Working title: Designing Lightness

Saving materials and energy

1 An understanding with lightness (Introduction)

What exactly is lightness? Predecessor books. Experience. Increasing insight. Aspects of meaning (metaphors and reality). Wrong pride and prejudice. Mass Machismo. The paradox of airplanes: boasting about their weight. The new book's aim. Brief overview of parts, chapters and intentions. Movie stars understand their body mass (J. Leto HIV Rayon) Web information. Lightness App?

Why? Section: Necessity

2 Lightness matters (intro to necessity)

Observation: people, stuff and means of transportation. Organization. (Dabawallah in Mumbai). Design: Add maximum value to minimum mass. Materials and structures. Semantic ambiguities. Interesting misunderstandings. Forces and perception of beauty. The involvement of air. Sizing up volume to save material weight. Persons, project, process, phenomenon. >> Three aspects of urgency: history, convenience, sustainability.

3 Forces of history

The need to carry. The need to settle down. The need to expand. The need to transport. The need to be informed. The need to carry once more. Together they require reconsideration of structures and consumption of raw materials. People (Gaudi, Buckminster Fuller, Brunel, Brunelleschi). Examples (archery, water wells, grids in ancient architecture, chariots). Pragmatism. The S-curve.

4 Just snap your fingers

Lightness is the engine of technological development. We humans strive to be omnipotent and omnipresent. Hyperconvenience is what we want and what we want to show off. And we work quite hard to be able to produce the idleness that we cannot afford to consume. We get it from lightness, which provides speed and ease. Ray Kurzweil, Skype, Toyota i-REAL, electronic lense, game farm. We seem to be succeeding, apart from the side effects. Elfs, angels and light gods. Dancing.

5 Not our fault

Sustainability characterizes a state of humanity, in which future survival depends on mutual adaptation with self created biotope circumstances. Currently it is mostly addressed as a goal that can be reached by: suppressing carbon dioxide emission, reusing everything produced, and various nostalgic lifestyles. Lightness precedes emission suppression and recycling in that it implies reduction of mass and energy to achieve sufficient convenience. Dematerialization and reduction of the use of energy in the complete cycle of human production and consumption can limit the burden which mankind is putting on its living environment, thereby extending its future quality.

What? Section: Principles of saving weight

6 Intro

Material reduction in design requires special skills. Overview is important, since lightness depends on intelligently combining and processing different materials to balance their properties, considering results on different levels of scale, sometimes from mega all the way to nano. Detailed understanding of structural principles is an important prerequisite. Properties and behaviour.

7 There are always three

Lightweight does not just depend on the weight of materials involved. Aluminium is heavier than concrete. Other properties are at least as important, which are determined by processing: material + process + concept (function/identity). Measurable lightweight objects may look heavy.

8 Pull or push

Structures deal with forces, usually the ones caused by gravity and carrying loads, but others as well, such as wind, or handling. Tension, caused by pulling, requires less material mass than pressure, which can lead to buckling. Many materials are not equally suited for both tension and pressure, which occur in bending and torsion. For lightness tension must prevail. Bridges, Kite surfing, tensegtity. Prestressing and (mis)understandings. Flatness. Toys as models.

9 The designer/composer

Apart from dealing with forces there may be a range of other requirements, concerning moisture, sound, temperature, insulation, colour, chemical behaviour, etc. It is the task of designers to compose different materials with different properties to produce the right balance for the entire structure to do its job well.
Designing material structures starts at the atom level. Structures can be defined quite precisely, through analyzing familiar solutions, combining elements, creating geometric arrangements with fibres, lamination and putting parts together. Nano, 3D printing, composite building,

10 Traffic jams of forces

Forces crowd structures. They need space, wide cross sections, to keep stress at acceptable levels and want to travel from one structural end to the other - top down in the case of gravity - with maximum convenience along the shortest possible trajectory. As a designer you need to avoid obstacles and sharp corners in structures, because stress concentrations require extra measures to compensate for lack of cross section. Koolhaas CCTV, riveting, holes and cuts, Dutch water piping system.

11 Nature works

Structures in nature adapt to forces by themselves. They understand what's going on and express this in their appearance, without any aesthetic intentions. Nature has no desires. It is just there and it can be understood.
Understanding the forces is more fruitful than copying the images that represent them.
Hexagons and honeycombs, trees, soap and foam, Michell, tensegrity, random and methodical.

12 Babylon

Lightness has at least two meanings. Lack of weight and brightness. They stem from different 'light' predecessors in early language. Ambiguity causes the word light to be perceived as a metaphor that in case of structures acts as a decoy from the rather banal 'absence of weight'.
On top of this, engineers, designers and architect have different interpretations of identical terms and images. Seemingly straightforward notions like 'function'

and 'strength' can lead to radical misunderstanding. In particular the word 'material' is confusing.
The honeycomb structure and Snelson's tensegrity art have a strong aesthetic appeal that may distract beholders from understanding material behaviour caused by forces.

How section: The making of

13 Intro

Development of lightweight structures can't happen without exploring methods and procedures to make them. This is an exciting ongoing evolution fed by vision and recombination, trial and error and of course creativity. There is constant change: backdrop dynamics.

14 Two and two together

In the past metal and plastic monomaterial production has been in the lead because of its elastic predictability and the belief it fuelled progress. The behaviour of combinations of materials, or composites, is more complicated, because it depends on the design of their very guts.
Composites consist of materials with complementary properties. Processing consists of preparing those and than bringing them together.

13 Thin bits

Fibres, glass, carbon, aramid, dyneema, basalt, steel, aluminium (and other metals), leaves, straw, even seaweed and tendons. Spider webs. Put together by knitting, weaving, (non-weaving), winding, cross plying. Weaving technology. Jacquard, the father of all weaving potential, and artificial memory too. Pros and cons. Opportunities, potential. Reality check.

16 Taking the pressure

Thermoplastics, thermoset, carbohydrate based, lactate based, bonding agents, bioplastics, concrete, loam. Chemical development. Micro-organism doing the hard work. From crystals and plastics to biostrength (back to wood and tendons through a microscope. Properties and *behaviour*. *(Behaviour is important, because it includes time and is dynamic and requires sensibility and experience)*

17 Wine and helium

Or rather fluid and gaseous substances are an important supporting component. Filling tanks, lifting elements, moon dwellings, beer bags and lots of other fun objects. Inflatables. Optimum shapes. Composition. Winding and pressurizing. Car tyres. Maria Blaisse. Synthetic and organic foams.

18 The merger

Definition of required results in recipes, algorithms and moulds. Stitching, bonding, printing, fibre steering, cutting. Frozen textiles. RIM, vacuum injection, laminating, pultrusion, pressing. Comparison with metal technology. Building products.

Mass production.

Tjeerd's hand made bicycle, palm leaf slippers. 'Natural structures. Trees, animals. Cochayouyo surfing boards. Biocomposites.

19 Strong and stiff

Properties: designed to perform. Strength, stiffness, insulation. Dampening, Speed of handling. Impact. Conceptual differences. The edge effect. Structures from the bottom up. They can be designed for strength, stiffness and extra properties, dealing with light, electricity, elastic deformation, maintenance, and decoration.

20 The sum of properties

Designers tend to think in a linear way. Parallel combinations are not easy. Structure deals with forces, and the rest: lightweight acoustics, transparency, climate control, insulation, electric conductivity, fire resistance, chemical resistance, etc. Finding the right balance depends on people, requirements, circumstances, atmosphere, resources, clients, the weather, health and of course chance. A good project is a near perfect coincidence.

21 Way back when

Lightweight structures are not new. They have always been there as a result of pragmatic considerations in between the need to carry, to the availability of materials, evolved through ingenuity and time to challenge ideas in practice. There are examples of ancient contraptions that are no longer fully understood. How on earth did they do this? Maya's. Toys, kites. Juncker. Josep Adell's masonry. Tutankhamen, archery, cycling, Mosquito, Horten, Jean Prouvé, etc. Travel light: Alexine Tinne, vs Maxim's climbing story

22 Avant gardes

War and sports, as well as the desire for hyperconvenience are incentives for innovation. The heavy light paradox: heavy to train, light to win. Karel van het Reve characterized revolution as a period of time with low predictability of future changes. There are differences in different fields. We can be fairly certain that passenger airplanes are here to stay and that they will evolve towards more efficiency. The future for fighter airplanes is less certain. Cars are on the verge of a radical change in energy consumption, but the speed of change is as yet undefined. The paradox of sports: reducing effort to win. Increasing insight drives technological evolution, beautifully demonstrated by artist Theo Jansen, but in industry too. Functional segregation and integration. Identity and design require extra attention. Discovery of material experimentation among designers.

23 Blackboards, screens and apps

Algorithms always have weaknesses: assumptions. This implies that they offer less certainty where circumstances are structure specific, at transitions, attachments and edges.

Since composites are specific for applications, engineering calculations have a different character than the more generic ones for metals. There is lamination theory. In the end, like in all engineering, there always needs to be a proof of the pudding. Testing builds up from material structures through parts and consequently the complete concept. Testing and improving continues to refine design and improve the predictive capacity of calculations.

State of the art section: Acceptance

24 Intro

The fact that saving weight has definite advantages is being recognized. Airplanes save fuel. Cars gain in range, and turn safer. FR lightweight bridges are produced in considerable quantities. Light builds pride. Structures are securing a place among other concepts, such as communication technology because they have jumped on the lightness bandwagon.

Pragmatism en regional differences. Labour and automation.

25 Flying

Boeing 787and Airbus A350 are at the forefront of an industry in which Fibre Reinforced Polymers are taking over more parts of aircraft structures. Applying plastics is no longer strange. Advantages of composite technology are being recognized. Unmanned flying is taking of. Quadrotors are fashionable, although the first one was built in the 1920's and Sikorsky had to hand over its award for the first manpowered chopper. Food logistics (Tacocopter) Parts and the whole (pipes, engines) Saving Fuel

26 Wheels

For Super cars, like the Bugatti Veyron and the Lamborghini Sesto Elemento CFRP is standard. BMWi3: the first full composite commercial car. Trucks and Trailers, trains. Bicycles: high end commercial bikes. Extending the range.

27 Ships

Polyester has been in use for a long time, but now lightness is starting to be a feature in large racing ships (America's cup). Large freighters pulled by kites: doubtful, but a sign that saving energy is valued. Speed

28 Bridges and buildings

Suspension bridges and stayed bridges. FRP bridges. Common for decks. Proven environmental advantage. Maintenance free. Corn based polymers. Parts, bridges, sneakers, Carbon print (suggestive looks, the painted carbon bridge.

29 Live light

God's own gadgets. Toys, trolleys, Google glass, clothing, lightweight luggage is taking over from elaborate leather as a status symbol, the symbolism implying that suggestion of lightness is stronger than the real deal (reality is frequently inadequate)

The future section: No predictions

30 Learn from the past.

Document mistakes. Think per unit weight. (Cu vs. Al for conductivity) Pantheon. Everything starts with a brainwave that can be promising and doubtful, and that can be tested pragmatically. And quickly. A sketch of technological development with examples from the past and translated into the future. Crossroads: Junckers and felt pens for Ferrari. Promising seeds.

31 New materials

Making combinations on increasingly smaller scales. Nor just fibres and matrices, but nanomixtures and nana laminates.

32 Conceptual balance

There is always a trade off. No matter what: steel has a certain Young's module. Morphology has to do the trick. No structure exists just within itself. It is an entity that has been born in a certain understanding of a physical as well as within a dynamic social force field. Change one thing and the system gets a different personality. Knowledge increases and belief systems change. Nobody understands the whole package. Changing circumstances entail a fascinating evolution of technology.

33 Upcoming techno phenomena

Interpretation and reality: 3D printing, the bio factor, from crude to detailed. How do things come about? Chance, markets and in-betweeners. Speculative stupid media and smart reality checks. Automatic cars, family aircraft versus administrative precision and inclination towards hermetic security. Global and local transportation (all from the viewpoint of structures.)

(Structure is one of those ambiguous words!) Tradition. Set ambitious goals

34 Immaterial growth

Continuous innovation effort embedded in economic reasoning: saving money as well. In the wake of notorious 'rebound effect': economic savings through environmental improvements produces a economic profit that is used to undo the improvements. A lighter plane is more fuel efficient, because of which more people can afford to fly. How to beat the conundrum.

35 Boundaries and Opportunities

Reputations of materials and technologies. The lightest and the heaviest. Strategic change and revolutions. Bureaucracy, systems, knowledge and intelligence. We humans are an inventive bunch. Understanding our achievements is something else. Even the implications of the wheel are not fully understood. Always keep an open mind.

Backpack A list of the remarkable and occasionally useful materials (the exotic ones)_Lists, diagrams etc.