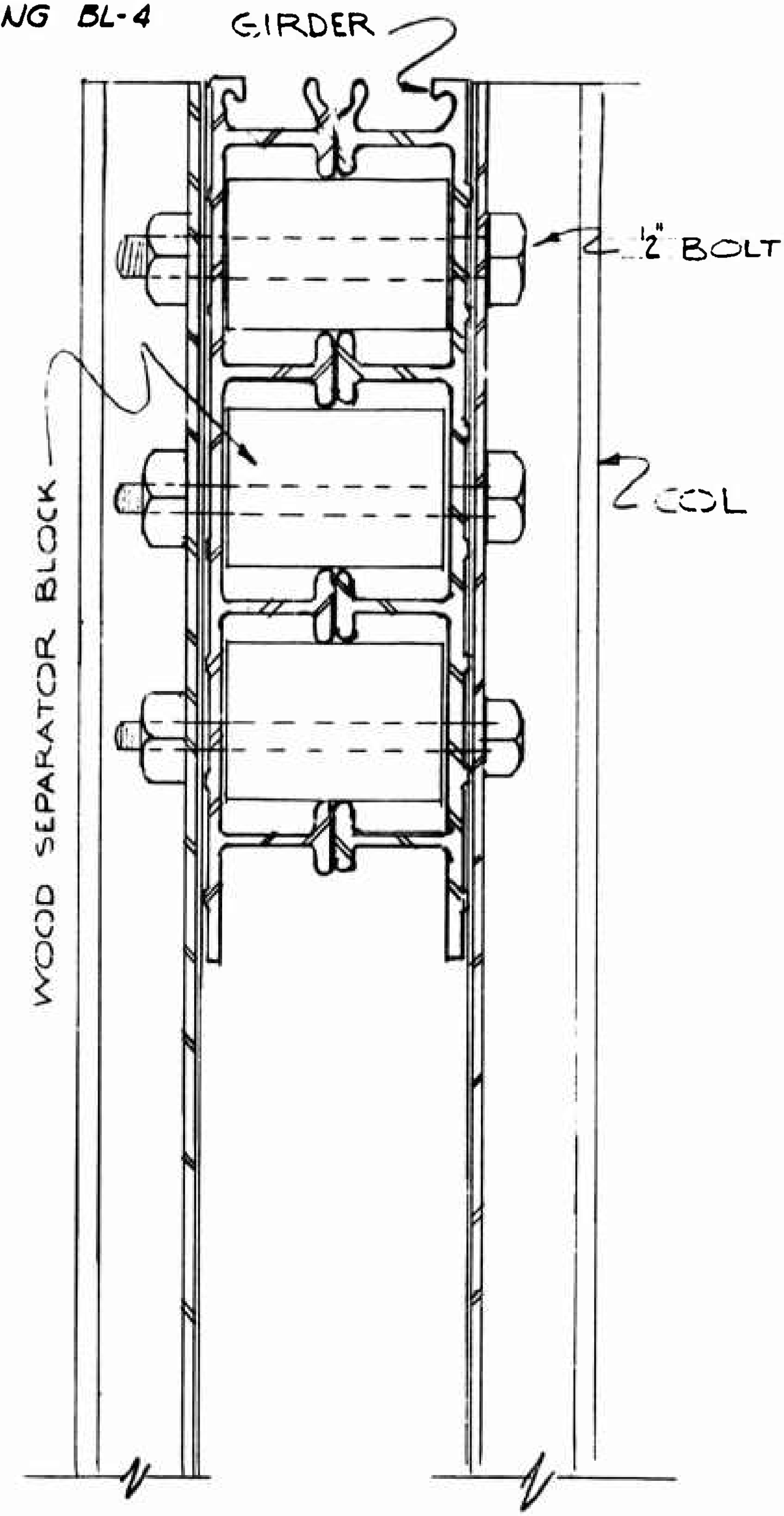
EXTERIOR WALL SECTION

SCALE 1" = 1'-0"



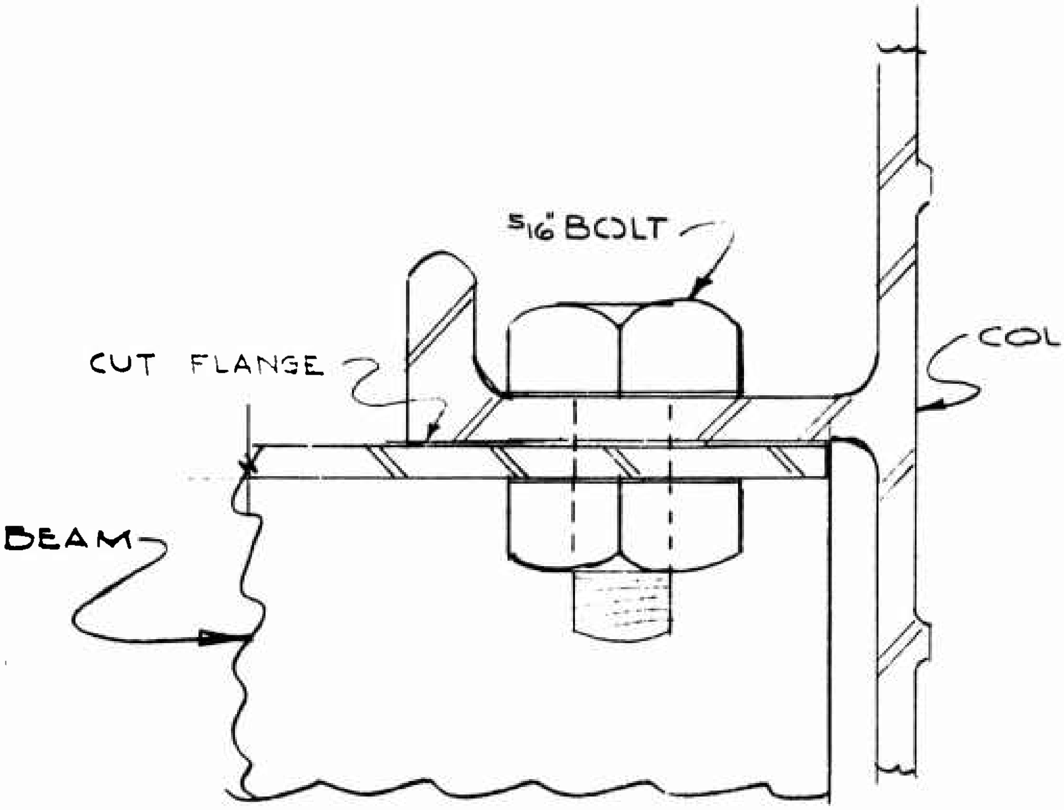
ALTERNATIVE TO GRADE BEAM AS SHOWN ON DR BL-2

DRAWING BL-4



GIRDER TO COL CONNECTION

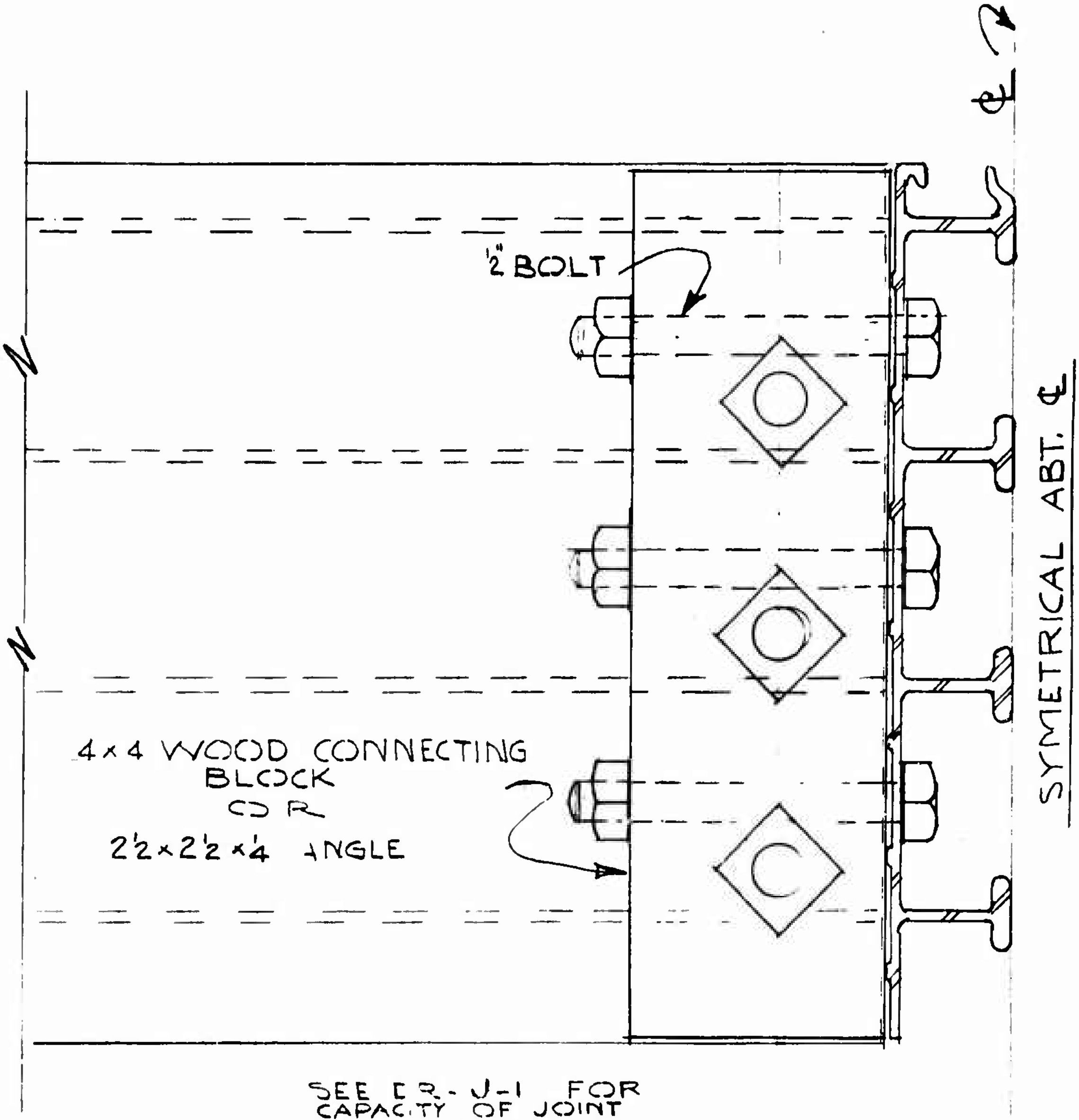
SCALE 6" = 1'-0"



BEAM TO COL CONNECTION

SCALE 24" = 1'-0"

# DRAWING BL-6

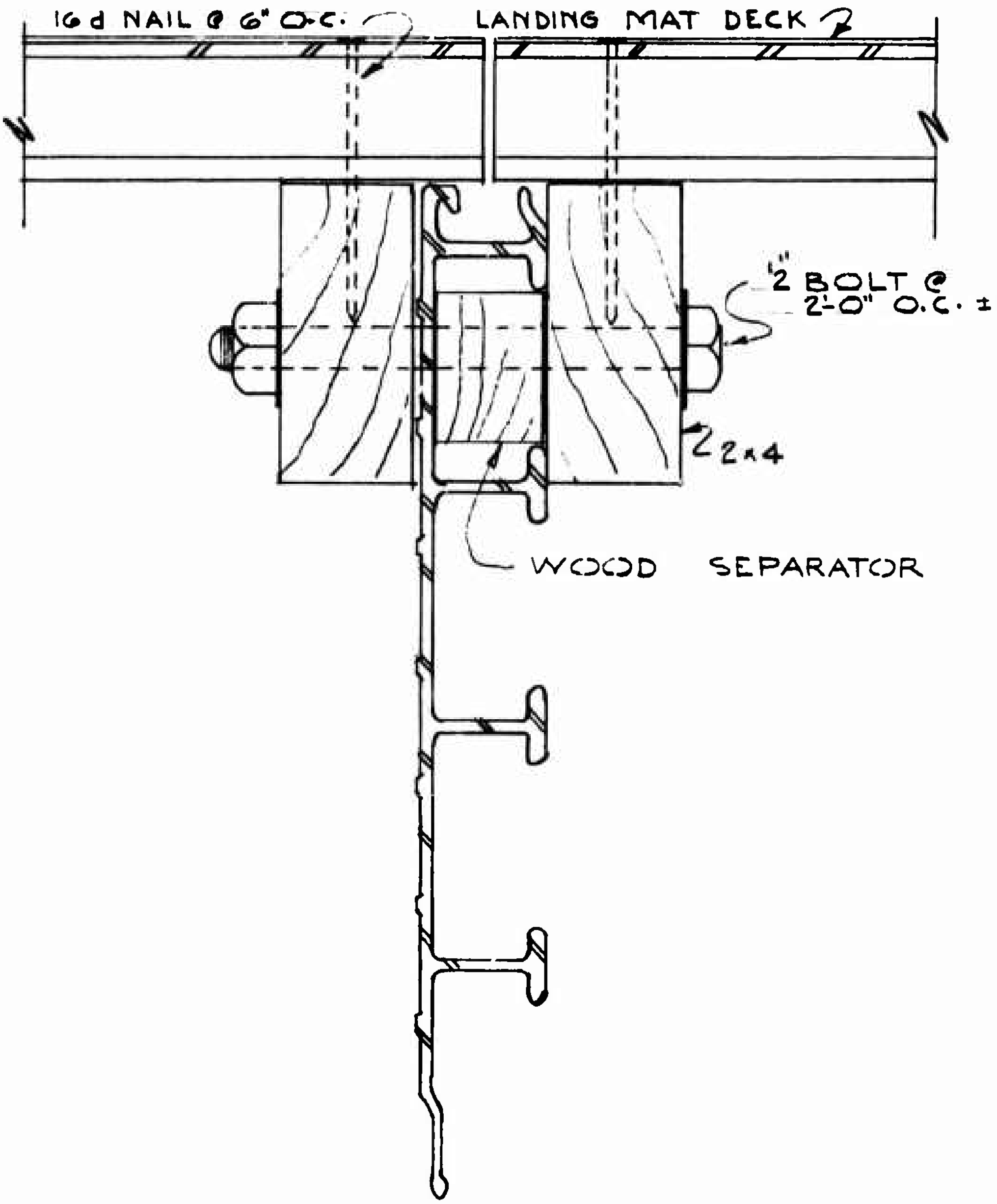


SEE DR-J-1 FOR CAPACITY OF JOINT

## BEAM TO GIRDER CONNECTION

SCALE 6" = 1'-0"

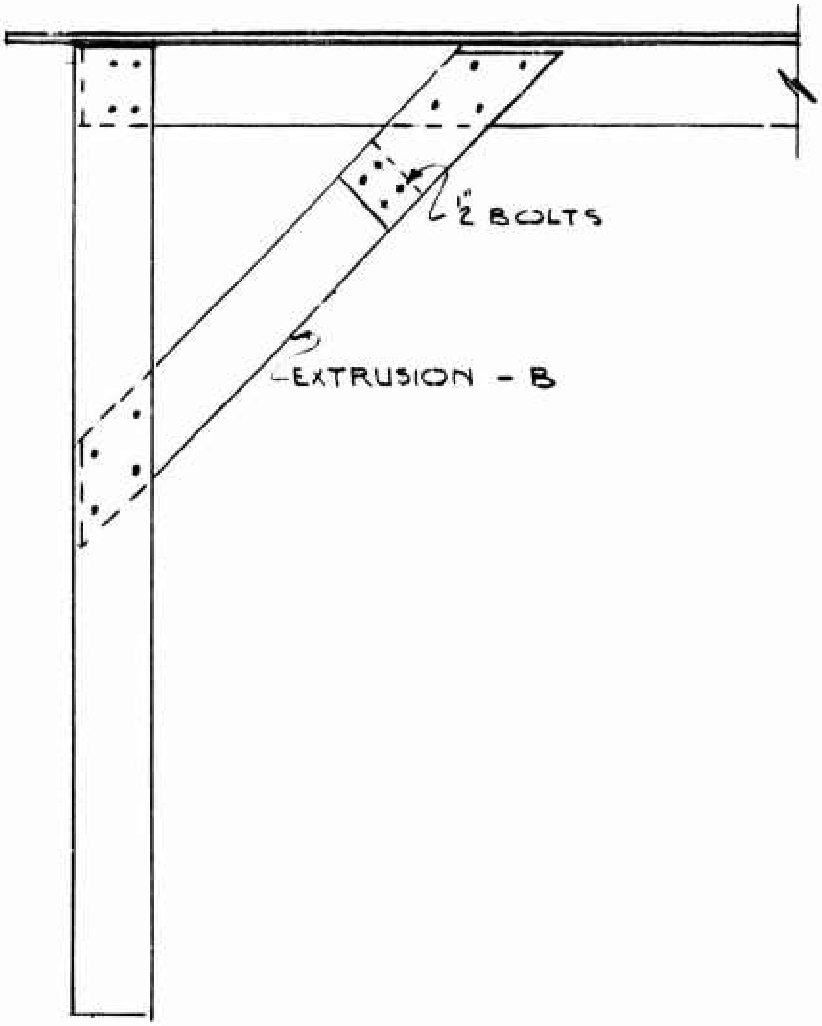
DRAWING BL-7



## TYPICAL BEAM SECTION

SCALE 6" = 1'-0"

DRAWING BL-8



TYPICAL KNEE BRACE DETAIL

SCALE 1" = 2'-0"

## BRIDGES

The slab and beam units given in the first sections of this report can readily be adapted for short span bridging for any vehicle classification. Drawing BR-1 illustrates one possible bridge unit having an overall length of twelve feet. This unit can be used for short crossings or as bays for multi-span bridges.

The stringers of this bridge are fabricated from two A Extrusions of the T-11 Aluminum Landing Mat. The maximum concentrated load and the maximum uniform load for this section are given in Table B-2, Sheet 20 . For an eleven foot span the concentrated load is 27.2 kips and the uniform load is 4.94 kips per foot. The maximum bridge loads using these values, (based on guaranteed minimum yield strength) are; for wheel load, 54.4 kips and for track loading, 9.88 kips per foot of track. The loads for a similar bridge utilizing the T-8 Magnesium Landing Mat can be determined from Table B-9, Sheet 27 .

The bridge deck consists of landing mats layed transverse to the direction of traffic, nailed directly to the stringer. Treadways consisting of two landing mat sections are placed next to the curb over the length of the span. These sections bolted or nailed to the decking will provide longitudinal distribution of the wheel loads to the decking and lateral strength to the bridge.

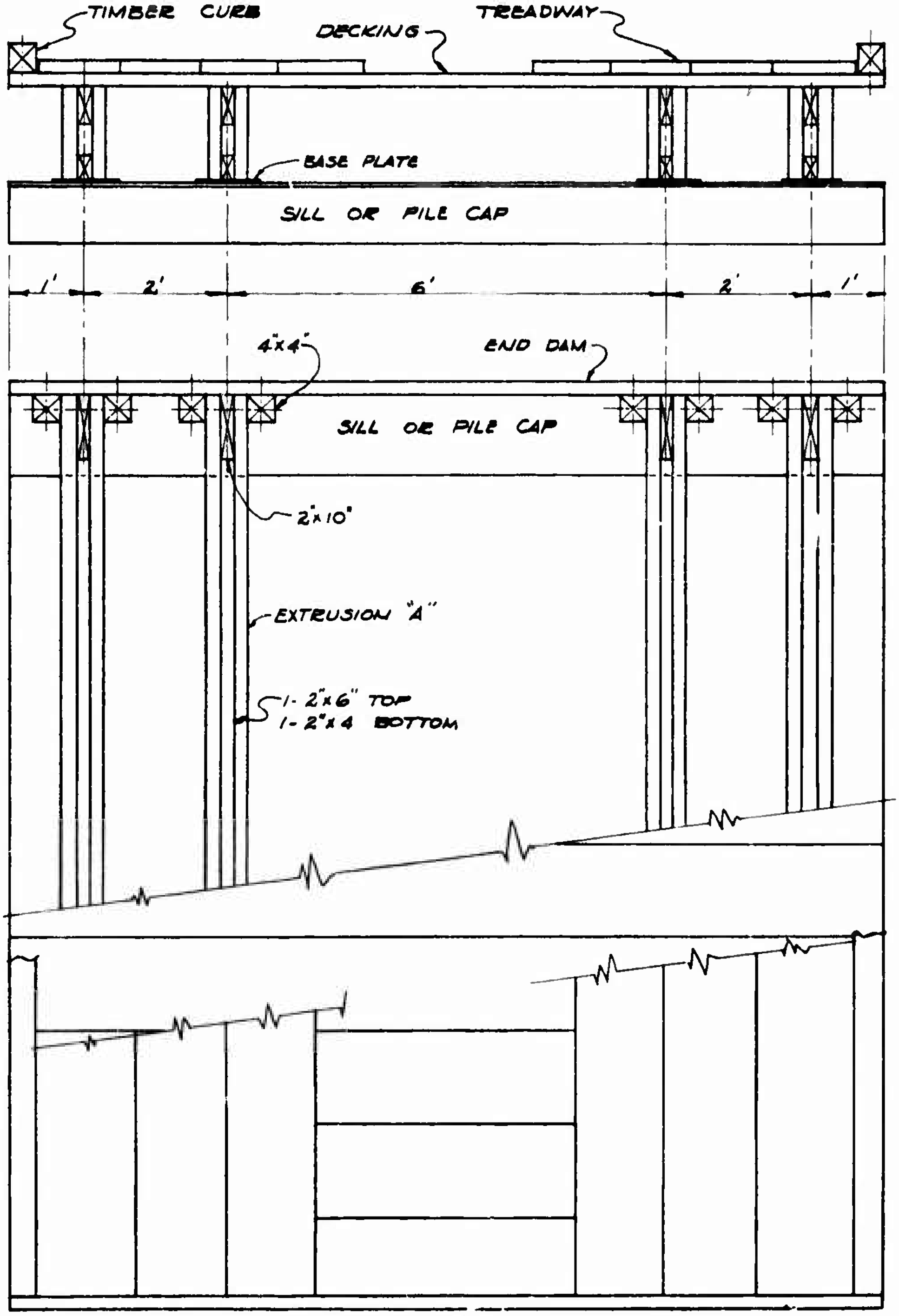
Bridges of any desired capacity may be constructed by varying the number of stringers used and the arrangement of the decking. For light loads, such as foot bridges or infantry support bridges, spans of greater length can be constructed similar to the bridge described here. In the longer spans, transverse diaphrams consisting of single extrusions will be necessary for lateral stability.

The bridge described can be constructed entirely at the bridge site or partially prefabricated and assembled at the site. Lighter bridges can be entirely prefabricated and assembled in a rear area and transported to the site.

The approximate weight of the bridge shown in Drawings BR-1 and BR-2 is 2,100 pounds.

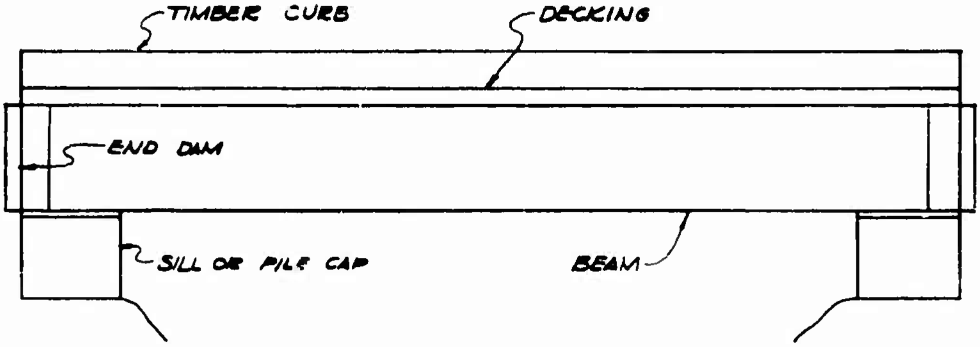
DRAWING BR-1

## 12' BRIDGE
ALUMINUM LANDING MAT T-11

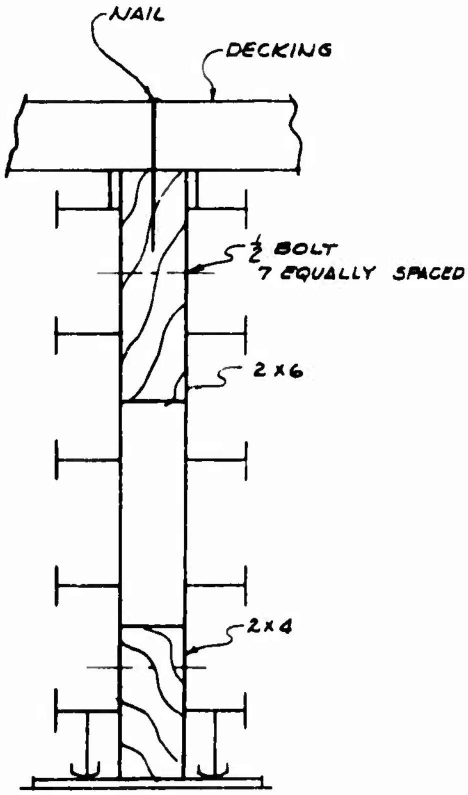


FRAMING PLAN

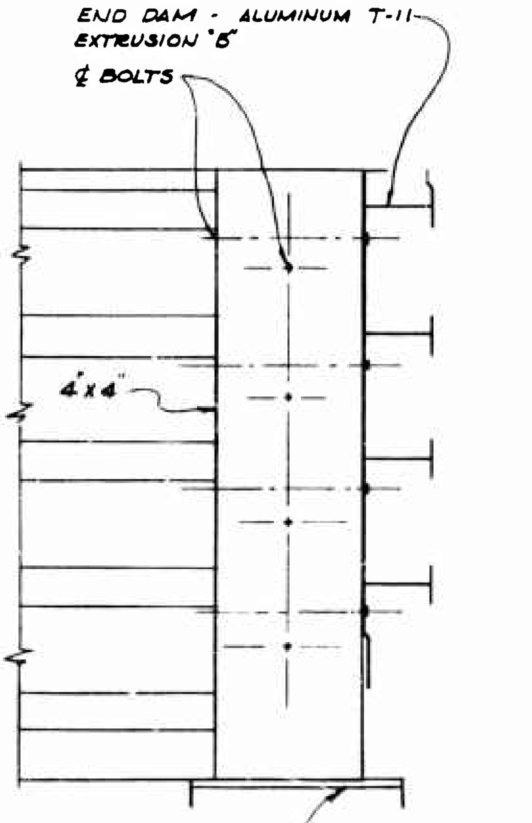
DRAWING BR-2



SIDE ELEVATION



BEAM SECTION



BEAM
END JOINT

## CULVERTS

The extruded sections of the T-8 Magnesium Landing Mat and the T-11 Aluminum Landing Mat may be adapted easily into forms quite satisfactory for culverts. In the pages that follow are presented four such types. These culverts are not presented as the ultimate in design using these mat sections, but rather are presented as four quite satisfactory sections to show that the mat components are practical for this application.

### Culvert Loads

Any typical culvert loading can be obtained from the Slab loading diagrams. Conditions will exist where a combination of these diagrams apply.

### Triangular Culvert

Drawing CU-1, Sheet 81 , shows the cross section of a triangular culvert of small cross section area. The minimum open cross section area is 1.1 square feet if the culvert is made from the T-11 Aluminum Mat components and 1.3 square feet if made from the T-8 Magnesium Mat components. Design of this culvert type and all other calls for the flange sections to be outside to provide a smooth waterway. Drawing CU-1 shows the apex of the triangular culvert at the top. The apex may be placed down equally as well. Construction with the apex up is slightly easier and results in fewer backfill problems. The culvert with apex down provides better hydraulic properties.

### Box Culvert-Landing Mat Longitudinal

Drawing CU-2, Sheet 81 , shows one form of a box culvert. The minimum open cross section area is 3.3 square feet if the T-11 Aluminum Mat sections are used and 3.8 square feet if the T-8 Magnesium Mat sections are used. Flange sections of the mat are placed outside.

### Box Culvert-Landing Mat Transverse

Drawing CU-3, Sheet 83 , shows a form of a box culvert that can be constructed of any desired size up to six feet on a side. It is necessary that the extrusions be cut into lengths equal to the desired dimensions of the sides of the culvert.

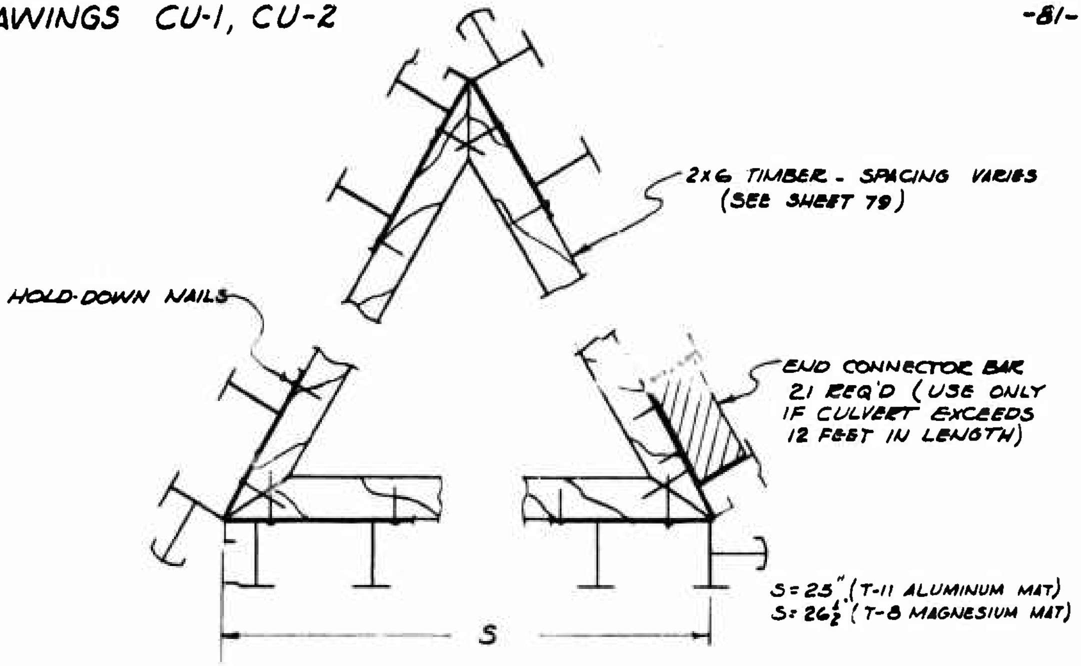
No supports are needed other than at the corner joints. The corner joints can be made using the wood section or the angle as shown on Drawing CU-3. Transverse joints require no modification of the landing mats.

Construction of the culvert can be made on the site, partially prefabricated in a shop and erected on the site, or completely fabricated in the shop and transported to the site.

## Multiple Box Culverts

Drawing CU-4 shows the cross section of a form of a box culvert that can be built hurriedly to span drainage systems of widely varying sizes. In many instances this culvert could be used for temporary culverts where the total construction would consist of stacking sand bags for supports and laying landing mat sections for decking for the road bed. Depending upon the size of the drainage ditch to be spanned and on the duration of use, one of the other more permanent forms of support illustrated could be used.

## DRAWINGS CU-1, CU-2



DRAWING CU-1
TRIANGULAR CULVERT (USES ENTIRE MAT SECTION ON EACH SIDE)
MINIMUM OPEN CROSS SECTION AREA
1. T-11 ALUMINUM MAT - 1.1 $FT^2$
2. T-8 MAGNESIUM MAT - 1.3 $FT^2$

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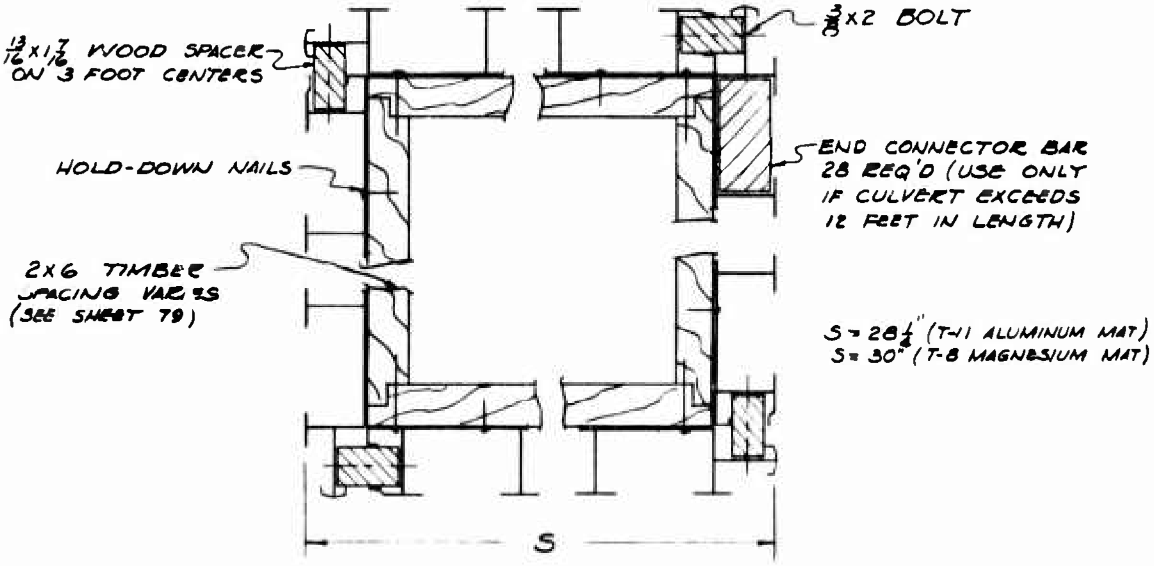
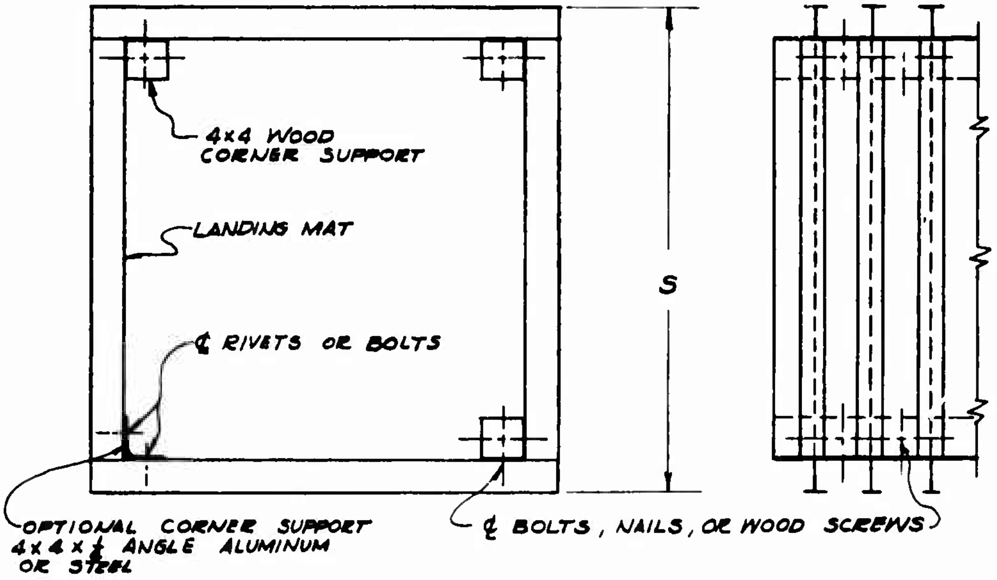
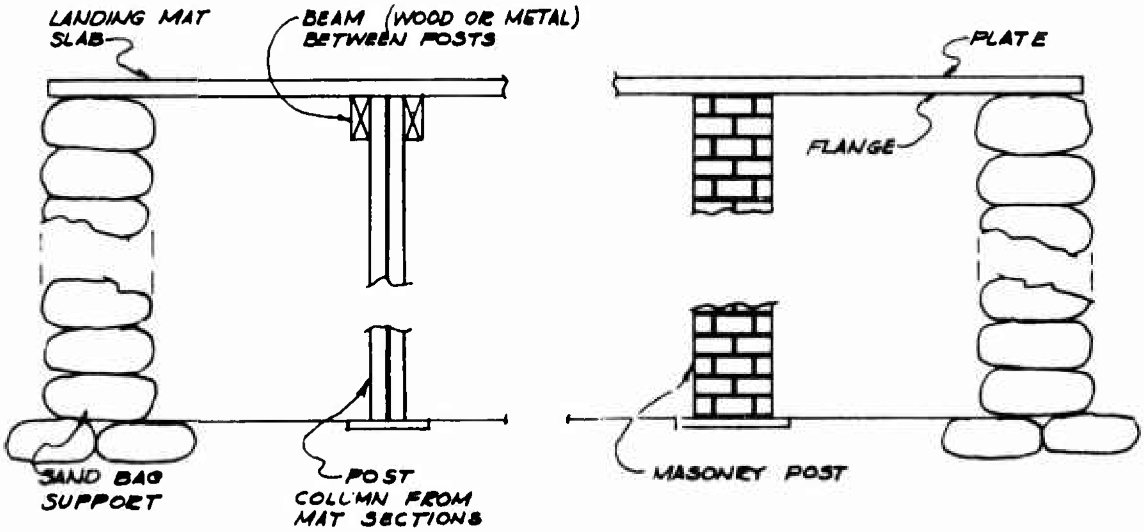


DRAWING CU-2
BOX CULVERT - LANDING MAT LONGITUDINAL (USES 4 ENTIRE MAT SECTIONS)
MINIMUM OPEN CROSS SECTION AREA
1. T-11 ALUMINUM MAT - 3.3 $FT^2$
2. T-8 MAGNESIUM MAT - 3.8 $FT^2$



DRAWING CU-3
BOX CULVERT - LANDING MAT - TRANSVERSE
VALUES OF S UP TO 6'



DRAWING CU-4
MULTIPLE-BOX CULVERT (SHOWS ALTERNATE METHODS OF SUPPORT. POSTS TO BE LOCATED ON 3, 4, OR 6 FOOT CENTERS DEPENDING ON LOADING CONDITIONS - SEE SHEET 79)

## FABRICATION AND ERECTION

The connections required for joining landing mat sections, both single pieces and built-up sections, are the same type as used in normal construction of rolled sections. Where square sections of wood are used to transmit shear the bolts are arranged just as if a connection angle were used. The wood end pieces on built-up beams perform the same functions as end stiffener angles on plate girders. Hold-down nails or bolts, when the landing mat section is used as a slab for flooring or decking, duplicate wood deck nailing.

Erection will follow normal procedures. The principal difference between erecting a WF section and a beam built up of Extrusion A or B is the difference in weight; and the mat section will in many cases have the advantage that it can be erected by manpower, where mechanical power would be required for the heavier steel.

Mat flooring or decking can be placed with less manpower than any other type because it interlocks and stays put and because of the large area covered by each operation.

In general it can be said that no case has been considered where mat material will be more costly to erect than accepted sections. Saving from this advantage will be only a small per cent of the total cost.

Shear connections on the Tee side, which were not found necessary in this study, may cost slightly more than, say, for a WF section because of bending in the bolts.

Erection problems, either introduced or eliminated by the mat, will not determine its use. They are not significant.

The most useful beams built-up from the mat section are made by combining two or more Extrusions A. We are not aware of any plan to ship a certain proportion of the extrusions as separates, even though we recognize the advantages of such a procedure. Hence, it is assumed here that if an extrusion is needed it must be obtained by punching, drilling or cutting the rivets connecting extrusions A and B. Experience with airplane frames of aluminum indicate that these rivets can either be chisled out by one blow of a hammer or drilled or punched out with little difficulty. This is the most frequently desired modification -- practically the only one -- required.

## COSTS

The landing mat is a costly section, and when used for any of the many purposes for which it can be adapted, will generally be costlier than normal construction, using standard sections. There is possibly one exception; that is the case where the mat is at hand and any other material would involve extra time, labor, or transportation costs. The value of time will be determined by the responsible parties on the work site. It is presumed that on occasion time is an exceptionally valuable commodity.

The cost comparisons tabulated below are based on civilian conditions. When a heavy material like steel must compete with a piece of magnesium after being transported halfway around the world, these comparisons will be altered.

### RELATIVE COSTS

| | SLABS | BEAMS | COLUMNS | AVERAGE |
|---|---|---|---|---|
| WOOD | 1.0 | 1.0 | 1.0 | 1.0 |
| STEEL | 1.0 | 1.0 | 1.2 | 1.1 |
| ALUMINUM (T11) | 4.4 | 2.3 | 2.4 | 3.0 |
| MAGNESIUM (T8) | 8.0 | 6.5 | 4.8 | 6.5 |

## CONCLUSIONS

1. It is likely that the mat section under consideration is the most versatile structural section that has ever been shaped. One can do anything with it that he can do with a plate and do almost everything better because of its larger moment of inertia.

2. Built-up sections are easily and simply assembled. The strength of these sections can be varied over a wide range.

3. Because of the large strength/stiffness ratio, deflections must receive more consideration than for any other material. For example, if vehicles move over a mat deck at critical speeds, the deflections, if synchronized with spring deflections, could be disagreeable and possibly dangerous. Since deflection considerations will limit loads, the yield point stress will seldom be reached in slabs except for extremely short spans.

4. The evidence of versatility of the section accumulated fairly rapidly in this study and it has been difficult to decide how many trees it should take to make a forest. It would have been easy, and was at first tempting, to add detail on detail of adaptability. Instead we have concentrated on investigating the structural properties of the section under stress conditions which exist under all predictable uses, and on delineating a fairly comprehensive series of examples to show how the perfectly general load tables are used for any specific application.

The examples of elements assembled to form structures were selected to show how an assembly can be made. The choice of structures shown as examples does not imply that they are the most important uses.

5. Fabrication and erection problems will seldom be a handicap. They are normal procedure.

6. Economic comparisons show that the mat as a structural member costs considerably more than wood or steel. Whether it is worth the extra cost will depend on the value of time under any existing condition.

## REFERENCES

(By the Aluminum Company of America)

1. Aluminum Company of America; "Alcoa Structural Handbook", 1956.
2. Riveting Alcoa Aluminum, 1954.
3. Forming Alcoa Aluminum, 1953.
4. Welding Alcoa Aluminum, 1955.
5. Alcoa Aluminum Aluminum Handbook, 1956.

(By the Reynolds Metals Company)

6. Machining Aluminum Alloys. 1952.
7. The A-B-C's of Aluminum, 1955.
8. Welding Aluminum, 1953.
9. Fastening Methods of Aluminum, 1951.
10. Designing with Aluminum Extrusions, 1954.
11. Aluminum Forming, 1952.
12. "Aluminum in Modern Architecture", 1956.

(By the Dow Chemical Company)

13. The Dow Chemical Company, "Technical Memorandum No. 15, "Crippling Strength of Magnesium Sheet and Extrusions".
14. Magnesium Design Notes, 1955.
15. Joining Magnesium, 1953.
16. Magnesium Alloys and Products, 1953.
17. Maching Magnesium, 1954.
18. Air Force Manual 86-3; "Planning and Design of Theater of Operations Air Bases", March 1955.

(By The Department of the Army-Field Manuals)

19. FM 5-5 Engineer Troops
20. FM 5-6 Operation of Engineer Troop Units
21. FM 5-9 Elementary Bridging

22. FM 5-10 Routes of Communication

23. FM 5-15 Field Fortifications

24. FM 5-22 Camouflage Materials

25. FM 5-30 Engineer Field Manual

26. FM 5-32 Land Mine Warfare

27. FM 5-34 Engineer Field Data

28. FM 5-132 Engineer Combat Battalion Divisional

29. FM 5-134 The Armored Engineer Battalion

(From Miscellaneous Sources)

30. Priest, H. Malcolm; "Design Manual for High-Strength Steels; Davis & Warde, Inc., Pittsburg, Pennsylvania.

31. The American Association of State Highway Officials; "Standard Specifications for Highway Bridges", 1953.

32. ANC-5, "Strength of Metal Aircraft Elements", March 1955.

33. Peck, Ralph B., Hanson, Walter E., Thornburn, Thomas H.; "Foundation Engineering"; John Wiley & Sons, Inc,; New York.