MANCHESTER SCHOOL OF ARCHITECTURE

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Manchester Metropolitan University

B.15
MODELMAKING
WORKSHOP

Sustainable Modelmaking

Contents

Front cover image: Mixed media final model by Rodrigo Urquza; Jesomite, Balsa, Plywood, Paper, Packing card.

Salvaged timber inside B15

Recycled materials, racking and drawers in B15

Introduction

The construction industry is responsible for around one-third of carbon dioxide equivalent (CO2e) emissions in the global carbon footprint (IEA, 2023). Across all sectors, industry needs to reduce carbon emissions to avert the worst effects of climate change; striking a balance between environmental concerns, social concerns, and economic concerns.

We have written this guide to encourage you to make more sustainable choices in your model-making practices. Model making, by its nature, mimics the construction process at smaller scales. By creating models that have less environmental impact, you can begin to think like a sustainable architect in practice, so preparing for the demands of a more sustainable industry in the future.

It might be easy to say that you will dispense with physical model making and move to digital models to save on the environmental costs of materials. However, physical model making is a valuable tool which can enhance your learning experience by being more tactile and intuitive compared to digital simulations. Physical model-making is a really important skill to learn, and has been part of architectural practice for millennia. Models help you to practically apply abstract design theory and to communicate and refine your ideas. Moreover, digital activities also have their own carbon footprint and often rely on energy hungry data stores, which are estimated to now have a larger environmental impact than the aviation industry (Hodgkinson, Jackson & Jackson, 2023).

We don't want to tell you what to do. Our intention with this guide is to nudge you towards making choices that will benefit people and planet. We urge you to make more (physical) models; but to reduce, recycle, and reuse wherever you can.

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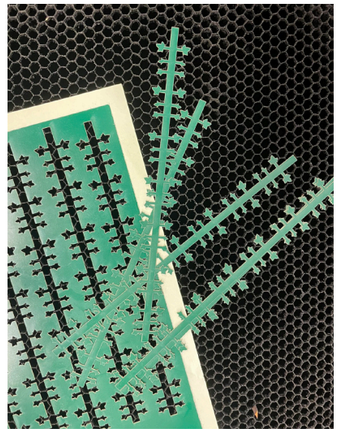
Quick Guide

Material	Recyclability	Reusability	Harmful Chemicals	Overall Sustainability rating
Paper	High	High	No	Very good
Cardboard	High	High	No	Very good
Balsa Wood	Limited	High	No	Good
Plywood	Limited	High	Check*	Medium
Cork Sheets	Yes	Yes	Check*	Very Good
Plaster	Limited	Yes	No	Good
Jesomite	Limited	Yes	No	Good
Foam board	No	No	No	Medium
Silicone Rubber	No	Yes	No	Medium
Epoxy Resin	No	No	Yes	Low
Acrylic Sheets	Limited	Limited	Yes	Low

This table is a quick guide to the overall sustainability of materials available for modelmaking

**Check - some forms of these products may use adhesives that can be harmful.*



Laser cut paper leaves

This section sets out some simple 'rules of thumb' - general principles that should guide you towards making models that are better for the environment.

The most important thing though is to plan before you begin, always asking yourself what you need to demonstrate - is it exploration, is it a presentation model - and decided what are the best suited materials for that purpose.

BEFORE YOU BEGIN

Think about why you are modelmaking. The more you understand the direction that you are going in, even if it's simply exploring shapes and forms, the more sustainable that your modelmaking practice will be.

Keep it simple. Simple, uncomplicated materials and hand-work as opposed to using machines usually tend to be lower in energy costs and health risks (e.g. air, dust, Volatile Organic Compounds [VOCs])

Plan your model in advance. Think about what you want to communicate, and what is needed in terms of size and layout versus the cost (£'s) and environmental cost.

Reuse existing materials. Reusing is preferable to recycling or buying new materials. Often materials that are labelled as 'recycled' can be recycled using highly energy intensive processes. Ask the workshops if they have existing material and reuse your old models or your friends' models.

Reduce any materials that you use. Only use the amount of material that you need. Be efficient.

Pay attention to the process. Some forms just don't need to be 3D printed or laser cut; both processes use more energy than handwork. Simple forms can be made from scraps can still convey the message required.

MAKING

Optimise your materials and minimise any off-cuts. Consider the layout on your sheets before you begin cutting. Aim for minimal off-cuts.

Use equipment properly. By thinking about each component you are trying to produce beforehand it is possible to produce the desired shape without unnecessary waste.

Reduce. Only use the amount of material that you need and minimise high embodied energy materials.
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AFTERLIFE

Consider the future reusability of your model.

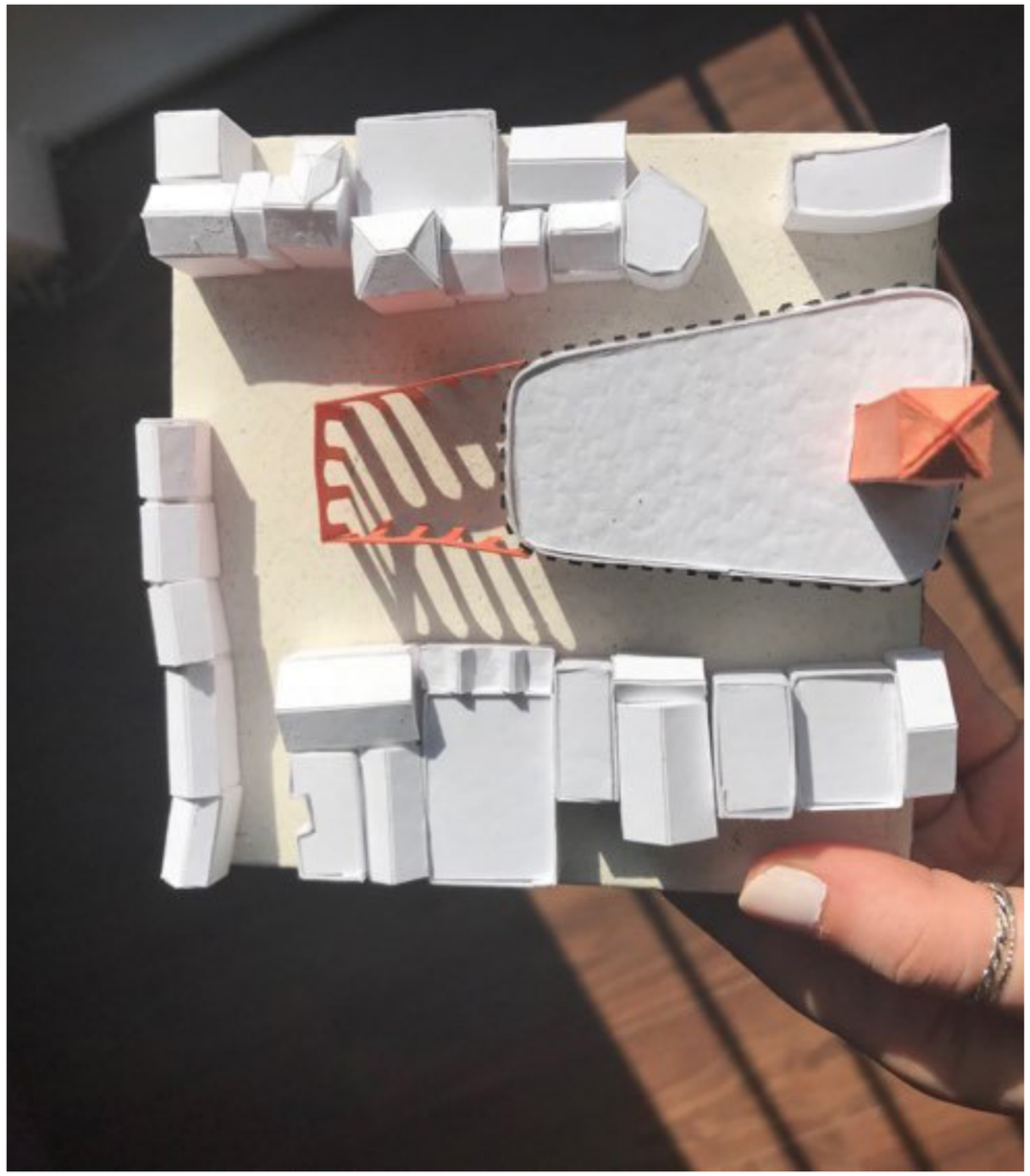
Have a plan for what you will do with it when you have finished.

Can others reuse parts of it?

Where can you recycle bits that can't be reused?

Ultimately, how will you avoid your model, or any part of it, going into landfill?

Rules of Thumb



Handmade paper model by Tara Aves

Paper

What is it?

Paper is fundamental and widely used material. It is typically made from processed plant fibres, primarily wood pulp or recycled paper, which are then formed into sheets.

How to use paper in modelmaking

Architects and designers utilise paper for a variety of model types, ranging from initial concept sketches to intricate presentation models.

Paper is valued for its affordability, ease of manipulation, and its ability to represent a wide range of architectural details and forms.

The environmental costs of paper

Depending on various factors including its source and production methods, paper, when derived from responsibly managed forests or recycled materials, can be an environmentally friendly choice.

Sustainable paper production often involves reducing energy use and emissions. Some manufacturers employ renewable energy sources to power their facilities, minimising the environmental footprint. Nevertheless, it's essential to consider the specifics of the paper's production to assess its sustainability.

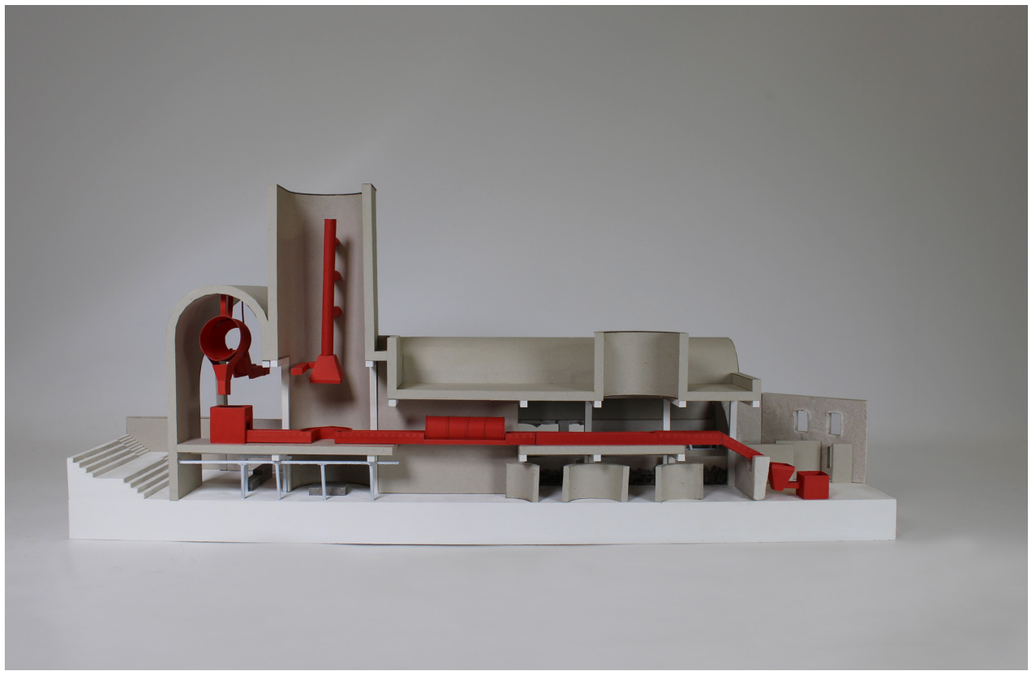
How reusable and recyclable is it?

High recyclability. Most paper products can be efficiently recycled in designated bins. Recycling paper reduces the demand for fresh pulp and lessens the volume of waste sent to landfill..

Paper models can be reused. Elements of old models can be disassembled, and the materials can be repurposed for new projects, reducing the need for entirely new model materials.

Paper models can be preserved and used for educational purposes or exhibitions.

Packing card greyboard and clay form finding, by Maria Figueiredo



Coloured paper and card model by Millie Evans

Cardboard

What is it?

Cardboard is a versatile and popular material for architectural model-making. It consists of layers of paper or cardboard fibres glued together.

Cardboard is available in various thicknesses and can be cut, scored, and shaped to represent different building elements and details.

The most common types of cardboard used in modelmaking is packing card, corrugated cardboard, coloured mountboard, and grey board.

How to use carboard in modelmaking?

Carboard is often used for creating study models, conceptual models, and even presentation models.

Cardboard offers a lightweight, rigid, and easily workable medium for creating architectural models.

The environmental costs of cardboard

Cardboard is recognised for its sustainability in architectural model-making. It is primarily derived from renewable sources, particularly wood pulp from sustainably harvested trees.

The manufacturing processes for cardboard have evolved to incorporate responsible sourcing and reduced chemical use.

In terms of energy consumption, cardboard production generally demands less energy compared to materials like plastic or metal. Manufacturers have adopted more energy-efficient processes, making it an environmentally responsible choice for model creation.

You don't need to buy new cardboard for your model. Why not reuse any packaging that has been delivered to your home?

Recyclability and Reusability:

High recyclability. Most cardboard **pro**ducts can be conveniently recycled. This contributes to the reduced need for new raw materials, minimising waste in landfills.

Cardboard models are amenable to reusability. Elements of a model can be disassembled and repurposed in new projects, reducing the requirement for entirely new models.

Models can be stored and reused as instructional tools in architectural education, offering a sustainable alternative to one-time use.

Cardboard and balsa, by Alicia Desmay Hernandez

Handcut grey board and balsa interior, by Valeria Szegal

Balsa wood

What is balsa wood?

Balsa wood comes from the balsa tree, which grows quickly and reaches heights of 30 metres in only 15 years. The Balsa tree is native to South American rainforests, and most balsa used in the world comes from Ecuador where it is grown in dense plantations.

How to use balsa wood in modelmaking

Balsa wood is a light but strong material, which makes it a highly popular choice for architectural model making. It is a type of wood that comes from the balsa tree, known for its low density and ease of cutting and shaping.

Architects and designers use balsa wood to create various types of architectural models, from conceptual studies to detailed presentation models.

Balsa's fine grain, workability, and lightweight characteristics make it an ideal choice for representing structural elements, creating building details, and crafting intricate models.

The environmental costs of balsa wood

Balsa wood is known for its sustainability. The balsa tree is fast-growing, which reduces the pressure on forests. Additionally, it is cultivated in plantations, minimising the impact on natural ecosystems.

You should look out for 'Forest Stewardship Council (FSC)' certification as a guarantee that the wood comes from forests that are sustainably managed.

The energy use in the production of balsa wood is relatively low. The wood is harvested, processed, and cut into sheets with minimal energy consumption.

The sustainability of balsa wood is further enhanced by its biodegradability.

However, there are transportation costs associated with balsa wood as it mainly comes from South America.

Recyclability and Reusability

Balsa wood is not typically recyclable in the same way as some other materials like paper or cardboard. Though due to its organic nature, it can degrade over time, returning to the environment.

However, balsa wood models can be reused. Sections of old models can be repurposed, integrated into new projects, or modified for different presentations.

The lightweight nature of balsa wood models makes them easy to handle and store, extending their usability.

1: 100 sectional model using etched 3mm plywood, by Daniel Kempski

Plywood

What is Plywood?

A versatile and durable material. It is constructed by layering thin sheets of wood (called veneers) and bonding them with adhesives under high pressure and heat.

How to use plywood in modelmaking

Architects and designers often use plywood for creating a wide range of architectural models, from early design sketches to detailed presentation models.

Its structural stability, smooth surface, and ability to be cut, shaped, and finished make it an ideal choice for various model types.

The environmental costs of plywood

The sustainability of plywood hinges on the sourcing and production methods. Plywood can be made from sustainably harvested wood, where responsible forest management practices are employed.

You should look out for 'Forest Stewardship Council (FSC)' certification as a guarantee that the wood comes from forests that are sustainably managed.

The production of plywood however typically requires substantial energy, particularly during the pressing and bonding stages.

Some manufacturers aim to reduce the environmental impact by utilising energy-efficient technologies and sustainable sourcing.

Additionally, sustainable plywood options may use adhesives with lower formaldehyde emissions.

Note that the UK doesn't have enough reserves to produce its own plywood to the vast majority of the product is imported, which adds further carbon emissions to the transportation costs.

Recyclability and Reusability

Plywood is recyclable but typically not as straightforward to recycle as paper or cardboard due to the adhesive content. However, some recycling facilities can process plywood into other wood products or use it for energy recovery.

Plywood models can be reused effectively. Elements of old models can be disassembled and repurposed for future projects, reducing the need for entirely new materials. This reusability extends the lifespan of plywood models, conserves resources, and minimises waste.

Cork sheets

Handcut paper, cork, card and tracing paper, by Samantha Cutler

What are cork sheets?

Cork used in construction comes from the bark of the cork oak tree (Quercus Suber), a slow-growing evergreen tree which is native to the Mediterranean. Whilst the cork oak tree's growing range is limited, the cultivation supplies wider ecosystem benefits in a rich agroforestry system. Once the tree is 25 years old, the bark can be stripped once every nine to twelve years to allow time for sufficient regeneration, leaving the tree unharmed.

How is cork used in modelmaking?

Cork sheets are a highly valued material in model making, and have been used for hundreds of years. Cork is most famous in use for study models of ruined Italian architecture and brought back as aids by 'grand tour' architects such as Sir John Soames.

Cork sheets are lightweight, versatile and have a natural and visually appealing texture. Cork sheets are frequently used to create a wide range of architectural models, from initial concept studies to detailed presentation models.

Cork sheets are easy to cut and shape, making them suitable for re representing diverse design elements, including topography, facades, and interior finishes.

What are the environmental costs of using cork sheets?

Cork sheets are known for their exceptional sustainability. The cork oak tree's bark is harvested every 9 to 12 years without damaging the tree itself. This renewable source minimises the environmental impact.

The harvesting process for cork bark is low in energy use. Harvesters carefully remove the bark by hand, without the need for energy-intensive processes or machinery.

However, cork sheets that are light in colour are glued using polyurethane, but dark in colour are formed under pressure without any added glues. Polyurethane is non-biodegradable and can contribute to microplastic pollution, which damages ecosystems and human health. The production of polyurethane also consumes finite amounts of energy and fossil fuels.

Recyclability and Reusability:

Cork sheets are fully recyclable and biodegradable. At the end of their useful life, they can be recycled into new cork products or returned to the environment without causing harm.

Cork sheets can be effectively reused in architectural model-making. Elements of old models can be disassembled, and cork sections can be incorporated into new projects, contributing to waste reduction and resource conservation.

Plaster cast and laser cut plywood, by Jasmine Cornish and Ugne Boskaite

Plaster

What is plaster

Plaster is made from a paste of water, sand, and lime or gypsum that hardens when it dries to create a dense, solid surface.

You can also buy plasterboard as a ready made substitute from most DIY stores. Plasterboard provides a consistent slab of plaster which often comes with a layer of paper adhered to the outside which can be removed with a wet cloth.

How to use plaster in modelmaking?

Plaster is a versatile and traditional material. Architects and designers utilise plaster to create three-dimensional representations of architectural elements, interiors, and landscapes.

Plaster's workability, affordability, and ability to capture fine details make it suitable for crafting intricate model components, including building facades, ornamental details, and terrain features.

Pre-cast plasterboard provides a consistent slab of plaster that can be easily worked using hand tools or in machine cutting.

The environmental costs of plaster

The sustainability of plaster as a model-making material is relatively favourable. Plaster is primarily composed of gypsum, a naturally occurring mineral that is abundant and widely available. The mining and processing of gypsum require less energy compared to many other materials used in model making.

Plaster's environmental impact is relatively low, and it does not rely on non-renewable fossil fuels for its production. However, there can be energy consumption associated with transportation and heating to create the plaster.

Recyclability and Reusability:

Plaster models are typically not recycled in the same way as materials like paper or cardboard due to the complexity of separating plaster from other materials. However, plaster can be broken down and its components can be reused.

Old plaster models can be crushed, remixed, and re-cast into new model elements, contributing to resource conservation and waste reduction.

Additionally, elements of plaster models, such as architectural details or terrain features, can be preserved and reused in other architectural projects, enhancing their reusability.

CNC machined jesomite

Jesomite

What is Jesomite?

Jesomite is a water-based composite material made from gypsum plaster and an acrylic resin liquid.

Jesomite is a practical alternative to casting in plaster. It is much safer than using an epoxy resin as it does not emit toxic fumes when used. Jesomite also has a much faster curing time compared to epoxy resin.

Jesomite is durable and strong, and can be easily handled and transported.

How to use Jesomite in modelmaking

Jesomite can be mixed to create a wide variety of colours, textures and finishes, particularly adept at mimicking different types of surfaces such as stone and metal. This makes it ideal for detailed façade models.

Jesomite captures small details very well, making it suitable for intricate, small-scale models.

Jesomite can also have pigments added to it to represent different colours and shades.

The environmental costs of Jesomite

Jesomite is considered to be environmentally friendly because it is non-solvent, lightweight, and doesn't require chemicals or large equipment.

Jesmonite's manufacturing process often uses recycled water and co-generated electrical power to minimise its environmental impact.

However, Jesmonite does contain acrylic plastic, which can release harmful chemicals into the environment over time, such as microplastics from sanded surfaces.

Is it reusable? Can it be recycled?

Jesomite can be hard to recycle. However, it can be reused in several different ways.

Leftover colored Jesmonite can be used to create terrazzo patterns with a stone-like finish.

Any Jesomite leftovers can be regifted to someone else.

Excess material from the mixing bowl can be saved and reused.

Leftover material can be used to make moulds.

Model using foam board as the insulating material, by Katie Williams

Foam board

What is foam board?

Foam board is a lightweight and versatile material. It consists of a foam core, usually made of polystyrene or polyurethane, sandwiched between two paper or plastic sheets.

How to use foam board in modelmaking

Architects and designers frequently employ foam boards to create various types of architectural models, including conceptual studies, detailed presentation models, and prototypes.

Its ease of cutting, shaping, and the ability to hold adhesive materials make it ideal for representing building elements, site contours, and design concepts.

What are the environmental costs of foam board?

The sustainability of foam board as a modelmaking material is mixed. The production process generally involves the use of non-renewable fossil fuels for both the foam core and paper or plastic facings.

Energy use during manufacturing can be relatively high, which raises concerns about its environmental impact.

Some manufacturers have been working on making foam board production more sustainable by using recycled materials, water-based adhesives, and energy-efficient practices. Nevertheless, the overall sustainability can vary depending on the source and production methods.

Recylcability and Reusability

Foam board can be challenging to recycle, primarily due to its composite nature. Disassembling and separating the foam core from the paper or plastic facings can be difficult.

Reusability is also limited, as foam board models are typically custom-made for specific projects and may not readily adapt to other uses.

1: 10 detail fabrication using a silicone mould, by Jana Kefurtova

Silicone rubber

What is silicone rubber?

Silicone rubber is a synthetic, rubber-like material that is durable and resistant to heat, chemicals, and extreme weather conditions. It is made from silicone, oxygen, carbon, and hydrogen.

How to use silicone rubber in modelmaking

Silicone rubber is a versatile and highly flexible material.

Architects and designers often utilize silicone to create moulds and castings, enabling the replication of intricate design details and components.

Silicone rubber is prized for its ability to capture fine textures and intricate features with precision. It is particularly valuable for producing architectural model elements like facades, decorative elements, and intricate interior details.

Generally, silicone moulds should only be used when you require multiple casts. Single casts can be replicated using one-use formwork moulds.

What are the environmental costs of silicone rubber?

Silicone's sustainability factor is generally mixed. The primary component of silicone rubber is silicone, derived from sand, a naturally abundant material. While this is advantageous, the production of silicone typically involves energy-intensive processes, including the use of fossil fuels for high-temperature reactions.

Additionally, silicone is often treated with various additives and curing agents, which can introduce environmental concerns.

Recyclability and Reusability:

Silicone is not recyclable in the traditional sense. Once cured, it cannot be easily broken down or repurposed.

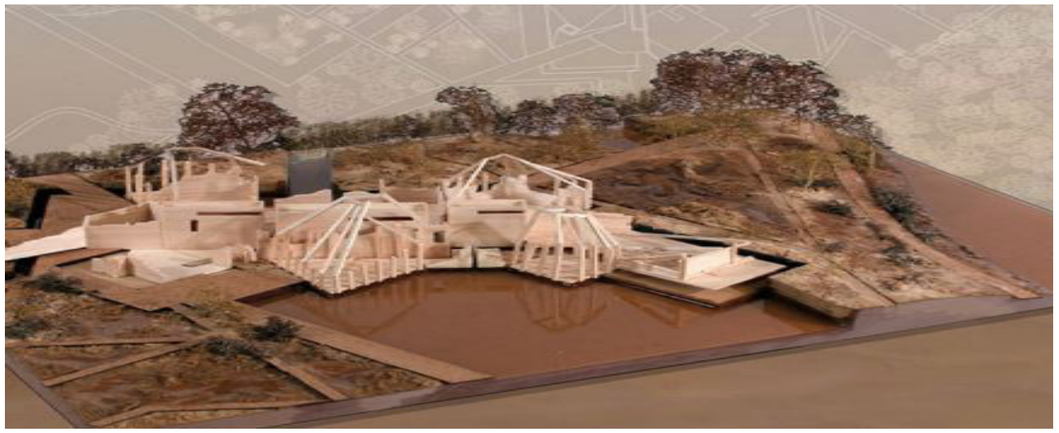
However, it is highly durable and can be reused multiple times in model-making.

Moulds created from silicone rubber can be used repeatedly to cast architectural model components, which extends the lifespan and reduces waste.

Silicone elements can be stored and incorporated into future model projects, contributing to their reusability.

Chopped up pieces of silicone can be used to bulk out larger moulds.

Epoxy resin used for landscape/water features by Daryl Quayle and Elliot Flynn



Epoxy resin used to accentuate water features, by Karolina Olszewska and Harry Richardson

Epoxy Resin

What is epoxy resin?

Epoxy resin is a class of thermosetting polymers made from monomers that contain at least two epoxide groups. They are chemically reactive intermediates that can be stimulated to cross-link, resulting in polymerisation into rigid three-dimensional chemical lattices.

Epoxy resins are known for their adhesive properties, resistance to chemicals and moisture, and ability to withstand moderate temperatures.

How to use epoxy resin in modelmaking

Epoxy resin is a versatile and durable material frequently employed in architectural model-making.

Architects and designers utilise epoxy resin to create transparent or solid components, such as water features, site elements, and detailed design features.

Epoxy resin is prized for its ability to capture fine details and produce glossy, translucent, or coloured surfaces, making it an ideal choice for adding realism and visual appeal to architectural models.

What are the environmental costs of epoxy resin?

Health warning! Epoxy resin can be toxic and commonly causes severe contact dermatitis. Gloves must be worn when handling resin components. The workshops are set up to remove chemical vapours.

Epoxy resin's sustainability factor is often a point of concern. The primary raw materials for epoxy resin include bisphenol-A (BPA) and epichlorohydrin, which are derived from petrochemical sources, making the material dependent on non-renewable fossil fuels.

The production of epoxy resin typically involves energy-intensive processes, including the use of high temperatures and chemical reactions. These processes result in a significant carbon footprint and environmental impact.

Recyclability and Reusability

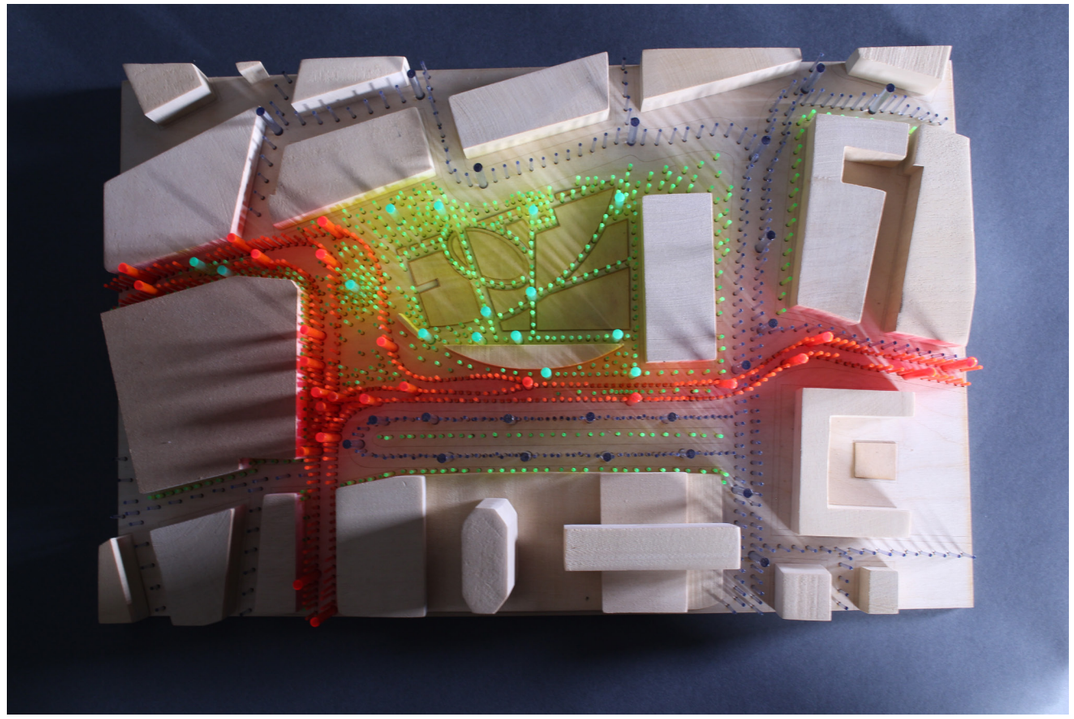
Epoxy resin is not easily recyclable, primarily due to its curing process, which results in a permanent chemical transformation. Once cured, it cannot be readily broken down or reprocessed.

However, it can be highly durable, making architectural model components made from epoxy resin reusable.

Models created with epoxy resin components can be disassembled, and elements can be integrated into new projects, extending their usefulness.

While the resin itself may not be recyclable, this reusability could contribute to waste reduction and resource conservation in architectural model-making.

Acrylic sheets



Conceptual site model using acrylic and timber caps, by Sam Hall

What are acrylic sheets?

Acrylic sheets, also known as plexiglass or acrylic glass, are transparent or colored thermoplastic sheets made from synthetic polymers (polymethyl methacrylate).

How to use acrylic sheets in modelmaking

Prized for their durability and versatility, acrylic sheets are widely used to create detailed and visually striking architectural models.

Architects and designers favour acrylic sheets for their ability to convey complex design features, interior spaces, and lighting effects.

They are moldable at high temperatures and solidify when cooled. They can then be cut, engraved and shaped to produce intricate architectural elements.

Acrylic sheets are strong, stiff, and have excellent optical clarity, making them a good proxy for glass in many applications.

They are also cost-effective, durable, and can be moulded and colored to fit specific needs.

What are the environmental costs of acrylic sheets?

The sustainability of acrylic sheets is a subject of concern. Acrylic is a petroleum-based product, meaning it is derived from non-renewable fossil fuels.

The production process typically involves energy-intensive procedures, including the extraction of raw materials, the manufacturing of acrylic sheets, and transportation. This results in a considerable carbon footprint and environmental impact.

While efforts have been made to reduce energy consumption and environmental impact through more efficient production methods and the use of recycled acrylic, the overall sustainability of acrylic sheets remains a matter of debate.

B15 has moved to stocking 'GreenCast' 100% recycled acrylic. Nevertheless, given the energy processes needed to recycle acrylic, this should be used as minimally as possible.

Recyclability and Reusability

Acrylic sheets are recyclable, but recycling can be challenging. They can be processed and transformed into new acrylic products, but this process is not as straightforward.

B15 collects waste acrylic that is periodically sent for recycling, so look out for the acrylic recycling bin.

The reusability of acrylic models is limited, as they are often tailored to specific projects and may not easily adapt to other uses.

Acrylic pieces can be preserved and used for educational or exhibition purposes, extending their lifespan and reducing waste.

Useful resources

The B15 workshop blog contains lots of useful insights not only in how to make models, but the latest thinking and work at the workshop to reduce its carbon footprint.

http://b15.humanities.manchester.ac.uk/

The B15 Materials List

B.15 Materials Lists: http://b15.humanities.manchester.ac.uk/?page_id=92

The International Living Future Institute's 'Red List' is a list of chemicals that are considered to be the worst in the building industry.

https://living-future.org/red-list/

References

Dunn, N. (2014) Architectural modelmaking. Second edition. London: Laurence King Publishing.

International Energy Agency. (2023) The Breakthrough Agenda Report, 2023. Available at: https://iea.blob.core.windows.net/assets/d7e6b848-6e96-4c27-846e-07bd3aef5654/THEBREAKTHROUGHAGENDAREPORT2023.pdf

Jackson, T.W. and Hodgkinson, I.R. (2023). Keeping a lower profile: how firms can reduce their digital carbon footprints. Journal of Business Strategy, 44: 6 [online] doi/10.1108/JBS-03-2022-0048

Schilling, A. (2021) Basics Modelbuilding. Basel: Birkhäuser.

Sir John Soames Museum (n.d.) Creating a cork architectural model [online] Available at: https://www.soane.org/collections/videos/creating-cork-architectural-model (accessed 28 Aug 2024)

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