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Wall Building
Technical Brief
Building Advisory Service and Information Network

Stone Walls in Mountainous Regions

Introduction

Stone is the natural walling material of mountainous regions. To haul up bricks or cement, often on human back, can take a few days. It makes more sense to bring the tools and the skill to the hills. Yet, unless traditional, the utilization of stone is limited, wasteful and also with little attention to environment. Stone foundations with a superstructure of other building materials are more common.

Local stone is cost-favourable as compared to transported building materials due to state-of-the-art technologies which have turned stone into a modern material which can provide local employment.

Stone is one of the few building materials applicable "as is" with hand tools: further processing or technological inputs are optional. Stone needs no warehousing for storage and packaging requirements are minimal.

In any pilot project within a sponsored model housing scheme a small pilot plant would encourage and facilitate the production of stone components like sills, lintels and paving elements.

It would also lead to the establishment of local stone supplies which, with quality control and transfer-of-experience potentials keep the wall building costs down.

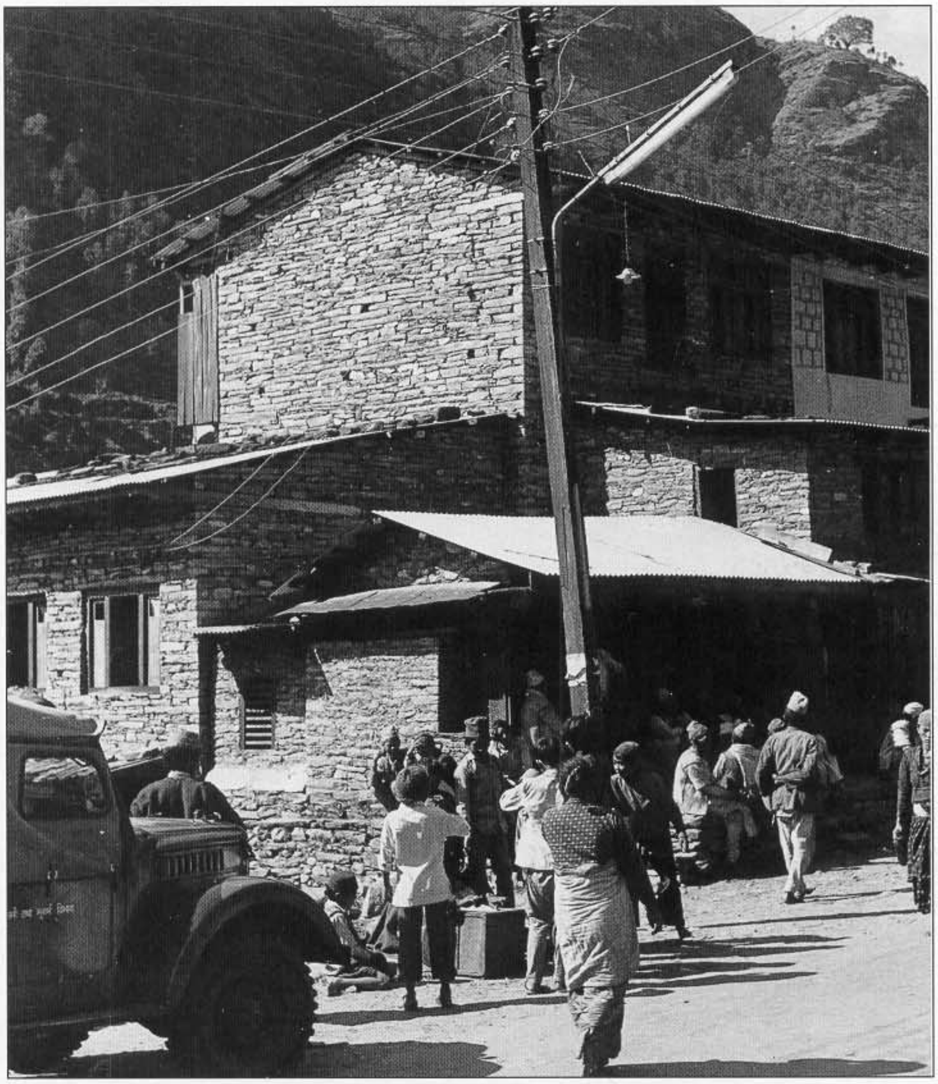

Figure 1: Stonehouses near Prithvi Rajmarg Highway in Nepal

Location profile

The more common, typically populated mountainous region is of a limestone type or contains rocks like basalt, sandstone, phyllites, schists, etc., usually overgrown with shrubs and with occasional trees on sparse topsoil. A limestone topography is more often than not strongly affected with karstic features, it has extensive terracing supported and enclosed by dry walling. Rainfall in most mountainous regions is seasonal, with notable exceptions.

Stone resources

The stone resources on the slopes are easiest to extract when outcropping in hill ledges or from previous excavations or riverbeds, terraces or abandoned quarries. They vary from fine grained to coarse grained with various degrees of crystallinity, various tonalities and textures or ornamentations. As a start stone outcrops situated near the construction sites could be used. The larger waste heaps from previous quarrying enables proper grading and selection on a wider scale.

Stone Identification

General guidelines

Stone as a local material is usable practically without complicated further processing other than ornamental. Being a mono-technology, the material itself needs no transformation; what one has to know about stone is concerned with its extraction, selection and shaping:

The bedding and layering of stone at the source has to be checked for the required

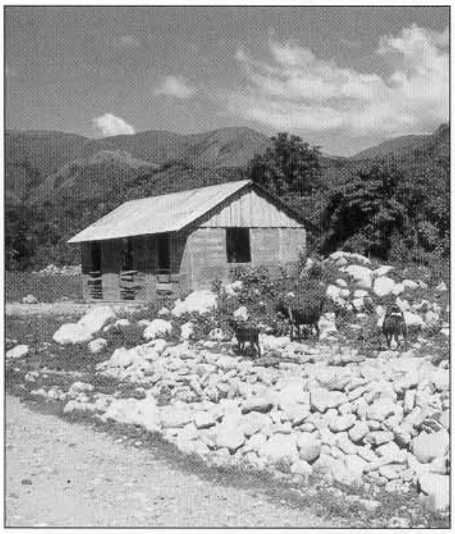

Figure 2: Stones resources in the Dominian Republic

thickness. Already applying a hammer or a crowbar gives much information about cohesion, hardness, soundness and/ or breakability.

If the stone "rings true"and reverberates, then flaws are unlikely. These are indicated by a dull sound, as in striking a cracked clay vessel or flowerpot. Therefore clayey, marly and the softer chalky stone varieties should be avoided. Scratching the stone, soaking it in water for a few days will also give much information about hardness, coherence and porosity. Highly porous stones will increase in weight; even hard marls and clays, which look stone-like when dry, and can disintegrate during soaking. Limestone rocks are either hard or chalky limestones, or clay and marly varieties.

Cleavability and jointing are important for a good workability. A chisel-pointed hammer, mason's hammer, or a chisel will indicate breaking directions. Weathering changes can be observed by comparing the natural "skin" of the stone with a freshly broken surface.

In a regional investigation a prime resource target are slabby limestone layers; these are easy to trim on the sides, the top and bottom being naturally flat.

Applications

The preparation and construction of the foundations and the stability of the walls, are basic in planning.

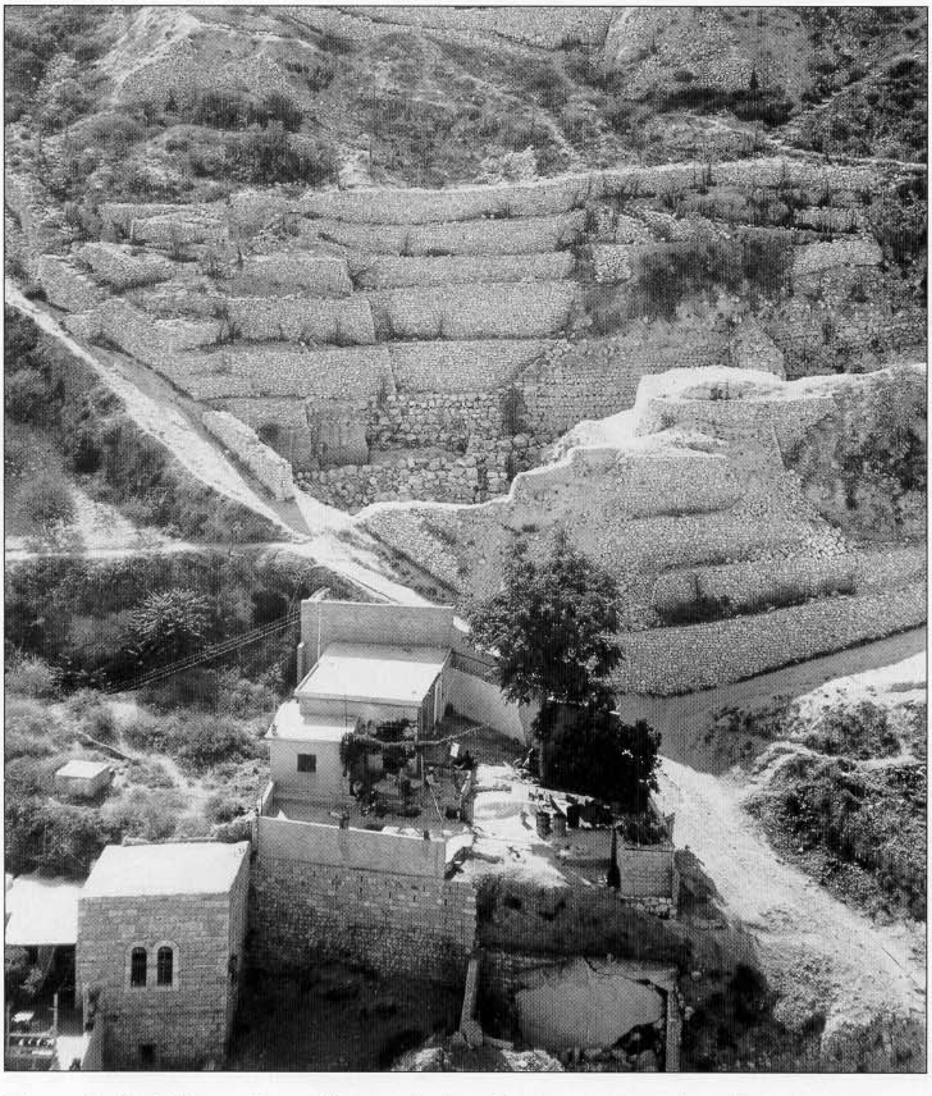

Figure 3: Retaining walls and houses built with stone in Jerusalem, Israel

Stone Foundations

A trench is dug in the shape of he house, tamped down, and then filled in by systematically laying boulders of large stones, possibly topped by an insitu cast reinforced concrete ring beam and/ or some courses laid with shaped stones in a preselected pattern. The foundation wall above the foundation seating could also be of poured concrete together with any stone material. Strength of the foundation is increased by selecting and stacking the stones with a minimum of concrete or mortar and applying the principles of drywall building. A slight inward angle of the stones toward the centre causes the outer layers of the structure to lean in against themselves, increasing stability. Good drainage channels should be built around the house and filled with small gravel to allow rain water to drain off.

Any structure above ground must be of the same quality as its substructure, the foundation and foundation wall. It is also necessary to always examine the subsoil and ground water level to avoid differential settlement and also to ensure the stability of the subsoil which e.g. should not be affected by a close-by river in a surrounding hill site. Backfill on the building site may require pre-consolidation. Any performance records of neighbouring foundations are important to note.

The depth of the foundation strip and thickness of the foundation wall depend on the resistance of soil or rock, and on the need for protection from harmful climatic effects due to variations in seasonal humidity. Foundation walls resting straight on the ground with variable strength often fracture, due to their unequal settlement, the more so in walls with irregular masses, even on uniformly yielding soil. Failure can be prevented by extending the base of foundation walls for an equal weight distribution of the structure over the substratum. Poor resistance of soil/rock is another cause of unequal settlement, since nearly all soils, unlike solid rock and gravel, are compressible under pressure.

Settlement causes no problem if uniform and of shallow depth, with the relative position of the parts of the structure remaining unaltered. The bases of the structure are invariably made wider than the superincumbent mass to increase the stability by distributing the load over an area sufficiently large for safely withstanding the pressure and for counteracting failure, especially where foundations do not reach the bedrock.

In stony ground, the building is usually put up onto rock . If the bedrock is not sound and insitu, it has to be treated like a soil base. If sound and uniform, the lowest stone course acts as an initial base directly on the foundation footing, preferably with squared slabs.

To use locally quarried stone is most economical. The design of foundation walls and above ground walls should take advantage of available stone shapes and sizes. As mentioned above in some cases a concrete footing or a reinforced ring beam on top of the foundation wall may be more expedient than trying to match random shaped stones.

Basic Types of Foundations

- Foundation in trenches: 30-80 cm in depth and wider than the planned walls above are sufficient where the unit load is less than the practical resistance of the soil.
- Foundations with footings: these should always be wider than the wall above so that the load can be spread over a larger area.

The base of the trench, the weight of the incumbent structure and environmental factors determine the need for concrete. For a compacted base of clayey soil, or clay, with or without stone, a footing course is sufficient for a one to two storey building. Stone courses below ground level are part of the wall and require as much attention as visible courses; they determine the level of the structure and carry more weight than any other course.

To complete the foundation, it is levelled with long stone slabs of about 30cms thickness. As such slabs are not always available, or complicated to square with basic tools (few hand guillotines can tackle lengths of more than 70 cms), a continuous concrete belt, 20 to 30 cms thick, is cast to take the lowest stone course.

This is especially important and should always be considered in earthquakeprone areas. A damp-proof course above ground level is also recommended.

Wall construction

- Retaining walls: these serve to keep back earth, soil, infill, or are used for terracing. They can also preserve contour levels for road cuttings or control erosion, with only one face exposed. Such walls usually do not exceed 1 meter in height. If built dry (without mortar) they usually have a thickness of about 45-50 cms. Retaining walls can be built with fieldstones.
- Free-standing wall: these are walls which have both faces exposed. The construction of the first course required for ashlar, slabby or squared stones is fairly straight forward. Random rubble requires "course-in" with quoins (corner stones).

Continuing on the floor slab, the footing of a wall is set in a bed of mortar brought to level. Stones with vertical faces on the outside, set at fairly regular intervals, form the pattern of the wall and fix the courses. Big stones in the first course prevent settling problems which occur when larger stones are used higher up and are put onto smaller stones, especially of irregular shapes as with random rubble. For solid walls the building work goes on from one side of the wall. If the two faces consist of stone "cladding" and fill, one face is worked at a time. Filling in between the faces is gradual as the structure rises. Infill just consists of packing material, it does not hold the wall together, but rather it tends to push the faces apart. It is therefore necessary to "bind "the wall together. This is achieved by using long narrow stones, which are set aside during sorting, when also stones for the finish are dressed. These "binding" stones are necessary in every other course. They are essential for the wall's stability. Care during sorting ensures that stone sizes are proportioned to the wall dimensions. Low walls require small and narrow stones. Larger stones should be used for higher walls.

Whether to use small odd-shaped stones for the foundation and to save the bigger flat stones for the wall courses is debatable. The foundation is critical and settlement may lead to cracks in the incumbent courses. Depending on the nature of the soil under the foundation, irregular shapes provides better anchoring than a flat underside. Wall courses require a stronger mortar to ensure that stones stay on top of each other.

Composite walls may contain several materials across their width; e.g. stone and concrete, various stone materials such as pebbles and broken slabs laid in a sand and lime mortar bed. The method used is a variation of the "banked stone system": rough or cut blocks or slabs of stone are used as "form boards" in place of shuttering on the outer side of the exposed wall face. This is common in the Middle East.

Stability of walls

Walls tend to support each other, especially when enclosing a space. The minimum thickness, required for their stability, increases with the wall length. The smaller the space in between walls, the greater the strength of the connecting wall. Various tying or bonding devices compensate for inadequacies in stonework, increase stress resistance and im-

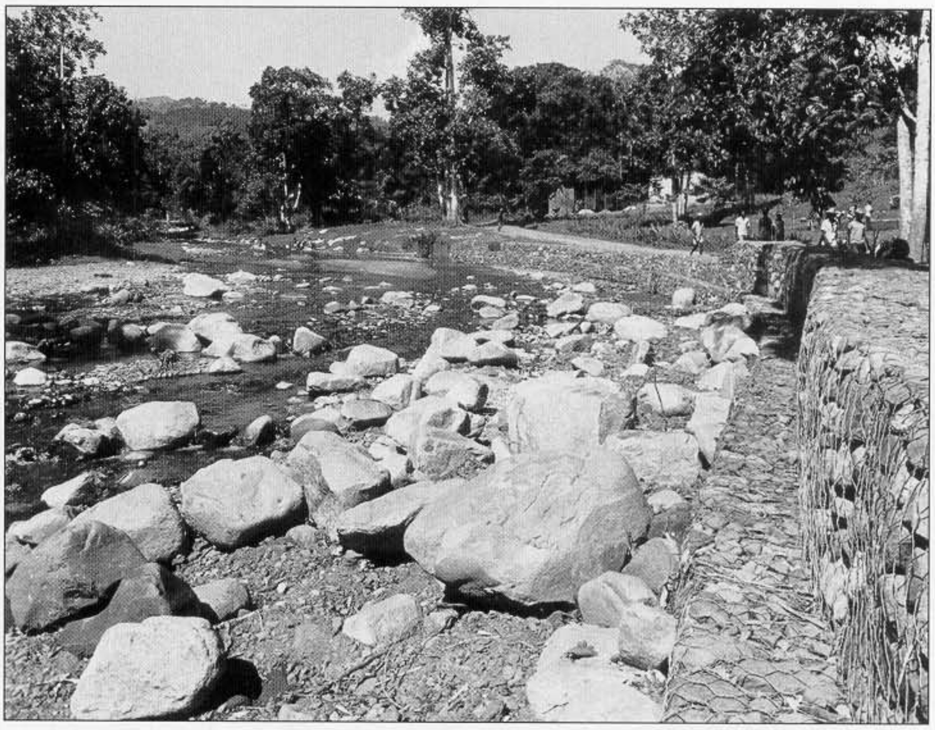

Figure 4: The use of river boulders and construction of gabions in Haiti for conservation of river banks and to prevent erosion during flooding

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The Use of Natural Slabby Stone Deposits for Wall Construction

Introduction

The most convenient stone source for building walls are layered rock outcrops. Their advantage is the unformity which is lacking in boulders and cobbles deposits. Slabby stones are also easy to extract. The quarried slabs can be shaped with simple tools. They can be handled and transported without difficulties.

The term "slab", originally any massive rectangular piece of stone, is used in this context to describe rectangular units which are units larger than the size of bricks. For flooring or paving they are known as flagstones. Stone slabs, especially if regular and parallel, are the most sought after materials for stone structures particularly in areas with limited processing facilities for stone blocks. They are used for walls as building stones and for cladding. As an instant structural building material, natural slabs require only trimming to the required size on four sides before placement.

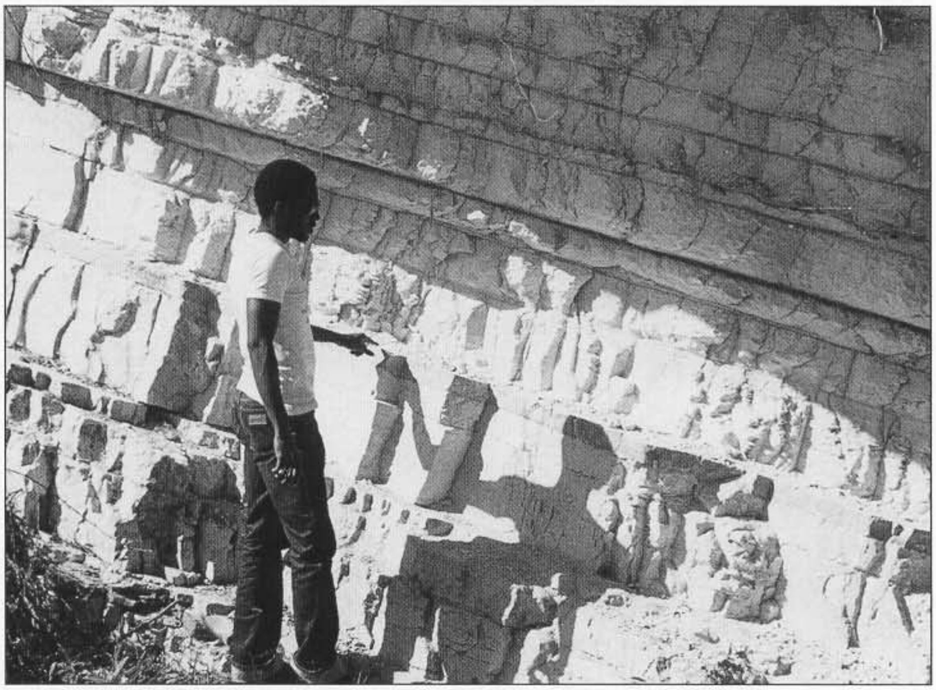

Figure 1: "Layered rock outcrops in Haiti"

Apart from its use for walling when cut to size, a slab could also serve as a hearth of a fireplace, as a kitchen counter, as the floor or partition of a latrine, as paving slabs, wall panels, units to clad walls (known as facing slabs). etc.

Identifications of deposits

Slabs occur in outcrops or layers as thin bedded deposits whether igneous, metamorphic or sedimentary. Large slab deposits can dominate the rural and urban character and environment of structures in whole regions as for example in the Verona area in Italy. Ancient structures, retention walls, paths etc.often lead to slabby outcrops covered in time by surficial vegetation.

Figure 2: "Near horizontal layers of Rodeador marble, Minas Gerais, Brazil, showing Karstic rills on well developed joints"

Slabby layers are not only convenient sources, they possess a flexibility for extraction and working, provided that the

Figure 3: "Karstic features on joints and leverage with hammer leads"

dressed product meets the required standards and specifications. Deposits near any construction site, have proved to be the most economical, locally available building material. Popular thicknesses of slabby stones are not exceeding 20 cms.

Extraction and shaping

Any overburden, when it is present, should be cleared manually rather than with a bulldozer to avoid crushing thinner stone layers, unless a wheeled shoveldozer is available. The plane of easiest splitting is sometimes called the clift, as distinct from the direction of easiest splitting, known as the rift, which is more likely to be identified on igneous rocks than on limestone and other sedimentary rocks.

Depending on the quarry and the nature of the layers, freely parting slabs are prised loose with crowbars, as for example in La Rioja, Argentina, where oolitic sandstone slabs of 2 to 7 cms thickness are produced.

For thicker slabs crowbars are no longer sufficient. These slabs are separated by vertical wedges and manipulated to make the best use of the natural properties of the stone. Generally the break is most successful when the weight is equal on both sides of the wedge, standing up-right in the thicker beds, and pointing slightly away in thinner beds. The stone should be split into equal halves where possible. If one side is weaker, the blow will tend to run out towards the weaker side, causing an uneven break. Where drills are used, the wedge should be placed at least half of its length into the hole, but it should never reach the bottom. Delay between blows should be minimized, so that the whole row of wedges works as one. Firm and rapid blows are important, as extra hard blows will make a wedge fly out.

Where jackhammers are unavailable, holes can be made with a round steel crowbar about $1^1/_2$ meters long and sharpened to a chisel edge, the barramina, or with jumper drills. Abrasives like a silica sand sludge speed up the drilling. Hole spacing and depth are dependent on how easily the material splits, and varies from quarry to quarry. To guide the line of fracture, tough or soft stones require deeper holes.

Alternatively, depending on the nature of the stone material, staggered pits or continuous grooves are preferred for straight breaks (when the drilling of holes would take more time than chasing). These are chased with a hammer and chisel. The groove tapers to the bottom, with the end finer than the edge of the breaking wedge. Wedges in many sizes are traditionally the main tool for splitting stone or detaching stone masses by insertion in induced or natural cracks of joint cavities, similarly to those made for parting slabs.

In 40 to 60 cm thick slabby layers, a v-shaped groove or pit, about 10 to 15 cms deep, is chased along the whole length of the block to be cut. The pit is lined with scales, long strips of tin. Small wedges are then inserted. These are gently tapped with light sledgehammers until the stone splits. Chasing a continuous groove takes an hour per meter, although the actual splitting blows only last a few seconds. Accurate and true chasing prevents a faulty cut. Where available, plugs, more slender than the wedge, and feathers, with a taper corresponding to the plug, have now largely replaced wedges but need insertion holes. Quarry floors require meticulous cleaning by broom or compressed air, before a next layer of stone is removed; the larger sized stone waste is cleaned and then squared by guillotine.

Dressing Slabs and Building Stones

Slabs are shaped by dressing, that is by slicing with a saw to be smoothed with chisels, or by rubbing with abrasive or harder stones and at times by applying a polished finish. Polished marble table

tops and kitchen counters are regularly crafted by hand on the island of Romblon in the Philippines. Counters, often matched with hand carved marble kitchen sinks and wash basins, are common fittings in Greece, Turkey and the eastern Mediterranean islands. In eastern Portugal thick granite slabs constitute whole facades in large buildings and are also important components in houses and cottages.
Flooring, stairways, steps and paving consume more slab material than any other type of construction. In flooring for latrines the slabs have a hole and are often made of slate as, for example, in the foothills of the Himalayas.

Slabs in Foundations

As already stated above, the use of slabby stones has the geometrical advantage over the use of boulders or irregular shaped stones. Slabby stones have natural parallel faces and require less fitting time. Otherwise the technique applied for its use in foundations is similar to that used for boulders. (ref. Technical Brief on "The Boulder Concept").

Slabs in Dry Walling

With slabby stone material, unlike with other stone shapes, the basic technology for dry or mortared walls are akin. Dry walls are usually "monolithic" with or without a framework, whereas other types can vary from cavity walls to hybrids using various stone types and infillings together with an array of metal frameworks and anchorings. Dry walls are more intricate.

Slabs for use in dry walls are normally 30 cms wide and 7 to 20 cms thick in various lengths. The wall building technique is similar to mortared wall construction, using less wide and shorter stones.

Wall Building

The shape and dressing of local slabby stones depends on the skill of the stone mason and the use on the skill of the builder. The two construction methods for slabby stone walls are based on filling a framework (skeleton wall), or on using massive coursing:

- Skeleton wall: this consists of wooden poles and beams which form a framework, which is then filled-in with stones.
  This is also known in the Caribbean as "Spanish Walling" (for example in Jamaica). This type of wall, braced by diagonal timber pieces, is an indigenous type of stone nogging, reputedly introduced by the Spaniards. The stones are keyed in to form a tight knit, and then mortared with sand and lime. This type of wall is more flexible than a massive wall and suitable for use in earthquake and hurricane prone areas. Skeleton frames in Haiti which are common between Miragooane and Fond des Negres in the South, use vertical uprights.

- Coursed type of wall: this is monolithic and more common in areas with high seasonal temperature difference.

Both types of wall can be of a dry-stone or built with mortar. Frequently used finishes of walls include coursed, random or snecked rubble.

The straight run of the wall is turned at a right angle by corner stones or quoins, to enclose space or to form a framework to be filled with stones. In stone rondavels, for instance at Maseru in Lesotho, the individual stones, whether slabs, ashlars, or boulders are gradually turned until a circle or oval shape is attained. To build the all stone pilot house as shown in Fig. 4 La Rioja, Argentina, slabs 2 - 10 cms thick and 30 cms wide, were cut in various length to provide building elements. With perfectly flat layers, at the top and bottom, semi-dry walling can be conside-

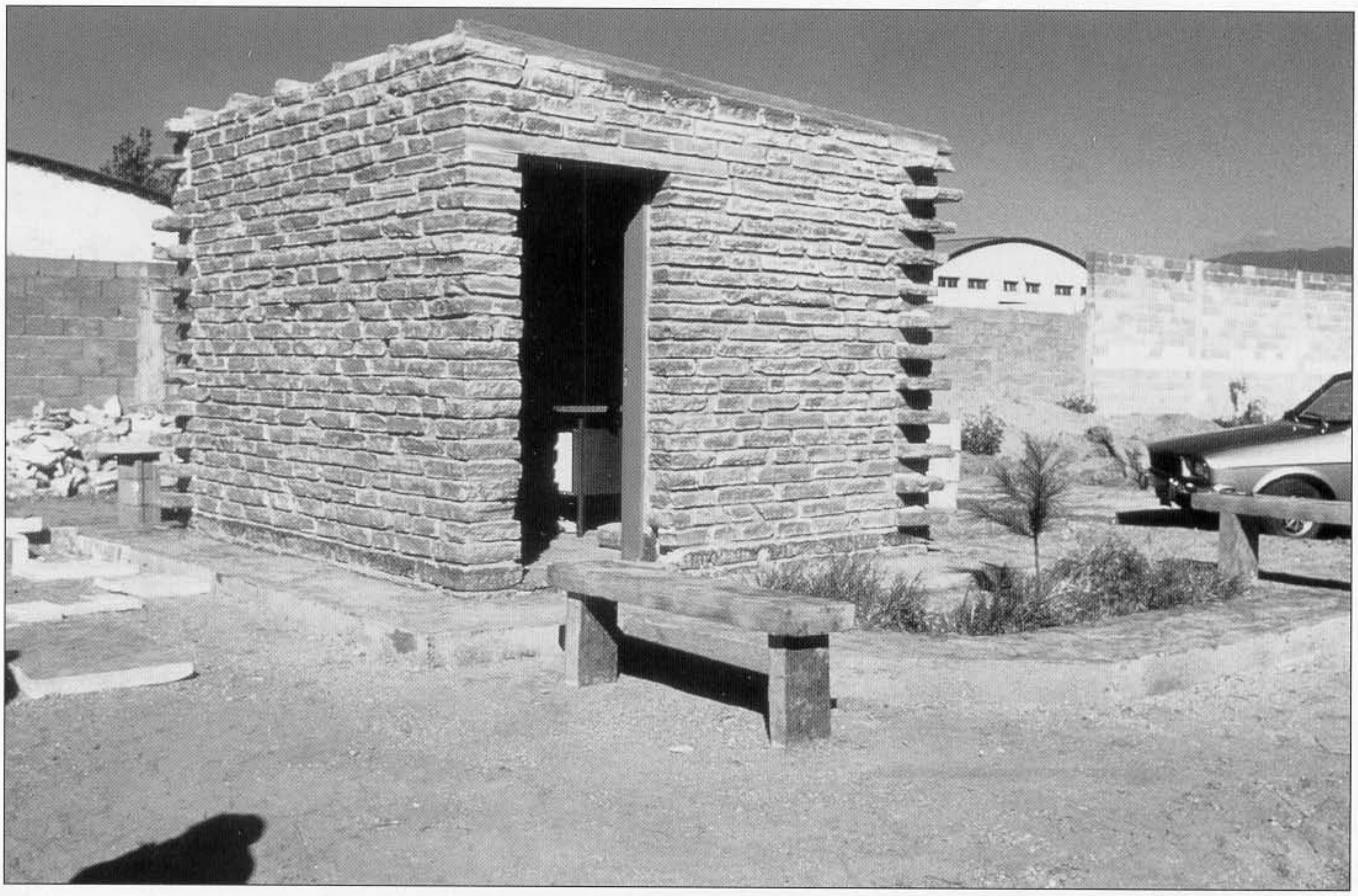

Figure 4: "La Rioja, Argentina"

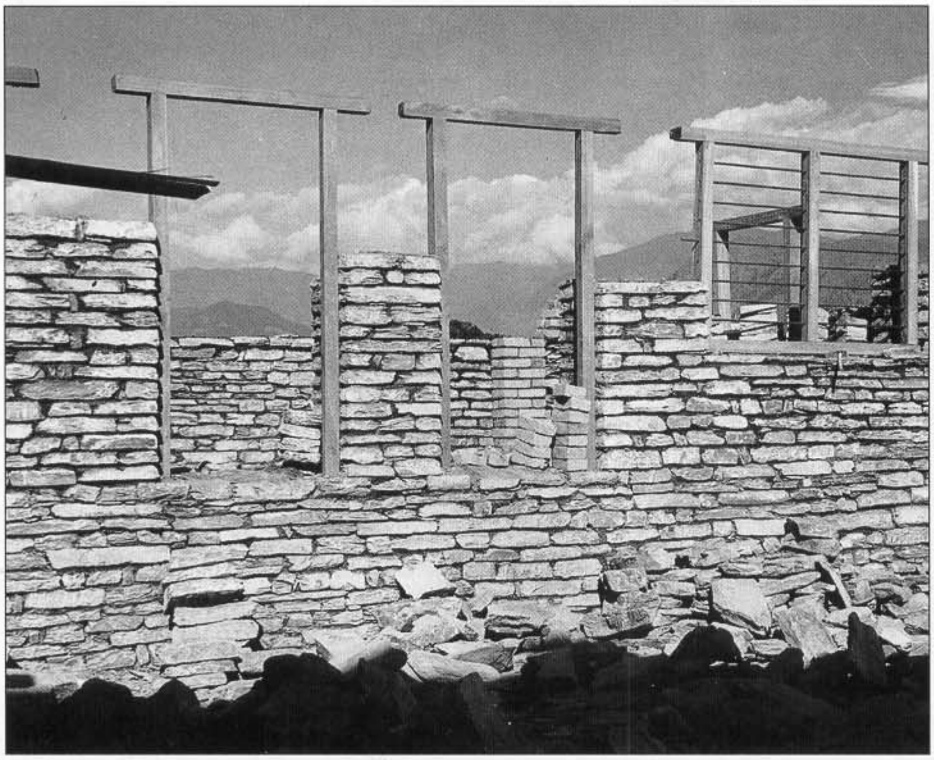

Figure 5: "Slabby stone walls and window openings in Nepal"

red. Grooved edges, for interlocking, can be cut by dove-tailing with a power tool, slicing the remaining core with the saw, carving the core by hand with a chisel and levelling the groove by fraising for smooth fitting.

Floors

Flooring slabs are laid in a geometrical pattern and smoothened by handgrinding using an abrasive brick at the end of a broomstick, and water.

Roofs

Rectangular slabs of 2.30 m length for roofing have a rebated joint to allow for expansion and are cut and grooved with a dry diamond disc power saw. Overlap of the roof provides added protection against sun or rain. For the kitchen working tops the smoothest slab is set aside to facilitate later polishing before fitting.

Note:

The term "stone walling", when used, is to emphasize a mortared wall version as opposite to dry-stone walls laid without mortar.

Glossary

- oolitic: sedimentary rock characterized by small spherical grains of calcium carbonate
- rift: cleavage, direction of easiest splitting
- cavity wall: two parallel single leaf walls, usually at least 50 mm apart from each other, effectively tied together with wall ties.

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What is BASIN?

Building materials and construction technologies that are appropriate for developing countries, particularly in the low-income sector, are being developed, applied and documented in many parts of the world. This is an important prerequisite for providing safe, decent and affordable buildings for an ever-growing population.

But such new developments can do little to improve the building situation, as long as the information does not reach potential builders. The types and sources of information on standard and innovative building technologies are numerous and very diverse, making access to them difficult.

Thus, in order to remedy this drawback, Shelter Forum, GATE, ITDG, SKAT and CRATerre are co-operating in the Building Advisory Service and Information Network, which covers five principal subject areas and co-ordinates the documentation, evaluation and dissemination of information.

All five groups have a co-ordinated database from which information is available on Documents, Technologies, Equipment, Institutions, Consultants as well as on Projects and Programmes. In addition, printed material or individual advice on certain special subjects is provided on request. Research projects, training programmes and other field work can be implemented in co-operation with local organizations, if a distinct need can be identified and the circumstances permit.

BASIN is a service available to all institutions and individuals concerned with housing, building and planning in developing countries, but can only function efficiently if there is a regular feedback. Therefore, any publications, information, personal experiences, etc. that can be made available to BASIN are always welcome and will help BASIN to help others.

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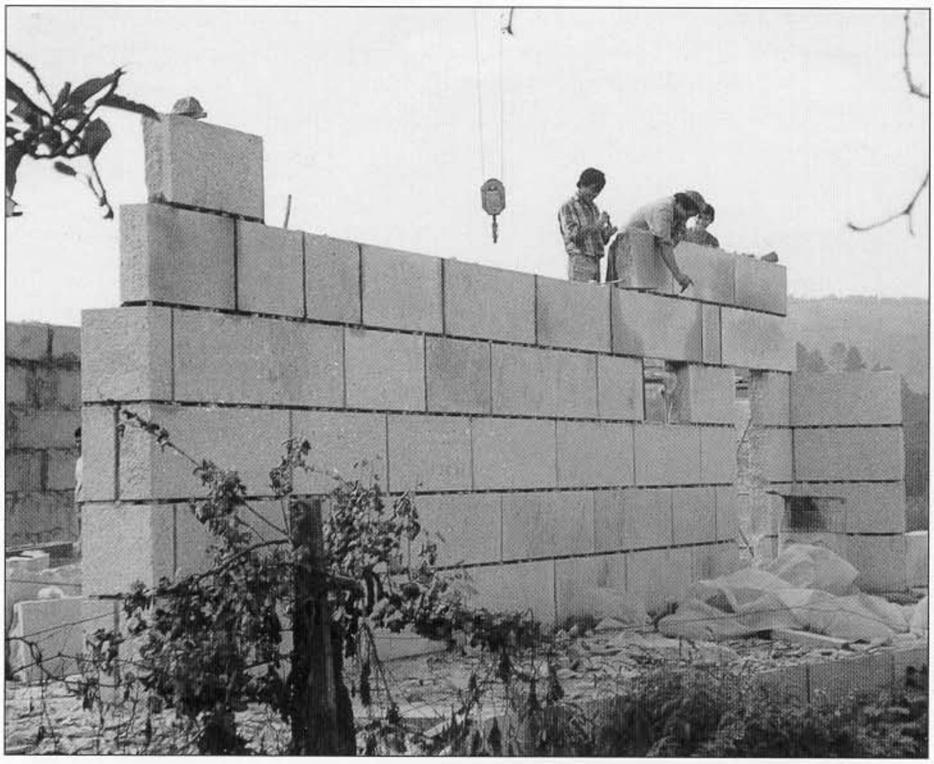

Figure 5: Stone house in Alpindurada near Oporto, Portugal

part a certain amount of pliability. Such devices (with exception of quoins) include corner ties, jambs or piers made of cut stone, hard-stone cupola ties, and iron or wooden ties which bind the corners of a building. Floors act as braces or stays in a structure; as do partition walls, corner returns and wall heads (butresses). Some details like this, e.g. window or door openings are shown in Figure 5.

Production of Building Stones

Shapes used for building stones are a matter of expedience and preference.The various ashlar and rockface patterns require basically similar extraction techniques.

Stone shapes, textures and construction patterns can be combined in many different wall types. Whereas the needs of individual builders may be supplied from small ledge quarries and existing waste heaps, any larger buildings, such as schools, etc. require an extraction of the stones from geologically planned quarries.

Extraction

Stones from insitu rock are removed with appropriate extraction tools such as saws, drills, hammers, chisels for breaking and cutting, as well as levers, jacks etc. which are primarily used for loosening the stones. Exploitation of unconsolidated stone involves collection of the stones by lifting, manual grading and moving the stones with various devices including stone sleighs, wheeled carts and self-propelling earthmoving equipment. For larger stones, other types of lifting equipment can be used with planks, beams, ropes and/ or cables.

Removal from the quarry face can be done with levers, bars or specially designed or adapted handtools hand-drills, jackhammers and mechanical jacks, which are used for cutting, chanelling, wedging and other treatments, depending on the nature of the deposit, production and use requirements.

The simplest way is to prise a bed with a lever, or where joints are wide enough, to force the rock apart with jacks. Where available, a shoveldozer should be used to prise rocks loose. In other cases wedges or plugs are used. Shallow furrows or grooves can be drilled or cut into the rock for insertion of the wedges. The drilling can be done with pointed bars or plug drill and hammers, jackhammers or electrical drills where a generator or a power grid is available. More recently, self-propelling mechanical chisels e.g. of the Bobcat type, are used to subdivide rock bedding.

Stone saws are available from small 5 HP models with 60 to 200 cms sawing discs which can cut dimension stones in the quarry. Depending on the hardness of the stone, tungsten carbide or diamond segments are used. Except where the use of hand-tools is preferable (e.g. when working with near horizontal and well developed slabby beds) the compressed air jackhammer is still the most versatile extraction equipment.

Stone breaking and dressing

Stone breaking requires suitable support from benches, floors, sand-boxes, plants, pipes or angle iron. Whereas in extraction, the bar or lever is the most versatile tool used for prising, lifting, breaking, drilling and even testing, for breaking the stone a hammer is preferred.

Hammers may be chisel-pointed at one end or can be used in conjunction with chisels. The ability to strike with a minimum effort is a combination of hammer

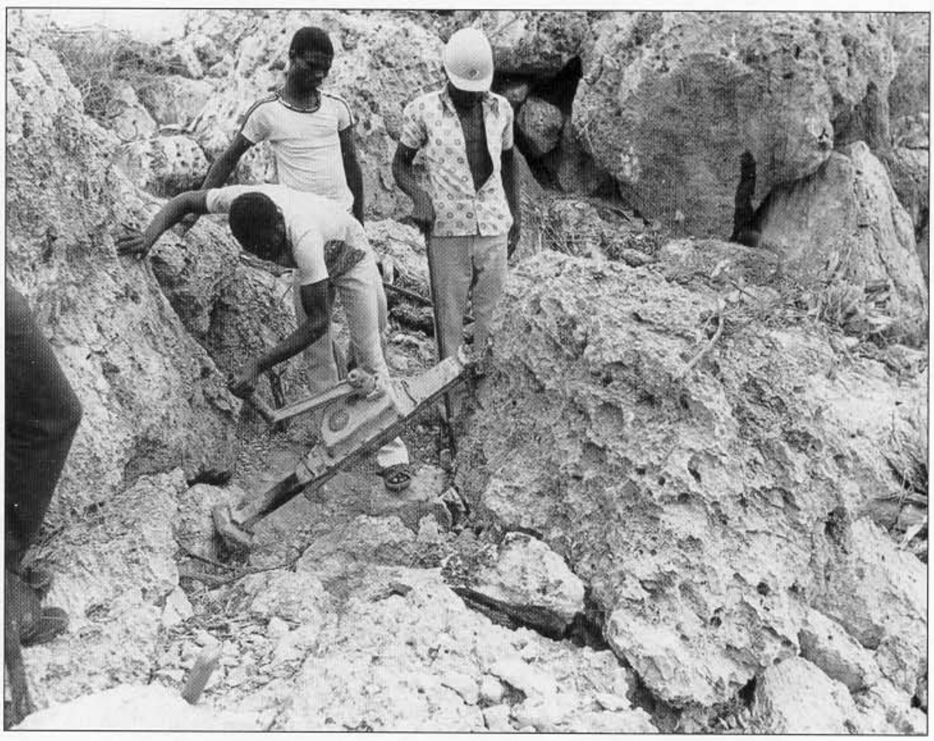

Figure 6: Prising rocks loose by mechanical jack in Morne La Pierre, Gonaives, Haiti

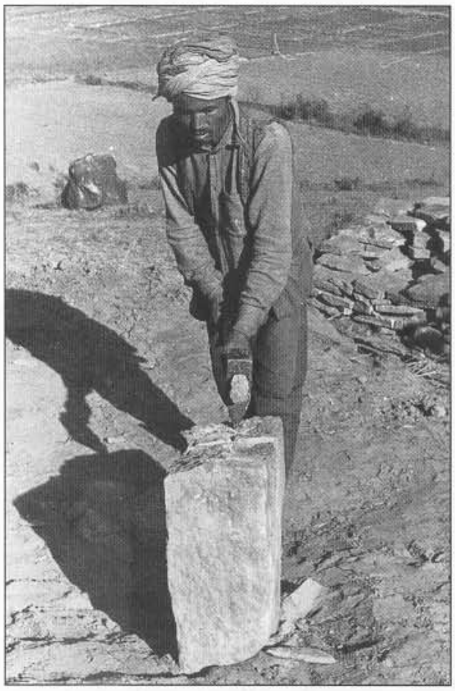

Figure 7: Breaking stone in Surketh, Western Nepal

weight and shape, handle length and the holding, swinging and stance of the worker. With a hammer of approximately 5 kgs weight a stone mason can break a rock mass of many tonnes.
Equally important is the natural breaking direction. The aptitude of the mason's ability as to where to hit the stone makes the difference between a fragmented result and fairly straight cuts and regular shapes. The working position for the actual finishing of stone pieces differ in various parts of the world; some masons work in a sitting or squatting position, the stone is layed flat on the ground or supported at an angle.

Apart from the hammer, the chisel is also a very good tool for shaping and dressing stone surfaces. Tungsten carbide tips save grinding time and are also used with compressed air tools.

Saws, both hand and power operated, subdivide soft stone blocks. Hard varieties require wedging devices and guillotines for breaking. Dry cutting diamond disc power tools find increasing use for on the site trimming of building stones and are useful to cut grooves for wedging, instead of the laborious groovings by hammer and chisel or pick; their use is especially important for modular building stone units and components which require a tight fit or where channel or V-jointings are wanted.
Handoperated guillotines are particularly efficient for the production of building stones from thick slabs of widths between 15 and 70 cms, and thicknesses between 7 and 30 cms; larger pressures up to several hundreds of tonnes can tackle larger dimensions and meet the needs of big construction projects.

Masonry practices

Typical stone types for walls include: ashlar (uncoursed and brought to courses), squared rubble (which can be uncoursed), snecked rubble (brought to courses), polygonal rubble (mainly from quarry waste). Cornerstones from these stone types (quoins) are usually squared to provide a loadbearing framework and neat appearance.

Laying the lowest course of the wall needs particular care. Besides ashlar and rubble, slabby stone (flagstone) and components make up the four principal stone types for walls. Natural slabby stone are used in thin layers for face walls, fences and for the construction of pavements and floors. Components are cut stone, other than ashlar and are used for lintels, sills, caps and similar masonry units. The thickest and heaviest rocks should be kept for the lower courses to avoid unnecessary lifting. When laying a wall, the following should be considered:
The best flat face of the narrow dimension of each stone should face outward and be bedded solidly on the stones below. Uneven surfaces of stones (which make the stone "wobble") should be chipped

Figure 8: House in Alpindurada near Oporto, Portugal

and dressed straight rather than shimming the wall with small stone pieces and wedges which tend to work loose in time on the outer faces. In massive walls the principle of two-over-one and one-over-two prevents lines of weaknesses appearing in the wall.

Joints must never have a vertical "run" through the wall. In cases where not sufficient bond is provided, the wall could "fold-up", as dynamic stresses concentrate at the weakest point. Every 2 to 3 meters a long tie stone helps in tying one face to another. Rectangular stones of even thickness, the longer the better, should be reserved for wall ends and corners, especially for external walls. The higher a wall, the wider and deeper the footings should be. The importance of "bed-laying" of building stone cannot be overemphasized.

Mortar

The amount of mortar (preferably a mortar on a lime base) for filling the joints or for putting up the walls partly dry, depends on the type of stone available, its use and size of structure required. The stone is usually stronger and more durable than the mortar in which it is bedded. Well tied, stacked and bonded stonework without mortar is more stable. In some cases it is also more attractive than an indifferently built wall with thick mortar joints. However, walls have to be less massive with a mortar bond. Mortar seals the joints between the stones and enables the use of different shapes and sizes. It also facilitates the use of surface rendering.

Cement (or hard) mortars are more vulnerable to strains in the walls. Mortar for stonework walls should be less wet than mortars used for clay brick and/or concrete block walls. One reason for this is to prevent dribbles and rims on the finished wall. Raised joints (pointing) for stone walls are to be discouraged. They serve no useful purpose.

Conclusion

In general it can be observed that dimension stone production with low initial capital investment, labour-intensive inputs, low-grade skills, negligible energy inputs imply low production costs. The low value-to-weight ratio makes distribution a critical factor. It is very important to consider proper planning of any construction site near stone sources. Small-scale artisan units and stone masons' workshops should be located near intended markets.

Reliable quarries require a geological investigation for optimal supplies. In an integrated stone development project building stones are produced from blocks too small for marble production. A geological survey of stone sources should be conducted within a radius of approximately 10 kms from the processing site and/ or building site. Such a survey normally also provides the necessary information on the volume of available reserves.

Glossary

- phyllite: a clayey rock intermediate in metamorphic grade between slate and schist
- schist: a foliated metamorphic rock which splits easily
- marl: a calcerous clay
- karst: uneven morphology due to enlargement of joints by water action
- rubble: walling stone of irregular shape and sizes
- ashlar: finely squared stone to given sizes
- snecked wall: squared rubble wall uncoursed, built to a regular pattern consisting of one riser, two levellers and one sneck (a small roughly squared stone used in snecking).

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What is BASIN?

Building materials and construction technologies that are appropriate for developing countries, particularly in the low-income sector, are being developed, applied and documented in many parts of the world. This is an important prerequisite for providing safe, decent and affordable buildings for an ever-growing population.

But such new developments can do little to improve the building situation, as long as the information does not reach potential builders. The types and sources of information on standard and innovative building technologies are numerous and very diverse, making access to them difficult.

Thus, in order to remedy this drawback, Shelter Forum, GATE, ITDG, SKAT and CRATerre are co-operating in the Building Advisory Service and Information Network, which covers five principal subject areas and co-ordinates the documentation, evaluation and dissemination of information.

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