This text introduces subject matter related to the set out and construction of timber stairs. It builds on knowledge and skills acquired during the first stage, which should be revised and practiced throughout the course. Reference may be made to “Basic Building and Construction Skills”, produced by TAFE and Addison, Wesley, Longman Australia Pty Limited, to re-examine and reinforce these basic skills.

The main areas covered are:

Internal and external stairs and associated balustrades. Various stair types are outlined, including dogleg, quarter space and single flights. Internal stairs will have closed risers, handrails and balusters, while the external stairs will be open riser with handrails and guardrails.

BCA requirements are covered to allow for design and construction of residential stairs, including slope relationship formula (2R + G) and maximum spaces between treads to create safe open riser stairs.

Method of setting out, cutting and assembling internal and external stairs is covered as well as the calculation of quantities and cost of materials for both internal and external stairs.

Note: This text only covers stair types and stair requirements for residential construction.

A comprehensive ‘Glossary of Terms’ is included at the end of this text, which provides a detailed description of trade terms, technical content and some trade jargon.
STAIR BUILDING

STAIRS

A stair consists of a number of steps, made up of treads and risers, combined and supported to provide continuous access between floors and/or landings. It may also be referred to, more commonly, in the plural sense as a ‘Stairway’.  

Note: It is preferable to use the terms Stair or Stairway as opposed to Staircase, which originally referred to the space in which a flight was built.

Fig. 1 Stairs for residential construction
DEFINITIONS - Stair Types

**Bracketed stair:** Also referred to as ‘Cut and bracketed’, it is a stair with strings having the shape of treads and risers cut out on the top edge and fitted with an ornamental bracket, or fret work, underneath.

**Circular stair:** A stair with or without a central well having steps, which radiate from a common centre.

**Closed stair:** A stair, which has side walls or partitions on both sides and is usually closed by a door at one end. It may also be referred to as a ‘Boxed stair’, or an ‘Enclosed stair’.

**Closed string stair:** A stair in which the treads are not visible in a side view of the stair flight.

**Dogleg stair:** Also referred to as a ‘Half-turn stair’, it is a stair with two flights between storeys, which are connected by a rectangular half landing for a 180° turn. The outer strings of each flight are housed into a common newel post, which does not allow for any stairwell.

**Geometric stair:** A continuous sweeping or flying stair, with no newel posts or landings, having a continuous curved string and handrail. It may be designed to fit a semicircular or elliptical stairwell.

**Helical stair:** A stair with a circular plan where all the treads are winders. This stair is also known as a ‘Spiral stair’ or ‘Winding stair’.

**Open newel stair:** An open stairwell with two landings between floors, short flights between landings, and newel posts at the corners.

**Open riser stair:** A stair consisting of strings and treads with no riser boards between treads, thus leaving the risers open.

**Open stair:** A stair, which is not enclosed by walls or separated from the space where it is placed.

**Open string stair:** A stair with a cut string to the shape of the risers and treads, on one or both sides, facing the stairwell.

**Quarter turn stair:** A stair with two flights at right angles to each other with a quarter space landing between them.

**Return flight stair:** A dogleg stair where the outer strings of each flight are vertically above each other.

**Spine string stair:** An open riser steel stair with a single central spine (spine string) and welded tread supports.

**Winding stair:** A circular or curved stair, which changes direction by means of winders, with or without landings.
Common Stair types

Stairs may be designed in a variety of forms to provide practicality, function, decoration and/or aesthetic appeal. Some of the types available are as follows:

Fig. 2 Straight open-riser

Fig. 3 Dogleg

Fig. 4 Quarter turn

Fig. 5 Geometrical circular

Fig. 6 Spiral or Helical
MATERIALS USED FOR STAIRS

Stairs may be constructed from a wide range of materials, which include stone, brick, timber, steel, concrete and/or combinations of these.

STONE

This was probably the first material used for purpose made stairs in the history of building. Evidence of this can be seen in such early structures produced firstly by the Egyptians in many of their temples and sarcophagi (burial tombs), then the Greeks in structures found at the Acropolis, followed by the Romans in structures like the Colosseum and the Forum Romanum. Spiral stone stairs were also very popular throughout history with many being used in medieval English castles through to more modern Spanish structures, as found in the towers of Antonio Gaudi’s Sagrada Familia in Barcelona.

Fig. 7 Detail of a typical stone spiral stair flight
BRICK

Small flights of solid brick stairs are used externally for access to and from low patios and verandahs. They are usually laid on a concrete strip footing on either side to support the enclosing wing walls and may have treads constructed of brick-on-flat, brick-on-edge or a rendered brick finish. Dry pressed bricks are preferred for brick stairs and steps as they don’t have holes through them, like the extruded types, and may be laid frog down to provide a neat finish.

CONCRETE

Reinforced concrete stairs are more commonly found in commercial construction, however this method of construction may also be used in residential buildings where the upper floor is also concrete. The most common use of concrete stairs in residential construction, is externally from balconies and verandahs.
STEEL OR IRON

Steel stairs are more commonly associated with external commercial fire stairs, however they may also be used internally.

The most common construction type is the spiral stair, used in many Victorian period buildings where narrow building designs only provided compact areas for stairs.

Spiral stairs had a revival during the 1960’s and early 70’s in many contemporary cottages, although they were simplified in design and detail using a steel spine and handrail, supporting timber treads.

Some newer versions are of all timber construction using modular units and spacers to construct the flight.

The tread width in the slope relationship, i.e. the preferred going width to step rise, is calculated at 7/10 (seven tenths) of the distance between the outside of the centre pole and the inside of the handrail. This allows a person to ascend or descend the flight safely and easily.

Fig. 10 Typical elevation and plan of an iron spiral stair
OTHER TYPES

Straight flight steel stairs are most commonly used in commercial work as fire stairs and catwalks. They are normally constructed of galvanised steel with chequer-plate treads and landings, having open risers.

Combinations of steel and timber may be used for internal stairs or steel and precast concrete treads for external use. The usual method of design is to have a steel spine or carriage piece with welded angular brackets, to support and provide fixing for the treads. Solid or laminated timber may be used for the treads and the handrails are typically made of fabricated steel.
TIMBER STAIRS

Timber stairs are probably the most common form of stair found in a residential building. They comprise of strings, treads, risers, landings and handrails and are normally closed riser construction, for internal use, and open riser construction for external use. Where the treads and risers are to be covered with carpet the base material may be of structural particleboard or MDF (Medium Density Fibreboard). Timber stairs, which are to be stained or clear finished, are normally made from hardwood timbers, as they provide the best resistance to wear and tear. Commonly used timbers may include meranti, brushbox, Sydney bluegum, jarrah, grey gum, turpentine and many other species. Naturally soft timbers, such as most of the conifers, should be avoided for traffic areas.
PARTS OF TIMBER STAIRS

**String:** There may be one or two strings to a flight, which are the inclined sides of the stairs designed to carry the load transferred from the treads and risers.

**Tread:** This is the wide horizontal member between strings to form the top of the step.

**Riser board:** This is the narrow horizontal member between strings to form the vertical face of each step.

**Nosing:** This is the rounded front edge of the tread, which projects past the face of the riser board. Its purpose is to finish the tread edge and widen the tread to prevent the riser from being kicked or scraped.

**Glue blocks:** Triangular blocks of timber fitted under the back of the tread/riser connection to hold the two together.

**Wedge:** These are tapered lengths of timber driven into prepared tapered housings in the string, placed behind the riser and under the tread to ensure a tight top side gap-free fit.

**Newel post:** This is an upright post, to which the strings and handrail are attached.

**Handrail:** A rail fixed between newel posts parallel to the top edge of the string, to provide a safety rail for stair users.

**Balusters:** These are the small sectioned vertical members, with a Max. 125mm opening size placed between the handrail and string.

**Balustrade:** This is the whole framing, which comprises of a handrail, balusters, newel posts and string or kick plate for landing balustrades.

**Spandrel:** This is the triangular shaped space formed between the underside of the string and the floor.
LANDINGS
A flight of stairs is limited to 18 risers, before it must have a break. This break may be in the form of another floor level or a landing. A landing may take the following forms:

**Half-space landing:** This is a landing formed between flights at 180° to one another, often referred to as a ‘Dogleg’ stair.
The length of the landing is equal to the width of the flight and the width of the landing is equal to twice the width of the flight, plus a stairwell if required.

![Fig. 15 Half-space landing](image)

**Quarter-space landing:** This is a landing formed between flights at 90° to one another, often referred to as a ‘Quarter-turn’ stair.
The length of the landing is equal to the width of the flight and the width of the landing is also equal to the width of the flight.

![Fig. 16 Quarter-space landing](image)

**Intermediate landing:**
This is a landing formed between flights running in the same direction.
The length of the landing is equal to at least the width of the flight and the width is equal to the width of the flights.

![Fig. 17 Intermediate landing](image)
PROPORTIONS OF STAIRS

When measuring up for stairs, it is important to know the exact measurements of the length and height of the flight, to allow for accurate calculation of the treads and rises. The following proportions must be obtained:

**Rise of Flight:**
This is the vertical distance measured between landings or between finished floor levels.

**Going of Flight:**
This is the horizontal distance measured between the face of the first riser and the face of the last riser.

![Diagram of Rise and Going of Flight](Fig. 18 Rise and Going of a flight)

**Rise of Step:**
This is the vertical distance measured from the top of one tread to the top of the next tread.

**Going of Step:**
This is the horizontal distance measured between the face of one riser and the face of the next riser. *(The nosing is not included in this measurement)*

**Note:** The rise and going proportions must remain the same throughout the flight(s) of stairs.

![Diagram of Rise and Going of Step](Fig. 19 Rise and Going of a step)
BCA COMPLIANCE REQUIREMENTS

Stairs for residential use must comply with the following:

Maximum Risers: The minimum number of risers required to make a flight is two (2) and the Maximum number of risers allowed without a break/landing/floor is eighteen (18).

Risers and Goings: All risers and goings must be equal throughout the flight or connected flights.

Open Risers: Where open risers are used, the gap between the top of one tread and the bottom of the next tread must not exceed 125mm.
Note: 125mm is the estimated minimum size of a young child’s head, which if able to pass through the gap would allow the child’s body to follow.

Spiral Stairs: These stairs must not be wider than 1.0m and must have the allowable tread width for the stair at seven tenths (7/10) of the flight width out from the face of the central support pole.

Flight Width: According to the BCA, there is no maximum or minimum width of a flight for residential construction, however it is suggested that the flight be at least equal to the average width of an adult person’s shoulders, which is 600mm.

Tread Finish: Treads must have a non-slip finish or have a non-skid strip fixed close to the edge of the nosing.

Other critical dimensions are shown on the following diagram:
STAIRS WITH WINDERS

An alternative to a single level landing is the use of ‘Winders’, which are normal treads with a tapered length. They have a constant rise to match the other parallel steps and should have a tread going to match other parallel treads, when measured at the centre of the flight width for flights less than 1.0m wide.

*Note: Flights greater than 1.0m wide should have the tread going measurement at 400mm out from the inside handrail side.*

Where winders are used instead of a landing, the tread size may be different from the parallel treads provided all the winders are the same size and there are is a maximum of only three (3).

![Fig. 21 Layout for stair winders](image)
DETERMINING STEP PROPORTIONS

The accepted formula, as per BCA, for calculating riser and tread dimensions for stairs, often referred to as ‘Easy going stairs’, is twice the rise plus one going, or $(2R + G)$. The result of this calculation must fall between 550mm and 700mm, known as the Slope Relationship.

**TABLE 1**
ACCEPTABLE PROPORTIONS FOR STAIRS

<table>
<thead>
<tr>
<th>RISER (R) (mm)</th>
<th>GOING (G) (mm)</th>
<th>SLOPE RELATIONSHIP (2R+G) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>Max.</td>
<td>Min.</td>
</tr>
<tr>
<td>115</td>
<td>190</td>
<td>240</td>
</tr>
</tbody>
</table>

Calculating Rise and Going for a Flight

The basic information required to calculate the rise and going for any flight of stairs is:

- The rise of the flight;
- Going of flight and whether it is restricted or unrestricted; and
- Basic knowledge of BCA requirements and formula for slope relationship.

**METHOD 1**
The following steps outline the method adopted to calculate the rise and going for a given flight of stairs with an ‘unrestricted’ going:

**METHOD 2**

**STEP 1** Obtain the rise of the flight;

**STEP 2** Assume a suitable rise, when the average rise is $(190 + 115) \div 2 = 153$mm ;

**STEP 3** Establish the number of risers by dividing the assumed rise into the rise of the flight;

**STEP 4** Establish the length of the going by using the average slope relationship measurement, i.e. $(550 + 700) \div 2 = 625$mm, substitute the average rise measurement for ‘R’ in the formula, then transpose the formula to find ‘G’.

The following steps outline the method adopted to calculate the rise and going for a given flight of stairs with a ‘restricted’ going:

**STEP 1** Obtain the rise of the flight;

**STEP 2** Assume a suitable rise, when the average rise is $(190 + 115) \div 2 = 153$mm ;

**STEP 3** Establish the number of risers by dividing the assumed rise into the rise of the flight;

**STEP 4** Establish the length of the going by dividing the assumed rise into the restricted flight going. Check to see if both the rise and going measurements comply, by substituting them for ‘R’ and ‘G’, and apply the formula $(2R + G)$. 

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**Example 1:**

Using ‘Method 1’, calculate the number and size of the rises and goings for a flight of stairs with a rise of flight of 2.650m and an unrestricted going of flight.

**STEP 1**  
Rise of flight = 2650mm

**STEP 2**  
Assume a rise, say average = \((190 + 115) \div 2 = 153\)mm

**STEP 3**  
Number of risers = \(2650 \div 153 = 17.32\) risers  
There must be full equal-sized risers, therefore round off to 17 risers.  
\[ \therefore \text{The height of each riser} = 2650 \div 17 = 155.88\text{mm, say 156mm} \]

**STEP 4**  
The number of goings will be one (1) less than the risers, therefore 16 goings.  
The size of the goings will be based on the average slope relationship measurement  
\[ = (550 + 700) \div 2 = 625\text{mm}. \]

Now substitute the known measurements for the formula symbols:

\[ = (2R+G) = 625 \]
\[ = (312 + G) = 625 \]

Now transpose the formula to find the value of ‘G’:

\[ \therefore 'G' = 625 - 312 \]
\[ = 313\text{mm} \]

Therefore, there will be **17 risers at 156mm** and **16 goings at 313mm**.

*Note: The total length of the flight going will be 16 \(\times\) 313 = 5.008m*
Example 2:

Using ‘Method 2’, calculate the number and size of the rises and goings for a flight of stairs with a rise of flight of 1.900m and a restricted going of flight of 3.350m.

**STEP 1**  Rise of flight = 1900mm

**STEP 2**  Assume a rise, say average = \((190 + 115) \div 2 = 153\text{mm}\)

**STEP 3**  Number of risers = \(1900 \div 153 = 12.418\) risers

There must be full equal-sized risers, therefore round off to 12 risers.

\[ \therefore \text{The height of each riser} = 1900 \div 12 = 158.333, \text{say 158mm} \]

**STEP 4**  The number of goings will be one (1) less than the risers, therefore 11 goings.

The size of the goings will be based on the length of the flight going divided by the number of goings:

\[ = 3350 \div 11 = 304.5, \text{say 305mm} \]

Therefore, there will be **12 risers at 158mm** and **11 goings at 305mm**.

**Check formula for compliance with BCA**

\[ \therefore (2R + G) = (\text{between 550 and 700mm}) \]

\[ = 316 + 305 = 621\text{mm}, \text{therefore it complies.} \]
METHOD OF MEASURING UP for TIMBER STAIRS

The accuracy of the finished product will depend on the accuracy of the initial measuring up on-site. There are several points to consider and critical information to record, as follows:

- Measure the finished floor to finished floor height to establish the rise of the flight, or to determine whether or not a landing will be required between flights. A more accurate method of establishing the rise would be to mark the height onto a rod or batten;
- Check the walls for parallel, square and straight to ensure a proper fit, or to allow for coverstrips where the strings do not fit neatly to the walls;
- Check the position of existing windows to ensure the flight(s) do not pass across an opening;
- Check the going of the flight for restrictions, e.g. doorways, walls, available headroom, etc. and record the going of the flight, as required;
- Note the bearing position for the top of the flight to allow for fixing and finishing of the top riser and nosing, if required; and
- Calculate a suitable rise and going for each step, based on the slope relationship formula, i.e. \((2R + G) = 550\) to \(700\)mm.

Fig. 24 Check on-site details
SETTING OUT THE STRINGS

Once the rise and going of each step is established, carry out the following:

**STEP 1** Select string material, place any bows up and set a margin line from the top edge, for closed strings, to ensure the nosing stays within the width of the string.

![Fig. 25 Set a margin line as required](image)

- String
- Margin line

**STEP 2** Set up a steel square with the calculated rise and going measurements for each step, including the set back distance for the margin line. Start from one end to allow for riser, newel post and point of attachment notch, then mark out all the rise and tread positions.

*Note: These set out positions represent the top of the tread and the face of the rise.*

![Fig. 26 Set out the strings](image)

- Steel square set up for step set out
- Margin line
- String
STEP 3  Set out for the thickness of each rise and tread, including a stopped housing for the end of the tread nosing, ready to be trenched. The strings should be set out and trenched as a pair.

STEP 4  Set out the complete string with allowances for wedges under treads and behind risers, tenons into newel posts and reduction of string length to fit between newel posts.