Hariyo Ban Program

Building Material Selection and Use

An Environmental Guide

USAID
FROM THE AMERICAN PEOPLE

WWF

care

FECOFUN

NATIONAL TRUST FOR NATURE CONSERVATION
NEPAL 1982

Hariyo Ban Program

Building Material Selection and Use

An Environmental Guide

Cover photo credit:
Brick factory © WWF Nepal, Hariyo Ban Program/ Amit Pradhan

Published by:
WWF Nepal, Hariyo Ban Program
PO Box: 7660
Baluwatar, Kathmandu, Nepal
T: +977 1 4434820, F: +977 1 4438458
hariyobanprogram@wwfnepal.org, www.wwfnepal.org/hariyobanprogram

Disclaimer: This environmental guide is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents of this document are the responsibility of WWF and do not necessarily reflect the views of USAID or the United States Government.

Acknowledgments

Many people contributed to this guide. We are very grateful to Missaka Hettiarachchi, WWF-US Fellow, and Charith Fonseka, Lecturer, University of Moratuwa, Sri Lanka for undertaking extensive research and writing the guide. Many people reviewed it or helped in other ways, including Mr. Padma Kumar Mainalee, Deputy Director General, Department of Urban Development and Building Construction; Diwat Shrestha, Training Director, Council for Technical Education and Vocational Training; Sanjaya Uprety, Associate Professor, Institute of Engineering; and Chandra Laxmi Hada, Anita van Breda, Judy Oglethorpe, Jennifer Pepson Elwood, Keshav Khanal, Sabitra Dhakal and Rabindra Shah from WWF. Amit Pradhan and Jyoti Shrestha undertook production management.

We are very grateful to the US Agency for International Development (USAID) for supporting Hariyo Ban Program's green recovery work, including production of this guide. In particular, Netra Sharma Sapkota and Bronwyn Llewellyn provided support and encouragement for the green recovery work.

Introduction

Two massive earthquakes that hit Nepal on 25 April and 12 May, 2015 caused far-reaching social, economic and environmental damage. Thirty-one of the country's 75 districts were affected leaving over 8,790 deaths and 22,300 people injured. A total of 498,852 houses were categorized as fully collapsed or damaged beyond repair and 256,697 partly damaged. The earthquakes triggered thousands of landslides that destroyed 2.2% of forest cover in six affected districts (National Planning Commission 2015). Material demand to rebuild half a million destroyed houses and other infrastructure will put much additional pressure on Nepal's already stressed natural resources.

The Post Disaster Needs Assessment (PDNA), Rapid Environmental Assessment (REA) and Post Disasters Recovery Framework (PDRF) carried out by the Government of Nepal identified promoting the use of safe and green building materials and reuse of disaster debris as a key principle for environmentally sound reconstruction. If sound practices are not used, we can create many future problems 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 sustainable construction material sourcing and use are rare in Nepal. This guide to responsible building materials aims to provide guidance on sound practices for government, NGO and UN staff involved in relief, recovery and reconstruction after major disasters. Nepal has a wealth of building materials which, if selected, extracted, processed and used in a sound manner, can make a major contribution to better and safer reconstruction without creating additional environmental problems for the future.

Aim

The aim of this publication is to provide general guidance for engineers, architects, project managers and technicians working in disaster reconstruction projects in Nepal to select, source (or procure) and use building materials in an environmentally responsible manner. It is assummed that users have a basic knowledge about building materials and the construction process, but not advanced technical training.

Communities at risk due to landslides in Rasuwa

© Samir Jung Thapa

Building Material Database for Nepal

Key Concepts »

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? However, the first criterion for an environmentally responsible material is the safety of the structure built using it. "Not safe" is "not green."

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 natural resources, such as clay for bricks, sand for cement, and trees 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 top soil 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 officially certified is 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 a disproportionate burden on women, children, differently-abled or socially marginalized is not sustainable. Furthermore, material sourcing should not adversely impact established local livelihoods.

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 to prevent waste of materials during the transportation and construction phases. Designing structures and specifying materials for optimal design rather than either over-engineering 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 needing to be replaced.

Use local sources where this can be done in a sustainable way. Local procurement of materials can be a more environmentally sound strategy than the procurement of distant materials through 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.

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 in disaster debris. If using disaster debris, project managers must ensure that the debris meets applicable specifications for strength and safety.

Use materials with recycled content and recycle as much as possible. 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. Left over material or material packaging should also be considered for reuse, repurposing, and/or recycling.

Disposal of waste material after reconstruction is always a challenge

Project Cycle and Materials »

Material related decisions in a construction project are not all made at one time. Different issues on material selection, sourcing, procurement, storage, use and disposal emerge at different stages of the project cycle. Figure 1 gives the typical building material related decisions you have to make and sustainability tips at different stages of the project cycle.

For example, materials that can substantially impact the cost of construction and project management have to be selected very early at 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 reuse or disposal methods and disposal sites should be identified well ahead of commencing construction.

Figure 1: Material related decision in the construction project cycle

Building debris after the earthquake in Kathmandu

General References

IASC [Inter Agency Standing Committee]. Debris as a Construction Material: The Environmental and Economic Benefits.

Ministry of Science, Technology and Environment. 2015. Nepal Earthquake 2015: Rapid Environmental Assessment. MoSTE, Kathmandu, Nepal.

National Planning Commission. 2015. Nepal Earthquake 2015: Post disaster needs assessment. NPC, Kathmandu, Nepal. http://www.npc.gov.np/images/download/PDNA_Volume_A.pdf

National Reconstruction Authority. 2016. Nepal Earthquake 2015: Post Disaster Recovery Framework. NRA, Kathmandu, Nepal.

UNDP [United Nations Development Program] . 2013. Debris Management: The Door to Development. UNDP. http://www.ht.undp.org/content/dam/haiti/docs/reduction%20de%20la%20pauvrete/Debris%20-TOI%20EN%20Final%2020130718.pdf

UNDP. Environmental Procurement Practice Guide. UNDP. http://www.ht.undp.org/content/dam/haiti/docs/reduction%20de%20la%20pauvrete/Debris%20-TOI%20EN%20Final%2020130718.pdf

UNEP [United Nations Environmental Program]. 2008. After the Tsunami: Sustainable building guidelines for South-East Asia. UNEP. http://www.unep.org/sbci/pdfs/After-Tsunami-Sustainable-building-guidelines.pdf

WWF Nepal. 2014. Beyond Investment: Developing sustainable green infrastructure in Nepal. Hariyo Ban Program, WWF Nepal, Kathmandu, Nepal. www.wwfnepal.org

WWF & American Red Cross. 2010. Module 5: Materials and the Supply Chain, Green Recovery and Reconstruction Toolkit (GRRT). WWF and American Red Cross. http://green-recovery.org/wordpress/wp-content/uploads/2010/11/Module-5-Content-Paper.pdf

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
A - General Construction Material								
A1	River sand	Concrete, cement mortar, plaster, as a bedding material, asphalt	Extracted from rivers, streams and river banks/floodplains. Over-extraction or extraction in inappropriate places can cause bed deepening, bank erosion, head cutting (vertical erosion) upstream, sedimentation and lateral erosion downstream, lowering of water table, destruction of aquatic habitats, loss of agricultural land, and damage to infrastructure. Artisanal river-sand mining is a dangerous occupation.	Transport using large trucks can damage rural roads and cause noise and dust	None	Manufactured sand (crushed rock / gravel), quarry dust, crushed rubble (debris)	• Use alternatives to concrete / mortar: e.g. stabilized earth walls (Refer to section B) • To avoid waste: Use premixed (ready-mix) concrete instead of in-situ mixing Use optimum concrete mix design (don't over specify)* Use standard bricks to minimize mortar and plaster*	Environmental, health, and safety guidelines for construction materials extraction [12] Sustainable Concrete Construction [6] Information on sustainable aggregates [http://www.sustainableaggregates.com/]
A2	River gravel / boulders	Concrete, random rubble masonry, aggregate base concrete (ABC), road base, manufacturing sand, asphalt	Same as above	Often used after crushing into uniform sizes or fines (sand). Crushing plants cause noise, air pollution, silting of water bodies/ wetlands etc. Transport affects rural roads.	None However, in case of landslide blocking a natural waterway, removal of boulders and gravel may help in restoring the stream ecosystem.	Crushed rock, crushed rubble (debris)	• To avoid waste: Use alternatives to concrete / mortar: e.g. stabilized earth walls Use premixed concrete instead of in-situ mixing Use prefabricated concrete items Reuse gravel and boulders, e.g. from building rubble.	Refer to A1

* Refer to Nepal National Building Code- NBC 101/ NBC 110 (http://www.dudbc.gov.np/buildingcode)

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
A3	Quarried rock	Concrete, random rubble masonry, aggregate base concrete (ABC), road base, manufacturing sand, asphalt	Extracted from quarries; involves blasting. Quarries cause noise, dust, air pollution, habitat destruction, vibration if not properly managed. Unplanned rock quarrying can cause landslides and hydro-geological impacts including changes to water supplies. Unplanned, unprotected blasting causes occupational hazards.	Often used after crushed into uniform sizes or fines (sand). Crushing plants cause noise, air pollution, silting of water bodies / wetlands etc. Transport affects rural roads. Leaves large pits in the area, which can cause health hazards.	None	Rubble reuse	Refer to A2	Technical guidelines on stone quarrying [8, 18] Environmental, health, and safety guidelines for construction materials extraction [12] Sustainable Concrete Construction [6] Information on sustainable aggregates [http://www.sustainableaggregates.com/]
A4	Cement	Concrete, mortar, plaster, stabilized earth construction/ blocks [consistent quality, predictable structural strength]	Manufactured using limestone and other minerals extracted from quarries or mines. Can cause severe mining impacts. Extraction of limestone can cause alteration in pH value / alkalinity of soil, impacting hydro-geology and livelihoods.	Manufacturing process causes severe air pollution and dust. Cement production has high energy requirement – results in carbon emissions if fossil fuels are used.	None	Lime mortar, other cement derived material (not suitable for concrete)	• To avoid waste: Use alternatives to concrete / mortar: e.g. stabilized earth walls Use premixed concrete instead of in-situ mixing Use prefabricated concrete items Use optimum concrete mix design (don't over specify) * Use standard bricks to minimize mortar and plaster * Store properly* • Dispose of waste properly and safely; avoid unmanaged and unmonitored disposal	Sustainable Concrete Construction [6]

* Refer to Nepal National Building Code- NBC 101/ NBC 110 (http://www.dudbc.gov.np/buildingcode)

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
B - Wall material								
B1	Burnt bricks	Walls, columns, foundations, floor paving	Requires clay. Clay mining causes natural habitat and farmland destruction, pollutes water bodies, creates ponds where disease vectors can breed, alters local hydrological regime, and may cause soil erosion.	Manufactured in wood or coal fired kilns. Firewood demand threatens forests; coal releases carbon. Kilns cause severe air pollution. Transportation may contribute to air pollution.	None	Cement blocks, stabilized earth blocks, stabilized earth walls, straw clay walls, bamboo/timber reinforced earth walls, prefabricated wall panels. Flyash-Sand-Lime-gypsum Boards (environmentally friendly, uses industrial wastes and excellent in size, reduces mortar consumption, quick drying-excellent strength, reduced water absorption and shrinkage) Clay flyash burnt bricks (environmentally friendly and energy efficient technology, better thermal performance)	• To reduce pollution: Promote improved technology in brick kilns (e.g. when rebuilding after disasters) Purchase bricks made in kilns that are using less polluting technology • To avoid waste: Use standard lengths and optimal wall thicknesses Use good packaging/ loading practices when transporting * Store in a dry place in suitable stack heights • Encourage reuse of bricks from demolished buildings	Indian Standard for Common Burnt Clay Building Bricks [2] Guidelines for compressed stabilized earth blocks [19,21] Guidelines for rammed earth construction [16,17] Environment Friendly Indian Building Material for Cost Effective Housing [1-6, 13-16]
B2	Cement blocks	Walls	Requires cement, and quarried and mined material – e.g. sand, rock chips, gravel. (See above for impacts)	Manufactured using powered or manually operated pressure molds. Casting yards can cause dust, noise and silt problems. May make water bodies unusable. Use and transport of cement may have hazardous impact on environment.	No firewood demand Air pollution minimal	Stabilized earth blocks, stabilized earth walls, straw clay walls, bamboo/timber reinforced earth walls, prefabricated wall panels.	• To avoid waste: Ensure quality control in manufacturing Use standard lengths and optimal wall thicknesses Proper package/ loading practices in transporting Store in a dry place in suitable stack heights *	Aggregate Concrete Blocks A Guide to Selection & Specification [4] Sustainable Concrete Construction [6]

* Refer to Nepal National Building Code- NBC 101 (http://www.dudbc.gov.np/buildingcode)

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
B3	Compressed stabilized earth blocks (CSEB)	Walls [*not suitable for high moisture environments or load bearing walls*]	Requires soil with small amounts of sand and cement. Soil extraction can cause habitat destruction, landslides, fouling of water bodies and hydrological alteration.	Manufactured using powered or manually operated pressure molds. Casting yards can cause dust and silt problems.	No firewood demand No air pollution Minimum demand for quarried material	Stabilized earth walls, straw clay walls, bamboo/timber reinforced earth walls, prefabricated wall panels	• To avoid waste: Ensure quality control in manufacturing Use standard lengths and optimal wall thicknesses Use good packaging/ loading practices when transporting Store in a dry place in suitable stack heights Use interlocking blocks and construction methods to reduce cementmortar need	Guidelines for compressed stabilized earth blocks [19,21] Guidelines for rammed earth construction [16,17]
B4	Earth walls (Stabilized earth, clay-straw, rammed earth, bamboo reinforced earth)	Walls [*not suitable in high moisture environments or for load bearing walls*]	Requires soil. Soil extraction can cause habitat destruction, landslides, fouling of water bodies and hydrological alteration.	Fabricated in-situ using wooden or steel formwork and soil / clay.	No firewood demand No air pollution Zero demand for quarried material No transport		• Design and construct properly to ensure long-term durability • Only use in areas where earth can be extracted without causing hazards or environmental impacts	Guidelines for rammed earth construction [16,17] Bamboo in Nepal: A Management Guide [1] Guidelines For Building Bamboo-Reinforced Masonry in Earthquake-Prone Areas in India [15]

* Refer to Nepal National Building Code- NBC 101 (http://www.dudbc.gov.np/buildingcode)

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
C - Wood and Timber								
C1	Natural forest timber	Roof structure, beams, columns, door and window frames, decks, floor paving, roof tiles, wall panels, formwork	Unsustainable or inappropriate forest timber extraction can cause forest destruction, soil erosion, landslides, land degradation, habitat destruction, and can increase flood risk. Transport of logs can damage forests and rural roads.	Processed in timber mills. Poorly managed mills cause solid waste pollution, inefficient timber use, and noise and air pollution. Many types of timber require treatment for pest control. Using toxic chemicals for treatment causes environmental and health hazards.	Can be a renewable resource if managed well; forest management for timber production can be combined with biodiversity conservation and ecosystem services such as landslide prevention and water supplies.	Farmed timber, plywood, fiber board, bamboo	• Sustainable sourcing: Source timber from forests where it has been logged sustainably following approved forest management plans (e.g. from well managed community forests, private forests or government forests) • To avoid waste: Where possible do proper structural design for timber structures and calculate the timber need accordingly (do not over design / over specify) * Minimize off-cuts * Treat timber susceptible to insect attack for long-term durability; Borates are less harmful than some other products though care should be taken Minimize the use of formwork Ensure storage in covered dry place, with proper stack heights. Allow air circulation and support well to avoid sagging. * • Encourage timber reuse from debris (e.g. door and window frames, roof members)	Indian Standard for Common Burnt Clay Building Bricks [2] Guidelines for compressed stabilized earth blocks [19,21] Guidelines for rammed earth construction [16,17]
C2	Plantation timber	Roof structure, beams, columns, door-window frames, decks, floor paving, roof tiles, wall panels, formwork	Monoculture timber plantations can cause land degradation, habitat and biodiversity loss, and hydrological problems. Transport of logs can damage adjoining forests and rural roads.	Same as above	Minimum impact on natural forests. Over-extraction can be controlled.	Plywood, fiber board, bamboo	Refer to C1	Refer to C1

* Refer to Nepal National Building Code- NBC 112 (http://www.dudbc.gov.np/buildingcode)

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
C3	Plywood/ laminated panels, chip board, fiber boards	Wall panels, floor panels, formwork, partition walls, formwork [*only suitable for temporary use in external work*]	Manufactured using timber-mill by-products or farmed soft wood. (see above)	Manufactured in large factories with energy intensive processes. Chemical binders and treatment chemicals (e.g. formaldehyde) are used in manufacturing. Process results in air pollution. Additional chemical treatment may be needed. (see above)	Minimum impact on natural forests. Uses timber mill by-products. Can be pre-formed to efficient sizes and thicknesses.	Woven bamboo panels	• To avoid waste: • Use standard sizes (minimize off-cuts) Encourage reuse in formwork Ensure good storage in covered dry place, with proper stack heights. Allow air circulation and support well to avoid sagging. • Treat properly for long-term durability • Discourage use for firewood • Dispose of safely; avoid unmanaged and unmonitored disposal	Refer to C1
C4	Bamboo (technically a grass)	Roof structure, woven wall panels, partitioning, formwork props, scaffolding [*Workability is low*]	Extracted from natural or farmed bamboo groves. Unmanaged extraction may cause habitat destruction, river bank erosion	Usually used directly without any processing. However, bamboo can be processed into high-quality products such as panels and mats. Some products require energy intensive factory processes. These processes may cause air and water pollution if not properly managed.	Fast growing and renewable. Minimum impact on natural forests, unless forests are removed to plant bamboo. Supports indigenous livelihoods and knowledge. Can be a substitute for slower growing timber. Bamboo stabilizes the earth with its roots, preventing erosion. Re-grows from shoots; no need for replanting.		• Use only when sustainable harvesting is possible • Have a harvesting plan • Encourage reuse in formwork • Treat for long-term durability and procure value-added products from local industries (use natural seasoning or non-toxic certified treatment chemicals. Borax or boric acid treatment is common; though should be carried out with care and training, as both chemicals have proven health hazards) • Ensure storage in a good place, with proper stack heights. Allow air circulation and support well to avoid sagging	Bamboo technology [1,25]

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
D - Roofing material								
D1	Asbestos cement sheets	Roofing, ceilings [*banned in Nepal due to health hazards*]		**Extremely hazardous** to human health. Not recommended in any new construction, and illegal in Nepal	None	Clay roof tiles, thatching material, aluminum sheets, plastic roofing sheets, corrugated galvanized iron sheets	• Not recommended for any new construction • Use health and safety guidelines in removal and disposal	Guidelines for management and removal of asbestos [23,5]
D2	Clay roof tiles	Roofing [*provides high level of thermal comfort*]	Requires clay. Clay mining causes habitat destruction, fouling of water bodies, hydrological alteration	Manufactured in wood-fired kilns, but more controlled process than brick making. If not properly managed kilns can cause severe air pollution.	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 • Store in a dry place in suitable stack heights • Ensure proper package and loading/ unloading when transporting	Environmental, Health and Safety guidelines for construction material extraction [12] Guidelines for proportioning Calicut tiled timber roof structures [3]
D3	Corrugated galvanised iron (CGI) sheets	Roofing, wall panels [*low thermal comfort, low durability in corrosive environments, use for wall panels suitable only in temporary installations*]	Manufacturing process requires large quantities of steel, zinc and other metals. May contribute to mining impacts.	Manufactured in large factories, using energy intensive processes, often with carbon emissions from fossil fuel energy sources. Poorly managed factories cause severe air and water pollution. Manufacturing process may release toxic heavy metals.	None	Clay roof tiles, aluminum sheets, plastic/reinforced plastic roofing sheets, thatching material	• Use certified products • Avoid using in corrosive environments • If used for wall panels, avoid contact with ground or high levels of moisture • Encourage reuse of un-corroded sheets from old buildings • Store in a dry place in suitable stack heights • Never dispose in a natural environment and encourage recycling • Esnure CGI sheet production factories adhere to Environmental Acts National Environmental (Protection and Quality) Regulations	CGI technical guidelines [27,20]z

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
D4	Thatching material	Roofing [low durability, *only usable in certain types of roof designs*]	Harvested from natural or farmed vegetation: palm leaves, reed, grasses. May have impacts on forests and natural vegetation if not properly managed.	Processed in household or small-scale industries. Material needs to be seasoned. May cause water pollution if not properly managed.	No requirement for quarried material or clay. No firewood or energy requirement. Can support indigenous livelihoods and knowledge, and be part of sound grassland management, reducing the need for grass fires.		• Only use thatching material that can be obtained locally without environmental damage • Support local livelihoods and industries • Use local knowledge where possible • Treat for long-term durability	A guide to good thatching practice - South Africa [7]
D5	Aluminium sheets	Roofing, wall panels [*use for wall panels suitable only in temporary installations*]	Manufacturing process requires large quantities of aluminium and other metals. May contribute to mining impacts.	Manufactured in large factories using energy intensive processes, often with carbon emissions from fossil fuel energy sources. Poorly managed factories cause severe air and water pollution. May release toxic heavy metals.	None	Plastic / fiber reinforced plastic roofing sheets, clay tiles, thatching material	• Use certified products - Nepal National Building Code NBC 101 : 1994 • If used for wall panels, avoid contact with ground or high levels of moisture • Encourage reuse of sheets from old buildings • Store in a dry place in suitable stack heights • Never dispose in a natural environment and encourage recycling	A guide to good thatching practice - South Africa [7]
D6	Plastic / fiber reinforced plastic roofing sheets	Roofing, wall panels [use for wall panels suitable only in temporary installations]		Manufactured in medium/ large factories. Some harmful organic compounds and fibers with health hazards may be used in reinforced plastic sheets. Manufacturing process may cause water and air pollution if not properly managed.	Less environmental damage if natural fibers and safe petroleum by-products are used in manufacturing.	Thatching material	• Use certified products if possible • Where possible support local industries that are following environmentally safe processes • Encourage the use of natural fibers (e.g. coir) in fiber reinforced plastic sheets • Store in a dry place in suitable stack heights • Never dispose in a natural environment	Plastic Sheeting: A guide to the specification and use of plastic sheeting in humanitarian relief [14] Reuse, recycle and disposal of emergency plastic sheets [10]

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
E -Finishing material								
E1	Ceramic tiles	Floor tiling, wall tiling	Requires clay. Clay mining causes habitat destruction, fouling of water bodies, hydrological alteration.	Manufactured in large industrial kilns. Highly energy intensive. If not properly managed factories can cause air and water pollution, and carbon emissions. Toxic compounds may be used in glazing.	None	Terracotta tiles, cement tiles, vinyl tiles, polymer composite tiles Bamboo mat boards (environment friendly & energy efficient, stronger than plywood, termite proof, good in harsh climatic condition)	• Ensure optimal design (use only where necessary, limit aesthetic use). • Use certified products • Use quality products for long-term durability • Use standard sizes and shapes to minimize off-cuts • Ensure correct transport and handling • Store in safe dry place in proper stack heights	Environment Friendly Indian Building Material for Cost Effective Housing [53-54]
E2	Parquet	Floor paving	Manufactured using timber (see timber)	(see plywood)	None	Ceramic tiles, terracotta tiles, cement tiles, vinyl tiles, polymer composite tiles	Same as above	
E3	Lime mortar / lime putty	Plastering, filler, paint	Manufactured using limestone or coral. Coral extraction causes serious environmental damage. Mining small outcrops of limestone may also have significant environmental impacts.	Requires kilning to produce usable non-hydraulic or hydraulic lime. Kilning process (especially small scale) causes air pollution.	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 • Use only in plaster (not mortar) • Mix only in required amounts to minimize waste • Store in a dry place in proper stack heights • Never dispose of hardened lime in a natural environment	Technical guidelines on stone quarrying [8, 18]
E4	Chemical fillers	Filler	Requires mined and quarried material. See quarried rock for impacts.	Manufactured in large factories. Can cause air and water pollution if not properly managed.	Can reduce the demand for lime produced in harmful small-scale industries.		• Use certified products • Finish the walls smoothly before application and apply in optimum thicknesses (do not over-specify) • Mix only in required amounts to minimize waste • Store the containers properly closed (air tight) in safe places • Never dispose of hardened filler or the containers in a natural environment • Follow Health and Safety Executive (HSE) guidelines when working with chemical fillers	

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
E5	General emulsion or enamel paint	Painting	Requires a variety of base chemicals and mined and quarried material	Manufactured in large factories. Can cause air and water pollution if not properly managed. Enamel paint requires solvents during use. Some solvents may be harmful to human health and environment.	None	Water-based paints, natural pigments	• Use certified products (refer to additional resources for certified products) • Check the contents and avoid using paints with lead (Pb) or any other toxic material • Specify only the required number of coats • Store containers properly closed (air tight) in safe places • Never dispose of paint or containers in the natural environment • Limit the use of solvents and educate craftspersons about safe use and disposal of solvents.	Comprehensive Guide on Painting for Buildings-Government of India [11] Study of lead in paints in Nepal [1]
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*]	Requires a variety of base chemicals. Production processes of some of these chemicals may be extremely damaging to the environment and human health.	Manufactured in large factories. Can cause air and water pollution. May release heavy metals and harmful organic compounds to the environment.	None		• Use only where it is absolutely necessary and avoid if possible • Only specify if essential for the strength or durability of the building – not for ease of construction • Should be handled by only trained craftsmen • Store containers properly closed, in a safe place under lock and key • Should be treated as hazardous waste in disposal	Refer to E5
E7	Termite treatment chemicals	Chemical treatment to eradicate termites (applied to soil around the perimeter and the sub-floor of a building)	Requires a variety of chemicals.	Produced in large factory. Production process may release heavy metals and toxic organic compounds to the environment. Industrial accidents may cause serious hazards to people and environment.	None	Use of ground electrocution; integrated pest management	• Use only if absolutely necessary • Only use certified products (refer to additional resources for certified products) • Treat as hazardous waste in disposal • Only use in specified dosages • Store chemical containers in a safe location • Treat as an “extremely hazardous” waste in disposal	

No.	Material	Types of use [special technical remarks]	Environmental costs / benefits			Management & Alternatives		
			Issues in material extraction	Issues in production / treatment / transport / toxicity	Environmental benefits	Potential material alternatives	Better practices	Key Specific Resources *[References / web links]*
E8	Glass	Window panes	Quarried and mined material required in production.	Massive combustion of fossil fuel. Emits sulphur dioxide. If unmanaged, may cause water pollution.	Glass is a fully recyclable material. Chemically inert.		• To avoid waste: Use standard sizes and minimize off-cuts Only use the required thickness; however thin plate glass is susceptible to easy breaking and waste of material Ensure proper and safe transport, handling and storage	
E9	Tarpaulin sheets	Shelter material and wall panels (in temporary structures), weather proofing building sites	Tarpaulin sheet comprises of layered sheets that sandwich a polyester woven fabric base between plastic films. Crude oil is the main raw material used for production.	Emission of greenhouse gases during production. Untreated wastes from factories contain toxic chemicals and cause water pollution.	None	Waterproof canvas, thatching material	• To avoid waste: Properly tie and join the sheets to avoid tearing Use the whole sheet, do not cut Store in covered dry place, away from fire hazards • Reuse old tarpaulin sheets • Recycle where possible; since tarpaulin is a non-biodegradable material, special care should be taken when disposing – in well managed landfill sites if possible	Plastic Sheeting: A guide to the specification and use of plastic sheeting in humanitarian relief [14] Reuse, recycle and disposal of emergency plastic sheets [10]

References

1. http://green-recovery.org/
2. Bradshaw R. I. 1997. Bamboo in Nepal, A Management Guide. www.robibradshaw.com
3. Bureau of Indian Standards. 2005. Indian Standard, Common Burnt Clay Building Bricks – Specification. Bureau of Indian Standards. https://law.resource.org/pub/in/bis/S03/is.1077.1992.pdf
4. Chandrakeerthi S. R. de S. 1995. Development of Guidelines for proportioning Calicut tiled timber roof structures. Colombo: Institution of Engineers Sri Lanka. http://iesl.ceylonhost.com/IESL_publications/Civil%20Engineering/Building%20Engineering/Development%20of%20Guidelines%20for%20Proportioning%20Calicut%20Tiled%20Timber%20Roof%20structure%20by%20S.R.De.S.%20Chandrakeerthy%20%201997.PDF
5. Concrete Block Association. 2007. Aggregate Concrete Blocks: A Guide to Selection & Specification. United Kingdom: Concrete Block Association. www.cba-blocks.org.uk
6. Department of Labour. 1995. Guidelines for the management and removal of asbestos. Wellington, New Zealand: Occupational Safety and Health Service, Department of Labour. http://www.waikato.ac.nz/hrm/internal/health&safety/asbestos.pdf
7. Dhir. R. K. 2002. Sustainable Concrete Construction. Thomas Telford Publishing, Thomas Telford Ltd. ISBN: 0 7277 3177 7
8. Division of Building and Construction Technology. 1998. A guide to good thatching practice. Cape Town, South Africa: CISIR. http://www.sa-thatchers.co.za/wp-content/uploads/2010/09/AGuideToGoodThatchingPractice.pdf
9. European Bank for Reconstruction and Development. 2014. Sub-sectoral Environmental and Social Guideline: Quarrying. European Bank for Reconstruction and Development. www.ebrd.com/downloads/policies/environmental/mining/stone-sand.pdf
10. Geological Survey of India. 2009. A Model Document on Impacts and Methodology of Systematic and Scientific Mining of the River Bed Material. New Delhi: Geological Survey of India. www.portal.gsi.gov.in/gsiDoc/pub/riverbed_mining_guidelines.pdf
11. Global Shelter Cluster. 2010. Reuse, recycle and disposal of emergency plastic sheets. Geneva: Global Shelter Cluster. www.sheltercentre.org/.../reuse-recycle-and-disposal-emergency-plastic
12. Government of India, Ministry of Railways. 2007. Comprehensive Guide on Painting for Buildings. India: Centre for Advanced Maintenance Technology.
13. Grégoire G. 2007. Environmental, Health, and Safety Guidelines for Construction Materials Extraction. International Finance Corporation, World Bank Group. http://www.ifc.org/wps/wcm/connect/a99ab8804365b27aa60fb6d3e9bda932/EHS-Guidelines+101-Webinar.pdf?MOD=AJPERES
14. IFRC, UN/OCHA, CARE. 2009. A Guide to the Planning, Use, Procurement and Logistics of Timber as a Construction Material in Humanitarian Relief. Geneva: IFRC. http://www.ifrc.org/PageFiles/95530/D.03.c.01.%20Timber%20Guidelines-EN.pdf
15. International Federation of Red Cross. 2007. Plastic Sheeting; A guide to the specification and use of plastic sheeting in humanitarian relief. Switzerland: International Federation of Red Cross. www.ifrc.org/PageFiles/71111/D.03.a.01.Plastic%20Sheeting_Englis.pdf
16. Iyer S. 2002. Guidelines For Building Bamboo-reinforced Masonry In Earthquake-prone Areas In India. https://arch.usc.edu/sites/default/files/mbs/.../shreemathi%20iyer.pdf
17. Jayasinghe C. and Kamaladasa. N. 2006. Compressive Strength Characteristics of Cement Stabilized Rammed Earth Walls. www.elsevier.com/locate/conbuildmat
18. Kandamby T. and Jayasinghe C. 2011. Cement Stabilized Rammed Earth for Wall Junctions of Two Storey Houses. Sri Lanka: University of Moratuwa. www.civil.mrt.ac.lk/conference/raghu/26.pdf
19. Maharashtra Pollution Control Board. 2006. Guidelines for Environmentally Sound Operations for Stone Quarries. Mumbai: Maharashtra Pollution Control Board. http://mpcb.gov.in/ereports/pdf/GUIDELINES%20FOR%20STONE%20QUARRYING.pdf
20. Maïni S. 2009. Earthen Architecture for Sustainable Habitat and Compressed Stabilized Earth Block Technology. http://www.ada.gov.sa/idc/groups/public/documents/ar_ada_researches/004568.pdf
21. Nepal Standards Institute. 2003. Specifications for Galvanized Corrugated Sheet. Kathmandu: Nepal Standards Institute. http://nbsm.gov.np/file/download/file1712045347.pdf
22. Perera A.A.D.A.J. 2008. Innovations, Applications and Standards of Compressed Stabilized Earth Blocks. www.irbnet.de/daten/iconda/CIB15593.pdf
23. Practical Action. 1992. Non-poisonous Timber Protection. Warwickshire, UK: Practical Action. http://sheltercentre.org/sites/default/files/PA_NonPoisonousTimberProtection.pdf
24. Safe Work Australia. 2011. How to Safely Remove Asbetos: Code of Practice. Sydney: Safe Work Australia. http://www.workcover.nsw.gov.au/__data/assets/pdf_file/0016/15217/how-to-safely-remove-asbestos-code-of-practice-3561.pdf
25. Sah R. C. and Yadav K. 2010. Study of Lead in Paints in Nepal. Kathmandu: Center for Public Health and Environmental Development. www.cephed.org.np/pdf/31420818225.pdf
26. Salam K. and Pongen Z. 2008. Hand Book on Bamboo. Guwahati, India: Cane and Bamboo Technology Centre.
27. Shelter Cluster. 2010. Selection and Safe Use of Chemical Wood Protection. Geneva: Global Shelter Cluster. www.sheltercluster.org
28. Shelter Cluster Nepal. 2015. Technical and Implementation Modalities Guidance Document Annex: Corrugated Galvanised Iron (CGI) Specifications for Roofing. Kathmandu: Shelter Cluster Nepal. https://www.sheltercluster.org/sites/default/files/docs/cgi_specification_150708.pdf
29. WWF. 2006. Keep It Legal: Best Practices for Keeping Illegally Harvested Timber out of Your Supply Chain. Washington D.C: WWF. assets.panda.org/downloads/keep_it_legal_final_no_fsc.pdf
30. https://www.unido.org/fileadmin/user_media/Publications/Pub_free/Environment_friendly_Indian_building_material_technologies_for_cost_effective_housing.pdf

WWF Nepal, Hariyo Ban Program
PO Box: 7660, Baluwatar, Kathmandu, Nepal
T: +977 1 4434820, | F: +977 1 4438458
hariyobanprogram@wwfnepal.org,
www.wwfnepal.org/hariyobanprogram