

Structures

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## LIST OF KEYWORDS AND TERMS

Basic structural concepts  
Loads and applied forces  
Basic components support loads  
Transfer forces  
Construction systems

Building professions: architects, engineers, building surveyors, health inspectors, building practitioners, foundation engineers, building inspectors

### Four basic structural requirements

Stability: Does there exist within the structure a collapse mechanism?

Equilibrium: Are loads applied to structure balanced by reactions?

Strength: Do stresses within the structure exceed permissible limit?

Stiffness: Is behaviour of structure acceptable?

MATERIALS : cost, environment, finishes internal, external finishes, durability, failure, aggregate, alternatives, concrete, course, fine; mild, galvanised, steel, timber, wire - chain, tie wire, guy wire, wood - heartwood, compressed, medium density fibreboard (MDF)

STRUCTURE: loads, wind, movement, foundations, beams, columns, trusses, flat slabs, pratt girder, flat arch, .

CONSTRUCTION: crafts, machinery, skills, workers, manufactured products, manufactured systems, details, components, drainage, putting things together and making it work, dimensions, layout, construction sequence, demolition.

COMMUNICATIONS: drawings, standards, surveys, photos, site inspections, instructions, supervision

COMMUNITY: building law, codes, standards, courts, arbitration, building surveyors, building approval, adjacent properties, egress, risk to public

FACILITIES: heating, health and amenity, natural light, artificial light, light courts, habitable space, non-habitable space, carport, fireplaces, hot water, cold water, drainage, waste removal, sewerage

Structure: stability, strength and deformation of buildings.

Fire : safety for occupants of the building and for the public, fire resistance, fire separation, egress, smoke control, protection of openings.

Serviceability: Durability and performance, moisture, deterioration, maintenance

Forces

- Coplanar forces are forces that are with a single plan.
- Parallel forces are forces that all in in same direction.
- Concurrent forces are forces with their lines of action intersecting at one common point.

Statics : Statics concerns effects of forces on bodies that remain at rest.

Dynamics : Dynamics is concerned with forces and movements (behaviour) of bodies.

Newton's Laws

First Law

A body will remain at rest or in uniform motion in a straight line unless it is forced to change this state by forces applied to it.

Example of application : This law introduces the concept of equilibrium condition. If all forces acting on a body are balanced an equilibrium or static condition exists. If forces are out of balance, change will occur and a static condition will not exist.

Second Law

A body acted upon by an external force will accelerate in proportion to the magnitude of this force in the direction in which this force acts.

This produces the formula :

$$F = m.A$$

This law provides explanation of the effect of gravity of bodies and forces of bodies accelerating.

Third Law

To every action or force there is an equal and opposite reaction or force.

Units

The SI ( Systeme International d'Unites - the International System of Units) system of units are used in Australia.

Time	second					
Mass	kilogram		kg			
Density	kilogram per cubic metre		kg/m <sup>3</sup>			
Length	metre		m			
Area	square metre			m <sup>2</sup>		
Volume	cubic metre			m <sup>3</sup>		
Force	newton		N		kN	
Moment	Newton metre		Nm			
Pressure	pascal			N/m <sup>2</sup>	kPa	
Stress	stress			N/m <sup>2</sup>		MPa

Normally the following unit are used for the following situations

Area		mm <sup>2</sup>
Deflection		mm
Span		m
Load Point		kN
Load distributed	kN/m	
Stress		MPa
Soil bearing press	kPa	

Relationship between kg and N

1 kg under the action of gravity applies force of 9.8 N

Acceleration due to gravity is dependant on the distance from the centre of the earth. g on the top of a mountain is significantly less than that at sea level.

Sydney	9.796830
Washington	9.800984
International Standard	9.806650

A person of 83 kgm causes a force of  $9.8 \times 83 = 813.4 \text{ N} = 0.81 \text{ kN}$

The moon has a smaller gravitational force, its acceleration due to gravity is approximately  $1.67 \text{ m/s}^2$ .

A person of 83 kgm on the moon causes a force  $1.67 \times 83 = 138.61 \text{ N}$

### Scalar and vector

Scalar quantities are described by magnitude.

Vector quantities are described by magnitude, direction and sense.

Centre of mass : The centre of mass is the point at which the mass could be assumed to be concentrated without effecting the force it produces.

Components of forces	Horizontal Vertical
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Equilibrium condition and resultants

### Procedure for solving problems

- (i) write down and sketch information
- (ii) decide on what principles are to be used in the analysis
- (iii) select process - analytical, graphical, computer etc
- (iv) check dimensions are dimensional consistent
- (v) analysis
- (vi) check solution by intuition and if appropriate another process.
- (vii) state solution clearly and any assumptions made.

### **CLASSIFICATION SYSTEMS**

One of the first problems an architect will encounter will be the difficulty of familiarity with the whole range of structural possibilities for a particular problem. The modern architect when solving the structural problems is faced with a field so wide that no single engineer will raise claim to be proficient in all its many subjects.

Some classifications systems used with structure and building construction are as follows:

#### 1. Structure System (Method proposed by Heinrich Engel, Structure Systems )

The five groupings are:

FORM-ACTIVE STRUCTURES

VECTOR ACTIVE STRUCTURES

BULK ACTIVE STRUCTURES

SURFACE ACTIVE STRUCTURES

VERTICAL STRUCTURAL SYSTEMS

#### 2. LINE AND SURFACE ELEMENTS

A simple classification system is to divide building structures into three types.

straight line elements	beams, columns, and ties
shaped line elements	arches cables and frames
surface elements	slabs, shells, or prestressed membranes

Andrew Orton, The way we build now - form scale and function.

#### 3. ELEMENT AND MATERIAL

The following groupings have been used by W. Morgan in his book The Elements of Structure.

The masonry arch, vault and dome

The beam - timber iron and steel

The beam and slab - reinforced concrete

The beam : prestressed concrete

The framed beam and truss

The column

The modern arch and portal frame

Folded slabs, shells, hyperbolic paraboloids

Braced domes and geodesic domes

Grid roofs and floors

Suspended cable structures

Retaining walls.

#### 4. FIRE RESISTANT CONSTRUCTION

Type A

Type B

Type C

Car-parks etc

#### 5. CLASSIFICATION OF OCCUPANCY (Regulations)

Class I House

Class II Flats

Class III Hotel

Class IV Residence attached to a commercial building.

Class V Offices

Class VI Shops

Class VII Factory

Class VIII Warehouse

Class IX Public School, theatres hospitals etc

Class X Out buildings etc

STRUCTURE AND STRUCTURAL APPLICATIONS	ELEMENTS CONNECTIONS & TYPE OF SYSTEM	PROBLEMS & ISSUES
1.		
2.		
3.		

4.		
5.		
6.		
7.		
8.		