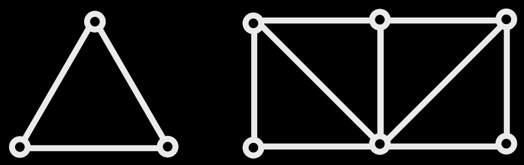
Trusses

- **What is a truss**

  a truss is an assembly of linear members connected together to form a triangle or triangles that convert all external forces into axial compression or tension in its members

- **Single or number of triangles**

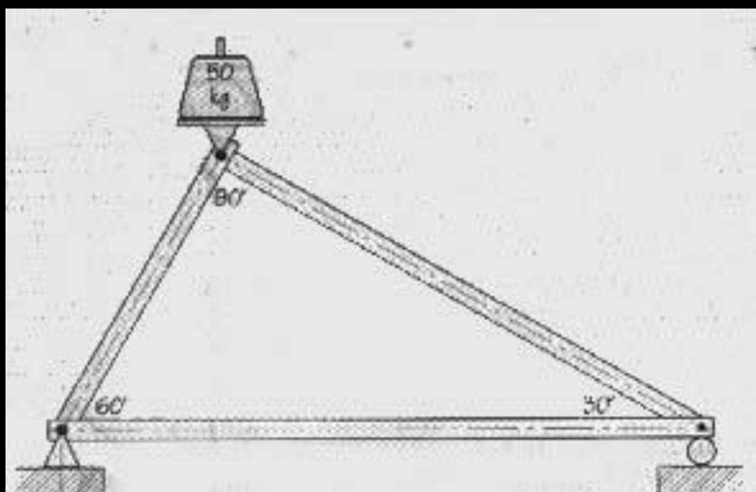
  a triangle is the simplest stable shape

- **Joints assumed frictionless hinges**

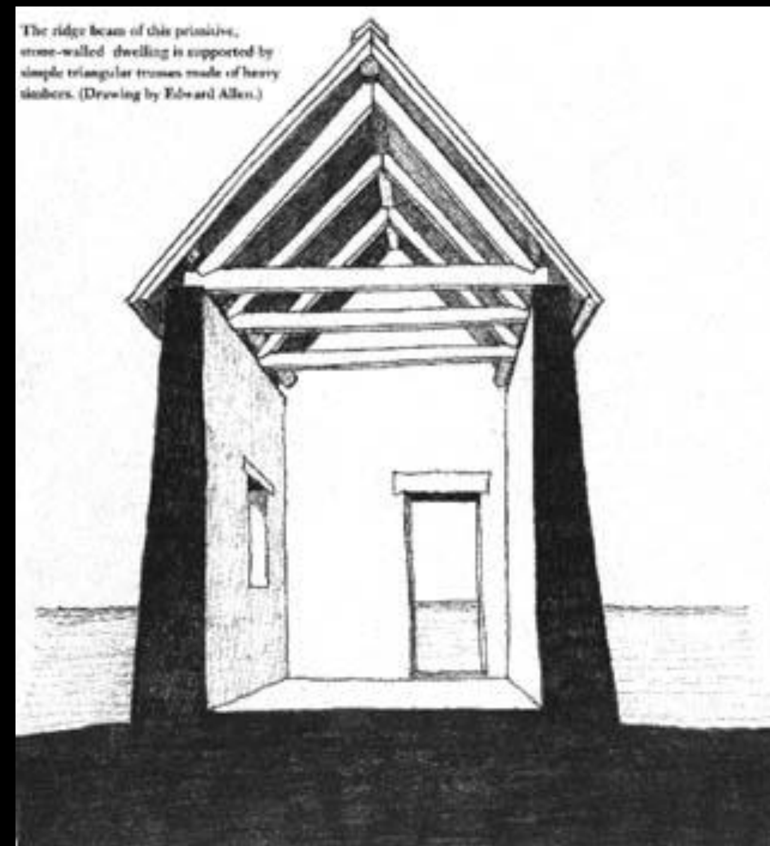
  loads placed at joints

Simple Trusses

Simple Truss



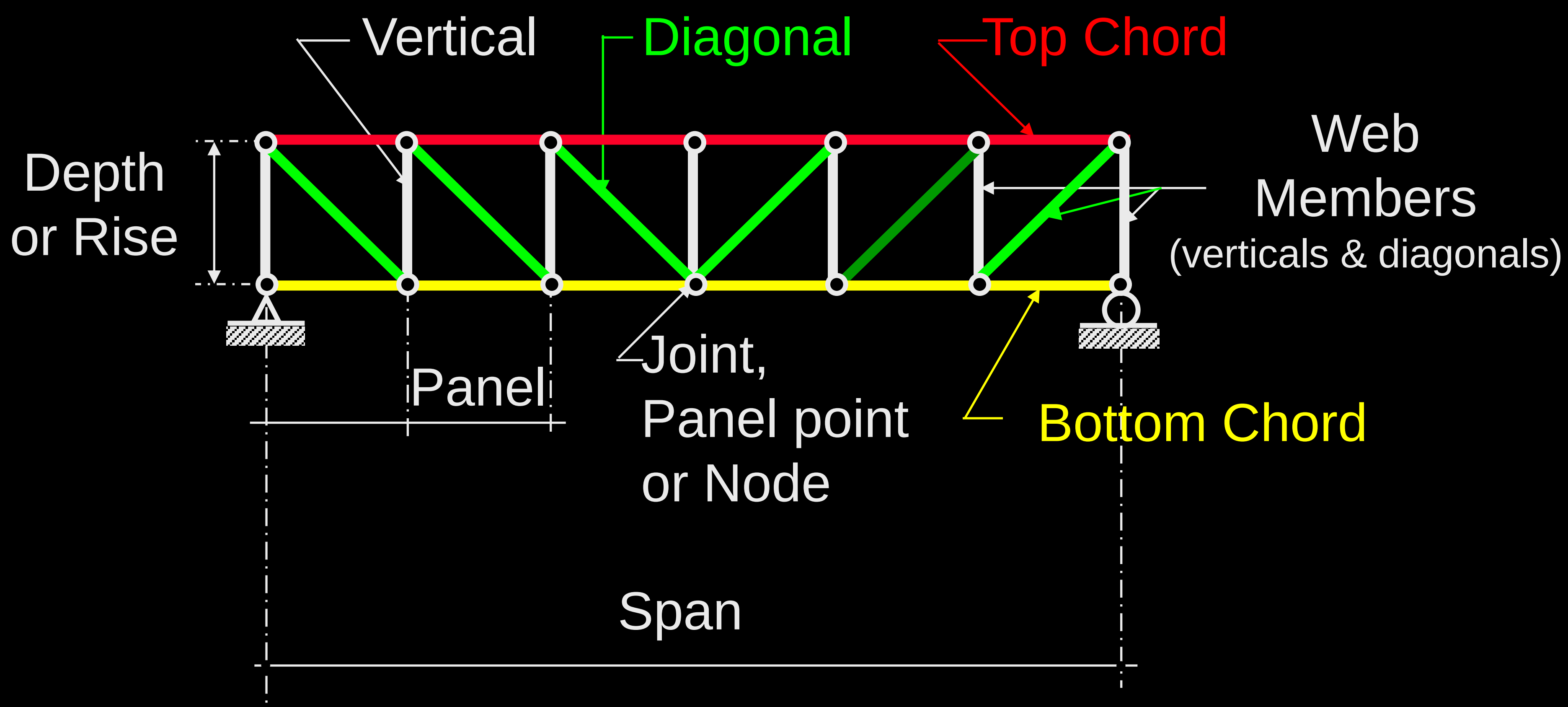
Rafter pair - Joist
simple roof construction
loading along rafters - bending



The ridge beam of this primitive, stone-walled dwelling is supported by simple triangular trusses made of heavy timbers. (Drawing by Edward Allen.)

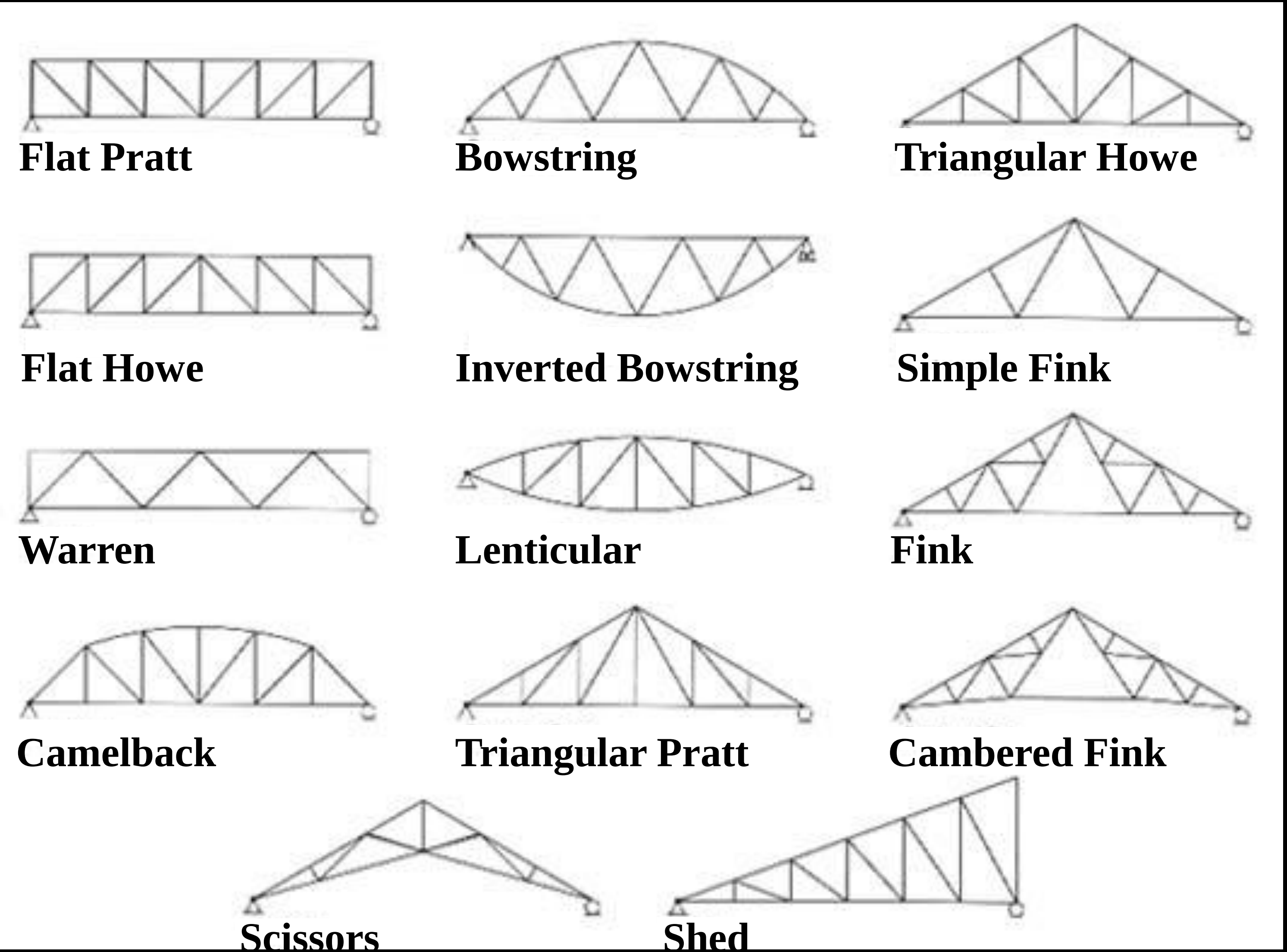
Primitive dwelling
heavy timber trusses

Truss Terminology



Flat Truss or Parallel Chord Truss

Truss Types


Flat Pratt
Bowstring
Triangular Howe
Flat Howe
Inverted Bowstring
Simple Fink
Warren
Lenticular
Fink
Camelback
Triangular Pratt
Cambered Fink
Scissors
Shed

Why Trusses?

- A truss provides depth with less material than a beam
- It can use small pieces
- Light open appearance (if seen)
- Many shapes possible

Multipanel Trusses
Sainsbury Centre

Norwich, England

Foster & Partners
Anthony Hunt Associates

Warren Trusses
Centre Georges Pompidou

Paris

Piano & Rogers
Ove Arup & Partners

Shaping Structures: Statics, W. Zalewski and E. Allen (1998)

3-Hinged Truss Arches
Waterloo Terminal for Chunnel Trains

Nicholas Grimshaw & Partners
Anthony Hunt Associates

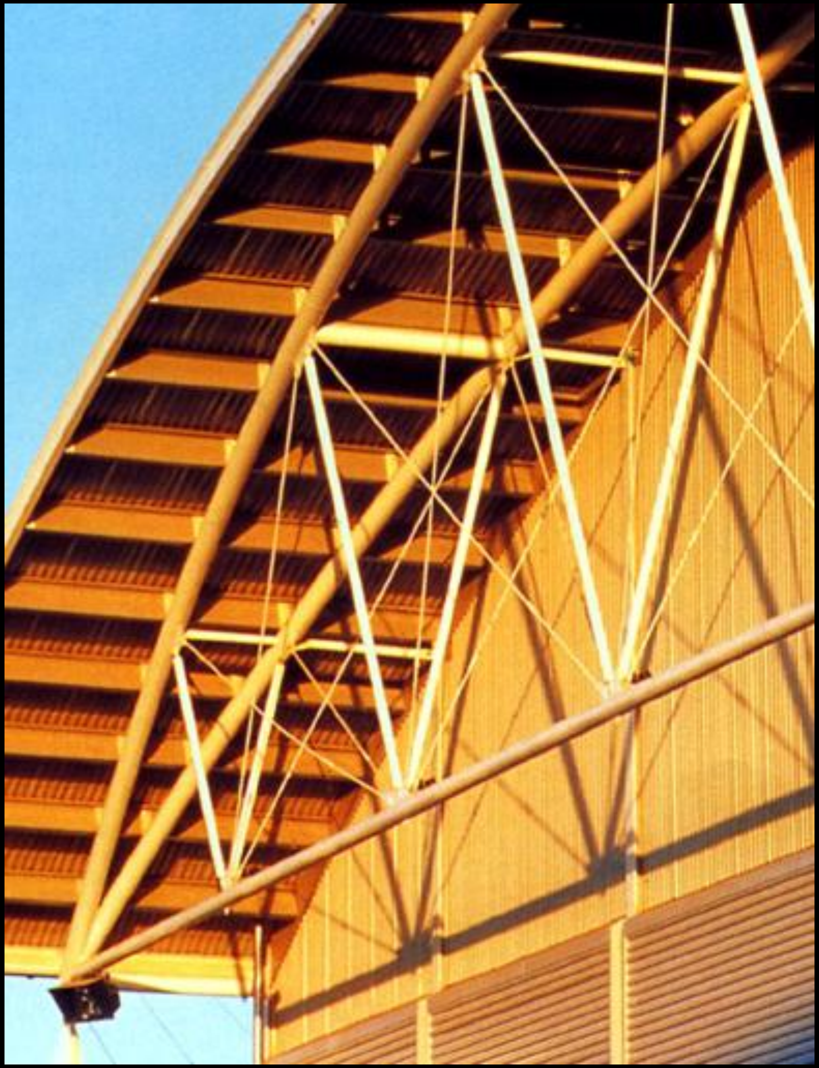
Shaping Structures: Statics, W. Zalewski and E. Allen (1998)

Stadium Australia
Homebush, Sydney, 1999

Bligh Lobb Sports Architects
Sinclair Knight Merz (SKM)
Modus Consulting Engineers

Why not Trusses?

- Much more labour in the joints
- More fussy appearance, beams have cleaner lines
- Less suitable for heavy loads
- Needs more lateral support



Real Applications

- Domestic roofing, where the space is available anyway
- Longspan flooring, lighter and stiffer than a beam
- Bracing systems are usually big trusses

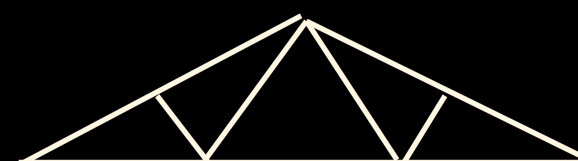
Longspan floor trusses

Realistic Shapes

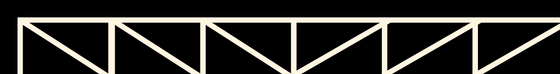
- **Span-to-depth ratios are commonly between 5 and 10**
- **This is at least twice as deep as a similar beam**
- **Depth of roof trusses to suit roof pitch**

Typical proportions

Beam, depth = span/20



Truss, depth = span/4



Truss, depth = span/10

Making the Joints

- Gangnail joints in light timber
- Gusset plates (steel or timber)

Nailplate joint

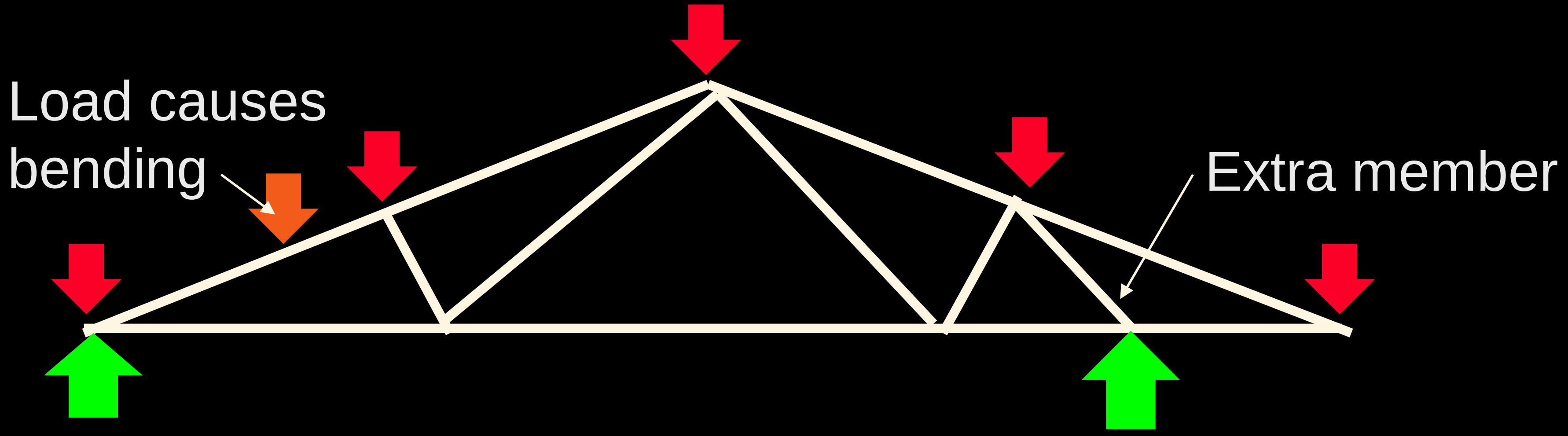
Making the Joints (cont.)

- Welded joints in steel
- Various special concealed joints in timber

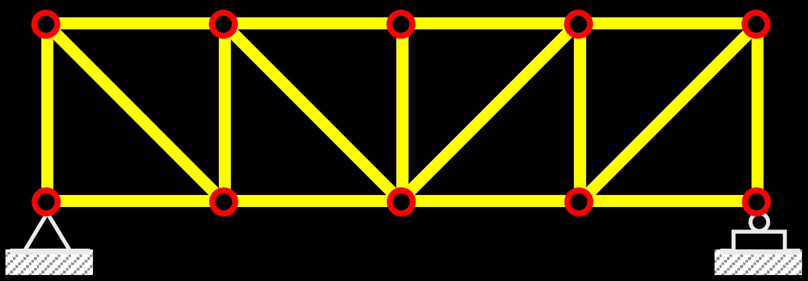
Steel gussets concealed in slots in timber members

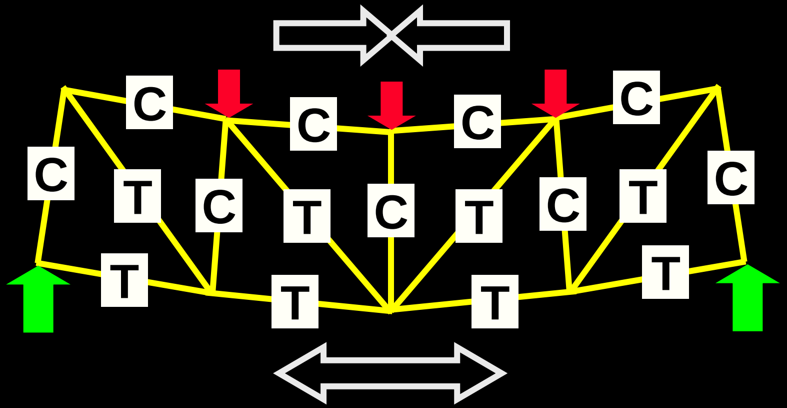
How Trusses Work

- The members should form triangles
- Each member is in tension or compression
- Loads should be applied at panel points
- Loads between panel points cause bending
- Supports must be at panel points



How Trusses Work
forces in members

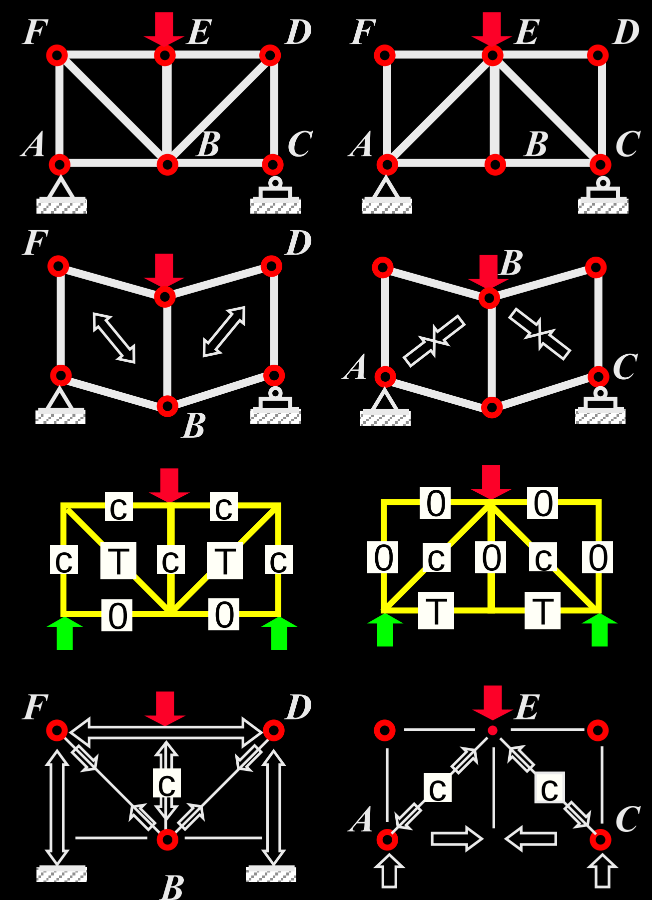




Only tension & compression forces are developed in pin-connected truss members if loads applied at panel points

How Trusses Work
forces in members (cont.)

Truss A   Truss B



Basic truss assemblies

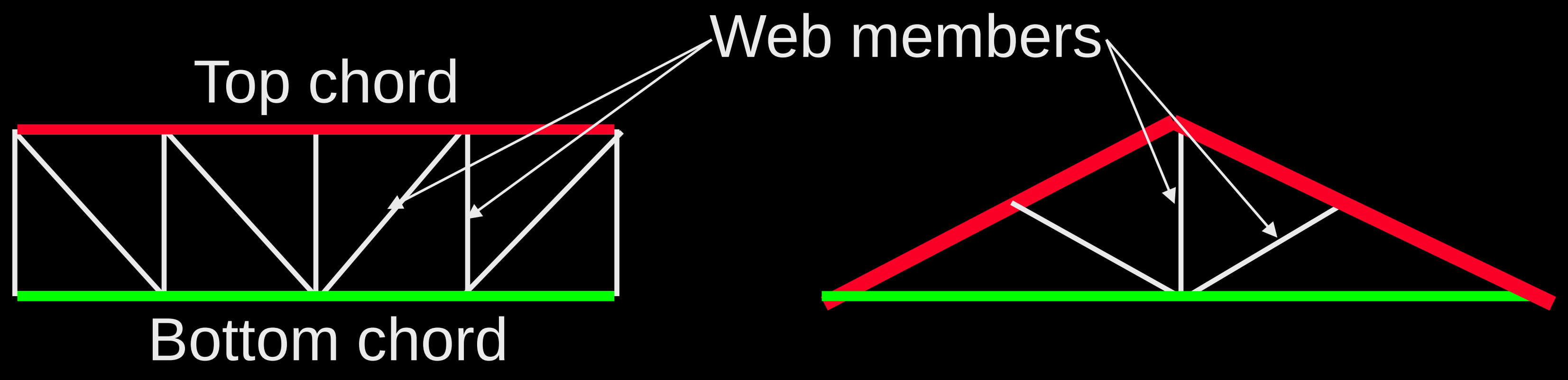
Imagine diagonals removed
Look at deformation that would occur
Look at role of diagonal in preventing deformation

Final force distribution in members

Analogy to ‘cable’ or ‘arch’ action

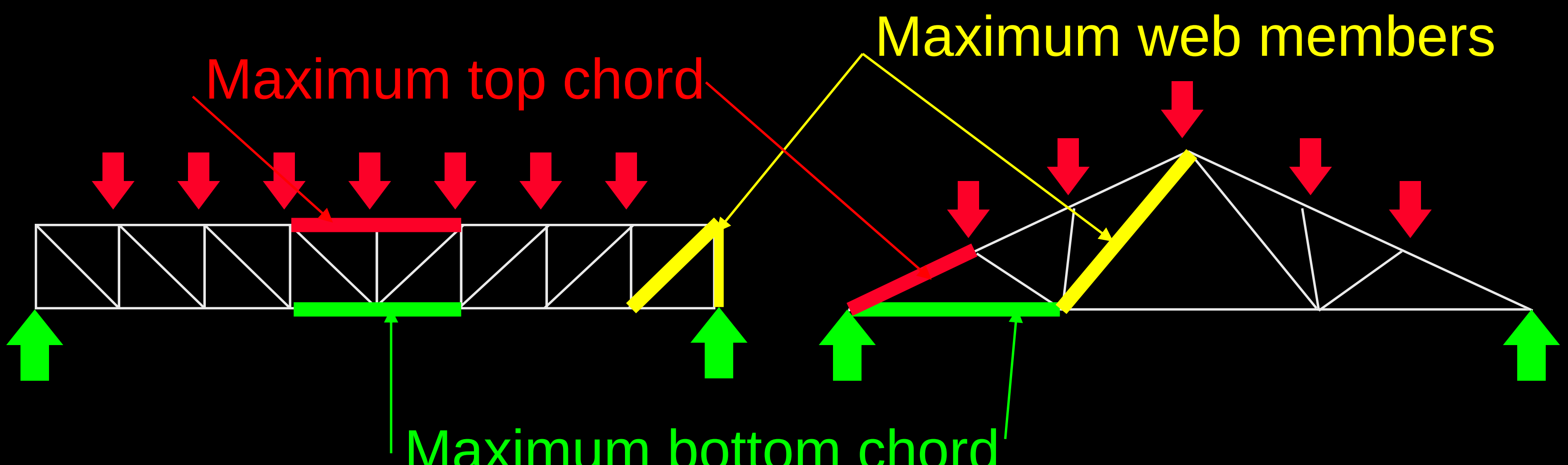
The Chords and the Web

- The top and bottom chord resist the bending moment
- The web members resist the shear forces
- In a triangular truss, the top chord also resists shear



What we Need to Know

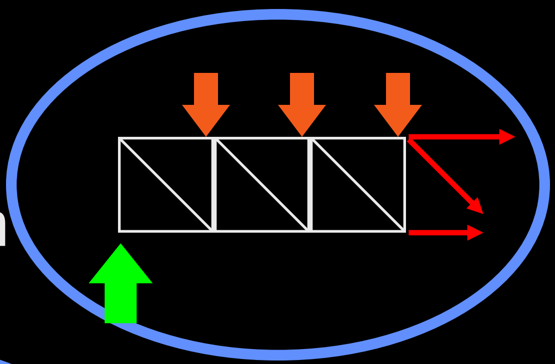
- For detailed design, forces in each member
- For feasibility design, maximum values only are needed

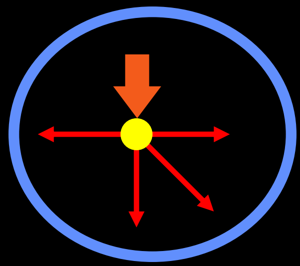


How to Analyse a Truss

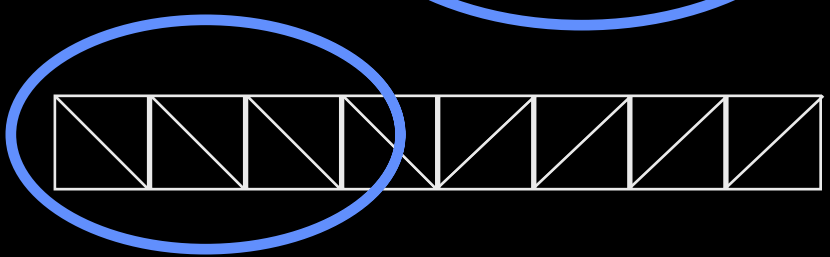
- **Find all the loads and reactions (like a beam)**
- **Then use 'freebody' concept to isolate one piece at a time**
- **Isolate a joint, or part of the truss**

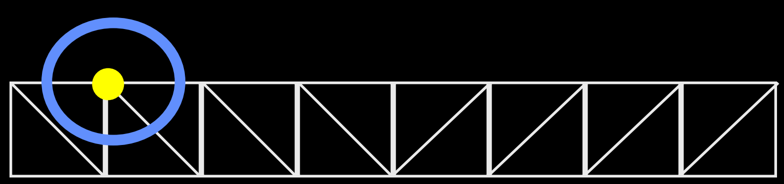
This piece of truss in equilibrium





This joint in equilibrium





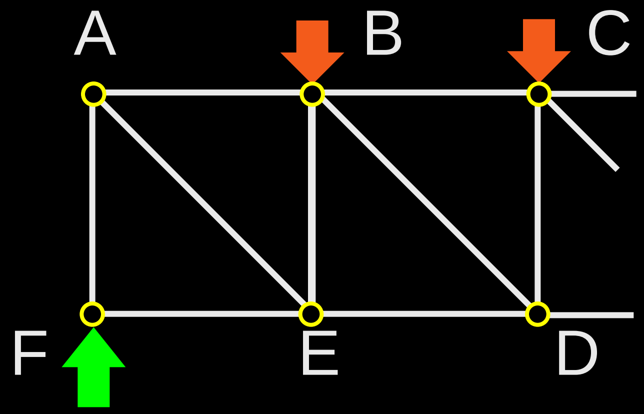
Methods for Analyzing Trusses

- Three methods

1. Method of Joints
2. Method of Sections
3. Graphical Method

Method of Joints
isolating a joint

- **Have to start at a reaction**
- **Move from joint to joint**
- **Time-consuming for a large truss**

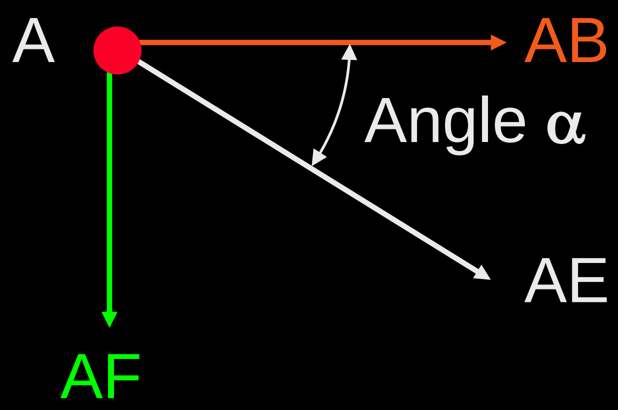


Start at reaction (joint F)
Then go to joint A
Then to joint E
Then to joint B ...

generally there is only one unknown at a time

Method of Joints
dealing with inclined forces

- **Resolve each force into horizontal and vertical components**



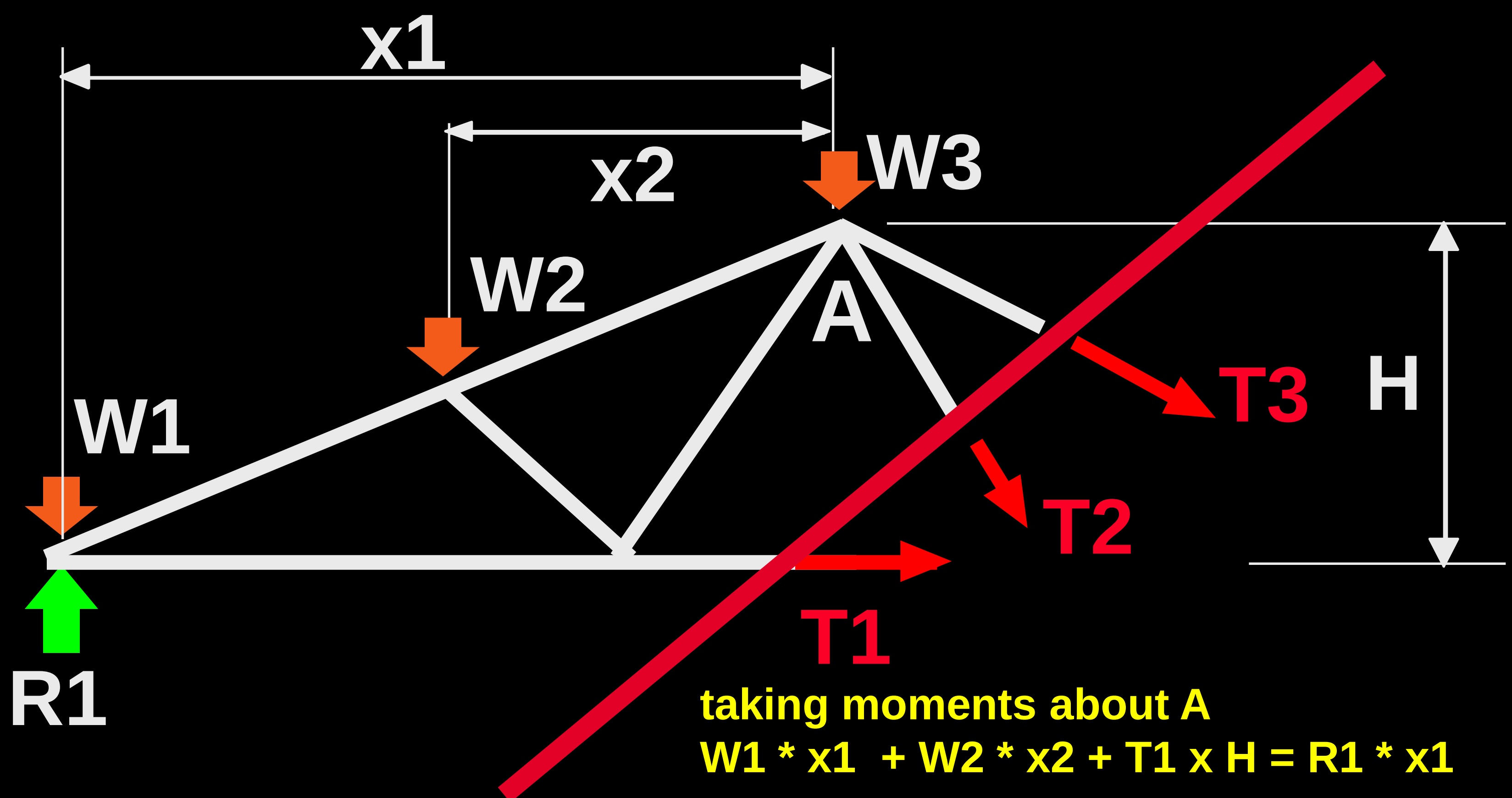
If you don't know otherwise, assume all forces are tensile (away from the joint)

Vertically:
$AF + AE \sin \alpha = 0$

Horizontally:
$AB + AE \cos \alpha = 0$

Method of Sections
cutting through members

- Quick for just a few members

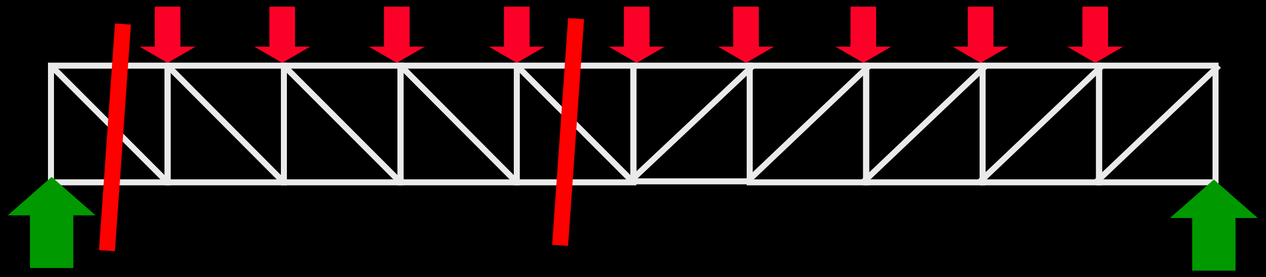


taking moments about A

W1 * x1 + W2 * x2 + T1 x H = R1 * x1

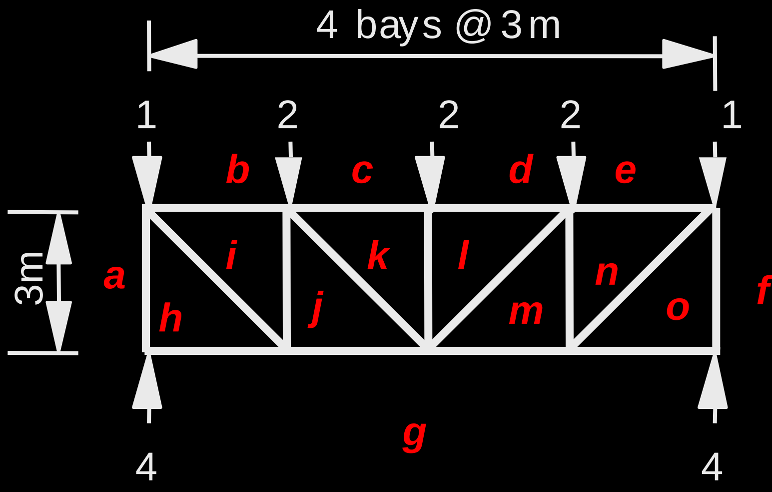
Method of Sections
advantages

- useful to find maximum chord forces in long trusses

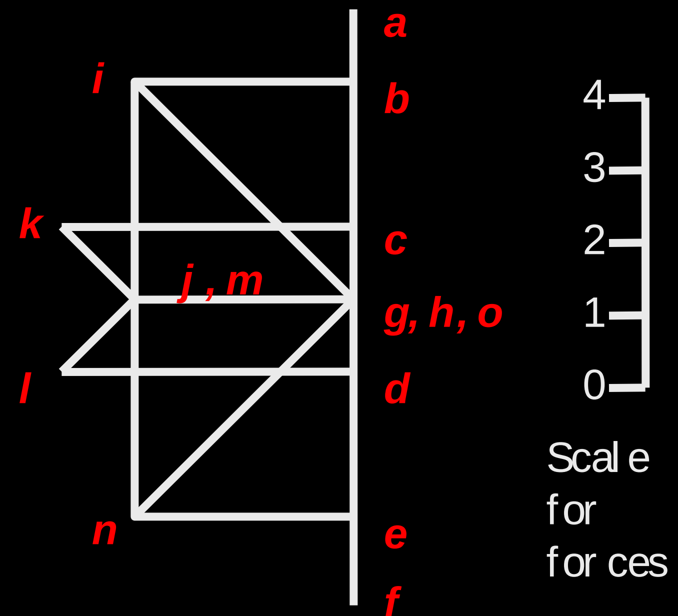


Graphical Method
drawing conclusions

- Uses drafting skills
- Quick for a complete truss



Bow's Notation

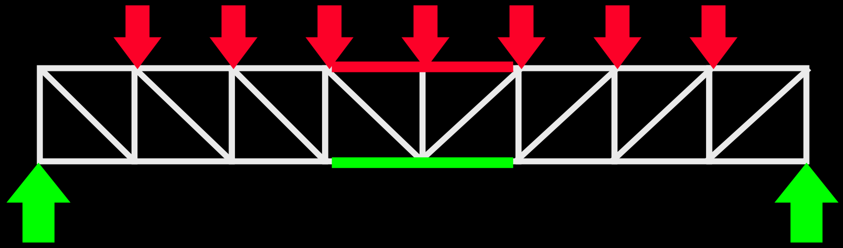


Maxwell diagram

Peter Smith 1998/Mike Rosenman 2000

Quick Assesment parallel trusses

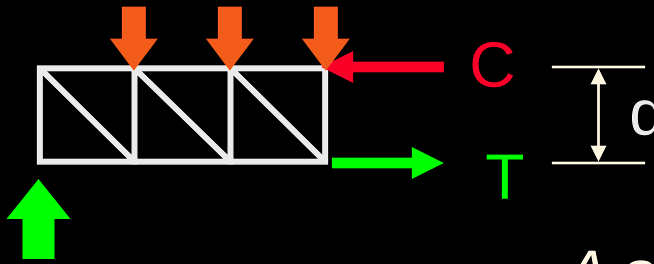
- **The chords form a couple to resist bending moment**
- **This is a good approximation for long trusses**



First find the Bending Moment as if it was a beam

Resistance Moment
= Cd = Td

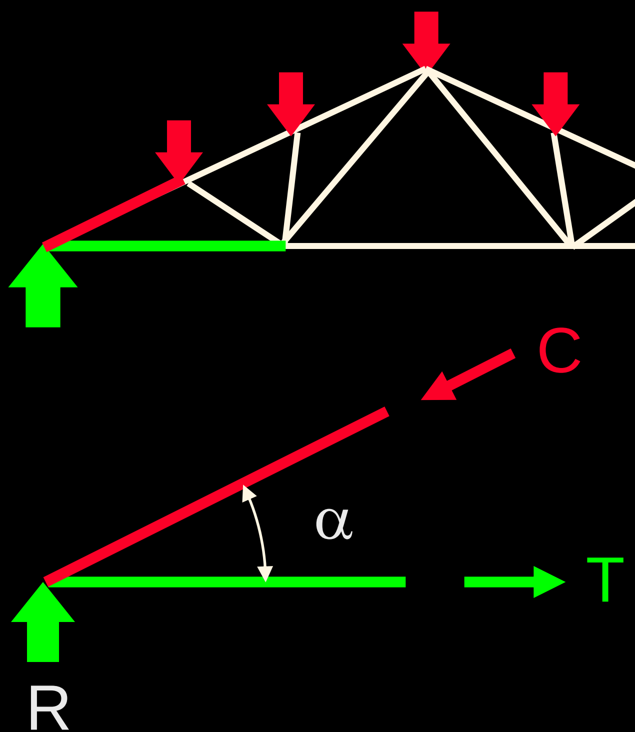
therefore C = T = M / d



A shallower truss produces larger forces

Quick Assesment
pitched trusses

- **The maximum forces occur at the support**



First find the reactions

Then the chord forces are:

$C = R / \sin \alpha$

$T = R / \tan \alpha$

A shallower truss produces larger forces