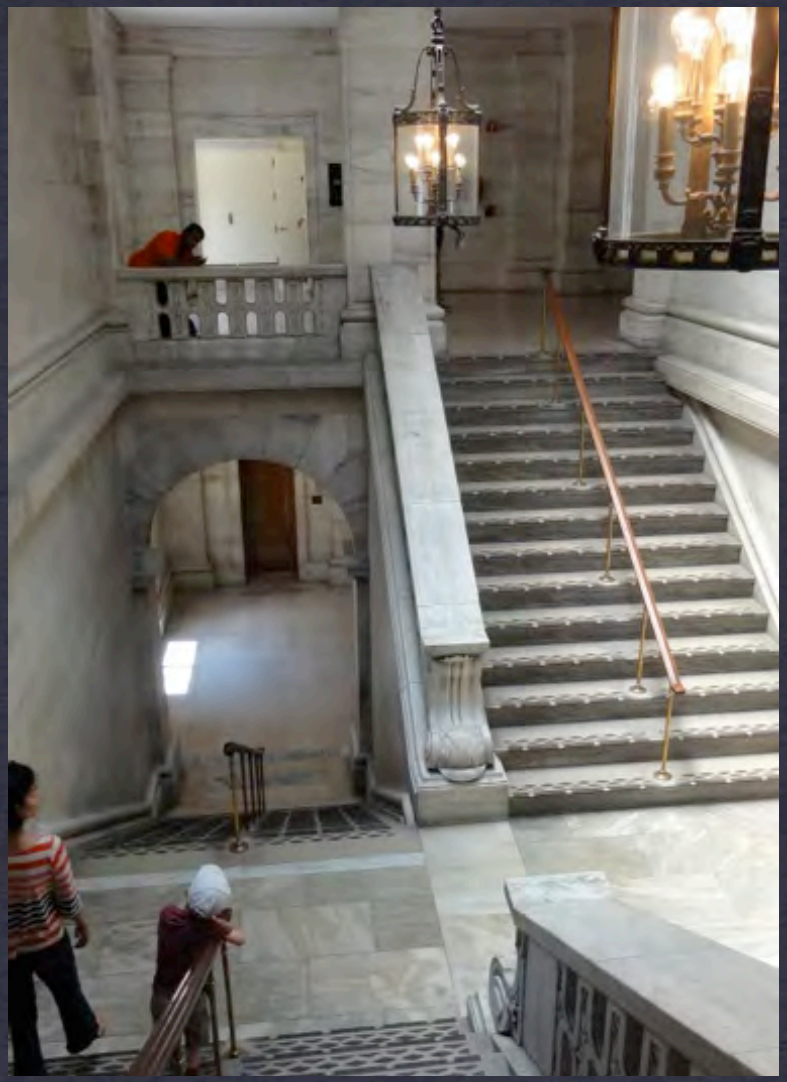

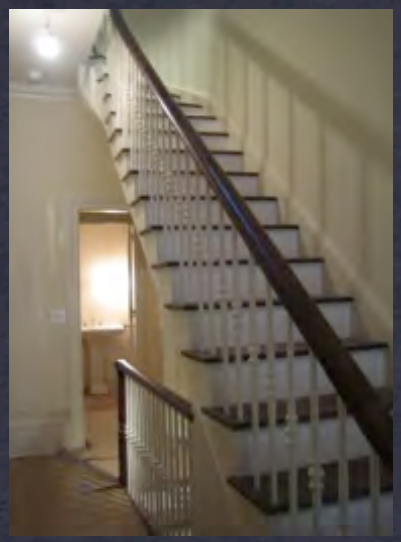

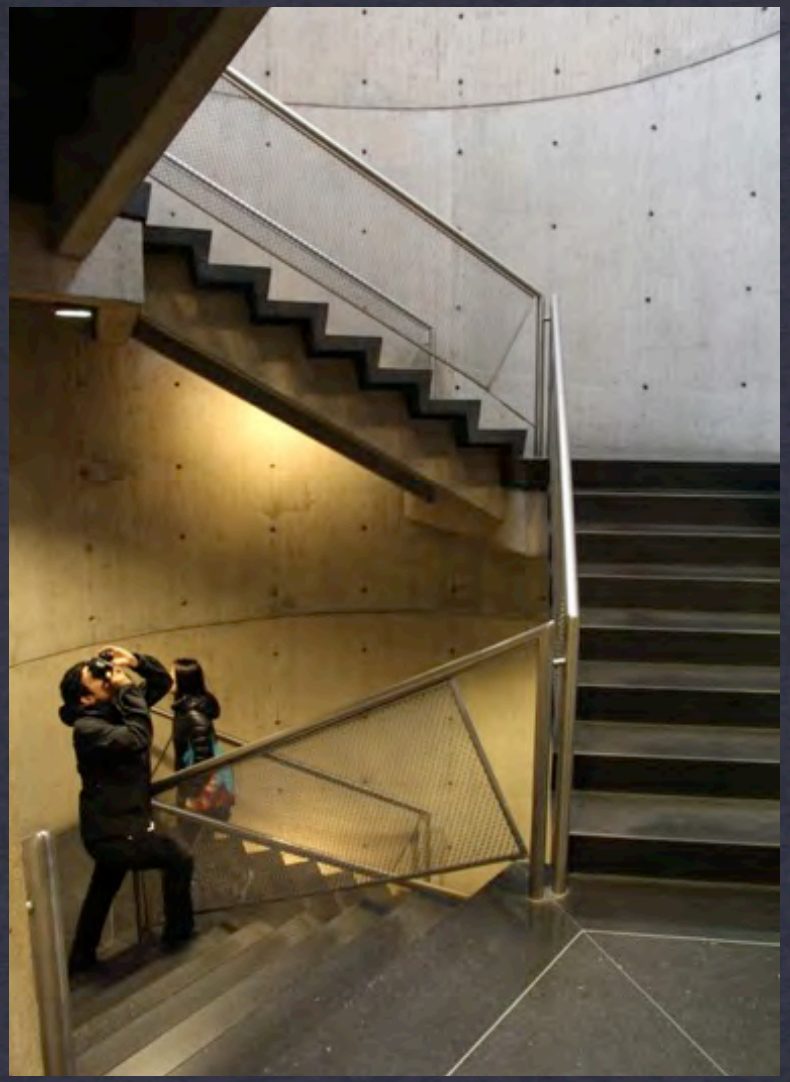

SUBJECT

STAIRS

design and detailing

Building Construction Illustrated, ch. 9

DATE SPRING 2012

PROFESSOR MONTGOMERY

STAIRS

power of stairs_marking entry

professor Montgomery

arch 1130

STAIRS

power of stairs_public space

professor Montgomery

arch 1130

STAIRS

professor Montgomery

power of stairs_public space

arch 1130

STAIRS

power of stairs_public space

professor Montgomery

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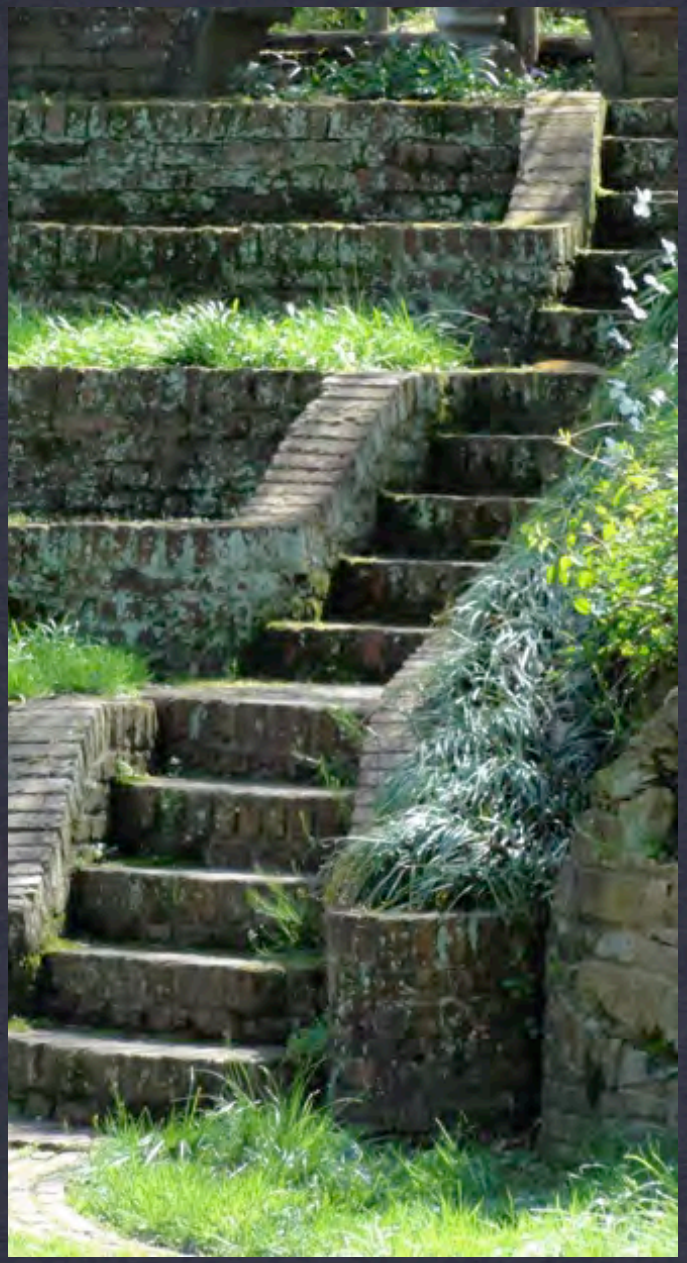

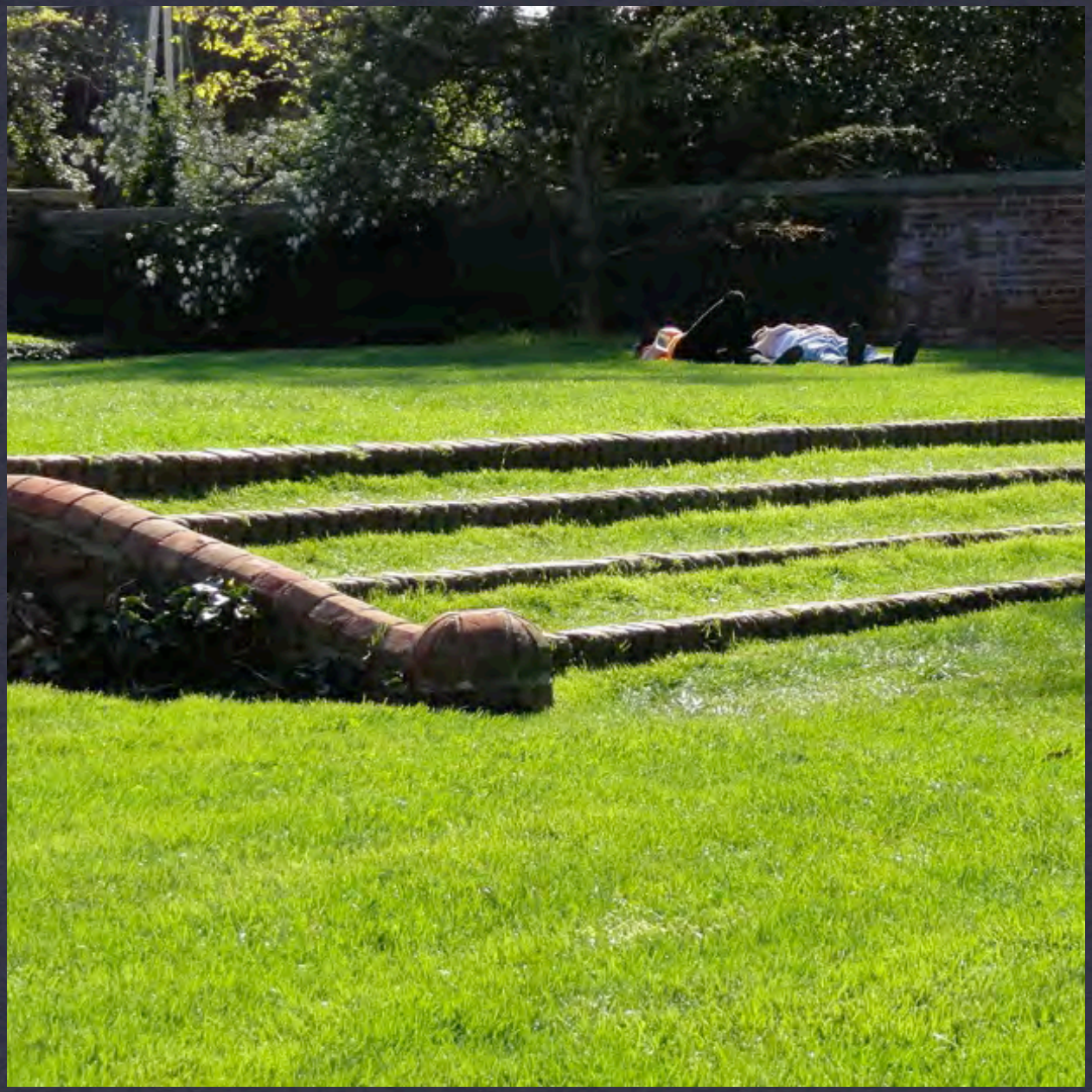

STAIRS

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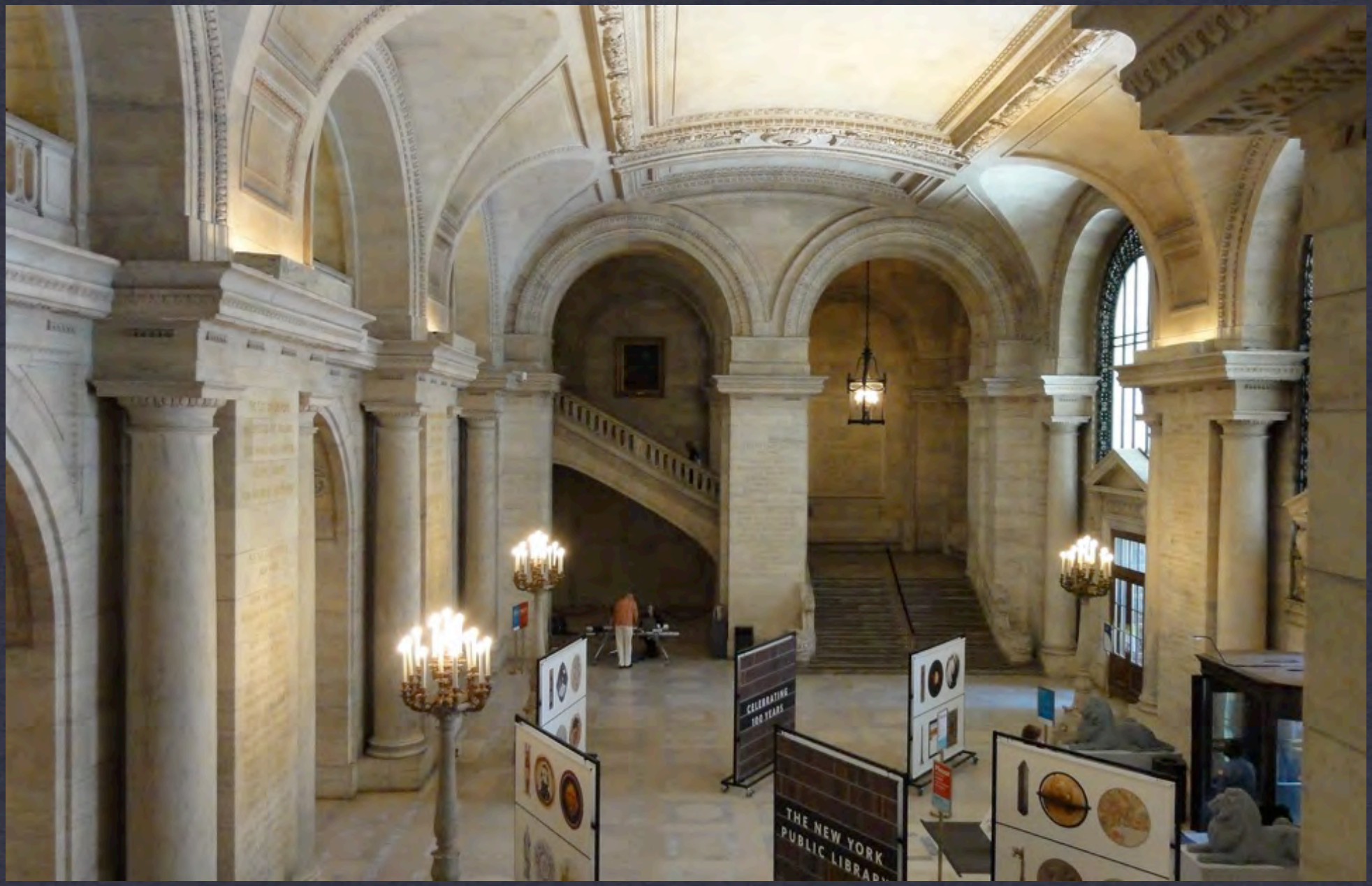
sculpture in a landscape

arch 1130



STAIRS

dramatic means of circulation

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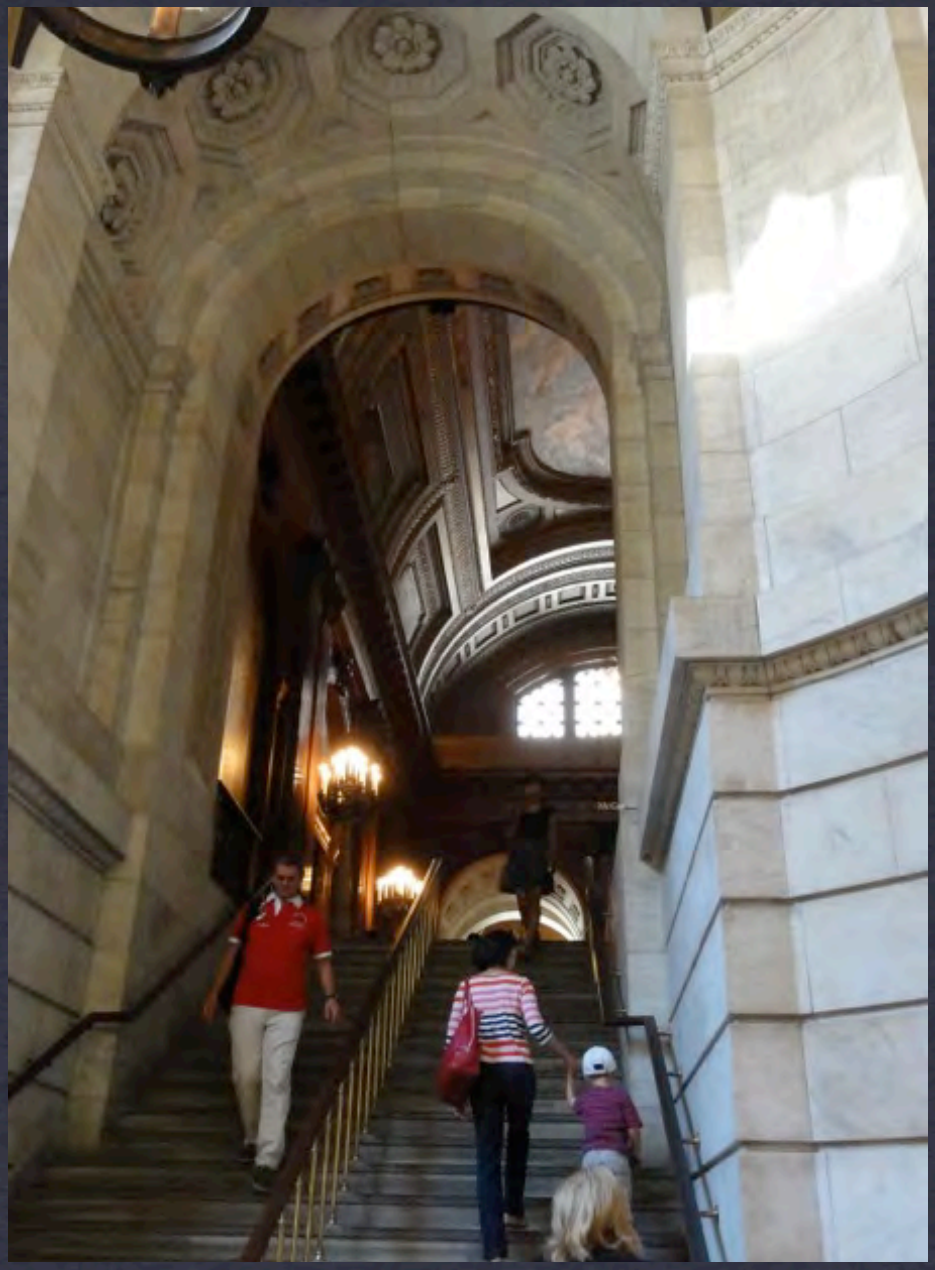
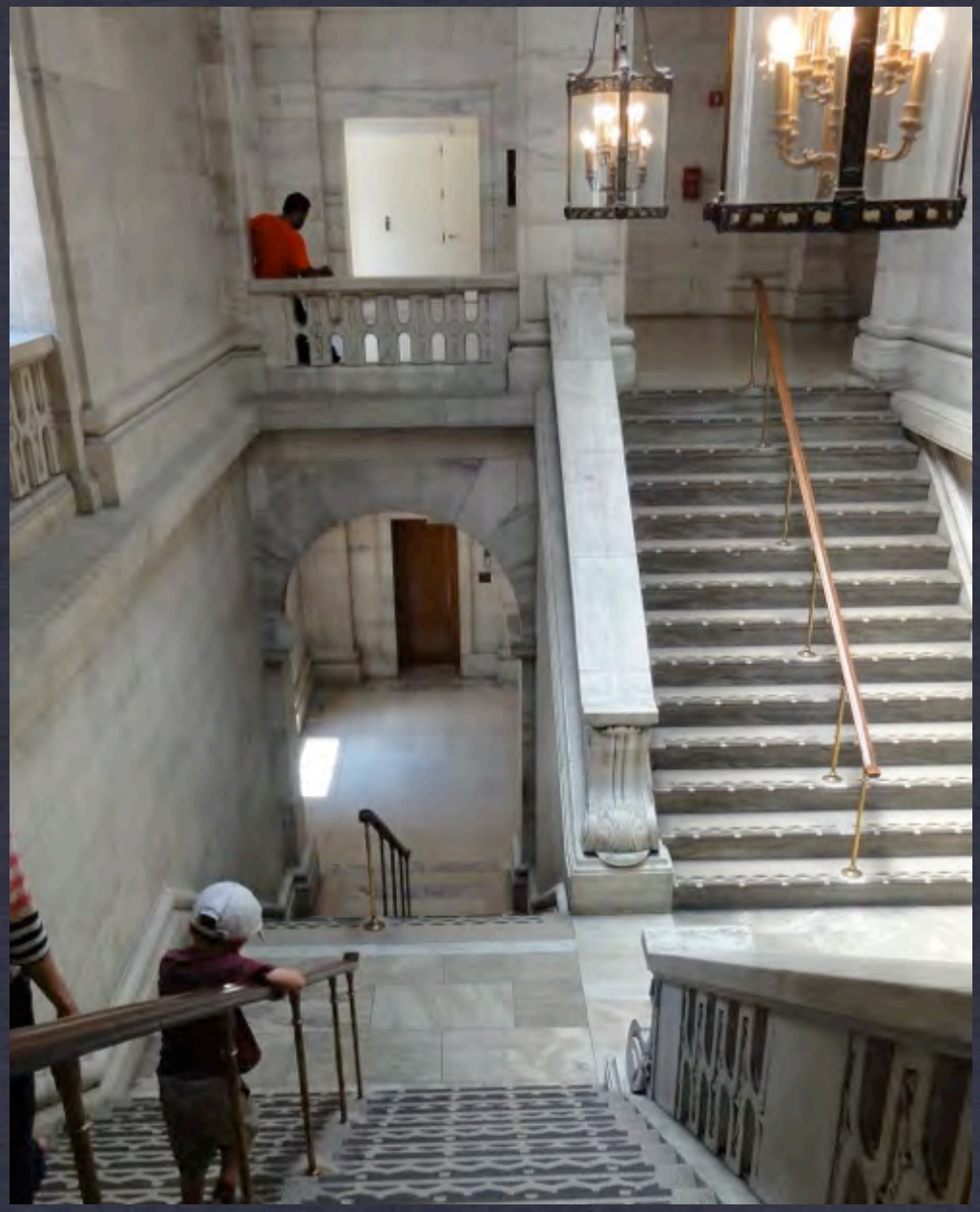
arch 1130





STAIRS

dramatic means of circulation

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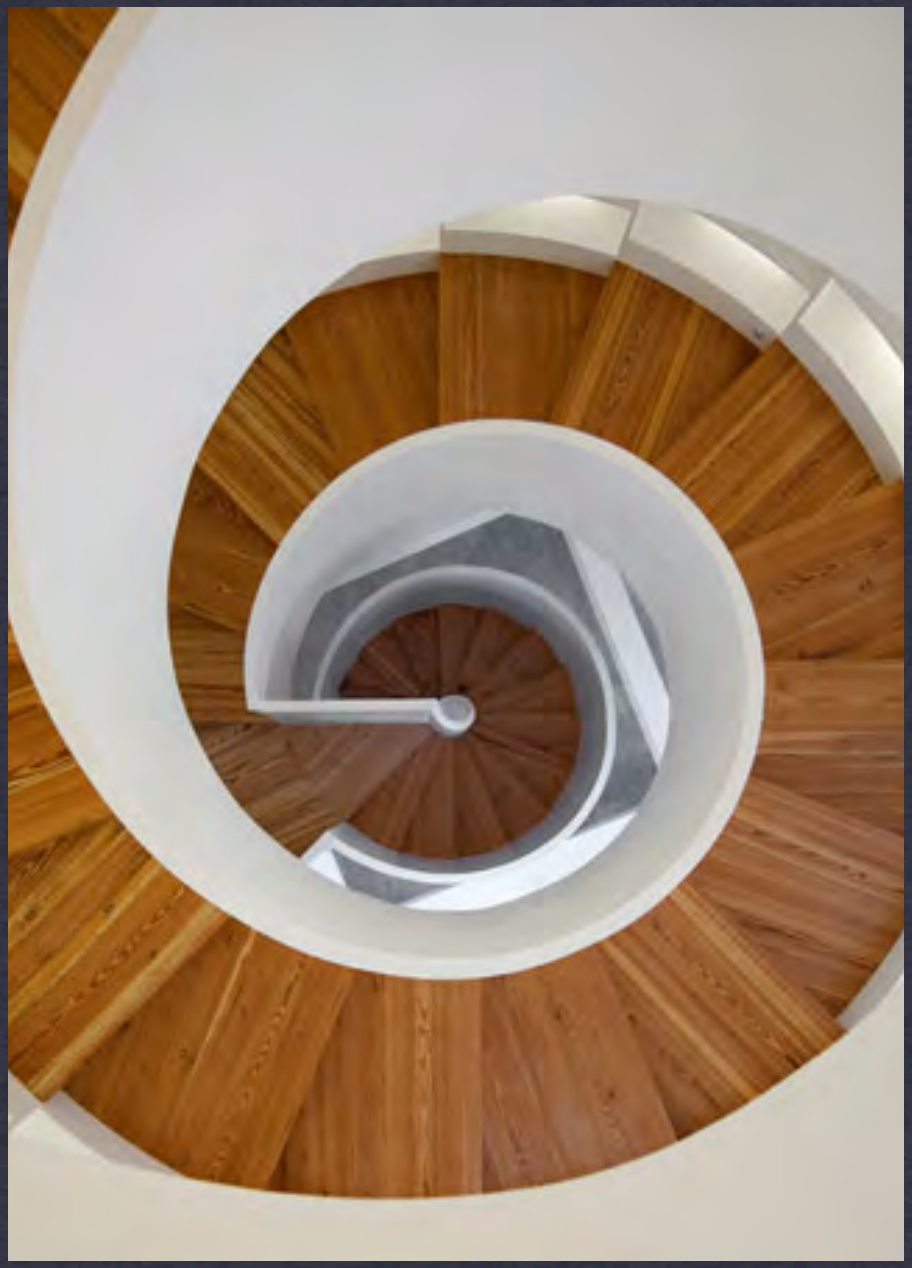

STAIRS

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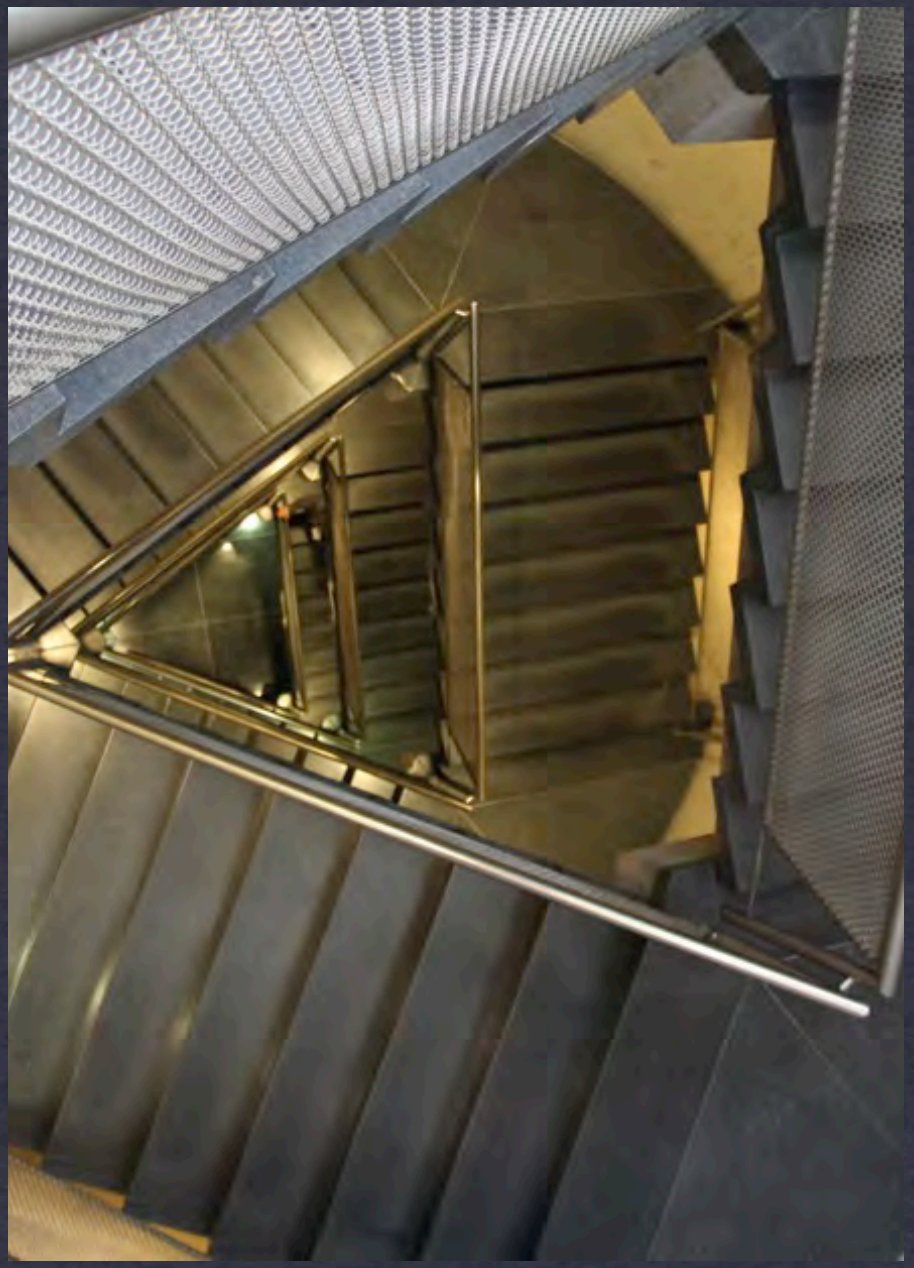
design drama

arch 1130



STAIRS

dynamic movement

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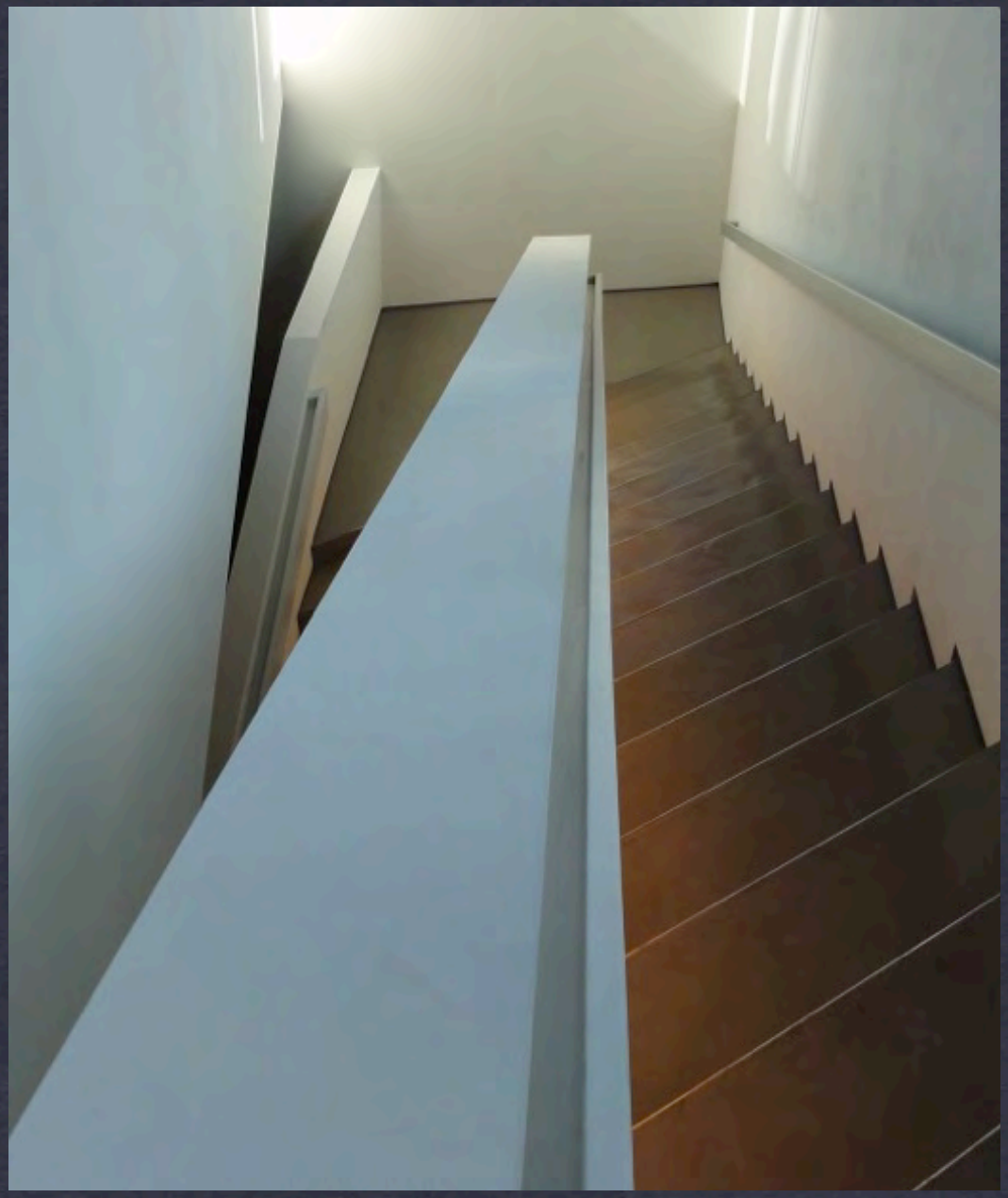

STAIRS

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ergonomic design

arch 1130

STAIRS

structural solutions

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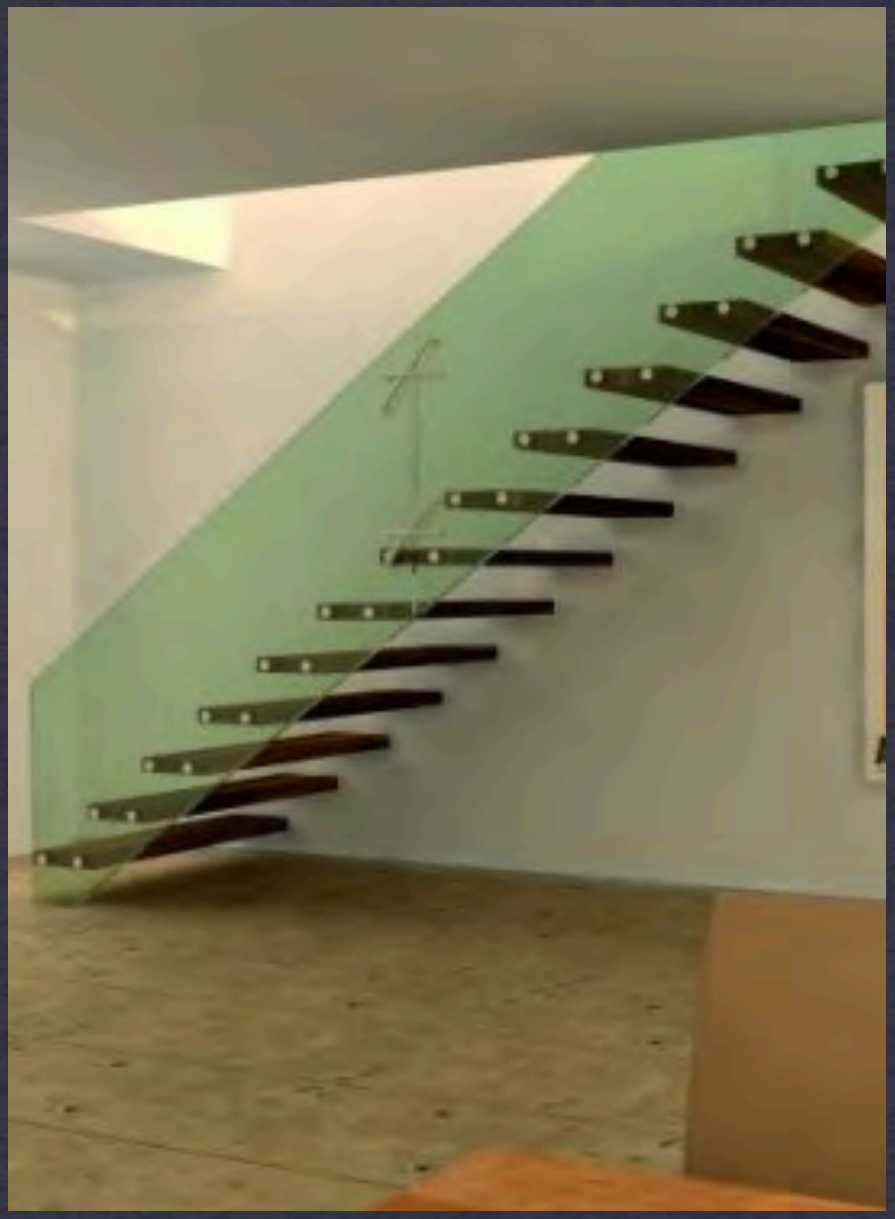
arch 1130



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structural solutions

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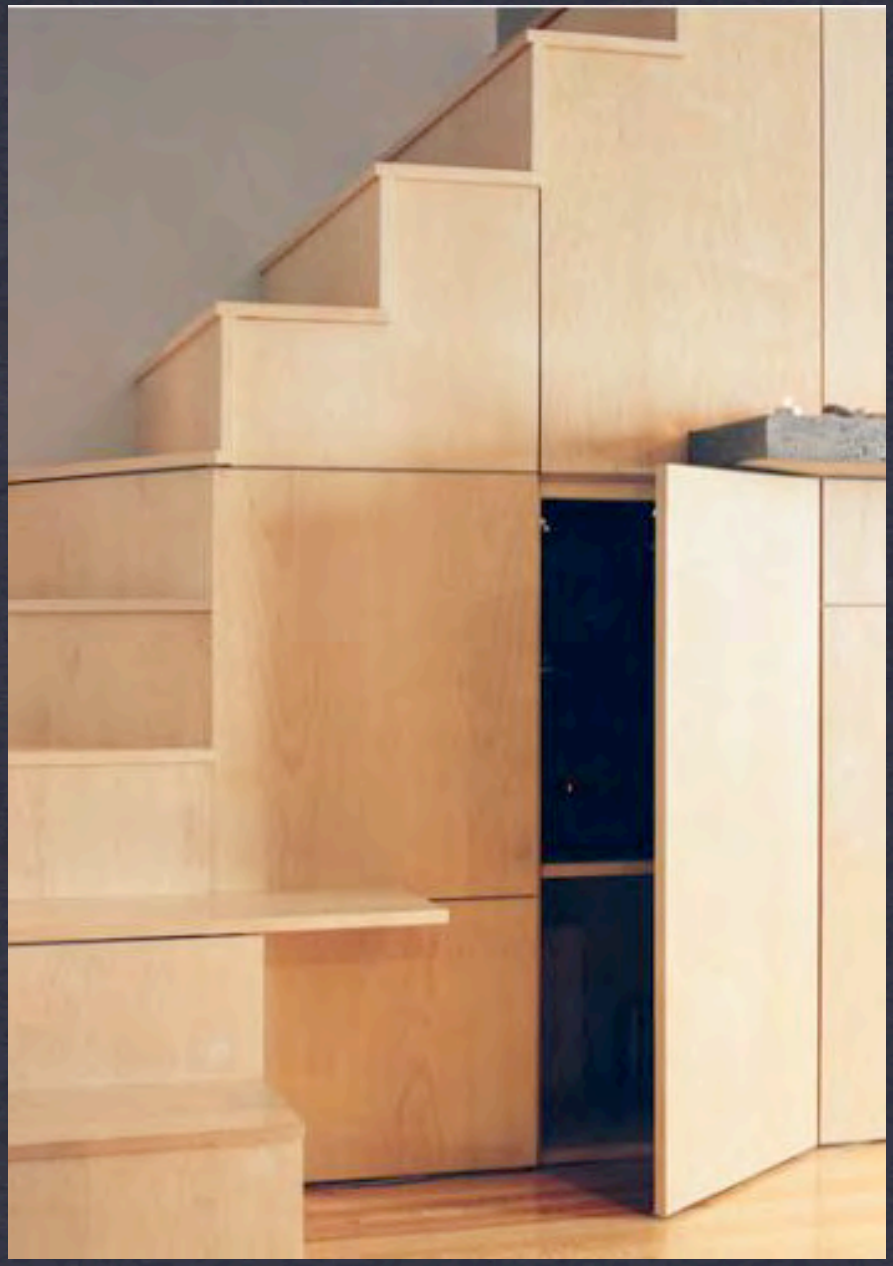

STAIRS

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dual use

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STAIR DESIGN + REQUIREMENTS

STAIRS

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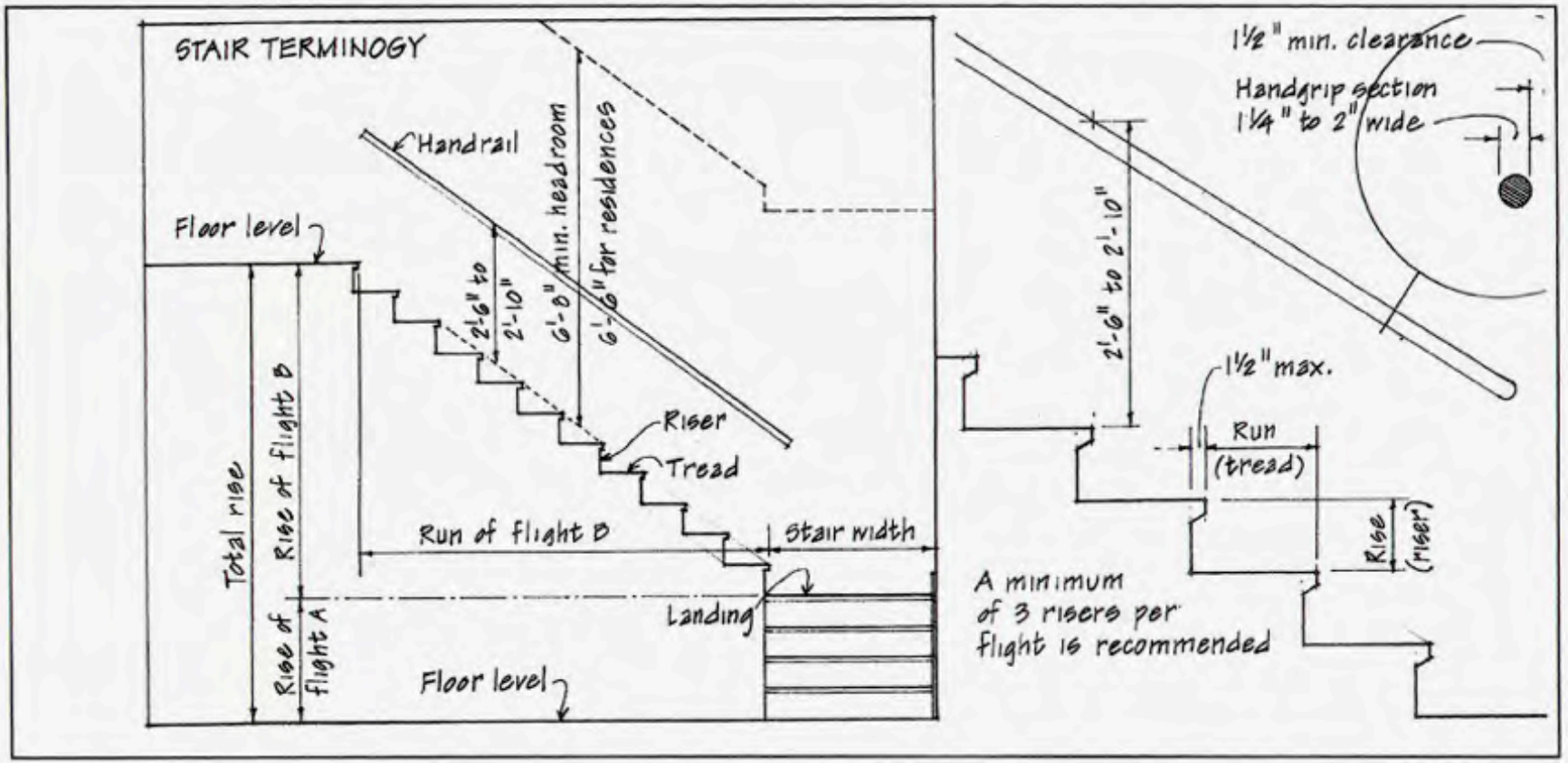
arch 1130

Stair Terminology



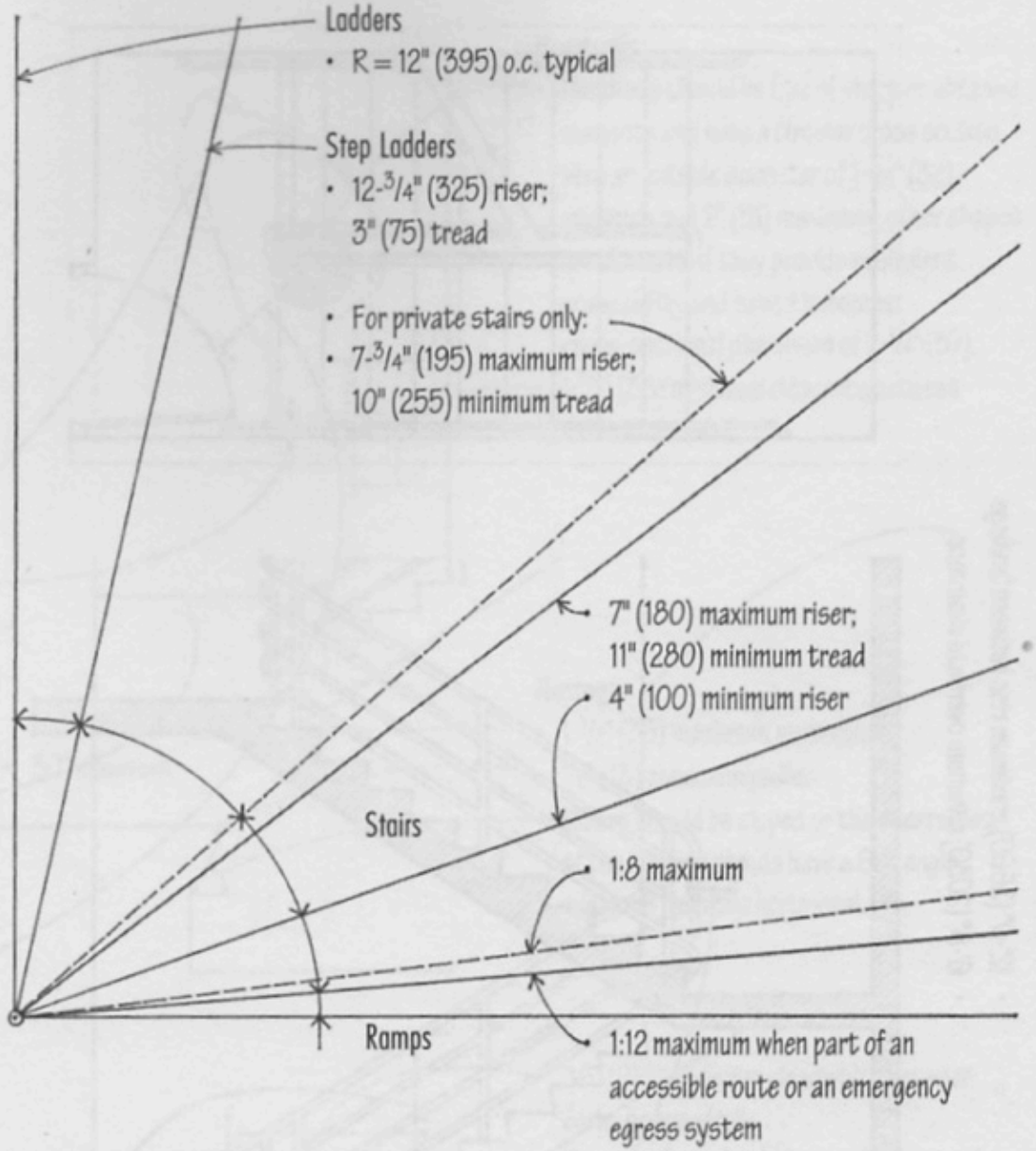
The dimensions of risers and treads in a stairway should be proportioned to accommodate our body movement. Their pitch, if steep, can make ascent physically tiring as well as psychologically forbidding, and can make descent precarious. If the pitch of a stairway is shallow, its treads should be deep enough to fit our stride.

Building codes regulate the minimum and maximum dimensions of risers and treads; see 9.04–9.05. For comfort, the riser and tread dimensions can be proportioned according to either of the following formulas:

- Tread (inches) + 2x riser (inches) = 24 to 25
- Riser (inches) x tread (inches) = 72 to 75

Exterior stairs are generally not as steep as interior stairs, especially where dangerous conditions such as snow and ice exist. The proportioning formula can therefore be adjusted to yield a sum of 26.

For safety, all risers in a flight of stairs should be the same rise and all treads should have the same run. Building codes limit the allowable variation in riser height or tread run to $^{3}/_{8}$" (9.5 mm). Consult the building code to verify the dimensional guidelines outlined on this and the following page.



STAIRS

the pitch of the stair

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arch 1130

- The actual riser and tread dimensions for a set of stairs are determined by dividing the total rise or floor-to-floor height by the desired riser height. The result is rounded off to arrive at a whole number of risers. The total rise is then redivided by this whole number to arrive at the actual riser height.
- This riser height must be checked against the maximum riser height allowed by the building code. If necessary, the number risers can be increased by one and the actual riser height recalculated.
- Once the actual riser height is fixed, the tread run can be determined by using the riser:tread proportioning formula.
- Since in any flight of stairs, there is always one less tread than the number of risers, the total number of treads and the total run can be easily determined.

Riser and Tread Dimensions

Riser inches (mm)	Tread inches (mm)
5 (125)	15 (380)
5-1/4 (135)	14-1/2 (370)
5-1/2 (140)	14 (355)
5-3/4 (145)	13-1/2 (340)
6 (150)	13 (330)
6-1/4 (160)	12-1/2 (320)
6-1/2 (165)	12 (305)
6-3/4 (170)	11-1/2 (290)
7 (180)	11 (280)
7-1/4 (185)	10-1/2 (265)
7-1/2 (190)	10 (255)

- Maximum riser height; minimum tread depth for accessible stairs and emergency egress

STAIRS

the pitch of the stair

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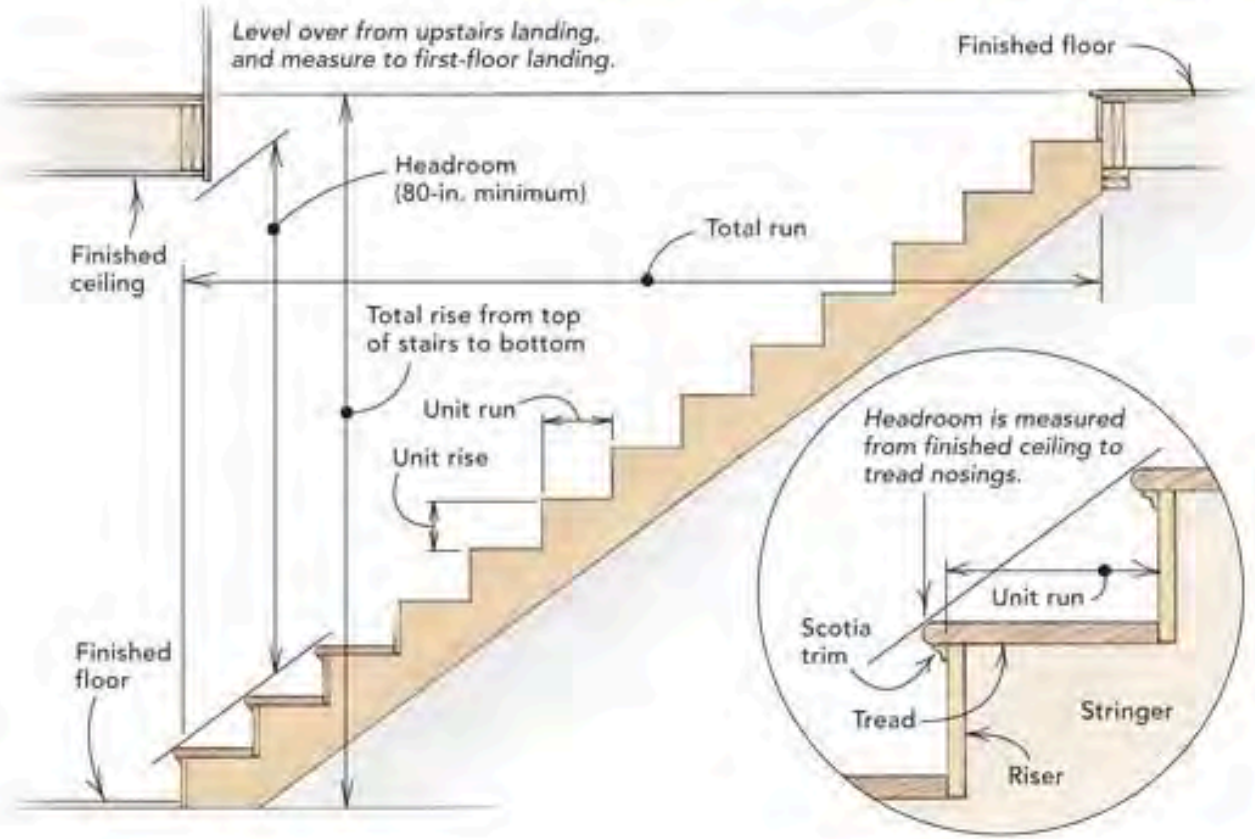
STAIR FORMULAS

Two formulas commonly are used to determine the proportions for interior residential stairs. The first, and most common, is (2 x rise) + (1 x run) = 25 ±1. This formula is incorporated into some building codes. The other formula is (rise) x (run) = 75 ±3. This formula is used for atypical applications like attic or landscape stairs. The example below shows the calculations for this stairway.



Rise calculations

102⅛	(total rise of stair)
÷ 7	(approximate riser height)
14+	(number of risers)
102⅛	(total rise of stair)
÷ 14	(number of risers)
7 5/16	(exact riser height)

Run calculations

(2 x rise) + (1 x run) = 25 ±1
14⅝ + (1 x run) = 25 ±1
25 – 14⅝ (2 x rise) = 10⅜ ±1
(Run can range from 9⅜ to 11⅜)

13 unit runs @ 10⅛ = 131⅝ total run

STAIRS

stair design process

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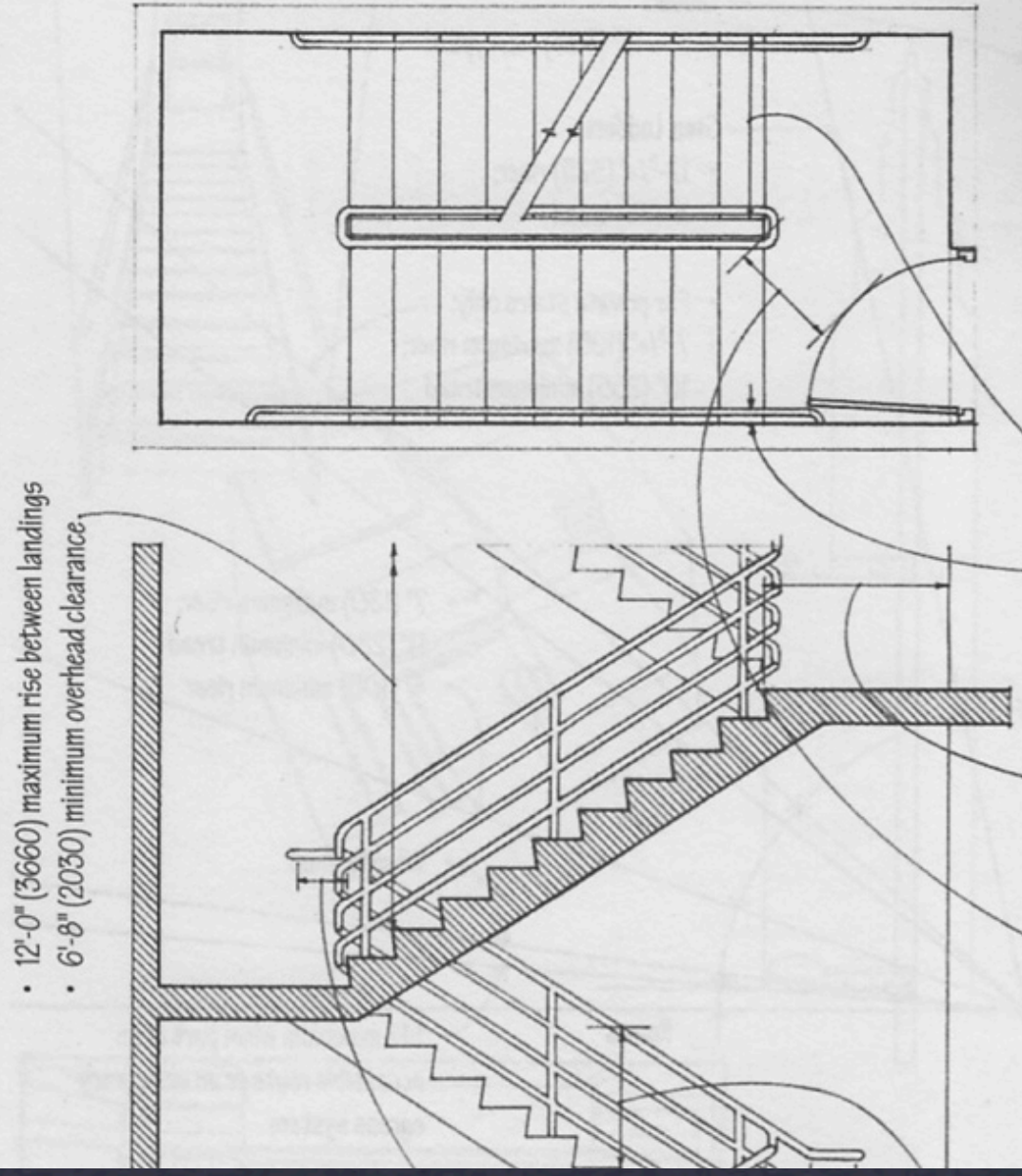

Stairway design is strictly regulated by the building code, especially when a stairway is an essential part of an emergency egress system. Because an accessible stairway should also serve as a means of egress during an emergency, the ADA accessibility requirements illustrated on the next page are similar to those of an emergency egress stairway.

Stairway Width

- The occupant load, which is based on the use group and the floor area served, determines the required width of an exit stairway. Consult the building code for details.
- 44" (1120) minimum width; 36" (915) minimum for stairways serving an occupant load of 49 or less.
- Handrails may project a maximum of 4-1/2" (115) into the required width; stringers and trim may project a maximum of 1-1/2" (38).

Landings

- Landings should be as least as wide as the stairway they serve and have a minimum length equal to the stair width, measured in the direction of travel. Landings serving straight-run stairs need not be longer than 48" (1220).
- Door should swing in the direction of egress. Door swing must not reduce the landing to less than one half of its required width.
- When fully open, the door must not intrude into required width by more than 7" (180).

STAIRS code requirements

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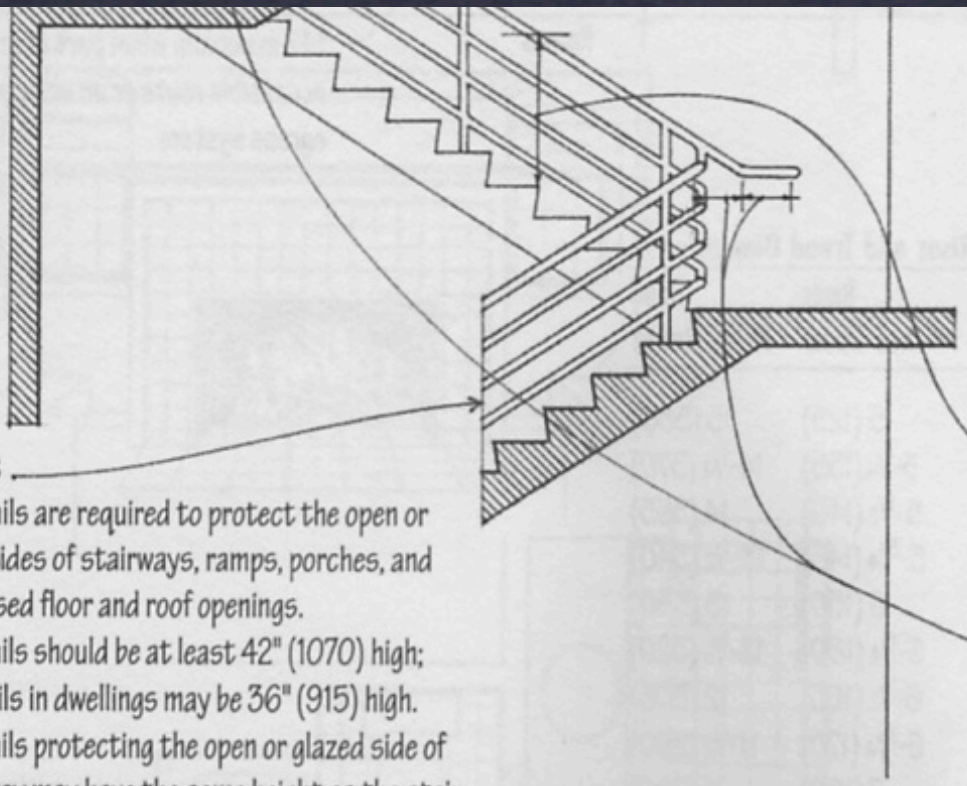

must not reduce the landing to less than one half of its required width.

- When fully open, the door must not intrude into required width by more than 7" (180).

Handrails

- Handrails are required on both sides of the stair. The building code allows exceptions for stairs in individual dwelling units.

Guardrails

- Guardrails are required to protect the open or glazed sides of stairways, ramps, porches, and unenclosed floor and roof openings.
- Guardrails should be at least 42" (1070) high; guardrails in dwellings may be 36" (915) high.
- Guardrails protecting the open or glazed side of a stairway may have the same height as the stair handrails.
- A 4" (100) sphere must not be able to pass through any opening in the railing from the floor up to 34" (865); from 34" to 42" (865 to 1070), the pattern may allow a sphere up to 8" in diameter to pass.
- Guardrails should be able to withstand a concentrated load applied nonconcurrently to their top rails in both vertical and horizontal directions. Consult the building code for detailed requirements.

- 34" to 38" (865 to 965) height above the leading edge of the stair treads or nosings.
- Handrails should be continuous without interruption by a newel post or other obstruction.
- Handrails should extend at least 12" (305) beyond the top riser and at least 12" (305) plus one tread width beyond the bottom riser. The ends should return smoothly to a wall or walking surface, or continue to the handrail of an adjacent stair flight.
- See the next page for detailed handrail requirements.

Treads, Risers, and Nosings

- A minimum of three risers per flight is recommended to prevent tripping and may be required by the building code.
- See the next page for detailed tread, riser, and nosing requirements.
- See 9.03 for tread and riser proportions.

STAIRS code requirements

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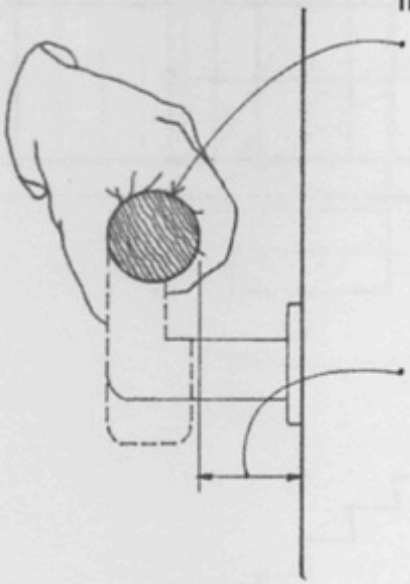
ADA Accessibility Guidelines

Accessible stairs should also serve as a means of egress during an emergency, or lead to an accessible area of refuge where people who are unable to use stairs may remain temporarily in safety to await assistance during an emergency evacuation.

Handrails



- Handrails should be free of sharp or abrasive elements and have a circular cross section with an outside diameter of 1-1/4" (32) minimum and 2" (51) maximum; other shapes are allowable if they provide equivalent graspability and have a maximum cross-sectional dimension of 2-1/4" (57).
- 1-1/2" (38) minimum clearance between handrail and wall

Risers and Treads

- Tread depth: 11" (280) minimum
- Riser height: 4" (100) minimum; 7" (180) maximum
- Uniform riser and tread dimensions are required.
- Open risers are not permitted.

Nosings

- 1-1/2" (38) maximum protrusion
- 1/2" (13) maximum radius
- Risers should be sloped or the undersides of the nosings should have a 60° angle minimum from the horizontal.

STAIRS

code requirements

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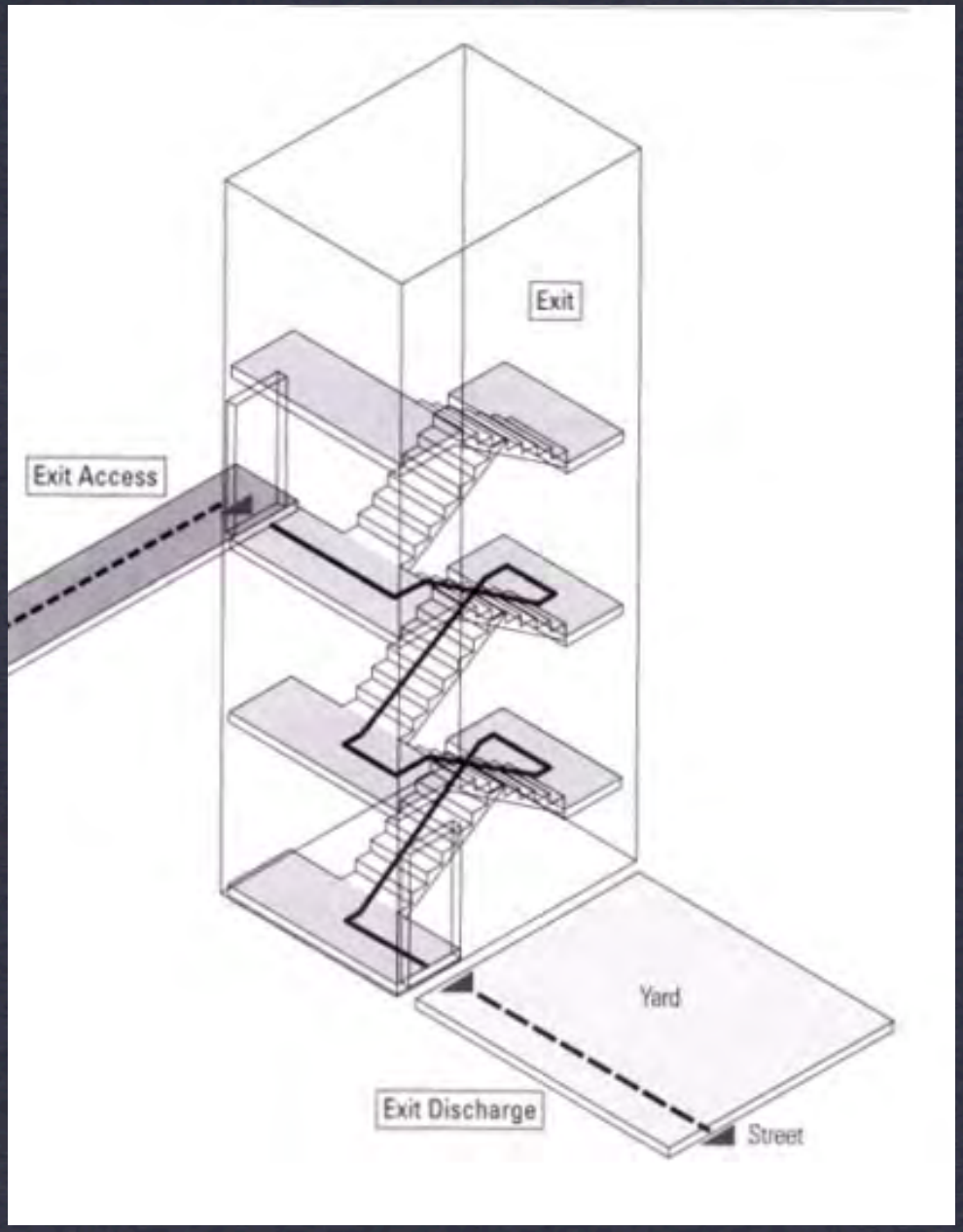

BUILDING CODES

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egress stairs

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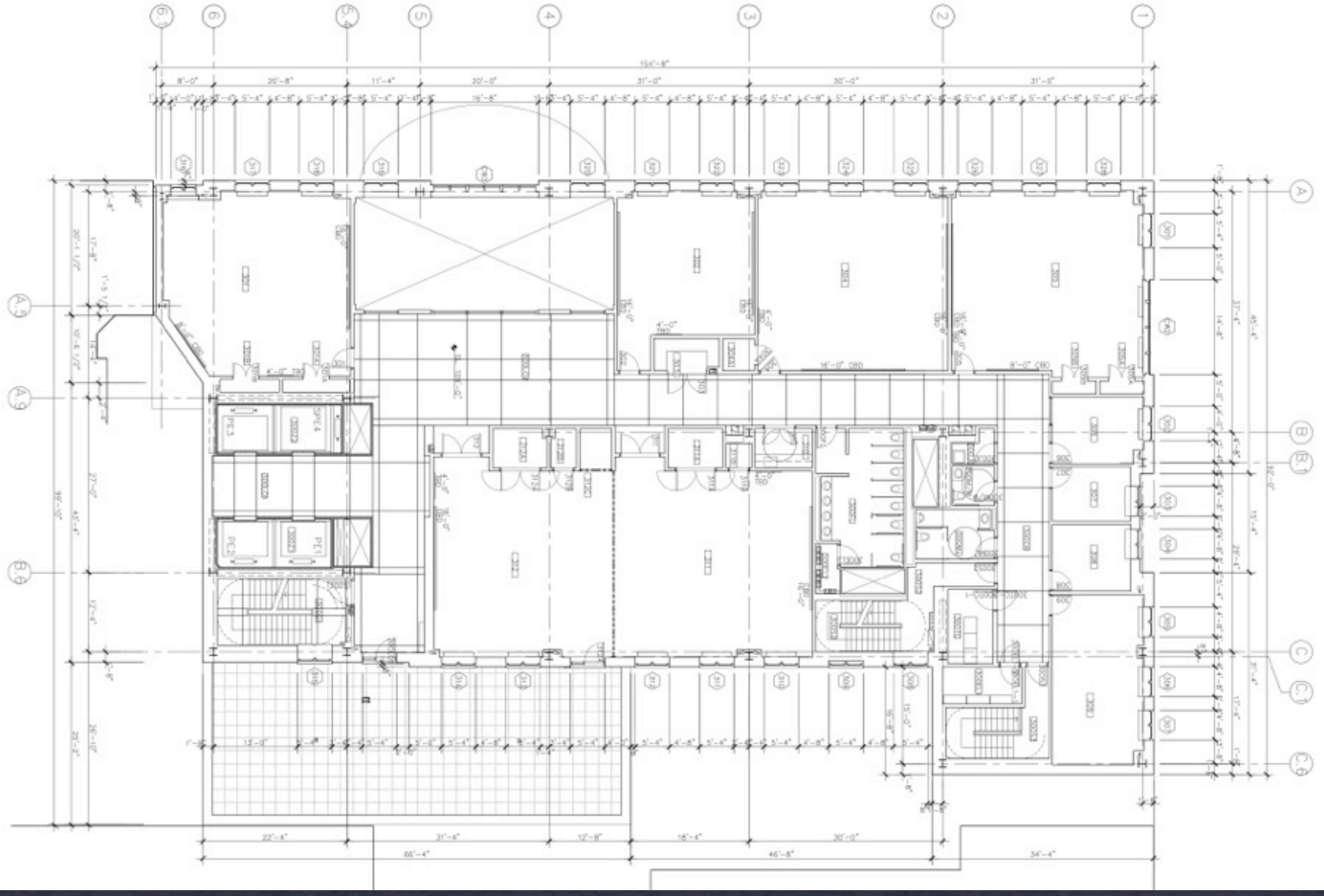

BUILDING CODES

egress stairs (# + placement)

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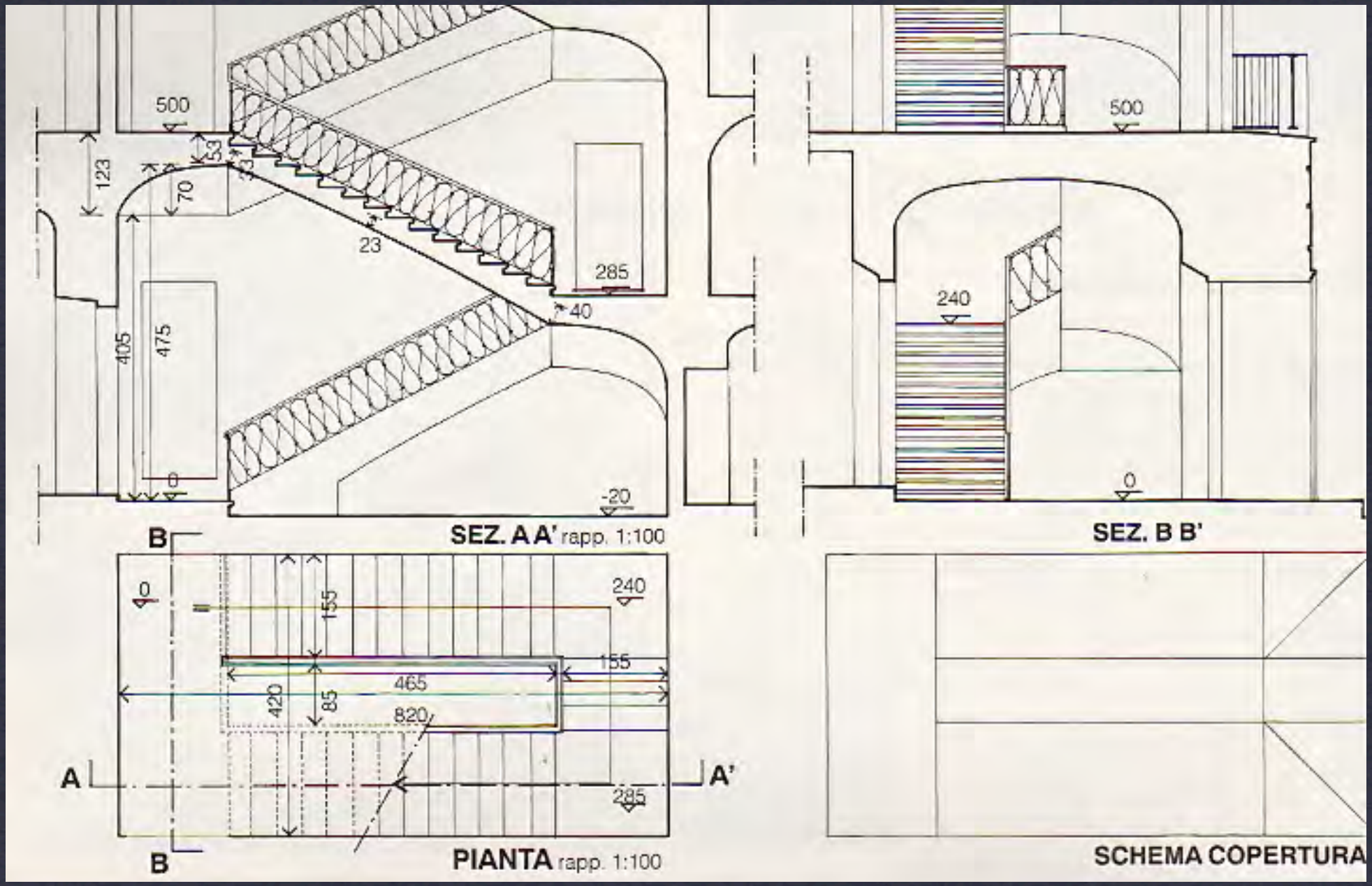

DRAWING STAIRS

multi view coordination

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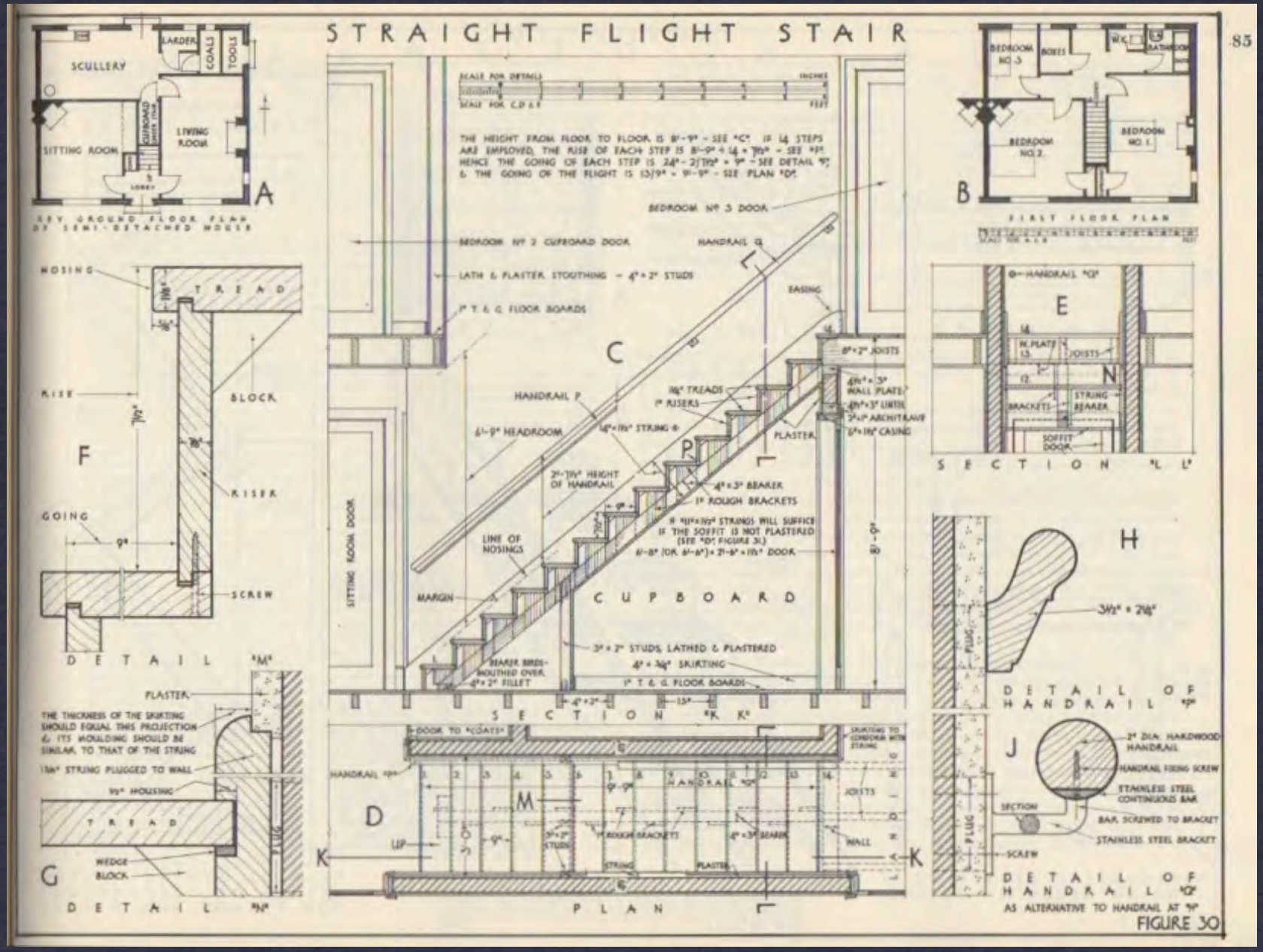

DRAWING STAIRS

resolving details + section + plan

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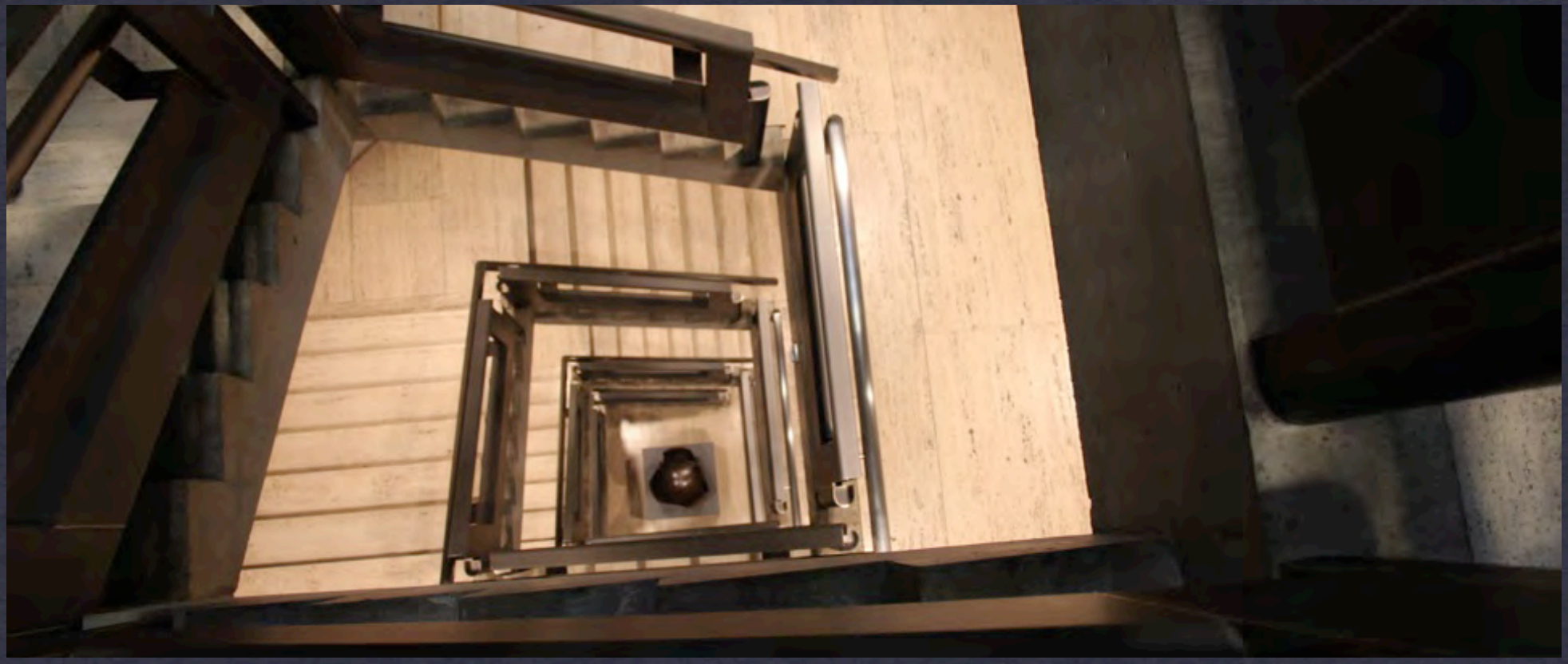
STAIR CONFIGURATION



STAIRS

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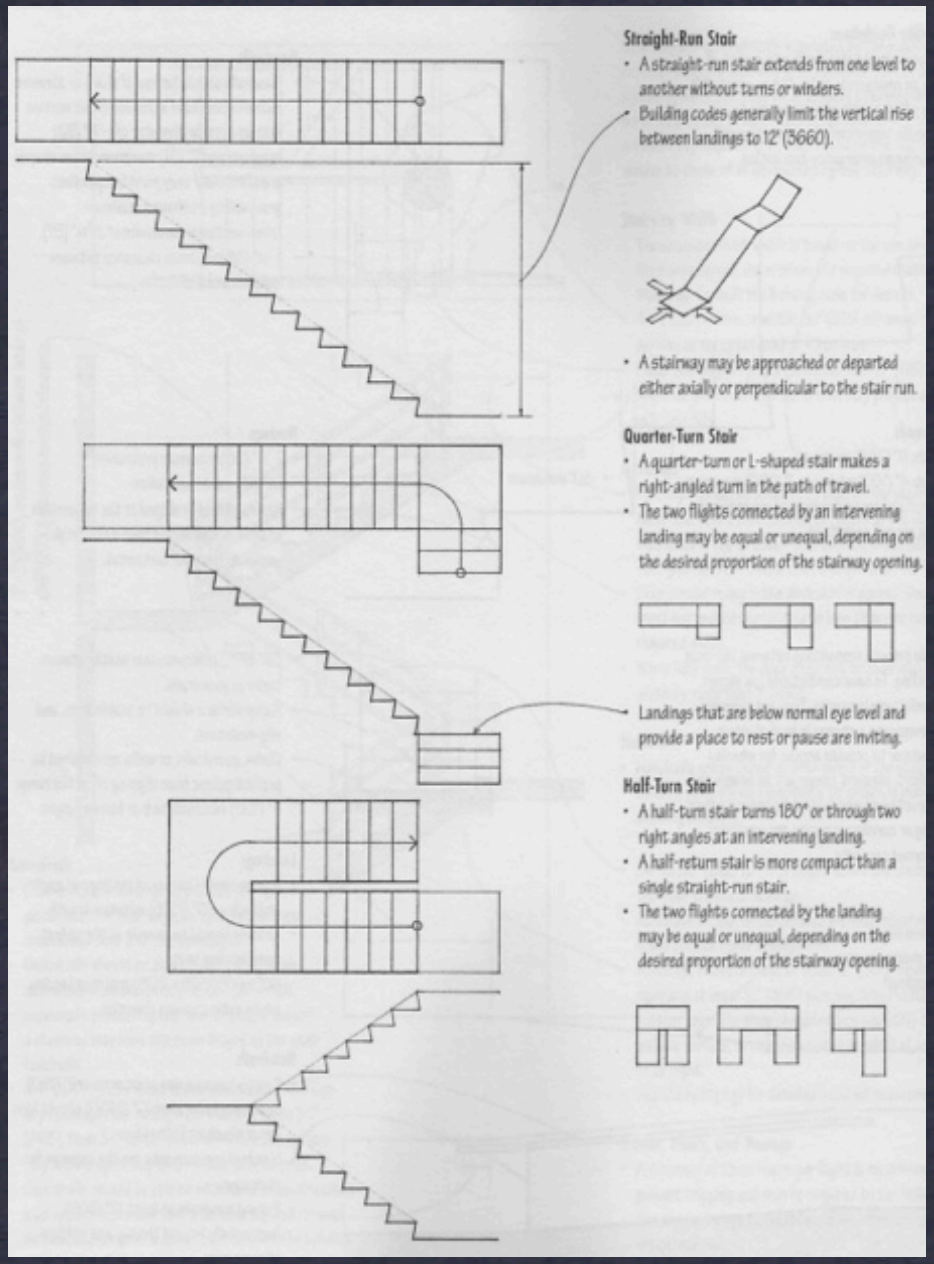

Straight-Run Stair

- A straight-run stair extends from one level to another without turns or winders.
- Building codes generally limit the vertical rise between landings to 12' (3660).
- A stairway may be approached or departed either axially or perpendicular to the stair run.

Quarter-Turn Stair

- A quarter-turn or L-shaped stair makes a right-angled turn in the path of travel.
- The two flights connected by an intervening landing may be equal or unequal, depending on the desired proportion of the stairway opening.
- Landings that are below normal eye level and provide a place to rest or pause are inviting.

Half-Turn Stair

- A half-turn stair turns 180° or through two right angles at an intervening landing.
- A half-return stair is more compact than a single straight-run stair.
- The two flights connected by the landing may be equal or unequal, depending on the desired proportion of the stairway opening.

Winding Stair

- A winding stair is any stairway constructed with winders, as a circular or spiral stair. Quarter-turn and half-turn stairs may also use winders rather than a landing to conserve space when changing direction.
- Winders can be hazardous since they offer little foothold at their interior corners. Building codes generally restrict the use of winders to private stairs within individual dwelling units.

Winders must have the required tread dimension at a point 12" (305) in from the narrow end of the treads.

6" (150) minimum at the narrow end of the treads

Circular Stair

- A circular stair, as its name implies, has a circular plan configuration. Even though a circular stair is constructed with winders, the building code may allow its use as part of the means of egress from a building if its inner radius is at least twice the actual width of the stairway.

10" (255) minimum at the narrow end of the treads

The inside radius should be at least twice the actual width of the stair.

Spiral Stair

- A spiral stair consists of wedge-shaped treads winding around and supported by a central post.
- Spiral stairs occupy a minimum amount of floor space, but building codes permit their use only as private stairs in individual dwelling units.
- See 9.12 for typical dimensions.

7-½" (190) minimum tread dimension at a point 12" (305) in from the narrow end of the treads.

9-½" (240) maximum riser height

6'-6" (1980) minimum headroom clearance

STAIRS

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stair configurations

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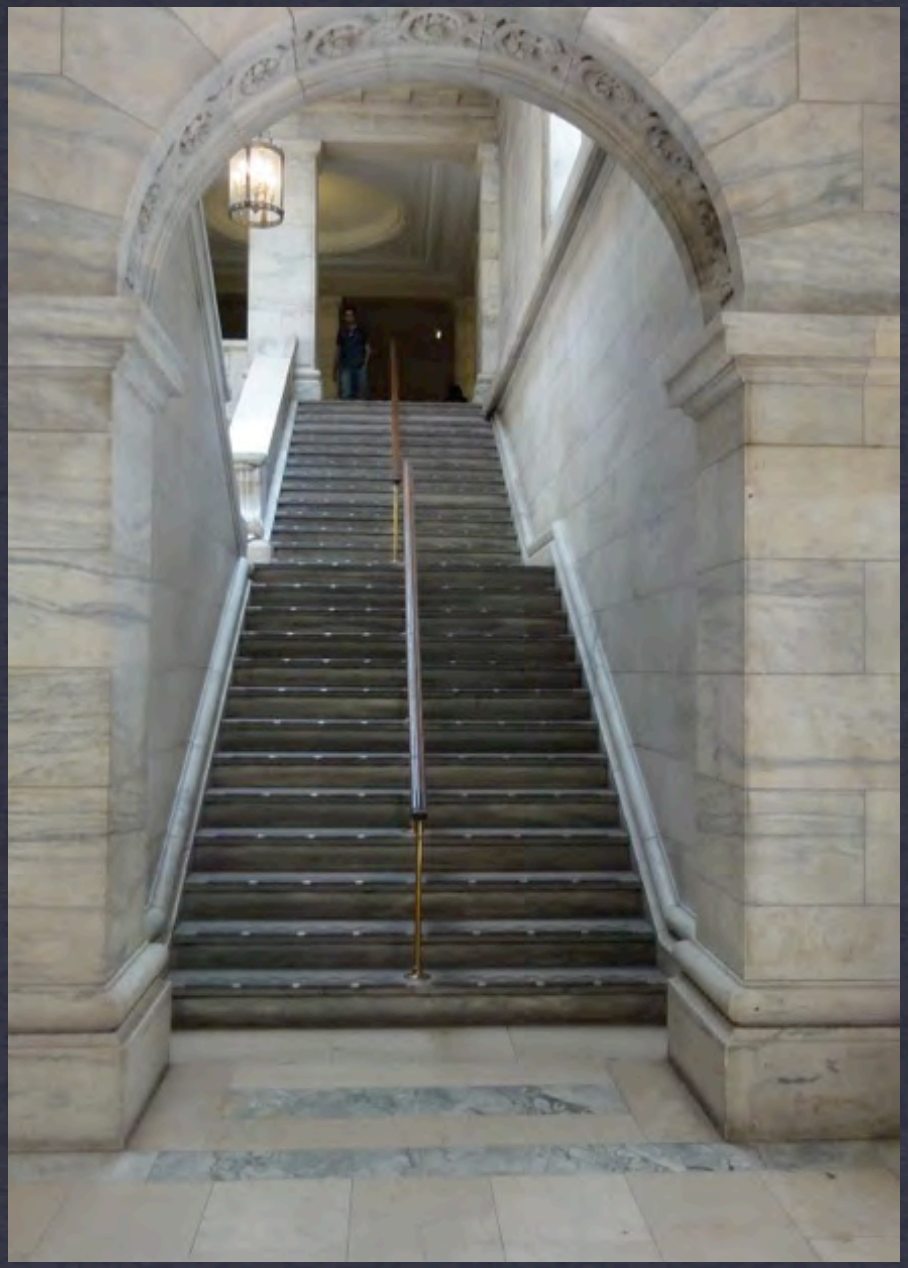

STAIRS

stair configurations_straight run

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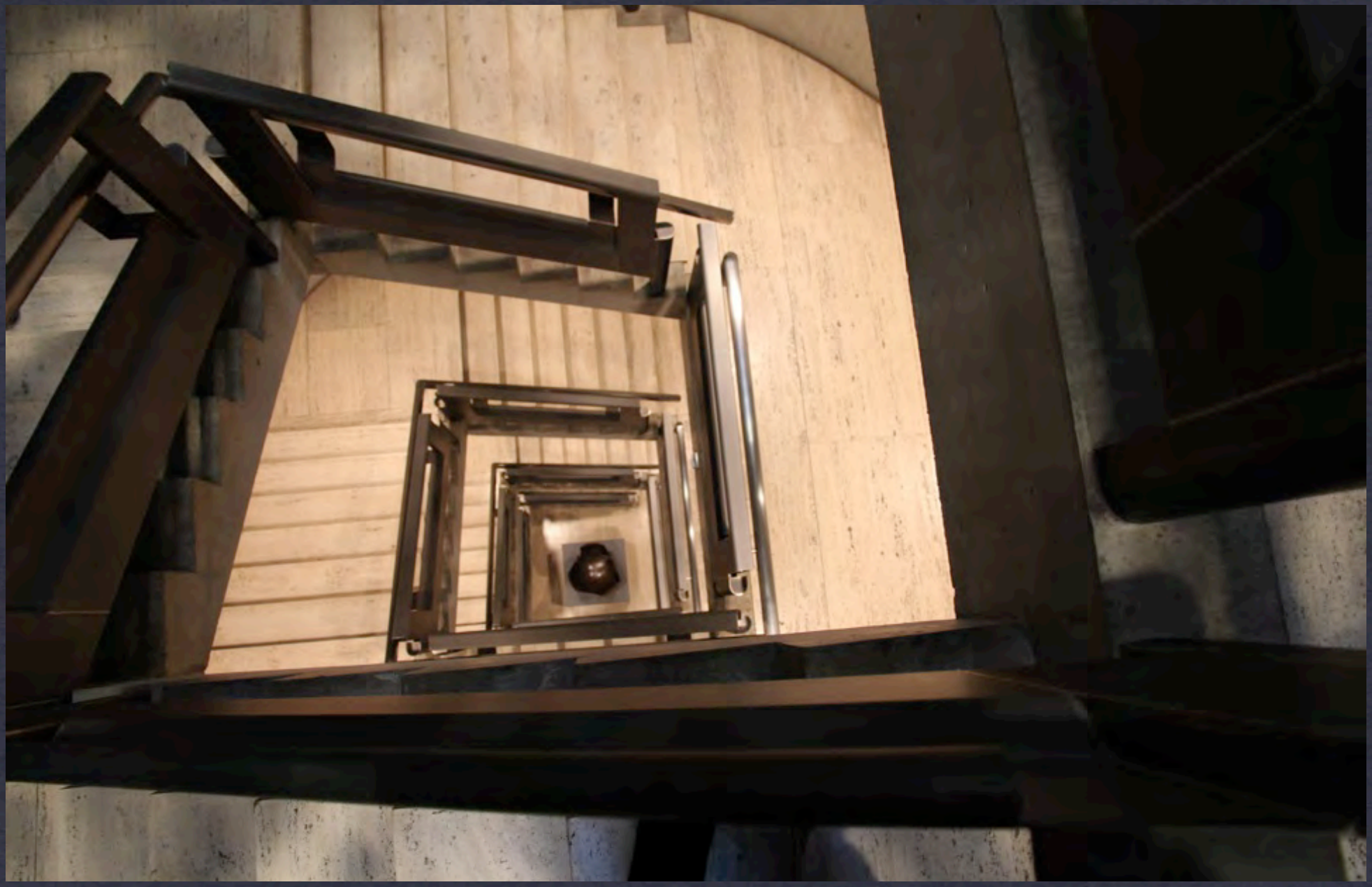

STAIRS

stair configurations_half turn

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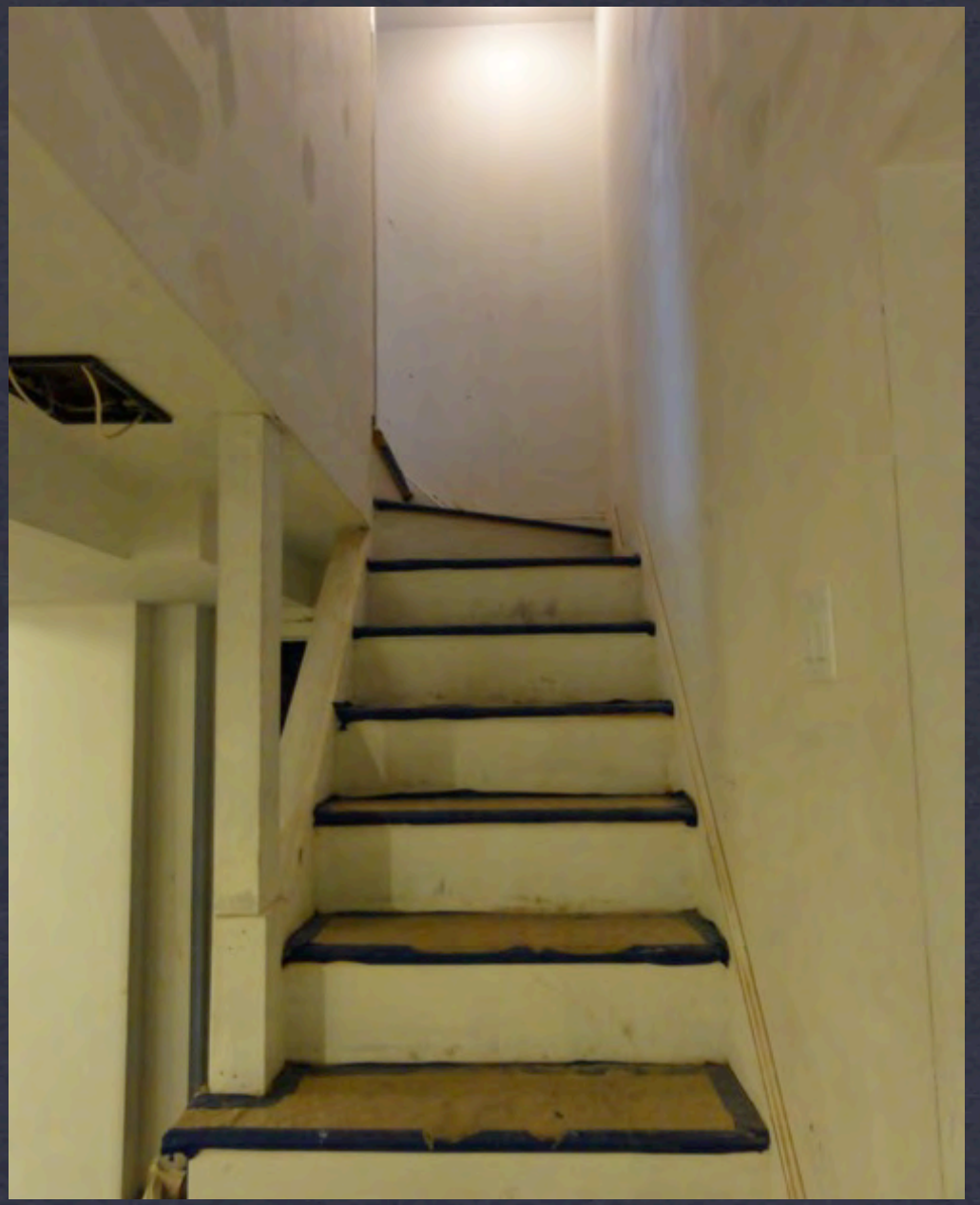

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stair configurations_winding

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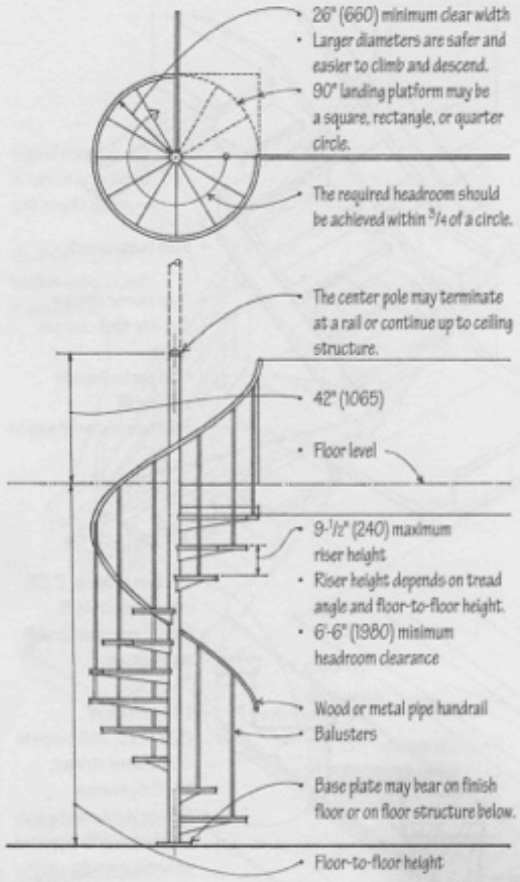
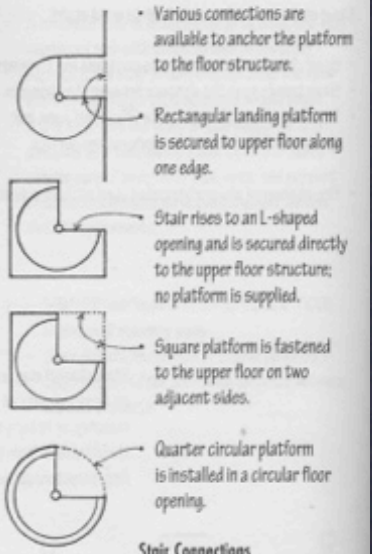
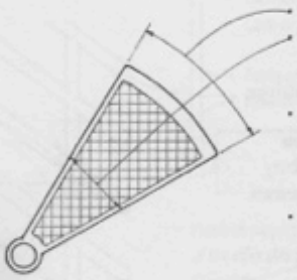


Plan and Elevation



Stair Connections



Stair Treads

Representative Sizes and Dimensions of Spiral Stairs*

Tread angle	No. of treads in 360°	Riser height	Headroom
22-1/2°	16	7" (180)	7'-0" (2135)
27°	13	7-1/2" to 8" (190 to 205)	6'-9" (2055)
30°	12	8-1/2" to 9-1/2" (215 to 240)	6'-9" (2055)

*Consult manufacturer's literature to verify these dimensional guidelines.

Stair Diameter	Well Opening	Landing Size	Width Pole to Rail	Center Pole/ Base Plate Diameter
60" (1525)	64" (1625)	32" (815)	26" (660)	4"/12" (100/305)
64" (1625)	68" (1725)	34" (865)	28" (710)	4"/12" (100/305)
72" (1830)	76" (1930)	38" (965)	32" (815)	4"/12" (100/305)
76" (1930)	80" (2030)	40" (1015)	34" (865)	4"/12" (100/305)
88" (2235)	92" (2336)	46" (1170)	40" (1015)	6"/12" (150/305)
96" (2440)	100" (2540)	50" (1270)	44" (1115)	6"/12" (150/305)

STAIRS

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stair configurations_spiral

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STAIR CONSTRUCTION & DETAILING

STAIRS

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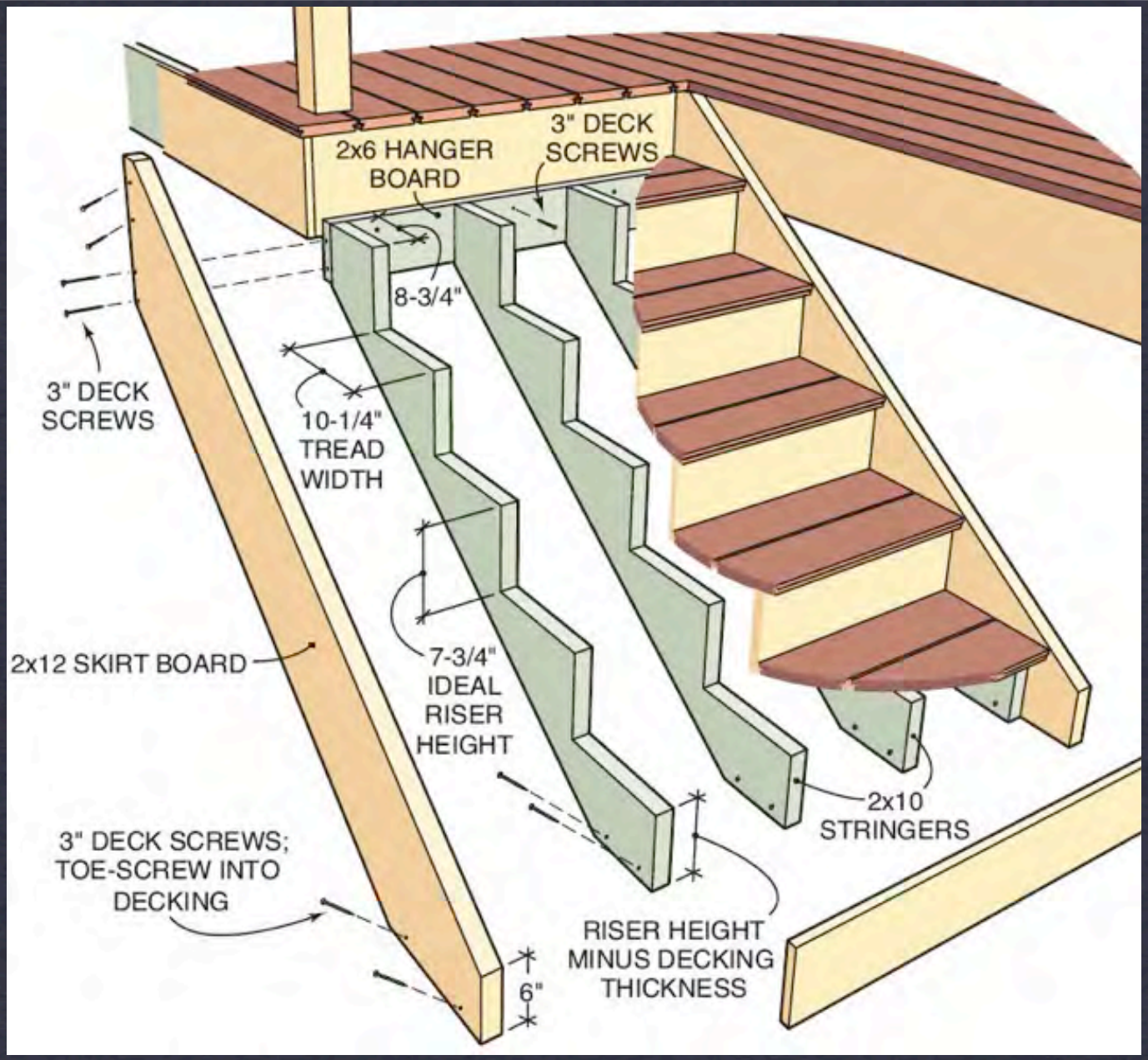

BUILDING STAIRS

wood construction

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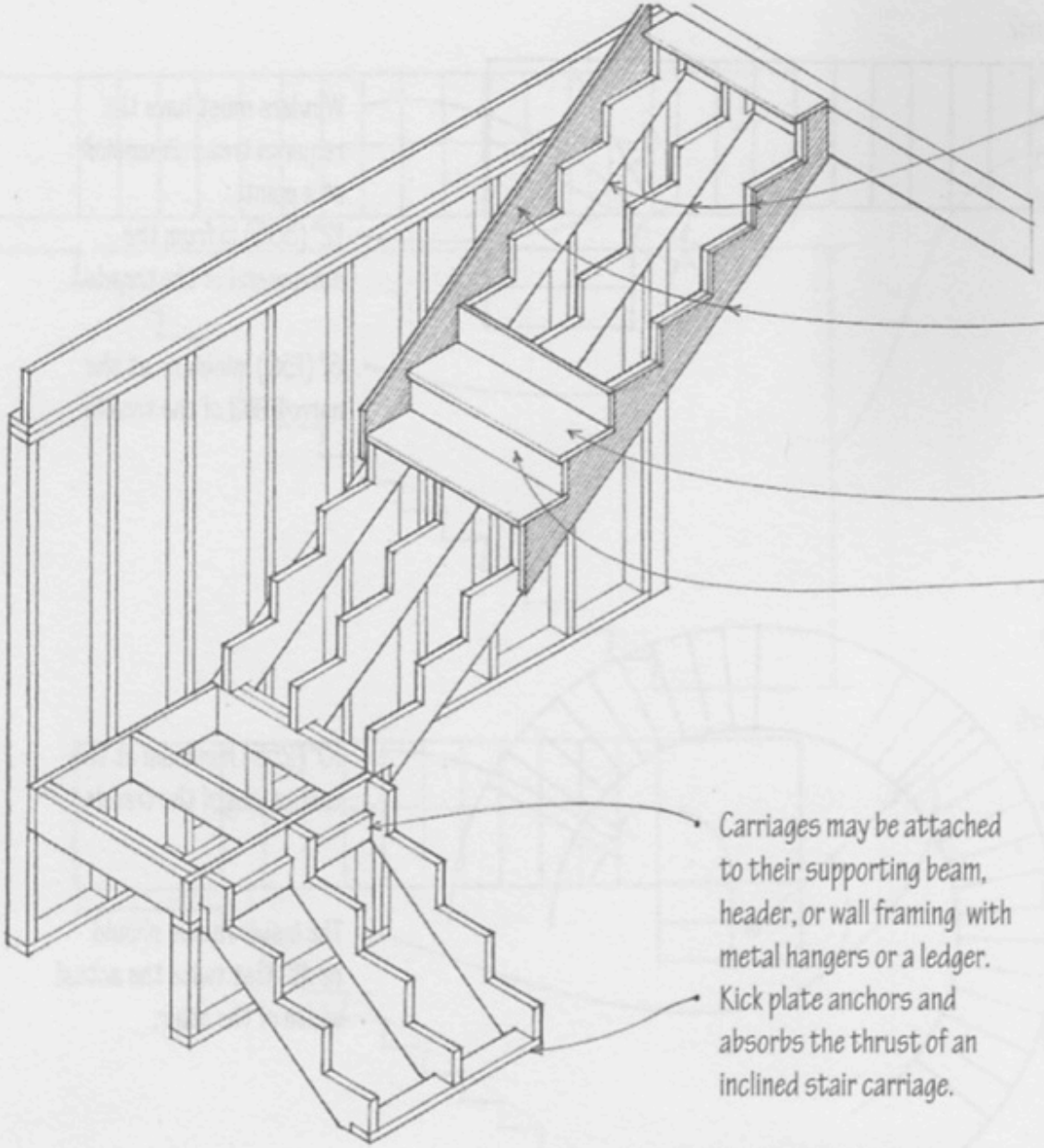

A wood stair is constructed of the following elements:

Carriages or rough stringers are the principal inclined beams supporting the treads and risers of a flight of stairs. The number and spacing of carriages required for a stairway depend on the spanning capability of the tread material.

Stringers are the sloping finish members running alongside a staircase, against which the risers and treads terminate.

Treads are the footways that span the distance between the supporting carriages.

Risers are the vertical boards that close off the stair space and help make the construction rigid; some stairs have no risers.

Carriages may be attached to their supporting beam, header, or wall framing with metal hangers or a ledger.

Kick plate anchors and absorbs the thrust of an inclined stair carriage.

See 9.04–9.05 for handrail requirements.

STAIRS

wood stair construction

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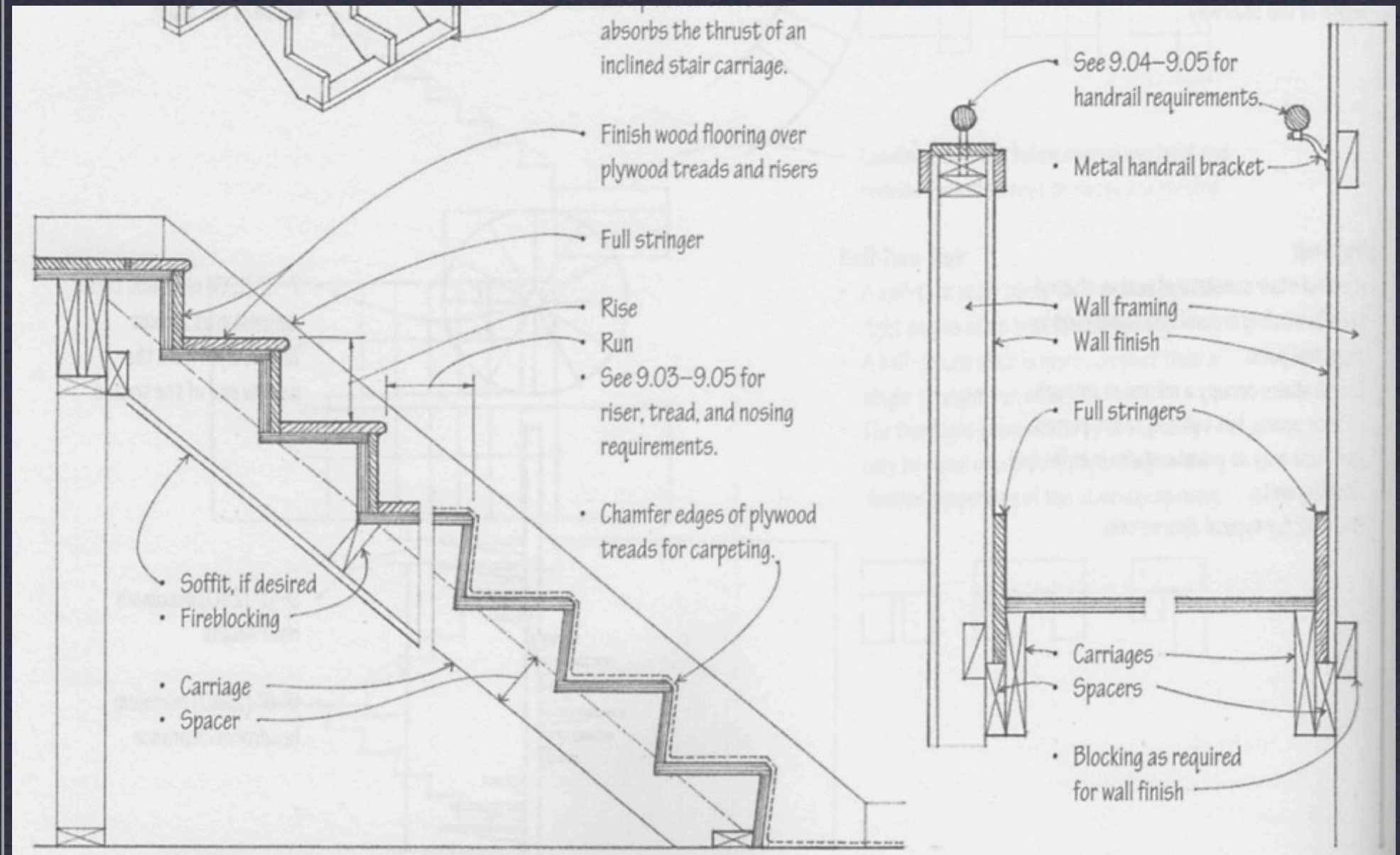
arch 1130



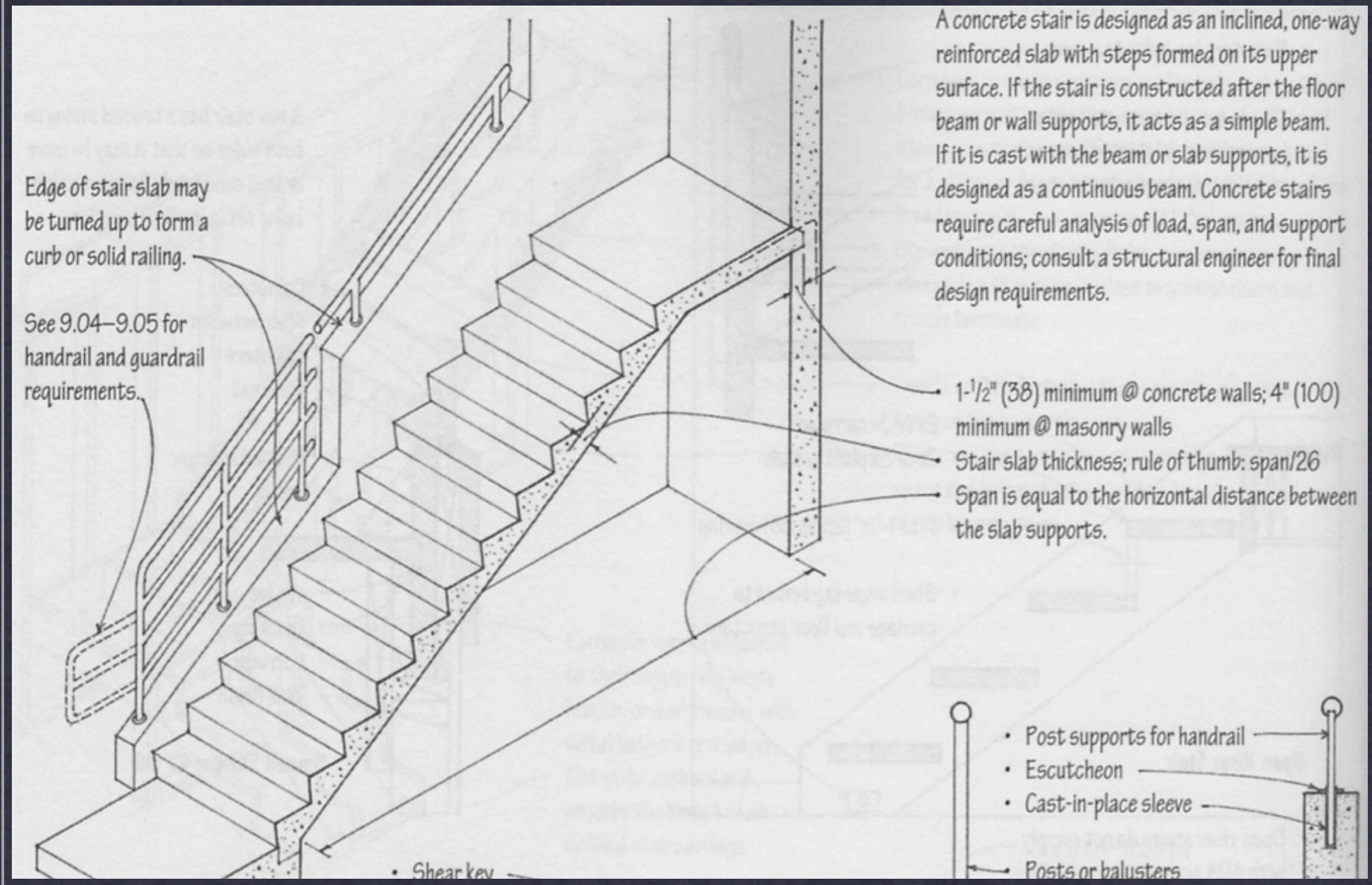
Closed-Riser Stair with Full Stringer

STAIRS

wood stair construction

professor Montgomery

arch 1130



STAIRS

concrete stair construction

professor Montgomery

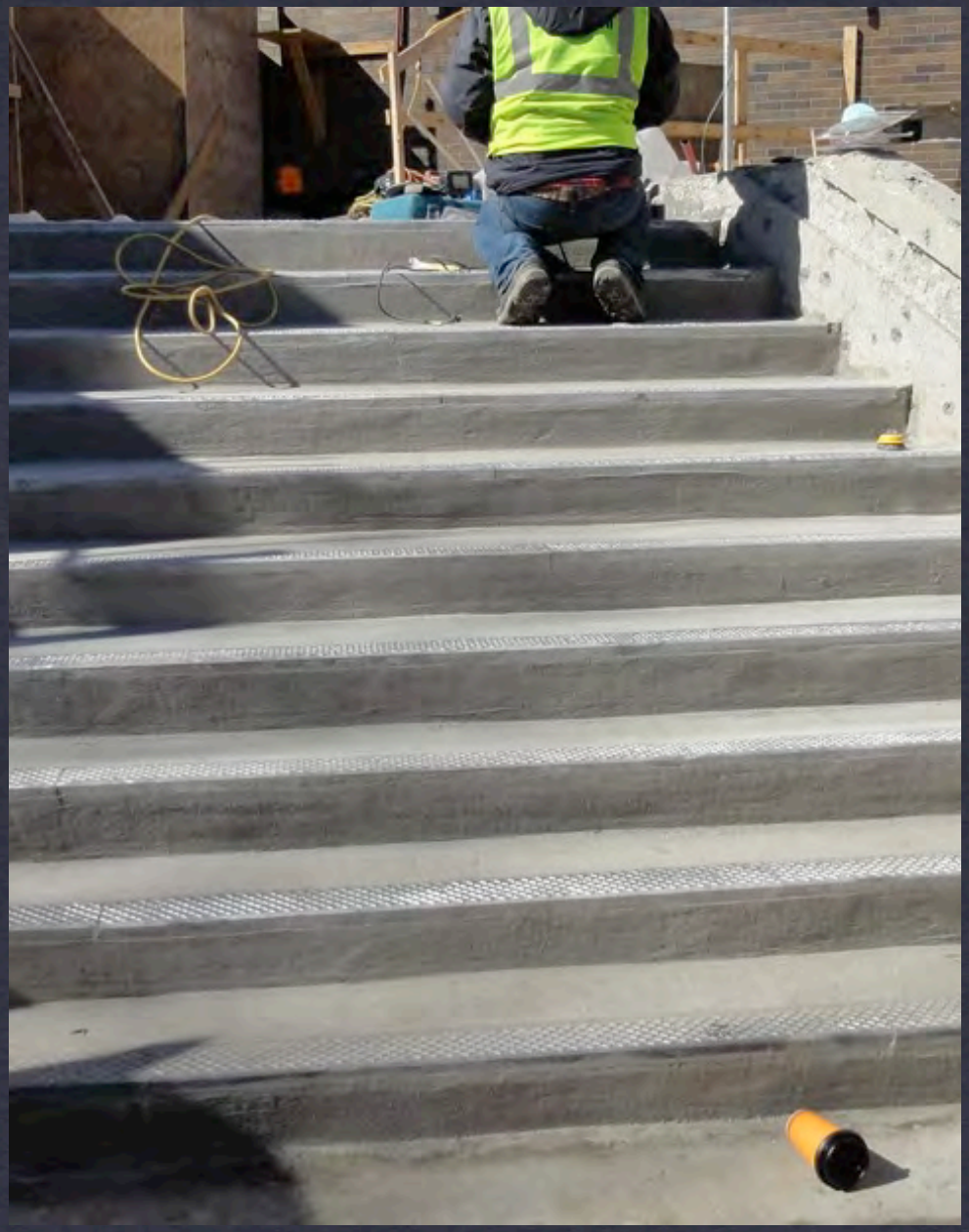
arch 1130

STAIRS

concrete stair construction

professor Montgomery

arch 1130



BUILDING STAIRS

professor Montgomery

concrete construction

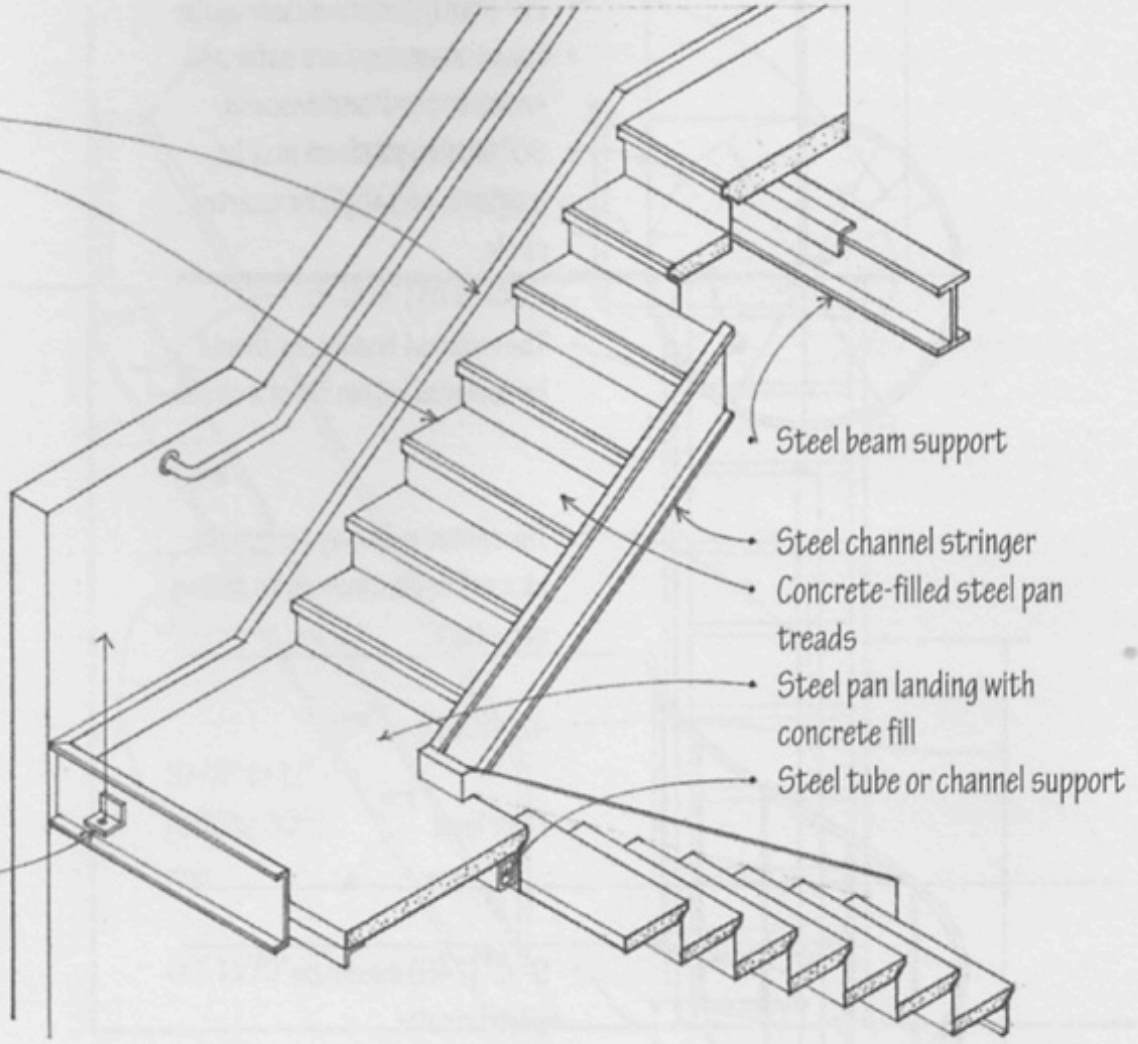
arch 1130

STEEL STAIRS 9.11

Steel stairs are analogous in form to wood stairs.

- Steel channel sections serve as carriages and stringers.
- Stair treads span the distance between the stringers.
- Treads may consist of concrete-filled steel pans, bar grating, or flat plates with a textured top surface.

- Pre-engineered and prefabricated steel stairs are available.



- Steel channel may rest on a bearing plate on masonry, or be hung on threaded rods from the floor structure above.

STAIRS

steel stair construction

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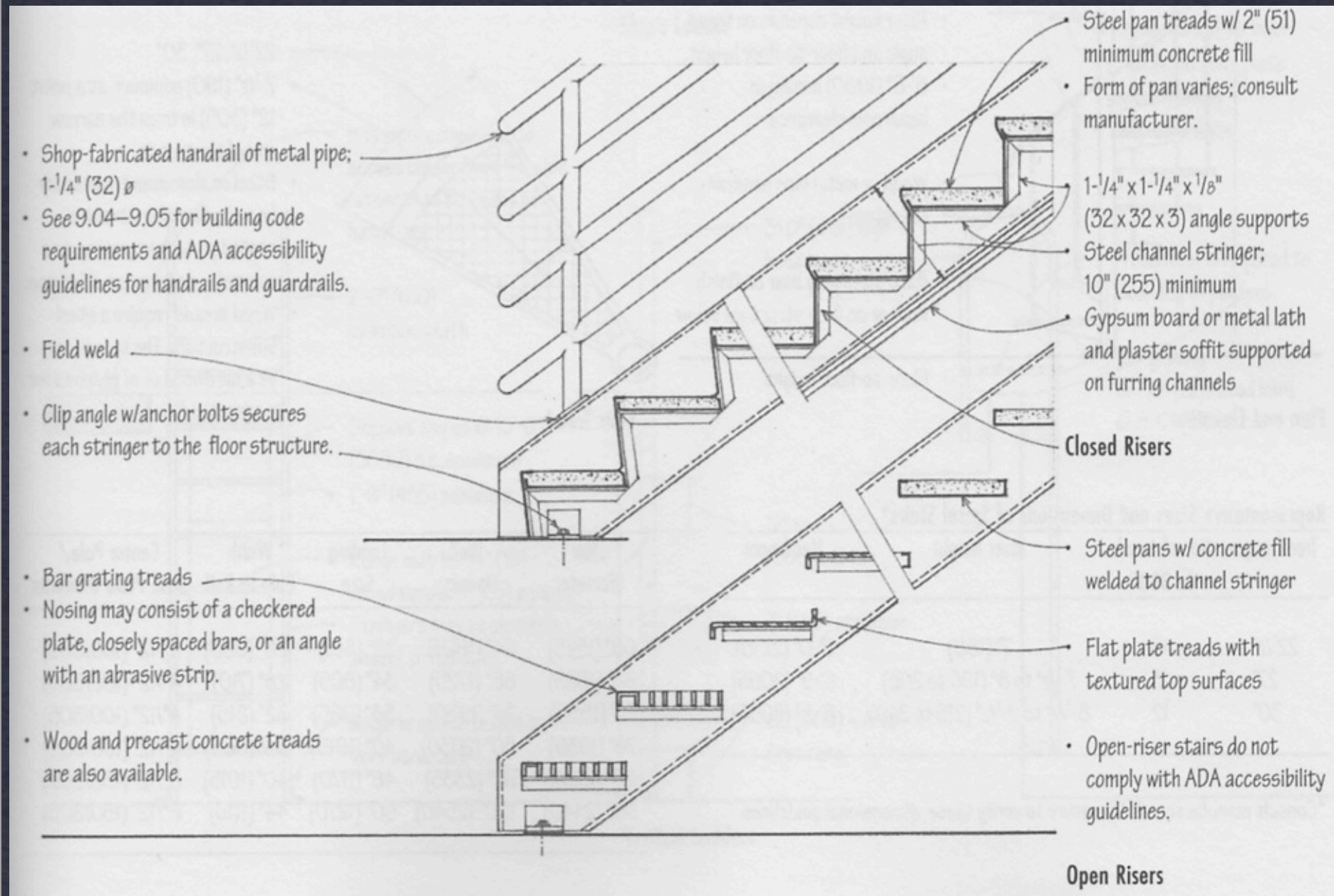

STAIRS

steel stair construction

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STAIRS

steel stair construction

professor Montgomery

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BUILDING STAIRS

steel construction

professor Montgomery

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STAIRS

steel + wood stair construction

professor Montgomery

arch 1130

wrap up

STAIRS ARE WONDERFUL DESIGN OPPORTUNITIES IN BUILDINGS.

THEY PROVIDE THE ARCHITECT WITH AN ELEMENT OF DRAMATIC FLOW AND MOVEMENT VERTICALLY INTO THE UPPER OR LOWER REACHES OF A BUILDING OR A LANDSCAPE

STAIRS REQUIRE GREAT ATTENTION TO DETAIL. MOST IMPORTANTLY, THROUGH ERGONOMIC STUDY, STAIRS MUST ACHIEVE A LEVEL OF COMFORTABLE, EASY USABILITY.