Building Material Selection and Use

An Environmental Guide

Prepared for WWF Environment and Disaster Management Green Recovery Connect

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ACRONYMS

ABC	Aggregate Base Concrete
ACI	American Concrete Institute
BRE	Building Research Establishment
CBO	Community-based Organization
CGI	Corrugated Galvanized Iron
CSEB	Compressed Stabilized Earth Block
GESI	Gender Equality and Social Inclusion
HSE	Health and Safety Executive
NGO	Nongovernmental Organization

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EDM

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INTRODUCTION

Increasing populations, rising urbanization, economic expansion, and the emergence of new industrial centers are among the driving factors of increasing demand for construction material around the world. Reconstruction needs after major disasters only compound this issue. Exponential increases of material extraction, processing and disposal can cause significant environmental and social impacts such as erosion, deforestation, landslides, and floods; deprive communities of essential livelihood resources; and put people, infrastructure, and ecosystems at greater risk of future disasters.

Practical guidelines for responsible material selection and use for government agencies, nongovernmental organizations (NGOs) and the private sector are rare. This guide aims to fill a gap and provide guidance on better practices for government agencies, private sector companies, NGOs, and community-based organizations (CBOs) for environmentally responsible selection, sourcing, use and disposal of construction material.

A number of construction materials are available in different regions of the world. If selected and used in an environmentally responsible manner along with the employment of responsible construction technology and practices, future construction needs can be met while creating a resilient built environment.

AIM

The aim of this document is to provide a general guideline for engineers, architects, project managers, and technicians in construction projects to select, source (or procure), and use specific building materials in an environmentally responsible manner. It is assumed that the user has a basic knowledge about building materials and the construction process, but it is not necessary to have advanced technical training to use this tool.

The guide provides information on environmental better practices related to design, planning, storage, use, and disposal for common building materials as well as key environmental costs and benefits. The guide also introduces the user to some useful overall concepts for environmentally responsible selection and use of building materials throughout a construction project and material life cycles.

This guide provides only general environmental information for each material; the actual process of material selection and use requires careful professional judgment in each individual case.

PROJECT CYCLE AND MATERIALS

Material-related decisions in construction projects are not made at one given time. Different issues are addressed in material selection, sourcing, procuring, storage, use and disposal and emerge at different stages of the project cycle. Figure 1 displays the typical building material-related decisions that need to be made and environmental issues at different stages of the project cycle.

For example, material selection can substantially impact the cost of construction and project management. This decision has to be made at the beginning of the inception stage even before the detailed designs are done—e.g., bricks versus rammed earth walls. More detailed issues such as using water-based paints instead of solvent-based paints, can be addressed later in the design stage or construction stage. Disposal of waste material is an issue that arises in the construction stage, but the reuse or disposal methods and sites should be identified well in advance of commencing construction.

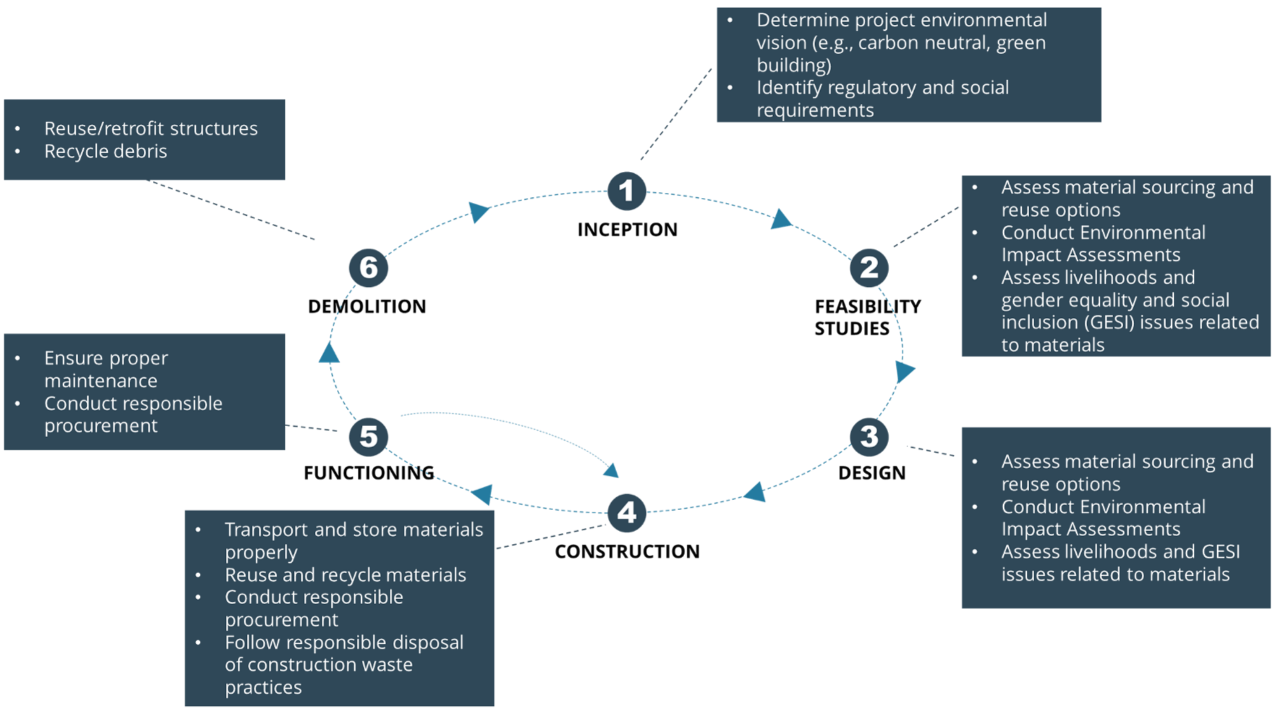

FIGURE 1. CONSTRUCTION PROJECT CYCLE AND MATERIAL-RELATED INTERVENTION POINTS

ENVIRONMENTAL GUIDE TO SELECTION OF COMMON BUILDING MATERIALS

No.	Material	Types of Use *[special technical remarks]*	Environmental Costs / Benefits		Management & Alternatives			Key Resources
			Environmental impacts	Environmental benefits	Potential material alternatives	Environmental Better practices (Design/Planning)	Environmental Better practices (Storage/Use/Disposal)	
A. General Construction Material								
A1	River sand	Concrete, Cement Mortar, Plaster (as a bedding material), Asphalt	**Extraction** Erodes channel bed and banks, increases channel slope, and leads to changes in channel morphology. These impacts may cause: • undercutting and collapse of river banks • loss of adjacent land and/or structures • upstream erosion • downstream erosion • downstream changes in patterns of deposition • destruction of riverine habitats **Transport** Transport using large trucks affects rural roads and may cause noise and air pollution. **Production/Treatment** None **Toxicity** None	None	Manufactured sand (crushed rock/gravel), Sea sand, Crushed rubble (debris), Fly ash/bottom ash, Recycled building and quarry dust	• Use alternatives to concrete/ mortar, e.g., stabilized earth walls (refer to section B) • Use premixed concrete instead of in-situ mixing • Use prefabricated concrete items • Optimize concrete mix design (don't over-specify) (BRE mix design, ACI method of concrete mix design) • Use standardized bricks to minimize mortar and plaster	**Storage** Store in a manner free from contamination by other site materials, for example, by providing containment with proper base and curb. Protect from rain and other water sources. **Use** Adhere to the building specifications mixing mortar and concrete and building. Overuse of the material will not add additional strength, and will cause waste. Mix in small adequate batches to minimize waste. Do not mix more fresh concrete/mortar than you will use in a two-hour period. **Disposal** Never dispose of washout cement, sand, cement mortar, or concrete in environment. They can be • reused on-site/off-site for construction purposes (e.g., filling), • safely transported to a construction material recycling facility, or • safely transported to a sanitary landfill	[10] [20] [27] [34] [37] [38]

A2	River gravel/ boulders	Concrete, Random rubble masonry, Aggregate base concrete (ABC), Road base, Manufacturing sand, Asphalt	**Extraction** Same as A1 **Transport** Transport using large trucks affects rural roads and may cause noise and air pollution. **Production/Treatment** Process often involves crushing into uniform sizes or fines (sand). Crushing plants cause noise, air pollution, silting of water bodies/ wetlands etc. **Toxicity** None	None	Crushed rock, Crushed rubble (debris)	• Plan and design construction to minimize waste • Use alternatives to concrete/ mortar, e.g., stabilized earth walls • Use premixed concrete instead of in-situ mixing • Use prefabricated concrete items	**Storage** Locate stockpiles to provide safe access for withdrawing material. **Use** Refer to A1 **Disposal** Refer to A1	Refer to A1
A3	Quarried rock	Concrete, Random rubble masonry, Aggregate base concrete (ABC), Road base, Manufactured sand, Asphalt	**Extraction** Extraction from quarries involves blasting. Quarries cause noise, dust, air pollution, habitat destruction and vibration if not properly managed. Unplanned rock quarrying can cause landslides and hydro-geological impacts. Without planning and protection blasting causes occupational hazards. **Transport** Transport using large trucks affects rural roads and may cause noise and air pollution. **Production/Treatment** Process often involves crushing into uniform sizes or fines (sand). Crushing plants cause noise, air pollution, silting of water bodies/ wetlands etc. **Toxicity** None	None	Crushed concrete, Broken brick (for certain uses only)	• Use optimum mix design to minimize the quantity of quarried rock used • Select a quarry site close to the construction site to minimize distance of transportation • Consider mixing with recycled material (crushed concrete or broken brick) in design	**Storage** Locate stockpiles to provide safe access for withdrawing material and ensure minimum spill and waste. **Use** Refer to A1 **Disposal** Refer to A1	Refer to A1

A4	Cement	Concrete, Mortar, Plaster, Stabilized earth construction/ blocks [*consistent quality, predictable structural strength*]	**Extraction** Uses limestone and other minerals extracted from quarries or mines in manufacturing, which can cause severe mining impacts. **Transport** Transport using large trucks affects rural roads and may cause noise and air pollution. **Production/Treatment** Produces greenhouse gases both, directly through the production of carbon dioxide when calcium carbonate is heated (producing lime and carbon dioxide), and indirectly through the use of energy, particularly if the energy is sourced from fossil fuels. **Toxicity** None	None	Lime mortar, Other cement-derived material (not suitable for concrete)	• Use alternatives to concrete/mortar, e.g., stabilized earth walls • Use premixed concrete instead of in-situ mixing • Use prefabricated concrete items • Optimize concrete mix design (don't over-specify) • Use standardized bricks to minimize mortar and plaster • Use precast concrete designs for construction; precast concrete can be designed to optimize (lessen) the amount of concrete used in a structure or element	**Storage** Store cement in a building that is dry, leak-proof, and as moisture proof as possible. There should be a minimum number of windows in the storage building. Stack the cement bags off the floor on wooden planks in such a way, so that bags are about 150 mm to 200 mm above the floor. **Use** Use quantities as specified in the optimum mix design. Avoid wastage by calculating adequate hauling times when purchasing premixed concrete and use retarders in case of long hauls. Do not mix more fresh concrete or cement than you will use in a two-hour period. Also refer to A1 **Disposal** Refer to A1 Never dispose of cement slurry or washout in streams or street drains. Never dispose of empty cement bags in the environment. Instead, dispose of them in a sanitary landfill.	Refer to A1 [2]
B. Wall Material								
B1	Burnt bricks	Walls, Columns, Foundations, Floor paving	**Extraction** Mining of surface clays, shales and some fire clays occurs in open pits with power equipment; then the mixtures require transport to plant storage areas. **Transport** Transport using large trucks affects rural roads and may cause noise and air pollution. **Production/Treatment** Brick firing is an energy-intensive process. The brick industry is therefore one of the largest consumers of coal and, hence, is also a significant air polluter. Air pollution and the use of good-quality agricultural soil are the major environmental concerns related to the use of bricks. Brick kilns may emit toxic fumes (suspended particulate matter, carbon monoxides, and oxides of	None	Cement blocks, Stabilized earth blocks, Stabilized earth walls, Straw clay walls, Bamboo/timber reinforced earth walls, Prefabricated wall panels	• Produce bricks on-site (e.g., stabilized earth blocks) • Encourage reuse of bricks from demolished buildings • Use standardized, quality-controlled bricks for construction • Reduce wastage by accurately estimating brick requirement • Use standard lengths and optimal wall thicknesses in design to minimize brick waste	**Storage** Properly package/load bricks during transport and store in a dry place in suitable stack heights. **Use** Not significant **Disposal** Reuse bricks/blocks for on-site/off-site construction purposes (e.g., filling, paving) or safely transport to a construction material recycling facility. Never dispose of bricks/blocks in streams, wetlands, coastal areas or agricultural lands.	[7] [10] [34] [38]

			sulphur—SOx) that are harmful to eyes, lungs, and throat. **Toxicity** None					
B2	Cement blocks	Walls	**Extraction** Requires cement, quarried and mined material (e.g., sand, rock chips, and gravel). (see A1, A2, A3, and A4) **Transport** Transport using large trucks affects rural roads and may cause noise and air pollution. **Production/Treatment** Manufacturing uses power or manually operated pressure molds. Casting yards can cause dust, noise and silt problems. **Toxicity** None	• No firewood demand • Minimal air pollution	Stabilized earth blocks, Stabilized earth walls, Straw clay walls, Bamboo/timber reinforced earth walls, Prefabricated wall panels	• Use standardized and good quality blocks for construction • Use accurate estimates to purchase blocks—this will minimize wastage • Produce concrete blocks on-site • Use standard lengths and optimal wall thicknesses in design to minimize brick waste	**Storage** Refer to B1 **Use** Not significant **Disposal** Refer to B1	Refer to B1 [11]
B3	Stabilized earth blocks/ CSEB	Walls [*not suitable for high-moisture environments or load-bearing walls*]	**Extraction** Requires soil with small amounts of sand and cement. Soil extraction can cause habitat destruction and landslides, and can pollute water bodies and alter hydrology. **Transport** Transport using large trucks affects rural roads and may cause noise and air pollution. **Production/Treatment** Manufacturing uses power or manually operated pressure molds. Casting yards can cause dust, noise and silt problems. **Toxicity** None	• No fire wood demand • No air pollution • Minimal demand for quarried material	Stabilized earth walls, Straw clay walls, Bamboo/timber reinforced earth walls, Prefabricated wall panels	• Design the building to match available block dimensions • Produce CSEB on-site with proper quality control, this will reduce the cost of transportation and production	**Storage** Refer to B1 **Use** Not significant **Disposal** Refer to B1	Refer to B1 [3] [6] [26]
B4	Earth walls (stabilized earth, clay-straw, rammed earth, bamboo reinforced earth)	Walls [*not suitable for high-moisture environments or load-bearing walls*]	**Extraction** Requires soil with small amounts of sand and cement. Soil extraction can cause habitat destruction and landslides, and pollute water bodies and alter hydrology. **Transport** Transport requirement is minimal. **Production/Treatment** Fabricating is in-situ using wooden or steel formwork and soil/clay. **Toxicity** None	• No fire wood demand • No air pollution • No demand for quarried material • Minimal transport requirement	Straw clay walls, Bamboo/timber-reinforced earth walls, Prefabricated wall panels	• Match available steel or wood formwork dimensions with the structural dimensions of the building • Reduce construction time with proper planning • Use only in areas where earth can be extracted without causing hazards or environmental impacts • Use standard lengths and optimal wall thicknesses	**Storage** Store soil in a dry, enclosed space. **Use** Use optimum mix proportions and only mix in small and adequate batches. **Disposal** Never dispose of demolished wall material in streams, wetlands or coastal areas. Reuse demolished walls material for on-site/off-site construction.	[21]
C. Wood and Timber								

C1	Forest timber	Roof structure, Beams, Columns, Door and window frames, Decks, Floor paving, Roof tiles, Wall panels, Formwork	**Extraction** Extraction can cause forest destruction, landslides, land degradation, and habitat destruction, and can increase flood risk. **Transport** Transport of logs can further damage forests and rural roads. **Production/Treatment** Processing takes place in timber mills. Mills that are poorly managed cause solid-waste pollution, and noise and air pollution. **Toxicity** Requires treatment for pest control. Using toxic chemicals for treatment causes environmental and health hazards.	• A renewable resource, if well managed	Farmed timber, Plywood, Fiber boards, Bamboo	• Do not over design/over specify— where possible, conduct proper structural design for timber buildings and calculate the timber need accordingly • Minimize cutoffs • Treat timber properly for long-term durability • Minimize the use of timber for formwork and use reusable modular formwork instead	**Storage** Store timber as close as practicable to your site. Properly store in a covered dry place, with proper stack heights. Allow air circulation and support well to avoid sagging. Keep it away from moisture as much as possible. **Use** Schedule timber delivery in-line with the phase of the project when it will be required to prevent unnecessary exposure of timber to the elements. Take extra care when handling to ensure that products are not spoiled while being moved. Use protection when handling and cutting chemically treated timber. **Disposal** Encourage timber reuse (e.g., door and window frames, roof members). Never dispose of timber in streams, wetlands, or coastal areas. Chemically treated timber cutoffs should be considered a hazardous material; never use as firewood.	[17] [19] [22] [28] [31]
C2	Farmed timber	Roof structure, Beams, Columns, Door and window frames, Decks, Floor paving, Roof tiles, Wall panels, Formwork	Same as C1	• Minimal impact on natural forests • Over-extraction can be managed	Plywood, Fiber boards, Bamboo	• Refer to C1	Refer to C1	Refer to C1 [8]
C3	Plywood/ laminated panels, Chip boards, Fiber boards	Wall panels, Floor panels, Formwork, Partition walls, [*only suitable for temporary use in external work*]	**Extraction** Extraction can cause forest destruction, landslides, land degradation, and habitat destruction, and can increase flood risk. **Transport** Transport of logs can further damage forests and rural roads. **Production/Treatment** Manufacturing uses timber-mill by-products or farmed soft wood and chemical binders. It takes place in large factories with energy-intensive	• Minimal impact on natural forests • Uses timber mill by-products • Ability to be preformed into efficient sizes and thicknesses	Woven bamboo panels	• Refer to C1 • Design to use standard panel sizes (minimize cutoffs)	**Storage** Refer to C1 **Use** Refer to C1 **Disposal** Refer to C1	Refer C1

			processes. Processing results in air pollution. (see C1) **Toxicity** Using binding material and treatment chemicals in manufacturing can cause environmental and health hazards.					
D. Roofing Material								
D1	Asbestos cement sheets	Roofing, Sheltering, Ceilings *[banned in many countries due to health hazards]*	**Extraction** Requires conventional mining practices to bring underground asbestos deposits and ore to the surface. **Transport** Transport of logs can further damage forests and rural roads. **Production/Treatment** Involves complicated processes that include mining and separating. **Toxicity** Extremely hazardous to human health.	None	Clay roof tiles, Thatching material, Aluminum sheets, Plastic roofing sheets, CGI sheets	• Do not recommend for any new construction	**Storage** Do not receive, store, distribute, or dispatch asbestos products from any place of work unless they are suitably sealed and labelled. **Use** Strictly follow health and safety guidelines in removal. **Disposal** Strictly follow health and safety guidelines in removal and disposal, as it is an extremely hazardous material.	[25] [32]
D2	Clay roof tiles	Roof sheltering *[provide high level of thermal comfort]*	**Extraction** Requires clay, and clay mining causes habitat destruction, pollutes water bodies, and alters hydrology. **Transport** Transport can damage rural roads. **Production/Treatment** Manufacturing uses wood-fired kilns, but the process is more managed than is brick-making. Kilns can cause severe air pollution due to improper quality control. **Toxicity** None	None	Plastic/fiber glass roofing sheets, Thatching material	• Minimize use in areas with widespread clay mining impacts • Minimize roof area in design • Encourage reuse from old buildings • Procure proper estimates to minimize wastage	**Storage** Store in a dry place in suitable stack heights and use proper packaging and loading/ unloading in transport. **Use** Not significant **Disposal** Refer to B1	[9] [14]
D3	Corrugated Galvanized Iron (CGI) sheets	Roof sheltering, Wall panels *[low thermal comfort, low durability in corrosive environments, use for wall panels suitable only in temporary installations]*	**Extraction** Manufacturing process requires large quantities of steel, zinc and other metals. May contribute to mining impacts. **Transport** Transport can damage rural roads. **Production/Treatment** Manufacturing takes place in large-scale factories using energy-intensive processes. Factories can cause severe air and water pollution, if poorly managed. Manufacturing processes may release toxic heavy metals.	None	Clay roof tiles, Aluminum sheets, Plastic/reinforced plastic roofing sheets, Thatching material	• Use optimum design calculations to minimize cut wastes • Use certified products and avoid using in corrosive environments • Avoid contact with ground or high levels of moisture if using for wall panels • Encourage reuse of un-corroded sheets from old buildings	**Storage** Store in a dry place in suitable stack heights and use proper packaging and loading/ unloading procedures in transport. **Use** Not significant **Disposal** Never dispose of CGI in the environment; it can be easily sold as scrap metal.	[33]

			Toxicity None					
D4	Thatching material	Roof sheltering *[low durability, only usable in certain types of roof designs]*	**Extraction** Natural or farmed vegetation (e.g., palm leaves, reed, grasses) is used in harvesting. Without proper management, it may have impacts on forests and natural vegetation. **Transport** Transport can damage rural roads. **Production/Treatment** Households or small-scale industries process material. Material needs seasoning and may cause water pollution if not properly managed. **Toxicity** None	• No requirement for quarried material or clay • No firewood or energy requirement • Can support indigenous livelihoods and knowledge	Clay roof tiles	• Use local knowledge where possible • Use basic building designs • Support local livelihoods and industries • Consider fire risk in planning and design since thatch is combustible	**Storage** Store in a dry place in suitable stack heights and order at correct time to avoid wastage. **Use** Use local thatching material that can be obtained without environmental damage. **Disposal** Does not harm the environment since it is biodegradable. However, avoid disposing of large quantities in streams, estuaries and coastal areas.	[29]
D5	Aluminum sheets	Roof sheltering, Wall panels *[use for wall panels suitable only in temporary installations]*	**Extraction** Manufacturing process requires large quantities of aluminum and other metals. May contribute to mining impacts. **Transport** Transport can damage rural roads. **Production/Treatment** Manufacturing takes place in large-scale factories using energy-intensive processes. Factories can cause severe air and water pollution, if poorly managed. **Toxicity** None	None	Plastic/fiber-reinforced plastic roofing sheets, Clay tiles, Thatching material	• Refer to D3 • Corrosion resistance makes aluminum sheets more environmentally appropriate in corrosive environments	**Storage** Refer to D3 **Use** Not significant **Disposal** Refer to D3	[1] [30]
D6	Plastic/ fiber-reinforced plastic roofing sheets	Roof sheltering, Wall panels *[use for wall panels suitable only in temporary installations]*	**Extraction** None **Transport** Transport can damage rural roads. **Production/Treatment** Manufacturing takes place in medium-to-large-scale factories using energy-intensive processes. Factories can cause severe air and water pollution if poorly managed. **Toxicity** May cause health hazards because of the use of some harmful organic compounds and fibers in reinforced plastic sheets.	• Reduce environmental damage by using natural fibers and safe petroleum by-products in manufacturing	Thatching material	• Encourage the use of natural fibers (e.g., coir) in fiber reinforced plastic sheets • Design to optimum criteria to minimize wastage • Also refer to D3	**Storage** Refer to D3 **Use** Use protection when cutting the sheets as dust and fumes may cause health hazards. **Disposal** Never dispose of in the environment; only dispose of in a sanitary landfill. Encourage reuse of material.	[16] [18]
E. Finishing Material								
E1	Ceramic tiles	Floor tiling, Wall tiling	**Extraction** Requires clay, and clay mining causes habitat destruction, pollutes water bodies, alters hydrology.	None	Terracotta tiles, Cement tiles, Vinyl tiles,	• Use optimal design (use only where necessary, limit aesthetic use)	**Storage** Requires proper transport and handling.	Refer to B1 [15]

			Transport Transport can damage rural roads. **Production/Treatment** Manufacturing takes place in large industrial kilns. It is highly energy intensive, and if not properly managed, factories can cause air and water pollution. **Toxicity** Glazing may use toxic compounds.		Polymer composite tiles	• Use standard sizes and shapes to minimize cutoffs	Store in safe, dry place in proper stack heights. **Use** Use protection when cutting. **Disposal** Refer to B1	
E2	Parquet	Floor paving	**Extraction** Manufacturing uses timber. (see C1) **Transport** See C1 **Production/Treatment** See C1 **Toxicity** See C1	None	Ceramic tiles, Terracotta tiles, Cement tiles, Vinyl tiles, Polymer composite tiles	• Limit foot traffic on finished wood flooring. Complete wood flooring toward the end of the construction project. • Use optimal design (use only where necessary, limit aesthetic use). • Use standard sizes and shapes to minimize cutoffs	**Storage** Refer to C1 and C3 **Use** Refer to C1 and C3 **Disposal** Refer to C1 and C3	Refer to C1 and C3 [23]
E3	Lime mortar/ lime putty	Plastering, Filler, Paint	**Extraction** Manufacturing uses limestone or coral. Coral extraction causes serious environmental damage. Mining small outcrops of limestone may also have significant environmental impacts. **Transport** Transport can damage rural roads. **Production/Treatment** Requires kilning to produce usable non-hydraulic or hydraulic lime. The kilning process (especially small-scale) causes air pollution. **Toxicity** None	None	Cement mortar, Chemical fillers	• Do not use lime made from coral or illegally mined limestone • Minimize the use of lime from small-scale producers with wood-fired kilns • Mix only required amounts to minimize waste	**Storage** Refer to A4 **Use** Refer to A4 **Disposal** Refer to A4	Refer to A4 [5] [36]
E4	Chemical fillers	Filler	**Extraction** Requires mined and quarried material. See A3 **Transport** See A3 **Production/Treatment** Manufacturing takes place in large-scale factories and can cause air and water pollution if not properly managed. **Toxicity** Production may use toxic compounds that can cause environmental and health hazards.	• Reduce the demand for lime produced in harmful small-scale industries	None	• Refer to the Material Safety Data Sheets before design or purchase • Avoid toxic fillers unless absolutely necessary and educate the craftsperson about safe use and disposal • Do not over-specify	**Storage** Store the properly closed containers (airtight) in safe places. **Use** Finish the walls smoothly before application and apply in optimum thicknesses (do not over-specify). Mix only required amounts to minimize waste. Strictly follow Health and Safety Executive (HSE) guidelines when working with chemical fillers. **Disposal** Never dispose of hardened filler or their containers in the environment. Instead, dispose of them in a sanitary	[24] [38]

							or hazardous waste disposal facility (for toxic fillers).	
E5	General emulsion or enamel paint	Painting	**Extraction** Requires a variety of base chemicals in addition to mined and quarried material. **Transport** Transport can damage rural roads. **Production/Treatment** Manufacturing takes place in large-scale factories and can cause air and water pollution if not properly managed. **Toxicity** Enamel paint uses solvents. Some solvents may be harmful to human health and the environment.	None	Water based paints, Natural pigments	• Refer to the Material Safety Data Sheets before design or purchase • Avoid toxic paints unless necessary, and educate the craftsperson about safe use and disposal • Specify only the required number of coats of paint • Limit the use of solvents and educate the craftsperson about safe use and disposal of solvents	**Storage** Store the properly closed containers (airtight) in safe places. **Use** Use protection when mixing and applying paints. **Disposal** Never dispose of hardened fillers or their containers in the environment; instead dispose of them in a sanitary or hazardous waste disposal facility (for toxic paints or solvents).	[13] [39]
E6	Epoxy paints/ solvent based paints/ anticorrosive paints/ strong adhesives/ paint remover	Painting, Metal protection (as adhesives) *[generally expensive and used only for specific purposes*]	**Extraction** Requires a variety of base chemicals in addition to mined and quarried material. **Transport** Transport can damage rural roads. **Production/Treatment** Manufacturing takes place in large-scale factories that can cause air and water pollution if not properly managed. Production processes of some of these chemicals may be extremely damaging to the environment and human health. **Toxicity** May release heavy metals and harmful organic compounds into the environment.	None	None	• Use certified products only • Use only where it is absolutely necessary and avoid if possible • Specify only if essential for the strength or durability of the building—not for ease of construction • Refer to E5	**Storage** Store the properly closed containers (airtight), in a safe, secured place—away from fire and flooding hazards. **Use** Should be handled only by trained crafts persons, using protective equipment and strictly following Health and Safety Executive (HSE) guidelines in mixing and use. **Disposal** Treat strictly as hazardous waste in disposal of excess material and containers.	Refer E5
E7	Termite treatment chemicals	Chemical treatment to eradicate termites (applied to soil around the perimeter and the subfloor of a building)	**Extraction** Requires a variety of chemicals. **Transport** Transport can damage rural roads. **Production/Treatment** Large-scale factories produce. **Toxicity** Production process may release heavy metals and toxic organic compounds into the environment. Industrial accidents may cause serious hazards to humans and the environment.	None	Use of ground electrocution, Integrated pest management	• Use only if it is necessary and avoid if possible • Only use certified products • Try to use integrated pest management methods to get rid of pests	**Storage** Store the properly closed chemical containers (airtight), in a safe, secured place—away from fire and flooding hazards. **Use** Only use in specified dosages and with trained and certified persons. Use protective equipment and strictly follow Health and Safety Executive (HSE) guidelines in mixing and use. **Disposal** Treat strictly as hazardous waste in disposal of excess material and containers.	[17] [35]
E8	Glass	Window panes	**Extraction** Requires quarried and mined material in production.	• Glass is a fully recyclable	Plastic polycarbonate	• Use standard sizes and minimize cutoffs	**Storage** Transport, handle, and store with care in proper stack height to avoid	[12]

			Transport Transport can damage rural roads. **Production/Treatment** Results in mass combustion of fossil fuel. Emits sulphur dioxide (SO_2), and if unmanaged, it may cause water pollution. **Toxicity** Minimal	material and is chemically inert		• Use only the required thickness; however, thin plate glass is susceptible to easy breaking and waste of material	breakage and waste. Glass can be hazardous to children. **Use** Handle carefully, using proper equipment; broken glass can cause serious injury. **Disposal** Glass can be easily sold for recycling, and it should never be disposed of in the environment.	
E9	Tarpaulin sheets	Shelter material and wall panels (in temporary structures), Weather proofing building sites	**Extraction** Tarpaulin sheets are layered sheets that sandwich a polyester woven fabric base between plastic films. Crude oil is the main raw material used for production. **Transport** Transport can damage rural roads. **Production/Treatment** Emits greenhouse gasses during production. Untreated wastes from factories contain toxic chemicals and cause water pollution. **Toxicity** Chemicals contain toxic substances.	None	Waterproof canvas, Thatching material	• Properly tie and join the sheets to avoid tearing • Use the whole sheet, do not cut • Reuse old tarpaulin sheets	**Storage** Store in covered dry place, away from fire hazards. **Use** Should be handled carefully. **Disposal** Recycle where possible or since tarpaulin is a nonbiodegradable material, special care should be taken when disposing of it.	[4] [18]

MATERIAL LIFE CYCLE

All materials come to the construction site through a process of extraction, transport, processing/manufacturing, packaging, and storage. Furthermore, the life of a material does not end after being used for construction; the structures are often demolished after a useful lifetime, and the materials are reused, recycled, repurposed, or disposed of. Some structures deteriorate with time, and the materials disintegrate into the environment. All these stages of the life cycle of a material may cause adverse environmental and social impacts.

Figure 2 displays the potential social and/or environmental impacts at different stages of a generic material life cycle.

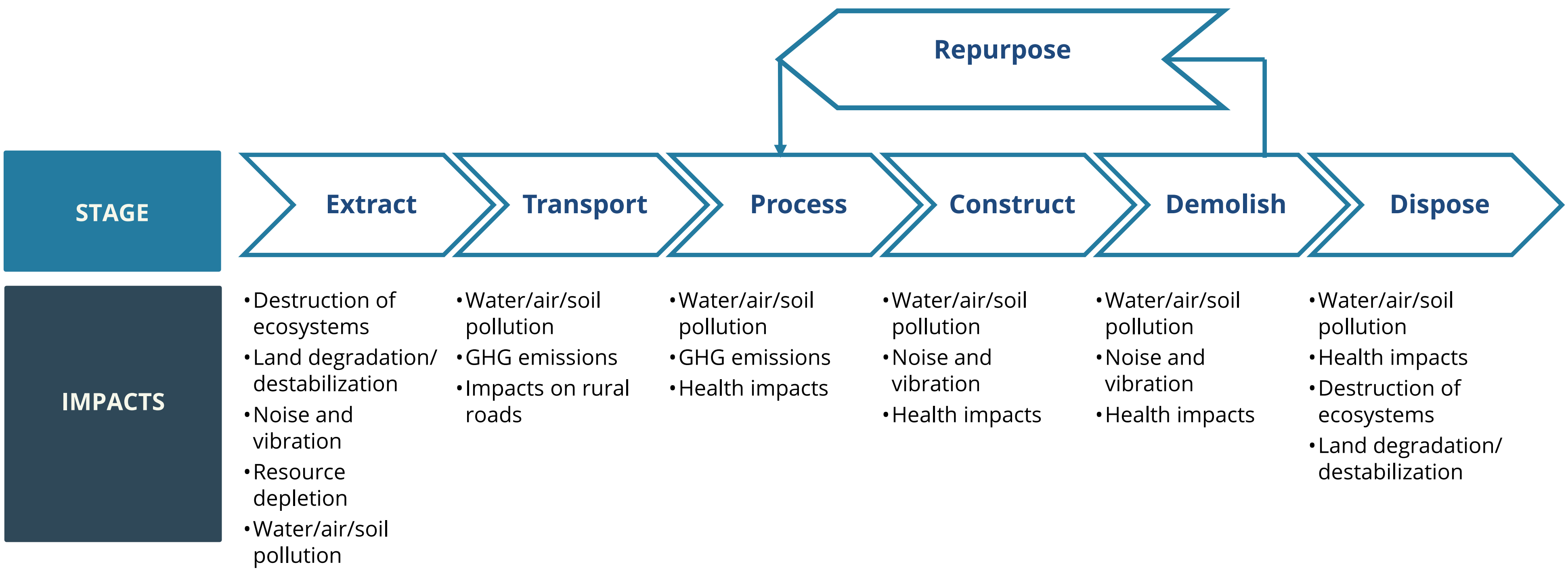

FIGURE 2. STAGES AND IMPACTS OF A MATERIAL'S LIFE CYCLE

RESPONSIBLE MATERIAL SELECTION AND USE: KEY CONCEPTS

1 **Think through the whole supply chain.** Environmental and social impacts from building materials can occur at any point in the supply chain, from sourcing raw materials, through processing and delivery to the site. This includes the social and environmental practices of manufacturers. For example, do working conditions at the processing plant meet responsible standards? Is the processing plant disposing of leftover material in an environmentally and socially responsible way?

The first criterion for an environmentally responsible material is the safety of the structure that will be built with it. "Not safe" is "not green."

2 **Only support sound and legal sourcing of materials.** In large-scale, post-disaster rebuilding, the demand for raw materials can quickly outstrip the supply of sustainably produced natural resources, such as clay for bricks, sand for cement, and wood for timber. For example, unsound excavation of clay or clear-felling of timber on steep hillsides to rebuild hundreds or thousands of houses increases the risk of landslides and topsoil erosion. Such environmental damage can increase risk and jeopardize the success of the overall recovery effort. Project managers should be aware of the sources of their building materials and make sure that they establish contract specifications for the use of sound and legally sourced materials. Using materials that have been credibly certified can be one strategy for ensuring that materials have been sourced sustainably. Material sourcing, processing, and use should be socially equitable. Any form of material sourcing that puts disproportionate burdens on women, children, differently abled or socially marginalized people is not sustainable. Furthermore, material sourcing should not disturb the established local livelihoods.

3 **Design to use fewer materials and reduce waste.** In designing structures such as houses, project managers should consider ways to effectively meet humanitarian needs with fewer materials. Reducing packaging materials and designing structures with standard material sizes can help prevent waste of materials during the transportation and construction phases. Designing structures and specifying materials for optimal design rather than either overengineering or creating rigid requirements can reduce material waste by allowing some flexibility in construction and in material options. For example, if one material or size is not available locally, another can be used in its place to achieve optimal design instead of importing additional materials to fit a very specific requirement. Following material-specific storing and handling guidelines also helps extend the shelf life of materials and ensures that materials are not damaged and will not need to be replaced.

4 **Use local sources—where this can be done in an environmentally responsible way.** Local procurement of materials can be a more environmentally sound strategy than the procurement of distant materials because of reduced carbon emissions from transportation and natural resource use in packaging. Give priority to materials selected or processed with traditional knowledge. When using local materials, however, project managers should make sure that extraction, processing, and use do not put people's health or environment at risk.

5 **Use disaster debris as a reconstruction material.** One of the most environmentally sustainable options for construction projects in a post-disaster setting is the reuse of building materials found in disaster debris. If using disaster debris, project managers must ensure that the debris meets applicable specifications for strength and safety.

6 **Use materials with recycled content and recycle.** Materials with recycled content are widely available. One example is cement produced with fly ash from coal-fired power plants. Project managers should consider using building materials with recycled content where practical to reduce demand on natural resources and lower the project's human and environmental impacts. Leftover material or material packaging should also be considered for reuse, repurposing, and/or recycling.

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