Nature & Architecture

Structure, Function & Aesthetics in Nature
Source of Inspiration for Architectural Design and Technology

The UIA GGWI (Great Green Wall Initiative): Interactive Webinar, 26th March 2022
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Abebe Bekila, Marathon, Rome Olympics, 1960
World record barefeet!

Bob Beamon, USA,
long jump 8.90m., +55cm,
Mexico Olympics, 1968
Abebe Bekila, Marathon, Rome Olympics, 1960
World record barefeet!
Altitude in Addis Abeba is 2.355m. Less air to breathe!

form follows function in biology
to survive species must adapt to the environment

Bob Beamon, USA, long jump 8.90m., +55cm, Mexico Olympics, 1968
Altitude Mexico 2.250m.
Less gravity force!
Vitruvius said, every building must be:

**strong**, **structure**, **useful**, **function**, **beautiful**, **aesthetics**

consider nature as structures
use them as source of inspiration for
architectural design - synthesis
right position of beams in relation to their section
distortion of beam under loads, cracks, up-compression, down-tension
smooth transfer of loads

Distribution of Loads in Structural Elements

**beams, columns-pillars, cables-wires**

- tension
- compression
- bending
- torsion
- shear
- transfer of loads on a pillar hand & foot
- design to enhance strength under compression
- healthy bone and osteoporosis

vector active structural elements
small section compared with their length
deformation of ‘hole-body’ arches and domes under horizontal or vertical pressure loads

distribution of loads in arches

the ‘converse’ shape of Eiffel tower in Paris from ‘curved’ to ‘concave’ arch from beam (compression) to wire (tension)

arches


Gateway, Eero Saarinen, 1965, St. Louis

Farkasret Mortuary, Imre Makovecz, Budapest, 1975

Stockley Park W2 Building, Peter Foggo.
distribution of loads in structural elements

cone types of skeletons frames
center top & rays

dome of spongilla frame
cone voronoi frame
cone triangles frame

cones
vaults, semi-hemi-cylinders

vault under pressure forces forces on individual arches surface active

bones of a hedgehog with extra ring layer for extra endurance during fall

2 side beams, support

4 points, support

arched bridge in Zagoria, Greece

9zone armadillo, extra supporting arches in Romanic temples
If the ring on the base is strong, then the diameter increases on a higher point.

deformation of a dome under pressure forces reduction of height, increase of the diameter of the ring and cracks.
domes, cupolas

Ball House, Dresden, 1928
Dalian Shell, China, 2009

pre-historic shelter - igloos

first inflated dome in 1948 with diameter of 15m
tensile membranes

form finding inspiration from nature

double curvature surfaces, surface - active

Hyperbolic paraboloid

Bat Weather Lately

Innverness, the venue of Joseph Banks’ 1766 expedition, where Dr. Robert Fludd, the Royal Astronomer, observed bats flying in formation. The bats, unlike birds, maintain a constant altitude, allowing them to soar effortlessly. This form of flight is inspired by the engineering principles found in nature. The tensile membranes and double curvature surfaces seen in these images are examples of how nature inspires modern form finding in architecture.

inspiration from nature
inflatable - pneumatic structures

form from suction (de-pressure)

deriving form from pressure – 1,2 inside – 1,0 outside
form from suction (de-pressure)
air pillows – air tubes – air halls
trees as smart structural elements
geodesic dome, truncated icosahedron with 20 hexagons-hexahedrons and 12 pentagons-pentahedrons

geodesic domes

20 hexagons - 12 pentagons

Elevation pattern of a truncated icosahedron

bee eyes (650X), wasp nest, ananas

radiolaria
wired surfaces

Preston river bridge, 2008, Sjölander da Cruz Architects.

birdcage, Munich Zoo
Frei Otto, Buro Happold, 1980

bubbles, moving sand, porcelain cracks, zelatine cracks, dragonfly feather, maple leaf

bridge from ants to make way from one leaf to another

dome of spongilla fly egg yolk (500X) - wireframe
Woodpecker has ‘elastic’ materials in his head between his beak and skull. Chimpanzee has lots of leaves and branches in his ‘soft’ ‘anti-shock’ bed.

Anti-vibration = joints - assembly connections, shock absorbers & anti-vibration mechanisms in nature & technology

Joints, holding fingers & zipper

Nature as a Source of Inspiration to increase the strength of structures
folded & folding structures
Reinforcement of concrete with ribs on the wires to improve adhesive welding through the increase of common surface between wires and cement and improve anchorage.

Leaf. Voronoi pattern, central axis.

Dragonfly feather. Axis on top, enhance sections on top.

Enhancement of strength by ribs.

Ribs in bamboo and seawater worms.

Boys, 1959

bubbles angle 120°

′watercube′

Beijing, 2008
corrugated wires in bungee jumping

Bridges with natural cables. Kakum, Ghana & Q’eswachaka, Peru

corrugated wire mesh

Corrugated form, structural panels. Reinforced plastic panel with corrugated chicken wire glass.

ripples, elasticity

ways to enhance the strength of structures
geometry design of structural elements
Double T beams from wood

Plastic structural elements (beams or pillars) with increased strength due to geometry design of the sections

Ways to enhance the strength of structures - geometry design of structural elements

Double T beams
And way of construction
Cutting along the length and welding.
Creation of hexagon holes for pipes
Improving the height of the beam
Reducing its weight
Improving its strength

Layers of structural wood with special profile sections

Special profile sections
Combinations of materials, (wood, metals, concrete) in building frames - skeletons

ways to enhance the strength of structures

Structural Elements With Many Materials

compound structures
multicore cables

Ropes, muscles, metal cables, nerves, multi-strand cables, multicore wires

Golden Gate Bridge, San Francisco, 1280m, 1933

Construction & building elements with many materials, multicore cables

Ways to enhance the strength of structures
Multilayered structural materials. Aluminium pipe with insulation layers, Wood ‘veneer’ and ‘ciment.wikibis’.

Multilayered material for tensile membranes
Ways to enhance the strength of structures

Multilayered structures

Layers – Onion - Cabbage
nature as a source of inspiration for tools & mechanisms

Use, properties: Shear, Penetration, Grip, Tightening, Opening and closing, Picking, Hinges, Cutting, Chopping, Grinding, Assembly, Storage, Fans, Anchoring, Aerodynamic, Antishock absorbers
Evolution of foot shapes and beaks from different birds in different environments.

hydro-aero-dynamics

genotype > environment > > phenotype

imitation of physical property, form from use, function

hydrodynamic shape, 'slipper' does not tip over easily

pangolin, butterfly's scales

skate & aeroplane
Camouflage - Stealth architecture

defence – attack, mimesis, hiding, optical illusion, blur, Stealth Architecture, Super-flattness
boat, Z. Hadid  
Toyo Ito, Bone Structure inside out  
Voronoi façade  
Richard Rogers  
Mallorca  
Marrakech  
Morocco  
Cities & Complexity, Batty, 2005  
Reaction-diffusion, blur-sharpen,
exoskeleton - bone structures  
life at the bottom of the sea

nature as the ultimate source of inspiration in architecture

the architects of nature  
microcosmos
Richard Rogers & Norman Foster

by Eva Jiricna
Thank You For Listening!

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