survey of cardboard furniture

why cardboard?

Cardboard offers a good opportunity for the design of sustainable furniture products.

Sustainability. In terms of a sustainable material cardboard is one of the best. The raw material of all paper products is cellulose fibre and this can come from a number of different plants. Cardboard ban be fully recycled and can be made from up to 100% of recycled paper and cardboard.

McDonough & Braungart (2002 -p5) oppose this view: "the tree, among the finest of nature's creations... is not a fitting resource to use in producing so humble and transient a substance as paper." They go on to reinforce their point by talking about how their book is made from synthetic paper instead. I would respond first to suggest they might have mentioned that paper doesn't have to come from trees. Hemp, for example, makes a superior paper, and has less than a year lead time rather than 15 or 20 years. Second, on practicalities, the paper industry is well established. In the study of social marketing "Choosing Green" (Durance, 2007), I concluded that social change was more likely to happen step by step rather than by sudden large leaps. Perhaps paper may not be the ultimate material, but it is better than others, and the opportunities for improving our overall sustainable practices is in the realm of the here and now.

Plastic, on the other hand, must be a lot worse. Plastic generally comes from non-renewable resources, and this in itself is is a long term problem, but the documentary *Addicted to Plastic* (2009) shows a very pressing immediate one - pollution of the worlds oceans. In some parts of the oceans, due to a combination of currents and atmospheric effects there are heavy concentrations of vast quantities of plastic. Bags and bottles float around, discarded fishing nets entrap marine life and it's there to stay as plastic takes very long time to degrade. When it plastic finally breaks down, it forms very small particles. In some of the sea vortexes samples of water were shown to contain a concentration of these particles 10 times more than organic matter which serves to sustain marine life.

Cardboard will not replace many of the current applications for which plastic is used, but there should be a conscious effort to replace as much as possible.

Cardboard is ubiquitous. Paper and cardboard products are all around us. Paper and paper products are widely used as packaging in the home. ABS (2003) shows that 88% of paper and cardboard was either reused or put into the recycled waste stream. This has also been the case in surveys taken in 1996 and 2000. Paper can be recycled between 1 and 7 times, depending on the final use. (TAPPI 2001)

Paper and cardboard products are all around us. It is a major product, produced by some of our biggest companies, yet in some areas such us furniture it hardly seems to have made any impact. Cardboard furniture appears to be thought more as a fringe product, a material useful for student projects, or for temporary applications such as exhibitions, rather than the mainstream.

New Technology. As paper products become more and more appreciated for their sustainability credentials, development is producing more technological advances, and more material formulations. There are opportunities for new technologies in the use of cardboard.

Cardboard is ubiquitous - products in the home
photo: David Durance

paper & cardboard commercial & industrial uses

home

- baking cups
- bibs
- carpeting & upholstery backsiding*
- cellulose sponges*
- cereal & other dried-food boxes
- chewing gum*
- coasters
- coffee filters
- combs & brush handles*
- coupons
- disposable diapers
- doilies
- drinking straws
- egg cartons
- emery boards
- fabric softener*
- facial & toilet tissue
- food thickeners*
- furniture polish*
- grease-proof meat wrapping paper
- grocery bags
- ice cream containers
- imitation leather*
- ink*
- labels for canned & bottled goods
- lamp shades
- lipstick & other cosmetics*
- liquid soap*
- luggage
- magazines, catalogs, & newspapers
- microwave-food containers
- milk cartons
- napkins
- paint & varnish*
- paper plates & cups
- paper towels
- pine oil & other household cleaners*
- pizza boxes
- place mats
- popcorn bags
- rayon clothing*
- sausage casings*
- shampoo thickeners*
- shoe boxes
- shoe polish*
- suntan lotion*
- tablecloths
- tea bags
- tool handles*
- tooth brush handles*
- toothpaste*
- turpentine*
- vacuum cleaner bags
- wallpaper
- waxed paper
- wicker furniture from twisted paper
- window shades

school & office

- bank checks
- banners
- books
- book marks
- business cards
- calendars
- cash register receipts
- construction & tracing paper
- crayons*
- crayon wrappers
- election ballots
- envelopes
- hair spray*
- index cards
- laminates for desk, counter & table tops
- library cards
- mailing tubes
- maps & world globes
- papier-mâché
- masking tape
- menus
- notebooks & notebook paper
- paper bags
- paper money
- photocopy & computer paper
- postage stamps
- poster board
- report cards
- shaving cream*
- shipping containers
- stationery
- tags & labels
- telephone directories

medicine and technology

- bandages
- Braille paper
- coffins
- coveralls for nuclear power workers
- eyeglass frames*
- hospital & surgical gowns, hats, masks & shoe covers
- medical charts
- piping for irrigation systems*
- prescription paper
- gauze
- purifying filters
- surgical dressings
- sutures
- pollen & dust masks

building materials and automotive

- caulk*
- car insulation
- car gaskets & filters
- car wax*
- cellophane*
- concrete mix*
- counter-top laminates
- fiber board
- flame-resistant paper
- flooring
- gypsum board
- insulation
- putty*
- roadside flares
- roofing paper
- roofing shingles*
- rust preventative*
- sandpaper
- spray paint*
- tar paper

recreation and miscellaneous

- accordions
- animal bedding
- board games
- bumper stickers
- CD & audio tape inserts
- coloring books
- confetti
- doll houses
- flashlight batteries
- football, bicycle, & other sports helmets*
- greeting cards
- gum & candy wrappers
- jigsaw puzzles
- kites
- molded carry-out food trays
- paper airplanes
- paper dolls
- paper flowers
- party hats & favors
- photographs
- playing cards
- ribbons & bows
- seedling planting pots
- stickers
- streamers
- tickets
- trading cards
- video cassette packaging
- wrapping paper

*these products are made from cellulose, oils, and resins, the natural wood chemicals which are byproducts of the papermaking process.

source: TAPPI (2001)

a typology of paper based furniture

As part of this project survey of furniture and related products made from paper, cardboard or paper pulp was made and assembled into a typography. The initial classification is based on the type of material used. Subclasses are based on material variants and the main method of construction used.

Material Classification

There are six classes of material defined in this typology: corrugated cardboard, paperboard, tube, pulp, paper maché[1], and paper cored board. Most or the exemplars surveyed fell easily into a a simple classification, a few were of mixed types, and some use a composites of cardboard and other material. These were provided for in classes 7 & 8.

1. Corrugated Cardboard. This is the material usually referred to by the term cardboard. It consists of a sheet of kraft paper which has been corrugated by passing it between a set of mated fluted rollers or *corrugators*. Either side of the corrugated sheet is glued a sheet of flat kraft paper. Sometimes just a single side only is covered, this is referred to as 'single-face'. Cardboard can have two or three layers of corrugations - 'double' or 'triple' flute cardboard.[2] These forms of cardboard have greater strength and stiffness and are often used to make larger cartons.

Cardboard also varies in the size of fluting, and the type and quality of paper. Fluting size is denoted by the letters A, B, C, D & E - 'A' flute is the smallest. Larger flutes make the corrugated core thicker, giving greater stiffness but also making the board more prone to local crushing. Multi-fluted board often has a different flute size in each layer, for example B/C. The smaller flute side is placed on the outside of cartons to give give the best performance, ie stiffness and resistance to crushing.

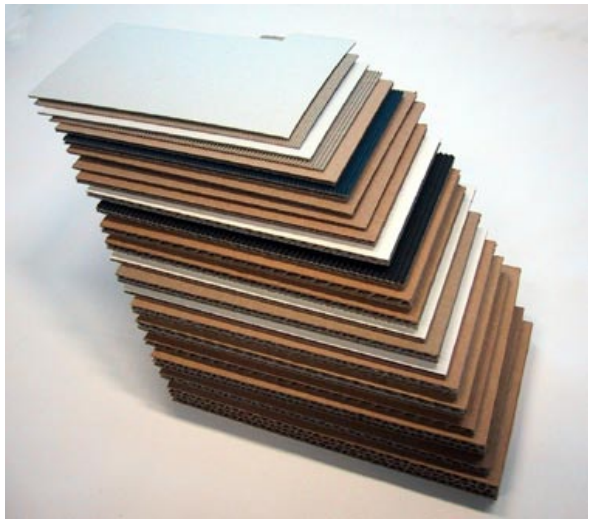
Stronger paper will improve strength and appearance, but increase cost.

Coatings can be put on the outside layers of the cardboard to modify its behaviour. They can make improve water resistance, toughness and printability.

There were four commonly used methods of constructing furniture from cardboard sheet found in the survey: folding, fabricating and laminating.

1.1 Folded. A sheet of cardboard (often a single sheet) is creased and folded into three dimensional forms and typically fastened with integral tab and slot methods, glue, adhesive tape or staples. Cardboard cartons are typical exemplars of this folding.

1.2 Laminated. Components are cut into a cross-section by laser, die cutter or knife (low volume). These cross-sections are assembled and fastened either mechanically or glued. To improve durability sometimes the terminating sections are made from an alternate material–fine fluted board, mdf or plywood.



Cardboard with various flute sizes.
image: http://upload.wikimedia.org/wikipedia/commons/f/fb/Cardboard_All_Flutes.jpg

Products are either entirely made from an assembly of laminations of the same shaped section (1.3.1 single section) or of several section (1.3.2). Either the sections vary throughout the product or components are made individually from laminated sections and then assembled.

1.3 Slotted Fabrication. Components are cut from a cardboard sheet with with laser, die cut or knife (low volume), and assembled in a grid. Slots the thickness of the cardboard are cut at grid intersections - so components of the grid are interlocked.

Fabricated products either remain as an open grid structure (1.3.1) or covered by sheets of cardboard or paperboard (1.3.2) - and often painted.

1 *Strictly spelt should be pâpier maché, but paper maché is common.*

2 *I've also heard this referred to as double or triple 'cushion'.*

1.4 Mechanical fastening. Other methods of joining cardboard together to make furniture are theoretically possible but appear not to be well represented in the survey results. However, MakeDo, a new fastening system, has the potential to develop exemplars in this classification. At this stage the classification remains somewhat provisional.

2. Tube. Cardboard tubes are made from paper or paperboard which is wound onto a mandrel to form a cylindrical tube. These are typically used in the packaging industries to wind textiles paper, plastic sheet or foils onto. Large diameter tubes with water resistant coatings are used in the building industry to form concrete columns.

3. Paper cored board. These boards have a core that is made from paper or cardboard with a cellular structure. They can be faced with paper or mdf, plywood or other materials. They have the property of great strength and stiffness to weight ratios.

3.1 Expanded Paper Honeycomb (EPH). This is material made by fabricating paper strips and expanding them out to create a structure with a hexagonal cell. It is usually faced with plywood or mdf and typically used to make shelves or flush-panel doors. An exception is 'void-former' which is only faced with kraft paper and used in the building industry as a consumable material to form cavities in concrete structures.

3.2 Triangular cell. Instead of a hexagonal honeycomb cell the core is made from fluted cardboard which has been laminated and sliced into blocks to make a sheets in various thicknesses.[3] This often referred to as triangular cell, although the actual shape is more semi-sinusoidal. As the flutes are much more tightly packed than honeycomb cells the boards have better rigidity, crush strength, and structural integrity than paper hexagonal cell board. They are also heavier and more expensive. While EPH can be supplied as a core only triangular cell boards are always faced with paper or other board as the cells would delaminate without this support.

4.1 Pulp. Paper is made from a slurry of pulped paper, and this classification furniture is directly moulded from a similar paper pulp slurry. Egg cartons are a result of this process.

4.2 Pulp board. Pulp paper is moulded into a board with a honeycomb structure. The board can be used in a similar way to paper cored boards. This is generally used like cored boards but is made with a different process.

5. Paper Maché. Paper Maché products are generally made by applying pieces of paper covered in adhesive paste onto a form. After several layers are made and dried, the form is removed. This process has been used for hundreds of years and is a traditional craft technique. The adhesive paste is usually made from flour and water, although other adhesives such as wallpaper paste and polyvinyl acetate (PVA wood working glue) can be used.[4]

The paper can be beaten to a pulp and having finer consistency can be used for finer details and for moulding. At this point there is a similarity between this form and that covered with the pulp classification, however being a stiffer compound than the slurry the moulding process is generally different.

6. Paperboard. This is made from several layers of plain kraft paper. Applications for furniture are limited because unmodified it is not very strong.

7. Mixed. In the mixed category furniture was made from a material that has combined characteristics of more than one of the previously defined classes, or is a product assembled from components belonging to one or more different classes defined in the typology.

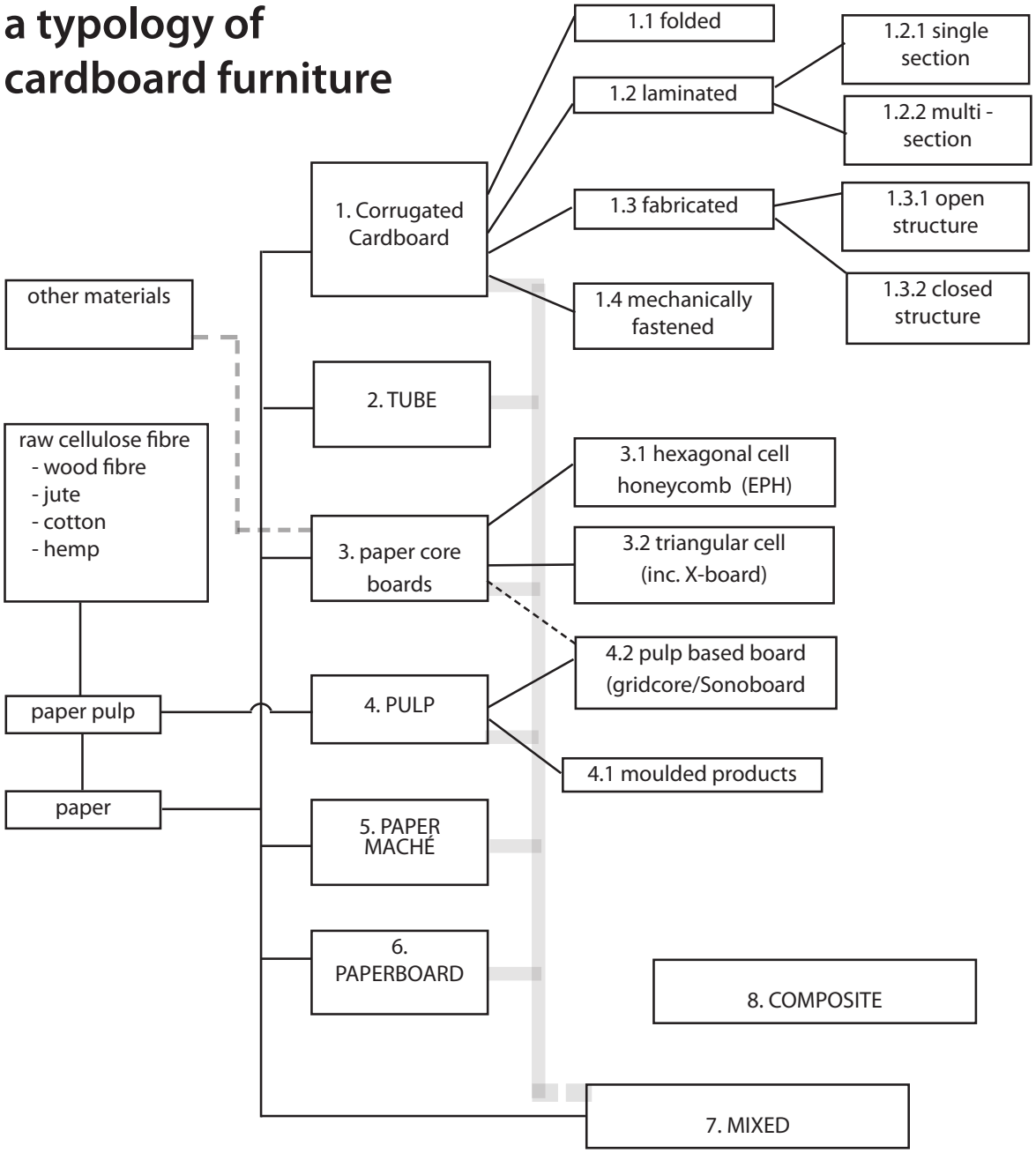
8. Composite. There are a few composite materials that include a paper component combined with another material such as plastic.

Tea room by Shigeru Ban
this shows a folded cardboard stool and a table with cardboard tube pedestal and honeycomb board top
http://web.mac.com/selophane/BlogImages/ShigeruBanTeaRoom.jpg

3 *Xanita "X-Board, readily available in Australia comes in thicknesses of of 10, 16 and 20 mm.*

4 *http://ultimatepapermache.com/paper-mache-recipes*

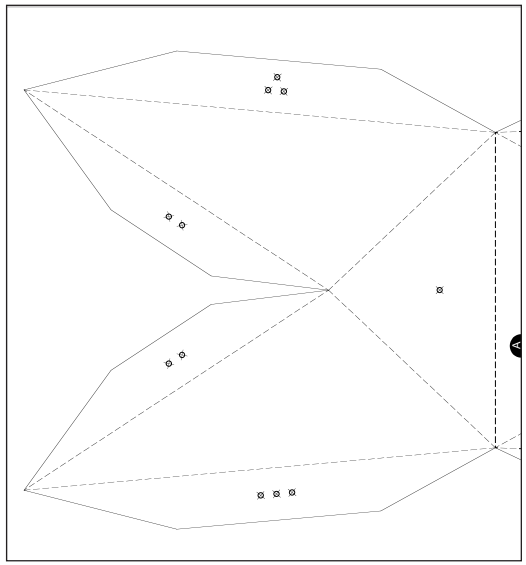
a typology of cardboard furniture



1.1 folded cardboard

Shoe box & rack - Acerly International

acerly.com.tw



right - models of children's furniture by Foldschool.

Foldschool sells plans on the web (eg below) so the furniture has an educational role as well as a functional one.

http://www.foldschool.com/_gallery/gallery.html

left - Children's Furniture and a wine rack by Kroom. Note the use of graphics printed on the cardboard. The wine rack is made to look like timber - complete with screws. Perhaps it alludes to where cardboard comes from, perhaps it's just kitsch.

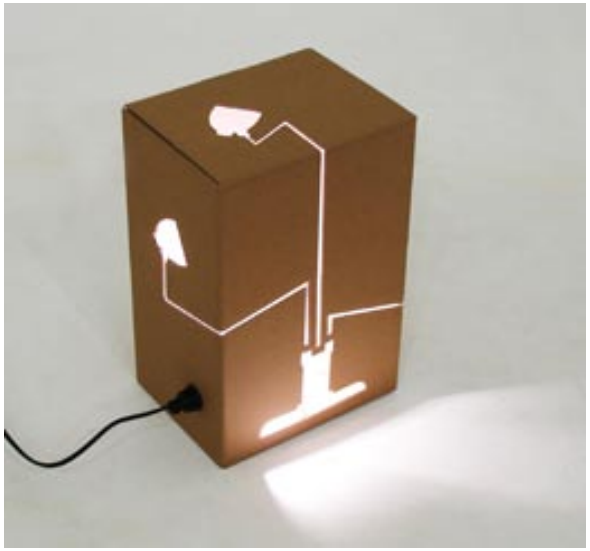
http://www.krooom.com/

David Graas: "This Side Up" - set of nested tables/stools

http://www.treehugger.co

Cardboard boat

http://www.thecardboardboatbook.com



above - Designframe, USA - "Pause stool"

image: Brower, Mallory & Ohlman, (2009)

David Graas - not a lamp (2004)

http://www.davidgraas.com/products

David Graas - not a box (2007)

The design cleverly uses the "lumiere" as the packaging for all the components

http://www.davidgraas.com/products

1.2.1
laminated cardboard with single section

Frank Gehry - Easy Edges Cardboard Furniture 1969-1973

The transformation of humble materials into elaborate and striking geometries–an intrinsic aspect of Gehry's early buildings–exists in a more intimate scale in his Easy Edges furniture. The rough appearance appealed to Gehry's informal design sense, and he discovered that while relatively malleable as a single sheet. It gains strength exponentially as it is laminated. Gehry added hardboard facing to the flat surfaces for increased strength and durability.

Gehry - Rocker image: liveauction.com

Gehry -wiggle chair - image nova68.com

http://www.1stdibs.com/archives/upload/8305/183/gehry.jpg

Gehry/Vitra 1972/2005 - 'low table set' -nesting tables - image: cite.co.nz

http://www.1stdibs.com/archives/upload/8305/183/gehry.jpg

"Experimental Edges" a second series of cardboard furniture was introduced by Frank Gehry in 1979. Gehry's intention was to make durable furnishings from throwaway material "to suit the homes of the young as well as old, as urban sophisticates as well as country dwellers" he has said.

As the material wears it becomes suedelike, malleable and soft.

ref: description accompanying Bubbles exhibit at MoMA

above - "Curumba", 1987 - image: sfmoma

right -"Bubbles Chaise Longue", 1987 - images: David Durance

Corrugated cardboard with fire retardant

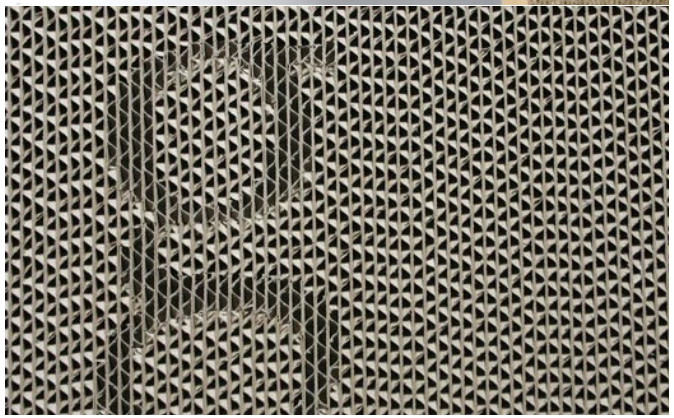
below - "Red Beaver", 1983 - image: hivemodern.com

Giles Miller

http://www.inhabitat.com

Miller, who just received his masters degree from the Royal College of Art (RCA) where he studied product design under the tutelage of Ron Arad, has been exploring various applications of corrugated cardboard since his undergraduate days at Loughborough University. Several pieces from his collection, including a wardrobe, grandfather clock and sidetable, have already been picked up by brands such as Dovetusai and Skitsch.

http://www.dwell.com/articles/live-from-london-giles-miller.html



"SPLAT" chair

http://www.therecyclewarehouse.com

N. Michelin 2005 - Caternary chair.
Claimed to ustilize the tensile strength of paper.
http://www.flickr.com/photos/nmichelin/48542115/

laminated seat from reused cardboard

www. gomi.com

4-petals coffee-table by Josh Levy

http://www.hometone.org/tags/coffee-table/6/

1.3.1
laminated cardboard furniture with multiple sections

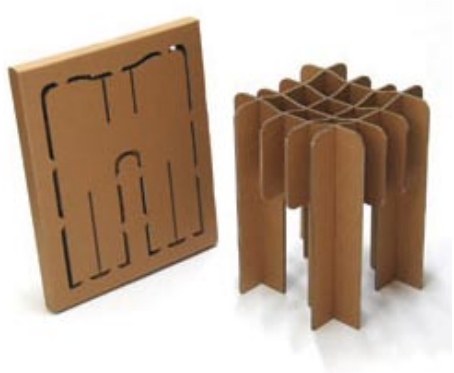
Store mannequin laminated from varying shaped cardboard sections. Displayed in the Museum of Art and design store NY.
photo: David Durance

above - coffee table by Leo Kempf
http://www.leokempf.com/cardboard.html

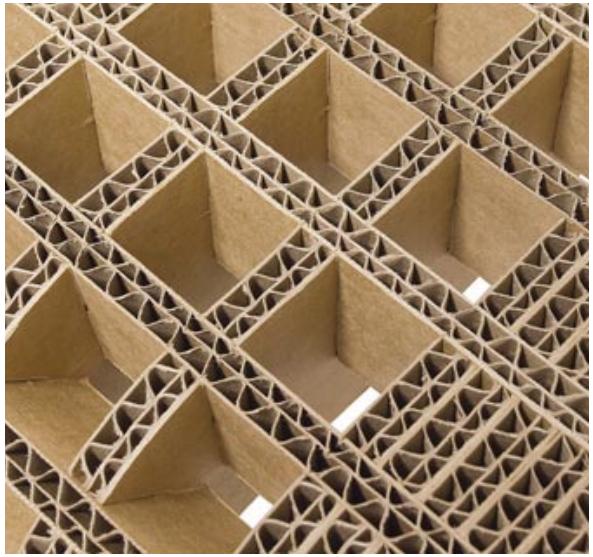
stool by David Durance
reused cardboard, laminated , sawn then glued

1.3.1
fabricated cardboard furniture with open structure

Furniture by David Graas - corrugated cardboard parts are flat-packed and slide together for user assembly.
http://www.davidgraas.com



far right - the appropriately named "Don't spill your coffee table" and "Don't spill your dinner table"
http://www.davidgraas.com/products



The "Build Up" range by Philippe Nigro
image: www.philippenigro.com
Many designers surveyed had a range of furniture, and they appeared to specialize in just one type of technology

Giles Miller

Giles Miller uses a technique of cutting components "on the bias" - at 45deg to the fluting. This gives components a more uniform appearance as there isn't one face showing a flute cross-sction and one showing flute edges.

http://3rings.designerpages.com/2009/10/16/giles-millers-cardboard-world-and-beyond/

1.3.2
fabricated cardboard furniture with covered structure

right - Bertrande Durand-Jenny - various

Instead of using multiple layers of cardboard for strength, the Cartonnistes use a tab and slot construction technique that requires a lot less cardboard, but is still sturdy and durable

http://www.lescartonnistesassocies.com/index.html

left - designer unknown

http://www.compagnie-bleuzen.com/vignette1.htm

Children's shelves by Miraki

Note the joining system

http://www.inhabitots.com/2009/11/17/mirakadi-paper-mache-and-cardboard-furniture/

Mike Sheldrake 2008 - isogrid surfboard - cardboard, fiberglass & epoxy resin

Sheldrake (2008) describes the process of making surfboards using a cardboard grid core. Ribs are laser cut and slotted together to form what he describes as a quarter isogrid, which is between a hexagonal honeycomb and true isogrid. He claims "The quarter isogrid is better suited than the conventional isogrid for a notched rib assembly, since ribs only intersect two at a time. Intersections are simpler and the average notch depth is shallower, retaining more of the ribs' strength, and simplifying reinforcement efforts". The outside is finished in fibreglass using an epoxy resin and the resulting surfboard is translucent.

Compared to a proper isogrid the ribs must be weaker because of the slots but the fibreglass skin would effectively close the section.

Sheldrake was a web programmer but turned to making his own surfboards three years ago, (Hammond 2009) effectively becoming one of the a "Pro-Ams" that Leadbeater refers to.

images: http://www.sheldrake.net/cardboards/

1.4
cardboard furniture with mechanical fastening

The mechanical fastening system devised by Makedo is intended for a range of applications from prototyping to playing. It can be used for other materilas apart from cardboard, but has been primarily designed for it, as evidenced by the inserting and cutting tool - left centre.

The company says "We love making. Not just making but making do - using the stuff we have, to make something new. makedo by name, 'make do' by nature", so there is a connection to the tinkering ethos.

left - the Makedo range

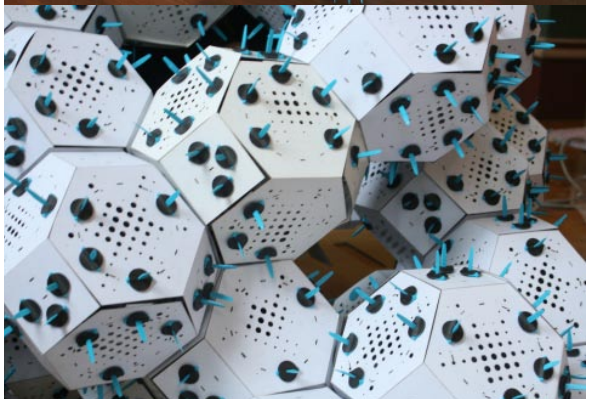
below - 'liquid city' by cache -paperboard, makedo

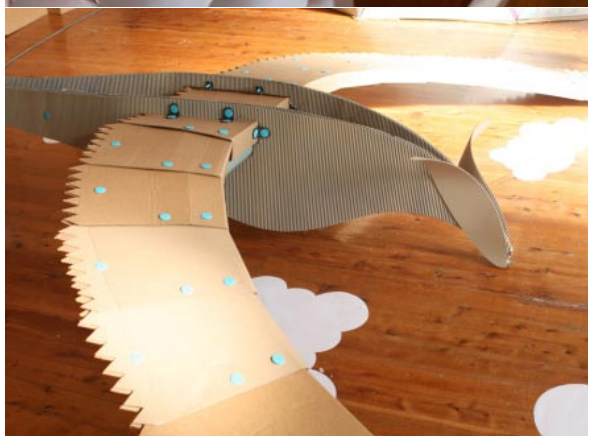
right - 'stealth table' by chris connell - x-board, makedo

centre right - paper cup part sphere - creator unknown

bottom right - cardboard bird - creator unknown

images: www.makedo.com





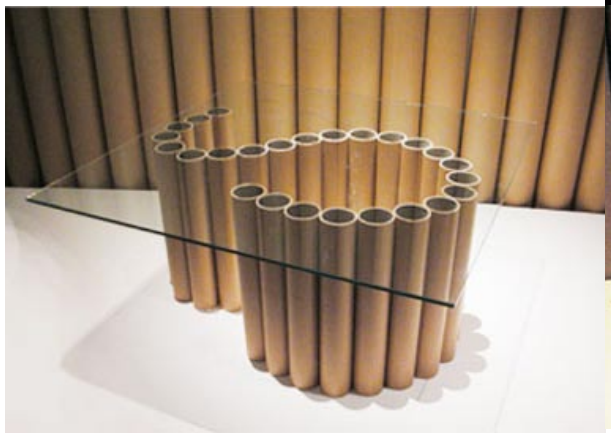
2.
cardboard tube

below: bridge and tower made from cardboard tube by re-known architect Shigeru Ban

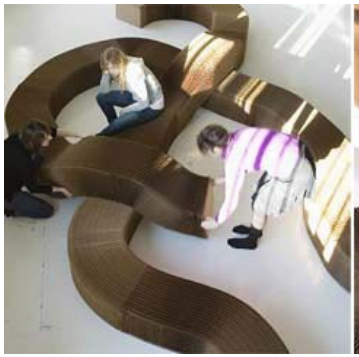
http://www.designboom.com/cms/images/andrea02/ban01.jpg

http://zedomax.com/blog/wp-content/uploads/2007/08/cardboard-bridge.jpg

right and below - Shigeru Ban 1998 cardboard tube furniture
http://www.designboom.com



3.1
Expanded paper honeycomb (EPH) furniture

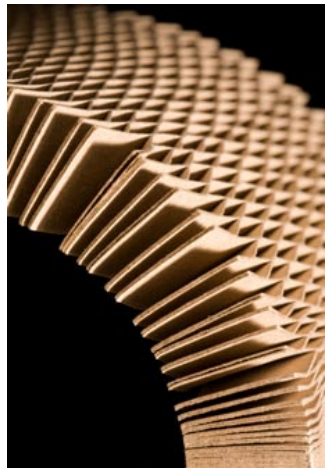


The paper lounge furniture by Molo Design is a series of seating elements in various materials and natural colours, all utilizing a honeycomb structure to fan open into various furniture such as, stools, benches, and loungers.

http://www.inhabitat.com

a4a design -EPH bookstack

http://www.a4adesign.it/



half expanded sheet of EPH

image - material connection

counter made from a stck of EPH board

images: David Durance

Honeycomb light by Molo -designed for indoor use it can accommodate LED or compact florescent lightbulbs.

http://www.inhabitat.com

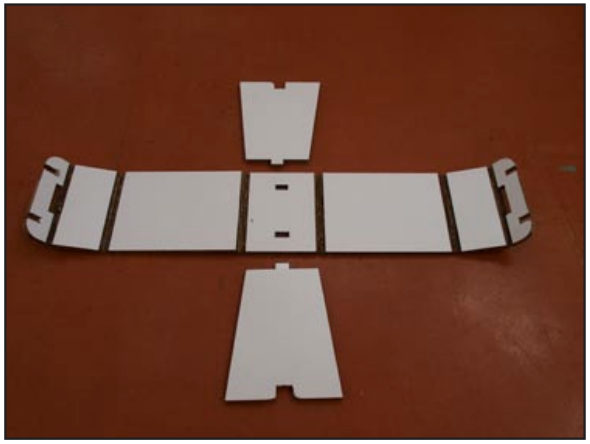
3.2.2
Triangular cell board

top - the system is made up from a single module
bottom -shelving/room divider system by freefoldfurniture
www.freefoldfurniture.com

top centre - Jacky Downing & James Burns - childrens chair
right - James Harris & Craig Artemiou -office table - 20mm X-board
the strength of this was demonstrated with a student jumping up and down on it
photo: David Durance

below, right - display unit, note edging
below, far right table with printed promotional material
www.xanita.com

image: material connection



Nick & Alex "Creator space" left child's seat
right - the same structure as the seat can be used for room dividers with 2 different configurations

4.1
moulded pulp

Katzutosh Amano & Shinichi Sasaki - "Mould Chair"
mades from cardboard pulp
Note the similarity to the Södra chair!
image Brower, Mallory & Olman (2009)

Södra - "Parupu" Pulp chair
made from paper pulp and PLA - poly lactic acid .
PLA created a harder and more water resistant material
photo: David Durance

Cat Scratcher Lounger by Bergan
a disposable product the cat can destroy
http://www.berganexperience.com/scratchlounger/index.html

Tamago series, Tamago collection, Merci Design
Tamago was conceived by the Latvian design team, Merci Design
http://www.tamago.lv

right - fruit punnet - New York
the use of pulp in the packaging industry is well established
photo: David Durance

4.2
pulp board

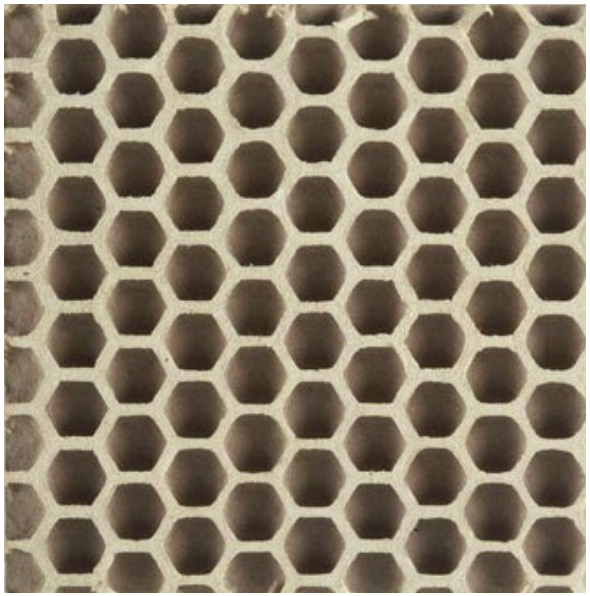
GRIDCORE *is " a lightweight honeycomb panel manufactured using 100% recycled card and paper pulp. , as well as agricultural fibers. The panels themselves can also be recycled. The panels are formaldehyde free and will not offgas during fabrication or after installation. Standard 3/4 in. Gridcore Panels have the bending strength of low-density particleboard at less than half the weight. They can be painted, laminated, edge banded, even curved to custom radii. Product applications include furniture, cabinetry, exhibits, displays, stage sets, interior design and industrial components. Gridcore was originally developed by the US Department of Agriculture."*

http://www.kingston.ac.uk/~kx19789/rematerialise/html_and_flash/index-application-wall-surfacing.htm

Gridcore *went out of production early 2002 but was then produced by Sonoco and marketed as* ***Sonoboard*** *up until about 2007.*

It is now no longer produced.

http://www.oikos.com/esb/50/gridcore.html - viewed 18 August 2009



GridCore about to be used in a Montana State University design-workshop

http://www.livearchitecture.net/blog/index.php?m=09&y=07&d=22&entry=entry070922-224842

5.
paper maché

Historical uses

Paper maché has been a commonly used material in furniture since the mid 1800's. It had begun to be used as early as the sixteen century for dolls' heads in France. In the nineteenth century the invention of efficient pressing and molding machines made it possible to produce innovative furniture from papier-mâché. The piece was treated with numerous coats of heavy lacquer (often black) before being decorated with gild and inlaid mother-of-pearl, often in a chinoiserie style. Many large and elaborate papier-mâché pieces were shown at the London Crystal Palace Exhibition in 1851, including a grad piano. The major producer of papier-mâché furniture in England at that time was the firm of Jennens & Bettridge. (*Origin of Innovative furniture, 2007)*

One surprising use of paper maché was in train carriage wheels. There were introduced in 1870 and used without incident until 1915. Their benefit was they reduced noise inside the carriages. Pullman had introduced his luxury carriages at this time, but he suspension system was not very sophisticated. Timber had been tried but there were failures. Paper maché wheels performed without incident (Cupery 1997).

bottom - Japanned table
http://www.tudor-rose-antiques.co.uk/product.asp?itemid=3502

left - http://www.oneofakindantiques.com/catalog/6779_english_papier_mache_tray_table_1880_1.htm

Paper maché railway wheels were used from 1870 to 1915 by US railways. They consisted of a steel hub and tyre with a paper maché infill covered by a protective metal disc. image : Cupery 1997)

Contemporary uses of paper maché

All of the surveyed paper maché artefacts are one-off or small batch produced items by craftspeople or amateurs. Many of the items produced are small - toys, ornaments and sculptures. They are usually decorated in a 'handcrafty' way - folksy, näive or kitsch style.

right - This cube shaped coffee table, made in Haiti, has a more contemporary style. However, the sea-from motif on the front keeps it within the craft based paper maché vernacular

http://www.vivaterra.com

left -Flying Dog Throne by Miraki - paper Maché

http://www.wedhorndesign.de/mirakadi.htmlmache-and-cardboard-furniture/

table by Suie Raskusin

http://www.sudierakusin.com

'Surfer Girl Clock' by Allie Scott

http://www.papiermache.co.uk/gallery/artist/391/

bottom - paer maché boat

http://blog.makezine.com/archive/2006/08/paper_boat.html

6.
Paper board

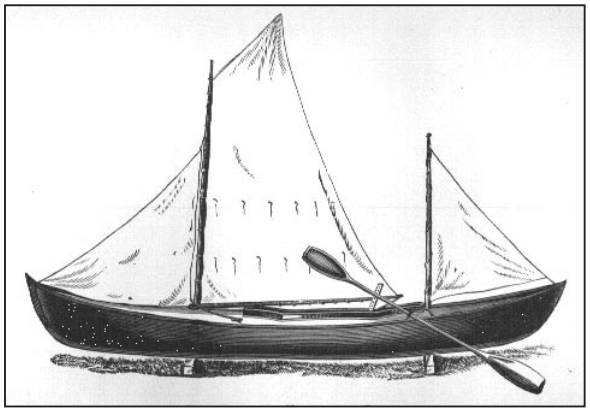
No exemplars of current furniture have been found during the survey for furniture made from plain paperboard, however there are some references to other products made from modified paperboard - Taylor Paper Glass and the paper boat technology developed by Waters and Sons in the 1860's and 1870's.

Taylor Paper Glass (TPG) is a composite used in some light aircraft construction. It uses Kraft paper 0.1 to 0.2mm thick, which is laid out on wooden formers and coated with polyester resin to set it in shape. Layers of fibreglass and resin are then coated on either side of the paper layer. The advantages claimed for this are the low cost of the core, a rigid, strong and lightweight composite sandwich structure without the need for expensive tooling (Mini-IMP 2009). **Other paper composites**. Norplex-Micarta (2009) make a number of paper composites using phenolic, malamine and expoxy resins. These find use in electrical engineering due to their insulative properties.

Paper Boats

> *"George Waters' first shell was built in 1867 and was formed using an old Josh Ward shell as a mold. Several large sheets of a high-quality manila paper were laminated over the mold to form the skin of the hull. Wood framework, a seat, oarlocks, & etc. were added after the hull was removed from the mold. By 1868 George had obtained a U.S. patent and was actively engaged in the commercial manufacture of paper shells in Troy, NY with his father Elisha and his brother Clarence. The first race won by a paper boat was on the 30th of October of 1867 when John McKiel of Cold Spring, NY was defeated by Henry Coulter of Pittsburgh. The Waters catalog of 1871 proudly lists a total of 14 races won by paper boats during 1868. In 1869 the list grows to 26 races and the sites include distant cities such as Savannah, Pittsburgh, Boston, and Toronto. A typical 31 ft. shell weighed approximately 22 lbs., (compared with about 40 lbs. for a comparable wood hull.) The light weight resulted from using only three layers of 0.015" thick manila paper for the hull, and but one layer of paper for the deck as well as a minimalist approach to wood supporting structure. In many ways it was a precursor to modern composite hull construction. (Cupery 2009 - 1)*

The boats were made from several layers of jute fibre paper laid out over a mould. The thickness varied between 2.5 and 5mm. Waterproofing was achieved by coating with shellac (Bishop, N 1878).[1]

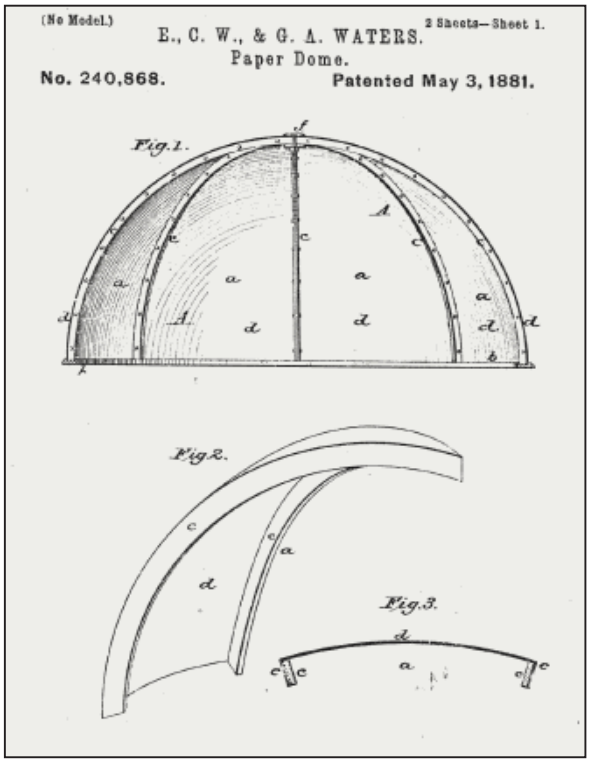


The Nautilus paper hulled canoe

1 *Nathanial Bishops book "the Journey of the paper canoe" recounts the author's 1874 journey of two thousand miles from Delaware to the Gulf of Mexico in a paper canoe*

Beginning in 1878, E Waters and Sons constructed several observatory domes across the US from paper. Domes were constructed from paper over a wooden frame; it was felt that other materials would be too heavy, leading to complexities in construction.[2] One of the domes was built at the West Point academy in 1881. It survived without incident until it was repaired1924, then eventually dismantled in 1958/9 - 77 years after initial construction. (Cupery 2009 -2)

paper dome patent (Cupery 2009 - 2)


(No Model.) 2 Sheets—Sheet 1.

E., C. W., & G. A. WATERS.

Paper Dome.

No. 240,868. Patented May 3, 1881.

Fig.1.

Fig.2.

Fig.3.

2 *Meanwhile in England the dome at Greenwich observatory was made from paper maché over an iron frame. (Cupery 2009 -2)*

7.
furniture from mixed classifications

below - furniture by Schmulb. Thiis is claimed to be made by the 'Schmulb Process' developed in the 1980s. This process is unspecified but it appears to be a combination of paper maché or similar technique over a structure of fabricated cardboard.
http://schmulb.com

right -334 bench by Oscar Lhermitte
The newspapers aren't glued, but mounted on 3 parallel steel bars. It is claimed to be able to support the weight of 5 people
http://www.oscarlhermitte.com

8.
furniture from paper/cardboard composites

Armacel is an Australian developed product. It is a process of vacuum forming PET sheet over a core, and has the claimed advantages of toughening and strengthening the core, as well as providing weather resistance.

Few exemplars of Armacel covered furniture exist, however it looks like a promising material especially for cardboard products.

"Armacel is a high-impact vacuum-tensioning process that is used to manufacture totally unique product solutions engineered to suit any customer or user requirement. Predominantly, little or no specialized tooling is required in the product design or manufacturing process thus providing Armacel manufacturers and end users with maximum flexibility and cost-saving advantages. The Armacel technology allows the creation of low cost and lightweight furniture products ideal for many applications. The ability to use low cost substrates that could not normally be considered makes many new products possible. Lightweight convention furniture is one application that utilizes the lightweight construction properties of Armacel solutions very well.

The unique AAPET plastic outer surface which results from the Armacel process is easy to clean, abrasion and chemical resistant, water resistant and can include fire retardant and UV protection agents suitable for outdoor use. Any number of separate and loose pieces can be combined and securely held together by the tensioning process itself; consequently eliminating the need to use fastener devices such as nails, staples, adhesive etc. Individual pieces can be hinged and the final product can also be drilled, heat welded and tapped if required."

www.Armacel, com.

right - products from Armacel covered cardboard - bookshelves, bin, pallets, stool.

bottom right - bicycle helmet, surfboard

See also chapter on "Cardboard in Architecture" (Appendix 1).