NAAMM STANDARD **AMP 510-92**

N•A•A•M•M 3/92 5 MISCELLANEOUS METAL | Metal Stairs

METAL STAIRS MANUAL

FIFTH EDITION

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AMP Architectural Metal Products Division of NAAMM
THE NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS

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FOREWORD

The first edition of the NAAMM Metal Stairs Manual was published in 1959 and proved to be one of the most widely used of all NAAMM publications. The second edition, published in 1971, contained much more data than the first edition, while the 1974 edition had only a few minor revisions.

The 1982 fourth edition underwent extensive revisions. The section on representative installations was divided into two sections: one of which illustrated stairs meeting NAAMM minimum standards; while the other illustrated custom designed stairs with special aesthetic effects. Also added was a new section containing recommended voluntary minimum standards for fixed metal stairs and guide specifications for the architect.

This 1992 edition of the NAAMM Metal Stairs Manual, like its predecessors, should be extremely helpful to architects, engineers and manufacturers. New design examples include an aluminum stairway and a ship's ladder. Photographs of several outstanding architectural designs have been added, and the section on construction details has been updated and expanded.

ACKNOWLEDGEMENTS

The committee responsible for the preparation of this revision of the NAAMM Metal Stairs Manual thanks all members of the Association who have assisted with this work.

NAAMM recognizes the American Institute of Steel Construction for the use of the table of steel channel properties and the Aluminum Association for the use of the table of aluminum channel properties.

The editor of the fifth edition was Jack Roehm, a past president of NAAMM, who retired as Technical Director in 1991. All members of the Association appreciate his input to this document as well as his years of service to NAAMM.

SECTION 1

GENERAL INFORMATION

CONTENTS

INTRODUCTION

Since prehistoric times, the stairway has provided the only means of moving, under one's own power, from one level to another in a building, within optimal limits of space, effort and safety. Even in buildings having elevators or ramps, stairs, too, are provided as a safeguard to the occupants in times of emergency. They are an essential building element, taken for granted in any multi-storied building. But stairs don't just happen; to best serve their purpose they must be correctly designed and properly built.

For centuries stairs have been made of stone masonry and wood. Metal stairs, by comparison, are a relatively new development. We're not sure when they first appeared, but quite likely the metal first used was wrought iron. By the time cast iron came into use for building facades, in the 1830's, its use for stair construction had probably also been explored, and perhaps was already well developed. Cast iron stairs became increasingly commonplace with various improvements and added embellishments from time to time, during the next hundred years, in many public and commercial buildings. With their paneled newels and their moulded and ornamented stringers, these heavy cast iron stairs are still in use in many of our older structures. As late as the early 1930's they were still being specified by the Treasury Department in its new post office buildings, and during those depression years, as many will recall, government building constituted a large share of our construction activity. Many of today's metal stair manufacturers began their operations during this cast iron era. But gradually this heavy cast iron, with its inflexibilities and its high production labor costs, gave way to much lighter, more efficient and less expensive steel as a more-logical material for stair construction, and by the 1920's many stairs were being built of steel.

During the past 70 years the techniques of steel stair construction have, in turn, undergone many changes, steadily improving and taking full advantage of technical developments as they have occurred. Rolled sections are now made of stronger steel; improved sheet material and modern forming methods have increased the use of cold formed section; and welding has replaced bolted connections in many cases. With the availability of suitable copper alloys and the growing use of aluminum and stainless steel in building construction, the use of non-ferrous metals has greatly increased the scope and the design potentials of metal stair construction.

As everyone knows, there are many kinds of stairs, serving a wide range of purposes. They may be purely functional or utilitarian, built at minimal cost, or they may be highly decorative architectural features, using the most expensive materials. Most stairs, of course, are of a quality that lies somewhere between these two extremes. But the design potentials of metal stair construction are limited only by the architect's ingenuity.

It is the purpose of this Manual to provide architects with comprehensive up-to-date information on the design and construction of metal stairs of all types. **Section 2** illustrates with photographs and principal details, installations representative of metal stairs which meet NAAMM minimum standards. **Section 3** illustrates with photographs and principal details installations representative of metal stairs custom designed to achieve esthetic effects as well as to serve the functional needs of the building. **Section 4** provides information on construction details and contains details of all parts of typical construction. **Section 5** provides examples illustrating the structural design of stairs and railings as well as engineering data on stair components. **Section 6** presents recommended voluntary minimum standards for fixed metal stairs and guide specifications for the architect. **Section 7** is a glossary in which will be found the definitions of terms commonly used in stair work.

The stair designs shown, as well as their accompanying details, are intended only as suggestions — examples of what may be done with metal stair construction. Generally speaking, the architect should be concerned, in his drawings, with conceptual and structural designs and the provision of sufficient details to clearly explain the materials to be used and the esthetic effect desired. If he provides complete details of all structural parts and their connections, such details must meet not only the load requirements but also their dimensional requirements and tolerances as specified in the governing codes and as may be specified for special conditions which may exist for certain installations. Special conditions may include government requirements for occupational safety or for physically handicapped persons. Detailing is often left to the fabricator, and will be shown on the shop drawings which he submits for the architect's approval. Although metal stairs of all types are essentially custom designed, each stair manufacturer has his own preferred and proven methods of fabricating typical repetitive parts, especially on the more common types of stair. What may be the best detail or connection method in the opinion of one manufacturer is not necessarily consistent with the practices of another. And when the architect is contemplating the use of special design features, he should contact one or more fabricators early in the design stage to avail himself of any suggestions which may result in better or more economical design. However, the architect or engineer responsible for the design must verify that details, connections, materials, etc., proposed by the manufacturer are structurally adequate and meet all of the requirements of the specifications.

ADVANTAGES OF METAL STAIRS

In designing most types of buildings, the architect has a choice of several materials for use in stair construction. Except in wood frame structures, he frequently chooses metal, because metal stairs offer certain advantages over those built with other materials. Among the more important of these advantages are the following:

Design Versatility

Metal is one of the most versatile building materials. It can be formed in many different ways, accepts an infinite variety of finishes, can provide almost any esthetic effect desired, and is compatible in appearance with all other architectural materials. Metal is appropriate for stairs of all kinds, from the purely functional service types to the most elaborate architectural types. It serves equally well for a simple straight-run stair or for the most complex and graceful curved stair. Whatever the architect's design calls for, it can be faithfully reproduced in metal, with a virtually unlimited latitude in the design of all major elements.

High Strength-to-Mass and Strength-to-Weight Ratios

Although the density of metal is higher than that of other stair materials, its strength is greater by a much larger ratio. Hence the sectional areas of metal stair members are much smaller than those needed if other materials are used. This high strength-to-mass ratio of metal is a valuable asset in situations where headroom or floor space is limited, because the structural members are of minimal size. In high-rise buildings especially, the saving of weight provided by metal stairs because of the high strength-to-weight ratio may also be an important consideration inasmuch as it reduces the amount of foundation work and framing required.

Accurate Dimensional and Quality Control

The safety of the user is always of paramount concern in any type of stair, and to a large degree safety depends upon the uniformity of riser and tread dimensions and the construction of railings. Metal stairs are shop fabricated under careful supervision, using the most modern tools and equipment. Their dimensions are carefully controlled, in accordance with the architect's design, and are held within close tolerances to provide true and uniform lines and faithful reproduction of design. This degree of accuracy cannot be economically achieved by the field construction methods used in building stairs of other materials.

Integral Railing Construction

One of the most important attributes of metal stair construction is the dependable stability of its railings. With other types of stair construction, field measurements are usually required, separate railing shop drawings must be made, and after fabrication the railing is delivered and installed as a separate entity. In the meantime temporary railings are often required. This is not the case with metal stairs. Railings are accurately fitted to metal stairs in the shop and, whenever feasible, are firmly secured in place and the stair is delivered as a complete unit. The more elaborate types of railing are also shop fitted, but may be shipped separately to be installed in the field as an integral part of the stair. Thus metal stairs offer the advantage of unified construction under a single responsibility, as opposed to the more complex and costly process of dealing with, and correlating the work of several different trades.

Early Availability

Because metal stairs are completely fabricated offsite, their manufacture is independent of construction progress at a building site. They are ready for installation whenever they are needed and building construction permits, and may be installed complete with railings as required. After installation the stair may be used immediately by workmen, eliminating the cost and safety hazards of temporary ladders, stairs and railings. Additional safety is realized because the toe plate forms a curbing at all open ends and open back edges of treads and prevents small tools and miscellaneous items from rolling off and causing possible injury to workmen below.

Metal stairs of the types commonly used in multistoried buildings may also be pre-assembled in the shop and delivered to the building site as prefabricated units. Such units may then be installed and ready for use even **before** the surrounding building frame is erected, providing even greater economies of time and cost.

Rapid Installation

Regardless of what type a metal stair may be, its installation usually requires much less time than that required for stairs of other materials. Under normal circumstances installation is simply a process of assembling prefitted parts wholly fabricated in the shop, and a minimum of field labor is required.

Economy

A true comparison of costs must take into account not only the price of the product in question, but also all of the costs affected by, or resulting from, the use of this product. Not only are metal stairs, per se, highly competitive in cost with stairs of other materials, but their use results in contingent economies which are often substantial. Metal stairs, though custom built, are usually constructed of sections that are readily available from stock or local warehouse. In most cases a minimum of detailing by the architect is required.

This results in a saving of time and cost to both architect and client. Because of the early availability and rapid installation of metal stairs, the cost of temporary stairs and railings in the building during construction is eliminated. And the time required for supervising, correlating and expediting the stair construction work is reduced by having the stair and railing both installed under a single responsibility.

Salvage Value

In some situations the salvage value of stairs may be a consideration. Metal stairs of the more common types can be dismantled, moved to another location and re-installed when building alterations are required. And finally, when they have served their purpose, and the building is demolished, metal stairs have scrap value.

With its 1971 Edition of the *Metal Stairs Manual,* NAAMM published for the first time a system of classifying stairs. It was believed that a logical classification system would reduce the confusion which existed in the terms used to refer to the different types of stairs and would be helpful to architects, engineers, manufacturers and all concerned. In the intervening years this has proven to be the case. It was published again, unchanged, in the 1982 (Fourth) Edition of the Manual. The NAAMM system has been accepted by the stair industry.

Under the NAAMM system, metal stairs are classified according to both Type and Class. The Type designation identifies the physical configuration or geometry of the stair, while the Class designation refers to its construction characteristics — the degree of refinement of fabrication and finish — and to the general nature of its usage. Obviously, the Type designations are applicable to stairs made by any material, but the various Classes, as here described, apply more particularly to metal stairs.

Types of Stairs

The four types of stairs classified in the system described in the two previous editions of the NAAMM *Metal Stairs Manual* are Straight Stairs, Circular Stairs, Curved Stairs and Spiral Stairs. Description of two other types of stairs, Winder Stairs and Alternating Tread Stairs, have been added to this fifth edition of the Manual. One type of ladder, namely Ship's Ladder has also been added. The representative installations shown in Sections 2 and 3 of the Manual illustrate these items. This listing of types is not necessarily all-inclusive but it represents the great majority of stairs. It is not uncommon to find two or more types, represented in the same stair, and in rare cases there may be found a stair which properly falls in none of these type categories.

The Workmen's Compensation Bureau has made the following recommendations for pitch of ramps, stairs and ladders:

Ramps: Pitch ranges from 0° to 20°.
Preferred maximum pitch: 15°.

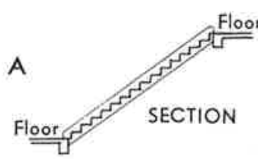
Stairs: Pitch ranges from 20° to 50°.
Preferred maximum pitch: 35°.

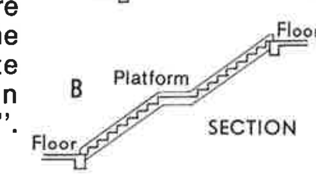
Ladders: Pitch ranges from 50° to 90°.
Preferred maximum pitch: 75°.

Pitches close to the maximum angles should be avoided wherever possible as they are uncomfortable and could be unsafe.

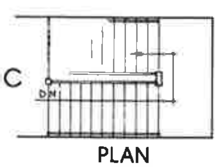
Straight Stairs are by far the most common type, representing the bulk of the stair market. Though the term "straight" is self-explanatory, for purposes of classification a straight stair is defined as one in which the stringers are straight members. Straight stairs, unlike stairs of the other three types, may be arranged in several different ways:

a) Straight run:
either a single flight extending between floors, as shown in "A" at the right, or
a series of two or more flights in the same line, with intermediate platforms between them, as shown in "B".

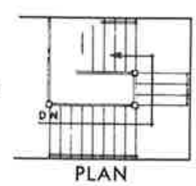
A


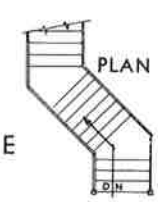
B


b) Parallel:
successive flights which parallel each other and are separated only by one or more intermediate platforms, as shown in "C".

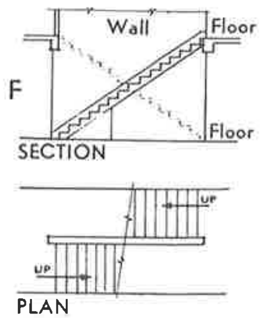
C


c) Angled:
successive flights placed at an angle of other than 180° to each other (often 90°), with an intermediate platform between them as shown in "D" or "E". The type shown in "D" at the right is often referred to as a "trussed" stair.

D


E


d) Scissor:
a pair of straight run flights paralleling each other in plan and running in opposite directions on opposite sides of a dividing wall, as shown in "F".



Circular Stairs are stairs which, in plan view, have an open circular form, with a single center of curvature. They may or may not have intermediate platforms between floors.

Curved Stairs are stairs which, in plan view, have two or more centers of curvature, being oval, elliptical or some other compound curved form. They also may or may not have one or more intermediate platforms between floors.

Spiral Stairs are stairs with a closed circular form, having uniform sector shaped treads and a supporting center column.

Winder Stairs in plan view are parallel or angled. However, unlike straight stairs, no platforms are used where the 180° angle occurs for the successive flights of parallel stairs, nor are platforms used for successive flights placed at angles other than 180° (often 90°). Instead, the stairs continue to rise through the angled areas with sector shaped treads having the same riser heights as the straight part of the stair.

Alternating Tread Stairs are an exception to the upper pitch limitation for stairs. In this type of stair the treads are alternately mounted on the left and right side of a center stringer. Because of this tread construction and the use of handrails on each side, these stairs permit safe descent facing outward from the stair. Generally, pitch angles used in these stairs will range from 56° to 68°.

Ship's Ladders generally have pitch angles ranging from 59° to 75°. They require flat treads and handrails on at least one side, depending on stair width.

Pre-assembled and Pre-erected Stairs are stairs whose components are assembled in the plant to make up units of varying sizes and degrees of complexity. These may be platform units, flight units, combination platform and flight units, or larger units comprising the complete floor-to-floor story-height stair. Pre-assembled stairs may be of the architectural class, but pre-assembly methods are commonly applied to stairs of the commercial and service classes because of the repetitive use of identical units. Pre-assembled units for multi-storied buildings may be designed to be self-supporting so that they may be pre-erected on the building site. Such units can be stacked one upon the other and field-connected to form stair towers. Stair towers can be erected and ready to use prior to erection of the surrounding building structure. The use of pre-assembled units and pre-erected stair systems usually effects considerable savings and expedites the construction of buildings.

Classes of Stairs

The Class designation of stairs, is a key to the type of construction, the quality of materials, details and finish and, in most cases, the relative cost. As stairs of all classes are built to meet the same standards of performance in respect to load carrying capacity and safety, these class distinctions **do not represent differences in functional value, but in character and appearance.** It is important to recognize that where function is the prime concern, and esthetics are of minor importance, significant economies can be achieved by specifying one of the less expensive classes. Detailed information on this matter of potential economies in design is provided in the fourth part of this section of the Manual.

The following descriptions indicate the general construction characteristics of each class, but it should be recognized that because each manufacturer has his own preferred methods of fabrication, the details of construction vary somewhat throughout the industry. The four classes of stairs, listed in the order of increasing cost (as a general rule), are described as follows:

Industrial Class: Stairs of this class are purely functional in character and consequently they are generally the most economical. They are designed for either interior or exterior use in industrial buildings such as factories and warehouses, or as fire escapes or emergency exitways. They do not include stairs which are integral parts of industrial equipment.

Industrial class stairs are similar in nature to any light steel construction. Hex head bolts are used for most connections, and welds, where used, are not ground. Stringers may be either flat plate or open channels; treads and platforms are usually made of grating or formed of floor plate, and risers are usually open, though in some cases filled pan type treads and steel risers may be used. Railings are usually of either pipe, tubing, or steel bar construction.

When used for exterior fire escapes the details of construction are similar, except that treads and platforms are of open design, usually grating or perforated floor plate. Also, the dimensions, methods of support and other details are usually dictated by governing code regulations.

Service Class: This class of stairs serves chiefly functional purposes, but is not unattractive in appearance. Service stairs are usually located in enclosed stairwells and provide a secondary or emergency means of travel between floors. In multi-storied buildings they are commonly used as egress stairs. They may serve employees, tenants, or the public, and are generally used where economy is a consideration.

Stringers of service stairs are generally the same types as those used on stairs of the industrial class. Treads may be one of several standard types, either filled or formed of floor or tread plate, and risers are either exposed steel or open construction. Railings are typically of pipe construction or a simple bar type with tubular newels, and soffits are usually left exposed. Connections on the under side of the stairs are made with hex head bolts, and only those welds in the travel area are smooth.

Commercial Class: Stairs of this class are usually for public use and are of more attractive design than those of the service class. They may be placed in open locations or may be located in closed stairwells, in public, institutional or commercial buildings.

Stringers for this class of stairs are usually exposed open channel or plate sections. Treads may be any of a number of standard types, and risers are usually exposed steel. Railings vary from ornamental bar or tube construction with metal handrails to simple pipe construction, and soffits may or may not be covered. Exposed bolted connections in areas where appearance is critical are made with countersunk flat or oval head bolts; otherwise hex head bolts are used. Welds in conspicuous locations are smooth, and all joints are closely fitted.

Architectural Class: This classification applies to any of the more elaborate, and usually more expensive stairs; those which are designed to be architectural features in a building. They may be wholly custom designed or may represent a combination of standard parts with specially designed elements such as stringers, railings, treads or platforms. Usually this class of stair has a comparatively low pitch, with relatively low risers and correspondingly wider treads. Architectural metal stairs may be located either in the open or in enclosed stairwells in public, institutional, commercial or monumental buildings.

The materials, fabrication details and finishes used in architectural class stairs vary widely, as dictated by the architect's design and specifications. As a general rule, construction joints are made as inconspicuous as possible, exposed welds are smooth and soffits are covered with some surfacing material. Stringers may be special sections exposed, or may be structural members enclosed in other materials. Railings are of an ornamental type and, like the treads and risers, may be of any construction desired.

General Requirements, All Classes of Stairs

All fixed metal stairs, regardless of class, are of fire resistant construction and are designed and constructed to carry a minimum live load of 100 pounds per square foot of projected plan area or an alternative concentrated load of 300 pounds applied at the center of any tread span. Railings and handrails are designed and constructed to withstand a minimum force of 200 pounds applied vertically downward and horizontally in a perpendicular direction at any point on the top rail. Complete suggested requirements for all classes of stairs can be found in the Recommended Voluntary Minimum Standards for Fixed Metal Stairs in Section 6 of the Manual.

Use of the Classification System

When using the system, both the Type and Class of stair should be stated. A stair design may readily be identified as, for example, a "straight parallel stair, commercial class", a "curved stair, architectural class", or a "spiral stair, service class". It should be recognized that some types of stair are necessarily made in only one or two classes of construction. Generally, the classes normally applicable to each type are as follows:

Straight stairs — all classes

Circular stairs — usually architectural class but may be commercial, service or industrial class

Curved stairs — architectural class only (always specially designed)

Spiral stairs — usually service or industrial class, but may be commercial or architectural class.

Winder stairs — all classes

Alternating tread stairs — industrial class

Ship's ladder — industrial class

Pre-assembled and pre-erected stairs — all classes

DESIGN FACTORS AFFECTING STAIR COSTS

This Manual is intended not only to stimulate the designer's imagination but also to encourage the appropriate and efficient use of materials and labor in stair construction. The interests of all concerned are best served when the stair is so designed and specified as to properly fulfill its intended purpose, yet provide maximum value received per dollar of cost. The following suggestions are offered as ways of avoiding unnecessary costs without sacrificing essential values. They deserve careful consideration, especially in the design of commercial and service class stairs in multi-storied buildings.

1. Stair Flight Construction

Especially on flights of relatively short run or narrow width, the load carried by the stringers should be checked to see that stringers are not oversized. On many stairs a 10″ channel weighing 6.5 lb./ft. may be adequate, in place of one weighing 8.4 lb./ft.

The use of plate stringers may sometimes effect savings, but in evaluating this possibility, the method of providing rail connections must be considered. Open channel stringers are generally cheaper than boxed stringers, and, for obvious reasons, straight stringers cost much less than curved stringers.

The welding of treads and risers directly to stringers (unit construction) will eliminate the need for carrier angles or bars and will sometimes reduce costs, but such construction should be used only when practically feasible. As welds are made on the upper side of a pan type tread, they are covered by the tread fill. The use of floor plate or tread plate for treads and risers usually results in maximum economy, as the need for tread fill is eliminated.

2. Platform Construction

The provision of a base or curb around platforms by exposing the upper part of the stringers above the platform floor increases costs. A structural frame with platform pan construction and fill on top of it is less expensive and often provides a satisfactory construction. Still further economy can be achieved by the use of a floor or tread plate platform, rather than pan construction and fill, where this type of construction is acceptable.

3. Railings

An economical type of rail for a stair is a steel pipe or tube rail connected at the ends by standard terminal castings to a square or rectangular tube newel. This construction provides rigid support at both ends of a flight, yet permits minor installation adjustments, where necessary, at floors and platforms.

The use of square or rectangular tube for the railing, in place of pipe, provides an alternative at slightly higher cost.

The use of continuous rails without interruption by newel posts or other obstructions, along the flight of the stairs and at floors and platforms between flights, as presently required by codes for most types of construction, increases the cost. However, it does improve the safety of stairs and facilitates their use by persons with certain physical handicaps.

Often, on relatively short flights, the need for intermediate posts on pipe rails can be eliminated by substituting a larger size pipe. This also reduces cost.

4. Connections and Finishing Work

The use of hex head bolts in place of flat or oval head bolts eliminates the necessity of countersinking and speeds stair assembly. Where appearance is not critical, welding neatly done but not ground smooth, provides maximum rigidity at minimum cost. The use of flat or oval head bolts, the grinding of welds and the complete removal of all sharp edges and burrs **only** on the travel surface and wherever they may be a hazard to stair users will result in some savings.

5. Expediting Installation

Metal stairs can usually be installed earlier in a steel framed structure than in one having a concrete frame. Because the erection tolerances in the steel framing around the stairwell are minimal, the stairs can be detailed, shop drawings can be prepared and approved and the stairs can be fabricated before the building frame is erected. In conventional practice the metal stairs can then be installed as soon as the frame is in place. Or, if some of the larger pre-assembled units are used, the stairs may be installed in place, completely self-supporting, **before** erection of the building frame. In any case, delays to subsequent construction are eliminated and overall construction costs are minimized.

If the building has a concrete frame, the stair fabricator can supply the contractor with the necessary detail drawings showing critical dimensions to be maintained, and if maintenance of these dimensions is guaranteed, he can proceed with fabrication so that the stairs can be installed as soon as forms are removed and the stairwell is cleared. Because of the probability of greater dimensional variations in a concrete frame than in a steel frame, consideration should be given to using tube newel railing construction which permits installation adjustments.

When stairs cannot be installed until walls are in place, the contractor should locate and set all anchors and anchor bolts, provide recesses and pockets in floors and walls, and fill in such recesses and pockets after the stairs are installed, all in accordance with the approved shop drawings. Of course it's his responsibility, too, to see that stairwells are cleared of all debris and interference before the installation begins.

When considered individually, these potential ways of reducing stair costs may not seem very significant, and the savings on a small job may not be very large. But collectively, and especially when applied to installations in multi-storied buildings, they can result in substantial economies.

SECTION 2

INSTALLATIONS REPRESENTATIVE OF STAIRS MEETING NAAMM MINIMUM STANDARDS

Photographs and principal details of a number of stairs, typical of those made by NAAMM member companies, are presented in this section of the Manual. Examples of all of the common types and classes of stairs are included. These types of stairs are readily available. They are fabricated from standard components and materials and installed in accordance with the practices developed by the metal stair industry over many years.

These stairs meet minimum standards recommended by NAAMM. However, because the design of stairs is controlled by building codes, the designer is advised that, should designs similar to any of those illustrated be considered for use, certain modifications may be necessary to conform to governing code requirements.

NOTE: In each case the descriptions given apply only to the stair shown.

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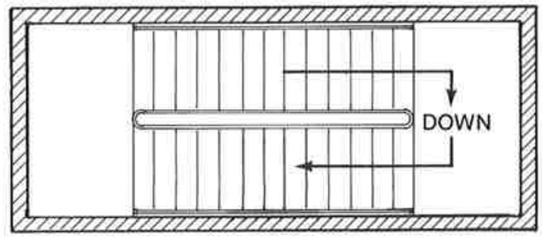
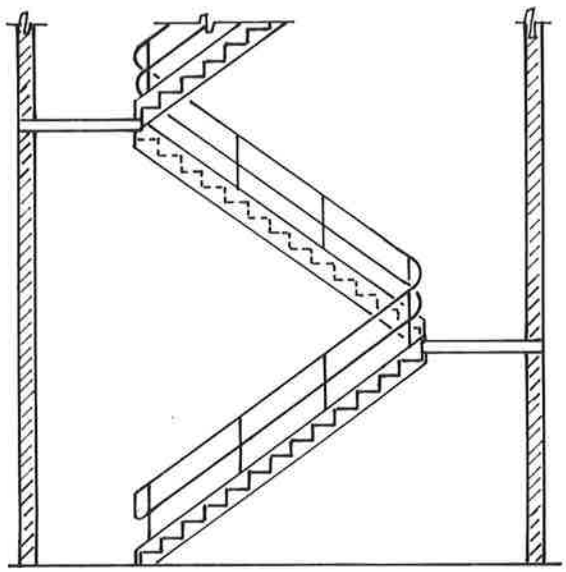
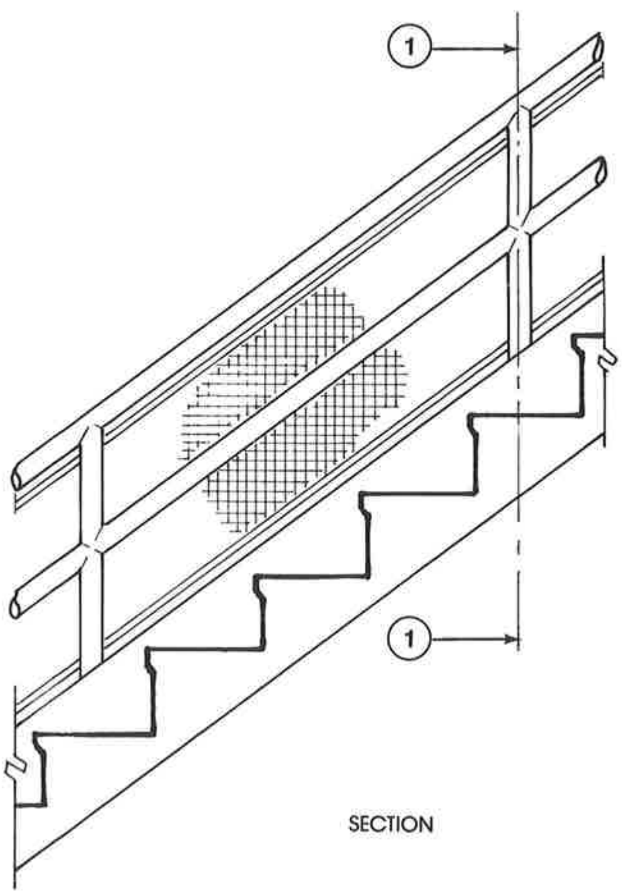


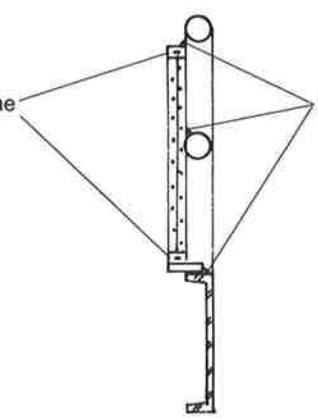
PLAN



ELEVATION



SECTION



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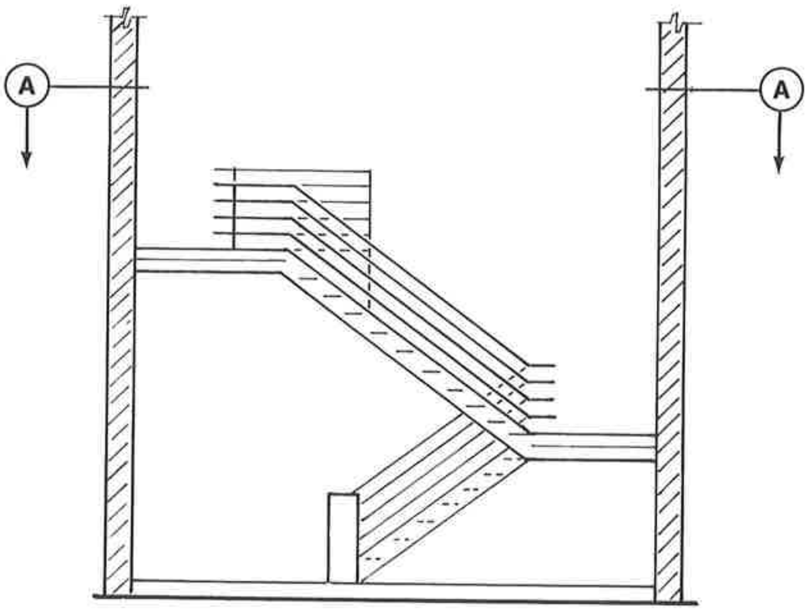
DESCRIPTION

Stringers — Steel channels.

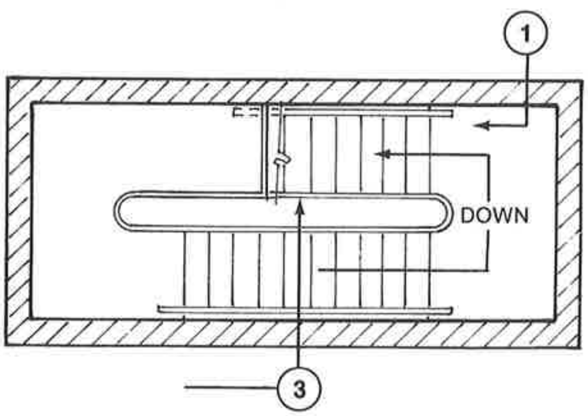
Treads and Risers — Sheet and steel.

Railing — Steel pipe mounted on stringers with framed woven wire panel attached by welding at all posts and rails.

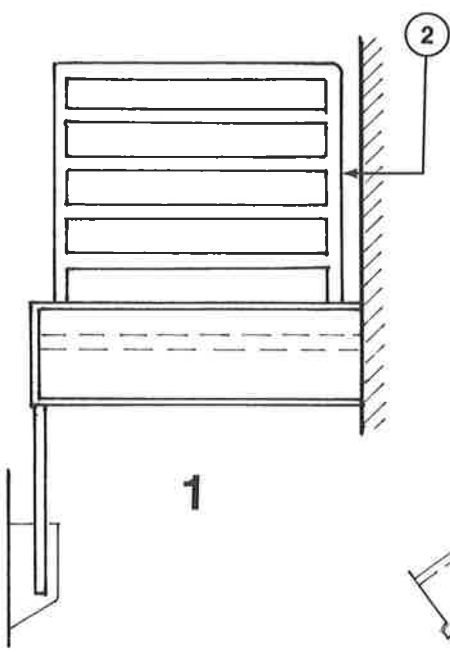
Finish — Painted.



SECTION THROUGH STAIR



PLAN A-A



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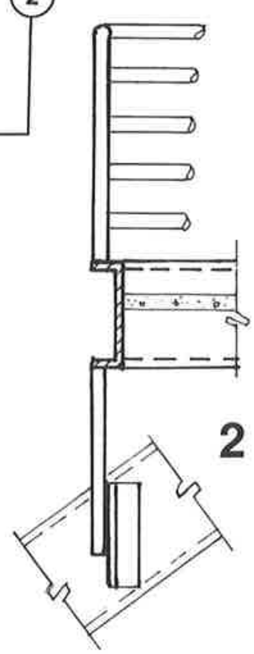

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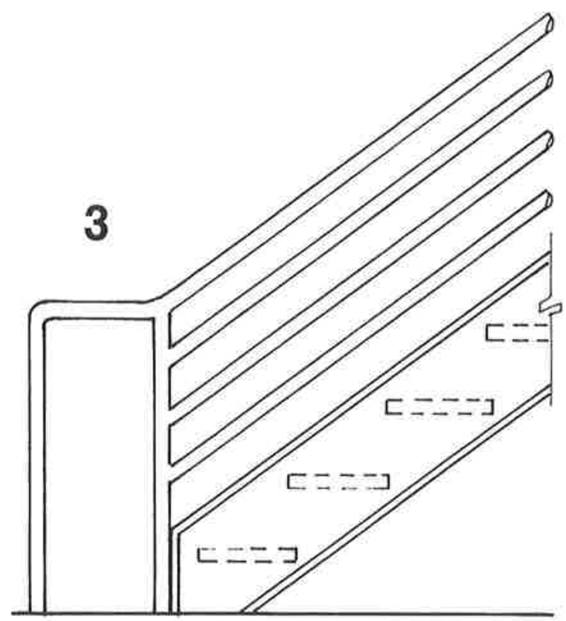

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DESCRIPTION

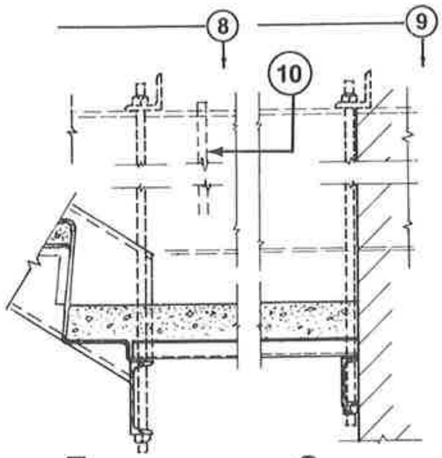
Stringers — Structural steel channels.

Treads — Steel pans, concrete filled.

Platforms — Steel sheet deck, concrete filled.

Railing — Steel pipe, welded to posts.

Finish — Steel painted.



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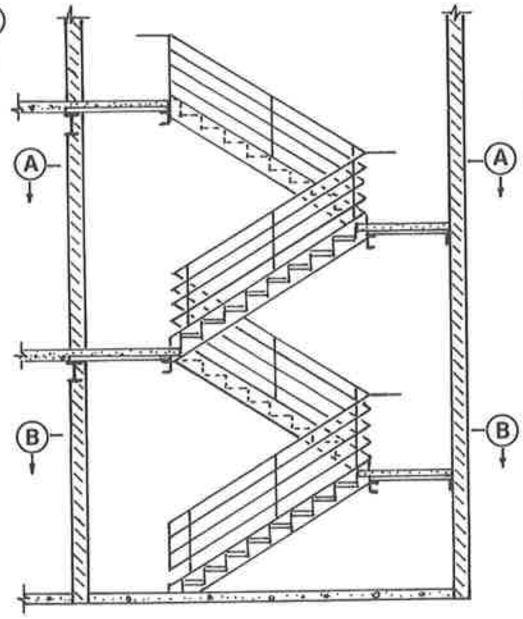
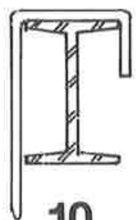


SECTION THROUGH STAIR



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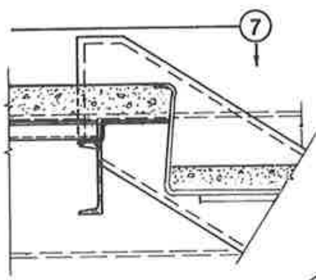

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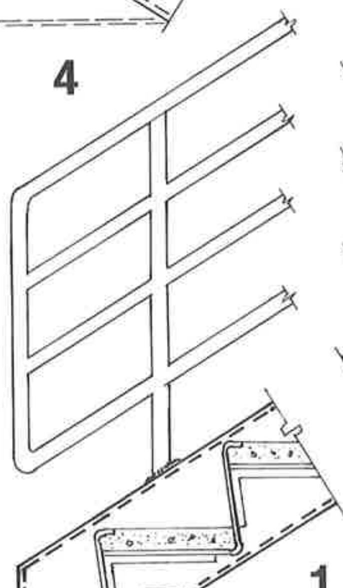

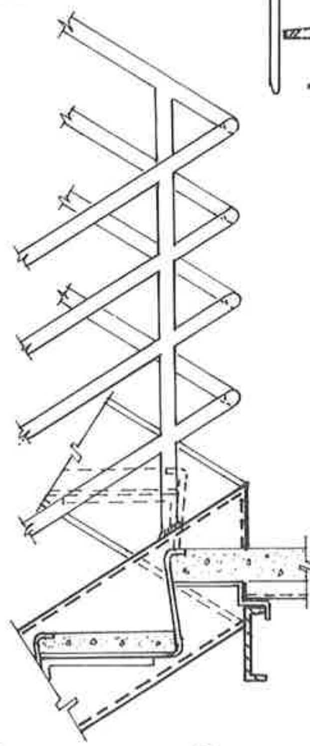

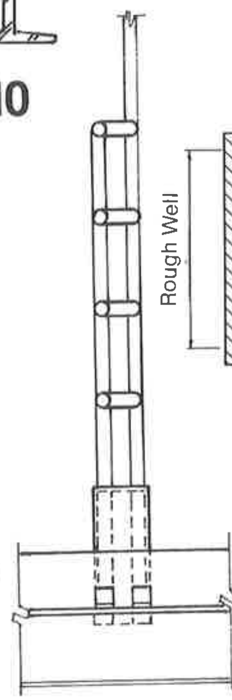

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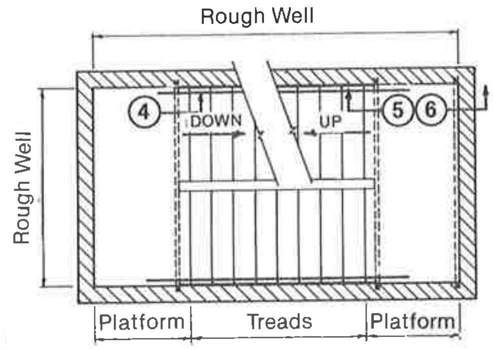
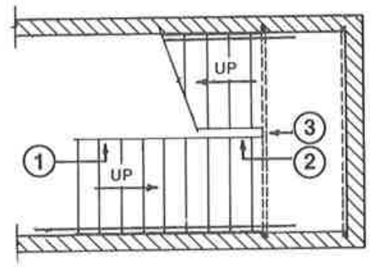


PLAN A-A



PLAN B-B

DESCRIPTION

Stringers — Structural steel channels.

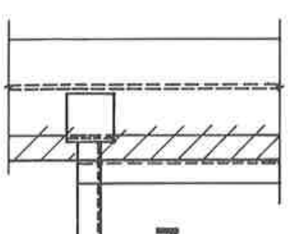
Treads — Formed steel sheet, concrete filled.

Risers — Formed steel sheet, exposed.

Platforms — Steel sheet deck, concrete filled; flight headers and platform headers structural channels; both suspended on hanger rods.

Railing — Steel pipe, welded.

Finish — Steel painted.



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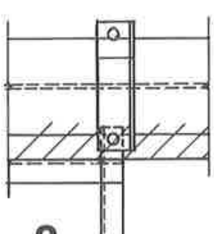

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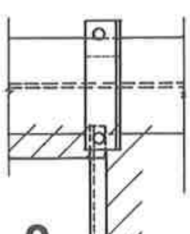

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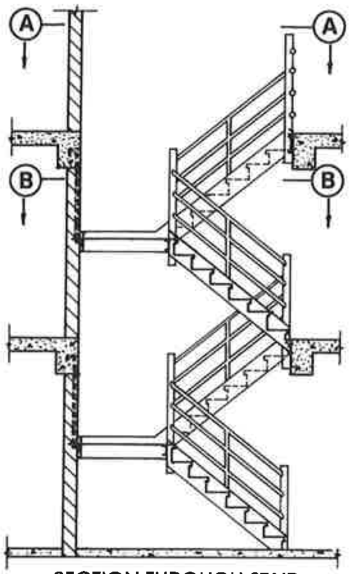
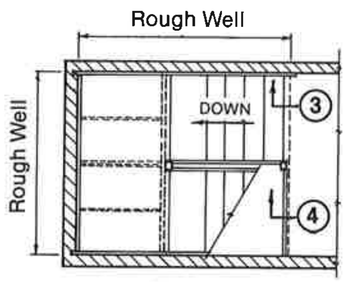
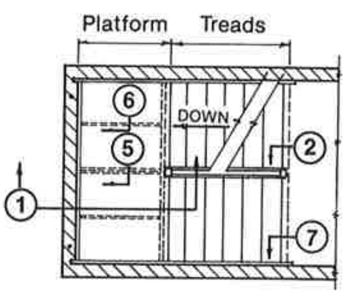


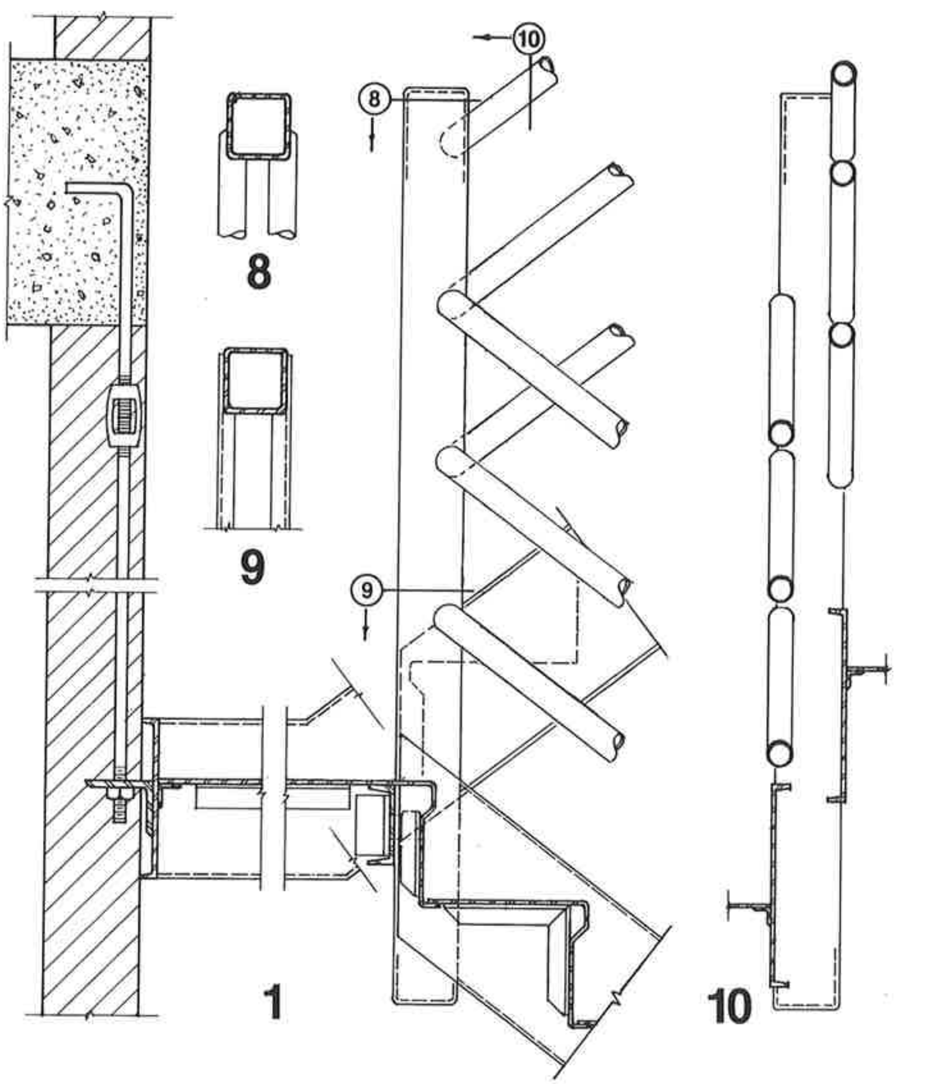
SECTION THROUGH STAIR

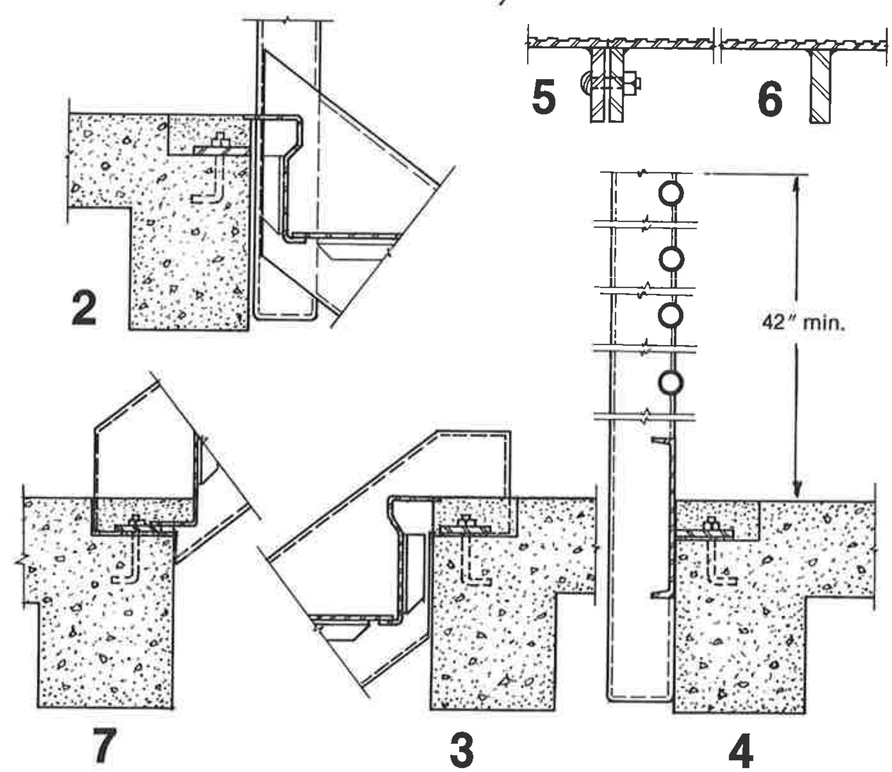


PLAN A-A



PLAN B-B





DESCRIPTION

Stringers — Structural steel channels.

Treads — Steel floor plate.

Risers — Steel sheet.

Platforms — Steel floor plate; flight headers structural steel channels; intermediate, supports steel bars at mid-point, steel bars at plate edge. Supported by hanger rods.

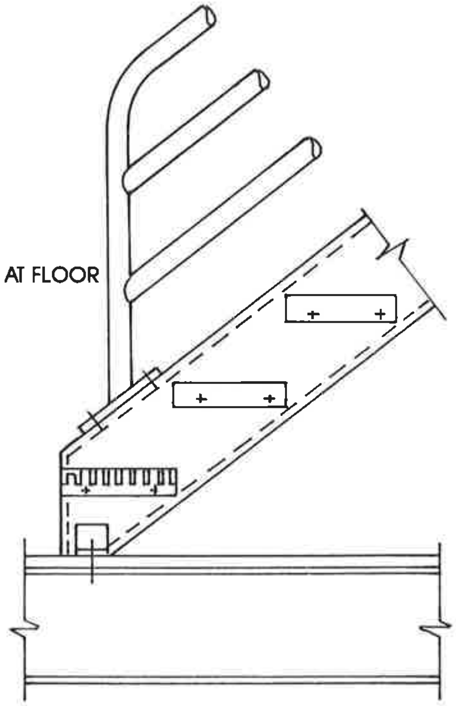
Newels — Square steel tubing, welded to face stringers at platforms.

Railing — Steel pipe welded to newels.

Wall Handrail — Steel pipe, malleable iron brackets.

Finish — Steel painted.

NOTE: Check governing code for rail spacing requirements.



DESCRIPTION

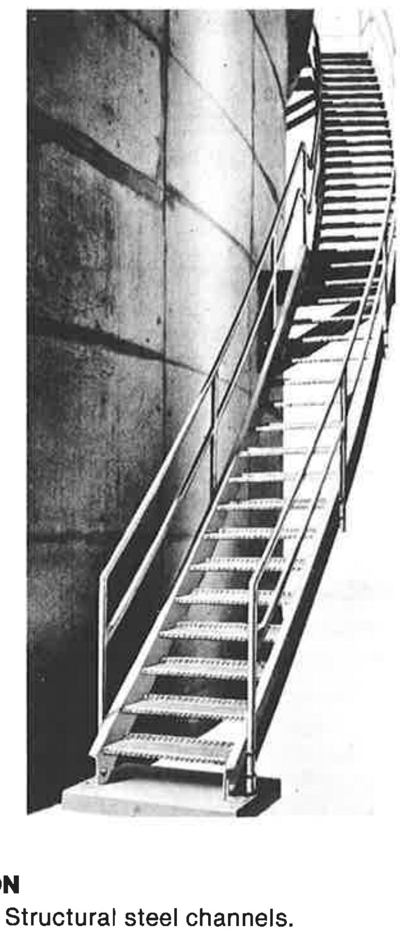
Stringers — Structural aluminum channels.

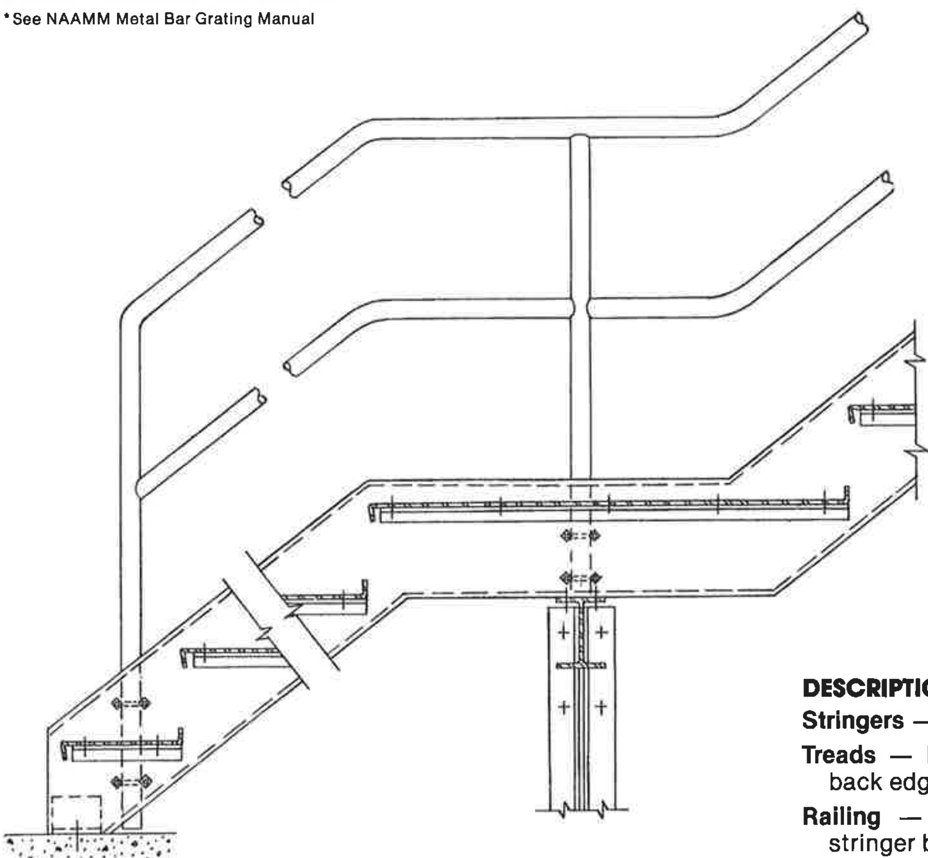
Treads — Aluminum bar grating*; abrasive nosing.

Railing — Aluminum pipe, bolted to stringer.

Finish — Aluminum anodized.

*See NAAMM Metal Bar Grating Manual





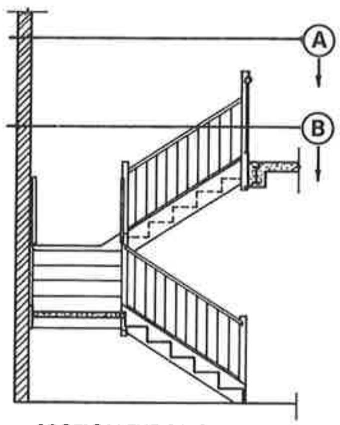
DESCRIPTION

Stringers — Structural steel channels.

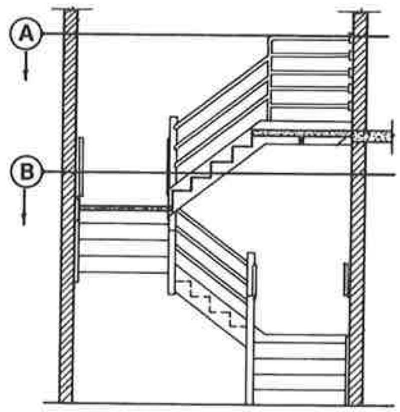
Treads — Floor plate formed with nosing and back edge stiffener.

Railing — Steel pipe, welded, connected to stringer by U-bolts.

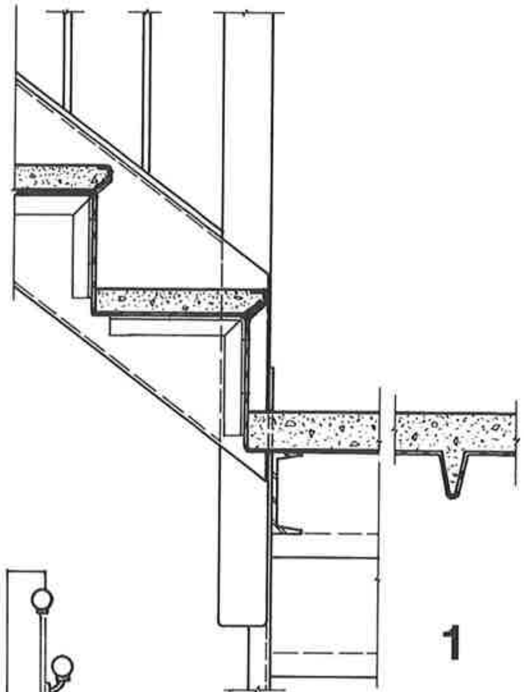
Finish — Steel painted.



SECTION THROUGH STAIR



SECTION THROUGH STAIR



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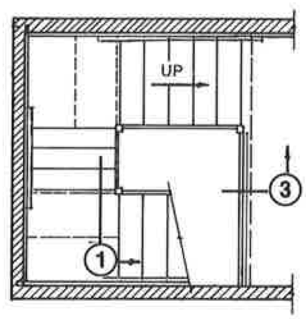
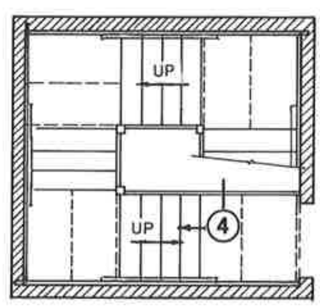
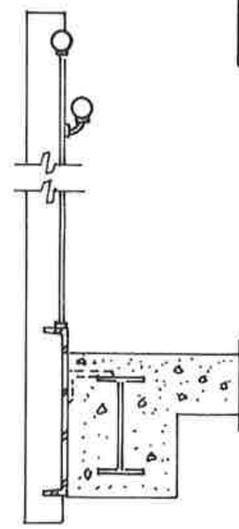


PLAN A



PLAN A



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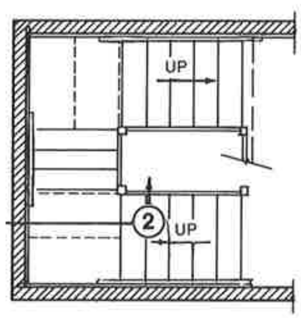
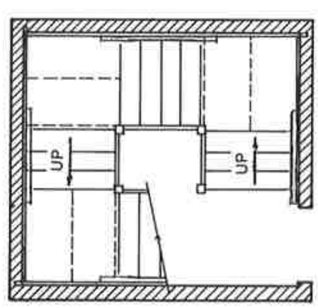


PLAN B



PLAN B

DESCRIPTION

Stringers — Structural steel channels welded or bolted to newels.

Treads — Formed steel sheet, concrete filled.

Risers — Steel sheet exposed.

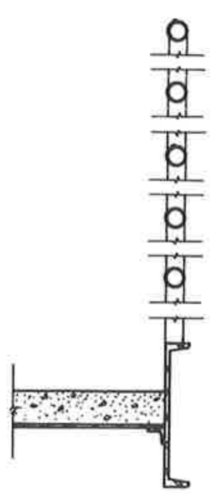
Platform — Steel sheel with ribs, concrete filled. Structural steel channel flight headers continuously welded to face stringers and bolted to wall stringers.

Newels — Square steel tubing, capped both ends.

Railing — Steel pipe handrail. Square steel bar balusters welded to top and bottom steel channels, or parallel steel pipes welded to newels.

Wall Handrail — Steel pipe on malleable iron brackets.

Finish — Steel painted.



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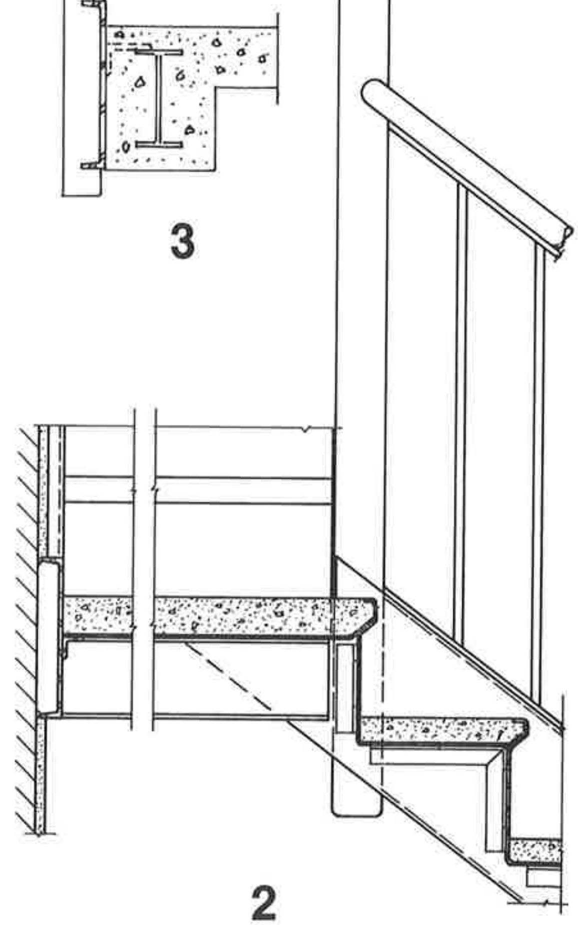

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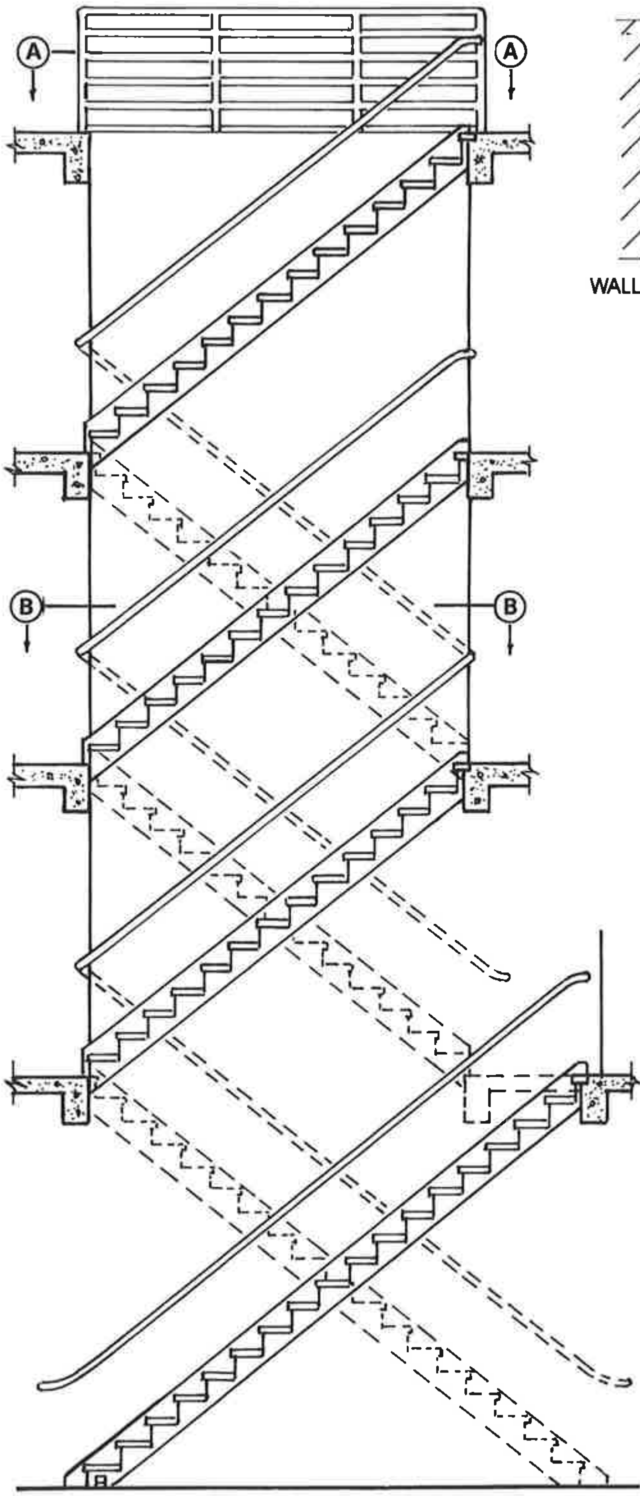
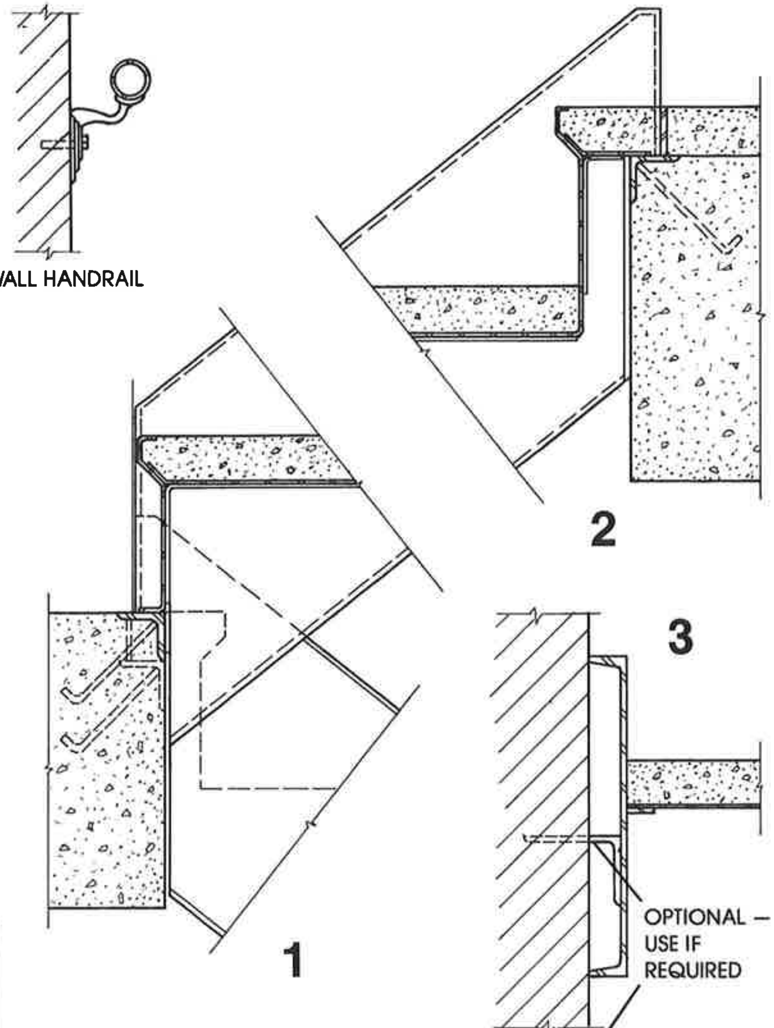
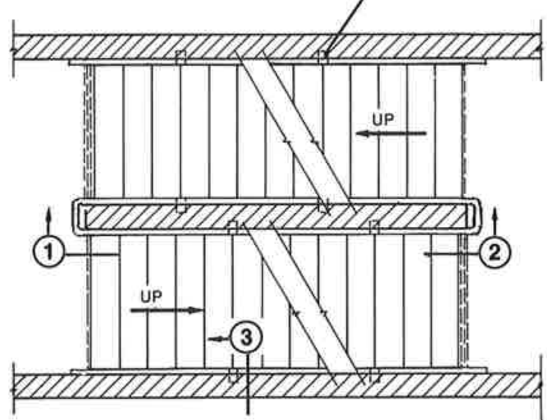
NOTE: For steel bar baluster guardrails side-mounted handrails are recommended.



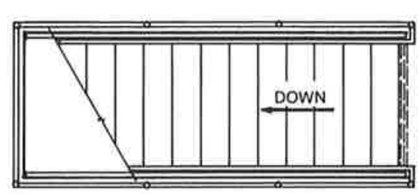
SECTION THROUGH STAIR

WALL HANDRAIL





PLAN B-B



PLAN A-A

DESCRIPTION

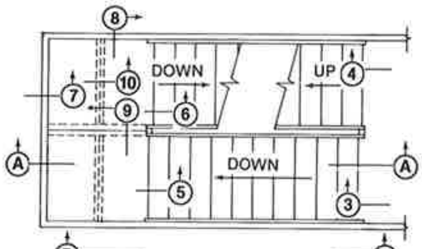
Stringers — Structural steel channels.

Treads — Steel sheet. Concrete filled.

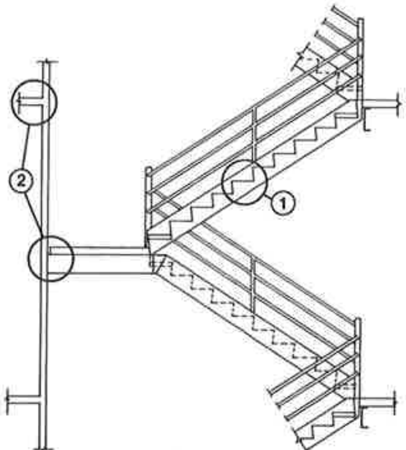
Risers — Steel sheet exposed.

Wall Handrail — Steel pipe on brackets, both sides of each flight.

Finish — Steel painted.

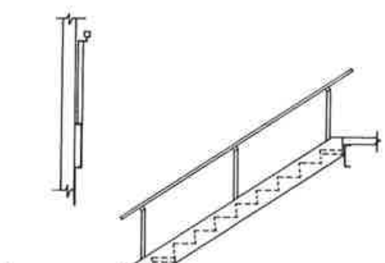


PLAN



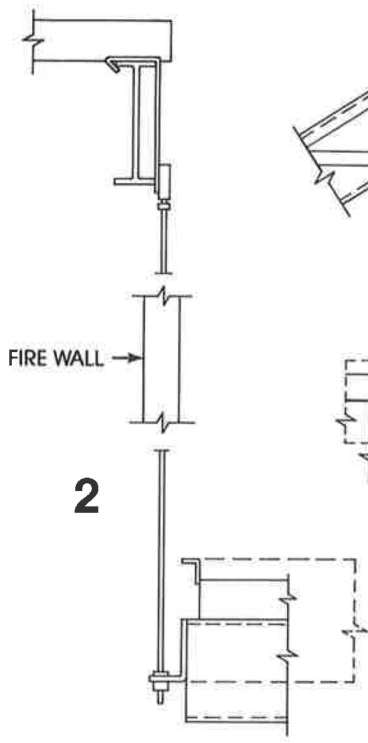
CLOSED RISER

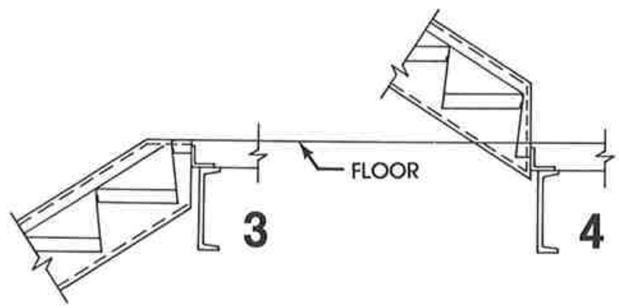
OPEN RISER

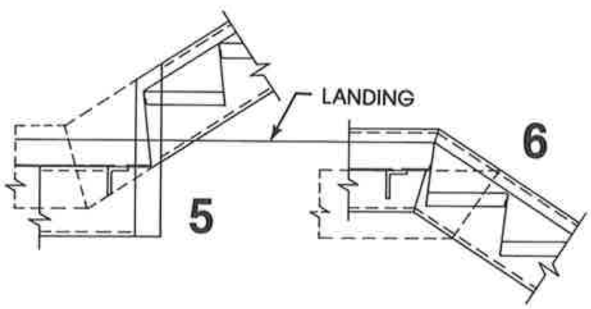


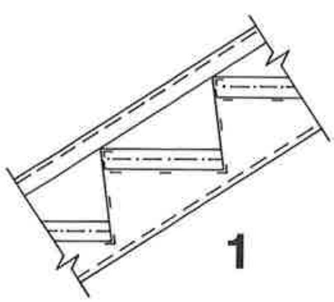
SECTION A-A

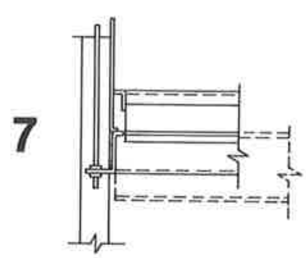
SECTION B-B

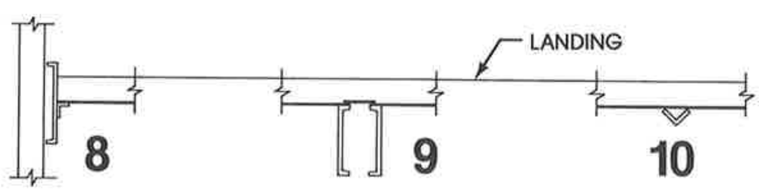












DESCRIPTION

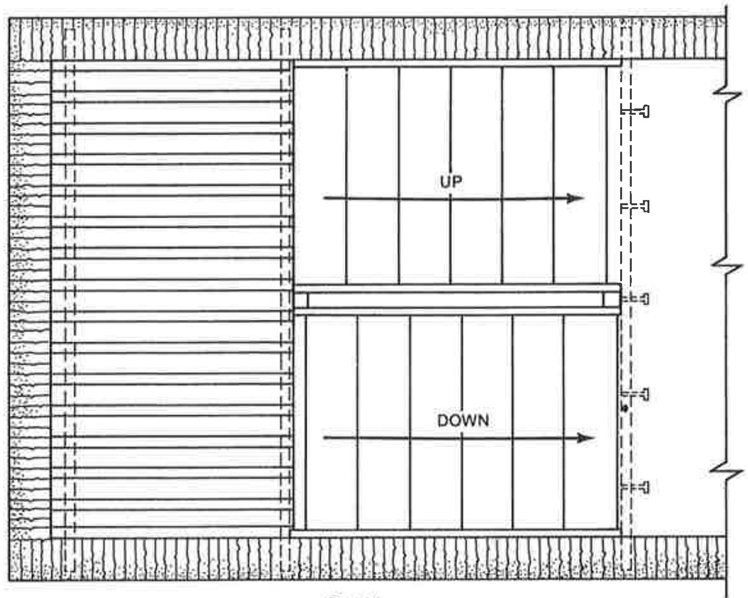
Stringers — Structural steel channels.

Treads and Risers — Formed steel sheet. Treads concrete filled. Risers exposed. May be open risers with floor plate or grating.

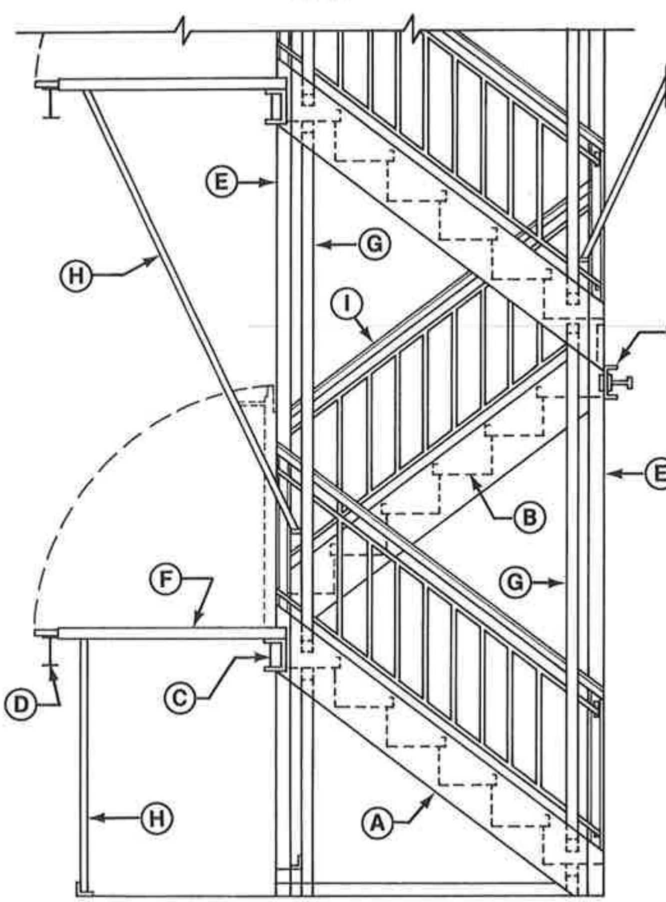
Landing — Steel sheet pans with welded angle stiffeners. Pans concrete filled.

Newels —Square steel tubing.

Railing — Square steel tubing. May be continuous around newel.



PLAN



SIDE ELEVATION

DESCRIPTION

Stair Stringers — (A) Structural steel channels.

Treads and Risers — (B) Formed steel sheet, concrete filled.

Headers — (C) Structural steel channels.

Platform Support — (D) Structural steel I-beam.

Newel — (E) Square steel tubing.

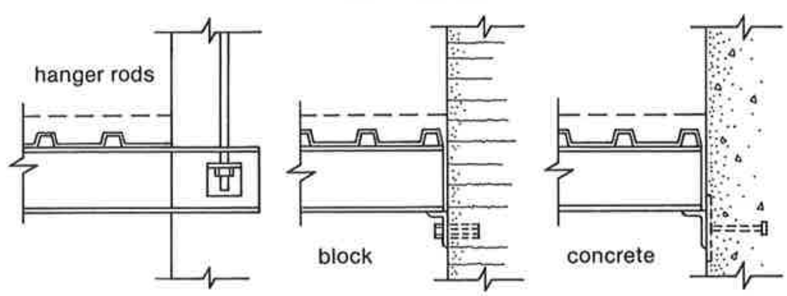
Metal Deck — (F) Ribbed steel sheet.

Temporary Bracing — (G) Steel angles.

Temporary Bracing — (H) Steel pipe.

Railing — (I) Balusters welded to flat bar, top and bottom. Steel pipe railings.

Finish — Steel painted.



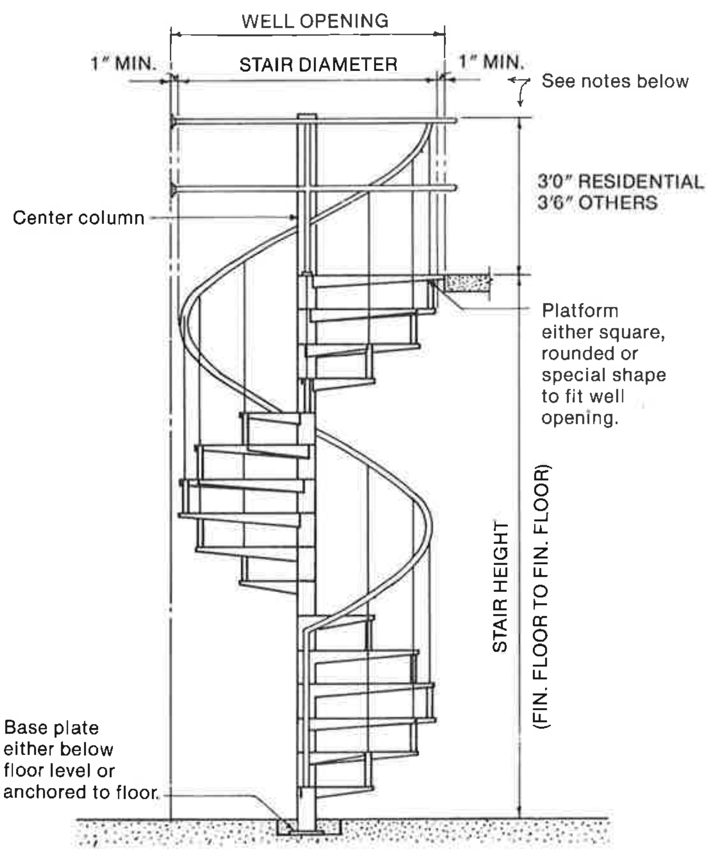
ALTERNATE METHODS OF SUPPORT

CONSTRUCTION: Material may be steel, stainless steel, cast iron or aluminum. Treads are supported in cantilever fashion by the column, each consecutive tread being rotated at a predetermined angle. The platform attaches to the column and is fastened to the floor structure to hold the column secure. The spiral railing is supported by balusters attached to the other ends of the treads.

TREAD DESIGNS: Fabricators provide several standard types and designs of treads and platforms. These include open riser, closed riser and cantilever types, with surface of checkered plate, abrasive plate, steel grating or plain surface to receive wood, resilient flooring, carpet or other covering. Pan type treads to receive concrete or terrazzo fill are also available.

STAIR HEIGHT: Spiral stairs are adaptable to any height, the height being equal to the distance from finished floor to finished floor.

HEADROOM: NAAMM recommends 78″ minimum. However, building codes generally dictate headroom requirements, some codes requiring 80″ minimum clearance. Minimum riser dimensions given are based on this requirement.
CAUTION: Depth of landing must be considered to determine the minimum headroom dimension.

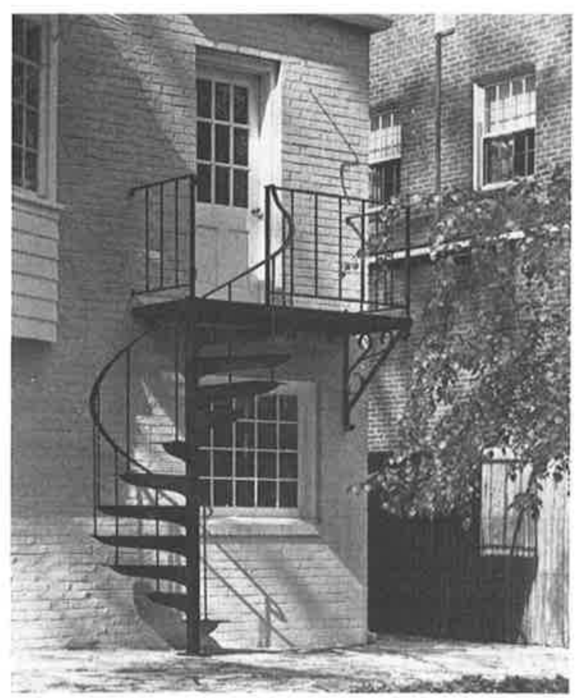


TYPICAL ELEVATION — RIGHT HAND OPEN RISER STAIR

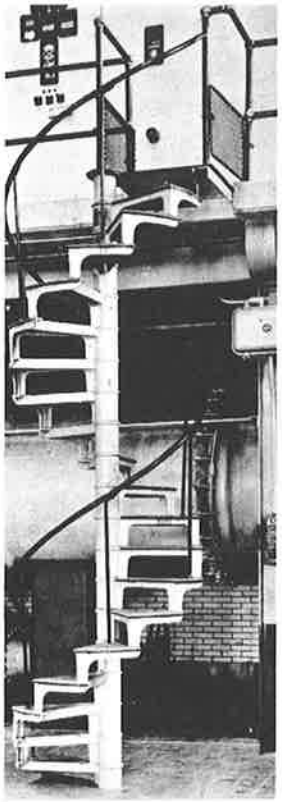
NOTES: Governing codes should be consulted by the architect to see that stairs conform to requirements. Consult manufacturers' catalog for details, and specifications.

RESIDENTIAL TYPE — INDOORS

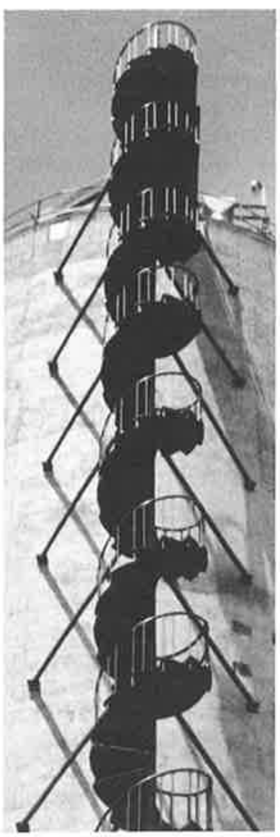
SPIRAL STAIRS are used either indoors or outdoors, conserve valuable floor or ground space and provide the most vertical ascent of any stair. They are of rugged self-supporting construction, graceful in design and architecturally attractive in appearance.



RESIDENTIAL TYPE — OUTDOORS

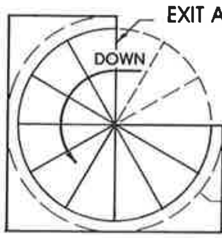


COMMERCIAL TYPE



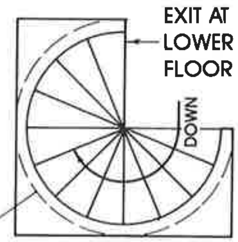
INDUSTRIAL TYPE

STAIR DIAMETER: Spiral stairs are availbale in various diameters from 3′6″ to 8′0″, normally in 6″ increments. A 4′0″ diameter is considered minimum for general access purposes; a 5′0″ diameter provides a comfortable general purpose stair. Larger diameters are used chiefly for architectural effect. NOTE that the diameter of the finished well opening should be at least 2″ greater than the stair diameter, to provide hand clearance.



Minimum clearance between well opening and handrail is 1″

Well opening may be either square or circular



PLAN AT TOP FLOOR
Left Hand, 30°, Full Circle

PLAN AT TOP FLOOR
Right Hand, 22½°, ¾ Circle

HAND OF STAIRS:
Left-hand stairs — User ascends in clockwise direction, with handrail at his left.
Right-hand stairs — user ascends in counter clockwise direction, with handrail at his right.

RISER HEIGHTS FOR VARIOUS TREAD ANGLES

TREAD ANGLE	MIN HEIGHT OF RISER*	TREADS PER 3/4 CIRCLE	TREADS PER FULL CIRCLE
30°	8-15/16″(-)	9	12
27°	8″	10	13 = 351°
24-1/2°	7-5/16″(-)	11	15 = 367-1/2°
22-1/2°	6-11/16″(-)	12	16

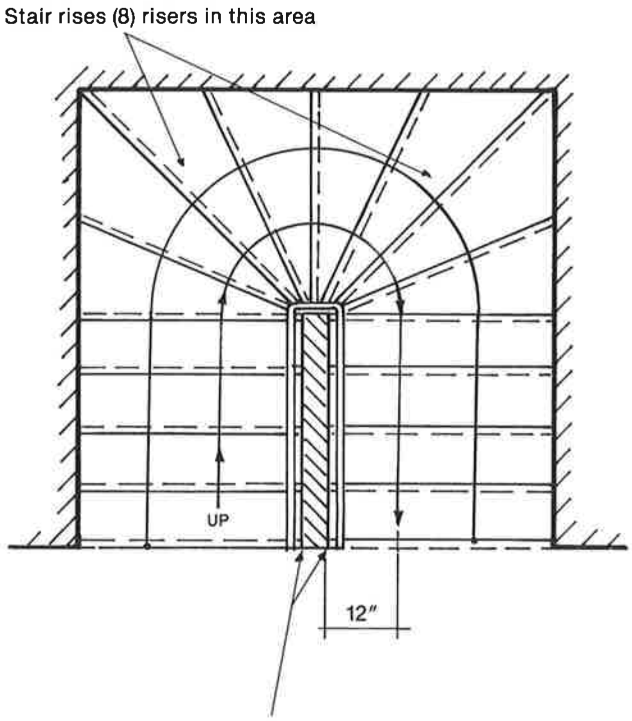
* Minimum height to attain 6′-6″ clear headroom using a 90° landing, 2″ thick.

CHART FOR SELECTION OF NUMBER AND HEIGHT OF RISERS

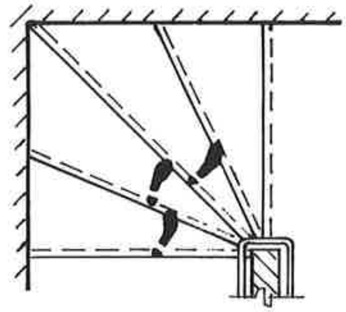
FLOOR TO FLOOR HEIGHT	NUMBER OF RISERS AND HEIGHT OF EACH IN INCHES								
	10	11	12	13	14	15	16	17	18
7′0″	8.4	7.6	7.0						
7′4″	8.8	8.0	7.3	6.8					
7′8″	9.2	8.4	7.7	7.0					
8′0″	9.6	8.7	8.0	7.4	6.9				
8′2″	9.8	8.9	8.2	7.5	7.0				
8′4″		9.1	8.3	7.7	7.1	6.7			
8′6″		9.3	8.5	7.8	7.3	6.8			
8′8″		9.4	8.7	8.0	7.4	6.9			
8′10″			8.8	8.2	7.6	7.1	6.6		
9′0″			9.0	8.3	7.7	7.2	6.7		
9′2″			9.2	8.5	7.9	7.3	6.9		
9′4″			9.3	8.6	8.0	7.5	7.0		
9′6″				8.8	8.1	7.6	7.1	6.7	
9′8″				9.0	8.3	7.7	7.2	6.8	
9′10″				9.2	8.4	7.9	7.4	6.9	
10′0″				9.3	8.6	8.0	7.5	7.0	6.7
10′2″					8.7	8.1	7.6	7.2	6.8
10′4″					8.9	8.3	7.7	7.3	6.9
10′6″					9.0	8.4	7.9	7.4	7.0
10′8″					9.1	8.5	8.0	7.5	7.1
10′10″						8.6	8.1	7.6	7.2
11′0″						8.7	8.2	7.8	7.3
11′2″						8.9	8.4	7.9	7.4
11′4″						9.0	8.5	8.0	7.6
11′6″							8.6	8.1	7.7
11′8″							8.7	8.2	7.8
12′0″							9.0	8.5	8.0

SPECIFICATIONS REQUIRED FOR PRICING AND MANUFACTURE:

1. Stair diameter and height from each finished floor to finished floor level.
2. Type of stair and tread surface or tread design.
3. Simple sketch showing all starting and landing positions, adjacent walls or partitions, if any, and size of well opening.
4. Type of metal.
5. Type of platform and well railing required.
6. Detail of any special design or requirement.



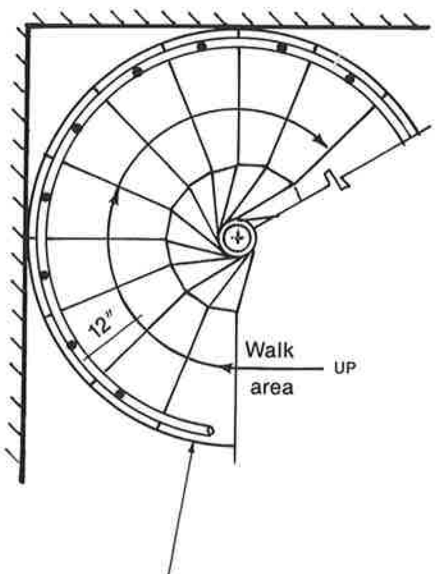
Handrail (inner) side of stair
WINDER STAIR



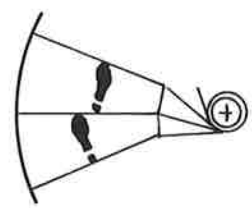
Winder stair walk pattern
(Rhythm broken)

Note diminished width of treads in walk area.

A stair is called a winder stair when the direction of a straight flight of stairs is changed by substituting fixed treads for a landing. The line of travel is close to the rail and the turn is made at the narrow width of the treads, breaking the walk pattern.



Handrail (outer) side of stair
SPIRAL STAIR

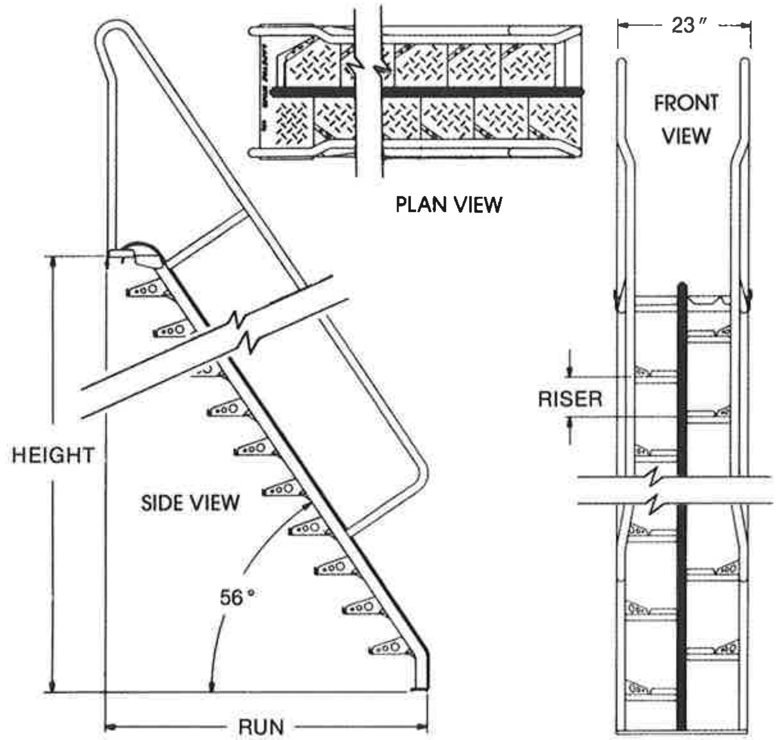


Spiral stair walk pattern
(Rhythm constant)

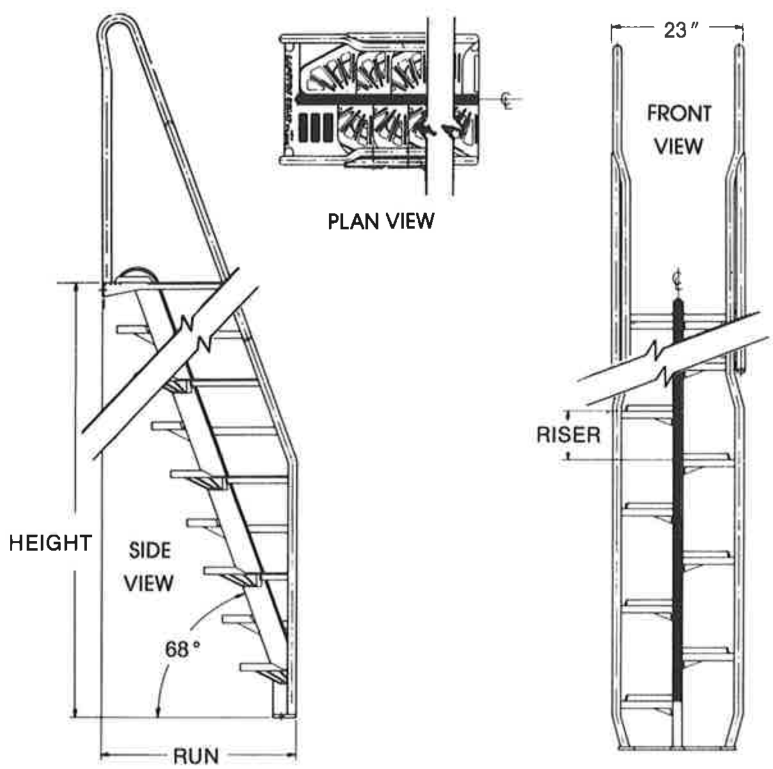
Note equal width of treads in walk area.

In a spiral stair the line of travel is at the outer or widest part of the tread. The walk pattern is also toward the spiral rail. At no time is the line of travel near the center pole or the inside of the tread. the hand is always on the rail whether ascending or descending.

56° STEEL



68° ALUMINUM



DESCRIPTION

Steel Stairs 56° or 68° angle.
Available in carbon steel or stainless steel.

Construction — All welded with bolt-on handrails.

Finish — Stainless steel, natural. Carbon steel, primer or optional safety yellow paint, also available with hot dipped galvanized coating.

Aluminum Stairs 68° angle.

Construction — All welded.

Finish — Natural.

DESCRIPTION

Stringers — Structural channels, aluminum or steel.

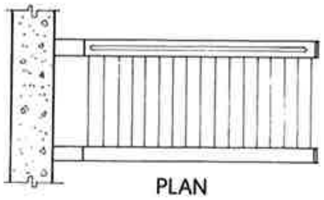
Treads — Rectangular bar grating. Aluminum grating bolted to aluminum stringer. Steel grating bolted or welded to steel stringer. Corrugated or abrasive nosing for aluminum grating. Checkered plate or abrasive nosing for steel.

Risers — Open.

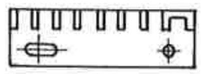
Railing — Pipe. Posts welded to railing. Aluminum posts bolted to aluminum stringer. Steel posts bolted or welded to steel stringer.

Fasteners — Stainless steel for aluminum. Steel for steel.

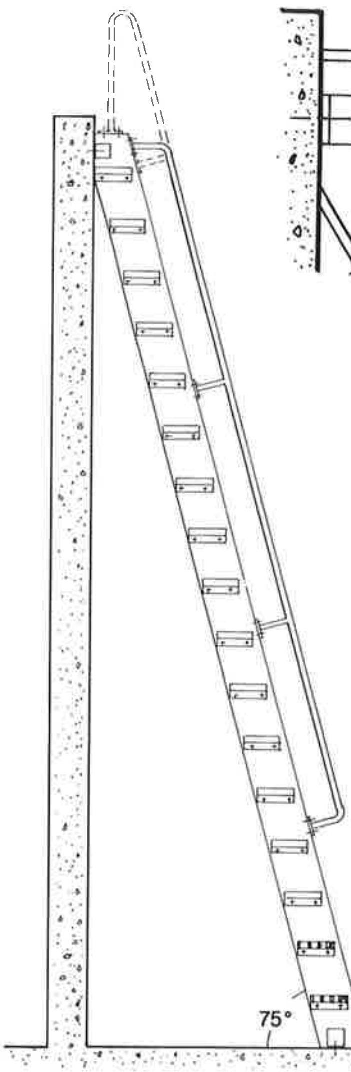
Finish — Aluminum, mill finish or anodized. Steel galvanized and/or painted.

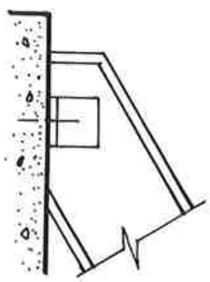


PLAN



Tread





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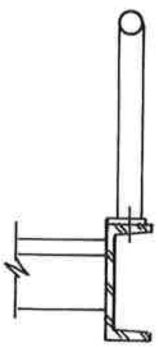

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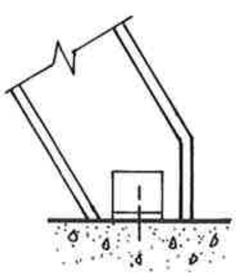

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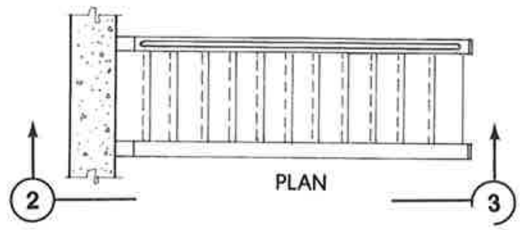
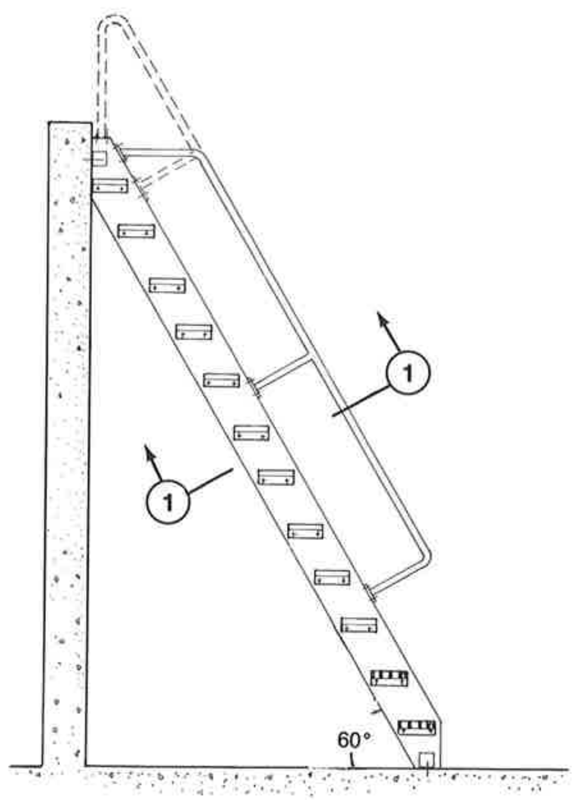
ELEVATION





ELEVATION

SECTION 3

INSTALLATIONS REPRESENTATIVE OF CUSTOM DESIGNED STAIRS

Section 2 presents the more standardized type of metal stair construction. This section presents stairs which were custom designed to achieve aesthetic effects as well as serve functional needs of the building. Photographs and details shown in this section of the Manual are mostly of stairs made by NAAMM members.

As in the case of Section 2, the designer is advised that, should designs similar to any of those illustrated in this section be considered for use, certain modifications may be necessary to conform to governing code requirements.

NOTE: In each case the descriptions given apply only to the stair shown.

CONTENTS

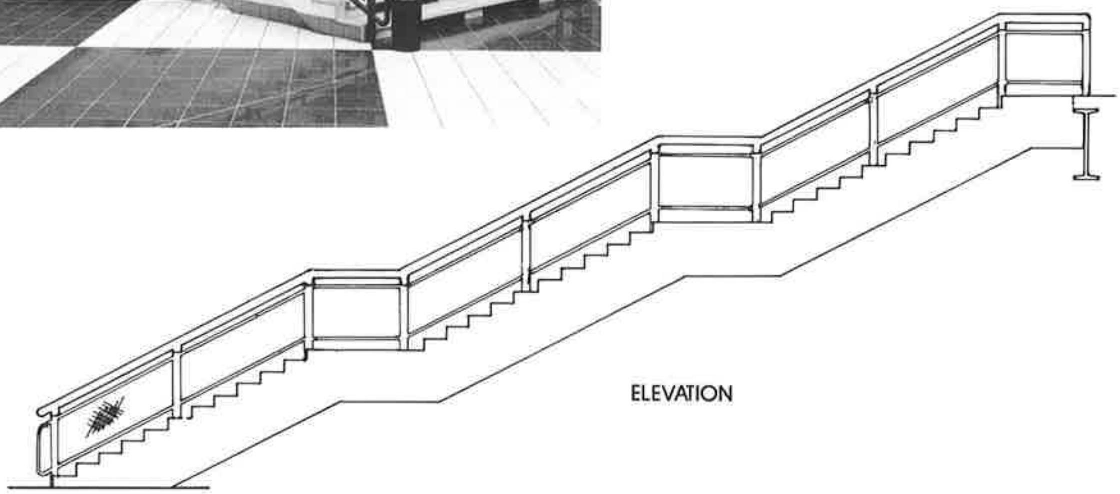
DESCRIPTION

Stringers — Steel I-beams.

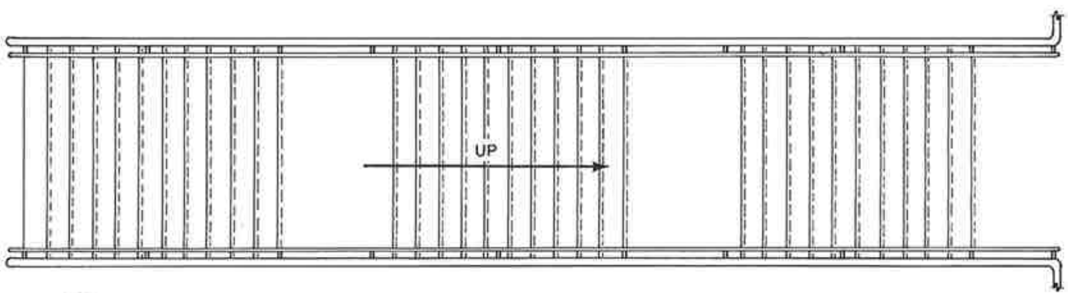
Treads — Steel pans, reinforced, filled with concrete. Open risers.

Railing — Steel pipe with brass tubing top rail and handrail. Infill framed expanded aluminum, attached to steel posts and rails.

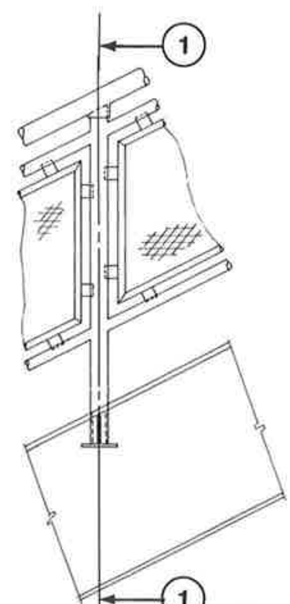
Finish — Painted steel. Natural brass.

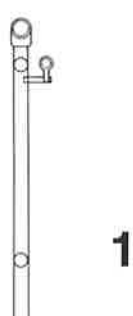


ELEVATION



PLAN





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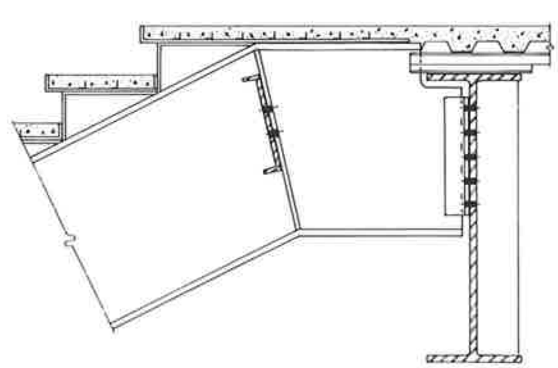


Stringer connection to existing steel

DESCRIPTION

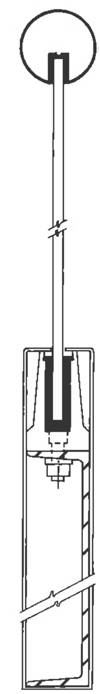
Stringers — Steel channels covered with formed stainless steel.

Treads and Risers — Z profile sheet steel formed to provide integral pan type tread and riser units. Supported on bent bar shelf and back-up welded to stringers. Filled with concrete and covered with carpeting.

Landing — Stiffened sheet steel pans, reinforced concrete filled, supported by structural channels.

Railing — Tempered glass panels supported in aluminum shoe moldings on resilient plastic setting blocks, two per panel, located at quarter points. Shoe moldings fastened to top of stringers with cap screws. Stainless steel circular cap railing.

Finish — All stainless steel #4 bright polish finish.



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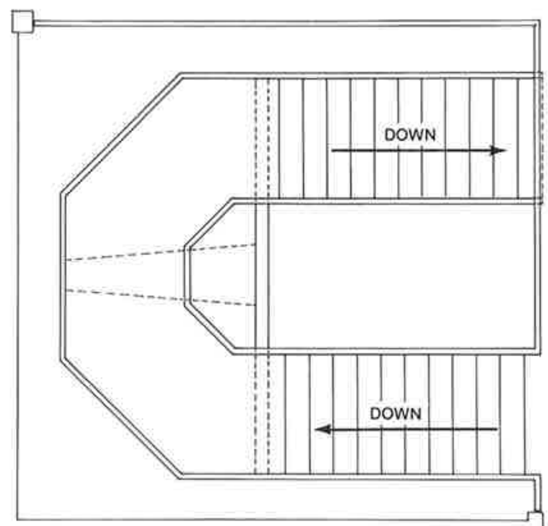
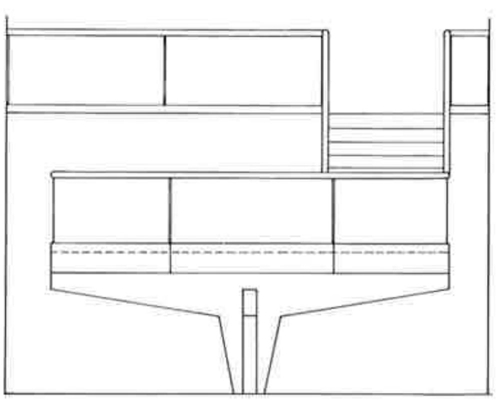
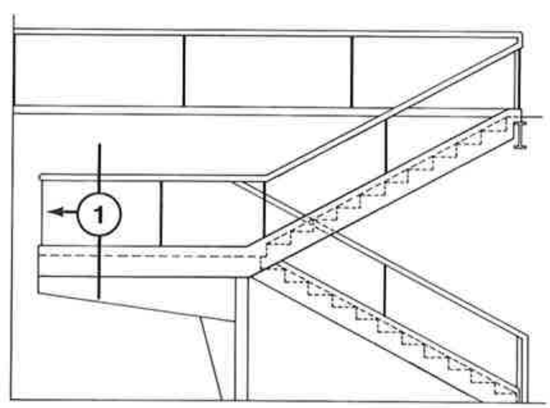


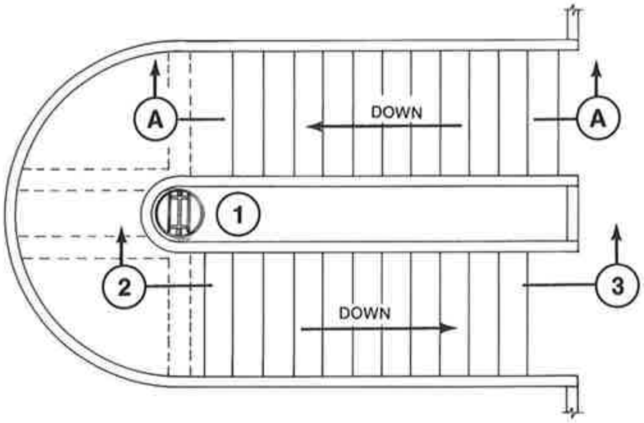
PLAN



REAR ELEVATION



SIDE ELEVATION



PLAN

DESCRIPTION

Stringers — Steel hollow rectangular shape.

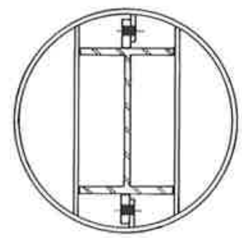
Treads and Risers — Integral pan tread and riser, formed steel, concrete filled.

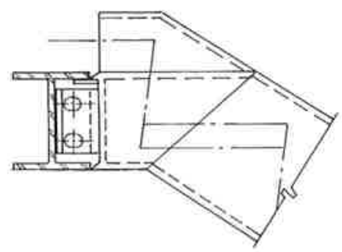
Platforms — Steel pan, concrete filled.

Railing and Posts — Steel pipe, welded connections.

Finish — Steel painted.

1





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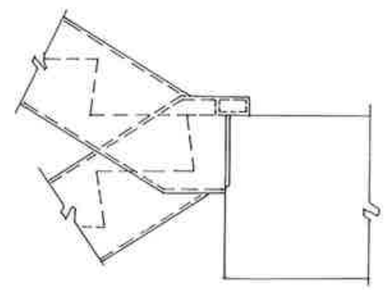

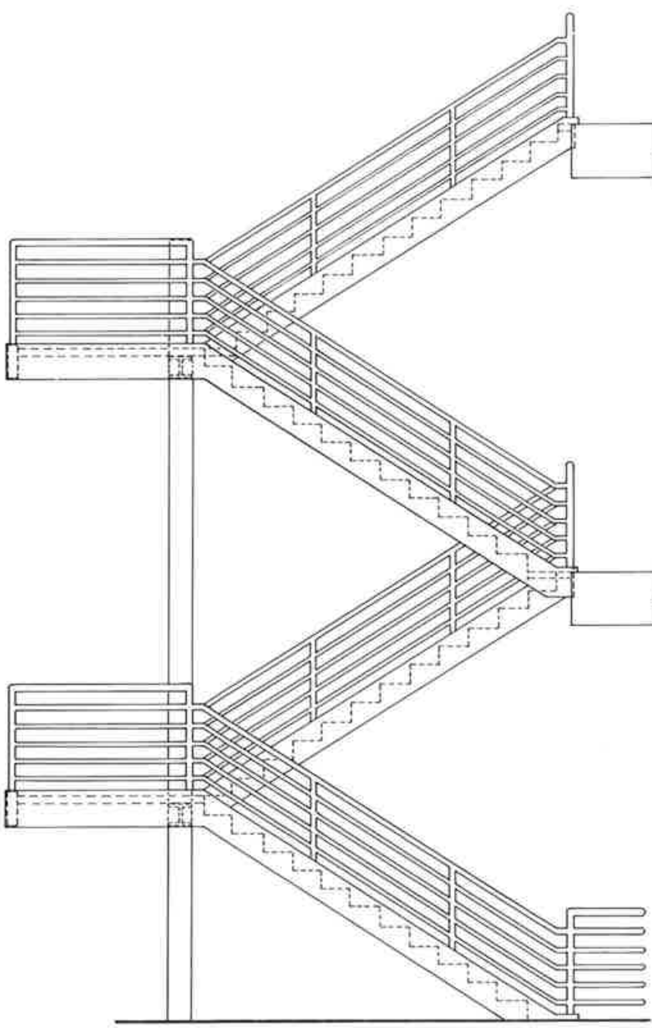

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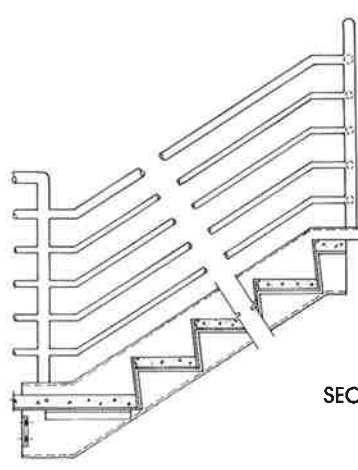
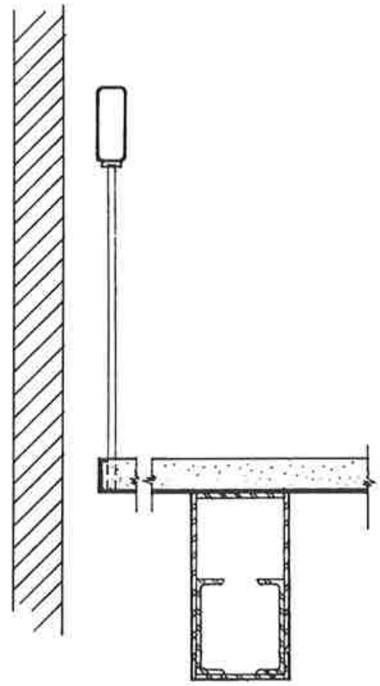


SECTION A-A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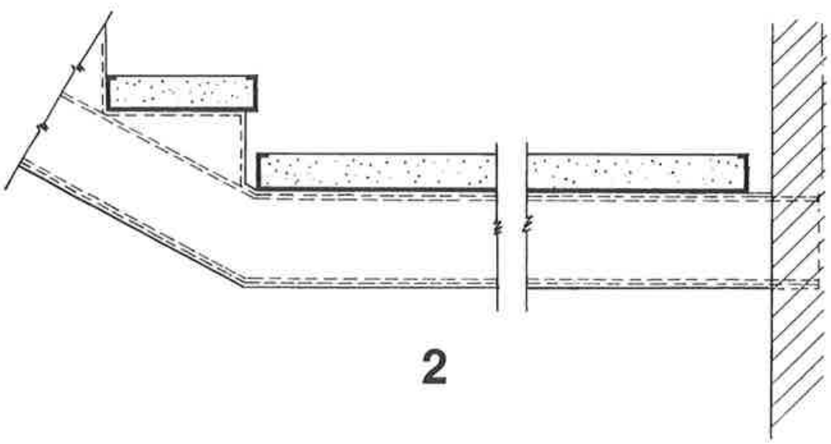
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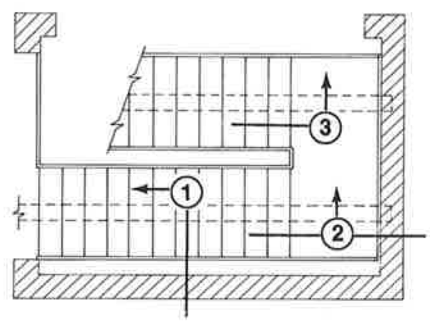
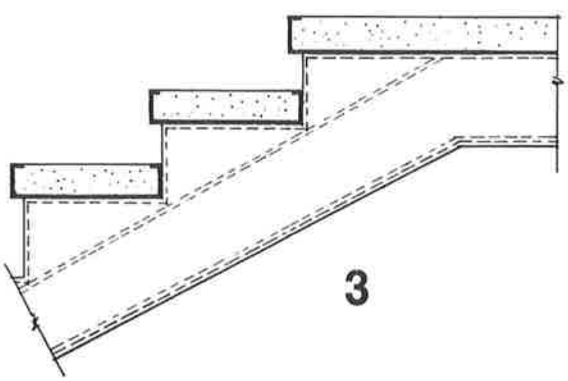


PLAN


3

DESCRIPTION

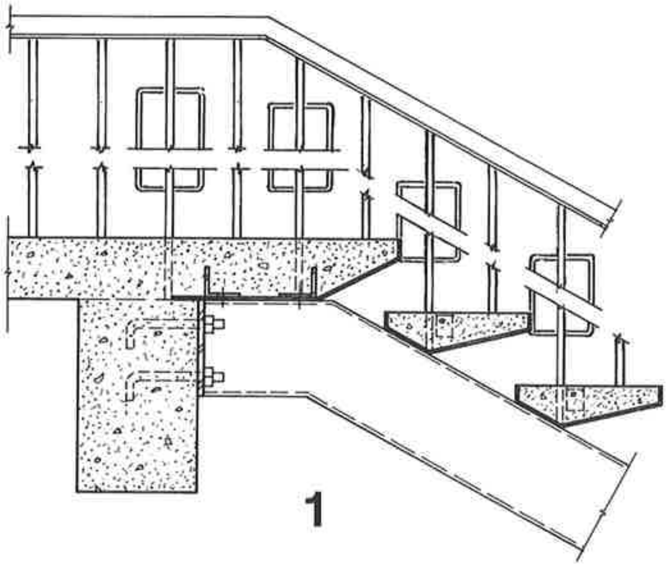
Stringers — Box construction, two structural steel channels boxed by steel plate.

Treads — Formed steel plate, concrete filled.

Landing — Formed steel plate, reinforced, concrete filled, supported by box stringers, bearing in masonry.

Railing — Square steel bars welded to treads and top channel, and connected to rectangular steel tubing.

Finish — Steel painted.



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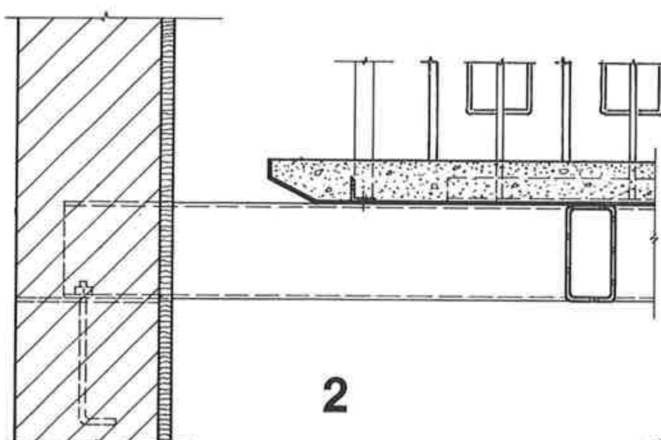

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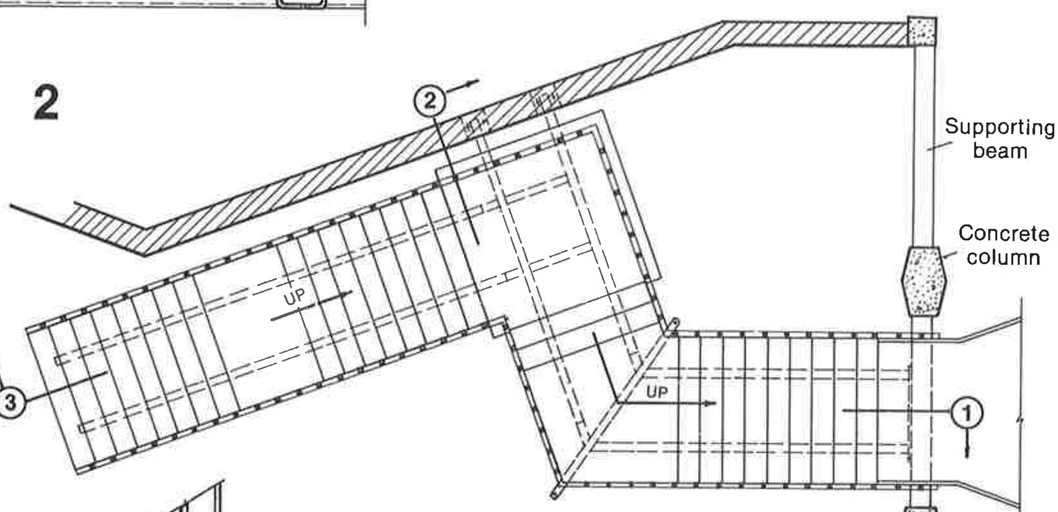
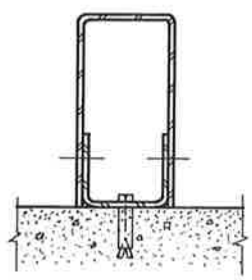


PLAN VIEW



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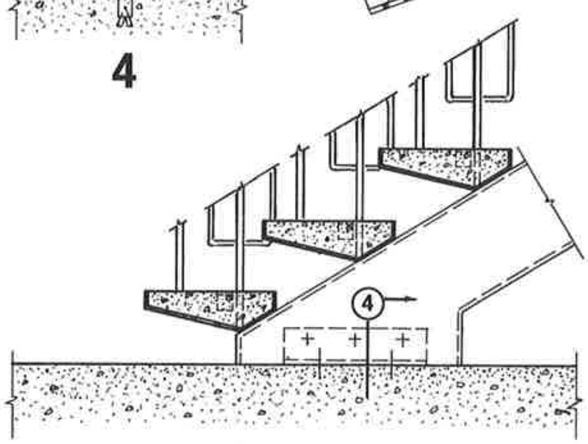


3

DESCRIPTION

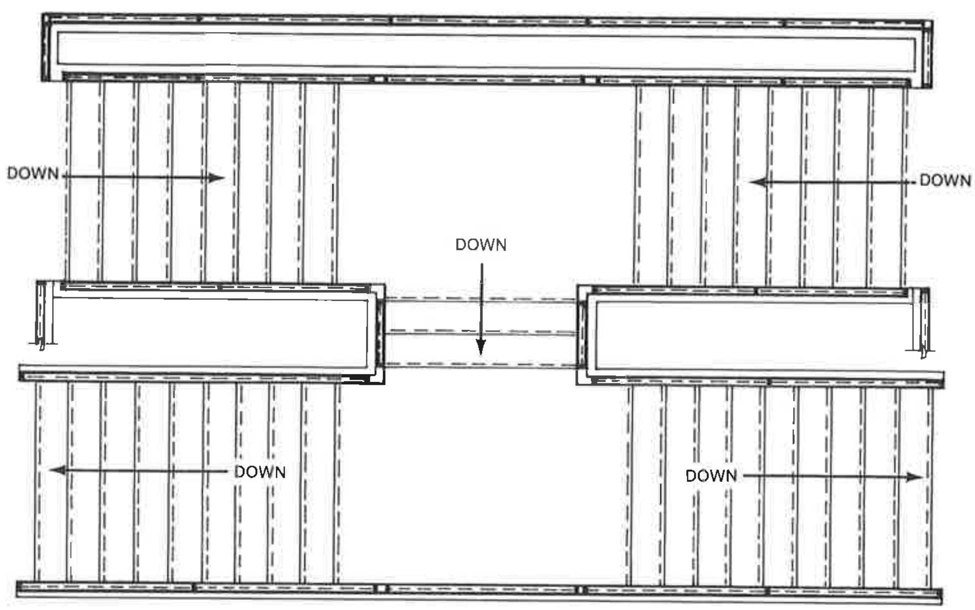
Stringers — Steel tube.

Treads — Formed steel plate, concrete filled; vinyl surface.

Platforms — Formed steel plate, concrete filled; vinyl surface. Steel tube supports, bearing on masonry or supported by steel hanger rods.

Railing — Balusters steel bars, welded to treads and platforms; top channel capped by handrail.

Finish — Steel painted.



PLAN

DESCRIPTION

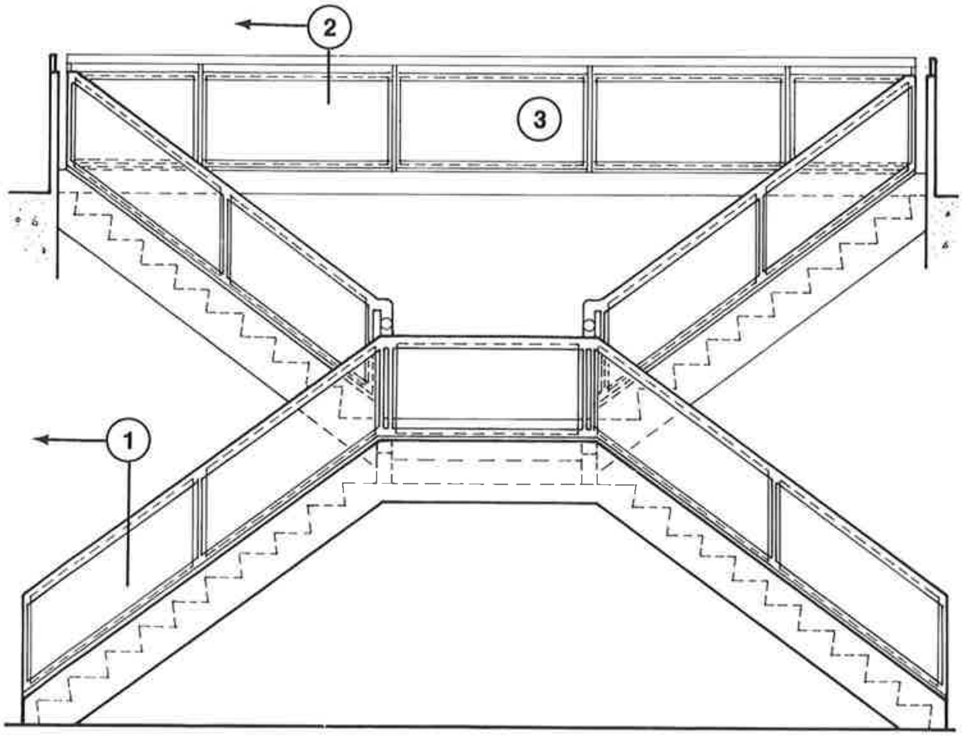
Top Rails, Base Rails and Posts — Extruded aluminum, welded connections.

Infill Panels — ¼" tempered glass supported between top and base rails.

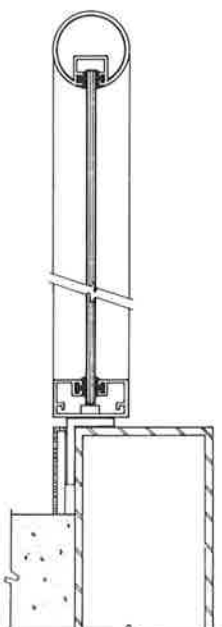
Stringers — Steel box beam covered with sheet rock.

Stairs — Poured-in-place concrete.

Aluminum Finish — Paint.



ELEVATION



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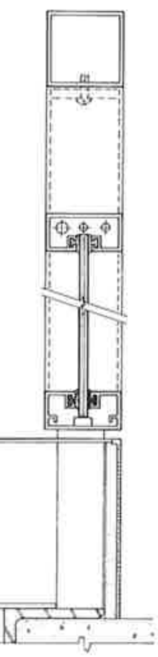

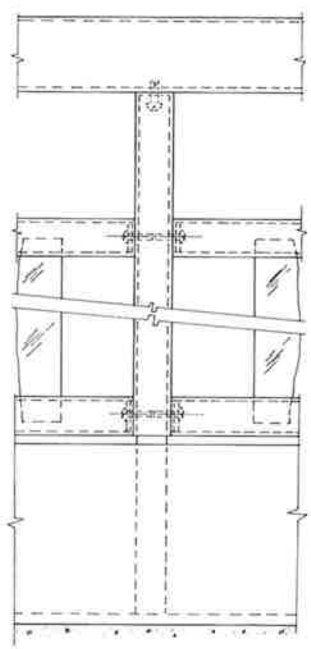

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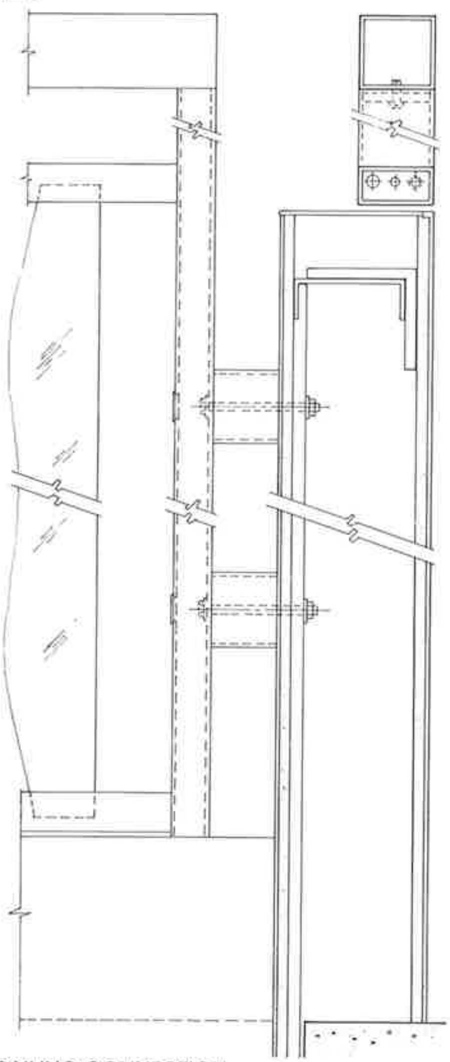
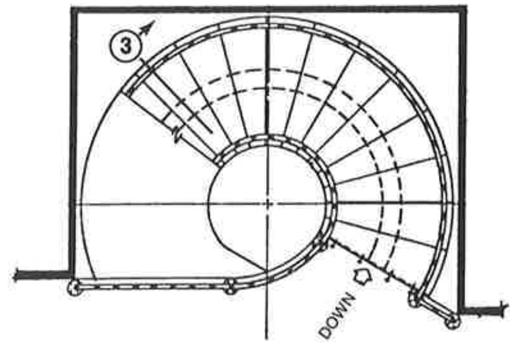
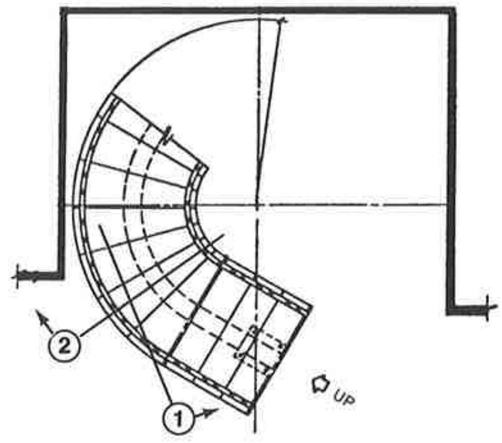


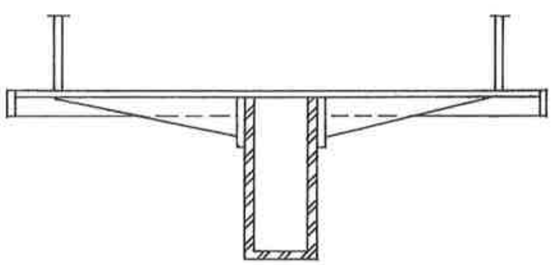
ELEVATION - RAILING CONNECTION TO WALL DETAIL



PLAN-UPPER LEVEL



PLAN-LOWER LEVEL



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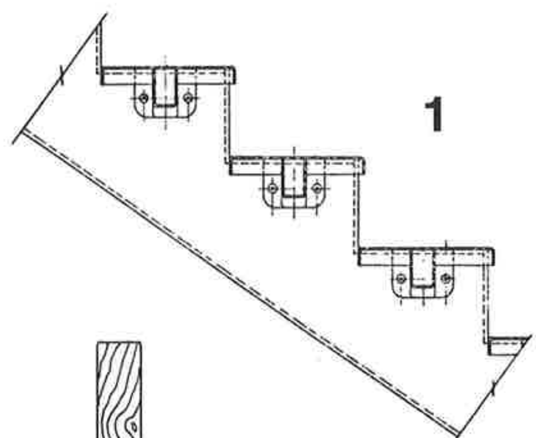

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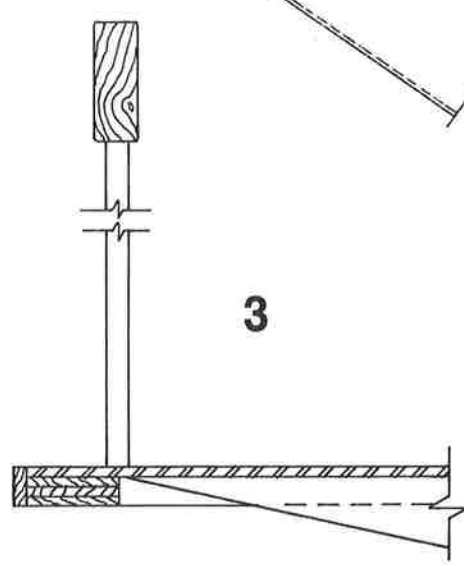


3

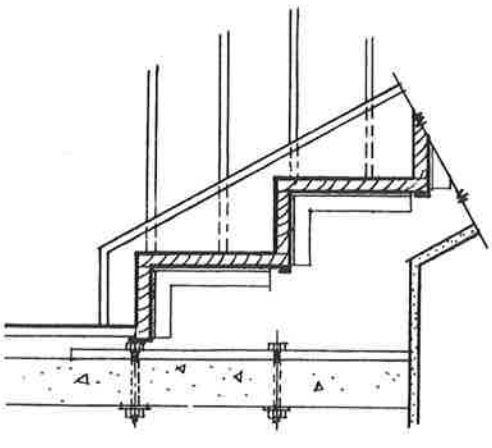
DESCRIPTION

Stringer — Welded steel plate.

Treads — Formed steel plate. Tapered center beams welded to tread plate and anchor plates. Anchor plates bolted to stringer. Plywood fillers in ends of treads. Oak end trim attached. Treads carpeted.

Railing — Round steel bar balusters welded to treads and attached to wood handrail at top.

Finish — Steel painted.



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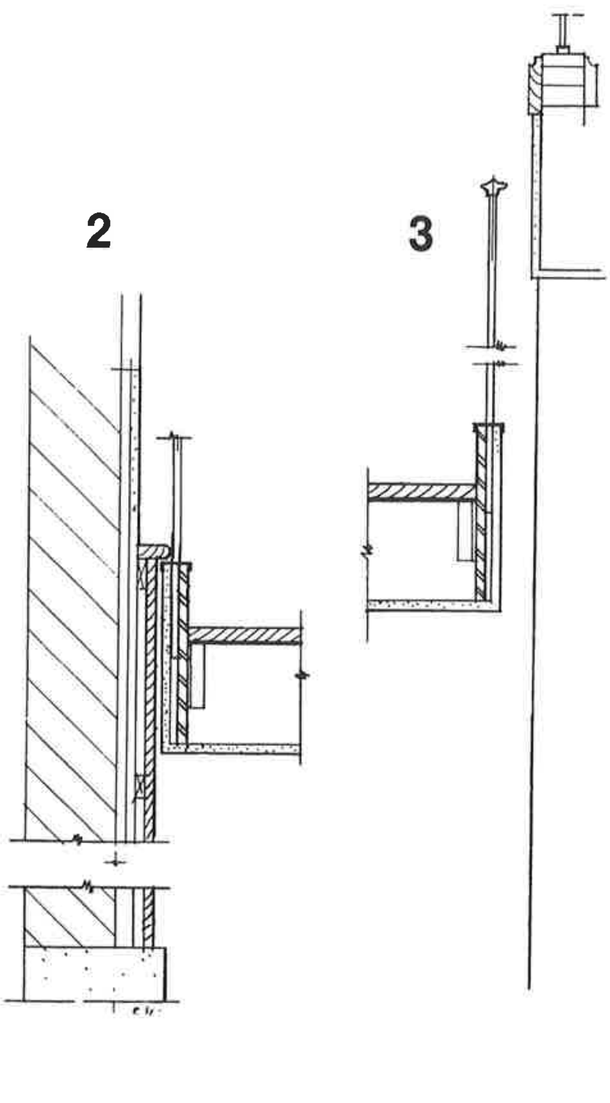
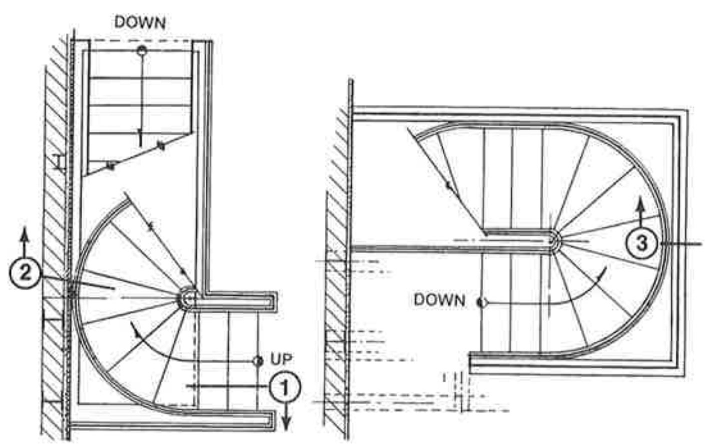




MAIN FLOOR PLAN BALCONY PLAN

DESCRIPTION

Stringers — Steel plate.

Treads and Risers — Steel sheet sub-treads and risers supporting wood treads and risers. Covered with carpeting.

Railing — Malleable iron ornamental balusters fastened to stringers through stringer cap. Steel handrail mounted on steel channel.

Finish — Metal painted. Plaster soffits and fascia.

DESCRIPTION

Stringers — Steel plate welded to form box, covered with brushed finish bronze.

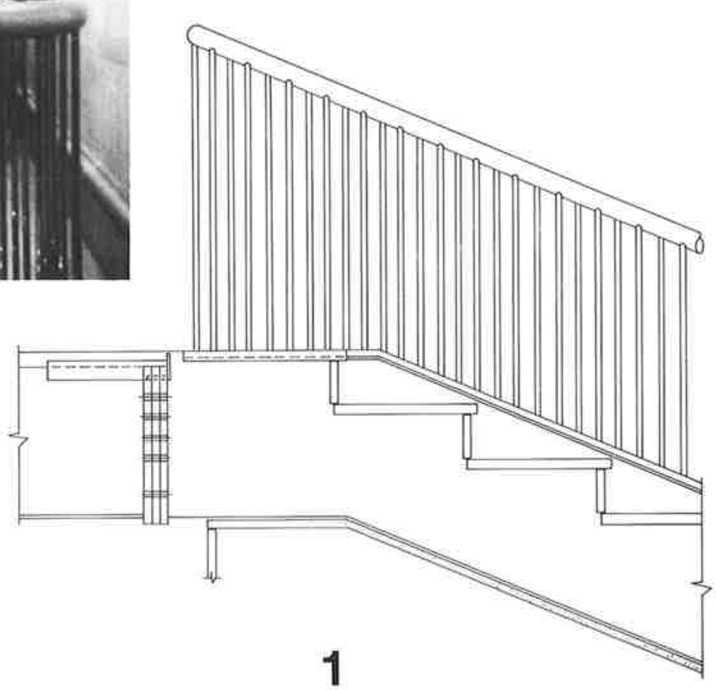
Treads — Formed steel pans filled with concrete covered by marble.

Risers — Formed steel covered by marble.

Fasteners — A325 bolts.

Railing — Polished bronze rod balusters. Polished bronze tube handrails. Polished cast bronze rail end cap.

Reveal — Bronze sheet.



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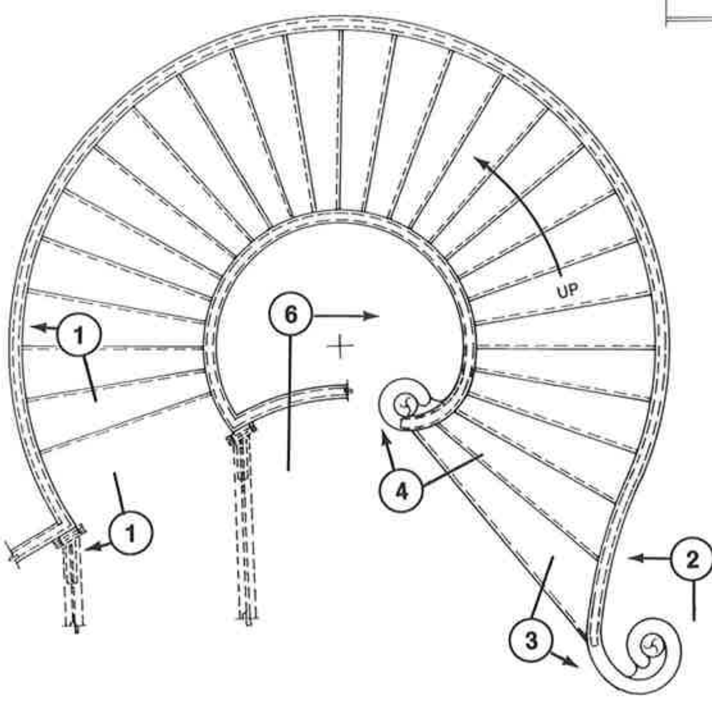
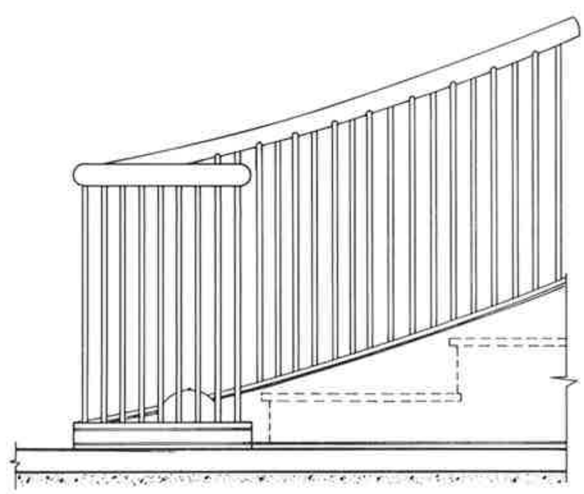


PLAN



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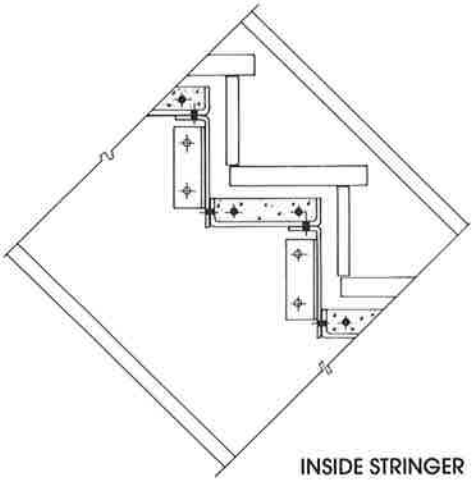
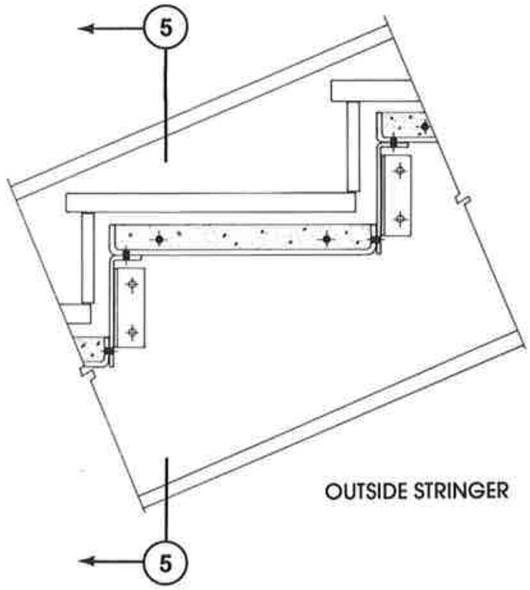
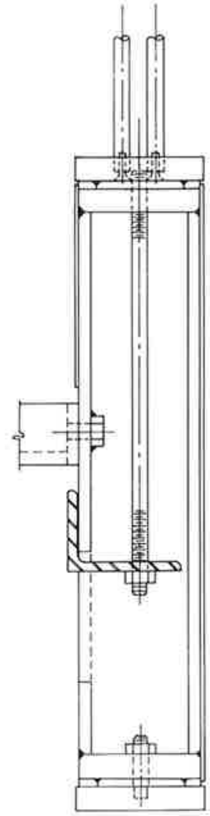


INSIDE STRINGER



OUTSIDE STRINGER



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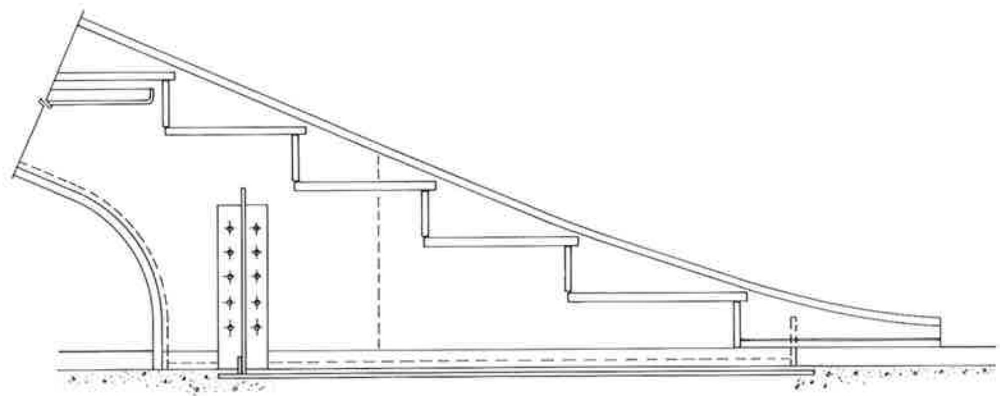

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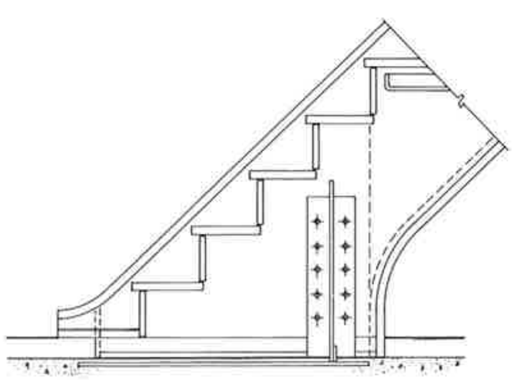

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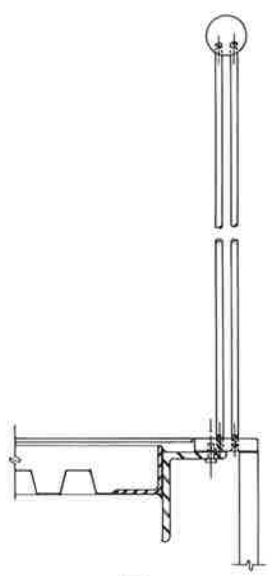


6

DESCRIPTION

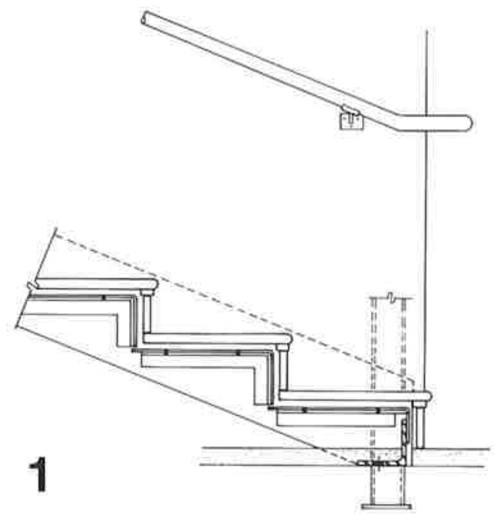
Stringers — Structural steel channels.

Treads and Risers — Formed steel sheet welded to stringer covered with marble.

Railing — Steel bar balusters. Bronze tube handrails.

Wall Handrail — Bronze cap on sculpture painted A36 steel.

Baluster — Sculpture painted A36 steel.



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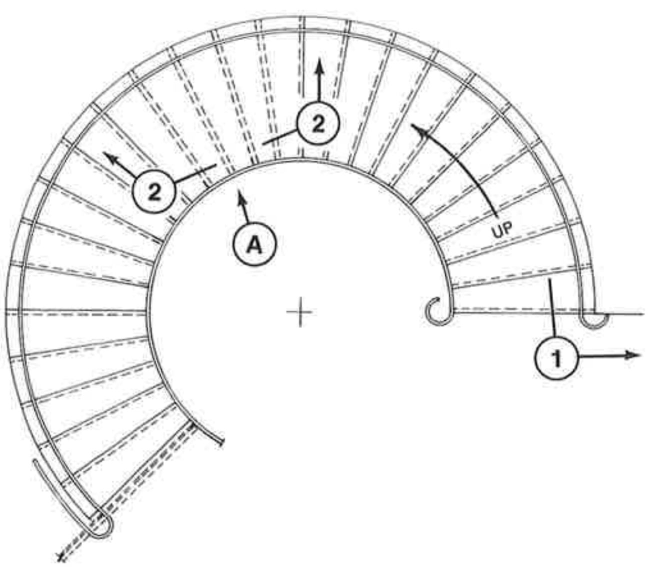
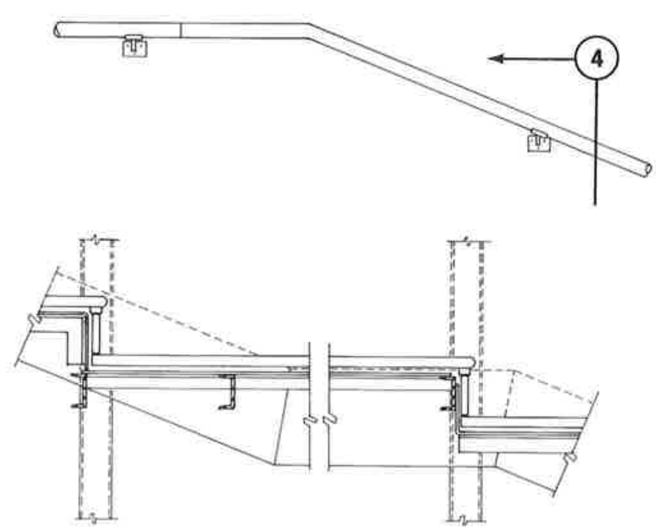


PLAN



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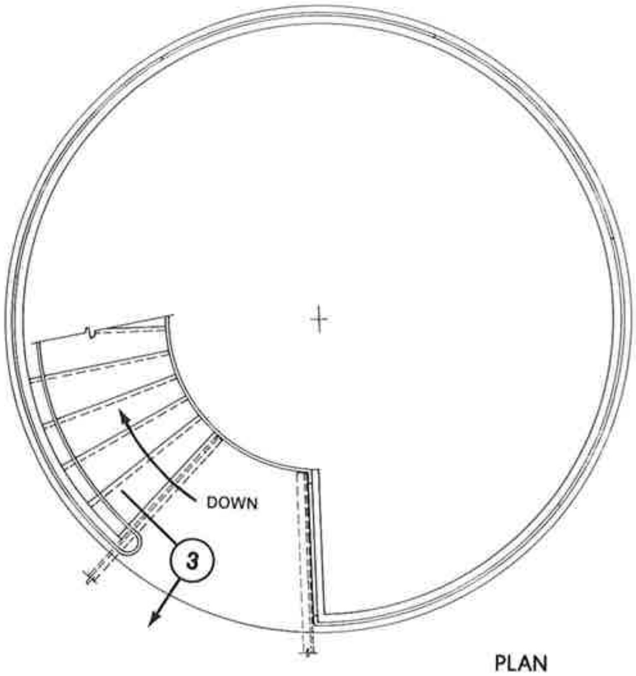

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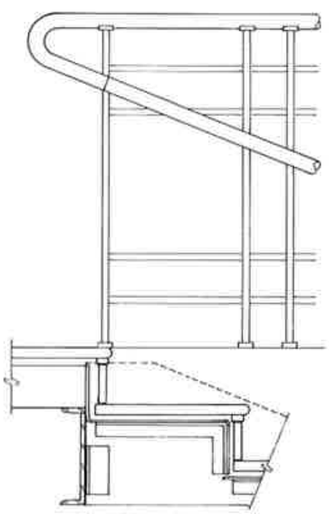

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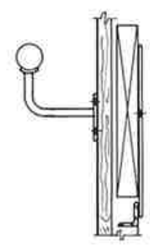
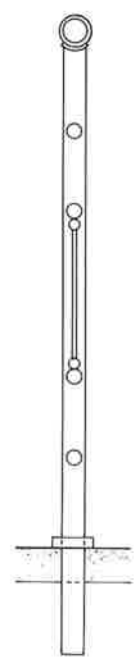


WALL HANDRAIL



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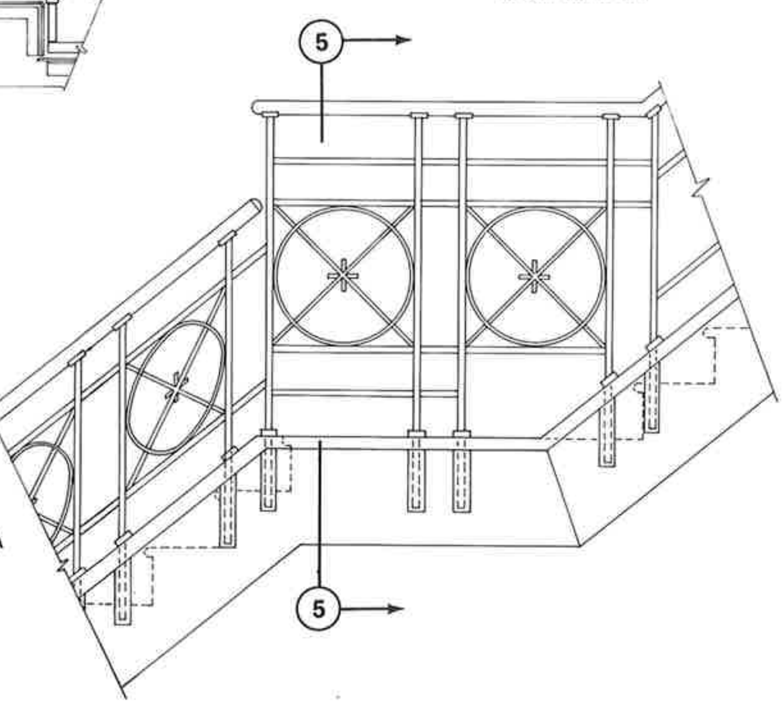
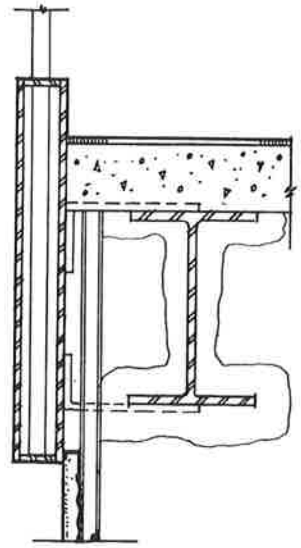
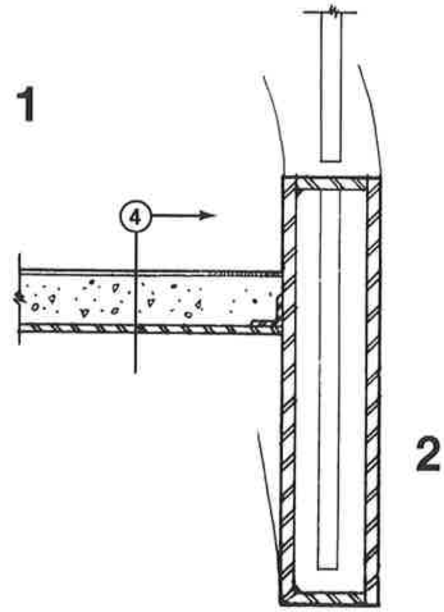
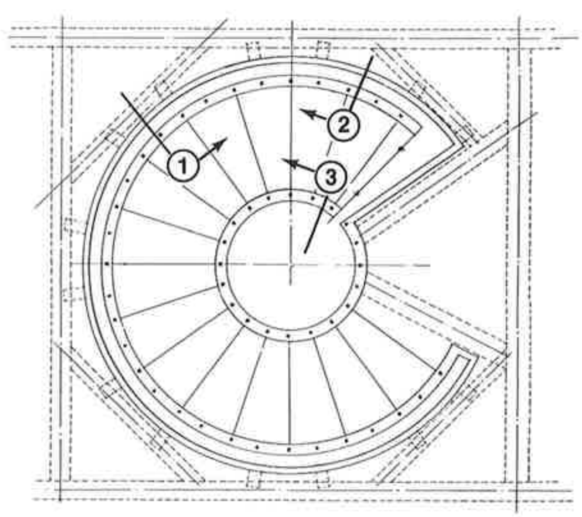


ELEVATION A-A







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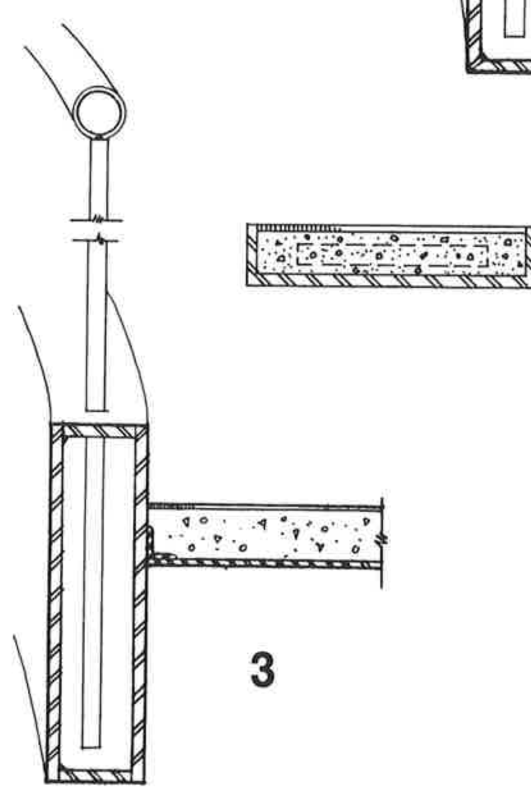


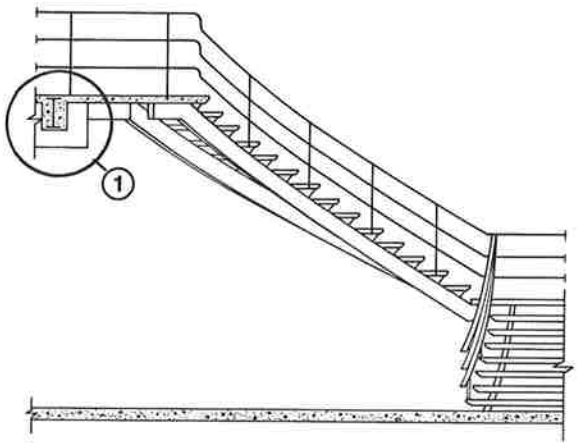
DESCRIPTION

Stringers — Welded steel plate box stringers.

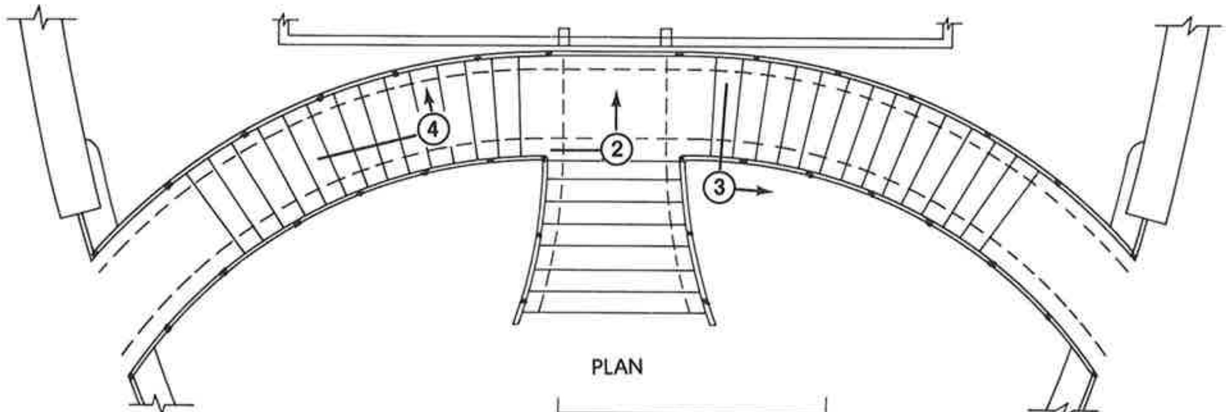
Treads — Formed steel plate, field welded to angles on stringers, concrete filled and covered with tile.

Railing — Square steel bar balusters welded to stringer-ers. Steel tubing handrail.

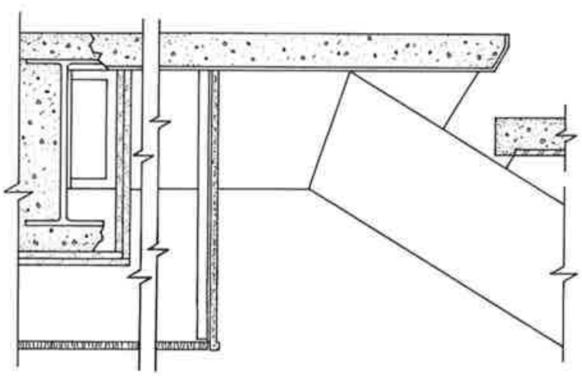
Finish — Steel painted.



SECTION



PLAN



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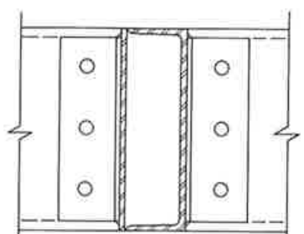
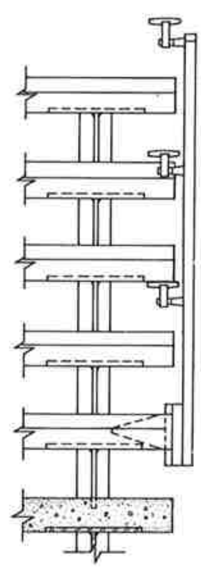


2

STRINGER INTERSECTION

4



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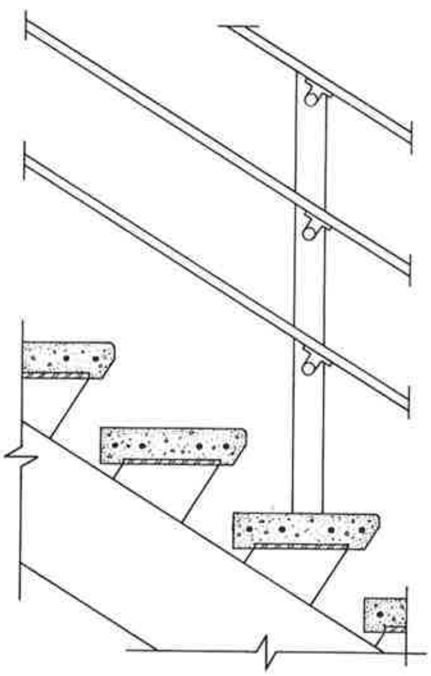


DESCRIPTION

Stringers — Structural steel channel and plate welded together after bending to form box section.

Treads and Risers — Reinforced precast terrazo with two setting plates per tread. Riser plates continuously welded to stringers. Setting plates in tread field welded to riser plates.

Railing — Aluminum balusters attached to post anchors cast in treads. Aluminum handrails.

Finish — Steel painted. Aluminum anodized.

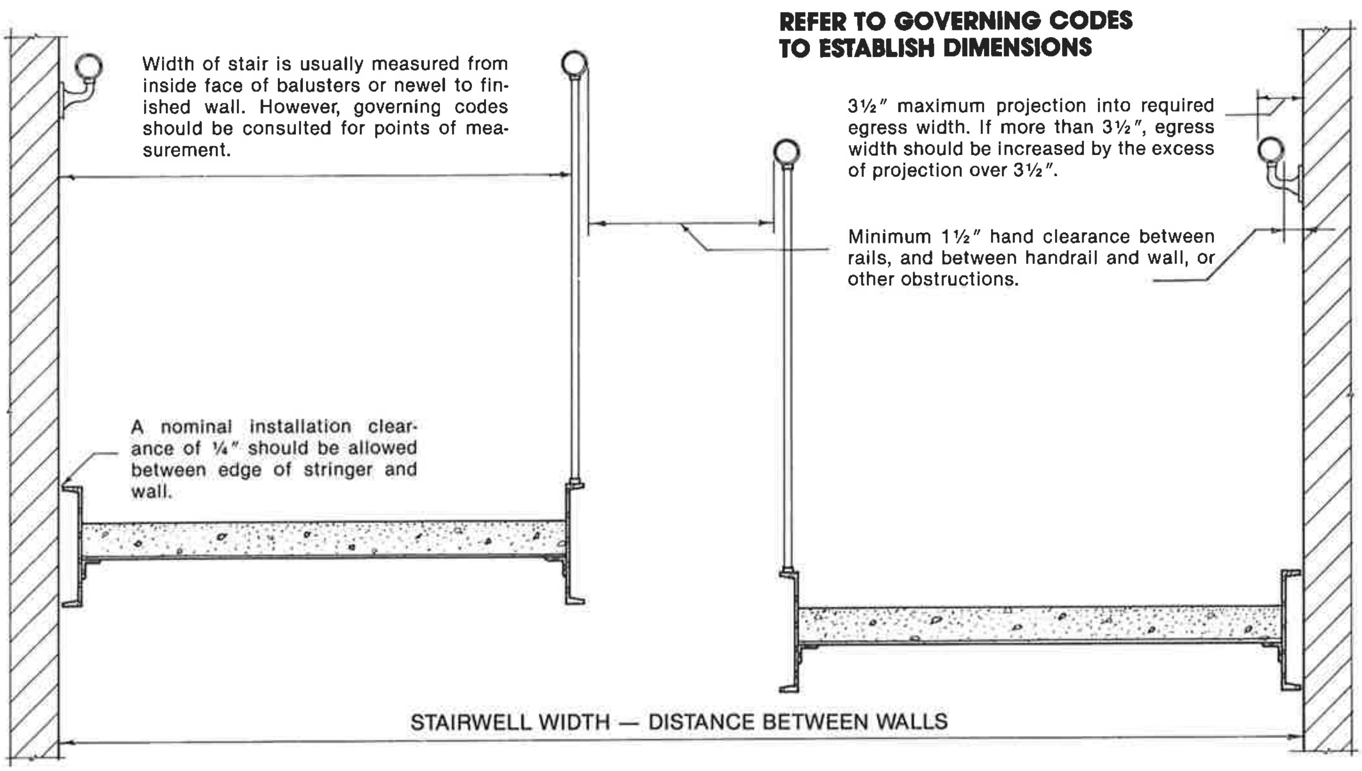
SECTION 4

CONSTRUCTION DETAILS

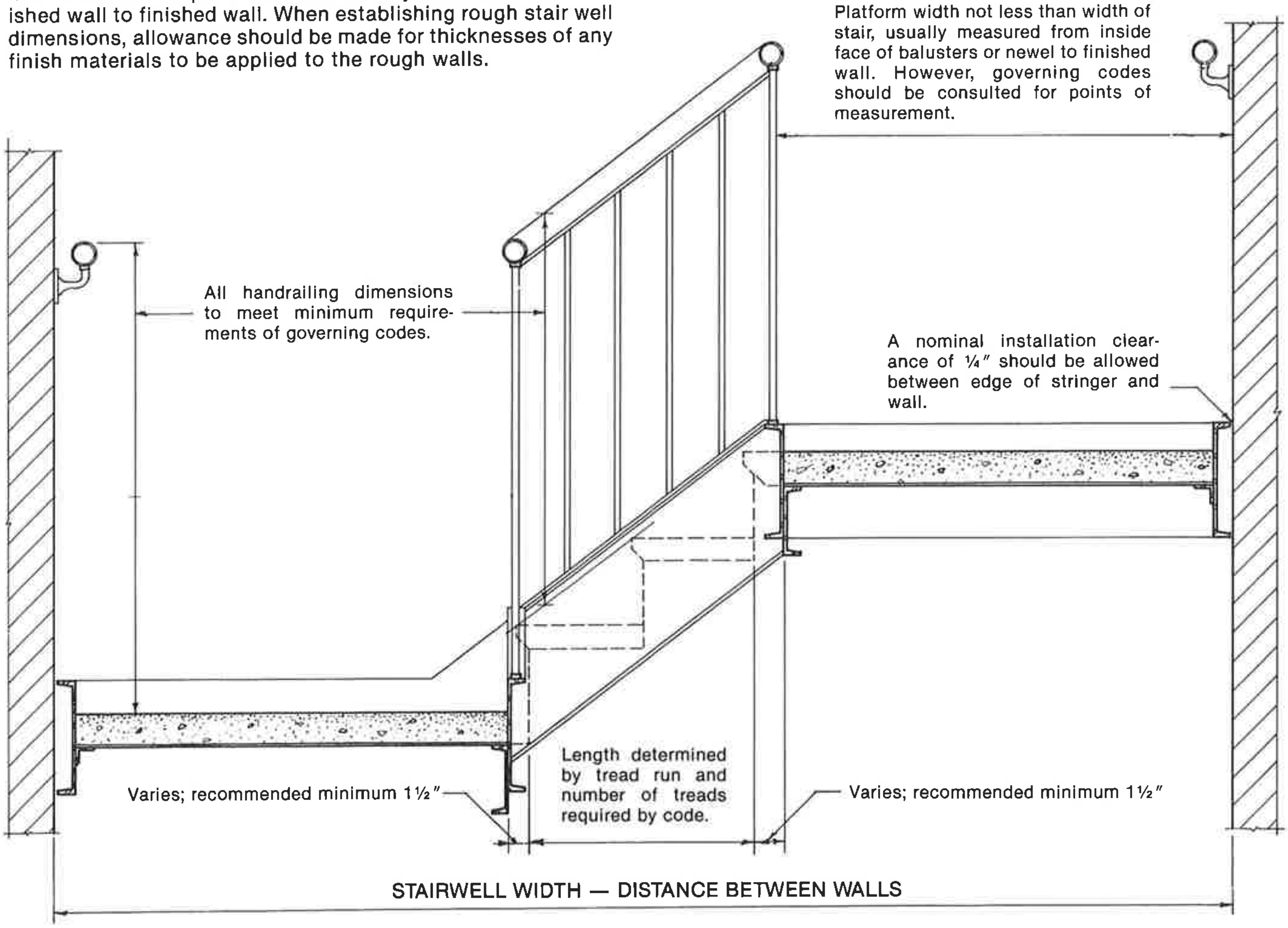
The drawings contained in this section illustrate the most commonly used and recommended details of metal stair construction. Because of the unlimited design variations possible, particularly in the architectural class, this is necessarily only a representative collection of such details.

The intent is to illustrate a variety of good construction practices, not a catalog of available designs. As some of the items shown may not be available from all stair manufacturers, it is recommended that before finalizing the specifications a NAAMM member company be consulted.

CONTENTS



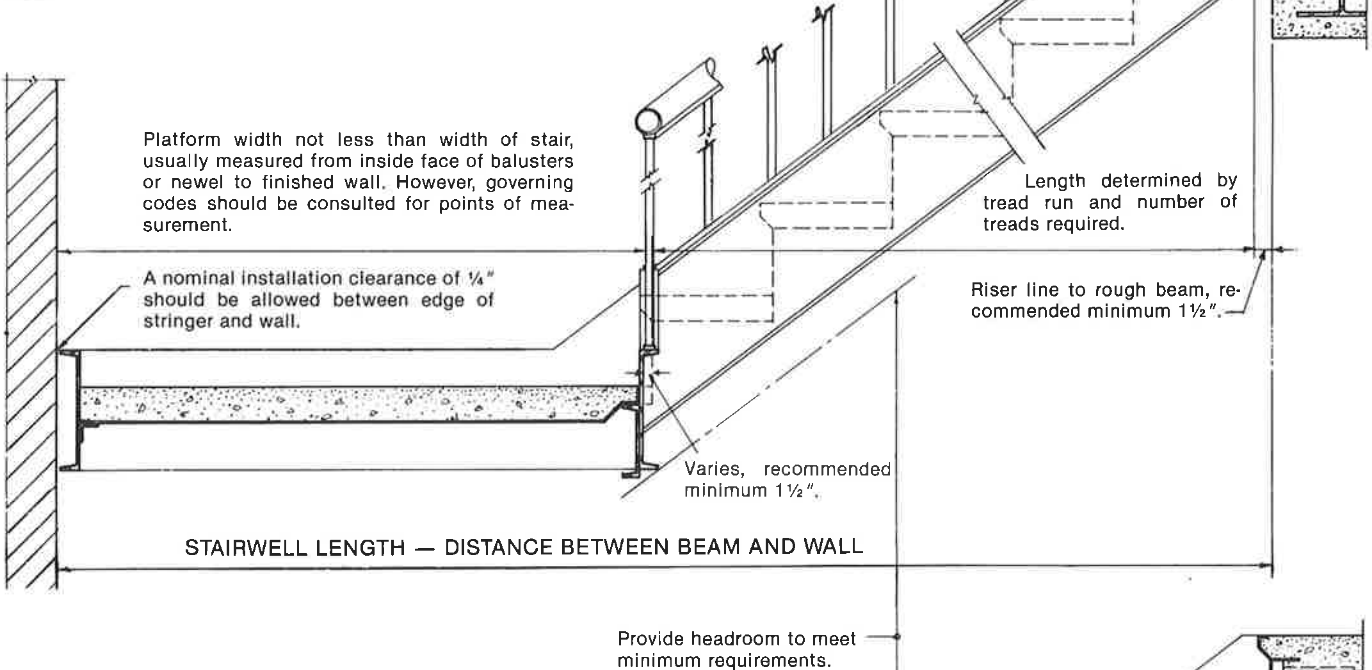
Minimum code requirements are usually measured from finished wall to finished wall. When establishing rough stair well dimensions, allowance should be made for thicknesses of any finish materials to be applied to the rough walls.



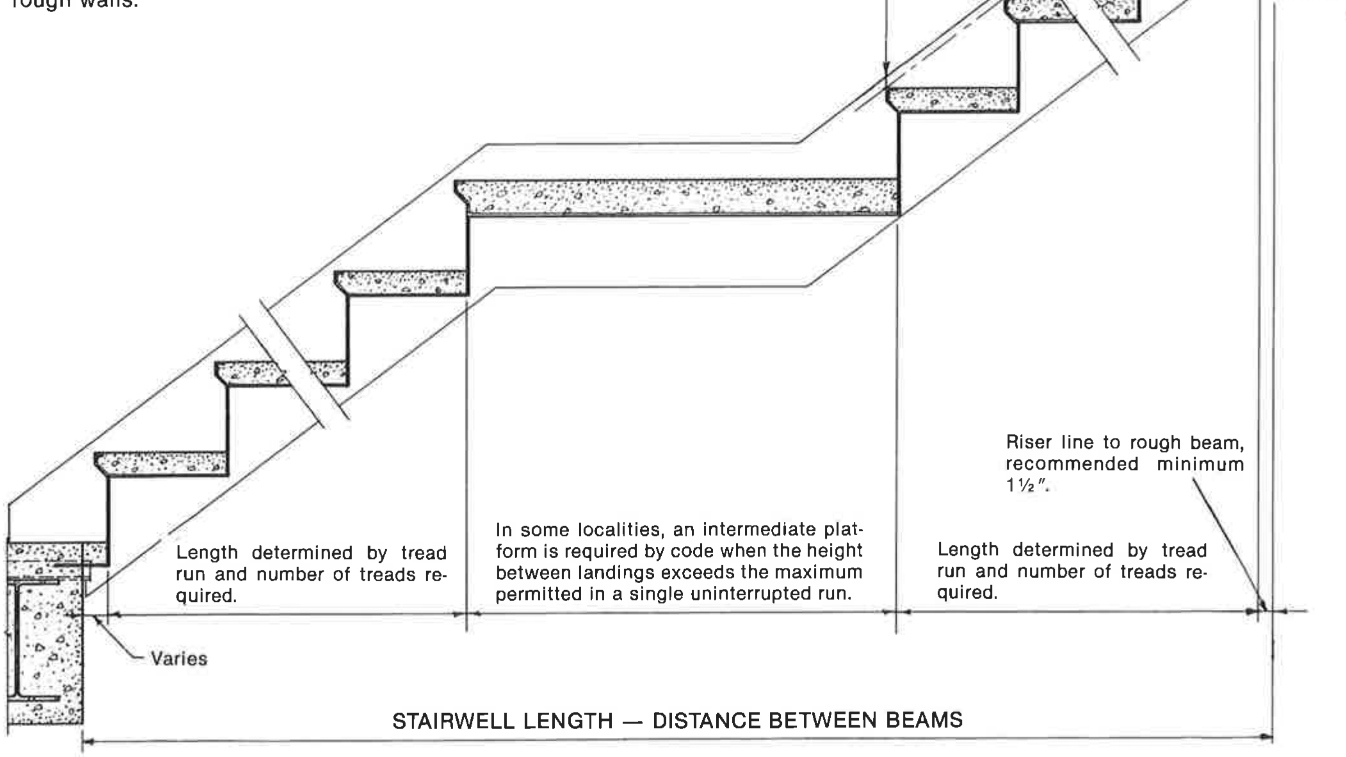
REFER TO GOVERNING CODES TO ESTABLISH DIMENSIONS

Height of riser and tread run vary according to governing codes. A tread of 10″ and a rise of 7″ to 7½″ are considered average. Stair treads for more comfortable runs are often 10½″ to 11″ with risers less than 7″. Treads and risers should be so proportioned that the sum of two risers and one tread run is not less than 24″ or more than 26″.

In establishing stairwell dimensions, tread run is always face to face of riser.



Minimum code requirements are usually measured from finished wall to finished wall. When establishing rough stair well dimensions, allowance should be made for thickness of any finish materials to be applied to the rough walls.



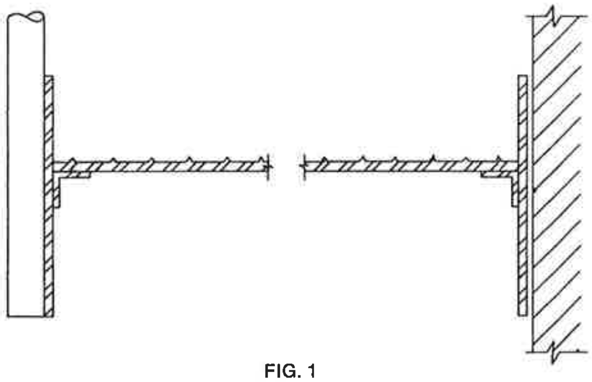


FIG. 1

Steel plate stringers, carrier angles, floor plate treads, pipe railing on side of face stringer. Aluminum tread plate may be used when specified. Wall not plastered. For plate data, refer to Page 5-7.

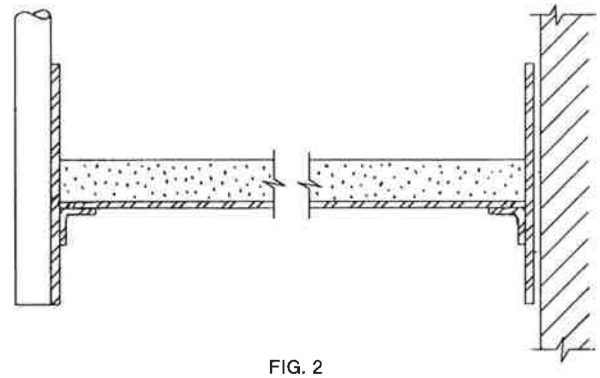


FIG. 2

Steel plate stringers, carrier angles, steel sub-tread and riser, concrete filled tread. Pipe railing on side of face stringer, wall not plastered.

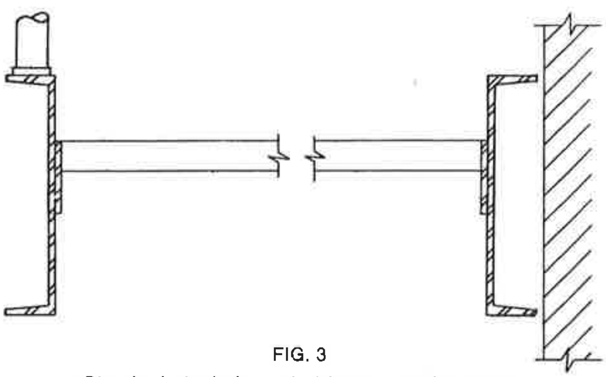


FIG. 3

Standard steel channel stringers, grating tread bolted or welded to stringer, pipe railing bolted or welded to top flange of face stringer. Wall not plastered. For grating tread sections, refer to Page 4-5.

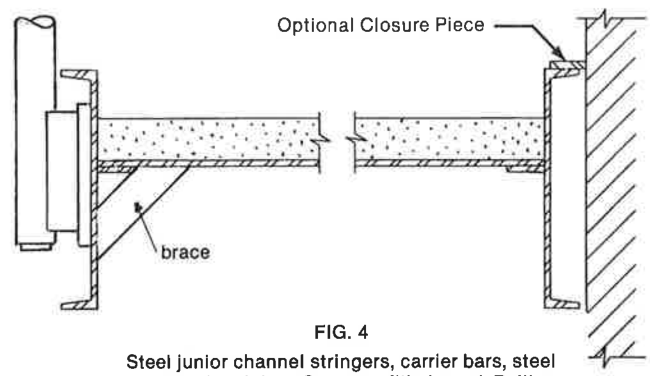


FIG. 4

Steel junior channel stringers, carrier bars, steel sub-tread and riser. Concrete filled tread. Railing fastened to web of face stringer which is braced to sub-tread. Optional closure piece fastened to top flange of wall stringer in the field. Wall not plastered.

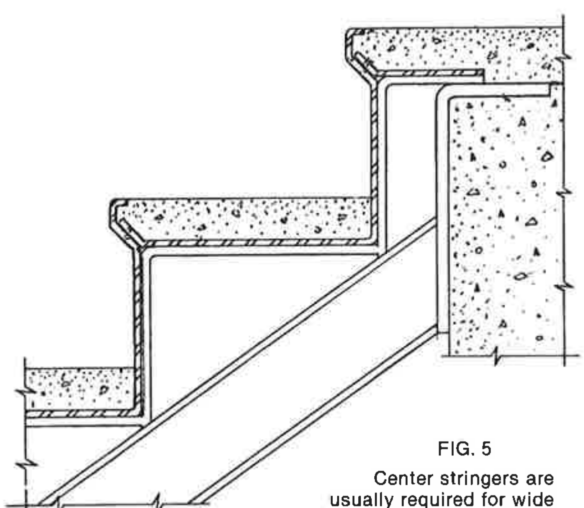


FIG. 5

Center stringers are usually required for wide stairs in excess of 6'-0" in width. They may be constructed of a structural beam or channel, with brackets for supporting treads and risers. Refer to page 4-17 for center railing adaptation to this condition.

CONSTRUCTION NOTES:

Where masonry walls are finished with glazed brick, tile, marble or other facing material, the stair should be erected before the finished wall material is installed to permit a proper fit between it and the wall stringer. Alternatively the wall stringer may be set out from the wall to provide clearance, this construction requiring supporting brackets or extension of wall stringers into the wall.

Steel plate stair stringers should be of sufficient width to receive the end of tread and riser, and in thicknesses as determined by the load and the design. Steel MC stringers are rolled in 10" and 12" depth. For average installation 10" channels are recommended. 12" channels are used where required by the design and the load.

Box type stringers may be constructed with rectangular tube steel. For load tables of steel stringer sections refer to Pages 5-11 and 5-12.

For details of metal stair soffits refer to Pages 4-12 and 4-13.

For sections of treads and risers, refer to pages 4-5 through 4-7.

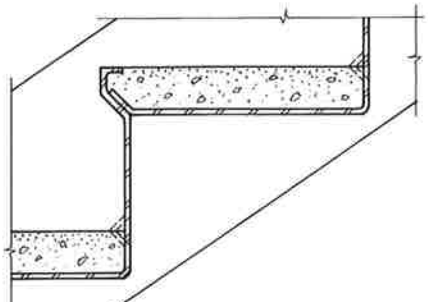


FIG. 6
Steel sub-tread and riser with formed nosing at 45 degrees, with or without sanitary cove. Concrete filled tread.

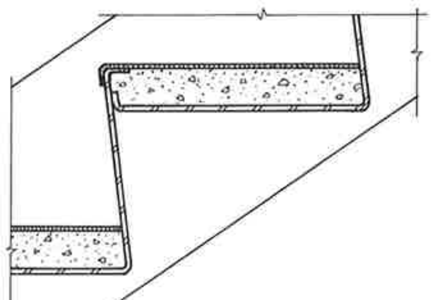


FIG. 7
Steel sub-tread and riser with riser sloped to meet formed nosing. Concrete filled tread with resilient tile covering.

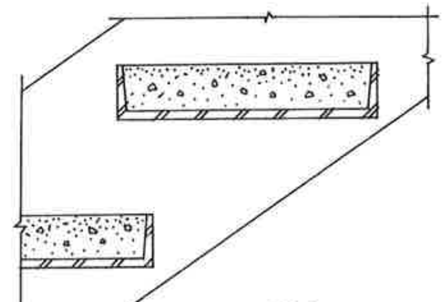


FIG. 8
Steel channel sub-tread concrete filled.

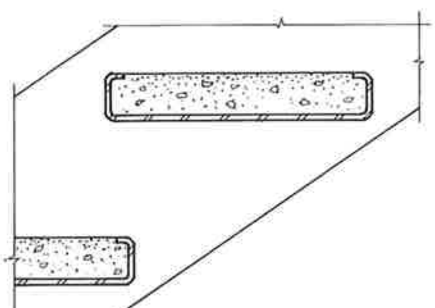


FIG. 9
Steel sub-tread without riser, concrete filled and reinforced.

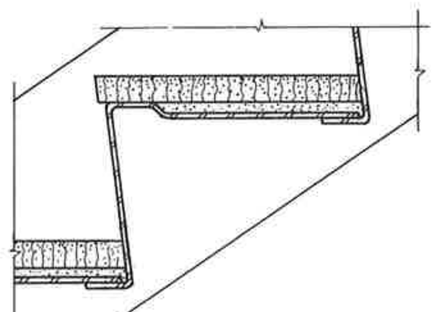


FIG. 10
Steel sub-tread and riser formed to receive pre-fabricated tread such as pre-cast concrete.

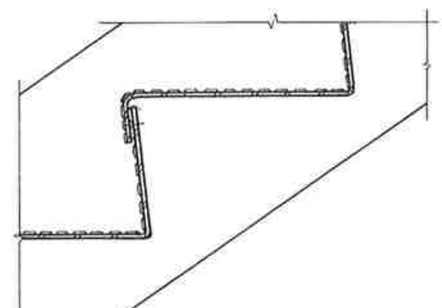


FIG. 11
Steel floor plate or aluminum tread plate formed tread and riser.

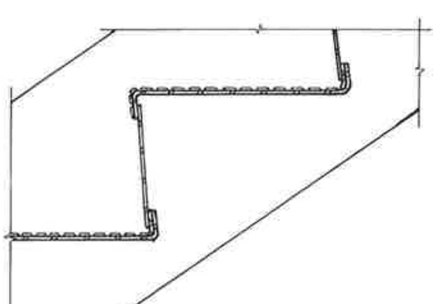


FIG. 12
Steel floor plate or aluminum tread plate formed tread with sheet steel or aluminum riser optional.

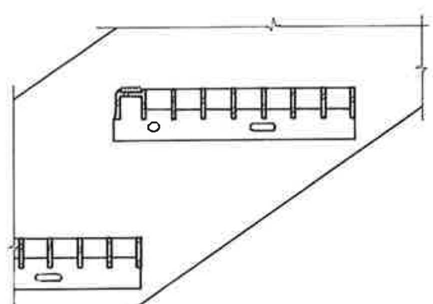


FIG. 13
Steel or aluminum grating with nosing. End plates welded to grating and bolted to stringer.

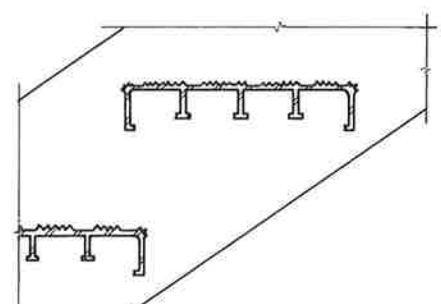


FIG. 14
Extruded aluminum tread.

CONSTRUCTION NOTES:

Sections shown on this page indicate the many different types of treads used for service type stairs, including pan type sub-tread and riser construction.

Treads can be supported by direct bolting or welding to stringers, or bolting or welding to support members. The tread width should always be greater than the tread run.

Refer to National Association of Architectural Metal Manufacturers' Metal Bar Grating Manual and to manufacturers' current literature for more detailed information.

Refer to Page 4-7 for details of safety nosings.

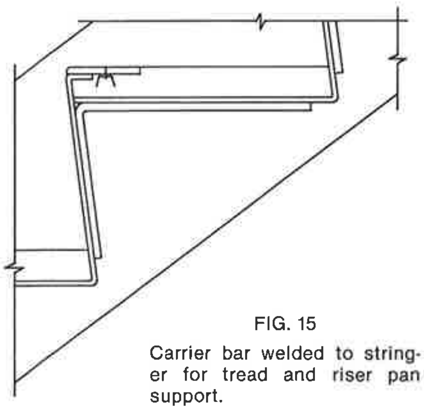


FIG. 15
Carrier bar welded to stringer for tread and riser pan support.

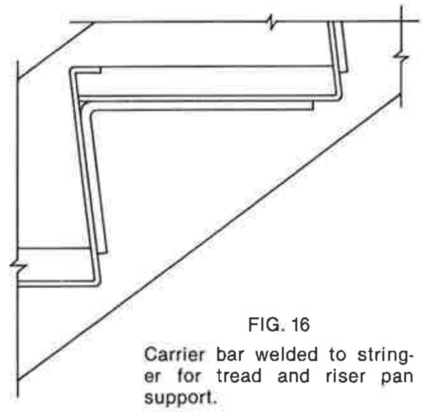


FIG. 16
Carrier bar welded to stringer for tread and riser pan support.

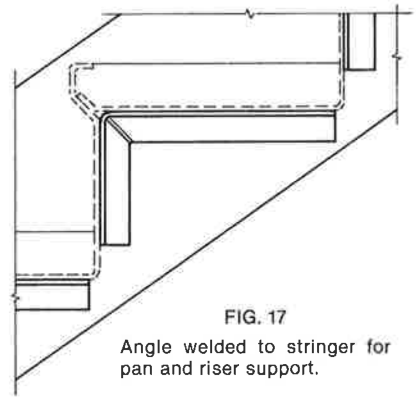


FIG. 17
Angle welded to stringer for pan and riser support.

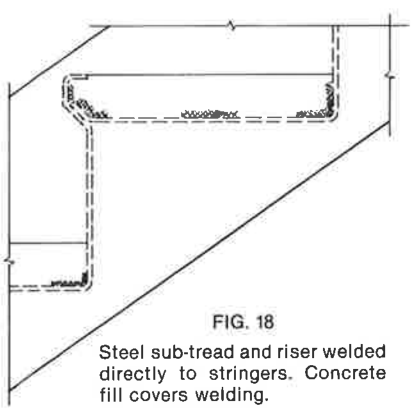


FIG. 18
Steel sub-tread and riser welded directly to stringers. Concrete fill covers welding.

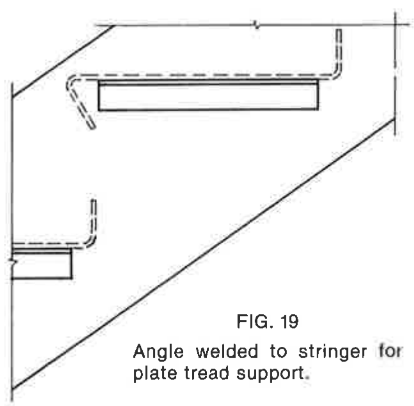


FIG. 19
Angle welded to stringer for plate tread support.

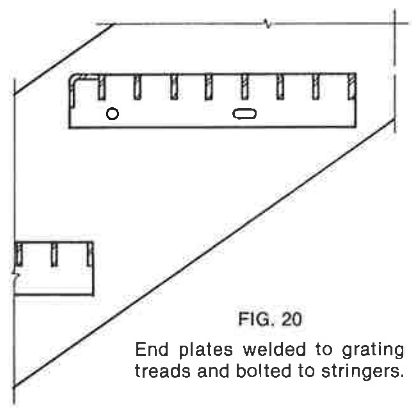


FIG. 20
End plates welded to grating treads and bolted to stringers.

CONSTRUCTION NOTES:

The tread and riser pan can be either welded or bolted to the supporting member. This is usually governed by the preference of the fabricator or the erector.

Treads made from grating or other pre-fabricated materials are usually furnished with end plates or angles standard with the manufacturer. These can be either welded or bolted to the stringers.

The concealed direct welding of the pan tread to the stringer as shown in Figure 18 results in a clean soffit appearance. This method is most efficiently used in "unit" or "pre-assembled" stairs where a complete stair flight is welded together in the fabricator's shop and delivered to the site in one piece.

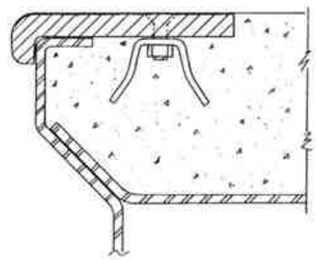


FIG. 21

Cast abrasive nosing with short lip, available in iron, bronze or aluminum as specified. Standard drilling with wing anchors, bolts and nuts or drilled as required.

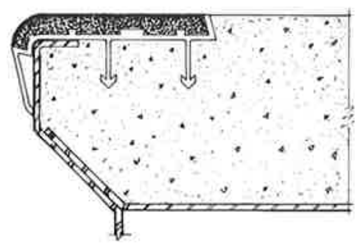


FIG. 22

Extruded aluminum base with epoxy top, containing abrasive. Available in colors. Integral anchors for fresh concrete. Also available drilled to specifications without the anchors.

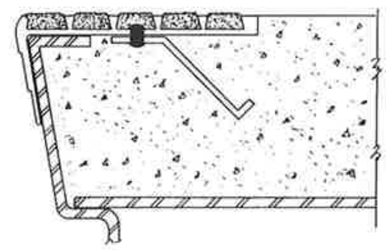


FIG. 23

Extruded aluminum with abrasive ribs. Special design for pan stairs with sloped risers. Drilled to specification or furnished with strap anchors or wing anchors.

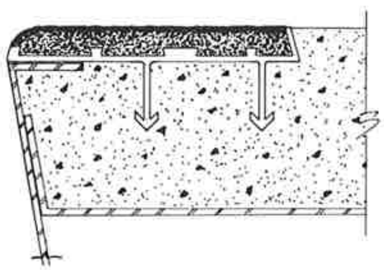


FIG. 24

Barrier free design to meet standards for the physically handicapped. Aluminum base with epoxy containing abrasive top. Integral anchors for fresh concrete.

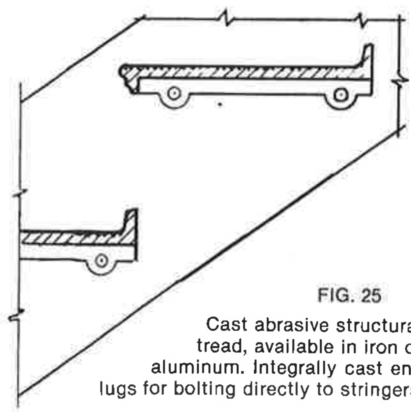


FIG. 25

Cast abrasive structural tread, available in iron or aluminum. Integrally cast end lugs for bolting directly to stringers.

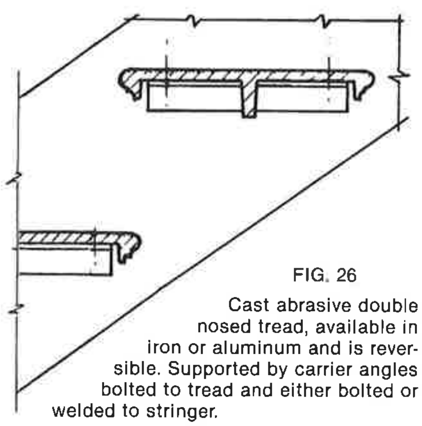


FIG. 26

Cast abrasive double nosed tread, available in iron or aluminum and is reversible. Supported by carrier angles bolted to tread and either bolted or welded to stringer.

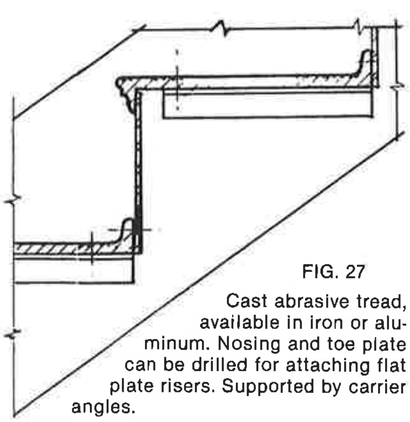


FIG. 27

Cast abrasive tread, available in iron or aluminum. Nosing and toe plate can be drilled for attaching flat plate risers. Supported by carrier angles.

CONSTRUCTION NOTES:

With reference to Figures 21, 22, 23 and 24 extreme care should be used to be sure the fill is fluid enough to flow completely around these anchors to insure a good bond of the anchors, but not so wet that shrinkage will occur.

Consult nosing manufacturers' current data for limitations of length, width, thickness and other features such as colors, anchors, variations in design, etc.

The inside corner of cast nosings must be clean and square to fit a formed nosing properly.

Cast abrasive treads, Figures 25, 26 and 27 and also cast abrasive platforms are cast from patterns that are standard with each manufacturer. Consult manufacturers' current literature and engineering data for limitations of loading, length, width, thickness and other features.

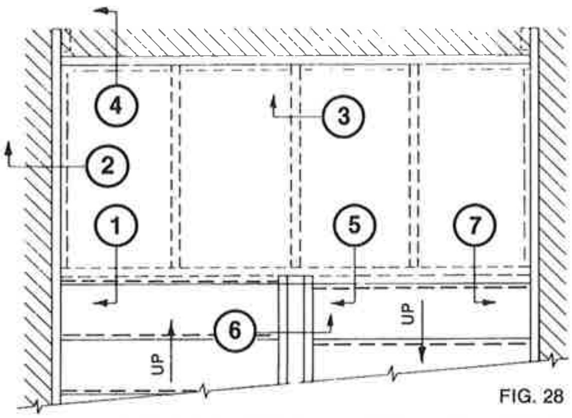


FIG. 28

STAIR PLATFORM WITH SHORT NEWEL POSTS AND MINIMUM WELL

Face stringers supported on channel header.
Ends of wall stringers supported by masonry wall.
Steel sheet subplatform supported on steel sections.
Concrete fill, 3″ minimum without reinforcing.
Exposed construction underneath.

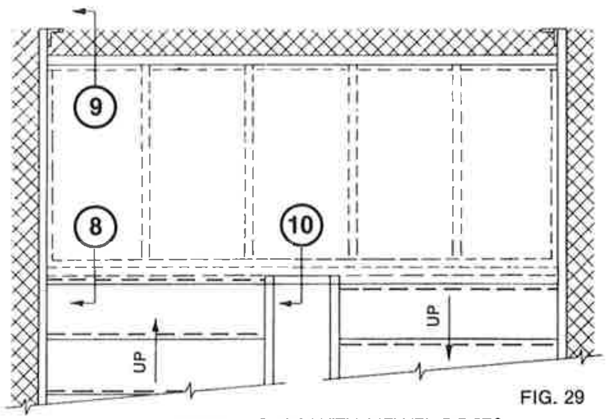


FIG. 29

STAIR PLATFORM WITH NEWEL POSTS AND OPEN WELL

Face stringers supported by newel posts on channel header.
Ends of wall stringers supported on struts.
Steel sheet subplatform supported on steel sections.
Concrete fill, 3″ minimum without reinforcing.
Plastered soffit construction underneath.

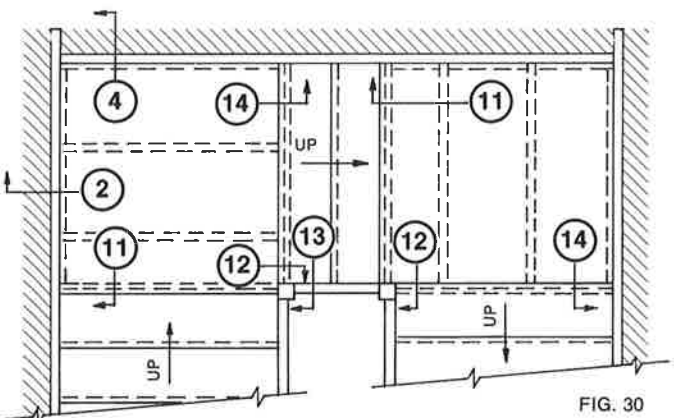


FIG. 30

STAIR WITH TWO PLATFORMS AND CONNECTING TREADS AND RISERS

Face stringers supported by newel posts.
Ends of wall stringers supported by masonry wall.
Steel sheet subplatforms supported on steel sections.
Concrete fill, 3″ minimum without reinforcing.
Lower face stringer and channel header in line to form structural support.
Exposed construction underneath.

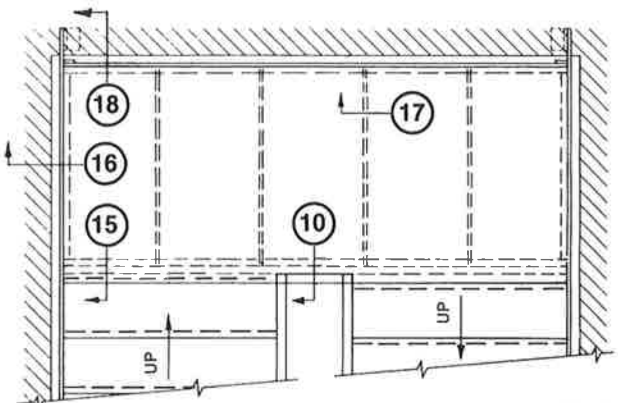


FIG. 31

STAIR PLATFORM WITH SECTIONAL SUBPLATFORM

Face stringers supported by newel posts on channel header.
Wall stringers set out from walls, ends supported by masonry walls.
Steel sheet subplatform in sections with up-turned flanges.
Concrete fill, 3″ minimum without reinforcing.
Exposed construction underneath.

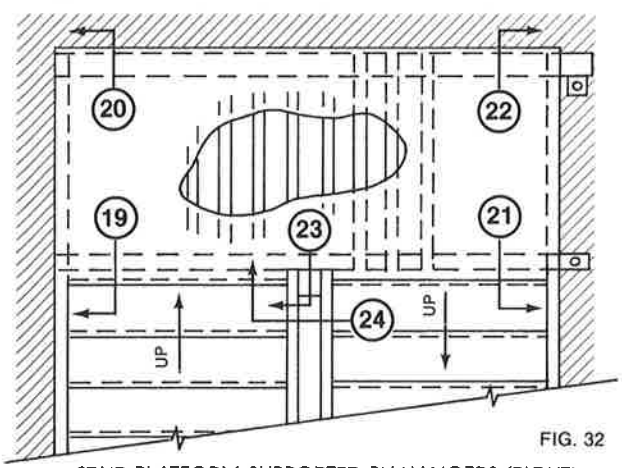


FIG. 32

STAIR PLATFORM SUPPORTED BY HANGERS (RIGHT) OR BY STRUCTURAL ANGLE SECURED TO WALL (LEFT)

Stringers supported on channel header.
Sheet steel, rib deck subplatform supported on steel sections.
Steel sections attached to hangers or to wall mounted angle.
Concrete fill.
Exposed construction underneath.

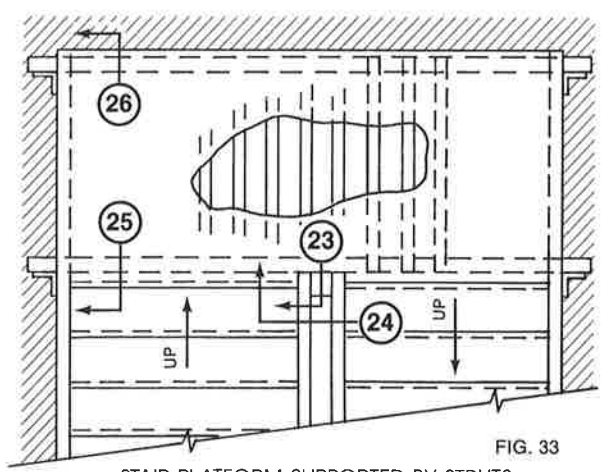


FIG. 33

STAIR PLATFORM SUPPORTED BY STRUTS

Stringers supported on channel header.
Sheet steel, rib deck subplatform supported on channel sections.
Channel sections anchored to struts.
Concrete fill.
Exposed construction underneath.

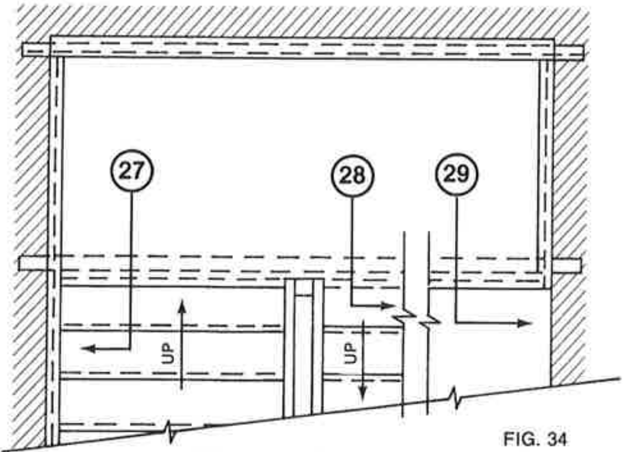


FIG. 34

STAIR PLATFORM
SUPPORTED ON MASONRY BEARING WALL

Stringers supported on channel header.
Steel sheet subplatform supported around periphery on stringers and channel sections.
Channel sections supported on masonry wall.
Concrete fill, 3″ minimum without reinforcing.
Exposed construction underneath.

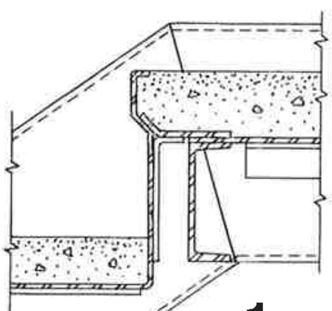
Details for indicated sections are shown on this and the following two pages.

Platform construction methods shown are typical for many uses of metal stairs. The details shown are often interchangeable, and can be modified in other ways to fit various conditions.

Supports for stair platforms are usually concealed in the walls which surround the stairs, and can either be the walls themselves when loadbearing, or may be struts to the floor below, or hangers from the floor above.

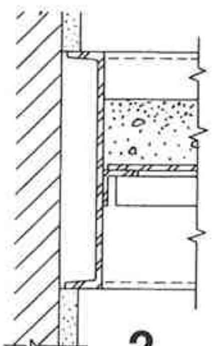
Stair winders are usually built as part of the stair platform. A newel post with sufficiently large base should be provided to receive the ends of the treads and risers. Local laws or ordinances should be checked for regulations covering this type of construction.

Reinforcing steel should be calculated for unusually large platforms. For sizes indicated here, the concrete fills shown have proven adequate as to allowable deflection and prevention of cracking.



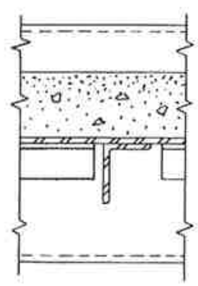
1

Steel channel header bolted or welded to wall stringer. Riser down from platform.



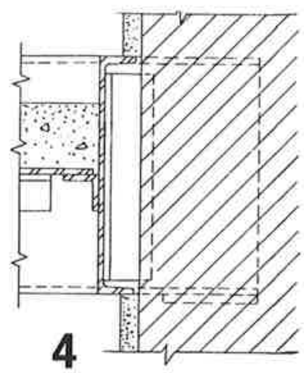
2

Platform wall stringer, plastered wall.



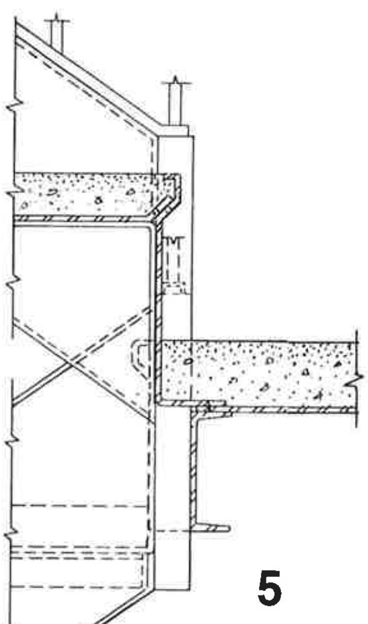
3

Angle subplatform support bolted or welded to stringer. May be angle, channel, I-beam or tee. Support size selected for load requirements.



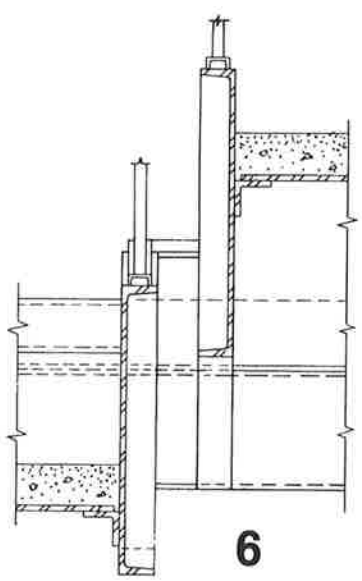
4

Wall stringer extended into masonry wall. Stair load or type of wall may require bearing place.



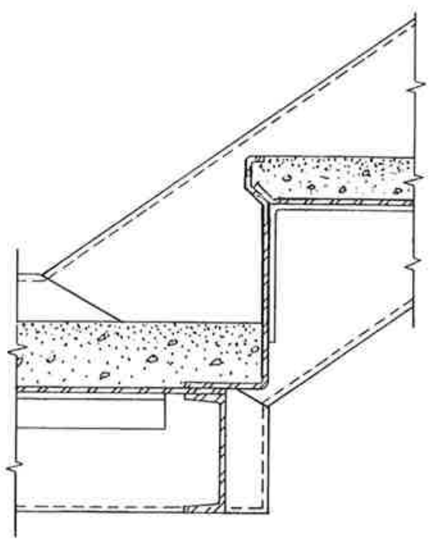
5

Square short newel to receive end of stringer, bolted or welded to channel header.



6

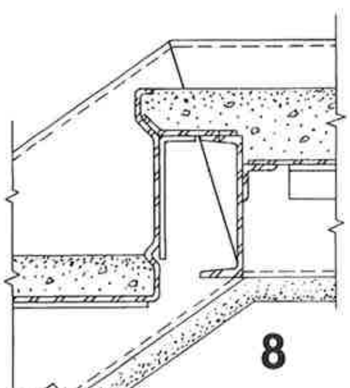
Elevation of stringer return at platform header.



7

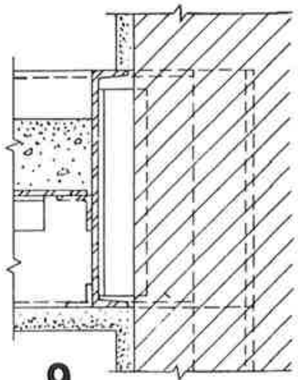
Steel channel header bolted or welded to wall stringer. Riser up from platform.

See Pages 4-8 & 9 for key plans showing locations of sections



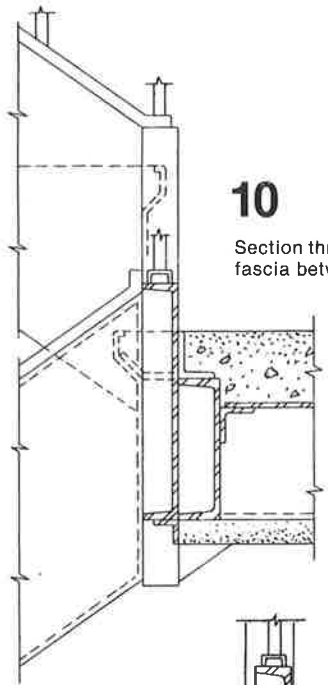
8

Steel channel header bolted or welded to wall stringer and extended above subplatform permitting larger header.



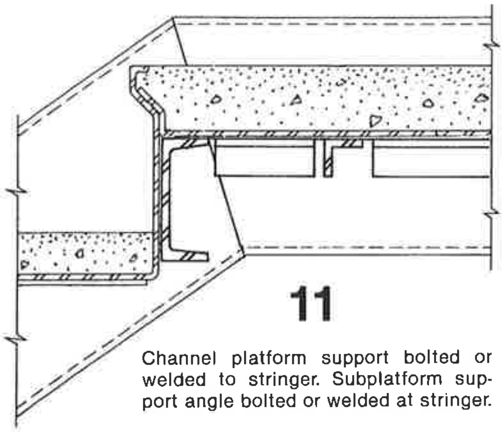
9

Wall stringer extended into wall and supported on steel angle strut to floor below. Beam, pipe, channel or other section may be used as strut.



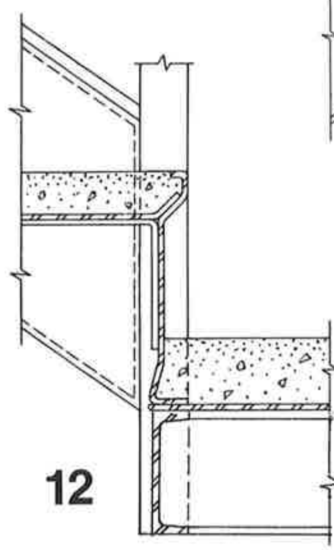
10

Section through platform fascia between newels.



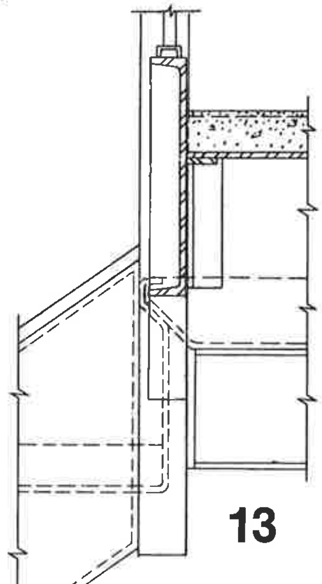
11

Channel platform support bolted or welded to stringer. Subplatform support angle bolted or welded at stringer.



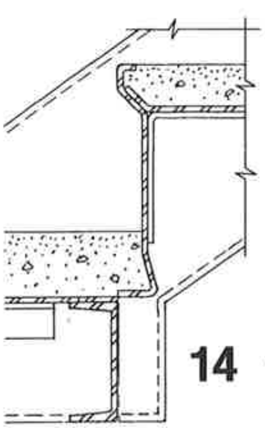
12

Channel platform support bolted or welded to newel. Riser up from platform.



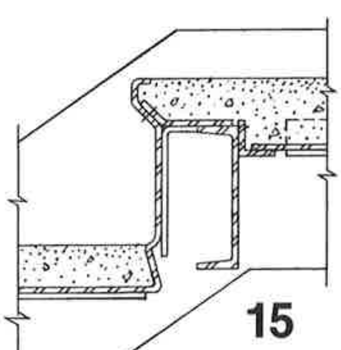
13

Stringers at platform landing bolted or welded to newel.



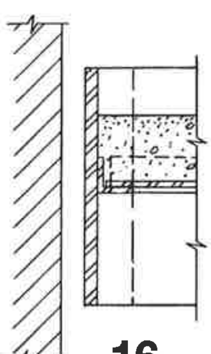
14

Channel platform support set below riser and bolted or welded to stringer. Opposite end connected to newel.



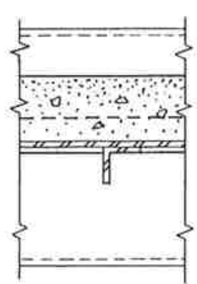
15

Steel channel header bolted or welded to wall stringer. Top of header raised above subplatform. Subplatform angles supporting brackets turned up. Riser down from platform.



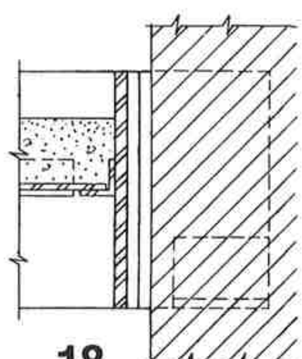
16

Plate wall stringer set out from wall. Subplatform with angle supporting brackets turned up.



17

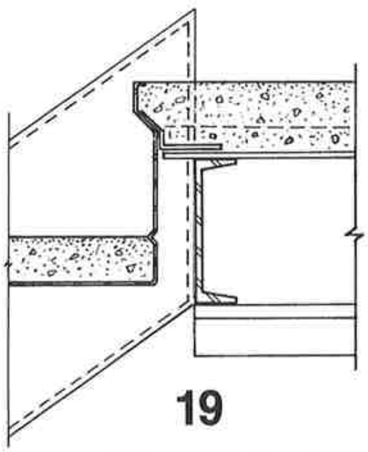
Angle subplatform support bolted or welded to stringer. Angle supporting platform sub-plate turned up on stringer.



18

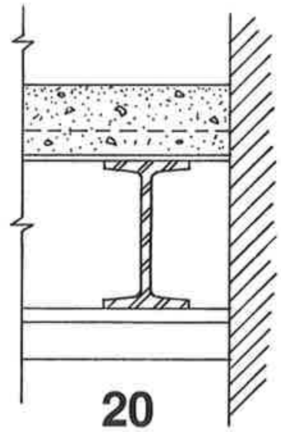
Plate wall stringer extended into masonry wall with angle bearing bracket. Subplatform with angle supporting brackets turned up.

See Pages 4-8 & 9 for key plans showing location of sections



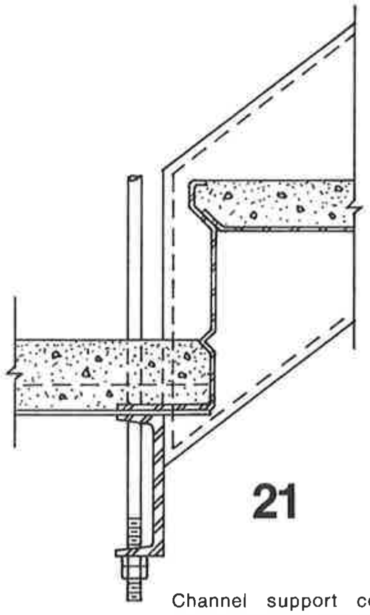
19

Channel platform support connected to stringer and mounted on wall angle.



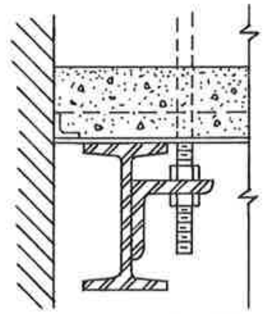
20

I-beam platform support mounted on wall angle.



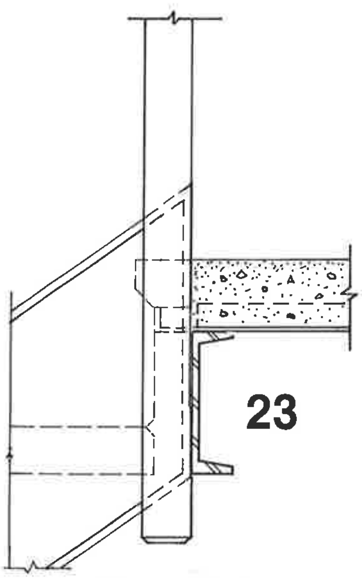
21

Channel support connected to stringer and suspended by hanger.



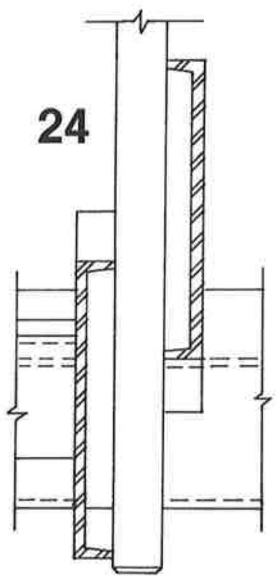
22

I-beam platform support suspended by hanger.



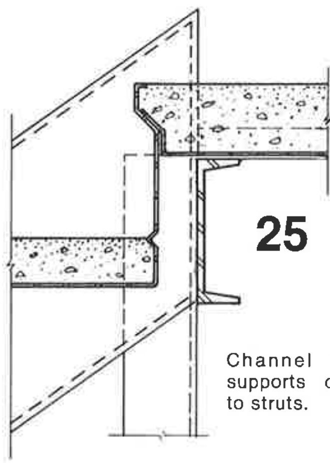
23

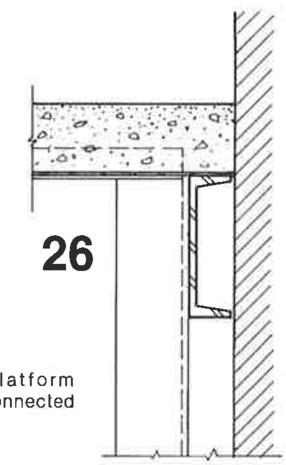
Stringers bolted or welded to channel header.



24

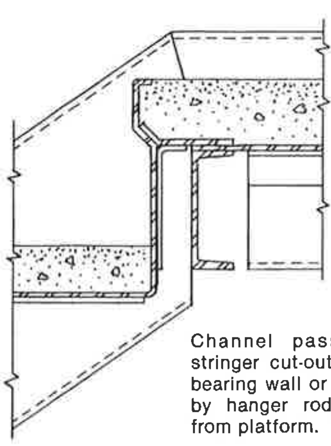
Stringers connected to newel.





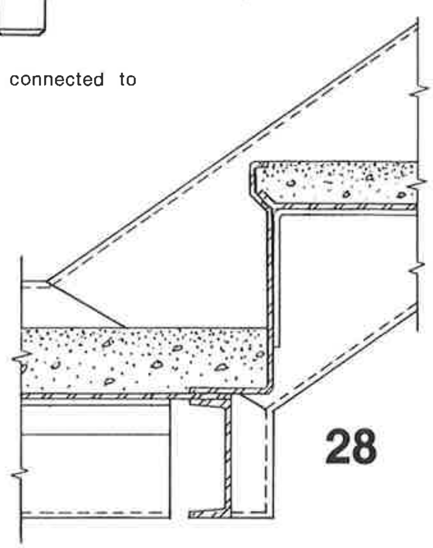
25 26

Channel platform supports connected to struts.



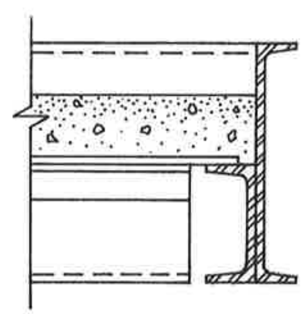
27

Channel passes through stringer cut-out to mount on bearing wall or be suspended by hanger rod. Riser down from platform.



28

Channel passes through stringer cut-out to mount on bearing wall or be suspended by hanger rod. Riser up from platform.



29

Edge of platform at open well. Face stringer attached to channel header. Channel stringer around platform.

TYPES PROVIDING INTERRUPTED SOFFIT SURFACES

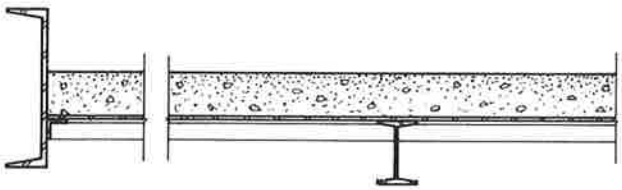


FIG. 35

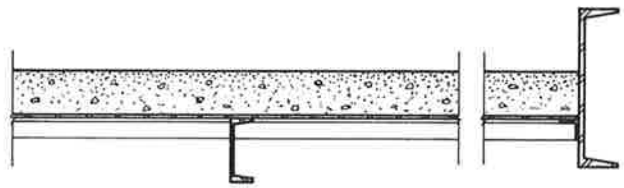


FIG. 36

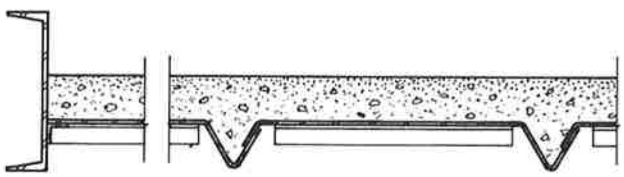


FIG. 37

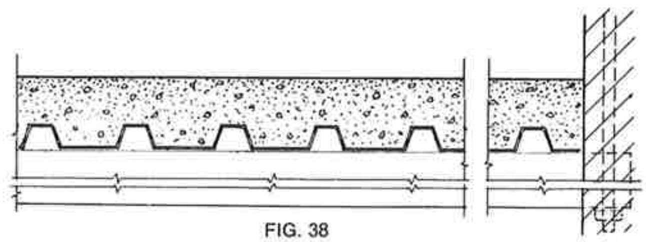


FIG. 38

TYPES PROVIDING SMOOTH SOFFIT SURFACES

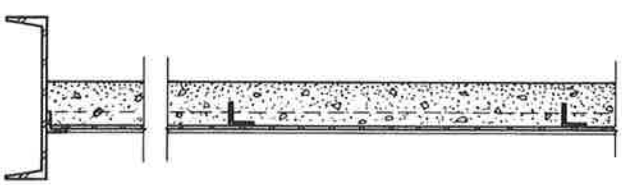


FIG. 39

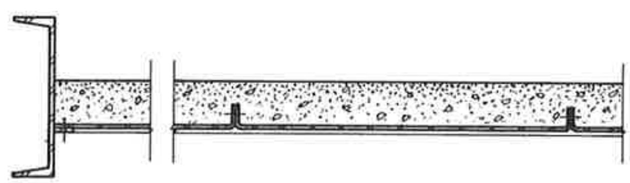


FIG. 40

2

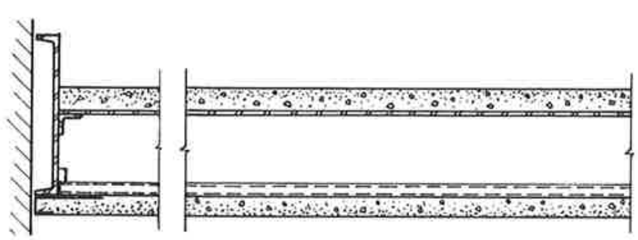
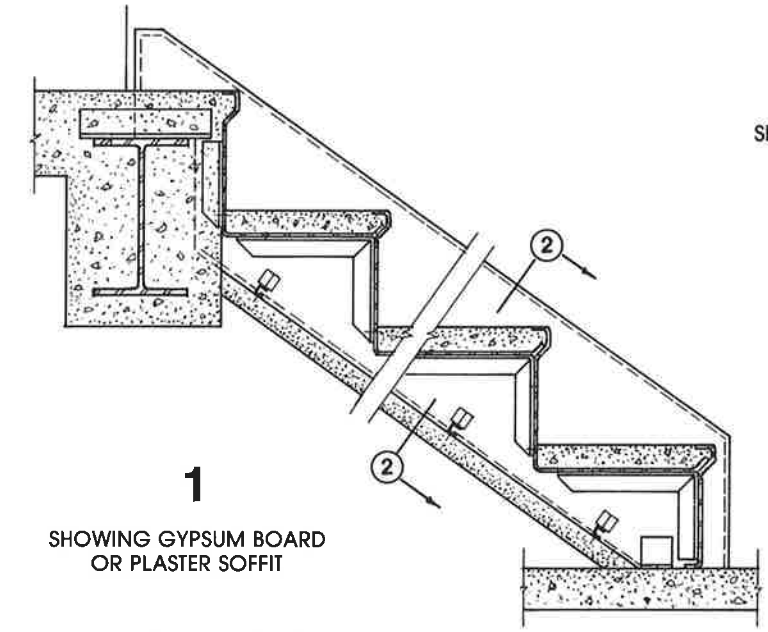


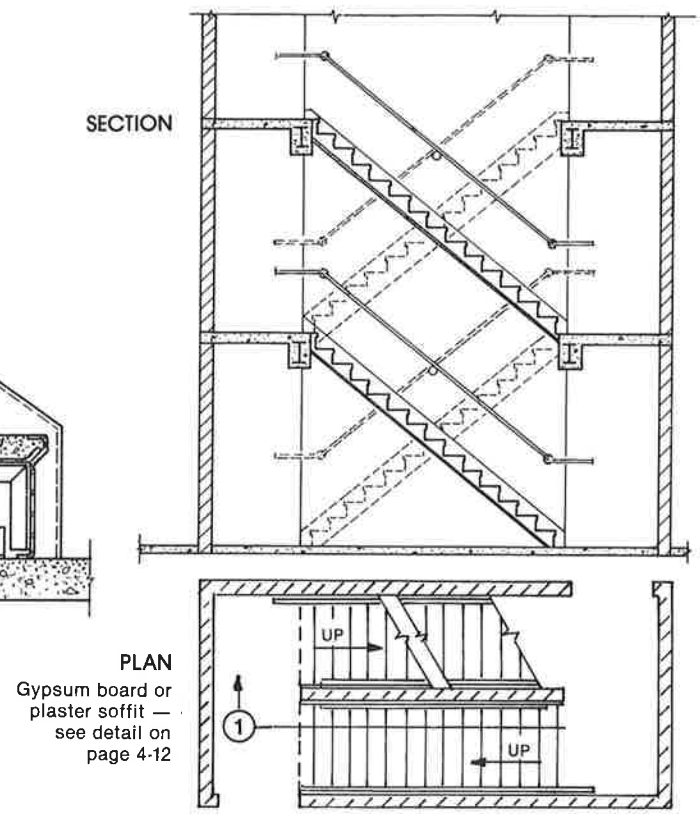
FIG. 41

Gypsum board or plaster soffit.



1

SHOWING GYPSUM BOARD OR PLASTER SOFFIT



CONSTRUCTION NOTES:

Gypsum Board or Plaster Soffit — 1¼″ × 1¼″ × ⅛″ steel angle clips welded to stringers approximately 12″o.c. to support furring channels, gypsum board or metal lath and plaster provided by others.

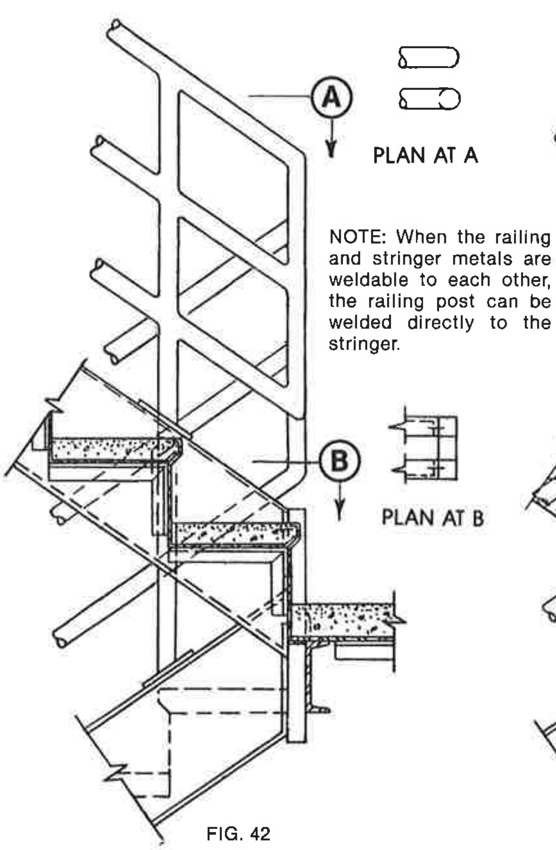


FIG. 42

Stair platform or landing with pipe railings, railings not connected, for stairwell having minimum clearance. Short newels, supported on header.

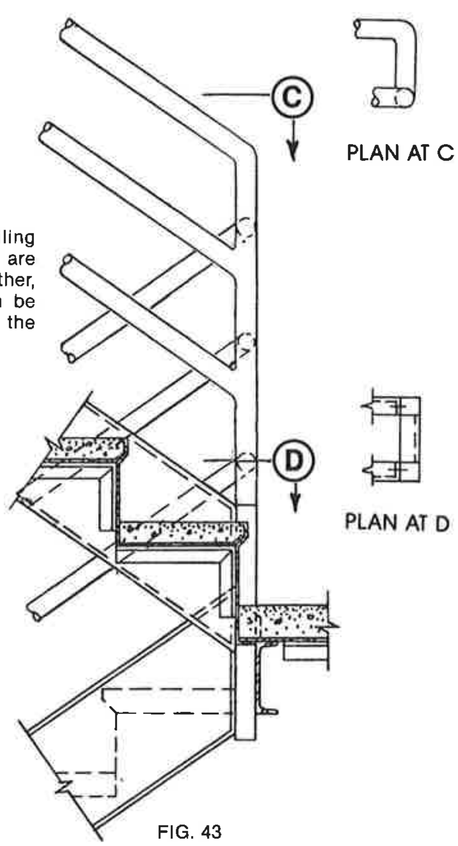


FIG. 43

Stair platform or landing with pipe railing, one post at return. Lower rail returned into post, two or more posts used at wide wells. Short newels, supported on header.

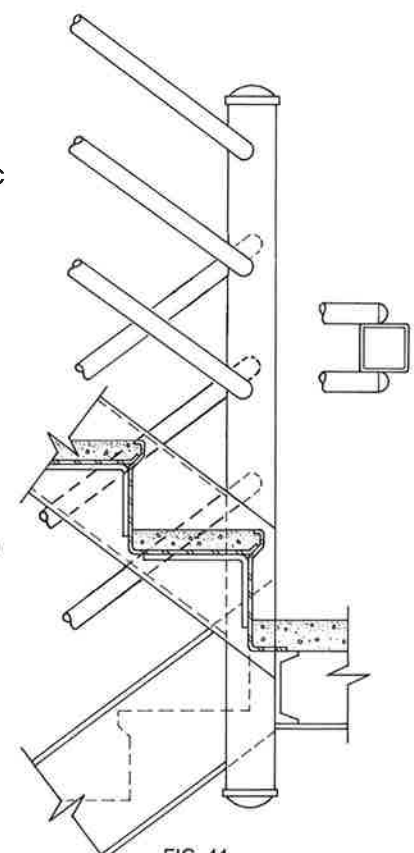


FIG. 44

Stair platform or landing with rectangular or square newel, pipe railing members capped and welded to newel post.

Conditions shown are typical for conventional type stairs with channel stringers. Material for railings may be pipe or tubing of steel, aluminum, stainless steel or bronze. Refer to Pages 5-30 to 5-34 for pipe and tubing data.

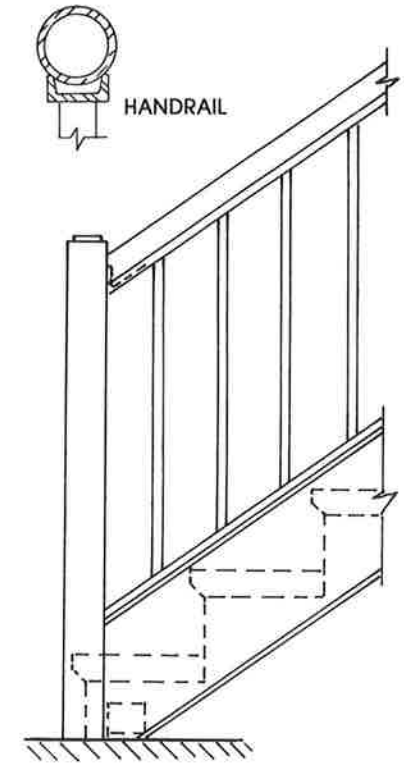


FIG. 45
Stair start with square newel, baluster type railing with channel top and bottom, pipe handrail.

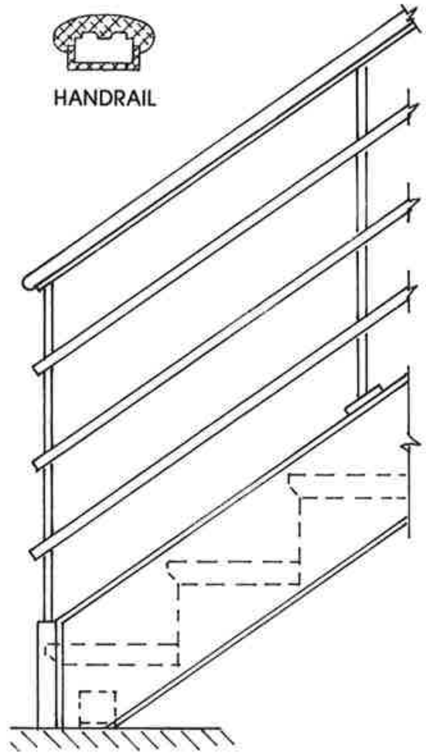


FIG. 46
Stair start with short newel, parallel bar type railing with end and intermediate posts of square, rectangular or round section, extruded handrail with mitered, forged or cast terminal.

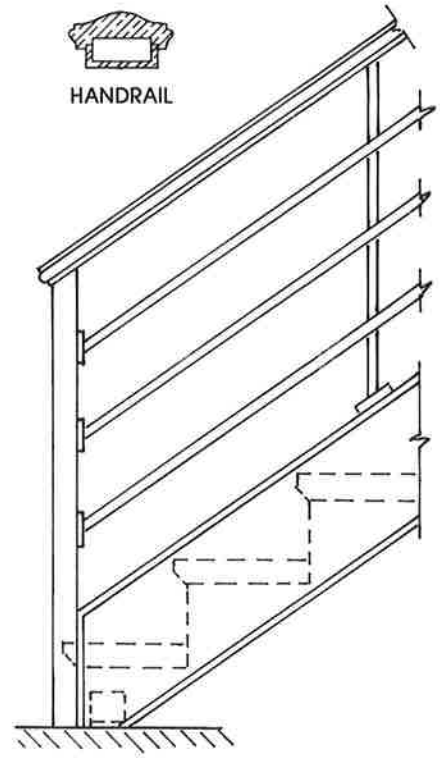


FIG. 47
Stair start with square newel, parallel bar type railing with intermediate posts of square, rectangular or round section; extruded or rolled handrail section mitered to form cap over newel.

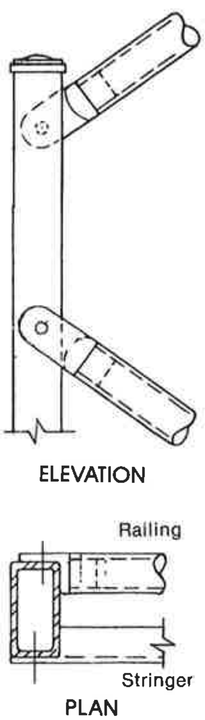


FIG. 48
Square or rectangular newel, pipe rail fitted with offset lug to center on stringer.

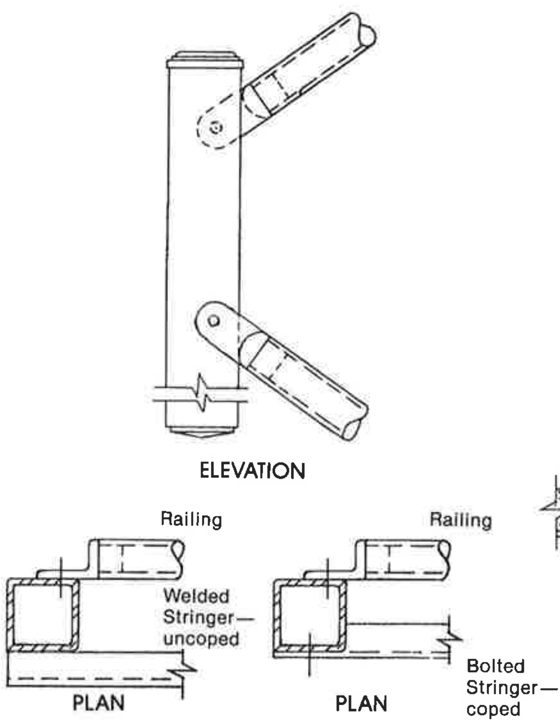


FIG. 49
Square or rectangular newel, pipe rail fitted with offset lug for positioning inside of stringer.

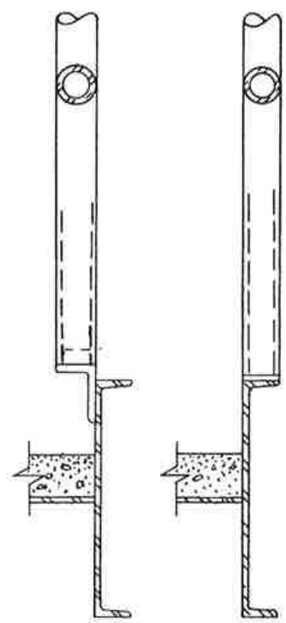


FIG. 50
Section showing fastening for intermediate posts to stringers.

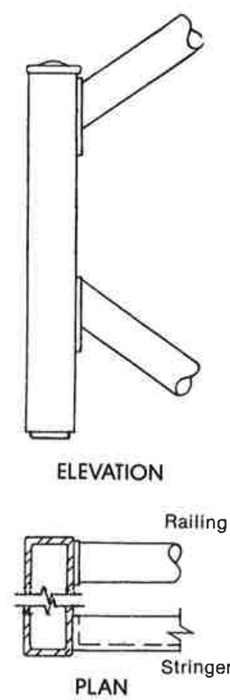


FIG. 51
Rectangular newel, pipe rail and stringer welded or bolted to face.

Conditions shown are typical for conventional type stairs with channel stringers. Newels may be special design. Posts caps and drops may be cast, pressed or steel plate. Refer to pages 5-30 thru 5-34 for pipe and tubing data.

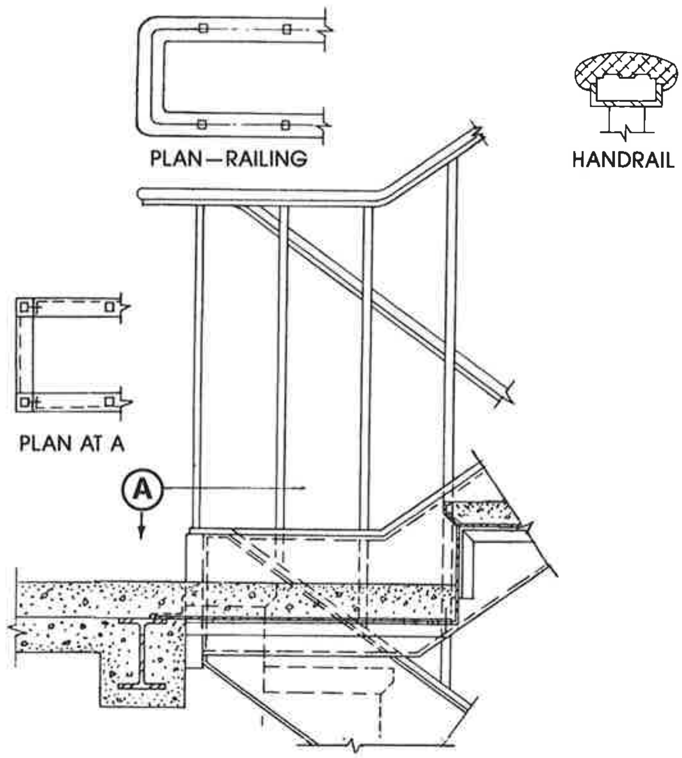
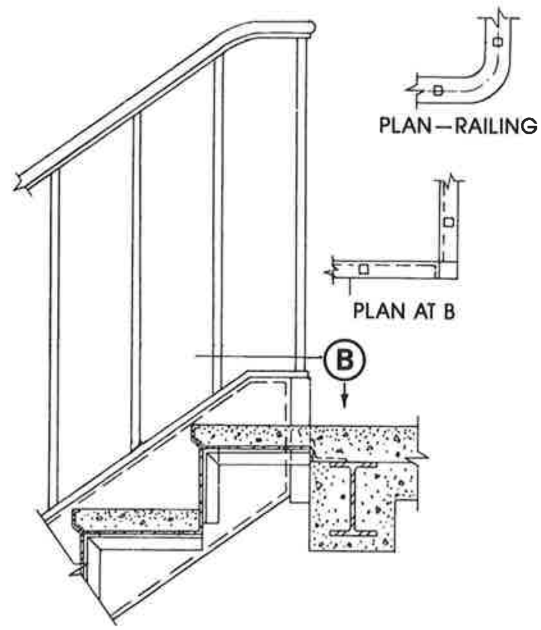


FIG. 52

Stair landing with stringers and fascia framed square. Square railing return, end balusters centered on newels and landing extended on up flight to set-back riser.



FIG, 53

Stair landing, with stringer and fascia at right angle. Landing extended on down flight to set-forward riser, producing easement in handrail.

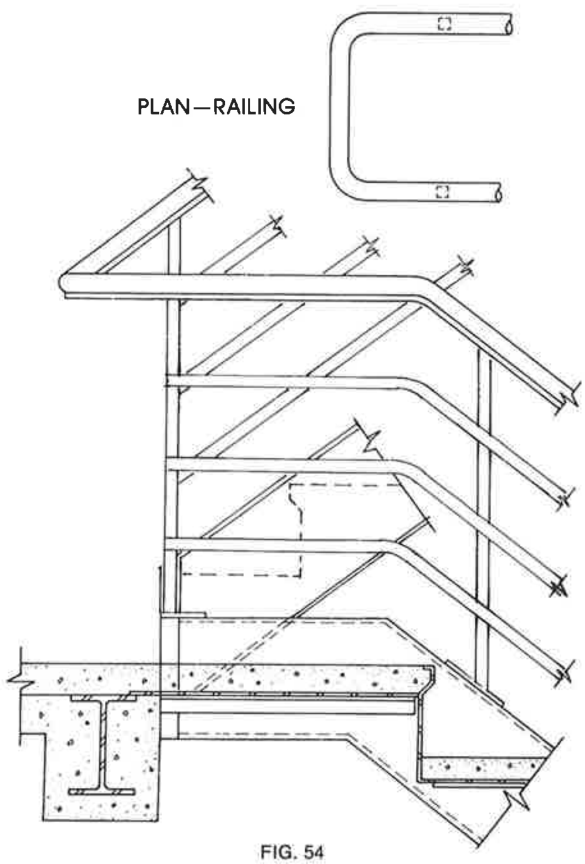


FIG. 54

Stair landing with stringers and fascia framed square. Radius railing return, parallel bar type railing with end balusters centered on newels. Landing extended on down flight to set-forward riser.

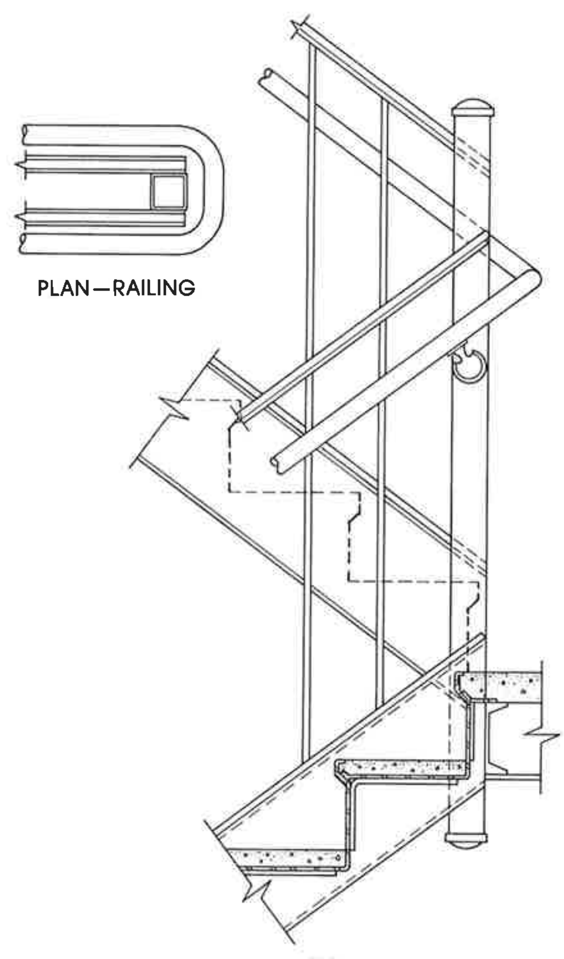


FIG.55

Stair landing with stringers and fascia framed into full height newel, baluster railing with channel top and bottom. Continuous pipe handrail offset from balusters and newels by brackets.

EXTRUDED ALUMINUM AND BRONZE POST SECTIONS TYPICAL OF SEVERAL MANUFACTURERS

Consult manufacturers' catalogs for contours, sizes and availability

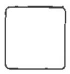


FIG. 56
1 1/4″


FIG. 57
2 3/4″


FIG. 58
2 3/4″


FIG. 59
2″
Aluminum only

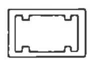


FIG. 60
1 5/8″

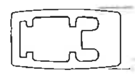


FIG. 61
2 3/8″
Aluminum only

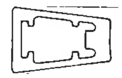


FIG. 62
2″
Aluminum only

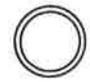


FIG. 63
Various

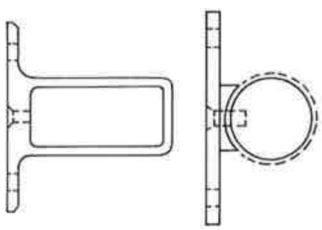


FIG. 64
Flanges for box and solid stringers.

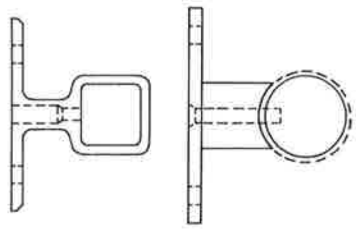


FIG. 65
Flanges for channel stringers.

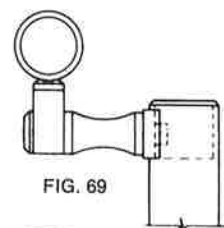


FIG. 69

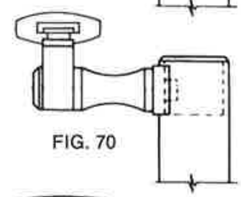


FIG. 70

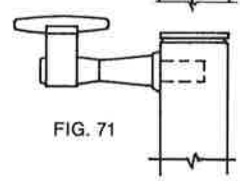


FIG. 71

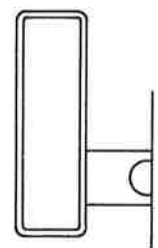


FIG. 72

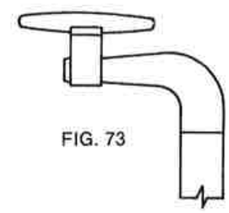


FIG. 73

FIG. 69-73
Sections — railing posts with brackets.

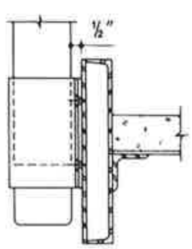


FIG. 66
Post mounted on box stringer.

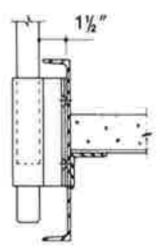


FIG. 67
Post mounted on channel stringer.

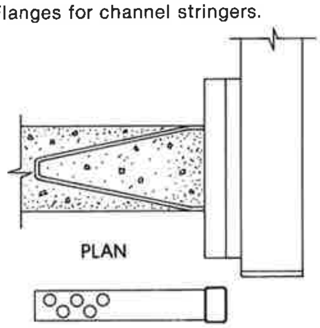


FIG. 68
Post mounted on concrete step using post anchor.

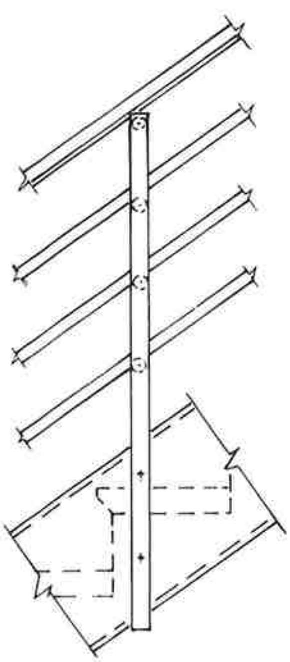


FIG. 74
Elevation; intermediate post set on face of box stringer.

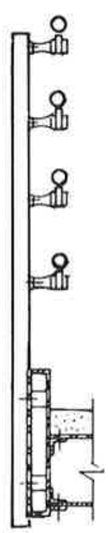


FIG. 75
Section; intermediate post set on face of box stringer.

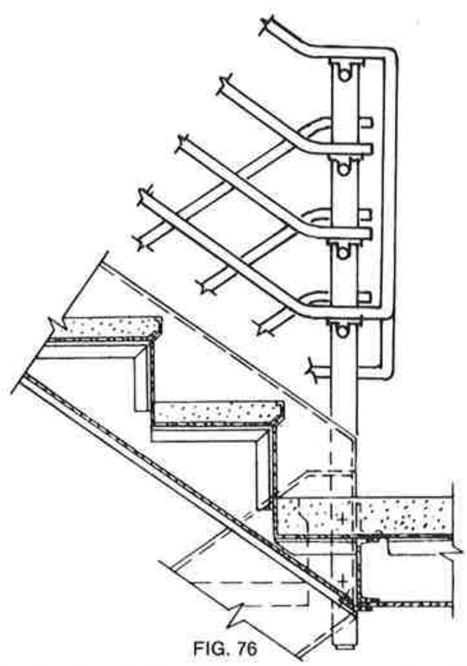


FIG. 76
Stair landing with box stringers attached to sides of newel, parallel type bar railing supported by brackets at newels and intermediate posts. Risers offset to allow metal soffits of stair to meet at intersection with soffit of landing. Bottom and top rails must be the same and have symmetrical cross section to obtain proper mitered connection.

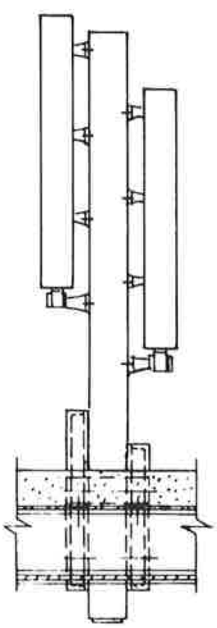


FIG. 77
Elevation of Figure 75. Rectangular newel post.

Center Railings are recommended for wide stairs. They may be a single pipe or tubing railing or they may be designed with double rails and panels of interesting design.

Note: A number of codes require that railings have a level extension beyond the nosings at the floors as indicated in Fig. 78 by dashed lines. This applies to both wall and center railings.

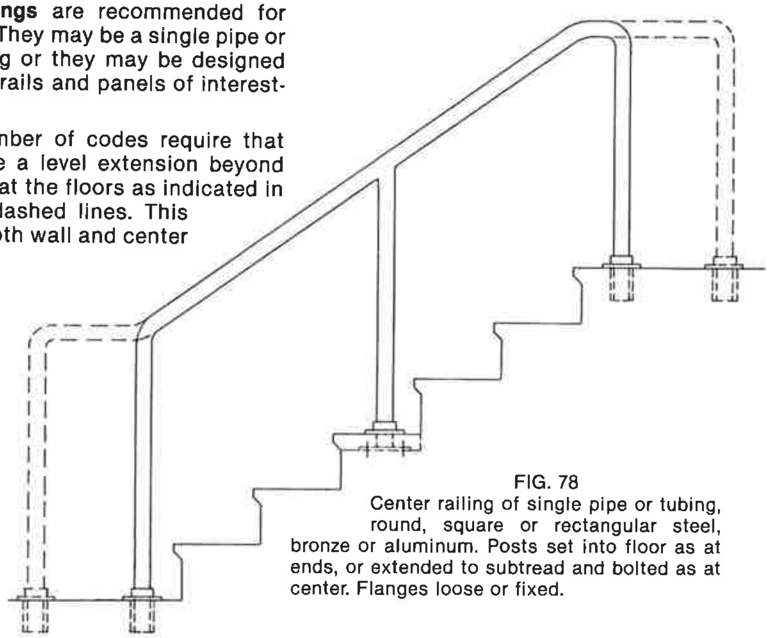


FIG. 78
Center railing of single pipe or tubing, round, square or rectangular steel, bronze or aluminum. Posts set into floor as at ends, or extended to subtread and bolted as at center. Flanges loose or fixed.

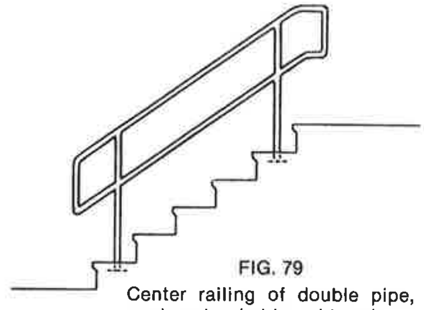


FIG. 79
Center railing of double pipe, posts extended to subtread.

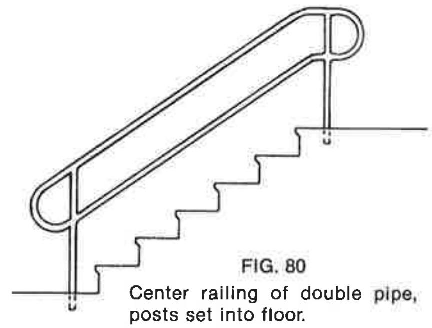
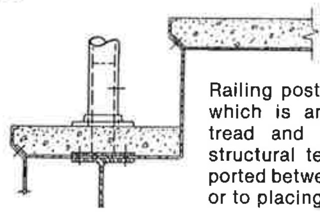


FIG. 80
Center railing of double pipe, posts set into floor.



Railing post set over dowel which is anchored to pan tread and reinforced with structural tee member supported between stringers prior to placing concrete fill.

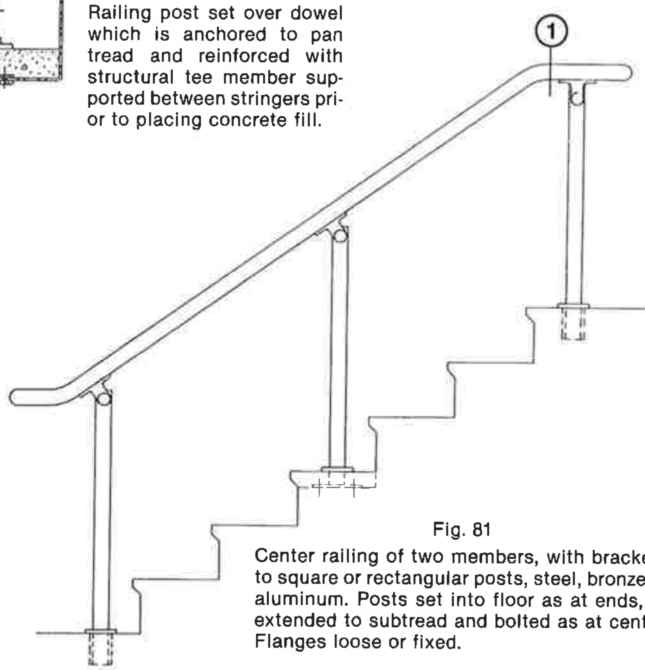
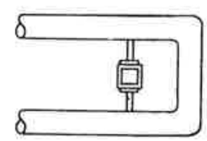
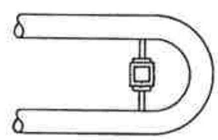


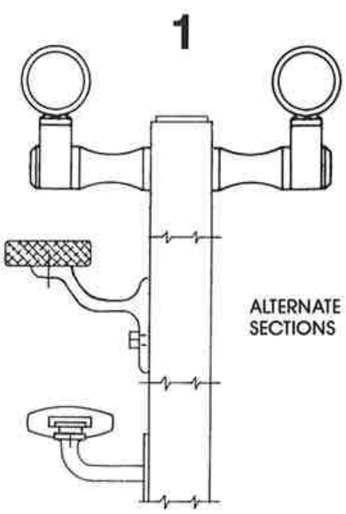
Fig. 81
Center railing of two members, with brackets to square or rectangular posts, steel, bronze or aluminum. Posts set into floor as at ends, or extended to subtread and bolted as at center. Flanges loose or fixed.

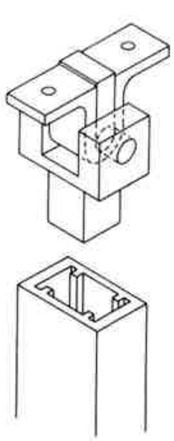


PLAN A
Handrail with square return mitered.



PLAN B
Handrail with round return.





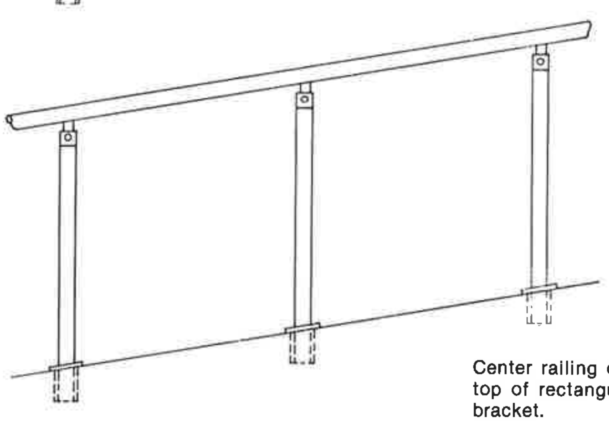
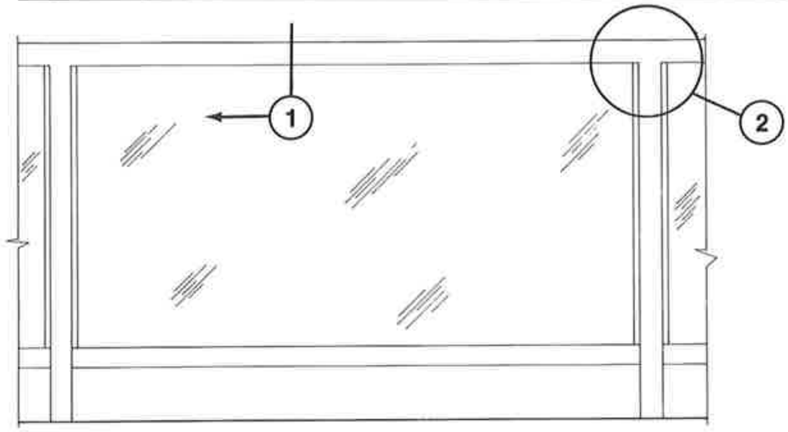
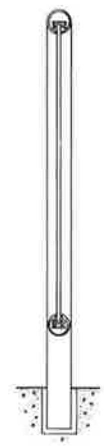


FIG. 82
Center railing of single member centered on top of rectangular post by means of hinged bracket.

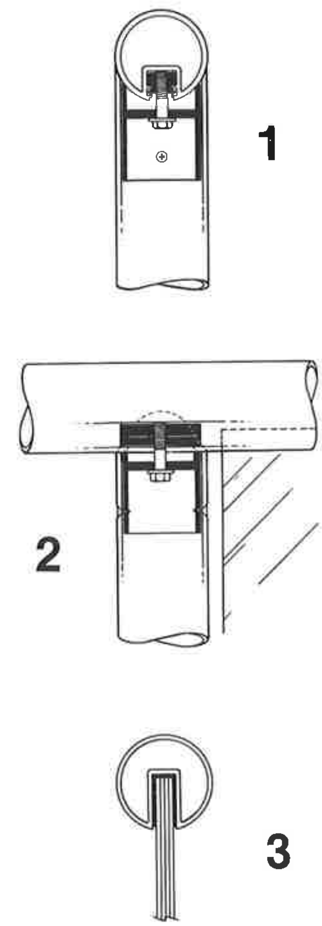
Non-ferrous or stainless steel sleeves may be used on exterior rails to prevent staining masonry or concrete.

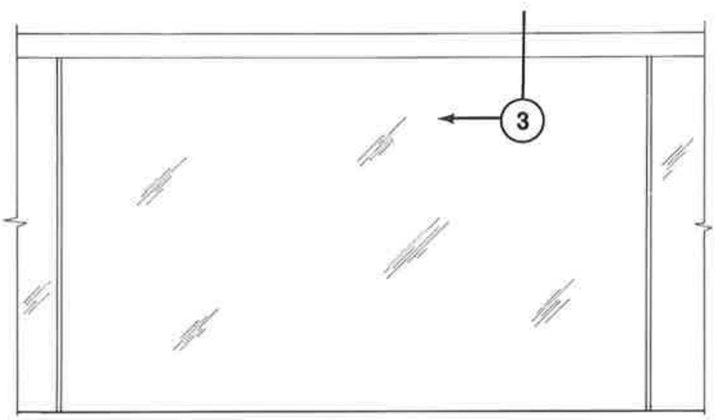


FRAMED GLASS PANELS



SECTION

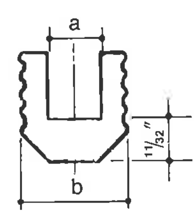




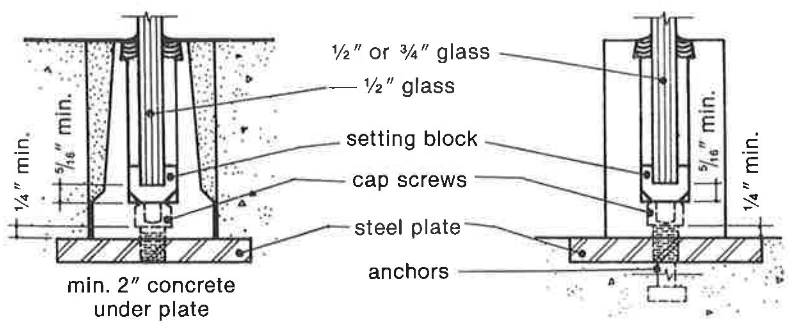
STRUCTURAL GLASS BALUSTERS

SECTION

SETTING BLOCK
Polyvinyl Chloride

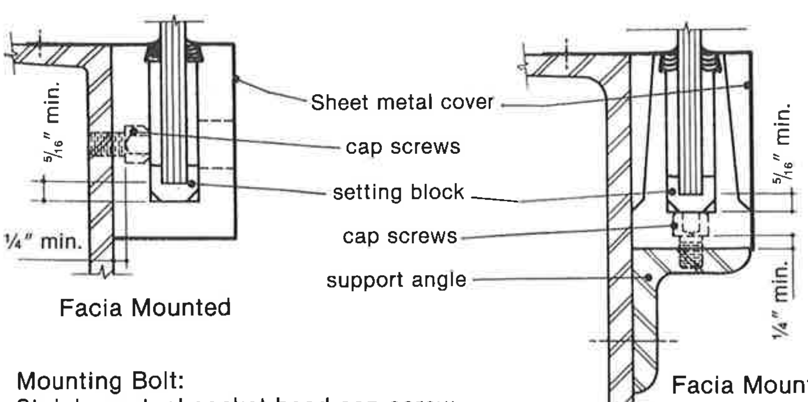


a	b
½"	1"
¾"	1¼"



Flush Mounted

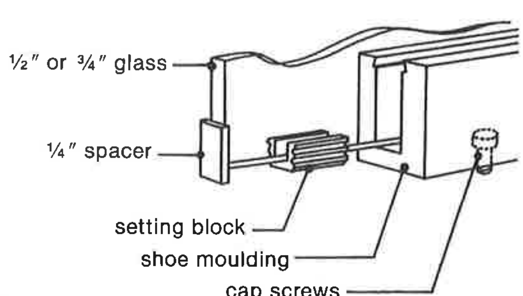
Surface Mounted



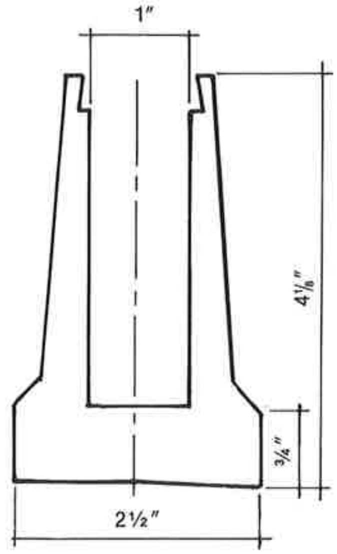
Facia Mounted

Facia Mounted

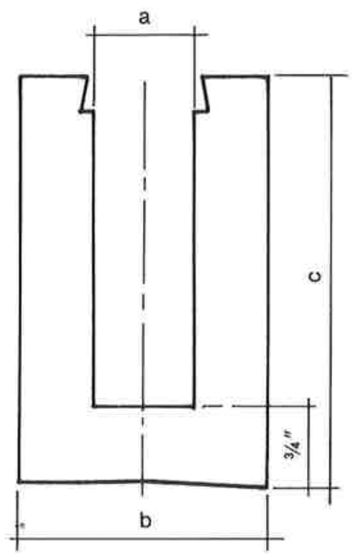
Mounting Bolt:
Stainless steel socket head cap screw.



SHOE MOULDING Aluminum

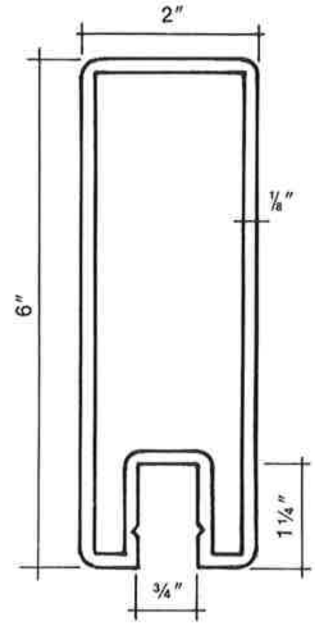


(6061-T6)



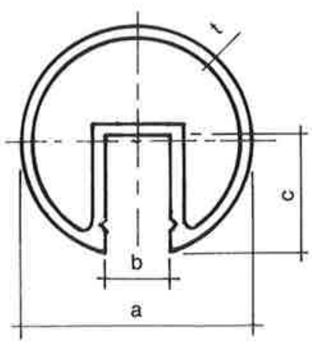
	a	b	c
	1″	2½″	4⅛″
†	1¼″	2¾″	4¼″

†For use with ¾″ glass

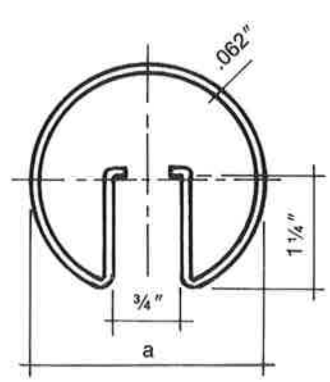


Aluminum

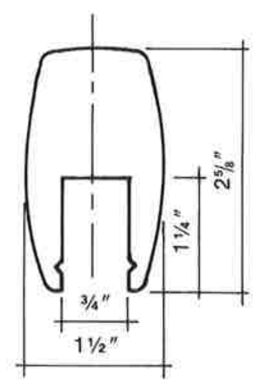
HANDRAIL MOULDINGS



Aluminum and Bronze



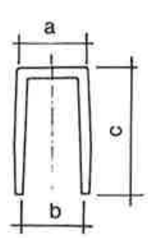
Stainless Steel

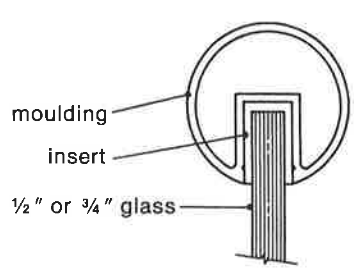


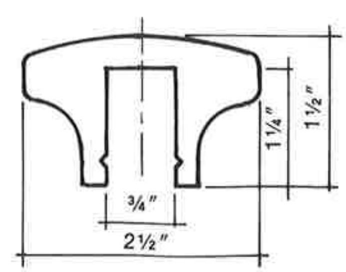
Aluminum

PROTECTIVE INSERT
Polyvinyl Chloride

a	b	c
¾″	½″	1″
¾″	½″	1¼″
1″	¾″	1¼″



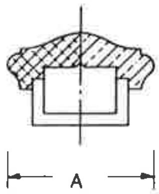




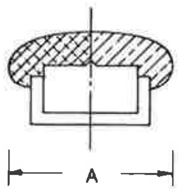
Aluminum

EXTRUDED ALUMINUM AND BRONZE HANDRAIL SECTIONS TYPICAL OF SEVERAL MANUFACTURERS

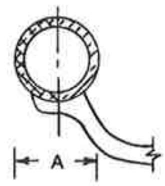
Most of these sections can be mounted on channels or flats, secured by screws from below. Some are designed for mounting on handrail brackets. The use of channels instead of solid bars often simplifies the attachment of baluster and ornaments. The channels may be of the same or a different metal.



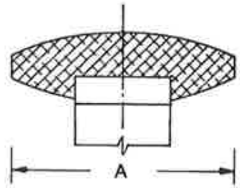
A = 1-5/8", 1-15/16", 2-1/4"
Aluminum and Bronze
FIG. 83



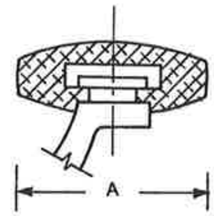
A = 1-3/4", 2-1/8"
Aluminum and Bronze
FIG. 84



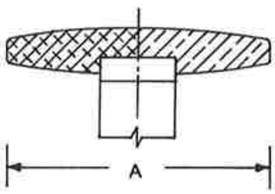
A = 1.66" and 1.90" typical.
Aluminum and Bronze
FIG. 85



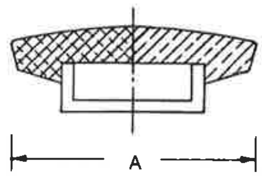
A = 2-3/8" Aluminum
FIG. 86



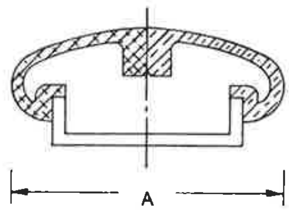
A = 1-1/2", 2", 2-1/2" Aluminum
FIG. 87



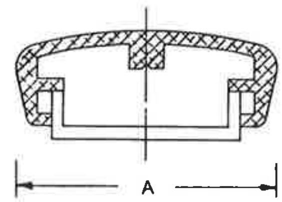
A = 3-1/4", 3-3/4" Aluminum
A = 2-1/4", 2-3/4" Bronze
FIG. 88



A = 2-3/4", 3"
Aluminum and Bronze
FIG. 89



A = 2-7/8"
Aluminum and Bronze
FIG. 90



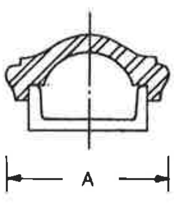
A = 2-3/4" Aluminum
FIG. 91

On projects requiring the development of original designs, the cost of special dies is not excessive when spread over a sufficient quantity. For moderate quantities, cost may be kept at a minimum by the use of available sections. Consult manufacturers' catalogs for exact contours, sizes and availability of specific sections.

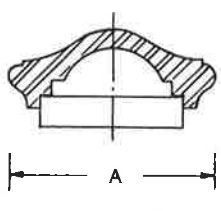
All sections have limitations in forming curves without distortion. Solid sections should be selected when curving is required. Stock corner bends are available for many handrail sections.

ROLLED STEEL HANDRAIL SECTIONS TYPICAL OF SEVERAL MANUFACTURERS

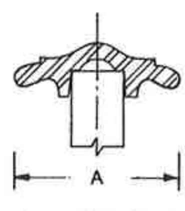
Most of these sections can be mounted on channels or flats, secured by screws or welding from below. Sometimes they are welded directly to the baluster (see Fig. 94) or attached to handrail brackets (see Fig. 85). The use of channels often simplifies the attachment of balusters and ornaments.



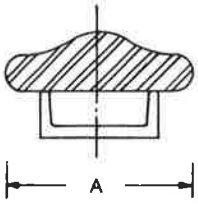
A = 1-3/4" Steel
FIG. 92



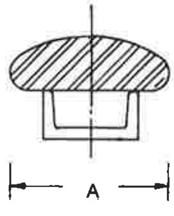
A = 1-15/16", 2-1/4" Steel
FIG. 93



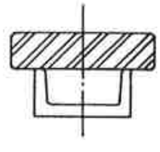
A = 1-3/4" Steel
FIG. 94



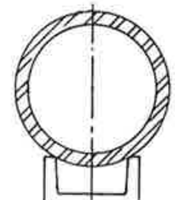
A = 2" Steel
FIG. 95



A = 1-3/4" Steel
FIG. 96



Various Steel
FIG. 97



Various, 1.66" typical Steel
FIG. 98

Extremely high tooling cost prohibits the use of special hot rolled steel sections even on large projects. The choice is limited to available stock sizes. Consult manufacturers' catalogs for exact contours, sizes and availability.

REPRESENTATIVE EXTRUDED AND TUBULAR STAINLESS STEEL HANDRAIL SECTIONS

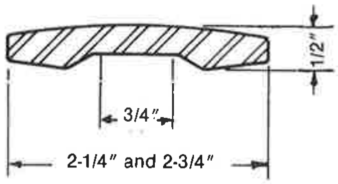


FIG. 99
Stainless Steel
Extrusion

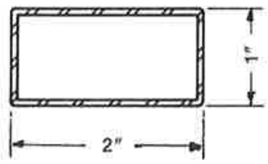


FIG. 100
Stainless Steel
(other sizes available)

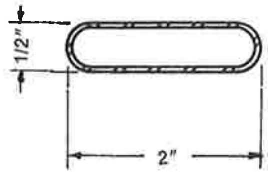


FIG. 101
Stainless Steel

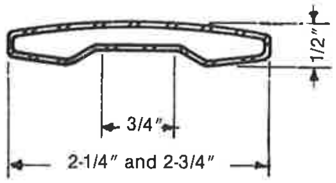


FIG. 102
Stainless Steel

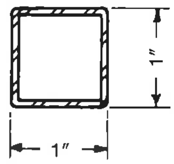
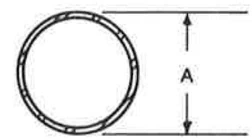


FIG. 103
Stainless Steel
(other sizes available)



A = Various
1.66" and 1.90" typical

FIG. 104
Stainless Steel

Stainless tubular handrail sections usually have a wall thickness of .065".

Consult manufacturers' data for exact contours, sizes and current availability of all of the above and other handrail sections.

PLASTIC HANDRAIL COVERINGS AVAILABLE FROM VARIOUS MANUFACTURERS

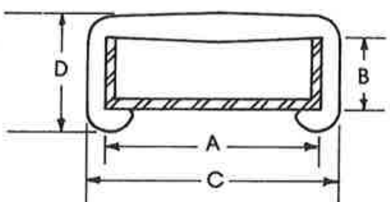


FIG. 105

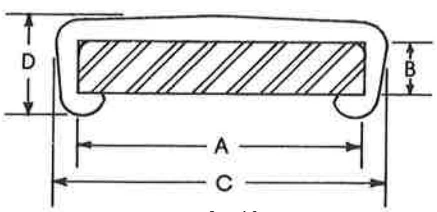


FIG. 106

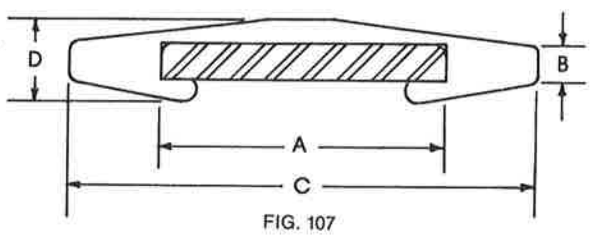


FIG. 107

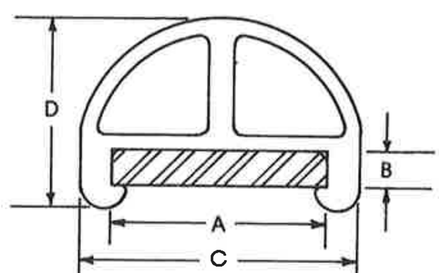


FIG. 108

GENERAL INFORMATION

Functional and decorative plastic handrail mouldings of polyvinyl chloride plastics are available in a variety of sizes and profiles, several of which are illustrated above. Consult suppliers current literature for variations in details and features.

Plastic handrail mouldings are not structural and require bar, tube, or channel members to support vertical and horizontal loads.

Plastic handrail mouldings are produced in a range of colors from subdued to bright, to suit either formal or informal design situations. The color is integral with the plastic, which is highly resistant to wear, weathering, and corrosion.

The thermoplastic material becomes pliable when heated (not over 165°F), at which time it can be fitted over the support member and conforms to vertical, horizontal or combined vertical and horizontal curves within certain limitations.

Lateral bends should have a minimum centerline radius of not less than 2 times the width of the plastic section or 2 1/2 to 3 times the width of the support section, whichever is greater. Mitered corners should be used if sharper turns are required.

Combined vertical and horizontal turns can be formed by twisting the moulding.

The material can be joined by thermal welding, and end caps can be shaped using a knife, file or abrasives.

The use of a cleaning solution for removing grease and foreign material is recommended after which a solvent is used for polishing or removing abrasive scratches. Normal cleaning requires only soap and water.

Table of dimensions for plastic handrail coverings

	A	B	C	D
FIG.	Inside Width	Inside Height	Outside Width	Outside Height
105	1" 1-1/4" 1-1/2"	1/2"	1-5/16" 1-9/16" 1-13/16"	1-3/16"
106	1-1/4" 1-1/2" 2"	1/4" 1/4" 3/8"	1-9/16" 1-13/16" 2-5/16"	9/16" 9/16" 11/16"
107	1-1/2" 2"	1/4"	2-3/4" 3-1/4"	1/2" 9/16"
108	1-1/4" 1-1/2"	1/4"	1-5/8" 1-7/8"	1-3/16" 1-5/16"

CAUTION:
Consult manufacturers for fabrication limitations.

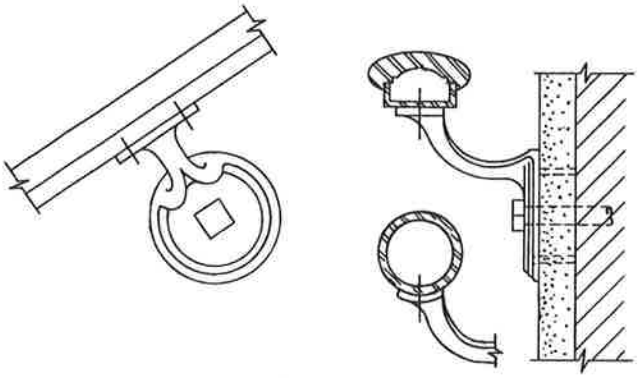


FIG. 109
Wall rail bracket of conventional cast design, malleable iron, aluminum or bronze. 3/8″ bolt into wall.

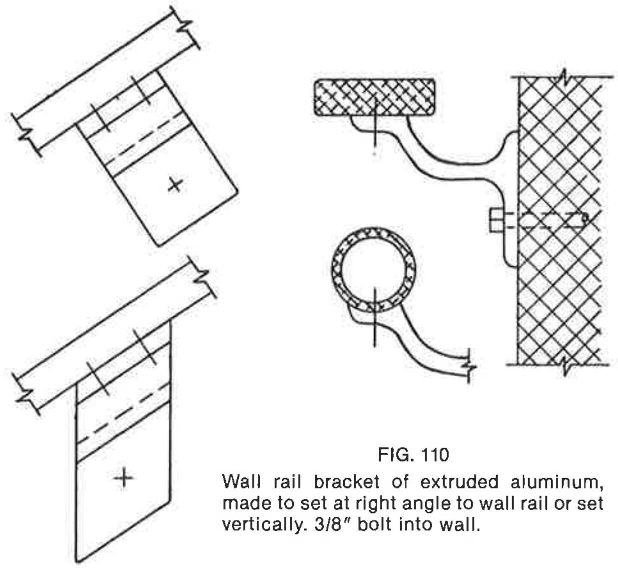


FIG. 110
Wall rail bracket of extruded aluminum, made to set at right angle to wall rail or set vertically. 3/8″ bolt into wall.

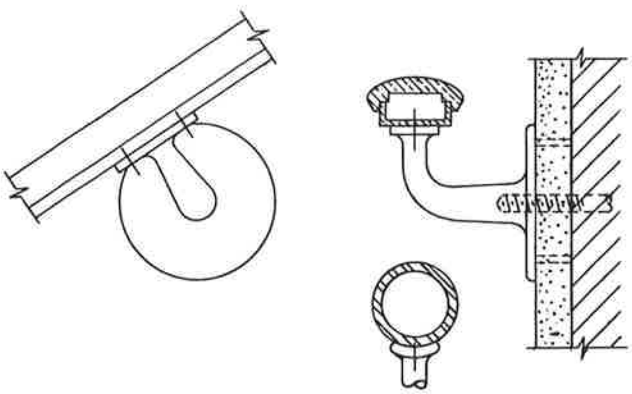


FIG. 111
Wall rail bracket of conventional cast design, malleable iron, aluminum or bronze, 3/8″ stud into wall, tapped into arm of bracket.

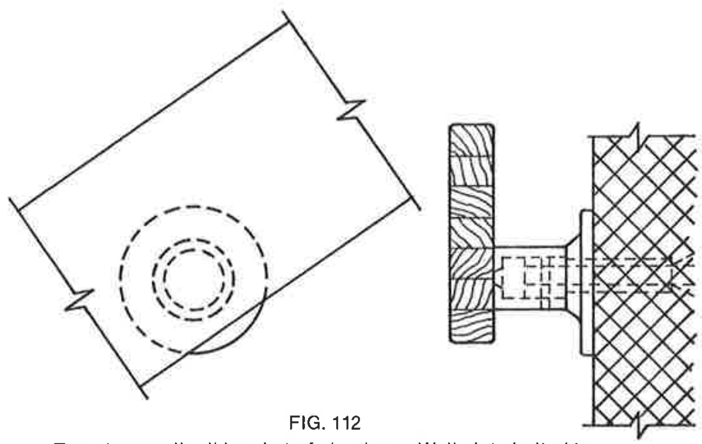


FIG. 112
Two-piece wall rail bracket of aluminum. Wall plate bolted into wall through expansion type anchor. Outer sleeve screwed to rail. Outer sleeve fastened to wall plate by set screw.

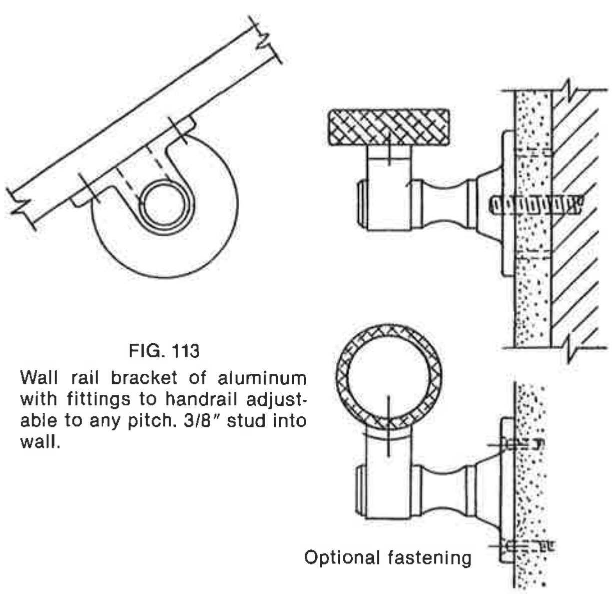


FIG. 113
Wall rail bracket of aluminum with fittings to handrail adjustable to any pitch. 3/8″ stud into wall.

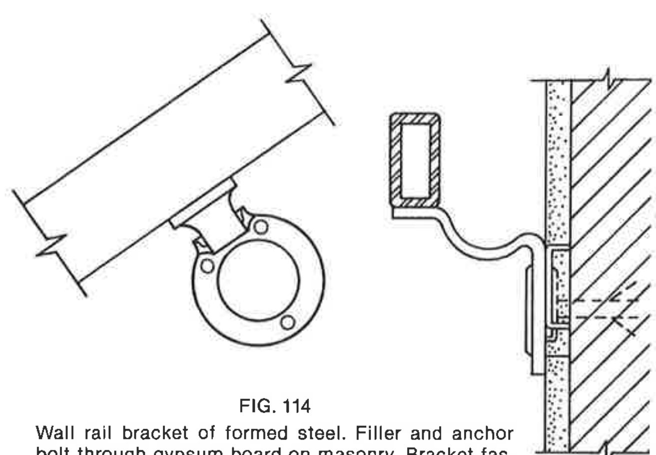


FIG. 114
Wall rail bracket of formed steel. Filler and anchor bolt through gypsum board on masonry. Bracket fastened to filler by three screws or by 3/8″ bolt through center.

IMPORTANT: Consult governing codes for minimum hand clearance and maximum projection allowable. The wall brackets shown above are typical of types commonly used. Consult manufacturers' literature for details and features of brackets currently available.

For bracket fastenings, refer to Page 4-23.

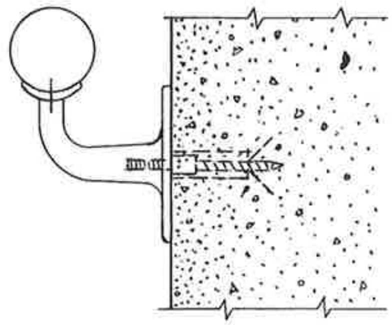


FIG. 115
Directly to concrete. Bracket tapped and anchored with stud and expansion type anchor.

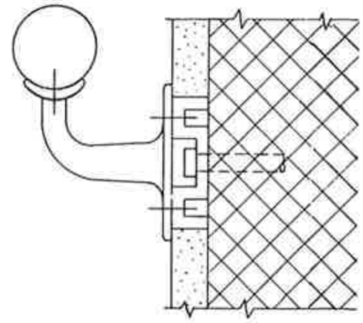


FIG. 116
Plaster on masonry. Three No. 10 machine screws, flat, round or oval head, into filler secured by one 3/8" bolt, anchorage optional.

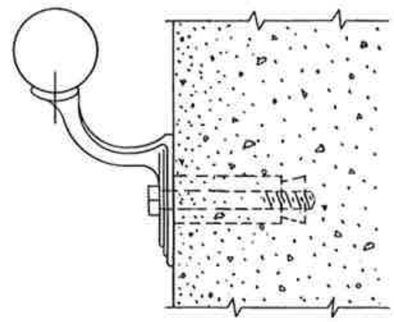


FIG. 117
Directly to concrete. One 3/8" bolt set in expansion unit, head exposed.

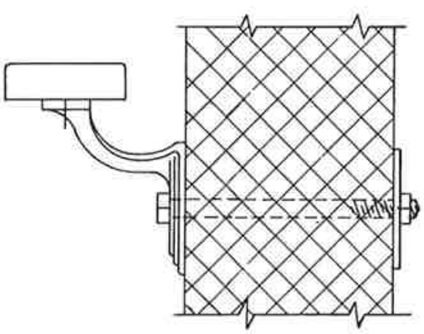


FIG. 118
To masonry wall not plastered. One 3/8" through bolt, exposed nut and washer on far side.

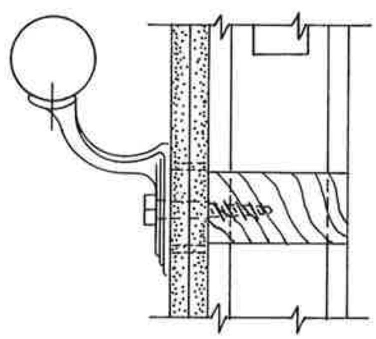


FIG. 119
Gypsum board on metal or wood framing, one 3/8" lag bolt into wood or 3/8" self-tapping screw into .0478" metal blocking.

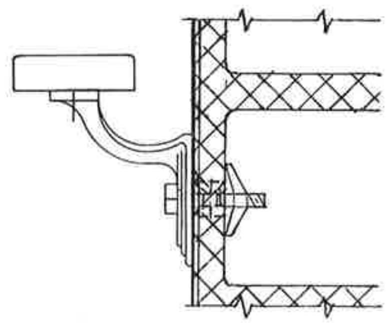


FIG. 120
Directly on hollow masonry wall. One 3/8" toggle type anchor.

WALL HANDRAIL BRACKETS — GENERAL INFORMATION

Wall rail brackets and handrail sections should be selected according to the strength and rigidity desired. In general, lighter sections require closer bracket spacing. Hard usage, as in factories and schools, requires substantial sections, closer bracket spacing, sturdy brackets and secure wall fastenings.

Fastenings as shown on this and the opposite page are typical, variations being dependent upon wall construction. Since new wall construction methods are developed from time to time, current manufacturers' literature for handrail brackets and anchoring devices should be consulted.

Bracket Spacing:
Spacing of brackets is recommended to be from three to six feet.

For Wood Frame Construction:
Brackets are usually fastened to wood construction by means of wood screws, with flat, round and oval heads. They may also be fastened by lag bolts using one bolt per bracket. Wood backing should be suitable for uniform spacing.

For Solid Masonry Construction:
Brackets are usually fastened to masonry construction by through bolts or by expansion bolts of various types. It is preferable to use brackets designed for one bolt, as bolts set too close will crack the masonry and become loose. They also may be fastened by wood screws or lag bolts into lead anchors.

For Hollow Tile or Block Construction:
Brackets can be fastened to hollow tile construction by toggle bolts or through bolts. If through bolts are not practical, a proper anchorage can be selected for each bracket at the job site when the anchorage hole is drilled.

For Lath and Plaster, and Dry Wall Construction:
Brackets are usually fastened to lath and plaster and wall board walls by screw anchors into wood or metal backing. Adequate back-up support for anchoring handrail brackets must be in place before plaster or dry wall is installed.

For Walls Faced with Marble or Other Paneling:
Where wall facings are not sufficiently rigid for securing brackets, bolts should be anchored into the backing before the facing is placed, which must be drilled for the bracket bolt.

Note: A number of codes require that wall handrails have a level extension beyond the nosings at the floors. This may be achieved with terminations as shown in Fig. 122 and Fig. 125.

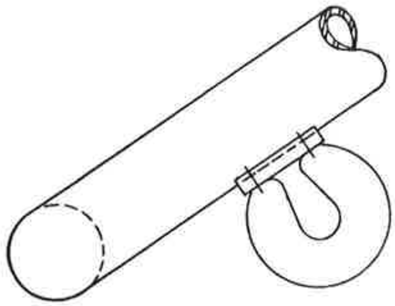


FIG. 121
Pipe wall handrail. Return to wall with clearance.

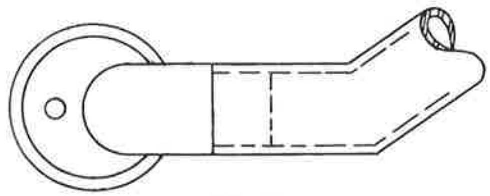


FIG. 122
Pipe wall handrail. Cast wall return.

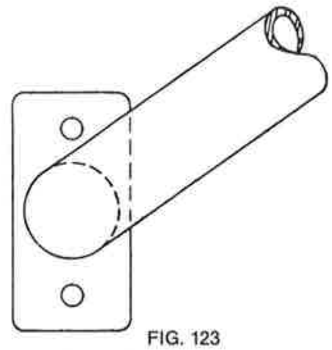
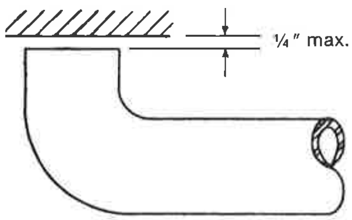
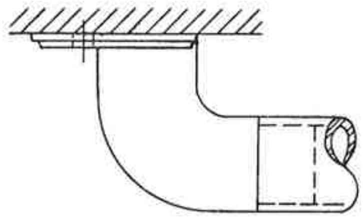


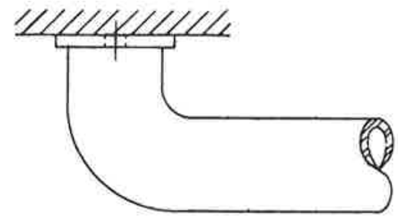
FIG. 123
Pipe wall handrail. 90° return to wall plate support of appropriate design.



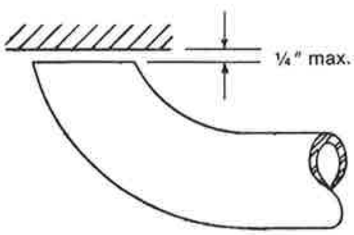
PLAN A
90° elbow return with clearance.



PLAN C
Cast return elbow with wall plate.



PLAN D
90° elbow return to wall plate.



PLAN B
Bent return with clearance. Returns A and B may be provided with rosette at wall, plain or ornamental.

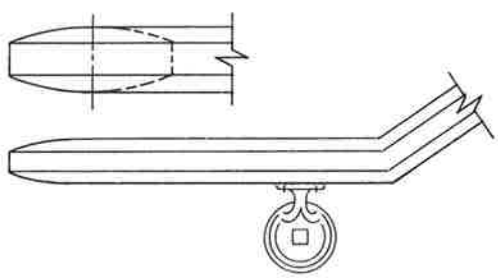
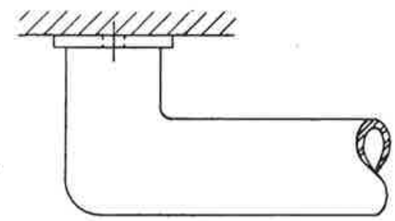


FIG. 125
Moulding wall handrail.



PLAN E
90° mitered return to wall plate.

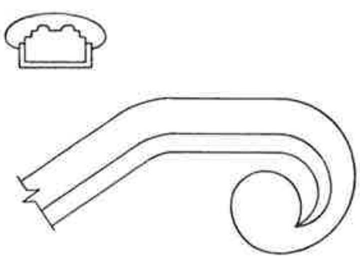
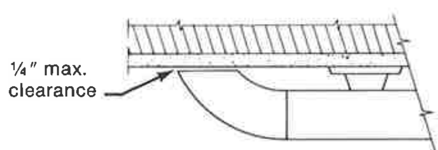
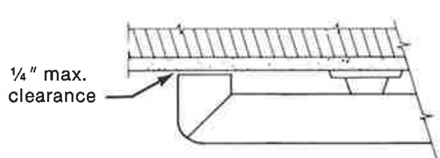


FIG. 124
Wall handrail with scroll terminal. Channel supporting bar.



Cast or formed corner bend cut to make wall return.



Mitered wall return.

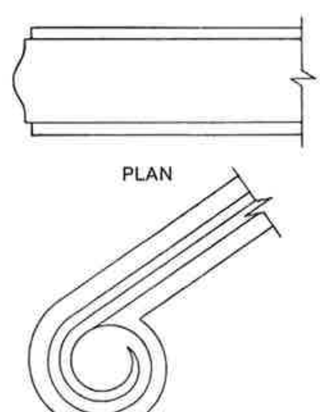


FIG. 126
Wall handrail terminal with cast volute.

These wall handrail terminals are typical for conventional type stairs and may be modified for other conditions. For other terminals, refer to current manufacturers' data.

For handrail sections, refer to Pages.......... 4-20, 4-21
For wall handrail brackets, refer to Page........... 4-22
For bracket fastenings, refer to Pages........ 4-22, 4-23
For pipe and tubing data, refer to Pages..... 5-30 to 5-34

SECTION 5
STRUCTURAL DESIGN AND DATA

CONTENTS

INTRODUCTION

In this section, examples are presented as guides in the structural design of stairs and railings. Several of these examples illustrate the design of stair framing members; others illustrate the design of their connections. Typical stair railing designs are provided also.

The first part of this section contains tables listing the load capacities, and deflections under loading, of principal stair members and parts. Tables listing the structural properties of many of the pipe, tube, bar, and rod sections commonly used in stair railing construction are found at the end of the section.

Although design tables may have been developed for the particular grade of material indicated, they may be used for other grades and stress levels by multiplying tabular values by appropriate ratios in most cases.

NAAMM recommends that fixed metal stairs be designed and constructed to support a minimum live load of 100 pounds per square foot of projected plan area. Also, an individual tread should be able to support a concentrated load of 300 pounds applied at its midspan with no other live load applied.

While limitations on allowable deflections may not be imposed, deflection under loading is an important consideration in establishing a psychological sense of structural integrity.

The American Iron & Steel Institute and ASTM are discouraging the use of gage numbers to define sheet steel thicknesses. The gage numbering system, based on an outdated system for specifying sheet steel, was developed originally when rolling mills could not hold to close tolerances. With improved technology mills are producing sheet steel for specific customer requirements to either minimum or nominal thickness. Current industry practice is to order and supply sheet steel by decimal thicknesses, not gage numbers. Consequently, in this 5th Edition of the *Metal Stairs Manual*, nominal sheet steel thicknesses have been shown in Tables, and gage numbers have been shown in parentheses for convenience in making the transition.

Although Load and Resistance Factor Design (LRFD) is being used in addition to Allowable Stress Design (ASD) by many engineers, the illustrative design examples in this manual follow the ASD procedure. However, Table 5.1 does not provide design stresses as in past editions. Instead, both yield and tensile stresses are given so that the designer must apply either a safety factor if using ASD or a load factor if using LRFD.

Table 5.1 MECHANICAL PROPERTIES OF METALS (1)

	Fy Min. Yield ksi	Fu Tensile Strength ksi
CARBON and ALLOY STEELS E = 29,000 ksi		
ASTM A29		
Bars		
Grades 1015 and 1020	33(2)	
ASTM A36		
Shapes, plates and bars	36	58
ASTM A53		
Pipe		
Type E, Grade B, welded	35	60
Type S, Grade B, seamless	35	60
ASTM A283		
Plates		
Grade C	30	55
Grade D	33	60
ASTM A366		
Cold-rolled sheet (commercial)	30(2)	
ASTM A500		
Tubing, welded and seamless (cold-formed)		
Grade B, round	42	58
Grade C, round	46	62
Grade B, square, rectangular or shape	46	58
Grade C, square, rectangular or shape	50	62
ASTM A501		
Tubing, welded and seamless (hot-formed)	36	58
ASTM A569		
Hot-rolled sheet and strip (commercial)	30(2)	
ASTM A570		
Hot-rolled sheet and strip (structural)		
Grade 30	30	49
Grade 33	33	52
Grade 36	36	53
Grade 40	40	55
ASTM A575		
Bars		
Grade M1020	35(2)	
ASTM A611		
Cold-rolled sheet (structural)		
Grade B	30	45
Grade C	33	48
Grade D	40	52
ASTM A786		
Floor plates	(3)	(3)

Footnotes:

(1) This listing does not exclude the use of metal ordered or produced to other than the listed specifications provided such metal conforms to the chemical and mechanical requirements of one of the listed specifications or other published specification which establishes its properties and suitability.

(2) This value based on many years of experience in using this steel for architectural metal work.

(3) As specified when ordering.

	Fy Min. Yield ksi	Fu Tensile Strength ksi
STAINLESS STEEL E = 28,000 ksi		
ASTM A167		
Plate, sheet and strip		
S30400	30	75
Other types	(3)	(3)
ASTM A312		
Pipe, welded and seamless		
S30400	30	75
ASTM A554		
Tubing, welded		
MT-304	30	75
ASTM A666		
Sheet, strip, plate and flat bar		
S30400 annealed	30	75
Other types	(3)	(3)
ALUMINUM E = 10,000ksi		
ASTM B209		
Plate		
6061-T4	16	30
6061-T6 and T62	35	42
ASTM B210		
Drawn seamless tubes		
6061-T6 and T62	35	42
6063-T6 and T62	28	33
6063-T832	35	40
ASTM B221		
Extruded bars, rods, shapes and tubes		
6061-T6 and T62	35	38
6063-T5 and T52	16	22
6063-T6	25	30
ASTM B241		
Seamless pipe and seamless extruded tube		
6061-T6 and T62	35	38
6063-T5	16	22
6063-T6 and T62	25	30
COPPER ALLOYS		
ASTM B43		
C23000 Red Brass, 85% (E = 17,000ksi)		
Drawn square and rectangular tubing	18	40
Annealed pipe	12	40
ASTM B135		
Muntz Metal, 60% (E = 15,000ksi)		
C28000	21	54
ASTM B455		
Architectural Bronze (E = 14,000ksi)		
C38500	16	48

Design stress, F, can be obtained by dividing yield stress, Fy, by an appropriate factor of safety, such as 1.65. Use of shape factor can result in a larger design stress. When aluminum is welded, a reduction in design stress should be made for stresses near the welds.

SYMBOLS USED IN STRUCTURAL CALCULATIONS

A	cross section area (sq in)
A_v	shear area (sq in)
C	stiffness of rail or post (lb-in)
CR	stiffness ratio for distributed loading
c	distance from neutral axis to extreme fiber of beam (in)
DL	dead load (psf or ksf)
Δ	deflection (in)
E	modulus of elasticity (psi or ksi)
F	maximum allowable tensile stress in bending (psi or ksi)
Fy	minimum yield stress (psi or ksi)
f	actual stress (psi or ksi)
kip-ft	kip-feet
lb-ft	pound-feet
lb-in	pound-inches
h	unsupported height of railing (in)
I	moment of inertia (in^4)
kip-in	kip-inches
K	bending moment constant, railing design
k	kips (units of 1000 lb)
k/ft	kips per lineal foot
k/in	kips per lineal inch
ksf	kips per square foot
ksi	kips per square inch
L	span length in feet
LL	live load (psf or ksf)
l	span length in inches
M	bending moment
P	concentrated load (lb or k)
P_f	load proportion factor
lb/ft	pounds per lineal foot
prov	provided
psf	pounds per square foot
psi	pounds per square inch
R	reaction (lb or k)
r	radius of gyration (in)
req	required
S	section modulus (in^3)
s	spacing of bolts
t	thickness (in)
V	total shear (lb or k)
v	shear per square inch (psi; ksi)
W	total uniform load (lb or k)
w	load per lineal foot (lb/ft or k/ft)
F.S.	factor of safety

FORMULAS

Allowable design stress, F = Fy/F.S.

Simple Beam (Span length in feet)

Uniform load over entire length

At mid-span, Max $M = wL^2/8 = WL/8$ (1)

At x, $M_x = wx(L-x)/2$ (2)

Concentrated load at mid-span

Max $M = PL/4$ (3)

Concentrated load at x

Max $M = Px(L-x)/L$ (4)

Combined loads or partial uniform loads

Max M occurs at $V = 0$

Required Section Modulus

$S = 12M/F$ (5)

Deflection - inches (Load in kips, span in feet)

Uniform load over entire span

$\Delta_{max} = 5WL^3(12)^3/384EI$ (7)

$= 0.000763WL^3/I$ (Steel) (8)

$= 0.00225WL^3/I$ (Aluminum) (9)

Concentrated load at mid span

$\Delta_{max} = PL^3(12)^3/48EI$ (10)

$= 0.00122PL^3/I$ (Steel) (11)

$= 0.00360PL^3/I$ (Aluminum) (12)

Combined loading

$\Delta_{max} = 0.000763(1.6P + W)L^3/I$ (Steel) (13)

$\Delta_{max} = 0.002250(1.6P + W)L^3/I$ (Aluminum) (14)

Limit Δmax

L/360

$I > = 0.00228(1.6P + W)L^2$ (Steel) (15)

$I > = 0.06750(1.6P + W)L^2$ (Aluminum) (16)

L/100

$I > = 0.006356(1.6P + W)L^2$ (Steel) (17)

$I > = 0.018750(1.6P \pm W)L^2$ (Aluminum) (18)

LOAD AND DEFLECTION TABLES FOR TREADS AND RISERS

The tables of engineering data and the sample calculations given in this section should be valuable aids to the designer of metal stairs. Uniform loads and deflections for typical treads, risers and subtreads are given on this page and on pages 5-7, 5-10 and 5-11. The formulas for uniformly distributed loading on simply supported beams are used to calculate the values given in the tables. Simply supported beams have unrestrained ends. This means that the values are conservative because tread ends are restrained when attached to the stair stringers. (See page 4-6) The industry unit for tread length is 22 inches and the unit for half tread length is 12 inches. The spans used in the load and deflection tables are multiples of the unit tread length and multiples of the unit tread length plus half unit length. As a matter of convenience to the designer the moment of inertia and section modulus are given for each design covered by the tables. This will facilitate the calculation of loads and deflections for spans other than those shown.

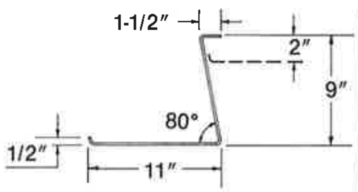


Table 5.2 LOADS IN KIPS AND DEFLECTIONS FOR Z PROFILE TREADS AND RISERS

SECTION			LOADS AND DEFLECTIONS FOR VARIOUS SPANS						
Thickness, in (ga)	I	S	34″	44″	56″	66″	78″	88″	100″
.0747 (14)	16.6	2.57	10.9	8.4	6.6	5.6	4.7	4.2	3.7
.1046 (12)	23.0	3.56	15.0	11.6	9.2	7.8	6.6	5.8	5.1
.1345 (10)	29.3	4.50	19.1	14.7	11.6	9.8	8.3	7.4	6.5
Deflection, Δ, inches			.012	.019	.031	.043	.061	.077	1.00

(A611 GrB, F = 18 ksi)

SAMPLE CALCULATION FOR 78″ SPAN WITH 14 GAGE RISER

$$M = FS = 18000 \times 2.57 = 46260 \text{ lb-in} \qquad W = \frac{8M}{L} = \frac{8 \times 46260}{78} = 4745 \text{ lbs} = 4.7 \text{ kips}$$

$$\Delta = \frac{5WL^3}{384EI} = \frac{5 \times 4745 \times 78^3}{384 \times 29 \times 10^6 \times 16.6} = 0.061 \text{ in}$$

To use Table for other steels with different values of F, multiply tabular load values by F/18.

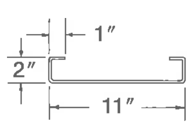


Table 5.3 LOADS IN KIPS AND DEFLECTIONS FOR TREADS

SECTION			LOADS AND DEFLECTIONS FOR VARIOUS SPANS			
Thickness, in (ga)	I	S	34″	44″	56″	66″
.0747 (14)	.625	.410	1.7	1.3	1.1	0.9
.1046 (12)	.827	.543	2.3	1.8	1.4	1.2
.1345 (10)	1.004	.660	2.8	2.2	1.7	1.4
Deflection, Δ, inches			.053	.088	.142	.196

(A570 Gr30, F = 18 ksi)

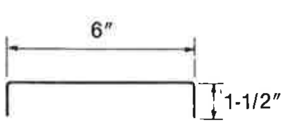


Table 5.4 SHIP'S LADDER TREAD — ALUMINUM (ASTM B209, 6061-4, F = 10,000 psi)

SECTION				LOADS FOR VARIOUS SPANS				
Thickness	A	I	S	plf/lb	18″	24″	30″	36″
1/8	1.07	.185	.155	w	458	258	165	115
				P	344	258	206	172
3/16	1.57	.259	.222	w	657	370	237	164
				P	493	370	296	246
1/4	2.04	.322	.282	w	837	471	301	209
				P	627	471	376	313

Table 5.5 LOADS FOR STEEL SHEETS

(Load in psf based on F = 20,000 psi)

t	SPAN							
in. (ga)	9″	12″	15″	18″	21″	24″	30″	36″
.1345 (10)	858	482	309	214	158	121	77	54
.1046 (12)	519	292	187	130	95	73	47	
.0747 (14)	265	149	95	66	49			
.0598 (16)	169	95	61					

Table 5.6 SHEET PROPERTIES (12″ width)

$I = 12t^3/12 \qquad S = 2I/t$

t	S	I	Wt-Steel	W-Aluminum
in (ga)	in^3	in^4	plf	plf
.0598 (16)	.00715	.000214	2.44	0.847
.0747 (14)	.01116	.000417	3.05	1.058
.1046 (12)	.02188	.001444	4.27	1.477
.1345 (10)	.03618	.002433	5.49	1.894
1/8	.03125	.001953	5.10	1.764
3/16	.0703	.00659	7.66	2.646
1/4	.125	.015625	10.2	3.528
5/16	.1953	.03052	12.75	4.410
3/8	.281	.05273	15.3	5.292

STEEL FLOOR PLATE AND ALUMINUM TREAD PLATE

Scale — Approximately Half Size

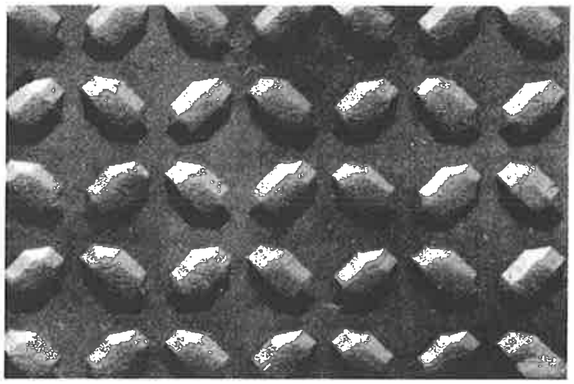


FIG. A Steel Floor Plate

FIG. B Steel Floor Plate

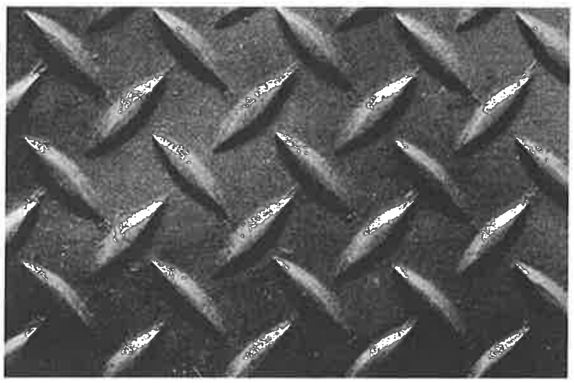


FIG. C Steel Floor Plate

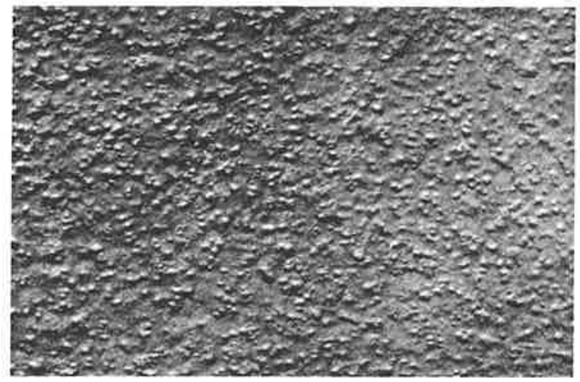


FIG. D Abrasive Floor or Tread Plate
Rolled in both steel and aluminum

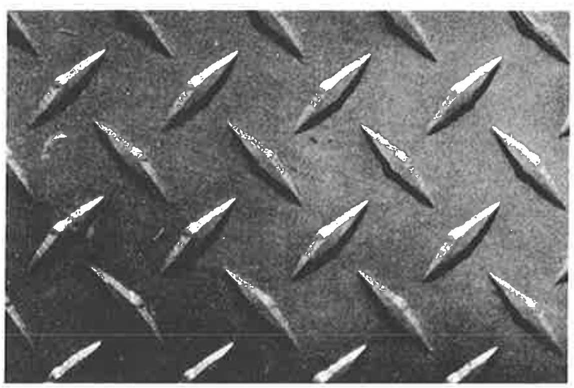


FIG. E Aluminum Tread Plate

Dimensions: Steel Floor Plate is produced in several designs and in thicknesses of 16, 14 and 12 gage, 1/8″, 3/16″, 1/4″, 5/16″, 3/8″, and 1/2″, in widths to 72″ and lengths to 30′-0″.

Aluminum Tread Plate is produced in thicknesses of 0.10″, 1/8″, 3/16″, and 1/2″, in widths to 60″ and lengths to 16′-0″.

Thickness is measured through the body of the plate, not including the raised portion.

Steel Floor Plate and Aluminum Tread Plate are used in stair construction for treads and platforms.

Surface: Steel Figs. A to C, and Aluminum, Fig. E, have regular mill finish.

Abrasive Plate, Fig. D, is produced in both steel and aluminum with the abrasive material rolled into the surface.

FLOOR PLATES

Floor plates having raised platforms are available from several mills, each offering their own style of surface projections and in a variety of widths, thicknesses, and lengths. A maximum width of 96 in. and a maximum thickness of 1 in. are available, but availability of matching widths, thicknesses, and lengths should be checked with the producer. Floor plates are generally not specified to chemical composition limits or mechanical property requirements; a commercial grade of carbon steel is furnished. However, when strength or corrosion resistance is a consideration, raised pattern floor plates are procurable in any of the regular steel specifications. As in the case of plain plates, the individual manufacturers should be consulted for precise information. The nominal or ordered thickness is that of the flat plate, exclusive of the height of raised pattern. The usual weights are as follows:

Table 5.7 THEORETICAL WEIGHTS OF ROLLED FLOOR PLATES

Gauge No.	Theoretical Weight per Sq. Ft. lb.	Nominal Thickness In.	Theoretical Weight per Sq. Ft. lb.	Nominal Thickness in.	Theoretical Weight per Sq. Ft. lb.
18	2.40	1/8	6.16	1/2	21.47
16	3.00	3/16	8.71	9/16	24.02
14	3.75	1/4	11.26	5/8	26.58
13	4.50	5/16	13.81	3/4	31.68
12	5.25	3/8	16.37	7/8	36.78
10	6.51	7/16	18.92	1	41.89

Note: Thickness is measured near the edge of the plate, exclusive of raised pattern.

Availability: Steel Floor Plate and Aluminum Tread Plate are usually available in warehouse stocks.

Floor Plate is the trade designation for steel. **Tread Plate** is the trade designation for aluminum. Other non-ferrous metals and stainless steel may be rolled for special requirements when the quantities are sufficient for mill tonnage. Refer to manufacturers' data.

Platform supported by channels, beams, angles or tees

LOAD AND DEFLECTION TABLES — FLOOR AND TREAD PLATE

Tables 5.8–5.11 show allowable load (w) in pounds per square foot and deflection (Δ) in inches. Weight of plate included.

Where stepped line is shown, loads above and to the right of this line cause deflections exceeding 1/100 of the span.

PLATFORMS

Table 5.8 STEEL FLOOR PLATE
Figs. A, B, C — page 5-6 — F = 18,000 psi (A786)

Plate Thickness		SPAN 1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"
1/8"	w	148	83						
	Δ	.298	.530						
3/16"	w	333	188	120	83				
	Δ	.198	.353	.551	.794				
1/4"	w	593	333	213	148	109	83	66	53
	Δ	.149	.265	.414	.596	.812	1.060	1.340	1.66
5/16"	w	927	522	333	232	170	130	103	83
	Δ	.119	.212	.331	.477	.650	.848	1.07	1.32
3/8"	w	1333	752	480	333	245	188	149	120
	Δ	.098	.176	.274	.396	.540	.705	.891	1.10

Table 5.9 ALUMINUM TREAD PLATE
Fig. E — page 5-6 — F = 16,000 psi (6061-T6)

Plate Thickness		SPAN 1'-0"	1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"
1/8"	w	313	134	78				
	Δ	.361	.813	1.43				
3/16"	w	722	320	181	116			
	Δ	.237	.532	.949	1.49			
1/4"	w	1250	555	312	200	139		
	Δ	.180	.405	.718	1.125	1.62		
5/16"	w	1960	870	490	314	218	160	
	Δ	.144	.323	.575	.900	1.29	1.76	
3/8"	w	2810	1250	703	450	312	229	173
	Δ	.111	.259	.461	.720	1.03	1.41	1.84

Table 5.10 STEEL ABRASIVE FLOOR PLATE
Figs. D, page 5-6
F = 16,000 psi (A786)

In computing effective abrasive plate thickness deduct 1/16" from nominal thickness, except for 1/8" plate, deduct 1/32".

Plate Thickness		SPAN 1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"
1/8"	w	80	45						
	Δ	.298	.53						
3/16"	w	148	83	53					
	Δ	.298	.530	1.190					
1/4"	w	334	188	120	83	61			
	Δ	.198	.353	.551	.794	1.082			
5/16"	w	591	333	213	148	109	83	66	
	Δ	.149	.265	.414	.596	.812	1.060	1.340	
3/8"	w	927	522	333	232	170	130	103	83
	Δ	.119	.212	.331	.477	.650	.848	1.07	1.32

Table 5.11 ALUMINUM ABRASIVE TREAD PLATE
Fig. D, page 5-6 (This material presently available only on special order)
Alloy 6061-T6 F = 16,000 psi

Plate Thickness		SPAN 1'-0"	1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"
1/8"	w	187	80					
	Δ	.39	.865					
3/16"	w	333	148	83				
	Δ	.39	.865	1.54				
1/4"	w	750	334	188	120			
	Δ	.257	.575	1.03	1.6			
5/16"	w	1334	591	333	213	148	109	
	Δ	.192	.432	.770	1.2	1.72	2.35	
3/8"	w	2080	927	522	333	232	170	130
	Δ	.128	.345	.615	.96	1.38	1.88	2.46

Tables 5.12 and 5.13 show allowable load (w) in pounds per lineal foot and deflection (Δ) in inches. Spans to right of stepped line should not be used to support concentrated loads greater than 300 lbs.

TREADS

(Tread dimensions may vary)

Table 5.12 STEEL FLOOR PLATE
Figs. A, B, C, page 5-6
F = 16,000 psi (A786)

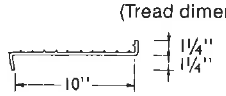


Plate Thickness	I	S	LOAD & DEFLEC.	SPAN 22"	34"	44"	56"	66"
1/8"	.165	.126	w	400	167	100		
			Δ	.021	.051	.085		
3/16"	.247	.189	w	600	251	150		
			Δ	.021	.051	.085		
1/4"	.335	.256	w	812	340	203	126	
			Δ	.021	.051	.085	.135	
5/16"	.447	.325	w	1031	432	258	159	115
			Δ	.020	.048	.081	.132	.183

Table 5.13 ALUMINUM TREAD PLATE
Fig. E, page 5-6
Alloy 6061-T6 F = 10,000 psi

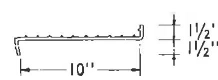


Plate Thickness	I	S	LOAD & DEFLEC.	SPAN 22"	34"	44"	56"
1/8"	.282	.184	w	364	153	91	
			Δ	.033	.079	.131	
3/16"	.440	.274	w	543	228	136	
			Δ	.031	.075	.126	
1/4"	.586	.365	w	724	303	181	112
			Δ	.031	.075	.126	.204
5/16"	.739	.480	w	912	382	228	141
			Δ	.031	.075	.126	.204

Plate Thicknesses shown in the above tables are those usually employed in stair construction. **Abrasive Plates** may be bent to 90 degrees when the abrasive surface is on the inside, using a radius not less than plate thickness. **Bends** are not recommended when the **Abrasive Surface** is on the outside of the turn. It is usually advisable to allow a slightly greater radius in bends of aluminum than in steel.

LOAD TABLES FOR PLATFORM SUPPORTS (Pages 5-8 and 5-9)

These tables list the total allowable uniform load in kips for the sections shown. **Total load deflection is limited to 1/360 of the span.** Greater deflection may be permissible if soffit is not plastered.

The calculations are based on the following assumptions:

a) The spans are simply supported.

b) Where the sheet is counted in the section, the effective width used is 12″ when acting in tension (at the bottom) and 16 times the thickness on each projecting side when acting in compression (at the top).

c) The values of moment of inertia (I), section modulus (S) and computed deflection include the effect of the sheet when counted as part of the section.

Required spacing of structural sections can be determined by reference to Table 5.19.

Design stresses used:

When sheet is included as part of section, 20,000 psi*

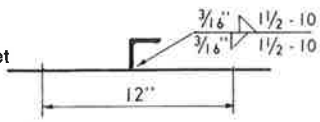
When sheet is not included as part of section,
22,000 psi on non-compact sections (channels, angles, tees). (A36)
24,000 psi on compact sections (I beams) (A36)

* A570 Gr33 or A611 GrC. If Grades 36, 40 or D are used, Tabular values may be increased by 10%.

SMOOTH SOFFIT DESIGNS

Table 5.14

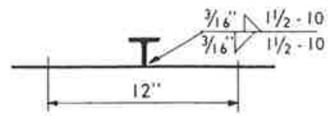
.1046″ (12 ga.) sheet
F = 20,000 psi



ANGLE		SECTION			SPAN			
Size	t	Area in²	I in⁴	S in³	4′0″	4′6″	5′0″	5′6″
1-1/4″ x 1-1/4″	3/16″	1.69	.336	.315	.90	.71	.58	
	1/4″	1.82	.392	.383	1.05	.83	.67	
1-1/2″ x 1-1/2″	3/16″	1.78	.567	.463	1.52	1.20	.97	.81
	1/4″	1.94	.665	.569	1.79	1.41	1.14	.94

Table 5.15

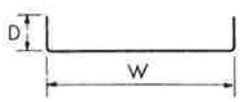
.1046″ (12 ga.) sheet
F = 20,000 psi



TEE		SECTION			SPAN			
Size	t	Area in²	I in⁴	S in³	4′0″	4′6″	5′0″	5′6″
1-1/4″ x 1-1/4″	3/16″	1.69	.336	.316	.90	.71	.58	
	1/4″	1.84	.397	.390	1.07	.84	.68	
1-1/2″ x 1-1/2″	3/16″	1.81	.581	.478	1.56	1.23	1.00	.83
	1/4″	1.97	.674	.581	1.81	1.43	1.16	.96

The capacity of these sections is less than 150 psf in some cases. To carry this load the concrete topping should be properly reinforced.

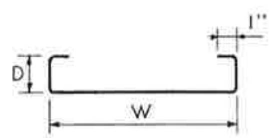
Table 5.16



F = 20,000 psi

SECTION						SPAN		
Size W x D	t in (ga)	Wt lb/ft	Area in²	I in⁴	S in³	4′0″	4′6″	5′0″
12″ x 1-1/2″	.1046(12)	5.33	1.53	.180	.138	.46	.39	.31
	.1345(10)	6.83	1.96	.225	.174	.59	.48	.39
	3/16″	9.37	2.70	.296	.234	.80	.64	.52
15″ x 1-1/2″	.1046(12)	6.45	1.85	.185	.140	.47	.40	.32
	.1345(10)	8.22	2.36	.231	.176	.60	.50	.40
	3/16″	11.33	3.26	.305	.236	.81	.66	.54
18″ x 1-1/2″	.1046(12)	7.53	2.16	.189	.141	.47	.41	
	.1345(10)	9.65	2.76	.236	.177	.60	.51	.41
	3/16″	13.28	3.82	.311	.238	.82	.68	.55

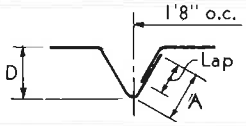
Table 5.17



F = 20,000 psi

SECTION						SPAN		
Size W x D	t in (ga)	Wt lb/ft	Area in²	I in⁴	S in³	4′0″	4′6″	5′0″
12″ x 1-1/2″	.1046(12)	5.92	1.71	.423	.359	1.11	.88	.71
	.1345(10)	7.53	2.17	.505	.430	1.35	1.06	.86
15″ x 1-1/2″	.1046(12)	7.00	2.02	.442	.362	1.16	.92	.75
	.1345(10)	8.96	2.57	.528	.435	1.41	1.11	.90
18″ x 1-1/2″	.1046(12)	8.12	2.33	.456	.365	1.19	.95	.77
	.1345(10)	10.35	2.97	.545	.438	1.45	1.15	.93

Table 5.18 V-RIBBED SOFFIT LOADS IN KIPS PER 1′8″



F = 20,000 psi

D	A	Lap
3″	2-3/4″	1-1/2″
3-1/2″	3-1/4″	2″
4″	3-3/4″	2-1/2″

D	t in (ga)	I in⁴	S in³	SPAN 4′0″	4′6″	5′0″	5′6″	6′0″	6′6″	7′0″	7′6″
3″	.0598(16)	.57	.30	.99							
	.0747(14)	.66	.35	1.17	1.04						
	.1046(12)	.93	.49	1.63	1.45	1.31					
	.1345(10)	1.22	.64	2.14	1.89	1.71	1.55	1.42			
3-1/2″	.1345(10)	1.86	.86	2.86	2.55	2.29	2.08	1.91	1.76	1.64	
4″	.1345(10)	2.77	1.12	3.74	3.32	2.98	2.72	2.49	2.30	2.14	1.99

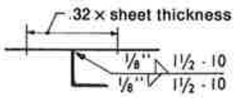
Table 5.19

TOTAL LOADS IN KIPS, AT 150 PSF, ON VARIOUS PANEL WIDTHS (SPACINGS) FOR VARIOUS SPANS

SPAN (feet)	WIDTH, INCHES 9	12	15	18	21	24
4′0″	.45	.60	.75	.90	1.05	1.20
4′6″	.506	.675	.844	1.013	1.182	1.35
5′0″	.562	.75	.938	1.125	1.313	1.50
5′6″	.619	.825	1.032	1.238	1.444	1.65
6′0″	.675	.90	1.125	1.35	1.575	1.80
6′6″	.731	.975	1.219	1.463	1.707	1.95
7′0″	.788	1.05	1.313	1.575	1.838	2.10
7′6″	.844	1.125	1.407	1.688	1.969	2.25
8′0″	.90	1.20	1.50	1.80	2.10	2.40

SOFFITS WITH SUPPORTING MEMBERS EXPOSED

Table 5.20



.1046 (12 ga.) sheet
F = 20,000 psi

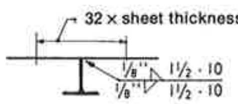
ANGLE		SECTION			SPAN					
Size In.	t In.	Area In²	I In⁴	S In³	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"
1-1/4 × 1-1/4	3/16	.783	.224	.282	.60	.47	.38			
	1/4	.913	.255	.340	.68	.54	.44			
1-1/2 × 1-1/2	3/16	.883	.371	.420	1.00	.79	.64			
	1/4	1.043	.412	.494	1.11	.87	.71			
2 × 2	3/16	1.063	.803	.760		1.70	1.38	1.14	.96	.82
	1/4	1.288	.935	.842		1.98	1.61	1.33	1.12	.95
	5/16	1.503	.979	.850		2.08	1.68	1.39	1.17	1.00
2-1/2 × 2-1/2	3/16	1.253	1.428	1.030		3.03	2.45	2.03	1.70	1.45
	1/4	1.543	1.610	1.100		3.26	2.77	2.29	1.92	1.64
	5/16	1.810	1.778	1.180		3.50	3.05	2.52	2.12	1.81

Table 5.21

F = 22,000 psi (A36)

ANGLE					SPAN					
Size In.	t In.	Area In²	I In⁴	S In³	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"
2 × 2	3/16	.715	.272	.190	.70	.58	.47			
	1/4	.938	.348	.247	.91	.74	.60			
	5/16	1.15	.416	.300	1.10	.88	.72			
2-1/2 × 2-1/2	3/16	.902	.547	.303			.89	.78	.65	.56
	1/4	1.19	.703	.394			1.16	1.00	.84	.72
	5/16	1.46	.849	.482			1.41	1.21	1.01	.86
	3/8	1.73	.984	.566			1.66	1.40	1.17	1.00
3 × 3	3/16	1.09	.962	.441				1.18	1.08	.98
	1/4	1.44	1.24	.577				1.54	1.41	1.26
	5/16	1.78	1.51	.707				1.89	1.73	1.54
	3/8	2.11	1.76	.833				2.22	2.04	1.79

Table 5.22



.1046 (12 ga.) sheet
F = 20,000 psi

TEE		SECTION			SPAN					
Size In.	t In.	Area In²	I In⁴	S In³	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"
1-1/2 × 1-1/2	3/16	.925	.382	.429	1.03	.81	.66	.54		
	1/4	1.09	.429	.509	1.15	.91	.74	.61		
1-3/4 × 1-3/4	3/16	1.03	.577	.590	1.55	1.22	.99	.82	.69	
	1/4	1.23	.651	.700	1.75	1.38	1.12	.92	.78	
2 × 2	1/4	1.43	.963	.853		2.04	1.65	1.37	1.15	.98
	5/16	1.66	1.05	.906		2.23	1.81	1.49	1.25	1.07
2-1/2 × 2-1/2	1/4	1.67	1.69	1.15		3.41	2.90	2.40	2.02	1.72
	5/16	1.98	1.89	1.25		3.70	3.25	2.68	2.25	1.92
	3/8	2.26	2.04	1.33		3.94	3.55	2.90	2.44	2.07
3 × 3	5/16	2.33	3.14	1.66		4.92	4.43	4.03	3.69	3.49
	3/8	2.66	3.37	1.77		5.25	4.72	4.29	3.93	3.42

Table 5.23

F = 22,000 psi (A36)

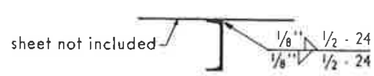
TEE					SPAN					
Size In.	t In.	Area In²	I In⁴	S In³	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"
1-3/4 × 1-3/4	3/16	.664	.185	.150	.50	.39	.32			
	1/4	.854	.233	.192	.63	.49	.40			
2 × 2	1/4	1.05	.370	.260	.95	.78	.64			
	5/16	1.28	.440	.310	1.14	.93	.76			
2-1/2 × 2-1/2	1/4	1.29	.720	.410			1.20	1.02	.86	.73
	5/16	1.60	.880	.500			1.47	1.25	1.05	.89
	3/8	1.87	1.00	.590			1.72	1.42	1.19	1.02
3 × 3	5/16	1.95	1.6	.740				1.97	1.81	1.63
	3/8	2.27	1.8	.86				2.29	2.10	1.83

Table 5.24

F = 24,000 psi (A36)

BEAM					SPAN					
Size	Wt lb/ft.	Area In²	I In⁴	S In³	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
S3	5.7	1.67	2.52	1.68	3.58	3.01	2.56	2.21	1.93	1.69
	7.5	2.21	2.93	1.95	4.16	3.50	2.98	2.57	2.24	1.97
S4	7.7	2.26	6.08	3.04	8.63	7.25	6.18	5.33	4.64	4.08
	9.5	2.79	6.79	3.39	9.64	8.10	6.90	5.95	5.19	4.56

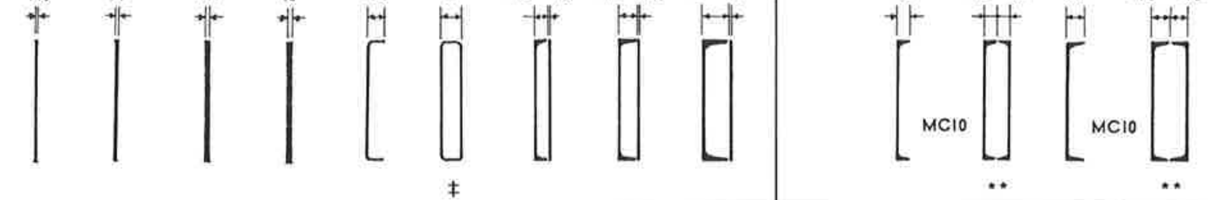
Table 5.25



F = 22,000 psi (A36)

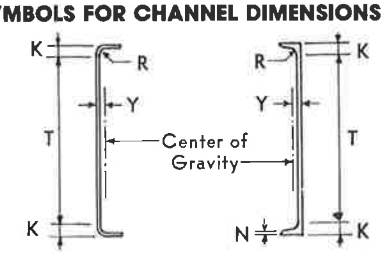
CHANNEL					SPAN					
Size	Wt lb/ft.	Area In²	I In⁴	S In³	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"
C3	4.1	1.21	1.66	1.10	2.35	1.98	1.69	1.46	1.27	1.11
	5.0	1.47	1.85	1.24	2.63	2.21	1.88	1.62	1.41	1.24
	6.0	1.76	2.07	1.38			2.10	1.82	1.58	1.39
C4	5.4	1.59	3.85	1.93			3.92	3.38	2.94	2.58
	7.25	2.13	4.59	2.29			4.67	4.03	3.51	3.08

Table 5.26 LOAD AND DEFLECTION TABLES FOR STEEL STRINGERS, RISERS AND SUBTREADS

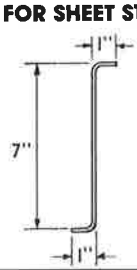


SEE GENERAL NOTES BELOW		10" DEPTH SECTIONS													
		FIBER STRESS = 20,000 PSI*									FIBER STRESS = 22,000				
		A283 GrD; A570 Gr33; A611 GrC (F_y = 33 ksi)									A36 (F_y = 36 ksi)				
		3/16"	1/4"	5/16"	3/8"	1½"	2" ‡	1⅛" 3/16"	1½" 3/16"	2⅝" 1/4"		1⅛" MC10	1⅛" 1⅛" **	1½" MC10	1½" 1½" **
Weight, lb. per ft.		6.38	8.5	10.6	12.8	8.03	14.53	12.88	14.78	23.8		6.5	13.0	8.4	16.8
Web Thickness, in.		.1875	.25	.3125	.375	.1875	.1875					.152		.170	
Area, sq. inches		1.88	2.5	3.13	3.75	2.3	4.27	3.79	4.34	6.99		.191	3.82	2.46	4.92
I, in.[4]		15.6	20.8	26.04	31.25	26.4	43.7	37.7	47.6	88.2		22.1	44.2	32.0	64.0
S, in.[3]		3.12	4.16	5.21	6.25	5.3	8.74	7.52	9.52	17.66		4.42	8.84	6.40	12.8
SPAN (feet)	**DEFL. (in.)**	**TOTAL ALLOWABLE UNIFORM LOAD IN KIPS**									**DEFL. (in.)**	**TOTAL ALLOWABLE UNIFORM**			
6	.07	6.9	9.3	11.6	13.8	11.6	19.1	16.7	21.2	39.3	.08	10.8	21.5	15.6	31.2
7	.10	5.9	7.9	9.9	11.9	9.9	16.4	14.3	18.2	33.7	.11	9.2	18.4	13.4	26.8
8	.13	5.2	6.9	8.7	10.4	8.7	14.3	12.5	15.9	29.5	.15	8.1	16.1	11.7	23.4
9	.17	4.6	6.2	7.7	9.3	7.7	12.7	11.1	14.1	26.2	.18	7.2	14.3	10.4	20.8
10	.21	4.2	5.6	6.9	8.3	6.9	11.5	10.0	12.7	23.6	.23	6.5	12.9	9.4	18.8
11	.25	3.8	5.0	6.3	7.6	6.3	10.4	9.1	11.6	21.4	.28	5.9	11.7	8.5	17.0
12	.30	3.5	4.6	5.8	7.0	5.8	9.5	8.4	10.6	19.7	.33	5.4	10.7	7.8	15.6
13	.35	3.2	4.3	5.3	6.4	5.3	8.8	7.7	9.8	18.1	.38	5.0	9.9	7.2	14.4
14	.41	3.0	4.0	5.0	6.0	5.0	8.2	7.2	9.1	16.8	.45	4.6	9.2	6.7	13.4
15	.47	2.8	3.7	4.6	5.6	4.6	7.6	6.7	8.5	15.7	.51	4.3	8.6	6.2	12.4
16	.53	2.6	3.5	4.3	5.2	4.3	7.2	6.3	7.9	14.7	.58	4.0	8.1	5.9	11.8
17	.60	2.4	3.3	4.1	4.9	4.1	6.7	5.9	7.5	13.9	.66	3.8	7.6	5.5	11.0
18	.67	2.3	3.1	3.9	4.6	3.9	6.4	5.6	7.1	13.1	.74	3.6	7.2	5.2	10.4
19	.75	2.2	2.9	3.7	4.4	3.7	6.0	5.3	6.7	12.4	.82	3.4	6.8	4.9	9.8
20	.83	2.1	2.8	3.5	4.2	3.5	5.7	5.0	6.4	11.8	.91	3.2	6.4	4.7	9.4
See drawings below	T					9.25		9.12	8.62	8.0		9.12	9.12	8.62	8.62
	N					.1875		.19	.25	.44		.19	.19	.25	.25
	K					.375		.44	.69	1.0		.44	.44	.69	.69
	R					.1875		.125	.25	.34		.125	.125	.25	.25
	Y					.26		.68	.85	1.39		.180	1.127	.284	1.50

SYMBOLS FOR CHANNEL DIMENSIONS



LOADS IN KIPS AND DEFLECTIONS FOR SHEET STEEL RISERS



SECTION			LOADS AND DEFLECTIONS FOR VARIOUS SPANS						
Thickness, in (ga)	I	S	34"	44"	56"	66"	78"	88"	100"
.0598 (16)	3.01	0.86	3.7	2.9	2.3	1.9	1.6	1.4	1.3
.0747 (14)	3.71	1.06	4.6	3.6	2.8	2.4	2.0	1.8	1.6
.1046 (12)	5.05	1.44	6.5	5.0	3.9	3.3	2.8	2.5	2.2
.1345 (10)	6.31	1.80	8.0	6.2	4.8	4.1	3.5	3.1	2.7
Deflection, Δ, inches			.021	.036	.058	.081	.113	.143	.186

Total allowable uniform load (W) in kips and deflection (Δ) in inches for sheet steel risers with turned edges. Riser supported laterally by bolted connections. Minimum bolt size is 1/4", maximum spacing 15". Allowable fiber stress used in calculations 18,000 psi. Weight of material is not included.

GENERAL NOTES

Allowable loads and deflections listed in tables are based on fiber stresses at column headings and apply to laterally braced members. Stringers are considered to be laterally braced by attached treads and risers. W = , 2FS/3L

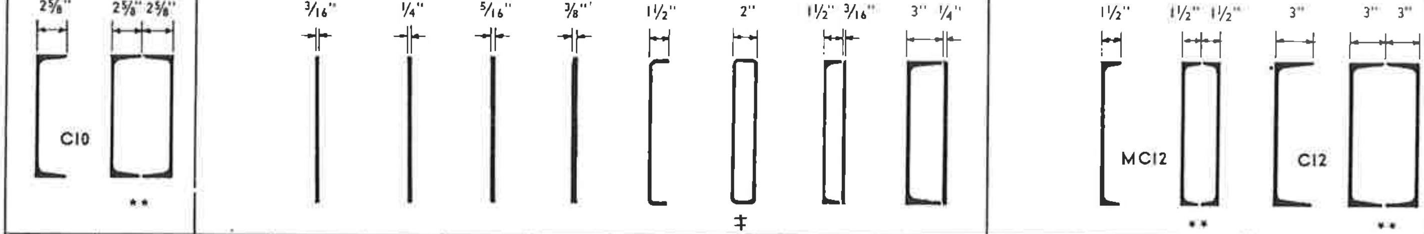
For stresses other than those listed, loads will be proportionately smaller or larger.

Loads below heavy lines will cause deflections exceeding 1/360 of span. Deflections for loads less than those listed will be proportionately less; see example at lower right of facing page.

Weight of material is not included.

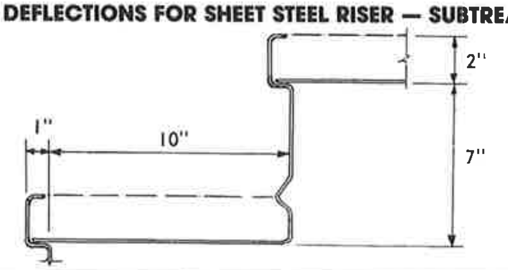
* When A36 plate or A570 Gr 36 is used, tabular values may be increased by 10%

‡ For A500 GrB, F_y - 46ksi and tabular values may be increased by 40%



PSI			12" DEPTH SECTIONS — FIBER STRESS = 20,000 PSI*									FIBER STRESS = 22,000 PSI			
A36			A283 GrD; A570 Gr33; A611 GrC (F_y = 33 ksi)									A36 (F_y = 36 ksi)			
C10, 2⅝"	C10, 2⅝" 2⅝" **		3/16"	1/4"	5/16"	3/8"	1½"	2" ‡	1½" 3/16"	3" 1/4"		MC12, 1½"	MC12, 1½" 1½" **	C12, 3"	C12, 3" 3" **
15.3	30.6	X	7.65	10.2	12.8	15.3	9.33	17.08	18.25	30.9	X	10.6	21.2	20.7	41.4
.240			.1875	.25	.3125	.375	.1875	.1875				.190		.282	
4.49	8.98		2.25	3.0	.375	4.5	2.68	5.02	5.35	9.09		3.10	6.20	6.09	12.18
67.4	134.8		27.0	36.0	45.0	54.0	42.6	72.0	82.4	165.0		55.4	110.8	129	258
13.5	27.0		4.5	6.0	7.5	9.0	7.1	12.0	13.73	27.5		9.23	18.46	21.5	43.0
LOAD IN KIPS		**DEFL. (in.)**	**TOTAL ALLOWABLE UNIFORM LOAD IN KIPS**								**DEFL. (in.)**	**TOTAL UNIFORM LOAD IN KIPS**			
33.0	66.0	.06	10.0	13.3	16.7	20.0	15.5	25.8	30.6	61.2	.07	22.6	45.2	52.6	105.2
28.3	56.6	.08	8.6	11.5	14.3	17.2	13.3	22.2	26.2	52.5	.09	19.3	38.6	45.0	90.0
24.8	49.6	.11	7.5	10.0	12.5	15.0	11.7	19.4	22.9	45.9	.12	16.9	33.8	39.4	78.8
22.0	44.0	.14	6.7	8.9	11.1	13.3	10.4	17.2	20.4	40.8	.15	15.0	30.0	35.0	70.0
19.8	39.6	.17	6.0	8.0	10.0	12.0	9.3	15.5	18.4	36.7	.19	13.5	27.0	31.5	63.0
18.0	36.0	.21	5.5	7.3	9.1	10.9	8.5	14.1	16.7	33.4	.23	12.3	24.6	28.7	57.4
16.5	33.0	.25	5.0	6.7	8.3	10.0	7.8	12.9	15.3	30.6	.27	11.3	22.6	26.3	52.6
15.2	30.4	.29	4.6	6.2	7.7	9.2	7.2	11.9	14.1	28.2	.32	10.4	20.8	24.3	48.6
14.1	28.2	.34	4.3	5.7	7.1	8.6	6.7	11.1	13.1	26.2	.37	9.7	19.4	22.5	45.0
13.2	26.4	.39	4.0	5.3	6.7	8.0	6.2	10.3	12.2	24.5	.43	9.0	18.0	21.0	42.0
12.4	24.8	.44	3.8	5.0	6.3	7.5	5.8	9.7	11.5	23.0	.49	8.5	17.0	19.7	39.4
11.6	23.2	.50	3.5	4.7	5.9	7.0	5.5	9.1	10.8	21.6	.55	8.0	16.0	18.5	37.0
11.0	22.0	.56	3.3	4.2	5.6	6.7	5.2	8.6	10.2	20.4	.61	7.5	15.0	17.5	35.0
10.4	20.8	.62	3.2	4.1	5.3	6.3	4.9	8.2	9.7	19.3	.68	7.1	14.2	16.6	33.2
9.9	19.8	.69	3.0	4.0	5.0	6.0	4.7	7.7	9.2	18.4	.76	6.8	13.6	15.8	31.6
8.0	8.0	X	X				11.25	X	10.63	9.75	X	10.63	10.63	9.75	9.75
.44	.44						.1875		.25	.50		.25	.25	.50	.50
1.0	1.0						.375		.69	1.12		.69	.69	1.12	1.12
.34	.34						.1875		.25	.38		.25	.25	.38	.38
.634	2.625						.23		.83	1.50		.269	1.50	.698	3.0

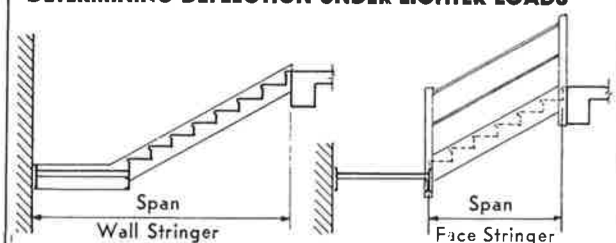
LOADS AND DEFLECTIONS FOR SHEET STEEL RISER — SUBTREADS



SECTION			LOADS AND DEFLECTIONS FOR VARIOUS SPANS						
Thickness, in (ga)	I	S	34"	44"	56"	66"	78"	88"	100"
.0598 (16)	10.7	1.60	6.8	5.2	4.1	3.5	3.0	2.6	2.3
.0747 (14)	14.2	2.13	9.0	7.0	5.5	4.6	3.9	3.5	3.1
.1046 (12)	19.7	2.97	12.6	9.7	7.6	6.5	5.5	4.9	4.3
.1345 (10)	24.9	3.74	15.8	12.2	9.6	8.2	6.9	6.1	5.4
Deflection, Δ, inches			.011	.019	.030	.043	.059	.075	.097

Total allowable uniform loads (W) in kips and deflection (Δ) in inches for sheet steel risers with subtread and concrete fill without metal mesh reinforcing. Riser supported laterally by bolted connections or welding (see page 5-19). Minimum bolt size is 1/4", maximum spacing 15". Design fiber stress 18,000 psi. Weight of material is not included.

DETERMINING DEFLECTION UNDER LIGHTER LOADS



Span in feet given in the table is the horizontal distance between supports.

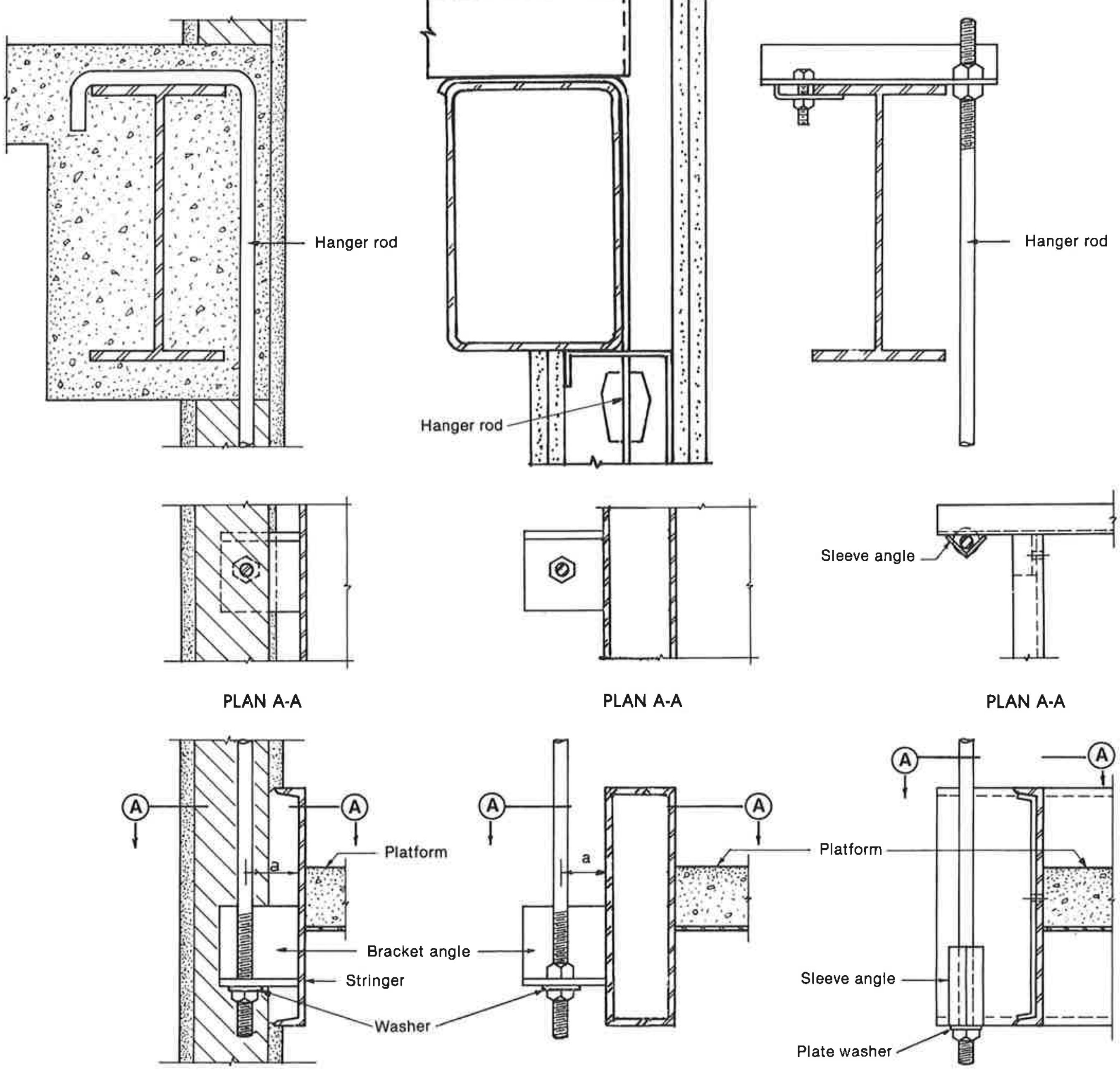
METHOD OF DETERMINING DEFLECTION:
Assume stair 4'0" wide, with a 10'0" span of twelve 10" treads. Live load 100 psf, dead load 50 psf. Total load = 150 × 4 × 10 = 6,000 lb. Load on one stringer = 1/2 of 6,000 or 3,000 lb. From table, MC10 × 8.4, 10' span, has allowable load of 9.4 kips and a deflection of 0.23 inches.

$$\text{Deflection} = \frac{3{,}000 \text{ (actual load)}}{9{,}400 \text{ (allowable load)}} \times .23'' = .074''$$

Concentrated loads such as header reactions will increase deflections. See Design Examples for deflection calculations.

** With properly designed continuous welds on both top and bottom flanges, tabular values may be increased by 10%

HANGER SUPPORTS



TYPE A	TYPE B	TYPE C
Bracket angle welded to stringer, hanger rod bent over and welded to top flange of floor beam.	Bracket angle welded to stringer, hanger rod bent over and welded to floor beam.	Sleeve angle welded to stringer extension, hanger rod carried by angle bolted to top flange of floor beam.

NOTE: To connect angle to stringer use 3/16″ weld all around. Check shear in stringer. Tables based on A36 steel. Hanger rod loads reduced for 33% impact.

Table 5.27

TYPES A & B — MAXIMUM LOAD ON BRACKET ANGLE (Kips)									
ANGLE SIZE	DIMENSION a, INCHES								
	2	2-1/2	3	3-1/2	4	4-1/2	5	5-1/2	6
4″ × 4″ × 3/8″	10.9	10.9	10.9	9.58	8.38	7.45	6.71	6.10	5.60
4″ × 4″ × 1/2″	14.5	14.5	14.5	12.4	10.8	9.64	8.68	7,89	7.23

CAUTION: To avoid cracking, hanger rods should be heated before bending. Bracket angle should be placed opposite a member which will provide resistance to twisting caused by eccentric loading.

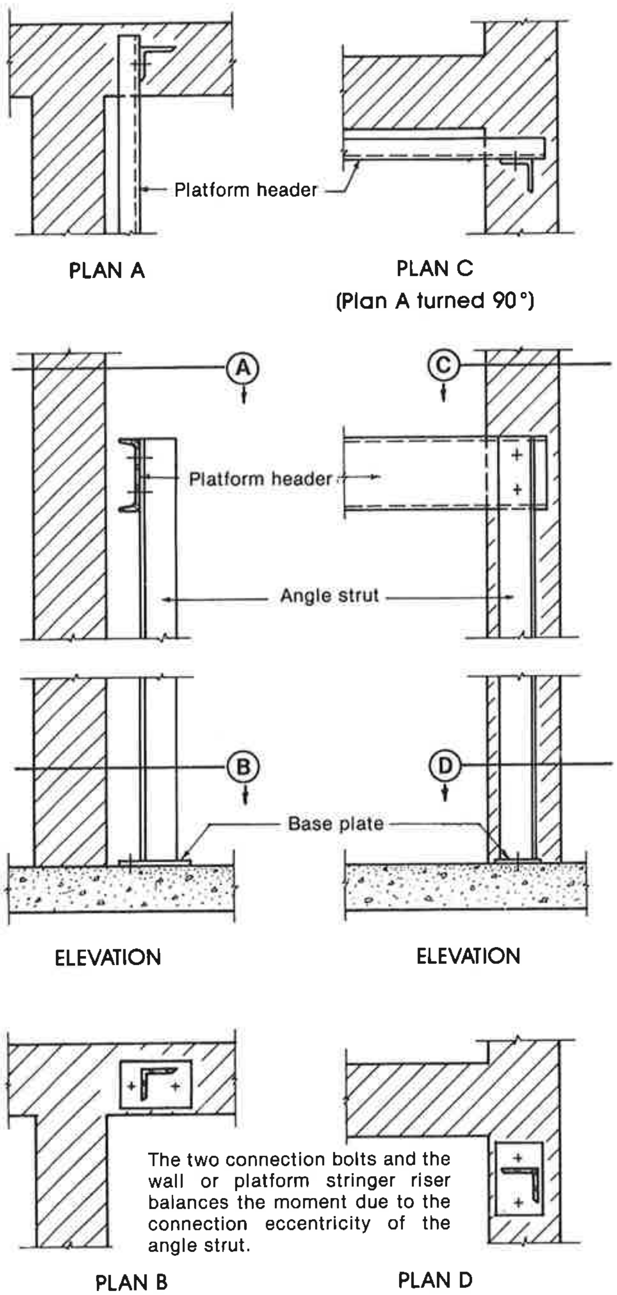
Table 5.28

MAX. HANGER ROD LOADS		
ROD DIAM.	TENSION (kips)	SHEAR (kips)
1/2″	2.83	1.89
5/8″	4.37	2.93
3/4″	6.36	4.29
7/8″	8.65	5.79
1″	11.30	7.59

Table 5.29

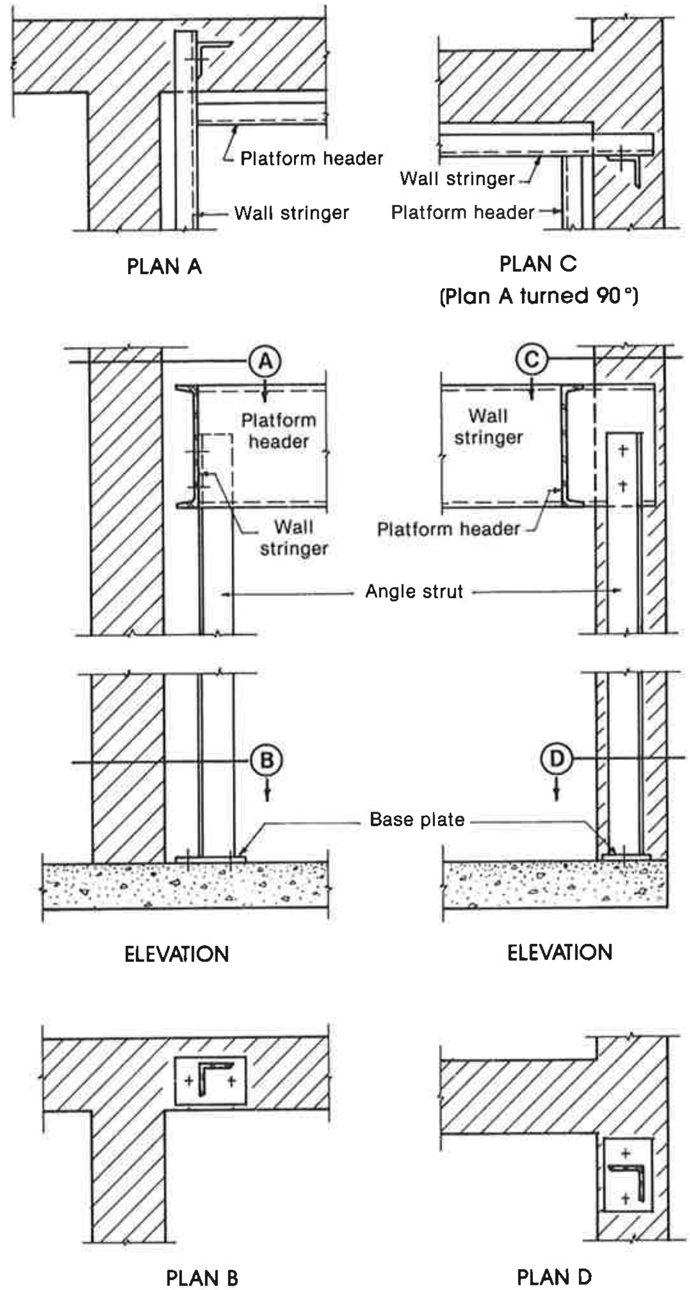
TYPE C — ANGLE SIZES	
ROD DIAM.	ANGLE SIZE
1/2″	1-1/4″ × 1-1/4″ × 1/8″
5/8″	1-1/2″ × 1-1/2″ × 3/16″
3/4″	1-3/4″ × 1-3/4″ × 3/16″
7/8″	2″ × 2″ × 1/4″
1″	2-1/2″ × 2-1/2″ × 1/4″

STRUT SUPPORTS



TYPE A

Platform header supported by angle strut in wall.



TYPE B

Wall stringer carries platform header and is supported by angle strut in wall.

Table 5.30

BOLT SPACING, S	A307 BOLTS	ALLOWABLE REACTION
3″	2 — 1/2″Φ	2.7k
	2 — 5/8″Φ	4.2k
	2 — 3/4″Φ	6.1k
4″	2 — 1/2″Φ	2.9k
	2 — 5/8″Φ	4.6k
	2 — 3/4″Φ	6.6k
5″	2 — 1/2″Φ	3.0k
	2 — 5/8″Φ	4.8k
	2 — 3/4″Φ	7.0k

Reaction based on effect of vertical shear and moment due to eccentricity.

Table 5.31

MAXIMUM COLUMN LOAD IN KIPS ON A36 STEEL ANGLE STRUTS

ANGLE			HEIGHT IN FEET										
Size	r_z	A	3	4	5	6	7	8	9	10	11	12	13
2″ × 2″ × 1/4″	.391	.94	13.0	9.3	5.9	4.1							
2-1/2″ × 2-1/2″ × 1/4″	.491	1.19		15.8	11.8	8.2	6.0	4.6		Conditions above and at the right of heavy line result in l/r ratio exceeding 200.			
3″ × 3″ × 1/4″	.592	1.44				14.3	10.5	8.2	6.4				
3″ × 3″ × 5/16″	.589	1.78					13.0	10.0	7.9				
3″ × 3″ × 3/8″	.587	2.11					15.0	11.3	9.0				
4″ × 4″ × 5/16″	.791	2.40								15.5	12.8	10.8	9.2
4″ × 4″ × 3/8″	.788	2.86									15.3	12.8	11.0

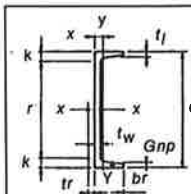


Table 5.32
STEEL CHANNELS AMERICAN STANDARD

Designation	Area A	Depth d	Web Thickness t_w		Web $\frac{t_w}{2}$	Flange Width b_f		Flange Average thickness t_f		Axis X-X I	Axis X-X S
	in.²	in.	in.		in.	in.		in.		in.⁴	in.³
C 15 × 50	14.7	15.00	0.716	11/16	3/8	3.716	3 3/4	0.650	5/8	404	53.8
× 40	11.8	15.00	0.520	1/2	1/4	3.520	3 1/2	0.650	5/8	349	46.5
× 33.9	9.96	15.00	0.400	3/8	3/16	3.400	3 3/8	0.650	5/8	315	42.0
C 12 × 30	8.82	12.00	0.510	1/2	1/4	3.170	3 1/8	0.501	1/2	162	27.0
× 25	7.35	12.00	0.387	3/8	3/16	3.047	3	0.501	1/2	144	24.1
× 20.7	6.09	12.00	0.282	5/16	1/8	2.942	3	0.501	1/2	129	21.5
C 10 × 30	8.82	10.00	0.673	11/16	5/16	3.033	3	0.436	7/16	103	20.7
× 25	7.35	10.00	0.526	1/2	1/4	2.886	2 7/8	0.436	7/16	91.2	18.2
× 20	5.88	10.00	0.379	3/8	3/16	2.739	2 3/4	0.436	7/16	78.9	15.8
× 15.3	4.49	10.00	0.240	1/4	1/8	2.600	2 5/8	0.436	7/16	67.4	13.5
C 9 × 20	5.88	9.00	0.448	7/16	1/4	2.648	2 5/8	0.413	7/16	60.9	13.5
× 15	4.41	9.00	0.285	5/16	1/8	2.485	2 1/2	0.413	7/16	51.0	11.3
× 13.4	3.94	9.00	0.233	1/4	1/8	2.433	2 3/8	0.413	7/16	47.9	10.6
C 8 × 18.75	5.51	8.00	0.487	1/2	1/4	2.527	2 1/2	0.390	3/8	44.0	11.0
× 13.75	4.04	8.00	0.303	5/16	1/8	2.343	2 3/8	0.390	3/8	36.1	9.03
× 11.5	3.38	8.00	0.220	1/4	1/8	2.260	2 1/4	0.390	3/8	32.6	8.14
C 7 × 14.75	4.33	7.00	0.419	7/16	3/16	2.299	2 1/4	0.366	3/8	27.2	7.78
× 12.25	3.60	7.00	0.314	5/16	3/16	2.194	2 1/4	0.366	3/8	24.2	6.93
× 9.8	2.87	7.00	0.210	3/16	1/8	2.090	2 1/8	0.366	3/8	21.3	6.08
C 6 × 13	3.83	6.00	0.437	7/16	3/16	2.157	2 1/8	0.343	5/16	17.4	5.80
× 10.5	3.09	6.00	0.314	5/16	3/16	2.034	2	0.343	5/16	15.2	5.06
× 8.2	2.40	6.00	0.200	3/16	1/8	1.920	1 7/8	0.343	5/16	13.1	4.38
C 5 × 9	2.64	5.00	0.325	5/16	3/16	1.885	1 7/8	0.320	5/16	8.90	3.56
× 6.7	1.97	5.00	0.190	3/16	1/8	1.750	1 3/4	0.320	5/16	7.49	3.00
C 4 × 7.25	2.13	4.00	0.321	5/16	3/16	1.721	1 3/4	0.296	5/16	4.59	2.29
× 5.4	1.59	4.00	0.184	3/16	1/16	1.584	1 5/8	0.296	5/16	3.85	1.93
C 3 × 6	1.76	3.00	0.356	3/8	3/16	1.596	1 5/8	0.273	1/4	2.07	1.38
× 5	1.47	3.00	0.258	1/4	1/2	1.498	1 1/2	0.273	1/4	1.85	1.24
× 4.1	1.21	3.00	0.170	3/16	1/16	1.410	1 3/8	0.273	1/2	1.66	1.10

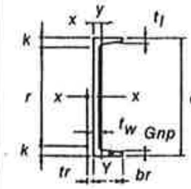


Table 5.33
STEEL CHANNELS MISCELLANEOUS

Designation	Area A	Depth d	Web Thickness t_w		Web $\frac{t_w}{2}$	Flange Width b_f		Flange Average thickness t_f		Axis X-X I	Axis X-X S
	in.²	in.	in.		in.	in.		in.		in.⁴	in.³
MC 18 × 58	17.1	18.00	0.700	11/16	3/8	4.200	4 1/4	0.625	5/8	676	75.1
× 51.9	15.3	18.00	0.600	5/8	5/16	4.100	4 1/8	0.625	5/8	627	69.7
× 45.8	13.5	18.00	0.500	1/2	1/4	4.000	4	0.625	5/8	578	64.3
× 42.7	12.6	18.00	0.450	7/16	1/4	3.950	4	0.625	5/8	554	61.60
MC 13 × 50	14.7	13.00	0.787	13/16	3/8	4.412	4 3/8	0.610	5/8	314	48.4
× 40	11.8	13.00	0.560	9/16	1/4	4.185	4 1/8	0.610	5/8	273	42.0
× 35	10.3	13.00	0.447	7/16	1/4	4.072	4 1/8	0.610	5/8	252	36.8
× 31.8	9.35	13.00	0.375	3/8	3/16	4.000	4	0.610	5/8	239	36.8
MC 12 × 50	14.7	12.00	0.835	13/16	7/16	4.135	4 1/8	0.700	11/16	269	44.9
× 45	13.2	12.00	0.712	13/16	7/16	4.135	4 1/8	0.700	11/16	269	44.9
× 40	11.8	12.00	0.590	9/16	5/16	3.890	3 7/8	0.700	11/16	234	39.0
× 35	10.3	12.00	0.467	7/16	1/4	3.767	3 3/4	0.700	11/16	216	36.1
× 31	9.12	12.00	0.370	3/8	3/16	3.670	3 5/8	0.700	11/16	203	33.8
MC 12 × 10.6	3.10	12.00	0.190	3/16	1/8	1.500	1 1/2	0.309	5/16	55.4	9.23
MC 10 × 41.1	12.1	10.00	0.796	13/16	1/8	1.500	1 1/2	0.309	5/16	158	31.5
× 33.6	9.87	10.00	0.575	9/16	5/16	4.100	4 1/8	0.575	9/16	139	27.8
× 28.5	8.37	10.00	0.425	7/16	3/16	3.950	4	0.575	9/16	127	25.3
MC 10 × 25	7.35	10.00	0.380	3/8	3/16	3.405	3 3/8	0.575	9/16	103	20.5
× 22	6.45	10.00	0.290	5/16	1/8	3.315	3 3/8	0.575	9/16	103	20.5
MC 10 × 8.4	2.46	10.00	0.170	3/16	1/16	1.500	1 1/2	0.280	1/4	32.0	6.40
MC 10 × 6.5	1.91	10.00	0.152	1/8	1/16	1.127	1 1/8	0.202	3/16	22.1	4.42
MC 9 × 25.4	7.47	9.00	0.450	7/16	1/4	3.500	3 1/2	0.550	9/16	88.0	19.6
× 23.9	7.02	9.00	0.400	3/8	3/16	3.450	3 1/2	0.550	9/16	85.0	18.9
MC 8 × 22.8	6.70	8.00	0.427	7/16	3/16	3.502	3 1/2	0.525	1/2	63.8	15.4
× 21.4	6.28	8.00	0.375	3/8	3/16	3.450	3 1/2	0.525	1/2	61.6	15.4
MC 8 × 20	5.88	8.00	0.400	3/8	3/16	3.025	3	0.500	1/2	54.5	13.1
× 18.7	5.50	8.00	0.353	3/4	3/16	2.978	3	0.500	1/2	52.5	13.1
MC 8 × 8.5	2.50	8.00	0.179	3/16	1/16	1.874	1 7/8	0.311	5/16	23.3	5.83
MC 7 × 22.7	6.67	7.00	0.503	1/2	1/4	3.603	3 5/8	0.500	1/2	47.5	13.6
× 19.1	5.61	7.00	0.352	3/8	3/16	3.452	3 1/2	0.500	1/2	43.2	12.3
MC 6 × 18	5.29	6.00	0.379	3/8	3/16	3.504	3 1/2	0.475	1/2	29.7	9.91
× 15.3	4.50	6.00	0.379	3/8	3/16	3.500	3 1/2	0.385	3/8	25.4	8.47
MC 6 × 16.3	4.79	6.00	0.375	3/8	3/16	3.000	3	0.475	1/2	26.0	8.68
× 15.1	4.44	6.00	0.316	5/16	3/16	2.941	3	0.475	1/2	25.0	8.32
MC 6 × 12	3.53	6.00	0.310	5/16	1/8	2.497	2 1/2	0.375	3/8	18.7	6.24

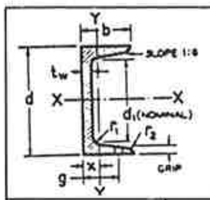


Table 5.34 ALUMINUM CHANNELS AMERICAN STANDARD†

† Areas and section properties listed are based on nominal dimensions. Weights per foot are based on nominal dimensions and a density of 0.098 pounds per cubic inch, the density of alloy 6061. See ALUMINUM STANDARDS AND DATA for applicable tolerances.

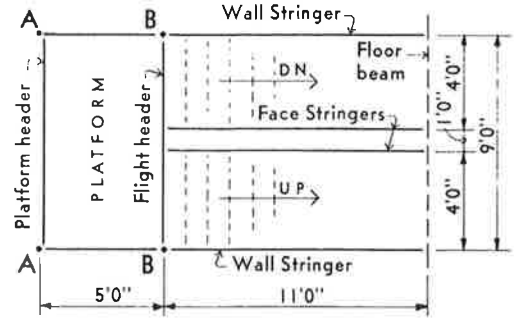
Users are encouraged to ascertain current availability of particular structural shapes through inquiries to their suppliers.

Size: Depth d in.	Size: Weight lb/ft	Width b in.	Web Thickness t_w in.	Area in.²	Avg Flange Thickness in.	Axis X-X: I in.⁴	Axis X-X: S in.³
3	1.42	1.410	0.170	1.20	0.270	1.66	1.10
3	1.48	1.427	0.187	1.26	0.270	1.69	1.13
3	1.73	1.498	0.258	1.47	0.270	1.85	1.24
3	1.95	1.560	0.320	1.66	0.270	1.99	1.33
3	2.07	1.596	0.356	1.76	0.270	2.07	1.38
4	1.85	1.580	0.180	1.57	0.293	3.83	1.92
4	2.16	1.647	0.247	1.84	0.293	4.19	2.10
4	2.50	1.720	0.320	2.13	0.293	4.58	2.29
5	2.32	1.750	0.190	1.97	0.317	7.49	3.00
5	3.11	1.885	0.325	2.64	0.317	8.90	3.56
5	3.97	2.032	0.472	3.38	0.317	10.43	4.17
6	2.83	1.920	0.200	2.40	0.340	13.12	4.37
6	3.00	1.945	0.225	2.55	0.340	13.57	4.52
6	3.63	2.034	0.314	3.09	0.340	15.18	5.06
6	4.48	2.157	0.437	3.82	0.340	17.39	5.80
7	3.38	2.090	0.210	2.87	0.364	21.27	6.08
7	3.54	2.110	0.230	3.01	0.364	21.84	6.24
7	4.23	2.194	0.314	3.60	0.364	24.24	6.93
7	5.10	2.299	0.419	4.33	0.364	27.24	7.78
7	5.96	2.404	0.524	5.07	0.364	30.25	8.64

Size: Depth d in.	Size: Weight lb/ft	Width b in.	Web Thickness t_w in.	Area in.²	Avg Flange Thickness in.	Axis X-X: I in.⁴	Axis X-X: S in.³
83	4.25	2.290	0.250	3.62	0.387	33.85	8.46
8	4.75	2.343	0.303	4.04	0.387	36.11	9.03
8	5.62	2.435	0.395	4.78	0.387	40.04	10.01
8	6.48	2.527	0.487	5.51	0.387	43.96	10.99
9	4.60	2.430	0.230	3.92	0.409	47.68	10.60
9	5.19	2.485	0.285	4.41	0.409	51.02	11340
9	6.91	2.648	0.448	5.88	0.409	60.92	13.54
9	8.65	2.812	0.612	7.35	0.409	70.89	15.75
10	5.28	2.600	0.240	4.49	0.434	67.37	13.47
10	6.91	2.739	0.379	5.88	0.434	78.95	15.79
10	8.64	2.886	0.526	7.35	0.434	91.20	18.24
10	10.37	3.033	0.673	8.82	0.434	103.45	20.69
12	7.41	2.960	0.300	6.30	0.498	131.84	21.97
12	8.64	3.047	0.387	7.35	0.498	144.37	24.06
12	10.37	3.170	0.510	8.82	0.498	162.08	27.01
12	12.10	3.292	0.632	10.29	0.498	179.65	29.94
15	11.71	3.400	0.400	9.96	0.647	314.76	41.97
15	17.28	3.716	0.716	14.70	0.647	403.64	53.82

EXAMPLE 1 — DESIGN OF STAIR FRAMING
Stair with one landing, supported at four points by hangers or struts.

Problem: Design framing members for stairs shown at right, using A36 steel. F = 22 ksi
Stringers are to be plate
Headers are to be channel sections,
LL = 100 psf; DL = 50 psf
Total load = 150 psf = .15 ksf



Solution:

a) Face stringers: (see NOTE below)

$$W = \text{ksf} \times \frac{\text{tread length}}{2} \times L$$

$= .15 \times 4/2 \times 11 = 3.3\text{k}$

From Table 5.26 on page 5-10,

select 3/16″ × 10″ plate* (W = 3.8k)

$R = W/2 = 3.3/2 = 1.65$ k

Deflection ok, as selection is above heavy line on table.

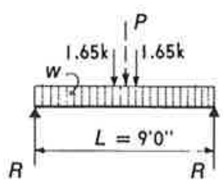
b) Wall stringers:

Span and load same as that of face stringers.

Use 3/16″ × 10″ plate*

$R = 1.65$ k

c) Flight header:



$$w = \text{ksf} \times \frac{\text{platform width}}{2}$$

$= .15 \times 5/2 = .375$ k/ft

To simplify calculations, on safe side, face stringer reactions are assumed to be combined as single load, P, at center.

$P = 2 \times 1.65 = 3.3$ k

$$M = \frac{wL^2}{8} + \frac{PL}{4} = \frac{.375 \times 9^2}{8} + \frac{3.3 \times 9}{4}$$

$= 3.8 + 7.4 = 11.2$ kip-ft

$$S_{req} = \frac{12M}{F} = \frac{12 \times 11.2}{22} = 6.1 \text{ in}^3$$

From Table 5.32 on page 5-14,

select C8 × 11.5 ; S = 8.14; I = 32.6

Limit deflection to L/360.
Formula 15 on page 5-4.

$I = .02288(1.6\,P + W)\,L^2$

$= .02288(1.6 \times 3.3 + .375 \times 9)\,9^2$

$= 16\text{in}^4$ (<32.6) OK

$$R = \frac{W + P}{2} = \frac{.375 \times 9 + 3.3}{2} = 3.34\text{k}$$

d) Platform header:

$$W = \text{ksf} \times \frac{\text{platform width}}{2} \times L$$

$= .15 \times 2.5 \times 9$

$= 3.375$ k

M = WL/8 (1)

$= 3.375 \times 9/8$

$= 3.80$ kip-ft

S = 12 M/F (5)

$= 12 \times 3.80/22$

$= 2.07 \text{ in}^3$

As 5″ depth is the minimum practical size of channel to be used, from Table 5.32 on page 5-14,

select C5 × 6.7 ; S = 3.00 in³; I = 7.49 in⁴

Check deflection:

$\Delta = .000763\, WL^3/I$ (8)

$= .000763 \times 3.375 \times 9^3/7.49$

$= .25$ in.

$$\text{allowable } \Delta = \frac{9 \times 12}{360} = .30 \text{ in. OK}$$

$R = W/2 = 3.375/2 = 1.69$ k

e) Support at points A:

Load = R of platform header = 1.69 k

Select support member from Tables 5.28 and 5.31 on pages 5-12 and 5-13:

Use either a 1/2″ Φ rod as a hanger, or a 2-1/2″ × 2-1/2″ × 1/4″ angle as a strut (not more than 8′ in height)

f) Support at points B:

Load = R of flight header + R of wall stringer

$= 3.34 + 1.65 = 4.99$ k

Select support member from Tables 5.28 and 5.31 on pages 5-12 and 5-13:

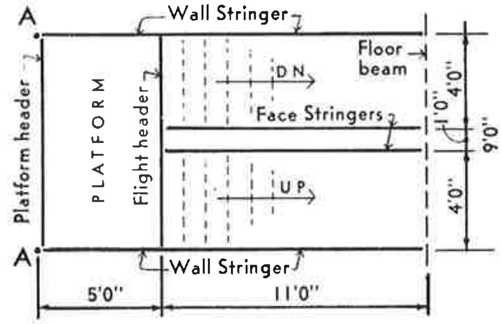
Use either a 3/4″ Φ hanger rod, or a 3″ × 3″ × 1/4″ angle strut (not more than 9′ in height)

* Since calculated bending stress is less than 20 ksi and thickness is 3/16, A570 Gr33 or A611 GrC may be used instead of A36.

NOTE: In this type of framing, where loading on face and wall stringers is the same, the face stringer section is determined by loading requirements. When loading on wall stringer is heavier, requiring a higher S value, the section selected for it should also be used for the face stringer, for sake of appearance. See the following examples.

EXAMPLE 2 — DESIGN OF STAIR FRAMING
Stair with one landing, supported at two corners "A" by hangers or struts.

Problem: Design framing members for stairs shown at right, using A36 steel. F = 22 ksi
All members to be channel sections
LL = 100 psf; DL = 50 psf;
Total load = 150 psf = .15 ksf



Solution:

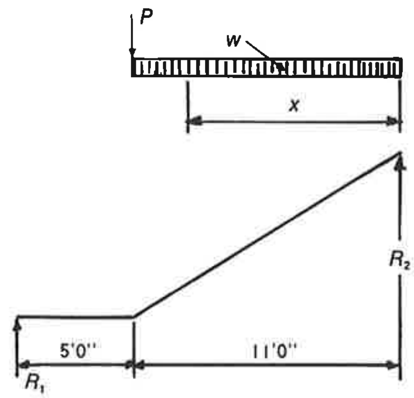
a) Face stringers:

$$W = \text{ksf} \times \frac{\text{tread length}}{2} \times L$$

$= .15 \times 4/2 \times 11 = 3.3$ k

As the wall stringers carry greater loads, and for practical reasons the two stringers should be of the same size, the section selected later for the wall stringer will be used also for the face stringer.

$R = W/2 = 3.3/2 = 1.65$ k



b) Flight header:

Select C8 × 11.5. See Example 1, part (c), page 5-15.

c) Platform header:

Select C5 × 6.7. See Example 1, part (d), page 5-15.

d) Wall stringers:

$$w = \text{ksf} \times \frac{\text{tread width}}{2}$$

$= .15 \times 4/2 = .3$ k/ft.

$P = R$ of flight header

$= 3.34$ k

$$R_1 = \frac{11w \times 11/2 + 11P}{L}$$

$$= \frac{11 \times .3 \times 5.5 + 3.34 \times 11}{16} = 3.43 \text{ k}$$

$$R_2 = \frac{11w \times (5 + 11/2) + 5P}{16}$$

$$= \frac{11 \times .3 \times 10.5 + 5 \times 3.34}{16} = 3.21 \text{ k}$$

x = distance to zero shear and maximum moment

$$= \frac{R_2}{w} = \frac{3.2}{.3} = 10.7'$$

$M = R_2x - (wx)x/2$

$= 3.21 \times 10.7 - (.3 \times 10.7)\,10.7/2$

$= 34.2 - 17.1 = 17.1$ kip-ft

$$S_{req} = \frac{12M}{F} = \frac{12 \times 17.1}{22} = 9.3 \text{ in}^3$$

From Table 5.33 on page 5-14, select
MC12 × 10.6; $S = 9.23$; $I = 55.4$

Check deflection: (Formula 11 on page 5-4)

The approximate deflection at the center can be found by assuming that the total load acts as a uniformly distributed load over total length of span.

$\Delta_{(approx.)} = .000763\,(W + P)L^3/I$

$$= .000763\,(.3 \times 11 + 3.34)\,\frac{16^3}{55.4}$$

$= .37''$ ok

$$\text{allowable } \Delta = \frac{16 \times 12}{360} = .53''$$

e) Support at end of wall stringer:

Load = R of wall stringer + R of platform header

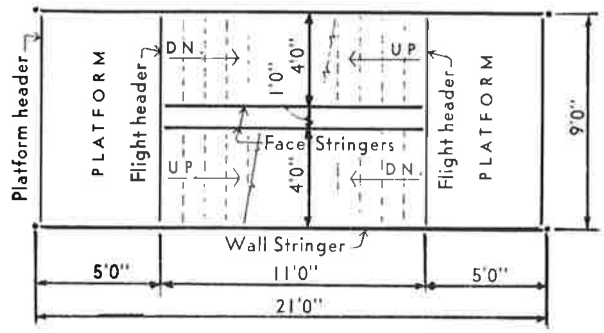
$= 3.43 + 1.69 = 5.12$ k

Select support members from Tables 5.28 and 5.31 on pages 5-12 and 5-13:

Use a 3/4″ rod as a hanger, or a 3″ × 3″ × 1/4″ angle as a strut (not more than 9′ in height)

EXAMPLE 3 — DESIGN OF STAIR FRAMING
Stair with two landings, supported at four corners by hangers or struts

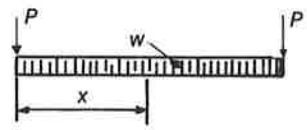
Problem: Design framing members for stairs shown at right, using A36 steel. F = 22 ksi
All members to be channel sections
LL = 100 psf; DL = 50 psf;
Total load = 150 psf = .15 ksf



Solution:

a) Face stringers:

See Example 2, part (a), page 5-16.



b) Flight header:

Select C8 × 11.5. See Example 1, part (c), page 5-15.

c) Platform header:

Select C5 × 6.7. See Example 1, part (d), page 5-15.

d) Wall stringers:

$$w = \text{ksf} \times \frac{\text{tread width}}{2}$$

$= .15 \times 4/2 = .3$ k/ft.

$P = R$ of flight header

$= 3.34$ k

$$R_1 = R_2 = \frac{wL + 2P}{2}$$

$$= \frac{.3 \times 11 + 2 \times 3.34}{2} = 4.99 \text{ k}$$

x = distance to zero shear and maximum moment

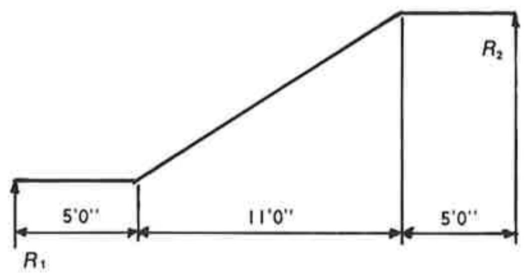
$$= \frac{R_1 - P}{w} = \frac{.499 - 3.34}{w} = 5.5 \text{ ft.}$$

$M = R_1(5 + x) - Px - (wx)x/2$

$= 4.99 \times 10.5 - 3.34 \times 5.5 - .3 \times 5.5 \times 2.75$

$= 29.5$ kip-ft

$$S_{req} = \frac{12M}{F} = \frac{12 \times 29.5}{22} = 16.1 \text{ in}^3$$



From Table 5.32 on page 5-14, select
C12 × 20.7; $S = 21.5$; $I = 129.0$

Check deflection: (Formula 11 on page 5-4)

The approximate deflection at the center can be found by assuming that the total load acts as a uniformly distributed load over total length of span.

$\Delta_{(approx.)} = .000763\,(W + 2P)L^3/I$

$$= .000763\,(.3 \times 11 + 2 \times 3.34)\frac{21^3}{129.0}$$

$= .55''$ ok

allowable $\Delta = 21 \times 12/360 = .70''$

e) Support at end of stringer:

Load = R of wall stringer + R of platform header

$= 4.99 + 1.69 = 6.68$ k

Select support members from tables on pages 5-12 and 5-13.

Use a 7/8″ rod as a hanger, or a 3″ × 3″ × 1/4″ angle as a strut (not more than 8′ in height)

EXAMPLE 4 — DESIGN OF CONNECTION OF HEADER TO STRINGER

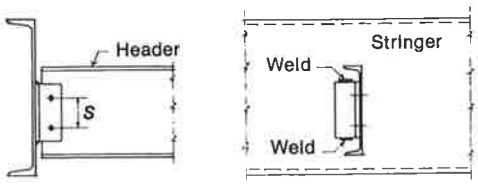
Problem: To determine the load carrying capacity of various types of header-to-stringer connections, using a 2 1/2″ × 2 1/2″ × 3/16″ angle with different sizes of bolts and welds,

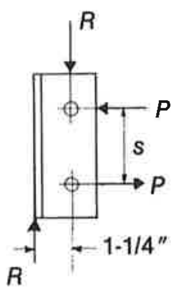
a) when connection angle is welded to stringer and bolted to header,
b) when connection angle is welded to header and bolted to stringer.

Use A36 steel for all members, A307 bolts and E60 welding electrodes.

Solution: CASE A —

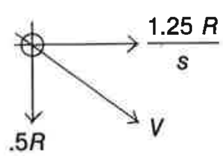
Connection angle welded to stringer, bolted to header. Eccentric load moment taken by bolts.





$$M = 1.25\,R$$

$$P = \frac{M}{s} = \frac{1.25\,R}{s}$$



$$V = R\sqrt{(0.5)^2 + \left(\frac{1.25}{s}\right)^2}$$

$$R = \frac{V}{\sqrt{.25 + \frac{1.5625}{s^2}}}$$

Substituting for V the following bolt shear values, the allowable reactions are computed for various values of s as shown in the table below.

Bolt shear values: 1/2″Φ — 1.96 kips
5/8″Φ — 3.07 kips
3/4″Φ — 4.42 kips

Allowable Reactions (kips)

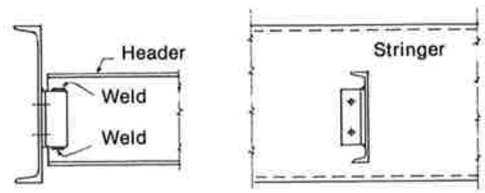
Bolts	spacing (s) of bolts		
	3″	4″	5″
2 — 1/2″Φ	2.7K	2.9K	3.0K
2 — 5/8″Φ	4.2K	4.6K	4.8K
2 — 3/4″Φ	6.1K	6.6K	7.0K

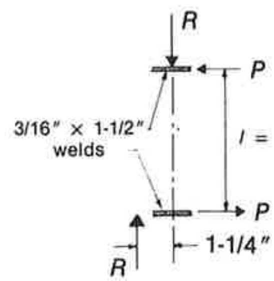
Assuming 3/16″ weld, minimum weld strength per inch of weld = 18 (3/16 × .707) = 2.4 k/in

Using two 3/16″ × 1-1/2″ welds,
weld strength = 2.4 × 1-1/2 × 2 = 7.2 k

Solution: CASE B —

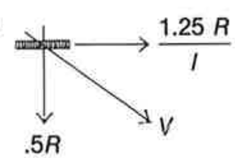
Connection angle welded to header, bolted to stringer. Eccentric load moment taken by welds.





$$M = 1.25\,R$$

$$P = \frac{M}{l} = \frac{1.25\,R}{l}$$



$$V = R\sqrt{(0.5)^2 + \left(\frac{1.25}{l}\right)^2}$$

$$R = \frac{V}{\sqrt{.25 + \frac{1.5625}{l^2}}}$$

Assuming a 3/16″ weld, minimum length of 1-1/2″, with shear value (V) of 1.5 × 2.4, or 3.6k, and substituting this value and various angle lengths (l), allowable reactions are computed as follows:

Angle length, l:	3-1/2″	4-1/2″	5″
Maximum R of welds:	5.86k	6.32k	(6.44k)*
Maximum V of bolts:	3.92k	6.14k	8.84k
Bolt sizes, 2 per joint:	1/2″Φ	5/8″Φ	3/4″Φ
Allowable reaction:	3.92k	6.14k	8.84k

*Value for two 3/16″ × 1-1/2″ welds. To provide weld strength equal to that of bolts, increase weld lengths.

$$\text{Weld length required} = \frac{8.84}{6.44} \times 1.5 = 2.05''$$

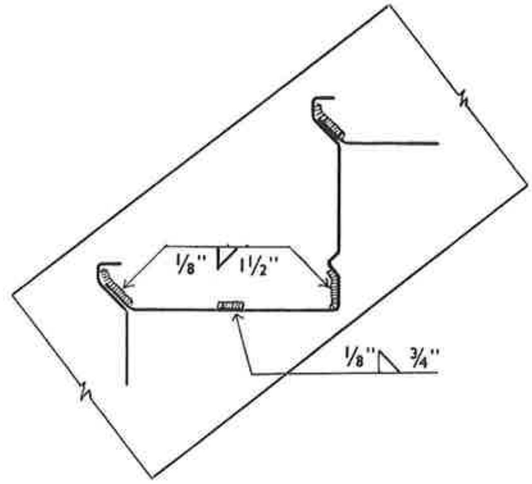
Use two 3/16″ × 2-1/8″ welds along top and bottom of the 5″ angle.

EXAMPLE 5 — DESIGN OF WELDED CONNECTION OF PAN TREAD-RISER TO STRINGER

Problem: Determine the carrying capacity of two welds connecting the riser directly to the stringer, without the use of carrier angles or bars.

Pan tread-riser is .0747″ (14 ga) steel
Tread dimensions — 4′ length, 10″ width
Total load on tread is 150 psf.

Assume all shear to be carried by two 1 1/2″ welds located on the riser.



Solution: Shear stress in riser steel governs.
Shear area (each weld), A_v = t of steel × length of weld
= .0747 × 15 = .112 in³

$V_{prov} = .4F_y \times 2A_v$
$= .4 \times 33 \times 2 \times .112 = 2.95$ k

W on tread = ksf × tread width × tread length
= .15 × 10/12 × 4 = .5 k

$R = W/2 = 2.5$ k

Because capacity of the two welds (2.95 k) far exceeds the end reaction (.25 k), two welds 1/8″ × 1-1/2″ (@ 1.6k/in) are adequate. To ensure structural integrity, 3/4″ welds should also be placed at mid-width of tread ends (to stringer) and at 15″ spacing along the length of the tread (to nosing).
In actual testing, such welds carried a load of 15 tons on a tread 42″ × 10.9″. When pan failure occurred, the welds remained intact.

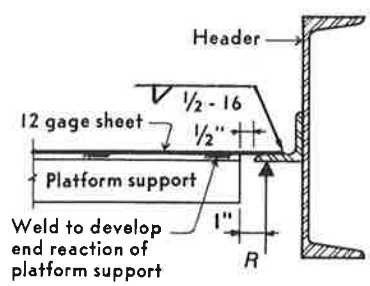
EXAMPLE 6 — CHECK BENDING STRENGTH OF PLATFORM SHEET AT END SUPPORT

Problem: Determine the need for mechanical connection between platform supports (welded to the under side of platform sheet) and the member carrying the platform.

Platform span is 6′0″, and the total load carried is 140 psf.

Subplatform sheet is .1046″ (12 ga) steel, F = 20,000 psi

From Table 5.5, supports on 15″ centers



Solution: The bending moment in a 12″ length of the subplatform sheet will be calculated, and the required S will be compared with the S provided.

$$R = psf \times \frac{\text{platform span}}{2} = 140 \times \frac{6}{2} = 420 \text{ lb.}$$

$M = R \times$ moment arm $= 420 \times 1 = 420$ lb-in.

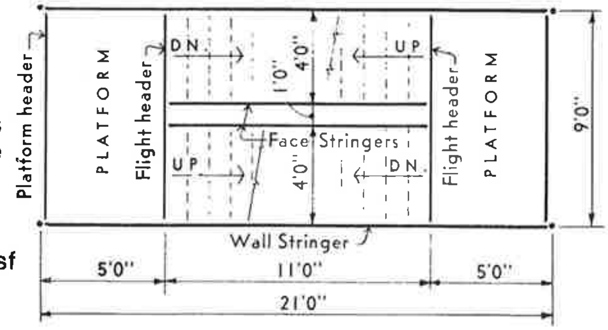
$$S_{req} = \frac{M}{F} = \frac{420}{20{,}000} = .021 \text{ in}^3$$

$S_{prov} = .0218$ in³ (Table 5.6)

Conclusion: Connection of the platform support by mechanical means to the member carrying the platform is not required in this case. For heavier loads or longer spans a thicker plate or standard connection angles would be required.

Platform Support. Load = 140 × 15/12 × 6 = 1,050 lb = 105 k
From Table 5.21 on page 5-9, select L3 × 3 × 3/16

EXAMPLE 7 — DESIGN OF STAIR FRAMING



Problem: Stair with two landings, supported at four corners. Design framing members for stairs and platforms shown at right, using 6061-T6 aluminum (For treads, use 6061-T4).

All members to be channel sections.

LL = 100 psf; DL = 5 psf; Total load = 105 psf = .105 ksf

Solution:

a) Face stringers:

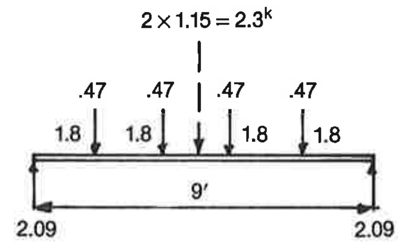
$W = .105 \times 4/2 \times 11 = 2.3$ k

$M = W/2 = 2.3/2 = 1.15$ k

Use wall stringer section for face stringer.

b) Flight header:

Use platform support reactions from (g); or assume uniformly distributed loading. Both face stringer reactions considered to be single load at mid-span.



$M = 2.09 \times 4.5 - .47 \times 2.7 - .47 \times .9 = 7.71$ kip-ft

$F = 16$ ksi

$S_{req} = 7.71 \times 12 / 16 = 5.78$ in^3

Find I required to satisfy deflection using Formula 16, page 5-4. Consider platform support load uniformly distributed.

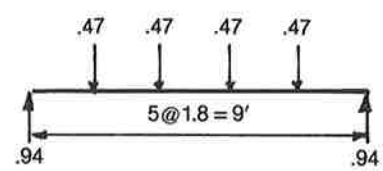
$I > = .0675\,(1.6 \times 2.3 + 4 \times .47)9^2$

$> = 30.4$ in^4

Use Table 5.34 on page 5-14

Select C8 × 4.25 ; $S = 8.46$ in^3; $I = 33.85$ in^4

c) Platform header:



$M = .94 \times 3.6 - .47 \times 1.8 = 2.54$ kip-ft $= 30.5$ kip-in

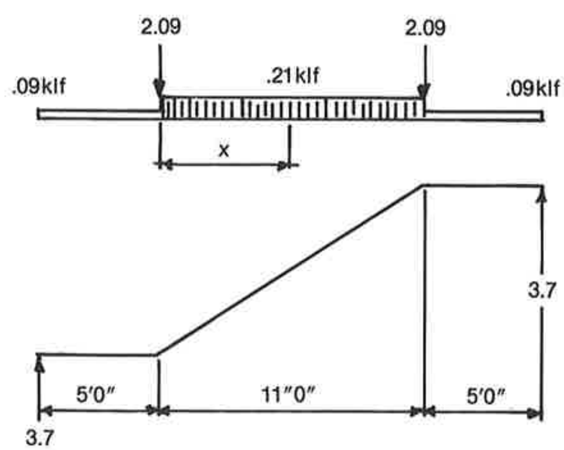
$S_{req} = 30.5 / 16 = 1.90$ in^3

To limit deflection to $L/360$ using Formula 16 assuming uniform load:

$I > = .0675(4 \times .47)9^2 = 10.3$ in^4

Select C6 × 2.83 ; $S = 4.37$ in^3; $I = 13.12$ in^4

d) Wall Stringer:



$M = 3.7 \times 10.5 - (5 \times .09)8 - 2.09 \times 5.5 - 5.5^2/2$

$= 20.3$ kip-ft.

$S_{req} = 20.3 \times 12 / 16 = 15.2$ in^3

Assuming all load to be uniformly distributed:

$I > = .0675 \times 7.4 \times 21^2 = 220.3$ in^4

limits deflection to $L/360$

Select C15 × 11.71 ; $S = 29.94$ in^3; $I = 314.76$ in^3

For less stringent deflection limitation:

Select C10 × 6.91 ; $S = 15.79$; $I = 78.95$ in^4

$\Delta = .00225 \times 7.4 \times 21^3 / 78.95$

$\Delta = 1.95$ in $= L/129$

EXAMPLE 7 — (cont)

e) Stair treads:

$w = 105 \times 10 / 12 = 87$ plf

$M = wL^2/8 = 87 \times 4^2 / 8 = 174$ lb-ft

$P = 300$ lb

$M = PL/4 = 300 \times 4 / 4 = 300$ lb-ft (controls)

$S = 300 \times 12 / 10{,}000 = .36$ in^3

From Table 5.13 on page 5-7:

1/4″ Plate Tread ; $S = .365$ in^3; $I = .586$ in^4

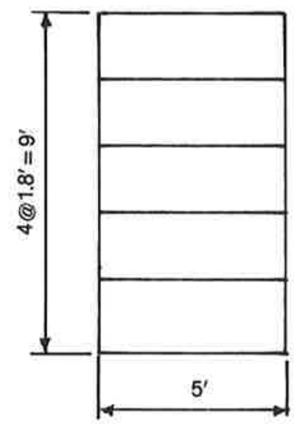
$= .0036PL^3/I$ (Formula 9 on page 5-4)

$= .0036 \times .3 \times 4^3 / .586 = .12''$

$L/360 = 4 \times 12 / 360 = .13''$ OK

f) Platform plate:

With 4 support channels, plate span = 1.8′
Investigate 12″ width section as simple beam
(Conservative since plate is continuous over channels)



$M = 105 \times 1.8^2 / 8 = 42.5$ lb-ft

$M = 300 \times 1.8 / 4 = 135$ lb-ft

$S = 135 \times 12 / 16{,}000 = .1012$ in^3

$I > = .01875(.105 \times 1.8)\, 1.8^2 = .0115$ in^4

From Table 5.6 on page 5-5:

1/4″ Plate; $S = .125$ in^3; $I = .01563$ in^4

g) Platform supports:

Span = 5 ft.

$W = .105 \times 1.8 \times 5 = .94$ k; $R = W/2 = .47$ k

$M = .94 \times 5 / 8 = .59$ kip-ft

$S = .59 \times 12 / 16 = .44$ in^3

$I > = .0675 \times .94 \times 5^2 = 1.59$ in^4

From Table 5.34 on page 5-14

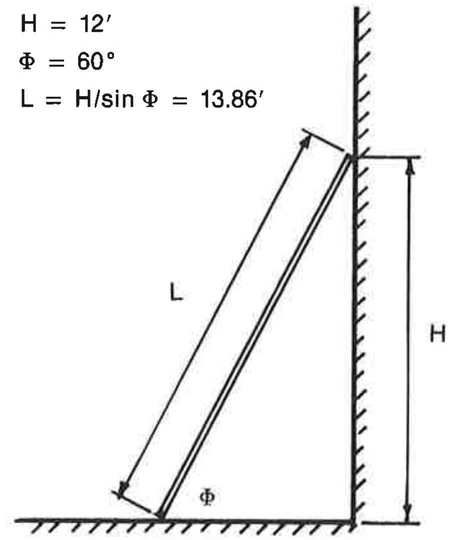
Select C3 × 1.42 ; $S = 1.10$ in^3; $I = .66$ in^4

EXAMPLE 7 —DESIGN OF SHIP'S LADDER

Ship's ladders are set at angles which may vary between 50° and 75° from the horizontal

Problem: Design stringers and treads for ship's ladder making a 60° angle with the horizontal to support a minimum tread load of 100 psf or a single load of 500 lb.
Use 6061-T6 for stringers.
Use 6061-T4 for treads.

$H = 12'$
$\Phi = 60°$
$L = H/\sin\Phi = 13.86'$



Solution:

a) Treads:

Tread width = 6″; tread span = 3′ = 36″

w = 500 / 3 = 167 plf

From Table 5.4 on page 5-5, select

channel channel 6 × 1-1/2 × 3/6 (164 plf)

b) Stringers:

Minimum depth = Tread width × sin Φ
= 6 × sin 60°
= 5.2″

Stringer load, W = number of treads × tread reaction
= 13 × 100 × 6/12 × 3 / 2
W = 975 lbs
P = 500 lbs

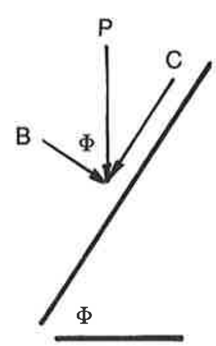
Resolve vertical load into beam and column loads:

$C_1 = P \times \sin\Phi = 500 \times \sin 60° = 433$ lbs

$B_1 = P \times \cos\Phi = 500 \times \cos 60° = 250$ lbs

$C_2 = W \times \sin\Phi = 975 \times \sin 60° = 844$ lbs

$B_2 = W \times \cos\Phi = 975 \times \cos 60° = 488$ lbs



Bending due to P, $M_1 = B_1 \times L / 4 = 250 \times 13.86 / 4 = 866$ lb-ft

Bending due to W, $M_2 = B_2 \times L / 8 = 488 \times 13.86 / 8 = 845$ lb-ft

Try C6 × 2.33; $A = 2.4$ in²; $S_x = 4.37$ in³; $r_x = 2.34$ in

$f_b = M_1 / S_x = 866 \times 12 / 4.37 = 2.378$ psi

$F_b = 11{,}000$ psi (reduced for welded connections)

$f_a = C_1 / A = 433 / 2.4 = 180$ psi

$L/r = 13.86 \times 12/2.34 = 71$

$L/r = > 65,\ F_a = 51 \times 10^6 / (L/r)^2 = 10{,}117$ psi

$f_a/F_a + f_b/F_b = .180/10.12 + 2.4/11 = .24 < 1.0$

$f_b = M_2 / S_x = 2{,}320$ psi

$f_a = C_2 / A = 352$ psi

$f_a/F_a + f_b/F_b = .25 < 1.0$

Use C6 × 2.33

DESIGN OF RAILINGS

Due to the greater consciousness of safety requirements and the increasing provision in many codes of load limits on railings, architects and engineers require detailed information concerning their loading criteria and structural design. They may be designed either to meet a particular building code regulation or to meet the requirements of a specific installation.

In the structural design of a railing it is essential to know:

1. The structural loading criteria as established by governing regulations;
2. The mechanical properties and allowable design stresses of handrail metals;
3. The properties of the sections to be used;
4. Formulas for engineering design in terms of loading, stress and deflection relationships, and
5. Proper method of attachment and soundness of supporting structure.

Each of these considerations will be discussed in some detail in the following paragraphs.

Structural Loading Criteria

In its Voluntary Minimum Standards for Fixed Metal Stairs NAAMM recommends that railings and handrails be capable of withstanding a minimum force of 200 pounds applied in any direction at any point on the top rail. This recommendation is based on a requirement originally established by the Occupational Safety and Health Administration of the Department of Labor. Other codes, including the Life Safety Code of NFPA have adopted this requirement. Some building codes may exceed this requirement. When such is the case the governing code will take precedence.

Uniform load requirements for railings may also be found in some codes. These may call for resistance to a uniform horizontal and vertical load of from 20 pounds to 50 pounds per lineal foot. In some instances the requirement is that the horizontal and vertical loads be acting simultaneously. A few codes specify a vertical loading of 100 pounds per lineal foot.

For guard rails there is an NFPA Life Safety Code requirement that intermediate rails, balusters, and panel fillers be designed to resist a uniform load of not less than 25 pounds per square foot of the gross area of the guard of which they are a part. This load, however, need not be additive to the uniform horizontal load on the railing, mentioned in the preceding paragraph, in designing the main supporting members of the guard.

Codes do not impose a limitation on the amount of deflection which may be allowed. However, deflection under loading is an important consideration in establishing a psychological sense of structural integrity.

Mechanical Properties of Metals

Mechanical properties of the metals and alloys used in railings, as established by their producers, are listed on page 5-3.

Because the nonferrous metals are highly ductile, their yield strengths are defined by the maximum unit stress developed in producing a specified permanent set. The magnitude of permanent set specified varies from 0.1% to 0.5% of the gage length of the tensile test specimen and depends on the standard adopted for each metal by the appropriate authority. Due to the uncertainties in alloy composition, most engineers prefer to use guaranteed minimum yield strengths rather than typical yield strengths.

A factor of safety must be applied, to take into account uncertainties in loading, methods of calculating stresses, and the variable properties of materials. For structural metals in buildings, a factor of 1.65 applied to minimum yield strength or 1.95 applied to ultimate strength is generally accepted as a minimum. In the following examples allowable stresses have been calculated by dividing minimum guaranteed yield strengths by 1.65. For round tube and pipe the allowable stress is increased by a shape factor.

Properties of Sections

Properties of some of the sections commonly used for railing construction are contained in the tables on pages 5-29 through 5-33. Properties of other sections can be found in the catalogs of their producers and in the AISC Manual of Steel Construction.

Formulas for Engineering Design

The determination of bending moments and stresses in the structural members of railings follows conventional engineering design procedures. Stresses are calculated from bending moments and section properties using the flexure formula:

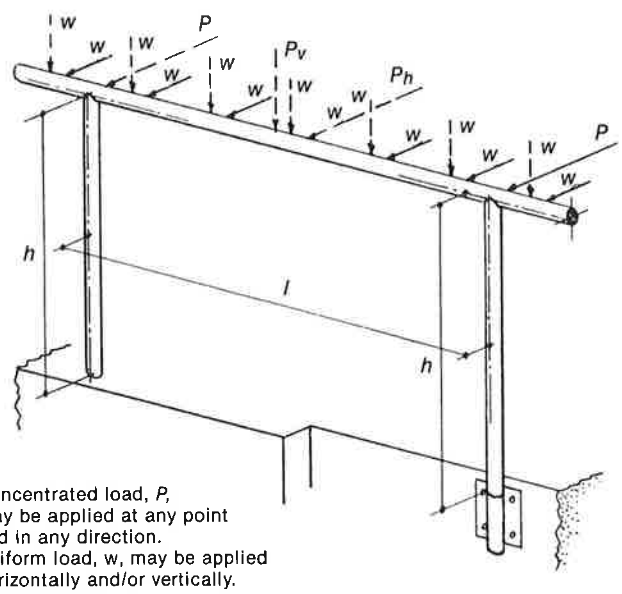
$$f = \frac{M \times c}{I} = \frac{M}{S} \text{ (see footnote)}$$

Railing posts act as columns in resisting vertical loading, and as vertical cantilever beams in resisting horizontal thrust applied to the top rail. Bending moment produced by horizontal loading normally controls design, and stresses are calculated by the formula:

$$f = \frac{M}{S} = \frac{w/12 \times l \times h}{S} \text{ for uniform loading}$$

$$f = \frac{M}{S} = \frac{P \times h}{S} \text{ for concentrated loading}$$

See page 5-4 for explanation of symbols used.



Concentrated load, *P*, may be applied at any point and in any direction. Uniform load, w, may be applied horizontally and/or vertically.

These formulas apply to straight-run railings with uniform post spacing. Although lateral bracing significantly reduces bending moment in posts, the concern here is only with the basic, statically determinate condition. The assumption that this condition exists will provide conservative design values in all situations.

Bending stresses in welded pipe railing posts are determined in the same way as for mechanically connected systems. When pipe or tubing is used, the post strength may be increased by inserting a reinforcement in the tube post.

In most railings the connections between posts and rails may be assumed to be free to pivot. The distribution of loads over two or more spans decreases the bending moment in rail members, and stresses for various span conditions are calculated by varying the bending moment constant *K*, as follows:

For uniform vertical or horizontal loading:

$$f = \frac{w/12 \times l^2}{S \times K}$$

$K = 8$ for one or two spans
$K = 9.5$ for three or more spans

For concentrated loads applied at mid-span:

$$f = \frac{P \times l}{S \times K}$$

$K = 4$ for one span
$K = 5$ for two or more spans

NOTE: Values of *K* reflect the relative maximum bending moment developed under the different loading and span conditions

Joints between posts and horizontal members in welded railings approach complete rigidity. Joint rigidity causes bending moments to be distributed among members and often results in structures which are statically indeterminate. Because the difficulty of accurately determining stresses in structurally indeterminate conditions may not be justified in terms of useful design data, many designers prefer to simplify the design process on the safe side by assuming pinned joint conditions even when joints are welded.

An important consideration in welded aluminum railings is the effect of welding heat on the structural properties of aluminum. For example, extruded pipe of aluminum alloy 6063-T52 has an allowable design stress of 11,500 psi, but within 1″ of a weld this allowable stress must be reduced to 8,000 psi. Since maximum bending moment in continuous horizontal members generally occurs at points of support, the reduced design stress will often control design.

Quality of workmanship in welded joints is also a very important factor in determining the strength of railing installations. Careful preparation, including accurate notching and fitting of pieces to be welded, helps achieve both structural soundness and satisfactory appearance. Special care should be taken to provide sound welds where subsequent grinding will remove weld material. Thin welds can produce stress concentrations which are subject to cracking.

Deflection Considerations

Despite an absence of deflection criteria for handrails, deflection behavior under load should be considered by the designer. Even though installations meet strength requirements, excessive deflection under load can produce a feeling of structural inadequacy on the part of those who are using the stairs and depending on the railing for their safety.

Lateral deflection of posts under horizontal, perpendicularly applied loads are calculated by the formulas:

$$\Delta = \frac{w/12 \times l \times h^3}{3 \times E \times I}$$ for uniform load on railing span

$$\Delta = \frac{P \times h^3}{3 \times E \times I}$$ for concentrated load at top of post

Vertical deflection of horizontal railing under vertically applied loads are calculated by the formulas:

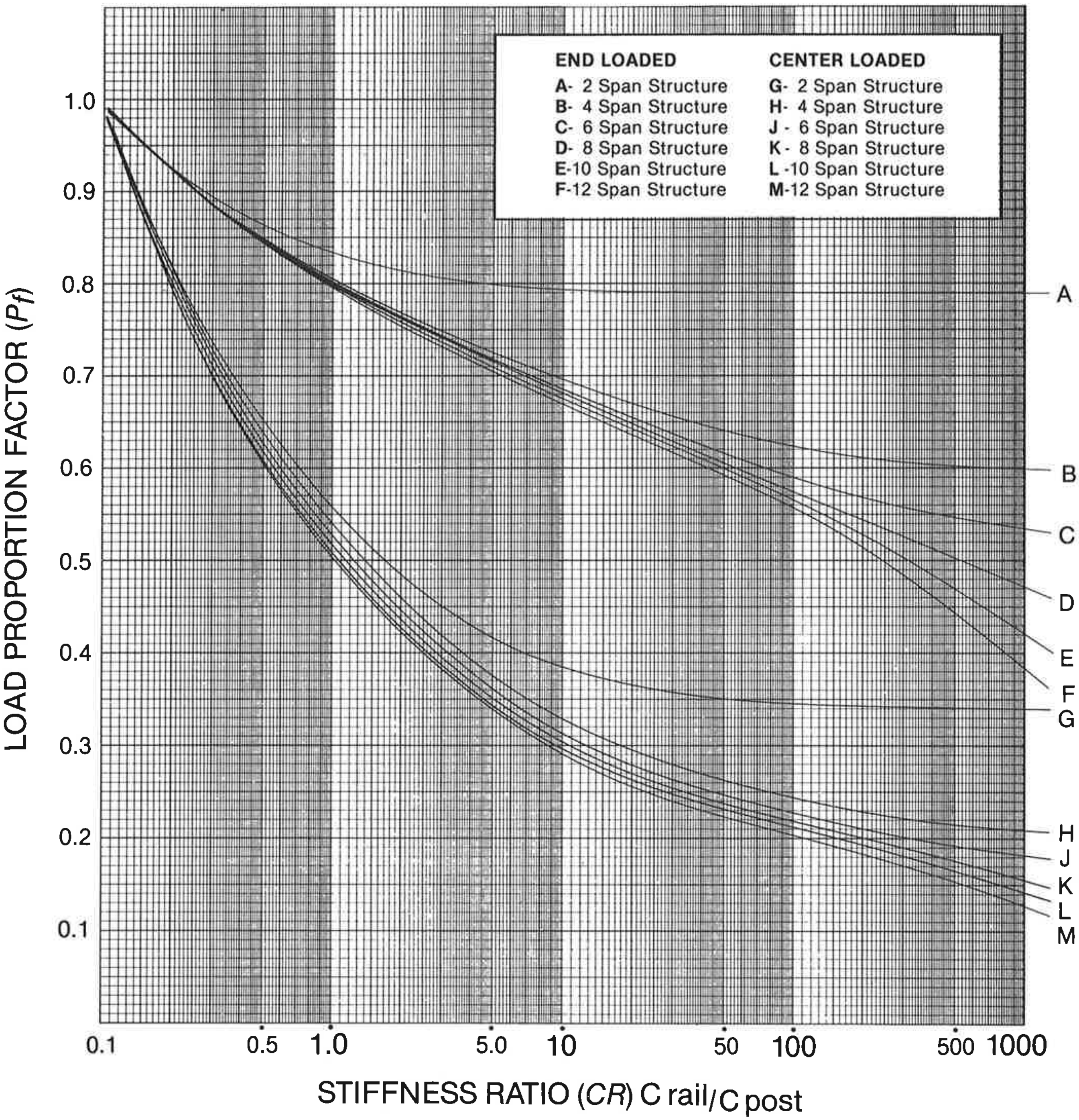
$$\Delta = \frac{5 \times w/12 \times l^4}{384 \times E \times I}$$ for uniform load

$$\Delta = \frac{P \times l^3}{48 \times E \times I}$$ for concentrated load at center of span

Load Distribution

The formula for concentrated post loading (page 5-23) applies to straight-run railings with uniform post spacing. For installations where the railing is laterally braced by a change in direction of attachment to other structure, bending moment in posts may be significantly reduced. Similarly, in a railing system where balusters or posts are mounted securely into the floor or stair slab, the load applied to the rail at a post is distributed to other posts on either side of the post under stress, reducing the load applied to that post. This reduction is dependent on the stiffness of the rail relative to the stiffness of the post and a load proportion factor which is found from the graph on page 5-25.

RAILING LOAD DISTRIBUTION DATA



The stiffness of a rail or post is

$$C = \frac{E \times I}{h} \text{ for the post}$$

$$C = \frac{E \times I}{L} \text{ for the rail}$$

Stiffness ratio is determined as

$$CR = \frac{C\text{ rail}}{C\text{ post}}$$

The stiffness ratio *(CR)* is then plotted on the graph above to obtain Load Proportion Factor (P_f).

When the load proportion factor has been determined, it is multiplied by the total load to determine the load one post must sustain.

Stiffness ratio for distributed loading.

$$CR = \frac{C\ \text{rail}}{C\ \text{post}} = \frac{E \times I / L}{E \times I / h}$$

As the post spacing increases, the proportion of load distributed becomes less and it is assumed that at maximum limits, the post is designed to sustain the total design load. Since the variety of possible installation conditions is virtually limitless, only the straight-run condition, which provides conservative design values for all situations, is presented.

In pipe railings, where posts and rails are of identical material and section and where post spacing usually varies between 3 feet and 6 feet, load distribution is fairly uniform and the greatest proportion of a concentrated load carried by any one post can be estimated as follows:

End posts: of a 2 span railing — 85%
of a railing of 3 or more spans — 82%

Intermediate posts: of a two span railing — 65%
of a railing of 3 or more spans — 60%

Thus, if a 200 lb. concentrated load is specified, actual design load to be applied at the top of end and intermediate posts of a railing of 3 or more spans would be 164 and 120 pounds respectively.

Note: If end posts differ from intermediate posts in strength, the load distribution pattern becomes indeterminate and end posts should then be designed to carry 100% of the concentrated load.

In single span railings, each post must be designed to carry the full concentrated load.

Examples of Typical Problems and Solutions

The following examples illustrate the solution of common types of railing design problems by the application of well known structural design formulas. It will be noted that in many cases these are solved by first equating the resisting moment to the bending moment produced by the applied loading.

1. Determine Maximum Post Spacing

Given: Horizontal loading at top of rail, w = 20 lb/ft
Railing height, h = 34 in

Use: 1-1/4″ schedule 40 aluminum pipe posts of Alloy 6063 T52. S = .235 in³, F = 11,500 psi

Determine maximum post spacing, l, in inches.

a) If using aluminum pipe with fittings and mechanical connections:

Equating resisting moment to applied moment,

$$F \times S = w/12 \times l \times h$$

$$\text{Solving for } l,\ l = \frac{F \times S}{w/12 \times h} = \frac{11{,}500 \times .235}{20/12 \times 34}$$

= 47.7 in. maximum

b) If the aluminum pipe is to be welded, the allowable stress must be reduced to 8,000 psi. Then

$$l = \frac{8{,}000 \times .235}{20/12 \times 34} = 33.2 \text{ in. maximum}$$

2. Determine Required Section Modulus of Post

Given: Concentrated perpendicular horizontal load at top of rail, P = 200 lb.
Height of rail, h = 34 in.
Post is 6063-T52 extruded aluminum pipe
Allowable design stress, F = 11,500 psi

Determine required section modulus and select suitable section.

Equating resisting moment to applied moment,

$$F \times S = P \times h$$

$$S = \frac{P \times h}{F} = \frac{200 \times 34}{11{,}500} = .591 \text{ in}^3$$

Suitable section is 2″ round pipe, standard weight, S = .731 in³ as found in Schedule 80, Table 5.35, on page 5-29.

Required section modulus may be reduced by considering load distribution.

3. Determine Maximum Span for Handrail

Given: Concentrated vertical load at midspan, P = 200 lb. Railing is to be installed with more than 3 spans. Bending moment constant, K = 5.

Use: Bronze tube 1.0″ × 2.0″ × .100″

S_X = .180 in³

F = 11,500 psi

Determine maximum span for handrail.

Equating resisting moment to applied moment,

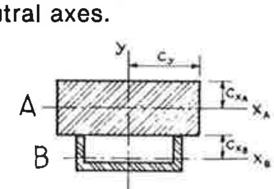
$$F \times S = \frac{P \times l}{K}$$

$$l = \frac{K \times F \times S}{P} = \frac{5 \times 11{,}500 \times .180}{200} = 51.75 \text{ in.}$$

4. Determine Maximum Span for a Combined Handrail Using Sections of Same Metal

Combined handrail sections are those which consist of pipe, tubing, flat bar or handrail moulding mounted on either flat bars or channels. For design purposes it is assumed that the two sections develop the same deflection under load, but act independently about their neutral axes.

If the two sections shown, a flat bar A and a mounting channel B, are of the same material, maximum fiber stress will be given by the formula



$$f = \frac{M \times c_{max}}{I_A + I_B}$$

in which I_A and I_B are the moments of inertia for the two sections about the axis of bending concerned, and c_{max} is c_{XA} or c_{XB}, whichever is greater, when considering vertical deflection, or c_y (1/2 width of wider section) when considering horizontal loading.

Given: Combined handrail section consisting of 2″ × 3/4″ aluminum flat bar (I_X = .070 in⁴) and a 1/2″ × 1-1/2″ × 1/8″ aluminum channel (I_X = .005 in⁴). *F*, both sections = 9500 psi.

Vertical loading, *P* = 200 lb. applied at any point

Bending moment constant, *K* = 5

The railing will have a minimum of three continuous spans on all runs.

Determine the maximum span for the combined section.

Equating resisting moment to applied moment,

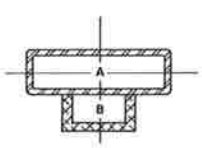
$$\frac{F \times (I_{XA} + I_{XB})}{c_{max}} = \frac{P \times l}{K}$$

$$l = \frac{F \times (I_{XA} + I_{XB}) \times K}{P \times C_{max}}$$

$$= \frac{9500 \times (.070 + .005) \times 5}{200 \times .375} = 47.5 \text{ in.}$$

5. Determine Maximum Span for Combined Handrail of Two Dissimilar Metals

For structural efficiency and/or economy, designers often combine sections of two different metals. Just as when the sections are of the same metal, it is assumed that both sections have the same deflection, but flex independently about their neutral axes. The distribution of load is a function of the relative stiffness of the two metals, and this is determined by their moments of inertia and moduli of elasticity. The distribution of the total load between the two sections, A and B, can be determined as follows:



Given: A. 2.0″ × .625″ × .083″ rectangular stainless steel tubing

I_{AX} = .026 in⁴ S_{AX} = .083 in³

E_A = 28 × 10⁴ psi F_A = 20,000 psi

B. 1.0″ × .500″ × .125″ extruded aluminum channel 6063-T6 alloy

I_{BX} = .005 in⁴ S_{BX} = .014 in³

E_B = 10 × 10⁶ psi F_B = 15,000 psi

Railing spans are not continuous.
For a concentrated vertical load *P* = 200 lb.

Load carried by A,

$$P_A = \frac{P}{1 + \dfrac{E_B \times I_B}{E_A \times I_A}} = \frac{200}{1 + \dfrac{10 \times .005}{28 \times .026}} = 187.1 \text{ lb.}$$

Load carried by B,

$$P_B = \frac{P}{1 + \dfrac{E_A \times I_A}{E_B \times I_B}} = \frac{200}{1 + \dfrac{28 \times .026}{10 \times .005}} = 12.9 \text{ lb.}$$

$P = P_A + P_B = 187.1 + 12.9 = 200$ lb

If uniform loading is called for, substitute w for P and determine load per foot for each section.

Determine maximum span for each section:

Equating resisting moment to applied moment

$$F \times S = \frac{P \times l}{K}$$

$$l_A = \frac{K \times F_A \times S_A}{P_A} = \frac{4 \times 20{,}000 \times .083}{187.1} = 35.5 \text{ in.}$$

$$l_B = \frac{K \times F_S \times S_B}{P_B} = \frac{4 \times 15{,}000 \times .014}{12.9} = 65.1 \text{ in.}$$

Maximum span is the lesser value, or 35.5 in.

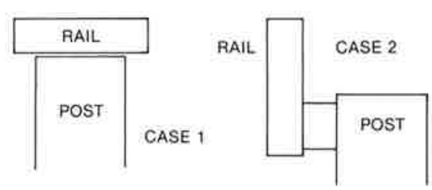
If uniform loading is called for apply the uniform loading formula on page 5-24.

6. Determine Horizontal and Vertical Handrail Deflection at Design Loading

Given: Post is square aluminum tubing, 2″ × 2″ × .125″ 6063-T52 alloy
Moment of inertia of post, I = .552 in⁴
Handrail is solid aluminum bar 3″ × 3/4″

Case 1: Uniform perpendicular horizontal load at top of rail, *w* = 40 lb/ft
Uniform vertical loading, *w* = 100 lb/ft
3″ dimension of handrail horizontal
I_X = .106 in⁴ I_y = 1.688 in⁴

Case 2: Concentrated horizontal or vertical loading at mid-span, *P* = 200 lb
3″ dimension of handrail vertical
I_x = 1.688 in⁴, I_y = .106 in⁴
Post spacing *l* = 48 in
Handrail height *h* = 34 in
Modulus of elasticity *E* = 10 × 10⁴ psi



Determine the total horizontal deflection of the post and handrail and the vertical deflection of the handrail at the center of the span.

Horizontal deflection of post:

Case 1:

$$\Delta p = \frac{w/12 \times l \times h^3}{3 \times E \times I} = \frac{40/12 \times 48 \times 34^3}{3 \times 10 \times 10^6 \times .552} = .380 \text{ in}$$

Case 2:

$$\Delta p = \frac{P \times h^3}{3 \times E \times I} = \frac{200 \times 34^3}{3 \times 10 \times 10^6 \times .552} = .475 \text{ in}$$

Horizontal deflection of handrail:

Case 1:

$$\Delta r = \frac{5 \times w/12 \times l^4}{384 \times E \times I_y}$$

$$= \frac{5 \times 40/12 \times 48^4}{384 \times 10 \times 10^6 \times 1.688} = .014 \text{ in}$$

Case 2:

$$\Delta r = \frac{P \times l^3}{48 \times E \times I_y}$$

$$= \frac{200 \times 48^3}{48 \times 10 \times 10^6 \times .106} = .435 \text{ in}$$

Total horizontal deflection of post and handrail:

Case 1: $\Delta = \Delta p + \Delta r = .380 + .014 = .394$ in

Case 2: $\Delta = \frac{\Delta p}{2} + \Delta r = .237 + .435 = .672$ in

Maximum handrail deflection occurs with loading at mid-span; post loading is then equally divided among two posts. When concentrated load is applied at the post, there is no handrail deflection. In that case maximum total deflection $= \Delta p$.

Notice the large increase in deflection in Case 2 because of the decrease in the moment of inertia resisting the horizontal load. This points out the need to evaluate horizontal deflections when handrails with low values for I_y are considered.

Vertical deflection of handrail:

Case 1:

$$\Delta r = \frac{5 \times w/12 \times l^4}{384 \times E \times I_x}$$

$$= \frac{5 \times 100/12 \times 48^4}{384 \times 10 \times 10^6 \times .106} = .543 \text{ in}$$

Case 2:

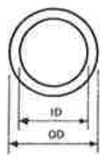
$$\Delta r = \frac{P \times l^3}{48 \times E \times I_x}$$

$$= \frac{200 \times 48^3}{48 \times 10 \times 10^6 \times 1.688} = .0273 \text{ in}$$

Consideration must also be given to a reasonable maximum limit on vertical deflection.

Table 5.35

ROUND PIPE



Steel
Stainless Steel
Aluminum
Brass

SCHEDULE 5						
Size (in.)	OD	ID	Area	I	S	r
1-1/4	1.660	1.530	.326	.104	.125	.564
1-1/2	1.900	1.770	.375	.158	.166	.649

SCHEDULE 10						
Size (in.)	OD	ID	Area	I	S	r
1-1/4	1.660	1.442	.531	.161	1.93	.550
1-1/2	1.900	1.682	.614	.247	.250	.634

SCHEDULE 40 (Standard Weight)						
Size (in.)	OD	ID	Area	I	S	r
3/4	1.050	0.824	.333	.037	.071	.334
1	1.315	1.049	.494	.087	.133	.421
1-1/4	1.660	1.380	.669	.195	.235	.540
1-1/2	1.900	1.610	.800	.310	.326	.623
2	2.375	2.067	1.075	.666	.561	.787
2-1/2	2.875	2.469	1.70	1.53	1.06	.947
3	3.500	3.068	2.23	3.02	1.72	1.16

SCHEDULE 80 (Extra Strong)						
Size (in.)	OD	ID	Area	I	S	r
3/4	1.050	.742	.433	.045	.085	.321
1	1.315	.957	.639	.106	.161	.407
1-1/4	1.660	1.278	.881	.242	.291	.524
1-1/2	1.900	1.500	1.068	.391	.412	.605
2	2.375	1.939	1.477	.868	.731	.766

Round pipe is used for many architectural products, including stair railings, as well as for structural purposes.

Dimensions and Weights: Pipe is produced in a variety of sizes and "schedules," of which those more commonly used in stair work are listed in the table above. Standard weight steel pipe is measured by I.P.S. (iron pipe size), which is the nominal inside diameter. When weight is not specified for steel, brass and aluminum pipe, standard weight is assumed to be implied.

Stainless steel pipe is produced in the same four schedules or weights. For Schedule 5 pipe the nominal wall thickness is .065" for 1" to 2" diameters and .083" for 2 1/2" to 4" diameters; for Schedule 10 pipe the nominal wall thickness is .109" for 1" to 2" diameters and .120" for 2 1/2" to 4" diameters. If wall thickness is not specified, Schedule 5 pipe is normally supplied.

Finishes: The usual paint coatings may be applied to steel pipe. Brass pipe usually is given a chemical or polished finish, aluminum pipe may have a mill finish or be polished or anodized, and stainless steel pipe may be polished or buffed as required. For general information on finishes the NAAMM Metal Finishes Manual should be consulted.

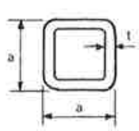
Round Tubing ia also available in steel, stainless steel, aluminum, bronze and other metals. It differs from pipe in that it may have thinner or thicker walls and is measured by a different system, stating the outside diameter in inches and the wall thickness in decimal inches. Size designations may differ somewhat with the metal used.

Steel tubing has a mill finish similar to that of cold drawn steel, and the usual paint coatings may be applied. Finishes for tubing or other metals are similar to those used on pipe made of these metals.

Availability: Both round pipe and round tubing, in the sizes commonly used in stair work, are usually stocked by warehouses. Manufacturers' catalogs should be consulted for currently available sizes.

Table 5.36

SQUARE TUBING



Steel
Stainless Steel

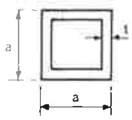
Some sizes listed may not be available in stainless steel.

Check with supplier.

a	t	Area	I	S	r	a	t	Area	I	S	r
.500	.065	.113	.004	.015	.178	1.500	.188	.987	.289	.385	.541
.625	.049	.113	.006	.020	.236	1.750	.065	.438	.208	.237	.668
.625	.065	.146	.008	.025	.230	1.750	.083	.553	.257	.294	.682
.750	.049	.137	.011	.030	.287	1.750	.120	.782	.348	.398	.667
.750	.065	.178	.014	.038	.281	2.000	.083	.636	.391	.391	.783
.750	.083	.221	.017	.045	.275	2.000	.120	.902	.534	.534	.769
.750	.120	.302	.021	.055	.262	2.000	.145	1.076	.621	.621	.760
.875	.065	.211	.023	.053	.332	2.000	.188	1.363	.754	.754	.744
1.000	.049	.186	.028	.056	.389	2.000	.250	1.750	.912	.912	.722
1.000	.065	.243	.036	.071	.383	2.500	.083	.802	.782	.626	.987
1.000	.073	.267	.039	.077	.380	2.500	.120	1.142	1.081	.865	.973
1.000	.083	.304	.043	.086	.376	2.500	.188	1.739	1.559	1.247	.947
1.000	.120	.422	.056	.111	.363	2.500	.250	2.250	1.922	1.538	.924
1.125	.065	.276	.052	.092	.434	3.000	.083	.968	1.374	.916	1.191
1.250	.065	.308	.072	.116	.485	3.000	.120	1.382	1.914	1.276	1.177
1.250	.083	.387	.088	.141	.478	3.000	.188	2.030	2.702	1.801	1.154
1.250	.090	.437	.098	.157	.473	3.000	.250	2.629	3.368	2.245	1.132
1.250	.120	.542	.117	.187	.464	3.500	.120	1.622	3.093	1.767	1.381
1.250	.135	.602	.127	.203	.459	3.500	.188	2.390	4.404	2.518	1.357
1.500	.065	.373	.128	.171	.586	3.500	.250	3.089	5.284	3.020	1.308
1.500	.083	.470	.158	.211	.580	4.000	.120	1.862	4.677	2.339	1.585
1.500	.120	.662	.212	.282	.565	4.000	.188	2.820	6.790	3.400	1.550
1:500	.140	.762	.237	.316	.558	4.000	.250	3.680	8.580	4.290	1.530

Table 5.37

SQUARE TUBING



Bronze
Aluminum

ALUMINUM					
a	t	Area	I	S	r
.500	.062	.109	.003	.014	.181
.625	.062	.140	.007	.024	.231
.750	.062	.171	.014	.036	.282
.750	.125	.312	.021	.056	.260
1.000	.125	.437	.057	.114	.361
1.250	.078	.366	.084	.134	.480
1.250	.125	.562	.120	.192	.462
1.500	.078	.444	.150	.200	.581
1.500	.125	.687	.218	.291	.564
1.750	.125	.812	.360	.411	.666
2.000	.078	.600	.370	.370	.785
2.000	.125	.937	.552	.552	.767
2.500	.125	1.187	1.119	.896	.971
3.000	.125	1.437	1.984	1.323	1.175
4.000	.125	1.937	4.854	2.427	1.583

BRONZE					
a	t	Area	I	S	r
.500	.093	.151	.004	.018	.171
.625	.093	.198	.010	.031	.220
.750	.093	.244	.018	.048	.271
1.000	.100	.360	.049	.098	.370
1.250	.100	.460	.102	.163	.471
1.500	.100	.560	.184	.245	.573
1.750	.100	.660	.300	.344	.675
2.000	.125	.938	.552	.552	.767
3.000*	.083	.968	1.374	.916	1.192

Architectural Bronze 385 Except (*) Red Brass 230

Square and Rectangular Tubing is available in the various metals as shown in the accompanying tables. Steel and stainless steel tubing is usually formed from cold rolled sheet, while the nonferrous tubing is an extruded product. This tubing is used for stair railings and newels, as well as for many other architectural products.

Steel tubing is also made in a structural grade, by a hot rolling process. This structural steel tubing is often used for newels in stair work, and for structural members of all kinds in building construction.

Dimensions: Tubing is generally measured by the outside dimensions in inches and wall thickness in decimal inches, though the system of measurement may vary somewhat with different metals. The sizes most commonly used in stair work are listed in the accompanying tables, but many other sizes are also available.

Corners: Steel and stainless steel tubing has slightly rounded corners, the radius of which approximates the wall thickness. Aluminum and bronze tubing normally has square corners.

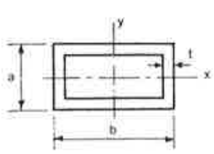
Finishes: The mechanically welded steel and stainless steel tubing has a clean bright surface which, in the case of steel may be painted, and in the case of stainless steel is usually polished. The nonferrous extruded tubing also is usually given a polished or buffed finish, and aluminum tubing is often anodized. For general information on finishes, the NAAMM Metal Finishes Manual should be consulted.

Structural steel tubing, being a hot rolled product, has a somewhat rougher surface, similar to that of mild steel, which may be scaly or sometimes have a light surface rust. This type of tubing is normally painted.

Availability: Most of the sizes shown in the tables, as well as many other sizes, are commonly available in warehouse stocks. Manufacturers' catalogs should be consulted for currently available sizes.

Table 5.38

RECTANGULAR TUBING

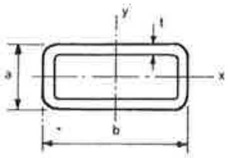


Aluminum

a	b	t	Area	I_x	S_x	r_x	I_y	S_y	r_y
.500	1.000	.125	.312	.009	.038	.174	.033	.066	.325
.750	1.500	.078	.327	.029	.078	.299	.091	.121	.527
.750	1.500	.125	.500	.040	.106	.282	.130	.173	.509
1.000	1.500	.078	.366	.058	.115	.397	.110	.147	.549
1.000	1.500	.125	.562	.081	.162	.380	.159	.212	.532
1.000	2.000	.125	.687	.105	.210	.391	.332	.332	.695
1.000	3.000	.125	.937	.153	.307	.404	.950	.633	1.007
1.250	2.500	.125	.875	.219	.351	.501	.678	.543	.881
1.250	3.000	.125	1.000	.259	.415	.509	1.079	.720	1.039
1.500	2.000	.125	.812	.278	.370	.585	.442	.442	.738
1.500	2.500	.125	.937	.337	.449	.600	.767	.613	.904
1.500	6.000	.125	1.812	.752	1.002	.644	7.197	2.399	1.993
1.750	3.000	.125	1.125	.566	.647	.710	1.338	.892	1.091
1.750	3.500	.125	1.250	.649	.742	.721	1.962	1.121	1.253
1.750	4.000	.125	1.375	.732	.836	.730	2.742	1.371	1.412
1.750	4.500	.125	1.500	.814	.931	.737	3.693	1.641	1.569
2.000	3.000	.125	1.187	.772	.772	.806	1.467	.978	1.112
2.000	4.000	.125	1.437	.992	.992	.831	2.976	1.488	1.439
2.000	5.000	.125	1.687	1.212	1.212	.847	5.204	2.082	1.756
2.000	6.000	.125	1.937	1.432	1.432	.860	8.276	2.759	2.067
3.000	5.000	.125	1.937	3.018	2.012	1.248	6.690	2.676	1.858
3.000	6.000	.187	3.226	5.010	3.340	1.246	15.032	5.011	2.159

Table 5.39

RECTANGULAR TUBING



Steel

Stainless Steel

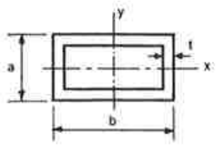
Some sizes listed may not be available in stainless steel.

Check with supplier.

a	b	t	Area	I_x	S_x	r_x	I_y	S_y	r_y
.500	1.000	.065	.178	.007	.027	.194	.021	.043	.347
.500	1.250	.065	.211	.008	.033	.198	.038	.061	.425
.625	2.000	.083	.408	.026	.083	.252	.181	.181	.665
.750	1.000	.065	.211	.018	.048	.292	.028	.057	.367
.750	1.250	.065	.243	.022	.058	.299	.049	.079	.451
.750	1.500	.065	.276	.025	.068	.304	.078	.104	.532
.750	1.500	.083	.346	.031	.082	.297	.095	.127	.526
1.000	1.250	.065	.276	.043	.085	.394	.061	.097	.470
1.000	1.250	.083	.346	.052	.104	.387	.074	.119	.463
1.000	1.500	.065	.308	.050	.100	.402	.095	.126	.555
1.000	1.500	.083	.387	.060	.121	.395	.116	.155	.548
1.000	1.500	.120	.542	.079	.158	.381	.155	.206	.534
1.000	2.000	.083	.470	.078	.156	.407	.238	.238	.711
1.000	2.000	.120	.662	.102	.204	.392	.322	.322	.697
1.000	2.500	.083	.553	.095	.191	.415	.418	.335	.869
1.000	3.000	.083	.636	.113	.226	.421	.668	.445	1.025
1.000	3.500	.083	.719	.130	.261	.426	.997	.570	1.177
1.250	1.750	.083	.470	.117	.187	.498	.199	.228	.651
1.250	2.000	.083	.512	.131	.209	.506	.276	.276	.734
1.250	2.500	.083	.595	.159	.255	.517	.479	.383	.897
1.250	3.000	.083	.678	.187	.300	.526	.756	.505	1.057
1.250	3.500	.083	.761	.216	.345	.532	1.119	.639	1.213
1.500	2.000	.083	.553	.200	.266	.601	.314	.314	.753
1.500	2.000	.120	.781	.270	.359	.588	.429	.429	.739
1.500	2.500	.083	.636	.241	.322	.616	.540	.432	.921
1.500	2.500	.120	.902	.326	.435	.601	.741	.593	.906
1.500	2.500	.145	1.096	.382	.510	.590	.879	.703	.895
1.500	3.000	.083	.720	.283	.377	.627	.845	.563	1.084
1.500	3.000	.120	1.022	.384	.512	.613	1.167	.778	1.069
1.500	3.000	.180	1.490	.518	.690	.589	1.627	1.085	1.045
1.500	3.500	.083	.802	.325	.433	.636	1.240	.708	1.243
1.750	3.000	.065	.601	.323	.369	.733	.746	.497	1.114
1.750	4.000	.065	.731	.415	.474	.766	1.509	.754	1.440
2.000	3.000	.083	.802	.543	.543	.823	1.021	.681	1.128
2.000	3.000	.120	1.142	.746	.746	.808	1.416	.944	1.113
2.000	3.000	.188	1.64	.977	.977	.771	1.86	1.24	1.06
2.000	3.000	.250	2.089	1.147	1.147	.740	2.203	1.469	1.030
2.000	4.000	.083	.968	.696	.696	.848	2.053	1.027	1.456
2.000	4.000	.120	1.382	.958	.958	.833	2.870	1.435	1.441
2.000	4.000	.188	2.030	1.329	1.329	.810	4.075	2.038	1.417
2.000	4.000	.250	2.630	1.627	1.627	.787	5.109	2.554	1.395
2.000	5.000	.188	2.390	1.628	1.628	.825	7.181	2.872	1.733
2.000	5.000	.250	3.089	1.918	1.918	.790	8.470	3.388	1.660
2.000	6.000	.188	2.750	1.927	1.927	.837	11.481	3.827	2.043
2.500	4.000	.180	2.210	2.236	1.789	1.005	4.733	2.366	1.463
2.500	5.000	.180	2.570	2.721	2.177	1.029	8.227	3.291	1.789
3.000	4.000	.120	1.622	2.412	1.608	1.219	3.774	1.887	1.525
3.000	4.000	.188	2.390	3.419	2.279	1.196	5.390	2.695	1.502
3.000	4.000	.250	3.105	4.278	2.852	1.174	6.795	3.398	1.479
3.000	5.000	.188	2.750	4.135	2.757	1.226	9.273	3.709	1.836
3.000	5.000	.250	3.535	4.934	3.290	1.150	10.960	4.386	1.760
3.000	6.000	.188	3.110	4.852	3.235	1.249	14.531	4.844	2.161
3.000	6.000	.250	4.057	6.098	4.066	1.226	18.546	6.182	2.138
3.000	8.000	.188	3.894	6.162	4.108	1.258	29.139	7.285	2.735
3.000	8.000	.250	5.089	7.567	5.045	1.219	36.531	9.133	2.679
4.000	6.000	.188	3.470	9.333	4.666	1.640	17.580	5.860	2.251
4.000	6.000	.250	4.533	11.854	5.927	1.618	22.499	7.500	2.228
4.000	6.000	.375	6.454	28.553	9.518	2.103	15.097	7.549	1.529
4.000	8.000	.188	4.269	11.837	5.919	1.665	34.862	8.715	2.858
4.000	8.000	.250	5.589	14.782	7.391	1.626	44.042	11.010	2.807
4.000	8.000	.375	7.954	59.860	14.966	2.743	20.042	10.021	1.587

Table 5.40

RECTANGULAR TUBING



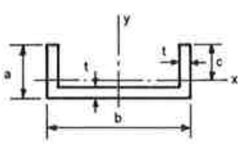
Bronze

a	b	t	Area	I_x	S_x	r_x	I_y	S_y	r_y
.500	1.000	.100	.260	.0086	.0345	.182	.0289	.0577	.333
.500	2.000	.100	.460	.0168	.0671	.191	.188	.188	.639
.750	1.500	.100	.410	.035	.093	.291	.110	.147	.518
1.000	1.500	.100	.460	.070	.139	.389	.135	.180	.541
1.000	2.000	.100	.560	.090	.180	.401	.278	.278	.705
1.000	3.000	.125	.937	.153	.307	.404	.950	.633	1.007
1.250	2.500	.125	.875	.219	.351	.501	.678	.543	.880
1.250	3.000	.125	1.000	.259	.415	.509	1.079	.720	1.039
1.500	3.000	.125	1.062	.396	.528	.611	1.209	.806	1.067
1.750	3.000	.125	1.125	.566	.647	.710	1.338	.892	1.090
1.750*	4.000	.083	.927	.517	.590	.747	1.894	.947	1.429
2.000*	3.000	.083	.802	.543	.543	.823	1.021	.681	1.128

Architectural Bronze 385 except (*) Red Brass 230

Table 5.41

EXTRUDED CHANNELS

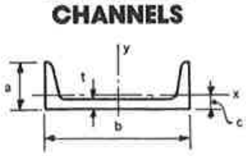


Aluminum Bronze

a	b	t	Area	I_x	S_x	r_x	C_x	I_y	S_y	r_y
1.000	.500	.125	.219	.005	.014	.145	.330	.028	.057	.361
1.000	.750	.125	.281	.015	.031	.231	.479	.040	.081	.380
1.000	1.000	.125	.344	.034	.055	.314	.619	.053	.105	.391
1.250	.500	.125	.250	.005	.015	.141	.344	.050	.080	.448
1.250	.625	.125	.281	.010	.023	.185	.424	.060	.096	.462
1.250	.750	.125	.312	.016	.032	.228	.625	.070	.112	.473
1.250	1.250	.125	.438	.069	.088	.397	.786	.110	.176	.501
1.500	.500	.125	.281	.005	.015	.136	.354	.080	.106	.532
1.500	.625	.125	.312	.010	.023	.181	.437	.094	.126	.550
1.500	.750	.125	.344	.017	.033	.224	.517	.109	.146	.563
1.500	1.000	.125	.406	.039	.059	.312	.668	.139	.185	.585
1.500	1.500	.125	.531	.123	.129	.481	.952	.198	.264	.611
1.750	.500	.125	.312	.005	.015	.133	.362	.118	.135	.614
1.750	.750	.125	.375	.018	.034	.220	.531	.159	.182	.652
1.750	1.000	.125	.438	.042	.060	.308	.688	.200	.229	.677
2.000	.500	.125	.344	.006	.015	.129	.369	.166	.166	.694
2.000	.750	.125	.406	.025	.039	.246	.543	.221	.221	.737
2.000	1.000	.125	.469	.043	.062	.304	.704	.276	.276	.767
2.250	.875	.125	.469	.031	.048	.256	.637	.331	.294	.840
2.500	.750	.125	.469	.020	.036	.207	.562	.383	.307	.904
2.500	1.000	.125	.531	.046	.064	.296	.732	.471	.377	.942
2.500	1.500	.125	.656	.102	.085	.393	1.187	.648	.518	.994
3.000	.500	.125	.469	.006	.017	.116	.387	.475	.317	1.010
3.000	1.000	.125	.594	.049	.065	.287	.753	.734	.489	1.110

Table 5.42

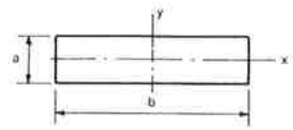
SMALL HOT ROLLED CHANNELS



Steel

b	a	t	Wt. (lb/ft)	Area	I_x	S_x	r_x	C_x	I_y	S_y	r_y
1	1/2	1/8	.84	.24	.0047	.015	.14	.17	.031	.063	.36
1-1/4	1/2	1/8	1.01	.30	.0057	.017	.14	.17	.060	.096	.45
1-1/2	1/2	1/8	1.12	.33	.0060	.018	.14	.16	.096	.13	.54
1-1/2	1/2	3/16	1.43	.42	.0088	.023	.14	.18	.11	.15	.52
1-1/2	3/4	1/8	1.18	.35	.007	.021	.13	.15	.22	.22	.72
2	9/16	3/16	1.86	.54	.011	.028	.14	.17	.26	.26	.69
2	1	1/8	1.80	.53	.046	.067	.30	.31	.32	.32	.78
2	1	3/16	2.60	.76	.068	.10	.30	.34	.42	.42	.75
2-1/2	5/8	3/16	2.27	.67	.015	.034	.15	.18	.50	.40	.86

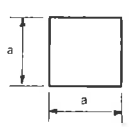
Table 5.43



FLATS
Steel Stainless Steel
Aluminum Bronze

a	b	Area	I_x	S_x	r_x	I_y	S_y	r_y
.250	1.000	.250	.001	.010	.072	.021	.042	.289
.250	1.250	.313	.002	.013	.072	.041	.065	.361
.250	1.500	.375	.002	.016	.072	.070	.094	.433
.250	1.750	.438	.002	.016	.072	.112	.128	.506
.250	2.000	.500	.003	.024	.072	.167	.167	.578
.250	2.500	.625	.003	.024	.072	.326	.261	.723
.250	3.000	.750	.004	.032	.072	.563	.375	.867
.250	3.500	.875	.005	.040	.072	.893	.510	1.012
.250	4.000	1.000	.005	.040	.072	1.333	.667	1.156
.250	5.000	1.250	.007	.056	.072	2.604	1.042	1.445
.3125	1.000	.313	.003	.019	.090	.026	.052	.289
.3125	1.250	.391	.003	.019	.090	.051	.082	.361
.3125	1.500	.469	.004	.026	.090	.088	.117	.434
.3125	2.000	.625	.005	.032	.090	.208	.208	.578
.375	1.000	.375	.004	.021	.108	.031	.062	.289
.375	1.250	.469	.005	.027	.108	.061	.098	.361
.375	1.500	.563	.007	.037	.108	.106	.141	.434
.375	1.750	.656	.008	.043	.108	.168	.192	.506
.375	2.000	.750	.009	.048	.108	.250	.250	.578
.375	2.500	.938	.011	.059	.108	.488	.390	.723
.375	3.000	1.125	.013	.069	.108	.844	.563	.867
.375	3.500	1.313	.015	.080	.108	1.340	.767	2.012
.375	4.000	1.500	.018	.096	.108	2.000	1.000	1.156
.500	1.000	.500	.010	.040	.145	.042	.084	.289
.500	1.250	.625	.013	.052	.145	.081	.130	.361
.500	1.500	.750	.016	.064	.145	.141	.188	.434
.500	1.750	.875	.018	.072	.145	.223	.255	.506
.500	2.000	1.000	.021	.084	.145	.333	.333	.578
.500	2.500	1.250	.026	.104	.145	.651	.520	.723
.500	3.000	1.500	.031	.124	.145	1.125	.750	.867
.500	3.500	1.750	.036	.144	.145	1.787	1.020	1.012
.500	4.000	2.000	.042	.168	.145	2.667	1.333	1.156
.625	1.000	.625	.020	.064	.181	.052	.104	.289
.625	1.250	.781	.025	.080	.181	.102	.163	.361
.625	1.500	.938	.031	.099	.181	.176	.235	.434
.625	2.000	1.250	.041	.131	.181	.417	.417	.578
.625	3.000	1.875	.061	.195	.181	1.406	.937	.867
.750	1.000	.750	.035	.094	.217	.063	.125	.289
.750	1.250	.938	.044	.117	.217	.122	.195	.361
.750	1.500	1.125	.053	.141	.217	.210	.281	.433
.750	1.750	1.313	.062	.166	.217	.335	.388	.506
.750	2.000	1.500	.070	.188	.217	.500	.500	.578
.750	2.500	1.875	.088	.234	.217	.977	.781	.727
.750	3.000	2.250	.106	.281	.217	1.688	1.125	.866
.750	3.500	2.625	.123	.329	.217	2.680	1.530	1.012
.750	4.000	3.000	.141	.375	.217	4.000	2.000	1.156
1.000	1.250	1.250	.104	.208	.289	.163	.261	.361
1.000	1.500	1.500	.125	.250	.289	.281	.375	.434
1.000	1.750	1.750	.146	.292	.289	.447	.510	.506
1.000	2.000	2.000	.167	.333	.289	.667	.667	.578
1.000	2.500	2.500	.208	.417	.289	1.302	1.042	.722
1.000	3.000	3.000	.250	.500	.289	2.250	1.500	.866
1.000	3.500	3.500	.292	.584	.289	3.573	2.040	1.012
1.000	4.000	4.000	.333	.667	.289	5.333	2.667	1.155

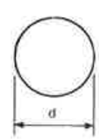
Table 5.44



SQUARES
Steel Stainless Steel
Aluminum Bronze

a	Area	I	S	r
.500	.250	.005	.021	.144
.625	.391	.013	.041	.181
.750	.563	.026	.070	.217
1.000	1.000	.083	.167	.289
1.250	1.563	.204	.326	.361
1.500	2.250	.422	.563	.433
1.750	3.063	.782	.893	.505
2.000	4.000	1.333	1.333	.577

Table 5.45



ROUNDS
Steel Stainless Steel
Aluminum Bronze

d	Area	I	S	r
.500	.196	.003	.012	.125
.562	.249	.005	.018	.141
.625	.307	.008	.024	.156
.750	.442	.016	.041	.188
.875	.601	.029	.066	.219
1.000	.785	.049	.098	.251
1.125	.994	.079	.140	.281
1.250	1.227	.120	.192	.313
1.500	1.767	.249	.331	.375
2.000	3.142	.785	.785	.500

SECTION 6

RECOMMENDED VOLUNTARY STANDARDS AND GUIDE SPECIFICATIONS

RECOMMENDED VOLUNTARY MINIMUM STANDARDS FOR FIXED METAL STAIRS

The recommendations in this section are based on the accumulated experience of many years by the manufacturers of metal stairs. They may not, however, conform to the building codes which govern design requirements for different areas of the country. The designer must, therefore, check governing code requirements and make certain that his design meets these requirements.

1. SCOPE

This standard defines the various classes of fixed metal stairs and their functions; sets forth minimum requirements for construction, proportions and dimensions of interior and exterior fixed metal stairs of all classes; applies to spiral stairs but not to other types of curved stairs.

2. PURPOSE

The purpose of this standard is to establish the minimum requirements for the design and construction of safe fixed metal stairs.

3. CLASSES OF FIXED METAL STAIRS AND THEIR FUNCTIONS

3.1 Industrial

Industrial metal stairs are purely functional in character and are generally the most economical. They are designed for either interior or exterior use in or on industrial structures, or as fire escapes or emergency exitways, primarily for use by employees. They do not include stairs which are an integral part of industrial equipment.

3.2 Service

Service metal stairs served chiefly functional purposes, are usually located in enclosed stairwells to provide a secondary or emergency means of travel between different floors or levels, and in multi-storied buildings commonly serve as fire stairs. They may serve either employees, tenants, or the public, and are generally used where economy is a consideration.

3.3 Commercial

Commercial metal stairs are generally intended to serve the public. They may be located either in the open or in enclosed stairwells in public, institutional or commercial buildings and are used where appearance and finish are important considerations.

3.4 Architectural

Architectural metal stairs are of more elaborate design and often serve as an architectural feature. They may be wholly custom designed or may represent a combination of standard parts and specially designed elements. They may be located either in the open or in enclosed stairwells in public, institutional, commercial or monumental buildings.

4. CONSTRUCTION

4.1 General Requirements, All Classes of Stairs

4.1.1 Fixed metal stairs shall be of fire resistive construction and shall be designed and constructed to carry a minimum uniform live load of 100 pounds per square foot of projected plan area or an alternative minimum concentrated load of 300 pounds applied at the center of any tread span.

4.1.2 Minimum Loads for Railings, Handrails and Infill Areas

4.1.2.1 Railings and handrails for structures shall be capable of withstanding a minimum concentrated load of 200 pounds applied vertically downward and horizontally at any point on the top rail. Vertical and horizontal loads shall not be applied concurrently.

4.1.2.2 Railings and handrails for structures other than one- and two-family dwellings shall be capable of withstanding a minimum uniform load of 50 pounds per foot applied vertically downward and horizontally at the top rail. Vertical and horizontal loads shall not be applied concurrently.

4.1.2.3 Railings and handrails for one- and two-family dwellings shall have the same requirements as 4.1.2.2 except the minimum uniform load shall be 20 pounds per foot instead of 50 pounds per foot.

4.1.2.4 Concentrated and uniform loads shall not be applied concurrently.

4.1.2.5 Infill areas shall withstand a 50 pound horizontal load distributed over a one square foot area, round or square, within the infill area. This load shall not be applied concurrently with other loads.

4.1.3 Continuous metal railings shall be provided at all open edges of every flight, platform and floor. Handrails between flights of stairs shall be continuous around newel posts. Where handrails are not continuous at the top or bottom of a flight they shall extend at least 12 inches beyond the top riser and at least 12 inches plus the depth of one tread beyond the bottom riser. At the top the extended handrail shall be parallel to the walking surface. At the bottom the extended handrail shall continue to slope for the depth of one tread with the remainder parallel to the walking surface. Tread depth is measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the tread's leading edge, which includes the nosing.

4.1.4 Stairs having an egress width of less than 44 inches shall have not less than one handrail for each flight. Stairs having an egress width of 44 inches but less than 88 inches shall have a handrail on each side of every flight, and those having an egress width of 88 inches or more shall have, in addition to handrails on each side, a center handrail in each flight. For spiral stairs handrails are required on both sides when egress width exceeds 48 inches.

4.1.5 Handrails shall be constructed so as not to cause loss of hand grip and their ends shall be returned to walls or terminated in newel posts or safety terminals.

4.1.6 Wherever required, stairs shall have a toe plate forming a curbing at all open edges of platforms and at all open ends and open back edges of treads.

4.1.7 All joints shall be neatly fitted, sharp edges shall be broken, all welding on exposed travel surfaces shall be smooth, and all mechanical connections in the travel area shall employ countersunk fasteners.

4.1.8 There shall be no projections, obstructions or rough surfaces that are hazardous to stair users in the area of travel.

4.2 Additional Requirements for the Various Classes of Stairs

4.2.1 Industrial Class Stairs

Treads of less than 9 inches in width shall have open risers. With treads of greater width, risers may be either open or solid.

Toe plates shall be provided in the manner prescribed in 4.1.6.

4.2.2 Service Class Stairs

Interior service stairs shall have solid risers.

Toe plates shall be provided in the manner prescribed in 4.1.6.

4.2.3 Commercial Class Stairs

Risers may be either open or solid.

All conspicuous welds shall be smooth and flush.

4.2.4 Architectural Class Stairs

Risers may be either open or solid.

All joints shall be as inconspicuous as possible, whether welded or made with mechanical connections.

5. PROPORTIONS AND DIMENSIONS

5.1 General Requirements, All Classes of Stairs

5.1.1 Within any one flight, there shall be no variation exceeding 3/16″ in the width of adjacent treads or in the height of adjacent risers. The tolerance between the largest and smallest treads or the largest and smallest risers shall not exceed 3/8″.

5.1.2 Treads and risers shall be so proportioned that the sum of two risers and one tread run shall be not less than 24 inches nor more than 26 inches. This does not apply to spiral stairs, the requirements for which are given in 5.2.5.

5.1.3 The length and egress width of intermediate platforms shall be not less than the egress width of the stair in which they occur.

5.1.4 No flight shall have a rise of more than 12 feet. Spiral stairs and alternating tread stairs are excluded from this requirement.

5.1.5 Handrails shall be located so that the upper surfaces of the top rails are not more than 38 inches nor less than 34 inches above the surfaces of the treads measured vertically from the forward edges of the treads or nosings. The upper surfaces of guard rails shall not be less than 42 inches above any platform, floor or ramp. They shall have a clearance of not less than 1½ inches from any other object.

5.1.6 Wall handrails shall be located so that their upper surfaces are not more than 38 inches nor less than 34 inches above the forward edges of treads, shall have a finger clearance of not less than 1½ inches from the wall, and shall project no more than 3½ inches into the required minimum egress width. See 5.2.5 for spiral stair requirements.

5.1.7 Headroom shall be not less than 6′8″.

5.2 Additional Requirements for the Various Classes of Stairs

5.2.1 Industrial Class Stairs

Riser height shall be not less than 6½ inches or more than 8½ inches and the tread, exclusive of nosing, shall be not less than 8 inches or more than 11 inches. Riser and tread proportions shall be within the limits prescribed in 5.1.2.

All treads shall have a slip resistant nosing which projects not less than ½ inch or more than 1 inch beyond base of riser.

5.2.2 Service Class Stairs

Riser height shall not be less than 6½ inches or more than 7¾ inches and treads, exclusive of nosing, shall be not less than 9 inches or more than 11 inches. Riser and tread proportions shall be within the limits prescribed in 5.1.2.

All treads shall have a nosing which projects not less than ½ inch or more than 1 inch.

5.2.3 Commercial Class Stairs

Riser height shall be not less than 5½ inches or more than 7½ inches and treads, exclusive of nosing, shall be not less than 10 inches or more than 14½ inches. Riser and tread proportions shall be within the limits prescribed in 5.1.2.

All treads shall have a nosing which projects 1 inch.

5.2.4 Architectural Class Stairs

Riser height shall be not less than 5½ inches or more than 7½ inches and treads, exclusive of nosing, shall be not less than 10 inches or more than 14½ inches. Riser and tread proportions shall be within the limits prescribed in 5.1.2.

All treads shall have a nosing which projects 1 inch.

5.2.5 Spiral Stairs

The requirements for riser height, tread width and width of stairs (not radius of tread) shall be as follows:

Riser Height — 9½″ maximum.
Tread Run — 7½″ minimum measured at 12″ from the narrow edge.
Stair Width — 26″ minimum.

Stair width defines the clear walking area between the outer edge of the supporting column and the inner edge of the handrail.

Balusters shall be spaced not more than 6″ apart.

5.2.6 Alternating Tread Stairs

Handrails — Shall be installed on both sides of stairs.

Tread Width — 8½″ minimum.
Tread Length (perpendicular to line of travel) — 7″ minimum.
Projected Tread — 5″ minimum.
Rise to Next Surface — 9½″ maximum.

When used as means of egress in buildings for space not exceeding 250 square feet with no more than five occupants the following dimensions apply:

Tread Width — 10½″ minimum.
Tread Length (perpendicular to line of travel) — 7″ minimum.
Projected Tread — 8½″ minimum.
Rise to Next Surface — 8″ maximum.

The initial tread shall begin at the same elevation as the platform, landing or floor surface.

5.2.7 Winders

Riser Height — 7″ maximum.
Tread Width — 9″ minimum measured at 12″ from the narrow edge with minimum tread width not less than 6″.

6. VERTICAL BARRIERS

A rail or barrier shall be provided at each side of every stair.

7. EGRESS WIDTH

Stairs used to provide a primary means of egress shall be in width units of 22 inches. Such width shall be measured between vertical barriers. No fraction of width units shall be considered except that 12 or more inches in addition to one or more width units shall be counted as a half unit. Normal egress width shall be 44 inches or two width units. Not all metal stairs are required to meet the width requirements of egress standards.

FOREWORD

Guide specifications are intended to be used as the basis for developing job specifications and must be edited to fit specific job requirements. Inapplicable provisions should be deleted, appropriate information should be provided in the blank spaces and provisions applicable to the job should be added as necessary. Notes to specifiers are given in italics directly following the paragraphs to which they apply. Dates given with ASTM and other standards were current at the time this manual was published. Specifier should use latest dates when preparing job specifications.

SECTION 05510 — STEEL STAIRS

PART 1 — GENERAL

1.01 SCOPE OF WORK

Fabricate and install metal stair assemblies in accordance with the requirements set forth in this section.

1.02 ADDITIONAL WORK INCLUDED IN THIS SECTION

The following items are often specified in sections other than 05510. If they are to be part of the metal stair contractor's work they must be specified here.

A. Reinforcing for wall rail brackets at dry wall partitions.
B. Framing for standpipes at platforms.
C. Framing around roof leaders.
D. Field measuring or weld plates, sleeves and insert locations.
E. Bonderizing of galvanizing materials.
F. Wood or glass for rails.
G. Wire mesh and rebar for treads and platforms.
H. Field measuring of new stair wells and verifying floor height.
I. Self furring lath for stair pans.
J. Continuous seal welding of fascia cover plates at boxed stringers.
K. Anchors or inserts for terrazzo or precast concrete.
L. Prime painting of galvanized materials.

The following items are not to be included in the metal stair contractor's work:

Temporary shoring or bracing

Demolition and removal of existing work

Clean up of existing construction prior to installation of stairs

Cutting, grouting and patching of tread fillers

Cleaning out of stair wells

Temporary wood filler for steel tread pans

Concrete supports for steel

Cutting; preparation of pockets; setting of plates, inserts, carpenter hardware or any other built-ins

Concrete fill for pans and platforms

Temporary lights and electricity

Temporary safety rails

Protection after erection

Wood trim for face stringers

Rubber treads or carpets

Slip-resistant oxide for concrete fill

Field painting

Final cleaning and protection of aluminum, stainless steel, bronze and glass

Light gauge metal framing attached to stair

***Exact** match of existing stair when extension required*

1.03 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. Section 03300 — Cast-in-place Concrete: Item(s)____________
B. Section 034__ — Precast Concrete: Item(s)____________
C. Section 04200 — Unit Masonry: Item(s)____________
D. Section 044__ — Stone: Item(s)____________
E. Section 05120 — Structural Steel: Item(s)____________
F. Section 05___ — Nosings: Item(s)____________
G. Section 05521 — Pipe and Tube Railings: Item(s)____________
H. Section 05720 — Ornamental Railings: Item(s)____________
I. Section 05999 — Miscellaneous Metals: Item(s)____________
J. Section 06431 — Wood Stairs and Railings: Item(s)____________
K. Section 078__ — Roof Hatches and Smoke Vents: Item(s)____________
L. Section 092__ — Plaster: Item(s)____________
M. Section 09400 — Terrazzo: Item(s)____________
N. Section 09650 — Resilient Flooring: Item(s)____________
O. Section 09680 — Carpeting: Item(s)____________
P. Section 09900 — Painting: Item(s)____________
Q. Section 106__ — Partitions: Item(s)____________

For small projects, or at the option of the specifier, this work may be incorporated with other narrow scope sections.

Structural framing and enclosures: Refer to ACI standards for concrete construction and AISC standards for steel construction. (Items A, B, C, D, E, I & L)

Stair & railing support: Bearing and anchorage points shall be structurally adequate to support the stairs and rails. Inserts, anchors, connectors, backup support and pockets to be installed by others shall be verfified to be in accordance with architect approved drawings prior to the start of erection. (Items A, B, C, D, E, I)

Tread materials: Specify method of support and coordination of shop drawings for anchorage. (Items B, D, I, J, M, N, & O)

Railings: Specify method of attachment and coordination of shop drawings. (Items G, H, I, J, L & P)

1.04 STRUCTURAL REQUIREMENSTS

The structural adequacy of the metal stair design is the responsibility of the designer.

A. Metal stair assembly shall carry a minimum uniform live load of _____ pounds per square foot of projected plan area.

B. Metal stair assembly shall carry a minimum concentrated load of _____ pounds applied at the center of any tread span.

Governing code shall be checked for load requirements. NAAMM recommends a 100 pound per square foot minimum uniform live load or alternatively a 300 pound minimum concentrated load, not applied concurrently.

C. Railing assembly shall withstand a minimum concentrated load of _____ pounds applied vertically downward or horizontally in any direction, but not simultaneously, at any point on the top rail.

Codes may vary in method of application and magnitude of load. Governing code should be checked for specific requirements. NAAMM recommends 200 pounds minimum concentrated load applied in any direction at any point on the top rail.

D. Railing assembly shall withstand a minimum uniform load of _____ pounds per foot applied (horizontally) (and) (vertically downward), but not simultaneously, on the top rail.

Some codes have requirements for uniform loading on the top rails. Loads may be applied horizontally or vertically or in both directions, but not simultaneously. Governing code should be checked for specific requirements. Uniform loads are not to be applied concurrently with concentrated loads.

1.05 QUALITY ASSURANCE

A. Fabricator Qualifications

If special or unusual capabilities are required they should be set forth here.

B. Installer Qualifications

State as required in 1.05 A. Or state specific qualifications required.

C. Regulatory Requirements

Determine code regulations that govern this work. Specify requirements and drawings that are necessary to meet governing codes.

1.06 REFERENCES

A. Aluminum Association (AA)
   1. Aluminum Standards and Data
   2. Designation System for Aluminum Finishes

B. American Concrete Institute (ACI)
   1. Recommended Practice for Concrete Formwork, ACI 347

C. American Institute of Steel Construction (AISC)
   1. Manual of Steel Construction

D. Iron and Steel Society (ISS)
   1. Steel Products Manual
      a. Sheet Steel
      b. Stainless and Heat Resisting Steels

E. American National Standards Institute (ANSI)
   1. ANSI Z97.1-1984 Safety Performance Specifications and Methods of Test for Safety Glazing Material used in Buildings.
   2. Ansi/NAAMM MBG 531-88 Metal Bar Grating Manual — 4th Edition.

F. American Society for Testing and Materials (ASTM)
1. A 29-90a Specification for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished, General Requirements for.
2. A 36-90 Specification for Structural Steel.
3. A 47-84(1989) Specification for Ferritic Malleable Iron Castings.
4. A 48-83(1990) Specification for Gray Iron Castings.
5. A 53-90a Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
6. A 123-89 Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
7. A 167-90 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
8. A 269-90a Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
9. A 312-89a Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
10. A 366-85 Specification for Steel Sheet, Carbon, Cold-Rolled, Commercial Quality.
11. A 500-90 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
12. A 501-89 Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
13. A 525-90 Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
14. A 526-90 Specification for Steel Sheet Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality.
15. A 569-85 Specification for Steel, Carbon (0.15 Maximum Percent), Hot-Rolled Sheet and Strip, Commercial Quality.
16. A 570-90 Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
17. A 575-89 Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
18. A 611-90 Specification for Steel, Sheet, Carbon, Cold-Rolled, Structural Quality.
19. A 635-90a Specification for Steel, Sheet and Strip, Heavy Thickness Coils, Carbon, Hot-Rolled.
20. B 43-88 Specification for Seamless Red Brass Pipe, Standard Sizes.
21. B 62-86 Specification for Composition Bronze or Ounce Metal Castings.
22. B 209-90 Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
23. B 210-90 Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes.
24. B 221-90 Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wires, Shapes, and Tubes.
25. B 241-90 Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.
26. B 455-89 Specification for Copper-Zinc-Lead Alloy (Leaded Brass) Extruded Shapes.
27. B 584-90 Specification for Copper Alloy Sand Castings for General Applications.
28. E 527- Practice for Numbering Metals and Alloys (UNS).

G. American Welding Society (AWS)
1. Specifications for Welding Rods and Bare Electrodes.

H. Copper Development Association (CDA)
1. Standards Handbook, Wrought Copper and Copper Alloy Mill Products. Part 2 — Alloy Data.
2. Standards Handbook, Cast Copper and Copper Alloy Products, Part 7 — Alloy Data.
3. Copper, Brass and Bronze Design Handbook for Architectural Applications.

I. General Services Administration (GSA), Federal Specifications (FS)
   1. FS-TT-P-641G(1) Primer Coating; Zinc Dust Oxide (for Galvanized Surfaces).
   2. FS-TT-P-645A Primer, Paint, Zinc Chromate, Alkyd Type.

J. National Association of Architectural Metal Manufacturers (NAAMM)
   1. Metal Finishes Manual

K Steel Structures Painting Council (SSPC)
   1. SSPC-SP2 Specification for Hand Tool Cleaning.
   2. SSPC-SP3 Specification for Power Tool Cleaning.

1.07 SUBMITTALS

A. Make submittals in accordance with Section 013_____.

If project specifications include a section in Division 1 establishing the general administration and procedural requirements for submittal of Shop Drawings, Samples and Certificates for the project, include A, above, and modify following paragraphs to avoid duplication.

B. Shop Drawings

1. Show sections and plans of stairs, dimensions and assembly of components.
   a. Stringers
   b. Treads
   c. Nosings
   d. Risers
   e. Headers
   f. Newels
   g. Platforms
   h. Struts, columns and hangers
   i. Railings
   j. Handrails
   k. Brackets
   l. Reinforcements
   m. Anchors
   n. Welded and bolted connections

If compliance with AWS standards for welding is specified, inspection of welds by a Certified Welding Inspector shall be included as a ***separate item.***

2. Comply with NAAMM minimum standards for construction, proportions and dimensions of fixed metal stairs.

Indicate NAAMM stair classification

Stair #________, #________, #________, _______________class stair

Stair #________, #________, #________, _______________class stair

Architectural drawings should indicate a stair designation for each stair on the job. To specify the desired construction, degree of finish, proportions and dimensions state the class of stair opposite each stair designation.

3. Show all field connections.

4. Provide setting diagrams for installation of anchors, location of pockets, weld plates for attachment of stairs and rails to structure, and blocking for attachment of wall rail.
5. Specify adequate back-up support for anchoring handrail bracket.
6. Indicate all required field measurements.
7. Submit one reproduceable sepia for approval.

OR

7. Submit ________ copies for approval.

C. Samples

1. Submit duplicate samples of railing showing style and finish. One approved sample will be returned to contractor.

   This is only specified if appearance sample is required. Applies to pipe, tubing and extrusions but normally does not apply to carbon steel.

2. Submit sample(s) of ____

   ____

   List specific components for which samples are required.

D. Certificates

1. Furnish manufacturer's certification that materials meet specification requirements.

OR

1. Furnish ________________ by an engineer registered in the state where the project is located showing that safety requirements are met.

   (certification) and/or (calculations)
   This requirement should be included ***only if called for by contract documents.***

E. Substitutions

1. Any changes in specified material must meet requirements of the General Conditions "or equal" clause. (See # ______________)

   Indicate Section & Paragraph of the General Conditions that sets out "or equal" requirements.

2. Change materials in stair #_____ from ________ to ________. Changes in architectural details to fabricator's standard procedures will be allowed when appearance and strength are not affected.

   State any alternatives that affect the work and/or bid price of this section, such as a change in material or a change to contractor's standard details.

1.08 DELIVERY, STORAGE AND HANDLING

A. Conform to requirements of Section 016_____.

   If project specifications include a section in Division 1 establishing the general requirements for Delivery. Storage and Handling of materials and equipment for the project, include A, above, and modify following paragraphs to avoid duplication.

B. Deliver materials to the job site in good condition and properly protected against damage to finished surfaces.

C. Storage On Site

1. Store material in a location and in a manner to avoid damage. Stacking shall be done in a way which will prevent bending.
2. Store aluminum, bronze and stainless steel components and materials in clean, dry location, away from uncured concrete and masonry. Cover with waterproof paper, tarpaulin or polyethylene sheeting in a manner that will permit circulation of air inside the covering.

D. Keep handling on-site to a minimum. Exercise particular care to avoid damage to finishes of materials.

For carbon steel delivery and erection reference should be made to the AISC Code of Standard Practice, Sections 6 and 7.

PART 2 — PRODUCTS

2.01 MATERIALS AND FINISHES

A. Carbon Steel

See page 5-3 for properties of steel.

1. Structural Plate ASTM____________________.

Insert the desired ASTM specification number. ASTM A 36 Structural Steel is the most widely used steel for structural plate.

2. Structural Shapes and Bars ASTM____________________.

Insert the desired ASTM specification number. ASTM A 36 Structural Steel is the most widely used steel for structural shapes and bars.

3. Miscellaneous Bar Shapes____________________________________.

Insert desired AISI designation or ASTM specification number.
ASTM A 29 Steel Bars.
AISI 1015 and 1020 Steel Bars.
ASTM A 575 Merchant Quality Steel Bars.
AISI M1020 Merchant Quality Steel Bars.

4. Structural Pipe ASTM____________________.

Insert desired ASTM specification number.
ASTM A 53 Black and Hot-Dipped, Zinc-Coated Welded and Seamless Steel Pipe.
Structural grade, untested pipe is accepted for structural and architectural applications.

5. ____________________Structural Tubing: ASTM____________________.

(round), (square), or (rectangular). Insert desired ASTM specification number.

ASTM A 500 Cold Formed Welded and Seamless Structural Tubing in Rounds and Shapes.
ASTM A 501 Hot Formed Welded and Seamless Structural Tubing.

Hot formed steel tubing is produced in rounds and shapes.

6. Sheet and Strip: ASTM______________________.

Insert desired ASTM specification number.
ASTM A 569 Commercial Quality. Hot-Rolled Sheet and Strip.
ASTM A 635 Hot-Rolled Sheet and Strip, Heavy Thickness Coil.
ASTM A 570 Structural Quality Hot-Rolled Sheet and Strip.
Commercial quality hot-rolled and strip are generally used in metal stair construction. However, where structural considerations are of primary importance structural quality should be specified.
ASTM A 366 Commercial Quality, Cold-Rolled Sheet.
ASTM A 611 Structural Cold-Rolled Sheet.
Cold-Rolled sheet is usually specified only when it is necessary to meet particular architectural finish requirements.

7. Castings: ASTM______________________.

Insert desired ASTM specification number.
ASTM A 47 Malleable Iron Castings (Grade 32510).
ASTM A 48 Gray Iron Castings (Class 30).
Class 30 means 30,000 psi tensile strength. Grade 32510 means 32,500 psi yield strength and tensile strength of 50,000 psi. Although malleable iron is stronger than gray and would be preferable for some applications, some items are available only in gray iron.

8. Finishes:

Refer to NAAMM Metal Finishes Manual for information on all finishes.

a. Surface Preparation. Remove loose scale, rust, grease, oil, moisture or other foreign materials to properly prepare the surface for subsequent coating application.

1) Remove mill scale, rust and dirt following SSPC-SP2 for hand cleaning and SSPC-SP3 for power tool cleaning.

b. Galvanizing:

1) Products fabricated from shapes, plates, bars and strips shall be galvanized in accordance with ASTM A 123.

2) Sheet products shall be galvanized in accordance with ASTM A 525 and ASTM A 526.

3) Minimum coating weight________oz/sq ft.

Coating Class G60 (Minimum Check Limit Triple-Spot Test 0.60 oz/sq ft. weight on both sides of the sheet combined) or heavier, is recommended for the use where exposures require durable protection. Refer to Table 1 of ASTM 525 for coating weights and tolerances.

c. Paint: Minimum one coat of rust-inhibitive primer__________________ ____________________________, FS- ____________________________

(standard shop primer) (manufacturer's name and number) (Federal Specification number).
FS-TT-P-641 Zinc Dust-zinc Oxide Primer Coating (For Galvanized Surfaces).
FS-TT-P-645 Alkyd Type, Zinc Chromate, Paint Primer. Other Specification. Select primer for drying time and compatibility with finish coat. Primer must be lead free.

d. Touch-up for Galvanized Surfaces: Use paint primer meeting FS-TT-P-645.

B. Stainless Steel: Type ______________________.

Specify AISI type 302, 304 or 316. 304 is generally the preferred type although 302 may often be used interchangeably with it. See page 5-3 of this manual for properties of type 304. Where severe corrosion conditions may be encountered 316 should be specified.

1. Sheet, Strip, Plate, and Flat Bar: ASTM ______________________.

Insert the desired ASTM specification number. ASTM A 167 Stainless and Heat Resisting Chromium-Nickel Steel for Plate, Sheet and Strip.

2. Pipe and Tubing: ASTM ______________________.

Insert the desired ASTM specification number. ASTM A 269 Seamless and Welded Austenitic Stainless Steel Tubing for General Service. ASTM A 312 Seamless and Welded Austenitic Stainless Steel Pipe.

3. Finish: AISI No. __________.

Insert desired AISI number. (Refer to NAAMM Metal Finishes Manual, Finishes for Stainless Steel AMP 503 for available finishes)

AISI No. 2D, dull mill finish is usually specified. When a general purpose polished finish is desired AISI No. 4 may be specified. Some unique proprietary finishes are also available. These must be specified by manufacturer and trade name.

C. Aluminum:

See page 5-3 of this manual for properties of aluminum alloys and The Aluminum Association's Aluminum Standards and Data for more information.

1. Extruded Bar and Shapes: Alloy ______________ meeting ASTM B 221.

Insert desired Aluminum Association Alloy Designation 6061-T6 or T62, 6063- T5 or T52, 6063-T6.

2. Extruded Structural Shapes: Alloy 6061-T6 meeting ASTM B 221.

3. Extruded Tube and Pipe: Alloy ______________ meeting ASTM B 241.

Insert desired Aluminum Association Alloy Designation 6061-T6 or T62, 6063-T5, 6063-T6 or T62.

4. Drawn Tube and Pipe: Alloy ______________ meeting ASTM B 210.

Insert desired Aluminum Association Alloy Designation 6061-T6 or T62, 6063-T6 or T62, 6063-T832.

5. Tread Plate:

a. For platforms: Alloy 6061-T6 meeting ASTM B 209.

Alloy 6061-T62 may be specified as an alternate.

b. For treads: Alloy 6061-T4 meeting ASTM B 209.

6. Finish: ______________________.

Specify The Aluminum Association Designation for mechanical, chemical, and anodic finishes. Architectural Class I anodic finish is generally recommended. Where color anodizing is specified, allowable variation is limited according to the color range of samples furnished by the finisher. For applied organic coatings specify the type fo coating and color required. (Refer to NAAMM Metal Finishes Manual Finishes for Aluminum AMP 501 for data on anodic and organic finishes).

D. Copper Alloys:

See page 5-3 for properties of these alloys. Alloy designations for copper alloys are those of ASTM E 527.

1. Copper Alloy No. C38500 (Architectural Bronze) meeting ASTM B 455 for shapes.

Architectural Bronze Alloy C38500 is extruded in the form of bars, standard shapes and special shapes such as handrail mouldings, square and rectangular tubing.

2. Copper Alloy No. C23000 (Red Brass, 85%) meeting ASTM B 43 for pipe.

Seamless brass pipe is usually supplied in Alloy C23000 which alloy provides a fair color match with Architectural Bronze Alloy C38500.

3. Copper Alloy No. C28000 (Muntz Metal, 60%) for sheet.

Panels, sheets and trim are usually supplied in Alloy C28000. This alloy provides a fair color match with Architectural Bronze Alloy C38500.

4. Copper Alloy No. C83600 meeting ASTM B 62 and B 584 for sand castings.

5. Finish: ______________________.

(M32-Medium Satin) (M42-Fine Matte). These are the two mechanical finishes most commonly specified for architectural bronze. Other mechanical finishes plus chemical and organic finishes are available. (Refer to NAAMM Metal Finishes Manual Finishes for Copper Alloys AMP 502)

a. Apply a protective organic coating of clear lacquer approved by the Copper Development Association.

This paragraph should be included where protection of surface finish is believed necessary. A general list of clear organic coatings approved by the Copper Development Association is published in CDA's Copper, Brass and Bronze Design Handbook for Architectural Applications.

E. Glass: Type ________________, Thickness, ________________, Shall conform to the safety requirements of ANSI Z97.1.
Accessories: ____

____

Insert glass type and thickness. List glazing accessories.

F. Welding Rods and Bare Electrodes. Select in accordance with American Welding Society specifications for the metal alloys to be welded.

G. Fasteners: Match or be compatible with the metals being fastened.

2.02 FABRICATION

A. Components

1. Stringers: ______________________
2. Headers: ______________________
3. Treads: ______________________
4. Nosings: ______________________
5. Risers: ______________________
6. Platforms: ______________________
7. Struts: ______________________
8. Columns: ______________________
9. Soffits: ______________________
10. Railings: ______________________
11. Handrails: ______________________
12. Newels: ______________________
13. Other Items: ______________________

Where metal bar grating treads and platforms are to be used, they should be fabricated in accordance with the requirements of ANSI/NAAMM ***MBG 531 Standard for Metal Bar Gratings.***

It may not be necessary to specify material and finish requirements for all these components when a manufacturer's standard stair is being specified. This information is needed where there are special requirements and when custom designed stairs are called for.

Select materials and finishes to meet project requirements and indicate next to the component the appropriate references to paragragh 2.01 Materials and Finishes. For example: Railings: Aluminum extruded shapes as specified in 2.01.C.1 with finish as specified in ***2.01.C.6.***

This component list is supplied as a guide. The specifier may wish to add or subtract from the list for his particular project. Where appropriate for a project components may be simply identified by a manufacturer's standard part number.

B. Fabricate in compliance with shop drawings and commence fabrication only after these drawings have been approved.

C. Remove all sharp or rough areas on exposed travel surfaces.

D. Provide protection against galvanic action between dissimilar metals.

PART 3 — EXECUTION

3.01 INSTALLATION

A. Field check and verify that structural framing, enclosures, weld plates, blocking, size and location of pockets are as called for in approved shop drawings. Report discrepancies to Architect and Contractor for corrective action by responsible parties.

B. **Do not proceed with installation until stairwell is cleared.**

C. **Load, unload and handle material in a manner that will not strain, bend, deform or otherwise damage it.**

D. Erect stairs square, plumb, straight, true to line and level, with neatly fitted joints and intersections. Installation shall be secure and rigid.

E. Field welds in the area of travel shall be smooth.

F. Protect material from damage both before and during installation.

3.02 TOUCH-UP AND CLEAN-UP

A. Repair abraded galvanized finish by application of one coat of paint primer meeting FS-TT-P-645.

B. Touch-up field welds by application of one coat of primer as specified in 2.01.A.8.c.

C. Remove debris, containers and excess material resulting from work specified herein.

SECTION 7

GLOSSARY OF TERMS

Definitions of terms used in this Manual and other terms in common usage in the metal stair industry

GLOSSARY

ANGLED STAIR — A stair in which successive flights are at an angle of other than 180° to each other (often 90°) with an intermediate platform between them.

BALUSTER — One of a series of closely spaced upright members which support the handrail in a railing.

BALUSTRADE — A railing which is composed of balusters capped by a handrail, often serving as an architectural feature.

BEVEL — See Pitch.

BULLNOSE STEP — A tread with one or both ends having a semi-circular shape in plan; usually the first tread at the bottom of a flight.

CAP — A fitting used to close the end of a pipe or tubular rail or post, or the top end of a tubular newel.

CARRIER ANGLE — An angle connected to the inside face of a stringer to form a supporting ledge for the end of a tread or riser.

CARRIER BAR — A flat bar used in the same way as a carrier angle.

CHECKERED PLATE — See Floor Plate.

CIRCULAR STAIR — A stair which, in plan view, has an open circular form, with a single center of curvature.

CLOSURE BAR — A flat metal bar connected in the field to the top and/or bottom surface or edge of a wall stringer to close gaps between the stringer and the wall.

CURVED STAIR — A stair which, in plan view, has two or more centers of curvature, being oval, elliptical or some other compound curved form.

DROP — A fitting used to close the bottom end of a tubular newel.

EASEMENT — That curved portion of a handrail which forms a transition, in a vertical plane, between a horizontal and an inclined section of a handrail.

FASCIA — The exposed facing of the outer edge of a platform or floor; usually similar in detail to the face stringer.

FILL — A cementitious material such as concrete or terrazzo, which is placed over a metal substructure to provide the wearing surface of a tread or platform.

FIXED METAL STAIR — A permanently stationary series of three or more steps in one or more flights, providing pedestrian access between different floors or levels.

FLIGHT — An uninterrupted series of steps.

FLIGHT HEADER — See Header, Flight.

FLIGHT RISE — The vertical distance between the floor or platforms connected by a flight.

FLIGHT RUN — The horizontal distance between the faces of the first and last risers in a flight.

FLOOR PLATE — A steel plate having a raised pattern to provide a non-slip wearing surface; referred to as "tread plate" when made of aluminum.

GRAB RAIL (GRAB BAR) — A short length of rail located for safety and convenience.

GUARD-RAIL SYSTEM — A railing system usually located for protection of building occupants at or near the outer edge of a stair flight, ramp, landing, platform, balcony or accessible roof; at perimeter of any opening or accessible surface, such as an opening for stairway; or at a location where operating condition requires limitation of access to designated area, to guard against accidental fall or injury. See Railing System.

GUSSET — A plate used to construct or reinforce an angular joint between two or more members.

HAND OF SPIRAL STAIR — A term used to designate the direction of turn of a spiral strair.

Right-hand refers to a stair on which the user turns counter-clock-wise as he ascends.

Left-hand refers to a stair on which the user turns clockwise as he ascends.

HANDRAIL — The member which is normally grasped by the hand for support. This member may be part of the railing system or may be mounted on the wall or other building element. It is often, but not necessarily, the top member of the railing system. When part of the stair-rail system it parallels the pitch of the stair flight. See Wall Handrail.

HANDRAIL BRACKET — A device attached to a wall or other surface to support a handrail.

A left-hand handrail bracket is one which is located on the user's left as he ascends the stairs.

A right-hand handrail bracket is one which is located on the user's right as he ascends the stairs.

HANGER — A load-carrying tension member used to support a stair framing member by suspension from the floor construction or other support above.

HEADER, FLIGHT — A horizontal structural member at a floor or platform level, supporting the end(s) of one or more stringers.

HEADER, PLATFORM — A horizontal member supporting platform construction but carrying no stringers.

HEADROOM — The minimum vertical distance from the top surface of a tread or platform to the ceiling, soffit or other overhead obstruction, measured at the outer edge of the tread or platform.

I.P.S. — Iron Pipe Size; a nominal inside diameter dimension of pipe.

KICK PLATE — A vertical plate forming a lip or low curb at the open edge of platform or floor or at the back edge or open end of a tread on an open riser stair.

LAMB'S TONGUE — An ornamental curved and tapered fitting terminating a handrail.

LANDING — See Platform.

LATERAL SCROLL — A fitting which curves in a horizontal plane, used to terminate a handrail.

NEWEL — A post member supporting the end of a railing or serving as a common support for two railings.

NOSING — That part of a tread or platform which projects as a square, rounded or rounded and molded edge beyond the vertical face of the riser below it.

PAN BRACKET — See Carrier Angle or Carrier Bar.

PAN TREAD — See Tread, Pan Type.

PARALLEL STAIR — A stair consisting of flights which parallel each other and are separated by one or more intermediate platforms.

PITCH — The angle of slope of a flight, measured either in degrees or by the ratio of rise to run.

PITCH BLOCK — See Carrier Angle or Carrier Bar.

PITCH DIMENSION — The distance between the bases of the top and bottom risers in a flight, measured parallel to the pitch.

PLATFORM — A horizontal surface having a dimension parallel to the stringer greater than a tread width, occurring in a stair at the end of a flight or between flights, either at a floor level or between floors. In the latter case it is sometimes referred to as an intermediate platform or a landing.

PLATFORM HEADER — See Header, Platform.

PRE-ASSEMBLED STAIR — A stair whose components are assembled in the plant to make up units of varying sizes and degrees of complexity.

PRE-ERECTED STAIR — A stair unit for multi-storied buildings designed to be self supporting. Such units can be stacked one upon the other and field connected to form stair towers.

RAIL — See Handrail.

RAILING SYSTEM — A framework of vertical, horizontal or inclined members or panels, or some combination of these, supporting a handrail and located at the edge of a flight, platform or floor as a safety barrier.

RAKE — See Pitch.

RAKE DIMENSION — See Pitch Dimension.

RISE — See Flight Rise.

RISER — The vertical or inclined face of a step, extending from the back edge of one tread to the outer edge of the tread or lower edge of the nosing next above it.

RISER, OPEN — A term used to describe a stair having open spaces rather than risers between treads.

RISER HEIGHT — The vertical distance between the top surfaces of two successive treads.

RUN — See Flight Run and Tread Run.

SAFETY NOSING — A nosing having a slip resistant surface flush with the tread surface.

SAFETY TREAD — A tread which has a slip resistant top surface.

SANITARY COVE — A small projection formed in the face of a metal riser along its full length to provide an angled or curved transition between the tread surface and the riser face to facilitate cleaning.

SCISSOR STAIR — A straight stair which in plan view has two parallel flights between floors but in which the stairs are at a 180° angle to each other.

SHIP'S LADDER — A ship's ladder is named for its use as a stairway access between decks of a ship. These ladders ascend at steep angles of not less than 50° nor more than 77° with the deck, and cover the angularity of ascent between that of conventional stairs and straight ladders. They are not used for public stairways in buildings.

SIDE MOUNT — A method of railing support in which the posts are anchored to a vertical surface such as a fascia or stringer face. Also referred to as fascia bracket or fascia flange.

SOFFIT — The under side of a stair, whether exposed construction or an applied finish material.

SPIRAL STAIR — A stair with a closed circular form, uniform sector shaped treads and a supporting center column.

LIMITED ACCESS SPIRAL STAIR — A spiral stair serving an occupant load of 10 or less and from an area of 600 square feet or less.

PRIMARY ACCESS SPIRAL STAIR — A spiral stair serving an occupant load of 50 or less.

STAIR — A flight or series of connected flights extending between two or more floors within a given floor area or stairwell.

STAIR-RAIL SYSTEM — A railing system located along open side of stair or platform.

STAIRWAY — See Stair.

STAIRWELL — The vertical shaft space in a building occupied by a stair; also, the open well space between a series of flights.

STEP — The combination of a riser and the tread immediately above it.

STEP RISE — See Riser Height.

STORY HEIGHT — The vertical distance, in a building, between one finished floor and the next.

STRAIGHT RUN STAIR — A stair extending in a straight line between one floor and the next, and consisting of one flight or a series of flights with one or more intermediate platforms.

STRING — See Stringer, the preferred term.

STRINGER — An inclined structural member supporting a flight, or a structural member having an inclined section with a horizontal section at one or both ends, supporting a flight and one or two platforms.

STRINGER, BOXED — A stringer having a hollow square or rectangular cross section.

STRINGER, CENTER — A stringer located under a flight at its mid-width and supporting the treads, or treads and risers, by cantilever action.

STRINGER, CLOSED — See Stringer, Boxed.

STRINGER, FACE — A stringer which supports, on one side, the ends of treads and risers, and is exposed on the other side.

STRINGER, OPEN	A channel used as a stringer.
STRINGER, PLATE	A flat plate used as a stringer.
STRINGER, PLATFORM	A stringer, or that part of a stringer, which is used to support a platform.
STRINGER, TUBE	A stringer made from a metal tube section.
STRINGER, WALL	A stringer placed alongside a wall and usually carrying no railing.
STRUT	A structural member which resists axial compression loads. Generally used to support a stair framing member by column action.
SUB-PLATFORM	The metal subfloor over which a fill is placed to provide a platform.
SUB-TREAD	See Tread, Pan Type.
TOE BOARD	See Kick Plate.
TOE PLATE	See Kick Plate.
TRANSFER RAIL	See Grab Rail.
TRAVEL AREA	That area with which a stair user might normally make physical contact.
TREAD	The horizontal member of a step.
TREAD ANGLE	See Carrier Angle.
TREAD BAR	See Carrier Bar.
TREAD, GRATING TYPE	A tread fabricated from metal grating.
TREAD, PAN TYPE	A section formed from metal sheet to receive a fill and provide, when filled, either a tread or a combination of plates.
TREAD, PLATE TYPE	A tread, or combination tread and riser, fabricated from metal plate, floor plate, tread plate or a combination of plates.
TREAD BRACKET	See Carrier Angle or Carrier Bar.
TREAD LENGTH	The dimension of a tread measured perpendicular to the normal line of travel on a stair.
TREAD PLATE	A product similar to floor plate, but made of aluminum.
TREAD RUN	The horizontal distance between two consecutive risers, or, on an open riser stair, the horizontal distance between nosings or the outer edges of successive treads, all measured perpendicular to the front edges of the nosings or treads.
TREAD WIDTH	The tread run plus the projection of the nosing, if any.
VERTICAL BARRIER	A wall or railing adjacent or attached to the edge of a flight, platform or floor, to prevent persons from falling.
VOLUTE	A spiral or scroll-shaped fitting used to terminate a handrail.
WALL CLIP OR FLANGE	A bracket used for anchoring.
WALL HANDRAIL	A handrail attached to a wall adjacent to a stair and paralleling the pitch of the flight; also used along walkways, ramps, and corridors. Also referred to as a "wall rail."
WINDER	A tread having less width at one end than at the other.